NUCLEAR WASTE MANAGEMENT ORGANIZATION
SOCIÉTÉ DE GESTION DES DÉCHETS NUCLÉAIRES

Preliminary Assessment for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel

THE CORPORATION OF THE TOWNSHIP OF THE NORTH SHORE, ONTARIO

FINDINGS FROM PHASE ONE STUDIES

APM-REP-06144-0100

DECEMBER 2014

About the NWMO and its work

The Nuclear Waste Management Organization (NWMO) was created by Canada's nuclear energy generators in 2002 as a requirement of the *Nuclear Fuel Waste Act*. The Act requires the NWMO to study, recommend and then implement a plan for the long-term management of used nuclear fuel in Canada.

The NWMO approaches its work with the following vision: the long-term management of Canada's nuclear waste in a manner that safeguards people and respects the environment, now and in the future.

The NWMO is guided by five fundamental values:

Integrity: We will conduct ourselves with openness, honesty and respect for all persons and organizations with whom we deal.

Excellence: We will pursue the best knowledge, understanding and innovative thinking in our analysis, engagement processes and decision-making.

Engagement: We will seek the participation of all communities of interest and be responsive to a diversity of views and perspectives. We will communicate and consult actively, promoting thoughtful reflection and facilitating a constructive dialogue.

Accountability: We will be fully responsible for the wise, prudent and efficient management of resources, and be accountable for all our actions.

Transparency: We will be open and transparent in our process, communications and decision-making, so that the approach is clear to all Canadians.

The work of the NWMO is subject to federal regulatory oversight and is regulated under the *Nuclear Safety and Control Act*. The NWMO's work is required to meet all applicable regulatory standards and requirements for protecting the health and safety of persons, the environment and national security, and to respect Canada's international commitments on the peaceful use of nuclear energy. For financial surety, its work is also required to be fully funded by the waste-producing organizations through independently managed trust funds.

Preface

Since initiating the siting process in May 2010, the Nuclear Waste Management Organization (NWMO) has worked collaboratively with interested communities to implement Adaptive Phased Management (APM), Canada's plan for the safe, long-term care of used nuclear fuel. At this early point in the multi-year site selection process, the focus of work is on exploring potential to meet specific requirements to safely host a deep geological repository and Centre of Expertise, the core components of Canada's plan.

Findings summarized in this document have emerged from studies conducted as part of Phase 1 of the Preliminary Assessment, the initial phase of study in Step 3 of the nine-step process for selecting a site. This document reviews the outcome of desktop studies that explored the potential to find a site that can safely and securely contain and isolate used nuclear fuel from people and the environment for the long time period required. It also summarizes learning that transpired through working with the community to build understanding about APM, and to explore the project's potential to align with the long-term vision of the community in a way that contributes to its well-being.

The Township of The North Shore is one of 13 communities engaged in exploring potential interest in hosting this national infrastructure project. Findings from its Phase 1 Preliminary Assessment are intended to support the Township and the NWMO in taking stock of the community's potential to meet the requirements for hosting APM facilities. These assessments also provide the basis upon which the NWMO will identify a smaller number of communities to be the focus of the next phase of more detailed studies.

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The journey of the Township of The North Shore in the APM process began in April 2011 when ELNOS (the economic development corporation representing the area communities of Blind River, Elliot Lake, Spanish, The North Shore and Serpent River First Nation) approached the NWMO to learn more about the program. This request came to the NWMO in response to an open invitation to communities and groups to learn more about Canada's plan. Highlights of The North Shore's engagement to date in this Learn More process are provided below.

In August 2011, ELNOS board members, community representatives, members of Council, and Township staff received a briefing from the NWMO in Toronto. They had a formal Learn More briefing in November 2011 at which time they also toured the Pickering Waste Management Facility (PWMF) at the Pickering generating station.

The Township's Council passed a resolution to request a Learn More session and an initial screening of the community's potential suitability for the project in March 2012. This request came to the NWMO in response to an open invitation to communities to learn more about APM with the understanding the community could end its involvement at any time. In April 2012, the NWMO provided information to community officials regarding the initial screening phase of work.

Upon completing the initial screening in September 2012, the NWMO and the consultant that conducted the work presented findings to Council. Copies of the final report (summary version, as well as detailed report) were also provided. The report's findings indicated that "*the review of readily available information and application of the five initial screening criteria did not identify*
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obvious conditions that would exclude the Township of The North Shore from further consideration in the site selection process."

The Township has actively pursued learning opportunities to become better informed about the project and nuclear waste management in general. To make information about the project and the site selection process readily available to community members, Council asked the NWMO to set up an information kiosk about the APM Project in the municipal office. This is also the location of the NWMO community office.

At the invitation of Council, the NWMO convened Open Houses in The North Shore in September 2012 to review initial screening results and to share information about the project and site selection process. Invitations to these events were sent to residents of The North Shore, as well as leaders of surrounding communities. Individuals and groups who met with the NWMO during these events included members of Township council and staff, students, representatives from the business community, seniors, camp operators, health-care and social service providers, and representatives of local First Nation communities. Also in September 2012, a small community delegation attended the International Conference on Geological Repositories to learn about how other countries are approaching site selection processes.

In November 2012, Council expressed an interest in learning more about preliminary assessments, the next step in the site selection process. At Council's request, the NWMO provided a briefing to Council that outlined what would be involved should the Council wish to proceed to this step. After further consideration, Council passed a resolution later in November 2012 expressing its interest in continuing to learn more about APM and to initiate feasibility studies by proceeding to Step 3 for the first phase of preliminary assessment activities.

To facilitate learning and dialogue within the community, Council established The North Shore Community Liaison Committee (NSCLC) in February 2013. The NSCLC was directed by Council to help facilitate involvement of community members in learning about the project in an open and inclusive manner, and to help inform NWMO studies. The NSCLC held its first meeting in February 2013.

Beginning in February 2013, the Council, the NSCLC and the NWMO worked together to review plans for the range of technical and social well-being studies associated with the Step 3 Phase 1 preliminary assessment process. They also reviewed the resource program available to the community to support activities to learn about and reflect on its interest in the project, encourage local discussion, and engage with the NWMO as the assessment was undertaken. The community worked closely with the NWMO to plan local dialogues and engagement, as well as early outreach to First Nation and Métis communities in the area, and surrounding communities.

To support engagement in the assessment process, the NSCLC established a monthly meeting schedule, with NWMO staff attending as requested to be part of the discussion and to work with the committee to complete preliminary assessment studies. Meetings were advertised in advance and open to the public. The Council appointed a project co-ordinator. The NSCLC also established a website and regular community newsletter, sought presentations from NWMO staff specialists and other relevant individuals/organisations about topics of interest to the committee, and helped organize Open Houses. At these Open Houses, NWMO specialists used interactive exhibits, videos, poster displays and printed materials to help explain various aspects of APM and answer questions about the project.

Working collaboratively, the Township, the NSCLC and the NWMO also undertook a wide range of outreach activities with local individuals and groups such as political leaders, first responders, educators, health-care providers, municipal staff, community group members and First Nation and Métis leaders. To support ongoing dialogue with the community, the NWMO opened a local office in the community in October 2013.

A broad range of community leaders was engaged through individual briefings and conversations held as part of the study process.

The NSCLC made a visit to the OPG interim storage facility at the Western Waste Management Facility at the Bruce Nuclear Generating Station in August 2013, followed by a briefing with the NWMO. A supplementary tour was facilitated in July 2014 for members of the NSCLC who were unable to attend the first tour.

The NSCLC actively involved the community in the development of a community profile and community well-being assessment report. Open Houses were organized to share the progress of studies and learning, and to seek input from community members. Open Houses were convened in May 2014 to engage community members in discussion of the work involved in Phase 1 preliminary assessment studies and report on findings of work to date. CNSC staff made a presentation to the NSCLC in May 2014 as well.

Led by the NSCLC, engagement activities in 2014 also included hosting the NWMO's Mobile Transportation Exhibit. This exhibit provided community members an opportunity to see a licensed used fuel transportation container, and learn more about the robust regulations, policies and procedures that must be met. The exhibit's visit to the community in May 2014 coincided with the NWMO Open House.

Recognizing the importance of engaging First Nation and Métis communities in the area, and surrounding communities in discussion about this project, the Township and the NWMO began to reach out to groups and individuals beyond the community in a very preliminary way. This outreach included potentially affected First Nation and Métis communities, and mayors and council members of neighbouring communities.

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The objective of the site selection process, through several phases of progressively more detailed assessments, is to arrive at a single location for both the deep geological repository for Canada's used nuclear fuel and for the Centre of Expertise. The preferred site will need to ensure safety and security for people and the environment and contribute to the well-being of the area. Selecting a site will require many more years of detailed technical, scientific and social study and assessments, and much more engagement with interested communities, as well as potentially affected First Nation and Métis communities, and surrounding communities.

With 13 of the original 22 communities still engaged in exploring their interest and suitability for hosting APM, the site selection process must provide a basis for progressively identifying a smaller number of communities for more detailed assessment. Through increasingly more detailed studies, communities with strong potential to meet the project's specific requirements will be identified to become the focus of further assessment.

This process of stepwise reflection and decision-making will be supported by a sequence of assessments and engagement that will enable the NWMO and communities to learn more about
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the suitability of each potential siting area and make decisions about where to focus more detailed work. Communities may choose to end their involvement at any point during the site evaluation process until a final agreement is signed, subject to all regulatory requirements being met and regulatory approvals received.

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1. INTRODUCTION

1.1 The Purpose of This Document

Since May 2010, the Nuclear Waste Management Organization (NWMO) has worked with interested communities to implement Adaptive Phased Management (APM), Canada's plan for the long-term care of used nuclear fuel. The NWMO has worked collaboratively with interested communities to begin to explore their potential to meet site selection requirements for locating the deep geological repository and Centre of Expertise, the core components of Canada's plan.

Following a road map for decision-making that was developed collaboratively through two years of public engagement, the site selection process is now advancing through a multi-year series of steps and engagement to ensure, above all, that the site which is selected is safe and secure, and meets the highest scientific, professional and ethical standards.

This document, together with a series of supporting reports, captures learning to date from the Phase 1 Preliminary Assessment conducted with the Township of The North Shore, Ontario.

Findings summarized in this document have emerged from studies conducted as part of Phase 1 of the Preliminary Assessment – the initial phase of study in Step 3 of the nine-step site selection process. The document reviews the outcome of desktop studies that explored the potential to find a site which can safely and securely contain and isolate used nuclear fuel from people and the environment for the long time period required. It also summarizes the learning that has emerged through working with the community to help them understand the safety of the project, and explore the potential for the project to align with the values and aspirations of the community over the long term and contribute to the well-being of the community and area.

The findings presented in this Phase 1 report are intended to provide input to early stock-taking of the potential for the community to meet the requirements to host the APM facilities. It is also intended to be an aid in NWMO decision-making to identify the smaller number of communities as the focus of more detailed Phase 2 studies, should the community be willing to continue in the process.

1.2 Towards Partnership

Although the focus of this assessment is the Township of The North Shore, it is understood that a broader partnership involving potentially affected First Nation and Métis communities, and surrounding communities would be needed in order for the project to proceed in this or any other area.

Through working with The North Shore and other communities involved in the site selection process in Phase 1 activities, and initial outreach with First Nation and Métis communities in the area, and surrounding communities, the nature and shape of the partnerships required to implement the APM Project is beginning to emerge. This project will only proceed with the involvement of the interested community, potentially affected First Nation and Métis communities, and surrounding communities working in partnership to implement it.

1.3 A Matter of Responsibility

For decades, Canadians have been using electricity generated by nuclear power reactors in Ontario, Quebec and New Brunswick. Over 2.5 million used fuel bundles have been produced. When used nuclear fuel is removed from a reactor, it is considered a waste product, is radioactive and requires careful management. Although its radioactivity decreases with time, chemical toxicity persists and the used fuel will remain a potential health risk to people and the environment for many hundreds of thousands of years. Canada's used nuclear fuel is now safely stored on an interim basis at licensed facilities located where it is produced. Putting in place a plan for the long-term, safe and secure management of used nuclear fuel for the protection of people and the environment is an important responsibility that Canadians share. Through dialogues with citizens and Aboriginal peoples across Canada, the NWMO has heard that this generation wants to move forward in dealing with our used nuclear fuel, believing it to be imprudent and unfair to future generations to wait any longer.

1.4 The Foundation of Canada's Plan

The Government of Canada selected Canada's plan for the long-term management of used nuclear fuel in 2007. The plan, called Adaptive Phased Management, involves the development of a large national infrastructure project in an informed and willing host community. The project involves the long-term containment and isolation of used nuclear fuel from people and the environment in a deep geological repository in a suitable rock formation. It also involves the development of a Centre of Expertise and transportation plan.

As required by the *Nuclear Fuel Waste Act*, 2002, the NWMO is responsible for implementing Canada's Plan. The NWMO is committed to carrying out its work collaboratively with interested and affected citizens and organizations in a manner that is socially acceptable, technically sound, environmentally responsible and economically feasible.

Adaptive Phased Management (APM) – At a Glance:

- Was developed through a nationwide dialogue between 2002 and 2005
- Was selected as Canada's plan by the Government of Canada in 2007, consistent with the *Nuclear Fuel Waste Act*
- Key features include:
  - Safe and secure centralized containment and isolation of used nuclear fuel in a repository deep underground in a suitable rock formation
  - A series of steps and clear decision points that can be adapted over time
  - An open, inclusive and fair siting process to identify an informed and willing host community
  - Opportunities for people and communities to be involved throughout the implementation process
  - Optional temporary shallow storage at the central site, if needed
  - Long-term stewardship through the continuous monitoring of used fuel
  - Ability to retrieve the used fuel over an extended period should there be a need to access the waste or take advantage of new technologies
  - Financial surety and long-term program funding to ensure the necessary money will be available for the long-term care of used nuclear fuel

1.5 The Site Selection Process

Through a collaborative process in 2008 and 2009, the NWMO worked with interested Canadians to develop the decision-making framework for selecting a site for the project. The site selection process is laid out in the NWMO's document: "*Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel*" (NWMO, 2010).

The site selection process is designed to ensure safety, security and protection of people and the environment. Reflecting the guidance provided by Canadians, the site selection process is built on a set of principles that reflects the values and priorities of Canadians on this issue. The process also contains a number of steps that these Canadians told us need to be part of the decision-making process to ensure it is an appropriate one for Canada, as set out in the table on the next pages.

Phase 1 Preliminary Assessments are conducted as part of Step 3 activities early in the site selection process. Several additional steps must be completed over the course of the next several years before a preferred site will be identified and environmental assessment and regulatory review will be sought. Interested communities may leave the site selection process at any time during this process until a final agreement is signed, subject to all regulatory requirements being met and regulatory approval received.

It is fundamental to the siting process that only an informed and willing community be selected to host the project as evidenced by a compelling demonstration of willingness involving community residents. The project will only be implemented in an area in which robust safety requirements can be met and well-being will be fostered.

Table 1-1: Steps in the Site Selection Process – At a Glance

Getting Ready	**The NWMO publishes the finalized siting process, having briefed provincial governments, the Government of Canada, national and provincial Aboriginal organizations, and regulatory agencies on the NWMO's activities**. The NWMO will continue briefings throughout the siting process to ensure new information is made available and requirements which might emerge are addressed.
Step 1	**The NWMO initiates the siting process with a broad program to provide information, answer questions and build awareness among Canadians about the project and siting process.** Awareness-building activities will continue throughout the full duration of the siting process.
Step 2	**Communities identify their interest in learning more, and the NWMO provides detailed briefing. An initial screening is conducted.** At the request of the community, the NWMO will evaluate the potential suitability of the community against a list of initial screening criteria.
Step 3	**For interested communities, a preliminary assessment of potential suitability is conducted.** At the request of the community, the NWMO will conduct a feasibility study collaboratively with the community to determine whether a site has the potential to meet the detailed requirements for the project. Regional engagement will be initiated, and an initial review of transportation considerations will be conducted. Interested communities will be encouraged to inform surrounding communities, including potentially affected Aboriginal communities and governments, as early as possible to facilitate their involvement.
	Phase 1: For interested communities passing the Initial Screening, a preliminary desktop assessment is conducted. Some communities may be screened out based on these assessments.
	Phase 2: Field investigations and expanded regional engagement proceed with smaller number of communities.
Step 4	**For interested communities, potentially affected surrounding communities are engaged if they have not been already, and detailed site evaluations are completed.** In this step, the NWMO will select one or more suitable sites from communities expressing formal interest for regional study and/or detailed multi-year site evaluations. The NWMO will work collaboratively with these communities to engage potentially affected surrounding communities, Aboriginal governments and the provincial government in a study of health, safety, environment, social, economic and cultural effects of the project at a broader regional level (Regional Study), including effects that may be associated with transportation. Involvement will continue throughout the siting process as decisions are made about how the project will be implemented.

Step 5	**Communities with confirmed suitable sites decide whether they are willing to accept the project and propose the terms and conditions on which they would have the project proceed.**
Step 6	**The NWMO and the community with the preferred site enter into a formal agreement to host the project.** The NWMO selects the preferred site, and the NWMO and community ratify a formal agreement.
Step 7	**Regulatory authorities review the safety of the project through an independent, formal and public process, and if all requirements are satisfied, give their approvals to proceed.** The implementation of the deep geological repository will be regulated under the *Nuclear Safety and Control Act* and its associated regulations to protect the health, safety and security of Canadians and the environment, and to respect Canada's international commitments on the peaceful use of nuclear energy. Regulatory requirements will be observed throughout all previous steps in the siting process. The documentation produced through previous steps, as well as other documentation that will be required for a licence application, will be formally reviewed by regulatory authorities at this step through an Environmental Assessment, and if this assessment is successful, then licensing hearings related to site preparation (and possible construction) of facilities associated with the project. Various aspects of transportation of used nuclear fuel will also need to be approved by regulatory authorities.
Step 8	**Construction and operation of an underground demonstration facility proceeds.**
Step 9	**Construction and operation of the facility**.

1.6 Initial Community Involvement

Communities involved in this stage of work entered the site selection process by expressing interest in learning more about Canada's plan for the long-term management of used nuclear fuel and the APM Project (Step 2) as part of an open invitation process.

With this expression of interest, the NWMO undertook an Initial Screening as part of Step 2 studies and began working with the community as they learned about the project and reflected upon their interest in it. The purpose of the Initial Screening was to determine whether, based on readily available information and five screening criteria, there were any obvious conditions that would exclude the community from further consideration in the site selection process.

For communities that successfully completed an Initial Screening and decided to enter Step 3 of the site selection process (Preliminary Assessments), the NWMO began working with the community to conduct a preliminary assessment. The purpose of Preliminary Assessments is to continue the learning and reflection process within the community, begin to involve potentially affected First Nation and Métis communities, and surrounding communities in the process, and further explore the potential for the community to meet the detailed requirements for the project with more detailed scientific and technical studies.

Twenty-two communities have entered the site selection process since it began in 2010. There are 13 communities involved in the site selection process. For Phase 2, four assessments are in progress and two are anticipated to be initiated in 2015, pending confirmation of a path forward with the community. Figure 1-1 maps the locations of these communities in Saskatchewan and Ontario.

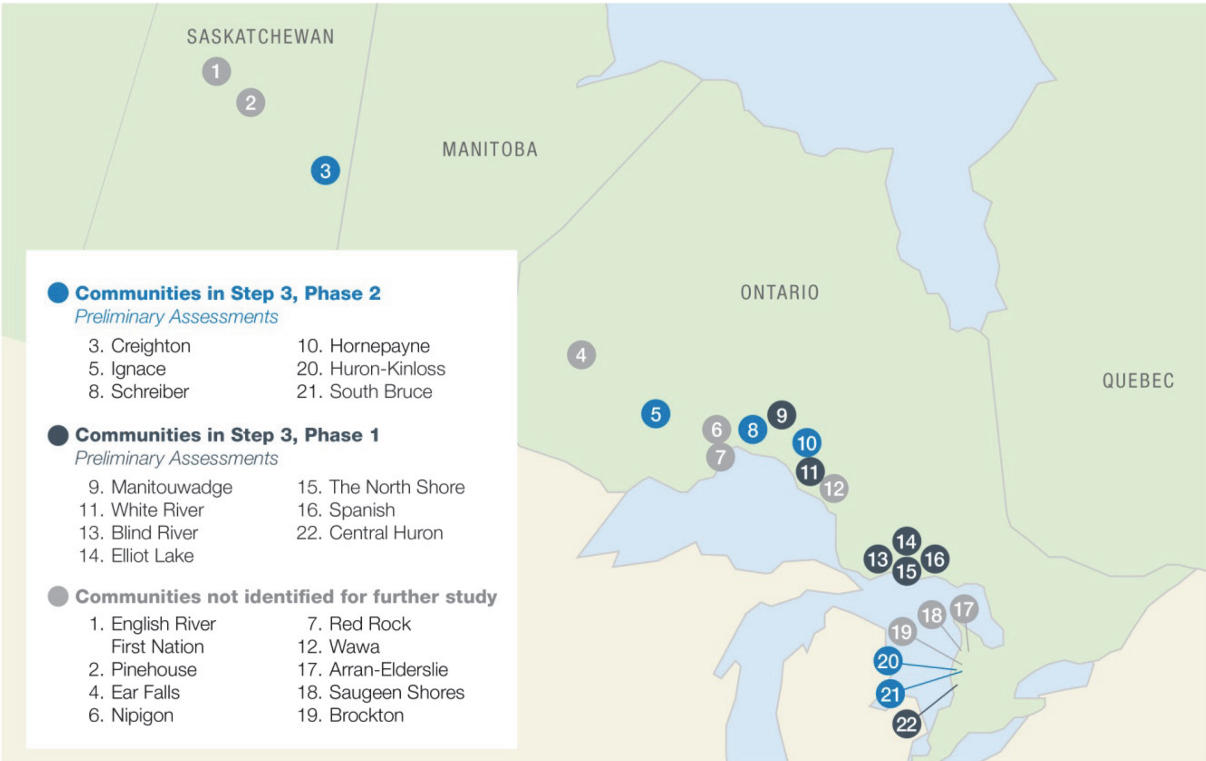

Figure 1-1: Communities Involved in the Site Selection Process

1.7 Approach to Preliminary Assessments

Preliminary Assessments address siting factors and criteria as described in the NWMO's document: "*Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel*" (NWMO, 2010). Preliminary Assessment studies in Step 3 of the siting process are being conducted in two phases, with the opportunity for stock-taking by both the community and the NWMO throughout.

- ***Phase 1:*** Assessments are conducted with all communities that successfully completed an Initial Screening and asked to be the focus of a Preliminary Assessment. This phase involves desktop studies to explore the potential to meet safety requirements, and includes studies of engineering, geoscientific suitability, environment and safety, and transportation. This phase also involves community-learning about the project, and engagement and reflection on the potential for the project to foster the well-being of the community and fit with its long-term vision. Working with communities, this phase also explores early indications as to whether it would be possible to sustain interest in learning through subsequent phases of work required to support informed decision-making and a compelling demonstration of willingness at a future stage. This phase begins to involve potentially affected First Nation and Métis communities, and surrounding communities, in a dialogue about the project that would continue in future phases. This phase of work is completed in a year or more.

- ***Phase 2:*** Assessments are conducted with a smaller number of interested communities identified by the NWMO based on the outcome of Phase 1 studies. Phase 2 work will further assess potentially suitable areas through detailed technical studies and field investigations. This phase also involves more detailed exploration of the potential to foster the well-being of the community. Learning and engagement are expanded to involve First Nation and Métis communities in the area, and surrounding communities, in exploring the potential to foster the well-being of the larger area, interest in the project, and the foundation to work together in partnership to implement the project. Together, the NWMO, potentially suitable communities, potentially affected First Nation and Métis communities, and surrounding communities, will reflect upon the suitability of the community and area to host the APM Project. Phase 2 Preliminary Assessments are expected to require a number of years to complete.

The focus of the preliminary assessments to date has been on Phase 1. The two-phased approach to assessments is discussed in "*Preliminary Assessment of Potential Suitability – Feasibility Studies*" (NWMO, 2011).

The NWMO has adopted an integrated approach to Preliminary Assessments, with assessments focused on safety and community well-being through study of many technical, scientific and social requirements for the project.

In assessing the siting factors and criteria, four overarching research questions have guided this early phase of Preliminary Assessment, and have been a focus of reflection by both the NWMO and the community. These questions are discussed in more detail in "*Preliminary Assessment of Potential Suitability – Feasibility Studies*" (NWMO, 2011).

1. Safety, security and protection of people and the environment are central to the siting process. ***Is there potential to find a safe site?***

   Safety was examined through several perspectives:
   - **Potential to find a site with suitable geology.**
   - **Potential to safely construct the facility at the potential site.**
   - **Potential for safe and secure transportation to the potential site.**
   - **Potential to manage any environmental effects and to ensure safety of people and the environment.**

2. The project will be implemented in a way that will foster long-term well-being of the community. ***Is there potential to foster the well-being of the community through the implementation of the project, and what might need to be put in place (e.g., infrastructure, resources, planning initiatives) to ensure this outcome?***

3. At a later step in the process, the community must demonstrate it is informed and willing to host the project. ***Is there potential for citizens in the community to continue to be interested in exploring this project through subsequent steps in the site selection process?***

4. The project will be implemented in a way that will foster the long-term well-being of the surrounding area. ***Is there potential to foster the well-being of the surrounding area and to establish the foundation to move forward with the project?***

These broad questions were addressed through a series of studies as outlined in Figure 1-2.

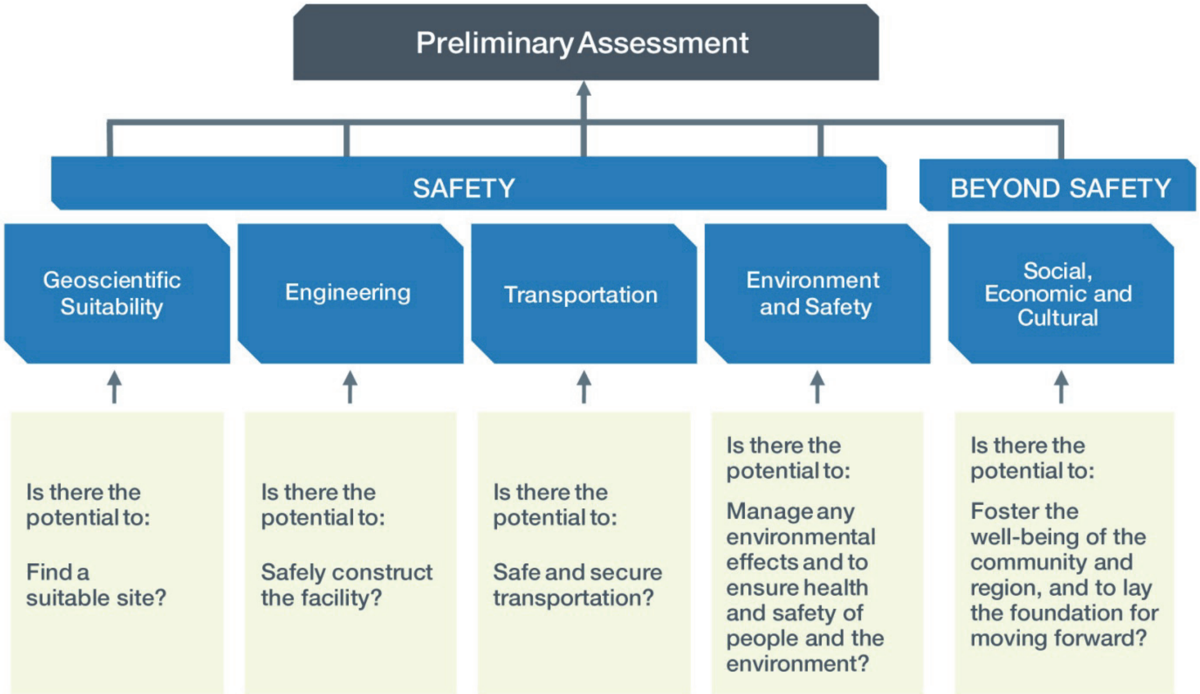

Figure 1-2: The Phase 1 Preliminary Assessment Studies

In Phase 1, studies have involved a range of activities. Some activities have been completed by expert consultants, such as the assessment of the geological characteristics of the area, which is one of several studies focused on assessing the potential to find a safe site. Other activities were completed in partnership with the community; for instance, exploring the potential for the project to be implemented in a way that contributes to the long-term well-being of the community. Throughout, the NWMO has worked with community leaders to engage residents, and begin to reach out to potentially affected First Nation and Métis communities and surrounding communities to involve them in the work. In Phase 2, these studies will be expanded through commencement of fieldwork and broadened engagement with communities progressing to Phase 2.

As discussed in the NWMO site selection process, the suitability of potential sites is assessed against a number of site evaluation factors, organized under six safety functions a site would need to satisfy to be considered suitable (NWMO, 2010). Phase 1 safety assessment studies initiated exploration of a subset of these factors using a desktop study approach. Phase 2 assessments will include field studies and borehole investigation, which will allow for a broadening of the assessment to more comprehensively address the evaluation factors. The six safety evaluation factors are:

- ***Safe containment and isolation of used nuclear fuel***: Are the characteristics of the rock at the site appropriate to ensuring long-term containment and isolation of used nuclear fuel from humans, the environment and surface disturbances caused by human activities and natural events?

- ***Long-term resilience to future geological processes and climate change****:* Is the rock formation at the siting area 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 geological and climate change process such as earthquakes and glacial cycles?
- ***Safe construction, operation and closure of the repository****:* Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance through future exploration or mining?
- ***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?
- ***Safe transportation:*** Does the site have a route that exists or is amenable to being created that enables the safe and secure transportation of used fuel from storage sites to the repository site?

A number of factors beyond safety were identified for assessment of the potential for the project to foster the well-being of the interested community (NWMO, 2010). Phase 1 community well-being studies were focused on each community that expressed interest in learning about the project. For this reason, the studies addressed the subset of factors pertaining to the community. Phase 2 studies are designed to expand the assessment to consider factors related to the surrounding area, including First Nation and Métis communities in the area and surrounding communities. The factors beyond safety are:

- **Potential social, economic and cultural effects during the implementation phase of the project, including factors identified by Aboriginal Traditional Knowledge.**
- **Potential for enhancement of the community's and the region's long-term sustainability through implementation of the project, including factors identified by Aboriginal Traditional Knowledge.**
- **Potential to avoid ecologically sensitive areas and locally significant features, including factors identified by Aboriginal Traditional Knowledge.**
- **Potential for physical and social infrastructure to adapt to changes resulting from the project.**
- **Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site.**

To ensure a broad, inclusive and holistic approach to assessment in these areas, a community well-being framework was identified to help understand and assess the potential effects of the APM Project. This framework was used to help explore the project, understand how the community and the surrounding area may be affected should the project be implemented in the area, and identify opportunities to leverage the project to achieve other objectives important to people in the community and surrounding areas.

1.8 Next Steps

The objective of the site selection process, through several phases of progressively more detailed assessment, is to arrive at a single location for the deep geological repository and Centre of Expertise. It will take several more years of detailed technical, scientific and social study and assessments, and more engagement with interested communities, potentially affected First Nation and Métis communities, and surrounding communities before a preferred safe site for the project can be confirmed.

With 13 communities continuing to explore potential interest and suitability for hosting the project, the siting process must provide a basis to progressively narrow the focus to communities with strong potential to meet requirements until a single preferred site and area is identified. These decisions will be supported by a sequence of assessments and engagement designed to enable the NWMO and communities to learn more about the potential suitability of each area and decide whether to proceed to the next stage.

The process of narrowing down the communities engaged in site selection commenced in Fall 2013 and will continue gradually over several years as more technical and social assessments are completed.

- In November 2013, the NWMO implemented an initial phase of narrowing down based on the results of Phase 1 Preliminary Assessment for an initial group of eight communities (English River First Nation, Pinehouse, Creighton, Ear Falls, Ignace, Schreiber, Hornepayne and Wawa). Four of these communities with strong overall potential to meet the site selection requirements were identified as warranting further study through Phase 2 assessments. These communities are Creighton, Ignace, Schreiber, and Hornepayne.

- In January 2014, the NWMO concluded siting studies in the Municipality of Arran-Elderslie and the Town of Saugeen Shores. Early findings indicate the Town of Saugeen Shores has very limited potential to contain areas that would meet the geoscientific site evaluation factors outlined in the site selection process document. Similarly, the Municipality of Arran-Elderslie does not contain sufficient land areas that have the potential to meet these factors (Geofirma, 2014; NWMO, 2014a).

- In June 2014, the Council of the Township of Nipigon passed a Resolution to discontinue its involvement as a potential host community for Canada's plan for the safe, long-term management of used nuclear fuel. The decision followed review of an interim report (NWMO, 2014b; DPRA, 2014; Golder, 2014), which the NWMO prepared at the request of the Township to report on preliminary assessment work completed in the community so far.

- In December 2014, the NWMO further narrowed down the remaining interested communities based on the results of Phase 1 Preliminary Assessment for the three communities located in Bruce County (Brockton, Huron-Kinloss, and South Bruce). Two of these communities with strong potential to meet the site selection requirements were identified as warranting further study through Phase 2 assessments. These communities are Huron-Kinloss and South Bruce.

- In 2015, the NWMO expects to complete Phase 1 Preliminary Assessments as requested for all remaining communities in the site selection process. As these assessments are completed, another phase of narrowing down will be implemented, with communities showing strong potential to be suitable identified for further study in Phase 2.

- Beginning in 2014, Phase 2 Preliminary Assessment studies will take place over a multi-year period with a smaller number of communities with relatively strong potential to host APM. Over this period, field studies will commence, and engagement will be broadened. Building on earlier studies, Phase 2 will include preliminary geoscientific- and environment-focused field investigations, more detailed social and economic studies, awareness building and deepening learning and reflection by the interested community, and broadening of engagement to involve potentially affected First Nation and Métis communities, and surrounding communities in learning and assessment of the suitability of the area.

- By the end of the second phase of study, one or possibly two communities with strong potential to meet requirements to host the facility will be the focus of Step 4, Detailed Site Characterization. This step will include extensive studies to assess and confirm safety, and may require a number of years to complete. Findings will support identification of the preferred location that will be the focus of a regulatory approvals process led by the Canadian Nuclear Safety Commission (CNSC).

1.9 Moving Forward in Partnership

Each community engaging in Phase 1 Preliminary Assessments has helped initiate the process of relationship building that is needed to support the implementation of APM. The NWMO has learned a great deal from communities over the course of these initial studies about working together to envision the project and how best to implement the project with those potentially affected.

Through work with interested communities, and initial outreach to First Nation and Métis communities in the area, and surrounding communities, the NWMO is learning about the nature and shape of partnerships that will be required to implement the APM Project together. Involving potentially affected First Nation and Métis communities, and surrounding communities in learning and decision-making will be an important focus of activity of Phase 2 work with communities that proceed in the siting process. The implementation of Canada's plan will only proceed with the involvement of the interested community, potentially affected First Nation and Métis communities, and surrounding communities working in partnership to implement the project.

As Canada continues along the path of implementing APM, it will take our best knowledge and expertise, the continued leadership of communities, and all of us working together to ensure the safe long-term management of Canada's used nuclear fuel.

1.10 Organization of Report

Phase 1 Preliminary Assessment studies were initiated with the involvement of four communities in the siting process: the City of Elliot Lake, the Town of Blind River, the Township of The North Shore, and the Town of Spanish. Safety-related Preliminary Assessment studies were conducted in an integrated manner. For the purpose of these early studies, an "Area of Study", or "Area", was identified that included these four communities and the surrounding area. The boundaries of the Area of Study were defined to encompass the main geological features within the communities and their periphery. Community well-being assessment studies were conducted individually for each community to better understand the potential for the APM Project to align with the interest of each community, and to understand where future activities in the Area might best focus.

Should studies continue in the Area, the next phase of work (Phase 2) is intended to involve First Nation and Métis communities in the area, and surrounding communities, in the conduct of the studies.

Findings from the Phase 1 Preliminary Assessment for the Township of The North Shore are outlined in the chapters of this report. The chapters are based on a series of supporting technical documents, each of which is identified in the relevant chapter.

Report Overview

- ***Chapter 2*** – Brief introduction to the community.
- ***Chapter 3*** – Preliminary assessment of Engineering, which explores the potential to safely construct the facility at the potential site.
- ***Chapter 4*** – Geoscientific preliminary assessment, which explores the potential to find a suitable site within the community or surrounding area.
- ***Chapter 5*** – Preliminary Environment and Safety assessment, which explores the potential to manage any environmental effects and to ensure safety of people and the environment.
- ***Chapter 6*** – Preliminary assessment of Transportation, which explores the potential for safe and secure transportation to the potential site.
- ***Chapter 7*** – Preliminary Social, Economic and Cultural assessment, which explores the potential to foster the well-being of the community and surrounding area, and potential to create the foundation for community and area confidence and support needed to implement the project.
- ***Chapter 8*** – Taking into account the assessment in each of the major fields of investigation, this chapter concludes with reflections on potential suitability of the community and area and a discussion of the work which would be required if a decision were made to proceed to further studies.

2. INTRODUCTION TO THE TOWNSHIP OF THE NORTH SHORE

The Township of The North Shore is located along the North Channel of Lake Huron, and includes the communities of Algoma Mills, Spragge, and the Pronto East Subdivision. These communities developed as a result of industries such as logging, sawmills, and some commercial fishing.

The Township of The North Shore was created as an Improvement District in 1973, after the amalgamation of several Townships (Shedden, Lewis, Spragge, Long, and the eastern portion of Striker). In 1974, the Township was enlarged to include some North Channel islands. The Township of The North Shore and the Township of Shedden, which became the Town of Spanish, separated in 1985. The population of the Township of The North Shore was 509 in 2011.

Figure 2-1 shows the Township of The North Shore in its regional context. There are a number of Aboriginal communities and organizations around the area including Whitefish Lake First Nation, Wikwemikong Unceded First Nation, Serpent River First Nation, Mississauga #8 First Nation, Sagamok Anishnawbek First Nation, and Whitefish River First Nation. Métis Councils in the area include Historic Sault Ste. Marie Métis, North Channel Métis, Sudbury Métis, and the North Bay Métis.

A more in-depth discussion of The North Shore and the surrounding area is contained in the Community Profile (HSAL, 2014) and is woven throughout the chapters of this report, including the geoscientific characteristics of The North Shore area, the natural environment, transportation infrastructure, and the people and activities which contribute to the well-being of the community.

Figure 2-1: The North Shore and Surrounding Lands

Safety: Potential to Find a Site That Will Protect People and the Environment Now and in the Future

Any site that is selected to host the Adaptive Phased Management (APM) Project must be demonstrated to be able to safely contain and isolate used nuclear fuel for a very long period of time. The preferred site will need to address scientific and technical siting factors that acknowledge precaution and ensure protection for present and future generations.

A fundamental component of APM is the long-term containment and isolation of used nuclear fuel in a deep geological repository. The ability of the deep geological repository to safely contain and isolate used nuclear fuel relies on the form and properties of the waste, the human-made or engineered barriers placed around the waste, and the natural barriers provided by the host rock formation in which the repository will be located.

Transportation is an important consideration in the assessment of the safety of any site. In order for a site to be considered technically safe, a transportation route must be identified, or be capable of development, by which used nuclear fuel can safely and securely be transported to the site from the locations at which it is currently stored. Physical security aspects of the project and site, and potential to meet Canadian Nuclear Safety Commission (CNSC) requirements are also important and will be assessed at a later phase of study.

The potential to find a safe site is examined from four perspectives. In each, a strong potential must be demonstrated to meet or exceed the regulatory expectations of the CNSC, the guidance of the International Atomic Energy Agency and evolving international best practice. The four perspectives are:

Engineering – Is there the potential to safely construct the facility in the area?

Geoscientific suitability – Is there the potential to find a site in the area with suitable geoscientific characteristics?

Environment and safety – Is there the potential to manage any environmental effects and to ensure health and safety of people and the environment in the area?

Transportation – Is there the potential for safe and secure transportation from interim storage facilities to a site located in the area?

Preliminary Assessments at this phase of work focus on the potential to find broad siting areas in the vicinity of the interested community that entered the site selection process, and meet engineering, geoscientific, environment and safety, and transportation requirements at a high level. Should the community be selected to proceed to Phase 2, the next phase of work will involve identification of specific locations for more detailed studies. These safety-related studies, particularly those related to understanding geoscientific suitability and environmental effects, would be conducted collaboratively with the community, First Nation and Métis communities in the area, and surrounding communities as possible.

Throughout this work, the NWMO will look to Aboriginal peoples as practitioners of Traditional Knowledge to help, to the extent they wish, to guide the decisions involved in site selection and ensure that the factors and approaches used to assess the site appropriately interweave Traditional Knowledge.

3. PRELIMINARY ASSESSMENT OF ENGINEERING

3.1 Engineering Assessment Approach

The objective of the engineering preliminary assessment is to assess the potential to safely construct and operate the facility in the Area of Study. The chapter also identifies infrastructure that would be required to safely construct and operate the facility in the Area. This chapter presents a brief description of the facilities to be constructed and the characteristics of used fuel as the material to be managed, identifies additional infrastructure requirements for the project in this community, and concludes with an area-specific estimate of cost. The findings of the preliminary assessment to determine the engineering feasibility to safely construct the Adaptive Phased Management (APM) facility in the Area are presented at the end of this chapter.

3.2 Characteristics of the Material to Be Managed: Used Nuclear Fuel

For decades, Canadians have been using electricity generated by nuclear power reactors in Ontario, Quebec and New Brunswick. When used nuclear fuel is removed from a reactor, it is considered a waste product, is radioactive and requires careful management. Although its radioactivity decreases with time, chemical toxicity persists and the used fuel will remain a potential health risk for many hundreds of thousands of years. For this reason, used fuel requires careful management essentially indefinitely.

The nuclear fuel in Canadian (CANDU) reactors is natural uranium dioxide (UO_2) which is pressed into ceramic pellets and placed inside a fuel element or sheath made of a zirconium-tin alloy. The most common type of fuel bundle contains 37 fuel elements which are welded to end plates to form a bundle.

Each fuel bundle has a length of 500 millimetres, a diameter of 100 millimetres and a mass of about 24 kilograms. Other types of CANDU fuel bundles have similar dimensions and mass, but differ in the number or configuration of the fuel elements. The reference design for a deep geological repository assumes an average out-of-reactor cooling period of 30 years which results in a thermal output of 3.5 watts per bundle.

A standard CANDU fuel bundle is illustrated in Figure 3-1.

Figure 3-1: CANDU Fuel Bundle

To date, Canada has produced over 2.5 million used fuel bundles. If Canada's existing reactors operate to the end of their planned lives, including planned refurbishments, the inventory that will need to be managed in the APM facility could be 4 million bundles or more, depending on future operating experience. The NWMO reviews projected used fuel inventories annually, and has assumed a reference used fuel inventory of 4.6 million used CANDU fuel bundles (Garamszeghy, 2013).

