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 WHITE RIVER, ONTARIO

FINDINGS FROM PHASE ONE STUDIES

APM-REP-06144-0081

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 White River 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 Town 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 White River in the APM process began in December 2011 when the Mayor and Council 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 White River's engagement to date in this Learn More process are provided below.

In March 2012, community representatives, members of Council and Township staff requested and received a briefing from the NWMO in Toronto. They toured the Waste Management Facility at the Darlington generating station. Also in March 2012, representatives from the Township met with members of the Canadian Nuclear Safety Commission (CNSC) in Ottawa to continue their learning.

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 April 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 May 2012, the NWMO delivered a presentation to community officials in White River to review the plan for conducting this initial screening and to confirm details of the work.
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Upon completing the initial screening in October 2012, the NWMO and the contractor 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 obvious conditions that would exclude the Township of White River 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. It was later moved to the NWMO community office.

At the invitation of Council, the NWMO convened open houses in White River in November 2012 to review initial screening results and to share information about the project and site selection process. Open houses were advertized and invitations to these events were sent to residents of White River as well as leaders of surrounding communities. Individuals and groups who met with the NWMO during these events included members of town council and staff, students, representatives from the business community, seniors, health-care and social service providers, and representatives of local First Nations communities.

Early in 2013, Council expressed an interest in learning more about preliminary assessments, the next step in the site selection process. At their request, in January 2013, 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 January 2013 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 White River Community Nuclear Liaison Committee (CLC) in October 2013. The CLC 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 CLC held its first meeting in October 2013.

Beginning in October 2013, the Council, the CLC and the NWMO worked together to review plans for the range of technical and social studies associated with the Phase 1 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 surrounding communities and Aboriginal people.

To support engagement in the assessment process, the CLC 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 committee also appointed a project coordinator, established a website and regular community newsletter, sought presentations from NWMO staff specialists 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 CLC 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 Nations leaders. To support ongoing dialogue with the community, the NWMO opened a local office in the community in January 2014.

The NWMO also took part in a number of community activities as a way to interact with residents and share information about the project. A broad range of community leaders was engaged through individual briefings and conversations held as part of the study process.

The CLC 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 April 2014 to engage community members in discussion of the work involved in Phase 1 studies.

The CLC made a visit to the OPG interim storage facility at Darlington in May 2014, followed by a briefing with the NWMO. Led by the CLC, 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 took place in June 2014 and coincided with a community barbeque.

Recognizing the importance of engaging surrounding communities and Aboriginal peoples 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 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.
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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 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 White River, 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 White River, 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 White River 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.

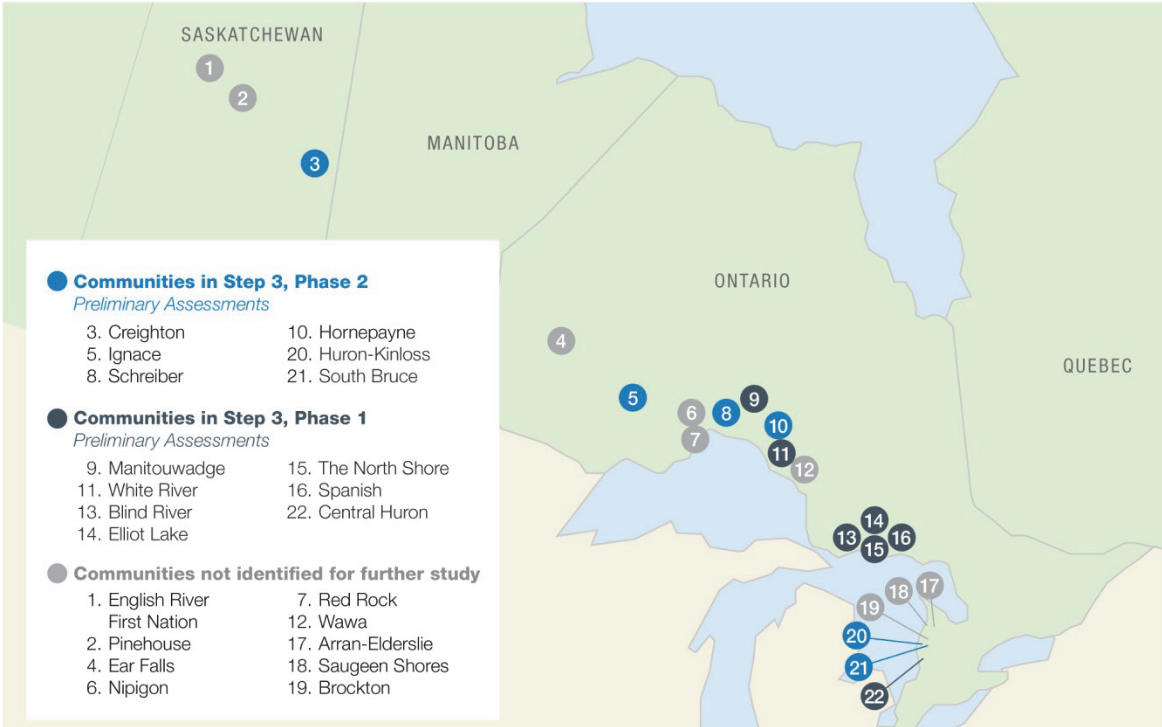


Figure 1-1: Communities Involved in the Site Selection Process

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.

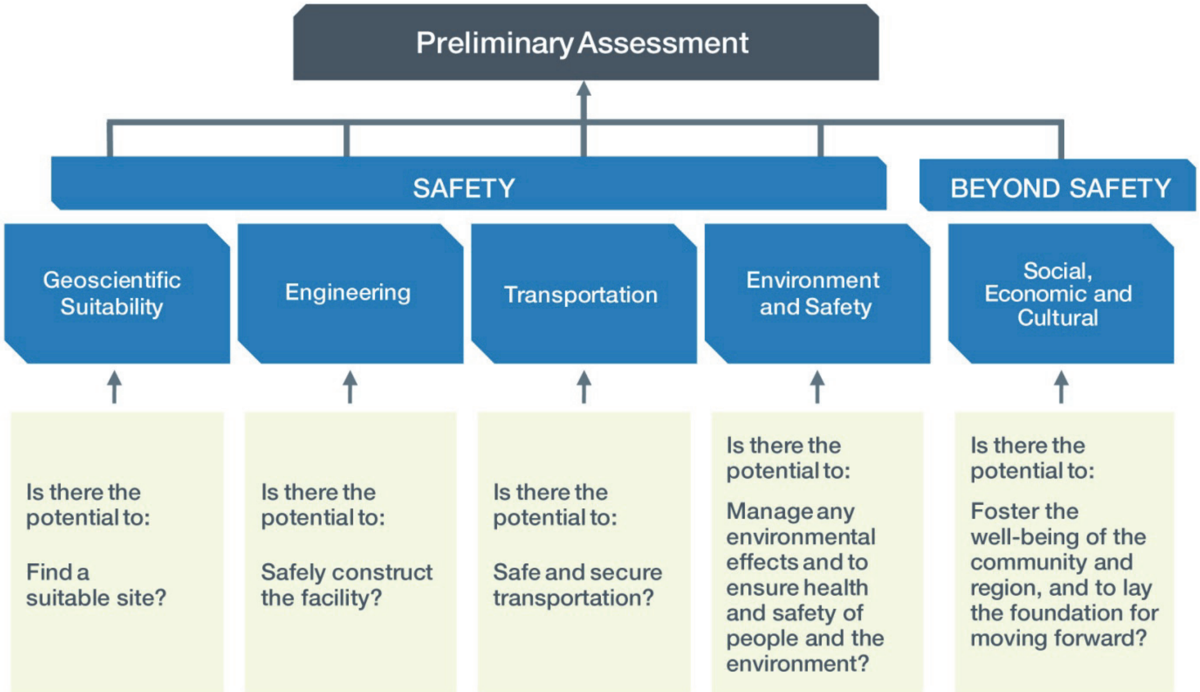


Figure 1-2: The Phase 1 Preliminary Assessment Studies

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

Findings from the Phase 1 for the Township of White River 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 WHITE RIVER

The Township of White River is located in the Algoma District, approximately 95 kilometres east of Marathon and 92 kilometres northwest of Wawa at the intersection of Trans-Canada Highway 17 and Highway 631. The community is primarily situated along and on the south side of Highway 17, and to the north of the Canadian Pacific Railway tracks and the White River.

According to 2011 Census data, the total population of the Township is 607. The Township of White River was incorporated in 1889 and celebrated its 125^{th} anniversary in 2014. The community's history is closely linked to the Canadian Pacific Railway. In 1961, the Trans-Canada Highway 17 was constructed through White River, leading to tourism and forestry industries in White River.

Today, White River remains a railway town and CP maintains a switch yard, turn-around track, and maintenance facility in the community. White River's economy is primarily based on the forest industry and the CPR. White River is the birthplace of the black bear that inspired the story of Winnie-the-Pooh.

The White River area lies within the Boreal Forest Region. The community is surrounded by wilderness, providing outdoor recreational opportunities for residents and tourists.

Figure 2-1 shows White River in its regional context. There are a number of Aboriginal communities and organizations in the White River area including Ojibways of Pic River (Heron Bay) First Nation and Ojibways of Pic Mobert First Nation. Métis Councils in the area include the Historic Sault Ste. Marie Métis Council and the North Channel Métis Council.

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

Figure 2-1: White River 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 White River area. The chapter also identifies infrastructure that would be required to safely construct and operate the facility in White River. 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 a community-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 White River 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.

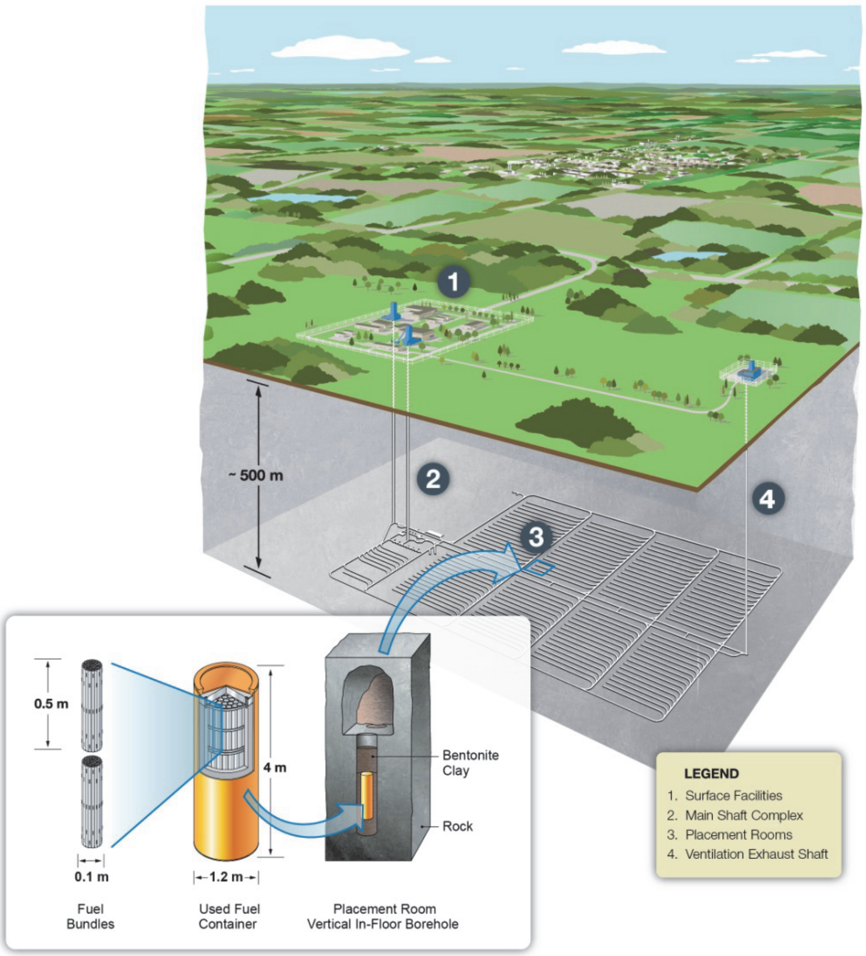


Figure 3-2: Illustration of an APM Facility

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.

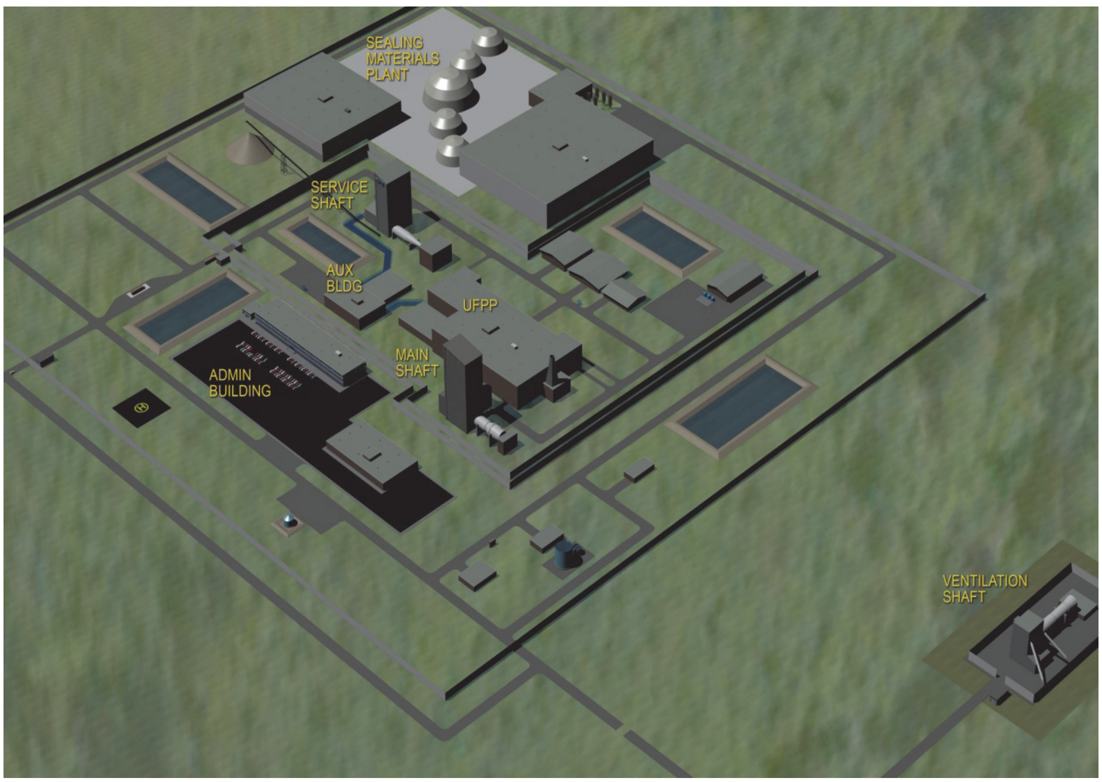


Figure 3-3: APM Surface Facilities

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.

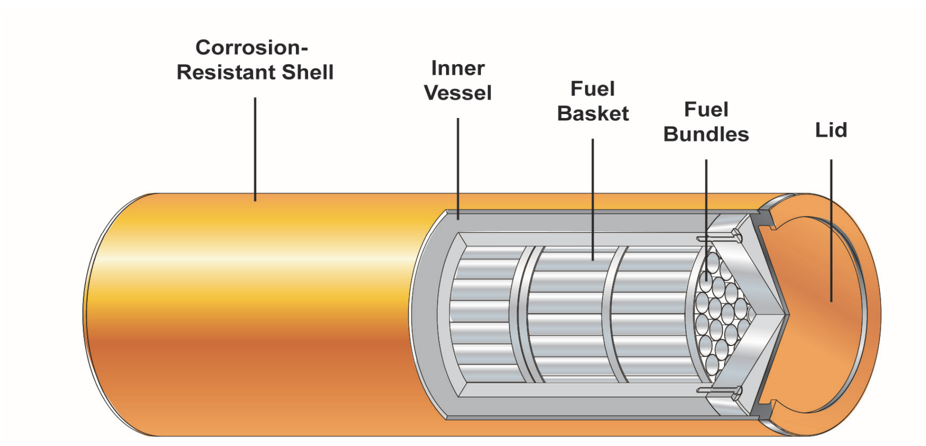


Figure 3-4: Example of a Used Fuel Container for a Deep Geological Repository

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.

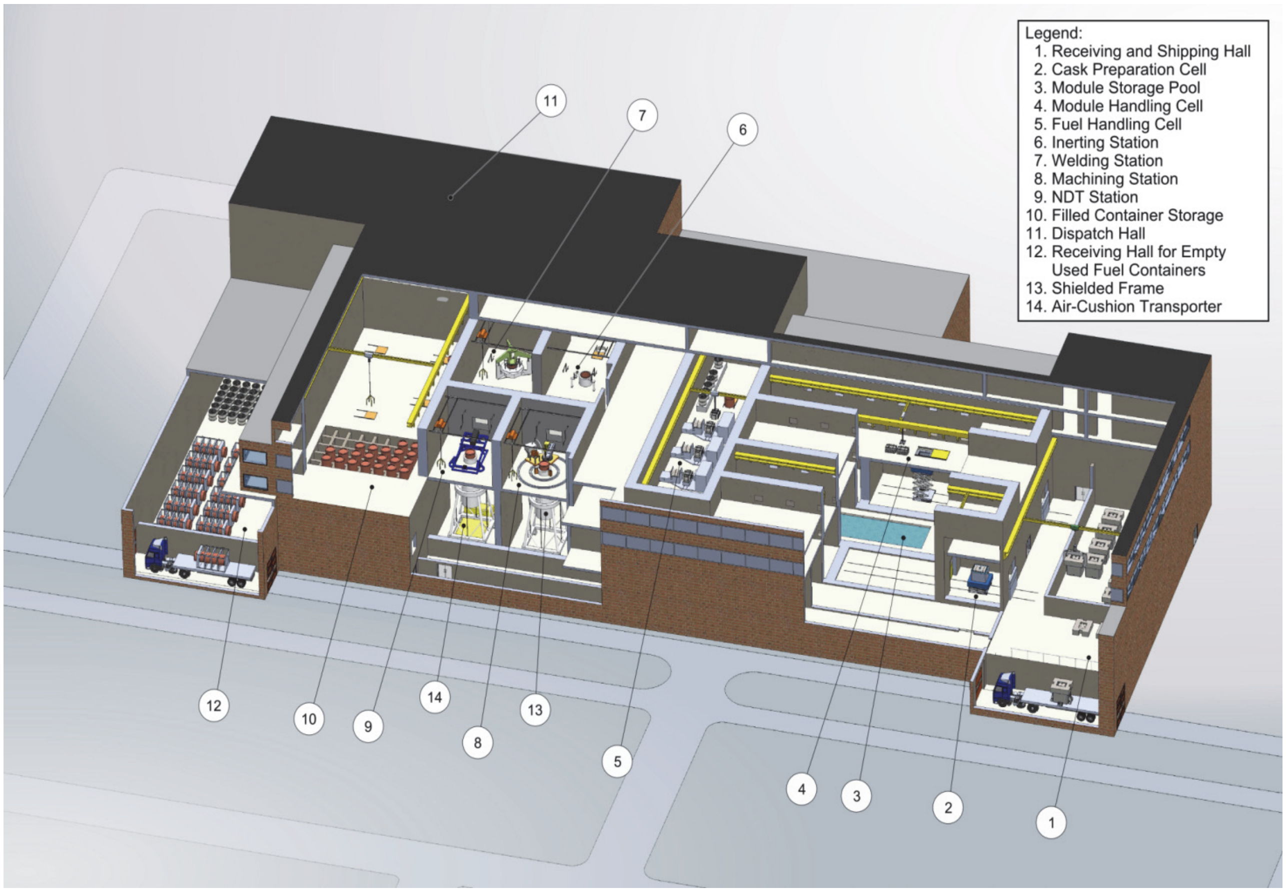


Figure 3-5: Conceptual Layout of a Used Fuel Packaging Plant

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 may 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

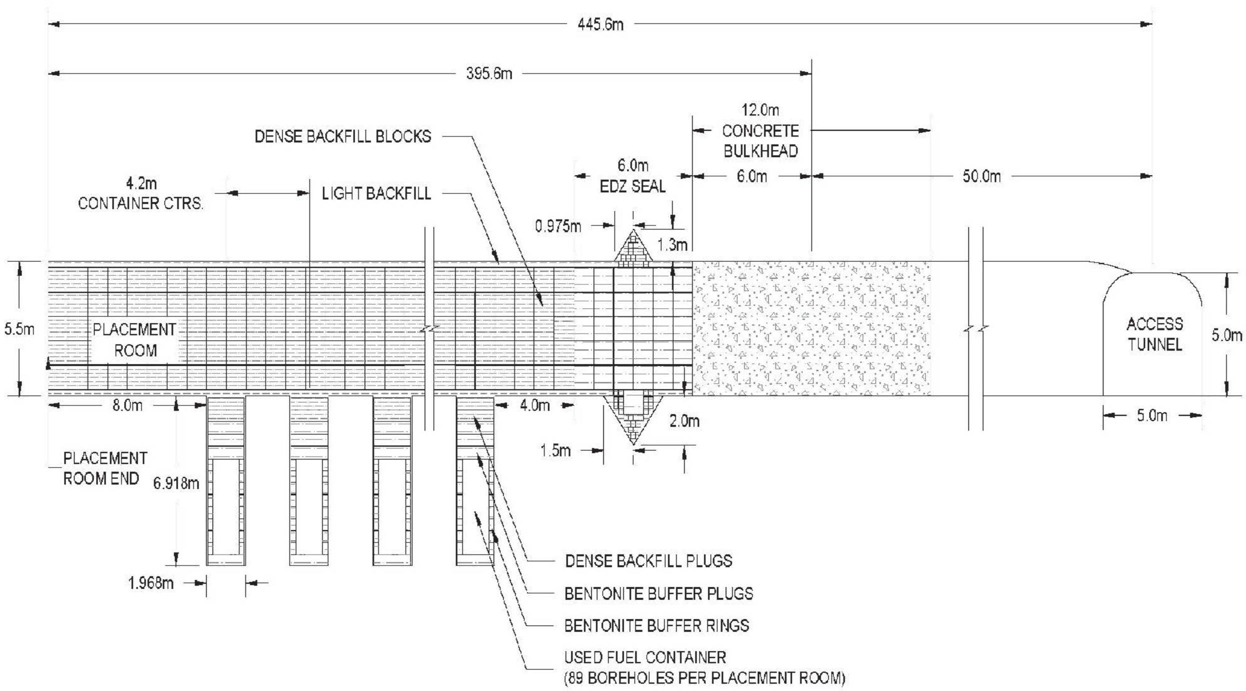
The deep geological repository is a network of underground tunnels, placement rooms for used fuel containers, supporting infrastructure, and provision for an underground facility for site-specific demonstration of repository technology.

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.

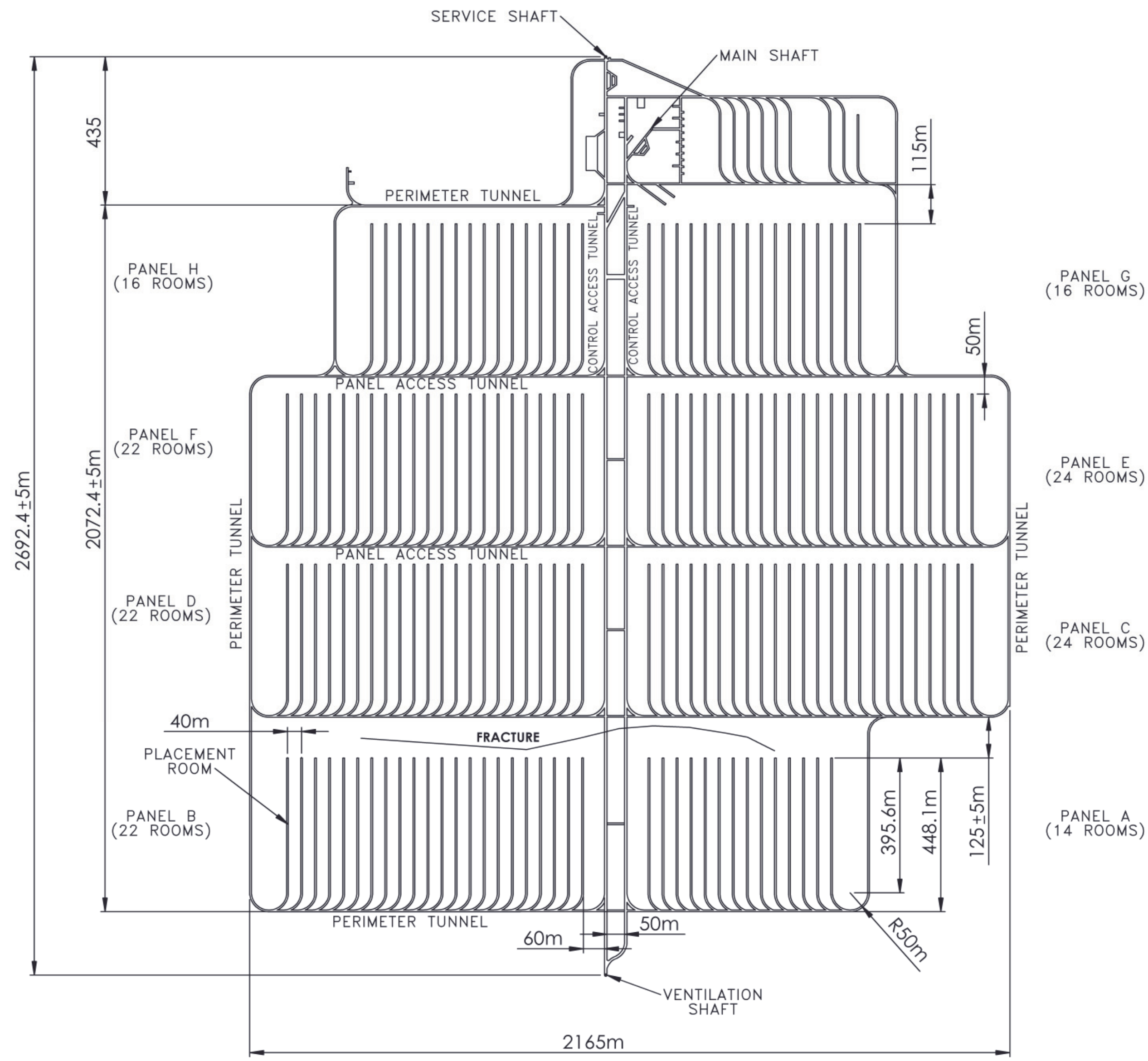


Figure 3-8: Example Underground Layout for a Deep Geological Repository

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 White River Area

The Township of White River and the surrounding region is located on the Canadian Shield in an area that is characterized by moderate relief which is amenable for the construction of an APM facility. The White River area contains existing infrastructure that could be used for the APM Project, including a highway and a high-voltage transmission line. In addition, a major rail line passes through the White River 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 White River 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 a cost estimate included for financial planning purposes.

