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Canada North Environmental Services Limited Partnership

A First Nation Environmental Services Company

NUCLEAR WASTE MANAGEMENT ORGANIZATION
ADAPTIVE PHASED MANAGEMENT PROJECT – NORTHWESTERN ONTARIO REGION

ENVIRONMENTAL MEDIA BASELINE PROGRAM – PRELIMINARY SAMPLE DESIGN FEASIBILITY ASSESSMENT

Final Report


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LIST OF ACRONYMS

Term	Description
AAQC	Ambient Air Quality Criteria
AMIS	Abandoned Mines Information System
AOI	Area of Interest
APM	Adaptive Phased Management
BOLD	Barcode of Life Database
CAAQS	Canadian Ambient Air Quality Standards
CCME	Canadian Council of Ministers of the Environment
CES	Critical Effect Size
CIE	International Commission on Illumination
COPC	Contaminant(s) of Potential Concern
CSM	Conceptual Site Model
DGR	Deep Geological Repository
DOC	Dissolved Organic Carbon
ECCC	Environment and Climate Change Canada
ELC	Ecological Land Classification
eDNA	environmental DNA
EEM	Environmental Effects Monitoring
EHP	EHP Environment Ltd.
IA	Impact Assessment
IK	Indigenous Knowledge
IWA	Ignace Withdrawal Areas
LSA	Local Study Area
MECP	Ontario Ministry of the Environment, Conservation and Parks
MEND	Mine Environment Neutral Drainage Program
MNRF	Ontario Ministry of Natural Resources and Forestry
MTO	Ontario Ministry of Transportation
NAPS	National Air Pollution Surveillance (Network)
NHIC	Natural Heritage Information Centre

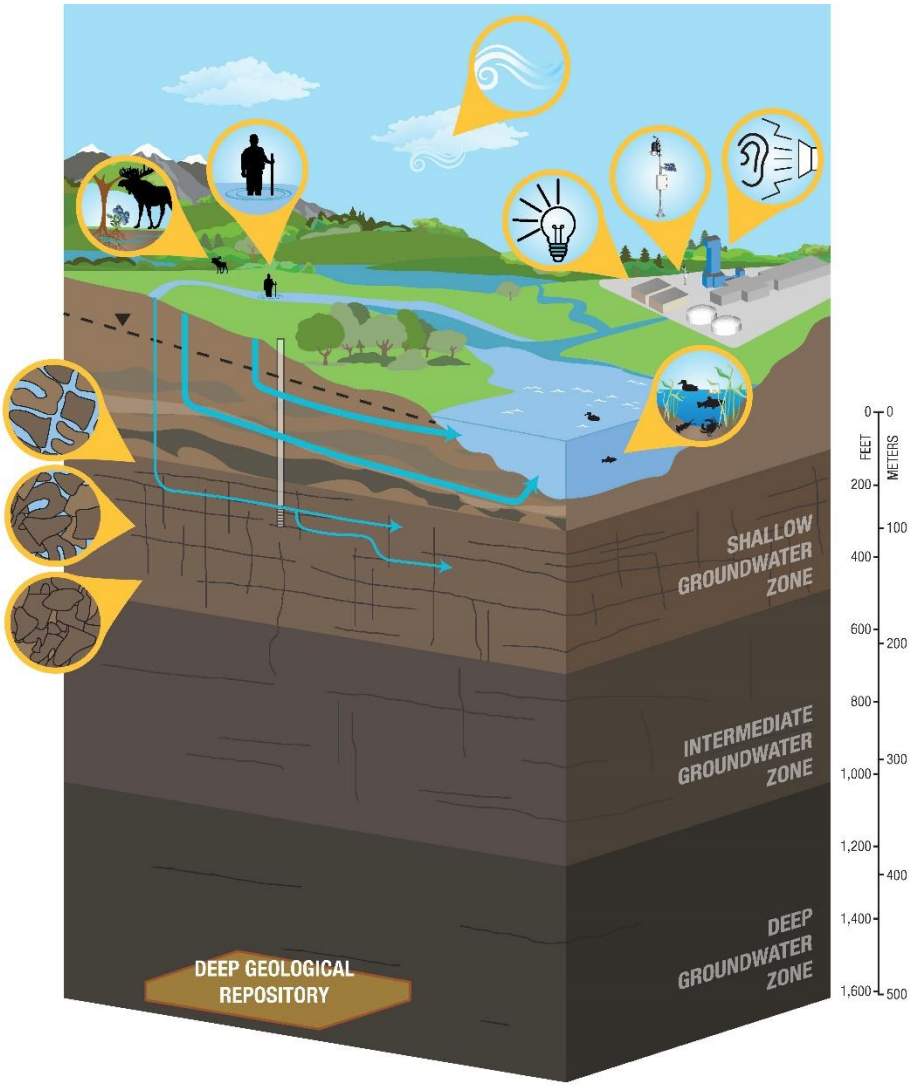
LIST OF ACRONYMS (Continued)

Term	Description
NWMO	Nuclear Waste Management Organization
OSAP	Ontario Stream Assessment Protocol
PAH	Polycyclic Aromatic Hydrocarbon
PHC	Petroleum Hydrocarbon
RSA	Regional Study Area
SAR	Species at Risk
SSA	Site Study Area
SWH	Significant Wildlife Habitat
TOC	Total Organic Carbon
ULR	Upward Light Ratio
U.S. EPA	United States Environmental Protection Agency
VC	Valued Component
VOC	Volatile Organic Compound
WLON	Wabigoon Lake Ojibway Nation
XRF	X-Ray Fluorescence

EXECUTIVE SUMMARY

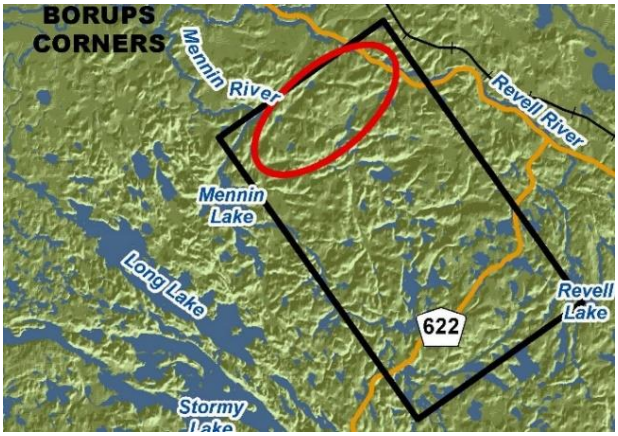
INTRODUCTION

The objective of this report is to present and gather feedback on sample design options for environmental baseline studies to be completed at the Nuclear Waste Management Organization's (NWMO) proposed location for the Deep Geological Repository (the Project) in the Northwestern Ontario region. The Environmental Media Baseline Program will characterize parts of the environment before development of the Project. The focus is on components that have potential to interact with the Project and include: 1) tissues; 2) hydrology; 3) surface water parameters; 4) air quality, noise, and light; 5) shallow groundwater; and 6) soil quality. This is depicted in the Conceptual Site Model below:



The Environmental Media Baseline Program sample design has the following objectives.

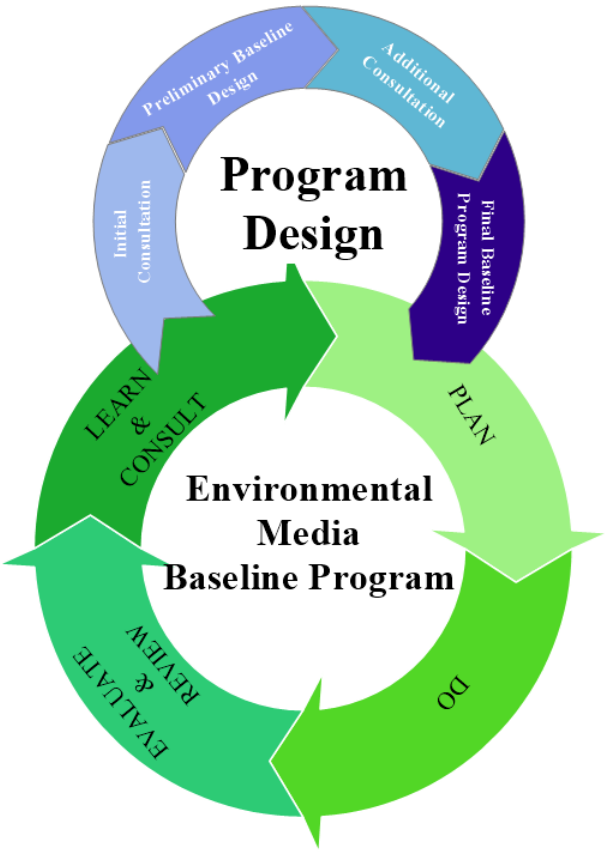
1. **To collect data of high importance to stakeholders and rights-holders.**
2. **To collect data that are of high quality and are statistically rigorous.**
3. **To collect data that will provide adequate information for future modelling and preparation of an Impact Assessment.**
4. **To maximize opportunities for community involvement in completing the sampling, if desired.**



The NWMO has selected an Area of Interest as a future site for the Project (see red ellipse in picture). Some studies have already started in this area, such as water, soil, and sediment sampling. The Environmental Media Baseline Program sample design will build on those studies. Other types of studies, such as looking at animal use of the area, are not a part of this program, but will be studied as part of a Biodiversity Baseline Program before Project development.

This preliminary assessment report is being provided to the NWMO, stakeholders, and rights-holders for review and input before creating the final sample design. Some key program elements that were identified in the initial workshops are not included in detail in this report, as additional input from the community is required at the follow up workshops for rights-holder or stakeholder guidance (as noted in Appendix B). For example, the initial workshops clearly identified the importance of incorporated ceremony and Spirit into the program. This input will be sought in the follow up workshops and will be detailed in the final program design. Additionally, an overview of the input process will be included in the final design report.

Field sampling and reporting for the Environmental Media Baseline Program will take place over multiple years. Our Study Team will complete annual reviews and a thorough three-year program update to modify the Environmental Media Baseline Program as needed. The following diagram illustrates the project process.



SAMPLE DESIGN OPTIONS

Initial input provided through stakeholder and rights-holder workshops led by the NWMO, alongside evaluations of standard best practices and emerging technologies, was used to develop preliminary sample design options. There are many factors that can be modified in the sample design such as:

- **sample type**
- **sample size**
- **sampling method**
- **sample location**
- **laboratory method**
- **what is measured in the sample**

Since there are many possibilities, our Study Team came up with a set of options for each component that vary some of the factors listed above. For other factors, such as sample size in many cases, assumptions were made in order to provide information on relative costs for the options (within ± 30% to 50% accuracy) for this preliminary report. All of the above factors will be re-assessed for the final sample design once input from the NWMO and stakeholders/rights-holders is incorporated.

The list of Contaminants of Potential Concern (COPC) measured in each component (i.e., water, soil) needs to be extensive to characterize the environment before the Project starts; however, it is also important that the contaminants measured are relevant to the Project. The list included in this report was developed alongside the NWMO and includes numerous metals, radionuclides, and other parameters used to characterize the environment. The focus was on identifying contaminants of highest relevance to the Project (e.g., copper) and/or the community (e.g., mercury).

Provided below is summary information about the sample design options considered and recommended in this report for each of the six components.

TISSUE

Tissue chemistry includes testing baseline levels of metals and radionuclides in various parts of plants (e.g., berries, leaves, etc.) and animals (e.g., flesh, organs, etc.). This component is of particular interest to stakeholders/rights-holders, as demonstrated by the input provided during the initial community workshops held by the NWMO.

A preliminary list of tissue types to test (called Valued Components [VCs]) was put together from:

1. **available stakeholder/rights-holder input,**
2. **plants and wildlife commonly identified for Indigenous traditional foods programs,**
3. **plants and wildlife commonly identified in the uranium mining industry and nuclear power generation in Canada, and**
4. **plants and wildlife recommended in guidance documents.**

Since there are so many potential Valued Components to sample, our approach was to group them into primary (higher priority) and secondary (lower priority) categories, as well as those not required, using the information sources listed above. Measuring radionuclides requires a large amount of material be submitted to the laboratory; therefore, the ability to collect enough material for meaningful results without causing too much mortality was also considered when selecting primary Valued Components. The inclusion of certain Valued Components will be refined following further engagement with stakeholders/rights-holders.

Our Study Team is proposing that traditionally harvested plants and wildlife be collected by community members during hunting, trapping, fishing, and harvesting activities. A biologist with the assistance of local stakeholders/rights-holders would collect samples of those plants and wildlife that are not traditionally harvested from the area (e.g., deer mice), collected using non-lethal techniques (e.g., wolf hair), and to fill gaps.

The sample design options presented in this report vary in categories (primary and/or secondary), contaminants (metals and/or radionuclides), and sampling methods (lethal and/or non-lethal). For all options, a dietary survey is recommended to collect information on the quantity, type, and general harvest locations of traditional foods consumed by stakeholders/rights-holders local to the Project.

The option our Study Team is recommending involves lethally sampling primary Valued Components for metals and radionuclides using the sampling methods discussed above, and non-lethally sampling secondary Valued Components for metals. For the non-lethal program, samples of hair, feathers, or scales would be collected and analysed. Measuring radionuclides is not an option using this laboratory method and, thus, only metals would be measured. This new innovative technique involves doing metal analyses using laser ablation, while maintaining industry-standard laboratory techniques and detection limits. The recommended option, presented below, has a high level of community involvement in both the dietary study and sample collection.

Recommended Option	Justification/Considerations
Dietary study for the identified stakeholders/rights-holders. Lethal sampling for all primary categories and measuring metals and key radionuclides. Non-lethal sampling for all secondary categories and measuring metals.	**Advantages:** High level of community involvement. Metals and radionuclides are sampled for primary Valued Components, while metals are sampled for secondary; secondary Valued Components are not killed. Use of emerging technology that requires smaller sample size, reduces sampling time, and is more cost effective than lethal methods. **Disadvantages:** Radionuclides are not measured in secondary Valued Components.

HYDROLOGY

Hydrology is the movement of water in the environment through precipitation (snow, rainfall), surface water (rivers, streams, lakes, wetlands), and groundwater. It is important to understand changes in flow throughout the year to prevent negative impacts to the local environment and understand risks for flooding or drought. Hydrological studies provide information used to protect the local water supply, fish and wildlife habitat, and people and their homes, recreational activities, and businesses.

The proposed plan consists of understanding current hydrological conditions by collecting data and information on flow in small streams and large rivers, and local weather patterns (temperature, rain, and snowfall) in order to assist in Project planning and design decisions to avoid, minimize, and monitor Project-related environmental impacts.

Flow

Flow monitoring in small streams consists of one option which includes manually monitoring for seasonal flow measurements. The proposed plan includes monitoring during the spring melt and the late summer dry period in all three years of the Environmental Media Baseline Program.

For larger rivers near the Project, such as Mennin River and Revell River, two options exist, both of which require developing a relationship between water depth (stage) and flow (discharge), using data collected manually at the sampling location(s) over three to six visits in the first year to capture a variety of flow conditions. The location(s) would be determined following stakeholder/rights-holder input.

In subsequent years, flow would be estimated using the stage-discharge rating curve and water level measurements, which can be obtained in two ways. The first involves installing a staff gauge and manually taking periodic water level measurements. The second option involves installing a water level sensor to obtain automatic measurements. While the first option is less expensive and consists of a simpler field protocol, it does not provide continuous (hourly) measurements, equipment can be lost during flood or spring melt conditions, and it possibly requires more field visits and time. While the second option has higher installation and maintenance costs and potential equipment failures, it provides a more complete dataset of the water level and estimated flow variability and is therefore recommended. Both options could involve training a community member to assist in the field when taking flow measurements.

Recommended Option	Justification/Considerations
Obtain manual flow measurements in small streams and Mennin Lake, and in larger rivers in Year 1. Install a water level sensor in larger rivers to obtain automated water level measurements in subsequent years. Trained community members could be involved in installation and maintenance.	**Advantages:** Water level sensor provides a more complete dataset of flow variability in rivers since continuous water level data would be collected and converted to flow estimates. **Disadvantages:** Water level sensor is more expensive to install and maintain. Possible equipment failure could result in lost data.

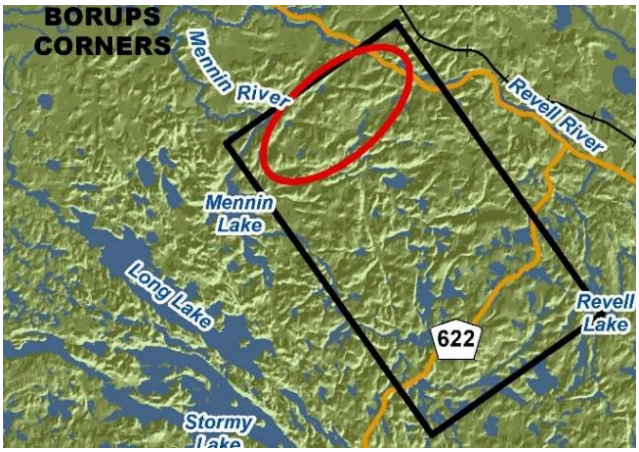
Meteorology

To monitor local weather patterns (temperature, rain, and snowfall), the recommended option consists of installing an automatic meteorological station since there are no existing stations near the near the potential location of the Project. This is preferred over obtaining data from existing distant stations, as the data will be site-specific and more appropriate to use and inform local hydrology. The meteorology data can also be used to derive a localized hydrology model of the area, which can support future climate change analyses. (Photo credit: By Famartin - Own work, CC BY-SA 3.0, https://commons.wikimedia.org/w/index.php?curid=26864657).

Recommended Option	Justification/Considerations
Install an automatic meteorological station.	**Advantages:** Obtain site-specific data that will be more appropriate to use than data from distant weather stations. This data will inform local hydrology. **Disadvantages:** Possible equipment failure could result in lost data.

SURFACE WATER PARAMETERS

The surface water parameters component measures baseline surface water and sediment quality (i.e., sand, soil, and debris at the bottom of a waterbody), which includes communities of phytoplankton (algae) and zooplankton (bugs) in the water column and benthic invertebrates (bugs) in the sediment. This component is an essential part of the Environmental Media Baseline Program because of potential Project interactions mainly related to effluent discharge and water withdrawal.



The Local Study Area is proposed to include waterbodies in the Area of Interest (red ellipse in the figure), waterbodies downstream in the Mennin Lake drainage, and reference stations. It is not known if the Mennin Lake drainage will be impacted by the Project since the Project design hasn't been finalized, but an assumption was made that the Mennin Lake drainage will be the discharge site for treated effluent for this preliminary report. A Regional Study Area will be included for surface water quality only and will include waterbodies to be identified as being significant to community members during further engagement activities.

Surface Water Quality

A surface water quality sampling program will occur in the Local Study Area to fill multiple data objectives. An extensive list of contaminants to be monitored is proposed, including general water chemistry parameters, nutrients, ions, total and dissolved metals, parameters related to treated sewage effluent, and radionuclides. The number of water samples was estimated for this preliminary report in order to provide high level cost estimates, and it was assumed that quarterly sampling (four times a year; once per season) will be completed to capture seasonal differences.

In the Local Study Area, the sample design options provided by our Study Team vary in sampling methods. In addition to using standard field methods, a sample design option was included for the installation of an autonomous remote monitoring station. Although the remote station allows for continuous data collection over the long-term, it has high installation and maintenance costs and would need to be supplemented with field collections since it is unable to measure all parameters required, such as radionuclides. Our Study Team therefore does not recommend the use of a remote monitoring station.

A regional program is also proposed that would include waterbodies of significance to local stakeholders/rights-holders. In the Regional Study Area, the sample design options provided by our Study Team vary in sampling methods and community involvement. The recommended option, presented below, is for the water sampling program to consist of near-shore surface grabs collected entirely by community members and analysed for a slightly smaller list of contaminants to remove those contaminants related to treated sewage effluent and second tier radionuclides.

Recommended Option	Justification/Considerations
Local Study Area: Water sampling four times per year at eight locations using standard field methods and complete list of contaminants; sampling conducted by a consultant with a community member as a field assistant.	**Advantages:** Follows accepted regulatory protocols. More cost effective and allows more study areas and parameters to be sampled than the other option of a remote monitoring station. Involves community members.
Regional Study Area: Water sampling four times per year at eight locations using surface grabs and a reduced list of contaminants with sampling conducted by only community members.	**Advantages:** Entirely community-based, it is a cost effective program that will provide long-term capacity building and employment for local groups like the Wabigoon Lake Ojibway Nation. **Disadvantages:** Surface grabs may not be representative of the entire waterbody. No limnology measurements (dissolved oxygen, temperature, pH, conductivity).

Sediment Quality

The sample design options provided for the sediment quality component are located in the Local Study Area and reference areas. The list of contaminants proposed for sediment includes metals, moisture, total organic carbon, particle size, nutrients (e.g., ammonia, nitrate, phosphorus), and a comprehensive list of radionuclides. Since sediment sampling requires experience with sampling equipment and protocols, it is recommended that community members be involved as field assistants, which will provide a training opportunity, capacity building, and temporary employment. Sediment sampling is recommended in Year 1 only as concentrations of contaminants in sediment change slowly over time.

Sample design options have been included for collecting five sediment samples from five or eight locations. Sample design options were also provided for using either a grab or a core sampler. While both of these sampling methods are recognized in guidance documents as accepted practices, our Study Team is recommending core samplers as they do not disturb the top layer of the sediment as much as grab samplers do and they enable sampling a set horizon (e.g., 0 to 2 cm sediment depth). All options recommend training a community member to assist in the field. The recommended option is presented below.

Recommended Option	Justification/Considerations
Sediment sampling in eight areas using a core sampler in Year 1 only; sampling conducted by a consultant with a community member as a field assistant.	**Advantages:** A core sampler enables precision in the sediment horizon being sampled. Involves community members. Samples a higher number of locations and an extensive list of contaminants. **Disadvantages:** Obtains a limited sample volume; thereby, requiring additional field time and compositing of subsamples. Core sampler does not penetrate firm substrates.

Plankton

Plankton (phytoplankton/chlorophyll and zooplankton) was paired with the surface water quality program as plankton provide an assessment of water quality and an indication of nutrient levels. The number of samples to be obtained at each station and the number of stations to be sampled in the Local Study Area and reference areas was matched to the surface water program. Quarterly sampling was assumed to capture seasonal data; however, monthly data may be required from key stations during critical seasons (e.g., summer algal blooms).

Sample design options are provided in the report using standard field sampling and laboratory methods. For phytoplankton, the use of an autonomous remote water quality meter (described above under Surface Water Quality) to measure chlorophyll a and blue green algae was also considered, which would be a worthwhile addition if the meter was already being installed as part of the surface water quality program. For zooplankton, an option was also provided for using environmental DNA (eDNA) laboratory analyses, which is a novel and emerging method for identifying species presence/absence in the environment from a water sample. Our Study Team recommends initiating the process of building an eDNA barcode reference sequence library to enable future biomonitoring of eDNA. The recommended option, presented below, involves training a community member to assist in the field.

Recommended Option	Justification/Considerations
Quarterly sampling at eight locations using standard field methods (paired with water quality sampling); sampling conducted by a biologist with a community member as a field assistant. For zooplankton, laboratory analyses includes traditional taxonomy and eDNA.	**Advantages:** Methods follow accepted regulatory procedures, while also enabling future monitoring using eDNA. Allows more spatial coverage than five locations and a larger number of endpoints than a remote water quality meter. Involves community members. **Disadvantages:** The inclusion of eDNA is slightly more expensive than traditional methods only.

Benthic Invertebrates

The benthic invertebrate sampling program was paired with the sediment program as benthic invertebrates provide information on sediment quality and the ecology of the area.

As with the sediment sample design options, options for benthic invertebrates were included for five or eight locations. Options were also provided for using traditional laboratory methods for species identification, as well as building an eDNA barcode sequence library to enable future biomonitoring of eDNA. All options recommend training a community member to assist in the field. The recommended option is presented below

Recommended Option	Justification/Considerations
Sampling at eight locations using standard field methods (paired with sediment quality sampling); sampling conducted by a biologist with a community member as a field assistant. Includes traditional species identification and eDNA.	**Advantages:** Field and traditional species identification methods follow accepted regulatory procedures, while also enabling future monitoring using eDNA. Allows more spatial coverage than five locations. Involves community members. **Disadvantages:** The inclusion of eDNA is slightly more expensive than traditional methods only.

AIR QUALITY, NOISE, AND LIGHT

The existing air quality, noise, and light conditions in the Project area will be characterized for comparison to future modelled or measured levels. Feedback from stakeholders/rights-holders indicated that there was a concern with regards to the cumulative impact of the Project in combination with existing facilities in the area, particularly with regard to air quality. Furthermore, air quality is an indicator of change in human and environmental health, while noise and light changes may impact members of the community and non-human biota.

Air Quality

The contaminants that have been considered for inclusion in the air quality program have been sorted into two tiers (Tier 1 and Tier 2). Tier 1 includes conventional air quality contaminants that are tracked by provincial and national monitoring programs and are expected to be readily measurable in the area, as well as key radiological contaminants that may be of concern to the community, such as radon. The Tier 2 contaminants include trace contaminants that may be present in low amounts, such as metals and radionuclides.

The recommended air quality program consists of using approved air quality monitoring methods in the immediate vicinity of the potential Project location (i.e., the Site Study Area). A secondary network of offsite passive air monitoring stations in the Local Study Area is recommended to expand the spatial coverage of the program to within approximately 10 km of the potential Project location. The program involves training a community member to assist with the operation of the program, with the intent of passing responsibility for it to the community.

Recommended Option	Justification/Considerations
Continuous air quality monitoring within the Site Study Area and passive monitoring within the Local Study Area. Monitoring completed by a consultant and a community member (with the intent of passing responsibility over to community member).	**Advantages:** Follows accepted regulatory procedures. Provides coverage for complete list of Tier 1 and Tier 2 contaminants. Passive monitoring within the Local Study Area is more cost effective than continuous monitoring. Involves the community. **Disadvantages:** Initial setup costs are high for continuous monitoring.

Noise

The Environmental Media Baseline Program will include measurement programs to characterize the existing noise levels in the Site Study Area and the Local Study Area. Noise from the Project is expected to be confined to the Local Study Area. The proposed program will occur in Year 1 only and account for seasonal variability. The recommended option for baseline noise monitoring involves training a community member to assist in the facilitation of the program.

Recommended Option	Justification/ Considerations
Seasonal monitoring completed by a consultant and a community member.	**Advantages:** Follows accepted regulatory procedures. Involves the community.

Light

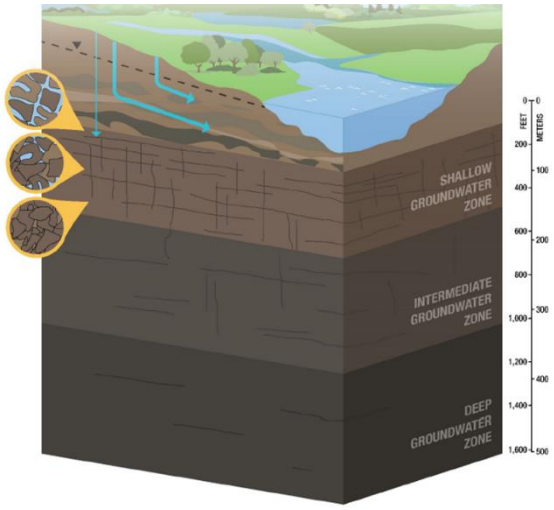
The Environmental Media Baseline Program will include a measurement program to characterize the existing light conditions in the Site Study Area. The measurements will consist of illuminance (i.e., the amount of light being received at a sensitive location), and sky glow (the extent to which the sky is illuminated by artificial sources). The recommended option involves training a community member to assist in the facilitation of the program.

Photo credit: Henry Gressmann; https://unsplash.com/photos/fu8cGhFH7R0

Recommended Option	Justification/ Considerations
Discrete monitoring completed by a consultant and a community member.	**Advantages:** Follows accepted regulatory procedures. Involves the community.

SHALLOW GROUNDWATER

Groundwater is a part of the overall natural water cycle and is water that moves below the ground surface. It starts as precipitation and can enter and move in the ground from surface flow (i.e., lakes and streams) and from subsurface flow (i.e., underground). Eventually groundwater discharges back to the surface (i.e., to lakes, streams and seeps) and continues to participate in the water cycle.



Groundwater occurs in the openings between soil particles, in pore spaces, and fractures in rock. Generally, there are less openings and less pathways for groundwater movement the deeper you go below the ground surface. The focus of the Environmental Baseline Monitoring Program is the shallow groundwater (top ~100 m).

Physical Hydrogeology

Physical hydrogeology is the science of the flow and storage of water in soils and rocks. The proposed program involves assessing groundwater physical parameters (i.e., depth to water table, flow rate and direction, hydraulic conductivity, and connectivity of fracture network) as these are all key to defining the impacts on groundwater withdrawal activities on potentially sensitive

receptors (wetlands, rivers, water supply wells), siting monitoring wells to evaluate the potential impacts from the Project to both groundwater quality and quantity, and evaluating the potential for groundwater and surface water interactions. Sample design options are included in this report for collecting physical hydrogeology parameters from the proposed boreholes and wells within the Local Study Area. The recommended option, completed in Year 1 only, is presented below.

Recommended Option	Justification/Considerations
Single well test such as slug tests (constant or rising head), and type curves (AQTESOLV) to calculate an estimated hydraulic conductivity and determine site-specific hydraulic parameters. With the addition of pump tests or pressure pulse testing to evaluate site-specific hydraulic parameters.	**Advantages:** Contains the most comprehensive data set to evaluate hydraulic conductivity, water elevations, and potential effects of drawdown. **Disadvantages:** Low permeability of rock may make pump tests difficult. Well network needs to be designed to allow for observation from multiple points.

Groundwater Quality

Groundwater quality is the science of the chemistry of the groundwater. Measurements of groundwater chemistry provide essential information on groundwater quality and for predicting how contaminants could move from a Deep Geological Repository to the environment. Information to be collected as part of the shallow groundwater component of the program should include geochemistry of the shallow groundwater (top ~ 100 m), presence of contaminants, and potential effects of changing chemical conditions due to groundwater withdrawal. The sample design options provided for the shallow groundwater quality and temporal water elevation data collection component vary in sampling methods, frequency, and community involvement. The recommended option includes sampling the planned wells to be installed within the Local Study Area, as well as up to seven private water supply wells in the region (Regional Study Area), and includes a high level of community involvement.

Recommended Option	Justification/Considerations
Local Study Area: Groundwater sampling four times a year using standard field methods and manual monitoring techniques, with the use of pressure transducers to monitor groundwater elevation data continuously. Sampling conducted by a professional geoscientist with a community member as a field assistant. Reduction after Year 1 in sampling frequency and/or locations.	**Advantages:** Follows accepted regulatory protocols. Enables monitoring of groundwater elevation changes over time. Involves community members. **Disadvantages:** Reduction in sample frequency and type may miss longer term trends.
Regional Study Area: Groundwater sampling four times a year using standard field methods in Year 1 by a professional geoscientist with a community member as a field assistant. Sampling four times a year in subsequent years using tap or grab sampling by community members only.	**Advantages:** Follows accepted regulatory protocols for Year 1. Entirely community-based monitoring program in subsequent years that is also less invasive to well owners (water supply does not need to be shut off, and equipment does not need to be pulled from the well). **Disadvantages:** Possibility of poor sample quality due to interference from existing water piping system, although mitigated by results of Year 1.

SOIL QUALITY

The soil quality component of the Environmental Media Baseline Program includes assessing soil at the ground surface, beneath the ground surface, and soil and rock at a depth down to 100 m. Soil quality, and the protection of soil is listed by the community as important. Soil and near-surface bedrock quality supports the health of plant tissues including edible plants, roots, flowering bushes, traditional medicines, and rock, and can also impact animal tissues, surface water quality, and sediment quality.

The recommended option for soil sampling is to sample in Year 1 only using standard field methods and co-locate samples with tissue samples and groundwater well locations. Bedrock sampling should also be co-located with groundwater well locations in Year 1 only, using standard field methods as well as geologic core-logging at specified intervals in conjunction with handheld X-Ray Fluorescence (XRF) in order to identify sulfides, lithological heterogeneities, and fractures/veined intervals. The recommended options, discussed below, involve training a community member to assist in the programs.

Recommended Option	Justification/Considerations
Soil: Standard field methods. Sampling conducted by a professional geoscientist with a community member as a field assistant.	**Advantages:** Follows regulatory accepted chemical characterization methods. Involves community members. **Disadvantages:** Does not include a new or innovative technology such as eDNA.
Bedrock: Standard field methods but with the addition of geologic core-logging and hand-held X-Ray Fluorescence analysis. Sampling conducted by a professional geoscientist with a community member as a field assistant.	**Advantages:** Follows regulatory accepted chemical characterization methods. Involves community members. Maximizes the information gained from the boreholes that may not be captured by constant-interval sampling **Disadvantages:** X-Ray Fluorescence analysis increases cost.

An additional component to the soil program is to characterize the gamma radiation levels of the surficial soils in the area to support future impact and risk assessments. The gamma radiation survey, completed in Year 3 only, will characterize the background levels of gamma radiation in the area of the proposed Project at one meter above ground surface. The recommended option, discussed below, involves training a community member to assist in the program.

Photo credit: Geomatrix Earth Science Ltd.

Recommended Option	Justification/ Considerations
Traditional ground survey (by foot or ATV) completed by an external consultant (four-person team) with a trained community members as an assistant.	**Advantages:** Follows regulatory accepted sampling methods Involves community members.

PATH FORWARD

There are a number of components that require input from the NWMO and stakeholders/rights-holders before our Study Team can provide a final sample design that is informed by community input, maintains statistical rigour, and considers budget. Input is needed on:

- **Valued Components to sample, especially primary and secondary plants and wildlife for tissue component;**
- **key sampling locations locally and in the region;**
- **effect sizes (amount of change in Valued Component endpoint that is of concern), which will be used to recommend adequate sample sizes using statistical analyses;**
- **Contaminants to measure in each Valued Component type;**
- **sampling methods, especially the inclusion of new and emerging technologies;**
- **ways to integrate the Spirit, or Aatsokewinan, into the baseline collection; and**
- **the level of community involvement in the sampling program.**

1.0 INTRODUCTION

The Nuclear Waste Management Organization (NWMO) was established in 2002 with the objective of developing and implementing a plan for long-term management of Canada's used nuclear fuel. Since that time, a large amount of consultation, decision making, and studies have been undertaken. This process has included the adoption of Adaptive Phased Management (APM) as the plan, undertaking a siting process for the Deep Geological Repository (DGR) and other project infrastructure (called the Project), and conducting preliminary studies. From an initial list of 22 communities, five remain in the site process as a potential host community for the Project, including Ignace, Ontario (the Northwestern Ontario region). The NWMO's aim is to select a single preferred site by 2023.

On behalf of the NWMO, Canada North Environmental Services (CanNorth), in collaboration with its subconsultants (Geosyntec Consultants International Inc. [Geosyntec], Independent Environmental Consultants [IEC], and Zajdlik & Associates Inc.), technical advisors, and academic experts, is designing an Environmental Media Baseline Program for the Northwestern Ontario region to collect data to be used in stakeholder/rights-holder engagement, further project planning, and ultimately an Impact Assessment (IA) should the community remain in the process and become the single preferred site for the Project.

1.1 Study Area Overview

Previous siting studies conducted by the NWMO in collaboration with local communities and rights-holders established an Area of Interest (AOI) for the Project that is located approximately 40 km west of Ignace, Ontario, within the northern portion of the Revell Batholith Temporary Withdrawal Area (see Figure 1.1). The AOI is defined by an oval that is approximately 4.4 km by 8.7 km and extends from immediately north of Highway 17 in a southwest direction (Figure 1.2). Within the AOI are two primary roads, a network of operations roads and temporary access roads constructed to support borehole drilling and logging, and several small watercourses and wetlands.

The land required to accommodate the Project will include an approximate footprint of 625 m x 700 m for the DGR surface facilities, and an approximate footprint of 500 m x 500 m for the offsite excavated rock management area (Figure 1.3). There is also likely to be a buffer that will be cleared beyond the fence boundary to serve as a fire break in the event of a forest fire in the future. Additional land will be required for access roads, water

management infrastructure, and potentially for a construction camp site. The potential location of the Project infrastructure within the AOI is currently unknown.