The repository will need to be large enough to contain and isolate the volume of used fuel from existing plants in Canada. The specific amount of used fuel to be placed in the repository will be agreed with the community using the best information available at the time, and an open and transparent consultation process involving surrounding communities and others who are interested and potentially affected. Regulatory review processes and approvals, which are required by law before the project can proceed, will be based on a specific fuel inventory and will involve an open and transparent consultation process.

3.3 Conceptual Description of the APM Facility

Conceptual reference designs have been developed by the NWMO as a basis for planning and costing. Some aspects of the reference design may be refined through discussions with potential host communities and those in the surrounding area to ensure that it better addresses their values, needs and preferences while still maintaining its primary safety functions. Some aspects of the reference design will also be refined through technology development and demonstration programs conducted in Canada and internationally. Other aspects of the design can only be confirmed once a potential site has been identified and site-specific technical and scientific studies have been completed. Canada's plan, called Adaptive Phased Management, is designed to be implemented collaboratively with an informed and willing host community.

The reference design of the APM facility is a complex with a combination of surface and underground structures designed to provide multiple engineered and natural barriers to safely contain and isolate Canada's used nuclear fuel over the long term. The APM facility will require a dedicated surface area of nominally 600 metres by 550 metres for the main surface buildings and about 100 metres by 100 metres for the ventilation shaft area, which can vary with actual site characteristics. In addition, the APM facility will need an excavated rock management area of about 700 metres by 700 metres for the rock excavated from the underground repository; its location would be determined in collaboration with the community.

An illustration of the conceptual APM facility is shown in Figure 3-2.

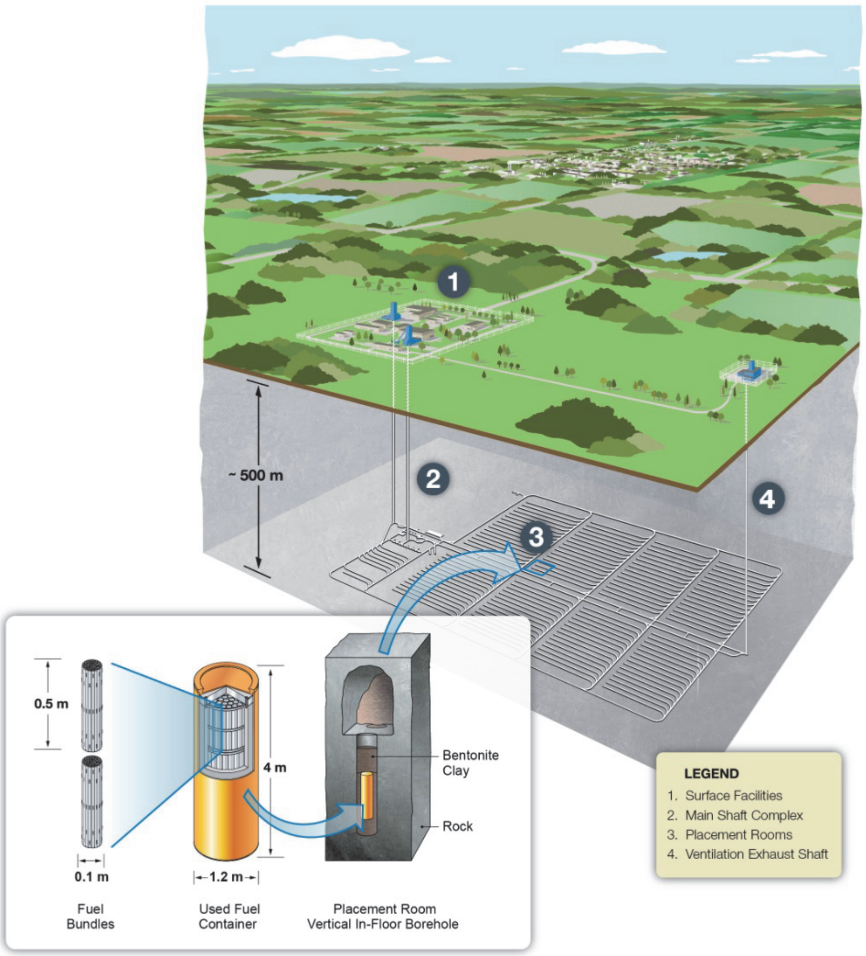

Figure 3-2: Illustration of an APM Facility

The underground footprint of the repository will depend on a number of factors, including the particular characteristics of the rock at the preferred site, the final design of the repository and the inventory of used fuel to be managed.

The layout of the underground repository has been developed for a projected reference inventory of 4.6 million used CANDU fuel bundles. It would require a subsurface area of about two kilometres by three kilometres at a depth of approximately 500 metres in suitable rock. The exact depth and layout will depend on the characteristics of the chosen site.

3.4 APM Surface Facilities

The used nuclear fuel will be transported from the licensed interim storage facilities at the reactor sites to the APM facility in transportation packages certified for road, rail and ship (CNSC, 2013). The packages will be received at the Used Fuel Packaging Plant where the used fuel bundles will be transferred into corrosion-resistant used fuel containers. The used fuel containers will be filled, sealed, inspected and dispatched for placement in the underground repository.

The APM surface facilities consist of a Nuclear Security Protected Area for all buildings and activities associated with the receiving, handling and storage of used nuclear fuel, and a Balance of Site for the remaining buildings and activities. The Nuclear Security Protected Area includes the Used Fuel Packaging Plant, the shaft buildings, auxiliary building, quality control offices, laboratory, active waste handling facilities, switch yard, and transformer area.

The Balance of Site includes the administration building, fire hall, security monitoring room, cafeteria, water and sewage treatment plants, fuel storage tanks, water storage tanks, air compressor building, concrete batch plant, and sealing materials compaction plant. An excavated rock management area for the excavated rock from the underground repository would also be required; its location would be determined in collaboration with the community.

The principal APM surface facilities are illustrated in Figure 3-3. The key structures in the APM surface facilities are described below.

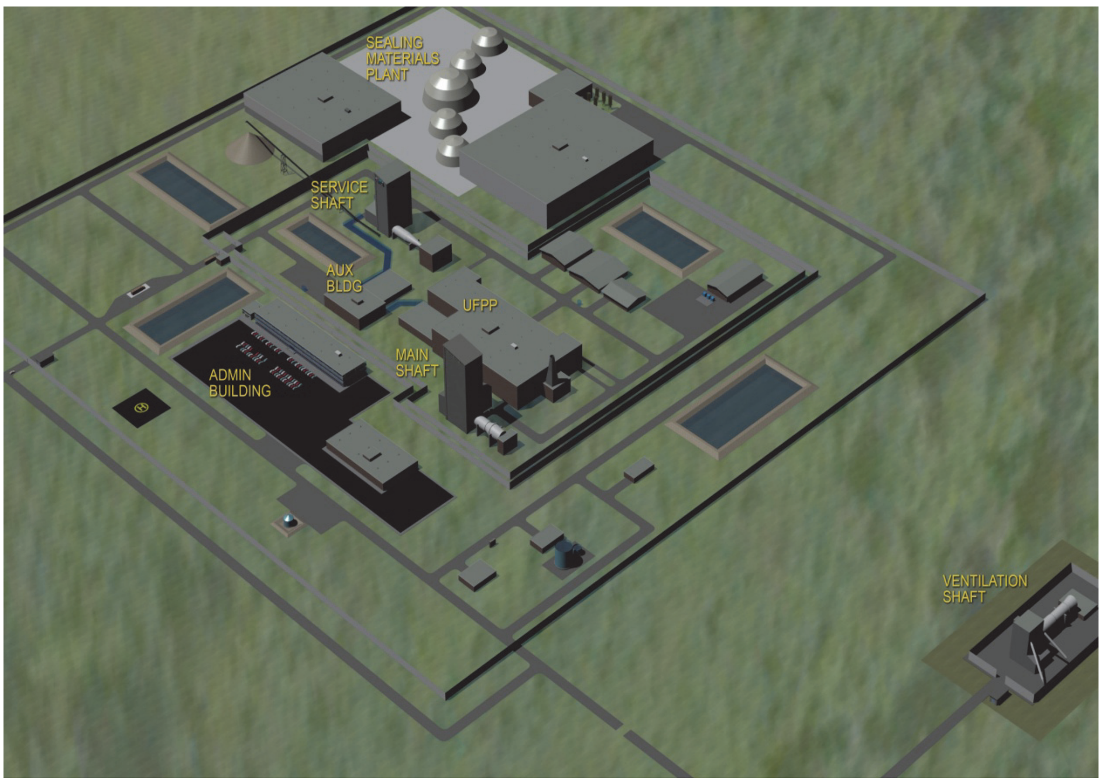

Figure 3-3: APM Surface Facilities

3.4.1 Used Fuel Container

The used fuel container is one of the principal engineered barriers in the multi-barrier deep geological repository concept. The key features of the design of the used fuel container are corrosion resistance, mechanical strength, geometry, capacity and compatibility with surrounding sealing materials such as bentonite clay.

The reference design of the used fuel container employs an outer corrosion-resistant material, and an inner supporting material. The container is designed for a load of 45 megapascals, which will withstand the combined mechanical and hydraulic pressures in a repository, including glacial events with up to three kilometres of ice combined with lithostatic loads at 500 metres depth, and the swelling pressure of the bentonite buffer seal surrounding the container. The NWMO is examining several used fuel container designs for the deep geological repository and will further study, test and refine these designs over time.

The deep geological repository will require thousands of used fuel containers over the operating period. The used fuel containers and supporting components will be manufactured and assembled at the Container Manufacturing Plant, which could potentially be located in the community or surrounding region. For each year of operation, hundreds of used fuel containers will need to be manufactured and shipped to the repository site.

An example of a design for a used fuel container is illustrated in Figure 3-4. It employs an outer corrosion-resistant shell and an inner vessel for strength. This reference container holds 360 used fuel bundles distributed in six layers of 60 bundles per layer in three steel baskets (with two bundle layers per basket). Other configurations with differing numbers of bundles are also possible. The final design will affect the number of containers required.

For a reference used fuel inventory of 4.6 million bundles, a total of 12,800 of these used fuel containers would be placed in the repository. At a placement rate of 333 containers per year (i.e., one to two containers per working day), the used fuel containers would be placed underground over a 38-year operating period.

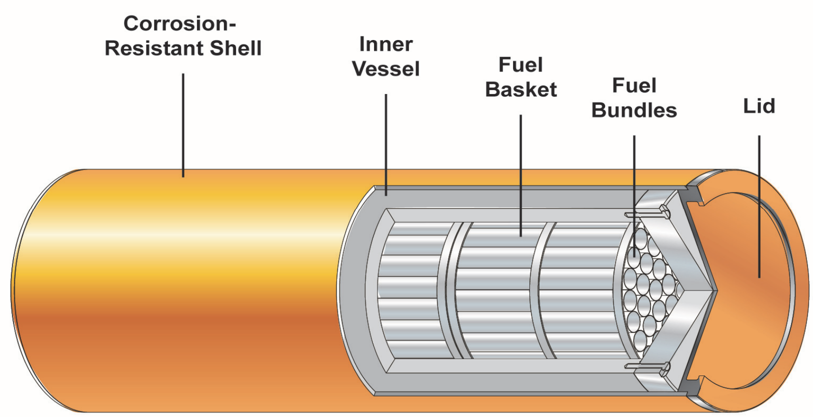

Figure 3-4: Example of a Used Fuel Container for a Deep Geological Repository

3.4.2 Used Fuel Packaging Plant

The Used Fuel Packaging Plant is an important facility for transferring Canada's used nuclear fuel from interim storage to a deep geological repository. The Used Fuel Packaging Plant encompasses all necessary areas and equipment for receiving used fuel transported from the interim storage sites to the repository, receiving empty containers, loading used fuel into the containers, and sealing, inspecting and dispatching filled containers for underground transfer and placement in the deep repository. There are also provisions for cutting open and emptying any used fuel containers that do not fulfill specified requirements following non-destructive testing and examination.

To ensure reliable delivery of used fuel containers to the deep geological repository, the plant includes storage areas for used fuel, empty containers and filled containers. Used nuclear fuel will be packaged and placed in the repository as it is received; thus it is expected that there will be only minimal storage of used fuel in the Used Fuel Packaging Plant for a short duration of time.

A conceptual layout of the Used Fuel Packaging Plant is illustrated in Figure 3-5.

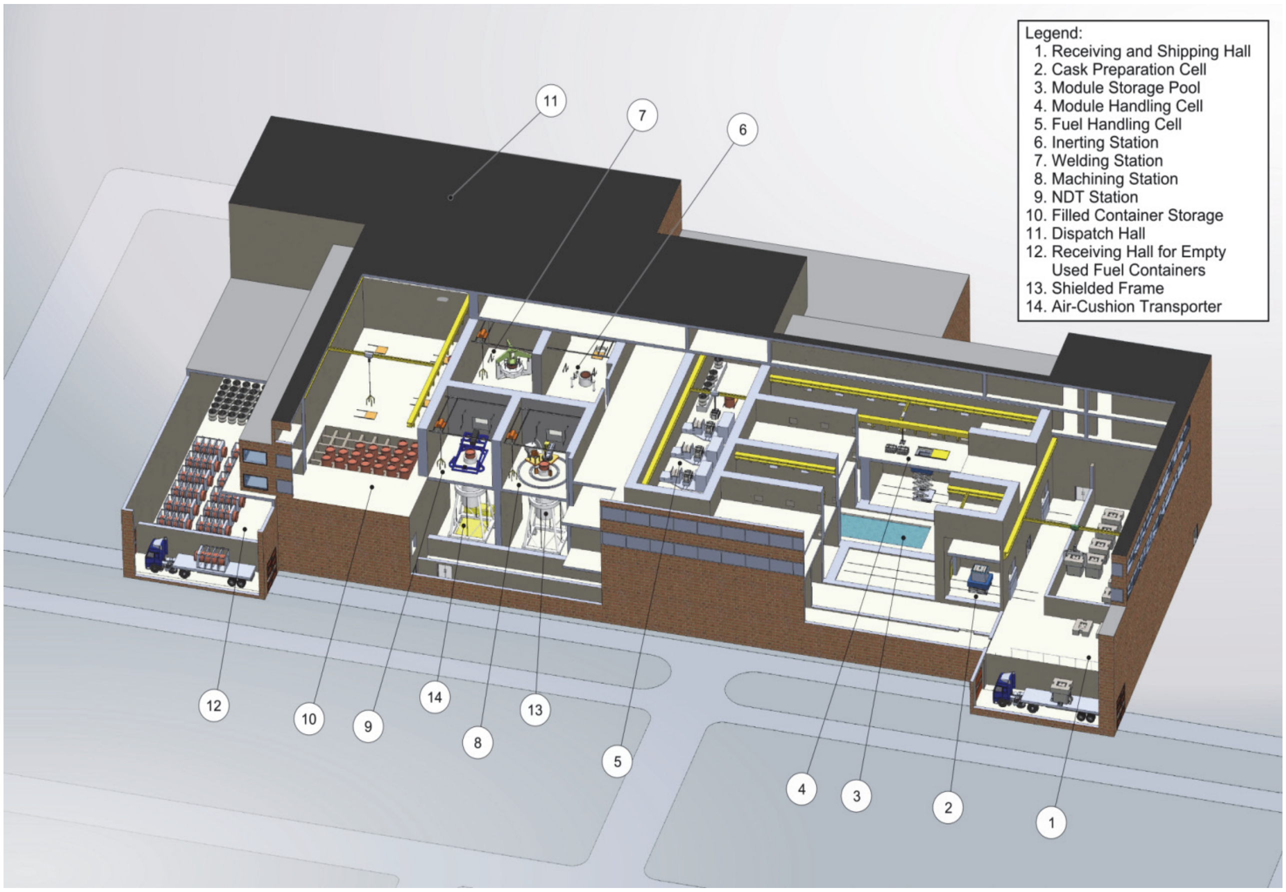

Figure 3-5: Conceptual Layout of a Used Fuel Packaging Plant

3.4.3 Sealing Materials Production Plants

The Sealing Materials Production Plants provide materials for the clay-based and cement-based engineered barriers in the repository that backfill and seal excavation openings, and inhibit groundwater movement, microbial activity, and radionuclide transport in the region surrounding the used fuel containers.

The sealing materials prepared at the production plants include materials such as:

- Highly compacted bentonite blocks;
- Dense backfill composed of bentonite and aggregate;
- Light backfill composed of bentonite and sand;
- Gapfill composed of bentonite pellets;
- Shaft seal composed of bentonite and sand; and
- Low-heat high-performance concrete.

The aggregate plant will use a portion of the excavated rock as possible from the repository to manufacture the crushed rock and sand for the backfill and concrete. These products will be stockpiled and stored on-site for use in the compaction plant where presses will be used to prepare dense backfill blocks and gapfill material (see Figure 3-6). Buffer disks and rings would also be produced at this compaction plant, depending on the container placement method chosen for the repository.

Figure 3-6: Example of a Large Press for the Sealing Materials Compaction Plant

3.4.4 Shafts and Hoists

The conceptual reference design for the APM Project includes three shafts to facilitate the transfer of rock, material, equipment and people between the surface facilities and the underground repository. The three shafts are:

- Main Shaft: Conveys the used fuel containers within a shielded transfer cask;
- Service Shaft: Conveys personnel, equipment, waste rock and sealing materials; and
- Ventilation Shaft: Will handle the majority of the repository exhaust to the surface and will be equipped with as an emergency egress.

The headframes of the three shafts will be durable and easily maintainable structures that provide a high level of protection against weather-related disturbances. All shafts will be concrete-lined as needed to minimize inflow of water and to provide a durable, easy-to-maintain surface.

During closure, the shafts will be sealed, and all headframes and peripheral equipment will be removed.

3.5 Underground Facilities

The deep geological repository is a network of underground tunnels, placement rooms for used fuel containers, supporting infrastructure, and provision for an underground facility for site-specific demonstration of repository technology.

The repository is expected to be constructed at a single elevation at a depth of about 500 metres below ground surface. The exact depth will be determined as part of the detailed site characterization and final design. Excavation of rock is primarily done with controlled drill and blast. Rock boring technology will be used to create the in-floor boreholes that are shown in Figure 3.7.

An example design and layout of a repository based on the in-floor placement of used fuel containers in boreholes drilled along the room centre line is illustrated in Figure 3-7. This approach for container placement is consistent with reference repository designs developed by the national radioactive waste management organizations in Sweden (SKB) and in Finland (Posiva). Each placement room is designed to be 5.5 metres high with a length of 396 metres and a centre-to-centre room spacing of 40 metres. Within a placement room, the in-floor boreholes are two metres in diameter and have a centre-to-centre spacing of 4.2 metres.

Each borehole in the floor along the placement room centre line has a used fuel container surrounded by highly compacted bentonite buffer disks, rings and gapfill pellets. The placement room above the boreholes is filled with dense backfill blocks and other sealing materials such as bentonite/sand mixtures. Each group of placement rooms, or a “placement panel,” would require about three to four years to develop, and would be excavated in parallel with container placement operations in a previously completed panel in another area of the repository.

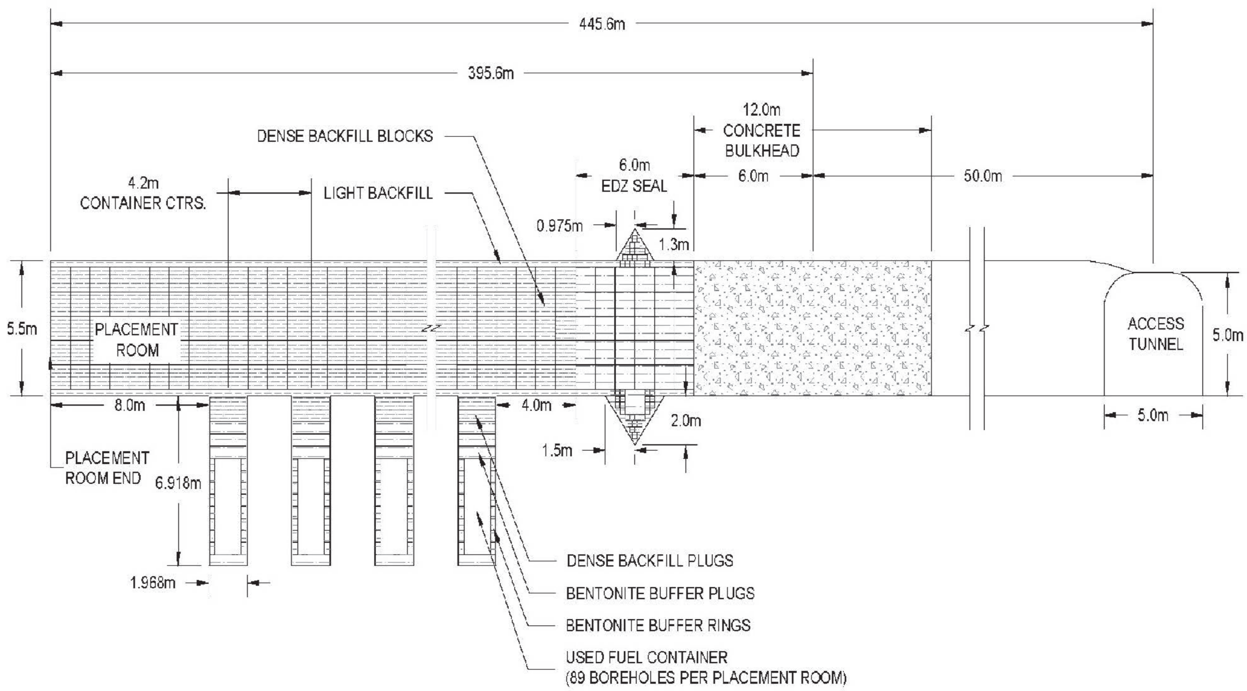

Figure 3-7: In-Floor Borehole Placement of Used Fuel Containers

The placement room spacing and used fuel container spacing are conservatively designed to ensure the repository meets thermal-mechanical design requirements (e.g., at least 25 centimetres of buffer with temperatures below 100 degrees Celsius).

The repository layout is expected to have a rectangular configuration with two central access tunnels and two perimeter tunnels connected by panel access tunnels that provide access to the used fuel container placement rooms. The placement rooms are grouped in panels, as illustrated in Figure 3-8. The exact arrangement of the panels will depend on the site (e.g., to avoid any potential fractures in the rock mass).

After used fuel container placement, the room will be filled with dense backfill blocks. Light backfill will be placed in the interstitial spaces and compacted in situ to fill the residual volume between the backfill blocks and the excavated rock. A six-metre-thick bentonite seal and a 12-metre-thick concrete bulkhead will be used to seal the entrance to the placement rooms. Monitoring equipment will be installed to confirm the performance of the repository system. The repository design includes provision for an underground demonstration facility (UDF) located near the main shaft and service shaft area. The purpose of the underground demonstration facility is to support site-specific demonstration of repository technology such as placement and retrieval of used fuel containers, and long-term tests such as corrosion and monitoring tests.

An example underground layout for a deep geological repository would require an underground footprint of about two kilometres by three kilometres, as illustrated in Figure 3-8.

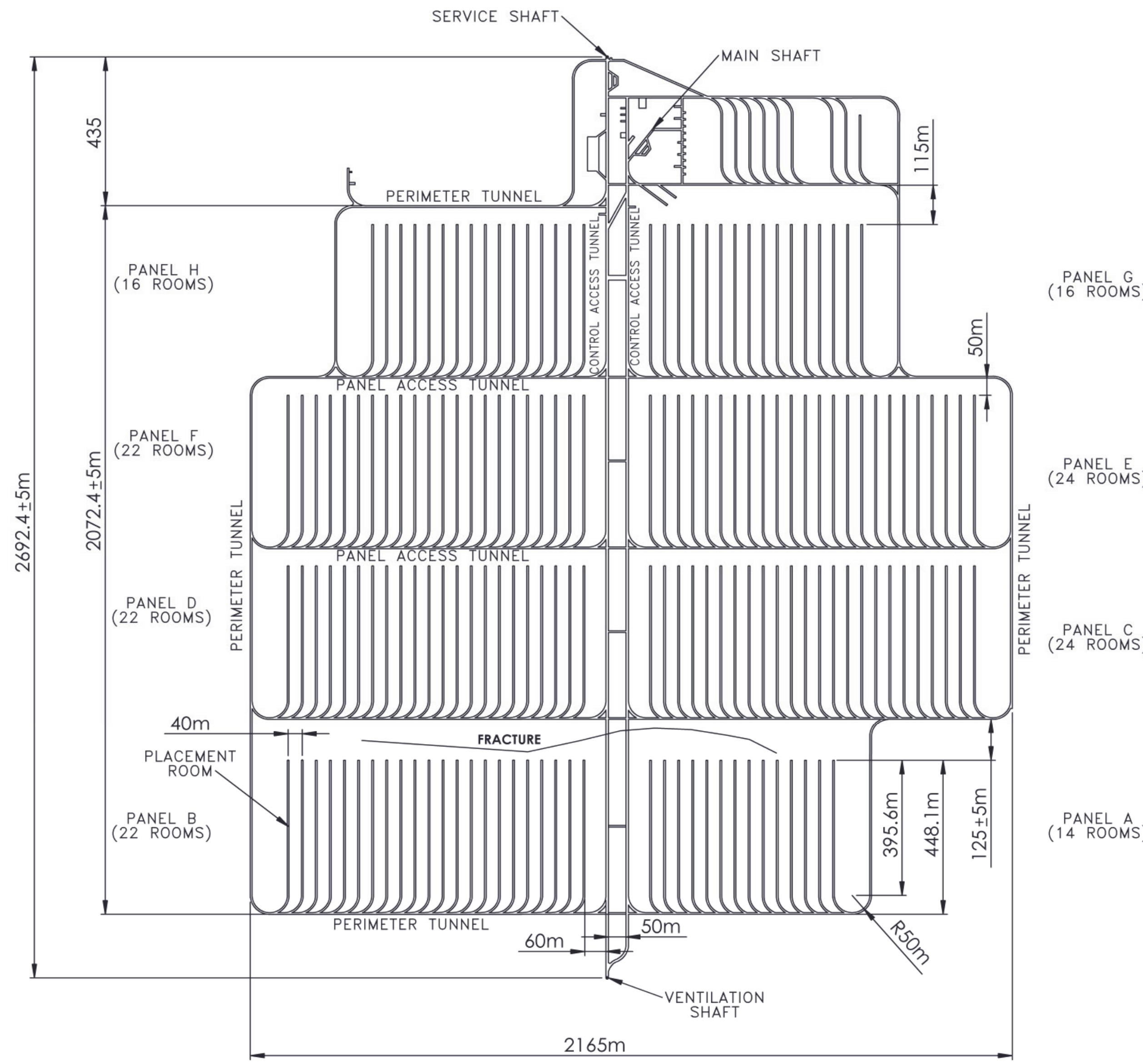

Figure 3-8: Example Underground Layout for a Deep Geological Repository

3.6 Centre of Expertise

A Centre of Expertise will be established for the one or more communities in which a site has been selected for detailed evaluation (Step 4 of the siting process). The centre will be located in or near the community, as determined with the community. Its purpose will be to support the multi-year testing and assessment of the site on technical safety and community well-being-related dimensions, which are key components of the site selection process. It will be the home for an active technical and social research and technology demonstration program during this period, involving scientists and other experts in a wide variety of disciplines, including geoscience, engineering, and environmental, socioeconomic and cultural impact assessment.

The technologies and monitoring processes involved in the operation of a deep geological repository may be of interest and have applications in the community beyond the deep geological repository. This will be explored with the community. The design details of the Centre of Expertise would be developed with the community, potentially affected First Nation and Métis communities, and surrounding communities, with their preferences in mind. Discussion of the design details is also an important opportunity for involvement of youth. The Centre of Expertise could also be designed as a focus for engaging members of the community to learn more about the project, and to view the scientific and engineering work-in-progress involved in site assessment, through public viewing galleries and interactive displays. The centre could be created as a small science centre, highlighting and demonstrating the science and technology being used to determine whether the site is suitable. It may be developed as a meeting place and learning centre for the community, and as a destination that welcomes interested visitors from the region and beyond.

Should the site ultimately be selected to host the deep geological repository, the Centre of Expertise would be expanded to include and support construction and operation of an underground facility designed to confirm the characteristics of the site. The centre would become a hub for knowledge sharing across Canada and internationally.

As with some other aspects of the project, the exterior design of facilities, and the way they are incorporated into the landscape of the area, will be a subject of discussion and shared planning with those living in the area.

3.7 Engineering Feasibility in the Area

The Area of Study is located on the Canadian Shield and is characterized by moderate to rugged relief that is suitable for the construction of an APM facility. The Area contains existing infrastructure that could be used for the APM Project, including highways and high-voltage transmission lines. In addition, a major rail line passes through the Area, which could facilitate the transport of goods and materials to the site.

In order to implement the APM Project at a particular site in the Area, it is anticipated that the following infrastructure would be needed:

- Main APM surface facilities including:
  - Used Fuel Packaging Plant
  - Main Shaft, Service Shaft and Ventilation Shaft Complexes
  - Sealing Materials Production Plants
  - Administration Building, Fire Hall and Cafeteria
  - Quality Control Offices and Laboratory
  - Water Treatment Plant
  - Sewage Treatment Plant
  - Storage Areas and Commons Services
  - Stormwater run-off ponds
- A few tens of kilometres of highway to provide access to the APM facility;
- A few tens of kilometres of high-voltage transmission line to supply up to 32 megawatts of electricity;
- A few kilometres of water pipe to supply up to 200 cubic metres of water per day;
- A Centre of Expertise;

- Provision for accommodation for temporary workers for the limited period of construction; and
- An excavation rock management area within a few tens of kilometres of the APM facility.

As well, there are opportunities for a number of components associated with the APM repository to potentially be developed locally to improve the well-being of the community or surrounding region. These include a Container Development Laboratory and a Container Manufacturing Plant, as well as infrastructure associated with the transportation of used fuel from the interim storage locations to the site of the APM facility.

The development of this infrastructure has been assumed in the APM repository design and cost estimate included for financial planning purposes.

3.8 Engineering Costs for the Area

The APM facility is a large national infrastructure project funded by the waste owners. A cost estimate for a deep geological repository and a used fuel transportation system has been developed for a reference inventory of 4.6 million used fuel bundles (see Section 3.2).

The estimated cost for the APM facility in the Area– that is the deep geological repository and surface handling facilities, as well as the Centre of Expertise – is $20.1 billion (2010 $). (The transportation costs from the interim storage facilities at the reactor sites to the central APM facility in the Area have been calculated separately and are discussed in Chapter 6.) This cost estimate includes site selection and approval, construction, operation, extended monitoring, decommissioning and closure.

A summary of the project cost estimate for an illustrative implementation schedule is given in Table 3-1. The first year of project implementation, year Y01, is 2010. The cost estimate includes labour, materials and equipment, fuel, utilities, taxes, fees, accommodation, communication and other expenses.

Table 3-1: Estimated APM Facility Expenditures by Implementation Phase

Project Phase	Year	Cost 2010 $ ($ billion)
Site Selection and Approvals	Y01 – Y15	$1.5
Construction	Y16 – Y25	$3.6
Operation	Y26 – Y63	$12.0
Extended Monitoring	Y64 – Y133	$1.8
Decommissioning and Closure	Y134 – Y163	$1.2
	Total	**$20.1**

The annual cash flow (2010 $) for the deep geological repository is illustrated in Figure 3-9.

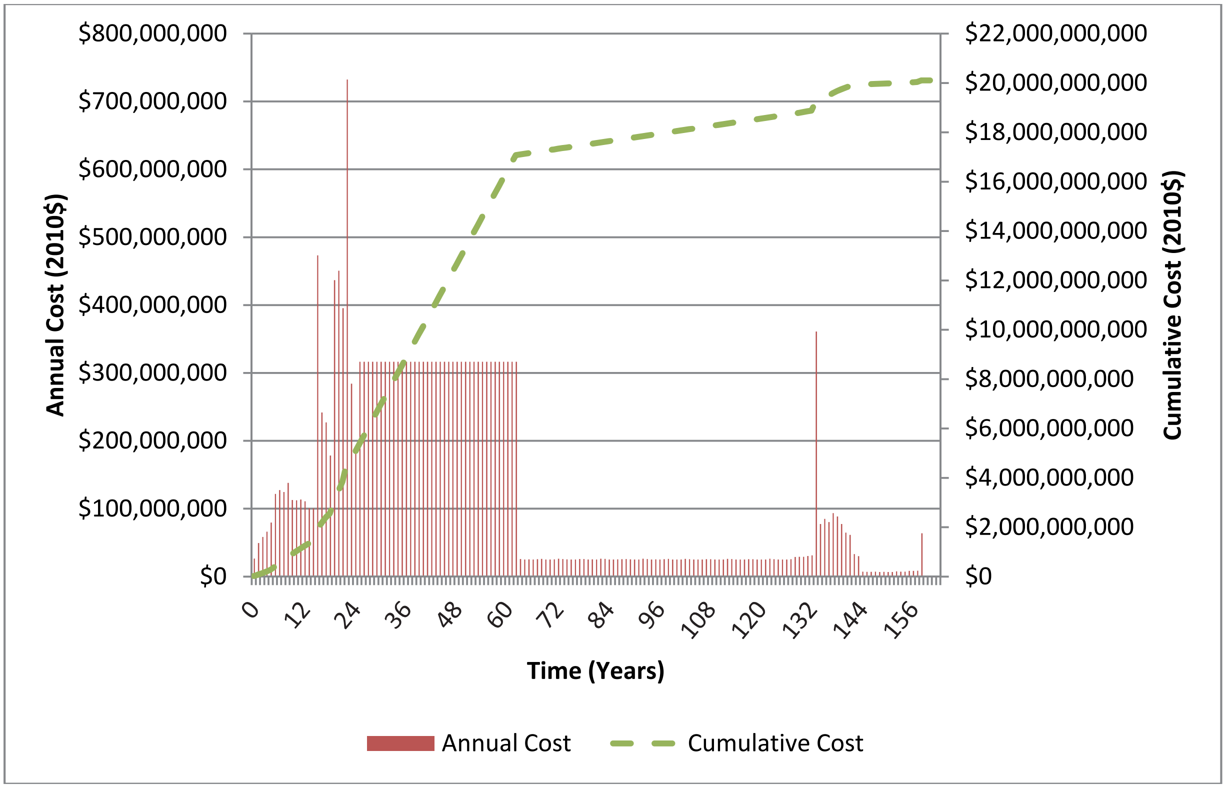

Figure 3-9: APM Cost Estimate for a Deep Geological Repository in the Area

3.9 Engineering Findings

The engineering assessment of the Area found that the APM facility has the potential to be safely constructed and operated. The surface land is characterized by moderate to rugged relief, and sufficient space exists outside protected areas and major bodies of water to successfully locate the surface facilities. Additional information on the physical geography of the area is presented in Section 4.3.1. There are few surface topography features that would limit the construction and operation of the surface and underground facilities required by the APM Project. Further, the Area is located close to key infrastructure for the APM facility, including highways and high-voltage transmission lines. As well, an existing main rail line could facilitate the transport of goods and materials to the community (see transportation discussion in Chapter 6).

There are opportunities for new businesses and additional infrastructure associated with the APM repository to potentially be located in the community to enhance economic development and community well-being. This infrastructure could include the Container Development Laboratory and the Container Manufacturing Plant. The development of these facilities would be determined collaboratively with the community.

As more information on the geology and characteristics of potential candidate sites becomes available in later phases of the APM Project and further input is obtained from the community and surrounding region, the APM facility design, layout, infrastructure and engineering feasibility will be further refined.

4. PRELIMINARY ASSESSMENT OF GEOSCIENTIFIC SUITABILITY

4.1 Geoscientific Preliminary Assessment Approach

The objective of the Phase 1 geoscientific desktop preliminary assessment is to assess whether the Town of Blind River, the City of Elliot Lake, the Township of The North Shore, the Town of Spanish and their periphery (i.e., the Area of Study), contain general areas that have the potential to satisfy the geoscientific evaluation factors outlined in the site selection process document (NWMO, 2010). This chapter presents a summary of a detailed geoscientific desktop preliminary assessment conducted by Golder Associates Ltd. (Golder, 2014). The assessment focused on the Town of Blind River, the City of Elliot Lake, the Township of The North Shore, the Town of Spanish and their periphery (Figure 4-1).

The geoscientific desktop preliminary assessment of potential suitability built on the work previously conducted for the initial screenings (Geofirma, 2012a,b,c,d) and included the following activities:

- Detailed review of available geoscientific information such as geology, structural geology, natural resources, hydrogeology, and overburden deposits;
- Interpretation of available geophysical surveys (magnetic, gravity, radiometric, electromagnetic);
- Lineament studies using available satellite imagery, topography and geophysical surveys to provide information on the characteristics such as location, orientation, and length) of interpreted structural bedrock features;
- Terrain analysis studies to help assess factors such as overburden type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, and groundwater discharge and recharge zones; and
- The identification and evaluation of general potentially suitable areas based on key geoscientific characteristics and the systematic application of NWMO's geoscientific site evaluation factors.

The details of these various studies are documented in a main Geoscientific Suitability Report (Golder, 2014) and three supporting documents: terrain analysis (JDMA, 2014a), geophysical interpretation (PGW, 2014), and lineament interpretation (JDMA, 2014b).

4.2 Geoscientific Site Evaluation Factors

As discussed in the NWMO site selection process, the suitability of potential sites is evaluated in a staged manner through a series of progressively more detailed scientific and technical assessments 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 (NWMO, 2010):

- ***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 caused by human activities and natural events?

- ***Long-term resilience to future geological processes and climate change***: Is the rock formation at the siting area 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 geological and climate change processes such as earthquakes and glacial cycles?
- ***Safe construction, operation and closure of the repository:*** Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance through future exploration or mining?
- ***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?

The assessment was conducted in two steps. The first step assessed the potential to find general potentially suitable areas within the Area using key geoscientific characteristics that can realistically be assessed at this stage of the assessment (Section 4.4.1). The second step assessed whether identified general potentially suitable areas have the potential to ultimately meet all the safety functions outlined above (Section 4.4.2).

The remainder of this chapter provides an overview of the geoscientific characteristics of the Area (Section 4.3), followed by a summary of the geoscientific assessment of suitability (Section 4.4).

4.3 Geoscientific Characteristics of Blind River, Elliot Lake, The North Shore, and Spanish, and Surrounding Area

The following sections provide a summary of available geoscientific information for the Area as they relate to physical geography, bedrock geology, Quaternary (surficial) geology, seismicity, structural geology, hydrogeology, and natural resources.

4.3.1 Physical Geography

The four communities lie within the Penokean Hills physiographic region. This area is south of the Abitibi Upland and is bordered to the east by the Cobalt Plain and the Laurentian Highlands according to Thurston (1991). The Penokean Hills are composed of folded Proterozoic stratified rocks while the north part of the Area lies within the Abitibi Upland, a broadly rolling surface of Canadian Shield bedrock that occupies most of north-central Ontario (NRCan, 1997).

The topography of the Area is generally high in the northern and central part of the area and low in the southern part (Figure 4-2). The elevation gradient from north to south is from 612 to 176 metres above sea level, with this elevation drop occurring over an approximately 90 kilometre distance. The highest point in the Area is within the highlands north of the Aubinadong River and the lowest point is defined by the surface of Lake Huron. Areas of sharp local topographic relief are expected to represent bedrock hills, such as the cuestas and hogback ridges around the Boland and Little White rivers formed by the Nipissing diabase sills. None of the surficial deposits in the Area display topographic prominence of this magnitude.

Exposed bedrock and thin sediment veneer is mapped for approximately 76 per cent of the overall Area (JDMA, 2014a). About 11.5 per cent of the Area is occupied by water bodies of various sizes (not including Lake Huron). Twenty-three of the lakes are larger than 10 square kilometres, and nine of them are larger than 20 square kilometres (Figure 4-1).

4.3.2 Bedrock Geology

Information on the bedrock geology of the Area was obtained from publicly available reports and geologic maps, as well as from the geophysical interpretation conducted as part of this preliminary assessment (PGW, 2014). The main geoscientific desktop preliminary assessment report (Golder, 2014) provides a detailed description of the regional and local geology of the Area.

Geological mapping coverage is good and generally up to date throughout most of the study area, though most mapping is focused on the sedimentary rocks of the Huronian Supergroup, the volcanic rocks (greenstone belts) and the mafic intrusive rocks because of their mineral potential. Geophysical data (magnetic) from the Ontario Geological Survey (OGS) and the Geological Survey of Canada (GSC) is of low resolution (805 metre line spacing) for most of the area, particularly over the northern part. Two additional magnetic/electromagnetic surveys obtained from the Ontario Geological Survey (OGS) and one GSC magnetic survey provided higher resolution coverage over approximately five per cent of the area. Additional high resolution geophysical data (100 to 200 metre line spacing) were also found in the OGS Assessment File (AFRI) database in the form of maps. Of these, eight files provided images of magnetic data, as well as radiometric (four files), time-domain electromagnetic (two files), frequency-domain electromagnetic (one file) and very low frequency (VLF) (four files).

As shown on Figure 4-3, the bedrock geology of the Area is dominated by the large Ramsey-Algoma granitoid complex. These intrusions were emplaced into the older rocks of the Whiskey Lake and Benny Lake greenstone belts. Several smaller intrusive bodies are distributed throughout the Area, including the Cutler pluton, the Seabrook Lake intrusion, the Parisien Lake syenite, and the East Bull Lake intrusive suite, among others. The Huronian Supergroup underlies the southern portion of the Area (Figure 4-3) and consists of a group of metasedimentary rocks (stratigraphically youngest) and lesser (stratigraphically oldest) metavolcanic rocks ranging in age from 2.5 to 2.2 billion years old. At least four generations of mafic dykes ranging from 2.473 to 1.235 billion years old cut the area, each in a predictable orientation.

The initial screenings (Geofirma, 2012a,b,c,d) identified the Ramsey-Algoma granitoid complex in the Area as potentially suitable for hosting a deep geological repository. Greenstone belts, the sedimentary rocks of the Huronian Supergroup and the small intrusive bodies in the area were deemed not suitable due to their heterogeneity, structural complexity and potential for mineral resources.

The Ramsey-Algoma granitoid complex is approximately 2.716 to 2.651 billion years old and is generally described in the literature as largely consisting of a massive to foliated granite-granodiorite suite intruding a tonalite-granodiorite suite. The geophysical interpretation by PGW (2014), based largely on the aeromagnetic data, subdivides the Ramsey-Algoma granitoid complex into distinct anomalies with strongest magnetic responses predominantly associated areas of mapped granite to granodiorite units, and slightly weaker response associated with the mapped gneissic tonalite units. On the surface, the Ramsey-Algoma granitoid complex dominates the northern portion of the area, occupying approximately 6,320 square kilometres in the Area. There is only limited data on the thickness of the Ramsey-Algoma granitoid complex in the Area. Cruden (2006) used gravity and seismic measurements to estimate the regional thickness of late Archean granites to be on the order of one to three kilometres thick.