3.8 Engineering Costs for White River

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 White River – 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 White River 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.

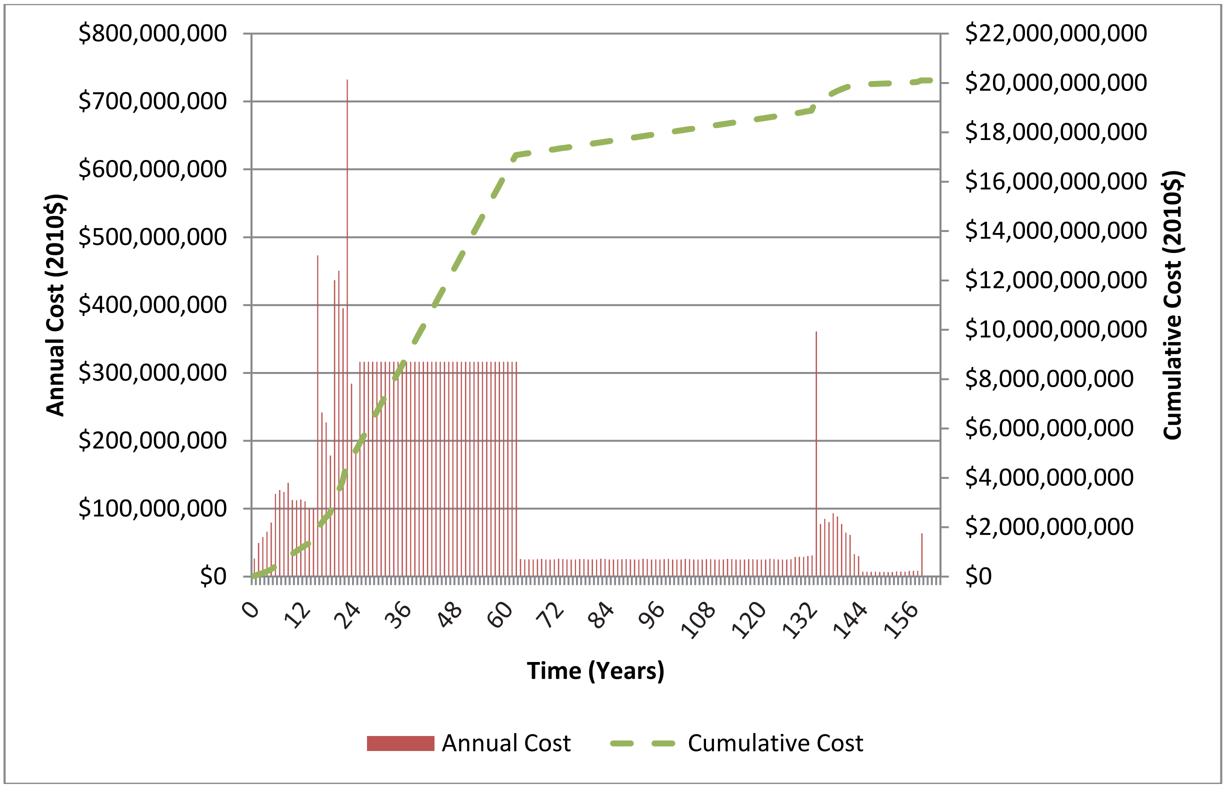


Figure 3-9: APM Cost Estimate for a Deep Geological Repository in White River

3.9 Engineering Findings

The engineering assessment of the White River area found that the APM facility has the potential to be safely constructed and operated. The surface land is characterized by moderate 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 Township of White River is located close to key infrastructure for the APM facility, including highways and a high-voltage transmission line. 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 desktop geoscientific preliminary assessment is to assess whether the White River area contains 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 desktop geoscientific preliminary assessment conducted by AECOM Canada Ltd. (AECOM, 2014a). The assessment focused on the Township of White River and its periphery, which are referred to as the “White River area” (Figure 4-1). The boundaries of the White River area shown on Figure 4-1 have been defined to encompass the main geological features within the Township and its surroundings.

The desktop geoscientific preliminary assessment built on the work previously conducted for the initial screening (Golder, 2012) 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 (AECOM, 2014a) and three supporting documents: Terrain Analysis (AECOM, 2014b); Geophysical Interpretation (PGW, 2014); and Lineament Interpretation (SRK, 2014).

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 cylces?
- ***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 White River 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 White River area (Section 4.3), followed by a summary of the geoscientific assessment of suitability (Section 4.4).

4.3 Geoscientific Characteristics of the White River Area

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

4.3.1 Physical Geography

A detailed discussion of the physical geography of the White River area is provided in the terrain analysis report (AECOM, 2014b). The White River area lies within the Abitibi Upland physiographic region (Thurston, 1991), a subdivision of the extensive James physiographic region (Bostock, 1970). The region is generally characterized by abundant bedrock outcrop with shallow drift cover and a rugged topography. Bedrock-controlled terrain dominates the majority of the area and results in significant differences in elevation over short distances; the maximum relief within the White River area is approximately 311 metres (Figure 4-2). The highest point of land within the area, 622 metres above sea level, occurs approximately 13 kilometres northeast of the settlement area of White River, and the lowest point (311 metres above sea level) is the level of Kabinakagami Lake in the northeast corner of the White River area. Notable variations in elevation caused by the relief of the bedrock surface are prevalent throughout the majority of the White River area. The White River area can be viewed as consisting of a broad, dissected plateau which has higher elevations in the western and southern regions and a lower ground surface along its northern boundary (AECOM, 2014b).

Waterbodies within the White River area occupy approximately 10 per cent (514 square kilometres) of the land surface (Figure 4-1). While the lakes are widespread, lake density is greatest in areas of high elevation and relief and, as such, more lakes occur in bedrock-dominated terrain in the southern and west-central portions of the area. In general, the lakes are of a modest size with the majority having a surface area of less than two square kilometres.

Seven of the lakes are larger than 10 square kilometres, and four of them are larger than 20 square kilometres (AECOM, 2014b).

4.3.2 Bedrock Geology

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

Geological mapping at a regional scale (1: 250,000) is available for the entire White River area (OGS, 2011). Recent mapping of the White River area, largely completed by the Ontario Geological Survey (OGS) and the Geological Survey of Canada (GSC), is of varying detail depending on scale, but is considered to be of high quality (e.g., Williams, 1989; Card, 1990; Williams *et al.*, 1991; Muir, 2000; 2003). Low-resolution magnetic data from the GSC (Ontario #8 and #17) provides complete coverage of the entire White River area (GSC, 2013). Higher resolution geophysical surveys from the OGS (Oba-Kapuskasing Survey, Manitouwadge Survey, and Hemlo Survey) provide coverage for the area, and consist of three magnetic and frequency-domain (FDEM) surveys. These were flown at a lower terrain clearance (45 and 55 metres) compared to the GSC surveys, and with flight line spacing of 200 metres and 100 metres (OGS, 2002a; 2002b; 2003). One covers the northwest part of the White River area, and two additional surveys extend into the area to the northeast and southwest, focused on greenstones. In addition, the OGS Assessment File Research Imaging (AFRI) database was queried for airborne geophysical surveys located within the White River area, and 23 files were downloaded for review (PGW, 2014).

As shown on Figure 4-3, the main geological units in the White River area include the intrusive graintoid rocks of the Black-Pic and Pukaskwa batholiths, several smaller granitoid intrusions (e.g., Strickland, Anahareo Lake plutons), the supracrustal rocks of the Dayohessarah and Kabinakagami greenstone belts, and several suites or swarms of mafic diabase dykes.

The initial screening (Golder, 2012) indicated that there were large areas within the Township of White River and its periphery that were potentially suitable for hosting a deep geological repository. The Black-Pic batholith, Pukaskwa batholith, Strickland pluton, and Anahareo pluton were considered as potentially suitable host rocks. Rocks of the Dayohessarah and Kabinakagami greenstone belts were not considered suitable due to their heterogeneity, structural complexity, and potential for mineral resources.

The Black-Pic batholith is a large, regionally-extensive intrusion that encompasses a roughly 3,000 square kilometre area within the Wawa Subprovince. In the White River area, the batholith is described as a gneissic tonalite in a compilation map of Santaguida (2001); however, Fenwick (1967), similarly to Milne (1968), mapped the batholith as uniform, biotite granitic gneiss and biotite granite which becomes gneissic near the boundary with the Dayohessarah greenstone belt. Fenwick (1967) also noted the occurrence of migmatites composed of highly altered remnants of pre-existing volcanic and sedimentary rocks mixed with variable amounts of granitic material. In general, much of the variability in magnetic responses shown within the Black-Pic batholith presumably corresponds to numerous generations of intrusions as well as younger granitic rock phases identified within the batholith (Jackson *et al.*, 1998; Zaleski *et al.*, 1999). The gravity response over the Black-Pic batholith suggests that the

Black-Pic batholith may be composed of denser rock or may reflect a thinner intrusive unit compared to others in the White River area (PGW, 2014).

The Pukaskwa batholith is a large, regionally-extensive intrusion covering an area of at least 5,000 square kilometres in the Wawa subprovince. The Pukaskwa batholith extends over a large portion of the south-central portion of the White River area (Figure 4-3), and is described as comprising foliated tonalite and gneissic tonalite suites (Santaguida, 2001). Regionally, the Pukaskwa batholith is a multi-phased intrusion emplaced over an extended period of time (Stott, 1999; Beakhouse and Lin, 2006; Beakhouse *et al.,* 2011). The oldest and most abundant of the phases is a group of gneissic, well-foliated tonalite to granodioritic rocks. Another phase consists of foliated granodiorite to quartz-monzodiorite that is widespread but volumetrically limited. The youngest phase comprises a group of granodioritic to granitic units that form large, homogeneous plutons and small dykes. A fairly uniform and weak background magnetic response exists within the northern Puskawa batholith. To the east, a large area of fairly uniform and low background magnetic response is associated with the gneissic tonalite suite that extends east and northeast of White River within the Pukaskwa batholith (PGW, 2014). The slightly higher magnetic responses within the Pukaskwa batholith at the southern edge of the White River area may reflect a subtle increase in background magnetic response reflecting the increased presence of magnetic minerals of the bedrock lithology, as well as locally an increased response from the diabase dykes present. Along the northern part of the Pukaskwa batholith, a relatively strong magnetic response extends over the mapped boundary into the Black-Pic batholith (PGW, 2014).

The Strickland pluton occurs in the northeast portion of the White River area bordering the greenstone belts. The pluton occupies an area of approximately 600 square kilometres and has maximum dimensions in the area of 34 kilometres north-south and 55 kilometres east-west (Figure 4-3). Stott (1999) described the Strickland pluton as a relatively homogeneous, quartz porphyritic granodiorite, although near the outer margin of the pluton, adjacent to the greenstone belt, granodiorite to tonalite and diorite are present. The major portion of the mapped Strickland pluton shows a high background magnetic intensity and the magnetic field decreases gradationally to the southwest which reflects, at least partially, a reduced number of northwest-striking dykes (PGW, 2014).

The Anahareo Lake pluton is a large felsic intrusion of which approximately 690 square kilometres located within the southern and southeastern parts of the White River area (Figure 4-3). The intrusion was mapped by Siragusa (1977; 1978) as being dominantly granodiorite and quartz monzonite.

The bedrock geology of the Anahareo Lake pluton shows a fairly uniform distribution of weak magnetic response. A regional gravity low correlates well with a granite-granodiorite phase of the Anahareo Lake pluton, suggesting that the Anahareo Lake pluton thickens in that area (PGW, 2014).

Several generations of Paleoproterozoic and Mesoproterozoic diabase dyke swarms crosscut the White River area (Figure 4-3), including: the Matachewan Suite, the Marathon Suite dykes, the Biscotasing Suite dykes, the Sudbury Suite dykes, and the Abitibi Suite dykes.

4.3.3 Quaternary Geology

The terrain analysis report (AECOM, 2014b) provides a detailed description of the Quaternary geology of the White River area. Quaternary deposits in the White River area comprise different types of glacial deposits that accumulated with the progressive retreat of the Laurentide Ice Sheet during the end of the Wisconsinan Glaciation (AECOM, 2014b).

As shown on Figure 4-4, the majority of the White River area consists of extensive tracts where bedrock is at or near surface. It is common in these areas of bedrock terrain for the rock to be overlain by a veneer, or in some instances a blanket, of overburden, most frequently ground moraine (till). The overburden is often in the range of one to three metres in thickness; however, on the sides of some of the bedrock hills, and in the low areas between hills, the overburden can thicken to as much as five metres. Valleys and lowland areas typically have extensive and thicker surficial deposits (morainal, glaciofluvial, glaciolacustrine and organic) that frequently have linear outlines. The drill hole database maintained by the Ministry of Northern Development and Mines (2013) contains records of 299 drill holes that are predominantly located over mafic metavolcanic rocks in the White River area. The average depth of overburden recorded in the drill logs is 8.1 metres, with approximately 41 per cent of the holes having less than three metres of overburden.

4.3.4 Structural Geology

4.3.4.1 Mapped Faults

Mapped regional structures in the White River area include a limited number of unnamed faults as well as a series of dykes and sills that may reflect regional tectonic events (Figure 4-3). Mapped faults generally have either a northwest- or northeast-trending orientation, although a grouping of semi-circular faults is present west of Dayohessarah Lake (OGS, 2011). The origin and geologic description of these semi-circular features is largely unknown.

In addition to mapped faults, several generations of diabase dykes intrude the rocks of the White River area. The five dyke swarms in the White River area are generally distinguishable by their unique strike directions, crosscutting relationships and, to a lesser extent, by magnetic amplitude. The Matachewewan Suite is most predominant of all dyke swarm recognized in the White River area. Individual dykes are generally up to 10 metres wide, and can be up to several 10s of kilometres in length.

4.3.4.2 Lineament Interpretation

A detailed lineament study was conducted for the White River area using multiple datasets (SRK, 2014). 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 remote sensing data consisting of 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 White River area. The observed density and distribution of surficial lineaments is influenced by overburden coverage, which masks surface expressions of potential fractures.

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 White River area are shown on Figure 4-6. The figure shows that the density of geophysical lineaments is lower in areas of low resolution such as in the northwest portion of the White River area. This observation suggests that the other rock bodies in the White River area may have a similar geophysical lineament density as where high resolution aeromagnetic data are available.

Figures 4-5 and 4-6 also show the classification 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. A notable decrease in lineament density occurs when only those lineaments of greater than kilometres are considered. When lineaments greater than10 kilometres are considered, density across the area is generally low.

4.3.5 Erosion

There is no site-specific information on erosion rates for the White River 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 glaciations. 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 3 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 White River 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 2013 in the White River area (Earthquakes Canada, 2013).). Three earthquakes with Nuttli magnitudes between 2.2 and 2.5 have been recorded; two were centred west of Kabinakagami Lake and the other along Trans-Canada Highway 17 west of the Township. Other seismic events in close proximity to the area have epicentres approximately 12 kilometres to the north (magnitude 2.6), and 27 kilometres to the west (magnitude 2.1).

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 White River 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 isostatic rebound is still occurring across most of Ontario. Present-day uplift rates are about 10 milimetres per year near Hudson Bay, where the ice was thickest at the last glacial maximum (Sella et al., 2007). 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. Current rates of isostatic uplift in the White River area are not precisely known, although Lee and Southam (1994) estimated that the land is rising at a rate of 2.9 millimetres per year at Michipicoten, Ontario, some 260 kilometres to the southeast.

No neotectonic structural features are known to occur within the White River area. McMurry et al. (2003) summarized several studies conducted in a number of other granitic intrusions in the Canadian Shield and in the crystalline basement in western Ontario. 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 on groundwater in the White River area was obtained from the Ontario Ministry of the Environment (MOE) Water Well Record (WWR) database (MOE, 2013). The Township of White River obtains its municipal water supply from Tukanee Lake, located five kilometres north of the settlement area, and from groundwater sources; however, a small number of wells exist in the White River area serving individual private residences. The vast majority of the water wells are located within the community of White River, in close proximity to Highways 17 or 631. Figure 4-4 shows the location of water wells in the White River area. The MOE water well database contains a total of 31 water well records for the White River area for which useful information is available (wells with no recorded depth are excluded). A summary of these wells is provided in Table 4-1 below.

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

Water Well Type	Number of Wells	Total Well Depth (metres)	Median Well Depth (metres)	Static Water Level (metres below ground surface)	Tested Well Yield (litres per minute)	Depth to Top of Bedrock (metres)
Overburden	15	4.6 to 38.7	16.5	0.9 to 3.0	4.5 to 909	N/A
Bedrock	16	15 to 99.1	36.8	1.2 to 8.5	4.5 to 1,250	1.5 to 27.1

4.3.7.1 Overburden Aquifers

There are 15 water well records in the White River area that extract groundwater from an overburden aquifer. Water wells confirmed to be developed in overburden are largely within glaciolacustrine deposits in the central portion of the Township of White River, and have depths of between 4.6 and 38.7 metres below ground surface indicating that bedrock is at a greater depth (MOE, 2013). Wells terminating in sand and gravel have reported test pumping rates of 4.5 to 909 litres per minute; however, these yields may not be reflective of aquifer capacity, as the wells primarily supply residences with limited demand. Static water levels in the wells are shallow, ranging from 0.9 to 3.0 metres below ground surface. The limited number of well records limits the interpretation of available information regarding the extent and characteristics of overburden aquifers in the White River area.

4.3.7.2 Bedrock Aquifers

No information was found on deep bedrock groundwater conditions in the White River area at a typical repository depth of approximately 500 metres. Within the White River area, 16 water wells are recorded as being developed in bedrock (MOE, 2013). These wells encountered bedrock at depths ranging from 1.5 to 27.1 metres below ground surface, and have maximum depths of between 15.0 and 99.1 metres below ground surface. The Ontario Ministry of the Environment (MOE) Water Well Records (WWR) indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the White River area or anywhere else in northern Ontario.

4.3.7.3 Regional Groundwater Flow

There is little known about the hydrogeologic properties of the deep bedrock in the White River area, as no deep boreholes have been drilled for this purpose. 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 and resulting in diffusion-dominated groundwater movement (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 White River area would need to be evaluated at later stages of the assessment, through the collection of site-specific information.

4.3.8 Hydrogeochemistry

No information on groundwater hydrogeochemistry was found for the White River 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 advective 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 advective 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 3 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).

4.3.9 Natural Resources

Information regarding the mineral resource potential for the White River area was obtained from a variety of sources, as described by AECOM (2014a). Figure 4-8 shows the areas of active exploration interest based on active mining claims, as well as known mineral occurrences identified in the Ontario Geological Survey Mineral Deposit Inventory Version 2 (MNDM, 2013). There are currently no producing metallic mineral mines in the White River area. The only mine to briefly operate in the area was the Hiawatha Gold Mine, located in the Kabinakagami greenstone belt. There is the potential for economically exploitable base and precious metal mineralization within the greenstone belts and mineral exploration is active (MNDM, 2013). Metallic mineral occurrences in the White River area include: gold, base metals, and platinum group metals. All these occurrences are considered to be of sub-economic potential.

The Ontario Ministry of Natural Resources (MNR, 2013) records indicate that 21 sand and gravel pits are licensed under the *Aggregate Resources Act* in the White River area. Seven of the pits are located in the vicinity of the settlement area of White River or along Trans-Canada Highway 17 to the west of the town. The potential for a building stone extraction in the White River area has been recognized, and regional investigations of the bedrock have been conducted and reported on by the Ontario Geological Survey. While the potential for a building stone quarry in the White River area exists, past exploration activity has been limited. To date, no reports of kimberlite intrusions, with which diamonds are associated, have been reported in the White River area. No record of peat extraction exists for the White River area. Organic deposits in the area are of small to moderate size, and appear to hold limited potential for development (Monenco Ontario Limited, 1981).

The White River 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 and Thermal Properties

There is no readily available geomechanical information on the potentially suitable bedrock units in the White River area. However, there is a fair amount of data from comparable geologic units in the Canadian Shield that can provide insight into the possible rocks mass properties in the White River area (AECOM, 2014a). There are also no site-specific thermal conductivity values for the White River area. Some useful generic comparisons are provided in a summary of thermal conductivity values for two granitic intrusions of the Canadian Shield in the main geoscientific suitability report (AECOM, 2014a). Site-specific geomechanical thermal and thermal properties of the potentially suitable geological units within the White River area would need to be investigated during subsequent field evaluations stages.

4.4 Potential Geoscientific Suitability of the White River Area

This section provides a summary of how key geoscientific characteristics were applied to the White River 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 the 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 (Golder, 2012) were not considered. Such areas include rocks of the Dayohessarah and Kabinakagami greenstone belts and detached fragments, which were not considered suitable due to their heterogeneity, structural complexity and potential for mineral resources. Areas containing small greenstone and gabbroic bodies were also not considered due to their small size and/or potential geological heterogeneity/structural complexity. In the White River area, the Black-Pic batholith, Pukaskwa batholith, Anahareo pluton, and Strickland pluton were considered as potentially suitable host rocks (Figure 4-3). Within these intrusions, the geophysical data were examined (PGW, 2014), such that areas with "quiet" aeromagnetic signatures were favoured. These intrusions were further evaluated on the basis of the subsequent considerations.

- ***Structural Geology:*** Areas within or immediately adjacent to regional faults were considered unfavourable. Published bedrock geology maps of the area indicate a limited number of faults in the area that generally trend either northwest or northeast. A group of semi-circular faults that occurs west of Dayohessarah Lake (Figure 4-3) was avoided. The thicknesses of the batholiths and plutons in the White River area are unknown and were therefore not a differentiating feature.

- ***Lineament Analysis:*** In the search for potentially suitable areas, there is 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 is considered that areas covered by more than 2 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., in Finland; POSIVA, 2007). At this stage of the assessment, preference was given to areas with greater mapped bedrock exposures. The extent of bedrock exposure in the White River 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 geologic mapping.

- ***Protected Areas:*** All provincial parks and conservation reserves within the White River area were excluded from consideration in the selection of potentially suitable areas. Five protected areas were identified as being completely or partially within the White River area. These features occupy a combined total of approximately 175.7 square kikometres (Figure 4-1). The Kwinkwaga Ground Moraine Conservation Reserve accounts for the majority of this total as it covers an area of 126.5 square kilometres.

- ***Natural Resources:*** The potential for natural resources in the White River area is shown on Figure 4-8. As noted above, the Dayohessarah and Kabinakagami greenstone belts have known potential for exploitable natural resources and were not considered due to its unfavourable geology. Gabbroic bodies were also excluded from consideration based on their potential to host base metal and/or PGE mineralization. The mineral potential of the potentially suitable geological units identified above is considered to be low. At this stage of the assessment, areas of active mining claims located in geologic environments judged to have low mineral resource potential were not systematically excluded.

- ***Surface Constraints:*** Areas of obvious topographic constraints (density of steep slopes), large water bodies (wetlands, lakes), and accessibility were considered for the identification of potentially suitable areas. While areas with such constraints were not explicitly excluded at this stage of the assessment, they are considered less preferable, all other factors being equal. The White River area is moderately rugged as bedrock dominated regions have a knobby topography with local areas of significant relief present across the area (Figure 4-2). While the lakes are widespread, lake density is greatest in areas of high elevation and relief and, as such, more lakes occur in bedrock dominated terrain in the southern and west-central portions of the area. Only in a few areas does size of water bodies or the concentration of smaller lakes affect the placement of general potentially suitable areas. Large organic deposits are found only in the north-central portion of the area where it is presumed they are underlain by fine-grained sediments (Figure 4-4).

The consideration of the above key geoscientific characteristics and constraints revealed that the White River area contains at least four general areas that may warrant further consideration. These general areas are located within the Pukaskwa batholith and the Anahareo Lake and Strickland plutons. Interpreted surficial and geophysical lineaments are shown in Figures 4-5 and 4-6, respectively. The other key geoscientific characteristics are shown on Figure 4-9 and Figures 4-10 to 4-12 for each identified general potentially suitable area.

At this early stage of the assessment, the boundaries of the identified general potentially suitable areas are not yet defined. The location and extent of specific potentially suitable areas would need to be refined through more detailed assessments and field evaluations.

4.4.1.1 Potentially Suitable General Areas within the Pukaskwa Batholith (Figure 4-10)

The Pukaskwa batholith is an approximately 2.720 to 2.680 billion year old gneissic complex covering 1,392 square kilometres of the southwest quadrant of the White River area. As discussed in Section 4.3.2, the batholith consists of gneissic, well-foliated tonalite to granodioritic rocks. The thickness of the batholith in the White River area is not known, but it is expected to be greater than three kilometres based on the interpretation of regional gravity data (PGW, 2014) and the regional geological model for the area (Beakhouse et al., 2011). The northern boundary of the Pukaskwa batholith with the Black-Pic batholith is arbitrarily placed at the mapped contact of the gneissic and foliated tonalite suites north of Trans-Canada Highway 17. The gneissic tonalite suite east of the settlement area of White River, between the Anahareo Lake and Strickland plutons, is considered to be part of the Pukaskwa batholith, although its boundaries are poorly mapped.

The Pukaskwa batholith has low potential for natural resources and is mostly free of significant surface constraints (i.e., topography and large water bodies). Three protected areas overlie parts of the batholith: the Pokei Lake/White River Wetlands Provincial Nature Reserve, the Kakakiwibik Esker Conservation Reserve, and the Kwinkwaga Ground Moraine Conservation Reserve. Identification of potentially suitable areas outside protected areas within the Pukaskwa batholith was mainly based on geological setting, lineament analysis, and overburden cover.