Figure 1.1 Site location

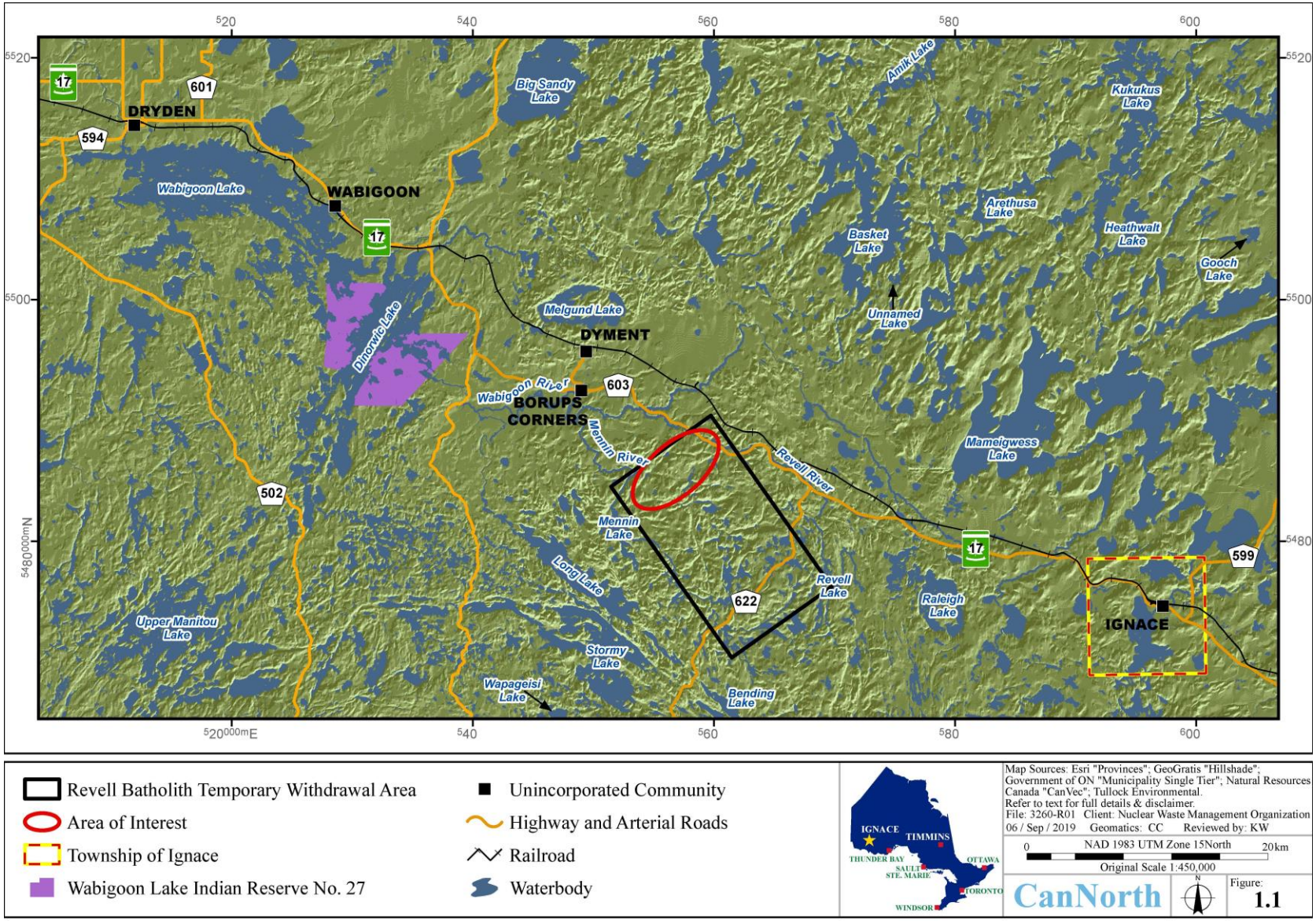


Figure 1.2 Location of Area of Interest that may contain the Project footprint along with current and future boreholes

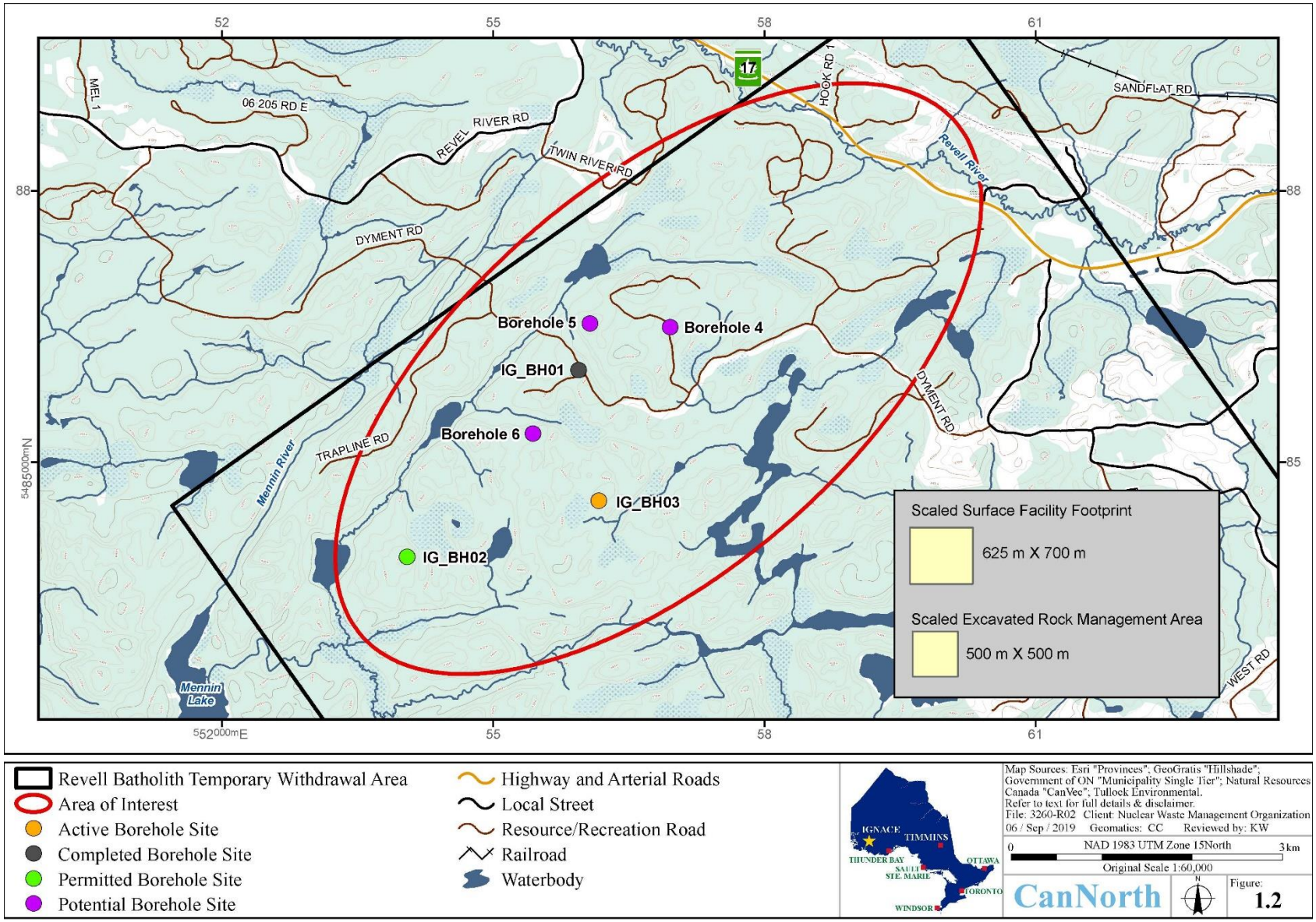
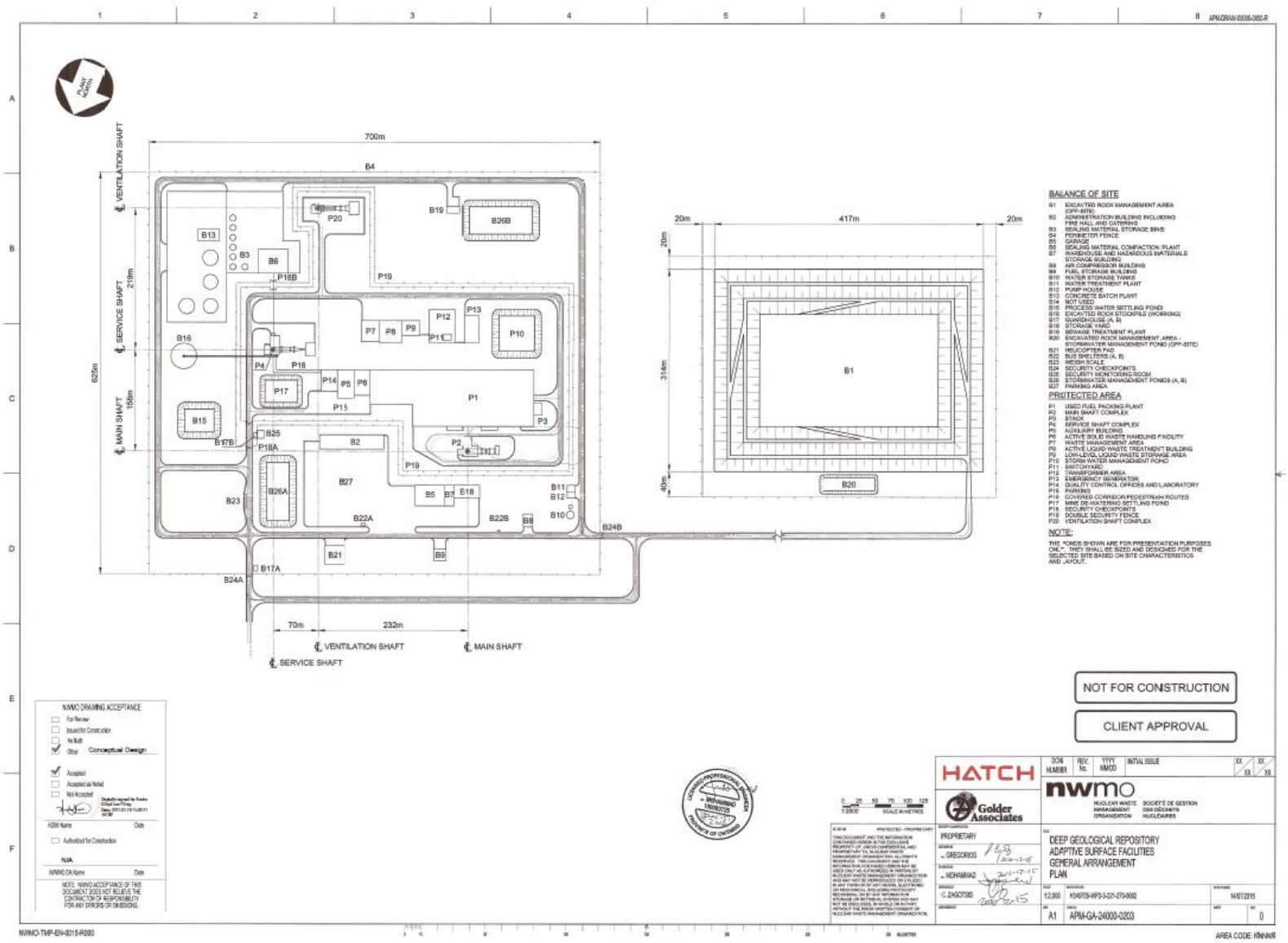


Figure 1.3 Surface facilities layout



1.2 Program Objectives

The purpose of a monitoring program needs to be clearly defined to ensure that appropriate data are collected. The purpose of the Environmental Media Baseline Program is to characterize environmental baseline conditions prior to development of the DGR so that potential effects of the major stages of the Project (construction, operation, extended monitoring, decommissioning, and postclosure) can be measured, or that a lack of detectable effects is defensible. Information from the Environmental Media Baseline Program can also provide insight to existing pressures or sensitivities in the environment, and inform project design elements to avoid or minimize potential effects.

The focus of the Environmental Media Baseline Program is on selected environmental components that have the potential to be impacted by the Project. Sampling should focus on those specific environmental effects that are "important", "likely," and "negative/positive". A sampling program that creates data that is useful in making defensible decisions for carefully selected environmental components is ultimately more useful than a program that samples many environmental components but provides insufficient information to inform defensible decisions. Additionally, a key objective in the design of the Environmental Media Baseline Program is to ensure information of high importance to surrounding communities, stakeholders, and rights-holders is collected so that the potential for Project-related effects on the environment can be effectively monitored over the long-term and supports an adaptive management program.

Although there are other components that will require assessments prior to construction of the DGR, design of this Environmental Media Baseline Program is specifically focused on six components, which include those of interest to stakeholders/rights-holders in the area (see Section 3.1):

1. Tissue samples (e.g., blueberry chemistry)
2. Hydrology
3. Surface water parameters (e.g., water quality)
4. Air quality, noise, and light
5. Shallow groundwater (e.g., groundwater chemistry)
6. Soil quality

The overall objective of the Environmental Media Baseline Program is to ensure the quality of science contributes to a trusted process and credible outcomes. The design of this program acknowledges that evidence comes in many forms and includes Indigenous

Knowledge (IK) and community knowledge. This program seeks to integrate that knowledge to collect evidence and build the environment pillar in the 5-pillar sustainability based IA framework. While the data collected from this program will also contribute to the other four pillars (health, social, cultural, and economic), separate baseline data collection programs will be implemented to fill the baseline data needs of these other four pillars. Elements of biodiversity and ecological services that will also contribute to the environment pillar will be evaluated in a separate scope of work.

1.3 Report Objectives

The objective of this preliminary sample design feasibility assessment report is to provide the NWMO, stakeholders, and rights-holders with a document that presents study design options for each of the six components and includes the following information:

- A review of environmental work done to date.
- Consideration of input received from stakeholders/rights-holders through the initial community input workshops led by NWMO.
- The Conceptual Site Model (CSM) to provide a description of how the current Project design is predicted to interact with the environmental components included in the Environmental Media Baseline Program during different Project stages.
- Sample design options for each of the six components included in the Environmental Media Baseline Program that maximize the use of IK and community involvement.
- Method options for the Environmental Media Baseline Program that are based on innovation and best practices.
- Benefit/drawback analyses for each sample design option to evaluate:
    - ability to meet data quality objectives,
    - sampling effort,
    - level of community involvement, and
    - relative costs.
- Recommendations for preferred sample design options and path forward.

This report will be provided to stakeholders and rights-holders for review and input to help inform the detailed sample designs that will be developed for each of the chosen options. Following this, data collections and reporting for the Environmental Media Baseline Program will take place over multiple years. Our Study Team will complete annual reviews and a thorough three-year program update to modify the Environmental Media Baseline

Program as needed, based on data collected in previous years and also on continued feedback from stakeholders and rights-holders.

2.0 REVIEW OF WORK COMPLETED TO DATE

Through collaboration with Canadians, First Nations, and Métis from 2008 to 2010, the NWMO developed a nine-step site selection process in order to ensure that the site which is selected for the DGR is safe and secure, and meets the highest scientific, professional, and ethical standards. The multi-year, community-driven site selection process was initiated in 2010 (Step 1: NWMO Initiates the Process), while interested communities were subjected to an initial screening as part of Step 2 (Initial Screening) between 2010 and 2012. Step 3 (Preliminary Assessments of Suitability) was initiated in 2015 for the 22 interested communities that progressed through Step 2. The first phase of Step 3 (Phase 1 – Desktop Studies and Engagement) has been completed, while the second phase (Phase 2 – Field Studies and Engagement) is ongoing. As of August 2019, five potentially suitable siting areas remain in the site selection process, including the Northwestern Ontario region. A summary of the studies completed or ongoing for the Northwestern Ontario region as part of Step 3 (Phases 1 and 2) is provided below. A complete list of reports consulted as part of the development of the Environmental Media Baseline Program is provided in Appendix A.

2.1 Step 3: Phase 1 – Desktop Studies and Engagement

Phase 1 studies were completed in order to advance understanding of the environment of the potentially suitable siting areas, including the Northwestern Ontario region, and assess whether it was possible to identify potentially suitable repository areas within each area. Key activities completed in Phase 1 include:

- working with the community to agree on how the work will proceed, including plans for involvement of citizens and surrounding communities, including First Nations and Métis;
- conducting scientific and technical studies to further explore the potential suitability of the geology in the area and to collect preliminary information on the local environment;
- exploring the potential effects of the Project on the long-term well-being of the community through desktop studies and community engagement;
- involving community members in the assessments and in learning about the Project; and
- summarizing the information learned from the Phase 1 studies to identify communities with low potential to be suitable for the Project.

The desktop studies for the Northwestern Ontario region that were reviewed in developing the Environmental Media Baseline Program relate to the community profile of Ignace and nearby communities, land use and protected areas, geology, terrain, topography, watershed boundaries, previously documented species of concern, commercial and recreational fisheries, and available regional information on meteorology, air quality, groundwater quality, and sediment quality. Regional information was obtained from regulatory sources such as the Ontario Ministry of the Environment (MOE; now Ontario Ministry of the Environment, Conservation and Parks [MECP]), the Natural Heritage Information Centre (NHIC), and Ministry of Natural Resources and Fisheries (MNRF). A list of the reports produced and a summary of the information provided in each as it relates to the components included in this Environmental Media Baseline Program is presented in Appendix A.

2.2 Step 3: Phase 2 – Field Studies and Engagement

Phase 2 studies were initiated in 2016 as a series of field and engagement activities of the potentially suitable repository areas that were identified within each of the potentially suitable siting areas. For the Northwestern Ontario region, five potentially suitable repository areas were identified, termed the Ignace Withdrawal Areas [IWA]. Information from the Phase 2 studies and others were used to select the socially and technically preferred IWA as the Revell Batholith (IWA-A), and to narrow down the AOI where the Project could be located (see Figure 1.2). Phase 2 studies are included in Appendix A and summaries are provided below.

2.2.1 Community Engagement

During Phase 2, NWMO staff and contractors have continued to meet with municipal representatives, First Nation and Métis leaders, organizations and communities, key opinion leaders, community liaison committees, and citizens to better understand the thoughts and concerns of people who wish to be engaged. Figure 2.1 shows the location of the First Nation and Métis communities in the Northwestern Ontario region. The nearest First Nation community to the Revell Batholith is that of Wabigoon Lake Ojibway Nation (WLON).

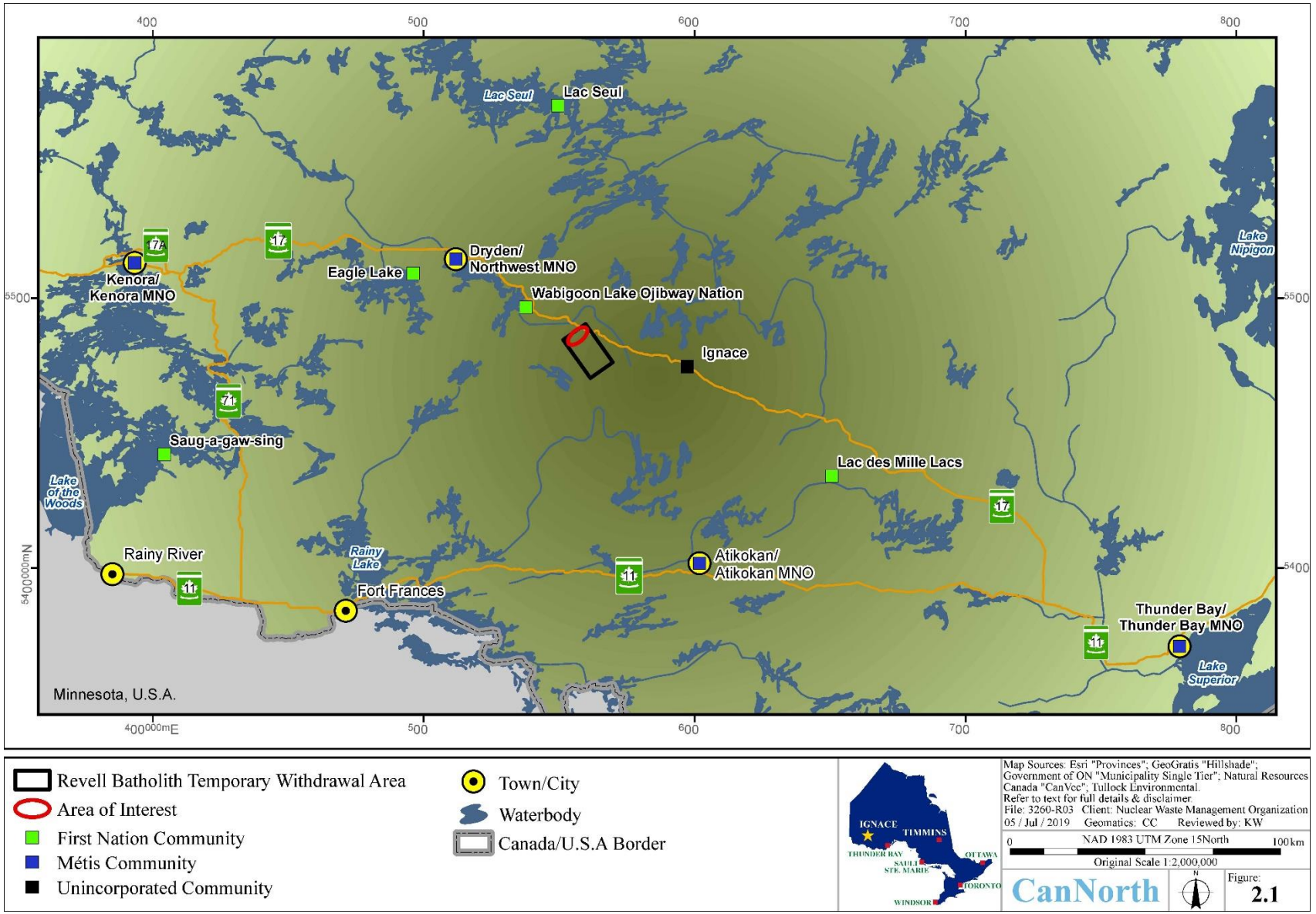
The engagement activities being carried out as part of the Phase 2 assessments will help develop a more detailed understanding of potential Project benefits, opportunities to work together, and how potential negative effects of the Project can be managed. Extensive conversations have been had about topics such as the basis for confidence in the safety of the Project, local land uses that need to be taken into account in planning field studies in

the area, potential economic effects of the Project, and the long-term vision for the area held by area residents (NWMO 2017a).

Numerous open houses have been held in the vicinity to support ongoing learning and engagement of people related to each major assessment and field activity (NWMO 2017a). Representatives from the NWMO have also participated in many community and area events, and several opportunities have been provided for youth engagement to facilitate youth in learning more about the Project and to gain youth perspectives.

Specific to the design of the Environmental Media Baseline Program, the NWMO recently held a series of workshops with stakeholders/rights-holders to provide direction to the Environmental Media Baseline Program design; this is discussed further in Section 3.1.

Figure 2.1 Location of communities in the region



2.2.2 Environmental Characterization of Borehole Sites

Desktop studies in combination with field verifications were conducted to narrow down potential siting areas areas within the five potential IWAs. Only the information applicable to the socially and technically preferred IWA (the Revell Batholith, or IWA-A) are discussed herein. Data and field observations were compiled to produce sensitivity mapping, including Ecological Land Classification (ELC), candidate Significant Wildlife Habitat (SWH), stream reach classification, and potential presence of Species at Risk (SAR). The results were documented in Tulloch (2018a) and carried forward in further assessments. The scope of further environmental studies was narrowed down to three borehole sites (boreholes 1, 2, and 3) and four potential borehole access roads. The new study area was presented along with the results of the sensitivity mapping in Figure 2.2. Detailed environmental characterization of the borehole sites are presented in Tulloch (2018b) based on field investigations from May to November 2017; key results from this report are summarized below.

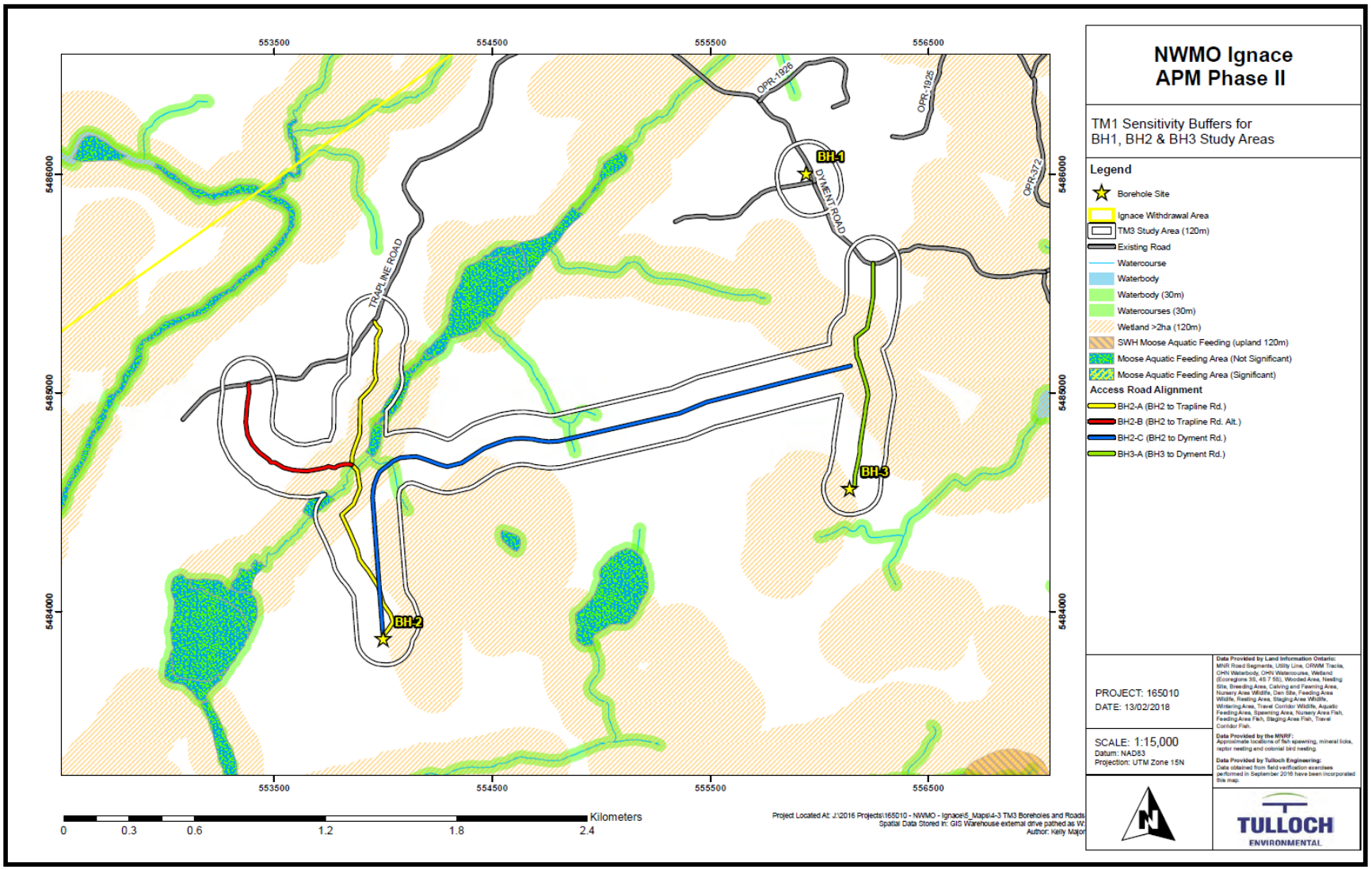
According to the ELC, most of the study area consisted of undeveloped upland habitat dominated by jack pine (*Pinus banksiana*) and black spruce (*Picea mariana*), and 11% of the area was classified as wetlands. Soil types ranged from silty clay/silty loams (fine-textured) to silty sands/medium sands (coarse-textured), with moisture levels varying from fresh to moist. Searches for two rare plant species (Vasey's rush [*Juncus vaseyi*] and brook cinquefoil [*Potentilla rivalis*]) were conducted, and the species could not be found (Tulloch 2018b).

The 2017 field studies found 33 migratory bird species in the study area shown in Figure 2.2, which may also breed in the area. Suitable habitat was found within the study area for several SAR, including common nighthawk (*Chordeiles minor*) and eastern whip-poor-will (*Caprimulgus vociferus*), but only common nighthawk was observed during the field studies. One distant eastern whip-poor-will call was heard during the survey, but it was estimated to be approximately 600 m from the study area and was therefore confirmed absent from the study area. An olive-sided flycatcher (*Contopus cooperi*) was also observed near a watercourse approximately 100 m from the study area. It is noted, however, that the estimated and observed locations of the eastern whip-poor-will and olive-sided flycatcher are within the AOI that is being studied as part of the Environmental Media Baseline Program. No sign of woodland raptor nesting was found (Tulloch 2018b).

Suitable habitat was found for mountain lion (*Puma concolor*) in the study area, but targeted surveys could not be performed due to the large home range of the species. Studies also found potential foraging and day-roosting habitat for little brown myotis (*Myotis lucifugus*) and northern myotis (*Myotis septentrionalis*) within the area; however, the presence of these two endangered bat species could not be confirmed.

One permanent watercourse connected to Mennin Lake was considered direct fish habitat, while three intermittent streams contributing to the main watercourse were considered indirect fish habitat. Although fish collection was not conducted during the 2017 field investigation, gill netting, minnow traps, and backpack electrofishing were used to examine fish species assemblage in the 2016 field sampling (Tulloch 2018a). Finescale dace (*Chrosomus neogaeus*), white sucker (*Catostomus commersonii*), yellow perch (*Perca flavescens*), blacknose shiner (*Notropis heterolepis*), and Iowa darter (*Etheostoma exile*) were observed during the preliminary field studies in the Revell Batholith (Tulloch 2018a).

Figure 2.2 Borehole sites and sensitivity mapping



Note: From Tulloch (2018b).

2.2.3 Biodiversity Studies

During the 2018 environmental study conducted in the Northwestern Ontario region, natural heritage field assessments were carried out at six possible future borehole locations in the Revell Batholith, as shown in Figure 2.3 (Locations A-F). Local flora/fauna, SAR, and SWH were identified and assessed in the field studies, which investigated plants, amphibians, mammals, migratory birds, and fish species in the study area (Tulloch 2019a). Locations of the biodiversity observations and study equipment are presented in Figure 2.3.

General methods of investigation for animal species included site reconnaissance, motion activated wildlife cameras (Trailcams), automated wildlife recordings (Songmeters), and night acoustic surveys. General site reconnaissance was conducted twice in May and June 2018 at each location. One Trialcam and one Songmeter per site were set up throughout June 2018. In May and June 2018, three night acoustic surveys were performed. The Ontario ELC system was employed to describe the local soil substrates and plant communities. Suitable habitat for Vasey's rush and brook cinquefoil were visited to search for these rare plant species (Tulloch 2019a).

As in 2017, common nighthawk was observed in and around the study area in 2018. Olive-sided flycatcher was the only other SAR bird species observed (calling) in the study area (Location C). Although several of the locations studied had suitable habitat for eastern whip-poor will, it was confirmed absent from the area based on the results of acoustic nightjar surveys (Tulloch 2019a).

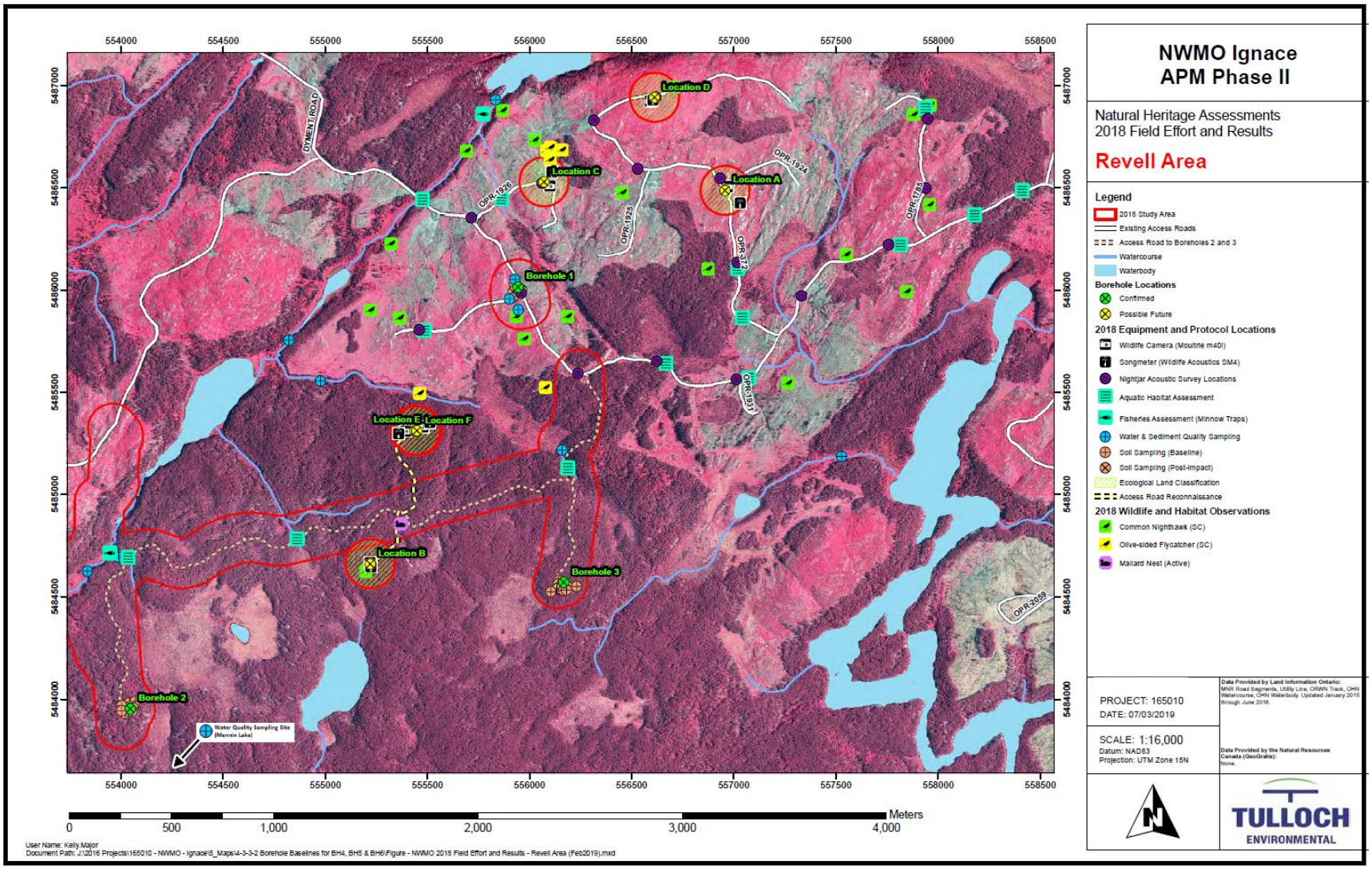
For amphibians, five species were identified in the study area, including American toad (*Bufo americanus*), grey treefrog (*Hyla versicolor*), green frog (*Rana clamitans*), spring peeper (*Pseudacris crucifer*), and wood frog (*Lithobates sylvaticus*). Mammals observed by Trailcams on site include black bear (*Ursus americanus*), Canada lynx (*Lynx canadensis*), grey wolf (*Canis lupus*), moose (*Alces alces*), and snowshoe hare (*Lepus americanus*) (Tulloch 2019a). None of the amphibians and mammals is a SAR.

The majority of the study area is covered by jack pine and black spruce (Tulloch 2019a). Other plant species growing in the area includes speckled alder (*Alnus incana*), trembling aspen (*Populus tremuloides*), and white birch (*Betula papyrifera*). No rare plant species were found at all locations (Tulloch 2019a).