4.3.3 Quaternary Geology

The terrain analyses report (JDMA, 2014a) provides a detailed description of Quaternary geology of the Area. The Quaternary geology of the area is dominated at surface by different types of glacial deposits that accumulated with the progressive retreat of the ice sheet during the end of the Wisconsinan glaciation. This period of glaciation began approximately 115,000 years ago and peaked about 21,000 years ago. The northward retreat of the ice sheet in the Area started approximately 12,000 years ago.

As shown on Figure 4-4, the Area is dominated by exposed bedrock or bedrock having only a thin mantle (less than 1 metre) of unconsolidated sediments (Gartner, 1978a,b,c; 1980 a,b; Roed and Hallet, 1979a,b,c,d; 1980a,b; VanDine, 1979a,b,c,d; 1980a,b,c,d; Gartner et al., 1981). Bedrock and thin veneer comprises 76 per cent of the Area. Thicker overburden deposits tend to occur in low lying areas.

Information on overburden thickness comes from water wells and diamond drill holes in the greenstone belts. Recorded depths to bedrock in the Area generally range from 0 to 137 metres. Water well and drill hole data is sparse on the Ramsey-Algoma granitoid complex but these observations provide an indication of the typical values and variability in overburden thicknesses that can be expected in the Area (JDMA, 2014a).

4.3.4 Structural Geology

4.3.4.1 Mapped Faults

Mapped structures in the Area include large scale folds, several ages of differently oriented mafic dyke swarms and a mosaic of brittle faults. Their complex present day geometrical arrangement is attributed to the protracted history of tectonic events that has overprinted the area.

Some of the most prominent geological features within the Area and surrounding region are several distinct mafic dykes swarms (Figures 4-3). These include the northwesterly trending intrusions corresponding to the approximately 2.473 billion year old Matachewan dyke swarm (Buchan and Ernst, 2004). The Matachewan dykes are orthogonally crosscut by the approximately east-west trending approximately 2.22 billion year old Nipissing intrusions (Corfu and Andrews, 1986), the younger, less frequent, northeasterly trending approximately 2.167 billion years old Biscotasing dykes (Buchan et al., 1993) and the east-northeast trending 2.1 billion year old Kapuskasing/Marathon dykes (not mapped within the Area). Later emplacement at approximately 1.238 billion years ago of the Sudbury dyke swarm (Krogh et al., 1987), and a suite of approximately 2.5 to 1.6 billion years old mafic dykes of uncertain affinity known as the North Channel dyke swarm (OGS, 2011a) provide evidence to the long and complicated crustal deformation that has occurred in the Area.

The Murray fault (referred to in the literature by some as the Murray fault zone) is a major east-trending structure that can be traced a few hundred kilometres from Sault Ste. Marie to Sudbury (Robertson, 1967). Within the Area, the Murray fault runs along the shoreline of Lake Huron (Figure 4-3) where it is a steeply south-dipping fault zone with approximately 15 to 20 kilometres of reverse sense offset (Zolnai et al., 1984). It records both dextral (Bennett et al., 1991), and sinistral (Abraham, 1953) movement. The Murray fault system appears to have been initiated prior to deposition of the Huronian Supergroup, but periodic reactivation occurred synchronous with and after sediment deposition (Reid, 2003, Dyer 2010). The most recent movement on the Murray fault was during the Grenville Orogeny, 1.250 to 0.98 billion years ago (Robertson, 1970; Card, 1978; McCrank et al., 1989; Piercy, 2006). The regional scale arcuate east-trending Flack Lake fault (Figure 4-3) extends for about 150 kilometres and transects both the Huronian Supergroup rocks and the Ramsay-Algoma Granitoid Complex. The Flack Lake fault is interpreted as a north-directed listric thrust that reactivated an earlier normal fault. Its movement history may be related to post-Nipissing and Penokean events (Bennett et al., 1991). Additional mapped brittle faults in the area include the Spanish American fault, Pecors Lake fault and Horne Lake fault that cut the Huronian sequence, and the parallel Nook Lake fault within the Archean basement directly north of the Quirke Lake syncline (Robertson, 1968).

4.3.4.2 Lineament Investigation

A detailed lineament investigation was conducted for the Area using multiple datasets (JDMA, 2014b). Lineaments are linear features that can be observed on remote sensing and geophysical data and which may represent geological structures (e.g., fractures). However, at this stage of the assessment, it is uncertain if interpreted lineaments are a reflection of real geological structures, and whether such structures extend to depth. The assessment of these uncertainties would require detailed geological mapping and borehole drilling.

Surficial lineaments were interpreted using satellite imagery (SPOT) and digital elevation model data (CDED). Surficial lineaments are interpreted as linear traces along topographic valleys, escarpments, and drainage patterns such as river streams and linear lakes. These linear traces may represent the expression of fractures on the ground surface which may not extent to significant depth. Figure 4-5 shows surficial lineaments interpreted in the Area. The observed density and distribution of surficial lineaments is influenced by overburden and vegetation coverage, which masks surface expressions of potential fractures. The most notable feature of the CDED lineament orientations, when plotted on a rose diagram weighted by length, are the dominant west-northwest and north-northwest trends (Figure 4-5 inset). There is also a notable east-west trend. These trends correspond to known dyke orientations.

Geophysical lineaments were interpreted from available aeromagnetic data. They are less affected by the presence of overburden and reflect potential structures that may or may not have surficial expressions. However, the density and distribution of geophysical lineaments is influenced by the resolution of the available aeromagnetic coverage. Geophysical lineaments interpreted in the Area are shown on Figure 4-6. The density and distribution of geophysical lineaments is influenced by the resolution of the available aeromagnetic coverage for the Area, which varied from 805 to 100 metres line spacing. The density of interpreted geophysical lineaments is much higher in areas of higher resolution such as on the sedimentary rock of the Huronian Supergroup, the Whiskey Lake and Benny Lake greenstone belts, and the Seabrook Lake and East Bull Lake intrusions, and an area just east of White Owl Lake.

Figure 4-5 and 4-6 also show the distribution of surficial and geophysical lineaments by length (longer than one, five and 10 kilometres). The figures show that the spacing between lineaments increases as shorter lineaments are filtered out. Longer lineaments are more likely to extend to greater depth than shorter lineaments. Within the Ramsey-Algoma granitoid complex lineaments longer than five kilometres and 10 kilometres are spaced between 0.6 and 14.9 kilometres and between 1.1 and 24 kilometres, respectively.

In summary, the lineament interpretation indicated a moderate to high density of surficial lineaments and a low to moderate density of geophysical lineaments in general, across the area. The low to moderate density of geophysical lineaments is in part due to the low resolution of aeromagnetic data. In areas where high resolution magnetic data is available, geophysical lineament density is high. It is possible that such a high density of geophysical lineaments exists across the Area. At this stage of the assessment, it is uncertain whether interpreted lineaments represent true bedrock structural features (e.g., individual fractures or fracture zones) and whether these features extend to typical repository depths. This would need to be investigated during subsequent site evaluation stages through detailed geological mapping and borehole drilling.

4.3.5 Erosion

There is no site-specific information on erosion rates for the Area. Past studies reported by Hallet (2011) provide general information on erosion rates for the Canadian Shield. The average erosion rate from wind and water on the Canadian Shield is reported to be a few metres per 100,000 years. Higher erosion rates are associated with glaciation. The depth of glacial erosion depends on several regionally specific factors, such as the ice-sheet geometry, topography, and history, as well as local geological conditions, such as overburden thickness, rock type and pre-existing weathering. Various studies aimed at assessing the impact of glaciations on erosion over crystalline rocks reported average erosion rates varying from 10 or 20 metres, to up to 120 metres over three million years (Flint, 1947; White, 1972; Laine, 1980 and 1982; Bell and Laine, 1985; and Hay et al., 1989).

4.3.6 Seismicity and Neotectonics

4.3.6.1 Seismicity

The Area lies within the Canadian Shield, where large parts have remained tectonically stable for the last 2.5 billion years (Percival and Easton, 2007). Figure 4-7 shows the locations and magnitudes of seismic events recorded in the National Earthquake Database (NEDB) for the period between 1985 and 2012 in the Area. Historically, very few earthquakes have occurred within the Area. Over this time period, all recorded seismic events in the area had magnitudes ranging from less than one to three (Nuttli magnitude, m_N) (NRCan, 2013).

4.3.6.2 Neotectonic Activity

Neotectonics refers to deformations, stresses and displacements in the earth’s crust of recent age or which are still occurring. These processes are related to tectonic forces acting in the North American plate as well as those associated with the numerous glacial cycles that have affected the northern portion of the plate during the last million years, including all the Canadian Shield (Shackleton et al., 1990; Peltier, 2002).

The geology of the Area is typical of many areas of the Canadian Shield, which has been subjected to numerous glacial cycles during the last million years. Post-glacial rebound of the land is still occurring across most of Ontario. Present-day uplift rates are in the order of about 10 millimetres per year near Hudson Bay, where the ice was thickest at the last glacial maximum. The uplift rates generally decrease with distance from Hudson Bay and change to subsidence (one to two millimetres per year) south of the Great Lakes. Present-day rebound rates in the Area are expected to be about two to four millimetres per year (Sella et al., 2007).

No neotectonic structural features are known to occur within the Area. McMurry et al. (2003) summarized several studies conducted in a number of other granitic intrusions in the Canadian Shield. These studies found that fractures below a depth of several hundred metres in plutonic rocks are ancient features. Subsequent stresses, such as those caused by plate movement or by continental glaciation, generally have been relieved by reactivation along the existing zones of weakness rather than by the formation of large new fracture zones.

4.3.7 Hydrogeology

Information regarding groundwater use in the Area was obtained from the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database (MOE, 2013). Water wells in the Area obtain water from the overburden and the shallow bedrock and are mostly located close to Lake Huron or close to Elliot Lake. The MOE database contains 785 water well records in the Area, 538 of which provided useful information regarding depth to bedrock, yield and other parameters summarized in Table 4-1.

Table 4-1: Water Well Record Summary for the Area

Water Well Type	Number of Wells	Total Well Depth (metres)	Static Water Level (metres below ground surface)	Tested Well Yield (litres per minute)	Depth to Top of Bedrock (metres)
Overburden	181	2.4 to 136.8	-0.9 to 44.8	4.5 to 1,137	Not Applicable
Bedrock	357	3 to 216	0.3 to 28.2	4.5 to 341	0 to 136.8

4.3.7.1 Overburden Aquifers

There are 181 water well records in the Area that can be confidently assigned to the overburden aquifer. These wells have depth ranges between 2.4 to 136.8 metres and have pumping rates of 4.5 litres per minute to 1,137 litres per minute (Table 4-1). These well yields reflect the purpose of the wells (i.e., the majority being private residential supply) and do not necessarily reflect the maximum sustained yield that might be available from the overburden aquifer.

The number of well records, and their clustered locations, limits the interpretation of available information regarding the extent and characteristics of overburden aquifers in the Area. However, as these water wells are located within glaciofluvial or glaciolacustrine terrain, it is likely that similar terrain mapped in the Area (Figure 4-4) will also host shallow overburden aquifers.

4.3.7.2 Bedrock Aquifers

Limited information was found on deep groundwater conditions in the Area at a typical repository depth of approximately 500 metres. In the area there are 357 well records that can be confidently assigned to the shallow bedrock aquifer. These wells range from three to 216 metres in depth. The Ontario Ministry of the Environment (MOE) water well records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in Area or anywhere else in northern Ontario. Flow meter testing carried in the mafic East Bull Lake intrusion in two deep boreholes (850 and 480 metres, respectively) indicated that water was entering the boreholes from fractures above a depth of 200 metres (Paillet and Hess, 1986).

4.3.7.3 Regional Groundwater Flow

There is little known about the hydrogeological properties of the deep bedrock in the Area. Experience from other areas in the Canadian Shield has shown that active groundwater flow in bedrock is generally confined to shallow fractured localized systems, and is dependent on the secondary permeability associated with the fracture network (Singer and Cheng, 2002). For example, in Manitoba's Lac du Bonnet batholith, groundwater movement is largely controlled by a fractured zone down to about 200 metres depth (Everitt et al., 1996).

The low topographic relief of the Canadian Shield tends to result in low hydraulic gradients for groundwater movement in the shallow active region (McMurry et al., 2003). At greater depths, hydraulic conductivity tends to decrease as fractures become less common and less interconnected (Stevenson et al., 1996; McMurry et al., 2003). Increased vertical and horizontal stresses at depth tend to close or prevent fractures thereby reducing permeability (Stevenson et al., 1996; McMurry et al., 2003). However, fracture networks associated with deep faults and shear zones will influence advective groundwater flow around bodies of rock characterized by diffusion limited conditions.

The exact nature of deep groundwater flow systems in the Area would need to be evaluated at later stages of the assessment, through the collection of site-specific information.

4.3.8 Hydrogeochemistry

Little information on groundwater hydrogeochemistry was found for the Area. However, available literature indicates that groundwater within the Canadian Shield can be subdivided into two main hydrogeochemical regimes: a shallow fresh water flow system; and a deep, typically saline water flow system (Singer and Cheng, 2002).

Gascoyne et al. (1987) investigated the saline brines found within several plutons of the Canadian Shield and identified a chemical transition at around 300 metres depth marked by a uniform, rapid rise in total dissolved solids and chloride. This was attributed to active flow and mixing above 300 metres, with a shift to diffusion-controlled flow below that depth. It was noted that major fracture zones within the bedrock can, where present, extend the influence of active flow processes to greater depths and hence lower the transition to the more saline conditions characteristic of deeper, diffusion-controlled conditions.

Groundwater research carried out in AECL's Whiteshell Underground Rock Laboratory (URL) in Manitoba reported total dissolved solids values ranging from three to 90 grams per litre at depths of 300 to 1,000 metres (Gascoyne et al. 1987; Gascoyne, 1994; 2000; 2004). In some regions of the Canadian Shield, total dissolved solids values exceeding 250 grams per litre have been reported at depths below 500 metres (Frape et al., 1984).

Hydrogeochemical data, limited to the East Bull Lake intrusion, are available. Raven et al., (1987) reported that the groundwater in the East Bull Lake intrusion transitions from fresh in the near surface to saline water below a depth of approximately 400 metres. Frape et al. (2003) reported that water samples taken from 460 metres and 429 metres at East Bull Lake had chloride concentrations in groundwater of one gram per litre and 2.5 grams per litre, while Bottomley et al. (2003) reported that a seep in the Stanleigh Mine at 960 metres had chloride concentrations in groundwater of 28 grams per litre.

Site-specific conditions will influence the depth of transition from advective to diffusion-dominated flow, which may occur at a depth other than the typical 300 metres reported by

Gascoyne et al. (1987). Such conditions will need to be evaluated during subsequent site evaluation stages.

4.3.9 Natural Resources

Information regarding the mineral resource potential for the Area has been obtained from a variety of sources, as described by Golder (2014). Figure 4-8 shows the areas of active exploration interest identified in the Ontario Geological Survey Mineral Deposit Inventory Version 2 (OGS, 2011b). There are currently no active mines in the Area, but the region has a long history of uranium mining and mineral exploration continues there today. Potential for metallic mineral resources in the area is limited to the rocks of the Huronian Supergroup, the Whiskey Lake and Benny Lake greenstone belts and the East Bull Lake and other small intrusions. As shown on Figure 4-8, numerous uranium, gold and base metal showings and occurrences, as well as active mining claims are present within these rocks in the Area.

The mineral potential in the Ramsey-Algoma granitoid complex is relatively low compared to the other rocks listed above based on the relatively few mineral occurrences and active mining claims shown on Figure 4-8. Despite covering a large area, there are only 134 active claims throughout the Ramsey-Algoma granitoid complex. However, many of the 134 claimed areas overlap rocks from the Whiskey Lake greenstone belt, East Bull Lake intrusive suite, or the Huronian Supergroup, which are likely the targeted rocks for mineral exploration. There are some mineral occurrences and/or discretionary occurrences for niobium, iron, copper, lead, uranium, gold, molybdenum, and silica in the Ramsey-Algoma granitoid complex, but none are known to be economically viable.

There are numerous sand and gravel pits within the Area. These are typically shallow pits of limited surface extent exploiting glaciofluvial outwash or lacustrine beach deposits. An alternative source of aggregate is the bedrock, of which Nipissing diabase is considered the best suited for crushed stone production. There are two discretionary occurrences for building stone (granite) reported within the Ramsey-Algoma granitoid complex, near the mouth of the Blind River. There is also a building stone quarry on the border of Cadeau and Tennyson townships, about 20 kilometres east of the City of Elliot Lake. However, the risk that these resources would pose for future human intrusion is negligible, as quarrying operations for granite and aggregate would be limited to very shallow depths.

The Area is located in a crystalline rock geological setting where the potential for petroleum resources is negligible and where no hydrocarbon production or exploration activities are known to occur.

4.3.10 Geomechanical Properties

Limited information on geomechanical rock properties is available for the intrusive rocks within the Area. Information is limited to in situ stress measurements from the Stanleigh and Denison uranium mines (Kaiser and Maloney, 2005). However, there is a fair amount of data from comparable geologic units in the Canadian Shield that can provide insight into the possible rock mass properties in the Area (Golder, 2014).

There are no site-specific thermal conductivity values or detailed quantitative mineral compositions for the Area. The main geoscientific suitability report (Golder, 2014) provides useful generic comparisons of thermal properties for crystalline rocks of the Canadian Shield.

Site-specific geomechanical and thermal properties of the potentially suitable geological units within the Area would need to be investigated during subsequent field evaluation stages.

4.4 Potential Geoscientific Suitability of the Area

This section provides a summary of how key geoscientific characteristics were applied to the Area to assess whether it has the potential of containing general areas that are potentially suitable for hosting a deep geological repository (Section 4.4.1). The potential of identified areas to ultimately satisfy all geoscientific evaluation factors and safety functions outlined in NWMO`s site selection process is also described (Section 4.4.2).

4.4.1 Potential for Finding General Potentially Suitable Areas

The potential for finding general areas that are potentially suitable for hosting a deep geological repository was assessed using the key geoscientific characteristics briefly described below.

- ***Geological setting:*** Areas of unfavourable geology identified during the initial screening (Geofirma, 2012a,b,c,d) were not considered. The rocks of the Huronian Supergroup, greenstone belts and the small intrusive bodies were considered unfavourable. These geological units were considered not suitable due to their lithological heterogeneity, structural complexity and mineral potential. Potentially suitable geological units in the Area included the Archean Ramsey-Algoma granitoid complex and gneissic rocks. In the Area, the granitoid complex generally consists of granitic, granodioritic and granitic gneiss with numerous greenstone enclaves and massive to foliated granite, granodiorite, and syenite intrusions. The geological setting of the main potentially suitable geological unit is further discussed in Sections 4.4.1.1 and 4.4.1.2.

- ***Structural Geology:*** Areas within or immediately adjacent to regional faults and shear zones were considered unfavourable. There are two large-scale faults mapped in the Area: the Murray fault system and the Flack Lake fault (Figure 4-3). While there is no evidence to suggest that the Murray fault had been tectonically active within the past approximately 1.250 to 0.98 billion years (Robertson, 1970; Card, 1978; McCrank et al., 1989; Piercy, 2006) and the Flack Lake fault within the past 1.8 billion years (Bennett et al., 1991), they were avoided in selecting general potentially suitable areas. There are also several mapped brittle faults occurring mainly in the rocks of the Huronian Supergroup and the greenstone belt. The potential host rock unit thickness is estimated to be one to three kilometres, based on geophysical data. This thickness was considered sufficient for repository siting purposes.

- ***Lineament Analysis:*** In the search for general potentially suitable areas, there was a preference to select areas that have a relatively low density of lineaments, particularly a low density of longer lineaments as they are more likely to extend to greater depth than shorter lineaments (Section 4.3.4.2). For the purpose of this assessment, all interpreted lineaments (fractures and dykes) were conservatively considered as conductive (permeable) features. In reality, many of these interpreted features may be sealed due to higher stress levels at depth and the presence of infilling.

- ***Overburden:*** The distribution and thickness of overburden cover is an important site characteristic to consider when assessing amenability to site characterization of an area. For practical reasons, it was considered that areas covered by more than two metres of overburden deposits would not be amenable to trenching for the purpose of structural mapping. This consideration is consistent with international practices related to site characterization in areas covered by overburden deposits (e.g., POSIVA, 2007 in Finland). At this stage of the assessment, preference was given to areas with greater mapped bedrock exposures. The extent of bedrock exposure in the Area is shown on Figure 4-4. Areas mapped as bedrock terrain are assumed to be covered, at most, with a thin veneer of overburden and are therefore considered amenable to geological mapping.

- ***Protected Areas:*** All provincial and national parks within the Area were excluded from consideration. There are 15 provincial parks, 12 conservation reserves and four forest reserves in the Area (Figure 4-1). The provincial parks and reserves occupy a combined area of approximately 1,700 square kilometres. Several of these parks and reserves occur within the Ramsey-Algoma granitoid complex, which is the geological unit of interest.

- ***Natural Resources:*** The potential for natural resources in the Area is shown on Figure 4-8. The rocks of the Huronian Supergroup, the Benny Lake and Whiskey Lake greenstone belts and the Seabrook Lake, Parisien Lake and East Bull Lake intrusions all have known potential for natural resources, are internally heterogeneous and are, in some cases, too small; therefore, they were not considered as favourable. In contrast, the granitoid complex in the Area has low potential for economically exploitable natural resources. At this stage of the assessment, areas of active mining claims were not systematically excluded if the claims were located in geologic environments judged to have low mineral resource potential.

- ***Surface Constraints:*** Areas of obvious topographic constraint (density of steep slopes), large water bodies (wetlands, lakes), and accessibility were considered for the identification of general potentially suitable areas. While areas with such constraints were not explicitly excluded at this stage of the assessment, they were considered less preferable, all other factors being equal. Much of the granitoid complex has rugged topography (Figure 4-2). The majority of the Area is accessible by existing highways, secondary roads and/or logging roads.

The consideration of the above geoscientific evaluation factors and constraints showed that the Area contains at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors. These four general areas are located within the Ramsey-Algoma granitoid complex in the northern half of the Area, north of the municipal boundaries of Elliot Lake and Blind River. Interpreted surficial and geophysical lineaments are shown in Figures 4-5 and 4-6, respectively. The other geoscientific characteristics are shown on Figure 4-9. The general locations of these four general areas are shown on Figures 4-10 to 4-13. Key geoscientific characteristics shown on these maps include: bedrock geology, protected areas, areas of thick overburden cover, surficial and geophysical lineaments, existing road network, natural resources potential and mining claims.

As discussed in Section 4.3.2, the Ramsey-Algoma granitoid complex is a large heterogeneous grantoid complex that has an estimated thickness greater than one kilometre. The granodiorite to gneissic tonalite rocks in the Area generally have excellent bedrock exposure, low potential for natural resources, are well drained, and contain large areas that are outside protected areas and surface constraints (i.e., large water bodies and wetlands), although the terrain is modest to rugged. There are a number of mapped faults in the area, as well as four known dyke swarms that have affected the Area. The main constraining factors used in the selection of general potentially suitable siting areas within the granitoid complex were protected areas, surface constraints, structural geology and lineament density.

No general potentially suitable areas were identified within the municipal boundary of Blind River. This area is located almost entirely within the rocks of the Huronian Supergroup that were not suitable because of their mineral potential and structural complexity. In addition, a large portion of the municipal area is occupied by the Blind River and Matinenda Provincial Parks and the Mississagi Delta Provincial Nature Reserve.

No general potentially suitable areas were identified within the municipal boundary of Elliot Lake. This area is located largely within the rocks of the Huronian Supergroup that are considered not to be suitable. The portion of the municipal boundary that occurs within the Ramsey-Algoma granitoid complex, north of Elliot Lake, is in close proximity to the rocks of the Huronian Supergroup that have high mineral potential. Several past producing mines are located close to this area and several current mineral claims are present (Figure 4-8). In addition, the Ramsey-Algoma granitoid complex south of Elliot Lake is lithologically heterogeneous, with metavolcanic, amphibolites and ultramafic rocks encountered in several boreholes in the area (Figure 4-4). A portion of the municipal area is occupied by the Matinenda Provincial Parks and the Glenn N. Crombie Conservation Reserve.

No general potentially suitable areas were identified within the municipal boundary of The North Shore. This area is located largely within the rocks of the Ramsey-Algoma granitoid complex. However, in this location, the granitoid complex is cross cut by numerous mafic dykes, exhibits a high apparent lineament density and is lithologically heterogeneous, with metavolcanic, amphibolites and ultramafic rocks encountered in several boreholes in the area. The area is also in close proximity to the regional Murray fault system, which runs from Sault St Marie to Sudbury, and corresponds to a marked change in metamorphic grade.

No general potentially suitable areas were identified within the municipal boundary of Spanish. About half of this area is within the rocks of the Huronian Supergroup that were considered not to be suitable. About half of the municipality is located within the rocks of the Ramsey-Algoma granitoid complex. However, in this area the lithology is heterogeneous and there is close proximity to the Murray fault and mineral occurrences (Figure 4-8).

The following section provides a summary of how the key geoscientific factors and constraints discussed above were applied to the Ramsey-Algoma granitoid complex to identify general potentially suitable areas. At this early stage of the assessment, the boundaries of these general areas are not yet defined. The location and extent of general potentially suitable areas would be further refined during subsequent site evaluation stages.

4.4.1.1 General Potentially Suitable Area - North East Ramsey-Algoma (Figure 4-10)

The first general potentially suitable area occurs within the north-eastern portion of the Ramsey-Algoma granitoid complex (Figure 4-10). The general area is bounded by the Mississagi River Provincial Park to the west and the Mozhabong Conservation Reserve to the east. The general area is accessible via Highway 553 and local roads directly access the area. As discussed in Section 4.3.2, bedrock in this general area is mapped as massive granodiorite to granite with a thickness of greater than 1 kilometre. Bedrock exposure is very good.

The area is 11.5 kilometres north of the Flack Lake fault and 71 kilometres north of the Murray fault. Though these faults are far from the area, their potential impact on the suitability of the area would need to be further assessed. No smaller-scale faults were mapped within the area. The Sudbury and Matachewan dykes are the predominant mapped dykes present in the area.

The geophysical data interpretation found variable magnetic responses in the area. Given the low resolution of the geophysical data in the area, lithological homogeneity is uncertain at this stage and would need to be further investigated in subsequent stages of the site evaluation process.

Additional insight into the potential suitability of this area is provided by the analysis of interpreted lineaments (Section 4.3.4.2). The identified potentially suitable area encompasses an area of lower density of lineaments. The distribution of lineament density as a function of lineament length is strongly influenced by the amount of exposed bedrock and resolution of available geophysical data. Figures 4-6 and 4-10 show interpreted geophysical lineaments in this general potentially suitable area have spacing of 1.4 to 6.6 kilometres for lineaments greater than five kilometres and 1.9 to 14.3 kilometres for lineaments greater than 10 kilometres. The low geophysical lineament density is likely due to the low resolution of the aeromagnetic dataset, and would need to be further investigated during subsequent stages of the site evaluation process. In areas where higher resolution geophysical data are available, the density of geophysical lineaments is much higher. For example, in the high resolution data area of the Seabrook Lake intrusion (NW part on Figure 4-6), the spacing between geophysical lineaments ranges from 200 to 800 metres. It is possible that such a high density of geophysical lineaments exists across the Area.

The surficial lineament density (Figures 4-5 and 4-10) in this general area is moderate, which is a consequence of the extensive bedrock exposure in the general area identified. The interpreted surficial lineaments in this general potentially suitable area have spacing of 0.6 to 3.3 kilometres for lineaments greater than five kilometres and 1.1 to 4.4 kilometres for lineaments greater than 10 kilometres.

As discussed in Section 4.3.2, the Area contains numerous mapped and interpreted dykes as it lies within regional dyke swarms. As previously mentioned, in areas where higher resolution geophysical data are available, the frequency of dykes is much higher. Although a large number of these dykes are identifiable in the aeromagnetic data in the Area, there remain some uncertainties regarding the distribution and structural impact of the dykes. Main uncertainties are related to: the potential for smaller-scale dykes to be present between interpreted dykes; the potential underestimation of geophysical brittle (fractures) and ductile lineaments due to the predominance and masking effect of the dyke signatures in the geophysical dataset; and the potential damage that may have been caused to the host rock during dyke emplacement.

This general potentially suitable area is Crown land and lies outside protected areas (Figure 4-9). It is free of active mining claims (Figures 4-8 and 4-10) and free of mineral known occurrences.

4.4.1.2 General Potentially Suitable Area - North Central Ramsey-Algoma, north of Mississagi River (Figure 4-11)

The second general potentially suitable area occurs within the north-central portion of the Ramsey-Algoma granitoid complex, north of the Mississagi River (Figure 4-11). The general area is bounded by the Mississagi River Provincial Park to the south and the Wagong Lake Forest Reserve to the north. The area is generally accessible via logging roads. As discussed in Section 4.3.2, the bedrock in this general area is mapped as massive granodiorite to granite and gneissic tonalite granite with a thickness of greater than one kilometre. Bedrock exposure is moderate to good.

The area is 48 kilometres northwest of the Flack Lake fault and 93 kilometres north of the Murray fault; however, the potential impact of these regional features on the suitability of the area needs to be further assessed. No smaller-scale faults were mapped within the area. The Sudbury, Matachewan and Biscotasing dykes are the predominant mapped dykes present in the area.

The geophysical data interpretation found magnetically quiet responses in the area. Given the low resolution of the geophysical data in the area, lithological homogeneity is uncertain at this stage and would need to be further investigated in subsequent stages of the site evaluation process.

The identified potentially suitable area encompasses an area of lower density of lineaments. The distribution of lineament density as a function of lineament length is strongly influenced by the amount of exposed bedrock and resolution of available geophysical data. Figures 4-6 and 4-11 show interpreted geophysical lineaments in this general potentially suitable area have spacing of 0.6 to 7.2 kilometres for lineaments greater than five kilometres and 2.6 to 7.2 kilometres for lineaments greater than 10 kilometres. As discussed earlier, the low geophysical lineament density is likely due to the low resolution of the aeromagnetic dataset, and would need to be further investigated during subsequent stages of the site evaluation process. In areas where higher resolution geophysical data are available, the density of geophysical lineaments is much higher. It is possible that such a high density of geophysical lineaments exists across the Area.

The surficial lineament density (Figures 4.5 and 4-11) in this general area is moderate, which is a consequence of the extensive bedrock exposure in the general area identified. The interpreted surficial lineaments in this general potentially suitable area have spacing of 1.1 to 4.4 kilometres for lineaments greater than five kilometres and 1.4 to 6.6 kilometres for lineaments greater than 10 kilometres.

As discussed in Section 4.3.2, the Area contains numerous mapped and interpreted dykes as it lies within regional dyke swarms. As previously mentioned, in areas where higher resolution geophysical data are available, the frequency of dykes is much higher. Although a large number of these dykes are identifiable in the aeromagnetic data in the Area, there remain some uncertainties regarding the distribution and structural impact of the dykes. Main uncertainties are related to: the potential for smaller-scale dykes to be present between interpreted dykes; the potential underestimation of geophysical brittle (fractures) and ductile lineaments due to the predominance and masking effect of the dyke signatures in the geophysical dataset; and the potential damage that may have been caused to the host rock during dyke emplacement.

This general potentially suitable area is Crown land and lies outside protected areas (Figure 4-9). It is free of active mining claims (Figures 4-8 and 4-11) and free of known mineral occurrences.

4.4.1.3 General Potentially Suitable Area - North Central Ramsey-Algoma, south of Mississagi River (Figure 4-12)

The third general potentially suitable area also occurs within the north-central portion of the Ramsey-Algoma granitoid complex, south of the Mississagi River (Figure 4-12). The general potentially suitable area is bounded by the Mississagi River Provincial Park to the north and the Rawhide Lake Conservation Reserve to the south. The general area is accessible via Highway 546 and directly via logging roads. As discussed in Section 4.3.2, bedrock in this general area is mapped as massive granodiorite to granite with a thickness of greater than one kilometre. Bedrock exposure is very good.

The area is 24 kilometres northwest of the Flack Lake fault and 66 kilometres north of the Murray fault; however, the potential impact of these regional features on the suitability of the area needs to be further assessed. No smaller-scale faults were mapped within the area. The Sudbury, Matachewan and Biscotasing dykes are the predominant mapped dykes present in the area. The geophysical data interpretation found magnetically quiet responses in the area. Given the low resolution of the geophysical data in the area, lithological homogeneity is uncertain at this stage and would need to be further investigated in subsequent stages of the site evaluation process.

The identified potentially suitable area encompasses an area of lower density of lineaments. The distribution of lineament density as a function of lineament length is strongly influenced by the amount of exposed bedrock and resolution of available geophysical data. Figures 4-6 and 4-12 show interpreted geophysical lineaments in this general potentially suitable area have spacing of 1.1 to 6 kilometres for lineaments greater than five kilometres and five to 11 kilometres for lineaments greater than 10 kilometres. As discussed earlier, the low geophysical lineament density is likely due to the low resolution of the aeromagnetic dataset, and would need to be further investigated during subsequent stages of the site evaluation process. In areas where higher resolution geophysical data are available, the density of geophysical lineaments is much higher. It is possible that such a high density of geophysical lineaments exists across the Area.

The surficial lineament density (Figures 4-5 and 4-12) in this general area is moderate, which is a consequence of the extensive bedrock exposure in the general area identified. The interpreted surficial lineaments in this general potentially suitable area have spacing of 0.6 to 3.3 kilometres for lineaments greater than five kilometres and 1.1 to 3.3 kilometres for lineaments greater than 10 kilometres.

As discussed in Section 4.3.2, the Area contains numerous mapped and interpreted dykes as it lies within regional dyke swarms. As previously mentioned, in areas where higher resolution geophysical data are available, the frequency of dykes is much higher. Although a large number of these dykes are identifiable in the aeromagnetic data in the Area, there remain some uncertainties regarding the distribution and structural impact of the dykes. Main uncertainties are related to: the potential for smaller-scale dykes to be present between interpreted dykes; the potential underestimation of geophysical brittle (fractures) and ductile lineaments due to the predominance and masking effect of the dyke signatures in the geophysical dataset; and the potential damage that may have been caused to the host rock during dyke emplacement. This general potentially suitable area is Crown land and lies outside protected areas (Figure 4-9). It is free of active mining claims (Figures 4-8 and 4-12) and free of known mineral occurrences.

4.4.1.4 General Potentially Suitable Area - North West Ramsey-Algoma (Figure 4-13)

The fourth general potentially suitable area occurs within the north-western portion of the Ramsey-Algoma granitoid complex (Figure 4-13). The general area is bounded by the Seabrook Lake intrusion to the west and Highway 129 to the east. The area is generally accessible via Highway 129. Bedrock in this general area is mapped as massive granodiorite to granite. Bedrock exposure is very good.

The area is 35 kilometre northwest of the Flack Lake fault and 80 kilometres north of the Murray fault; however, the potential impact of these regional features on the suitability of the area needs to be further assessed. No smaller-scale faults were mapped within the area. The Sudbury and Matachewan dykes are the predominant mapped dykes present in the area. The geophysical data interpretation found magnetically quiet responses in the area. Given the low resolution of the geophysical data in the area, lithological homogeneity is uncertain at this stage and would need to be further investigated in subsequent stages of the site evaluation process.

The identified potentially suitable area encompasses an area of lower density of lineaments. The distribution of lineament density as a function of lineament length is strongly influenced by the amount of exposed bedrock and resolution of available geophysical data. Figures 4-6 and 4-13 show interpreted geophysical lineaments in this general potentially suitable area have spacing of 0.6 to 14.9 kilometres for lineaments greater than 5 kilometres and 17.6 to 24 kilometres for lineaments greater than 10 kilometres. As discussed earlier, the low geophysical lineament density is likely due to the low resolution of the aeromagnetic dataset, and would need to be further investigated during subsequent stages of the site evaluation process. In areas where higher resolution geophysical data are available, the density of geophysical lineaments is much higher. It is possible that such a high density of geophysical lineaments exists across the Area.

The surficial lineament density (Figures 4-5 and 4-13) in this general area is moderate, which is a consequence of the extensive bedrock exposure in the general area identified. The interpreted surficial lineaments in this general potentially suitable area have spacing in the order of 0.6 to 7.7 kilometres for lineaments greater than five kilometres and 1.1 to 7.7 kilometres for lineaments greater than 10 kilometres.

As discussed in Section 4.3.2, the Area contains numerous mapped and interpreted dykes as it lies within regional dyke swarms. As previously mentioned, in areas where higher resolution geophysical data are available, the frequency of dykes is much higher. Although a large number of these dykes are identifiable in the aeromagnetic data in the Area, there remain some uncertainties regarding the distribution and structural impact of the dykes. Main uncertainties are related to: the potential for smaller-scale dykes to be present between interpreted dykes; the potential underestimation of geophysical brittle (fractures) and ductile lineaments due to the predominance and masking effect of the dyke signatures in the geophysical dataset; and the potential damage that may have been caused to the host rock during dyke emplacement.

This general potentially suitable area is Crown land and lies outside protected areas (Figure 4-9). It is free of active mining claims (Figures 4-8 and 4-13) and free of mineral occurrences. However, the area is just east of the Seabrook Lake intrusion, where rare earth mineral occurrences have been identified. The effect that such occurrences could have on the potential suitability of this general area would need to be further assessed in future stages of the site selection process.

4.4.1.5 Other Areas

Given the very large geographic extent of this rock type in the area, it may be possible to identify additional general potentially suitable areas. However, the four general areas identified are those judged to best meet the preferred geoscientific characteristics outlined in Section 4.4.1, based on the currently available information.

4.4.2 Evaluation of the General Potentially Suitable Areas

This section provides a brief description of how the four identified general potentially suitable areas were evaluated to verify if they have the potential to satisfy the geoscientific safety functions outlined in NWMO's site selection process and discussed in Section 4.2. At this early stage of the site evaluation process, where limited data at repository depth exist, the intent is to assess whether there are any obvious conditions within the identified potentially suitable areas that would fail to satisfy the safety functions.

4.4.2.1 Safe Containment and Isolation of Used Nuclear Fuel

This function requires that the geological, hydrogeological, chemical and mechanical characteristics of a suitable site promote long-term isolation of used nuclear fuel from humans, the environment and surface disturbances; promote long-term containment of used nuclear fuel within the repository; and restrict groundwater movement and retard the movement of any released radioactive material. This requires that the repository be located at a sufficient depth, typically around 500 metres, in a sufficient rock volume with characteristics that limit groundwater movement.

The geophysical interpretation conducted as part of this preliminary assessment indicates that the estimated thickness of the Ramsey-Algoma granitoid complex is greater than one kilometre (Golder, 2014). Therefore, the rock in the four general potentially suitable areas identified in this granitoid complex extends well below typical repository depths (approximately 500 metres), which would contribute to the isolation of the repository from human activities and natural surface events.

Analysis of interpreted lineament spacing indicates that the four general potentially suitable areas in the Area have the potential to contain structurally-bounded rock volumes of sufficient size to host a deep geological repository (Golder, 2014). The classification of lineaments by length shows that the spacing between lineaments increases as shorter lineaments are filtered out. Longer lineaments are more likely to extend to greater depth than shorter lineaments. All four general potentially suitable areas are located some distance from mapped faults but several generations of dykes are present in well defined orientations corresponding to distinct dyke swarms. In areas where higher resolution geophysical data are available, the frequency of interpreted dykes is much higher. In these areas, the interpreted geophysical dyke lineament spacing is between approximately 100 metres and two kilometres. This high density of interpreted dykes is likely representative of what could be expected in areas with low resolution aeromagnetic surveys.

As discussed in Golder (2014), there is limited information on the hydrogeological properties of the deep bedrock in the Area. However, as discussed in Section 4.3.7.3, available information for similar geological settings in the Canadian Shield indicates that active groundwater flow within structurally bounded blocks tends to be generally limited to shallow fracture systems, typically less than 300 metres. At greater depths, hydraulic conductivity tends to decrease as fractures become less common and less interconnected. Experience from other areas in the Canadian Shield indicates that ancient faults, similar to those in the Area, have been subjected to extensive periods of rock-water interaction resulting in the long-term deposition of infilling materials that contribute to sealing and a much reduced potential for groundwater flow at depth.

Information on other geoscientific characteristics relevant to the containment and isolation functions of a deep geological repository, such as the mineralogy of the rock, the geochemical composition of the groundwater and rock porewater, the thermal and geomechanical properties of the rock, is limited for the Area. The review of available information from other locations with similar geological settings did not reveal any obvious conditions that would suggest unfavourable mineralogical or hydrogeochemical characteristics for the granitic plutonic rocks characterizing the four general potentially suitable areas identified within the Area (Golder, 2014).

In summary, the review of available geoscientific information, including completion of a lineament analysis of the area, did not reveal any obvious conditions within the four identified general potentially suitable areas that would fail to satisfy the containment and isolation function. Potential suitability of these areas would need to be further assessed.

4.4.2.2 Long-term Resilience to Future Geological Processes and Climate Change

This safety function requires that the containment and isolation functions of the repository are not unacceptably affected by future geological processes and climate changes, including earthquakes and glacial cycles. A full assessment of these processes requires detailed site-specific data that would be typically collected and analyzed through detailed field investigations. The assessment would include understanding how the site has responded to past glaciations and geological processes and would entail a wide range of detailed studies involving disciplines such as seismology, hydrogeology, hydrogeochemistry, paleohydrogeology and climate change. At this stage of the site evaluation process, the long-term stability function is evaluated by assessing whether there is any evidence that would raise concerns about the long-term stability of the four general potentially suitable areas identified in the Area.

The Area is located within the Canadian Shield, where large portions of land have remained tectonically stable for more than one billion years. As discussed in Section 4.3.6.1, very few earthquakes of Nuttli magnitude greater than three have been recorded within the Area.

The geology of the Area is typical of many areas of the Canadian Shield, which has been subjected to numerous glacial cycles during the last million years. Glaciation is a significant past perturbation that could occur again in the future. However, as discussed in Section 4.3.6.2, findings from studies conducted in other areas of the Canadian Shield suggest that deep crystalline rocks, particularly plutonic intrusions, have remained largely unaffected by past perturbations such as glacial cycles. As discussed in Sections 4.3.5 and 4.3.6.2, other related long-term processes such as glacial rebound (land uplift) and erosion are expected to be low and unlikely to affect the performance of a repository in the Area.

In summary, available information indicates that the identified areas in the Area have the potential to satisfy the long-term stability function. The review did not identify any obvious conditions that would cause the performance of a repository to be substantially altered by future geological and climate change processes. The long-term stability of the Area would need to be further assessed through detailed multidisciplinary site specific geoscientific and climate change site investigations.