The assessment of the key geoscientific characteristics identified one general potentially suitable area, referred to herein as the southwest Pukaskwa area, which is entirely within the Pukaskwa batholith's foliated tonalite suite (Figure 4-3). The general potentially suitable area is located southwest of the settlement area of White River, and extends from Lost Lake in the north to the southern boundary of the area with Pickerel and Whitefish lakes being the approximate western and eastern limits, respectively (Figure 4-10). The magnetic signature over the southwest Pukaskwa area, while moderately noisy, is more active in the southern half of the area. As the area is only covered by a low-resolution geophysical survey (805 metres line spacing), detail is lacking in the processed magnetic images. A regional gravity low is present across the southwest Pukaskwa area suggesting that the batholith may extend to a considerable depth (PGW, 2014). The general potentially suitable area has good bedrock exposure, contains no mapped faults and is distal to major regional structures; the Wawa-Quetico Subprovince boundary is approximately 78 kilometres to the north and the Agawa Canyon Fault is approximately 63 kilometres to southeast.

The general area identified in the Pukaskwa batholith was based, in part, on the analysis of interpreted lineaments completed by SRK (2014). Figure 4-6 shows a limited number of geophysical lineaments throughout those parts of the batholith. The low density of geophysical lineaments, however, is presumably due in a large part to the low resolution of the available aeromagnetic data rather than the absence of brittle structures. The spacing between the longer geophysical lineaments (i.e., greater than 10 kilometres) in the general potentially suitable area ranges from approximately 1.5 to six kilometres (SRK, 2014). Virtually all the geophysical lineaments in the southwest Pukaskwa area exceed 10 kilometres in length and most likely represent dykes (Figures 4-6 and 4-10). Interpreted dykes within the area are generally consistent with those mapped by the Ontario Geological Survey (Figure 4-3). The dominant orientation of longer geophysical lineaments in the Pukaskwa batholith is northwest, with a far lesser number trending northeast.

The assessment of potentially suitable areas within the Pukaskwa batholith also took into consideration interpreted surficial lineaments. Thin overburden cover and areas of outcrop enabled a detailed assessment of the bedrock structure of the southwest Pukaskwa area and indicated it has a low to moderate density of surficial lineaments (Figure 4-5). At the desktop stage, it is uncertain whether surficial lineaments represent real bedrock structure and how far they extend to depth, particularly in the shorter lineaments.

Figures 4-5 and 4-6 also show lineaments classified by length (one kilometre, five kilometres, and 10 kilometres). The density of lineaments in the southwest Pukaskwa area decreases only slightly when the less than one kilometre long lineaments are not considered, indicating their small population. A notable decrease in density occurs when the lineaments less than five kilometres in length are not considered. The filtering out of the less than10 kilometres long features results in another visible, but less dramatic, decrease in density.

The current assessment revealed that dykes tend to have well-defined orientations, consistent with the geological history of the area (SRK, 2014). There remain some uncertainties, however, regarding the nature and distribution of the dykes. For example, the potential existence of thin dykes, which are too small to be identified with any confidence from the geophysical data, cannot be ruled out. Another aspect of uncertainty associated with the presence of dykes relates to understanding the extent of damage to the host rock as a result of dyke emplacement. It is well understood, but not easily quantifiable from geophysical data alone, that dyke propagation will induce damage to the host rock within an envelope around the dyke that varies with the size of the intrusion (e.g., Meriaux et al., 1999).

The southwest Pukaskwa batholith general potentially suitable area consists entirely of Crown Land and does not contain any protected areas (Figures 4-1 and 4-10). The mineral potential of the southwest Pukaskwa area is considered to be low based on the geologic setting and a lack of recorded mineral occurrences. A number of recently staked mining claims are present in the batholith west of the Township of White River; however, no information exists on the commodity of interest (Figure 4-8 and 4-10). These mining claims are not thought to impact the potential suitability of the southwest Pukaskwa area, as they are located in a geological environment considered to have a low mineral resource potential.

The southwest Pukaskwa area is well-drained by numerous streams, rivers, and lakes. This general potentially suitable area drains to Lake Superior, through the White tertiary watershed, and has permanent water bodies that occupy approximately seven per cent of the land surface (AECOM, 2014). Although the great majority of the southwest Pukaskwa area is classified as bedrock terrain (Figure 4-4) with thin overburden cover, local accumulations of till can reach several metres. Relief in this general potentially suitable area is modest; however, steep slopes of varying heights frequently occur in areas of bedrock dominated terrain. The thickness of glaciofluvial deposits is highly variable, but can achieve depths of up to several tens of metres. The southwest Pukaskwa area is easily accessible by two local roads and a number of trails that branch off from them (Figure 4-1).

Inherent uncertainties associated with the general area in the Pukaskwa batholith relate to lack of detailed geologic mapping, the low resolution of available geophysical data, the potential presence of smaller-scale dykes not identifiable on aeromagnetic data, and the potential damage of the host rock due to dyke emplacement. In addition, uncertainty remains in relation to the lithologic homogeneity at a local scale, to the indigenous fracture pattern within and adjacent to each dyke, and to the related effects on the bulk thermal conductivity of the bedrock.

4.4.1.2 Potentially Suitable General Areas within the Anahareo Lake Pluton (Figure 4-11)

The Anahareo Lake pluton is a relatively uniform felsic intrusion of which approximately 891 square kilometres is located within the southern and southeastern parts of the White River area (Figure 4-3). The multi-phase pluton primarily consists of granodiorite and quartz monzonite. No age date is available for the pluton, and it is assumed, based on regional studies, that it was emplaced between 2.697 and 2.680 billion years ago. However, if, as Siragusa (1978) suggests, it post-dates the major period of tectonism in the area, it may be somewhat younger. The thickness of the Anahareo Lake pluton is not known; however, its size and gravity signature suggest a thickness of several kilometres, far exceeding that required for the construction of a waste repository.

The Anahareo Lake pluton has low potential for natural resources, and is mostly free of protected areas and significant topographic constraints. The percentage of water cover is limited despite the presence of a few larger lakes. Identification of potentially suitable areas within this intrusion was mainly based on geological setting, structural geology, lineament analysis and overburden cover.

Two general potentially suitable areas were identified within the Anahareo Lake pluton and small parts of the adjacent Pukaskwa batholith. One potentially suitable area was identified in the southeast of the Township of White River (referred to herein as the Negwazu Lake area) extending from the Negwazu Lake northward to just south of Highway 631, between Trans-Canada Highway 17 and the White River area boundary east of Negwazu Lake (Figure 4-11). Approximately the northern third of the general potentially suitable area is within the Pukaskwa batholith. The other potentially suitable area is located mainly within the Anahero Lake pluton, east of the Anahareo Lake area (referred to herein as the Anahareo Lake area). The area extends from the southern boundary of the White River area, northwest to the boundary of the pluton and the Pukaskwa batholith. The northeast and southwest edges of the block parallel and are equidistant from a mapped fault south of Anahareo Lake; the northeast boundary is placed just north of Anahareo Lake.

Both general potentially suitable areas have relatively good bedrock exposure with the terrain in a large portion of both areas consisting of bedrock-drift complex (Figure 4-4). The resource potential of both general potentially suitable areas is considered to be low as neither have any mineral occurrences of mining claims despite the fact that the areas are proximal to either or both of the Dayohessarah and Kabinakagami greenstone belts. The Negwazu Lake area contains no mapped faults; a single fault of limited length is present in the Anahareo Lake general potentially suitable area (Figure 4-11). Major regional structures are removed from the areas with the closest one being the Agawa Canyon Fault to the southeast.

The magnetic signature is relative quiet for the Negwazu Lake general potentially suitable area and moderately noisy for the Anahareo Lake general potentially suitable area. Detail in the magnetic signature of the two areas is limited as the areas are covered by low resolution geophysical surveys. The fact that the general potentially suitable areas are positioned within a negative gravity anomaly, which includes most of both the Anahareo Lake pluton and the Pukaskwa batholith, suggests that the intrusions have considerable thickness, perhaps of several kilometres (PGW, 2014).

The analysis of interpreted lineaments enables additional insight to be gained into the potential suitability of the two general potentially suitable areas identified within the Ahanareo Lake pluton. The Negwazu Lake and Anahareo Lake general potentially suitable areas both have a low apparent geophysical lineament density as interpreted from the regional scale magnetic coverage (Figure 4-6). The low density of geophysical lineaments, however, is presumably due in a large part to the low resolution of the available aeromagnetic data rather than the absence of brittle structures. The majority of the geophysical lineaments identified within the general potentially suitable areas have a length of greater than five kilometres and have a northwest orientation. The spacing between the longer geophysical lineaments (i.e., greater than 10 kilometres) in the two general potentially suitable areas ranges between approximately two and eight kilometres; shorter lineaments have a closer spacing (SRK, 2014). In the Negwazu Lake general potentially suitable area, the longer geophysical lineaments have both northwest and northeast orientations, while in the Anahareo Lake general potentially suitable area, lineaments of this length only trend northwest.

Surficial lineaments density in the Negwazu Lake and Anahareo Lake general potentially suitable areas is low and low-to-moderate, respectively (Figure 4-5). Outcrops and broad expanses of thin overburden cover allow an assessment of the bedrock structure of those portions of the Anahareo Lake pluton and Pukaskwa batholith within the general potentially suitable areas. A zone with a slightly lower density of surficial lineaments, located northwest of Anahareo Lake, is likely due to the presence of a broad area of glaciofluvial sediments the thickness of which masked the bedrock and hindered the identification of lineaments. As is previously noted, there is a degree of uncertainty as to whether the surficial lineaments represent bedrock structures extending to depth.

Figures 4-5 and 4-6 also show lineaments classified by length (one kilometre, five kilometres, and 10 kilometres). There is a negligible decease in density of lineaments for the Negwazu Lake and Anahareo Lake general potentially suitable areas when lineaments of less than one kilometre long are not considered. A notable decrease in density takes place when the less than five kilometres lineaments are not considered. Another marked, but less significant, drop in lineament density occurs when not considering the less than 10 kilometres long features. With the removal of the less than 10 kilometres lineaments, the two general potentially suitable areas in the Anahareo pluton and adjoining portions of the Pukaskwa batholith have very low lineament densities.

As noted in the discussion of the Pukaskwa batholith, all the White River area, including the Anahareo Lake pluton, contains numerous mapped and interpreted dykes as the area is within regional dyke swarms (Figures 4-3 and 4-6). Within the two general potentially suitable areas, northwest-oriented dykes interpreted from the surficial data were generally consistent with mapped dykes. Although a small number of northeast trending dykes were identified from the surficial data sets, the agreement with mapped dykes was poor. The previously noted uncertainties regarding the identification, distribution, and structural impact of the dykes would need to be assessed during subsequent site evaluation stages. This would include an understanding of the indigenous fracture pattern within and adjacent to each dyke, and the related effects on the bulk thermal conductivity of the bedrock.

The two general potentially suitable areas identified in the Anahareo Lake pluton and small areas of the Pukaskwa batholith consists entirely of Crown Land and do not contain any protected areas (Figure 4-1). The areas are deemed to have low potential for natural resources as no mineral occurrences or mining claims are documented near the areas (Figure 4-8). The Negwazu Lake and Anahareo Lake general potentially suitable areas are well-drained by numerous streams, rivers, and lakes, with permanent water bodies occupying approximately 13 and 10 per cent of the surface area, respectively. The Negwazu Lake general potentially suitable area straddles the continental divide with the great majority of the general potentially suitable area being within the White tertiary watershed that drains to Lake Superior. The remainder of the Negwazu Lake and all Anahareo Lake general potentially suitable areas drain northeast through the Upper Kabinakagami tertiary watershed to James Bay (AECOM, 2014b). Relief in both general potentially suitable areas is modest; however, the ground surface is rugged with steep slopes (greater than six degrees) occupying approximately 30 per cent of the land surface.

The Negwazu Lake general potentially suitable area is accessible by trails and logging roads branching off Trans-Canada Highway 17 to the west of area, and Highway 631 parallels the northern edge of the area at a reasonably close distance. Additional access is provided by the rail line that traverses the south edge of the area (Figure 4-1). Access can be gained to the Anahareo Lake general potentially suitable area via a major logging road that approaches Anahareo Lake from the south, and forest resource roads that enter the area.

The uncertainties associated with the two general potentially suitable areas identified in the Anahareo Lake pluton relate to the lack of detailed geologic mapping, low resolution of available geophysical data, the potential presence of smaller-scale dykes not identifiable on aeromagnetic data, and the potential damage of the host rock due to dyke emplacement. In addition, uncertainty remains in relation to the litholithic homogeneity and contacts at a local scale. The potential impact of mapped faults in/near the areas would require further assessment.

4.4.1.3 Potentially Suitable General Areas within the Strickland Pluton (Figure 4-12)

The Strickland pluton, located in the north-central portion of the White River area, occupies approximately 783 square kilometres of land between the Dayohessarah and Kabinakagami greenstone belts (Figure 4-3). The pluton is a relatively homogeneous, quartz porphyritic granodiorite that displays a degree of post-emplacement deformation. Although no age date is available for the pluton, its petrographic similarity to the Dotted Lake batholith suggests it may be of the same age, that is, approximately 2.697 billion years old. The thickness of the pluton is unknown; however, a large part of the intrusion occupies a gravity low indicating it extends to a considerable depth.

The Strickland pluton has low potential for natural resources, and is mostly free of protected areas and significant surface constraints (i.e., topography and large water bodies). Identification of potentially suitable areas within this intrusion was mainly based on geological setting, structural geology, lineament analysis, and overburden cover.

One general potentially suitable area was identified in the Strickland pluton, herein referred to as the Nameigos Lake area. The area is bounded by Nameigos and Gourlay lakes to the southeast and northwest, respectively, and extends northeast from the Strickland River Mixed Forest Wetland Conservation Reserve to the Beaton Lake area (Figure 4-12). The Nameigos Lake general potentially suitable area has a quiet aeromagnetic signature, and forms part of a large gravity low that extent northward from the Pukaskwa batholith indicating that the pluton likely extends well below the planned repository depth of approximately 500 metres in this general potentially suitable area (PGW, 2014). The general potentially suitable area is midway between the Wawa-Quetico Subprovince boundary to the north and the Agawa Canyon fault to the south, each of which is roughly 40 kilometres distant. A short west-northwest trending mapped fault is present immediately north of Nameigos Lake.

The identification of the Nameigos Lake area general potentially suitable area was based, in part, on the analysis of interpreted lineaments. Apparent geophysical lineament density is also low for the general potentially suitable area (Figures 4-6 and 4-12) with the longer geophysical lineaments (i.e., greater than 10 kilometres), having a spacing of between 1.5 and seven kilometres, and only a limited number of shorter geophysical lineaments are recognized in the area. However, the low density of geophysical lineaments may be due to, in large part, the low resolution of the available aeromagnetic data rather than the absence of brittle structures. Most geophysical lineaments identified in the Nameigos Lake general potentially suitable area have a northwest orientation.

The general potentially suitable area has a low apparent surficial lineament density (Figure 4-5), such that virtually all mapped dykes are being identified in the surficial data sets. At the desktop stage, it is uncertain whether surficial lineaments represent real bedrock structures and how far they extend to depth, particularly in the shorter lineaments.

Figures 4-5 and 4-6 also show lineaments classified by length (one kilometre, five kilometres, and 10 kilometres). As is the case with other general potentially suitable areas in the White River area, the removal of the less than one kilometre lineaments has little effect on the density given the low number of features of this length. Lineament density decreases significantly after the filtering of the lineaments of less than five kilometres, with a further slight reduction with the removal of the lineaments less than 10 kilometres in length. The progressive filtering indicates that the Strickland pluton in the Nameigos Lake area achieves a low lineament density once lineaments less than five kilometres are removed.

A number of northwest and northeast trending dykes have been interpreted as crossing the Nameigos Lake general potentially suitable area (Figure 4-6). Uncertainties exist in relation to the number, size, and an understanding of possible damage to the host rock resulting from dyke emplacement that would need to be assessed during subsequent site evaluation stages. This would include an understanding of the indigenous fracture pattern within and adjacent to each dyke, and the related effects on the bulk thermal conductivity of the bedrock.

The Nameigos Lake general potentially suitable area consists entirely of Crown Land and contains no protected areas, although a conservation reserve is located immediately to the south (Figure 4-1). No mineral occurrences are present in the general potentially suitable area, but parts of four mining claims cover a minor amount of land in the eastern portion (Figure 4-8). The Nameigos Lake area is generally well-drained by streams and rivers, although small wetlands occur in bedrock basins; approximately 11 per cent of the surface area is covered by permanent water bodies. The general potentially suitable area lies astride the continental divide with over 75 per cent draining to James Bay through either the Nagagami or Upper Kabinakagami tertiary watersheds. The southwestern part of the area drains to Lake Superior via the White tertiary watershed (AECOM, 2014b). The terrain over nearly three-quarters of the Strickland pluton in the Nameigos Lake general potentially suitable area is classified as bedrock-drift complex indicating that the overburden is generally thin and outcrops are common (Figure 4-4). Steep slopes account for a very small percentage (approximately seven per cent) of the surface area (AECOM, 2014b). Access to the potential potentially suitable area is excellent as Highway 631 traverses the area and forest resource roads are present in the northern portion of the area (Figure 4-1).

The uncertainties associated with the general area identified in the Strickland pluton relate to the lack of detailed geologic mapping, the low resolution of available geophysical data, the potential presence of smaller-scale dykes not identifiable on aeromagnetic data, and the potential damage of the host rock due to dyke emplacement. The potential impact of a mapped fault in the area would require further assessment.

4.4.1.4 Other Areas

The Black-Pic batholith occupies a large area in the northwest quadrant of the White River area. Geological mapping (Figure 4-3) and mineral exploration have shown that the batholith contains numerous small fragments of greenstone and gabbroic intrusions in the White River area. Given the geographic extent of this batholith in the White River area, it may be possible to identify additional general potentially suitable areas; for example, along Kabossakwa and Matthews Lakes, there may be areas with potential, considering the low lineament density and bedrock at or near surface around those lake areas. Nevertheless, the four general areas identified are those judged to best meet the preferred geoscientific characteristics outlined in Section 4.4.1, based on available information.

4.4.2 Evaluation of General Potentially Suitable Areas in the White River Area

This section provides a brief description of how the four identified 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 geoscientific information is available, the intent is to assess whether there are any obvious conditions within the identified potentially suitable areas that would fail to satisfy the geoscientific 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.

As discussed in Section 4.3.2, available information reviewed as part of this preliminary assessment indicates that the thickness of the Pukaskwa batholith, and Anahareo Lake and Strickland plutons in the White River area are unknown but are estimated to be well in excess of one kilometre. The Pukaskwa batholith is believed to extend to a depth of greater than three kilometres based on its size and an understanding of the regional geologic history and structure. No information exists on the thickness of the Anahareo Lake and Strickland plutons, but their areal extent and late stage emplacement suggest that these intrusions are likely to extend below typical repository depth (approximately 500 metres). Therefore, the depth of the rock in the four potentially suitable areas would contribute to the isolation of the repository from human activities and natural surface events.

Analysis of lineaments interpreted during this preliminary assessment (Section 4.3.4.2) indicates that the four general potentially suitable areas in the White River area warrant further consideration as they have the potential to contain rock volumes of sufficient size to host a deep geological repository. Given the potential for lithological homogeneity of the Pukaskwa batholith and the Anahareo Lake and Strickland plutons, zones of lower lineament density were the favoured locations for the identified general areas. Within the four general potentially suitable areas, the spacing between longer lineaments (greater than 10 kilometres) was an additional consideration since these were most likely to appear in multiple data sets, and hence most likely to represent real features with a potential to extend to repository depth. In these general potentially suitable areas, longer lineaments occurred with spacing on the order of 1.5 to greater than six kilometres, suggesting there is potential for sufficient volumes of structurally favourable rock at typical repository depth.

As discussed in AECOM (2014a), there is limited information on the hydrogeologic properties of the deep bedrock in the White River 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 also shows that ancient faults and fractures similar to those in the White River area are often sealed by infilling materials, which results in 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, and the thermal and geomechanical properties of the rock, is limited for the White River 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 rocks in the four general potentially suitable areas identified within the White River area (AECOM, 2014a).

Dykes associated with Matachewan, Biscotasing and Marathon dyke swarms have been mapped and/or were identified during the lineament analysis of the White River area. At this desktop stage of the investigation, information about the hydraulic and thermal conductivity properties is lacking, and there is uncertainty as to whether the existence of dykes will have a positive or negative impact on the thermal conductivity of the surrounding host rocks. In addition, the potential existence of thin/narrow dykes, which are too small to be identified with any confidence from the geophysical data, or the presence of damage to the host rock (i.e., additional smaller lineaments) associated with dyke emplacement cannot be ruled out at this time. These aspects of uncertainty would require additional investigation.

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 be 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 desktop preliminary assessment 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 White River area.

The White River area is located in the Superior Province of the Canadian Shield, where large portions of land have remained tectonically stable for the last 2.5 billion years. Although a number of low magnitude seismic events (i.e., less than magnitude 3) have been recorded in the surrounding region, there are no recorded earthquakes with the White River area (Figure 4-7).

A significant nearby regional feature is the east trending Wawa-Quetico subprovince boundary, located approximately 30 kilometres north of the area. In addition, several mapped faults are present within the White River area (Figure 4-3). There is no evidence to suggest these faults have been tectonically active within the past 1.1 billion years. The youngest major event of brittle fault displacement is constrained by the approximately 1.1 billion year old Keweenawan dykes that transect the White River area with no apparent fault offset. This suggests that only limited displacement could have occurred along the interpreted fault network since the intrusion of these dykes. The structural geology of the White River area and associated fracture network will require additional assessments and field evaluations.

The geology of the White River 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 various studies conducted in other areas of the Canadian Shield suggest that deep hydrogeological and hydrogeochemical conditions in crystalline formations, particularly plutonic intrusions, have the potential to remain 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 long-term performance of a repository in the White River area.

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 White River area. The areas are characterized by low 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 potentially suitable geologic units in the White River 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 White River 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 (AECOM, 2014a).

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

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.

In the White River area, the Dayohessarah and Kabinakagami greenstone belts have the greatest mineral potential, with the bedrock comprising the felsic batholiths and plutons having low potential (Section 4.3.9). No known or significant economic mineralization has been identified to date in the Pukaskwa batholith, the Anahareo Lake pluton, and the Strickland pluton within the White River area. Active mining claims exist over the Pukaskwa batholith in area west of the settlement of White River; however, these claims have been staked only relatively recently, and there is no history of exploration for the ground or reported mineral occurrences. Also, the review of available information did not identify any groundwater resources at repository depth for the White River area. As discussed in Section 4.3.7, the Ontario Ministry of the Environment Water Well Records indicate that no potable water supply wells are known to exploit aquifers at typical repository depths in the White River area or anywhere else in northern Ontario. 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.

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.

As described in Section 4.3.2, the bedrock in the two general potentially suitable areas largely within the Anahareo Lake pluton and the single area in the Strickland pluton is relatively homogeneous granite-granodiorite that will not be difficult to characterize. Similarly, the well-foliated tonalite to granodioritic rocks bedrock in the general potentially suitable area in the Pukaskwa batholith should not pose an impediment to site characterization.

Interpreted lineaments represent the observable two-dimensional expression of three-dimensional features. The ability to detect and map such lineaments is influenced by topography, the character of the lineaments (e.g., width, orientation, age), and the resolution of the data used for the mapping. The two factors that significantly influenced the lineament interpretation for the White River area are the low resolution magnetic geophyisical survey coverage for the majority of the area, and the large extent of bedrock at or near surface across the area. The low resolution geophysical coverage is compensated, in part, by the thin overburden that enables the recognition of lineaments from satellite imagery and by the topographic data.

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 White River area is characterized by very good bedrock exposure over the identified general siting areas. These areas are dominated by exposed bedrock or a thin till veneer. There are also limited surface water bodies in the four general potentially suitable areas. Access is good throughout the areas via secondary roads from Trans-Canada Highway 17 to the west and Highway 631 to the north.

4.5 Geoscientific Preliminary Assessment Findings

The objective of the Phase 1 geoscientific preliminary assessment was to assess whether the White River area contains general areas that have the potential to satisfy the geoscientific site evaluation factors outlined in NWMO's site selection document (NWMO, 2010).

The preliminary geoscientific assessment built on the work previously conducted for the initial screening (Golder, 2012) and focused on the Township of White River and its periphery, which are referred to as the "White River area" (Figure 4-1). The 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. Where information for the White River area was limited or not available, the assessment drew on information and experience from other areas with similar geological settings on the Canadian Shield. The key geoscientific characteristics used relate to: geology; structural geology and distribution of lineaments; distribution and thickness of overburden deposits; surface conditions; and the potential for economically exploitable natural resources. The desktop geoscientific 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);
- 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 White River area contains at least four general areas that have the potential to satisfy NWMO's geoscientific site evaluation factors. Two of these areas are within the Anahareo Lake pluton, one is located in the Pukaskwa batholith, and one is located in the Strickland pluton.

The Pukaskwa batholith, Anahareo Lake pluton, and Strickland pluton containing the four identified potentially suitable areas appear to have a number of geoscientific characteristics that are favourable for hosting a deep geological repository. They all appear to have sufficient depth and extend over large areas. The four identified general potentially suitable areas identified in the White River area have good bedrock exposure, low potential for natural resources, and contain limited surface constraints.

While the identified general potentially suitable areas appear to have favourable geoscientific characteristics for hosting a deep geological repository, there are inherent uncertainties that would need to be addressed during subsequent stages of the site evaluation process. Main uncertainties include the low resolution of available geophysical data over most of the potentially suitable areas, the influence of regional structural features, and the presence of numerous dykes.

The identified general potentially suitable areas are located away from regional structural features, such as the Quetico-Wawa Subprovince boundary. However, the potential impact of these regional features on the suitability of the four general potentially suitable areas would need to be further assessed. The area contains numerous dykes. While the spacing between mapped and interpreted dykes and lineaments within the four general potentially suitable areas appears to be favourable, the potential presence of smaller dykes not identifiable on geophysical data, and potential damage of the host rock due to the intrusion of dykes, would need to be assessed.