Although no fish habitat was found at the future borehole locations, water crossings along the access roads for boreholes 2 and 3 were assessed for fish using minnow traps (Tulloch

2019a). Fish captured during the assessment included white sucker, yellow perch, and northern pike (*Esox lucius*), none of which has an endangered status (Tulloch 2019a).

Figure 2.3 Locations of observations and equipment in the 2018 natural heritage assessments



Note: From Tulloch (2019a).

2.2.4 Surface Water, Sediment, and Soil Monitoring

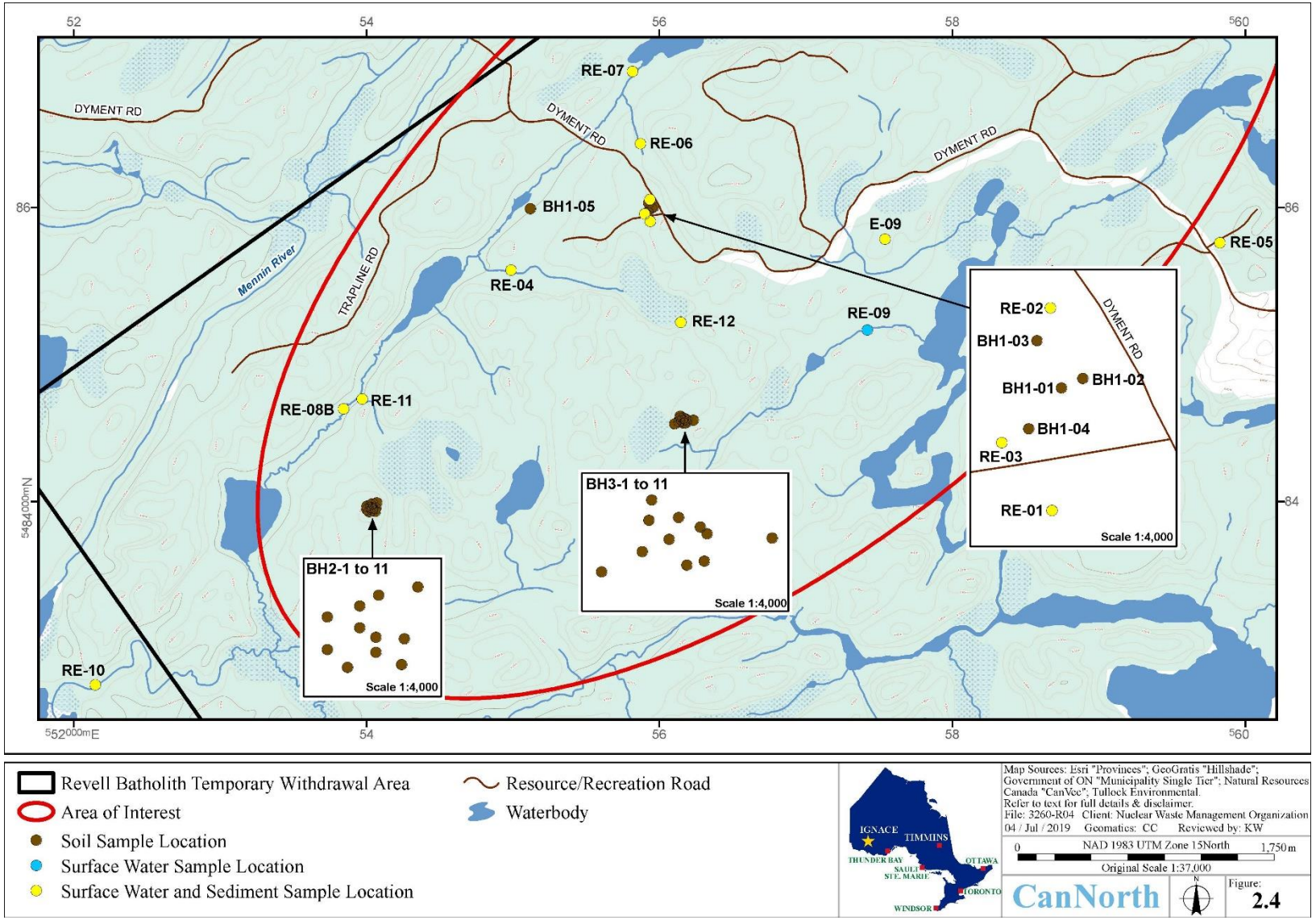
The baseline sampling program of surface water, sediment, and soil around the proposed borehole sites was conducted in 2017 and 2018 and is ongoing. The purpose of this sampling program was to understand the background environmental conditions of the study area surrounding the borehole locations (Tulloch 2019b). Surface water, sediment, and soil samples were taken from the locations shown in Figure 2.4.

Surface water samples were taken from the 12 sampling locations (see Figure 2.4) in June and October 2018. Samples were taken from only five locations in August because of the lack of water at the other seven locations. In-situ limnology parameters (pH, temperature, conductivity, dissolved oxygen, and oxidation-reduction potential) were measured at each location in August and October 2018 (Tulloch 2019b). Sediment samples were collected using a Petite Ponar at all 12 locations after the water sampling in October 2018. Soil sampling occurred at boreholes 1, 2, and 3 in August 2018. Five samples were taken at borehole 1, and nine samples from each location were taken at borehole 2 and borehole 3. Four additional samples were taken downgrade of borehole 2 and borehole 3 (Tulloch 2019b).

All samples collected in the field (water, sediment, and soil) were submitted to AGAT Laboratories for analysis (Tulloch 2019b). Polycyclic Aromatic Hydrocarbons (PAHs), Volatile Organic Compounds (VOCs), Petroleum Hydrocarbons (PHCs) and general water quality parameters (including metals) were analyzed for the surface water samples, while PAHs, VOCs, PHCs, and general inorganic parameters (including metals) were analyzed the sediment and soil samples (Tulloch 2019b).

The results found seven exceedances in surface water compared with the provincial water quality guideline (MOECC 1994), including pH, aluminum (dissolved), iron, cadmium, cobalt, total phosphorus, and toluene. Toluene exceedances were also detected in the field blank, suggesting potential sample cross-contamination (Tulloch 2019b). Cyanide concentrations in sediment were found to exceed the applicable regulatory guideline at four locations (Tulloch 2019b). In soil, cyanide was also found to be the only exceeding parameter at borehole 2 and 3 locations. Most concentrations of PAHs, PHCs, and VOCs in water, sediment, and soil were below laboratory detection limits, which were also below applicable regulatory guidelines (Tulloch 2019b).

Figure 2.4 Locations of existing water, sediment, and soil sampling stations in the Area of Interest



Note: Figure adapted from Tulloch (2019b).

3.0 SAMPLE DESIGN CONSIDERATIONS

There are many factors that can be modified during design of the Environmental Media Baseline Program including objectives, sample components, sample locations, sample sizes, Contaminants of Potential Concern (COPC), field and laboratory methods, and the extent of community participation. Key items our Study Team considered when formulating sample design options include:

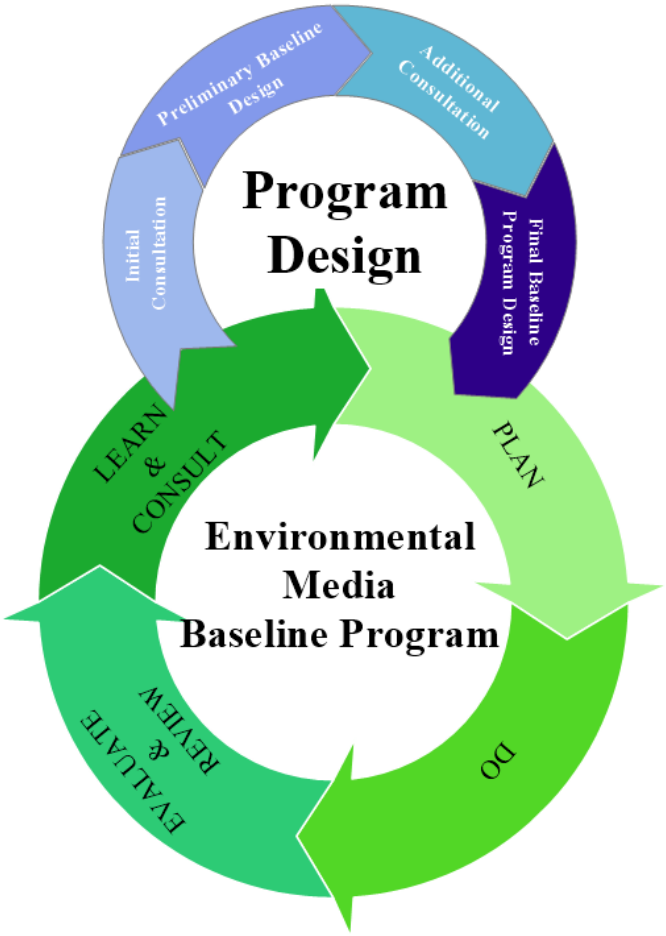
1. Stakeholder/rights-holder interests/concerns and involvement
2. Current and future land use
3. Relevance to potential Project interactions
4. Current best practices and emerging technologies
5. Regulatory requirements
6. End uses of the data
7. Scientific rigour
8. Flexibility to change the program over time

The sections below provide information on the stakeholder/rights-holder input, potential Project interactions and assumptions made at this preliminary stage of the Environmental Media Baseline Program design, the proposed COPC list, statistical considerations, and data handling and management. The Environmental Media Baseline Program will ultimately be based on an evaluation of the various study design options, discussed in Section 4.0.

3.1 Stakeholder/Rights-Holder Input

As discussed previously (see Section 2.2.1), the NWMO has been actively involved with stakeholders/rights-holders throughout the site selection process. Consideration of stakeholder input and IK from local First Nation and Métis communities is imperative in the design of a successful baseline program that is accepted by local communities. It must be emphasized that the sample design options for the various components of the Environmental Media Baseline Program presented herein are preliminary and this is an iterative, adaptive management process. Input from stakeholders/rights-holders has been considered in the design options, but further involvement from the interested communities will be necessary to arrive at a finalized Environmental Media Baseline Program that maximizes stakeholder/rights-holder input and participation. This process is illustrated in Figure 3.1 and discussed further in sections 5.2 and 6.0.

Figure 3.1 Adaptive management process for Environmental Media Baseline Program



Several workshops have been held with the following stakeholders and rights-holders to provide direction to the Environmental Media Baseline Program design[1]:

- WLON Men's Group
- WLON Knowledge Keepers
- WLON Women's Group
- Dyment
- WLONYouth
- Ignace High School
- Ignace Silver Tops

[1] Disaggregation was not a regulatory requirement at the time these workshops were carried out; while some of the input can be disaggregated, this will be a consideration in workshop design going forward.

- Ignace Community Group representatives (i.e., churches, community associations, sports clubs, etc.)
- Métis Nation of Ontario (MNO)
- Community Open Sessions

During the workshops, three questions were asked to help guide the discussions:

1. What are the questions or concerns you have about your environment?
2. What are the current stressors on your environment?
3. What are the key elements of a trustworthy and open environmental monitoring program?

Appendix B provides a log of the input received[2]. The workshops found that people from different groups shared many of the same or similar concerns; overall, the dominant concerns are related to the following:

- honesty and transparency, with publicly accessible data;
- engagement with and involvement of local communities, especially with regards to training and employment opportunities for residents (especially youth) and consideration of input and knowledge (especially from Elders) in the design of the Environmental Media Baseline Program;
- potential impacts on air, water and soil quality, fish, vegetation (berries, mushrooms, wild rice, medicinal plants), and wildlife; and
- respecting the land and Spirit.

The Environmental Media Baseline Program will, to the extent possible, incorporate the community concerns, as detailed in Appendix B. Aspects that are not directly addressed in the Environmental Media Baseline Program are also identified, with rationale and suggestions for how they could be addressed in other studies. The Environmental Media Baseline Program will establish the expected concentrations of COPC in media (for example, water, soil, fish, and plants). This is part of the information needed to assess potential changes in the environment as a result of the Project. It is acknowledged, however, that this is only part of the story and additional information will also need to be

[2] Note that due to scheduling difficulties, the workshop with the MNO was held too late to incorporate the results into this preliminary sample design feasibility assessment; the results will be considered as part of the final program design.

collected, such as data from a separate biodiversity study, to be able to address the larger questions.

The Environmental Media Baseline Program will aim to incorporate IK into the study design whenever possible. For example, community input will be used to help inform sampling locations, based on importance to community members and/or knowledge of ideal locations to obtain specific samples. The incorporation of input from the initial stakeholder/rights-holder engagement workshops into the design of each component of the Environmental Media Baseline Program is discussed throughout Section 4.0. Some key program elements that were identified in the initial workshops, such as the importance of incorporating ceremony and Spirit into the program, are not included in detail in this report as additional guidance is required from the community during follow up workshops. This is discussed further in Section 6.0 and will be detailed in the final program design. Additionally, an overview of the input process will be included in the final design report.

3.2 Conceptual Site Model

The NWMO developed a preliminary description of the Project that provides a proposed site layout and describes the works and activities likely to be associated with the construction, operation, extended monitoring, decommissioning, and postclosure phases (NWMO 2016). Our Study Team used this preliminary description to develop a CSM for the Project (presented in Appendix C). The CSM integrates information to identify how the various Project components and stages interact with one another and the environment. This is important to help identify the following:

- Study area
- Valued Components (VCs)
- Contaminants of Potential Concern (COPC)
- Potential pathways of effects
- Assumptions

3.2.1 Study Area

The Environmental Media Baseline Program will include monitoring the boundary of the facility that may be located somewhere within the AOI (called the Site Study Area [SSA]), in environments surrounding the facility (called the Local Study Area [LSA]), and in some cases, in a larger area (called the Regional Study Area [RSA]). The proposed LSA and

RSA for each of the components of the Baseline Design are discussed within applicable subsections of Section 4.0.

3.2.2 Valued Components

Valued Components (VCs) can encompass aspects of biological (e.g., moose, water quality, etc.), physical (e.g., change in aquatic habitat, change in topography, etc.), and social (e.g., increased population, increased traffic, jobs, road access to wilderness, impacts on natural resource use, etc.) environments, and are selected with consideration of potential residual environmental effects to be included within a future IA. The VCs are very specific to each sampling component (i.e., tissue, surface water, etc.) and are thus discussed further within applicable subsections of the sample design options in Section 4.0.

3.2.3 Contaminants of Potential Concern

A comprehensive list of COPC is required for a baseline sampling program to provide a complete picture of the natural constituents in the environment; however, it is also important that the COPC list meets project objectives, is relevant to potential project interactions with the VCs, and is not cost prohibitive. In general, only those contaminants that will potentially have interactions with the Project will be included. There are some exceptions where a contaminant may be included due to a high level of community concern, and the potential for cumulative effects. For example, mercury is not expected to have any Project-environment interactions, but methylmercury may be included as a COPC in fish tissue due to stakeholder/rights-holder concerns around mercury levels in fish. The inclusion of other contaminants that may be present in the environment as a result of other industrial or agricultural sources, such as dioxins, furans, and the herbicide glyphosate is still being discussed and will be finalized as part of the final program design.

The COPC list was developed in collaboration with the NWMO for Year 1 of the Environmental Media Baseline Program and with consultation of numerous reports (e.g., Ontario Hydro Nuclear 1993; NWMO 2017b; SENES 2012; Amiro 1992; Liberda and Leung 2018). As discussed in Appendix D, the focus is on contaminants that could be emitted through the potential pathways of effects identified in the CSM (Appendix C). In consideration of these pathways, the proposed COPC list contains a wide suite of parameters, including numerous metals and radionuclides, as well as generic parameters routinely used to characterize components of the environment. Focus was on identifying the radionuclides of highest relevance to the Project to be measured in each media type.

Decisions on which radiological COPC to include has a significant impact on the cost of the Baseline Project.

Similarly, decisions made on certain metals will also have a significant impact on the analytical costs. Examples include whether or not low level mercury analyses is required in a certain medium, the inclusion of total and dissolved metal analyses for certain media, and the importance of measuring COPC not included as part of a routine ICP-MS scan, such as bromine, cesium, and samarium. Design options have been provided for comprehensive suites of COPC (listed for each media and sample design option in Appendix E); however, the COPC may require further refinement prior to the final sample design.

The NWMO initiated a surface water, sediment, and soil sampling program in the AOI in 2017, implemented annually (refer to Section 2.2.4). In addition to general water quality parameters, this program included measuring suites of PAHs, PHCs, and VOCs. During development of the COPC list these parameters were identified as having potential Project interactions (Appendix C); however, since these COPC are already being measured in surface water and sediment throughout the AOI and near vicinity, they will not be included in the Environmental Media Baseline Program. This will avoid duplication of efforts and will allow for budget to be re-allocated to measuring other COPC of interest.

3.2.4 Potential Pathways of Effects

In order to focus design of the Environmental Media Baseline Program on the Project, it is important to understand the multiple pathways through which the Project could affect the various environmental components during each Project phase. Examples of potential Project-related interactions include blasting residuals, combustion by-product emissions, suspended particulates, treated effluent(s), accidental surface releases, noise and light during construction and operation, and run-off or leaching from disturbed soils and the excavated rock pile. Further information on potential pathways of effects is provided in the CSM in Appendix C.

3.2.5 Climate Change Impacts

The NWMO prepared a method development document in 2019 to anticipate the impacts of climate change on the DGR study sites (Roberts et al. 2019). Recent climate projections predict a 3°C to 4°C increase in temperature by the 2050s and an approximate increase of 6°C by the 2080s. In general, this increase in average temperatures is expected to be more

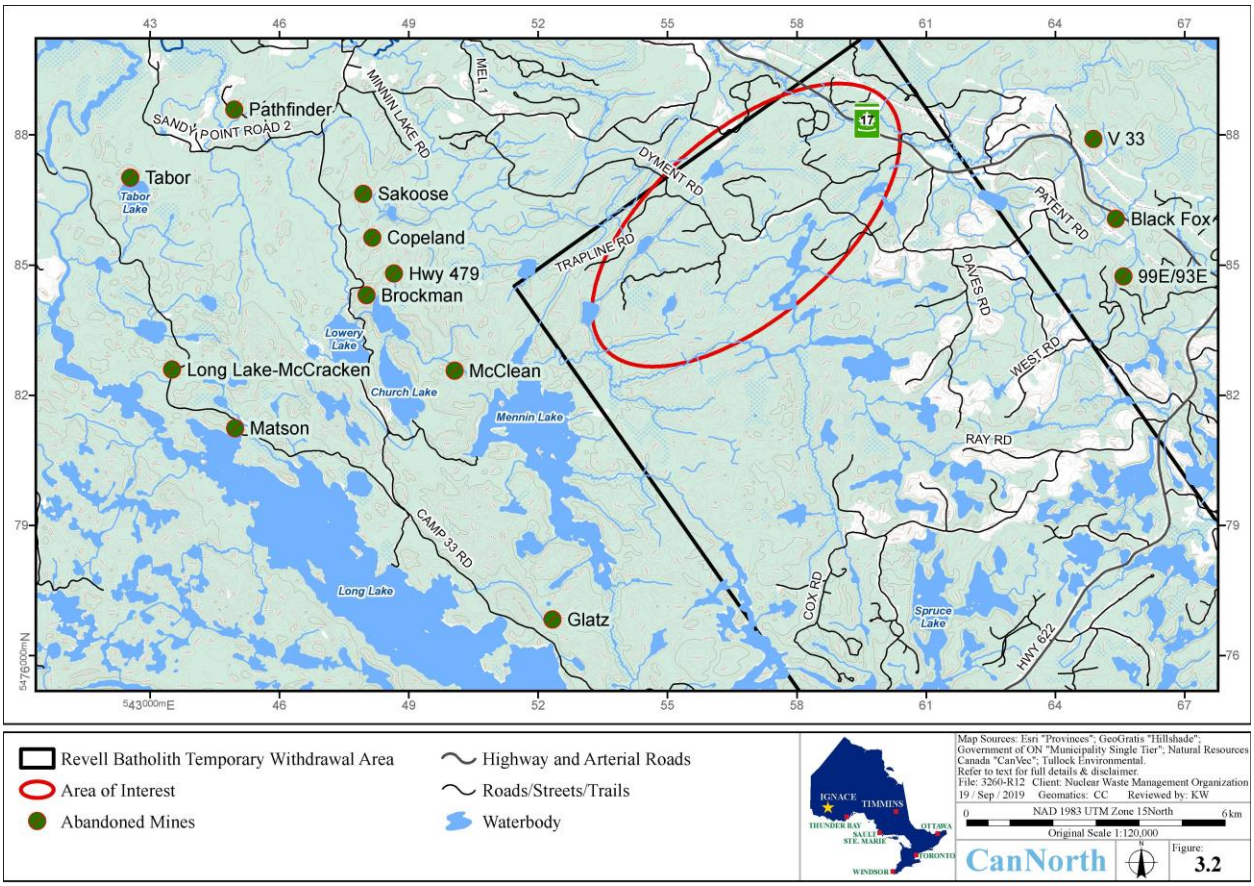
substantial during winter months compared to summer months (approximately 1.8°C greater change in winter in the 2050s and 2°C greater change in the 2080s).

In the Northwestern Ontario region, precipitation is expected to experience an increase of 50 mm/year to 75 mm/year by the 2050s and a 100 mm/year to 125 mm/year increase by the 2080s (Roberts et al. 2019). The projected increases in annual precipitation are mainly driven by an expected increase in winter and spring precipitation.

3.2.6 Previous Activities in the Area

Using the Abandoned Mines Information System (AIMS [MNDM 2019]), no abandoned mines were found within the AOI or Revell Batholith Temporary Withdrawal Area. As shown in Figure 3.2, however, there are several abandoned mines in the vicinity of the Project, including several that are in close proximity to the Mennin Lake drainage. According to AIMS, the abandoned mines contain a variety of hazardous features such as water-filled shafts, rotten tramway and mill foundations, leaching and tailing areas, and open cuts.

Figure 3.2 Abandoned mines in the region of the Project



3.2.7 Assumptions

A number of assumptions had to be made about the Project when evaluating preliminary sample design options for the Environmental Media Baseline Program because the Project design and location have not been finalized. Detailed assumptions are provided in the CSM (Appendix C).

3.3 Statistical Considerations

As discussed previously, the purpose of the Environmental Media Baseline Program is to characterize environmental baseline conditions prior to development of the DGR so that potential effects of the Project can be measured, or that a lack of detectable effects is defensible. Not only should effects be measurable, but they should be measured with an agreed upon degree of precision so that defensible statements about possible Project-associated effects are possible. In order to develop a sampling program that is sufficiently

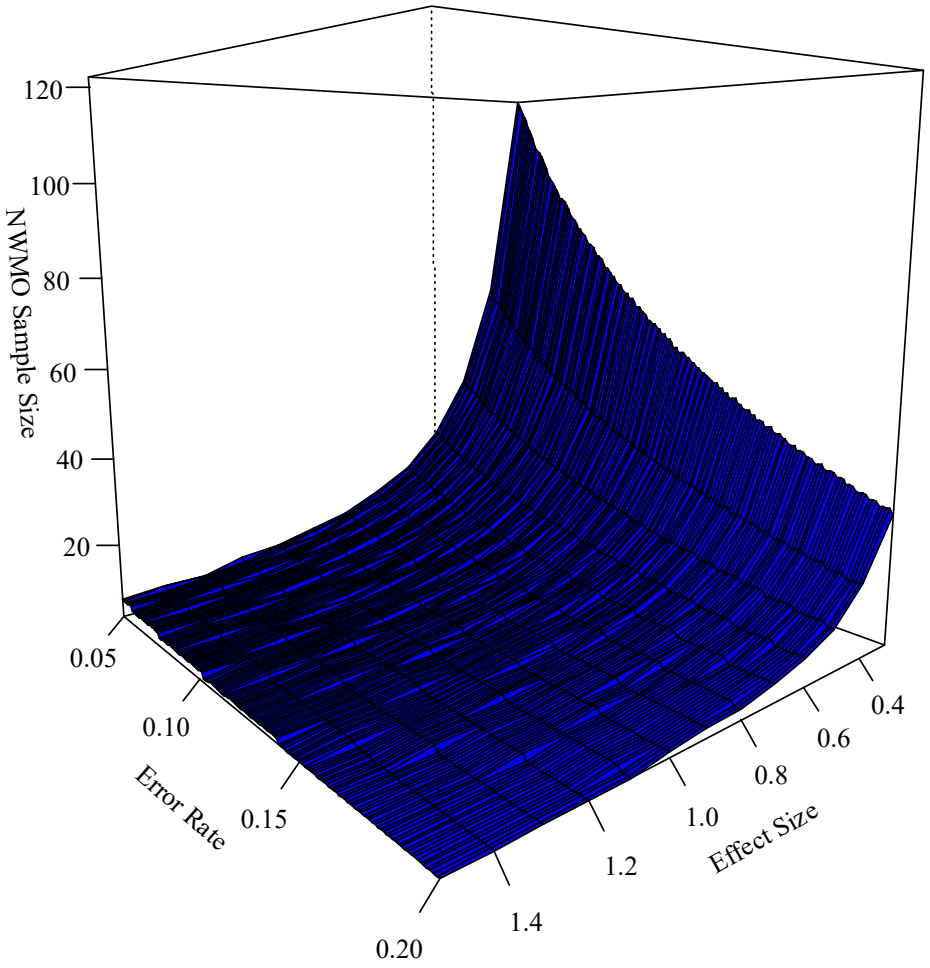
powerful to defensibly demonstrate that an effect has or has not occurred, the statistical design of the program must be carefully considered.

When designing a sampling program to collect data that will be used to make decisions about the effect of a project using data collected from the natural environment, sample size is a key component. Sample size is influenced by the following three factors:

- The amount of natural variability, as natural sources of variation affect the ability to make conclusions about the effect of a project. If there is a large amount of variability, more samples need to be collected to understand that variability, and to make good decisions.
- The Critical Effect Size (CES), which is a measure of how much change is to be detected/acceptable. If only very large changes are to be detected, then fewer samples are required. This is also related to the closeness of the minimum laboratory detection limits to applicable regulatory guidelines; the nearer the limits are to guidelines, the more samples are required to increase the certainty in the measured data.
- The amount of certainty required for any conclusions drawn from the data regarding whether or not the Project is having an adverse effect. The more certainty required, the more samples are required.

Determining preliminary sample size estimates is based on collecting enough samples such that a before-and-after comparison can be made during future monitoring. When making decisions about a Project-associated effect, two types of errors can be made: a Type I error, whereby it is concluded that the Project is having an effect when it actually is not; and a Type II error, whereby it is concluded that the Project is not having an effect when it actually is. Both of these errors can be reduced by collecting more samples, but additional sampling increases the cost and there is also a threshold at which point collecting more samples does not significantly lower the rates for these errors. Figure 3.3 shows that the more errors in conclusions we are willing to accept, the fewer samples are required. It also shows that as the size of the effect we would like to detect gets smaller, the number of samples increases.

Figure 3.3 Sample size estimation for a hypothetical biological measurement endpoint



Statisticians have developed methods to determine sample size based on these considerations, but inputs to these methods are required from regulators, rights-holders, and stakeholders. Initial sampling is also necessary to understand and estimate local variability. Since the necessary workshops to obtain input on the CES and acceptable levels of uncertainty have not occurred yet, and only limited (if any) sampling of the environmental components has been conducted, preliminary sample sizes have been estimated by the Study Team using their knowledge of similar systems to estimate expected variability for those variables that will be measured, the degree of change that has been typically considered as unacceptable by subject experts, and conventionally accepted degrees of uncertainty when making decision using information that is naturally varying. These preliminary sample size estimates will be updated as part of the final sample design following workshops with stakeholders/rights-holders on preliminary design, and acquisition of available site-specific data that will be used to estimate local variability. The

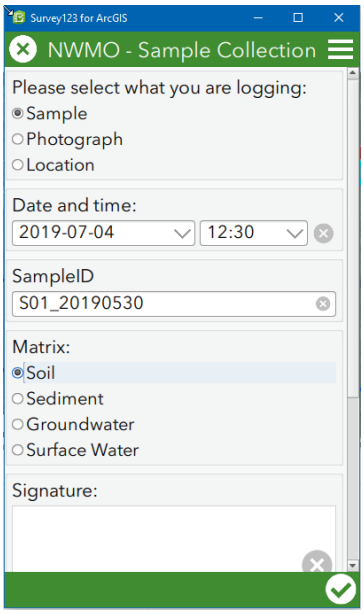
sample size estimates will also be updated as necessary during the annual reviews of the Environmental Media Baseline Program, as estimates of natural variability are obtained from the collected data.

3.4 Data Handling and Management

The Environmental Media Baseline Program needs to be developed with consideration of data collection, storage, and management. Stakeholders/rights-holders have also indicated a desire for open access to the data collected as part of the Environmental Media Baseline Program. Detailed procedures for data handling and management will be developed as part of the final program design, but it is recommended that it involve a modernized digital workflow to facilitate efficient data collection, transparency, and data access for all levels of stakeholders/rights-holders. Consideration will be given to the use of mobile app-based software, social media, and other technological aides, especially as this may encourage and facilitate community participation.

Digital data collection, using customized forms on tablets or cell phones, could be synchronized to the cloud directly from the field or nearest Wi-Fi access point. Digital forms could be custom-built using a combination of mapping input tools, drop-down boxes, radio buttons, and pre-populated textboxes to minimize the burden on busy field staff and limit the potential for data transcription errors. Figure 3.4 provides an illustration of a potential data collection screen. Data would be geotagged and timestamped automatically, which maximizes the value of the collected data for subsequent usage.

Figure 3.4 Example of digital field collection input on a tablet or cell phone



Once collected, data would first be checked for completeness and accuracy via automated processes, and then could be made publicly available in a custom-built interactive web mapping application. Although publicly available, selected data sets could be temporarily secured from view or access by use of usernames and passwords. Custom reporting and data access tools may include:

- on-demand data filtering (i.e., see all data from a given location / period-of-time / consultant);
- temporal trends (i.e., stream flow measurements, groundwater levels over time);
- spatial trends (i.e., COPC results from various locations);
- direct links to PDF reports; and
- other tools identified during workshops with NWMO and stakeholders/rights-holders.

Consideration can be given to additional fields that may be an asset for community members collecting samples and allow for the maximum amount of information to be gathered. This could include adding pictures or a recording function to allow oral notes. This type of information may be useful when reviewing the information to be able to interweave Western science and IK. In addition, training modules or videos could be developed to train users on sample collection methods, provide reminders of key steps at the time of sampling, and provide information on accessing and viewing the data.

4.0 SAMPLE DESIGN OPTIONS

This section contains the study design options proposed for each component of the Environmental Media Baseline Program (tissue, hydrology, surface water parameters, air quality, noise, and light, shallow groundwater, and soil). The objective is to utilize the initial input provided through stakeholder and rights-holder workshops to develop a suite of sample design options and to identify where further feedback is required. This will provide enough information to allow the NWMO, stakeholders, and rights-holders to evaluate the value, methods, benefits/drawbacks, and relative costs of each option. Relative costs were estimated based on Class 4 estimates (± 30% to 50% accuracy) that were developed based on the Cost Estimate Classification System of AACE International (2005) and will change as detailed study designs are developed. There are components identified in the sections below and in Section 6.0 where further input from the NWMO, stakeholders, and rights-holders is specifically required. The incorporation of IK and community input into the final study design is a key component of the study design process.

Detailed information on each sample design option is provided in Appendix E, including a description of the objective, potential Project interaction, study area, sampling approach and method, COPC, stakeholder/rights-holder involvement, benefits/drawbacks, and estimated costs. For each sampling component, the sections below identify the proposed study area, data objectives and end use, VCs, and a summary of the sample design options including recommendations.

4.1 Tissue

Obtaining and chemically analyzing tissue samples is an important component of baseline studies, as it provides data to be used in Human Health and Ecological Risk Assessments, the IA, and establishes baseline COPC concentrations to which data from future monitoring programs can be compared. Furthermore, it is a critical piece to help address IK issues brought forth by stakeholders/rights-holders related to potential impacts to fish, vegetation (berries, mushrooms, wild rice, medicinal plants), and wildlife that are used as food sources.

With innovative planning, a tissue monitoring program can engage local stakeholders and rights-holders to participate in the sampling program and build trust in the monitoring program, as well as effectively incorporate IK in the sample design.

4.1.1 Study Area

The study areas for the tissue sampling component of the Environmental Media Baseline Program will include the following:

- LSA_{TIS} – Portions of the AOI and the Mennin Lake drainage that are most relevant to the Project interactions and contain habitat types where target selected VCs can be obtained.
- RSA_{TIS} – Lands and waterbodies beyond the AOI that stakeholders and rights-holders consider being of high importance and express concern over the potential for Project interactions.

Sampling areas will be species-specific and may include multiple locations in the LSA_{TIS} and RSA_{TIS} depending on the distribution and home range of the target species. For instance, the sampling area for moose will be the whole RSA_{TIS} due to their large home range, whereas fish will be targeted from multiple locations progressively downstream of the Project, as well as multiple locations within the RSA_{TIS} that are of significance to the local communities. Reference locations will also be selected for relevant tissue, such as berries and fish, in order to measure concentrations on an ongoing basis that would not be influenced by the Project. In addition to providing valuable information to the stakeholder/rights-holders, sampling completed in the RSA_{TIS} study area will serve as regional data for comparison to data collected within the LSA_{TIS}.

4.1.2 Data Objectives and End Use

The tissue chemistry component is of particular interest to stakeholders/rights-holders, as demonstrated by the input provided during the community workshops held by the NWMO (see Section 3.1). There are multiple data objectives that include both community assurance and scientific rigour. The selection of certain VCs will be based on those that the communities feel are most relevant, even if there is a low probability of a VC having a Project interaction. Chemically analysing tissue samples from plants and animals is an important component of baseline studies as it provides data to be used in Human Health and Ecological Risk Assessments, the IA, and establishes baseline COPC concentrations to which data from future monitoring programs can be compared.

4.1.3 Valued Components

A comprehensive list of potential VC categories for tissue chemistry was assessed to determine which VC categories should be considered as tissue monitoring endpoints during the Environmental Media Baseline Program. This preliminary list was derived from available stakeholder/rights-holder input (Appendix B), VCs commonly identified for First Nation traditional foods programs (Chan et al. 2014; CanNorth 2011, 2014, 2017a, 2018a, 2018b), VCs commonly identified in the uranium mining industry and nuclear power generation in Canada (CanNorth 2017b; AREVA 2016; EcoMetrix 2016), and those recommended in guidance documents (CSA 2012; Environment Canada 2012a; BCMOE 2016; CCME 2016a; CNSC 2018). Further community input and use of IK is needed to solidify VC selection prior to completion of the final study design.

Each potential VC category was evaluated in a matrix based on the following:

- Community/IK
  - Cultural significance to rights-holders in the broader LSA_{TIS} /RSA_{TIS}.
  - Traditional food sources known to occur in the LSA_{TIS} /RSA_{TIS}.
  - Hunting/trapping/fishing sources known to occur in the LSA_{TIS} /RSA_{TIS}.
  - Tourism/economic importance in the RSA_{TIS}.
- Ecological Risk
  - Likelihood of receiving the greatest exposure to COPC due to habitat, behavioural trait, or home range.
  - Representation of various levels in the trophic web (e.g., carnivore, herbivore, insectivore).
  - At-risk species that could potentially exist within the LSA_{TIS}.
- Human Health Risk
  - Likelihood of exposure pathway relevant to human health.
- Practical Implementation
  - Known to occur in the LSA_{TIS} area and would be potentially exposed to COPC from the Project.
  - Possible to achieve sample number and weight requirements for meaningful chemical analysis (i.e., able to achieve adequate laboratory detection limits for the COPC).

Each VC category was given a rank of 1 (low), 2 (medium), or 3 (high) based on its importance to either stakeholders/rights-holders, human health risk, or ecological risk.