4.4.2.3 Safe Construction, Operation and Closure of the Repository

There are few surface constraints that would limit the construction of surface facilities in the four general potentially suitable areas identified in the Area (Golder, 2014). The general potentially suitable areas are characterized by rugged to moderate topographic relief and each contains enough surface land outside protected areas and major water bodies to accommodate the required repository surface facilities.

From a constructability perspective, limited site-specific information is available on the local rock strength characteristics and in-situ stresses for the Area. However, as discussed in Section 4.3.10, there is a fair amount of information at other locations of the Canadian Shield that could provide insight into what might be expected for the Area in general. Available information suggests that granitic and gneissic crystalline rock formations within the Canadian Shield generally possess good geomechanical characteristics that are amenable to the type of excavation activities involved in the development of a deep geological repository (Golder, 2014).

The four general potentially suitable areas are situated in areas having good outcrop exposure. At this stage of the site evaluation process, it is not possible to determine the exact thickness of the overburden deposits in these areas due to the low resolution of the data. However, it is anticipated that overburden cover is not a limiting factor in any of the identified general areas.

In summary, the four identified general potentially suitable areas in the Area have good potential to meet the safe construction, operation and closure function.

4.4.2.4 Isolation of Used Fuel from Future Human Activities

A suitable site must not be located in areas where the containment and isolation functions of the repository are likely to be disrupted by future human activities. These include areas containing economically exploitable natural resources or groundwater resources at repository depth. No known economic mineralization has been identified to date within the Ramsey-Algoma granitoid complex in the area, but the Huronian Supergroup, greenstone belts and some of the small intrusions have mineral potential (Section 4.3.9). Active mining does not extend into any of the four general potentially suitable areas.

The review of available information did not identify any groundwater resources at repository depth for the Area. As discussed in Section 4.3.7, the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database (MOE, 2013) indicated that no potable water supply wells were known to exploit aquifers at typical repository depths in the Area. Experience from other areas in the Canadian Shield with similar types of rock has shown that active groundwater flow in crystalline rocks is generally confined to shallow fractured localized systems.

In summary, the potential for the containment and isolation function of a repository in the Area to be disrupted by future human activities is low.

4.4.2.5 Amenability to Site Characterization and Data Interpretation Activities

In order to support the case for demonstrating long-term safety, the geoscientific conditions at a potential site must be predictable and amenable to site characterization and data interpretation. Factors affecting the amenability to site characterization include: geological heterogeneity; structural and hydrogeological complexity; accessibility, and the presence of lakes or overburden with thickness or composition that could mask important geological or structural features.

The bedrock in the general potentially suitable areas identified in the Ramsey-Algoma granitoid complex is interpreted as relatively heterogeneous and fairly easy to characterize. The apparent homogeneity shown on maps may in part reflect less detailed mapping.

Interpreted geophysical dyke lineaments in the Area, including the identified general potentially suitable areas, show distinct, very well defined orientations that can be assigned to specific generations of dykes. This aids the amenability to characterize these features. The Area has a high surficial lineament density, but this is likely due to the greater bedrock exposure. It is likely that unidentified lineaments exist and subtle unidentified structural features may also be expected. The degree of structural complexity associated with the orientation of lineament features and its impact on site characterization activities would need to be further assessed in future phases of the site selection process.

The identification and field mapping of structures is strongly influenced by the extent and thickness of overburden cover and the presence of large water bodies. The four identified general potentially suitable areas are amenable to site characterization as they contain sufficient areas with good bedrock exposure and limited surface water cover.

In summary, the review of available information did not indicate any obvious conditions that would make the rock mass in the four potentially suitable areas unusually difficult to characterize.

4.5 Geoscientific Preliminary Assessment Findings

This report presents the results of a geoscientific desktop preliminary assessment to determine whether the Town of Blind River, City of Elliot Lake, Township of The North Shore, Town of Spanish and their periphery contain general areas that have the potential to satisfy the geoscientific evaluation factors. At this stage of the assessment, the intent is not to identify specific repository-scale sites, but rather to identify general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in the site selection process document (NWMO, 2010). The location and extent of potentially suitable areas would need to be refined during subsequent site evaluation stages through more detailed studies and field evaluations.

The preliminary geoscientific assessment built on the work previously conducted for the initial screenings (Geofirma, 2012a,b,c,d) and focused on the Town of Blind River, City of Elliot Lake, Township of The North Shore, Town of Spanish and their periphery, which are collectively referred to as the “Area of Study” (Figure 4-1). The geoscientific preliminary assessment was conducted using available geoscientific information and key geoscientific characteristics that can be realistically assessed at this early stage of the site evaluation process. These include geology, structural geology, interpreted lineaments, distribution and thickness of overburden deposits, surface conditions, and the potential for economically exploitable natural resources. Where information for the Area was limited or not available, the assessment drew on information and experience from other areas on the Canadian Shield. The geoscientific desktop preliminary assessment included the following review and interpretation activities:

- Detailed review of available geoscientific information such as geology, structural geology, natural resources, hydrogeology, and overburden deposits;
- Interpretation of available geophysical surveys (magnetic, gravity, radiometric, electromagnetic);
- Lineament studies using available satellite imagery, topography and geophysical surveys to provide information on the characteristics such as location, orientation, and length) of interpreted structural bedrock features;
- Terrain analysis studies to help assess factors such as overburden type and distribution, bedrock exposures, accessibility constraints, watershed and subwatershed boundaries, and groundwater discharge and recharge zones; and
- The identification and evaluation of general potentially suitable areas based on key geoscientific characteristics and the systematic application of NWMO's geoscientific site evaluation factors.

The geoscientific desktop preliminary assessment showed that the Area contains at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors. All four general areas are located within the Ramsey-Algoma granitoid complex in the northern half of the Area, north of the municipal boundaries of Elliot Lake and Blind River.

The Ramsey-Algoma granitoid complex containing the four identified potentially suitable general areas appears to have a number of geoscientific characteristics that are favourable for hosting a deep geological repository. The bedrock within this granitoid complex is estimated to have sufficient depth and extends over large areas. The bedrock within the four potentially suitable areas has good exposure, although the bedrock has not been mapped in detail in these areas and some lithological heterogeneity has been found. All four potentially suitable areas have low potential for natural resources; are easily accessible using the existing secondary and logging road network; contain limited surface constraints; and are amenable to site characterization.

No general potentially suitable areas were identified within the municipal boundary of Blind River. This area is located almost entirely within rocks of the Huronian Supergroup that were not considered suitable because of their mineral potential and structural complexity. In addition, a large portion of the municipal area is occupied by the Blind River and Matinenda Provincial Parks and the Mississagi Delta Provincial Nature Reserve.

No general potentially suitable areas were identified within the municipal boundary of Elliot Lake. This area is located largely within rocks of the Huronian Supergroup that were considered to be not suitable. The portion of the municipal boundary that occurs within the Ramsey-Algoma granitoid complex, north of Elliot Lake, is in close proximity to the rocks of the Huronian Supergroup that have high mineral potential. Several past producing mines are located close to this area. In addition, the Ramsey-Algoma granitoid complex south of Elliot Lake is lithologically heterogeneous. A portion of the municipal area is occupied by the Matinenda Provincial Park and the Glenn N. Crombie Conservation Reserve.

No general potentially suitable areas were identified within the municipal boundary of The North Shore. This area is located largely within rocks of the Ramsey-Algoma granitoid complex. However, in this location, the granitoid complex is crosscut by numerous mafic dykes, exhibits a high apparent lineament density and is lithologically heterogeneous. This area is also in close proximity to the regional Murray fault system, which runs from Sault Ste. Marie to Sudbury, and corresponds to a marked change in metamorphic grade.

No general potentially suitable areas were identified within the municipal boundary of Spanish. About half of this area is within rocks of the Huronian Supergroup that were not considered suitable. About half of the municipality is located within the rocks of the Ramsey-Algoma granitoid complex. However, in this area of the Municipality, the lithology is heterogeneous and there is close proximity to the Murray fault and mineral occurrences.

While the four general potentially suitable areas identified appear to have favourable geoscientific characteristics, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. The main uncertainties are associated with the low resolution of available geophysical data, proximity to the Murray and Flack Lake faults, and the potential geological, structural and hydrogeological significance of the four known dyke swarms in the Area.

The four potentially suitable areas are located in areas of lower density of geophysical and surficial lineaments. However, the interpreted lower density of geophysical lineaments is likely due to the low resolution of available geophysical data. In the high resolution data area of the Seabrook Lake intrusion, the spacing between geophysical lineaments range from 200 to 800 metres. It is possible that such a high density of geophysical lineaments exists across the Area.

The Area contains numerous dykes that are associated with major regional dyke swarms. While the spacing between mapped and interpreted dykes and lineaments within the four potentially suitable areas appears to be favourable, the low resolution of available geophysical data, and the strong magnetic signature of the dykes could be masking the presence of smaller scale dykes and fractures not identifiable from available data. In areas where higher resolution geophysical data are available, the frequency of dykes is much higher.

Should the Area be selected by the NWMO to advance to Phase 2 study and remain interested in continuing with the site selection process, several years of progressively more detailed studies would be required to confirm and demonstrate whether the Area contains sites that can safely contain and isolate used nuclear fuel. This would include the acquisition and interpretation of higher resolution airborne geophysical surveys, detailed field geological mapping and the drilling of deep boreholes.

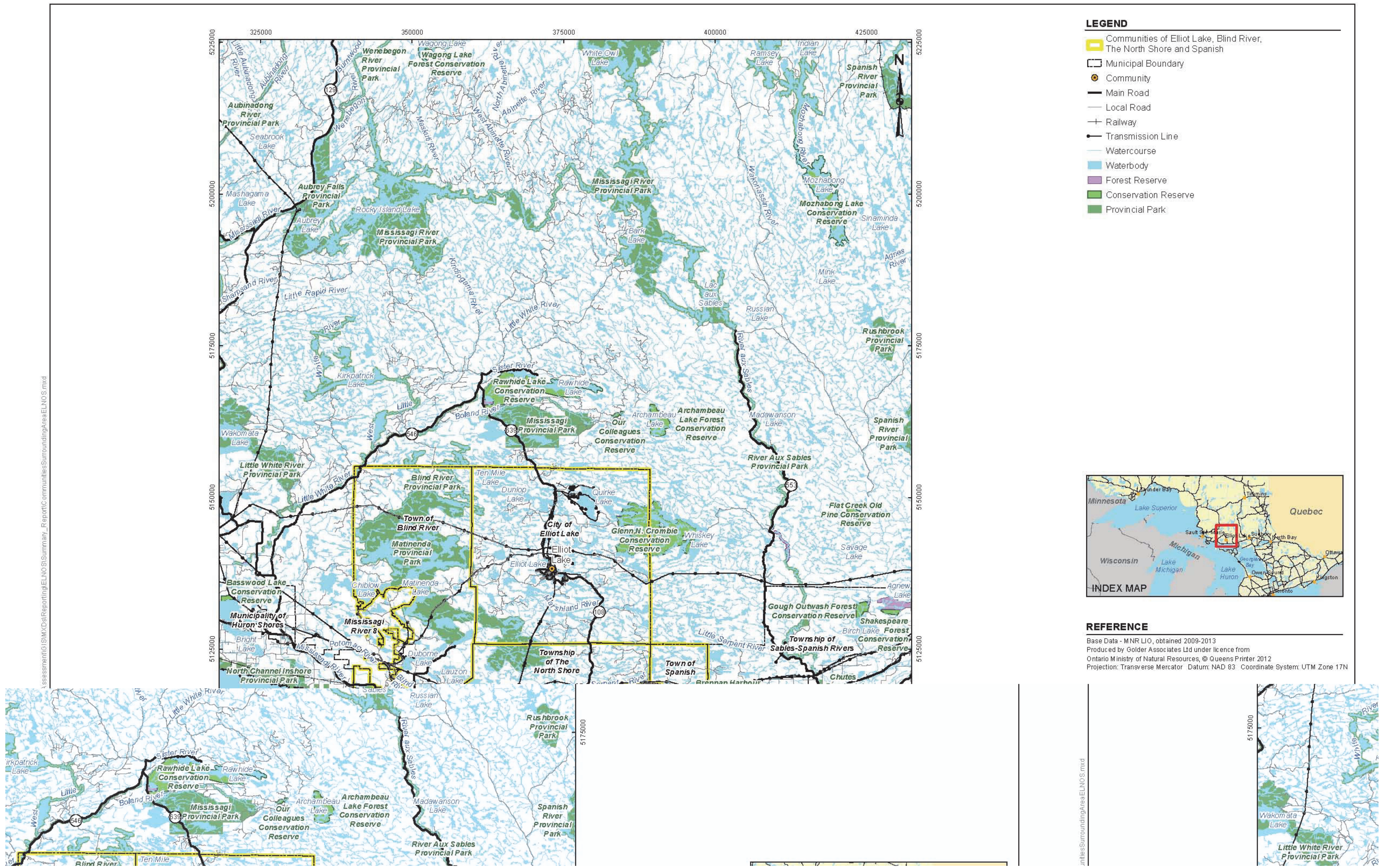

Figure 4-1: Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

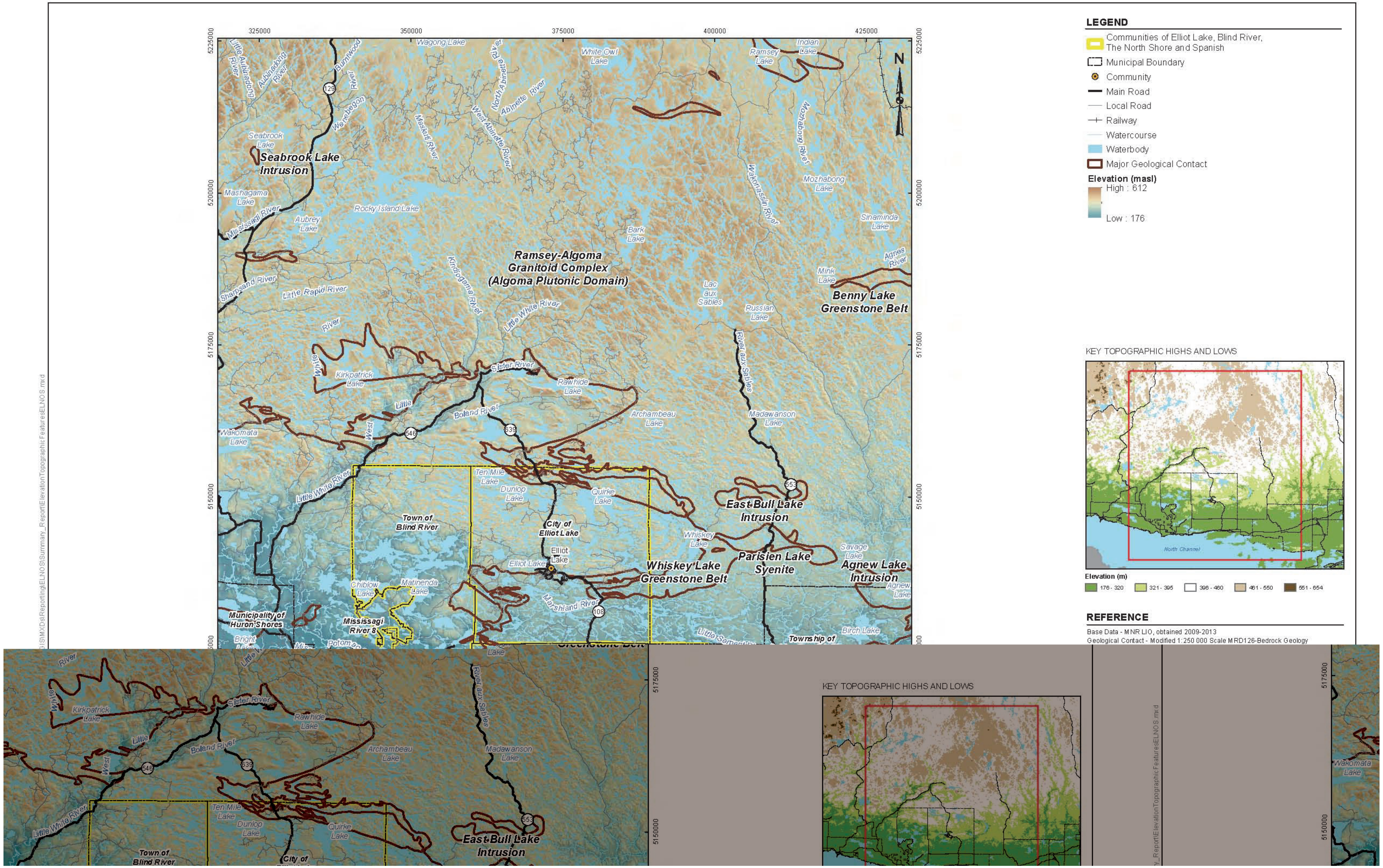

Figure 4-2: Elevation and Major Topographic Features of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

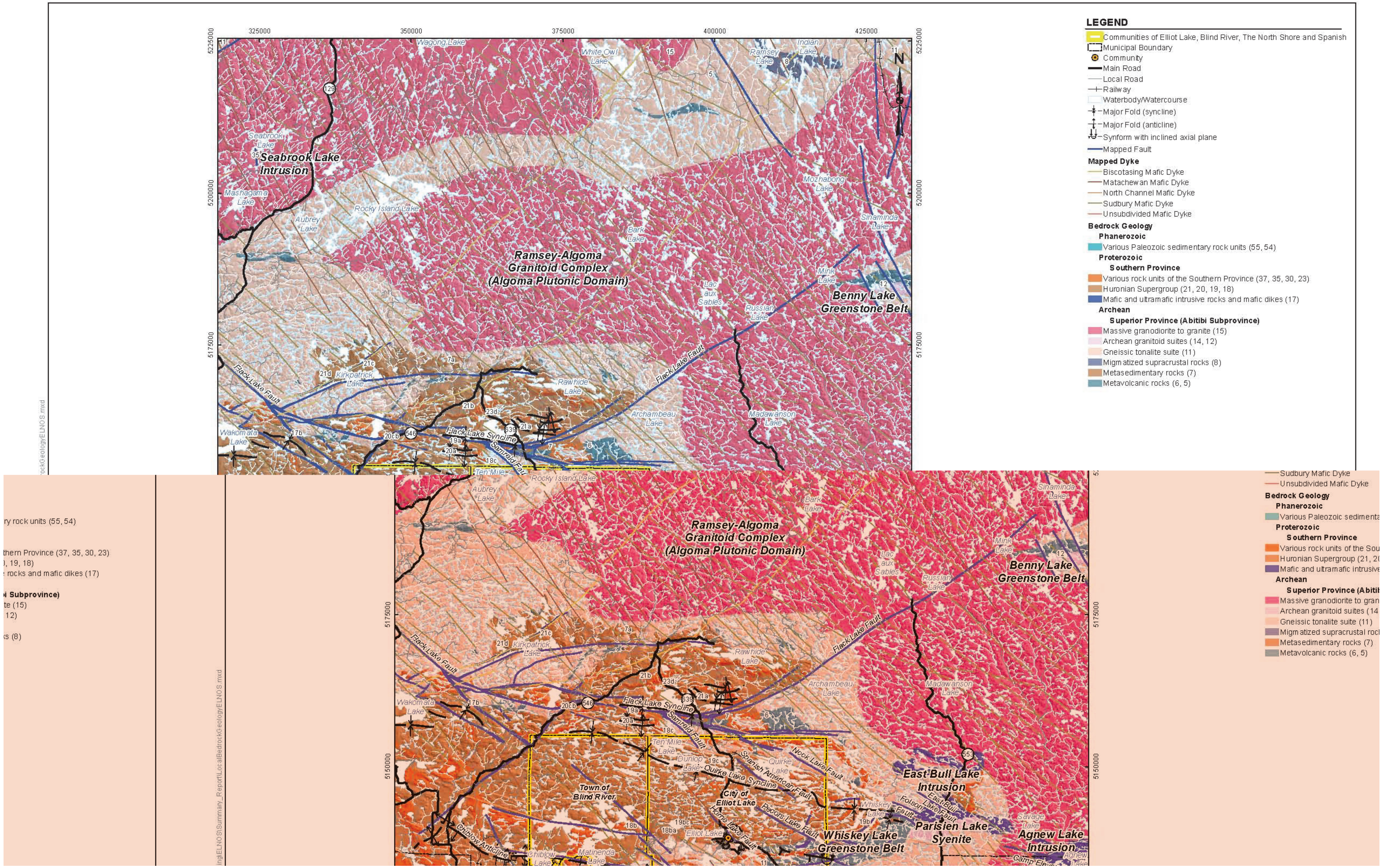

Figure 4-3: Bedrock Geology of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

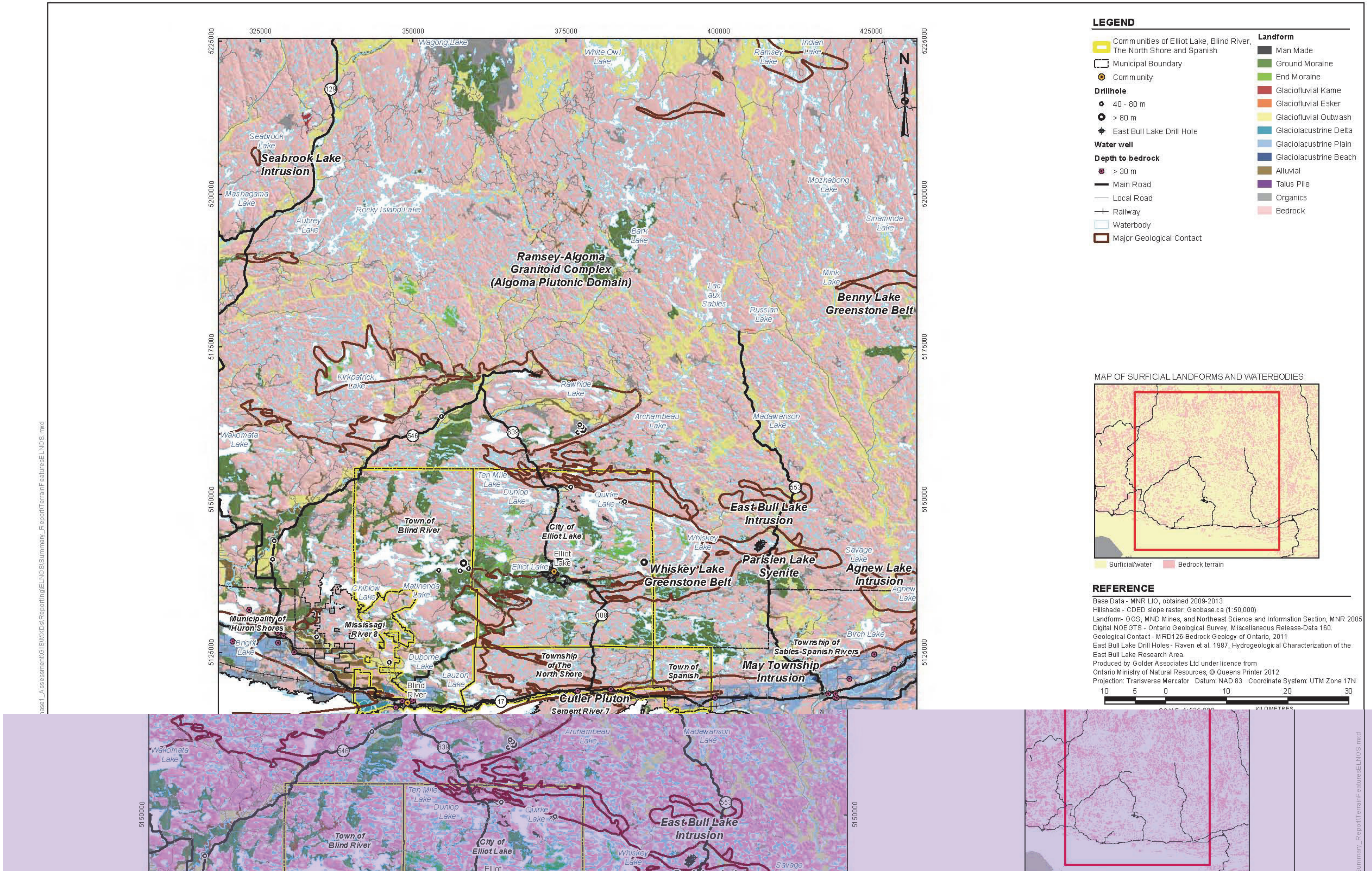

Figure 4-4: Quaternary Geology of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

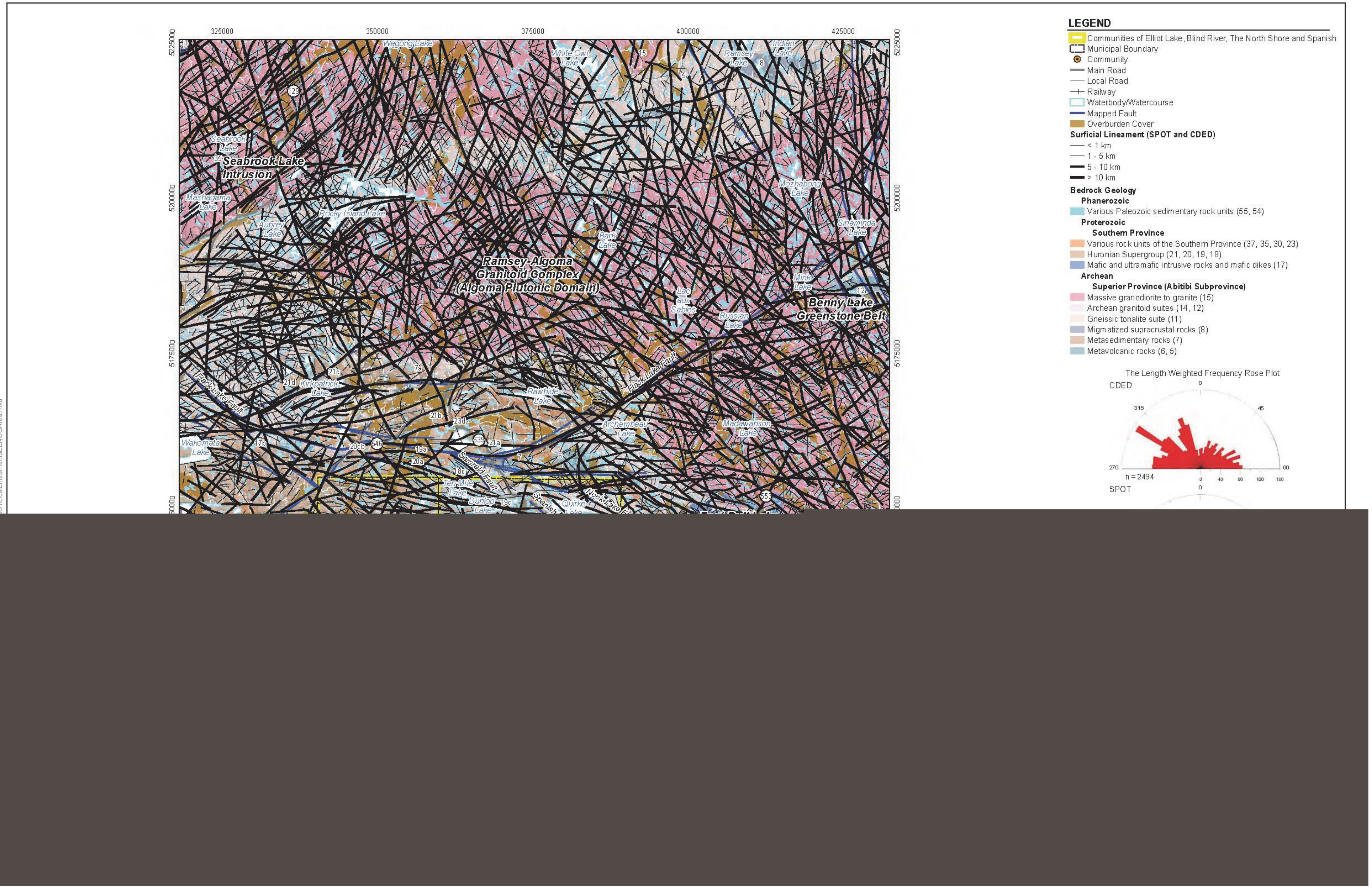

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Figure 4-5: Surficial Lineaments of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

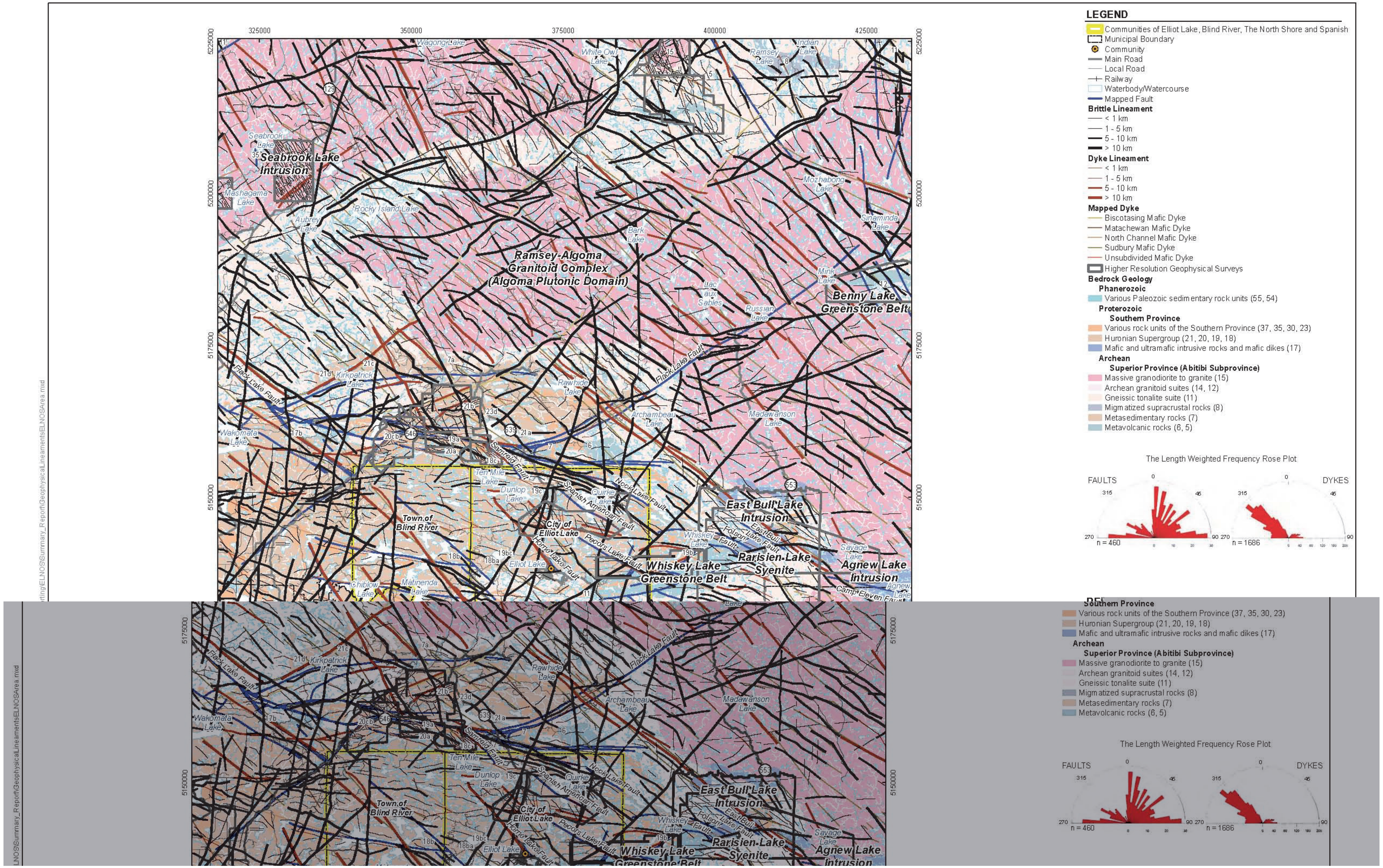

Figure 4-6: Geophysical Lineaments of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

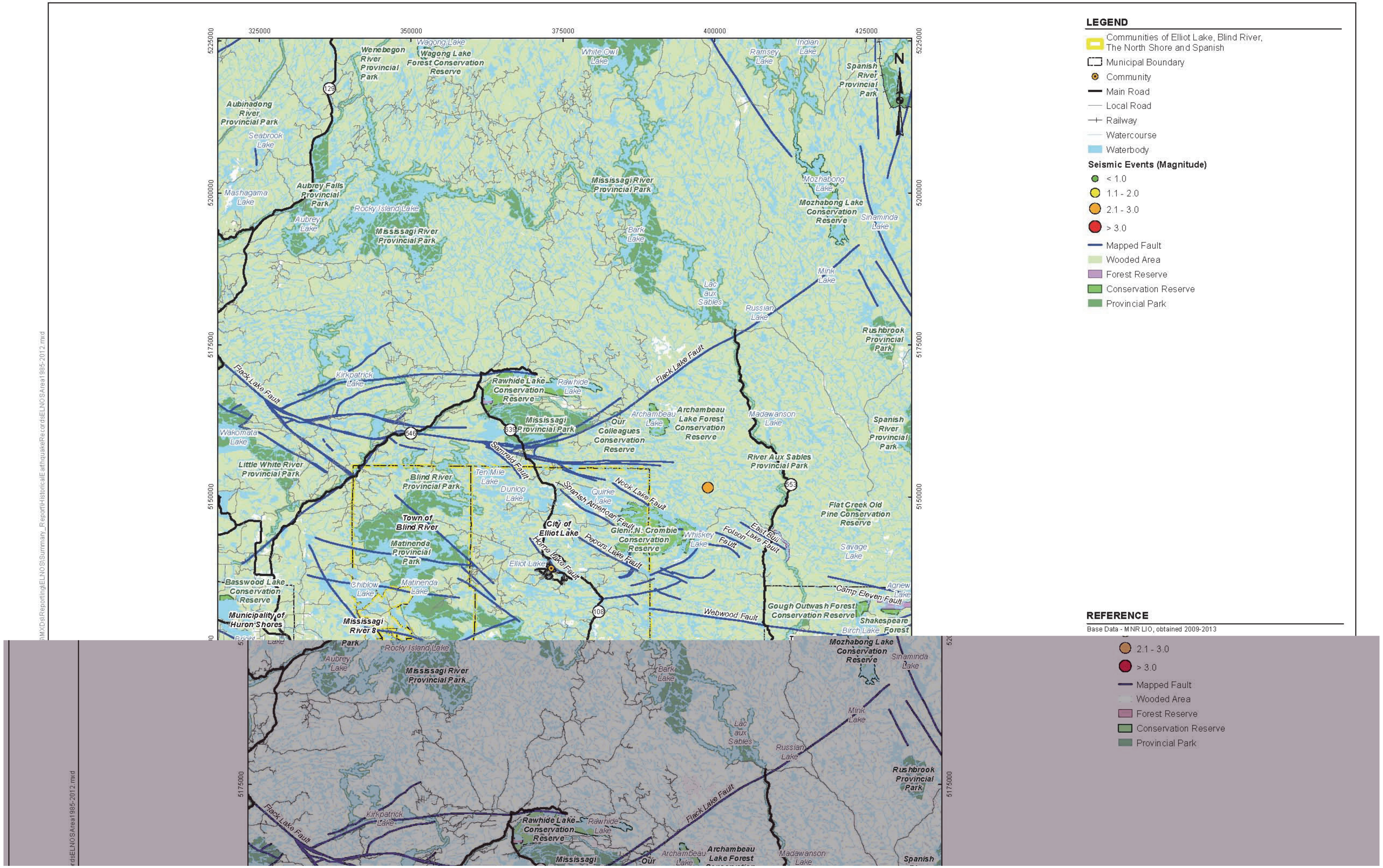

Figure 4-7: Historical Earthquake Records of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area (1985-2012)

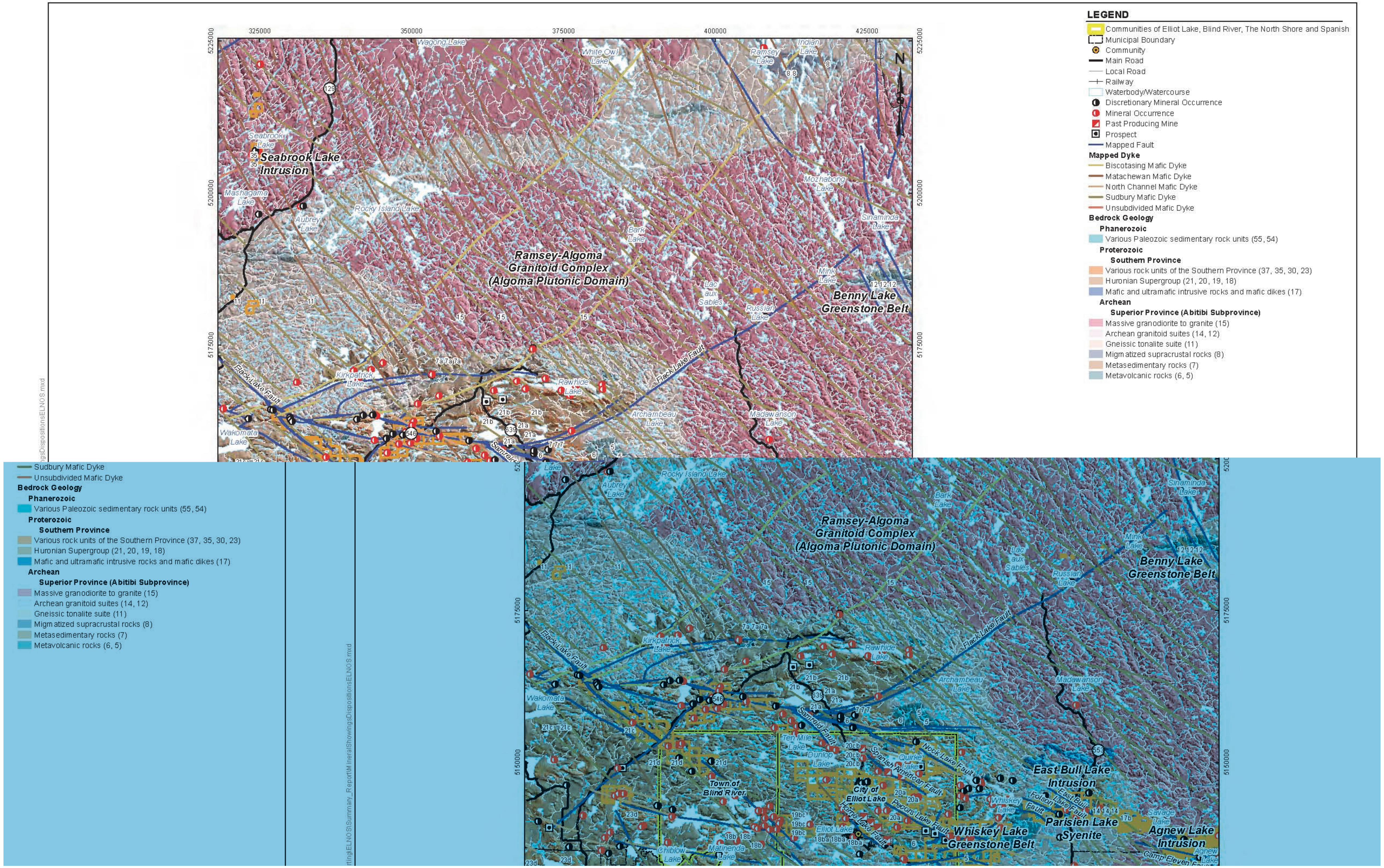

Figure 4-8: Mineral Resources in the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

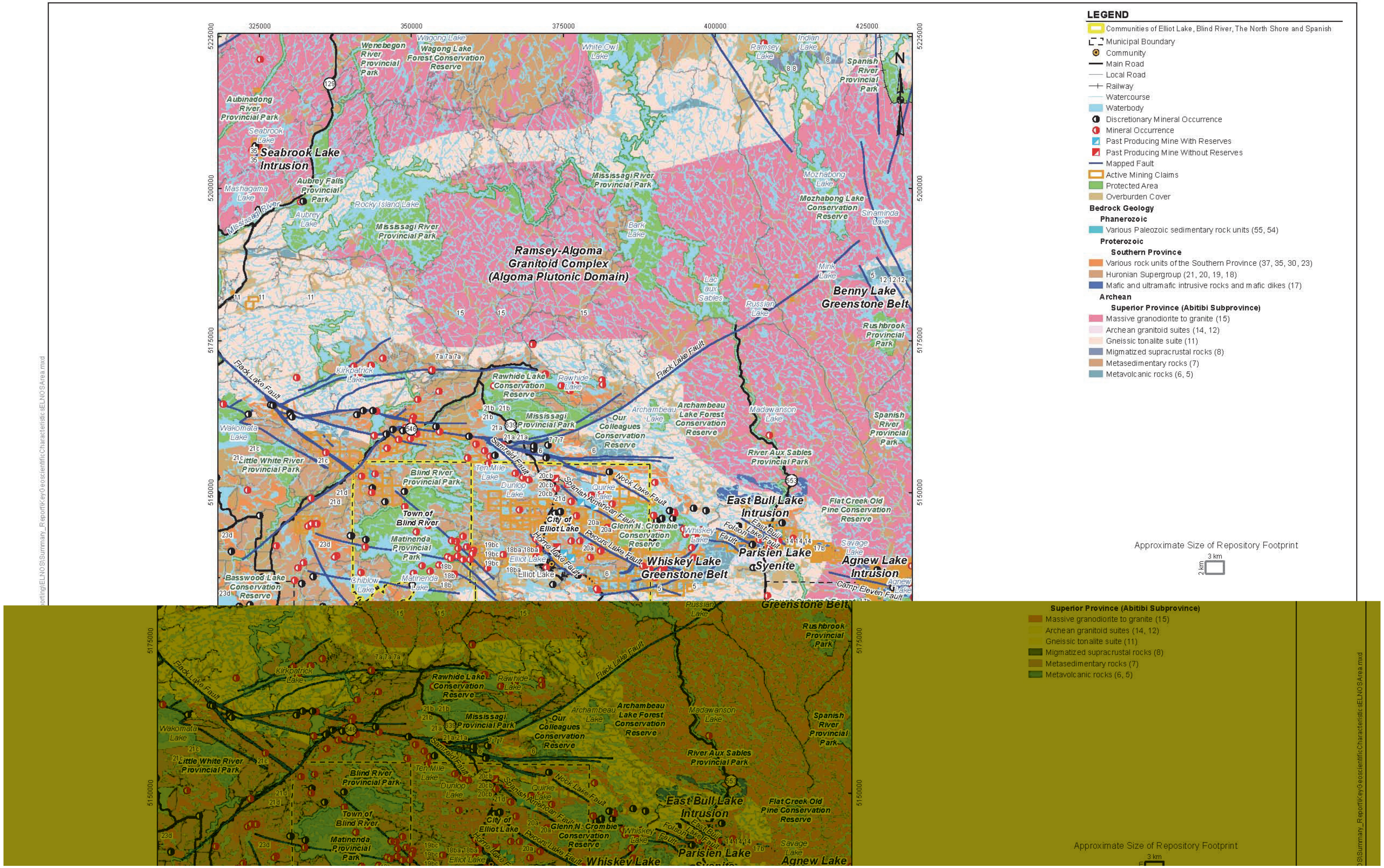

Figure 4-9: Geoscientific Characteristics of the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