Should the community of White River be identified 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 geoscientific studies would be required to confirm and demonstrate whether the White River 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.

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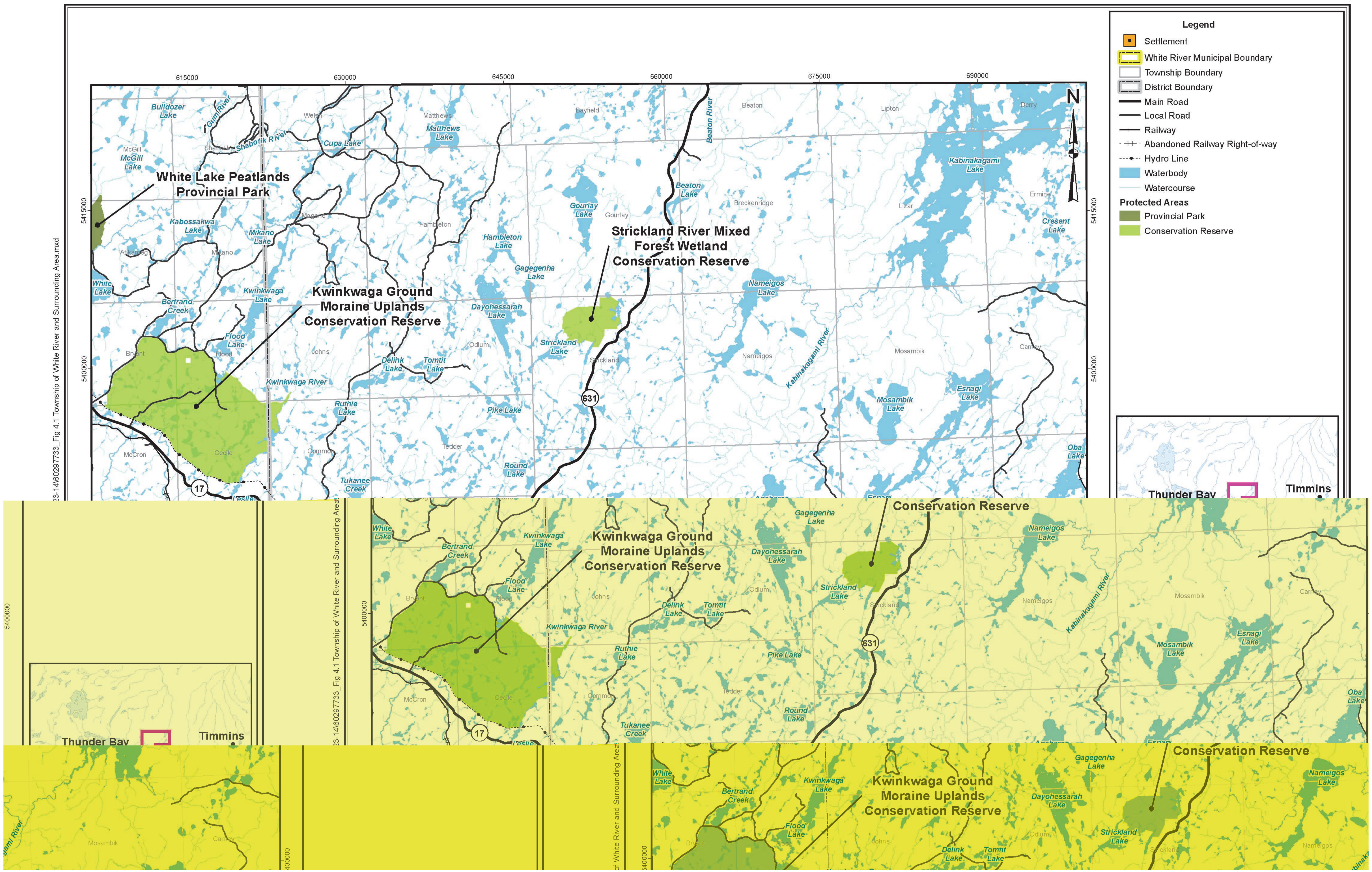