Furthermore, the practical implementation of collecting sufficient material and sample sizes for meaningful results was also ranked. VC categories that received total scores between 10 and 12 were selected as primary VCs to include in the tissue component of the Environmental Media Baseline Program, while those that scored between 7 and 9 were selected as optional, secondary VCs. It is recognized that these secondary VCs may still be of importance to stakeholders/rights-holders; the need to collect tissue samples for COPC content will be evaluated based on further input from communities. VC categories that scored less than 7 will be considered in the overall Human Health and Ecological Risk Assessment; however, baseline tissue monitoring is not needed for these categories. The full matrix is provided in Appendix F, along with the rationale for selection of primary and secondary VC categories that are considered for baseline tissue monitoring. However, it is emphasized that this exercise was undertaken in order to provide the NWMO, stakeholders, and rights-holders with preliminary options; the inclusion of certain VCs will be refined following further workshops.

High level fish, wildlife, plant, and land use information in the Northwestern Ontario region is available from the MNRF databases (e.g., fish community composition in larger lakes) and from stakeholder/rights-holder engagement sessions (Appendix B). Information on species that occur in the AOI is being collected as part of the Phase 2 assessments and preliminary information is summarized in Section 2.2. Therefore, more details on the specific VCs sampled from each VC category will also be refined as more site specific information becomes available.

4.1.3.1 Aquatic Valued Components

The following primary aquatic VC categories are considered essential components for evaluation in the aquatic baseline tissues assessment of the LSA_{TIS} and RSA_{TIS}:

- Flesh tissue of key large-bodied predatory (e.g., walleye, lake trout, and northern pike) and bottom feeding (e.g., lake whitefish, cisco, and white sucker) fish species in both the LSA_{TIS} and RSA_{TIS}, based on species availability.
- Roots and/or shoots of representative aquatic macrophytes (e.g., sedge species from LSA_{TIS}, wild rice from RSA_{TIS}).
- Flesh tissue of key herbivorous (e.g., Canada goose) and omnivorous (e.g., mallard duck) aquatic birds from both the LSA_{TIS} and RSA_{TIS}.

Additional secondary aquatic VC categories are considered as an optional addition to the main list, the inclusion of which will be decided based on input. The secondary VC categories include:

- Flesh tissue of representative semi-aquatic mammal (e.g., beaver) from the LSA_{TIS} and RSA_{TIS}.
- Flesh tissue of representative amphibian (e.g., boreal chorus frog or wood frog) from the LSA_{TIS} and RSA_{TIS}.
- Flesh tissue of key piscivorous (e.g., merganser or loon) aquatic bird from the LSA_{TIS} and RSA_{TIS}.
- Flesh tissue of representative planktivorous fish species (e.g., emerald shiner or longnose dace) from the LSA_{TIS} and RSA_{TIS}.
- Aquatic emergent insect chemistry (e.g., dragonflies)

4.1.3.2 Terrestrial Valued Components

The following primary terrestrial VC categories are considered essential components for evaluation in the terrestrial baseline tissues assessment of the LSA_{TIS} and RSA_{TIS}:

- Flesh and organ tissue of key ungulates (e.g., moose and whitetail deer) from the RSA_{TIS}.
- Flesh tissue of representative small mammals (e.g., mice, shrews, and snowshoe hare) from the LSA_{TIS} and RSA_{TIS}.
- Flesh tissue of key upland game bird (e.g., ruffed grouse) from the LSA_{TIS} and RSA_{TIS}.
- Berry chemistry of key edible berry species (e.g., blueberry, cranberry, and raspberry).
- Vegetation chemistry of key edible or medicinal use plants (e.g., wild mushroom, Labrador tea, and Chaga) from the LSA_{TIS} and RSA_{TIS}.

Additional secondary terrestrial VC categories are considered as an optional addition to the main list, the inclusion of which will be decided based on input. The secondary VC categories include:

- Chemistry (tissue or hair) of representative large carnivores (e.g., lynx or wolf) from the RSA_{TIS}.

- Vegetation chemistry of representative browse species (e.g., willow) from the LSA_{TIS} and RSA_{TIS}.
- Terrestrial insect chemistry from the LSA_{TIS} and RSA_{TIS} (e.g., caterpillars).

4.1.4 Sample Design Options Overview

The sampling design options provided for the tissue monitoring component vary in VC category inclusion and sampling methods and include:

- **Option 1**. Dietary study for the identified stakeholders/rights-holders. Sampling of primary VC categories; sampling completed by community members through hunting and gathering activities alongside sampling completed by a biologist with community members for certain VCs.
- **Option 2**. Dietary study for the identified stakeholders/rights-holders. Sampling completed as in Option 1 but with a complete list of all primary and all secondary VC categories.
- **Option 3**. Dietary study for the identified stakeholders/rights-holders. Sampling completed as in Option 2 but with non-lethal sampling completed for secondary VCs.

4.1.4.1 Traditional Foods Dietary Survey

The dietary survey would collect information on the quantity, type, and general harvest locations of traditional foods consumed by stakeholders/rights-holders local to the Project. The information would be collected through an interview process using a food frequency questionnaire. This survey would be conducted prior to the Environmental Media Baseline Program, and ideally prior to finalization of the study design so that these data can be used to inform VC selection and sampling locations. The collected data would also be valuable to provide site specific information for a Human Health and Ecological Risk Assessment completed for the Project.

This program will enable community members to conduct their own IK-based dietary survey to help determine the VCs to be sampled and the hunting, fishing, and gathering locations that are of the highest importance to them. The dietary survey would be completed by local stakeholders/rights-holders who would be hired and trained in the interview process. This will provide a short-term employment opportunity and allow community members to be further engaged in the tissue component of the Environmental Media Baseline Program.

4.1.4.2 Contaminants of Potential Concern

A comprehensive COPC list was developed in collaboration with the NWMO as discussed in Section 3.2.3. For the tissue sampling program, COPC include percent moisture and a full suite of metals including mercury. Key radionuclides including gross-α, gross-β, H-3, C-14, Sr-90, I-129, and Cs-137 were included in this preliminary assessment for select VCs where adequate sample volume/weight can be achieved. The preliminary list of COPC is provided in Appendix E for each VC category; this list may be refined based on additional input.

4.1.4.3 Sample Size and Frequency

A number of factors must be considered in terms of sampling size and frequency, including the availability of VCs within the study area, the ability to collect sufficient volume/weight of the sampling material to achieve meaningful results, and the ability to collect a sufficient number of replicates to obtain statistically sound estimates (refer to Section 3.3). For the purpose of obtaining initial estimates of local variability, the sample size of each endpoint has been estimated at five, and the sampling species selected for each VC category took into consideration the sample volume/weight requirements to achieve meaningful analytical detection limits. In cases where multiple species of concern have been identified within a VC category, species can alternate by year to ensure all species identified as significant to stakeholders/rights-holders and Human Health Ecological Risk Assessments are incorporated into the Environmental Media Baseline Program. For instance, two large-bodied fish species (one piscivore and one bottom-feeding) will be monitored during each year of the three-year program, but the species can alternate between years. There is also the opportunity to sample the same species in multiple years to obtain estimates of temporal variability and to increase sample sizes if variability in COPC concentrations is higher than anticipated. Consideration will need to be given to the balance between obtaining data for the range of species of interest locally and the ability to provide sufficient data for statistical analysis.

The number of sampling areas and replicate samples per VC category assumed for this preliminary assessment are summarized in Table 4.1 for primary VCs and in Table 4.2 for secondary VCs. Once additional existing data are evaluated and additional community input is provided, the species, areas, and number of replicate samples will be further refined.

Table 4.1 Preliminary tissue sampling requirements for Primary Valued Components

VC Category	Example VC[a]	Radio-nuclides Included?	Number of Sampling Areas		Number of Samples per Area[b]			Total
			RSA_{TIS}	LSA_{TIS}	Year 1	Year 2	Year 3	
Aquatic								
Large-bodied Fish – Piscivores	Walleye	✓	4	3	5	-	-	35
	Northern Pike	✓	4	3	-	5	-	35
	Lake Trout	✓	4	NE	-	-	5	20
Large-bodied Fish – Benthivores	White Sucker	✓	4	3	5	-	-	35
	Lake Whitefish	✓	4	NE	-	5	-	20
	Cisco/Lake Herring	✓	4	NE	-	-	5	20
Aquatic Macrophytes	Sedge Species (roots and shoots)	✓	1	3	5	-	-	40
	Manoomin (Wild Rice)	✓	4	NE	-	5	-	20
	Rat Root/Sweet Flag (root)	✓	2	2	-	-	5	20
Aquatic Birds – Herbivores	Canada Goose	✓	2	1	5	-	-	15
Aquatic Birds – Omnivores	Mallard Duck	✓	2	1	-	5	-	15
Terrestrial								
Terrestrial – Berries	Blueberry	✓	3	2	5	-	-	25
	Cranberry	✓	3	2	-	5	-	25
	Raspberry	✓	3	2	-	-	5	25
Terrestrial Vegetation – Edible or Medicinal Use	Wild Mushroom	✓	2	1	5	-	-	15
	Chaga	✓	2	1	-	5	-	15
	Labrador Tea	✓	2	1	-	-	5	15
Upland Game Birds	Ruffed Grouse	✓	2	1	5	5	5	45
Small Mammals	Snowshoe Hare	✓	2	1	5	-	-	15
	Deer Mice	✓	2	1	-	5	-	15
	Shrew	✓	2	1	-	-	5	15
Ungulates	Moose Flesh	✓	1	NE	5	5	5	15
	Moose Kidney	✓	1	NE	5	5	5	15
	Moose Liver	✓	1	NE	5	5	5	15
	Whitetail Deer Flesh	✓	1	NE	5	5	5	15
	Whitetail Deer Kidney	✓	1	NE	5	5	5	15
	Whitetail Deer Liver	✓	1	NE	5	5	5	15

Notes: Species, sampling areas, and number of samples may be refined based on evaluation of existing data and review of additional stakeholder/rights-holder input; NE: Not Evaluated (species not identified within LSA_{TIS}/species has larger home range than LSA_{TIS}).

[a]Unless otherwise noted, sample is flesh tissue.

[b]Where multiple species of concern have been identified within a Valued Component (VC) category, species sampled can alternate year by year to ensure all species identified as significant to the community and Human Health and Ecological Risk Assessment (HHERA) are incorporated into the Environmental Media Baseline program.

Table 4.2 Preliminary tissue sampling requirements for Secondary Valued Components

VC Category	Example VCs[a]	Radio-nuclides Included?	Number of Sampling Areas		Number of Samples per Area[b]			Total
			RSA_{TIS}	LSA_{TIS}	Year 1	Year 2	Year 3	
Aquatic								
Small-bodied Fish – Planktivores	Emerald Shiner or Longnose Dace	-	1	3	5	-	-	20
Amphibians	Frog	-	2	1	5	5	5	45
Semi-aquatic Mammals	Beaver	-	2	1	5	-	-	15
	Muskrat	-	2	1	-	5	-	15
	Mink	-	2	1	-	-	5	15
Aquatic Birds – Piscivores	Merganser or Loon	-	2	1	5	-	-	15
Emergent Aquatic Insects	Dragonflies	-	1	2	5	-	-	20
Terrestrial								
Large Mammals – Carnivores	Wolf or Lynx	-	1	NE	5	5	5	15
Terrestrial Vegetation – Browse	Willow	-	3	2	5	-	-	25
Terrestrial Insects	Caterpillars	-	1	2	5	-	-	20

Notes: Species, sampling areas, and number of samples may be refined based on evaluation of existing data and review of additional stakeholder/rights-holder input; NE: Not Evaluated (species not identified within LSA_{TIS}/species has larger home range than LSA_{TIS}).

[a]Sampling could be lethal (flesh) or none lethal methods (scale, feather, hair), depending on options.

[b]Where multiple species of concern have been identified within a Valued Component (VC) category, species sampled can alternate year by year to ensure all species identified as significant to the community and Human Health and Ecological Risk Assessment (HHERA) are incorporated into the Environmental Media Baseline program.

4.1.4.4 Sampling Methods

Traditionally harvested VCs from within the LSA_{TIS} and RSA_{TIS} (e.g., fish, moose, deer, manoomin, rat root/sweet flag, and more) will be collected during local rights-holders hunting, trapping, fishing, and harvesting activities. A biologist with the assistance of local stakeholders/rights-holders will collect VCs not traditionally harvested from the area (e.g., deer mice), VCs collected using non-lethal techniques (e.g., wolf hair), and any outstanding VCs required from the LSA_{TIS} and RSA_{TIS} not already submitted by local rights-holders in the given year.

Non-lethal sampling of some of the VC categories is included as an option, as it is not always possible or desirable to lethally capture some key species recommended for the Environmental Media Baseline Program. For these key species, very small non-lethal samples could be acquired for metals analysis by TrichAnalytics Inc. TrichAnalytics is the

only laboratory in North America currently using laser ablation and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) for analysis of biological tissues on a microscopic level. Very small samples can be submitted for this analysis (50 mg of tissue versus >5000 mg for traditional analyses). This new innovative technique allows for the completion of conventional metal analyses using laser ablation, all while maintaining industry-standard laboratory techniques and detection limits. Using this technique, hair samples from some of the mammal species targeted (e.g., wolves, beaver, muskrat, mink), feather samples from bird species not traditionally hunted (e.g., loons), and individual insect samples (e.g., dragonfly or caterpillar) can be assessed for the full suite of metals. Hair samples are appropriate for monitoring changes to VCs, compared to tissue samples that should be gathered to support the human health assessment. Where possible, ageing structures will also be collected with the tissue sample for age analysis. Although using this non-lethal method omits the inclusion of radionuclide analyses, it provides a non-intrusive and cost effective method for obtaining some data from these endpoints.

Where possible, it is recommended that tissue samples be co-located with environmental samples. For example, surficial soil samples should be collected from the same location as plant tissue analysis. This will provide additional information for predictive assessments.

4.1.4.5 Stakeholder/Rights-Holder Involvement

A key component of the tissue baseline sampling program is stakeholder/rights-holder involvement be included at all stages. This will enable stakeholder/rights-holders to test the components and locations of the environment that are of most concern to them before the Project begins.

The traditional foods dietary survey component of the tissue program would be completed almost entirely by local stakeholders/rights-holders hired from the region, with training and management provided by the Study Team. Employing individuals from the community to complete the interviews is beneficial as they are familiar with the local study area, cultural and traditional foods usually eaten, preparation methods, and portion sizes. The Study Team lead will guide them through the process of formulating the dietary survey and associated forms, ethics, conducting the interviews, mapping, data gathering, and data transfer. Data collected during the interview process will be reviewed, compiled, and analyzed by the Study Team.

The information gained during the traditional foods dietary survey, alongside further engagement activities can be utilized to establish the final tissue baseline study design.

Once finalized, the tissues component of the Environmental Media Baseline Program would be completed by stakeholders/right-holders, with technical assistance from a biologist for certain media (i.e., small mammals or insects). The objective is to retain samples from local stakeholders/rights-holders during hunting, trapping, or gathering activities in order to maximize community involvement and reduce lethal sampling required specifically for the Environmental Media Baseline Program. It is also recommended that a community liaison and/or elder be hired to assist in the coordination of the tissue sampling and to aid in the dissemination of information back to leadership and the broader community.

4.1.4.6 Recommendations

The recommended sample design is Option 3 as it fully covers all primary and secondary VCs, which will provide baseline information on all VC categories that were identified as a concern from a community and Human Health and Ecological Risk Assessment perspective. Furthermore, this option incorporates non-lethal sampling methods for VCs not traditionally hunted in the region (e.g., loons) or hunted in sufficient quantities to collect a meaningful sample size (e.g., wolf, beaver). The laser ablation metal analyses will also allow for individual insect and small-bodied fish samples due to the low weight requirements. However, there are drawbacks to this option including that radionuclide analyses is not available using this non-lethal method. Ultimately, more input is required before the final study design to determine the final VCs, COPC list, sampling technology, sampling locations, and sample sizes.

4.2 Hydrology

The hydrology component of the Baseline Program will consist of monitoring nearby waterways (rivers, streams and lake) and local meteorology.

4.2.1 Study Area

The LSA for hydrology (LSA_{HYD}) has the same boundaries as the AOI, as shown in Figure 4.1. Waterbody maps have confirmed the presence of many wetlands, streams, rivers and lake(s) within the LSA_{HYD}. Historic and more recent flow data are not available for the streams within the LSA_{HYD}. More detailed and site-specific information on flow, floods, and wetlands are required to better characterize the LSA_{HYD} and to better understand potential interactions between surface water features and the Project.

Outside of the AOI, the regional study area for hydrology (RSA_{HYD}) is defined by areas downstream of the AOI on the Revell River and below Mennin Lake on Mennin River (Figure 4.2). The baseline conditions on both rivers should be studied to better understand the interactions that may occur from either water withdrawal or effluent discharge, which are more likely to occur in these larger rivers than the small streams in the LSA_{HYD}.

Many of the waterbodies in the LSA_{HYD} are in headwater basins that contribute flow to Mennin Lake, with water flowing generally to the southwest. In addition, the northwest area of the LSA_{HYD} crosses with the ridge line between the Revell River and Mennin River basins, which both eventually go into Wabigoon Lake. Close to Mennin Lake, the surface topography appears to be relatively flat (range of 30 m to 40 m) with multiple stream courses and wetlands criss-crossing the landscape. The largest rivers appear to be the Mennin River to the southwest of the LSA_{HYD} and the Revell River in the northeast section of the LSA_{HYD}. Given the larger flows in these two rivers, they are more likely candidates for water withdrawals and assimilating effluent discharges.

Given the topography, small drainage basins, and number of wetlands, it will be important to understand the flow ranges in these streams, including whether some of them are intermittent, whether the wetland areas may be intermittent, and whether any seasonal flooding may occur. Additionally the current and intended land uses within the LSA_{HYD} and RSA_{HYD}. Understanding the flows will also inform the site design for water withdrawal and effluent discharge needs and how to effectively reduce water quality impacts. Given the location of lakes, watercourses and wetlands, there are three or four sites within the AOI on which the Project could be situation that would not impinge upon watercourses or wetlands. This information will be important for the construction, operation, and extended monitoring phases of the Project.

More site-specific precipitation and meteorological data are also required to better understand the hydrology in the LSA_{HYD}, especially with regards to seasonal weather patterns (rainfall and snowfall) and assess the potential for flooding and freezing near the Project. This information will also be important for stormwater and hydrology modelling to understand how much water is running off the Project and needs to be treated before discharge. In addition, hydrology efforts should be co-ordinated with the shallow groundwater and soils studies to provide a more complete picture of the LSA_{HYD} hydrology.

Figure 4.1 The Mennin Lake drainage in the Area of Interest

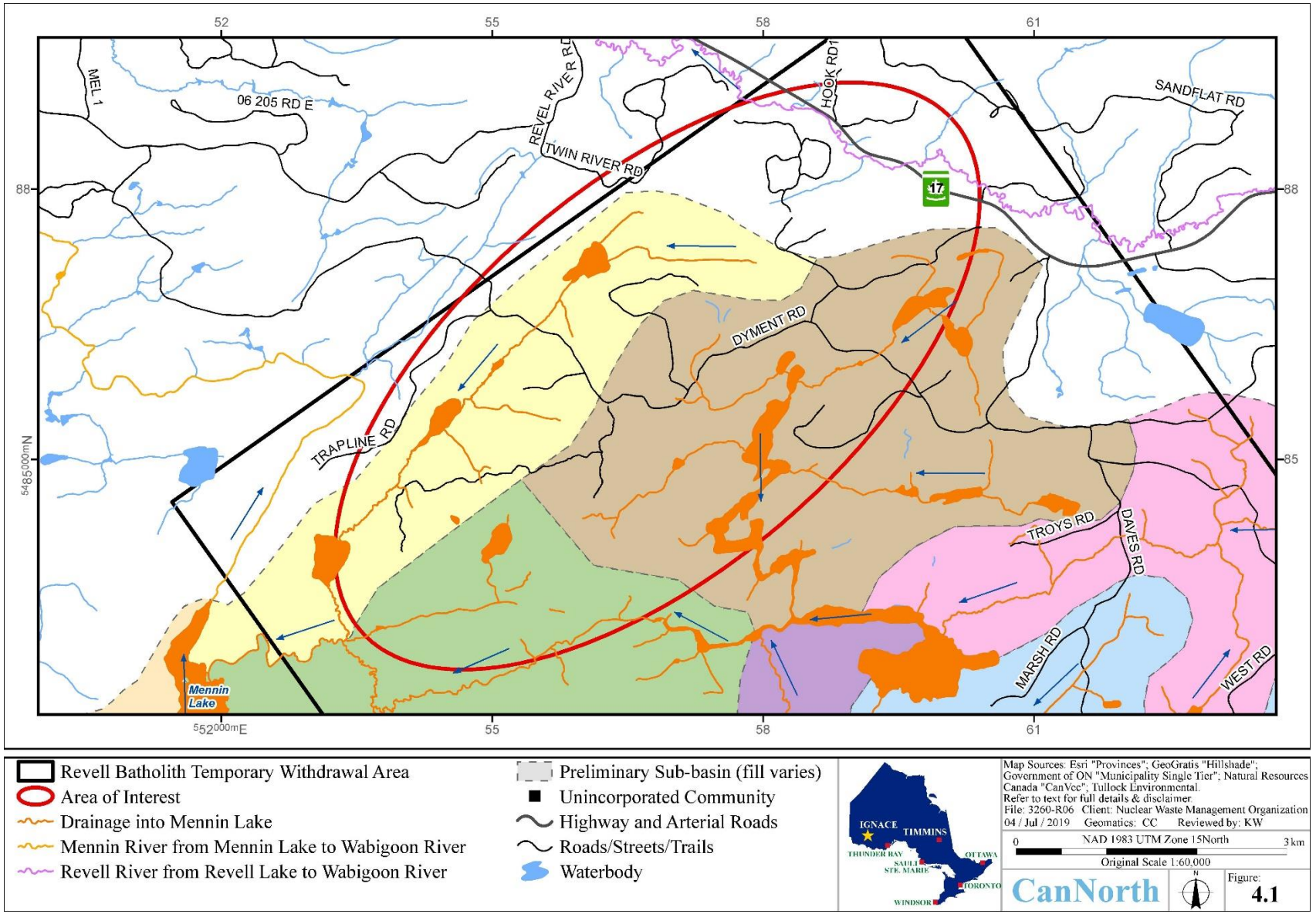
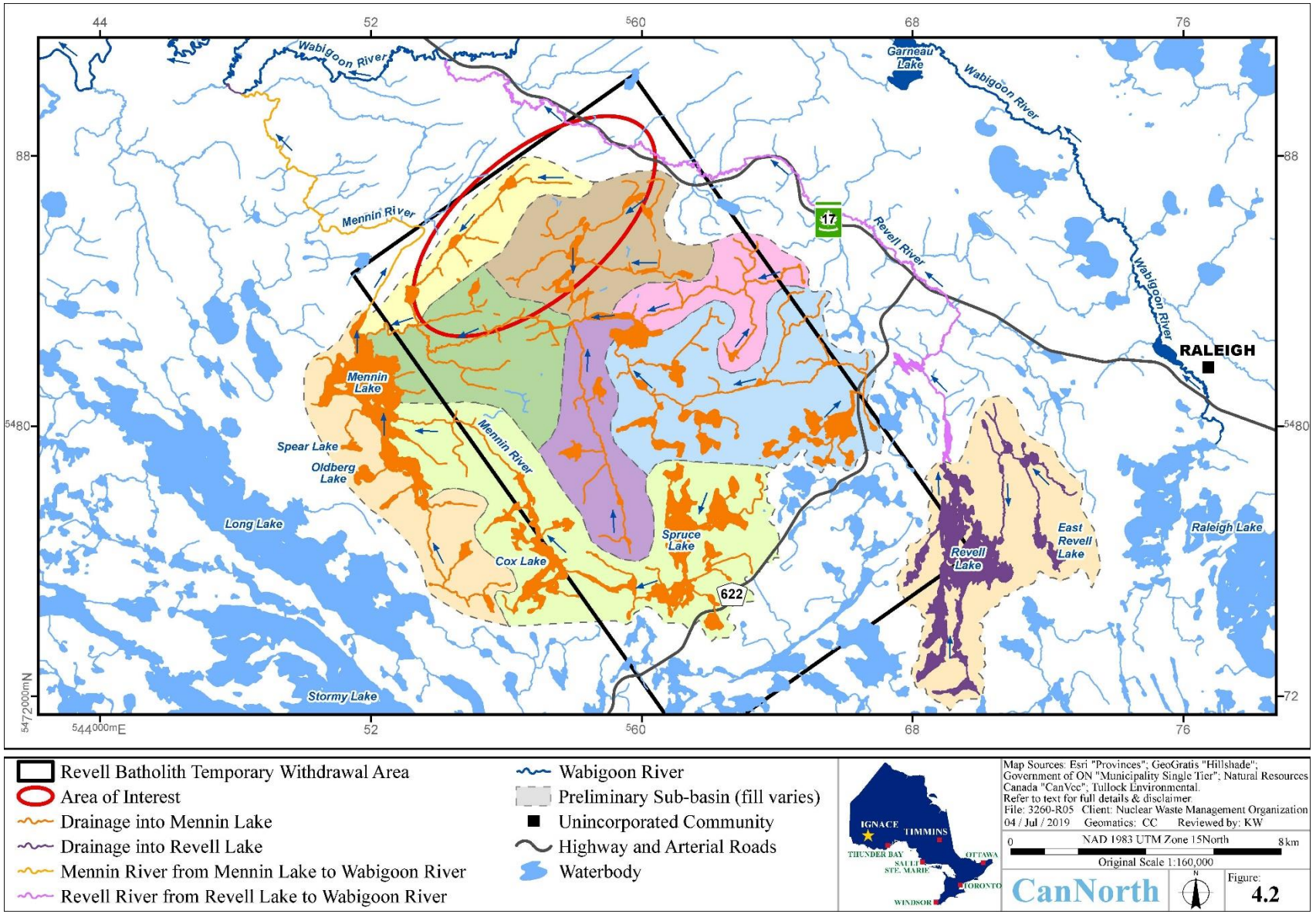


Figure 4.2 Locations of the Mennin Lake and Revell Lake drainages



4.2.2 Data Objectives and End Use

The purpose of the hydrology Environmental Media Baseline Program will be to determine the existing conditions within the SSA, LSA_{HYD}, and RSA_{HYD} within three years in order to assess the impacts and feasibility of the design and construction of the Project. More specifically, to understand the frequency and extent of possible flooding which may impact the Project, the intensity of rainfall conditions which impacts stormwater management and effluent discharge, and any low flow conditions which may impact the availability of water for supply withdrawal or the assimilative capacity of receiving waters for effluent discharge.

The objectives for the hydrology flow data collection include the following.

1. Characterizing the seasonal changes in the river flow on the Mennin River and Revell River as source for water supply and possible receiving water for effluent from the Project.
2. Characterizing the higher flows in the smaller streams of the LSA_{HYD} to better understand the potential for local flooding, which may impact the Project.
3. Monitoring the water level of nearby Mennin Lake.
4. Monitoring the local meteorology in the LSA_{HYD} to inform any hydrologic and stormwater analyses necessary for the site and assist in characterizing a 1-in-500-year storm event.
5. Collecting enough hydrology data to support a hydrology model for the LSA_{HYD}.

End uses for the data include but are not limited to the following.

- Analyze the seasonal flows from the Mennin River below Mennin Lake and Revell River for its assimilative capacity for estimated effluent discharge from the Project.
- Analyze the flows in the Mennin River below Mennin Lake and Revell River to understand the flow through from the lake and the ability of the lake to serve as a water supply source for the Project.
- Analyze the water level on Mennin Lake to understand historical conditions and in order to determine potential impacts.
- Analyze the on-site meteorology to understand the seasonal trends in precipitation, snow, and air temperatures and compare these measurements with flow measurements in the larger river(s) and smaller streams to get a basic understanding of the local hydrology. Results for these field measurements should be analyzed

considering soil moisture data and shallow groundwater data, discussed elsewhere in this report (see Sections 4.6 and 4.5, respectively). Utilize the meteorology data to drive a localized hydrology model of the AOI, if necessary, which can be used as a local baseline model of the AOI to support any PMP or climate change analyses. Analyze the on-site meteorology data collected with other meteorology data collected in the region (40+ km away) which may have longer term records to understand if there are similar trends in the data and can these longer records inform characterizing a 1-in-500- year storm events.

- Analyze the spring snow melt flow measurements in the smaller streams near where the Project may be placed to understand how high flows could be in these smaller sub-basins. This would also support developing any local hydrology and storm flood models. The data and local hydrology could also be used to understand the impact of a 1-in-500-year storm event.
- Provide the necessary data to use in modelling to predict and assess the Project impacts in an IA for the chosen site of the Project.

4.2.3 Valued Components

The VCs in the hydrology component of the Environmental Media Baseline Program include:

- Hydrology
    - Stream and River Flow
        - increases in river and stream flow that result in flooding;
        - decreases in river and stream flow that result in drought conditions (i.e. loss of aquatic habitat);
    - Lake Water Level
        - increase in lake water level that might result in flooding;
        - decrease in lake water level that might result from drought condition;
- Meteorology
    - intense rainfall events; and
    - lack of rainfall (and combined with high air temperatures).

4.2.4 Sample Design Options Overview

4.2.4.1 Hydrology

Flow and water level monitoring will need to be carried out in small streams, larger rivers, such as Mennin and Revell rivers and Mennin Lake. Sampling methods differ depending on the size of the waterbody being measured.

Estimating Flow in Smaller Streams

There is only one option being presented for flow monitoring of smaller streams, which involves manually monitoring each year for seasonal flow measurements. During all three years of the Environmental Media Baseline Program, manual flow measurements would be conducted during the spring melt, and also in the late summer dry period (at the same sites) to enable quantitative comparisons with the high flows once snow melt has ceased. It is proposed that five sites within the LSA_{HYD} be sampled, the exact locations of which will be determined as part of the final design, after stakeholder/rights-holder input.

As per the guidelines of the Ontario Stream Assessment Protocol (OSAP 2017) and Ministry of Transportation (MTO) guidance (MTO 1997, 2016, 2019), the manual flow measurements will be obtained via the following steps:

1. dividing the river channel cross-section into equally spaced segments;
2. taking depth measurements to obtain the cross-sectional area of each section;
3. taking velocity measurements of each section; and
4. multiplying the velocity by cross-sectional area to get a flow through each section.

This methodology assumes the smaller streams and creeks are narrow with limited flow and can be readily traversed by foot. One disadvantage to this design option is that continuous flow data are not being collected, and accessing the flow monitoring sites may take some effort.

Estimating Flow in Larger Rivers

To estimate flow in larger rivers (i.e., Mennin River and Revell River), stream flows and water levels must first be measured so that a stage-discharge rating curve can be developed in Year 1. This relationship can then be used in subsequent years to convert measured water levels to flow estimates. Sampling locations will be determined following further stakeholder/rights-holder input.

Manual flow measurements will be obtained during Year 1 of the Environmental Media Baseline Program, using the methodology outlined previously in the section on Estimating Flow in Smaller Streams. It is recommended that this be completed during three to six field site visits in order to estimate river flow under a variety of flow conditions so that an accurate curve can be developed. The first field visit will include surveying in a detailed channel cross-section below and above the water line to bank full or flood conditions.

Water level measurements will be obtained using one of two options:

- **Option 1:**
    - Install one water level sensor (pressure transducer or other) for hourly water level measurements on the Mennin and Revell rivers in the same mobilization trip to the site. This would include an instrumentation box, solar panels, tripod stand or pole in concrete, and other equipment away from the river channel. Data can be recorded locally and downloaded periodically during site visits. Alternatively, data could be transmitted via radio or cell depending on the availability of local receiving networks.
    - Once installed, the water level gauge stations would be visited at a minimum quarterly to check on equipment, replace batteries, download data if necessary, and troubleshoot any equipment issues.
    - The frequency of site visits can be coordinated with other field studies to reduce costs and limit carbon footprint, but more frequent visits are recommended to ensure no issues arise with the equipment or data collected.
    - Advantages: Continuous water level data would be collected and converted to flow estimates based on the stage-discharge rating curve.
    - Disadvantages: Costlier to install and maintain; possible equipment failures could result in lost data.
- **Option 2:**
    - During the first field visit, place one permanent staff gauge in both the Mennin and Revell rivers (protected from possible flood conditions) and relate the staff measurements to survey channel cross section.
    - Subsequently, periodic field visits will include simply taking visual staff gauge readings and then utilizing the stage-discharge rating curve to estimate flow.
    - The frequency of site visits can be coordinated with other field studies to reduce costs, but a minimum of every month during the thaw season.

- Advantages: The cost is lower for fixed field equipment and there is a simpler field protocol.
- Disadvantages: No continuous (hourly) stage measurements which means not capturing the seasonal flow changes as accurately. Staff gauge could be blown out during flood conditions. May require more field visits and therefore staff time to take staff gauge readings.

Lake Water Level

There is only one option being presented for monitoring the water level in Mennin Lake, which involves manually monitoring for the 3 years of the Environmental Media Baseline Program using a staff gauge. The sampling location will be determined following further stakeholder/rights-holder input. Lake water level measurements will be obtained using the following option:

- During the first site field visit, install one permanent staff gauge in Mennin Lake and identify if the staff measurements can be related to any other surveyed information (water level monitoring on the Mennin River, for example). It is not critical that the staff gauge be tied to an elevation, but it may be useful later.
- Subsequently, periodic field visits will include simply taking visual staff gauge readings.
- The frequency of site visits can be coordinated with other field studies to reduce costs, but a minimum of every month during the thaw season.

The advantages of this option include a lower cost for fixed field equipment and a simpler field protocol, although the disadvantage is that it will not provide continuous (hourly) stage measurements of the lake.

4.2.4.2 Meteorology

The nearest weather stations are approximately 40 km to 100 km away from the AOI and is not appropriate to represent site-specific conditions. It is recommended that an automatic meteorological station be installed within the AOI.

It is our understanding that NWMO is planning to install a meteorological station and therefore discussion of the relevant components are provided in this section for informational purposes. The collection of site-specific data will help to better understand

weather conditions and seasonal patterns in the immediate area, and will also help to form an understanding of seasonal flood and flow conditions.

Two possible locations have been identified for locating the automatic meteorological weather station. The first is along Dyment Road in the LSA_{HYD} and near the SSA, while the other is along Highway 17 within the AOI.

The station should measure air temperature, total precipitation (rainfall and estimate of snowfall), wind direction and wind speed, relative humidity or dew point temperature, atmospheric pressure, soil moisture (coordinated with the soils component of the Environmental Media Baseline Program) and solar radiation. It is recommended that sampling be completed hourly using a continuous meteorological station. The minimum sampling duration should be one year; however, it is recommended that data be collected for the three years of the program to develop a more robust dataset.

A continuous meteorological station will require ongoing maintenance, including checking equipment, troubleshooting issues, calibrating instruments, swapping out batteries or other faulty equipment, cleaning equipment as necessary, and downloading data (if telemetry is not used). The frequency of site visits can be coordinated with other field studies to reduce costs, but at a minimum of three times during the thaw season. An approach needs to be developed for how the meteorological station will operate over the winter without losing power and handling extreme cold temperatures.

4.2.4.3 Stakeholder/Rights-Holder Involvement

The hydrology component of the Environmental Media Baseline Program may provide an opportunity to employ local community members to conduct monitoring and maintenance of the equipment. There are four areas where local community members can be employed:

1. Provide field assistance in installing and maintaining the water level gauges on the larger rivers.
2. Provide field assistance in developing the stage-discharge relationship on the larger rivers.
3. Provide field assistance with manually measuring flow on the smaller streams.
4. Provide field assistance with manually measuring the water level in Mennin Lake.
5. Provide field assistance for installing and maintaining the meteorological station on site.

4.2.4.4 Recommendations

The recommended sample option for measuring stream flow in the smaller streams is to measure the flow manually twice a year during the three years of the Environmental Media Baseline Program (during the spring melt and also in the late summer dry period).

The recommended sample option for measuring water levels in the larger rivers is Option 1 because it will result in a more complete dataset of the flow variability in the rivers that may be used for withdrawal and for effluent discharge. Developing the stage discharge relationship is not optional because it is essential for converting water level measurements to estimates of flow in subsequent years.

The recommended sample option for water level measuring in Mennin Lake is to measure the lake levels manually using a permanent staff gauge.