Figure 4-10: Key Geoscientific Characteristics of the Ramsey-Algoma Granitoid Complex (North East)

Figure 4-11: Key Geoscientific Characteristics of the Ramsey-Algoma Granitoid Complex (North Central)

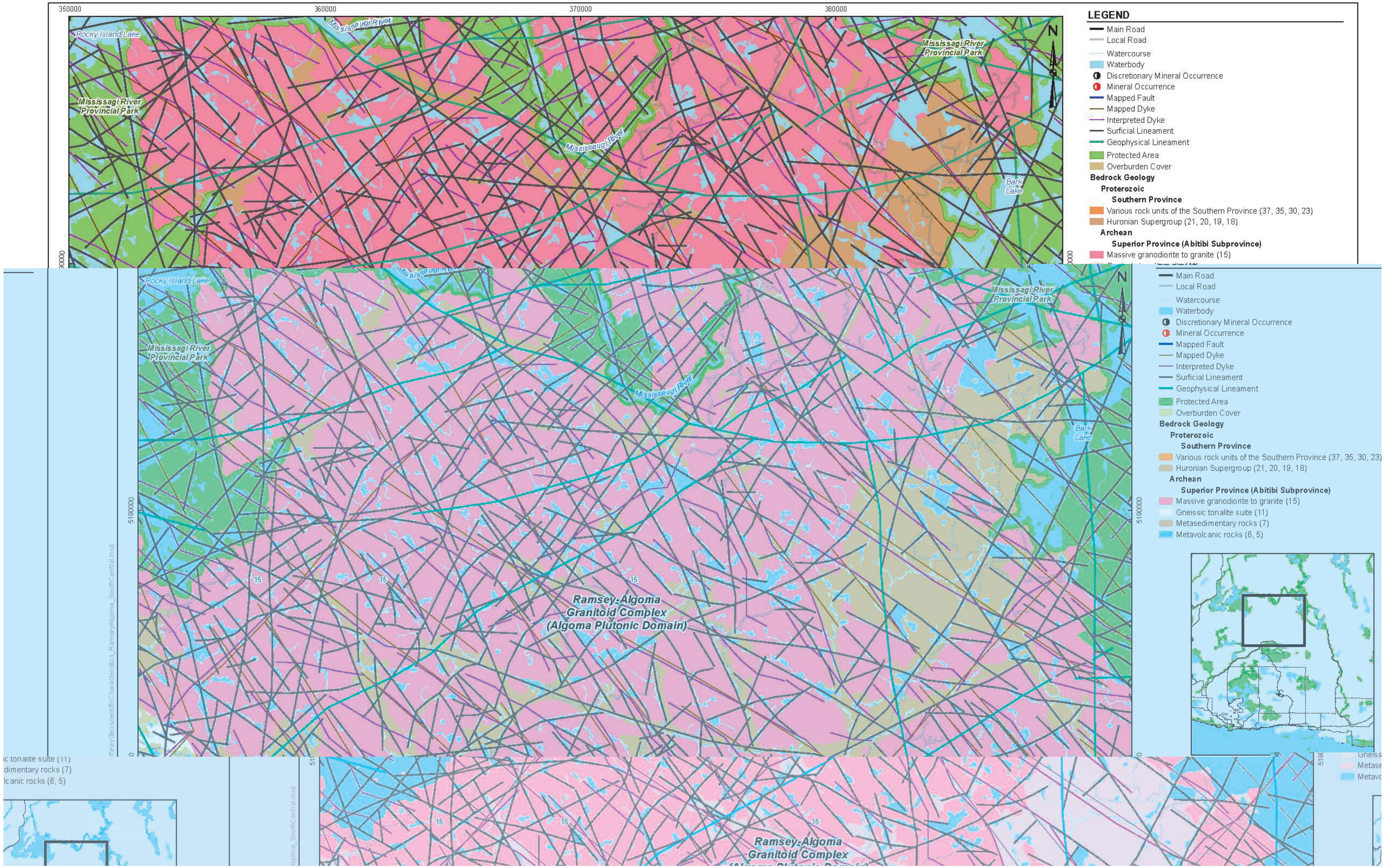

Figure 4-12: Key Geoscientific Characteristics of the Communities Ramsey-Algoma Granitoid Complex (South Central)

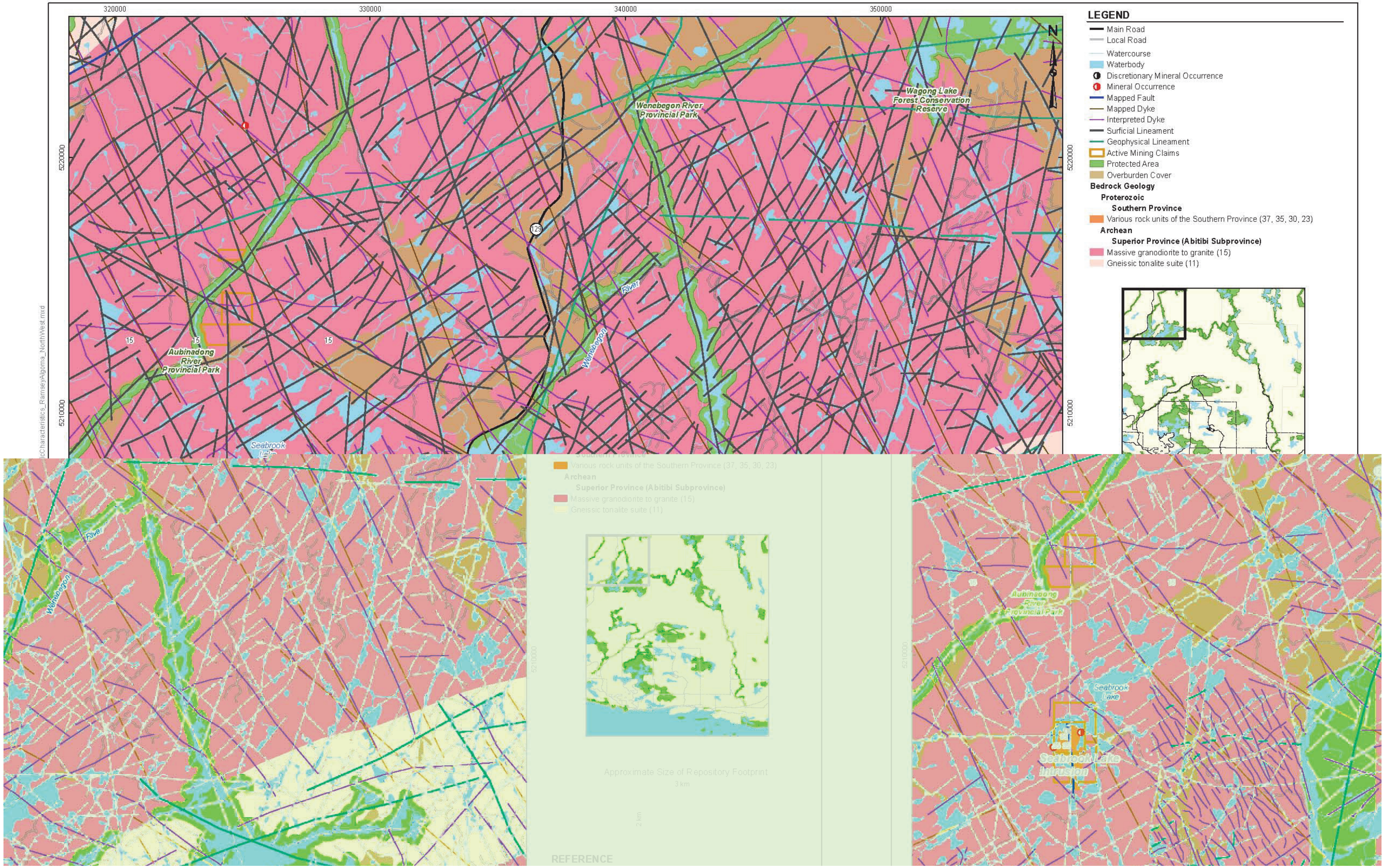

Figure 4-13: Key Geoscientific Characteristics of the Ramsey-Algoma Granitoid Complex (North West)

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5. PRELIMINARY ENVIRONMENT AND SAFETY ASSESSMENT

5.1 Environment and Safety Assessment Approach

The objective of this preliminary assessment is to assess the potential to ensure the health and safety of people and the environment within the communities of Blind River, Elliot Lake, The North Shore and Spanish and surrounding area (i.e., the Area of Study), and to explore the potential to manage any environmental effects that might result from the Adaptive Phased Management (APM) Project. The environment and safety assessment considered the following questions:

1. Is there anything in the natural environment that would preclude siting the repository somewhere in the communities of Blind River, Elliot Lake, The North Shore and Spanish and surrounding area?
2. If the repository is located somewhere in the communities of Blind River, Elliot Lake, The North Shore and Spanish and surrounding area, would environmental effects that could not be managed be likely to occur during siting, construction, operation, or decommissioning and closure of the repository?
3. If the repository is located somewhere in the communities of Blind River, Elliot Lake, The North Shore and Spanish and surrounding area, would postclosure health or environmental effects that could not be managed be likely to occur?

The assessment presented here takes into account the following factors:

- Safe containment and isolation of used nuclear fuel;
- Safe construction, operation and closure of the repository; and
- Potential to avoid ecologically sensitive areas and locally significant environmental and cultural features.

The assessment is conducted at a desktop level (i.e., based on readily available information). It is expected that surface natural environment information is not uniformly available within the Area, so that a lack of identified features in some locations could simply be due to data limitations. It is also clear that there is limited information at typical repository depths, which limits the ability to make substantive comments on postclosure safety beyond those presented in the geoscientific assessment (Chapter 4). It is intended that suitability of potential siting areas will be further evaluated in a staged manner through a series of progressively more detailed scientific and technical studies. As part of these future activities, discussions with interested communities, First Nation and Métis communities in the area, and surrounding communities, as well as field studies, would be undertaken to aid in the characterization of environmental conditions.

The Initial Screening criteria include that there must be sufficient available land and that the available land must be outside protected areas, heritage sites, provincial parks and national parks (NWMO, 2010). This chapter begins to provide information on environmental features in the Area that may help inform the identification of potential suitable sites during subsequent stages of the site selection process.

The information presented in this chapter includes the following:

- General description of the environment;
- Assessment of potential effects on people and the environment in various project phases through closure and monitoring; and
- Assessment of postclosure safety aspects.

5.2 Description of the Environment

The environment and safety assessment is conducted within a defined geographic area around the communities of Blind River, Elliot Lake, The North Shore and Spanish, referred to as the “Area of Study”, as noted above. For the purpose of this preliminary assessment, the area considered is the same as that selected for geoscientific assessment shown on Figure 4-1.

A detailed description of the environment for the Area is provided in Golder (2014). Summary information is presented here.

5.2.1 Communities and Infrastructure

Figure 5-1 shows the location of the Area within the regional area. Figure 5-1 also shows the infrastructure and major land use within the Area, including the locations of parks, protected lands and Crown reserve lands.

The municipalities of Blind River, Elliot Lake, The North Shore, and Spanish are approximately 14,450 square kilometres in size (LIO, 2013), with a population of 16,102 (Statistics Canada, 2013). The Area is located along the north shore of Lake Huron, approximately 100 kilometres west of Sudbury and 145 kilometres east of Sault Ste. Marie. More information on Blind River is provided in Chapter 7.

There are a number of Aboriginal communities and organizations around the Area including Whitefish Lake First Nation, Wikwemikong Unceded First Nation, Serpent River First Nation, Mississauga #8 First Nation, Sagamok Anishnawbek First Nation, and Whitefish River First Nation. Métis Councils in the area include Historic Sault Ste. Marie Métis, North Channel Métis, Sudbury Métis, and the North Bay Métis.

The Trans-Canada Highway 17 heads east-west through the communities of Blind River, Algoma Mills, Serpent River, Spanish and Massey; Highway 108 heads north from Highway 17 through Elliot Lake. A rail corridor, operated by the Huron Central Railway (HCRY), runs approximately parallel to Highway 17 through the area. A natural gas pipeline runs westward from Elliot Lake to the southwestern part of the Area. There are 230-kilovolt and 115-kilovolt transmission line corridors running through the area, one paralleling Highway 17, another further north running through Blind River and Elliot Lake, and a third running from north to south along the western edge of the Area. The area is serviced by two airports, two emergency landing strips and five seaplane bases. There are five operating landfills within the Area (MOE, 2013a). There is one waste water treatment plant located in Blind River and one in Elliot Lake. Spanish operates sewage lagoons, and The North Shore has a waste water service system in place for a number of households in one of its subdivisions.

There are 15 provincial parks, 12 conservation reserves and four forest reserves located in the Area.

The Ontario Archaeological Sites Database identifies 85 known archaeological sites in the Area, with 23 of these found within municipal boundaries of Elliot Lake, Blind River, The North Shore and Spanish. Archaeological sites identified at the periphery of these communities include sites in the Mississagi River Provincial Park and the Mississagi Delta Provincial Nature Reserve (von Bitter, 2013). There are five historic burial sites and no national or provincial heritage sites identified in the Area (Parks Canada, 2013; OHT, 2013; MTCS, 2013). The presence of local heritage sites would need to be confirmed in discussion with the communities and First Nation and Métis communities in the area.

Trapline Licence Areas are located throughout most of the Area, outside Provincial Parks, Conservation Reserves, communities and Indian Reserves.

As discussed in Section 4.3.7, water wells in the Area obtain water from the overburden or shallow bedrock. The Ontario Ministry of the Environment (MOE) Water Well Information System (WWIS) database contains 785 records in the Area, of which 538 provide useful information on depth to bedrock, yield and other relevant parameters. These 538 water wells range from 2.4 to 216 metres in depth (MOE, 2013b). No potable water supply wells are known to exploit aquifers at typical repository depths in the Area, or anywhere else in northern Ontario. The Area obtains its municipal water supplies from surface water and from overburden and shallow bedrock aquifers.

5.2.2 Natural Environment

As described in Chapter 4, the Area lies in the Penokean Hills physiographic region to the south, composed of folded Proterozoic stratified rocks, and the Abitibi Upland physiographic region to the north, featuring the broadly rolling surfaces of Canadian Shield bedrock that occupies most of north-central Ontario (NRCan, 1997). The land surface around the Area varies across the region and elevation ranges from 612 metres above sea level north of the municipal boundaries of Blind River and Elliot Lake to 176 metres above sea level in the south along the Lake Huron shoreline. The terrains are either exposed at surface or shallowly covered with Quaternary glacial deposits. Terrains in the Penokean Hills and Abitibi Upland contain numerous lakes and the terrain of the Area is typical in that regard.

Geologically, the Area is underlain by Archean-age rocks of the Superior Province of the Canadian Shield which are, in turn, overlain in the south portion of the Area by early Proterozoic rocks of the Southern Province. The bedrock geology in the Area is dominated by the Ramsey-Algoma granitoid complex, a large granitic complex that intruded older greenstone belts.

The Area has a continental climate, with cold winters and mild summers. Most precipitation falls in the late spring into early fall in the form of showers and thunderstorms associated with traversing weather systems. Prolonged periods of extreme cold can also be experienced in the region during the winter.

Figure 5-2 shows the significant natural features within the Area, including watershed boundaries, significant ecological areas, wintering areas, migration routes and nesting areas for known rare species. This information will be further developed in the future through discussions with interested communities and First Nation and Métis communities in the area, as well as field studies, should the community proceed in the site selection process.

The Area is located within the St. Lawrence drainage basin. Drainage occurs generally from the north in the Abitibi Upland to the south towards the Penokean Hills and to Lake Huron. The Area contains numerous lake trout and brook trout lakes including several deep, clear inland lakes that support inland fisheries (MNR, 2013a). The water bodies noted are actively managed and support provincial and federal biodiversity initiatives, as well as supporting local sport fishing and tourism (MNR 2010a,b).

The Area lies within the Great Lakes-St. Lawrence Forest Region (MNR, 2013b). Tree species found in the area include: eastern white pine, red pine, jack pine, black spruce, eastern hemlock, yellow birch, poplar and white birch. Forestry is a major industry in the area and the largest single land use, with more than 60 per cent productive forest. The Area contains portions of two Forest Management Units (FMU): the Northshore (FMU 680), managed by Northshore Forest Inc. and the Spanish (FMU 210), managed by Domtar Inc. The region's forests provide habitat for wildlife including game, fur-bearing mammals and birds. Management of featured species populations (e.g., moose) and concentration and nesting areas for raptors, herons and waterfowl are a focus of Ontario Ministry of Natural Resources (MNR) forest management planning in this area.

The Natural Heritage Information Centre (NHIC) database (NHIC, 2013) shows the occurrence of species that are listed as Endangered (END), Threatened (THR) or Special Concern (SC) either under the provincial *Endangered Species Act* (ESA) or the federal *Species at Risk Act* (SARA). The Royal Ontario Museum range maps (ROM, 2013) indicate the potential for Species at Risk (SAR) to exist within the Area, based on the principles of range mapping. Habitats within the Area have the potential to directly or indirectly support the needs of 30 designated SAR (NHIC, 2013; NHIC, 2005; ROM, 2013; Oldham and Weller, 2000; BSC, 2006; Domtar, 2010; BCI, 2013a,b; Jones et al., 2013; Dobbyn, 1994). These species include: eastern cougar, little brown myotis (bat), northern myotis (bat), shortnose cisco and wood turtle. Further data collection through site-specific surveys and potential discussions with interested communities and First Nation and Métis communities in the area would be needed to refine habitat use and suitability for these species, should the community proceed in the site selection process.

5.2.3 Natural Hazards

Natural hazards may be important with respect to operational and postclosure safety of the repository. Potential natural hazards that could occur in the Area are described in the Environment Report (Golder, 2014). A preliminary qualitative assessment of natural hazards is summarized below. These identified natural hazards represent ways in which the natural environment could potentially affect the APM Project during the various phases of implementation (see Table 3-1). As with all large-scale construction projects, the design process will take into account the site-specific characteristics of the natural environment, and mitigate the risks associated with occurrence of these natural hazards, as appropriate.

- Earthquakes – Low risk – Located in a seismically stable region of the Canadian Shield and has a low seismic hazard rating (NRCan, 2010) (see Chapter 4 for additional information).
- Tornadoes/Hurricanes – Low risk – Located in an area with a low tornado frequency (less than 0.2 tornadoes per year per 10,000 square kilometres), but where there is a potential for F2-F5 tornadoes (Sills et al., 2012), and is located outside the geographic area where hurricanes occur.
- Flooding – Moderate risk – Possible risk of flash flooding in some areas due to moderately sized catchments and moderately rugged terrain. Risk will vary based on specific location.

- Drought – Low risk – Risk of drought is low and unlikely to affect the viability of local water sources.
- Snow/Ice – Possible risk – Total average annual snowfall is moderate (303 centimetres), and extreme snowfall events can occur.
- Fire – Possible risk – Forest fires occur in the area, although historically they have been less than 50 square kilometres in size and have affected less than one per cent of the area over a 35-year period.
- Landslide – Possible risk – Some landslide risk in areas of high topographic gradients. Risk will vary based on specific location.
- Tsunami – Low risk – Low seismic hazard rating and low potential along immediate Lake Huron / North Channel shoreline.

5.2.4 Environment Summary

Table 5-1 presents summary information for the Area taken from the Environment Report (Golder, 2014).

Table 5-1: Summary of Environmental Features within the Area

Environmental Feature	Summary
Protected Areas	
Known Heritage Sites (Including Archaeological Sites)	Yes
Provincial Parks, Conservation Reserves	Yes
Wetlands	Yes
Infrastructure	
Availability of Major Water Source Within 5 kilometres	Yes
Major and Minor Road Access	Yes
Major Utility Alignments	Yes
Nearby Communities	Yes
Land Use	
Water Body/Wetland Coverage	11.5% / 5%
Active Agriculture	Yes
Active Forestry	Yes
Active Trapping and Hunting	Yes
Active Sport or Commercial Fishery	Yes
Natural Environment	
Potential Habitat Area for Endangered/Threatened/Species at Risk	Yes
Presence of Known Important Terrestrial Habitat Areas	Yes
Presence of Known Important Aquatic Habitat Areas	Yes
Areas of Natural and Scientific Interest (ANSIs) and Earth or Life Science Sites	Yes

Environmental Feature	Summary
Natural Hazards	
Occurrence of Forest Fires	Yes
Potential for Earthquakes	Low
Potential for Tornadoes or Hurricanes	Low
Potential for Flooding, Drought, Extreme Snow and Ice	Possible
Potential for Landslides	Possible

5.3 Potential Environmental Effects

This section presents the results of a high-level screening assessment performed to identify potential interactions between the APM Project and the environment. The assessment considers:

- Activities associated with each project phase through closure and monitoring;
- Potential interaction of the activities with the environment;
- Environmental components that could be affected by the interaction;
- Potential effects of the interaction with the environmental components; and
- The potential for mitigation measures to avoid or minimize adverse effects.

The interactions, effects and mitigation measures are determined by reference to existing Canadian and international environmental assessments, and not through site-specific analyses. Lastly, a judgment of the significance of residual adverse effects is made assuming implementation of feasible management or mitigation.

Since specific candidate site(s) within the Area have not been defined, the assessment reflects general conditions across the area. A full environmental assessment would eventually be completed for any preferred site once determined, in accordance with the *Canadian Environmental Assessment Act*.

The environment is described by individual environmental components, each of which represents physical, biophysical or social features that could be affected by the project. Environmental components used to understand the potential for environment effects at this preliminary assessment phase are:

- Atmospheric Environment: air quality, noise, vibration and light;
- Subsurface Environment: geology, hydrogeology and groundwater quality;
- Aquatic Environment: surface water quality, surface water quantity and flow, sediment quality, and aquatic habitat and communities including sensitive species;
- Terrestrial Environment: vegetation communities, soil quality, wildlife habitat and communities, natural heritage features and sensitive species;
- Radiation and Radioactivity: radiation dose to humans, including members of the public and project workers, and radiation dose to non-human biota; and
- Cultural Resources: Aboriginal heritage resources and Euro-Canadian heritage resources.

5.3.1 Potential Effects during the Site Selection Process

As explained in Section 1.5, the site selection process includes the identification of potential sites within the smaller number of communities and subsequent detailed investigations of preferred sites in communities that continue in the site selection process. These investigations will involve field surveys to better characterize the site-specific environment, including airborne geophysics, detailed geological mapping, drilling and testing of boreholes, and environmental surveys. Activities may include line cutting and temporary road construction activities to construct access routes to sites undergoing detailed evaluation.

Table 5-2 summarizes the generic project-environment interactions that could occur during the site selection process. These activities may result in environmental effects associated with noise, vegetation clearing for site access, drilling/blasting and increased traffic. Site-specific project-environment interactions for the Area would need to be evaluated during subsequent steps of the site selection process.

Implementation of an environmental management plan for these activities would be expected to reduce the effects. For example, drilling fluids associated with site exploration boreholes would be contained at the site and disposed of appropriately. In addition, the location of drill sites and the alignment of roads for access to drill sites (if required) would be determined collaboratively with the community and First Nation and Métis communities in the area, and be designed to avoid protected areas, habitat areas for species of conservation concern and heritage sites. Timing of construction activities would be controlled to mitigate effects on biota if any potential interactions are identified.

Overall, no project-environment interactions are identified that would prevent activities associated with site selection in the Area.

Table 5-2: Potential Interactions with the Biophysical Environment during Site Selection Process

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle emissions, dust, noise, light, vibration from blasting	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow from site clearing and blasting	Yes	Yes	No
Aquatic Environment	Change in surface water quality and flow from site clearing, disturbance to aquatic habitat or biota from access construction, vibration due to blasting	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from access construction, noise, vibration from blasting, increase in traffic	Yes	Yes	No

Environmental Component	Main Considerations	Is there Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Radiation and Radioactivity	None – no additional radiation beyond natural background	No	—	—
Cultural Resources	Disturbance of archaeological resources from clearing	Yes	Yes	No

5.3.2 Potential Effects during Construction

The Construction Phase comprises the development of the selected site, construction of facilities, utilities and infrastructure necessary to support development and operation of the project, and excavation of the underground facilities and some of the placement rooms. During this phase, surface and underground facilities will be installed and commissioned, and will be ready to begin receiving used fuel. This phase could take 10 or more years to complete. A general description of the facility is provided in Chapter 3. Site preparation and construction would occur following completion and approval of an environmental assessment under the *Canadian Environmental Assessment Act*, and after applicable permits have been obtained.

A sizable workforce would be expected. Since the communities of Elliot Lake, Blind River, The North Shore and Spanish and their periphery contain a large area in which the repository could be located, accommodations for the temporary construction workers may be needed. Should this be needed, the location of this camp would be determined collaboratively with the community, potentially affect First Nation and Métis communities, and surrounding communities, and will take into account opportunities for fostering well-being of the community and area as discussed in Chapter 7.

Lay-down areas with storage and yard facilities for materials and equipment will also be necessary. It is assumed that new access road and railway systems may be required to provide access to the project site.

Temporary infrastructure to support the construction workforce and activities, including sewage treatment, water supply, and waste management facilities, would be made available at the project site until permanent infrastructure (i.e., powerhouse, water treatment plant, sewage treatment plant, landfill) is established. Electricity for site preparation activities and for early construction activities is assumed to be provided by diesel generators. Heating for construction trailers and any temporary worker accommodations is assumed to use natural gas or propane.

During site preparation, the main activities would include clearing existing vegetation, levelling the site and installing site drainage systems to manage surface run-off. Fuel storage and water storage tanks would also be located at the site to facilitate construction activities.

The major activity during construction would be the development of underground facilities. Repository construction begins with shaft sinking and full development of underground tunnels and service areas. This will include development of the Underground Demonstration Facility. The service shaft, waste shaft and upcast ventilation shaft would be excavated by controlled drill and blast techniques. Repository access tunnels would also use controlled drill and blast techniques, designed to minimize damage to the surrounding rock. Once the shafts and access tunnels are complete, the first panel of placement rooms would be excavated. The remainder of placement room excavations would take place during the Operation Phase.

For a 4.6 million fuel bundle repository, storage of the excavated rock is expected to require an area of about 700 metres by 700 metres, with a height between three metres and six metres. A small portion of the excavated rock would be maintained on-site to support aggregate operations, with the balance transferred to an excavated rock management area, whose location would be determined collaboratively with the community and First Nation and Métis communities in the area (Chapter 3). The excavated rock management area will include a stormwater run-off pond to collect and manage the effluent before release to the environment in accordance with applicable regulatory requirements. Depending on the composition of the excavated rock and the consequence of its exposure to environmental conditions, some consideration may need to be given to the potential production of acid rock drainage. Any mitigating measures required will form part of the overall environmental management program that will be developed in detail in later steps of the site selection process.

The construction of both above ground and underground facilities will require dewatering, as well as surface water run-off management, during the construction stages. Intermediate and deep groundwater generated during dewatering will require treatment for dissolved solids (e.g., iron and manganese) prior to release into the environment, whereas shallow groundwater and surface water run-off is not likely to require significant treatment. Water taking and water discharge into the environment will be strictly managed in accordance with provincial regulations.

During this phase, it would also be necessary to construct the permanent surface buildings and complete installation of common services, including waste management systems, utilities, and process and potable water supplies. Given that landfill space in the Area is limited, and taking into account that many existing local commercial facilities operate their own landfills, it is assumed that a landfill would be constructed and operated at the project site throughout the Construction, Operation, Extended Monitoring, and Decommissioning and Closure Phases. It is assumed that an aggregate (rock crushing) plant and a concrete batch plant would need to be established on-site, and then operate as necessary until the repository is closed.

Buildings and facilities that are designated to be within the Nuclear Security Protected Area of the complex would be surrounded by a security fence, and lighting would be provided along the fence and at building entrances. A perimeter fence around the entire complex would also be installed. The fenced portion of the site is anticipated to occupy an area of about 600 metres by 550 metres; with an additional fenced portion measuring about 100 metres by 100 metres located some distance away, housing a ventilation shaft. During this phase, water would be required primarily for drilling and excavation, for concrete mixing, and for worker drinking and personal use. Service water would be provided from a local, suitable source.

Current planning assumptions indicate the duration of this period would be about 10 years. The material requirements during this phase (water, cement, rock movement, traffic) would be of a scale and nature similar to other large mine or construction projects.

Table 5-3 summarizes the project-environment interactions that are expected to occur during the Construction Phase. This phase is the most disruptive to the biophysical environment. Construction activities may result in environmental effects associated with vegetation clearing, drilling and blasting, excavation, excavated rock management, hardening of surfaces,

placement of infrastructure, surface water and groundwater management, emissions from vehicles and equipment, dust, noise and increased traffic.
In-design mitigation measures and implementation of an environmental management plan would reduce the environmental effects. Measures may include selection of infrastructure and corridor locations to avoid protected areas, habitat areas for communities or species of conservation concern, or heritage sites. Equipment will be designed to control emissions to air and to reduce noise. Dewatering for subsurface construction, surface water drainage management, operational and potable water supply, and waste water management would be designed and implemented in compliance with applicable regulations.

Within the Area, it is anticipated, based simply on the amount of area, that sites exist that avoid protected areas, and therefore, site preparation and construction activities could be undertaken. Feasibility will be reliant on appropriate understanding of the environmental conditions at the site scale, in-design mitigation, and compliance with an environmental management plan designed around applicable legislation.

Overall, no project-environment interactions are identified that would prevent activities associated with site preparation and construction in the Area.

Table 5-3: Potential Interactions with the Biophysical Environment during Construction

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle and equipment emissions, dust, noise, light, vibration due to blasting	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow due to withdrawal for supply, drawdown for drilling and construction dewatering, and management of run-off from hardened surfaces	Yes	Yes	No
Aquatic Environment	Change in surface water quality or flow, disturbance to aquatic habitat or biota due to placement of infrastructure and required water supply, vibration due to blasting	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from infrastructure or rock pile placement, noise, vibration from blasting, increase in traffic	Yes	Yes	No
Radiation and Radioactivity	Doses to humans and biota from radon and natural rock activity	Yes	Yes	No

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Cultural Resources	Disturbance of archaeological resources from clearing, placement of infrastructure, blasting	Yes	Yes	No

5.3.3 Potential Effects during Operation

The Operation Phase includes the receipt, packaging and placement of used fuel in the repository. For a used fuel inventory of 4.6 million bundles, repository operations would last about 38 years (Chapter 3). Facility operations would only begin when all approvals, including a Canadian Nuclear Safety Commission (CNSC) operating licence, have been received.

All used fuel manipulations will take place in the Used Fuel Packaging Plant. This is a multi-storey reinforced concrete structure designed for receiving empty used fuel containers, receiving filled transportation packages, transferring used fuel bundles from the transportation packages to the used fuel containers, and sealing, inspecting and dispatching filled used fuel containers for placement in the repository. Each placement site would be sealed following container placement. Once all sites in a placement room are sealed, the entire room would be closed and sealed.

Most steps in the packaging process are remotely operated, taking place in radiation-shielded rooms. Radioactive areas are maintained at a slightly negative pressure to preclude the spread of contamination. Ventilation air is cleaned, filtered and monitored prior to leaving the facility. Radioactive releases during normal operation are anticipated to be a very small fraction of the regulatory limits.

To meet regulatory requirements, the safety analysis will investigate the consequences of upsets and accidents occurring during the Operation Phase. While the specific events to be analyzed will be defined in the future, such occurrences as loss of power, loss of ventilation and dropping of a container will be addressed to verify and demonstrate robustness of the design. Analysis of similar events at other proposed used fuel repositories indicates the consequences are anticipated to be well below the regulatory limits.

An environmental monitoring system will be established to monitor for environmental effects, to optimize facility performance and to demonstrate regulatory compliance. The environmental monitoring program would consist, as a minimum, of the following components:

- Groundwater Monitoring;
- Stormwater/Surface Water Monitoring;
- Air Quality Monitoring;
- Meteorological Monitoring; and
- Seismic and Vibration Monitoring.

Maintenance of the equipment and facilities, including safety checks and inspections, would be routinely undertaken during this phase. Support activities that would be carried out include preparation of buffer, backfill and repository sealing materials used in borehole and placement room sealing, rock crushing and concrete mixing. The main external supplies would be the containers and the clay seal materials, which would be shipped through the area to the site.

The Operation Phase also includes continued excavation of additional placement rooms, which could involve drilling and blasting, tunnel boring, removal of rock and continued operation of the excavated rock stockpile area.

Raw water for the site would be sourced locally at the rate needed to meet the demands of site personnel, concrete production, sand production and dust control. Water is not required for cooling of the used fuel.

Sewage collected from all serviced buildings will be piped to a Sewage Treatment Plant for treatment to provincial standards prior to discharge.

Several ponds will be established to affect either process water or stormwater control. All the ponds will be lined over their base and embankments with polyethylene for protection and to prevent water infiltration into the ground. Collected flows will be quality monitored and treated as required before being directed to downstream process (e.g., aggregate crushing plant) or to the off-site discharge.

Low- and intermediate-level radioactive waste will be handled as separate waste streams.

Active solid waste may be generated in the Used Fuel Packaging Plant, the Auxiliary Building and the active liquid waste treatment process. These wastes would consist of such things as modules from the incoming transport containers, filters, spent resins and cleaning materials.

Active solid wastes that are not or cannot be decontaminated to free-release limits will be placed into approved transportation containers and shipped off-site to a licensed long-term management facility.

Active liquid waste may be generated in the Used Fuel Packaging Plant and the Auxiliary Building. These wastes would originate from decontamination of used fuel modules, cell wash downs, and the wet decontamination of used fuel transportation packages and containers. Active liquid waste would be managed in two facilities – a storage building and a waste treatment building, with the storage building incorporating secondary containment for spills or leaks. Most of these liquids will be cleaned on-site and returned to the environment with any residuals being sent to off-site disposal.

Monitoring would be conducted throughout the Operation Phase, including a period of time after the last used fuel containers have been placed prior to the start of decommissioning.

Activities could include emissions monitoring, environmental monitoring, repository performance monitoring and maintenance activities. Postclosure monitoring is discussed in Section 5.4.

Table 5-4 summarizes the project-environment interactions that are expected to occur during the Operation Phase. mplementation of an environmental management plan, well-defined operating procedures and follow-up on a comprehensive monitoring program would be expected to reduce the environmental effects.

Overall, no project-environment interactions are identified that would prevent operating the repository in the Area.

Table 5-4: Potential Interactions with the Biophysical Environment during Operation

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle and equipment emissions, dust, noise, light, vibration due to underground blasting	Yes	Yes	No
Subsurface Environment	Change in groundwater quality and flow due to withdrawal and dewatering, and management of run-off from hardened surfaces and the excavated rock pile	Yes	Yes	No
Aquatic Environment	Change in surface water quality or flow, disturbance to aquatic habitat or biota due to placement of infrastructure and required water supply, run-off from surfaces and the rock pile, and vibration due to underground blasting	Yes	Yes	No
Terrestrial Environment	Disturbance to terrestrial habitat or biota from infrastructure or rock pile placement/run-off, noise, vibration from blasting, increase in traffic	Yes	Yes	No
Radiation and Radioactivity	Doses to humans and biota from radon, natural rock activity and repository operation	Yes	Yes	No
Cultural Resources	Disturbance to local enjoyment of the area	Yes	Yes	No

5.3.4 Potential Effects during Decommissioning and Closure

The Decommissioning and Closure Phase of the project would begin once placement operations have been completed, sufficient performance monitoring data have been collected to support approval to decommission, a decommissioning licence has been granted, and the community has agreed to proceed to this phase. This phase would end when the repository has been sealed and all surface facilities have been decontaminated and removed. Monitoring would continue for a period of time as determined in discussion with regulatory authorities and the community.

The main activities undertaken during this phase would include:

- Decontamination, dismantling, and removal of surface and underground infrastructure and facilities, including water intake structures;
- Sealing of tunnels, shafts and service areas;
- Sealing of all surface boreholes and those subsurface boreholes not required for monitoring;
- Closure of the on-site landfill; and
- Monitoring as necessary.

Once the repository is sealed and all buildings and facilities are removed, the area must be shown to meet regulatory limits for the agreed-upon end-state land use. This would include landscaping and restoration of natural habitat on the site.

Before the facility is closed, used fuel handling activities would cease, all the underground placement rooms would be sealed and any related radiological emissions would stop. During closure, any residual radioactive materials would be removed. Structures used for radioactive work would be carefully dismantled to limit the amount of dust produced. Any radioactive soil would be managed in accordance with applicable regulations or guidelines. The radiological releases are anticipated to be a small fraction of regulatory limits and no greater than those during the Operation Phase.

Table 5-5 summarizes the project-environment interactions that are expected to occur during the Decommissioning and Closure Phase. The potential environmental effects are expected to be similar to those encountered during site preparation and construction, with the exception of the presence of residual radioactive materials.

The implementation of an environmental management plan specific to this phase of the project, along with continued occupational dose management programs, would reduce potential effects on humans and the environment. More generally, the net effect of the decommissioning would be to reduce the surface footprint of the repository and therefore would be, in general, beneficial to the environment after completion.

Overall, no project-environment interactions are identified that would prevent decommissioning and closing the repository in the Area.

Table 5-5: Potential Interactions with the Biophysical Environment during Decommissioning and Closure Activities

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Atmospheric Environment	Vehicle and equipment emissions, dust, noise, and light	Yes	Yes	No

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
Subsurface Environment	Change in groundwater quality and flow due to closure of system for withdrawal for supply and management of run-off from hardened surfaces and the rock pile	Yes	Yes	No
Aquatic Environment	Change in surface water quality or flow, disturbance to aquatic habitat or biota due to removal of infrastructure, run-off from the rock pile and required water supply	Yes	Yes	No
Terrestrial Environment	Clearing and disturbance to terrestrial habitat or biota from infrastructure or rock pile removal, noise, increase in traffic	Yes	Yes	No
Radiation and Radioactivity	Doses to humans and biota from radon and from residual radioactivity during infrastructure removal operations	Yes	Yes	No
Cultural Resources	Disturbance to local enjoyment of the area	Yes	Yes	No

5.3.5 Potential Effects during Monitoring

The conceptual project design makes provision for up to two periods of monitoring; however, specific details would be developed in collaboration with the local community. The first of these periods would occur during operation after the placement activities are completed and prior to the initiation of the Decommissioning and Closure Phase. The other monitoring period may occur during decommissioning. Activities during these monitoring periods could involve monitoring conditions in the repository itself, as well as monitoring environmental factors in the geosphere and biosphere (i.e., subsurface and surface environments).

Monitoring activities may require human presence. Such activities could include managing boreholes and acoustic monitors, and conducting air, water and biology surveys or sampling. These would likely use existing borehole sites and roads. When compared to the environmental effects associated with the earlier project phases, potential environmental effects associated with conducting this monitoring are likely to result in fewer environmental effects and are therefore not discussed further.

Following site restoration and a period of monitoring, and with community agreement, a licence to abandon the site would be obtained. In this regard, “abandon” (a term that exists within the regulatory framework) means that the site would not require ongoing regulatory controls and licensing by the CNSC. While further monitoring would not be legally required, monitoring could be continued depending on arrangements with the local community. It is possible that permanent markers would be installed to inform future generations of the presence of the sealed repository.

5.4 Postclosure Safety

5.4.1 Postclosure Performance

In the repository design, the radioactivity is initially contained within the used nuclear fuel. The bulk of the used fuel (98 per cent) is solid ceramic uranium dioxide.

The used nuclear fuel is sealed in durable metal containers and placed in an engineered structure excavated deep within a stable rock formation. The layout of the repository would be a network of tunnels and placement rooms designed to accommodate the rock structure and stresses, the groundwater flow system, and other subsurface conditions at the site. A clay buffer material would surround each container, and backfill material and other seals would close off the rooms and fill the shafts.

The rock and deep groundwater that surround the repository would provide stable mechanical and chemical conditions that would promote containment of the wastes for long times.

After closure, the repository would initially (within about 100 years) heat up to a maximum temperature of around 100°C (degrees Celsius) and then slowly cool back to ambient rock temperatures. Within several thousand years, natural groundwater within the rock would seep back into the facility and re-saturate the space in the clay buffer and room backfill. During this same period, the majority of the initial (and more radioactive) fission products in the used fuel would decay to stable, non-radioactive elements. However, the residual radioactivity is still hazardous, and would include long-lived fission products, actinides and uranium decay products.

The potential effects of the used fuel repository over the very long term would be from potential releases of radionuclides and other non-radioactive contaminants leached or dissolved from the placed used fuel. These contaminants could migrate into the bedrock and deep groundwater, and could eventually reach the surface environment.

5.4.2 Postclosure Assessment

To support the design and to check the long-term site safety, a postclosure safety assessment would be performed. In this assessment, computer models are applied to a suite of analysis cases to determine potential effects on the health and safety of persons and the environment. The assessment time frame typically extends from closure until the time at which the maximum impact is predicted, with a one-million-year baseline adopted based on the time period required for the used fuel radioactivity to decay to essentially the same level as that in an equivalent amount of natural uranium.

The postclosure assessment examines potential consequences from various postulated scenarios, ranging from likely to “what if.” The Normal Evolution Scenario represents a reasonable extrapolation of the site and repository, and accounts for anticipated significant events such as glaciation. Sensitivity studies assume degraded performance of various components of the multi-barrier system to demonstrate the conclusions are not especially sensitive to uncertainties in the input information. Disruptive Scenarios postulate the occurrence of unlikely events leading to possible penetration of barriers and abnormal loss of containment.

Assessing the postclosure suitability of the Area and specific sites therein for hosting the used fuel repository requires substantive site-specific information on the geology at repository depth. The suitability of the local geology for hosting a repository is discussed in Chapter 4. This geoscience assessment addresses factors such as:

- ***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 caused by human activities and natural events?
- ***Long-term resilience to future geological processes and climate change:*** Is the rock formation at the siting area geologically stable and likely to remain stable over the very long term in a manner that will ensure the repository will not be substantially altered by natural geological and climate change processes such as earthquakes and glacial cycles?
- ***Safe construction, operation and closure of the repository:*** Are conditions at the site suitable for the safe construction, operation and closure of the repository?
- ***Isolation of used fuel from future human activities:*** Is human intrusion at the site unlikely, for instance, through future exploration or mining?
- ***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?