Figure 4-1: Township of White River and Surrounding Area

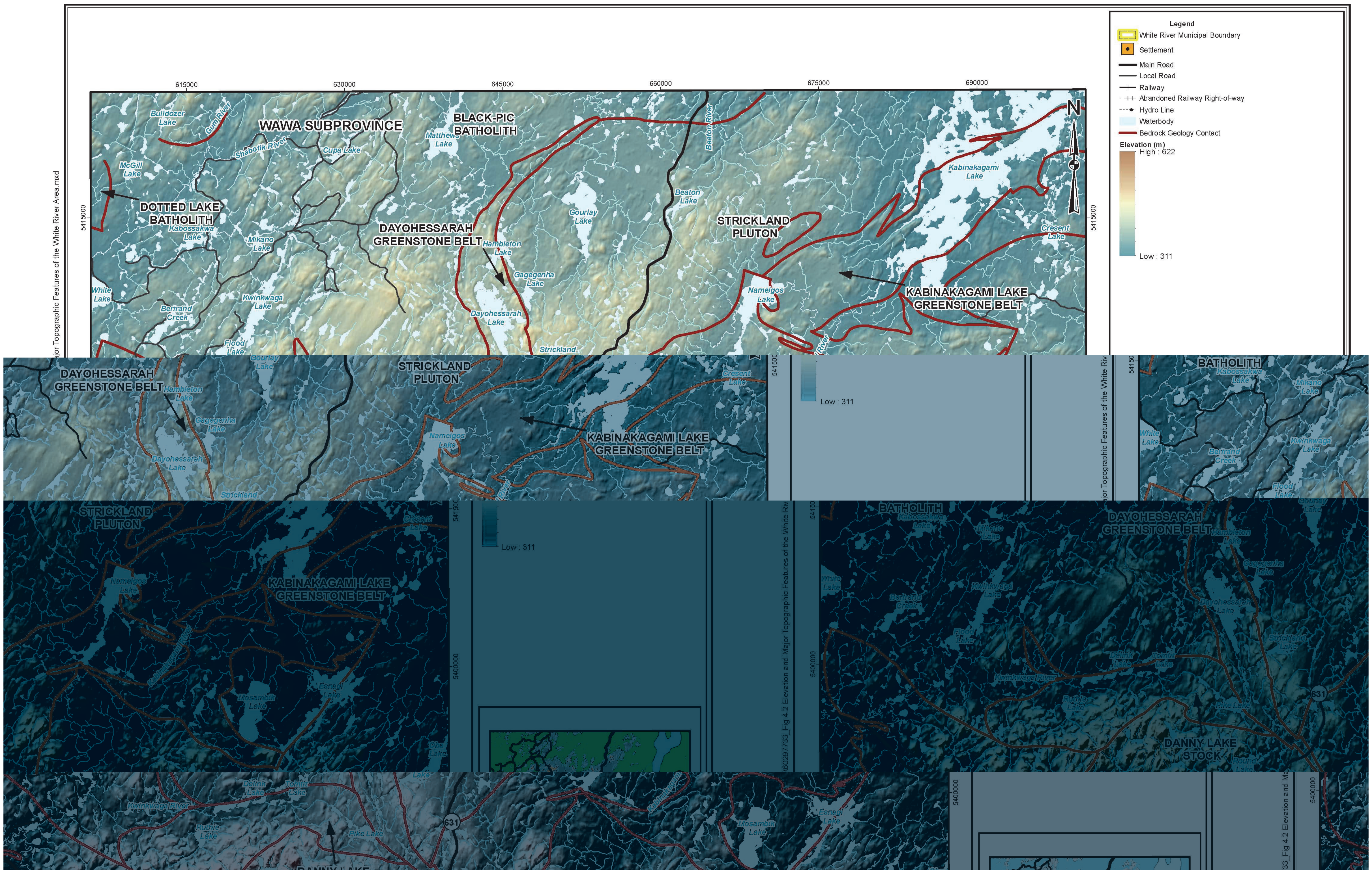

Figure 4-2: Elevation and Major Topographic Features of the White River Area

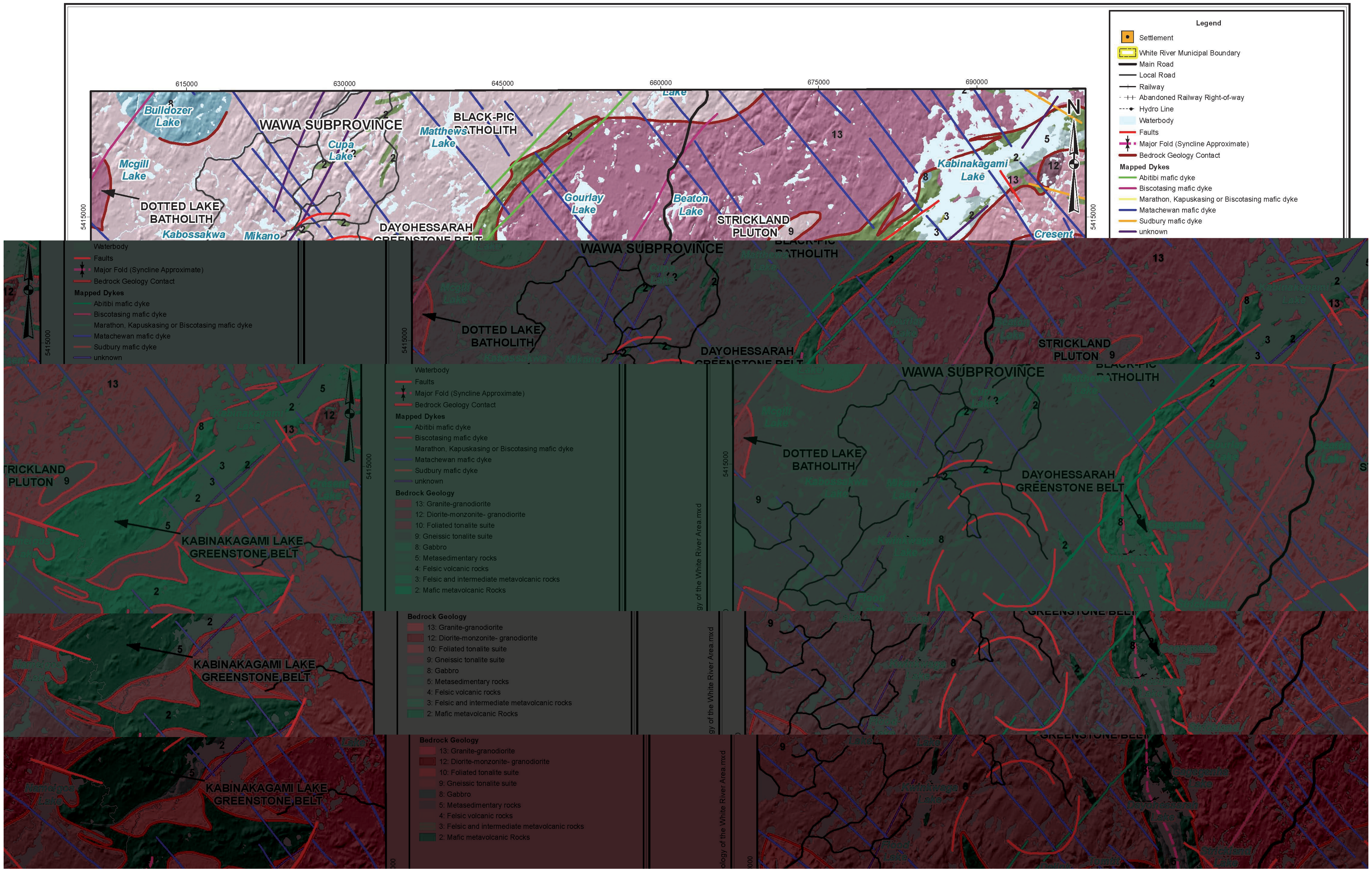

Figure 4-3: Bedrock Geology of the White River Area

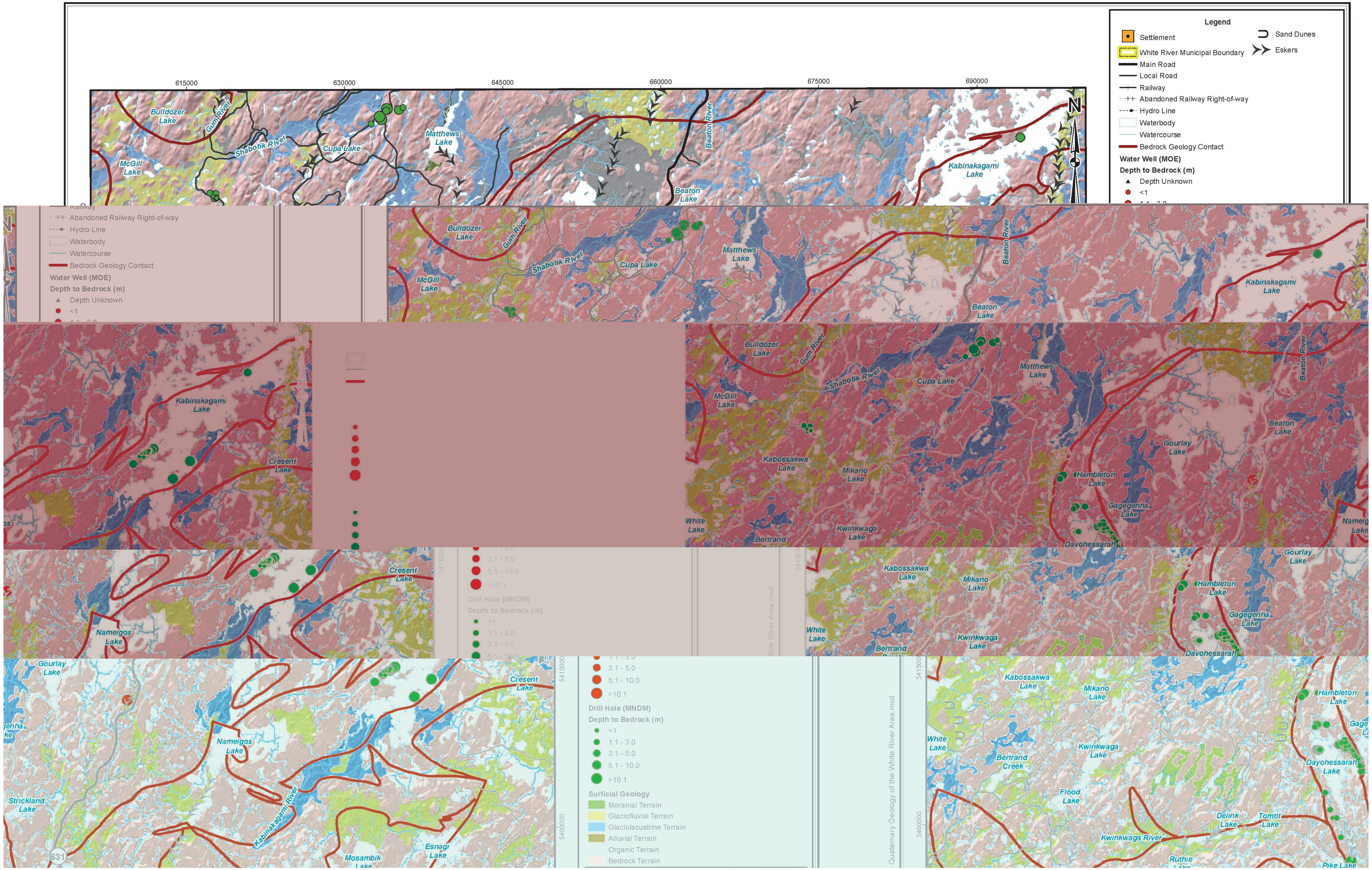

Figure 4-4: Quaternary Geology of the White River Area

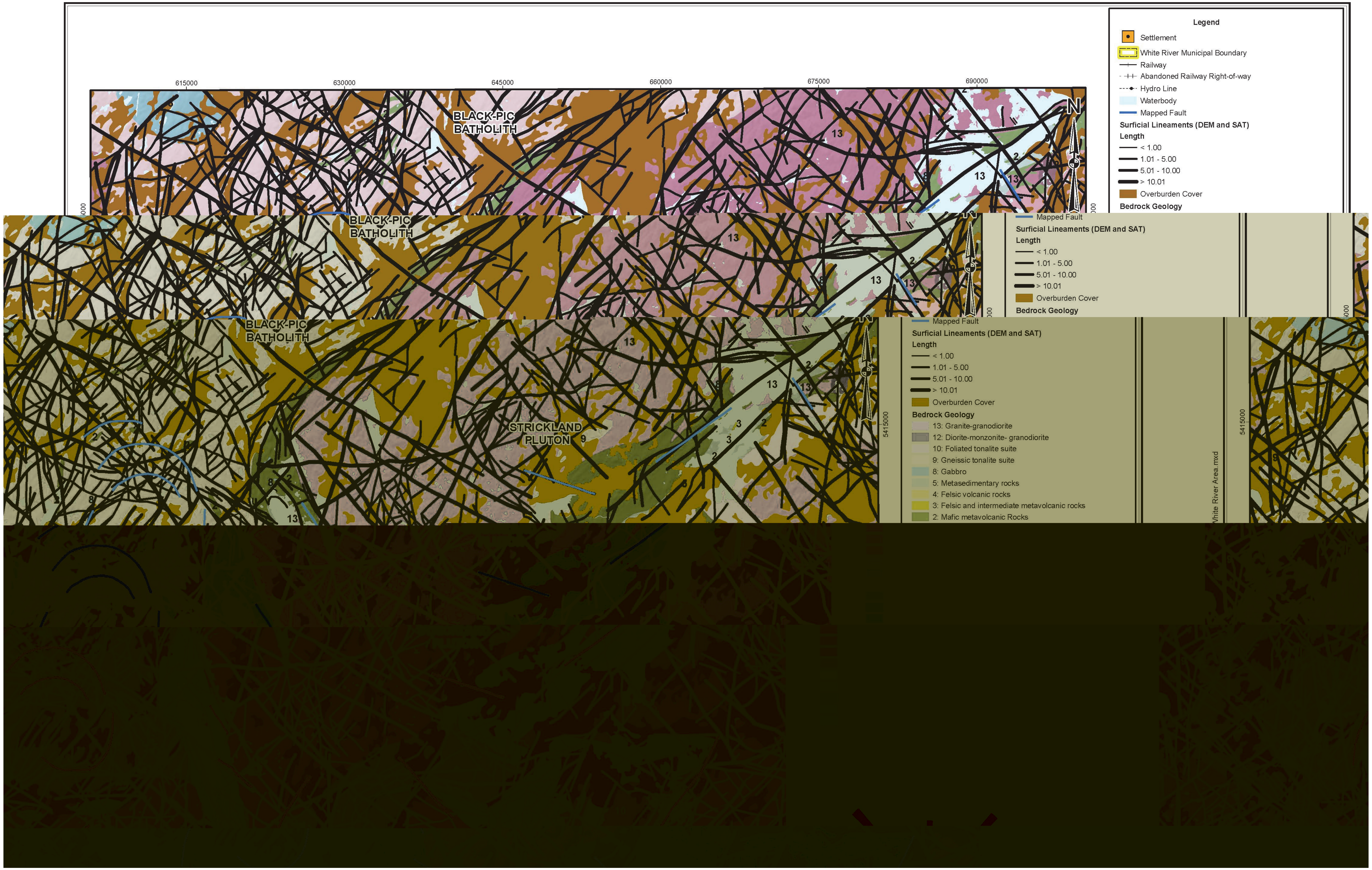

Figure 4-5: Surficial Lineaments of the White River Area

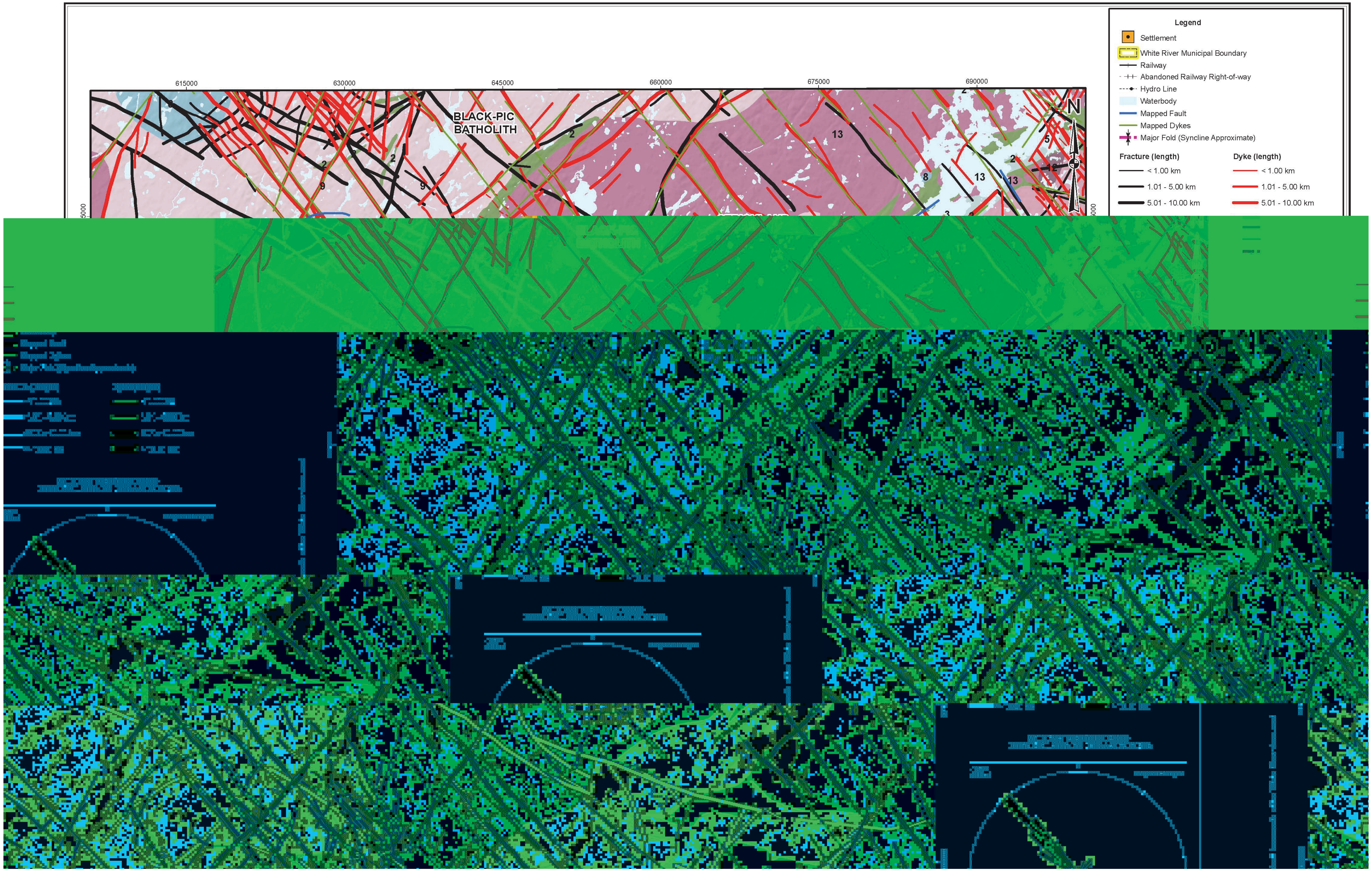

Figure 4-6: Geophysical Lineaments of the White River Area

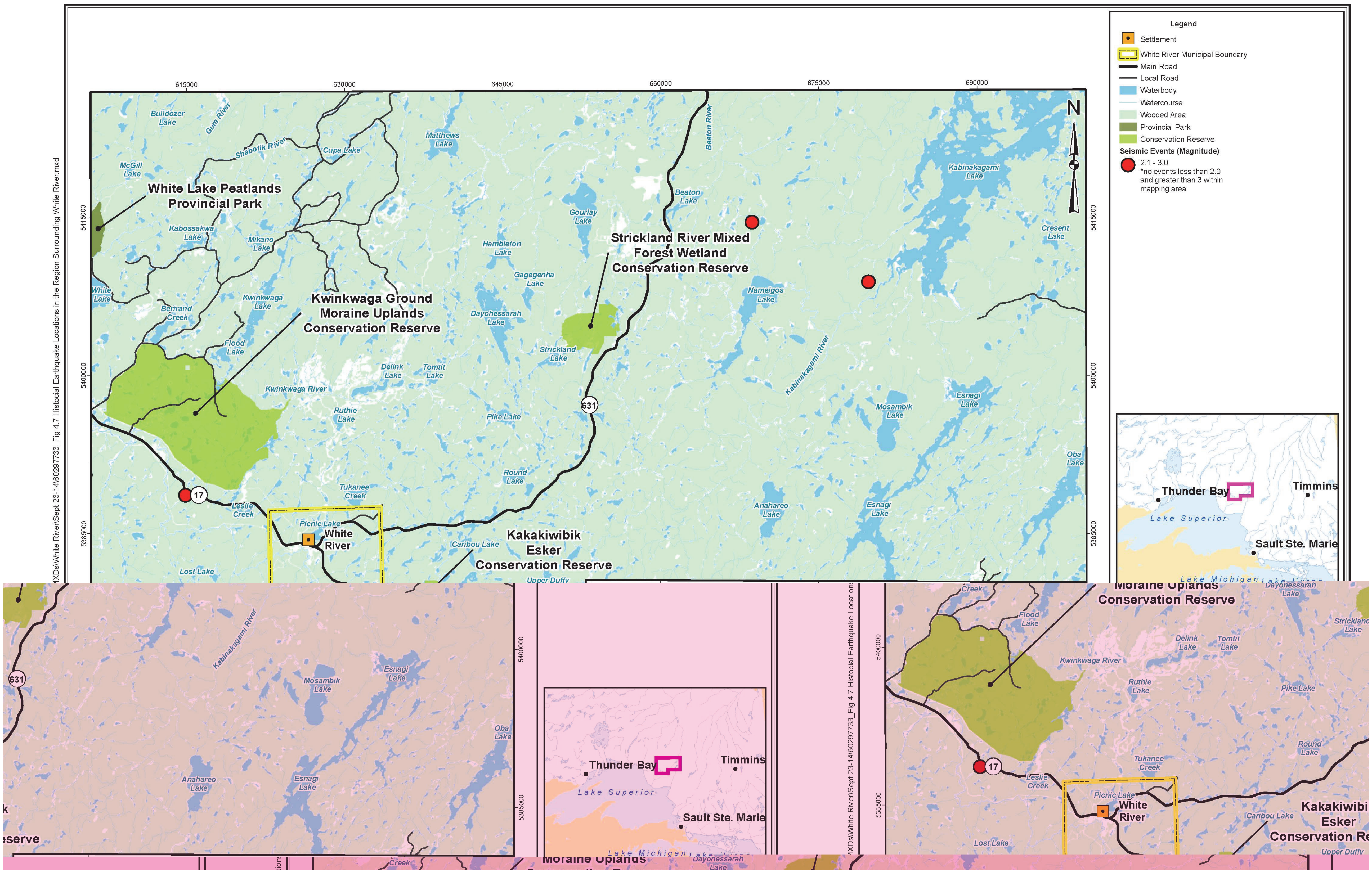

Figure 4-7: Historical Earthquake Records of the White River Area 1985-2013

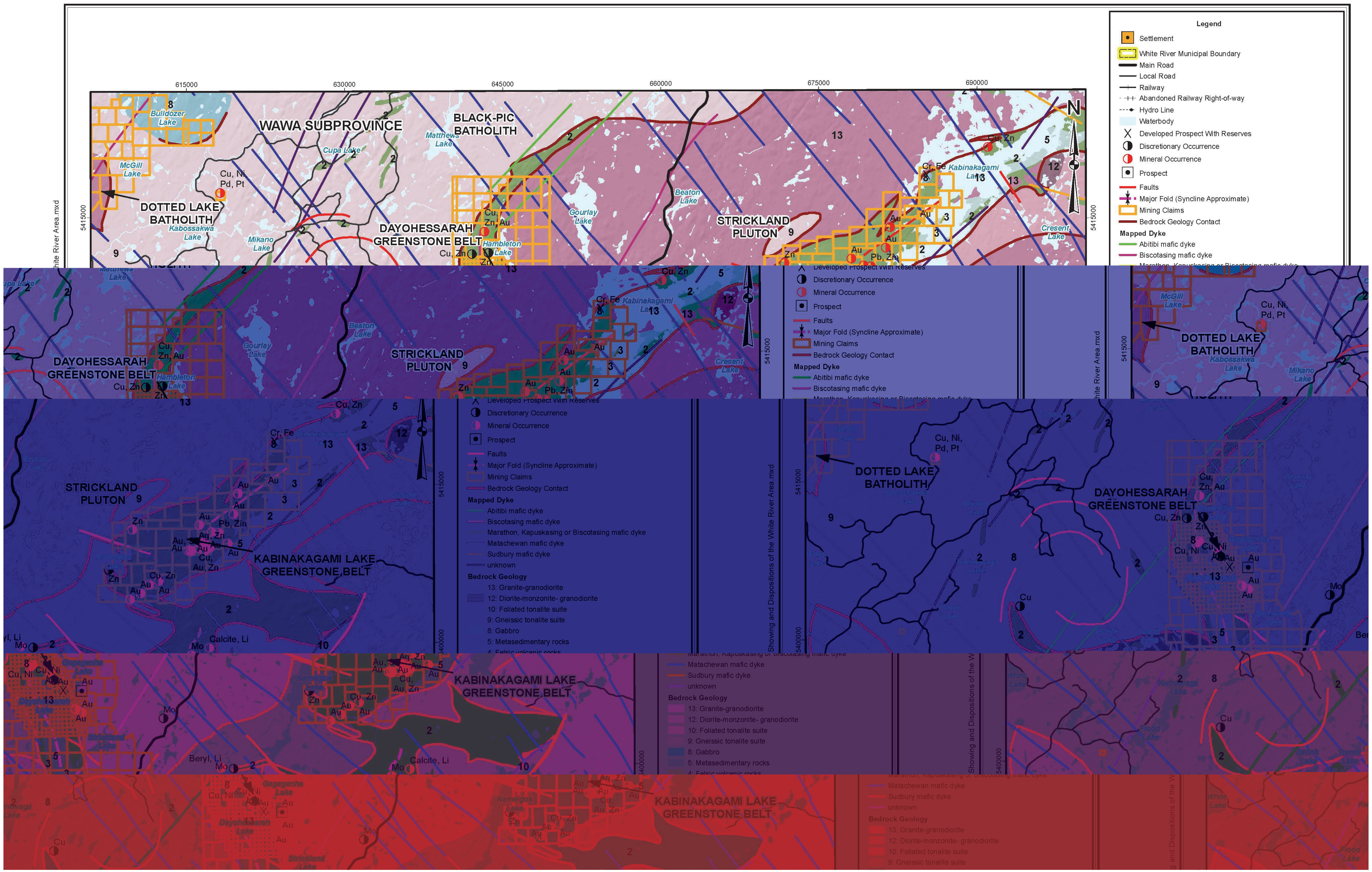

Figure 4-8: Mineral Resources in the White River Area

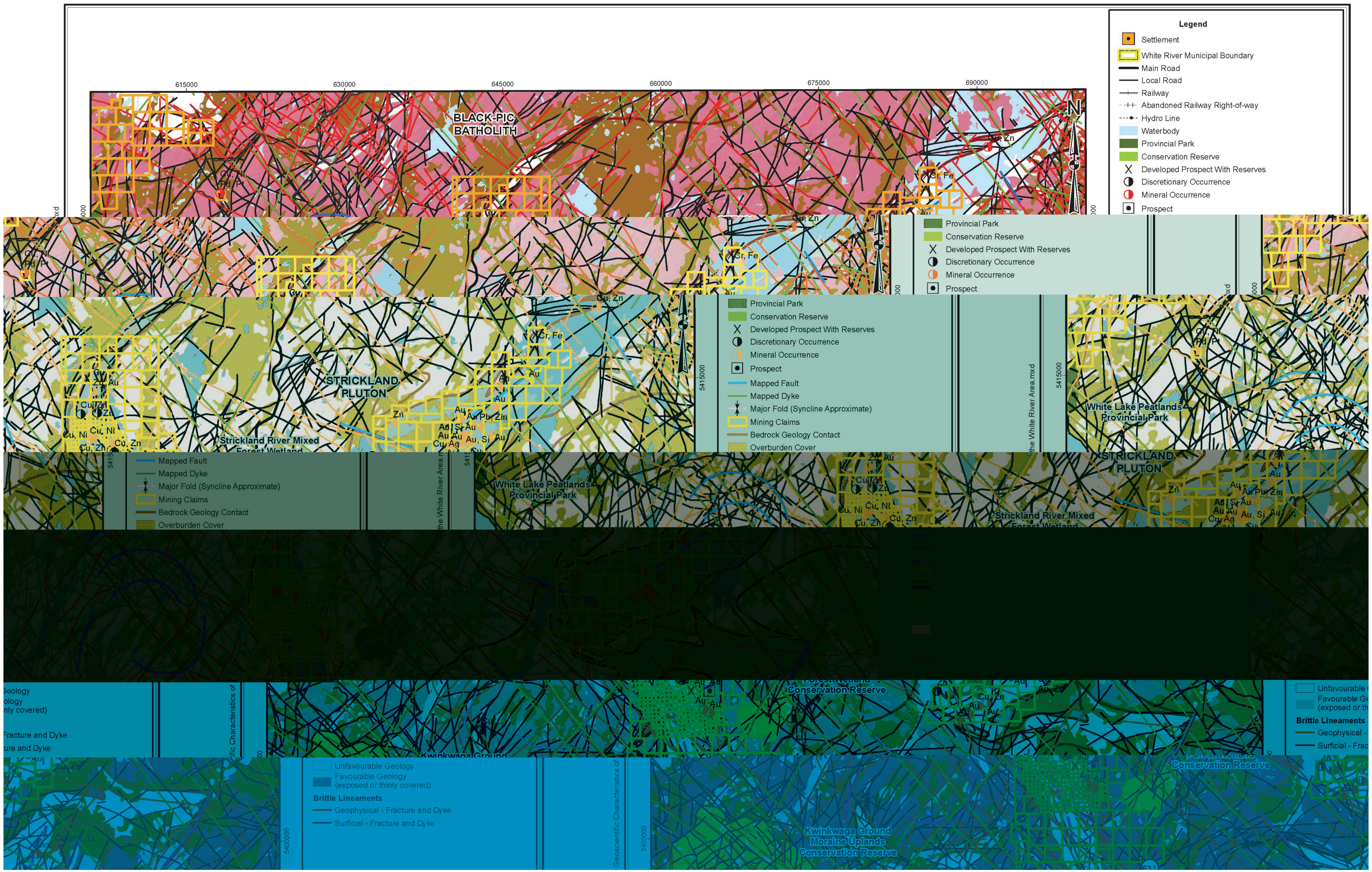

Figure 4-9: Key Geoscientific Characteristics of the White River Area

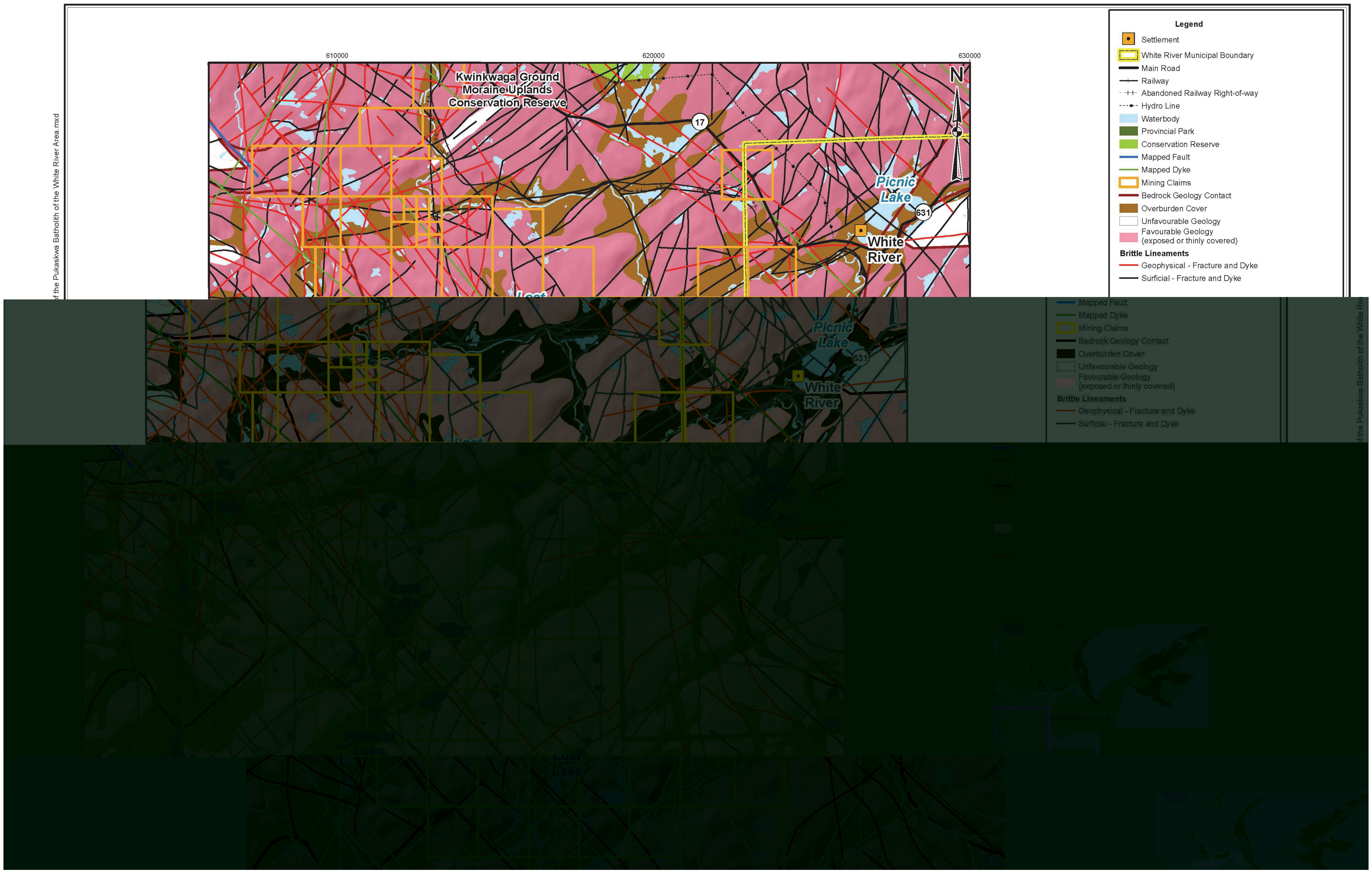

Figure 4-10: Key Geoscientific Characteristics of the Pukaskwa Batholith of the White River Area

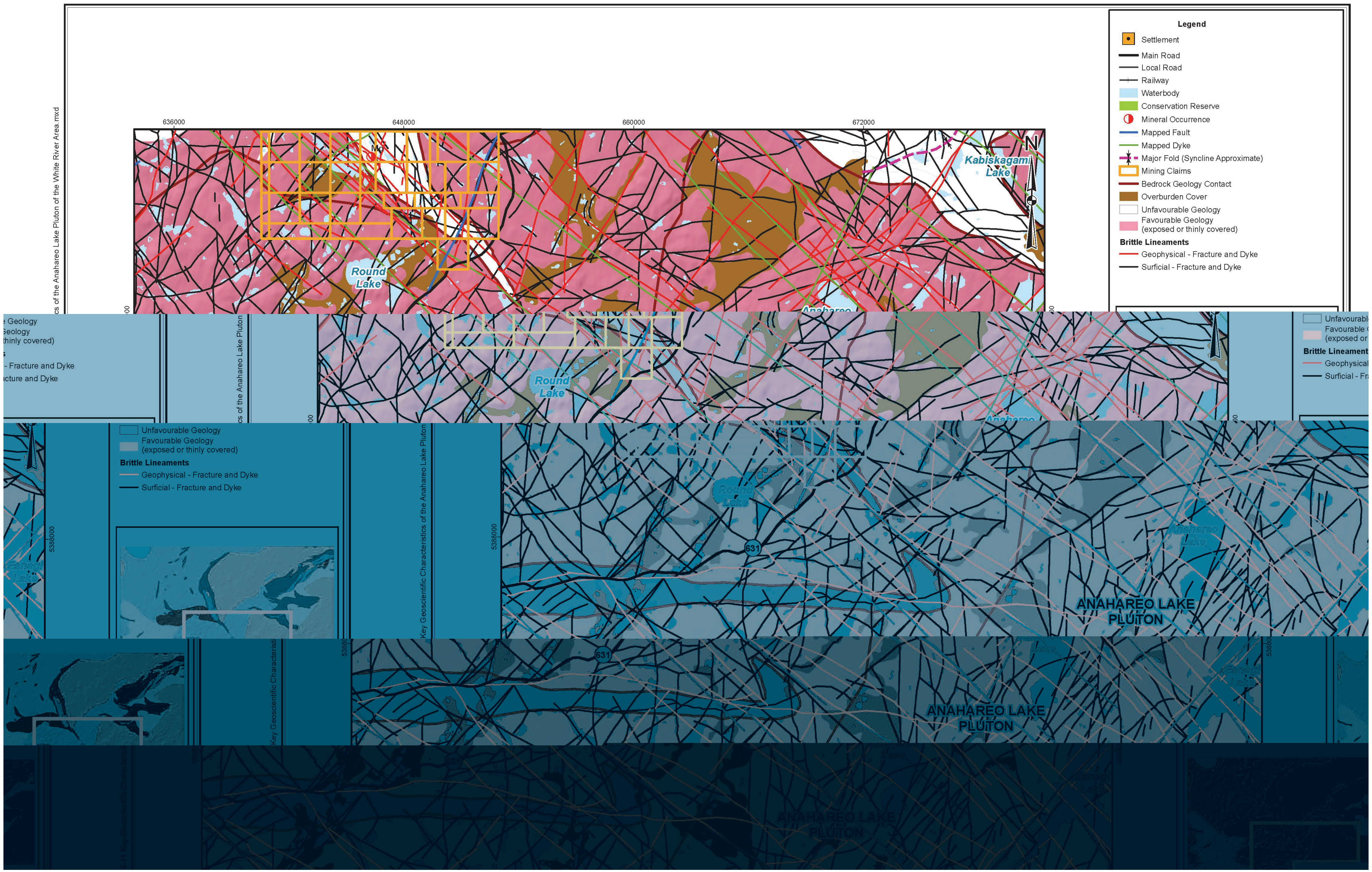

Figure 4-11: Key Geoscientific Characteristics of the Anahareo Lake Pluton of the White River Area

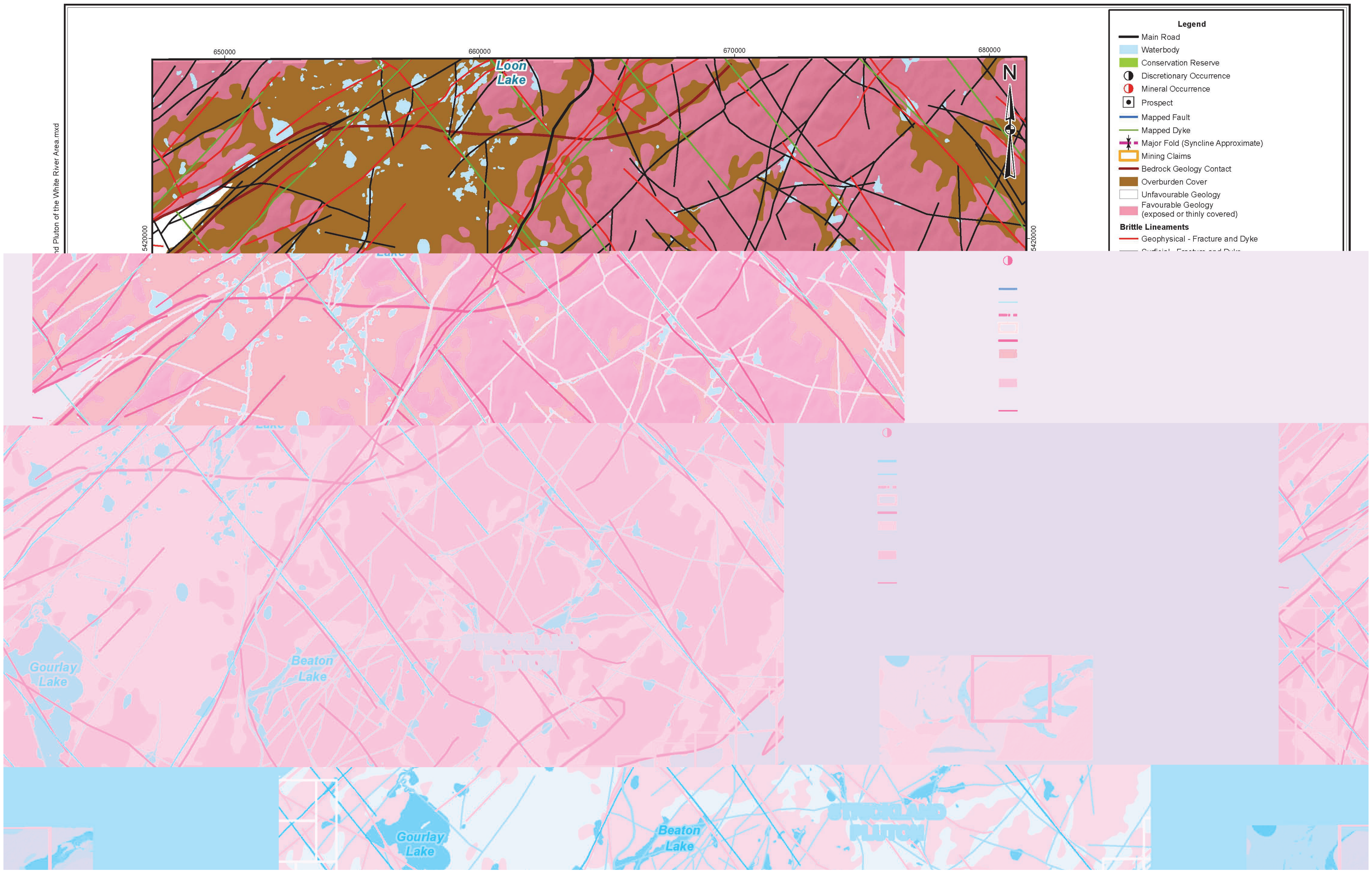

Figure 4-12: Key Geoscientific Characteristics of the Strickland Pluton of the White River Area

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 White River area, and to explore the potential to manage any environmental effects that might result from the Adaptive Phased Management (APM) Project. This is achieved by considering the following questions:

1. Is there anything in the natural environment that would preclude siting the repository somewhere in the White River area?
2. If the repository is located somewhere in the White River 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 White River 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 White River 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 White River 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 White River, referred to as the “White River area”. 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 White River area is provided in Golder (2014). Summary information is presented here.

5.2.1 Communities and Infrastructure

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

The Township of White River is approximately 102 square kilometres in size (LIO, 2013), with a population of 607 (Statistics Canada, 2013). The settlement area of White River is near the northeastern end of Lake Superior approximately 390 kilometres east of Thunder Bay, 95 kilometres east of Marathon and 92 kilometres northwest of Wawa, based on distance along major roads. More information on the White River area is provided in Chapter 7.

There are a number of Aboriginal communities and organizations in the White River area including Ojibways of Pic River (Heron Bay) First Nation and Ojibways of Pic Mobert First Nation. Métis Councils in the area include the Historic Sault Ste. Marie Métis Council and the North Channel Métis Council.

The main transportation routes include the Trans-Canada Highway (Highway 17), which passes southeast-northwest through the White River area, and Highway 631 which passes from White River to the northeast. A Canadian Pacific (CP) railway corridor runs through White River, approximately parallel to Highway 17, and then eastward through the community of Amyot. The Algoma Central Railway, currently owned and operated by Canadian National (CN), passes through the southeast corner of the White River area. A 115-kilovolt electrical transmission line runs from White River to the northwest, approximately parallel to Trans-Canada Highway 17. The White River airport, a seaplane base, is located northeast of town on the south end of Tukanee Lake (NRCan, 2009a). There are no gas pipelines in the White River area (NRCan, 2009b). There is one operating landfill (MOE, 2013a), and a waste water treatment plant within the White River area.

Two provincial parks (Pokei Lake/White River Wetlands Provincial Park and White Lake Peatlands Provincial Park), three conservation reserves, and two forest reserves are located in the White River area.

The Ontario Archaeological Sites Database identifies one known archaeological site in the White River area. This archaeological site is located outside the Township boundaries, at the mouth of Tedder River where it empties into Kakakiwibik Lake. The archaeological site was identified and recorded in 1970 as a campsite with extensive signs of burning and evidence of fire-cracked rock, but very few artifacts (von Bitter, 2013). No cultural affiliation or time period is recorded for the site. There is also one provincially designated historic site and one federally designated historic site, both within the Town of White River (OHT, 2013; MTCS, 2013; Parks

Canada, 2013). The presence of local heritage sites would need to be confirmed in discussion with the community and First Nation and Métis communities in the area.
Trapline Licence Areas are located throughout most of the White River area, outside Provincial Parks, Conservation Reserves, communities, and Indian Reserves.

As discussed in Section 4.3.7, water wells in the White River area obtain water from the overburden or shallow bedrock. The Ontario Ministry of the Environment (MOE) Water Well Information System (WWIS) database contains 33 records in the White River area, of which 31 provide useful information on depth to bedrock, yield, and other relevant parameters. These 31 water wells range from 4.6 to 99.1 metres in depth (MOE, 2013b). No potable water supply wells are known to exploit aquifers at typical repository depths in the White River area or anywhere else in northern Ontario. The Township of White River obtains its municipal water supply from a mixture of surface water (Tukanee Lake) and groundwater.

5.2.2 Natural Environment

As described in Chapter 4, the White River area lies in the Abitibi Upland physiographic region, a broadly rolling surface of the Canadian Shield bedrock that occupies most of north-central Ontario. Topography in most of the White River area is modestly rugged, with elevations ranging from about 622 metres above sea level approximately 13 kilometres northeast of the settlement area of White River, to about 311 metres above sea level in the northeast around Kabinakagemi Lake, and to the northwest.

Geologically, the White River area is situated in the Wawa Subprovince, which is part of the western region of the Superior Province of the Canadian Shield. The bedrock geology is dominated by granitic intrusive complexes, including the Pukaskwa and Black-Pic batholiths, the Strickland and Anahareo Lake plutons, and the Danny Lake stock. In the central part of the White River area, the Dayohessarah greenstone belt runs north-south, and in the northeastern part, the Kabinakagami greenstone belt runs southwest-northeast amidst the granitic intrusions (Williams et al., 1991).

The White River 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 White River 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 White River area straddles a drainage divide where the western part is located within the White and Michipicoten-Magpie watersheds of the Lake Superior drainage basin and the eastern part is located within Nagagami and Upper Kabinakagami watersheds that form part of the Hudson Bay drainage basin. Water bodies in the White River area are classified as warm and cool water, interspersed with the occasional smaller cold water body. Fish populations in the area are managed to maintain and maximize their size and availability to both locals and tourists to support recreational fishing. Fish that are commonly harvested include walleye, northern pike, lake trout, brook trout, smallmouth bass, and yellow perch (MNR, 2013a).

The White River area lies within the Boreal Forest Region (MNR, 2013b). The White River area contains portions of four Forest Management Units (FMUs): the Magpie Forest (FMU 565), the White River Forest (FMU 060), the Nagagami Forest (FMU 390), and the Hearst Forest (FMU 601). Typical forest types in the White River area include: lowland conifer forest, upland conifer forest, poplar forest, mixed-wood forest, jack pine forest, white birch forest, and white and red pine forest (Domtar, 2008). 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 White River area, based on the principles of range mapping. Habitats within the White River area have the potential to directly or indirectly support the needs of 18 designated SAR (NHIC, 2013; 2005; ROM, 2013; Oldham and Weller, 2000; BSC, 2006; Domtar, 2010; BCI, 2013a,b; Jones et al., 2013; Dobbyn, 1994). These species include four mammals (eastern cougar, woodland caribou, northern myotis, and little brown myotis), 11 birds (bald eagle, barn swallow, black tern, Canada warbler, chimney swift, common nighthawk, golden eagle, olive-sided flycatcher, rusty blackbird, short-eared owl and eastern whip-poor-will), one fish (lake sturgeon) and two invertebrates (monarch butterfly and rusty-patched bumble bee). 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 White River area are described in the Environment Report (Golder, 2014). A preliminary qualitative assessment of natural hazards is summarized in this section. 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 0.1 tornadoes per year per 10,000 square kilometres), but where there is a potential for F0-F1 tornadoes (Sills et al., 2012), and is located outside the geographic area where hurricanes occur.
- Flooding – Possible risk – Possible risk of flash flooding in some areas due to 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 (320 centimetres), and extreme snowfall events are possible.