The recommended option for the meteorological station is to locate it along Dyment Road in the LSA_{HYD}. This option is preferred since it's less likely to get vandalized or damaged and it would not require coordination or permission from the MTO. However, it is our understanding that NWMO is planning to install a meteorological station and therefore it is not necessarily associated with the Baseline Program. It is recommended that the station include a soil moisture probe and that the data be included in the analysis of the hydrological conditions of the study area. Measuring soil moisture will be coordinated with the soil component of the Environmental Media Baseline Program, discussed in Section 4.6.

This plan should be adjusted when the location of the discharge storage and the facility locations are known to measure baseline conditions and assess potential affects from the construction, operation and/or closure of the proposed facility. The hydrology data collected as part of this Environmental Media Baseline Program, along with the soils and shallow groundwater data, are intended to support a local hydrology model of the LSA_{HYD}.

4.3 Surface Water Parameters

The surface water parameters component includes assessing surface water and sediment quality, as well as select biological media during the Environmental Media Baseline Program. This component is an essential part of the Environmental Media Baseline Program because of Project interactions mainly related to effluent discharge and water withdrawal.

Phytoplankton, zooplankton, and benthic invertebrate communities are listed as elements of aquatic ecology that should be characterized when doing baseline programs for a DGR (CNSC 2018). Phytoplankton composition and biomass (primary production) provides an assessment of water-quality conditions and an indication of eutrophication (nutrient enrichment), while zooplankton composition and biomass (secondary production) supports both the water-quality and ecological assessment by providing insight to the quality of the food chain and the energy flow through the system (Green et al. 2015). Benthic invertebrates are important to sample as part of the Environmental Media Baseline Program because they are commonly used in biological effects monitoring programs to assess potential Project related impacts during the operational period (CSA 2010; Environment Canada 2012b; CNSC 2017).

4.3.1 Study Area

The LSA_{SW} includes waterbodies in the AOI and waterbodies downstream of the AOI with the potential of being impacted by the Project. As stated in the CSM (see Appendix C), since detailed Project information is pending, it has been assumed at this time that the Mennin Lake drainage (Figure 4.2) will be the site of treated effluent release. Thus, the LSA_{SW} includes waterbodies in the AOI and waterbodies in the Mennin Lake drainage.

The LSA_{SW} will also include reference stations situated in waterbodies located upstream of the AOI within the same Wabigoon watershed. It is important to sample reference locations during the Environmental Media Baseline Program to evaluate if changes observed during future monitoring are potentially Project related, or are due to other causes such as natural variation or climate change (CSA 2010; CCME 2015; CNSC 2017).

A RSA_{SW} was only established for surface water quality as the data quality objective is community assurance and the study area will include waterbodies of significance to the communities that are participating in the stakeholders/rights-holders workshops being held by the NWMO. The primary objective is to establish a monitoring program that can be conducted by community members, meets community needs, and provides regional information. Further input is needed from stakeholders/rights-holders to identify waterbodies of high interest (refer to Section 6.0).

Sampling stations will be established in areas that could be affected during each Project phase, at far-field sites where downstream or cumulative effects may occur, and at reference areas. Factors such as IK and community importance, representativeness, accessibility, site-specific conditions, and suitability for modelling needs, including

climate change modelling, will be taken into account when selecting station locations during the final sample design (CCME 2015). During early baseline studies, it is recommended that the scope of sampling be broader until variability and trends are better understood (Green et al. 2015; BCMOE 2016). Since the Environmental Media Baseline Program is being completed over multiple years, the data from each study year will be used to optimize the program. The sample design will also be modified as data are collected establishing lake depths through bathymetric mapping, and the presence or absence of lake stratification through vertical profiling.

4.3.2 Data Objectives and End Use

Surface water parameters are essential components when conducting site characterization of a DGR facility (CNSC 2018), as the Project has the potential of affecting aquatic environments through multiple pathways (Appendix C). COPC may be dissolved or suspended in the water and could be transported off site, be taken up by organisms, or be transferred to other media such as sediment (BCMOE 2016).

The baseline data will be used to:

- monitor components (e.g., water quality) and locations identified during the stakeholder/rights-holder engagement conducted by the NWMO;
- establish water and sediment quality prior to the Project commencing to see if there are COPC that are naturally elevated and if there is a need to develop site specific objectives;
- establish baseline water and sediment quality and plankton and benthic invertebrate community composition to enable long-term monitoring to evaluate temporal changes; and
- provide necessary data to use in modelling to predict and assess Project impacts in the IA.

4.3.3 Valued Components

The VCs selected for the surface water parameters component of the Environmental Media Baseline Program are routine for mining IAs, and are recommended in guidance documents (BCMOE 2016; CCME 2016a), including the CNSC (2018) *Guidance on Deep Geological Repository Site Characterization*. The VCs, which were also selected with consideration if stakeholder/rights-holder input, include:

- surface water quality;
- sediment quality and characterization;
- plankton community composition and biomass and chlorophyll concentrations; and
- benthic invertebrate community composition and biomass.

It is noted that the types of tissue chemistry, including benthic invertebrate, aquatic macrophyte, and fish tissue chemistry, are included as part of the tissue component of the Environmental Media Baseline Program (Section 4.1). Fish community and other types of biodiversity monitoring are outside of the scope of this sample design.

4.3.4 Sample Design Options Overview

The sample design options provided for each of surface water quality, sediment quality, plankton communities, and benthic invertebrate communities are summarized below, with detailed information provided in Appendix E.

4.3.4.1 Surface Water Quality

The sample design options provided for the surface water quality component vary in sampling methods and community involvement, and include:

- **LSA$_{SW}$: Option 1.** Quarterly water sampling at eight locations using standard field methods and COPC list; sampling conducted by a consultant with a community member as a field assistant.
- **LSA$_{SW}$: Option 2.** Same as Option 1, but with the addition of one continuous remote water quality meter situated in the Mennin Lake drainage near the AOI to collect real-time data for certain COPC.
- **RSAsw: Option 1.** Quarterly water sampling at eight locations using standard field methods and a reduced COPC list; sampling by a consultant with a community member as a field assistant.
- **RSAsw: Option 2.** Quarterly water sampling at eight locations using surface grabs and a reduced COPC list with sampling conducted by only community members.

Contaminants of Potential Concern

An extensive COPC list is proposed for surface waters in the LSA$_{SW}$, including general water chemistry parameters, nutrients, ions, total and dissolved metals, parameters related to treated sewage effluent (5 day Biological Oxygen Demand [BOD], E.coli, and total

coliforms), and a comprehensive list of radionuclides including gross-α and gross-β and top tier and second tier radionuclides listed in the COPC memo presented in Appendix D. The preliminary list of COPC is provided in Appendix E, which may be refined based on input. As discussed in Section 3.2.3, PAHs, PHCs, and VOCs have not been included in the surface water COPC list for this Environmental Media Baseline Program as they are already measured in the AOI as part of a separate monitoring program.

The proposed COPC list for the RSA_{SW} is slightly reduced from that in the LSA_{SW} in that parameters related to treated sewage effluent and second tier radionuclides are not included (Appendix E). This COPC list is based on the assumption that the waterbodies being sampled in the RSA_{SW} are not downstream of the effluent discharge; if one is, then the specific COPC list for that lake can be revised. Conversely, this list could be further refined to reduce costs (refer to Section 3.2.3).

Sample Size and Frequency

The number of samples required to achieve a certain monitoring precision depends on the variability; the greater the variation, the greater the number of samples needed to obtain a statistically sound estimate (CCME 2015). In absence of variance estimates and the determination of Critical Effect Sizes (CES; refer to Section 3.3), the number of water samples to be obtained at each station and the number of stations to be sampled in the LSA_{SW} has been estimated for this preliminary report. In the LSA_{SW}, it is assumed that three surface water samples will be taken at each sampling location, and that eight locations will be sampled quarterly. The final baseline sampling design document will provide detailed information on sample sizes and sampling locations once input on CES is acquired from the NWMO and stakeholders/rights-holders, and once variance estimates are calculated using surface water quality data collected in the AOI in 2017 and 2018 (Tulloch 2019b).

In the RSA_{SW}, it has been assumed that one sample will be taken quarterly from each of eight waterbodies identified as priorities by stakeholders/rights-holders. Since the waterbodies being sampled are not anticipated to be near to the AOI, the potential for Project interaction is low; as data are obtained, the need to provide more statistical rigour or re-evaluate sample sizes will be examined. The idea of this community-based monitoring program is to obtain an extended temporal data set over the long-term for each of these waterbodies.

For this preliminary assessment, it is assumed that quarterly sampling will be conducted at all stations to capture seasonal data; however, once existing data are evaluated, there is the potential that monthly data may be required from key sampling stations during critical seasons (e.g., freshet, summer/winter low flows) to further establish variability. Once the temporal and spatial variability of water quality parameters are firmly established, COPC that have low variation and a low probability of exceeding water quality guidelines may be analyzed less frequently.

Sampling Methods

In the LSAsw, water quality investigations will involve taking limnological measurements and collecting water samples for chemical analyses. In addition to using standard sampling methods (e.g., YSI multi-meter and Van Dorn water sampler) to conduct quarterly sampling by field personnel, a sample design option has been included for the installation of a long-term, autonomous remote water quality monitoring station to measure water quality parameters on a continuous basis (LSA_{SW}: Option 2). Continuous water quality monitoring systems provide real-time data that accumulate a large data set.

EHP Environment Ltd. (EHP) has developed a continuous monitoring water quality station which can be tailored specifically to the Environmental Media Baseline Program. It is noted that this company provides these monitoring systems to Posiva at the Finnish DGR site and has several large mining clients. The EHP-QMS is a surface water quality monitoring station that has been designed specifically for field conditions: it is well suited to be installed in ponds, basins, lakes, rivers, channels, and pipes; it can be subjected to harsh, cold weather; it is easy to move; and sensors can be added and/or removed over time to meet changing needs. Monitoring data collected at each monitoring station is transmitted wirelessly via a GSM/GPRS modem and each station is powered by rechargeable batteries and solar panels. The EHP-QMS monitoring capabilities includes pH, conductivity, turbidity, Dissolved Oxygen (DO), temperature, Dissolved Organic Carbon (DOC), Total Organic Carbon (TOC), nitrite, nitrate, ammonia, phosphorous, dissolved trace metals (arsenic, cadmium, copper, lead, mercury, nickel, and zinc), salinity, flow rate (only where discharge graphs are available), pressure (water level data), humidity, rainfall, solar radiation, wind speed and direction, and pore pressure. Measurement detection limits of the above mentioned parameters are comparable to laboratory reporting detection limits. The monitoring stations are typically functional for over ten years, but require continual costs including a monthly internet user interface cost, a monthly cell/satellite phone data transmission cost, and semi-annual maintenance.

Stakeholder/Rights-Holder Involvement

The surface water monitoring program affords an excellent opportunity to employ local community members to conduct sampling during the Environmental Media Baseline Program. For the more technical studies proposed for the LSA_{SW} that include use of a limnology meter and water sampler, it is proposed that a consultant conduct the first year of sampling alongside community members to establish the stations and sample protocols and to enable training. There is the option that future monitoring could be entirely transferred to community members if desired; however, data quality would need to be a consideration.

For sampling in the RSA_{SW}, a sample design option is provided in Appendix E where the sampling is completed entirely by community members (RSA_{SW}: Option 2) and consists of simply collecting surface water grabs from waterbodies identified to be of highest interest to the communities. The program would still be organized and managed by the consultant (in order to facilitate transfer of samples to the lab and for data QA/QC and analyses), but the field sampling would be completed by the community members. Online forms and apps can be developed so that data collections and data transfer by community members are easily accomplished.

Recommendations

The recommended sample option in the LSAsw is Option 1 as it contains sampling methods accepted by regulatory agencies and the cost is significantly lower than installing a remote water quality meter. The meter is unable to measure all parameters required during the Environmental Media Baseline Program, such as radionuclides; thus, its use would still need to be supplemented with field collections. The benefits/drawbacks and timing for installation of a remote water quality meter can be discussed further with NWMO.

The recommended sample option in the RSAsw is Option 2 as the data objective is community assurance; thus, an entirely community-based monitoring program would align with this objective.

In the design, an assumption was made that the sampling effort and COPC list will remain the same for all three sampling years; however, this will be evaluated on an annual basis and is subject to change.

4.3.4.2 Sediment Quality

The sample design options provided for the sediment quality component are located in the LSAsw, as well as reference areas, and they vary in sampling method and number of sampling areas. The options include:

- **Option 1.** Sediment sampling in eight areas using a core sampler; sampling conducted by a consultant with a community member as a field assistant.
- **Option 1.** Sediment sampling in five areas using a core sampler; sampling conducted by a consultant with a community member as a field assistant.
- **Option 3.** Sediment sampling in eight areas using a grab sampler; sampling conducted by a consultant with a community member as a field assistant.
- **Option 4.** Sediment sampling in five areas using a grab sampler; sampling conducted by a consultant with a community member as a field assistant.

Contaminants of Potential Concern

The COPC list proposed for sediment includes metals, moisture, total organic carbon, particle size, nutrients, and a comprehensive list of radionuclides including gross-α and gross-β and top tier and second tier radionuclides listed in the COPC memo presented in Appendix D. The complete list of COPC is provided in Appendix E. The option to only measure the top tier radionuclides will be discussed with the NWMO in order to optimize the radionuclides that require measuring as part of the Environmental Media Baseline Program.

Sample Size, Frequency, and Location

For this preliminary assessment, it is assumed that five sediment samples will be taken during Year 1 at each study area. In each sampling area, the five replicate stations will be separated by a minimum a distance of 20 m, which allows sufficient physical separation for the samples to be considered as statistical replicates, according to the Metal Mining Environmental Effects Monitoring (EEM) program guidance document (Environment Canada 2012b). The final study design document will provide detailed information on sample sizes once input on CES is acquired from the NWMO and stakeholders/rights-holders, and once variance estimates are calculated using the sediment quality data collected in the AOI in 2017 and 2018 (Tulloch 2019b).

Sample design options have been provided for conducting sediment sampling at five locations and eight locations in the LSAsw and at reference areas; eight locations would have a higher overall cost. Monitoring of sediments should be focused on depositional areas where sediments and associated contaminants are expected to accumulate (CSA 2010). Where possible, locations will be coincident with benthic invertebrate community sampling to provide information on habitat characteristics and COPC concentrations in order to identify if these factors contribute to differences in benthic invertebrate community composition between study areas.

Sampling Methods

Sample design options are provided for using either a grab (or discrete) sampler (e.g., Ekman dredge or Petite Ponar) or a core sampler (e.g., Tech-ops corer). Both of these sampling methods are recognized in guidance documents as accepted practices (CCME 2016a, 2016b). The decision of which sampling method to use depends on data objectives, required sample volume, and substrate composition. Gravity core samplers are recommended for programs where it is important to maintain the integrity of a sediment profile and to obtain information from distinct vertical sediment horizons (e.g., 0 to 2 cm, 2 to 4 cm horizons). Compared to grab samplers, coring devices create minimal water disturbance during descent and leave fines and chemicals at the sediment-water interface minimally disturbed (CCME 2016b). Finer sediment particles are of greater interest in terms of contaminant loads because most chemical contaminants preferentially bind to silts and clays (BCMOE 2016). The disadvantages of a coring device are that a limited sample volume is obtained resulting in additional field time and compositing of subsamples, and coring devices do not penetrate firm substrates. Thus, both methods have benefits and drawbacks.

Sediment sampling will focus on the biologically active zone located in the upper sediment horizon to provide the most relevant data for risk assessments (CCME 2016a). Using a coring device, this can be set as the uppermost 2 cm, or a larger horizon can be utilized to increase sample volumes. Using a grab sampler there is less accuracy for sampling a set horizon size as the surficial sediment is removed using a scoop.

Stakeholder/Rights-Holder Involvement

Since sediment sampling requires experience with sampling equipment, protocols, QA/QC procedures, and data recording, it is recommended that community members be involved in the sampling program as field assistants to the consultant retained to conduct the

Environmental Media Baseline Program. This will provide a training opportunity, capacity building, and temporary employment to community members.

Recommendations

Sediment sampling in key areas located within the LSAsw and in reference areas will be an important component of the Environmental Media Baseline Program; however, the number of areas sampled is somewhat dependent on NWMO's budget allocation to this component of the program as well as stakeholder/rights-holder input. The COPC list, particularly radionuclides, included in the analytical analyses also has budget implications and will be discussed with the NWMO. Following input from the NWMO and stakeholders/rights-holders on this preliminary assessment, the study design will be optimized to obtain robust and statistically rigorous information, while working within budget constraints. For this preliminary assessment, sediment sampling was included for Year 1 only; therefore, there is the option of completing additional sampling at the same locations or new locations for years 2 and 3.

It is recommended that a coring device be used as the sediment sampling method in order to sample a pre-determined sediment horizon, which will enable direct comparisons with sediment samples collected during future monitoring, and to ensure fine grained sediments are retained; however, some study areas may not be conducive to the use of a coring device. During the 2018 sampling program conducted in the AOI, even the use of a Petite Ponar grab sampler was challenging due to the high abundance of semi-aquatic vegetation (Tulloch 2019b). Thus it is recommended that a coring device be implemented as the primary method, with alternate grab methods used in locations where coring cannot be conducted. The cost difference between sampling methods is minimal.

4.3.4.3 Plankton

The sample design options provided for the plankton component are located in the LSAsw, as well as reference areas, and they vary in sampling method and number of sampling areas. The options include:

- **Phytoplankton/Chlorophyll Option 1:** Sensors to measure chlorophyll a and blue green algae are added to the continuous remote water quality meter proposed in the surface water component above.

- **Phytoplankton/Chlorophyll Option 2:** Quarterly phytoplankton sampling at eight locations using standard field methods (paired with water quality sampling); sampling conducted by a biologist with a community member as a field assistant.
- **Zooplankton Option 1:** Quarterly zooplankton sampling at eight locations using standard field methods (paired with water quality sampling); sampling conducted by a biologist with a community member as a field assistant.
- **Zooplankton Option 2:** Same as Option 1, but with the addition of environmental DNA (eDNA).
- **Zooplankton Option 3:** Quarterly zooplankton sampling at five locations using standard field methods (paired with water quality sampling); sampling conducted by a biologist with a community member as a field assistant.
- **Zooplankton Option 4:** Same as Option 3, but with the addition of eDNA.

Sample Size and Frequency

The number of plankton samples to be obtained at each station, and the number of stations to be sampled in the LSA_{SW} and reference areas was matched to the surface water program. In addition, a sample design option was provided for conducting zooplankton sampling at a reduced number of locations, which would require a reduced sampling effort and have lower analytical costs. Quarterly sampling is assumed to capture seasonal data; however, monthly data may be required from key sampling stations during critical seasons (e.g., summer algal blooms) to further establish variability. The final study design document will provide detailed information on sample sizes and sampling locations and the program will continue to be optimized annually.

Sampling Methods

The first option for assessing phytoplankton/chlorophyll in the LSAsw includes utilizing autonomous remote water quality sensors to collect real-time, continuous data monitoring chlorophyll a and blue green algae concentrations. More detailed information on this technology is provided in Section 4.3.4.1.

There are many field methods for obtaining plankton samples to conduct taxonomic enumeration and biomass estimations. It is assumed here that phytoplankton sampling will be conducted in the euphotic zone using a discrete water sampler (e.g., Van Dorn, Kemmerer, or Niskin sampler), whereas zooplankton will be sampled using a fine mesh (64 µm to 256 µm) conical plankton net (e.g., Wisconsin net, bongo net) towed through

the entire water column vertically. These plankton sampling methods are recognized in guidance documents as common and accepted practices (CCME 2011; Green et al. 2015; Government of British Columbia 2013).

A novel and emerging method for identifying species presence/absence in the environment is the use of eDNA, and the use of this technology is proposed in this preliminary assessment as an option for zooplankton and benthic invertebrates. It is also recommended for fish community studies; however, that is outside the scope of this Environmental Media Baseline Program. This technology is not currently standard methodology for baseline monitoring programs but considering monitoring for the Project is anticipated to continue for 100+ years, it could prove advantageous to look towards the future, as it is possible that existing taxonomic methods will eventually be replaced by eDNA. Research initiatives are currently being undertaken between academia and mining companies to move this technology forward as a monitoring tool.

Environmental DNA refers to any genetic material that is deposited to the environment such as shed skin, hair, or tissues; secretions such as mucous or blood; reproductive propagules such as larvae or spores; and intact organisms such as bacteria. Analyzing eDNA from a water sample can reveal information on all species present (both targeted and incidental) in the environment as long as the species is in the DNA barcode sequence library, eliminating the need to physically observe, isolate, and identify individual specimens. One benefit is that eDNA analyses can provide species level resolution where it may be difficult to identify the organisms beyond family or genus using existing taxonomy methods. However, at this time, eDNA analyses does not provide information on density, abundance, or biomass of each species, which are key metrics; thus, data quality objectives for the Project will influence whether this sampling method alone could suffice.

To provide expertise on eDNA analyses, our Study Team includes Dr. Robert Hanner from the Biodiversity Institute of Ontario (University of Guelph). In Year 1, it is recommended that a baseline taxonomic survey of as much biodiversity as possible be conducted so that a barcode reference sequence library can be built from expert identified reference specimens. This phase of library construction involves putting the provenance data (what it is, who identified it, when/where it was collected, digital images of the voucher) into the Barcode of Life Database (BOLD) and then adding the genetic barcode for each specimen. This reference library construction is typically done using Sanger sequencing and yields high quality reference sequence data. Once a couple of iterations of barcoding and metabarcoding are undertaken to ensure reference libraries are comprehensive, the program

could shift to using this same metabarcoding approach to identify community composition from eDNA samples.

Stakeholder/Rights-Holder Involvement

Since plankton sampling requires experience with sampling equipment, protocols, QA/QC procedures, and data recording, it is proposed that a biologist conduct the first year of sampling alongside community members. There is the option that future monitoring could be entirely transferred to community members alongside the surface water quality monitoring program completed in the LSA. To minimize the risk of false negatives with eDNA studies, it is preferred that the DNA be extracted and stabilized on site. Dr. Hanner has provided advice that a sampler could be easily trained to perform this task in a short period of time (a few hours). Learning these techniques will provide a training opportunity, capacity building, and temporary employment to community members.

Assumptions

The phytoplankton surveys are designed as add-ons to the surface water program because they are sampled in the same way as a water sample. Therefore, additional costs would only be as a result of additional sensors for the autonomous water quality meter (chlorophyll a and blue-green algae), equipment rentals, and laboratory analyses. Similarly, it was assumed that the zooplankton survey would be conducted concurrently with the surface water and phytoplankton survey; thus, only equipment rentals, laboratory analyses, and some extra field time would be required.

Recommendations

Option 2 is recommended to document baseline phytoplankton and zooplankton community composition as well as chlorophyll concentrations in the LSAsw and reference areas. Standard taxonomic laboratory analyses are recommended since this is an accepted regulatory approach and plankton are a routinely assessed component of baseline programs. The use of the remote water quality meter is more geared towards ongoing monitoring of potential eutrophication and algal blooms and not towards obtaining baseline data on phytoplankton community composition in the study area; however, if a meter of this type is being installed to monitor other water quality parameters, then adding sensors for this type of monitoring is a viable option. It is also recommended that the process of building a DNA barcode reference sequence library from expert identified reference specimens be initiated for zooplankton to enable future biomonitoring of eDNA. The cost

additions for this process are not anticipated to be substantial, but will be further clarified for the final sample design.

4.3.4.4 Benthic Invertebrates

The sample design options provided for the benthic invertebrate community component are located in the LSAsw, as well as reference areas, and they vary in sampling method and number of sampling areas:

- **Option 1:** Annual benthic invertebrate sampling at eight locations using standard field methods (paired with sediment quality sampling); sampling conducted by a biologist with a community member as a field assistant.
- **Option 2:** Same as Option 1 but with the addition of eDNA.
- **Option 3:** Annual benthic invertebrate sampling at five locations using standard field methods (paired with sediment quality sampling); sampling conducted by a biologist with a community member as a field assistant.
- **Option 4:** Same as Option 3 but with the addition of eDNA.

Sample Size and Frequency

Again, sample design options have been provided for conducting sampling at five locations and eight locations. The final study design document will provide detailed information on sampling locations. The number of samples to be obtained at each sampling location (n = 5) in Appendix E is based on other regulatory monitoring programs, such as EEM programs (Environment Canada 2012b). Benthic invertebrates are sampled once per year and with consistent timing each year to avoid confounding the data with seasonal variance in the communities (U.S. EPA 2003; Environment Canada 2012b; CCME 2016a).

Sampling Methods

There are many methods for sampling benthic invertebrates, particularly depending on habitat (i.e., lentic or lotic). It is assumed here that benthic invertebrate sampling will be conducted concurrent with the sediment sampling in lentic systems (i.e., lakes) using a grab sampler (e.g., Ekman dredge, Petite Ponar); however, the equipment used will depend on site conditions. This benthic invertebrate sampling method is recognized in guidance documents as common and accepted practices (Environment Canada 2012b), and provides the necessary data to determine a multitude of endpoints used for biological effects monitoring, such as density, richness, and diversity.

In addition to traditional taxonomic laboratory analyses for benthic invertebrate enumeration, the inclusion of building a DNA barcode sequence library for benthic invertebrates in the study area was provided as an option to enable future biomonitoring using eDNA.

Stakeholder/Rights-Holder Involvement

Since benthic invertebrate sampling requires experience with sampling equipment, protocols, QA/QC procedures, and data recording and it will be conducted at the same time as the sediment program, it is recommended that community members be involved in the sampling program as field assistants to the consultant retained to conduct the Environmental Media Baseline Program. This will provide a training opportunity, capacity building, and temporary employment to community members.

Assumptions

It has been assumed that the benthic invertebrate surveys would be completed in conjunction with sediment sampling for Year 1; thus, professional time and field disbursements would be shared between these components.

Recommendations

For the benthic invertebrate component, Option 2 is recommended as the sampling methods, existing taxonomic enumeration laboratory methods, and endpoints are accepted by regulatory agencies, a larger sample size (e.g., eight locations versus five) provides more spatial coverage of the LSAsw and reference areas, and the approach integrates an emerging technology that may be more widely implemented in the future.

4.4 Air Quality, Noise, and Light

Air quality, noise, and light are all being considered as part of the Environmental Media Baseline Program. Local stakeholders and rights-holders identified air quality and noise as important considerations in the Environmental Media Baseline Program. There was a specific concern regarding the potential for cumulative impacts from the Project combined with the operation of existing facilities (i.e., the mill) and future facilities (i.e., new mining operations). As the Environmental Media Baseline Program is focused on ambient air, noise, and light monitoring, the impact of any facilities that are currently operating will be accounted for in the monitoring data.

4.4.1 Study Area

The LSA for air quality (LSA_{AQ}) includes the lands beyond the SSA where there is a potential for air quality effects to occur from the Project. For this preliminary assessment, this has been defined as the lands within approximately 10 km of the SSA, which includes the nearest community of Borups Corners. Note that there are other sources of air releases in the LSA_{AQ}, such as local industry (e.g., TransCanada Pipelines Station 58), transportation (e.g., Trans-Canada Highway), and intermittent and seasonal sources (e.g., forest fires), all of which will contribute to existing and future air quality conditions within this boundary. The exact boundaries of the LSA_{AQ} may change based on stakeholder/rights-holder input, as well as results of any future modelling studies.

The RSA_{AQ} includes lands beyond the LSA_{AQ} that are relevant to the assessment of long-range air quality effects of the Project on local communities. Typically, the RSA_{AQ} is set with consideration of nearby existing air quality monitoring networks, such as those operated by the federal (Environment and Climate Change Canada [ECCC]) and provincial (MECP) governments, in order to assist with the description of existing conditions. Given the remote location, there are no existing air quality monitoring stations within a reasonable offset from the Project. The nearest stations that measure the types of chemical parameters typically included in an Air Quality Assessment are in Thunder Bay (approximately 250 km from the LSA_{AQ}) and Winnipeg (approximately 350 km from the LSA_{AQ}). As a result, the Environmental Media Baseline Program is intended to fill this data gap. The RSA_{AQ} has been defined as the lands within approximately 50 km of the LSA_{ATM}, which extends to the Town of Ignace, Dryden, and the WLON. Again, the exact boundaries may change based on stakeholder/rights-holder input and results of any future modelling studies.

The LSA_{NO} includes the lands beyond the SSA where there is a potential for noise effects to occur from the Project. For the purposes of this assessment, this has been defined as the lands within approximately 5 km of the SSA. Note that there are other sources of noise emissions in the LSA_{NO}, such as transportation sources, which will contribute to the existing and future noise conditions within this boundary. Given the nature of noise propagation, noise emissions are not expected to extend beyond the LSA_{NO} and a regional study area was therefore not defined for noise.

The study area for the baseline light monitoring would be restricted to the SSA given the nature of the surrounding environment (i.e., intrinsically dark). As such, local and regional study areas were not defined for light.

4.4.2 Data Objectives and End Use

The principle objectives and end use for the air quality, noise, and light monitoring components of the Environmental Media Baseline Program include the following:

- Establish accurate and representative air quality, noise, and light levels prior to Project commencement, assess spatial and temporal variability, and further define the statistical objectives for the monitoring program (i.e., degree of change, sampling frequency, and number of locations and samples).
- Assess the current conditions relative to MECP and ECCC standards and limit values for COPC.
- Provide necessary data inputs to predict and assess Project-related effects in the IA and, in particular, the air quality, noise, and light impact assessments and Human Health and Ecological Risk Assessment.
- Provide ongoing and reliable information to aid in the determination of air quality trends over time.
- Share information with the community about air quality, noise and light levels and build capacity, if needed.

4.4.3 Valued Components

Air quality is a common VC considered in an IA that is used as an indicator of change in human and environmental health. In this context, members of the community and non-human biota (e.g., aquatic plants, invertebrates and fish, amphibians, reptiles, birds and mammals) could be exposed to COPC in air produced by activities during the construction, operation, and decommissioning phases of the Project. Air quality is also an important pathway that could lead to the transmission of COPC to other media (i.e., deposition of air contaminants into freshwater, soil, plants, etc.).

Noise and light are also important VCs as these can also impact members of the community and non-human biota.

4.4.4 Sample Design Options Overview

The sample design options provided for the air quality, noise, and light components of the Environmental Media Baseline Program are summarized below, with detailed information provided in Appendix E and Appendix G.

4.4.4.1 Air Quality

The sample design options provided for the air quality component vary in approach and community involvement, and include:

- **SSA: Option 1.** Continuous air quality monitoring using standard methods and complete Tier 1 and 2 COPC list; operations and maintenance activities completed by an external consultant (two person team).
- **SSA: Option 2.** Same as Option 1, with operations and maintenance activities completed by an external consultant and a trained community member (with the intent of passing responsibility over to community member).
- **LSA_{AQ}: Option 1.** Passive air quality monitoring using standard methods and complete Tier 1 and 2 COPC list; operations and maintenance activities completed by an external consultant (two person team).
- **LSA_{AQ}: Option 2.** Same as Option 1, with operations and maintenance activities completed by an external consultant and a trained community member (with the intent of passing responsibility over to community member).

Contaminants of Potential Concern

The preliminary COPC considered in the air quality component of the Environmental Media Baseline Program were identified in the CSM (see Appendix C) and are summarized in Table 4.3. The Tier 1 (primary) COPC include a) conventional air quality contaminants that are expected to be readily measurable within the SSA, LSA_{AQ}, or RSA_{AQ} and b) key radiological COPC that may be of greater concern in the community. Conventional parameters include those that are the subject of provincial and national air monitoring initiatives. The Tier 2 COPC include other air quality contaminants that are a) expected to be present in low-level amounts in the SSA, LSA_{AQ}, or RSA_{AQ}, b) associated with a future project interaction, and c) may be of concern within the community. The Tier 2 (secondary) COPC list includes trace organics/toxics (VOCs, PAHs) and trace metals (naturally occurring or the product of local industry), and other radionuclides of interest to the NWMO.

Where applicable, concentrations of the COPC will be compared to relevant ambient air quality standards to provide context to the measured results, and also to available data from provincial, federal, or international (e.g., Minnesota) monitoring stations to evaluate how the local air quality compares to that of the broader region. The most relevant sources of

ambient air quality objectives/standards include the most recent Ambient Air Quality Criteria (AAQC) from the MECP (2019) and the Canadian Ambient Air Quality Standards (CAAQS) from the Canadian Council of Ministers of the Environment (CCME 2017).

Table 4.3 Summary of COPC options for air quality

Tier	Category	COPC
Tier 1 COPC	Conventional Parameters	Carbon Monoxide (CO) Nitrogen Oxides (NOx) Sulphur Dioxide (SO_2) Total Suspended Particulate Matter (TSP) Suspended Particulate Matter <10 micron (PM_{10}) Suspended Particulate Matter <2.5 micron ($PM_{2.5}$)
	Radiation/Radioactivity	Tritium Carbon-14 Radon Radionuclides: Sr-90, I-129, Cs-137 Gross-α and Gross-β External Gamma
Tier 2 COPC	Trace Organics and Toxics	Volatile Organic Compounds (VOCs) Polycyclic Aromatic Hydrocarbons (PAHs)
	Trace Metals	Conventional list of 31 metals (U.S. EPA Method 6010)
	Radiation/Radioactivity	Radionuclides: Cl-36, Co-60, Se-79, Ru-106, Pu-238, Pu-239, Pu-240, Pu-241, Am-241, Cm-244

Sampling Methods

An adaptive monitoring approach will be employed for the Environmental Media Baseline Program, which will allow for adjustments to be made based on lessons learned from initial sampling efforts in Year 1. The foundation of the Environmental Media Baseline Program will be based on standard methods that are recognized by the MECP, ECCC, and the United States Environmental Protection Agency (U.S. EPA) as being acceptable for use in ambient air monitoring studies. These methods have undergone rigorous evaluation, and have been designated as "reference methods" or "equivalent methods" by the U.S. EPA (2018), and adopted by the MECP (2008) and ECCC (2004). Utilizing these methods will ensure that the concentrations of the COPC are being characterized accurately using proven and reliable methods. It is envisioned that a permanent air monitoring station, similar to those operated by the MECP and ECCC, will be commissioned within the SSA and will house the reference method instrumentation. The data collected at this station would be directly comparable to the regional data being collected by the MECP and ECCC National Air Pollution Surveillance (NAPS) networks.

In addition to providing proven, reliable methodology for characterizing baseline levels, the use of reference methods at permanent stations will also allow for other potentially

more flexible and inexpensive forms of monitoring to be incorporated, such as passive methods, portable methods, or new innovative technologies. These methods could then be applied further afield to provide a larger spatial characterization area, without the same need for power and security required for the reference methods.

For the Environmental Media Baseline Program, the potential to initiate a primary reference method monitoring program with a secondary network of offsite passive ambient air monitoring approaches within the LSA_{AQ} and/or RSA_{AQ} is being evaluated, which would also be co-located with the reference methods for ongoing validation. The passive monitoring approaches typically consist of specially-treated sample media that are exposed to atmospheric conditions for a known period, then retrieved, and analyzed at a laboratory for the associated pollutant. This form of measurement would provide a means of gathering data further afield from the project site, such as locations of community or ecological interest. In addition, as passive methods do not require a specialized technical background to deploy, this could increase the involvement of stakeholders/rights-holders in the Environmental Media Baseline Program.

Sampling Locations

The specific location for the monitoring station has yet to be determined. There are a number of technical considerations that will need to be considered in the siting process, including, but not limited to, access to power supply, horizontal and vertical placement of sampling probes, spacing from obstructions, tress and roadway and path interferences (U.S. Government 2012). Further, it would be beneficial to complete a preliminary baseline air dispersion modelling study to assist in the siting of the active and passive monitoring stations within the SSA and LSA_{AQ}. This modelling would be expected to include consideration to the current rail/road traffic as well as the future facility operations.

Ideally, the locations at which baseline monitoring data is collected will be maintained throughout all phases of the Project. The use of fixed points and standard methods throughout the life of the Project will continually provide a basis to validate any emerging technologies that may come to be available, which can then be considered for ongoing substitution into the secondary monitoring network.