At present, due to the limited site-specific information on the geology available at this stage in the assessment process, it is not possible to conduct a detailed postclosure safety assessment. Therefore, the current postclosure safety assessment conclusion is the same as the assessment presented in Chapter 4, where it is judged that there are geological units that are potentially suitable for hosting the repository within the Area.

However, it is possible to draw on the results from a number of postclosure safety assessments examining similar but hypothetical sites and repository designs, in order to build confidence in long-term safety.

Five major postclosure safety assessments for a deep geological repository for used CANDU fuel have been carried out over the last 20 years, with four assessments performed for hypothetical sites on the Canadian Shield and one hypothetical site in the Michigan Basin (AECL, 1994; Goodwin et al., 1996; Gierszewski et al., 2004; NWMO, 2012; NWMO, 2013). Similar studies assessing repository concepts in crystalline rock have also been published in other countries, notably Sweden (SKB, 2011) and Finland (Posiva, 2007). Although the geologic environment and details of the repository concept vary from study to study, all studies found that management of used nuclear fuel in a deep geological repository is a safe viable option for protecting humans and the environment from the associated long-term hazards. A brief summary of the scenarios analyzed in the Canadian postclosure safety assessments is provided to illustrate this point.

The most likely scenario by which any radionuclide from a deep geological repository can reach the biosphere is through transport from a failed or defective container through the water within the rock porosity. Due to the multiple engineered barriers and the relatively impermeable nature of the Canadian Shield at suitable sites, the analyses show that most of the radioactivity would remain trapped within or near the repository and decay away. The small amounts reaching the biosphere after thousands or millions of years lead to maximum dose rates for suitable sites that are orders of magnitude below the regulatory dose limit (i.e., 1.0 milliSievert (mSv) per year) and the Canadian background dose rate (i.e., roughly 1.8 milliSieverts (mSv) per year).

The potential chemical toxicity hazard posed by a deep geological repository has also been examined (NWMO, 2012; NWMO, 2013). While the used fuel does not contain hazardous chemicals, it is largely uranium (a heavy metal), and it contains small amounts of other elements that can be toxic in sufficiently high concentrations. Safety assessments indicate that the natural and engineered barriers can provide effective protection against transport of potentially hazardous elements from the repository.

In practical terms, there would be no noticeable effect at the site or surrounding environment.

5.5 Climate Change Considerations

5.5.1 Near-Term Climate Change

Due to the long duration of the project, it is prudent to consider how climate change might have an influence on the repository site.

Over the course of the project lifespan from site preparation to closure (approximately a century), regional climate parameters such as temperature, precipitation and wind could be altered. These changes could lead to, for example, an increase or decrease in surface waters, extent of forestry, local agriculture, storm frequency and intensity, or the frequency of forest fires.

While such changes could affect the schedule, they will have essentially no effect on the safety of the repository during the Operation Phase. As noted earlier, water is not required to maintain cooling of the used fuel, so any interruptions to the water or power supply would have essentially no effect on public safety. The range in weather conditions would be taken into account in the design of surface facilities (e.g., by ensuring that the repository shaft collars are located above areas that could be affected by flooding).

Climate change could alter habitat suitability and availability for aquatic and terrestrial biota, with a shift in the composition of plant communities towards those better adapted to warmer conditions. This shift in forest type could, in turn, affect available habitat for boreal-oriented species. Development of re-vegetation plans at closure would take into account how plant community attributes may be altered in response to climate change.

During postclosure, the depth of the repository and the applied sealing measures essentially isolate the repository from all surface effects except glaciation, which is discussed in the next section.

5.5.2 Glaciation

The Canadian Shield has been covered by ice sheets for nine major glacial cycles over the past one million years. These cycles, with a period of approximately 100,000 years, are believed to be largely related to variations in solar insolation and the location of the continents.

The continents will not change position significantly over the next million years, and the variation in solar insolation is predictable based on known earth orbital dynamics. Studies indicate that over the next 100,000 years or so, the amplitude of insolation variations will be smaller than during the last glacial cycle (Berger and Loutre, 2002). It is also clear that the composition of greenhouse gases is presently significantly larger than usual. Such conditions could suppress the initiation of a glacial cycle for 50,000 years or longer. Beyond this time, a larger reduction in solar insolation is anticipated, and therefore a stronger trigger to initiate a new glacial cycle will occur.

While the timing of the onset of the next cycle cannot be determined, the first ice sheet advance over the repository site is not anticipated to occur within the next 60,000 years, with even longer delays (up to 500,000 years) proposed in some studies (Berger and Loutre, 2002; Archer and Ganopolski, 2005). This implies that a significant time period is available for radioactivity levels in the used fuel to decay prior to glacial onset.

The geology of the Area is typical of many areas of the Canadian Shield. A review of the findings of previous field studies involving fracture characterization found that fractures below a depth of several hundred metres in a number of plutons in the Canadian Shield are ancient features. Subsequent stresses, such as those caused by glaciation, generally have been relieved by reactivation along the existing zones of weakness rather than by formation of large new fracture zones. The repository would be located to avoid or minimize contact with fracture zones.

Glacial/interglacial cycling will affect hydrogeological conditions in the overburden and shallow bedrock groundwater zones. Future ice sheets will cause significant changes in the surficial physical environment and the shallow groundwater zone in relation to the formation of permafrost, altered hydraulic pressures and flow rates, and penetration of glacial recharge waters. In low porosity, low permeability systems, geochemical and isotopic data suggest that only the upper, actively circulating groundwater system was affected by past glaciations, with deeper, denser, high-salinity waters largely unaffected.

The effects of glaciation on a deep geological repository have been assessed in the Glaciation Scenario study for a hypothetical site on the Canadian Shield (Garisto et al., 2010). The study shows that the net impact would not be significantly different from that associated with the assumption of a constant climate and the consequences would be well below regulatory limits. Site-specific studies are necessary to understand potential effects over the long term that could occur because of the presence of the closed used fuel repository. Subject to these studies, it is assumed that the repository can be placed sufficiently deep that it would not be affected by glaciation.

5.6 Environment and Safety Findings

Based on the available environmental information and the anticipated project activities, no environmental conditions have been identified that would preclude siting the repository somewhere within the Area. The assessment has identified some specific areas that would be excluded as they contain parks and protected areas. Subsequent to the identification of more specific potential siting areas, a more definitive environmental evaluation could result in the exclusion of additional areas based on such things as, for example, the presence of migration routes, the proximity to important habitats and cultural sensitivity. Discussions with interested communities, potentially affected First Nation and Métis communities, and surrounding communities, as well as field studies, would be needed to fully characterize the environmental conditions in these potential siting areas.

The findings also indicate that the Site Selection, Construction, Operation, Decommissioning and Closure, and Monitoring Phases will result in effects to the environment. Because many of these effects would be similar to other large industrial or mining projects, it is anticipated that the long-term interactions or potential environmental consequences can be managed or mitigated through a combination of in-design features, operating procedures and implementation of a sound environmental management plan. These mitigating measures would be defined in later phases of the project as more information becomes available.

At present, due to the limited site-specific information on the geology at depth available at this stage in the assessment process, it is not possible to conduct a site-specific postclosure safety assessment. The current postclosure safety conclusion is therefore the same as the assessment in the geoscientific suitability chapter (Chapter 4), where it is judged that there are geological units that are potentially suitable for hosting the repository. Site-specific safety assessments would be created at later phases of the project when more information on the local geology becomes available.

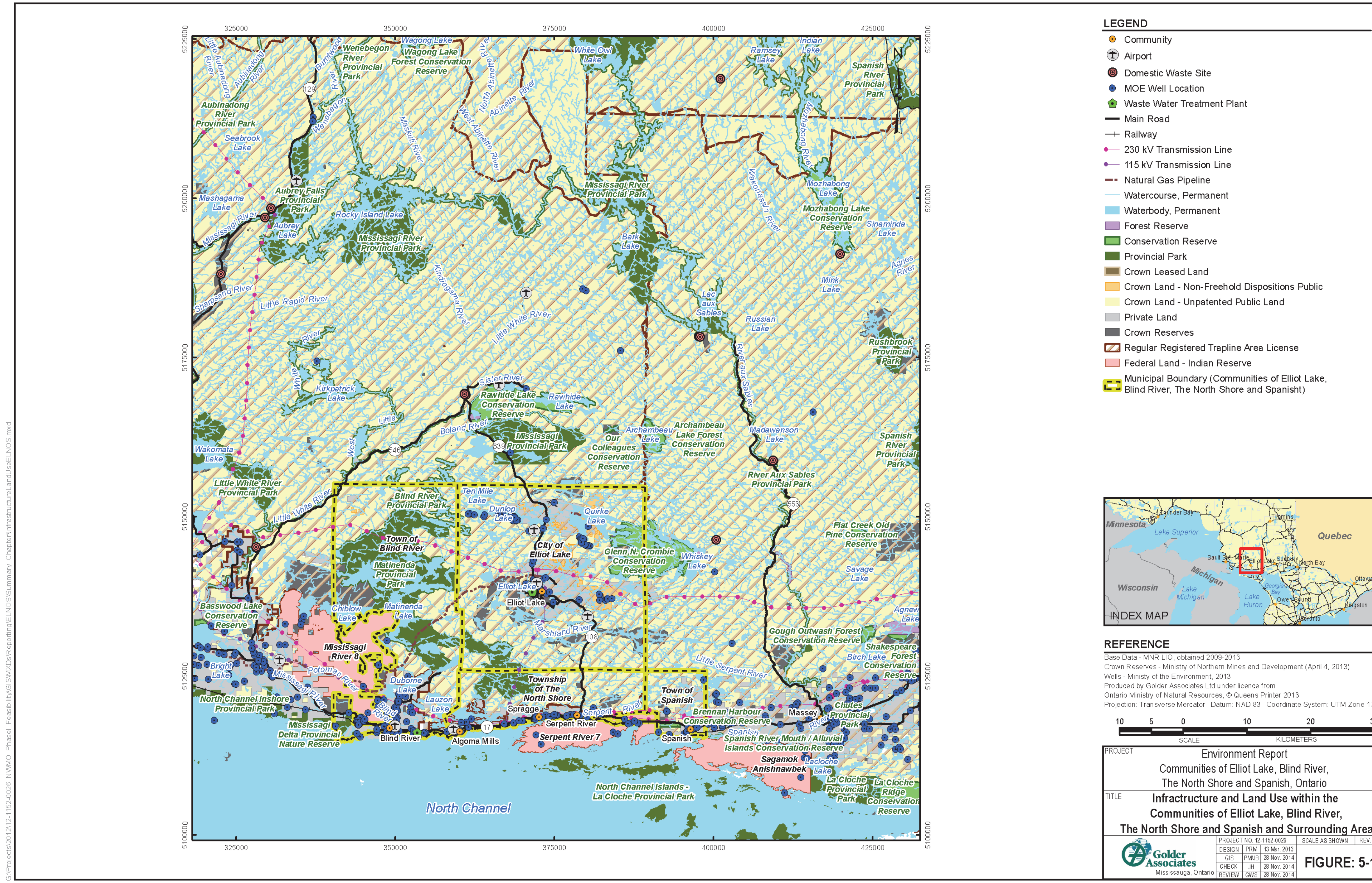

Figure 5-1: Infrastructure and Land Use within the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

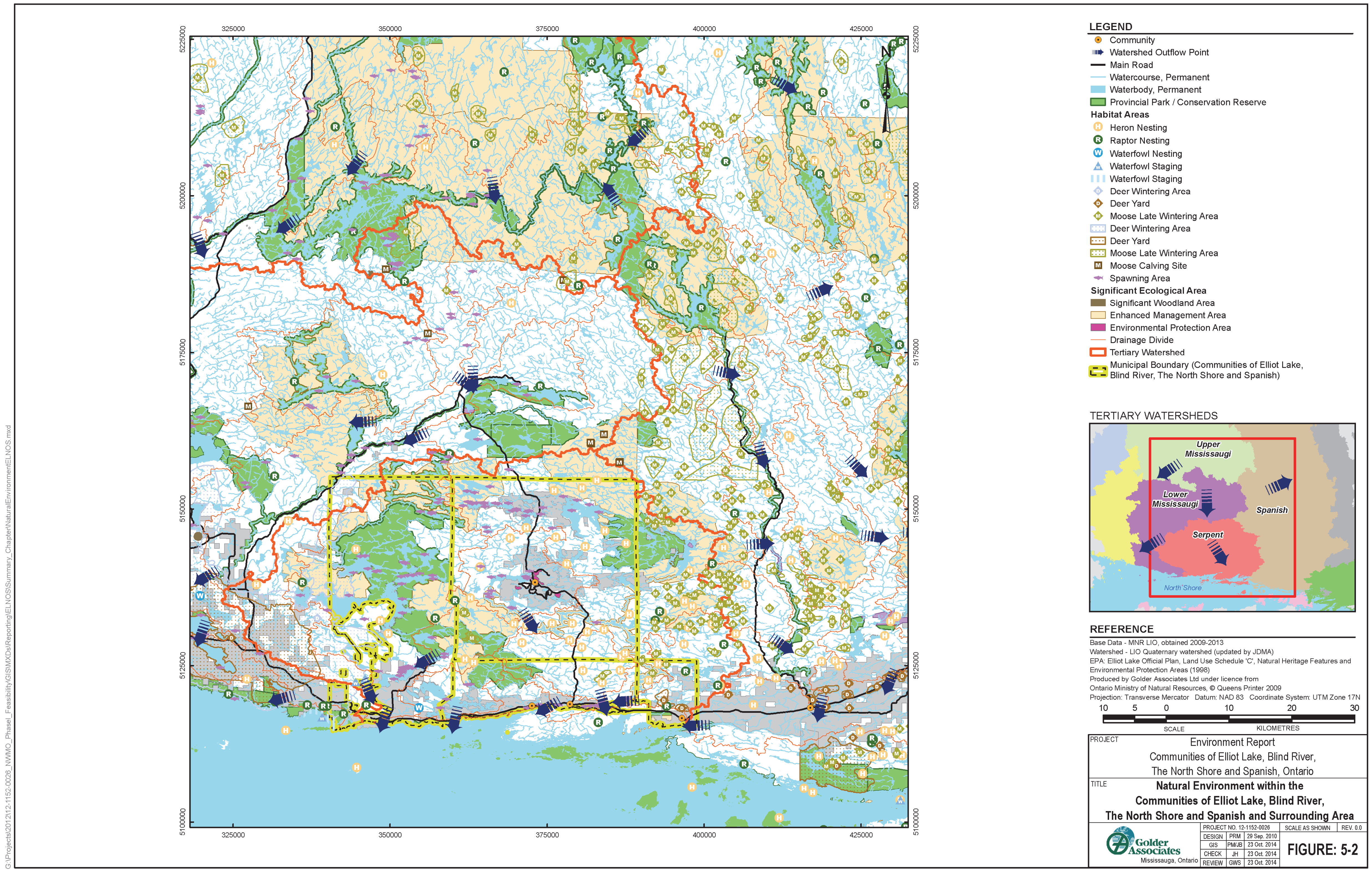

Figure 5-2: Natural Environment within the Communities of Elliot Lake, Blind River, The North Shore and Spanish and Surrounding Area

6. PRELIMINARY ASSESSMENT OF TRANSPORTATION

6.1 Introduction

Canada's used nuclear fuel is currently located at seven interim storage sites located in four provinces. The ability to transport used nuclear fuel using existing or developing transportation systems is an integral element of a long-term management plan.

For more than 40 years Canadian and international experience has demonstrated that used nuclear fuel can be transported safely and securely. The NWMO is committed to maintaining this high standard of safety and will meet or exceed regulatory safety requirements. The NWMO is employing the Adaptive Phased Management (APM) project management approach in planning and operating its transportation program. In support of this approach, the NWMO is monitoring and incorporating lessons learned from successful used fuel and radioactive material transportation programs in Canada and in other countries.

The approach taken in preparing this chapter serves two functions. First, it describes the comprehensive transportation safety regulation and oversight processes which the NWMO will meet and how the NWMO plans to meet them. Second, it presents results of a desktop analysis that was prepared based on publicly available transportation information, supplemented by information provided by the community and observations during staff visits to selected communities. As part of Step 3 of the Siting Process, a Preliminary Assessment was prepared and focused on the following question: "Can a transportation route be identified or developed for the safe and secure transportation of used nuclear fuel to the site from the locations at which it is stored?" The Preliminary Assessment of geoscientific suitability suggests there are potentially suitable general areas north of the communities of Blind River, Elliot Lake, The North Shore, and Spanish (see Section 4.4.1). The findings of the transportation assessment on the feasibility of locating the APM Project in a representative area north of these communities are presented at the end of the chapter.

In reviewing the available and/or developing transportation infrastructure, there is no intent to select a preferred mode of transportation, or a preferred route, or to commit to specific operational details related to a future transportation system. These activities will be addressed through a future dialogue with federal, provincial and local authorities and communities along potential transportation routes as a large group with a shared interest.

6.2 Regulatory Framework

The safe and secure transportation of used nuclear fuel is regulated through a comprehensive, multi-agency framework of regulations, oversight and inspections. The process builds on the legal and traditional roles of federal, provincial and local agencies.

The responsibility for regulating the safe transportation of used nuclear fuel in Canada is jointly shared by the Canadian Nuclear Safety Commission (CNSC) and Transport Canada. The *Nuclear Safety and Control Act*, 1997, the *Packaging and Transport of Nuclear Substances Regulations* and the *Nuclear Security Regulations* authorize the CNSC to regulate all persons who handle, offer for transport, transport or receive nuclear substances. The *Transportation of Dangerous Goods Act*, 1992, and Transport Canada's *Transportation of Dangerous Goods Regulations* regulate the safe commercial transport of listed hazardous goods, including used nuclear fuel.

The CNSC and Transport Canada regulations follow the International Atomic Energy Agency's (IAEA) Safety Standards Series regulations (Requirements No. TS-R-1) (IAEA, 2000). The CNSC and Transport Canada regulations cover the certification of the package design, the licence to transport, security planning, training requirements for the shipper and transporter, emergency response planning, and communication procedures. These requirements are in addition to the normal commercial vehicle and rail operating and safety regulations, and are similar to those used internationally. Packages designed for the transport of used nuclear fuel in Canada must be certified by the CNSC.

The provinces are responsible for developing, maintaining and operating the road infrastructure, for conducting safety inspections of the commercial vehicles and their drivers, and for law enforcement. Local governments provide traffic law enforcement and emergency response resources in the event of a transportation incident. The interaction and cooperation between these agencies provides for a comprehensive regulatory and oversight process, ensuring the safe and secure transportation of used nuclear fuel.

6.2.1 Canadian Nuclear Safety Commission

The *Nuclear Safety and Control Act*, 1997 established the CNSC as the responsible agency for regulating possession of radioactive materials; for the design, testing, and certification of transport packages; and for regulating the safe and secure transport of nuclear substances in Canada. The CNSC works closely with Transport Canada in creating safety regulations, reviewing transportation operations, transport security and emergency response plans, training of the persons involved in transporting radioactive substances, and the oversight of radioactive material shippers.

The CNSC's *Packaging and Transport of Nuclear Substances* and *Nuclear Security Regulations* set out a comprehensive framework for the transportation of radioactive material, including the package design requirements, operational controls during transport, security from threats, loading and unloading, and inspection and maintenance requirements for the package. The regulations also require quality control at every step of the transport process.

The CNSC establishes the criteria and certifies the design of all Type B transport packages (the type required to transport used fuel), including those to be used by the NWMO. The CNSC requires that a Type B package pass strict testing which simulates transportation accident conditions, such as the package being in a collision, being hit by sharp objects, being engulfed in a petroleum fuel fire and being submerged in 200 metres of water. During these tests, the package must be able to meet the public protection requirements for the radioactive material while in transport.

6.2.2 Transport Canada

The *Transportation of Dangerous Goods Act,* 1992, and the *Transportation of Dangerous Goods Regulations* regulate the transportation of all dangerous goods within Canada, including the classification, packaging, labelling, documentation, safe handling, emergency response planning, training, and conveyance of such goods. In order to perform this function, Transport Canada has classified all dangerous goods into nine classes. Used nuclear fuel is designated as Class 7, "Radioactive Material."

The Transport Canada regulations prescribe the labels and safety marks that must be placed on any package and vehicle while transporting dangerous goods. These labels and placards provide valuable information to emergency responders when they respond to an accident, and assist them in determining what safety precautions are needed as they carry out their life saving and fire fighting duties. Transport Canada requires that all persons handling, transporting, and/or offering to transport dangerous goods must be trained in the safe handling of the materials as applicable to their assigned duties.

Transport Canada and the provinces have a shared responsibility for the safety of trucks, and their operators. For highway vehicles, this includes the licensing of vehicles, vehicle safety inspections, and the qualification and hours of service requirements for operators. For rail, Transport Canada inspects the operating companies for compliance with vehicle, operations, signals, track, motor, and crew safety regulations. The provinces, through an Administrative Agreement process, have taken the lead for enforcing compliance with Transport Canada's safety requirements.

6.2.3 Provincial and Local Safety Responsibilities

The provinces have the legal authority for regulating all highway transportation functions, and through the Administrative Agreements with Transport Canada, they can enforce safety regulations for Class 7 shipments. Along with Transport Canada, the provinces enforce vehicle and driver safety through both scheduled and random inspections.

Provinces also develop, maintain, and operate the provincial highway systems over which the NWMO shipments will travel. Some of these systems have operating limitations caused by weather, soils, highway geometry, tunnels, and bridges. As the provinces adopt their transportation improvement plans, some of these limitations may be addressed, thereby improving the system safety.

Local governments, through their first responders, provide the initial resources when responding to emergency and law enforcement incidents. They are also enabled to enforce local and provincial regulations governing safety and commercial vehicle operation. Local communities are responsible for developing, operating, and maintaining local streets and roadways.

6.3 Transportation Safety

The NWMO will be the responsible party for shipping Canada's used nuclear fuel to a repository. The reference plan is to use the Used Fuel Transportation Package (UFTP) for the transport of used fuel. In July 2013, the CNSC re-certified the UFTP as meeting their current regulations (CNSC, 2013).

6.3.1 CANDU Used Nuclear Fuel

CANDU nuclear fuel is a solid uranium dioxide ceramic pellet and is used to produce electricity for Canadians. The pellets are placed into a corrosion resistant metal tube of a zirconium-tin alloy. Typically, 37 of these tubes are mounted together in a cylindrical array called a fuel bundle. After the fuel bundle expends its heat-producing energy, it is removed from the reactor and placed in a pool of water to cool. Additional information on used nuclear fuel is provided in Section 3.2.

The radioactivity of used fuel initially drops quickly following removal from the reactor. After being out of the reactor for seven to 10 years, the radioactivity has decayed by 99 per cent, and the fuel bundles are placed into interim dry storage containers. The fuel is held in these containers until readied for transport to a repository. Based on the current Preliminary Waste Acceptance Criteria, the used fuel accepted for transport to the repository facility will have been out of the reactor for 10 years or more. However, the reference design for a deep geological repository assumes an average out-of-reactor period of 30 years.

6.3.2 Used Fuel Transportation Package

The NWMO will be transporting the used fuel bundles to the APM repository facility in the UFTP, which will be certified by the CNSC to the regulations in force at the time of shipment.

To be certified, the UFTP must, among other things, pass a series of performance tests as specified in the CNSC regulations, thereby demonstrating its ability to withstand severe impacts, fire, and immersion in deep water[1]. These tests are designed to ensure that the radioactive material is not released during a transportation accident and that radiation levels outside the package are well below the regulatory dose limits.

The UFTP is a cube about two metres in size (see Figure 6-1). When filled, the UFTP will carry approximately five tonnes of used CANDU fuel. The total package weight, when filled, is about 35 tonnes. As shown in Figure 6-1, the UFTP can hold a total of 192 bundles of used CANDU fuel in two storage racks, which are called modules. The UFTP body is manufactured from a single piece of stainless steel with walls approximately 27 centimetres thick.

The seal between the package lid and body is provided by a double gasket and the lid is attached with 32 bolts. Seal integrity is tested prior to and after each shipment.

[1] For more information on package performance tests, see http://nuclearsafety.gc.ca/eng/licenseesapplicants/packagingtransport/certification-process-for-transport-packages.cfm.

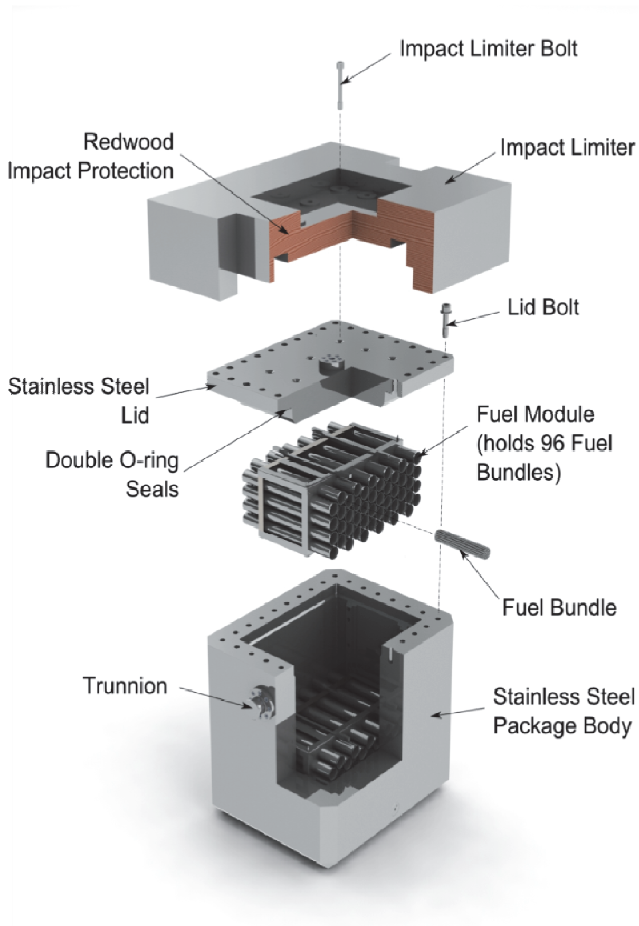

Figure 6-1: Used Fuel Transportation Package

6.3.3 Commercial Vehicle Safety

Commercial vehicle and driver safety are important to the NWMO. All commercial vehicles carrying dangerous goods are subject to Transport Canada safety requirements and inspection. NWMO vehicles will be inspected for safety defects at the points of origin and destination. They are also subject to scheduled and random safety inspections by Transport Canada and the provinces as they travel the roadways. This is standard practice within the Canadian transport industry and for radioactive material shipments internationally.

6.3.4 Radiological Safety

Packages used to transport used fuel are designed in accordance with the requirements prescribed by the CNSC's *Packaging and Transport of Nuclear Substances Regulations*. The CNSC regulations are based on standards set by the IAEA and tested through use and practice. The objective of the regulations is to ensure that the radiation levels from the package will allow safe handling and transport, and, in the event of an accident, the package will prevent a radiological release that exceeds applicable regulatory criteria.

The packages are designed to shield radiation such that levels on the outside the package are below prescribed limits. Through procedures minimizing the handling of the package, the total radiation dose to the handling and transport personnel can be kept at a low level. Experience from existing shipments both within Canada and internationally demonstrates that this goal can be readily achieved.

6.3.5 Radiological Dose

Radiation is found in many forms. People are exposed to natural background radiation every day from the ground, building materials, air, food, outer space (cosmic rays), and even from elements occurring naturally in the body. The CNSC *Radiation Protection Regulations* have set an annual radiation dose limit of one milliSievert (mSv) per year for members of the public to limit exposure from nuclear-related activities. The radiation dose is about half of the average background radiation dose received by Canadians (1.8 milliSieverts per year). For comparison, the typical dose received from one dental X-ray is approximately 0.01 milliSieverts.

Radiological doses to the public from used fuel transport have been calculated for members of the public. Three scenarios were identified to estimate radiological doses to the public: 1) residents along the transport route; 2) persons sharing the transport route; and 3) persons sharing the refueling and rest stops. The highway mode was conservatively chosen as the example since the shipments will be sharing the roadway and refueling stops with the public, and there will be a larger number of shipments using this mode.

Table 6-1 shows the annual maximum individual dose to the public for each of the three scenarios (Batters et al., 2012). In all cases, the maximum individual dose to the public under routine transport and accident conditions is well below the regulatory public dose limit of 1.0 milliSievert per year.

Table 6-1: Maximum Public Individual Dose due to Used Fuel Transported by Road

Annual Dose	Distance to package	Frequency (per year)	Dose (mSv/year)	Assumptions / Comments
During Transport				
Resident along Transport Route	30 metres	620 shipments	0.000013	Person living 30 metres from route exposed to all 620 shipments (including one unplanned stop).
Public in Vehicle sharing Route	10 metres	2 shipments	0.00022	Person in vehicle 10 metres from transport package for one hour twice per year.
During ½ hour Rest Stop				
Public in Vicinity at Rest Stop	15 metres	31 shipments	0.00012	Trucks alternate between 10 rest stops. Person present at given stop five per cent of time (i.e., five per cent of shipments).

The NWMO is committed to protecting its workers, drivers and the public, and will apply the "As Low As Reasonably Achievable (ALARA) principle" in the design of the transportation system and during operations. This includes the proper use of shielding and dosimetry combined with the application of radiation control techniques and operating procedures. As part of the NWMO's transportation planning process, additional dose studies will be conducted for workers (i.e., drivers, inspectors, emergency responders).

6.4 Used Fuel Quantities and Transport Frequency

The reference used fuel inventory being used for the APM Preliminary Assessments is 4.6 million fuel bundles (Garamszeghy, 2011). The distribution of the fuel bundles is provided in Table 6-2. Using the UFTP package, the NWMO Transport Program anticipates it will require about 24,000 truck trips over 38 years to move the inventory to the repository site.

The APM facility is designed to process approximately 120,000 used fuel bundles per year, which equates to receipt of approximately 620 UFTPs per year. However, the total number of shipments will depend on the chosen transport mode. For instance, a tractor-trailer can transport one 35 tonne UFTP at a time; whereas, rail shipments may contain multiple UFTPs in a single train.

Table 6-2: Estimated Used Fuel Quantities by Owner

Owner	Number of Used Fuel Bundles
Ontario Power Generation	4,026,000
AECL	32,600
Hydro-Québec	268,000[a]
New Brunswick Power	260,000
TOTAL (rounded)	**4,600,000**

Note:
[a] The 268,000 fuel bundle inventory assumes refurbishment of the Gentilly 2 Nuclear Generating Station. In 2012, Hydro-Québec announced their decision to permanently shut down Gentilly 2. The actual fuel bundle inventory for Gentilly 2 is approximately 130,000 bundles.

6.5 Used Fuel Transportation Experience

Used nuclear fuel has been transported routinely in Canada since the 1960s, with over 500 used nuclear fuel shipments having been made to date (Stahmer, 2009). Since the closing of AECL's reactor at Rolphton, Ontario, the number of shipments has averaged between three and five shipments per year.

Used fuel shipments are common in other countries, such as the United Kingdom, France, Germany, Sweden, and the United States. Over the past 40 years, worldwide there have been more than 23,000 shipments of used fuel. Great Britain and France average 550 shipments per year, mainly by rail. In the United States, used fuel shipments take place mainly by road, and approximately 3,000 shipments have been made to date. In Sweden, approximately 40 shipments by water are made between the reactor sites and a central storage facility each year.

Internationally and in Canada, there have been no serious injuries, health effects, fatalities, or environmental consequences attributable to the radioactive nature of the used nuclear fuel being transported.

6.6 Transportation Operations

6.6.1 Responsibility

The NWMO will have overall responsibility for transportation of used nuclear fuel to the repository. This includes planning, licensing, training, safe operation, security, and tracking of all shipments. The NWMO will work with the CNSC, Transport Canada, the provinces, and local agencies to ensure workers and first responders are adequately trained prior to commencing shipments. The NWMO will ensure that all transportation equipment, packages, and transportation activities (for road and rail shipments) meet regulatory requirements.

The NWMO transportation process is planned to begin with loading the used fuel into the UFTP by the fuel owner. The NWMO will certify that the packages are loaded in accordance with CNSC and Transport Canada regulations. Upon dispatch, the vehicle and drivers will be subject to a safety inspection. The vehicle, UFTP, and driver would also be inspected at the repository.

The driver of the vehicle will be responsible for package safety during transport. The driver will ensure that all documentation, labelling, and safety requirements have been met prior to departure and continue to be met en route. The shipments must have a security escort who is responsible for the physical security of the package and vehicle, communications, tracking, and monitoring of the locks and seals.

First response to radiological emergencies will be provided by trained first responders in accordance with the command and control process as described in the Emergency Management Framework for Canada, local and provincial plans, and existing mutual aid agreements. The NWMO will co-ordinate its planning with the provinces and first responders along the designated routes to provide used fuel-specific training and to conduct exercises. It is anticipated that the existing agreements between nuclear facilities in Ontario, Manitoba, Québec, and New Brunswick will be expanded to accommodate the requirements of NWMO shipments.

6.6.2 Communications

An NWMO central command centre will provide a single point of contact for all transportation-related communications. This allows quick access to shipment information and tracking, and would serve as a single point of contact for incident commanders, the CNSC, and Transport Canada. Communications during a trip would be in accordance with a Transportation Security Plan, which will require review and approval by the CNSC.

The function of the transport command centre is anticipated to be similar for all shipments, independent of mode. The centre will be responsible for tracking all shipments and normal vehicle communications, and in the event of a transport incident, it will be the primary contact for incident commanders. The transport command centre would notify local emergency response agencies for assistance, such as the local police, fire, and the emergency response teams. There will also be a return to normal operations and recovery plan to address those activities needed to return the shipment to normal operations and complete the trip to the repository.

6.6.3 Security

Security is focused on preventing diversion, physical damage, or sabotage of the UFTP. Security will be multi-layered, consisting of a combination of intelligence gathering; engineered, deterrent, and response measures to protect the UFTP; use of information safeguards to protect shipment information; and multi-agency response agreements.

Security provisions during transportation will ensure that the used nuclear fuel will receive adequate physical protection against threats and will be in accordance with the requirements of The CNSC's *Nuclear Security Regulations* pursuant to the *Nuclear Safety and Control Act*. The CNSC Regulatory Guide G-208 "Transportation Security Plans for Category I, II or III Nuclear Material" (CNSC, 2003) will be used for guidance to establish and implement Transportation Security Plans.

6.6.4 Emergency Response Planning

Emergency response resources include local law enforcement, fire fighting, first responders, medical triage, and leaders of affected communities. The NWMO will work with the CNSC, Transport Canada, the provinces, and local responders to encourage cooperative emergency response planning, and to identify and address training and exercise needs.

The NWMO will work with the CNSC and local response agencies to coordinate planning and preparedness activities based on the CNSC's *HazMat Team Emergency Response Manual for Class 7 Transport Emergencies (INFO-0764, Rev. 2)* (CNSC, 2009) and Transport Canada's *Emergency Response Guidebook* (Transport Canada, 2012). Additionally, the NWMO will incorporate the current *Emergency Management Framework* (Public Safety Canada, 2011) guidance agreed to by Public Safety Canada and the provinces and local response agencies.

6.7 Transportation Logistics to the Representative Area

Transport logistics to a potential repository site in the area north of the communities of Blind River, Elliot Lake, The North Shore, and Spanish are discussed in this section. Only for the purpose of this Preliminary Assessment, the potential repository site is assumed to be located somewhere within a semicircular area approximately 75 kilometres in radius extending west, north and east of the intersection of Highways 546 and 639 (see Figure 6-3).

Figure 6-2 presents a generalized description of the highway and railroad transport processes for used nuclear fuel from interim storage sites to an APM repository site. An APM repository site located within the representative area would be accessible by truck via existing roadways and a service road to the receiving facilities.

The representative area is accessible from the south via Highways 129, 546, 108 and 553 which branch north off Trans-Canada Highway 17between Sudbury and Sault Ste. Marie. Highway 129 extends northward to Highway 101 near Chapleau, providing road access to the representative area from the north. Highway 17 is maintained to the highest provincial standards and is important to interprovincial movement of goods and services.

The Canadian Pacific Railway (CPR) mainline runs northwest from Sudbury through Chapleau. The mainline lies approximately 30 kilometres east of the most easterly portion of the representative area. The short-line railroad, the Huron Central Railway (HCRY), runs parallel to Highway 17 between Sudbury and Sault Ste. Marie, and lies approximately 60 kilometres south of the representative area. In 2010, HCRY received $33 million in funding for rehabilitation of the railway.

There are few rail spurs along the tracks between Sudbury and Sault Ste. Marie, and Sudbury and Chapleau; however, if rail is a preferred mode, an intermodal facility could be constructed along the rail lines with trucks used for the last stage of transport to the receiving facility at the repository.

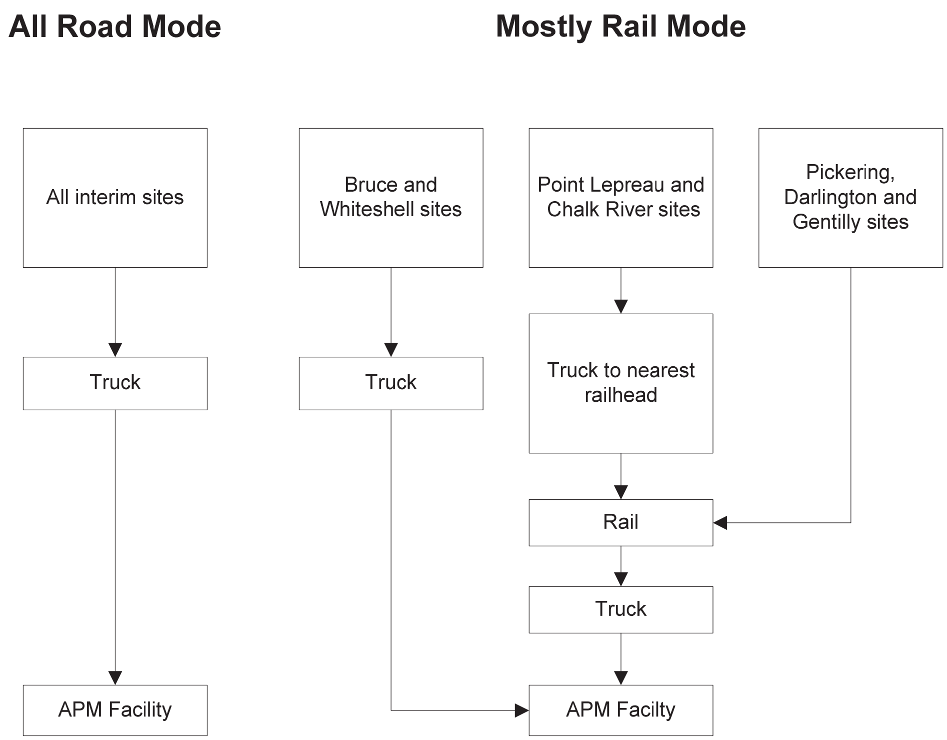

Figure 6-2: Example Transport Processes for Used Nuclear Fuel

Figure 6-3: Junction of Highways 546 and 639

6.7.1 Existing Transport Infrastructure

Travel distances from the interim storage sites to a repository site within the representative area are summarized by mode of transportation in Table 6-3.

Table 6-3: Transport Summary From Interim Storage Sites to the Representative Area

Transport Scenario	Transport Mode	Number of Shipments	Return Distance (kilometres)
All Road	Road	24,000	36,400,000
Mostly Rail	Road	35,800	6,130,000
	Rail	2,400	3,800,000

6.7.2 Road Transport from Interim Storage to a Repository

The shortest transport routes and associated distances for road transport are provided in Table 6-4. In general terms, the road system begins at the interim storage site and uses local roads to access the national highway system. The national highway system includes Trans-Canada Highway 17, which passes near the representative area. As planned, an existing local access road (such as Highways 129, 546, 108 and 553) would be used to access the site or a new road constructed to provide access from Highway 17 or the local roads to the repository site.

In Step 3 of the APM Siting Process, the following transportation question is to be answered:

"Can a transportation route be identified or developed for the safe and secure transportation of used nuclear fuel to the site from the locations at which it is stored?"

To address this question, the following transportation characteristics were considered:

1. Is there a continuous public road system connecting the interim storage facilities to the community capable of supporting an average of two heavy trucks per day for the duration of a 38-year transportation campaign?
    a. Are there design, operating or structural deficiencies which would limit the use of a segment of the roadway system by heavy trucks (e.g., weight limits for bridges, or narrow lanes)? If so, is there a transportation improvement program in place to address those deficiencies?
    b. Are there two or more serviceable routes providing access from the interim storage facilities to the community? (Required by the *Nuclear Security Regulations*). If not, is one planned?
    c. Are there travel limitations regarding the use of the roadway by heavy trucks due to reoccurring weather or seasonal conditions?

2. Are there emergency response resources for those roadways providing access from the Canadian national roadways to the community, and what are their capacities?

Table 6-4: All Road Transport from Interim Storage Sites to the Representative Area

Interim Storage Site	Distance Site to DGR (kilometres)	Number of Shipments	Return Distance (kilometres)
1 – Whiteshell	1,540	2	6,200
2 – Bruce	670	10,220	13,670,000
3 – Pickering	630	4,150	5,229,000
4 – Darlington	670	6,720	8,978,000
5 – Chalk River	530	30	31,800
6 – Gentilly	1,040	1,500	3,120,000
7 – Point Lepreau	1,850	1,450	5,365,000
	Totals (rounded)	**24,000**	**36,400,000**

In this assessment, transportation distances are determined by the shortest routes between the interim storage sites and the repository. Preferred routes will be determined by the NWMO with the involvement of communities.

Truck access from the interim storage sites to the representative area can be accomplished entirely by existing road ways. Based on Ontario Ministry of Transportation records, there are no significant impediments to travel between the interim storage sites and the representative area. The average daily travel (vehicle) count for segment of Highway 17 between Blind River and Spanish ranges between 4,550 to 4,750 vehicles per day; for Highway 108 through Elliot Lake, the vehicle count is 2,350 vehicles per day (MTO, 2009); and for Highway 129, traffic volumes are low with large portions of the highway seeing less than 500 vehicles per day. Two trucks a day more to the existing traffic count would be a small addition (less than one per cent).

The Ontario Ministry of Northern Development and Mines Northern Highways Program (MNDM, 2012) includes the culvert rehabilitation west of Nairn Centre. The program also includes the rehabilitation of several bridges along Highway 17 west of Blind River as well as resurfacing of the roadway west of Blind River.

The provincial road system and mine access roads serving the Area are constructed to support high volumes of heavy trucks. Local streets generally support residential, recreational and retail uses and, in general, are not built to support heavy truck traffic on a routine basis. Therefore, if access is not directly from a provincial or existing mine access road, upgrades or new roadways may be required to provide the level of service required by a potential repository site.