- Fire – Possible risk – Forest fires occur in the area, although historically they have been less than 25 square kilometres in size and have affected approximately seven per cent of the area over a 35-year period.
- Landslide – Possible risk – Possible landslide risk due to steep topographic gradients in some areas and thin soil cover over crystalline rock. Risk will vary based on specific location.
- Tsunami – No risk – Low seismic hazard rating and lack of large water bodies.

5.2.4 Environment Summary

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

Table 5-1: Summary of Environmental Features within the White River 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	10%/8%
Active Agriculture	No
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
Natural Hazards	
Occurrence of Forest Fires	Yes
Potential for Earthquakes	Low

Environmental Feature	Summary
Natural Hazards continued	
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 White River 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 White River 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 White River 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
Radiation and Radioactivity	None – no additional radiation beyond natural background	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	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 sizeable workforce would be expected. Since the Township of White River and its 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 affected 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 the 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 White River 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 White River 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 White River 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. 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. Implementation 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 White River 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 White River 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
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

Environmental Component	Main Considerations	Is There Potential for an Effect?	Is Management and Mitigation Possible?	Are Significant Residual Effects Anticipated?
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 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 White River 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 White River 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 White River 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 White River 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.

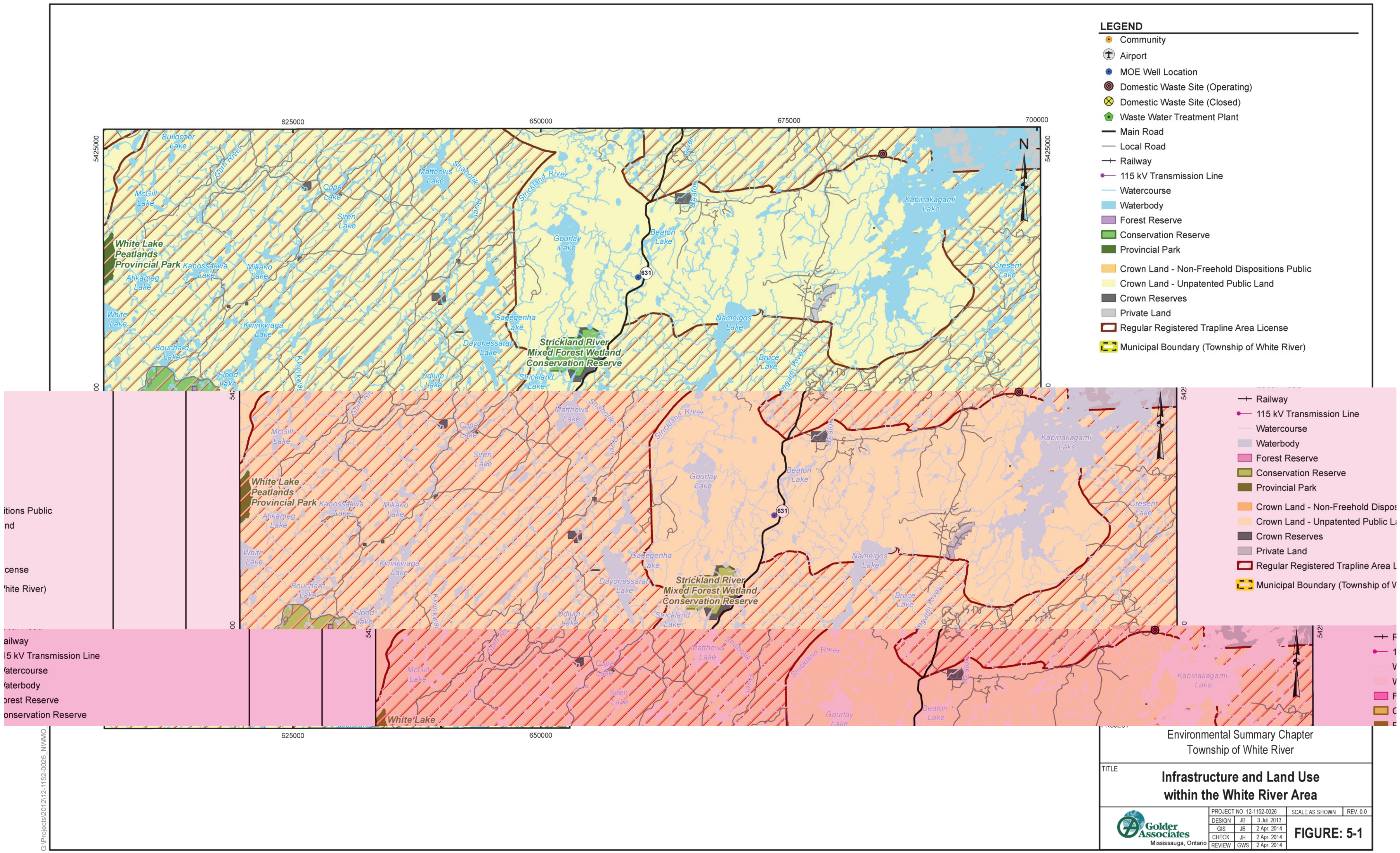

Figure 5-1: Infrastructure and Land Use within the White River Area

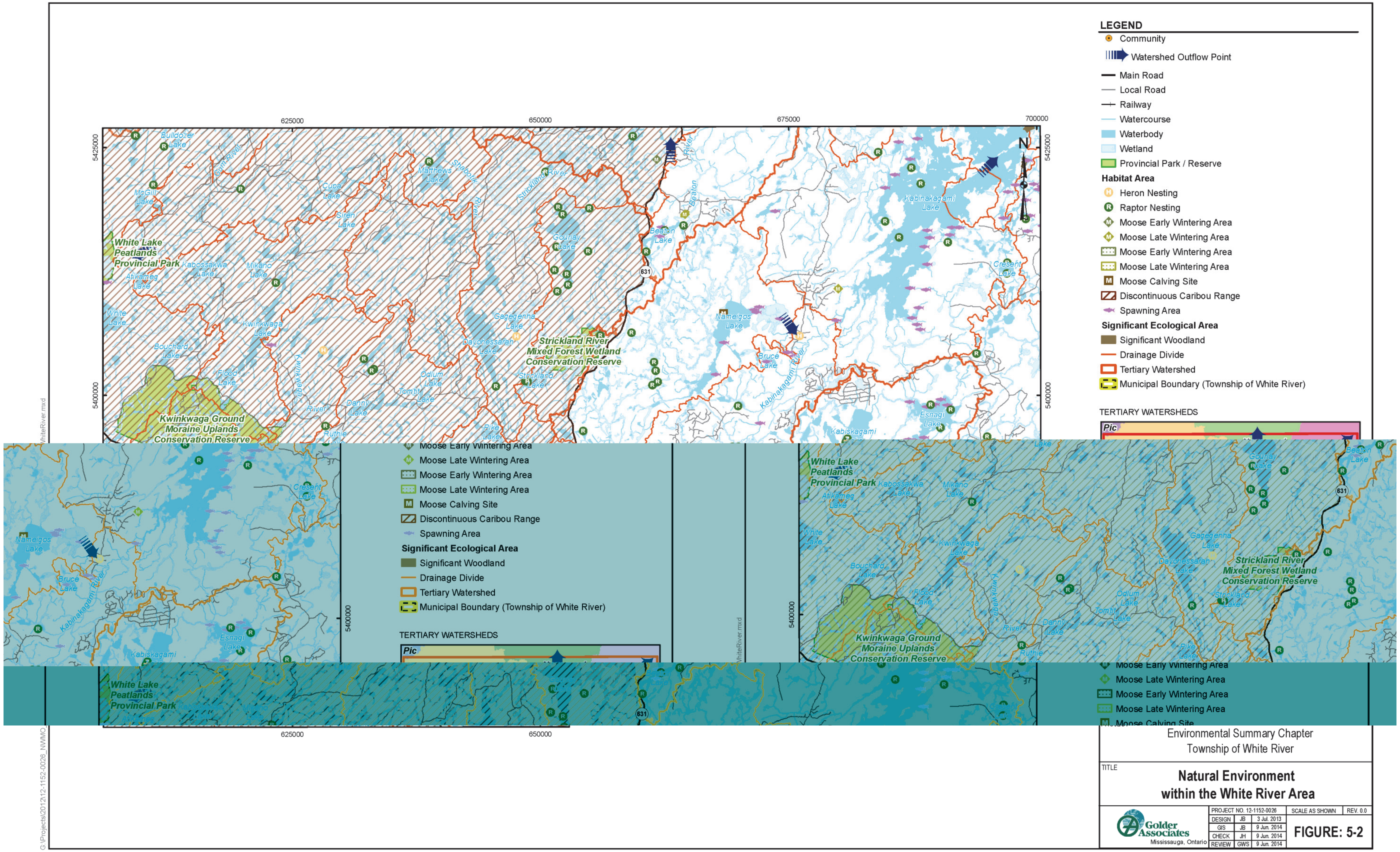

Figure 5-2: Natural Environment within the White River Area

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 publically 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 findings of the transportation assessment on the feasibility of locating the APM Project in the White River area 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*. 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.

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

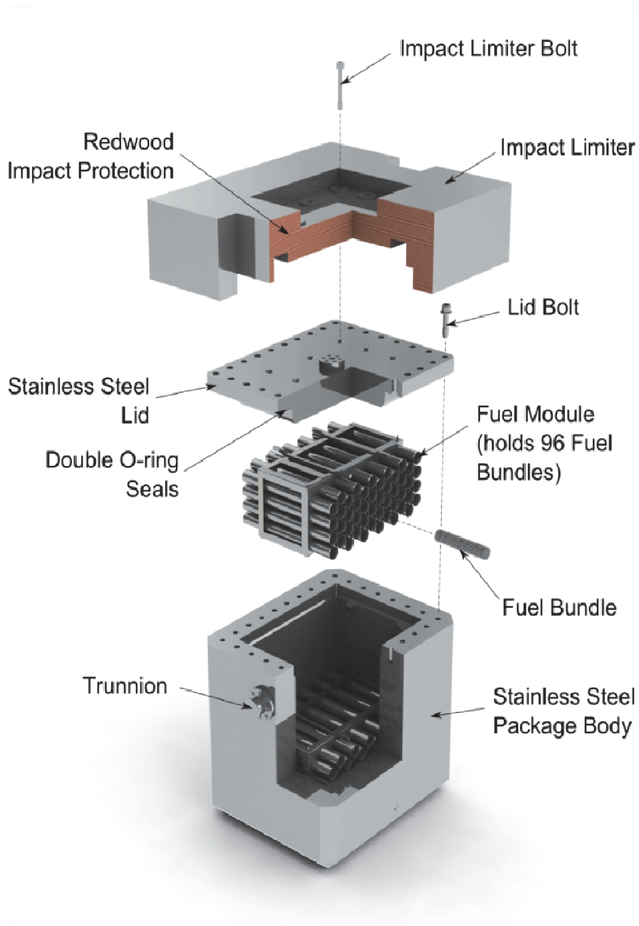

Figure 6-1: Used Fuel Transportation Package

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 White River

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 near White River would be accessible by truck via existing roadways and a service road to the receiving facilities.

White River is located on Trans-Canada Highway Highway 17 and the cross-continental railroad operated by the Canadian Pacific Railway (CPR). Both systems are maintained to the highest provincial standards and are important to the inter-provincial movement of goods and services.

If rail is a preferred mode, rail service could be extended from the existing switch yard in White River to a service spur leading directly to the receiving facility at the repository.

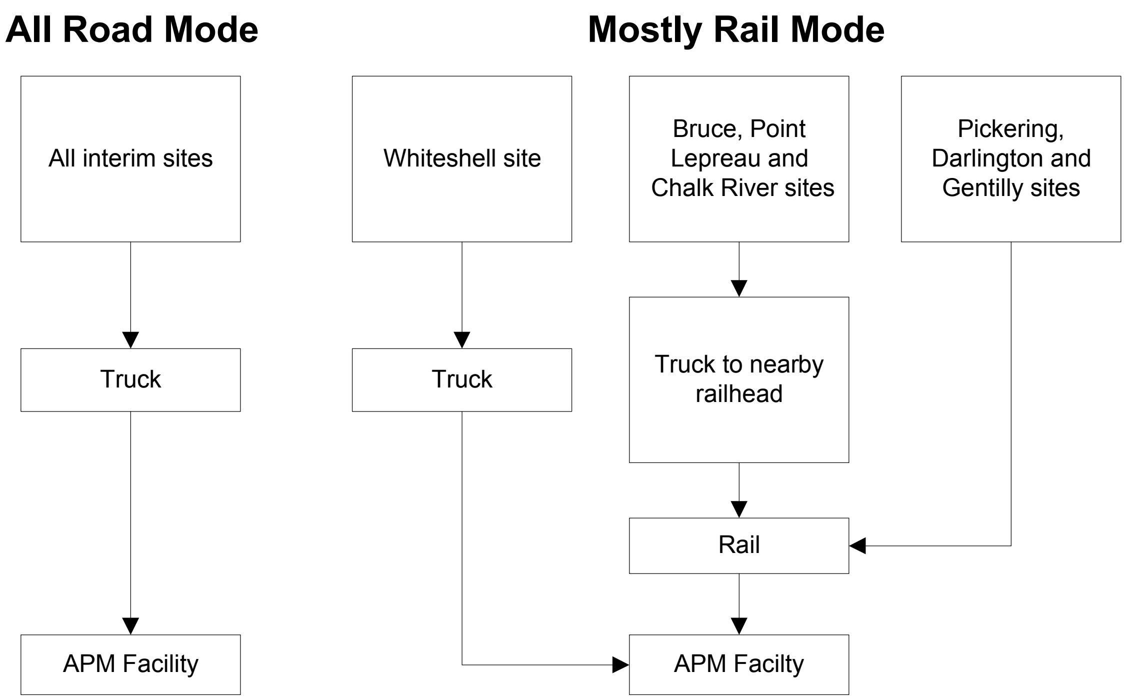

Figure 6-2: Example Transport Processes for Used Nuclear Fuel

6.7.1 Existing Transport Infrastructure

Travel distances from the interim storage sites to a repository site near White River, Ontario are summarized by mode of transportation in Table 6-3.

Table 6-3: Transport Summary from Interim Storage Sites to White River, Ontario

Transport Scenario	Transport Mode	Number of Shipments	Return Distance (kilometres)
All Road	Road	24,000	55,460,000
Mostly Rail	Road	11,700	1,791,000
	Rail	2,400	5,394,000

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 Highway 17 of the Trans-Canada Highway, which passes through White River, Ontario. As planned, an existing local access road would be used or a new road constructed to provide access from Highway 17 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 White River, Ontario

Interim Storage Site	Distance Site to DGR (kilometres)	Number of Shipments	Return Distance (kilometres)
1 – Whiteshell	1,020	2	4,100
2 – Bruce	1,070	10,220	21,870,000
3 – Pickering	1,020	4,150	8,466,000
4 – Darlington	1,060	6,720	14,246,000
5 – Chalk River	920	30	55,000
6 – Gentilly	1,440	1,500	4,320,000
7 – Point Lepreau	2,240	1,450	6,496,000
	Totals (rounded)	**24,000**	**55,460,000**

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 White River, Ontario can be accomplished entirely by existing roadways. Based on Ontario Ministry of Transportation records, there are no significant impediments to travel between the interim storage sites and White River area. The average daily travel (vehicle) count for the White River segment of Highway 17 is 1,900 vehicles per day (MTO, 2009). Two trucks a day more to the existing traffic count would be a small addition (less than 0.1 per cent).

The Ontario Ministry of Northern Development and Mines Northern Highways Program (MNDM, 2012) includes the resurfacing of Highway 17 east of White River. The program also includes the culvert replacement west of White River.

The local road system within White River supports the current residential uses, and, in general, is not built to support large trucks on a routine basis. Therefore, local road upgrades and/or an access road may be required to service a potential repository site.

White River is accessible via an alternative route, although it involves additional mileage. The alternative route is Highway 11 north to Highway 631, then south through Hornepayne to White River.

Emergency response resources are provided by the volunteer Fire Department, the Algoma Emergency Medical Services (EMS) and the Ontario Provincial Police. The Fire Department is a member of the Algoma District Mutual Aid Program, providing help to other communities in emergencies, as far away as Chapleau, Spanish and Wawa. The White River Medical Clinic provides basic medical care. The closest fully accredited medical facilities are the Lady Dunn Health Centre, situated approximately 93 kilometres away in Wawa, and the Wilson Memorial General Hospital, situated approximately 95 kilometres away in Marathon. The hospitals provide a full range of health-care services including 24 hour emergency nursing coverage.

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?

The CPR operates a mainline track from Sudbury through White River to Thunder Bay, Ontario. The shortest transport routes and associated distances for mostly rail mode transport are provided in Table 6-5.

Rail service between the interim storage sites, via an intermodal transfer near the storage sites, and White River is feasible. The switch yard in White River offers an opportunity to construct either an intermodal transfer facility or to construct a switch for a local rail line providing service directly to the repository site.

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 (with 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 Canadian National Railway operates a Trans-Canada rail line, which includes the Algoma Central Railway, north of White River. Trains could use the northern route, transfer to the CPR line in Franz, Ontario and travel to White River. This option does add mileage to the routing.

Table 6-5: Mostly Rail Transport from Interim Storage Sites to White River, Ontario

Interim Storage Site	Distance Site to DGR (kilometres)	Number of Shipments	Return Distance (kilometres)
1 – Whiteshell	**1,020**[a]	**2**	**4,100**
2 – Bruce	**80**[b]	**10,220**	**1,640,000**
	1,090	1,020	2,224,000
3 – Pickering	900	420	756,000
4 – Darlington	930	670	1,246,000
5 – Chalk River	**10**[c]	**30**	**7,200**
	780	3	4,000
6 – Gentilly	1,610	150	483,000
7 – Point Lepreau	**50**[d]	**1,450**	**145,000**
	2,270	150	681,000
Totals (rounded)	**Road**	**11,700**	**1,791,000**
	Rail	2,400	5,394,000

Notes:
[a] Road mode from Whiteshell to repository site near White River
[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
Bold text indicates road mode transportation; rail mode transportation is shown in plain text.

6.7.4 Weather

There are no vehicle weight restrictions on Trans-Canada Highway 17 during the spring thaw months. Similarly, no weather or seasonal restrictions were identified for rail transport to White River, Ontario. 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 near White River, Ontario would produce approximately 1,740 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 66,500 tonnes of equivalent carbon dioxide emissions.

Transport by mostly rail mode would produce approximately 890 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 55.5 million kilometres, about 94 road collisions have been estimated over the 38-year operating period of the APM facility.

6.7.7 Transportation Costs to White River

This section considers the used nuclear fuel transportation logistics from the existing interim storage sites to a hypothetical APM repository site located near White River, Ontario to estimate transportation costs. Existing surface mode transport infrastructure and transport distances from the interim used fuel storage sites to White River 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 near White River, Ontario 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 White River is projected at $1.09 billion over the 38-year campaign (in constant 2010 $). The variance is $4.54 million over the reference case estimate, or 0.4 per cent higher.

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

Total Cost	Transportation to White River	Variance to Reference Case	
Package Loading & Transportation	**$1,090,000,000**	**$4,540,000**	**0.4%**
Cost Breakdown			
Route and System Development	$19,000,000	$0	0%
Safety Assessment	$5,290,000	$0	0%
Capital Equipment and Facilities	$327,000,000	$0	0%
Operations	$558,000,000	$4,540,000	1%
Environmental Management	$8,400,000	$0	0%
Decommissioning	$42,700,000	$0	0%
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 White River 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.

White River is located on Trans-Canada Highway 17 between Sault Ste. Marie and Thunder Bay, ON. Highway 17 is one of Canada's two east-west intercontinental highways and is maintained to the highest provincial level of service. The Ontario Ministry of Transportation's current highway investment program includes resurfacing the roadway east of White River and culvert replacement. 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, operations and closure. The average vehicle travel on Highway 17 for the White River region is 1,900 vehicles daily.

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

White River is on the Canadian Pacific Railway's Trans-Canada Route, providing rail access to the community. CP maintains a switch yard, turn-around track, and maintenance facility in White River. Minimal investment would be required to provide the infrastructure required by an NWMO facility, including a grade separated rail crossing with Highway 17 to access a site to the east or north of White River.

The transport of used nuclear 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 White River, to advance to the future it has set out for itself. It is understood that 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 in the area.

In some areas, including White River, geoscientific studies have identified potentially suitable areas that are located outside the municipal boundaries of interested communities, and in territory for which Aboriginal peoples have a claim. Adaptive Phased Management also involves a large project that has the potential to affect the broad area in which it is implemented. Should studies continue in an 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 First Nation and Métis communities and surrounding municipalities, as well as their interest in implementing the project together. 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.

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 that 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 that the factors and approaches used to assess the potential to contribute to well-being and 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 White River, Ontario if the project were to be implemented in the area. More detailed information can be found in the White River Community Profile (DPRA, 2014a) and Community Well-Being Assessment report (DPRA, 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 White River. 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 Nations 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.

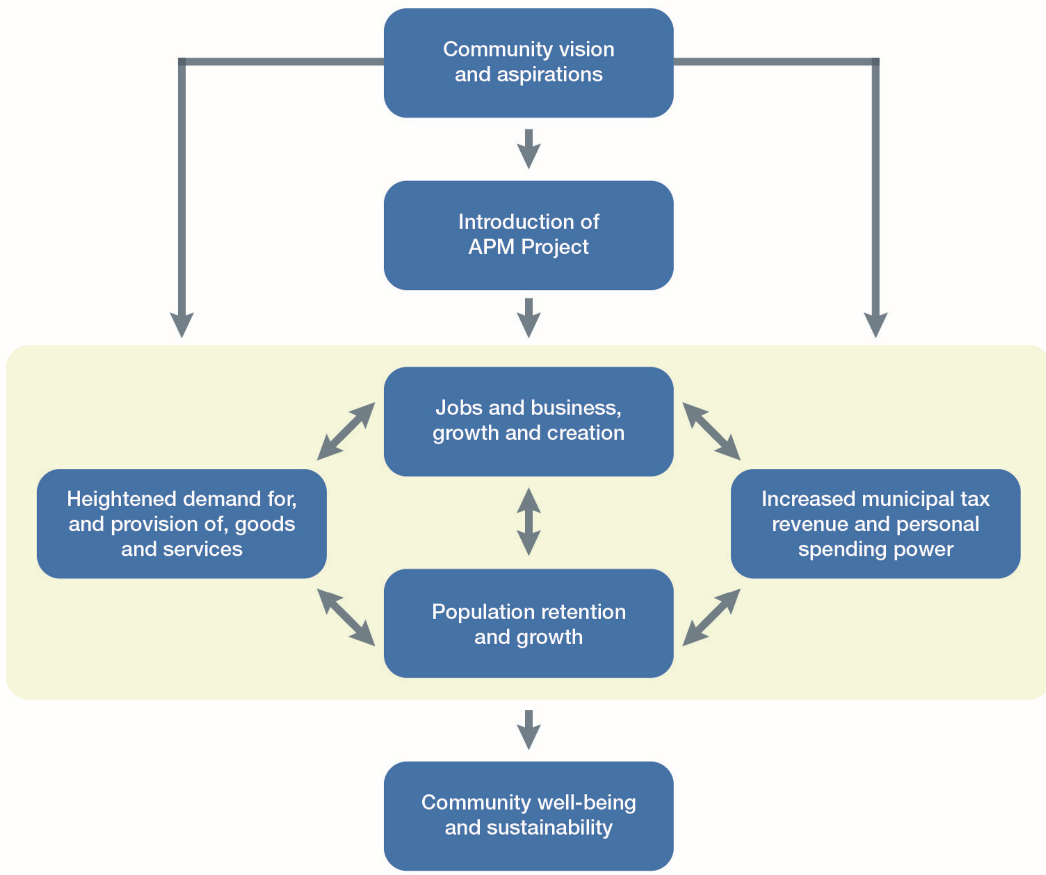

Figure 7-1: Direct and Indirect Effects From the Project

7.2 Community Well-Being Assessment – Implications of the APM Project for White River

The potential effect of the project, should it be implemented in the White River area, on the people, economics, infrastructure, social assets and natural environment of White River is discussed below. The discussion starts with an overview of the aspirations and values of White River, 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 White River has expressed explicit values, aspirations and desires for its community. These have been identified through discussion with community members and documented in the White River Community Profile (DPRA, 2014a) and various other community reports, including The Official Plan (1983). Key themes are summarized in this section. The Preliminary Assessment is measured against these values and aspirations.

The Township of White River is a resilient community, having faced significant social, cultural, and economic changes due to the various “boom and bust” cycles associated with the community’s transportation and natural resource-based economy. Perhaps one of the greatest recent changes in the community occurred when the White River Mill closed in January 2007. However, the White River Mill has since reopened in September 2013; a sign of forestry revitalization in northern Ontario and the entrepreneurial spirit that exists in White River. The community’s population has declined over the last 20 years, as families and youth have had to move elsewhere for employment and educational opportunities. There is a desire to maintain, if not grow, the population to better support the school, community organizations, facilities and services. White River continues to explore ways to diversify their economy, provide local employment, and to address the out-migration of community members (particularly youth) in search of employment or education. Four targeted industry sectors have been identified by the Township – tourism, forestry, mining, and energy - to provide new economic opportunities and support overall community aspirations. An improved municipal finance position is sought to redistribute the tax burden and increase revenues so community facilities, programs and services can be maintained or enhanced. In general, White River aspires to grow its population via economic diversification, local employment, and business opportunities.