Recommendations

Air monitoring within the SSA, LSA_{AQ} and RSA_{AQ} is a key component of the Environmental Media Baseline Program that will support future impact and risk

assessments. The use of approved standard air quality testing methods recognized by the MECP, ECCC, and the U.S. EPA is highly recommended and would form the basis of the primary monitoring program that is focused on the Tier 1 and 2 COPC in the SSA. A further secondary network of offsite passive ambient air monitoring stations is also recommended within the LSA_{AQ} and/or RSA_{AQ} to extend the spatial coverage of the program. The engagement of the local and Indigenous communities in the air quality component of the Environmental Media Baseline Program is also encouraged (i.e., SSA: Option 2; LSA_{AQ}: Option 2). A supportive framework that ensures the appropriate skills, education and training are developed and maintained may also be required to facilitate the program.

The extent of the COPC that are monitored and the number of sample locations is dependent on the NWMO's available budget, the statistical objectives of the program, and the requirements of stakeholders/rights-holders. For example, the monitoring of radionuclides (Tier 1 and 2), trace metals, PAHs and VOCs (Tier 2) have significant budget implications and may or may not provide useable data for future assessments. Similarly, there may be conventional parameters (Tier 1) that could also be assessed on a reduced schedule or eliminated. To this end, it may be prudent to complete a screening-level study of these COPC over a shorter timeframe to establish a more refined list of COPC to carry into the Year 2 and 3 monitoring programs.

Following input from the NWMO and stakeholders/rights-holders on this preliminary assessment, the study design should be modified to ensure that it is scientifically sound, incorporates IK, and is community focussed while working within budget constraints.

Further, it would be beneficial to complete a preliminary baseline air dispersion modelling study to assist in the siting of the active and passive monitoring stations within the SSA and LSA_{AQ}. The modelling could include current rail/road traffic as well as the future DGR operations, which would serve to optimize the siting process.

4.4.4.2 Noise

The sample design options provided for the noise component vary in approach and community involvement, and include:

- **SSA/LSA_{NO}: Option 1.** Continuous noise monitoring using standard methods; sampling activities completed by an external consultant (two person team).

- **SSA/LSA$_{NO}$: Option 2.** Same as Otion 1, with sampling activities completed by an external consultant and a trained community member (with the intent of passing responsibility over to community member).

Sampling Methods

Noise monitoring within the SSA and LSA$_{NO}$ is a key component of the Environmental Media Baseline Program that will support future impact assessments. The development of a program that conforms to standard methods and guidance outlined by various regulatory agencies (MECP 2013; Health Canada 2017; ISO 2017) is highly recommended for monitoring of noise levels.

A seasonal monitoring program (spring to summer and fall to winter) is anticipated, which is expected to be sufficient to characterise background noise levels in the SSA and LSA$_{NO}$. Type 1 (Class 1) integrating sound level meters would be employed that conform to the requirements of IEC 61672-1:2013 (IEC 2013). Employing these methods will ensure that the sound level data is robust and is collected using proven and reliable methods.

Sampling Locations

Ideally, the locations at which baseline monitoring data is collected will be maintained through all phases of the Project. It is anticipated that one location would be located within the SSA and one location would be located in the LSA$_{NO}$ close to the Trans-Canada Highway. Input from stakeholders/rights-holders may help define the locations.

Recommendations

Noise monitoring should be completed within the SSA and LSA$_{NO}$ and conform to standard methods and guidance outlined by the MECP, Health Canada, and the International Organization for Standardization (ISO). The engagement of the local and Indigenous communities in the noise monitoring program is also encouraged. A supportive framework that ensures the appropriate skills, education, and training are developed and maintained may also be required to facilitate the program.

Following input from the NWMO and stakeholders/rights-holders on this preliminary assessment, the study design should be modified to ensure that it is scientifically sound, incorporates IK, and is community focussed while working within budget constraints.

4.4.4.3 Light

The sample design options provided for the light component vary in approach and community involvement, and include:

- **SSA: Option 1.** Discrete campaign-based light monitoring using standard methods; sampling activities completed by an external consultant (two person team).
- **SSA: Option 2.** Same as Option 1, with sampling activities completed by an external consultant and a trained community member (with the intent of passing responsibility over to community member).

Sampling Methods

Illuminance is measured using a standard hand-held light meter over an imaginary vertical plane representing a receiving plane (e.g., window) at the location of interest. For planning future measurement initiatives (e.g., during construction, operations) it is beneficial to use a light meter that is also capable of measuring luminous intensity (candelas, or cd) as this can be used as an assessment of glare once the lighting fixtures associated with the project are in place.

Baseline sky glow can be measured using a Unihedron Sky Quality Meter (SQM). Sky glow is typically controlled by managing the Upward Light Ratio (ULR) of the design in accordance with criteria offered by the International Commission on Illumination (CIE 2003). ULR is not a baseline condition that can be measured in the field; it can only be determined through calculations or modelling of the designed lighting system for the Project. The measurement of sky brightness (or sky glow), in units of magnitudes per square arcsecond, can be tracked from baseline conditions through construction and operational phases to provide a measure of how the conditions have changed as a result of the Project.

Measurements should be conducted under equivalent conditions each time, as the atmospheric conditions, seasonal phenomena, and the lunar cycle can have a significant impact upon the results. Future measurements completed in conditions that differ from the baseline condition could result in attributing impacts to the Project when the difference may actually be due to the differing natural environmental conditions, which are unrelated to the Project.

In general, light studies should be completed in the summer, during a period with no significant light contribution from the moon, and no significant cloud cover. Summer measurements are recommended as there is no chance for snow cover, which would increase the reflected light component. Further, there should be no contribution from the moon, which means that measurements should be taken as close as possible to the New Moon phase in the lunar calendar. Lastly, sky forecasts should be used to select a night when there is no cloud cover, as presence of clouds may also increase the presence of reflected light.

Sampling Locations

Ideally, light monitoring data will be collected from the same locations throughout all phases of the Project. It is anticipated that a single location will be used for sky glow and four locations for illuminance that correspond with each cardinal direction along the property boundaries. Input from stakeholders/rights-holders may help define the locations.

Recommendations

Illuminance and sky glow monitoring should be completed within the SSA and conform to standard methods and guidance outlined by the CIE (2003). Further, light modelling should be completed to determine the ULR, luminous intensity (glare), and illuminance associated with the Project lighting design to ensure that the limits recommended by the CIE are met. The engagement of the local and Indigenous communities in the light monitoring program is also encouraged. A supportive framework that ensures the appropriate skills, education and training are developed and maintained may also be required to facilitate the program.

Following input from the NWMO and stakeholders/rights-holders on this preliminary assessment, the study design should be modified to ensure that it is scientifically sound, incorporates IK, and is community focussed while working within budget constraints.

4.5 Shallow Groundwater

As stated in REGDOC-2.9.1, *Environmental Principles, Assessments and Protection Measures* (CNSC 2017) groundwater protection is a specialized element of the overall environmental protection measures. Groundwater flow and associated contaminant transport can be more difficult to detect and delineate than that of surface water, particularly in the shallow fractured bedrock environment of the AOI. The shallow groundwater component of the Environmental Media Baseline Program is focused on

groundwater quality, groundwater elevation measurements, and determining the presence of aquifer and aquitard units (evaluation of transmissive units) within the top 100 meters below ground surface (m bgs). It does not include assessing groundwater physical parameters (i.e., flow direction, fracture density, hydraulic gradients, primary and secondary porosity, fracture network interconnectivity) although these are all key to defining the impacts of groundwater withdrawal activities on potentially sensitive receptors, such as surface water hydrology (wetlands, rivers, water supply wells), siting monitoring wells to evaluate the potential impacts from the Project to both groundwater quality and quantity at the LSA and RSA scales, and evaluating the potential for groundwater and surface water interactions.

Characterization activities are normally expected to continue into the site preparation, construction, and operational phases of a project (CNSC 2017) in order to contribute further to an adequate baseline for future monitoring, as well as to help confirm assumptions made during the early stages of the project. At this early stage of the Project, there are a number of unknowns that will need to be evaluated in order to fully characterize the hydrogeology of the area. There is little infrastructure (e.g. wells) present within the AOI to measure even the basic parameters needed to evaluate hydrogeology for the Project and installation of this semi-permanent infrastructure is expensive and requires significant surface and subsurface disturbances in the form of boreholes, access roads, and drilling pads. Therefore, it is recommended that the shallow groundwater component be conducted in stages to allow for optimization of the placement of monitoring locations that can be used for multiple purposes (physical flow parameters and geochemistry) and during multiple phases (e.g., construction, operation, postclosure) of the Project.

The scope of the shallow groundwater component is an essential part of the Environmental Media Baseline Program because of Project interactions related to dewatering activities, potential groundwater withdrawal for other uses (drinking water), potential COPC releases, or changes at surface and at depth impacting groundwater quality. Shallow groundwater is what interacts the most with the surface environment and the receptors (e.g., people, plants, animals) and is the focus of the Environmental Media Baseline Program. The shallow hydrogeology, which includes a more complex flow system of higher fracture density, interactions with surface water and water supply wells, needs to be understood due to the potential shallow or surface impacts during construction and operations phases. The data collected as part of the Environmental Media Baseline Program will be part of, and inform the further development of, the required groundwater protection programs and associated

monitoring that is required by the CNSC (2017) and to ensure that the programs address the requirements as laid out in CSA N288.7 (CSA 2015).

4.5.1 Study Area

Based on discussions with the NWMO geosciences group, shallow groundwater has been defined as groundwater located within 75 m to 100 m of ground surface. This is based on information gained by work done as a part of the case studies into crystalline rock including geochemical parameters (redox conditions and oxic versus sub-oxic zones) and fracture networks.

Currently, there is little site-specific information available for the AOI, with only one deep borehole having been drilled in the area. The deep borehole drilling program has different objectives than that of the shallow groundwater program, with a focus on the repository depth interval; however, information collected during implementation of this deep drilling program can inform the shallow groundwater component. Uncertainties in the hydrogeological conceptual model at this early stage include a lack of understanding of flow direction at various depths within the shallow groundwater interval, fracture network interconnectivity, and groundwater/surface water interactions. The shallow groundwater monitoring will need to be approached in a staged fashion. The collection of preliminary data, such as that obtained from the preliminary groundwater monitoring well network proposed by the NWMO and the groundwater flow model(s) being prepared by the NWMO, will inform the placement and depths of additional wells, as needed, up and downgradient of the Project.

The LSA_{HYG} will include the AOI and portions beyond the AOI that might be considered hydraulically downgradient from the Project that are most relevant to the Project interactions. The groundwater flow directions will be evaluated at multiple depths by measuring hydraulic gradients, pressure, and groundwater elevation in various wells. The baseline conditions of the groundwater quality, flow direction, and yield should be studied to better understand the interactions that may occur from either groundwater withdrawal or potential chemical interactions from the facility. More detailed and site-specific information on lithology, fracture density, flow direction, hydraulic conductivity and well yields are required to better characterize the LSA_{HYG} and to better understand potential interactions between surface water features, shallow groundwater flow, and the Project; however, characterizing these parameters is beyond the scope of this current phase of the project.

Ultimately groundwater monitoring for the Environmental Media Baseline Program will require monitoring wells to be established in areas that could be affected during each Project phase, at far-field sites where downgradient or cumulative effects may occur, and at reference areas upgradient of the Project. However, as mentioned previously, the monitoring will be conducted in a staged approach and the first step will be focused on characterizing the AOI in the vicinity of existing or planned deep borehole monitoring locations (NWMO 2019). In order to provide sufficient data to characterize the physical hydrogeology of the AOI, three areas of investigation are proposed within the LSA_{HYG}. These three geographic areas, which may also be investigated in a staged approach, will provide information to understand groundwater flow conditions at the AOI scale. Within each of the three areas, there will be sets of three monitoring locations to further understand the groundwater flow conditions at the local scale. These sets of three local monitoring locations will comprise monitoring at three depths to evaluate hydrogeological conditions at multiple depths. Factors such as representativeness, accessibility, site-specific conditions, and suitability for modelling needs (including the need to establish accurate boundary conditions for the groundwater flow model) will be taken into account when selecting station locations during the final sample design.

The LSA_{HYG} should also include monitoring wells situated upgradient of the AOI within the same Wabigoon watershed. It is important to sample reference locations during the Environmental Media Baseline Program to evaluate if changes observed during future monitoring are potentially Project related, or are due to other causes such as natural variation or climate change (CSA 2010; CCME 2015; CNSC 2017). The location of the additional monitoring locations further upgradient and downgradient of the Project (at the RSA and/or LSA scales) will be determined based on information collected in the first stage of the program and supported by the NWMO groundwater model. It has been assumed that one monitoring location will be instrumented upgradient of the AOI as a reference location that will include three monitoring depths.

The RSA_{HYG} will include groundwater quality monitoring of seven to ten existing private wells (some completed in bedrock and others in overburden) upgradient and downgradient of the AOI from portions of the Northwestern Ontario region considered to be important to local communities that are participating in the stakeholders/rights-holders workshops being held by the NWMO. The primary objective, at this early stage, is to establish a monitoring program that can be conducted by community members, meets community needs, and provides regional information. Once more information is collected from the proposed new monitoring wells being installed in the LSA_{HYG} as part of the first stage of

the shallow groundwater Environmental Media Baseline Program and using the results of the NWMO groundwater flow model(s), additional monitoring points may be installed upgradient and downgradient of the Project to further characterize both the groundwater quantity and quality of the regional flow system. However, at this early stage, optimizing the location of these monitoring points is premature.

4.5.2 Data Objectives and End Use

Groundwater protection is an inter-related system of initiatives, processes, and activities with the overall goal of protecting the quality and quantity of groundwater by minimizing interactions with the environment and surrounding communities from activities associated with a nuclear facility, allowing for effective management of groundwater resources (CNSC 2017). Shallow groundwater parameters are essential components when conducting site characterization of a DGR facility (CNSC 2018), as the Project has the potential of affecting both the quantity and quality of the groundwater resource and the aquatic environments through multiple pathways (Appendix C). Dewatering activities can impact water supply wells, sensitive wetlands or surface water bodies (Mårtensson and Gustafsson 2010). Contaminants may be dissolved or suspended in the groundwater and could be transported off site, be taken up by organisms directly (e.g., trees), or be transferred to other media such as sediment or surface water at groundwater discharge areas and then taken up by organisms, and to soil/rock through sorption (BCMOE 2016).

The first stage of the shallow groundwater monitoring baseline data will be used to:

- characterize the physical flow parameters of groundwater elevation and hydraulic conductivity, which will provide information on flow direction and information on the screened intervals of the wells. Other parameters should be collected as part of the groundwater monitoring network installation scope of work (separate scope), such as flow rates, fracture density, primary and secondary porosity, specific storage and yield, and hydraulic connectivity at the very local scale and AOI scale;
- monitor components (e.g., water quality) and locations identified during the stakeholder/rights-holder engagement conducted by the NWMO;
- establish groundwater quality prior to the Project commencing to see if there are COPC that are naturally elevated and if there is a need to develop site specific objectives;

- establish baseline shallow groundwater quality and groundwater elevations, flow direction, and gradients to enable long-term monitoring to evaluate temporal changes; and
- provide necessary data to use in modelling to predict and assess Project impacts in the IA.

One of the key end-uses of the data collected in the first stage of the shallow groundwater Environmental Media Baseline Program is providing input for the hydrogeologic model being prepared by the NWMO. The definition of regional hydrogeological units, regional and site-specific groundwater flow conditions, flow rate and direction, porosity, hydraulic conductivity, hydraulic heads and gradients, and location of existing and predicted future water-use areas (e.g., groundwater wells) are listed as elements of hydrogeology that should be characterized when conducting a baseline program for a DGR (CNSC 2018). Some of these parameters will be directly measured at varying scales at the Project and then used to inform the boundary conditions and calibration of the hydrogeologic model(s) being prepared by the NWMO. The NWMO model(s) will then be used to predict conditions at other locations and scales around the Site. These parameters, along with the groundwater flow model(s) being prepared by NWMO, will help inform the required extents of the various monitoring areas (LSA_{HYG}, RSA_{HYG}) to evaluate the impacts of the Project on the shallow groundwater elevations and quality (the current scope), the most representative water bodies to evaluate for groundwater/surface water interactions, and the potential impacts of dewatering activities on groundwater elevations with respect to sensitive receptors such as wetlands, lakes, rivers, and groundwater supply wells (beyond the current scope of work). The placement of the wells, as scoped by NWMO, are assumed to be to help resolve some of the questions related to understanding the shallow groundwater system and to help establish representative boundary conditions in the NWMO groundwater model.

In addition to the physical parameters noted above, geochemical parameters provide essential information on groundwater quality and for predicting how contaminants could migrate from a DGR to the biosphere. These include geochemical properties that can affect the migration of radionuclides in groundwater. Some of this information is beyond the focus of the shallow groundwater component and is being considered in the deep monitoring program (e.g., effective diffusion rates of radionuclides, properties that can affect the migration of radionuclides in groundwater, groundwater corrosivity toward engineered barriers, gas generation). However, information to be collected as part of the

shallow groundwater environmental baseline monitoring program should include groundwater geochemistry of the shallow interval (<100 m bgs), presence of COPC, and potential effects of changing redox conditions due to groundwater withdrawal.

4.5.3 Valued Components

The VCs selected for the shallow groundwater parameters component of the Environmental Media Baseline Program are routine for mining IAs, and are recommended in guidance documents (CCME 2016a), including the CNSC (2018) *Guidance on Deep Geological Repository Site Characterization*. The VCs include:

- physical and geochemical properties of hydrogeologic units;
- groundwater quality at the variable scale of groundwater flow system;
- evaluation of the impacts to groundwater quantity (data collected as part of this scope will help evaluate);
- the groundwater recharge and discharge areas (data collected as part of this scope will help evaluate); and
- the groundwater interactions with surface waters (data collected as part of this scope will help evaluate).

4.5.4 Sample Design Options Overview

There are a number of factors that could be altered to provide sample design options for shallow groundwater. The groundwater quality parameters including sampling frequency, COPC inclusion, sampling and measurement methods, and community involvement are some of the options. The sample design options provided for each of water elevation monitoring and groundwater quality are summarized below, with detailed information provided in Appendix E. The Environmental Media Baseline Program has been designed with the assumption that the monitoring is taking place in the ten 2-inch PVC wells that are planned for currently unknown locations within the AOI.

4.5.4.1 Shallow Groundwater Quality and Temporal Data

The sample design options provided for the shallow groundwater quality and temporal water elevation data collection component vary in sampling methods, frequency, and community involvement and include:

- **LSA_{HYG}: Option 1.** Quarterly groundwater sampling using standard field methods, manual monitoring techniques, and COPC list; sampling conducted by a professional geoscientist with a community member as a field assistant.
- **LSA_{HYG}: Option 2.** Same as Option 1, but with the addition of pressure transducers to monitor groundwater elevation data continuously over a longer time periods (e.g., could monitor daily elevation data over each quarter).
- **LSA_{HYG}: Option 3.** Same as Option 2, but with a reduction in sampling locations and/or frequency after the first year of data.
- **RSA_{HYG}: Option 1.** Quarterly water sampling using standard field methods and COPC list; sampling conducted by a professional geoscientist with a community member as a field assistant.
- **RSA_{HYG}: Option 2.** Quarterly water sampling using tap or grab sampling ahead of any in house treatment systems, standard COPC list with sampling conducted by only community members.
- **RSA_{HYG}: Option 3.** Combination of Option 1 and Option 2; Option 1 for one round of sampling and then Option 2 for future sampling events if data sets are comparable.

Sample Size and Frequency

The number of samples required to achieve a certain monitoring precision depends on the variability in hydrogeology and data; the greater the variation, the greater the number of samples needed to obtain a statistically sound estimate (CCME 2015). In absence of variance estimates and the determination of CES (Section 3.3), the number of groundwater samples to be obtained at each monitoring well and the number of wells to be sampled in the LSA_{HYG} has been estimated for this preliminary report. In the LSA_{HYG}, it is assumed that one groundwater sample per each of the nine proposed monitoring wells at each of three depth intervals will be taken for a total of 27 groundwater samples collected quarterly. The final study design document will provide detailed information on sample sizes and sampling methods once input on CES is acquired from the NWMO and stakeholders/rights-holders and may be changed after variance estimates are calculated using groundwater quality data the first year of data.

For collection of groundwater quality and temporal data in the RSA_{HYG}, it has been assumed that one sample will be taken quarterly from each of seven potential private wells either identified as priorities by stakeholders/rights-holders or that provide regional coverage and variability in screen intervals. Since the private wells being sampled are not

anticipated to be near to the AOI and may not be completed in hydrogeological intervals or watersheds that would be expected to be connected to the AOI, the potential for Project interaction is low; as data are obtained, the need to provide more statistical rigour or re-evaluate sample sizes will be examined. The idea of this community-based monitoring program is to obtain an extended temporal data set and provide information from the areas further upgradient and downgradient of the Project.

For this preliminary assessment, it is assumed that quarterly sampling will be conducted at the monitoring locations (yet to be determined) to capture seasonal data; however, once existing data are evaluated, there is the potential that the monitoring frequency may be reduced in future years at some or all locations to semi-annual sampling. Once the temporal and spatial variability of groundwater quality parameters are firmly established, COPC that have low variation and a low probability of exceeding water quality guidelines may be analyzed less frequently.

Sampling Methods

Groundwater sampling will be conducted in accordance with CCME (2016b). Low flow groundwater sampling methods will be used to minimize disturbance of the water column, and for example reduce turbidity which can yield non-representative elevated results for some metals, and highly sorbing organics that might be entrained on particulate matter in the groundwater samples for chemical analyses.

Groundwater elevations will be collected using either a standard water elevation tape for manual measurements or temporal data can be collected using pressure transducers (elevation corrected) that have conductivity, pressure and temperature sensors in one compact device. These level loggers have datalogger with memory for 27,000 sets of reading which allows for comprehensive temporal datasets.

Stakeholder/Rights-Holder Involvement

The groundwater monitoring program affords an excellent opportunity to employ local community members to conduct monitoring of groundwater elevations, collection of pressure transducer data, and to support sampling during the Environmental Media Baseline Program.

For sampling in the RSA_{HYG}, a sample design option is provided in Appendix E where the sampling is completed entirely by community members (RSA_{HYG}: Option 2) and consists

of simply collecting groundwater grab samples from private wells prior to any water treatment equipment. The program will still be organized and managed by the consultant (in order to facilitate transfer of samples to the lab and for data QA/QC and analyses), but the field sampling would be completed by the community members. Online forms and apps can be developed so that data collections and data transfer by community members are easily accomplished.

Recommendations

The recommended sample option for groundwater quality and temporal water elevation data in the LSA_{HYG} is expected to be Option 3. It contains sampling methods accepted by regulatory agencies, provides a more complete and accurate temporal data set for water elevations at a lower cost, and takes into account that many of the COPC are likely to be non-detectable in these wells and that not all COPC at all locations will require quarterly monitoring over the three-year period. The benefits/drawbacks, type, and timing for installation of a pressure transducers can be discussed further with NWMO.

4.5.4.2 Physical Hydrogeology

The sample design options provided for the physical hydrogeology component vary in sampling methods and community involvement and include:

- **LSA_{HYG}: Option 1.** Using lithology data, records of water loss or gain during drilling, fracture occurrence and description, and grain size distribution correlations from well records (use literature references for K) to estimate hydraulic parameters (conductivity, predicted drawdown).
- **LSA_{HYG}: Option 2.** Single well test such as slug tests (constant or rising head), and type curves (AQTESOLV) to calculate an estimated hydraulic conductivity and determine well-specific hydraulic parameters.
- **LSA_{HYG}: Option 3.** Same as Option 2 but with the addition of pump tests or pressure pulse testing to evaluate site-specific hydraulic parameters.

Recommendations

The recommended sample option for physical groundwater data in the LSA_{HYG} is Option 3 as it contains the most comprehensive data set to evaluate hydraulic conductivity, water elevations, and potential effects of drawdown. However, these tests are limited by the well network configuration, screened intervals and locations. These tests and others would be

better conducted in boreholes prior to installation of the wells to help determine the screened intervals. The benefits/drawbacks, types, and timing for the hydraulic tests can be discussed further with NWMO.

4.6 Soil Quality

The soil quality component of the Environmental Media Baseline Program includes assessing soil at the ground surface, beneath the ground surface, and soil and rock at depth down to 100 m. This component is an essential part of the Environmental Media Baseline Program because the Project will include building and roads constructed at the land surface, excavation of near surface soil and rock for building and hoist footings, and mine shafts, all of which will affect soil and rock at the surface above the depth of the DGR. Soil quality is an element of the terrestrial ecology that is described as requiring characterization for siting a DGR (CNSC 2018). Water-laden soils and sediments (i.e., in rivers, lakes, etc.) are handled in the sediment section of the surface water parameters component.

Soil quality supports the health of local edible plant species, burrowing animals, and protection of soil is cited by the community as important (Appendix B). Soil and near surface bedrock quality has an impact on VCs as identified by the community (Appendix C) including edible plants, roots, flowering bushes, traditional medicines, and rock. Soil quality impacts plant and animal tissue, surface water quality, and sediment quality and is therefore of critical importance to other elements of the Environmental Media Baseline Program.

Disturbance of shallow bedrock (<100 m) during excavation and construction has the potential to liberate metals associated with soil and rock due to changes in the geochemical conditions of the subsurface induced by construction activities (introduction of oxygen into the subsurface environment, exposure of reactive minerals to air) and resulting changes to weathering and drainage conditions (Mine Environment Neutral Drainage Program [MEND 2009]). Dewatering of the groundwater at the depth horizon of the DGR (<100 m) may affect shallow bedrock due to desaturation of the bedrock in the near surface environment; this may alter the geochemistry of the bedrock leading to impacts to the soil and bedrock quality and surrounding groundwater. The use of blasting agents for construction may also change the nitrogen content of the soil and bedrock. Deep bedrock placed on the surface within the excavated rock management area may affect the soil quality through the interaction of the excavated rock with air and water at the land surface,

and subsequent leaching of metals and other constituents (blasting agents) into the surficial soil and shallow bedrock.

4.6.1 Study Area

The SSA includes soil and shallow bedrock directly affected by the Project, including excavation, construction, and operation. This includes soil and shallow bedrock within the footprint of the surficial facilities as well as the excavated rock management area. The LSA_{SOIL} includes surficial soil and shallow bedrock surrounding the facility that may be impacted by the facility within the SSA (e.g., through runoff, dewatering activities, etc.) and support services (roads) leading to the facility. Soil quality effects from the construction and operation of the DGR are expected to be most relevant to the SSA and LSA_{SOIL}, although the regional area (RSA_{SOIL}) is a component of the study area associated with support services.

4.6.2 Data Objectives and End Use

Understanding terrestrial soil quality and bedrock chemistry is an essential component of site characterization of a DGR facility (CNSC 2018). Soil is the main medium from where COPC may partition into groundwater and soil vapour (CCME 2016b). Heterogenetic bedrock (consolidated or unconsolidated) may affect COPC distribution, especially in fractured areas (CCME 2016b). The Project may affect the surficial soil (<100 m) environment through a number of pathways described above and in Appendix C. Soil quality may be affected by excavation and construction activities, air deposition, and water (spills, runoff, leachate) and then transferred to other media such as plant tissue and subsequently up the food chain.

The baseline data will be used to:

- Establish surficial soil and bedrock quality to determine if there are COPC that are naturally elevated compared to either guidelines or regional data.
- Determine the surficial soil quality/health in relation to plant growth, to serve as a baseline for an evaluation of loss of soil quality during construction and operation.
- Determine if there are naturally occurring reactive minerals present in the surficial soil and bedrock that may serve as sources of COPC after being disturbed through excavation and construction activities.
- Provide necessary data to use in modelling to predict and assess Project impacts in the IA.

4.6.3 Valued Components

The VCs selected for the soil quality parameters component are routine for mining IAs, and are recommended in guidance documents (CCME 2016b; MEND 2001, 2009), including the CNSC (2018) *Guidance on Deep Geological Repository Site Characterization*. The VCs are detailed in Appendix C and include:

- Natural soil quality of surficial soil and unconsolidated overburden in the SSA, LSA_{SOIL}, and RSA_{SOIL}.
- Geochemical and radiological properties of surficial soil in the SSA, LSA_{SOIL}, and RSA_{SOIL}.
- Geochemical and radiological properties of consolidated overburden and deep bedrock in the SSA and LSA_{SOIL}.
- Lithological heterogeneity between overburden and bedrock, including metamorphism, alteration styles, structural relationships and fabric, mineralogy, occurrence and intensity); and ore mineralogy (sulphide types, abundance, mode of occurrence, extent of previous oxidation and an estimate of relative sulphide reactivity).

4.6.4 Sample Design Options Overview

The sample design options provided for soil and bedrock are summarized below, with detailed information provided in Appendix E. Sampling design options including sampling frequency and methods, COPC inclusion, and stakeholder/rights-holder involvement are evaluated below.

4.6.4.1 Soils and Unconsolidated Overburden

The primary source of surficial soil and near-surface unconsolidated overburden will be from material collected during drilling of shallow groundwater wells for the baseline groundwater characterization program. Other locations of surficial soil include those sampled for plant tissue analysis. The methods and sampling plan for surficial soil/unconsolidated material are described below.

- **LSA_{SOIL}/RSA_{SOIL}: Option 1.** Soil sampling using standard field methods and COPC list; following industry standard chemical characterization methods established by regulatory agencies (e.g., U.S. EPA) or detailed in guidance

documents (e.g., MEND); sampling conducted by a professional geoscientist with a community member as a field assistant.

- **LSA_{SOIL}/RSA_{SOIL}: Option 2.** Same as Option 1, but with the addition of alternate methods for measuring soil ecosystem health: genomic (DNA) and/or enzyme assay (e.g. fungi); this may require molecular analysis to build the enzyme assay to determine decay capacity/shifts in biogeochemistry of forest soils.
- **LSA_{SOIL}/RSA_{SOIL}: Option 3.** Same as Option 1, but with the addition of organic carbon quality testing to the standard dissolved inorganic and organic carbon analysis, organic carbon quality.

Contaminants of Potential Concern

The COPC for soil quality analysis will include total metals (major and trace element), VOCs, and radionuclides (Appendix D). Soil chemistry will include the analysis of soil nutrients (total phosphorus, potassium, and nitrogen), along with individual nitrogen species (ammonia, nitrite, nitrate, organic nitrogen), pH, TOC, DOC, grain size distribution, and soil moisture content.

Sample Size, Frequency, and Location

Surficial soil quality will be evaluated by co-locating samples with the samples collected for plant tissue analysis in the SSA, LSA_{SOIL}, and RSA_{SOIL}, to accurately represent soil quality diversity related to species of interest and distinct ecosite zones (Tulloch 2018b).

In addition, the assumption is that the nine boreholes being advanced to install the groundwater wells will be drilled and unconsolidated overburden, if present (well not located in an area with exposed bedrock), will be collected once during the drilling program. This will provide material to establish soil quality within vertical profiles in the AOI and will provide the ability to relate surficial soil quality with subsurface soil quality. Soil will be sampled in the top 15 cm and then at 2 m intervals through the column of unconsolidated material until bedrock is encountered, for an estimated assumed maximum total of 80 samples, depending on the thickness of unconsolidated material encountered. According to previous studies, soil and unconsolidated overburden is assumed to be encountered from approximately 0 m bgs to 15 m bgs (Appendix C).

Sampling Methods

Soil sampling will be conducted in accordance with CCME (2016b). Surficial soil samples (top 15 cm) should be collected from undisturbed areas, with the top layer of litter removed using a stainless-steel trowel.

Sampling of boreholes should be collected as discrete samples (e.g., split-spoon) from undisturbed continuous or semi-continuous soil core to minimize cross-contamination (CCME 2016b). Downhole descriptions of soils should be applied, including visual classification, grain size estimation, in-situ moisture content, color, and soil type. Soil classification should follow the Canadian System of Soil Classification (Soil Classification Working Group 1998).

Stakeholder/Rights-Holder Involvement

Stakeholders and rights-holders may be involved in sample collection by assisting trained field geologists and soil scientists, or through a training program to certify community members in the collection of samples. The majority of sample analysis is performed by certified laboratories due to the complexity of the chemical analytical methods and associated QA/QC requirements such that the data is reliable and useable for its intended purpose. However, alternative options to laboratory-based sample analysis include field measurements of soil pH, moisture content, and water-soluble nutrients such as ammonia, nitrate, and phosphate. The latter can be conducted using colorimetric methods available through commercial test kits (e.g., Hach Kits [Hach North America]). Stakeholders and rights-holders may deploy these methods in the field and record data for use in the broader soil quality characterization program and this data can augment laboratory-based methods. Data obtained in the laboratory can be made readily available for stakeholder and rights-holder review and use through distributed database platforms that allow for downloading and manipulation of the data but preserve the verified and validated data as unchanged. The laboratory-derived data can therefore become a resource for the community to more fully understand their baseline soil quality.

Recommendations

The recommended sample option for soil and unconsolidated overburden data in the LSA_{SOIL} and RSA_{SOIL} is Option 1 as it follows industry standard chemical characterization methods established by regulatory agencies and guidance documents. Although Options 2 and 3 may provide valuable data, there is uncertainty in the applicability at this time and

with development of these techniques. However, if eDNA is going to be attempted for other media e.g., (tissues or zooplankton) it may be beneficial to evaluate the soil quality using similar methods to build the co-located dataset. The benefits/drawbacks of the various options can be discussed further with NWMO.

Soil that is stockpiled at the land surface during and after construction of the DGR is recommended to be sampled and characterized as part of the ongoing characterization efforts. One composite sample should be obtained per stockpile, via composite sampling methods that are in accordance with CCME (2016b).

4.6.4.2 Bedrock and Consolidated Overburden

It is assumed that consolidated material, including overburden deposits and bedrock lithology, will be sampled over up to 100 m depth, at locations of the nine proposed borings for installation of the monitoring wells. The objective is to evaluate the reactivity of minerals and potential mobilization of COPC from disturbed bedrock when it is excavated and stockpiled on surface during construction. The sampling and analysis methods for consolidated material are detailed below and in Appendix E.

- **LSA$_{SOIL}$: Option 1.** Bedrock sampling using standard field methods and COPC list; following industry standard chemical characterization methods established by regulatory agencies (e.g., U.S. EPA) or detailed in guidance documents (e.g., MEND); sampling conducted by a professional geoscientist with a community member as a field assistant.
- **LSA$_{SOIL}$: Option 2.** The same as Option 1 but with the addition of geologic core-logging and hand-held X-Ray Fluorescence (XRF) analysis conducted in the field during the advancement of the 10 proposed shallow groundwater boreholes.

Contaminants of Potential Concern

Consolidated material will be analyzed for total metals (major and trace), as well as radionuclides (Tier 1; Appendix E). Additional analyses will include geochemical characterization, consisting of acid-base accounting (to understand the baseline acid-generating potential, acid-neutralizing potential, sulfidic mineral content [these are reactive minerals that may become activated upon excavation to the land surface]) and short-term ("static") and long-term ("kinetic") metal-leaching characteristics, in accordance with international guidelines (Price 1997; MEND 2009; INAP 2012).

Sample Size, Frequency, and Location

The assumption is that ten groundwater wells will be drilled, and that rock sampling will be conducted during the drilling program. Sampling at 5 m intervals is recommended where consolidated overburden units composed of glacial till (assumed to extend to 30 m depth in some locations) are lithologically heterogenetic (Appendix C). Within bedrock units composed of homogeneous basement granitoids (assumed to extend to 100 m depth) (Appendix C), sampling is recommended at 10 m intervals. A maximum of 100 borehole samples is assumed.

Good geologic and geochemical representation may require additional targeted sampling within discrete geologic units with notable heterogeneity (fracture density; mineralogy; weathering differential; and leaching properties) (MEND 2009). Therefore, up to five additional samples should be collected at key lithologic features (such as lithologic contacts, veins, grain size changes, and sulphide occurrences), for a comprehensive representation of the possible heterogeneity within the column. A maximum total of ten additional samples is assumed.