The representative area is accessible via an alternative route, although it involves additional mileage. The alternative route is Trans-Canada Highway 11 north to Highway 101, and then along Highway 129 south from Chapleau entering the representative area from the north.

Emergency response resources are provided by the volunteer Fire Department, the Algoma Emergency Medical Services (EMS) and the Ontario Provincial Police. The Fire Departments which operate out of fire stations located in Algoma Mills, Blind River, Serpent River, Elliot Lake and Spanish are all members of the Algoma District Mutual Aid Program, providing help to other communities in emergencies, as far away as Chapleau, Wawa and Hornepayne. St. Joseph's General Hospital in Elliot Lake provides a full range of healthcare services including 24 hour emergency nursing coverage for the region. The Blind River District Health Centre provides 24-hour emergency services and full range of healthcare including acute care, diagnostic imaging and rehabilitation.

6.7.3 Railroad Transport from Interim Storage to a Repository

In answering the question "Can a transportation route be identified or developed for the safe and secure transportation of used nuclear fuel to the site from the locations at which it is stored?" the following rail transportation characteristics were considered:

> Is there a continuous rail system connecting the interim storage facilities to the community capable of supporting an average of one 15-car train per week for the duration of a long term shipping campaign?

1. Are there design, operating, or structural deficiencies which would limit the use of a segment of the railway system by heavy trains (e.g., weight limits for bridges, track condition, sharp curves, or steep grades)? If so, is there a plan in place to address these deficiencies?
2. Are there two or more serviceable routes providing access from the interim storage facilities to the community (Required by the *Nuclear Security Regulations*)? If not, is one planned?
3. Is there an operating intermodal facility near the interim sites or the community? If not, could one be developed?
4. Are there travel limitations regarding the use of the railway consisting of heavy cars due to reoccurring weather or seasonal conditions?

Both trans-Canada railroads, the Canadian National Railway (CNR) and the Canadian Pacific Railway (CPR), operate tracks through Sudbury. The HCRY runs a single track from Sudbury to Sault Ste. Marie, which is located approximately 150 kilometres to the west of the representative area. The shortest transport routes and associated distances for mostly rail mode transport are provided in Table 6-5.

Although there is no direct rail access to the representative area, opportunities exist to construct an intermodal transfer providing service by truck directly to the repository site. For the purposes of this study, the intermodal facility is assumed to be located on the HCRY near the junction of Highways 17 and 108.

Table 6-5: Mostly Rail Transport from Interim Storage Sites to the Representative Area

Interim Storage Site	Distance Site to DGR (kilometres)	Number of Shipments	Return Distance (kilometres)
1 – Whiteshell	**1,540**[a]	**2**	**6,200**
2 – Bruce	**80**[b]	**10,220**	**1,635,000**
	750	1,020	1,530,000
3 – Pickering	560	420	470,000
4 – Darlington	590	670	791,000

Interim Storage Site	Distance Site to DGR (kilometres)	Number of Shipments	Return Distance (kilometres)
5 – Chalk River	**120**[c]	**30**	**7,200**
	340	3	2,040
6 – Gentilly	1,250	150	375,000
7 – Point Lepreau	**50**[d]	**1,450**	**145,000**
	2,120	150	636,000
Highways 17 and 108	**90**[e]	**24,070**	**4,333,000**
Totals (Rounded)	**Road**	**35,800**	**6,130,000**
	Rail	2,400	**3,800,000**

Notes:

[a] Road mode from Whiteshell to repository site within the representative area
[b] Road mode from Bruce to railhead near Goderich
[c] Road mode from Chalk River to railhead near Mattawa
[d] Road mode from Point Lepreau to railhead near Saint John
[e] Road mode from Highways 17 and 108 to repository site within the representative area

Bold text indicates road mode transportation; rail mode transportation is shown in plain text.

The NWMO's rail transportation requirement would be equivalent to one train per week carrying 10 to 12 UFTPs [an estimated total car count of between 8 and 10 railcars (including buffer cars), 2 power units and a security car)]. Canadian railroads have endorsed the Association of American Railroads' OT-55 Recommended Railroad Operating Practices for Transportation of Hazardous Materials (AAR, 2013; AAR, 2009); therefore, the used fuel trains could be operated as key trains, with an 80 kilometre per hour speed limit and special operating procedures.

To address the need for alternative routing, the CPR operates a mainline through Chapleau. The representative area can be accessed by rail and an intermodal facility along the CPR from the north. This option does add mileage to the routing.

6.7.4 Weather

There are no vehicle weight restrictions on Highways 17, 129 or 108 during the spring thaw months. Similarly, no weather or seasonal restrictions were identified for rail transport. However, seasonal restrictions may exist on local access roads within the representative area. Future phases of work will examine records related to the history of weather events.

6.7.5 Carbon Footprint

Carbon footprint is a representation of the impact transportation has on the environment. Greenhouse gas emissions produced by the transport of used fuel from the interim storage facilities to the repository site have been calculated for both the all road and mostly rail transport scenarios.

All road transport of 4.6 million fuel bundles from the interim storage sites to an APM facility in the representative area north of the four communities would produce approximately 1,140 tonnes of equivalent carbon dioxide emissions per year. Over the 38-year operating period of the APM facility, the all road transport of used fuel would produce approximately 43,600 tonnes of equivalent carbon dioxide emissions.

Transport by mostly rail mode would produce approximately 780 tonnes of equivalent carbon dioxide emissions per year.

In comparison, an average car produces approximately 5.1 tonnes of equivalent carbon dioxide emissions per year. Emissions from intermodal handling activities are assumed to contribute about two per cent of total emissions.

6.7.6 Conventional Accidents

It is important when discussing safe transportation to make a distinction between radiological incidents and conventional traffic accidents. Incidents are controlled through the design of the transportation package and execution of operating procedures (see Sections 6.3.4 and 6.3.5). Based on international experience, the design of the container, coupled with rigorous operating procedures, is sufficient to prevent any incident from occurring.

Conventional accidents are random and unexpected. Therefore, they are considered as part of the planning process and quantified using statistical analyses based on the distance travelled. In 2009, the Ontario Ministry of Transportation reported a conventional traffic accident rate of 1.7 collisions per one million kilometres travelled for Ontario (MTO, 2009), one of the lowest rates in North America. Accident frequency is proportional to the distance travelled. Using a return distance of 36.4 million kilometres, about 62 road collisions have been estimated over the 38-year operating period of the APM facility.

6.7.7 Transportation Costs to the Representative Area

This section considers the used nuclear fuel transportation logistics from the existing interim storage sites to a hypothetical APM repository site located in the representative area to estimate transportation costs. Existing surface mode transport infrastructure, transport distances from the interim used fuel storage sites to the representative area by road mode for a reference used fuel inventory of 4.6 million bundles are examined.

A summary of the transport costs (based on the APM repository design and cost estimate prepared for financial planning purposes) from the interim used fuel storage sites to a hypothetical APM repository site located in the representative area for road and rail mode of transport is provided in Table 6-6. The cost of transporting used nuclear fuel from the seven interim storage sites to the repository site is projected to be approximately $979 million over the 38-year campaign (in constant 2010 $). The variance is $104 million under the base case estimate, or 9.6 per cent lower.

Table 6-6: Used Fuel Transportation Program Costs – 4.6 million Bundles

Total Cost	Transportation to the Representative Area	Variance to Reference Case	
Package Loading & Transportation	**$979,000,000**	**-$104,000,000**	**-9.6%**
Cost Breakdown			
Route and System Development	$19,000,000	$0	0%

Total Cost	Transportation to the Representative Area	Variance to Reference Case	
Cost Breakdown continued			
Safety Assessment	$5,290,000	$0	0%
Capital Equipment and Facilities	$295,000,000	-$31,000,000	-9%
Operations	$486,000,000	-$68,000,000	-12%
Environmental Management	$8,400,000	$0	0%
Decommissioning	$37,800,000	-$4,890,000	-11%
Program Management	$127,000,000	$0	0%
Note: [a] All costs are rounded to three significant digits			

6.8 Transportation Findings

This transportation assessment includes two major components: a description of regulatory oversight, including how the requirements are being met by the NWMO transportation program; and a desktop analysis of transportation logistics assuming available transport infrastructure. If the APM Project were to be located in the representative area, the repository would be accessible by truck and railroad using existing roadways and railways. It is assumed that the necessary connecting road, railway and intermodal infrastructure would be constructed, thereby providing access from existing transportation infrastructure to the repository. Improvements, if required, to the transportation and intermodal infrastructure would be reviewed in detail in Phase 2 studies, should the community continue in the site selection process.

The Township of The North Shore and the Towns of Blind River and Spanish are located on the Trans-Canada Highway 17 between Sudbury and Sault Ste. Marie, and the City of Elliot Lake is located 27 kilometres to the north on Highway 108. Highway 17 is one of Canada's two east-west intercontinental highways and is maintained to the highest level of service. Only for the purpose of this Preliminary Assessment, the repository site is assumed to be within a semicircular area of an approximately 75-kilometre radius north of the four communities.

The Ontario Ministry of Northern Development and Mines current highway investment program includes resurfacing the roadway west of Blind River and bridge rehabilitation of the Mississagi River and the Lauzon Creek bridges. Given Highway 17 is a major link between provinces, it is anticipated that the roadway will continue to be maintained to a high provincial standard and would support repository construction, operation, and closure. The average vehicle travel on Highway 17 for the region is ranges from 4,550 to 4,750 vehicles daily. For Highway 108 to Elliot Lake, traffic volume averages 2,350 vehicles per day. Traffic volumes on local highways are typically less than 500 vehicles per day.

If ancillary businesses and services locate near the repository (package manufacturing, testing labs, vehicle maintenance, etc.), the delivery of materials and shipment of finished goods would have access to the rest of Canada. The highway would also facilitate the safe and efficient commuting for workers from the surrounding region, as required.

The Huron Central Railway, a part of the Canadian subsidiary of Genesee & Wyoming Inc., branches west from the CNR and CPR cross-continental mainlines in Sudbury to a CNR collector line in Sault Ste. Marie. The CPR mainline travels northwest from Sudbury through Chapleau.

The communities of Blind River, The North Shore, and Spanish are on the Huron Central Railway operated by Genesee and Wyoming Canada Inc., the Canadian subsidiary of Genesee and Wyoming. Elliot Lake is approximately 30 kilometres north of the railway. In 2010, $33 million in funding was announced for the rehabilitation of the railway. Work began in August 2011 and was completed in the summer of 2012.

Only for the purpose of this Preliminary Assessment, the representative area where the repository is assumed to be located is approximately 100 kilometres north of the HCRY and the eastern border of the area is approximately 30 kilometres west of the CPR mainline. There appears to be sufficient space for an intermodal transfer facility where needed, and the roads appear to be adequate to move the UFTP via Highway 17 and local highways to a repository site in the representative area north of the four communities.

The transport of used fuel is a highly regulated activity. The NWMO's transportation program is being developed to meet all aspects of the regulations, including packaging, radiological security, emergency response and conventional vehicle safety requirements.

Beyond Safety – Potential to Foster Community Well-Being With the Implementation of the Project Now and in the Future

As discussed in the previous chapters, any site that is selected to host the Adaptive Phased Management (APM) Project must be demonstrated to be able to safely contain and isolate used nuclear fuel, protecting humans and the environment over the very long term. The preferred site will need to address scientific and technical siting factors that acknowledge precaution and ensure protection for present and future generations. The previous chapters have explored, in a preliminary way, the potential to meet the safety-related requirements of the project. These requirements are fundamental, and no siting decision will be made that compromises safety.

Once confidence is established that safety requirements can be met, the potential for the project to help foster the well-being, or quality of life, of the community and area in which it is implemented becomes an important consideration. The ability to benefit from the project, and the resources that would be required from the NWMO to support achievement of this benefit, would be a consideration in the selection of a site after all safety considerations have been satisfied. The project will only be implemented in an area in which well-being will be fostered.

Preliminary Assessments begin with exploring the potential for the project to align with the vision and objectives of the community which expressed interest in the project and, in so doing, triggered studies in an area. The first phase of Preliminary Assessments (Phase 1) explores the potential for the project to help interested communities, such as The North Shore, to advance to the future it has set out for itself. It is understood this project may not align with the vision and objectives of all communities. Through this initial work, the interested community and the NWMO may learn that the project is not a strong fit with the long-term vision and objectives of the community, and further studies may be concluded.

As described earlier, Phase 1 Preliminary Assessment studies were initiated in this area with the involvement of four communities: the City of Elliot Lake, the Town of Blind River, the Township of the North Shore, and the Town of Spanish. For the purpose of these early studies, an “Area of Study” was identified that included these four communities and the surrounding area. The boundaries of the Area of Study were defined to encompass the main geological features within the communities and their surroundings.

The initial screening (Step 2) phase of work suggested there are potentially suitable rock formations both within the boundaries of the municipalities and in the surrounding area. Now, with the insight of the studies completed in Phase 1 Preliminary Assessments, we understand the land areas with strong potential to meet the technical safety requirements of the project are located outside the municipal boundaries of the four interested communities that entered the site selection process and in territory for which Aboriginal peoples have a claim. Should studies continue in the area, the next phase of work (Phase 2) is intended to explore the potential for the project to align with the vision and objectives of potentially affected First Nation and Métis communities, as well as their interest in implementing the project together. Nearby municipalities will also be involved. The project will only proceed with the involvement of the interested community, potentially affected First Nation and Métis communities, and surrounding municipalities working in partnership.

In planning Phase 1 assessment studies, community well-being assessment studies were designed to be conducted individually for each community to better understand the potential for the project to align with the interest of each community. With Phase 1 safety-related study findings suggesting the potentially suitable land is outside the municipal boundaries of the four interested communities, the community well-being studies address two questions. If the project were to be implemented in the area, and understanding the vision each community has for itself, is there potential to foster well-being of each community through the implementation of the project in the area? This is the fundamental question addressed in the community well-being assessment. However, in light of the findings of the technical studies, a second question is also considered in exploring the potential to foster well-being through the project: Among these four communities, where does the project most strongly align?

Understanding the potential for strong alignment of the project within these four communities would be a beginning point of the larger conversation that would be needed to explore the potential to foster well-being in the broader area and would be the focus of any future work. Future conversation would need to include First Nation and Métis communities in the area and neighbouring communities. It would also need to explore the interconnections among communities within the broader area, to understand how the individual interests of communities might best be addressed through a broader regional implementation strategy for the project in which the interests of all communities are considered in an integrated manner.

Throughout the NWMO's work to explore the potential to foster well-being through the implementation of the project, it is noted the project offers significant employment and income to a community and surrounding area, including the opportunity for the creation of transferable skills and capacities. However, with a project of this size and nature, there is the potential to contribute to social and economic pressures that must be carefully managed to ensure the well-being and sustainability of the community and area. Only through working together can the project be harnessed to maximize benefits to the area, manage any pressures which may come from the project, and ensure that the project fosters the long-term well-being and sustainability of the area consistent with the area's vision for the future.

Good decision-making will require the project is understood from all perspectives and is informed by the best knowledge and expertise. The NWMO continues to work with and learn from communities to advance the siting process together. The NWMO also continues to look to Aboriginal peoples as practitioners of Traditional Knowledge to help, to the extent they wish, to guide the decisions involved in site selection, and ensure the factors and approaches used to assess the potential to contribute to well-being appropriately interweave Traditional Knowledge throughout the process.

Learning to date from preliminary studies, and engagement with the interested community, is summarized in the chapter that follows.

7. PRELIMINARY SOCIAL, ECONOMIC AND CULTURAL ASSESSMENT

7.1 Approach to Community Well-Being Assessment

This chapter provides a preliminary overview of the potential for the Adaptive Phased Management (APM) Project to foster the well-being of the Township of The North Shore, Ontario if the project were to be implemented in the area. More detailed information can be found in The North Shore Community Profile (HSAL, 2014a) and Community Well-Being Assessment (HSAL, 2014b). The overview uses a community well-being framework to understand and assess how the APM Project may affect the social, economic and/or cultural life of The North Shore. It also discusses the relative fit of the APM Project for the community and the potential to create the foundation of confidence and support in this community that would be required for the implementation of the project.

A number of factors were identified as minimum criteria to consider in the multi-year process of study to assess the potential to foster well-being (NWMO, 2010).

- Potential social, economic and cultural effects during the implementation phase of the project.
- Potential for enhancement of the community's and the region's long-term sustainability through implementation of the project.
- Potential to avoid ecologically sensitive areas and locally significant features.
- Potential for physical and social infrastructure to adapt to changes resulting from the project.
- Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site.

Factors identified by Aboriginal Traditional Knowledge will help inform this assessment. In order to ensure that a broad, inclusive and holistic approach is taken to assessment in these areas, a community well-being framework was identified to help understand and assess the potential effects of the APM Project. This framework was used to help explore the project, understand how communities and the surrounding area may be affected if the project were to be implemented in the area, and identify opportunities to leverage the project to achieve other objectives important to people in the area.

The framework encourages exploration of the project through five different "lenses."

- ***People or Human Assets*** – How might the implementation of the project affect people?
- ***Economics or Economic Assets*** – How might the implementation of the project affect economic activity and financial health of the area?
- ***Infrastructure or Physical Assets*** – How might the implementation of the project affect infrastructure and the physical structures that the community has established?
- ***Society and Culture or Social Assets*** – How might the implementation of the project affect the sense of belonging within the community and among residents, and the services and network of activities created to serve the needs of community members?
- ***Natural Environment or Natural Assets*** – How might the implementation of the project affect the natural environment and the community's relationship with it?

In Phase 1 of this assessment, which is the focus of this report, the intent was to explore the potential to foster the well-being of the interested community. For this reason, the subset of factors and considerations related to the community are addressed at this time. Considerations related to potentially affected First Nation and Métis communities and surrounding municipalities are noted where early insight is available; however, more detailed work would be conducted in Phase 2 should the area advance to the next phase of study.

7.1.1 Activities to Explore Community Well-Being

Dialogue with interested communities and those in the surrounding area is needed to begin to identify and reflect upon the broad range of effects that the implementation of the project may bring. At this early phase of work, dialogue is focused on the interested community.

In concert with the interested community, the NWMO worked to develop an understanding of the community today, and its goals and aspirations for the future. To this end, information has been assembled and studied through a variety of means, including review of community plans and/or strategic planning activities, engagement activities, community visits and tours, briefings, one-on-one discussions, consultant observations, Community Liaison Committee meetings, open houses, and the development of a community profile.

7.1.2 Assumptions of the APM Project – Drivers of Community Well-Being

The APM Project is currently in the early stages of design, and for this reason, there remains flexibility in the nature and scope of its implementation. This provides an opportunity for the project to be structured and operated in a manner that suits the conditions and aspirations of the community and surrounding area. However, it is important at this early stage of the preliminary assessment to understand the potential implications of the project on the community and its surrounds. This requires some basic assumptions about the project and initial effects. The starting assumptions for this preliminary assessment include the following:

1. The on-site labour workforce required by the APM Project is in the range of 400 to 1,200 jobs, and further jobs (indirect and induced) and community wealth creation will result from project spending for goods and services and employee income spending (NWMO, 2012). The following table summarizes the estimated number of direct, on-site jobs throughout the life of the APM Project, which spans over 150 years.

Table 7-1: On-Site Workforce

APM Phase	Number of Years (Approx.)	Direct Jobs per Year (Approx.)	Primary Skills Required
Construction	10	400–1,200	Mining, engineering, geoscience, safety assessment, manufacturing, construction, trades, project management, social science, engagement, communication, transportation
Operation	30 or more	700–800	Mining, engineering, geoscience, safety assessment, manufacturing, trades support, project management, social science, engagement, transportation
Extended Monitoring	50 or more	100–150	Geoscience, safety assessment, mining
Decommissioning and Closure	30	200–300	Mining, construction, trades, geoscience, safety assessment, regulatory affairs
Long-Term Monitoring	100 or more	25–50	Environmental, health and safety monitoring

2. Realization of employment benefits within a community will depend on a variety of factors such as:

   a. Preference for local hiring and sourcing from local businesses;
   b. Training of local residents for positions in the project or in supporting services; and
   c. Planning to prepare for and leverage future opportunities.

   This project will be implemented through a long-term partnership involving the community, First Nation and Métis communities in the area, neighbouring communities, and the NWMO. Only through engagement, dialogue and collaboration will the NWMO ensure that needs are addressed at each stage of the process, and determine the specifics of how a partnership arrangement would work. For illustration purposes only, employment opportunities could be in the order of hundreds of new jobs (direct, indirect and induced) within the local area (AECOM, 2010). However, it will be up to communities to determine the nature and scope of how they wish to grow in discussions with the NWMO.

3. The NWMO is committed to working with communities and those in the surrounding area to optimize the benefits that will positively contribute to the overall well-being of the area.

The following figure provides a graphical representation of the direct and indirect effects that may result from the siting of the APM Project. The figure illustrates how the project could be the impetus for growth in population, business activity and municipal finances for the interested community and the broader area.

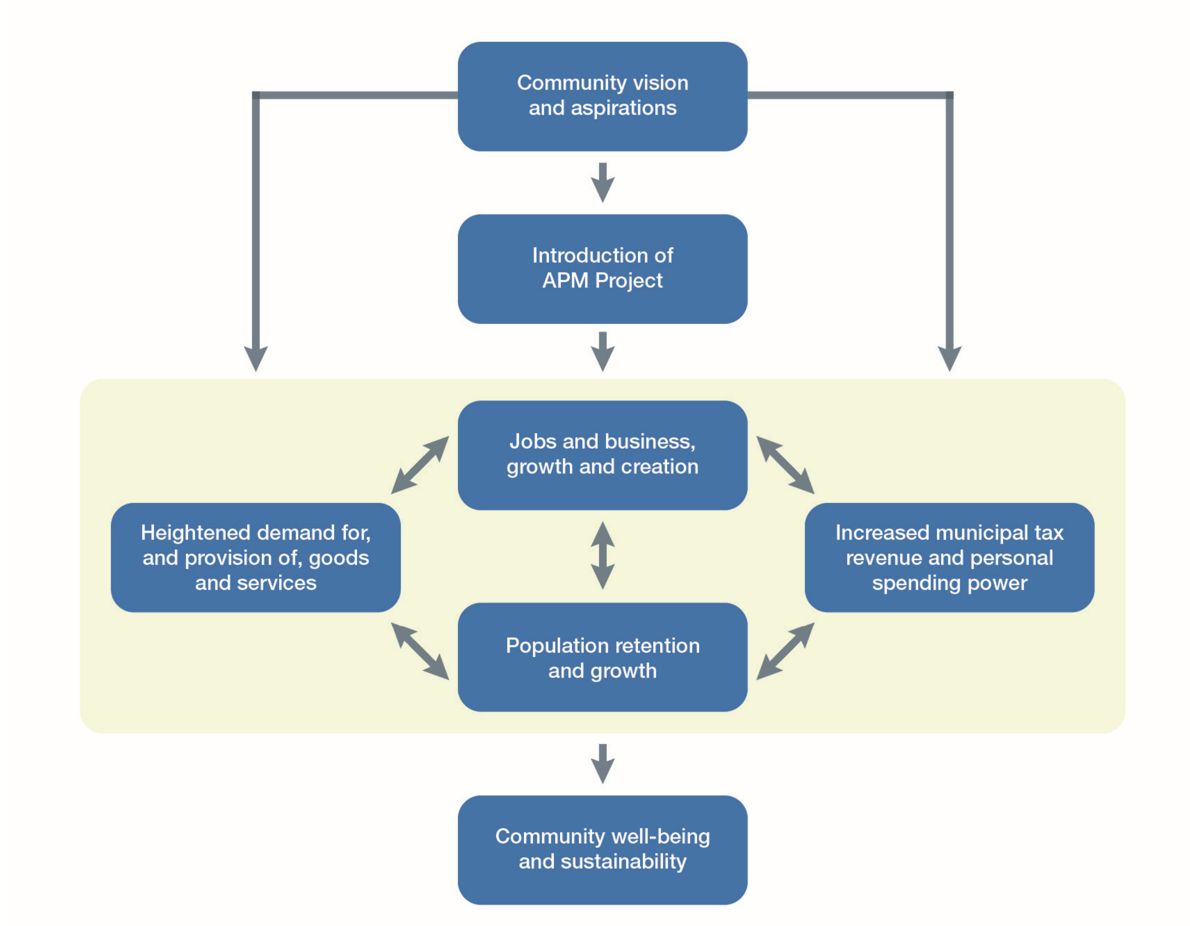

Figure 7-1: Direct and Indirect Effects From the Project

7.2 Community Well-Being Assessment – Implications of the APM Project for The North Shore

The potential effect of the project, should it be implemented in the Area, on the people, economics, infrastructure, social assets and natural environment of The North Shore is discussed below. The discussion starts with an overview of the aspirations and values of The North Shore, as the NWMO has come to understand them. This understanding of well-being from the community's perspective is the starting point for this Preliminary Assessment and informs the discussion throughout.

7.2.1 Community Aspirations and Values

The Township of The North Shore has expressed explicit values, aspirations and desires for its community. These have been identified through discussions with community members and documented in The North Shore Community Profile (HSAL, 2014a) and various other community reports, including the Draft Official Plan (2012). Key themes are summarized in this section. The Preliminary Assessment is measured against these values and aspirations.

1. **Recreational Activity Development:** The Township of The North Shore is seeking to support the growth of recreational opportunities along its shoreline including park and facility expansion while maintaining the natural environment.

2. **Provide Employment Opportunities:** The Township of The North Shore is seeking to provide meaningful and equitable employment opportunities for local residents. It is also seeking to encourage the younger population to live and work in the community.

3. **Development of Housing Opportunities:** The Township of The North Shore is seeking to encourage the development of affordable housing opportunities for local residents as well as any incoming populations. However, the Township of The North Shore would like to maintain quality of life and ensure that industrial-type growth occurs at an appropriate scale.

As expressed by the community, the community values its existing businesses, small town rural character, and unique natural environment along the north shore of Lake Huron.

As expressed by the community, current community challenges include the preservation of existing businesses and jobs in the community and attracting new businesses and jobs in a controlled, healthy and safe environment.

The following sections describe the implications of the APM Project for each of the community well-being “lenses” or asset categories.

7.2.2 Implications for Human Assets

The population of The Township of The North Shore has declined by 25 per cent over the past 15 years. For the most part, the population loss is the result of out-migration of skilled and young residents who typically are the most mobile. The losses in population were due to youth leaving the community for school and work. In addition, the closure of the Elliot Lake mines meant that some of the workers and their families who lived in the Township of The North Shore left in pursuit of other work. Since 1996, the population has been aging in the Township of The North Shore and in other communities along the north shore of Lake Huron.

In 2011, the top occupations in the Township of The North Shore were: transport and equipment operators and related occupations, education, law and social, community and government services, management and business, finance and administration services. The transport occupations include heavy equipment repair and trucking.

Given that there are no public primary or secondary schools in the Township of The North Shore, students attend classes at schools in other communities in the area. The area operates as a region and the Blind River schools are in close proximity. The exception is that the Township of The North Shore has the Rock Haven School for Exceptional Children, which runs programs for developmentally challenged children. There are no post-secondary educational programs or training facilities and students must go to larger centres such as Sault Ste. Marie or Sudbury.

There are no clinics or private health care services in the Township of The North Shore. Patients go to hospitals in the Town of Blind River (e.g., Blind River District Health Centre) the City of Elliot Lake (e.g., St. Joseph’s Hospital), Sudbury, and Sault Ste. Marie. Emergency services available to residents of The Township of The North Shore are adequate and they are equipped to handle emergency situations.

The APM Project has the potential to have a positive effect on the human assets in the Township of The North Shore. The APM Project has the potential to grow population through attracting workers and their families, as well as former out-migrants to the community. The presence of the APM Project in the Township of the North Shore or other area communities may maintain a broad demographic mix of the population by attracting and retaining a younger workforce as well as creating a more representative mix of age groups in the region.

The APM Project will be able to utilize the available skilled labour force already found within the area. In addition, the APM Project will contribute to labour and skills diversification within the communities with the influx of workers who have training in many different areas related to facility construction, operations and maintenance. Notwithstanding APM Project labour force requirements, transportation and government services occupations will continue to characterize the skills and labour supply in the Township of The North Shore. Some of these occupations may see an increase due to demands by the APM Project for certain services.

The project will bring direct, indirect and induced jobs to strengthen the foundation for population growth. The APM Project is a long-term project, with a much longer lifespan than other resource-based developments typical of northern Ontario. It has the potential to be a driver for population retention and growth. Employment opportunities could be in the order of hundreds of new jobs for current and new residents of The Township of The North Shore and surrounding local communities including First Nation and Métis communities (AECOM, 2010). With additional community development and support provided by NWMO, it is possible that these job numbers could be increased. These new jobs will bring spouses, partners, and families. The increased population will be a catalyst for spinoff growth and development.

Skills and labour supply would likely diversify and expand with the increased population and as a result of the on-site and in-community job opportunities. Indirect and induced jobs will also create opportunities for skills diversification and attract new residents with different levels of expertise. The APM Project will capitalize on the existing labour force skills and expertise and attract other highly educated and skilled workers. The project will provide opportunities for skilled workers and ongoing training, as well as opportunities for the next generations to pursue education paths to take advantage of careers associated with the project. There are major and positive educational benefits from the APM Project, including an increased population driving expanding enrolment and educational programming opportunities and potential partnerships with post-secondary institutions. It is further expected that the APM Project will include an international Centre of Expertise and thus attract attention from around the world.

The APM Project's new occupations will change the skills mix available within the local labour pool. Increased diversity may occur when new types of occupations and skills required for the APM Project that are presently not available within The North Shore are introduced. The APM Project will also attract workers into the community from other local and regional locations.

While the APM Project and the associated increase in population will place heightened demand on existing health and safety facilities and services, there is potential to expand and improve the existing levels of service. Proper planning would need to take place to ensure that potential increased social issues (generally associated with any large project that substantially increases local populations) are mitigated and that all age groups in the community are supported.

In summary, it can be expected that the APM Project would bring positive net benefits to the human assets in the Township of The North Shore were the project to be implemented in the area. The APM Project would help The Township of The North Shore realize its aspirations and goals. It would drive development and expansion in other aspects of its community well-being.

7.2.3 Implications for Economic Assets

Given that many of the communities in the area are a relatively short drive from each other, the labour force of each community is influenced by economic activities in the other communities. In the Township of The North Shore, the labour force and participation rate has decreased since 1996. This can be accounted for, in part, due to the closure of the uranium mines in Elliot Lake. The employment rate has remained relatively stable. That said, people in the work force have managed to obtain jobs.

Industries in which people were employed in 2011 in the Township of The North Shore include health-care and social assistance, manufacturing, construction, and retail trade, public administration, and other services. For those employed in health care and social services, most residents find employment in the surrounding communities of the Town of Blind River and the City of Elliot Lake. Several of the firms in the Township are large, very robust, international firms in the resource sector who continue to benefit from mining activities across northern Ontario, in southern Ontario and in the United States.

The Township of The North Shore is a fairly affluent community; however, there are residents on social assistance. In regards to tourism, there are many opportunities for snowmobiling, fishing, water sports, hunting, trapping and hiking. The Township sponsors a Canada Day celebration which is a local tourist attraction. The economy also benefits from waterfront and property development.

The Township of The North Shore is able to take on new enterprises. The community is entrepreneurial and has strong leadership through membership in the ELNOS Corporation.

With respect to employment, the APM Project will provide longer-term stability than resource sector employment. The APM Project will increase the number and diversity of skilled employment opportunities in the community and surrounding area. A greater variety in employment opportunities would offer more sustainable and diverse career paths for youth within the community and the surrounding region and further encourage youth to live and work in the Township of The North Shore.

The APM Project will attract large numbers of workers to the community from the region, province and other jurisdictions as well as increase the number of indirect and induced support industries and services. There may be continued stability and profitability for current industries with more demand for local business services from a growing population.

With respect to income, overall, the APM Project's income effects for local residents will be positive and help people to increase their current levels of disposable income. Rising household and individual incomes may be achieved when new residents begin earning higher incomes. Through the provision of new income opportunities, the APM Project is expected to help to reduce overall reliance on government transfer payments to individuals and families.
With respect to business activity, the APM Project and worker-related spending is expected to increase the number and diversity of businesses in the community and create new business linkages, synergies and agglomerations. The APM Project and worker spending will also

encourage people to spend money in the community. This is especially important for the retention of existing retail and development of new retail businesses.

The APM Project will expand the employment base, business sales and profitability within the community. Community-based businesses may have greater certainty and other similar firms may be attracted to the Township of The North Shore. Moreover, there is the potential for more hospitality services due to increased local demand.

The new business and industrial activity from the APM Project will allow the labour force of some sectors to grow and expand (e.g., retail and service sector, resource-based supply chain types of industries). The APM Project will provide increased stability and potential expansion in the entertainment and cultural industries.

With respect to recreation and tourism, the APM Project may increase the number of people using recreation facilities and natural areas in the Township of The North Shore due to population growth. In addition, with more people visiting the community for business-related activities, there is potential for the APM Project to require the development of additional tourist accommodation. The majority of tourist establishments are in neighbouring municipalities. With the potential for increased tourism, there may be greater support for the establishment of tourist facilities that will continue to make the Township of The North Shore an attractive place to live and to settle down in. Efforts may need to be taken to proactively manage effects due to the presence of the facility.

The economic buoyancy created among residents and local businesses will have positive implications for municipal finance. The assessment base will grow, and it will be more equitably spread across industry, residential and commercial components. Increased funding may greatly increase the Township of The North Shore’s ability to support expenditure budgets for new infrastructure (such as roads and water) and services (e.g., recreation) to support a growing population. Costs will rise given growth in the community and the associated increase in demand for infrastructure and services. Increased resources will also be available to plan and fund infrastructure and service expansions.

The APM Project would provide the Township of The North Shore with the potential for strong economic benefits through long term economic diversity and increased stability. Economic benefits will need to be carefully planned for and managed for the community to realise the full benefit of the project. For the Township of The North Shore to optimize project benefits, it would be helpful to support education and training of the labour force, enhance the capacity of the municipality and residents, and provide advice to businesses on project opportunities.

7.2.4 Implications for Infrastructure

While the Township of The North Shore’s Official Plan (2012) has designated commercial land uses, the commercial sector is not, as yet, well developed. The Township of The North Shore’s Official Plan (2012) has designated an industrial land use area. Industries currently located in the Township have made a major capital investment. The Township of The North Shore Official Plan identifies sensitive areas that need to be protected. The entire Township of The North Shore is designated as a Community Improvement Area.

Housing stock is in place. Some cottage housing has recently been constructed. There are limited housing options in the Township of The North Shore with no apartment-style dwellings. Rental housing in the Township of The North Shore is limited.

The Township of The North Shore has water and waste water infrastructure in place. Because the municipality is an amalgamation of smaller, spread out communities, municipal services vary across the municipality. A municipal water treatment and distribution system services the residences in the Serpent River Settlement area. Individual private water supply systems service most of the lots in the Township of The North Shore. Waste water is handled by individual private septic systems in Spragge, Serpent River, and Algoma Mills. The local landfill is over capacity although land is available for expansion.

The Township of The North Shore is accessible by road, rail and water (e.g., deep water port) and is in proximity to larger centres such as Sudbury and Sault Ste. Marie.

The APM Project has the potential to create net positive benefits on the physical assets of The Township of The North Shore. The APM Project has the potential to facilitate the expansion of the number of homes and the diversity of housing stock in the Township of The North Shore. An incoming population will cause demand for new housing stock in the Township of The North Shore and neighbouring communities. There is also potential to increase the cost of housing depending on the size and rate of labour in-migration. Any potential negative effects will need to be managed.

With an increased population and increased activities with the APM Project, there will be an increased demand for new infrastructure, but also the resources to support its development. The APM Project will result in the overall growth of the community and despite the availability of additional capacity, may require some additional planning and improvements for water and waste water and solid waste infrastructure. The community and the NWMO would need to work together in this area.

7.2.5 Implications for Social Assets

Lake Lauzon is a cottage area and includes a permanent and seasonal population that come from all over Ontario and the United States. Although there are no arts and multicultural groups in the Township of The North Shore, residents attend events in the neighbouring communities of Spanish, Elliot Lake, and Blind River. The Township of The North Shore has the North Channel Yacht Club (NCYC) located in Spragge.

There are a small number of recreational facilities used by local residents in the Township of The North Shore and other facilities in Elliot Lake, Blind River, and the Mississauga First Nation Reserve. The majority of recreation is focused on outdoor experiences such as fishing, hiking, hunting, sailing, and snowmobiling. The Spragge Recreation Area includes an ice rink, basketball and tennis courts, and a connection to the snowmobile trail.

Day care is primarily in the neighbouring communities of Blind River and Elliot Lake. There are a variety of social assistance and support programs offered at the local and regional level such as the Rock Haven School for Exceptional Children. The Township of the North Shore is a member of the Algoma District Services Administration Board, which provides administrative services regarding children's services, emergency medical services, housing services and Ontario Works and related social services.

The APM Project has some potential to have a net positive effect on the social assets of The Township of The North Shore were it to be implemented in the area. With respect to the community recreational facilities and programs and also the social services and organizations, the increased population associated with the APM Project would be expected to increase demand on these resources. However, this increased population would also be expected to heighten participation rates and create a larger base of human resources for volunteers. Increased funding and participation would allow The North Shore to upgrade and expand its recreational and social programs.

The APM Project will increase demands on existing social service providers and programs, particularly due to an influx of people associated with the APM Project. There may similarly be an increasing demand for a broader range of health and safety services. Upgrades to existing facilities as well as increases in services in the neighbouring communities of Elliot Lake and Blind River may be required, and local hospitals and clinics may need to hire permanent health specialists. The APM Project will also bring increased revenues and resources to support growth of social services and organizations.

However, there is uncertainty whether the implementation of the APM Project focused on the North Shore would be a good fit with the community character desired by The North Shore. While the Township of The North Shore seeks economic development, this development would need to be consistent with local desires to maintain the rural atmosphere and landscape of the community. There is uncertainty whether focusing implementation of the APM Project within the Township of The North Shore would be a good fit with retaining the small town and rural character desired overall by the community. Growth and development at a scale inconsistent with the small town and rural character desired by residents would be incompatible with residents' overall aspirations for the community.

The overall character of the community does have the potential to be enhanced if the project-related activity were focused on a neighbouring interested community. In this approach, the community would be able to work with the NWMO to participate in the project in a regional context. It would ensure the municipality participates in the APM Project and the socio-economic benefits of economic growth and demographic stability that it desires, and also retain community character. It appears that residents who would have been concerned about the fit of the project if actually located in The North Shore with respect to retaining rural small town characteristics would support further consideration of the project being located elsewhere within the nearby area. It is understood from this there would be similar support for exploring the implementation of the project in the broad area in a scenario in which The North Shore is not the primary focus of activity for the project.

7.2.6 Implications for Natural Environment

The Township is on the north shore of Lake Huron. This is a significant natural asset. There are a number of provincial parks in the region surrounding the Township of The North Shore such as the southern portion of the Matinenda Provincial Park. The Township of The North Shore area is situated on a naturally diverse part of the Precambrian Canadian Shield. The topography is typical of the Canadian Shield. Much of the Township is pristine, and residents are protective of the natural environment. Local habitats in the general region include dense forest, muskeg swamps, numerous lakes, winding rivers and hills, and the region has a diverse natural heritage. Local forests are a mixture of deciduous and coniferous trees.

As would be the case with any large construction project, natural areas might be affected during the various phases of the project. Effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained. It is understood at this point in time that no significant environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository taking into account mitigation that will be applied.

There may be population pressures on the natural environment with increased residential development, other urban growth and development. There may also be increased pressure on the natural environment due to desire for recreational activities. With additional people participating in recreational activities on area lakes and trails, more development may occur, requiring enhanced management practices.

The APM Project contains some flexibility with respect to on-site building designs and energy use to be consistent with environmental and social values. For example, the ability to use renewable sources of electric power, where feasible, coupled with energy-efficient building designs might limit the overall carbon footprint of the project.

7.2.7 Summary of APM and its Implications for The North Shore

Based on the foregoing discussion, while the APM Project has potential to foster the well-being of The North Shore there is uncertainty whether its implementation focused on The North Shore would be a good fit with retaining the rural and small town character desired by the community.

The overall objectives of the community, and in particular, with respect to the character of the community, are more strongly fostered if the project-related activity is focused on an interested neighbouring community. In this approach, the community would be able to work with the NWMO to participate in the project in a regional context. It would ensure The North Shore participates in the APM Project and the socio-economic benefits of economic growth and demographic stability that it desires, and also retains community character that is important to the community.

The community would benefit in a number of ways from the project being implemented in the area, and, in particular, if the focus of project-related activity is centred on a neighbouring community. Human assets will be enhanced in the Township of The North Shore with the introduction of the APM Project in the area. The presence of the APM Project will increase population levels and maintain a broad demographic mix of the population. The APM Project will contribute to labour and skill diversification due to an influx of workers. The APM Project will also attract workers from other local and regional communities. Additionally, due to the increased population, the APM Project will increase enrolment at local schools and will result in increased demand and also revenue supports for health and safety facilities and services.

Economic assets will be enhanced with the introduction of the APM Project. The APM Project will increase the number and diversity of skilled employment opportunities for residents. Through the provision of new and higher income opportunities, the APM Project will help to reduce overall reliance on government transfer payments to individuals and families. The APM Project is also expected to increase use of recreational facilities in the area due to increase in population.

In general, infrastructure will be enhanced with the APM Project. APM Project enhancements can bring the Township of The North Shore in line with its goals and aspirations to retain existing businesses and attract new businesses. With an increasing population and associated activities due to the APM Project, there will be more revenues to support updating and renewal of existing infrastructure.

Social assets have some potential to be enhanced in the Township of The North Shore with the introduction of the APM Project. With the influx of APM workers and families, there may be more variety in arts and cultural activities and more participation in the local arts and cultural scene. The APM Project will increase the demand and potential resources for existing social service providers and programs in neighbouring communities due to increased population associated with the APM Project. However, through population and increased economic activity, the APM Project is expected to provide the foundation to meet these demands.