The White River Community Development Corporation is working towards a Strategic Economic Plan in partnership with the Township. One of the key activities of the Corporation has been the public/private partnership with the White River Forest Products.

As expressed by the community, White River is seeking to grow its population and create community and economic growth for residents. White River seeks economic growth to address some of its important challenges such as declining population, lack of retail, commercial and industrial services, decreasing social and recreation programs, lack of specialized medical services, outmigration of youth, decreased tourism, and constrained municipal finances. Entrepreneurship and diversification are viewed as essential components for growing White River’s economy in the future (e.g., to fill existing service gaps in the community).

White River’s vision for the future includes an increased focus on tourism. White River is the home of the original black bear cub that was the impetus of the character ‘Winnie-the-Pooh’. The numerous outdoor recreation opportunities associated with the area’s natural setting, Winnie’s Hometown Festival, the White River Museum and the ‘Winnie-the-Pooh’ exhibit, as well as the ‘Winnie-the-Pooh’ statue and park located at the tourist centre, have all been identified as strategic focus areas for the future of tourism development. The future potential for tourism in White River may be limited by broader trends in that sector (e.g., declining numbers of American visitors; less vehicle-based tourism).

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

White River and many northern Ontario communities have experienced major declines in population. White River’s population has declined from 1,022 in 1996 to 607 in 2011. Residents have recently observed a slight increase in the town’s population since the re-opening of the White River Mill in 2013. The community has expressed the desire to grow to at least double the current population. Currently, the population is aging and there are limited opportunities to attract residents to the community.

In addition to experiencing a general decline in population trends over the past decade, White River has also experienced a noticeable reduction in the size of its labour force since 2006. There are limited local employment opportunities to attract a diverse and growing workforce.

The APM Project has the potential to attract population through attracting workers and their families, as well as former out-migrants to the community. The presence of the APM Project will 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. In addition, the APM Project would contribute to labour and skills diversification with the influx of workers who have training in many different areas related to facility construction, operations and maintenance.

The APM Project has the potential to bring in a large enough population to achieve the community's goal of increasing its population. This growth will rejuvenate retail options and community facilities and services. The APM Project would likely utilize any existing skilled labour force and attract a new skilled and diverse workforce as well as attracting new families. The APM Project offers the opportunity for local residents to obtain opportunities in direct, indirect and induced jobs.

White River has also experienced a decline in school enrolment, staffing, and a contraction in programming over the past 25 years. Students can attend the local elementary school or can be bussed to schools in Wawa. A wide range of new local employment/career opportunities with the APM Project would attract young families to the area, increasing school enrolment and potentially leading to additional school facilities and services in the community.

White River has a health clinic and medevac services, which provide basic health care in the local community. Specialty healthcare requires travel outside the community.

With the increase in population associated with the APM Project, demand for educational, recreation, health and safety facilities and services would increase in the community. This growth may also stimulate additional funding and resources for planning and expansion of facilities and services, and result in an increased ability to attract and retain highly qualified health-care professionals.

The APM Project has the potential to bring positive net benefits to the human assets of White River were it to be implemented in the area.

7.2.3 Implications for Economic Assets

In recent years, White River has experienced a number of local business closures, which has resulted in some declining employment and opportunities for residents. After the mill closure in 2007, many residents who could not find work locally moved, while others continue to commute elsewhere in the region (e.g., Richmont Mine, Barrick Gold Mines at Hemlo, or other mines in northwestern Ontario) or beyond (e.g., Alberta), while choosing to keep their families in White River. Out-migration of youth in search of job and career opportunities is also prevalent. Until recently, employment in the resource sectors has been declining; but now, economic activity is again centred on forestry, particularly the White River Forest Products Mill. There are opportunities for those who have remained in the community (mill, construction, regional mining). With declining population, it has become more difficult to find workers for labourer and service positions. There is a reliance on the foreign workers program to meet service job needs.

Median incomes were rising prior to closure of the White River Mill, although there was a decline upon its closure. Incomes may be stabilizing or increasing with recent forestry, construction, and mining activity in the area. Between 2005 and 2010, the proportion of income from government transfers more than doubled in the community.

Population decline has made it more difficult for community businesses, although those servicing construction and mining have been less affected since the recent economic downturn.

White River provides services to travellers along Trans-Canada Highway 17. White River is the hometown of the original black bear that became the popular Winnie-the-Pooh character. This has become a central focus of the town’s promotional efforts. One of the community’s main tourist attractions is ‘Winnie’s Hometown Festival', which takes place annually. In addition, White River offers outfitting experiences for people interested in hunting and fishing. White River markets itself as a location for the outdoor adventure enthusiast. However, economic circumstances, nationally and internationally, have adversely affected the tourism market in White River and elsewhere in northern Ontario (e.g., declining numbers of American visitors; less vehicle-based tourism). As such, the contribution of tourism to the economy of White River may continue to decline in the future. A few residents have expressed uncertainty about the alignment of the APM Project with community aspirations associated with Winnie-the-Pooh-themed tourism initiatives. While the APM Project may provide new markets for the local tourist industry, further work would be required to evaluate the potential to implement the project in a manner consistent with the aspirations of the community regarding tourism.

A Strategic Economic Plan for the community is currently being finalized. Economic development has been difficult given the overall economy; however, the Community Development Corporation has had recent success in terms of the mill re-opening. The successful efforts of the White River Community Development Corporation with respect to the public/private partnership with White River Forest Products, demonstrate that although White River is small in population, there is capacity within the community.

Should the APM Project locate in White River, there will be direct and indirect job creation and a diversity of career opportunities. Further induced employment will also occur as a result of income spending by direct and indirect workers. Jobs and business opportunities will be created and incomes will grow, as will household expenditures. The presence of additional long term and stable job opportunities will change the economic complexion of the community. Out-migration of youth will slow and in-migration will occur as White River becomes a larger employment centre. More households and greater expenditures open up market opportunities for local businesses to service the expanding needs of a growing and more affluent population.

Presently, the Township generates revenue primarily through taxes (property and payments in lieu of taxes), grants (conditional and unconditional) and user fees/service charges. In terms of municipal finance, liabilities have generally exceeded assets for the last decade. The APM Project will also allow White River to increase the municipal tax base to support maintenance and growth of community infrastructure and services.

White River may require assistance to effectively manage implications of the APM Project. This could include ensuring local residents are able to realize project direct and indirect employment opportunities as well as support for planning, implementing and managing economic development opportunities.

Overall, it can be expected that changes in community well-being related to the economic assets of White River as a result of the APM Project would be positive.

7.2.4 Implications for Infrastructure

While housing in White River is relatively inexpensive, prices are beginning to rise. There are few homes available for purchase or rent. A vacant apartment building complex in the community is reported to have been recently sold and is undergoing renovation. White River also has a senior housing complex in town. If the APM Project were to be implemented in White River, there is the potential to increase the cost of housing, depending on the size and rate of labour in-migration. Moreover, there may be instances where low-cost housing would be taken up by project workers. Further study and management of housing issues would be appropriate to ensure effects on housing affordability are minimized, and to ensure there is a strong supply of affordable housing and supply of rooms available for tourists and general travelling public.

The community has adequate municipal infrastructure to meet current needs of the population; however, there is a lack of funds, which makes it challenging to properly maintain and operate much of the infrastructure.

With the introduction of the APM Project and its associated local and regional economic opportunities in White River, there is the potential for increased demands on existing infrastructure, as well as increased resources and funding to support facility improvements. Overall, the changes in community well-being related to the infrastructure or physical assets of White River as a result of the APM Project would be positive.

7.2.5 Implications for Social Assets

In White River, the Tourism and Special Events Department organizes events (i.e., Winnie's Hometown Festival). There are limited facilities and organized recreational and sporting activities in the community. An abundance of fresh water lakes and forests in the Township's vicinity provide residents and tourists with a number of different recreational activities including: hunting and fishing, snowmobiling, cross-country skiing, hiking, touring, boating, and wildlife viewing.

White River has several organizations that provide limited social services to the community (i.e., White River Health Committee, Policing Committee, and the food bank). There have been mixed changes to social services and organizations in the community as some have opened and others have closed due to a lack of government funding. Overall, residents feel the community is friendly, safe, and tight-knit.

The APM Project will grow the population in White River, resulting in increased school enrolment, and revitalization of recreational and other programming, and community organizations. The project would be expected to have a positive influence on community dynamics through a more stable population base and the retention of younger families and youth, and by providing the ability to support its middle-aged and senior populations.

The APM Project will be compatible with White River's aspirations, including the desire to see growth and stability in the community. However, a few residents have expressed uncertainty about alignment of the APM Project with aspirations associated with Winnie-the-Pooh-themed tourism initiatives. White River does not appear to have a history of active community involvement on development issues, and has tended to defer to leadership on such initiatives.

The lower level of engagement and interest in development issues by residents adds to uncertainty about alignment of the APM Project with community values, and what would be required to successfully implement the project in White River.

With the possible introduction of the APM Project and its associated local and regional economic opportunities, there is the potential for population growth, which may place demands on existing facilities and services, and may create need for new facilities and services. Growth would also provide increased participation rates and funding to support the expansion of facilities and services. White River will require assistance to effectively manage implications of the APM Project such as assistance with planning, developing recreational facilities and services, social services and organizations, and accommodating a growing population.

Overall, the changes in community well-being related to the Social Assets of White River as a result of the APM Project appear to be positive.

7.2.6 Implications for Natural Environment

There are several provincial and national parks, as well as conservation reserves, located near White River. The natural environment is a source of pride in the community and is highly valued. The White River Forest 2008-2018 Forest Management Plan governs the use of lands in the surrounding area. Hunting and fishing are abundant in the area. Hunters have the opportunity to seek birds, small game, and large game such as moose.

Initial studies on the potential environmental effects associated with the project suggest that the APM Project is unlikely to have any significant negative effect on the natural environment that makes up the parks and protected areas near the community. In principle, there is the potential that visitation to the area may experience some decline as tourists might choose to avoid the area because of the presence of the facility. It is expected that through working with local communities and relevant authorities and clearly communicating with the public, any effects of the project on tourism can be mitigated. Further study is required to better understand and predict the potential effects of the project on visitor perception and use of the area.

As would be the case with any large project, natural areas might be affected during the various phases of the APM 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 negative environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository itself.

The project contains some flexibility with respect to on-site building designs and energy use to be consistent with broad 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 White River

Based on the foregoing discussion, the APM Project has potential to be a fit for the community of White River. Table 7-2 summarizes the overall community well-being implications for White River based on the five asset categories discussed above.

The APM Project would bring population growth and present significant opportunities for employment and economic development. Educational and health-care services would be enhanced in White River. Increased funding through a wider tax base would provide White River financial resources to better fund its infrastructure projects, educational developments, community and recreational facilities and programs, and social services and organizations.

There is interest in learning about the APM Project and many residents are supportive. The APM Project will be compatible with White River's aspirations, including the desire to see growth and stability in the community. However, a few residents have expressed uncertainty about alignment of the APM Project with aspirations associated with Winnie-the-Pooh-themed tourism initiatives. White River does not appear to have a history of active community involvement on development issues, and has tended to defer to leadership on such initiatives. The lower level of engagement and interest in development issues by residents adds to uncertainty about alignment of the APM Project with community values, and what would be required to successfully implement the project in White River.

Effective mitigation and environmental protection measures will ensure that the overall environmental integrity of the area is maintained.

The introduction of the APM Project to White River would create significant change. Changes could include the following:

- Increased number and diversity of employment and business/commercial opportunities (direct and indirect);
- Population growth due to in-migration of workers;
- Ability to retain youth/young families in the community
- Increased funding to improve and enhance municipal services (e.g., infrastructure, education, community/recreational facilities and programs, health /social services and organizations);
- Improved education and training, and development of a skilled workforce;
- Enhanced self-sufficiency for individuals, families, and the community as whole;
- Improved tax base/municipal revenues; and
- Increased demands on some existing infrastructure and services (e.g., housing, water and waste water systems) along with increased funding and resources to support expansion of infrastructure and services.

Table 7-2: Overall Community Well-Being Implications

Criteria / Measures	Ideal CWB Condition	Current White River Profile		Possible White River Profile with APM Project		Observations
OVERALL CWB IMPLICATIONS:						
Human Assets	Population growth occurs and youth are retained in the community	Declining	← (red)	Enhanced	→ (green)	• White River's 2011 population is decreasing and aging with limited opportunities to attract a working population. • APM Project would bring population growth, which is a key priority and aspiration for the community. • Youth would be retained through increased employment opportunities and new residents would be attracted to the area. • Improved education and training, and development of a skilled workforce. • Educational and health-care resources would be enhanced.
Economic Assets	Employment opportunities are available and tax base increases to fund community services and facilities	Negative	▬ (yellow)	Enhanced	→ (green)	• There is little business diversification occurring in the community; however, there is recent growth in mining and forestry, and a local hydroelectric project is under construction. The full impact of this activity over the long term is not yet known. • A few residents have expressed uncertainty about the alignment of the APM Project with community aspirations related to Winnie-the-Pooh-themed tourism initiatives. • There will be increased employment opportunities and a more diverse range of jobs. • Increased funding through a wider tax base would provide the financial resources for White River to fund its infrastructure projects, education, community and recreational facilities and programs, and health/social services and organizations. • The increased jobs from the APM Project would be the catalyst for White River to enhance its community well-being. • There is the potential for niche markets associated with the APM Project to increase tourism; further study is required to better understand the potential effects on visitor perception and use of the area.
Infrastructure Assets	Infrastructure is maintained or improved to meet the needs of the community	Neutral	▬ (yellow)	Enhanced	→ (green)	• While housing in White River is relatively inexpensive, prices are beginning to rise. There are few homes available for purchase or to rent. • Facilities such as the waste treatment systems are costly to operate and maintain. • While placing increased demands on some of the infrastructure and services, overall, the APM Project would 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	Negative	← (red)	Enhanced	→ (green)	• There have been mixed changes to social services and organizations in the community as some have opened and others have closed due to population deceases and lack of available funding. • 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. • Initial indications are that the APM Project may be compatible with community aspirations, including the desire to see growth and stability. However, a few residents have expressed uncertainty about the alignment of the APM Project with community aspirations related to Winnie-the-Pooh-themed tourism initiatives. The lower level of engagement and interest by residents adds to uncertainty about the alignment of the APM Project with community values, and what would be required to successfully implement the project in White River.
Natural Environment	Natural areas, parks and conservation reserves are preserved and maintained for use and enjoyment	Maintained	▬ (green)	Maintained	▬ (green)	• 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 itself.

Legend	
Declining	← (red)
Stable	▬ (yellow)
Environment – Integrity Maintained	▬ (green)
Increasing – Enhanced – Positive	→ (green)
Uncertain	△

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7.3 Criteria to Assess Factors Beyond Safety – Summary in White River

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 has acknowledged that 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 White River against these original factors. It summarizes preliminary findings about the implications of the APM Project, were it to be implemented in the community, on various factors of well-being. For many evaluation factors, 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 engage neighbouring communities, communities on transportation routes and in particular, First Nation and Métis communities in the area. White River 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 two of White River's community neighbours also expressed interest in learning more about the APM Project, and are currently participating in the site selection process.

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

Factors Beyond Safety	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 but the community wants to learn more about safety and health considerations to strengthen their confidence in the safety of the project.
	Sustainable built environments	Enhanced	• Community infrastructure and built fabric would be enhanced through project activities and investments in the community.
	Sustainable natural environments	Maintained	• Effective mitigation and environmental protection measures would ensure that the overall environmental integrity of the area is maintained. • It is understood at this point in time that no significant negative environmental effects are likely during the construction, operation and decommissioning phases of the used fuel repository itself.
	Local and regional economy and employment	Enhanced	• Significant employment and population growth would occur in White River and surrounding communities – hundreds of new jobs might be created in White River. • With these jobs comes the potential to significantly increase the current population of White River. • New opportunities would be created for local businesses to serve the project and growing population.
	Community administration and decision-making processes	Uncertain	• Although a relatively small community, the White River Economic Development Committee has demonstrated success with the White River Forest Products public /private partnership. • Some local leadership has demonstrated interest in the project, while for others, there are uncertainties surrounding the suitability of the project. • There has been limited participation by community members in engagement to date, which may influence the community's ability to make informed and effective decisions about the project. • Going forward it is expected that local leadership would engage the community in decision-making with respect to the APM Project.
	Balanced growth and healthy, livable communities	Uncertain	• The APM Project generally appears to be a fit with primary community goals and aspirations for economic development and population growth. • A few residents have expressed uncertainty about the alignment of the APM Project with community aspirations related to Winnie-the-Pooh-themed tourism initiatives, and the lower level of engagement and interest by residents adds to uncertainty about the alignment of the APM Project with community values, and what would be required to successfully implement the project in White River.
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 of surrounding communities is at a preliminary stage and further dialogue will be required to understand and address questions and concerns about safety and health considerations related to the repository and transportation of used nuclear fuel.
	Sustainable built environments	Enhanced	• Infrastructure and built fabric will be enhanced through project activities and investments in the community and surrounding areas.
	Sustainable natural environments	Maintained	• Some natural areas may be affected during the construction, operation and decommissioning phases of the project. • Effective mitigation and environmental protection measures will be required to ensure that 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.
	Community administration and decision-making processes	Maintained	• Engagement of surrounding communities has been initiated and is coordinated and ongoing. • Surrounding communities currently participating in the NWMO's 'Learn More' program include Hornepayne and Manitouwadge.
	Balanced growth and healthy, livable communities	Enhanced	• Engagement of surrounding communities has been initiated and is ongoing. • Surrounding area communities are collectively seeking economic development and growth in the region; several participating in the NWMO's 'Learn More' program. • The APM Project generally appears to be in alignment with these aspirations.

Factors Beyond Safety	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 general potentially suitable sites for the project thus providing flexibility in selecting specific sites that can avoid ecologically sensitive areas and local 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	• White River and the surrounding areas are accessible by rail and highway, and have some limited social and economic support services. • White River will need a lot of capacity building and support to absorb the anticipated growth in population and economic activity. • Investments would be required to accommodate growth and special project needs.
	Potential for social infrastructure to be adapted to implement the project	Yes	• The community of White River has limited community capacity and social infrastructure in place to plan and adapt to changes resulting from the project. • The NWMO would have to work with the community and social service providers to plan and implement needed measures.
	The NWMO resources required to put in place physical and social infrastructure needed to support the project	To Be Determined	• White River would require a high level of assistance in terms of planning, and human and financial resources. • 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	To Be Determined	• White River is on the Trans-Canada Highway 17 and accessible from Trans-Canada Highway 11 via Highway 631. • White River is located on the CPR freight line. • As outlined in Chapter 6, the community and region have access to road and rail. • Project transportation will need to address community, logistical and regulatory matters across multiple provinces and multiple jurisdictions including: Ontario, Quebec, and New Brunswick. • Engagement of surrounding communities will be required to help build understanding and address questions and concerns.
	The availability of suitable safe connections and intermodal transfer points, if required, and potential to put them in place	To Be Determined	• Engagement of surrounding communities and those 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	890 - 1,740 tonnes of equivalent carbon dioxide emission is expected to be produced per year	• As outlined in Chapter 6, all-road transport of 4.6 million fuel bundles from the interim storage sites to an APM facility near White River would produce approximately 1,740 tonnes of equivalent carbon dioxide emissions per year. • Transport by mostly rail mode would produce approximately 890 tonnes of equivalent carbon dioxide emissions 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. However, engagement of surrounding communities and those on potential transportation routes will be required to understand and address questions and concerns.

7.4 Overview of Engagement in White River

The NWMO has engaged with, and supported White River 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;
- Both 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;
- Presentation to the White River Harmony Seniors Club;
- ‘Ask the NWMO’ columns in regional newspapers;
- Meetings/discussions with nearby First Nations and Métis Organizations;
- Attendance at regional meetings, conferences (e.g., Ontario West Municipal Conference, Good Roads Conference, and NOMA Conference);
- NWMO Used Fuel Transportation Exhibit; and
- Nuclear waste management facility tours.

Initial discussions with a cross-section of community leaders, briefings and conversations with community members, and conversations with residents during open houses suggest there is some interest in the community to continue to learn about the project and consider hosting it in the area. Discussions were held 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);
- Leaders in surrounding communities; and
- Residents.

Based on these discussions, there appears to be potential in the local community to sustain interest. There also appears to be interest to continue and move forward with the siting process. Some residents have noted that there is misinformation about the APM Project in White River.

7.4.1 Summary of Issues and Questions Raised

In White River, 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.

Throughout the various engagement activities, interests and questions expressed by Community Liaison Committee members and community members were documented. In White River, the majority of people engaged were perceived to be supportive of the APM Project and were interested in learning more. The key interests expressed included the following:

- Economic challenges in the community;
- Health, safety, and environmental risk;
- Transportation;
- Preservation of the natural environment (e.g., clean air, hunting, fishing); and,
- Community Engagement and the NWMO site selection process.

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 White River.

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

There appears to be potential for the APM Project to foster well-being in White River. The APM Project would bring population growth and present significant opportunities for employment and economic development. Educational and health-care services would be enhanced in White River. Increased funding through a wider tax base would provide White River with financial resources to better fund its infrastructure projects, educational developments, community and recreational facilities and programs, and social services and organizations. The APM Project would be compatible with community aspirations, including the desire to see growth and stability. However, a few residents have expressed uncertainty about the alignment of the APM Project with community aspirations related to Winnie-the-Pooh-themed tourism initiatives, and the lower level of engagement and interest by residents adds to uncertainty about the alignment of the APM Project with community values, and what would be required to successfully implement the project in White River.

There appears to be potential for sustained interest in the local community. There appears to be community leadership support for learning more about the APM Project, and some members of the community have expressed interest in learning about it.

There appears to be potential for the APM Project to foster well-being in surrounding communities. Preliminary discussions with residents and officials from surrounding communities have revealed an interest in the potential economic benefits offered by the project. Two surrounding communities (Manitouwadge and Hornepayne) are currently in the NWMO site selection process. At this time, there is a need for further understanding from potentially affected First Nation and Métis communities and surrounding communities regarding the potential for the APM Project to align with their community aspirations.

There is high potential for sustained interest in the surrounding communities. Nearby communities such as Manitouwadge and Hornepayne are in various phases of the NWMO site selection process. Through discussions with groups such as the Northeast Superior Mayors' Group and others, White River has taken steps to engage its neighbours. Further discussions will be required to gain an understanding of the potential interest in surrounding 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 general potentially suitable areas within the White River area, 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 community input 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 community 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 developed and sustained.

    a. The site selection process spans several years, and interest and conversation in the interested community and area needs to be developed and 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 municipalities would be substantial, and 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. White River will require support to prepare for the next phases of the siting process if they are to proceed.

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 in the area, 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.

In order 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 nuclear 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. Across communities and 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 in any community and area proceeding in the site selection process to support information 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 that 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, ultimately satisfying the conditions for successful implementation of the project.

8.2 Preliminary Conclusions

The preceding chapters of this report have examined, in a preliminary way, the potential for White River and area 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 White River area.
    - 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. There is potential to foster community well-being in White River through the implementation of the project in the area.

3. There is potential for sustained interest in White River 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 that 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;
- Transportation safety; and
- Social, economic and cultural effects within the community and surrounding area.

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 that the geographic area explored in this assessment 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 general area 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 White River area.

Based on this preliminary information, there are a number of observations that support the overall conclusion that there is potential to foster the well-being of the interested community through the implementation of the APM Project, and there is potential to sustain interest.

- If the APM Project were to be implemented in the area, there appears to be potential for the APM Project to foster well-being in White River. The APM Project would bring population growth and present significant opportunities for employment and economic development. Educational and health-care services would be enhanced in White River.

Increased funding through a wider tax base would provide White River with financial resources to better fund its infrastructure projects, educational developments, community and recreational facilities and programs, and social services and organizations. The APM Project would be compatible with community aspirations, including the desire to see growth and stability. However, a few residents have expressed uncertainty about the alignment of the APM Project with community aspirations related to Winnie-the-Pooh-themed tourism initiatives, and the lower level of engagement and interest by residents adds to uncertainty about the alignment of the APM Project with community values, and what would be required to successfully implement the Project in White River.

- There appears to be potential for sustained interest in the local community. There appears to be community leadership support for learning more about the APM Project and some members of the community have expressed interest in learning about it.

- There appears to be potential for the APM Project to foster well-being in surrounding communities. Preliminary discussions with residents and officials from surrounding communities have revealed an interest in the potential economic benefits offered by the project. Two surrounding communities (Manitouwadge and Hornepayne) are currently participating in the NWMO site selection process. At this time, there is a need for further understanding from potentially affected First Nation and Métis communities and surrounding communities regarding the potential for the APM Project to align with their community aspirations.

- There is high potential for sustained interest in the surrounding communities. Nearby communities such as Manitouwadge and Hornepayne are in various phases of the NWMO site selection process. Through discussions with groups such as the Northeast Superior Mayors’ Group and others, White River has taken steps to engage its neighbours. Further discussions will be required to gain an understanding of the potential interest in surrounding communities.

8.3.2 Uncertainties and Challenges

Based on this preliminary information, there are uncertainties and challenges that would need to be addressed if White River 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 arisen 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 meeting the requirements of the project in this area. Examples of the range and type of uncertainties and challenges that would need to be considered in planning and resourcing any further studies in the area include the following:

1. Geoscientific studies suggest that while the White River area appears to contain general land areas with favourable geoscientific characteristics for hosting a deep geological repository, there are inherent uncertainties that would need to be addressed. Main uncertainties include the low resolution of available geophysical data over most of the general potentially suitable areas, the influence of regional structural features, and the presence of numerous dykes.

2. Environment and safety studies suggest there is potential to implement the project safely and with respect for the environment in the White River 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 within the White River area, smaller, specific 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 community input 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 community expectations.

- 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.

6. Interest in further learning about the project needs to be developed and sustained.
    - The site selection process spans several years and interest and conversation in the community and area needs to be developed and 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. White River will require support to prepare for the next phases of the siting process if they are 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 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 White River 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 include areas in the vicinity of the community 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.

9. REFERENCES

References for Chapter 1

DPRA. 2014. Update on CWBA Findings to Date – Nipigon, ON. Technical Memorandum dated June 10, 2014. Toronto, Canada.