Sampling Methods

Geologic down-hole logging will be performed in conjunction with sample collection, during the advancement of the nine boreholes for the groundwater monitoring wells. A trained geologist will be required to perform the work and record information such as sample location, lithology, vein and fracture location, orientation, and composition, and sulphide occurrence. Hand-held XRF analysis will be used throughout core-logging at locations to be informed by geologic observations.

Geochemical sample selection and collection will be conducted in accordance with International guidelines (Price 1997; MEND 2009; INAP 2012). Samples collected during drilling should be collected at regular intervals across the width and depth of geologic units to capture notable differences in physical, mineralogical and geochemical properties of the material. The sampling interval dimensions should be dependent on the variability of these properties of interest, as determined during down-hole logging.

Drill core samples should be air dried or oven dried at low temperature. Prior to and after drying, the samples should be kept cool or in a freezer to minimize sulphide oxidation that may occur during drying and storage (MEND 2009).

Stakeholder/Rights-Holder Involvement

Stakeholders and rights-holders may be involved in sample collection by assisting trained field geologists and soil scientists, or through a training program to certify community members in the collection of samples. Stakeholders and rights-holders may team with the field geologists in order to assist with the geological logging, providing significant engagement with the community during borehole completion.

Recommendations

The recommended sample option for bedrock data in the LSA_{SOIL} is Option 2 as it follows industry standard chemical characterization methods established by regulatory agencies and guidance documents and also maximizes the information gained from the boreholes. Results of core-logging and XRF analysis will inform the presence of reactive minerals with depth and will also support additional sample selection for full geochemical and COPC characterization (for example, if visible sulphide minerals are noted, these samples will be included in humidity cell tests to understand the reactivity of the sulfides and potential for metal leaching).

Spectral gamma borehole logging is recommended as an alternative means to analyze natural radionuclide concentrations in overburden and bedrock. Spectral gamma borehole geophysical methods measure natural-gamma energy spectra, which are caused by the decay of uranium, thorium, potassium-40, and anthropogenic radioactive isotopes. Each of these isotopes has a spectral signature that enables its presence to be identified. Regular natural gamma tools provide a total count of natural gamma emissions from these isotopes. The spectral gamma tool measures the energy of the gamma emissions and counts the number of gamma emissions associated with each energy level (Hearst et al. 2000). This alternative method is proposed for bedrock analyses where analyzing for the full suite of first- and second-tier radionuclides may not be cost effective.

Bedrock that is stockpiled at the land surface during and after construction of the DGR is recommended to be sampled and characterized as part of the ongoing characterization program. It is understood that a baseline geochemical characterization program to evaluate geochemical properties of deep bedrock material (e.g. below 100 m) is to be conducted under another scope. Thus, consolidated material, including overburden and bedrock that will be sampled up to 100 m depth requires comprehensive representation to account for assumed lithological heterogeneity.

4.6.4.3 Gamma Radiation Survey

One of the components to characterize in the Environmental Media Baseline Program is the gamma radiation levels in the area to support future impact and risk assessments. The sample design options provided for the environmental gamma survey component vary in approach and community involvement, and include:

- **SSA: Option 1.** Environmental gamma survey completed by an external consultant (four person team).
- **SSA: Option 2.** Same as Option 1, but completed by an external consultant and trained community members.

Sampling Methods

Environmental gamma radiation data will be collected through roving transects using a GPS integrated gamma radiation surveying equipment either by foot or by ATV (depending on the site terrain and access issues). Gamma radiation measurements will be taken at a distance of approximately 1 m above the ground surface. Collected data will be mapped to ensure adequate coverage and accuracy. A reference area will also be included in the survey to establish the appropriate area and levels for any subsequent studies.

If the terrain is difficult to navigate (due to growth or wetlands) which would represent a health and safety risk to the ground crews, or if there are areas where sensitive species are present, then consideration could be given to a drone-based survey; for the purpose of this program it is assumed that a traditional ground survey is appropriate.

Sampling Location

The gamma radiation survey will cover a pre-defined area, meant to encompass the footprint of the facility and excavated rock management area, which is defined as the SSA. The final survey boundaries will be defined in consultation with NWMO. Depending upon the size of the survey area, the total survey area may be sub-divided into survey units, which will be surveyed and reported separately.

The gamma survey would require the development of work instructions and labour and equipment for an area of approximately 70 ha, and data mapping. This survey would only need to be completed one time and it is recommended that it occur at a time when the footprint of the facility and ERMA is well defined.

Stakeholder/Rights-Holder Involvement

The gamma survey represents an opportunity to employ local community members to assist in the survey. An experienced person would need to lead the survey and conduct the appropriate quality checks, but with training community members could readily assist.

Recommendations

A gamma radiation survey that uses a GPS integrated gamma surveying method and covers applicable areas within the proposed site is recommended. The recommended option for the gamma survey in the SSA is Option 2 as it contains sampling methods accepted by regulatory agencies and allows for the engagement of the local and indigenous communities. A supportive framework that ensures the appropriate skills, education and training are developed and maintained may also be required to facilitate the program.

5.0 SUMMARY

The purpose of the Environmental Media Baseline Program is to characterize environmental baseline conditions prior to development of the DGR so that potential effects of the Project can be measured, or that a lack of detectable effects is defensible. To achieve this purpose, our Study Team needs to ensure that the study design collects data that are of high quality, are statistically rigorous, and will provide adequate information for future modelling and preparation of an IA. Furthermore, key objectives in the Environmental Media Baseline Program design include: 1) ensuring data of high importance to surrounding communities, stakeholders, and rights-holders are collected, 2) integrating IK and community workshop input into the study design, and 3) maximizing community involvement in implementation of the program, if desired. These data objectives were forefront when assessing study design options to recommend in this preliminary sample design feasibility assessment.

5.1 Sample Design Options

The objective of this report is to utilize the initial input provided through stakeholder and rights-holder workshops, alongside evaluations of standard best practices and innovative and emerging technologies, to develop sample design options for six components (tissue chemistry, hydrology, surface water parameters, air quality, noise, and light, shallow groundwater, and soil) of the Environmental Media Baseline Program for the Project. For this preliminary sample design feasibility assessment, a number of assumptions were made about the Project and many study design details in order to provide options and relative costs. Appendix E provides tables that detail each option, including the sample sizes, COPC lists, VCs, etc. There are a number of factors and decisions that could affect the costs of each program significantly, such as COPC inclusion. Obtaining specific input from the NWMO, stakeholders, and rights-holders on the options presented in this preliminary report is an integral part of the final sample design study and the overall design development process. Components that require further input to inform the final study design are outlined in Section 6.0.

Table 5.1 presents a rationale table that summarizes the options presented in Appendix E and provides justification for sample design options that our Study Team recommends in this preliminary feasibility assessment. There are other aspects of the Environmental Media Baseline Program that are important but are not captured within the options analysis shown in Table 5.1. For example:

- It is recommended to co-locate tissue and environmental media samples (e.g. berries and soil) to maximize the use of this information.
- It may be beneficial to archive some soil samples for future analysis since analytical methods and/or COPC can change with additional understanding.
- All samples should be geotagged to allow for better data handling.

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
Tissue		
Tissue Species (vary depending on Option selected)	**Option 1**. Dietary study for the identified stakeholders/rights holders. Sampling of primary VC categories only.	- High level of stakeholder/rights-holder involvement in program. - Radionuclides and metals are tested for primary VCs. - Cons are that no secondary VCs are included for testing.
	Option 2. Dietary study for the identified stakeholders/rights holders. Sampling completed as in Option 1 but with complete list of all primary and all secondary VC categories.	- High level of stakeholder/rights-holder involvement in program. - Radionuclides and metals are tested for primary VCs. - Metals are collected for secondary VCs. - Cons are that all samples are collected lethally.
	Option 3. Dietary study for the identified stakeholders/rights holders. Sampling completed as in Option 2 but non- lethal sampling for all secondary VC categories.	- High level of stakeholder/rights-holder involvement in program. - Radionuclides and metals are tested for primary VCs. - Uses an emerging technology for secondary VCs. - Reduces sampling time and budget for secondary VCs. - Allows more spatial coverage and non-lethal testing for secondary VCs.
Hydrology		
Stream Flow	**Option 1**. Estimate flow in smaller streams in all three years using manual flow measurements; for larger rivers, install a water level sensor (pressure transducer or other) to measure levels and estimate flow from stage-discharge rating curve (developed in Year 1).	- Will provide a more complete dataset of the flow variability in rivers. - Continuous water level data would be collected and converted to flow estimates based on the stage-discharge rating curve. - Cons are that it is costlier to install and maintain, possible equipment failures could result in lost data.
	Option 2. Estimate flow in smaller streams in all three years using manual flow measurements; for larger rivers, install permanent staff gauge measure levels and estimate flow from stage-discharge rating curve (developed in Year 1).	- The cost is lower for fixed field equipment and there is a simpler field protocol. - Cons are no continuous (hourly) stage measurements (not capturing the seasonal flow changes as accurately), possibility of staff gauge blowing out during flood conditions, and may require more field visits and therefore additional time to take staff gauge readings.
Lake Water Level	**Option 1.** Install a permanent staff gauge in Mennin Lake and manually monitor water levels in each year.	- The cost is lower for fixed field equipment and there is a simpler field protocol. - Cons are no continuous (hourly) stage measurements (not capturing the seasonal flow changes as accurately).

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program (Cont'd)

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
Meteorology	**Option 1**. Install an automatic meteorological station.	- Obtain site-specific data that will be more appropriate to use than data from distant weather stations. - Coordination and learning of accessible points for measurements, understanding of the remote nature of one site option, preparing for wildlife encounters, health and safety of field crews. - Cons will be planning around weather (snow) and frost. *It is our understanding that NWMO is planning to install a meteorological station and therefore it is not necessarily associated with the Environmental Media Baseline Program.*
Surface Water Parameters		
Surface Water Quality	**LSAsw: Option 1**. Quarterly water sampling at eight locations using standard field methods and COPC list; sampling conducted by a consultant with a community member as a field assistant.	- Follows accepted regulatory protocols. - More cost effective and allows more spatial coverage and a larger COPC list than a continuous remote water quality meter. - Involves community members.
	LSAsw: Option 2. Same as Option 1, but with the addition of one continuous remote water quality meter situated in the Mennin Lake drainage near the AOI to collect real-time data for certain COPC.	- Remote water quality meter is costly and only enables measurement of select COPC at one location (unless multiple meters are installed). - Pros and cons of this method can be discussed with NWMO and at some point in the Project, its use may be advantageous.
	RSAsw: Option 1. Quarterly water sampling at eight locations using standard field methods and a reduced COPC list; sampling conducted by a consultant with a community member as a field assistant.	- Less involvement of community members.
	RSAsw: Option 2. Quarterly water sampling at eight locations using surface grabs and a reduced COPC list with sampling conducted by only community members.	- An entirely community-based monitoring program aligns with the objective of community assurance - Will provide long-term capacity building and employment for local groups like the Wabigoon Lake Ojibway Nation.

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program (Cont'd)

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
Sediment Quality	**Option 1**. Sediment sampling in eight areas using a core sampler; sampling conducted by a consultant with a community member as a field assistant.	- Enables a higher number of sampling locations, an extensive COPC list, and the use of an accepted sampling device that enables precision in the sediment horizon being sampled.
	Option 2. Same as Option 1 but only five areas.	- The number of sampling locations is lower than Option 1; however, the number of areas sampled is somewhat dependent on NWMO's budget allocation to this component of the Environmental Media Baseline Program.
	Option 3. Same as Option 1 but using a grab sampler instead of a core sampler.	- The use of a grab sampler may be required in some locations depending on substrate type, but it is not the preferred method as fine sediments can be lost and sediment horizon precision is not achievable.
	Option 4. Same as Option 3 but only five areas.	- Includes the use of a grab sampler and a lower number of sampling locations; thus, this is the least preferred option.
Plankton Community	**Phytoplankton/Chlorophyll Option 1**. Sensors to measure chlorophyll a and blue green algae added to the continuous remote water quality meter proposed under surface water quality.	- See above in surface water quality **LSA$_{SW}$: Option 2** - If a continuous remote water quality meter is installed, inclusion of these sensors would be a worthwhile addition.
	Phytoplankton/Chlorophyll Option 2. Quarterly phytoplankton sampling at eight locations using standard field methods (paired with water quality sampling); sampling conducted by a biologist with a community member as a field assistant.	- Follows accepted regulatory protocols. - Allows more spatial coverage and a larger number of endpoints than a continuous remote water quality meter. - Involves community members.
	Zooplankton Option 1. Quarterly zooplankton sampling at eight locations using standard field methods (paired with water quality sampling); sampling conducted by a biologist with a community member as a field assistant	- Option 2 is recommended over Option 1 as Option 2 includes an emerging technology that will enable future monitoring using eDNA.
	Zooplankton Option 2. Same as Option 1, but with the addition of environmental DNA (eDNA).	- Includes an emerging technology that will enable future monitoring using eDNA.
	Zooplankton Option 3. Same as Option 1 but at only five locations.	The number of sampling locations is lower than Option 1; however, the number of areas sampled is somewhat dependent on NWMO's budget allocation to this component of the Environmental Media Baseline Program. - Does not include an emerging technology (eDNA).
	Zooplankton Option 4. Same as Option 3, but with the addition of environmental DNA (eDNA).	The number of sampling locations is lower than Option 2; however, the number of areas sampled is somewhat dependent on NWMO's budget allocation to this component of the Environmental Media Baseline Program. - Includes an emerging technology (eDNA).

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program (Cont'd)

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
Benthic Invertebrate Community	**Option 1.** Annual benthic invertebrate sampling at eight locations using standard field methods (paired with sediment quality sampling); sampling conducted by a biologist with a community member as a field assistant.	- Option 2 is recommended over Option 1 as Option 2 includes an emerging technology that will enable future monitoring using eDNA.
	Option 2. Same as Option 1, but with the addition of eDNA	- Includes an emerging technology that will enable future monitoring using eDNA. - Provides better spatial coverage of the LSA_{SW} and reference areas (eight locations).
	Option 3. Same as Option 1, but at only five locations.	- The number of sampling locations is lower than Option 1; however, the number of areas sampled is somewhat dependent on NWMO's budget allocation to this component of the Environmental Media Baseline Program. - Does not include an emerging technology (eDNA).
	Option 4. Same as Option 3, but with the addition of eDNA.	- The number of sampling locations is lower than Option 2; however, the number of areas sampled is somewhat dependent on NWMO's budget allocation to this component of the Environmental Media Baseline Program. - Includes an emerging technology (eDNA).
Air Quality, Noise, and Light		
Air Quality	**SSA: Option 1.** Continuous air quality monitoring using standard methods and complete Tier 1 and 2 COPC list; operations and maintenance activities completed by an external consultant (two person team).	- Follows accepted regulatory protocols. - Provides coverage for complete list of Tier 1 and Tier 2 air quality COPC. - Some opportunities to refine the COPC list to better utilize resources and meet program objectives (screening level study). - Preliminary air dispersion modelling would aid program design. - Initial setup costs are high.
	SSA: Option 2. Same as Option 1, with operations and maintenance activities completed by an external consultant and a trained community member (with the intent of passing responsibility over to community member).	- Follows accepted regulatory protocols/standard methods. - Expensive but provides coverage for complete list of Tier 1 and Tier 2 COPC. - Some opportunities to refine the COPC list to better utilize resources and meet program objectives (screening level study). - Preliminary air dispersion modelling would aid program design. - Initial setup costs are high. - Involves the community in the program.
	LSA_{AQ}: Option 1. Passive air quality monitoring using standard methods and complete Tier 1 and 2 COPC list; operations and maintenance activities completed by an external consultant (two person team).	- Follows accepted regulatory protocols/standard methods. - More cost effective and allows more spatial coverage and considers the complete list of Tier 1 and Tier 2 COPC. - Some opportunities to refine the COPC list to better utilize resources.
	LSA_{AQ}: Option 2. Same as Option 1, with operations and maintenance activities completed by	- Follows accepted regulatory protocols/standard methods. - More cost effective and allows More spatial coverage and a full COPC list

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program (Cont'd)

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
	an external consultant and a trained community member (with the intent of passing responsibility over to community member).	- Some opportunities to refine the COPC list to better utilize resources. - Involves the community in the program.
Noise	**SSA/LSA$_{NO}$: Option 1**. Continuous noise monitoring using standard methods; sampling completed by external consultant (two person team).	- Follows accepted regulatory protocols/standard methods.
	SSA/LSA$_{NO}$: Option 2. Same as Option 1, with sampling completed by an external consultant and a trained community member (with the intent of passing responsibility to community member).	- Follows accepted regulatory protocols/standard methods - Involves the community in the program.
Light	**SSA: Option 1**. Discrete campaign-based light monitoring using standard methods; sampling activities completed by an external consultant (two person team).	- Follows accepted international protocols/standard methods.
	SSA: Option 2. Same as Option 1, with sampling activities completed by an external consultant and a trained community member.	- Follows accepted international protocols/standard methods. - Involves the community in the program.
Shallow Groundwater		
Groundwater Quality and Temporal Water Elevation Data	**LSA$_{HYG}$: Option 1**. Quarterly groundwater sampling using standard field methods, manual monitoring techniques, and COPC list; sampling conducted by a professional geoscientist with a community member as a field assistant.	- Follows accepted regulatory protocols. - Water elevation measurements collected manually, not sufficient data density to evaluate trends, changes in groundwater elevation over time. - Involves community members.
	LSA$_{HYG}$: Option 2. Same as Option 1, but with the addition of pressure transducers to monitor groundwater elevation data continuously over a longer time periods (e.g., could monitor daily elevation data over each quarter).	- Follows accepted regulatory protocols. - Water elevation measurements collected pressure transducers provides changes in groundwater elevation over time. - Involves community members. - Likely too many samples being collected for some parameters that are expected to be non-detectable.
	LSA$_{HYG}$: Option 3. Same as Option 2, but with a reduction in sampling locations and/or frequency after the first year of data	- Follows accepted regulatory protocols. - Water elevation measurements collected pressure transducers provides changes in groundwater elevation over time. - Involves community members. - Reduction in samples type and/or frequency being collected for some parameters based on first year of data.

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program (Cont'd)

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
Groundwater Quality and Temporal Water Elevation Data	**RSA$_{HYG}$: Option 1**. Quarterly water sampling using standard field methods and COPC list; sampling conducted by a professional geoscientist with a community member as a field assistant	- Follows accepted regulatory protocols. - Requires that water supply be shut off from the house and all equipment pulled from the private well to sample. - Involves community members.
	RSA$_{HYG}$: Option 2. Quarterly water sampling using tap or grab sampling ahead of any in house treatment systems, standard COPC list with sampling conducted by only community members.	- Does not require that water supply be shut off from the house and all equipment pulled from the private well to sample; however possibility of poor sample quality due to interference from existing water piping, system. - Involves community members.
	RSA$_{HYG}$: Option 3. Combination of Option 1 and Option 2; Option 1 for one round of sampling and then Option 2 for future sampling events if data sets are comparable.	- Contains one sampling round with sampling methods accepted by regulatory agencies (pump/equipment pulled and well developed and sampled as per standard methods). - Meets the data objective of community assurance by having two years of data (from existing tap or port) from an entirely community-based monitoring program if the data sets are comparable.
Physical Hydrogeology Data	**LSA$_{HYG}$: Option 1**. Using lithology data and grain size distribution correlations from well records (use literature references for K) to estimate hydraulic parameters (conductivity, predicted drawdown).	- Allows for estimates only. - No community involvement.
	LSA$_{HYG}$: Option 2. Single well test such as slug tests (constant or rising head), and type curves (AQTESOLV) to calculate an estimated hydraulic conductivity and determine site-specific hydraulic parameters.	- Direct well testing (well-specific test information). - Use of pressure transducers for single well will provide conductivity of well and possible indication of connection to other wells in area.
	LSA$_{HYG}$ Option 3. Same as Option 2 but with the addition of pump tests or pressure pulse testing to evaluate site-specific hydraulic parameters.	- Contains the most comprehensive data set to evaluate hydraulic conductivity, water elevations, and potential effects of drawdown. - Tests are limited by the well network configuration, screened intervals and locations. -These tests and others would be better conducted in boreholes prior to installation of the wells to help choose the screened intervals.

Table 5.1 Summary rationale table providing justification for recommended sample design options for the Environmental Media Baseline Program (Cont'd)

VC Category	Option Description	Justification for Recommendation and NWMO Considerations
Soil		
Soil Chemistry and Quality	**LSA$_{SOIL}$/RSA$_{SOIL}$: Option 1**. Soil sampling using standard field methods and COPC list; following industry standard regulations and guidelines (e.g. CCME, U.S. EPA; MEND); sampling conducted by a professional geoscientist with a community member as a field assistant.	- Follows industry standard chemical characterization methods established by regulatory guidance agencies and documents.
	LSA$_{SOIL}$/RSA$_{SOIL}$: Option 2. Same as Option 1, but with the addition of alternate methods for measuring soil ecosystem health: genomic (DNA) and/or enzyme assay (e.g. fungi).	- If eDNA is attempted for other media (e.g. tissues), it may be beneficial to evaluate the soil quality using similar methods. - May require molecular analysis to build the enzyme assay to determine decay capacity/shifts in biogeochemistry of forest soils. - Uncertainty in the applicability and development of these techniques at this time.
	LSA$_{SOIL}$/RSASOIL: Option 3. Same as Option 1, but with the addition of organic carbon quality testing to be the standard dissolved inorganic and organic carbon analysis, organic carbon quality.	- Uncertainty in the applicability and development of these techniques at this time.
Bedrock Chemistry	**LSA$_{SOIL}$: Option 1**. Bedrock sampling using standard field methods and COPC list; following industry standard regulations and guidelines (e.g. CCME, U.S. EPA; MEND); sampling conducted by a professional geoscientist with a community member as a field assistant.	- Follows industry standard chemical characterization methods established by regulatory guidance agencies and documents. - Does not make use of information to be gained from boreholes.
	LSA$_{SOIL}$: Option 2. Same as Option 1, but with the addition of geologic core-logging and hand-held X-Ray Fluorescence (XRF) analysis conducted in the field during the advancement of the ten proposed shallow groundwater boreholes.	- Follows industry standard chemical characterization methods established by regulatory guidance agencies and documents. - Maximizes the information gained from the boreholes.
Gamma Radiation Survey	**SSA: Option 1**. Environmental gamma survey completed by an external consultant (four person team).	- Does not allow for the engagement of the local and Indigenous communities. - Does not involve training or education to community members.
	SSA: Option 2. Same as Option 1, but completed by an external consultant and trained community members.	- Contains sampling methods accepted by regulatory agencies and allows for the engagement of the local and Indigenous communities. - A supportive framework that provides for education and training of community members may be required to facilitate the program.

Signifies recommended option

5.2 Community Involvement

There are two important components of stakeholder and rights-holder involvement in this project. The first is providing community input and IK for study design development of the Environmental Media Baseline Program. Initial community engagement workshops were completed and used to aid in developing the sample design options presented in this preliminary sample design feasibility assessment. The NWMO plans to conduct further community engagement workshops on this report to gather feedback and additional information. In Section 6.0, our Study Team has provided a list of key items that require further input during the second cycle of stakeholder and rights-holder engagement.

The second component is determining the level of community involvement during implementation of the Environmental Media Baseline Program. The WLON, which is the closest First Nation to the Project, has a vision of forming an environmental services provider. Some of the community members are already participating in environmental sampling being conducted as part of the Phase 2 studies in the Northwestern Ontario region. Our goal is to involve community members in as many aspects of the Environmental Media Baseline Program as possible to enable capacity building to further this vision. As discussed throughout Section 4.0, this could include the following:

- Being field assistants for numerous studies that require trained consultants to lead the work.
- Being trained to conduct sampling independently (e.g., collecting surface water grabs in the RSA_{sw}; see Section 4.3.4.1 for more information).
- Conducting a traditional foods dietary survey where community members are hired and trained to conduct interviews (see Section 4.1.4.1 for more information).
- Collecting tissue samples to submit for chemical analyses during routine hunting and gathering activities (see Section 4.1.4.4 for more information).
- Hiring a community liaison and/or elder to assist in the coordination of the tissue sampling program and to aid in the dissemination of information back to leadership and the broader community.

The level of involvement in the Environmental Media Baseline Program is up to the community and this should be discussed during the next round of stakeholder/rights-holder workshops. There are alternate options such as the community conducting their own sampling program independent of the Environmental Media Baseline Program.

There are a number of training/engagement opportunities that could be provided to local communities prior to and during the Environmental Media Baseline Program that are in addition to the hands-on training gained through working with a consultant to conduct field sampling. These could include training videos, conducting school visits, having students collect samples as part of school projects, or having a school field trip, and gaining certification through BEAHR (Building Environmental Aboriginal Human Resources) Indigenous training and employment program(s).

6.0 PATH FORWARD

There are a number of components that require further input from the NWMO and from stakeholders/rights-holders before our Study Team can provide a final sample design that is informed by community input/IK and maintains statistical rigour. It is vital that the Environmental Media Baseline Program achieve the data quality objectives to ensure the Project is able to proceed, if desired, onto the next stages of development with both community approval and scientifically sound baseline information. The following list outlines data gaps/decisions to be made prior to finalizing the Environmental Media Baseline Program study design. Some of these items are more relevant for the NWMO while others are relevant for the stakeholders/rights-holders.

- Our most current understanding of the Project design and the assumptions our Study Team made regarding Project interactions with the environment were described in the CSM (see Appendix C). If there any changes to the Project design and assumptions made that will affect development of the final study design these will need to be identified before the detailed design starts (by August 2019).
- The COPC list was developed by reviewing relevant documents and discussions with the NWMO (see Appendix D); however, there are also cost implications to including certain COPC that will need to be considered. Thus the COPC to include for each sample media requires further discussion and decision making with NWMO.
- The proposed study areas for each component were included in this preliminary sample design feasibility assessment and are based on assumptions made in the CSM and the initial stakeholder/rights-holder input. Additional community input is needed to refine the study areas and to aid in pinpointing sample locations and timing, particularly for certain components such as surface water quality monitoring and tissue sampling.
- Preliminary lists of VCs proposed to be sampled in the tissue component were included in this this preliminary sample design feasibility assessment; however, this requires further input from stakeholders/rights-holders to ensure VCs of importance to the communities are included in the Environmental Media Baseline Program.
- The community workshops identified consideration of Spirit or Aatsokewinan as important. We would like to discuss ways to integrate this into the baseline collection. This could include ceremony, for example the suggestion to “offer tobacco to Mother Earth when collecting” (comment 2B-2f, Appendix B).

- The objectives of the NWMO shallow groundwater sampling program need to be reconciled with those of the Environmental Media Baseline Program. The focus of the shallow groundwater baseline study is groundwater quality and water elevation data. However, a better understanding of the NWMO-proposed monitoring well network, which will be installed to further understand the shallow hydrogeology of the area, is needed to i) evaluate the rationale for selecting the locations and depths of the wells, and ii) provide input to the number and type of tests that are planned for the boreholes and to select screen intervals prior to installation of the wells. Engagement in the design of the NWMO-proposed monitoring well network is critical to determining whether the proposed well network will address the needs of the Environmental Media Baseline Program with respect to the scale, depths, and density required to establish a statistically defensible monitoring program.
- Statistical determination of the number of samples recommended to collect per media type will require acquisition of data available from the area (e.g., water, sediment, and soil chemistry data) in order to determine the expected variability, and a decision on the amount of change from baseline that would constitute a Project-related effect (i.e., CES).
- Options for novel and emerging technologies were included in this preliminary sample design feasibility assessment; however, there are benefits and drawbacks to their inclusion. Input is required on the desire to include each of these technology options in the Environmental Media Baseline Program.

In addition to some of the broader topics discussed above, provided below are examples of some specific questions that our Study Team proposes asking stakeholders/rights-holders during the second cycle of community workshops.

- Which lakes in the Northwestern Ontario region are of the highest importance for fishing?
- Which fish species are of the highest importance and consumed most frequently?
- What are the top medicinal plants and roots gathered in the region and AOI? How would they be used (consumed directly, tea, inhalation)? Is the AOI an area of high use?
- What are the most important plant types consumed by community members that are local to the Project? Is the AOI an area of high use?
- Do you eat moose or deer organs often (liver, kidney, etc.)?
- Do you eat lynx, beaver, muskrat or just trap it for furs?

- Input on wildlife abundance/use in the AOI?

However, if a formal traditional foods dietary study is undertaken, then a large amount of this information will be documented in a semi-quantitative manner through that process (refer to Section 4.1.4.1 for more information). In order to utilize data from a traditional foods dietary study to inform the VCs and sampling locations for the Environmental Media Baseline Program, the dietary study would need to be undertaken in advance of preparation of the final sample design.

Ultimately, the decisions made on the VCs, COPC, number of sampling locations, number of samples, sampling methods, and extent of community training and involvement will have large implications on NWMO's budget for the Environmental Media Baseline Program in the Northwestern Ontario region; therefore, the Study Team will need to work with the NWMO during development of the final study design to ensure budget expectations are respected.

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APPENDICES

APPENDIX A

SUMMARY OF INFORMATION ON PHASE 1 AND 2 REPORTS

APPENDIX A

Log of consulted reports.

Author	Title	Date	APM Report Number	Type of Evaluation	Relevant Component(s) of the Baseline Program						
					General Knowledge	Stakeholder/ Rights-Holder Input	Tissues	Surface Water	Shallow Ground-water	Soil	Air Quality, Noise, and Light
PHASE 1 REPORTS											
SENES Consultants	Phase 1 Preliminary Community Well-Being Assessment – Township of Ignace, Ontario	October 2013	REP-06144-0016	Desktop	X	X					
Golder Associates	Phase 1 Desktop Assessment, Environment Report – Township of Ignace, Ontario	November 2013	REP-06144-0010	Desktop	X			X	X		X
Golder Associates	Phase 1 Desktop Geoscientific Preliminary Assessment of Potential Suitability for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel – Township of Ignace, Ontario	November 2013	REP-06144-0011	Desktop	X			X	X		
JD Mollard and Associates Limited	Phase 1 Geoscientific Desktop Preliminary Assessment, Lineament Interpretation – Township of Ignace, Ontario	November 2013	REP-06144-0014	Desktop					X		
Paterson, Grant & Watson Limited	Phase 1 Geoscientific Desktop Preliminary Assessment, Processing and Interpretation of Geophysical Data – Township of Ignace, Ontario	November 2013	REP-06144-0013	Desktop					X		
JD Mollard and Associates Limited	Phase 1 Geoscientific Desktop Preliminary Assessment, Terrain and Remote Sensing Study – Township of Ignace, Ontario	November 2013	REP-06144-0012	Desktop				X	X		
Nuclear Waste Management Organization	Phase 1 Preliminary Assessments, Summary Findings and Decisions	November 2013	N/A	Desktop	X	X					
PHASE 2 REPORTS											
Tulloch Engineering Inc.	Adaptive Phase Management - Phase 2 Environmental Work, Technical Memorandum 1, Ignace, ON, Version 3.2	February 2018	N/A	Desktop and field	X		X	X	X	X	
Tulloch Engineering Inc.	Phase 2 Preliminary Environmental Studies – Township of Ignace and Area, Ontario	May 2018	REP-07000-0206	Desktop and field			X	X			
Tulloch Engineering Inc.	Adaptive Phase Management - Phase 2 Environmental Work, Technical Memorandum 3, Ignace, ON, Version 2.1	May 2018	REP-07000-0206	Field			X	X	X	X	
Tulloch Engineering Inc.	NWMO Ignace APM Phase II - Environmental Studies Revell Area, 2016 to 2018	July 2018	N/A	Field	X		X	X	X	X	
Golder Associates	Phase 2 Initial Borehole Drilling and Testing, Ignace Area. WP1 Data Report - Completion of Demobilization and Post-construction Activities for /G_BHOI	November 2018	REP-01332-0228	Field						X	
Golder Associates	Phase 2 Initial Borehole Drilling and Testing, Ignace Area. WP2 Data Report - Borehole Drilling and Coring for IG_BHOl.	December 2018	REP-01332-0229	Field					X		
Golder Associates	Phase 2 Initial Borehole Drilling and Testing, Ignace Area. WP3 Data Report - Geological and Geotechnical Core Logging, Photography and Sampling for IG_BHOl.	December 2018	REP-01332-0230	Field					X		
Golder Associates	Phase 2 Initial Borehole Drilling and Testing, Ignace Area. WP4b Data Report - Geomechanical Testing of Core for IG_BHOl.	December 2018	REP-01332-0232	Field					X		
Golder Associates	Phase 2 lnitial Borehole Drilling and Testing, Ignace Area. WP7 Data Report - Opportunistic Groundwater Sampling for IG_BH01.	December 2018	REP-01332-0236	Field					X		
Golder Associates	Phase 2 Initial Borehole Drilling and Testing, Ignace Area. WP5 Data Report - Geophysical Well Logging for IG_BH01	January 2019	REP-01332-0234	Field					X		

Author	Title	Date	APM Report Number	Type of Evaluation	Relevant Component(s) of the Baseline Program						
					General Knowledge	Stakeholder/ Rights-Holder Input	Tissues	Surface Water	Shallow Ground-water	Soil	Air Quality, Noise, and Light
Tulloch Engineering Inc.	Phase 2: Preliminary Environmental Studies, Township of Ignace, Ontario: 2018 Surface Water, Sediment and Soil Quality Monitoring Report, Version 0.1 Draft	February 2019	N/A	Desktop and field				X		X	
Tulloch Engineering Inc.	Map of specific area of interest	March 2019	N/A	Desktop	X			X	X	X	
Tulloch Engineering Inc.	Phase 2: Preliminary Environmental Studies, Township of Ignace, Ontario: Memorandum of 2018 Environmental Field Investigation Methods and Results, Version 0.1 Draft	March 2019	N/A	Desktop and field			X	X	X	X	
MISCELLANEOUS REPORTS											
B. D. Amiro	Baseline Concentrations of Nuclear Fuel Waste Nuclides in the Environment	April 1992	N/A	Desktop	X		X	X		X	X
Ontario Hydro Nuclear	Radiological Pathways Analysis for Chromic Emissions for the Used Fuel Disposal Concept. Support Document A-2, To the Preclosure Environmental and Safety Assessment	December 1993	N/A	Desktop	X			X		X	X
Ontario Hydro Nuclear	Derivation of the Source Term for Chronic Radioactive Emissions from the Used Fuel Disposal Centre During the Preclosure Phase	December 1993	N/A	Desktop	X			X			X
Ontario Hydro Nuclear	The Disposal of Canada's Nuclear Fuel Waste: Preclosure Assessment of a Conceptual System	June 1994	N/A	Desktop	X						
United States Department of Energy	DOE Handbook, Airborne Release Fractions/Rates and Respirable Fractions for Nonreactor Nuclear Facilities, Volume I - Analysis of Experimental Data	December 1994	N/A	Desktop							X
West Kitikmeot Slave Study Society	West Kitikmeot Slave Study - Final report	March 2001	N/A	Desktop		X	X	X			
CTECH Radioactive Material Management	Conceptual Design for a Deep Geologic Repository for Used Nuclear Fuel	December 2002	N/A	Desktop	X						
SENES Consultants	West Kitikmeot Slave Study State of Knowledge Report - 2007 Update	April 2008	N/A	Desktop		X	X	X	X	X	
Nuclear Waste Management Organization	Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel	May 2010	N/A	Desktop	X						
Erik Mårtensson, Lars-Göran Gustafsson, DHI Sverige AB	Hydrological and Hydrogeological Effects of an Open Repository in Forsmark - Final MIKE SHE Flow Modelling Results for the Environmental Impact Assessment	July 2010	N/A	Desktop				X	X		
Lucien Nel	Conventional Safety Assessment of a Used Fuel Repository	September 2010	TM-03620-T10	Desktop	X						
EcoAnalytica	The Terrestrial Ecosystems at Forsmark and Laxemar-Simpevarp - SR-Site Biosphere	December 2010	N/A	Desktop			X				
SENES Consultants	APM Site Boundary Assessment	January 2012	TM-03630-T07	Desktop	X			X			X
ECOMatters Inc.	Field Measurements of the Transfer Factors for Iodine and Other Trace Elements (NWMO TR-2009-35)	November 2012	N/A	Field			X	X		X	
SENES Consultants	Draft Community Profile – Township of Ignace, Ontario	July 2013	REP-06144-0015	Desktop	X						
Nagra	Technischer Bericht 13-01, Standortunabhängige Betrachtungen zur Sicherheit und zum Schutz des Grundwassers	August 2013	N/A	Desktop	X				X		
Nuclear Waste Management Organization	Preliminary Assessment for Siting a Deep Geological Repository for Canada's Used Nuclear Fuel, Findings from Phase One Studies – The Corporation of the Township of Ignace, Ontario	November 2013	REP-06144-0009	Desktop	X		X	X	X	X	X

Author	Title	Date	APM Report Number	Type of Evaluation	Relevant Component(s) of the Baseline Program						
					General Knowledge	Stakeholder/ Rights-Holder Input	Tissues	Surface Water	Shallow Ground-water	Soil	Air Quality, Noise, and Light
Nuclear Waste Partnership LLC (U.S. DOE)	Waste Isolation Pilot Plant Documented Safety Analysis	November 2013	N/A	Desktop	X						
IJC	International Lake of the Woods Basin Water Quality Plan of Study, Covering the Rainy-Lake of the Woods Watershed - Final Report	November 2014	N/A	Desktop		X		X	X		
Nuclear Waste Management Organization	Description of a Deep Geological Repository and Centre of Expertise for Canada's Used Uuclear Fuel	2015	N/A	Desktop	X						
MNRF	Steep Rock Mine Conceptual Rehabilitation Approaches	February 2016	N/A	Desktop	X			X		X	
Nuclear Waste Management Organization	Deep Geological Repository Conceptual Design Report Crystalline / Sedimentary Rock Environment	May 2016	APM-REP-00440-0015 R001	Desktop	X						
Nuclear Waste Management Organization	Sixth Case Study: Reference Data and Codes (NWMO-TR-2016-10)	December 2016	N/A	Desktop			X	X	X	X	X
Nuclear Waste Management Organization	Technical Report: Engagement Activities, 2014 to 2016	March 2017	N/A	Desktop		X					
Nuclear Waste Management Organization	Borehole Drilling: Public and Stakeholder Engagement Report - Ignace and Area	August 2017	N/A	Desktop		X					
Nuclear Waste Management Organization	Post Closure Safety Assessment of a Used Fuel Repository in Crystalline Rock (6th Safety Case Study; NWMO-TR-2017-02)	December 2017	N/A	Desktop	X		X	X	X	X	X
Nuclear Waste Management Organization	Implementing Adaptive Phased Management 2018 to 2022	March 2018	N/A	Desktop	X						
Kelly Liberda & Helen Leung	Preliminary Preclosure Accident Consequence Analysis for the APM Conceptual Design - 18090	March 2018	N/A	Desktop	X						
Canadian Nuclear Safety Commission	Class 1B facilities - Guidance on Deep Geological Repository Site Characterization. Draft. REGDOC-1.2.1	October 2018	N/A	Desktop	X						
Nuclear Waste Management Organization	What we Heard: Implementing Canada's Plan in 2018	December 2018	N/A	Desktop	X						
International Joint Commission	Watershed Board Seeks Public’s Views on Spring Water Levels and Aquatic Ecosystem Health Indicators	February 2019	N/A	Desktop		X		X			
Agnico Eagle Mines Limited	Hammond Reef	May 2019 (accessed)	N/A	Desktop and field	X	X	X	X	X	X	X
Ministry of Natural Resources and Forestry	Wabigoon Forest - 130 (effective on 1997/04/01) Final Plan (2019-2029)	May 2019 (accessed)	N/A	Desktop	X						
Grand Council Treaty #3	Our Nation	May 2019 (accessed)	N/A	Desktop		X					
WP (Wataynikaneyap Power)	Phase 1	May 2019 (accessed)	N/A	Desktop	X	X	X	X	X	X	X
Treasury Metals Inc.	Goliath Gold Project - Environmental Impact Statement	May 2019 (accessed)	N/A	Desktop	X	X	X	X	X	X	X
Nuclear Waste Management Organization	What We're Doing	May 2019 (accessed)	N/A	Field		X		X	X	X	
Nuclear Waste Management Organization	MNRF Ignace Borehole Drilling Project Submission - Initial Borehole Drilling in Ignace/Wabigoon	Unknown (no date)	N/A	Desktop and field	X	X			X		
Nuclear Waste Management Organization	Sample List of Project Interactions in Mining	Unknown (no date)	N/A	Desktop	X						
Nuclear Waste Management Organization	Baseline Monitoring Design and Considerations	Unknown (no date)	N/A	Desktop	X		X	X	X		X
OTHER											
Nuclear Waste Management Organization	Shape Files	Received March 2019	N/A	Desktop	X				X		
Ministry of Environment, Conservation and Parks	Mercury in fish tissue data for lakes in the study area	Received June 2019	N/A	Field			X	X			

APPENDIX B

STAKEHOLDER AND RIGHTS-HOLDER INPUT

APPENDIX B

Stakeholder and rights-holder input.