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Table 7-2: Overall Community Well-Being Implications

Criteria / Measures	CWB is Enhanced When …	Current North Shore Profile		Possible North Shore Profile with APM Project		Observations and Implications
	OVERALL CWB IMPLICATIONS					
Human Assets	Population growth occurs and youth are retained in the community	Negative		Enhanced		• APM could grow the community and provide increased stability through economic and demographic diversity. • Youth would be retained through employment opportunities and new residents would be attracted to the area.
Economic Assets	More diverse and stable employment opportunities are available	Neutral		Enhanced		• There will be further employment opportunities and a more diverse range of jobs. • Increased funding through Development Charges and a wider tax base would provide more financial resources for the Township of The North Shore to fund its infrastructure projects. • The increased jobs from the APM Project would be the catalyst for the Township of The North Shore to enhance its community well-being.
Infrastructure	Infrastructure is maintained or improved to meet the needs of the community	Neutral		Enhanced		• The APM Project, while placing increased demands on some of the infrastructure and services, would overall provide increased funding to improve and enhance existing services.
Social Assets	Opportunities exist for recreation and social networking. Community is cohesive, and community character is enhanced.	Neutral		Uncertain		• The community would see benefit to its Social Assets through increased participation and funding to its recreational facilities and programs as well as its social services and organizations. • While the APM Project has potential to foster the well-being of The North Shore if the project were implemented in the area, there is uncertainty whether the implementation of the APM Project focused on The North Shore would be a good fit with retaining the rural and small town character desired by the community. • The overall character of the community does have the potential to be enhanced if the project-related activity were focused on a neighbouring interested community. In this approach, the community would be able to work with the NWMO to participate in the project in a regional context, and helps ensure the municipality participates in the APM Project and the socio-economic benefits of economic growth and demographic stability it desires.
Natural Environment	Natural areas, parks and conservation reserves are preserved and maintained for use and enjoyment	Maintained		Maintained		• Effective mitigation and environmental protection measures will ensure the overall environmental integrity of the area is maintained. • It is understood at this point in time that no significant environmental effects are likely during the construction, operation, and decommissioning phases of the used fuel repository itself.

Legend	
Declining – Negative	
Neutral – Stable	
Environment – Integrity Maintained	
Increasing – Enhanced – Positive	
Uncertain	

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7.3 Criteria to Assess Factors Beyond Safety – Summary in The North Shore

The previous discussion has taken a holistic approach to the assessment, taking into account the aspirations of the community and the implications of the project for community well-being. The NWMO acknowledges the process of assessment of community well-being needs to be collaborative and reflective of the community. Before initiating the siting process, and beginning to engage interested communities in the assessment process to understand their aspirations, the NWMO identified five evaluation factors, which, at a minimum would need to be addressed (NWMO, 2010). Table 7-3 draws on information outlined in the previous discussion to understand the potential to foster well-being in The North Shore against these original factors. The table summarizes preliminary findings about the implications of the APM Project, were it to be implemented in the community, on various factors of well-being. Four measures are used: maintained, enhanced, diminished or uncertain. For other evaluation factors, two measures are used: yes or no. The overall conclusion using these evaluation factors and the understanding that has emerged to date is consistent with that outlined in the previous sections.

Over the course of discussions and conversations, the community identified a number of other important areas for consideration. The community expressed a strong desire to better understand how to engage neighbouring communities, communities on transportation routes and, in particular, First Nation and Métis communities in the area. The Township of the North Shore realizes that it would be essential to develop or enhance relationships with all the foregoing groups to support the implementation of the project. Noteworthy at this early stage is that three of the Township of The North Shore's neighbours also expressed interest in learning more about the APM Project and are participating in the site selection process. The community also expressed a strong interest in understanding how the project could be implemented while maintaining the community's rural and small town character.

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Table 7-3: Summary Table of Criteria to Assess Factors Beyond Safety

Factors that Address the Well-Being of a Community	Evaluation Factors to be Considered	Potential Effect of APM Project	Discussion Based on Preliminary Assessment
Potential social, economic and cultural effects during the implementation phase of the project, including factors identified by Aboriginal Traditional Knowledge	Health and safety of residents and the community	Maintained	• There is a strong safety case; however, the community is eager to learn more about safety and health considerations to enhance their confidence in the safety of the project.
	Sustainable built environments	Enhanced	• Community infrastructure and built fabric may be enhanced through project activities and investments in the community.
	Sustainable natural environments	Maintained	• Effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained. • It is understood at this point in time that no significant environmental effects are likely during the construction, operation, and decommissioning phases of the used fuel repository.
	Local and regional economy and employment	Enhanced	• Significant employment and population growth will occur in the Township of The North Shore and surrounding communities – hundreds of new jobs could be created in The Township of The North Shore. • With these jobs comes the potential to increase the current population of the Township of The North Shore and surrounding communities. • New opportunities would be created for local businesses to serve the project and a growing and more diverse population.
	Community administration and decision-making processes	Enhanced	• Local leadership has demonstrated interest in the project and it is expected local leadership will ensure residents have opportunities to learn more and engage in community decision-making.
	Balanced growth and healthy, livable communities	Enhanced if focus of activity is in neighbouring community	• The Township of The North Shore has expressed a strong desire to diversity its economy and continue to provide stable employment opportunities for new and existing residents. The APM Project appears to be a good fit with community objectives and aspirations in this regard. • There is uncertainty whether implementation of the APM Project focused on The North Shore itself would be a good fit with retaining the rural and small town character desired by the community. The APM's location in the broader area will have benefits.
Potential for enhancement of the community's and region's long term sustainability through implementation of the project, including factors identified by Aboriginal Traditional Knowledge	Health and safety of residents and the community	Maintained	• There is a strong safety case; however, engagement is at a preliminary stage and further dialogue would be required to understand and address questions and concerns about safety and health considerations related to the repository and transportation of used nuclear fuel. • When the uranium mines were operating, all regional communities benefitted and conversely experienced negative effects when the mines closed. Regional residents are familiar with radiation-related health and safety matters.
	Sustainable built environments	Enhanced	• Infrastructure and built fabric will be enhanced through project activities and investments in the community. • Regional communities have capacity to grow and their infrastructure accommodated workers and their families when uranium mines were operating.
	Sustainable natural environments	Maintained	• Some natural areas may be negatively affected by the project. • Further dialogue and effective mitigation and environmental protection measures would ensure the overall environmental integrity of the area is maintained.
	Local and regional economy and employment	Enhanced	• Substantial employment and economic development opportunities would extend to the surrounding region. • The area has first-hand awareness of the employment effects of uranium mining and closure of the mines.
	Community administration and decision-making processes	Maintained	• Engagement of surrounding communities is underway. All the local municipalities in the 'Learn More' process have demonstrated interest in the project and going forward. It is expected they will be able to make informed and effective decisions. • Engagement of communities further afield is at a preliminary stage.
	Balanced growth and healthy, livable communities	Enhanced	• Engagement of surrounding communities is underway. Three of these communities have expressed an interest in earning more, and are participating in the siting process as 'interested communities'. • Surrounding area communities are collectively seeking economic development and growth in the area. The APM Project appears to be in alignment with these aspirations. • Further dialogue would be required to explore aspirations for growth and well-being in the area. • The APM workforce would assist in balancing the demographic characteristics of the area and support community livability.

Factors that Address the Well-Being of a Community	Evaluation Factors to be Considered	Potential Effect of APM Project	Discussion Based on Preliminary Assessment
Potential to avoid ecologically sensitive areas and locally significant features, including factors identified by Aboriginal Traditional Knowledge	Ability to avoid ecologically sensitive areas and locally significant features	Yes	• As outlined in previous chapters of this report, the Area contains suitable sites for the project thus providing flexibility in selecting specific sites that can avoid ecologically sensitive areas and locally significant features.
Potential for physical and social infrastructure to adapt to changes resulting from the project	Potential for physical infrastructure to be adapted to implement the project	Yes	• The Township of The North Shore and the surrounding areas have multiple modes of transportation, social and economic support services, and capacity to absorb the anticipated growth in population and economic activity. • Local roads and rail infrastructure are in generally good shape and can accommodate some growth in population. Some local communities will need improved water and waste water services. • Some investments would be required to accommodate identified infrastructure deficiencies.
	Potential for social infrastructure to be adapted to implement the project	Yes	• The Township of The North Shore and surrounding communities have the necessary core of social infrastructure in place to plan for and adapt to changes resulting from the project.
	The NWMO resources required to put in place physical and social infrastructure needed to support the project	To be determined	• In all likelihood, the Township of The North Shore would require some assistance in terms of planning, human and financial resources. • Waste water services can be provided to additional communities. • Further studies will be required to explore the specifics of these requirements.
Potential to avoid or minimize effects of the transportation of used nuclear fuel from existing storage facilities to the repository site	The availability of transportation routes (road, rail, water) and the adequacy of associated infrastructure and potential to put such routes in place from a social perspective	To be determined	• As outlined in Chapter 6, the community and region have access to multiple modes of transportation that appear to have adequate capacity for this project. • The area has rail and industrial port facilities. • The accessibility of the Township of The North Shore to highways and roads is important to community well-being because it demonstrates connectivity between different transportation and community nodes. • Engagement of surrounding communities is underway. Engagement of communities further afield is at a preliminary stage and further dialogue will be required to help build understanding and address questions and concerns. • Engagement of surrounding communities and those on potential transportation routes is at a preliminary stage and further dialogue would be required to understand and address questions and concerns.
	The availability of suitable safe connections and intermodal transfer points, if required, and potential to put them in place from a social perspective	To be determined	• Rail and local port facilities and their location on Trans-Canada Highway 17 offer connections and intermodal transfer points. Raw and processed uranium is already transported by truck via Highway 17 through the communities. • Engagement of communities further afield on potential transportation routes is at a preliminary stage and further dialogue will be required to help build understanding and address questions and concerns.
	The NWMO resources (fuel, people) and associated carbon footprint required to transport used fuel to the site	780-1,140 tonnes of equivalent carbon dioxide emission is expected to be produced per year	• As outlined in Chapter 6, in a scenario of all road transport of 4.6 million fuel bundles from the interim storage sites to an APM facility near The Township of The North Shore, approximately 1,140 tonnes of equivalent carbon dioxide emissions is expected to be produced per year. • In a scenario of transport by mostly rail mode, approximately 780 tonnes of equivalent carbon dioxide emissions is expected to be produced per year.
	The potential for effects on communities along the transportation routes and at intermodal transfer points	To be determined	• As outlined in Chapter 6, there is a robust technical safety case for the safe and secure transport of used nuclear fuel. Engagement of surrounding communities is underway. Engagement of communities further afield on potential transportation routes is at a preliminary stage and further dialogue will be required to understand and address questions and concerns.

7.4 Overview of Engagement in The North Shore

NWMO has engaged with The Township of The North Shore leadership and community members, as well as initiated dialogue in First Nation and Métis communities in the area and surrounding municipalities through a variety of means, including the following:

- Several community open houses;
- Regular attendance at the Community Liaison Committee meetings;
- Informal and structured interviews with community members;
- Facilitating the Community Liaison Committee web page and newsletters;
- Preparation of written materials;
- Informal tours and visits with local residents;
- “Ask the NWMO” columns in regional newspapers;
- Attendance at regional meetings and conferences; and
- NWMO Mobile Transportation Exhibit.

Initial discussions with a cross-section of community leaders, briefings and conversations with community groups, and conversations with residents during open houses suggest there is interest in the community to continue to learn about the project and consider hosting it, or support the project being hosted elsewhere in the Area. To this end, opportunities for preliminary discussions were sought with the following:

- Local political leaders (e.g., Mayor and Councillors);
- Members of the Community Liaison Committee;
- Local business owners/operators;
- Local service providers (e.g., emergency services, social services, education);
- Community groups (e.g., clubs, associations and organizations);
- Surrounding community leaders (within the area); and
- Residents.

Based on discussions with the above, there appears to be a strong and growing potential to sustain interest in the local community and move forward with the siting process; in particular to further explore the potential for implementing the project in the broader area and where The North Shore is not a primary focus of project-related activity. It is understood growth and development at a scale inconsistent with the small town and rural character desired by residents, which would occur if The North Shore were the focus of project-related activity, would be incompatible with residents’ overall aspirations for the community.

The community has taken steps to engage some of its nearest neighbours (including First Nation and Métis communities in the area), and has begun to set the foundation for further constructive consideration of the project and opportunity to work collaboratively to explore the project and interest in the broader area. More engagement with communities in the wider area is required to better understand implications for those communities.

7.4.1 Summary of Issues and Questions Raised

In the Township of The North Shore, most of the people engaged were interested in learning more, were supportive of their community being involved in the siting process and look forward to next steps.

Several key interests were recurring and identify the areas which the community is most interested in learning more about. The core key interests expressed include the following:

- Health, safety and environmental risks;
- Community and infrastructure development; and
- Economic benefit and opportunities for growth.

In addition to the core key interests, a number of secondary key interests were also expressed and include the following:

- Potential for successful siting in the area, and not only in the community of The North Shore, underlining the interest in the project as regional and not simply a local initiative;
- Jobs directly related to the APM Project; and
- Relations with First Nations.

7.5 Community Well-Being Findings

At the outset of the site selection process, the NWMO framed four key questions respectively addressing safety, the well-being of the community, the well-being of surrounding area communities, and the potential to foster sustained interest in exploring this project through subsequent steps in the site selection process (NWMO, 2011). The discussion that follows addresses and elaborates on a subset of these questions related to community well-being in the context of the Township of The North Shore.

The preceding discussion has looked at the implications the APM Project might have on the community well-being of the Township of The North Shore. Additionally, key issues and concerns identified through engagement activities have been highlighted. Through desktop research, dialogues with community members and leaders, and on-going analysis, it is understood The Township of The North Shore has an interest in learning more about the APM Project to realize growth and development opportunities within the community and surrounding area.

While the APM Project has potential to foster the well-being of the Township of The North Shore if the project were implemented in the area, there is uncertainty and concern with respect to retaining the rural and small town character desired by the community if The North Shore were to be the focus of project-related activity in the area.

The overall character of the community is more strongly fostered if project activity is focused on an interested neighbouring community in the area. In this approach, the community would be able to work with the NWMO to participate in the project in a regional context. It would ensure The North Shore participates in the APM Project and the socio-economic benefits of economic growth and demographic stability, which are community objectives, and retain community character, which is also important to the community. Siting of the project in the broader area would fit with The Township of the North Shore's priorities and aspirations, and enable the community to plan for and realize the socio-economic growth and development it desires.

There appears to be high potential for sustained interest in the local community, and in particular as a regional project where project-related activity is not focused on The North Shore.

Many community leaders in the Township of The North Shore have stated they are supportive of learning about APM.

There is potential for the project to foster well-being in the surrounding communities. The aspirations of surrounding communities involved in the siting process align with those of the Township of The North Shore, particularly when considering the project as a broader regional initiative. They recognize the need for additional industry to provide economic diversification in the area to reach community development goals, and to maintain/increase quality of life. Preliminary discussions have revealed a strong interest in the economic development potentials offered by the project to the broad area. More dialogue and engagement will be needed to understand the perspective of First Nation and Métis communities, and others, in the area.

At this point in time, there appears to be a high potential for sustained interest in the surrounding communities. Three surrounding communities are actively involved in the siting process as interested communities, and support continuing to learn about the APM Project. Local community leaders have indicated it is important to have the involvement of First Nation and Métis communities in the area.

It is noteworthy the municipalities in the area, inclusive of Elliot Lake, Blind River, the Township of The North Shore and Spanish function as a region. Each is involved in the siting process as 'interested communities'. They are politically autonomous but they are also formally tied to one another through their political and administrative constituency as fellow neighbouring communities. For instance, there is a good working relationship among the local surrounding communities through the ELNOS Corporation. Beyond their shared interest in learning about the APM Project, these communities are connected through government ties and shared planning.

As well, there are a variety of other linkages that further speak to the broader connections between the municipalities. They share facilities and services, and have a common heritage with uranium mining. They come together for community events and have developed some relationships with First Nation and Métis communities in the area. They have a willingness to share common opportunities to benefit from the APM Project which has encouraged cohesion across the communities. Engagement of these communities would need to continue and be broadened to include potentially affected First Nation and Métis communities.

There are some uncertainties associated with the preceding analysis due to the preliminary nature of the work at this stage. These uncertainties and challenges include:

1. Among the generally potentially suitable areas, smaller, specific siting areas that are socially acceptable would need to be identified.

    a. Potential siting areas identified through scientific and technical studies must be the subject of input by communities to identify socially acceptable land areas.

b. Further engagement with potentially affected First Nation and Métis communities is required, including Aboriginal Traditional Knowledge holders in the area, to understand the additional factors that will need to be considered in identifying and assessing the suitability of specific potential sites. The NWMO acknowledges, respects and honours that Aboriginal peoples - Indian, Inuit and Métis peoples of Canada - have unique status and rights as recognized and affirmed in s.35 of the *Constitution Act*, 1982. The NWMO is committed to respecting the Aboriginal rights and treaties of Aboriginal peoples (NWMO, 2014).

2. Project implementation (including engineering, logistics and/or community well-being) must align with specific community and area aspirations.

    a. An acceptable project implementation plan must be identified that aligns the ultimate project configuration with area expectations.

    b. Effective project planning at a broader level, involving potentially affected First Nation and Métis communities and surrounding communities, will be important for successful implementation of the project.

3. Interest in further learning about the project needs to be sustained.

    a. The site selection process spans several years and interest and conversation in the interested community needs to be sustained throughout this process.

    b. The potential effects of the project on the interested community, First Nation and Métis communities in the area, and surrounding communities would be substantial. These communities will need support to further explore their interest and take an active role in discussions of how the project should be implemented.

    c. Opposition groups may actively seek to influence decision-making and community leaders will need to respond to these pressures. The Township of The North Shore will require support to prepare for the next phases of the siting process if it is to proceed. Along with other regional communities, many residents are familiar with radiation, uranium mining, uranium processing and transportation, and long term management of uranium mining tailings.

4. Transportation routes and mode(s) need to be designed and configured taking into account social values.

    a. Transportation considerations will need to be determined. Regulatory matters along routes in several provinces including, New Brunswick, Quebec and Ontario, would need to be addressed. Social questions and concerns would also need to be heard and taken into account.

5. Environment and safety evaluations need to be aligned with community input.

    a. This requires regard for input from the interested community and surrounding communities.

b. This requires engagement by the NWMO and input from the interested community and surrounding communities. This may require capacity building to enable this input, which could include Aboriginal Traditional Knowledge.

c. Input from transportation route communities will also need to be incorporated.

8. REFLECTION ON POTENTIAL SUITABILITY

8.1 Early Findings

The site selection process outlines a road map for decision-making, which involves many steps. Over the course of these steps, the NWMO and potentially interested communities, First Nation and Métis communities and surrounding municipalities reflect upon the suitability of the area to host the Adaptive Phased Management (APM) Project. This initial phase of Preliminary Assessment has focused on supporting reflection of an interested community in the area participating in the siting process.

To fully understand and assess the potential of an area to host the APM Project, detailed scientific and technical studies are required over many years. At this preliminary assessment phase of work, initial studies have been completed. However, more detailed study is required to assess suitability and ensure the conditions are there for the safe and secure containment and isolation of used fuel over the very long term.

The decisions that people will make in the future about learning more about the project, exploring the potential to foster well-being of the community and area, and ultimately whether they are willing to host the project in the area and are prepared to support its implementation, are also key determinants of suitability. At this early point in the site selection process, the NWMO cannot anticipate with certainty the outcome of a dialogue that would need to continue into the future to support informed decision-making. Engagement activities within the interested community would need to continue to unfold. These activities would need to be broadened to involve potentially affected First Nation and Métis communities and surrounding municipalities in the learning and decision-making process, to fully understand the suitability of an area and site to host this project.

At this early stage of work, the NWMO is able to make preliminary conclusions and observations about the potential to find a safe and secure site in the Area of Study will meet the robust scientific and technical requirements of the project. The NWMO is able to make preliminary conclusions and observations about the potential for the project to foster the well-being of the interested community if the project were to be implemented in the area. The NWMO is also in a position to reflect on the uncertainties and challenges associated with proceeding with more detailed studies in the area, and ultimately satisfying the conditions for successful implementation of the project.

8.2 Preliminary Conclusions

The preceding sections of this report have examined, in a preliminary way, the potential for the Study Area and The North Shore as a community to meet the broad range of siting conditions set for the project. Four overriding research questions have guided this preliminary assessment. In all cases, these questions can be answered affirmatively.

1. There is potential to find a safe site in the Area of Study.
    - There is the potential to find a site with suitable geology.
    - There is the potential to safely construct the facility at the potential site.
    - There is the potential for safe and secure transportation to the potential site.
    - There is the potential to manage any environmental effects and to ensure safety of people and the environment.

2. The APM Project has potential to foster the well-being of The North Shore if the project were to be implemented in the Area, but there is uncertainty whether implementation of the APM Project focused on The North Shore itself would be a good fit with retaining the small town and rural character desired by the community. The overall character of the community is more strongly fostered if project activity is focused on an interested neighbouring community in the area.

3. There is potential for sustained interest in The North Shore to support further learning about the project.

4. There is potential to foster well-being in the surrounding area through the implementation of the project in the area, as well as sustain interest to support further learning.

Preliminary assessment studies conducted to date suggest there is the potential for the area to be suitable for the project from the multiple perspectives of:

- Engineering logistics;
- Geoscientific suitability;
- Environmental health and safety; and
- Transportation safety.

Four communities in the area have expressed interest in learning about and exploring the implementation of the project in their area. Reflecting on the potential social, economic and cultural effects of the project on The North Shore, the well-being of the community appears to be best fostered if project-related activity is focused on a neighbouring community rather than on The North Shore itself. There is uncertainty and concern whether focusing implementation of the APM Project within the Township of The North Shore would be a good fit with retaining the small town and rural character that is an important objective of the community. Growth and development at a scale inconsistent with the small town and rural character desired by the community would be incompatible with the community's' overall aspirations.

These Preliminary Assessment studies addressed criteria that were set out in the siting process description as was feasible in this initial phase of work.

8.3 Observations About Suitability

8.3.1 General Observations

Based on this preliminary information, there are a number of observations that support the overall conclusion the Area has potential to meet the robust scientific and technical requirements of the APM Project.

- The APM Project has potential to be safely located in a suitable site in the Area of Study studied, in a manner that will protect people and the environment now and in the future.

- There is potential to find a site that does not adversely affect future options for other valued activities identified to date such as mining and recreation. In other words, there exists potential that a geologically and environmentally suitable site can be found that does not jeopardize future uses of the land and resources as the NWMO understands them today.

- From a technical perspective, there is potential to safely transport used nuclear fuel from existing storage facility sites to the Area.

Based on this preliminary information, there are a number of observations that support the overall conclusion there is potential to foster the well-being of The North Shore through the implementation of the project, and sustain interest. However, there is uncertainty and concern the small town and rural character that is important to the community can be retained if project-related activities were focused within The North Shore.

- The overall character of the community is more strongly fostered if the project-related activity is focused on a neighbouring interested community. In this approach, the community would be able to work with the NWMO to participate in the project in a regional context. This would ensure the municipality participates in the APM Project and the socio-economic benefits of economic growth and demographic stability it desires.

- There appears to be high potential for sustained interest in the local community. Many community leaders in the Township of The North Shore have stated they are supportive of learning more about APM.

- There is potential for the project to foster well-being in the surrounding communities. The aspirations of surrounding communities involved in the siting process align with those of the Township of The North Shore, particularly when considering the project as a broader regional initiative. Preliminary discussions have revealed a strong interest in the economic development potentials offered by the project to the broad area.

- At this point in time, there appears to be a high potential for sustained interest in the surrounding communities. Three surrounding communities are actively involved in the siting process and support continuing to learn about the APM Project. Local community leaders have indicated that it is important to have the involvement of First Nation and Métis communities in the area.

8.3.2 Uncertainties and Challenges

Based on this preliminary information, there are uncertainties and challenges that would need to be addressed if The North Shore continues in the site selection process. These uncertainties and challenges would be important to understand the potential to meet the requirements of the project in the area.

Some uncertainties and challenges are a result of being at an early phase of study with limited information available. Other uncertainties and challenges have been identified from the studies themselves, and may be unique to better understanding the potential suitability of a particular area. The difficulty and the level of resources required to successfully address the challenges and uncertainties may vary across the interested communities and areas.

The reader is encouraged to review the full report and supporting documents for a better understanding of the challenges and uncertainties associated with meeting the requirements of the APM Project in this area. Examples of the range and type of uncertainties and challenges which would need to be considered in planning and resourcing any further studies in the Area include the following:

1. Geoscientific studies suggest that while while the four general potentially suitable areas identified appear to have favourable geoscientific characteristics, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. The main uncertainties are associated with the low resolution of available geophysical data, proximity to the Murray and Flack Lake faults, and the potential geological, structural and hydrogeological significance of the four known dyke swarms in the Area.

2. Environment and safety studies suggest there is potential to implement the project safely and with respect for the environment in Area. A more definitive environmental evaluation would be required once smaller potential siting areas have been identified. These further studies could result in the exclusion of areas based on such factors as, for example, the presence of migration routes, the proximity to important habitats and cultural sensitivity. Discussions with interested communities, potentially affected First Nation and Métis communities and surrounding municipalities, as well as field studies, would be needed to fully characterize the environmental conditions in these smaller potential siting areas.

3. Environment and safety studies suggest that effects of the project on the environment can be managed or mitigated through a combination of in-design features, operating procedures, and implementation of a sound environmental management plan. As smaller potential siting areas are identified, these mitigating measures would need to be identified and their effectiveness confirmed.

4. Among the general potentially suitable areas, specific, smaller siting areas that are socially acceptable would need to be identified.
    - Potential siting areas identified through scientific and technical studies must be the subject of input by communities to identify socially acceptable land areas.

    - Further engagement with potentially affected First Nation and Métis communities is required, including Aboriginal Traditional Knowledge holders in the area, to understand the additional factors that will need to be considered in identifying and assessing the suitability of specific potential sites. The NWMO acknowledges, respects, and honours that Aboriginal peoples – Indian, Inuit and Métis peoples of Canada – have unique status and rights as recognized and affirmed in s.35 of the *Constitution Act*, 1982. The NWMO is committed to respecting the Aboriginal rights and treaties of Aboriginal peoples (NWMO, 2014).

5. Project implementation (including engineering, logistics and/or community well-being) must align with specific community aspirations.
    - An acceptable project implementation plan must be identified that aligns the ultimate project configuration with area expectations.
    - Effective project planning at a broader level, involving potentially affected First Nation and Métis communities and surrounding communities, will be important for the successful implementation of the project.

6. Interest in further learning about the project needs to be sustained.
    - The site selection process spans several years, and interest and conversation in the interested community and area needs to be sustained throughout this process.

    - The potential effects of the project on the interested community, First Nation and Métis communities in the area and surrounding municipalities would be substantial. These communities will need support to further explore their interest and take an active role in discussions of how the project should be implemented.

    - Opposition groups may actively seek to influence decision-making and community leaders will need to respond to these pressures. The North Shore will require support to prepare for the next phases of the siting process if it is to proceed.

7. Transportation routes and mode(s) need to be designed and configured taking into account social values.
    - Transportation considerations will need to be determined. Regulatory matters along routes in several provinces including, New Brunswick, Quebec and Ontario would need to be addressed. Social questions and concerns would also need to be heard and taken into account.

8. Environment and safety evaluations need to be aligned with community input.
    - This requires regard for input from the interested community and surrounding communities.

    - This requires engagement by the NWMO and input from the interested community and surrounding communities. This may require capacity building to enable this input, which could include Aboriginal Traditional Knowledge.

    - Input from transportation route communities will also need to be incorporated.

8.4 Partnership

The site selection process outlines a road map for decision-making, which involves many steps. Over the course of these steps, the NWMO, potentially interested communities, First Nation and Métis communities in the area, and surrounding municipalities reflect upon the suitability of the area to host the APM Project.

The implementation of the project will have an effect on the broad area in which it is sited. First Nation and Métis communities in the area and surrounding municipalities also need to be involved in decision-making about the project and planning for its implementation should it proceed in the area. Only through working together can the project be harnessed to maximize benefits to the area, manage any pressures that may come from it, and ensure it fosters the long-term well-being and sustainability of the area consistent with the area's vision for the future. This project will only proceed with the involvement of interested communities, potentially affected First Nation and Métis communities and surrounding municipalities working in partnership.

These initial studies have demonstrated it is possible to find land areas in the vicinity of The North Shore that have the potential to satisfy the geoscientific factors outlined in the NWMO site selection process and enable the project to be implemented in a way that is respectful of people and the natural environment. These general potentially suitable areas are on Crown land, and in territory for which Aboriginal peoples have a claim. As identified in the site selection process description (NWMO, 2010), the NWMO has committed to respect Aboriginal rights and treaties in the siting decision, and take into account that there may be unresolved claims between Aboriginal peoples and the Crown.

Furthermore, as outlined in the NWMO Aboriginal Policy (NWMO, 2014), the NWMO acknowledges, respects and honours that Aboriginal peoples – Indian, Inuit and Métis peoples of Canada –have unique status and rights as recognized and affirmed in s.35 of the *Constitution Act*, 1982. The NWMO is committed to respecting the Aboriginal rights and treaties of Aboriginal peoples.

8.5 The Way Forward

Through a multi-year sequence of engagement and assessments, the NWMO will lead a gradual narrowing down of communities and areas in the process to eventually arrive at a single preferred site with an informed and willing host.

The outcome of Phase 1 Preliminary Assessments will guide an initial phase of narrowing down of communities and areas engaged in site selection studies. The NWMO will identify a smaller number of communities and areas with strong potential to meet the requirements of the project to be the focus of Phase 2 Preliminary Assessments for detailed field studies and broadened dialogue.

Several more years of detailed studies would be required before confidence could be established that project requirements could be met in any potential siting area. For those that continue on in the process, a broad network of relationships would also need to be established in the area, involving the interested community, potentially affected First Nation and Métis communities and surrounding municipalities to reflect upon the suitability of the area to host the APM Project.

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10. GLOSSARY

GENERAL

Area of Study – the municipalities of Blind River, Elliot Lake, Spanish, and The North Shore, and the surrounding area as shown on Figure 4-1.

PRELIMINARY ASSESSMENT OF ENGINEERING

Backfill – The material used to refill excavated portions of a repository (drifts, disposal rooms or boreholes) during and after waste has been emplaced.

Barrier – A physical obstruction that prevents or delays the movement of radionuclides or other material between components in a system, for example a waste repository. In general, a barrier can be an engineered barrier which is constructed or a natural (or geological) barrier.

Bentonite – Soft light-coloured clay formed by chemical alteration of volcanic ash. It is composed essentially of montmorillonite and related minerals of the smectite group. Bentonite is used as backfill and buffer material in repositories.

Borehole – A cylindrical excavation, made by a drilling device. Boreholes are drilled during site investigation and testing and are also used for waste emplacement in repositories and monitoring.

CANDU – Canada deuterium uranium.

Limited access area – A designated area containing a nuclear facility and nuclear material to which access is limited and controlled for physical protection purposes.

Lithostatic pressure – Pressure due to the weight of overlying rock and/or soil and water.

Nuclear security protected area – A designated area within a nuclear facility to which access is restricted, controlled and guarded for security and physical protection purposes (i.e., an area that contains the used nuclear fuel).

Protected area – An area inside a limited access area containing Category I or II nuclear material and/or sabotage targets surrounded by a physical barrier with additional physical protection measures.

Repository – A nuclear facility where waste is emplaced for disposal.

Repository, geological – A facility for disposal of radioactive waste located underground (usually several hundred metres or more below the surface) in a geological formation to provide long-term isolation of radionuclides from the biosphere.

Used fuel – Irradiated fuel bundles removed from a commercial or research nuclear fission reactor. (Adapted from the *Nuclear Fuel Waste Act*.)

PRELIMINARY ASSESSMENT OF GEOSCIENTIFIC SUITABILITY

Aeromagnetic Data – Data gathered by measuring the Earth's magnetic field using an airborne magnetometer.

Aquifer – A geological unit or structure that is sufficiently porous and permeable to store, transmit, and yield significant or economic quantities of groundwater to wells and springs. A confined aquifer is bound by low permeability formations such that it is under pressure. An unconfined aquifer is one whose upper groundwater surface (water table) is at atmospheric pressure.

Basement – All deformed crystalline (igneous and metamorphic) rocks underlying variably deformed rocks of volcanic and metasedimentary origin in an area.

Batholith – A large intrusive body having an areal extent of $100km^2$ or more.

Bedrock – Consolidated rock that underlies soil or other unconsolidated material.

Brittle – The physical response in which a rock breaks along a surface under an applied stress at relatively low pressure and temperature, and usually results in formation of fractures and joints.

Brittle Lineament – An interpreted linear trace on remote sensing and geophysical data where the bedrock has undergone brittle deformation. These features are inferred to represent faults and brittle-ductile shear zones.

Canadian Shield – A large plateau that occupies most of eastern and central Canada and consists of exposed Precambrian basement rocks in a stable craton. It is surrounded by younger sedimentary rocks.

Craton – A large portion of a continental plate that has remained relatively tectonically stable since the Precambrian Era.

Crystalline Rock – A rock of igneous or metamorphic origin consisting wholly of mineral crystals.

Deformation – Any process of folding, faulting, shearing, or fabric development undergone by a rock as a result of Earth stresses; or the change in geometry of a body of rock as a consequence of Earth stresses.

Diffusion – Random movement of both ions and molecules in water from areas of higher concentration to areas of lower concentration.

Discretionary occurrence – An occurrence that does not meet any of the defined criteria of an occurrence as established by Ontario Mineral Deposits Inventory (MDI) database.

Ductile – Deformation without fracturing of the internal structure of a rock in response to stress. Ductile deformation usually occurs at several kilometers deep in the ground where high pressures are combined with high temperatures and low strain rates.

Dyke – A planar injection of magmatic or sedimentary material that cuts across the pre-existing fabric of a rock. Dykes can be formed by the filling of a crack/fissure from above, below, or laterally by forcible injection, or intrusion.

Dyke Lineament – An interpreted linear trace on remote sensing and geophysical data where the bedrock has undergone brittle deformation and has been subsequently infilled by a dyke.

Dyke Swarm – A concentration of vertical to subvertical dykes radiating around a central intrusion, or aligned parallel to subparallel over a large region of land.

Erosion – The process by which the surface of the Earth is worn away by the action of water, wind, or ice movement. The erosive process operates by the combined action of weathering and transportation, where first rocks are broken down (weathering), and then the smaller pieces are carried away (transportation).

Fault – A fracture or a zone of fractures that occurs as a result of brittle deformation and within which there is relative displacement of the fracture surfaces.

Fault Zone – A region, from metres to kilometers in width, which is bounded by major faults, and within which smaller faults may be arranged variably or systematically.

Felsic – Term to describe an igneous or metamorphic rock having abundant light-coloured minerals, including, for example, quartz and feldspar.

Foliation – Parallel alignment of minerals or structural features arranged in planes.

Fracture – A break in the rock mass, including cracks, joints, faults, and bedding partings.

Geomechanics – A branch of geology that embraces the fundamentals of structural geology and knowledge of the response of natural materials to deformation.

Gneiss – A banded rock formed by regional metamorphism, in which bands result from the separation of dark-coloured minerals (e.g., biotite, hornblende, pyroxenes) and the light-coloured minerals (e.g., quartz, feldspars).

Granite – A plutonic rock in which quartz constitutes 20 to 60 per cent of the felsic component, and in which the alkali feldspar/total feldspar ratio is restricted to the range of 35 to 90 per cent.

Granodiorite – Plutonic rock in which quartz constitutes 20 to 60 per cent of the felsic component, and in which the alkali feldspar/total feldspar ratio is restricted to the range of 10 to 35 per cent.

Gravity Data – Data gathered by measuring variations in the Earth's gravitational field caused by differences in the density of subsurface rocks.

Greenstone Belt – Group of mainly Archean aged metavolcanic rocks with lesser amounts of metasedimentary rocks, that are intruded by large granitic intrusions. Many mineral deposits of copper, nickel, iron, chrome, and gold, among others, occur in greenstone belts.

Heterogeneous - A volume of rock that exhibits spatial variability of its physical properties (e.g., lithology, porosity).

Homogenous – A volume of rock that exhibits spatial uniformity of its physical properties (e.g., lithology, porosity).

Hydraulic Conductivity – Ease with which water can move through a volume of rock, and is measured in unit length (e.g., metres) per unit time (e.g., seconds).

Hydrogeology – Branch of Geology that studies the movement and characteristics of subsurface waters.

Hydrogeochemistry – Branch of Geochemistry that studies the chemical characteristics of ground and surface waters and their interaction with the rock environment of an area.

Igneous Rock – A rock that solidified from molten or partly molten material (i.e., from magma).

In-Situ Stress – The current state of stresses in a rock mass/region, representing the magnitude of, and direction in which, the rock is being compressed due to crustal movement.

Intrusion – Igneous rock emplaced as magma in a pre-existing rock volume.

Iron Formation – A thin-bedded, chemical sedimentary rock containing at least 15% iron of sedimentary origin.

Isostasy – A process by which equilibrium is achieved between the sinking action of gravitational forces and the buoyancy of landmasses on the mantle. Changes in isostasy may result from periods of glaciations, active tectonics, and mass erosion.

Lineament – An interpreted linear trace that can be observed on remote sensing and geophysical data and which may represent geological structures (e.g., fractures).

Lithology – Set of physical characteristics of a rock, including color, grain size, and mineralogy.

Mafic – General term for igneous or metamorphic rocks composed primarily of ferromagnesian (iron- and magnesium-rich) and other associated dark-colored minerals.

Magnetic Data – See Aeromagnetic Data definition.

Massive (rock) – A durable rock that is considered to be essentially isotropic, homogeneous and free of fractures, bedding, foliation, and other planar discontinuities.

Metamorphic Rock – A rock derived from pre-existing rocks by mineralogical, chemical or structural changes in response to marked changes in temperature, pressure, shearing stress, or chemical environment.

Metasedimentary (rock) – Sedimentary rock that has been subjected to metamorphic processes, which resulted in alterations to the original mineral composition of the rock.

Metavolcanic (rock) – Volcanic rock that has been subjected to metamorphic processes, which resulted in alterations to the original mineral composition of the rock.

Migmatite – High-grade metamorphic rock that has undergone partial melting.

Neotectonics – Neotectonics refers to deformations, stresses and displacements in the Earth's crust of recent age or which are still occurring.

Nuttli Magnitude – Magnitude is a measure of the amount of energy released at the source of an earthquake. It is commonly described using the Richter scale (ML). However, this scale does not apply to Eastern North America where the seismic waves attenuate differently. As a result, a different scale, namely the Nuttli magnitude scale (Mn or mN), was adapted to better measure the seismic events in Eastern North America.

Occurrence – Evidence of mineralization present within a surface rock sample (channel or grab) and/or isolated diamond-drill intersection(s) that may or may not have the potential to be exploited. At least one sample must meet the minimum requirements for a mineral occurrence. This definition forms the basis of an occurrence used in the Mineral Deposit Inventory database maintained by the Ontario Geological Survey (OGS).

Outwash – Stratified detritus (i.e., sand and gravel) removed or "washed out" from a glacier by meltwater streams, and deposited in front of or beyond the end moraine or the margin of an active glacier.

Overburden – The silt, sand, gravel, or other unconsolidated material overlying the bedrock surface, either by having been transported or formed in place.

Paleo- – Prefix used when referring to something 'ancient' or 'old'.

Paleohydrogeology – Branch of hydrogeology concerned with the study of ancient hydrologic processes, regimes and associated hydrologic features preserved in the rock.

Pluton – A deep-seated igneous intrusion of small surface area.

Plutonic – Pertaining to an igneous rock or an intrusion formed at great depth.

Quaternary – Period of time of the Earth extending from approximately 2.6 million years ago until present time.

Sedimentary Rock – Rock formed by the accumulation of layers of clastic and organic material or precipitated salts.

Seismology – The study of seismic waves from earthquakes to investigate the structure and processes within the Earth.

Shear Zone – A zone of strong deformation that may exhibit brittle and/or ductile characteristics, surrounded by rocks that are less deformed.

Subprovince (geologic) – A fault-bounded, medium- to large-scale region characterized by similar rock types, structural style, isotopic age, metamorphic grade, and mineral deposits.

Supracrustal – Rocks that overlie the basement.

TDS – Abbreviation of the term Total Dissolved Solids; it expresses the quantity of dissolved material in a sample of water.

Tectonics – The study of the interplay between the plates that make up the outer part of the Earth, which usually results in earthquakes, creation of mountains, and fault movement, among others.

Terrain – An area of ground with a particular physical character.

Thermal Conductivity – Ease with which heat can move through a volume of rock, and is measured in unit energy (e.g., Watt) per unit distance (metre) and unit temperature (Kelvin).

Tonalite – Plutonic rock in which quartz constitutes 20 to 60 per cent of the felsic component, and in which the alkali feldspar/total feldspar ratio is restricted to the range of 0 to 10 per cent.

Ultramafic – Term to describe an igneous rock composed of > 90% mafic minerals.

PRELIMINARY ASSESSMENT OF ENVIRONMENT AND SAFETY

masl – metres above sea level.

ANSI – Area of Natural and Scientific Interest – An official designation by the Province of Ontario applied to areas of land and water that represent significant geological (earth science) and biological (life science) features.

Crown leased land – Crown land acquired by the Ministry of Natural Resources for reasons based on ecological sustainability, including ecosystem health, the protection of natural and cultural assets, recreation, and/or the protection of people and property.

Crown land – **Non-Freehold Dispositions Public** – Crown land that is a tenure holding, usually for a set term and a specific purpose (e.g., Lease, Licence of Occupation, Land Use Permit, Beach Management Agreement and Easement), excluding permanent disposition in the form of a patent.

Crown land – **Unpatented Public Land** – Crown land that has never been granted or sold by the Crown to people or organizations for their private use and is under the mandate or management of the Ministry of Natural Resources.

Crown reserves – Crown lands that have been withdrawn from dispositioning under Section 21 of the *Crown Minerals Act*.

Safety case – An integrated collection of arguments and evidence to demonstrate the safety of a facility. It includes a Safety Assessment, complemented by additional arguments and evidence in order to provide confidence in the long-term safety of the facility.

Postclosure – The period of time following closure of a repository, after the shafts have been sealed and surface facilities have been decommissioned.

PRELIMINARY ASSESSMENT OF TRANSPORTATION

Designated Licensing Authority – The position designated as being accountable to manage the regulatory interface with the Canadian Nuclear Safety Commission (CNSC) (any verbal or written exchange of information with a representative of the CNSC).

Role – A set of duties, responsibilities and accountabilities, usually associated with a particular job. Roles generally define who does what.

Testing – Performed to demonstrate that a structure, system, equipment, component or software meets specified requirements, or to substantiate the predicted performance.

PRELIMINARY SOCIAL, ECONOMIC AND CULTURAL ASSESSMENT

Community well-being – In the NWMO site selection process, community well-being is defined by the community to reflect its long-term vision, goals and objectives. Although there is no single definition, communities often include in their consideration elements relating to such things as economic health, the environment, safety and security, spiritual dimensions, social conditions, and enhancing opportunities for people and communities. The NWMO has adopted a Sustainable Livelihoods framework to encourage broad reflection and discussion by the community, inclusion of multiple perspectives, community leadership in the discussion, and establishment of a broad foundation for the assessment. The framework is expected to evolve over time as dialogue and reflection continue.