Geofirma Engineering Ltd (Geofirma). 2014. Interim Results of Geoscientific Preliminary Assessment, Sedimentary Sites, Southern Ontario. Technical Memorandum dated January 9, 2014. Ottawa, Canada.

Golder Associates Ltd (Golder). 2014. Interim Results of Geoscientific Preliminary Assessment, Township of Nipigon, Ontario. Technical Memorandum dated June 8, 2014. Mississauga, Canada.

Nuclear Waste Management Organization (NWMO). 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. Toronto, Canada. (Available at www.nwmo.ca)

Nuclear Waste Management Organization (NWMO). 2011. Preliminary Assessment of Potential Suitability – Feasibility Studies. Toronto, Canada.

Nuclear Waste Management Organization (NWMO). 2014a. Letter from K. Shaver to Mayor P. Eagleson and Mayor M. Smith Re: Adaptive Phased Management Site Selection Process – Interim Findings from Step 3, Phase 1 Preliminary Assessments. Dated January 16, 2014. Toronto, Canada.

Nuclear Waste Management Organization (NWMO). 2014b. Letter from K. Shaver to Mayor R. Harvey Re: Adaptive Phased Management Site Selection Process – Interim Report from Step 3, Phase 1 Preliminary Assessment. Dated January 16, June 11, 2014. Toronto, Canada.

References for Chapter 2

DPRA 2014. Community Profile: White River, Ontario. December 2014. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0087. Toronto, Canada.

References for Chapter 3

Canadian Nuclear Safety Commission (CNSC). 2013. Certificate for Transport Package Design, No. CDN/2025/B(U)-96 (Rev.7.). Ottawa, Canada.

Garamszeghy, M. 2012. Nuclear fuel waste projections in Canada – 2012 update. Nuclear Waste Management Organization Report NWMO TR-2012-13. Toronto, Canada.

References for Chapter 4

AECOM Canada Ltd. 2014a. Phase 1 Geoscientific Desktop Preliminary Assessment of Potential Suitability for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel, Township of White River, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0083. Toronto, Canada.

AECOM Canada Ltd. 2014b. Phase 1 Geoscientific Desktop Preliminary Assessment, Terrain and Remote Sensing Study, Township of White River, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0084. Toronto, Canada.

Beakhouse, G.P. and Lin, S. 2006. Tectonic significance of the Pukaskwa batholith with the Hemlo and Mishibishu greenstone belts. Ontario Geological Survey, Open File Report 6192, 7-1 to 7-7. Sudbury, Canada.

Beakhouse, G.P., Lin, S. and Kamo, S.L. 2011. Magnetic and tectonic emplacement of the Pukaskwa batholith, Superior Province, Ontario, Canada. Can. Journal of Earth Science 48, 187-204.

Bell, M. and E.P. Laine. 1985. Erosion of the Laurentide region of North America by glacial and glaciofluvial processes. Quaternary Research 23, 154-175.

Bostock, H.S. 1970. Physiographic subdivisions of Canada. *In* R.J.W. Douglas (ed.), Geology and Economic Minerals of Canada (5th ed.). Geological Survey of Canada, Economic Geology Report, No. 1, 9-30. Ottawa, Canada.

Card, K.D. 1990. A review of the Superior Province of the Canadian Shield, a product of Archean accretion. Precambrian Res 48, 99-156.

NRCan (Natural Resources Canada). 2013. Earthquakes Canada Website. (Retrieved from http://www.earthquakescanada.nrcan.gc.ca/historic-historique/caneqmap-eng.php). Accessed August 15, 2013.

Everitt, R., J. McMurry, A. Brown and C.C. Davison. 1996. Geology of the Lac du Bonnet Batholith, inside and out: AECL's Underground Research Laboratory, southeastern Manitoba. Field Excursion B-5: Guidebook. Geological Association of Canada — Mineralogical Association of Canada, Joint Annual Meeting. Winnipeg, Manitoba.

Fenwick, K.G. 1967. Geology of the Dayohessarah Lake area, District of Algoma. Ontario Department of Mines, Geological Report 49. Toronto, Canada.

Flint, R. 1947. Glacial Geology and the Pleistocene Epoch. New York, United States.

Frape, S.K., P. Fritz and R.H. McNutt. 1984. Water–Rock interaction and chemistry of groundwaters from the Canadian Shield. Geochimica et Cosmochimica Acta 48, 1617–1627.

Gascoyne, M. 1994. Isotopic and geochemical evidence for old groundwaters in a granite on the Canadian Shield. Mineralogical Magazine 58A, 319-320.

Gascoyne, M. 2000. Hydrogeochemistry of the Whiteshell Research Area. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10033-R00. Toronto, Canada.

Gascoyne, M. 2004. Hydrogeochemistry, groundwater ages and sources of salts in a granitic batholith on the Canadian Shield, southeastern Manitoba. Applied Geochemistry 19, 519-560.

Gascoyne, M., C.C. Davison, J.D. Ross and R. Pearson. 1987. Saline groundwaters and brines in plutons in the Canadian Shield: Special Paper 33, 53-68. *In* P. Fritz and S.K.Frape (eds), Saline water and gases in crystalline rocks. St. John's, Canada.

Golder Associates Ltd. (Golder). 2012. Initial screening for siting a deep geological repository for Canada's used nuclear fuel. Township of White River, Ontario. Prepared for Nuclear Waste Management Organization. Golder report 10-1152-0110 (12000). Mississauga, Canada.

GSC (Geological Survey of Canada). 2013. Geoscience Data Repository for Geophysical and Geochemical Data. (Retrieved from gdr.nrcan.gc.ca). Accessed 2013.

Hallet, B. 2011. Glacial Erosion Assessment. Nuclear Waste Management Organization Report NWMO DGR-TR-2011-18. Toronto, Canada.

Hay, W.W., C.A. Shaw and C.N. Wold. 1989. Mass-balanced paleogeographic reconstructions. Geologishce Rundschau 78, 207-242.

Jackson, S.L., Beakhouse, G.P. and Davis, D.W. 1998. Regional geological setting of the Hemlo gold deposit: an interim progress report. Ontario Geological Survey, Open File Report 5977. Sudbury, Canada.

Laine, E.P. 1980. New evidence from beneath western North Atlantic for the depth of glacial erosion in Greenland and North America. Quaternary Research 14, 188–198.

Laine, E.P. 1982. Reply to Andrew's comment. Quaternary Research 17, 125–127.

Lee, D.H. and C.F. Southam. 1994. Effect and implications of differential isostatic rebound on Lake Superior's regulatory limits. Journal of Great Lakes Research 20(2), 407-415.

McMurry, J., D.A. Dixon, J.D. Garroni, B.M. Ikeda, S. Stroes-Gascoyne, P. Baumgartner and T.W. Melnyk. 2003. Evolution of a Canadian deep geologic repository: Base scenario. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10092-R00. Toronto, Canada.

Meriaux, C., J. R. Lister, V. Lyakhovsky, and A. Agnon. 1999. Dyke propagation with distributed damage of the host rock. Earth & Planetary Science Letters 165, 177–185.

Milne, V.G. 1968. Geology of the Black River area, District of Thunder Bay. Ontario Department of Mines, Geological Report 72. Toronto, Canada.

MNR (Ministry of Natural Resources). 2013. Licence and permit list. (Retrieved from http://www.mnr.gov.on.ca/en/Business/Aggregates/2ColumnSubPage/STDPROD_091593.html). Accessed June 2013.

MNDM (Ministry of Northern Development and Mines). 2013. Geo-Claims Internet Application. (Retrieved from http://www.mndm.gov.on.ca/mines/claimaps_e.asp). Accessed May 2013.

Monenco Ontario Limited. 1981. Evaluation of the Potential of Peat in Ontario. Ontario Ministry of Natural Resources, Mineral Resources Branch, Occasional Paper No. 7. Toronto, Canada

Muir, T.L. 2000. Geologic compilation of the eastern half of the Schreiber-Hemlo greenstone belt. Ontario Geological Survey, Map 2614, scale 1:50,000. Sudbury, Ontario.

Muir, T.L. 2003. Structural evolution of the Hemlo greenstone belt in the vicinity of the world-class Hemlo gold deposit. Can. J. Earth Sci. 40, 395-430.

Nuclear Waste Management Organization (NWMO). 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel, Nuclear Waste Management Organization. (Available at www.nwmo.ca).

OGS (Ontario Geological Survey). 2011. 1:250 000 scale bedrock geology of Ontario. Ontario Geological Survey, Miscellaneous Release–Data 126 - Revision 1. Sudbury, Canada.

OGS (Ontario Geological Survey). 2002a. Ontario airborne geophysical surveys, magnetic and electromagnetic data, Manitouwadge area, Geophysical Data Set 1205 - Revised. Sudbury, Canada.

OGS (Ontario Geological Survey). 2002b. Ontario airborne geophysical surveys, magnetic and electromagnetic data, Hemlo area, Geophysical Data Set 1207 - Revised. Sudbury, Canada.

OGS (Ontario Geological Survey). 2003. Ontario airborne geophysical surveys, magnetic and electromagnetic data, Oba-Kapuskasing area, Geophysical Data Set 1024 - Revised. Sudbury, Canada.

MOE (Ontario Ministry of Environment). 2013. Water Well Database. Toronto, Canada. (Retrieved from http://www.ene.gov.on.ca/environment/en/resources/collection/data_downloads/index.htm#Well Records). Accessed February 2014.

Peltier, W.R. 2002. On eustatic sea level history: Last Glacial Maximum to Holocene. Quaternary Science Reviews 21, 377–396.

Percival, J.A. and R.M. Easton. 2007. Geology of the Canadian Shield in Ontario: an update. Ontario Power Generation Report 06819-REP-01200-10158-R00. Toronto, Canada.

PGW (Paterson, Grant & Watson Ltd.). 2014. Phase 1 Geoscientific Desktop Preliminary Assessment, Processing and Interpretation of Geophysical Data. Township of White River, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0085. Toronto, Canada.

POSIVA. 2007. Olkiluoto Site Description 2006. Prepared by Andersson, J., H. Ahokas, J.A. Hudson, L. Koskinen, A. Luukkonen, J. Löfman, V. Keto, P. Pitkänen, J. Mattila, A.T.K. Ikonen and, M. Ylä-Mella. 2007-03. Olkiluoto, Finland.

Santaguida, F. 2001. Precambrian geology compilation series – White River sheet. Ontario Geological Survey, Map 2666, scale 1:250,000. Sudbury, Canada.

Sella, G.F., S. Stein, T.H. Dixon, M. Craymer, T.S. James, S. Mazzotti and R.K. Dokka. 2007. Observation of glacial isostatic adjustment in “stable” North America with GPS, Geophys. Res. Lett. 34, L02306, doi:10.1029/2006GL027081.

Shackleton, N.J., A. Berger and W.R. Peltier. 1990. An alternative astronomical calibration of the lower Pleistocene timescale based on ODP Site 677. Transactions of the Royal Society of Edinburgh: Earth Sciences 81, 251-261.

Singer, S.N. and C.K. Cheng. 2002. An assessment of the groundwater resources of northern Ontario. Ontario Ministry of the Environment, Environmental Monitoring and Reporting Branch. Toronto, Canada.

Siragusa, G.M. 1977. Geology of the Kabinakagami Lake area, District of Algoma. Ontario Division of Mines, Geoscience Report 159, Map 2355, scale 1:63. Toronto Bay, Canada.

Siragusa, G.M. 1978. Geology of the Esnagi Lake area, District of Algoma. Ontario Geological Survey, Geoscience Report 176, Map 2382, scale 63,360. Toronto, Canada.

SRK Consulting Inc. 2014. Phase 1 Geoscientific Desktop Preliminary Assessment, Lineament Interpretation, Township of White River, Ontario. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report Number: APM-REP-06144-0086. Toronto, Canada.

Stevenson, D.R., E.T. Kozak, C.C. Davison, M. Gascoyne and R.A. Broadfoot. 1996. Hydrogeologic characterization of domains of sparsely fractured rock in the granitic Lac du Bonnet Batholith, Southeastern Manitoba, Canada. Atomic Energy of Canada Limited Report AECL-11558, COG-96-117. Pinawa, Canada.

Stott, G.M. 1999. Precambrian geology of the Dayohessarah Lake area, White River, Ontario. Ontario Geological Survey, Open File Report 5984. Sudbury, Canada.

Thurston, P.C. 1991. Archean geology of Ontario: Introduction. *In* Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, 73-78. Toronto, Canada.

White, W. 1972. Deep erosion by continental ice-sheets. Geological Society of America Bulletin 83, 1037–1056.

Williams, H.R. 1989. Geological studies in the Wabigoon, Quetico and Abitibi-Wawa subprovinces, Superior Province of Ontario, with emphasis on the structural development of the Beardmore-Geraldton Belt; Ontario Geological Survey, Open File Report 5724. Sudbury, Canada.

Williams, H. R., Stott, G.M., Heather, K.B., Muir, T.L. and Sage, R.P. 1991. Wawa Subprovince; In: Geology of Ontario, Ontario Geological Survey, Special Volume 4, Part 1, 485-525. Sudbury, Canada.

Zaleski, E., van Breemen O. and Peterson, V.L. 1999. Geological evolution of the Manitouwadge greenstone belt and the Wawa-Quetico subprovince boundary, Superior Province, Ontario, constrained by U-Pb zircon dates of supracrustal and plutonic rocks. Canadian Journal of Earth Sciences 36, 945-966.

References for Chapter 5

Archer, D. and A. Ganopolski, 2005. A movable trigger: Fossil fuel CO2 and the onset of the next glaciation. Geochemistry, Geophysics, Geosystems 6(5), 1-7.

Atomic Energy of Canada Limited (AECL), 1994. Environmental impact statement on the concept for disposal of Canada's nuclear fuel waste. Atomic Energy of Canada Limited Report, AECL-10711, COG-93-1. Chalk River, Canada.

Bat Conservation International (BCI), 2013a. BCI Species Profiles: Myotis lucifugus. Retrieved from (http://www.batcon.org/index.php/all-about-bats/species-profiles.html?task=detail&species=2040&country=43&state=all&family=all&start=25). Accessed April 2013.

Bat Conservation International (BCI), 2013b. BCI Species Profiles: Myotis septentrionalis. Retrieved from (http://www.batcon.org/index.php/all-about-bats/species-profiles.html?task=detail&species=2306&country=43&state=40&family=100&limitstart=0) Accessed April 2013

Berger, A. and M.F. Loutre, 2002. An exceptionally long interglacial ahead? Science 297, 1287-1288.

Bird Studies Canada (BSC), 2006. Environment Canada's Canadian Wildlife Service, Ontario Nature, Ontario Field Ornithologists and Ontario Ministry of Natural Resources. Ontario Breeding Bird Atlas Website. Retrieved from (http://www.birdsontario.org/atlas/index.jsp). Accessed July 2013.

Dobbyn, J.S., 1994. Atlas of the Mammals of Ontario. Federation of Ontario Naturalists, Toronto. 120p.

Domtar Inc. (Domtar), 2008. White River Forest 2008-2018 Forest Management Plan. April 2008. 373 p.

Garisto, F., J. Avis., T. Chshyolkova, P. Gierszewski, M. Gobien, C. Kitson, T. Melnyk, J. Miller, R. Walsh and L. Wojciechowski. 2010. Glaciation scenario: Safety assessment for a used fuel geological repository. Nuclear Waste Management Organization Technical Report NWMO TR-2010-10. Toronto, Canada.

Gierszewski, P., J. Avis, N. Calder, A. D'Andrea, F. Garisto, C. Kitson, T. Melnyk, K. Wei and L. Wojciechowski, 2004. Third Case Study - Postclosure Safety Assessment. Ontario Power Generation, Nuclear Waste Management Division Report 06819-REP-01200-10109-R00. Toronto, Canada.

Golder Associates Ltd. (Golder), 2014. Phase 1 Desktop Assessment, Environment Report, Township of White River. Golder Report 12-1152-0026 (4100) (4104). Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0082. Toronto, Canada.

Goodwin, B.W., T.H. Andres, W.C. Hajas, D.M. LeNeveu, T.W. Melnyk, J.G. Szekely, A.G. Wikjord, D.C. Donahue, S.B. Keeling, C.I. Kitson, S.E. Oliver, K. Witzke and L. Wojciechowski. 1996. The disposal of Canada's nuclear fuel waste: A study of postclosure safety of in-room emplacement of used CANDU fuel in copper containers in permeable plutonic rock. Volume 5: Radiological Assessment. Atomic Energy of Canada Limited Report, AECL-11494-5, COG-95-552-5. Chalk River, Canada.

Jones, C., R. Layberry and A. Macnaughton, 2013. Ontario Butterfly Atlas Online. Retrieved from (http://www.ontarioinsects.org/atlas_online.htm). Toronto Entomologists' Association. Accessed July 2013.

Land Information Ontario (LIO), 2013. Ontario Ministry of Natural Resources. Peterborough, Canada. Retrieved from (http://www.mnr.gov.on.ca/en/Business/LIO/) Accessed April 2013.

Natural Heritage Information Centre (NHIC), 2013. Ontario Ministry of Natural Resources. Peterborough, Canada. Retrieved from (http://www.mnr.gov.on.ca/en/Business/NHIC/) Accessed July 2013.

Natural Heritage Information Centre (NHIC), 2005. Ontario Odonata Atlas, Natural Heritage Information Centre, Ontario Ministry of Natural Resources. Peterborough, Canada. Retrieved from (http://nhic.mnr.gov.on.ca/odonates/about.html). Accessed July 2013.

Natural Resources Canada (NRCan), 2010. Seismic Hazard Map, Geological Survey of Canada. Ottawa, Canada. Retrieved from (http://www.earthquakescanada.nrcan.gc.ca) Accessed April 2013.

Natural Resources Canada (NRCan), 2009a. Aerodromes and Airports (2006). Atlas of Canada. Retrieved from (http://atlas.nrcan.gc.ca/site/english/maps/energy.html#infrastructure). Accessed June 2013.

Natural Resources Canada (NRCan), 2009b. Pipeline Infrastructure (2006). Atlas of Canada. Retrieved from (http://atlas.nrcan.gc.ca/site/english/maps/energy.html#infrastructure). Accessed June 2013.

Nuclear Waste Management Organization (NWMO), 2013. Adaptive Phased Management Postclosure Safety Assessment of a Used Fuel Repository in Sedimentary Rock. Nuclear Waste Management Organization Report NWMO TR-2013-07. Toronto, Canada.

Nuclear Waste Management Organization (NWMO), 2012. Adaptive Phased Management Used Fuel Repository Conceptual Design and Postclosure Safety Assessment in Crystalline Rock. Nuclear Waste Management Organization Report NWMO TR-2012-16. Toronto, Canada.

Nuclear Waste Management Organization (NWMO), 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. Toronto, Canada. (Available at www.nwmo.ca)

Oldham, M.J. and W.F. Weller, 2000. Ontario Herpetofaunal Atlas. Natural Heritage Information Centre. Ontario Ministry of Natural Resources. Peterborough, Canada. Retrieved from (http://nhic.mnr.gov.on.ca/MNR/nhic/herps/ohs.html). Accessed June 2013.

Ontario Heritage Trust (OHT), 2013. Retrieved from (http://www.heritagetrust.on.ca/Home.aspx). Accessed July 2013.

Ontario Ministry of the Environment (MOE), 2013a. Landfill Inventory Management Ontario (LIMO) List. Retrieved from (http://www.ene.gov.on.ca/environment/en/monitoring_and_reporting/limo/landfills/). Accessed June 2013.

Ontario Ministry of the Environment (MOE), 2013b. Water Well Information System (WWIS) Database. Accessed August 2013.

Ontario Ministry of Natural Resources (MNR), 2013a. Fisheries Management Zone Maps. Queen's Printer for Ontario. Retrieved from (http://www.mnr.gov.on.ca/en/Business/LetsFish/2ColumnSubPage/198481.html). Accessed June 2013.

Ontario Ministry of Natural Resources (MNR), 2013b. Forest Management Plans. Retrieved from (http://www.efmp.lrc.gov.on.ca/eFMP/home.do?currentFmu=&language=en). Accessed July 2013.

Ontario Ministry of Tourism, Culture, and Sport (MTCP), 2013. Heritage Properties Search Form. Retrieved from (http://www.hpd.mcl.gov.on.ca/scripts/hpdsearch/english/default.asp). Accessed June 2013.

Parks Canada, 2013. Canada's Historic Places. Retrieved from (http://www.pc.gc.ca/progs/lhn-nhs/index.aspx). Accessed June 2013.

Posiva, 2007. Safety assessment for a KBS-3H spent nuclear fuel repository at Olkiluoto, Summary Report. Posiva Report 2007-06. Eurajoki, Finland.

Royal Ontario Museum (ROM), 2013. Ontario's Biodiversity: Species at Risk. Toronto, Canada. Retrieved from (http://www.rom.on.ca/ontario/risk.php) Accessed June 2013.

SKB, 2011. Long-term safety for the final repository for spent nuclear fuel at Forsmark, main report of the SR-Site project. Swedish Nuclear Fuel and Waste Management Company Technical Report SKB TR-11-01. Stockholm, Sweden.

Sills, D., V. Cheng, P. McCarthy, B. Rousseau, J. Waller, L. Elliott, J. Klaassen and H. Auld, 2012. Using tornado, lightning and population data to identify tornado prone areas in Canada. Preprints, 26th AMS Conference on Severe Local Storms. Amer. Meteorol. Soc., Paper P59. Nashville, United States.

Statistics Canada. 2013. Census Profile. Retrieved from (http://www12.statcan.gc.ca/census-recensement/2011/dp-pd/prof/index.cfm?Lang=E). Accessed July 2013.

von Bitter, R., 2013. Personal Communication on July 12, 2013 re: Archaeological Sites Database. Ministry of Tourism, Culture, and Sport.

Williams, H.R., G.M. Stott, K.B. Heather, T.L. Muir, and R.P. Sage, 1991. White River Subprovince; *in* Geology of Ontario. Special Volume 4, Part I, 485-534.

References for Chapter 6

Batters, S., K. Tsang and U. Stahmer. 2012. Generic transportation dose assessment. Prepared by AMEC NSS for the Nuclear Waste Management Organization. Nuclear Waste Management Organization Report NWMO TR-2012-06.

Canadian Nuclear Safety Commission (CNSC). 2003. Transportation Security Plans for Category I, II or III Nuclear Material. Regulatory Guide G-208. March, 2003.

Canadian Nuclear Safety Commission (CNSC). 2009. HazMat Team Emergency Response Manual for Class 7 Transport Emergencies. INFO-0764 Rev. 2. July, 2009.

Canadian Nuclear Safety Commission (CNSC). 2013. Certificate for Transport Package Design. CDN/2052/B(U)-96 (Rev. 7). CNSC File 30-H1-118-0. July 29, 2013.

Garamszeghy, M. 2011. Nuclear fuel waste projections in Canada – 2013 update. Nuclear Waste Management Organization Report NWMO TR-2011-25. Toronto, Canada.

International Atomic Energy Agency (IAEA). 2000. Safety Standards Series. Regulations for the Safe Transport of Radioactive Material, 1996 Edition (Revised). Requirements No. TS-R-1 (ST-1, Revised). July 2000.

Ontario Ministry of Northern Development and Mines (MNDM). 2012. Northern Highways Program, 2012 – 2016. ISSN 1913-4568. November 2012.

Ontario Ministry of Transportation (MTO). 2009. Provincial Highways Traffic Volumes 1988-2009. Highway Standards Branch. Traffic Office.

Stahmer, U. 2009. Transport of Used Nuclear Fuel – A Summary of Canadian and International Experience. Nuclear Waste Management Organization Report NWMO TR-2009-14. April, 2009.

Transport Canada. 2012. Emergency Response Guidebook. A Guidebook for First Responders During the Initial Phase of a Dangerous Goods/Hazardous Materials Transportation Incident.

References for Chapter 7

AECOM. 2010. A Preliminary Assessment of Illustrative Generic Community Economic Benefits from Hosting the APM Project. Toronto, Canada. (Available at http://www.nwmo.ca/uploads_managed/MediaFiles/1497_nwmosr-2010-09_preliminary_ass.pdf)

DPRA 2014a. Community Profile: White River, Ontario. December 2014. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP-06144-0087. Toronto, Canada.

DPRA 2013b. Community Well-Being Assessment, White River, Ontario. December 2014. Prepared for Nuclear Waste Management Organization (NWMO). NWMO Report APM-REP- APM-REP-06144-0088. Toronto, Canada.

Nuclear Waste Management Organization (NWMO). 2012. Description of Canada's Repository for Used Nuclear Fuel and Centre of Expertise. Toronto, Canada. (Available athttp://www.nwmo.ca/brochures)

Nuclear Waste Management Organization (NWMO). 2011. Preliminary Assessment of Potential Suitability – Feasibility Studies. Draft for Discussion with Communities Involved in the Site Selection Process. Toronto, Canada.

Nuclear Waste Management Organization (NWMO). 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. Toronto, Canada. (Available at www.nwmo.ca)

Nuclear Waste Management Organization (NWMO) 2014. NWMO Aboriginal Policy. Toronto, Canada. (Available at http://www.nwmo.ca/uploads_managed/MediaFiles/2374_nwmo_aboriginal_policy_2014_-_english.pdf)

Township of White River. (revised) September 26, 1983. Official Plan for the Township of White River Planning Area. Prepared by Proctor & Redfern Limited. Sudbury, Canada.

References for Chapter 8

Nuclear Waste Management Organization (NWMO). 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel. Toronto, Canada. (Available at www.nwmo.ca)

Nuclear Waste Management Organization (NWMO) 2014. NWMO Aboriginal Policy. Toronto, Canada. (Available at http://www.nwmo.ca/uploads_managed/MediaFiles/2374_nwmo_aboriginal_policy_2014_-_english.pdf)

10. GLOSSARY

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.

Batholith – A large intrusive body having an areal extent of 100 square kilometres or more.

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

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 Deposit Inventory (MDI) database.

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 kilometres 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.

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.

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.

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 that may represent geological structures (e.g., fractures).

Lithology – Set of physical characteristics of a rock, including colour, 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.

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.

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.

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).

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.

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.

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.