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
1: ACCESSIBLE, RELIABLE DATA THAT TELLS A LOCAL HOLISTIC STORY				
1F-1: Environmental management specific to our area	1F-1a: Animal behaviour concern	Indirectly	Direct monitoring of wildlife populations and behaviour is outside the scope of the Baseline Program	Noise component of Baseline Program will indirectly investigate effects on wildlife; more specific information would need to be obtained through other studies
	1F-1b: Protecting the environment	Indirectly	The Baseline Program will establish existing environmental conditions in order to provide a reference against which future data can be compared	The sampling locations/boundaries are being selected to capture any areas potentially affected by the Project to ensure they are protected in the long-term
	1F-1c: Aerial survey	Indirectly	This is outside of the scope of the Baseline Program design and will be carried out as part of a separate study; the results will be used to confirm the wildlife Valued Components selected for inclusion in the Baseline Program	This work will be paired with the Biodiversity Study
	1F-1d: Disturbance of wildlife	Indirectly	Direct monitoring of wildlife populations and behaviour is outside the scope of the Baseline Program	Noise component of Baseline Program will indirectly investigate effects on wildlife; more specific information would need to be obtained through other studies
	1F-1e: Non-lethal sampling methods	Y	The Baseline Program will consider non-lethal sampling methods.	N/A
	1F-1f: Water quality	Y	Surface water quality is a component of the Baseline Program	N/A
	1F-1g: Sample/study the ecology of land	Partially	Some information on ecology of the land will be obtained in the Baseline Program (e.g. benthic invertebrate populations).	Separate biodiversity study will be conducted that will provide valuable information on ecology of the land.
	1F-1h: Monitor vegetation	Y	Edible vegetation has been identified as a Primary Valued Component of the tissue component of the Baseline Program	N/A
	1F-1i: Monitor wildlife	Partially	The Baseline Program will evaluate wildlife tissue concentrations, but direct monitoring of wildlife will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	1F-1j: Electrofishing	To be determined	Specific sampling methods for fish tissue cannot be determined until sampling locations, species, etc. are determined	This can be considered when developing the sampling protocol for the fish tissue component of the Baseline Program
1F-2: Relevant locations	1F-2a: Where it is happening	Y	Preliminary study areas have been set, but will be revised based on feedback and suggestions from stakeholders/rights-holders	Input from stakeholders/rights-holders is needed to finalize sampling locations
	1F-2b: Relevant Locations	Y	Preliminary study areas have been set, but will be revised based on feedback and suggestions from stakeholders/rights-holders	Input from stakeholders/rights-holders is needed to finalize sampling locations
	1F-2c: Trials in similar environments	For discussion	This does not meet the initial needs of the Baseline Program	As data are collected, this may be revisited (for future consideration)
1F-3: Test conduction	1F-3a: The equipment is provided	Y	NWMO will ensure people appropriate tools and equipment	N/A
	1F-3b: Direct funds from company/corporation	Y	NWMO will be fully funding the Baseline Program, regardless of who is executing it	N/A
	1F-3c: Qualified inspectors	Y	Local training will be provided as required to ensure that all work is being done by qualified people, as per CSA N288 standards; the data collected will be subject to rigorous QA/QC protocols (that will be defined as part of the Baseline Program design), and will also be reviewed annually by an external consultant to ensure data quality is acceptable and data objectives are being met	N/A
	1F-3d: Proper training	Y	The Baseline Program is being designed to identify opportunities for employment and training of local communities	N/A
	1F-3e: Experienced experts/professional	Y	Local training will be provided as required to ensure that all work is being done by qualified people, as per CSA N288 standards	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
1F-4: Data transparency	1F-4a: Data/research available to public	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party	N/A
	1F-4b: Transparency of info and data	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party, and with maximal input from stakeholders/rights-holders	N/A
	1F-4c: Validity (facts, tests, info)	Y	The final Baseline Program will provide Quality Assurance and Quality Control requirements and methods, and the results will be reviewed annually to ensure they are valid and meeting data quality objectives	N/A
	1F-4d: Decrease in wildlife population reason	Indirectly	The Baseline Program will evaluate wildlife tissue concentrations, but population studies will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	1F-4e: Background info why it's happening	Y	How to account for climate change/overall picture of changing environment is a design goal of the Baseline Program	The contract for analyzing the data collected under the Baseline Program will include requirements for backcasting and including historic information where possible; as there is not much information available, any insight or knowledge from community members would be helpful
1G-1: Understanding local impacts	1G-1a: Grass roots: trapping, hunting, harvesting	Y	It is hoped that tissue samples will be obtained from community members during regular hunting, fishing, and harvesting activities	N/A
	1G-1b: Safety and environment	Y	The goal of the Baseline Program is to establish enough information about the environment to make Project decisions that will protect people and the environment	N/A
	1G-1c: Forestry effects	Y	Although this will not be monitored directly, forestry effects will be captured in the cumulative effects section of the Baseline Program	N/A
	1G-1d: Responsibility for environmental cleanup if a disaster happens?	Indirectly	The Baseline Program will provide baseline conditions that can be used for reference for any cleanup.	NWMO has a commitment to the environment, including any cleanup
1G-2: Health of local ecosystem	1G-2a: Abundance and quality of berries	Y	Berries have been identified as a Primary Valued Component of the tissues component of the Baseline Program for chemical analysis	The NWMO acknowledges that chemistry is only part of the story; additional information related to abundance would need to be considered as part of a separate study
	1G-2b: Harold's blueberries	Y	The sampling locations for the Baseline Program can be selected to specifically capture Harold's blueberries, if this knowledge is shared	N/A
	1G-2c: Wild mushrooms	Y	Consideration was given to sampling of mushrooms in the tissue component of the Baseline Program.	Confirmation of species of highest concern/use/importance by stakeholders/rights-holders would be beneficial to the final Baseline Program design
	1G-2d: Canadian Jays	Partially	Birds in general have been identified as a Primary Valued Component of the tissue component for the Baseline Program for chemical analysis of tissues, but exact species is to be determined; population information can be collected as part of the Biodiversity Study	Chemical analysis of songbirds, such as Canadian Jays, is not recommended as this would require lethal sampling methods. Tissue sampling is considered for the food they eat (e.g. insects), and effects up the food chain can be modelled. Other effects on songbirds and Canadian Jays, such as behaviour and population, would need to be addressed in a separate biodiversity study
	1G-2e: Deer health	Partially	The Baseline Program will evaluate wildlife tissue concentrations, but monitoring of populations and overall health will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	1G-2f: Local cancer rates (people/animals)	Partially	The Baseline Program aims to establish existing environmental conditions; population health effects will be addressed as part of a separate study	The data obtained from the Baseline Program may be incorporated into separate health and well being studies that will directly address these issues
	1G-2g: Wild Flowers	Y	Vegetation chemistry of key edible or medicinal use plants has been identified as a Primary Valued Component of the tissues component of the Baseline Program for chemical analysis.	Clarification, is this flowers that may be consumed? Input on species of highest concern/use/importance by stakeholders/rights-holders would be beneficial. Effects on wild flower populations would be assessed in a separate study.

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
1G-2: Health of local ecosystem (continued)	1G-2h: Bird population health	Partially	The Baseline Program will evaluate wildlife tissue concentrations, but monitoring of populations and overall health will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	1G-2i: Moose health	Partially	The Baseline Program will evaluate wildlife tissue concentrations, but monitoring of populations and overall health will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
1H-1: Quality Control/Quality Assurance	1H-1a: Peer review of analyses	Partially/for discussion	The ERG will conduct a high level review, but not a detailed analysis	The requirement for detailed analysis can be considered
	1H-1b: Accountability (arms-length monitoring)	Y	The monitoring results will be reviewed annually by qualified personnel to ensure the results are valid and meet data quality objectives	N/A
	1H-1c: Auditing (continuous quality improvement)	Y	The monitoring results will reviewed annually to ensure that data are collected following the prescribed protocols and QA/QC measures are being followed; opportunities for improvement will be identified	N/A
	1H-1d: Metadata (public information)	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party	N/A
	1H-1e: Maintenance standards, public information	Y	The Baseline Program design will identify methods for data sharing; the annual reviews of the Baseline Program will analyze the data to identify gaps and updates, including regulatory standard	N/A
	1H-1f: Continuous evaluation and improvement	Y	The Baseline Program will be reviewed annually and revised as needed	N/A
1H-2: Reliable, valid data through expertise, training, and awareness	1H-2a: Select appropriate indicators to measure	Y	Valued Components are being selected with consideration of input from stakeholders and rights-holders	Further input is needed from stakeholders/rights-holders to finalize the Baseline Program (Valued Components, sampling locations, etc.)
	1H-2b: Valid and reliable data collection	Y	The final Baseline Program will provide Quality Assurance and Quality Control requirements and methods, and the results will be reviewed annually to ensure they are valid and meeting data quality objectives	N/A
1H-3: Evolving data collection R/T changing environment	1H-3a: Implementation/training	Y	The Baseline Program is being designed to identify opportunities for employment and training of local communities	N/A
	1H-3b: Operational control (training, who, competency)	Y	Local training will be provided as required to ensure that all work is being done by qualified people, as per CSA N288 standards	N/A
	1H-3c: Adaptive - changes as needed	Y	An adaptive framework is important. The Baseline Program will be reviewed annually and revised accordingly	N/A
	1H-3d: Scientifically based	Y	The Baseline Program is being designed with consideration of scientific rationale and methods, with input from experts on new and emerging technologies	N/A
	1H-3e: Protect integrity of the data collected	Y	The data collected will be reviewed; NWMO is currently reviewing their data management practices and requirements, and how to share the data	N/A
	1H-3f: Expertise (- scientific - environmental - qualified samplers)	Y	The Baseline Program is being designed with consideration of scientific rationale and methods, with input from experts on new and emerging technologies	Hiring of qualified personnel to complete the sampling will be assessed separately by the NWMO
1H-3: Evolving data collection R/T changing environment (continued)	1H-3g: Earwigs (what happened to cause changes?)	Y	How to account for climate change/overall picture of changing environment (i.e., cumulative effects) is a design goal of the Baseline Program	The contract for analyzing the data collected under the Baseline Program will include requirements for backcasting and including historic information where possible; as there is not much information available, any insight or knowledge from community members would be helpful
	1H-3h: Follow industry standard measurement techniques	Y	The Baseline Program is being designed with consideration of standard, regulatory approved sampling and analysis techniques	N/A
2: SPIRIT OF EVERYTHING				
	2B-1a: All wildlife	Y	Wildlife tissue chemistry is a component of the Baseline Program	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
2B-1: Manito Aatsokewinan	2B-1b: Wildlife/all nature	Y	Wildlife tissue chemistry is a component of the Baseline Program	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study
	2B-1c: Plants/medicines	Y	Edible and medicinal plants have been identified as Primary Valued Components of the tissue component of the Baseline Program for chemical analysis of tissue	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study
	2B-1d: Habitat of animals	Y	The Baseline Program is being designed to collect data from the terrestrial and aquatic environments in order to establish existing conditions in various habitats	The data collected will also be incorporated into the Biodiversity Study
	2B-1e: Why are animals and bids getting sick?	Y	How to account for climate change/overall picture of changing environment (i.e., cumulative effects) is a design goal of the Baseline Program	The contract for analyzing the data collected under the Baseline Program will include requirements for backcasting and including historic information where possible; as there is not much information available, any insight or knowledge from community members would be helpful
	2B-1f: Moose	Y	Ungulates (moose, deer) has been identified as a Primary Valued Component of the Baseline Program	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study
	2B-1g: Fish study	Partially	Fish tissue chemistry is a component of the Baseline Program	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study; input from stakeholders/rights-holders on priority fishing locations and species would be beneficial to the final Baseline Program design
	2B-1h: Deer study	Partially	Deer tissue can be sampled as part of the Baseline Program, but study of deer populations is outside of the scope of the Baseline Program design	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study
	2B-1i: Fishing	Partially	Fish tissue chemistry is a component of the Baseline Program	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study; input from stakeholders/rights-holders on priority fishing locations and species would be beneficial to the final Baseline Program design
	2B-1j: Aatsokewinan (Spirit of everything)	Y	Methods for incorporating spirituality and ceremony into the sampling program can be addressed with stakeholders/rights-holders	Further input is needed from stakeholders/rights-holders to identify needs and discuss opportunities and methods for incorporating Spirit
	2B-1k: Importance of water, animals, plants	Y	The Study Team and NWMO recognize the importance of these components and have included them in the Baseline Program design	N/A
2B-1: Manito Aatsokewinan (continued)	2B-1l: All animals, plants, medicines, soil, water	Y	The Study Team and NWMO recognize the importance of these components and have included them in the Baseline Program design	Further input on species of highest importance, important sampling locations, etc. would be beneficial to the final Baseline Program design
	2B-1m: Water	Y	Water chemistry and flow are components of the Baseline Program	N/A
	2B-1n: Fish habitat	Y	The Baseline Program is being designed to collect data from the aquatic environment (surface water, sediment, etc.) in order to establish existing conditions in lakes	The data collected will also be incorporated into the Biodiversity Study
	2B-2a: Finding a way of keeping nature natural	Indirectly	The Baseline Program will establish existing environmental conditions in order to provide a reference against which future data can be compared. Cumulative effects (from other industries such as forestry) will also be captured	The sampling locations/boundaries are being selected to capture any areas potentially affected by the Project to ensure they are protected in the long-term
	2B-2b: Respect the land and the gifts - water	Y	Opportunities for respecting the land, through Ceremony or other identified ways, can be incorporated into the Baseline Program	Further input from stakeholders/rights-holder on opportunities for respecting the land and the gifts is welcomed
	2B-2c: Someone with cultural/Traditional knowledge living the land	Y	The Baseline Program identifies opportunities for incorporating Traditional Knowledge into the design, such as via the Dietary Survey	Further input from stakeholders/rights-holder on opportunities for incorporating Indigenous Knowledge is welcomed

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
2B-2: Manachtooda Kitakeeminan (Natural Law)	2B-2d: Develop a new appreciation for water	For discussion	The Baseline Program can be designed to incorporate non-corporate methods and activities, such as Ceremony, to encourage appreciation of water and the environment as a whole	Further input from stakeholders/rights-holder on how to incorporate non-corporate methods is needed
	2B-2e: Food chain involved 3 generations	Y	The Baseline Program will establish existing environmental conditions in order to provide a reference against which future data can be compared; it can be designed to incorporate non-corporate methods and activities, such as Ceremony	Further input from stakeholders/rights-holder on how to incorporate non-corporate methods is needed
	2B-2f: Offer tobacco to Mother Earth when collecting	Y	This can be incorporated into the design, and can be carried out by community members involved in the sampling process	Further input from stakeholders/rights-holder on opportunities for incorporating this is welcomed
	2B-2g: Respecting nature (protection)	Partially	The Baseline Program is being completed to establish conditions to monitor any potential impacts in the future	N/A
	2B-2h: Knowledge transfer involving our youth	Y	The Baseline Program design identifies opportunities for learning from the community, and sharing this knowledge with youth via involvement in sampling, school visits, etc.	N/A
	2B-2i: Natural Law	Y	The Baseline Program will establish existing environmental conditions in order to provide a reference against which future data can be compared; the Baseline Program is being designed to include all parts of the environment, as all parts are important	N/A
	2B-2j: Elder Knowledge keepers - site visit verification	Y	The Baseline Program design identifies opportunities for community involvement in the site selection and sampling process	N/A
	2B-2l: Water	Y	Surface water parameters, including surface water quality, is a component of the Baseline Program design	N/A
	2B-2m: What happens to animals, will happen to us	Partially	The Baseline Program includes tissue sampling of wildlife so that potential exposures to humans can be estimated in future risk assessment work	N/A
2B-3: Holistic environmental awareness	2B-3a: Environment is a corporate word	For discussion	The Baseline Program can be designed to incorporate non-corporate methods and activities, such as Ceremony	Further input from stakeholders/rights-holder on how to incorporate non-corporate methods is needed
	3B-3b: Our view of the environment is the most important	Y	Stakeholder/rights-holder engagement and input is critical to the Baseline Program design	N/A
	2B-3c: Garbage on water, oil	Y	Contaminants and garbage related to project interactions have been incorporated into the Baseline Program	N/A
	2B-3d: Drugs in the water system	N	Pharmaceuticals in the water system as a result of flushing are not being monitored by the Baseline Program	Not currently incorporated but an issue for discussion going forward
2B-3: Holistic environmental awareness (continued)	2B-3e: Use of spraying	For discussion	Although this will not be monitored directly, forestry effects such as spraying will be captured in the cumulative effects section of the Baseline Program. Glyphosate is not currently included in the list of COPC, but this can be re-evaluated to align with new Impact Assessment regulations	The possibility of including glyphosate as a COPC for plants such as blueberries and wild rice can be discussed
	2B-3f: Effects of spruce bud worm on trees	Indirectly	The Baseline Program will evaluate wildlife tissue concentrations, but population studies will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	2B-3g: Air quality	Y	Air quality is a component of the Baseline Program	N/A
2C-1: Aatsokewinan (all spirits)	2C-1a: Spirituality	For discussion	The Baseline Program can be designed to incorporate non-corporate methods and activities, such as Ceremony, to encourage appreciation of water and the environment as a whole	Further input from stakeholders/rights-holder on how to incorporate non-corporate methods is needed
	2C-1b: Rock - ceremony bringing Rock up to surface that never should have seen light	For discussion	The Baseline Program can be designed to incorporate non-corporate methods and activities, such as Ceremony, to encourage appreciation of water and the environment as a whole	Further input from stakeholders/rights-holder on how to incorporate non-corporate methods is needed
	2C-1c: Anishinaabe ceremonies	For discussion	The Baseline Program can be designed to incorporate non-corporate methods and activities, such as Ceremony, to encourage appreciation of water and the environment as a whole	Further input from stakeholders/rights-holder on how to incorporate non-corporate methods is needed
3: PROTECTION OF LOCAL RESOURCES				
	3A-1a: Accurate presentation of all the facts	Y	The preliminary design for the Baseline Program is being provided to stakeholders and rights-holders for review and input. All data collected in the baseline program will be shared.	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
3A-1: Cooperation between people and the land	3A-1b: Trust - b/w the company and the people surveying the wildlife, water, land	Y	The Baseline Program is being designed to include input from stakeholders/right-holders and identify opportunities for further input in the hopes of fostering a trusting relationship	N/A
	3A-1c: Regular updates	Y	Stakeholders and rights-holders are being informed frequently and at all aspects of Baseline Program design; results of sampling will be made publicly available	N/A
	3A-1d: Transparency	Y	Stakeholders and rights-holders are being informed frequently and at all aspects of Baseline Program design, the data collected will be shared	N/A
	3A-1e: Frequent community discussion	Y	Stakeholders and rights-holders are being informed frequently and at all aspects of Baseline Program design	N/A
	3A-1f: Training for qualifications	Y	The Baseline Program is being designed with consideration of hiring and training stakeholders/rights-holders to be actively involved with the sampling	N/A
3A-2: Prevention and protection	3A-2a: Wolves are increasing	Indirectly	The Baseline Program will evaluate wildlife tissue concentrations, but population studies will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	3A-2b: Spruce bud worm - why?	Y	How to account for climate change/overall picture of changing environment (i.e., cumulative effects) is a design goal of the Baseline Program	The contract for analyzing the data collected under the Baseline Program will include requirements for backcasting and including historic information where possible; as there is not much information available, any insight or knowledge from community members would be helpful
	3A-2c: Are problems curable?	Y	How to account for climate change/overall picture of changing environment (i.e., cumulative effects) is a design goal of the Baseline Program	N/A
	3A-2d: Beaver dams	Indirectly	The Baseline Program includes monitoring of surface water flows (hydrology)	Hydrology can be affected by beaver dams

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
3B-1: Medicines and foods	3B-1a: Roots	Y	Edible plants, including roots, have been identified as a Primary Valued Component of the Baseline Program for chemical analysis of tissue	Input on species of highest concern/use/importance and important locations by stakeholders/rights-holders would be beneficial
	3B-1b: Wild rice	Y	Wild rice has been identified as a Primary Valued Component of the Baseline Program for chemical analysis of tissue	Input on species of highest concern/use/importance and important locations by stakeholders/rights-holders would be beneficial
	3B-1c: Edible plants	Y	Edible plants have been identified as a Primary Valued Component of the Baseline Program for chemical analysis of tissue	Input on species of highest concern/use/importance and important locations by stakeholders/rights-holders would be beneficial
	3B-1d: Water levels	Y	Hydrology, including water levels, is a component of the Baseline Program	Input on waterbodies (rivers, streams, lakes) of particular interest by stakeholders/rights-holders would be beneficial
	3B-1e: Medicines	Y	Medicinal plants have been identified as a Primary Valued Component of the Baseline Program	Input on species of highest concern/use/importance and important locations by stakeholders/rights-holders would be beneficial
	3B-1f: Soil testing	Y	Soil quality is a component of the Baseline Program	N/A
3B-2: Insects and worms	3B-2a: Bees (pollinate, make honey, medicine)	For discussion	The Baseline Program will evaluate wildlife tissue concentrations, but direct collection of bees is not recommended; monitoring of bee populations can be addressed as part of a separate study	Chemical analysis of bees is not recommended as this would require lethal sampling, and local populations are difficult to source; input on importance of honey or other medicine from bees by stakeholders/rights-holders would be beneficial, as bees can be included in the Biodiversity Study
	3B-2b: Insects	Y	Insects have been identified as a Secondary Valued Component of the tissue component of the Baseline Program and are thus an option for inclusion	N/A
	3B-2c: Worms	For discussion	Worms have been identified as Not Required for the tissue component of the Baseline Program (Appendix F) as concentrations can be modelled using soil chemistry data	If stakeholders/rights-holders prefer, worms can be collected for lethal sampling
3C-1: What we protect	3C-1a: Importance of animals, water, plants	Y	The Study Team and NWMO recognize the importance of these components and have included them in the Baseline Program design	N/A
	3C-1b: All animals, plants, medicines, soil, water	Y	The Study Team and NWMO recognize the importance of these components and have included them in the Baseline Program design	N/A
	3C-1c: Water	Y	Surface water parameters, including surface water quality, is a component of the Baseline Program design	N/A
	3C-1d: Fish habitat	Y	The Baseline Program is being designed to collect data from the aquatic environment (surface water, sediment, etc.) in order to establish existing conditions in lakes	The data collected will also be incorporated into the Biodiversity Study
	3C-1e: Impacts of our people if they make money, get trained	Indirectly	The Baseline Program is being designed to maximize community involvement, but impacts on the community will be addressed as part of a separate study	This will be considered as part of a separate socioeconomic study, which will take into consideration the level of community involvement in the Baseline Program
3D-1: Monitoring edible natural plants	3D-1a: Blueberries, cranberries, raspberries	Y	Edible plants, including berries, has been identified as a Primary Valued Component of the tissue component of the Baseline Program for chemical analysis of tissues	Input on important harvesting locations by stakeholders/rights-holders would be beneficial
	3D-1b: Flowering bushes (ruby throated humming bird)	Y	Plants have been identified as a Valued Component of the tissue component of the Baseline Program for chemical analysis of tissue	Input on species of highest concern/use/importance and important locations by stakeholders/rights-holders would be beneficial
	3D-1c: Low bush cranberries	Y	Edible plants, including berries, have been identified as a Primary Valued Component of the tissue component of the Baseline Program for chemical analysis of tissue	Input on important harvesting locations by stakeholders/rights-holders would be beneficial
	3D-1d: Mountain-ash (for jelly and food for birds)	Y	Edible plants have been identified as a Primary Valued Component of the tissue component of the Baseline Program for chemical analysis of tissue	Input on important harvesting locations by stakeholders/rights-holders would be beneficial

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
3D-1: Monitoring edible natural plants (continued)	3D-1e: Traditional medicines (balsam, blueberry stem)	Y	Medicinal plants have been identified as Primary Valued Components of the tissue component of the Baseline Program for chemical analysis of tissue	Input on species of highest concern/use/importance and important locations by stakeholders/rights-holders would be beneficial
4: UNDERSTANDING OF THE WATER SYSTEM				
4B-1: Take care of Nibi (water)	4B-1a: Water quality	Y	Monitoring water quality is a component of the Baseline Program	N/A
	4B-1b: Water sampling	Y	Surface water parameters, including surface water quality, is a component of the Baseline Program design	N/A
	4B-1c: Talk about watersheds	Y	Importance of local watersheds to local communities is being incorporated into the selection of sampling locations for the aquatic environment (surface water quality, sediment, fish, etc.). How the watersheds are all connected is important in designing the Baseline Program.	N/A
4D-1: Water quality	4D-1a: Water quality	Y	Monitoring water quality is a component of the Baseline Program	N/A
	4D-1b: Water environment (fishing, food chain, wild rice)	Y	Surface water parameters and wildlife tissue are components of the Baseline Program	Input on important species and fishing locations by stakeholders/rights-holders would be beneficial
4D-2: Monitor water to keep it in check	4D-2a: Monitor springs	Y	If spring water sources have the potential to be impacted by the Project, then water quality monitoring at these locations can be incorporated into the Baseline Program design	Input from stakeholders/rights-holders on important springs potentially affected by the Project would be required
	4D-2b: Monitor tributaries to Mennin	Y	This can be included when selection monitoring locations for the hydrology component of the Baseline Program design	N/A
	4D-2c: Monitor water quality	Y	Water quality is a component of the Baseline Program	N/A
4G-1: Water quality and education	4G-1a: Water quality of downstream watershed	Y	Downstream locations are included in the surface water quality component of the Baseline Program	Input on important waterbodies by stakeholders/rights-holders would be beneficial
	4G-1b: Water quality	Y	Surface water quality is a component of the Baseline Program	N/A
	4G-1c: Sample fish and water	Y	Monitoring water quality and fish tissue concentrations is a component of the Baseline Program	Input on important species and fishing locations by stakeholders/rights-holders would be beneficial
	4G-1d: Water quality effects	Y	The Baseline Program includes monitoring of surface water quality	N/A
	4G-1e: Health of the population monitor water quality	Y	The Baseline Program includes monitoring of surface water quality	N/A
	4G-1f: Air quality	Y	Monitoring of air quality is a component of the Baseline Program	N/A
	4G-1g: Water quality of spring water	Y	If spring water sources have the potential to be impacted by the Project, then water quality monitoring at these locations can be incorporated into the Baseline Program design	Input from stakeholders/rights-holders on important springs potentially affected by the Project would be required
	4G-1h: Water quality of surface water	Y	Monitoring water quality is a component of the Baseline Program	N/A
4G-2: Engage local stakeholders	4G-2a: Education, employment, youth moving to cities	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities, including youth	N/A
	4G-2b: Local impact	Y	The Baseline Program will establish existing environmental conditions in the local study area, and rely on input from the local communities	The sampling locations/boundaries are being selected to capture any areas potentially affected by the Project, with a focus on areas that are used by community members for hunting, fishing, etc.
	4G-2c: Educate local population	Y	NWMO has been and continues to be active in educating the nearby communities on Project progress, and education is an important component of the Baseline Program design	N/A
	4G-2d: Engage local stakeholders	Y	Input from stakeholders and rights-holders has been incorporated into the preliminary design, and will also be critical to the final design	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	4G-2e: Local jobs for local people	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities	N/A
4H-1: Communication and reporting	4H-1a: Internal/external communication and reporting	Y	Development of a data management tool for the collection, storage, visualization, and sharing of data will be part of the final design	N/A
	4H-1b: Provide clear answers to questions	Y	Every effort is being made to clearly and concisely answer all questions and concerns brought forward by stakeholders and rights-holders	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
and reporting	4H-1c: Addresses priority areas/impacts of nuclear waste storage	Y	Selection of sampling locations for the Baseline Program is being considered with input from stakeholders/rights-holders to help identify priority areas	Further input from stakeholders/rights-holders on areas of high importance for sampling as part of the Baseline Program is welcomed
5: CLEAR AND ACCESSIBLE COMMUNICATIONS				
5B-1: Action and communication	5B-1a: Trust each other	Y	Every effort is being made to address all questions and concerns and share development of the Project and Baseline Program as they progress in the hopes of fostering a trusting relationship	N/A
	5B-1b: Listen to each other	Y	Every effort is being made to address all questions and concerns and share development of the Project and Baseline Program as they progress	N/A
	5B-1c: Meaningful dialogue	Y	Every effort is being made to address all questions and concerns and share development of the Project and Baseline Program as they progress	N/A
	5B-1d: Look at what others have done - nuclear storage comparison	Y	A detailed review was completed in determining potential Project interactions and identifying Constituents of Potential Concern (COPCs)	N/A
5F-1: Public outreach	5F-1a: Social media outlets for transparency	For discussion	The data collected under the Baseline Program will be publically available, but specifics have not been determined	It is intended that there will be a media sharing platform set up; input from the community on preferred options and methods is welcomed
	5F-1b: Pictures to prove their statements	Y	Requirements for taking photos of sampling locations can be incorporated into the design of the Baseline Program, which can then be stored and shared with the public	N/A
	5F-1c: More videos on how to help explain work	Y	Opportunities for training, including videos, can be identified as part of the Baseline Program design	N/A
	5F-1d: Social media page	For discussion	The data collected under the Baseline Program will be publically available, but specifics have not been determined	It is intended that there will be a media sharing platform set up; input from the community on preferred options and methods is welcomed
5G-1: Clear and concise communications	5G-1a: Trustworthy communication of information	Y	Every effort is being made to address all questions and concerns and share development of the Project and Baseline Program as they progress	N/A
	5G-1b: Keep us all informed	Y	The NWMO is sharing progress of the Project and Baseline Program as they progress	N/A
	5G-1c: Honesty	Y	Every effort is being made to address all questions and concerns and share development of the Project and Baseline Program as they progress in the hopes of creating trust between all interested parties	N/A
	5G-1d: Openness	Y	The NWMO is sharing progress of the Project and Baseline Program as they progress. All data collected in the baseline program will be shared.	N/A
	5G-1e: Full information	Y	The NWMO is sharing progress of the Project and Baseline Program as they progress. All data collected in the baseline program will be shared.	N/A
	5G-1f: Communication in languages and methods that are accepted	For discussion	The information and data can be translated	Input from the community is needed to identify preferred translations
	5G-1g: How do we know what to ask	Y	NWMO has been holding information and engagement sessions to help facilitate information exchange	N/A
5H-1: Clear and concise communications	5H-1a: Share information through many mediums	Partially	The Baseline Program Design is considering ways to easily share the data, the mediums will be determined by NWMO	NWMO will consider how to share information on Baseline Program effectively
	5H-1b: Ensure info is relatable (e.g., social media)	Partially	The Baseline Program Design will provide information in a relatable form and will provide recommendations for the data collected. NWMO will decide how this information will be provided.	NWMO will consider how to share information on Baseline Program effectively
	5H-1c: Opportunity to share in all/any languages	For discussion	The information and data can be translated	Input from the community is needed to identify preferred translations
	5H-1d: Literacy make it simple	Y	Efforts are being made to keep the Baseline Program design simple and easy to read	Detailed information is provided in appendices, and the executive summary will be publicly accessible
	5H-1e: K.I.S.S presentation/on web	Y	Efforts are being made to keep the Baseline Program design simple and easy to read - detailed information is provided in appendices, and the executive summary will be publicly accessible	N/A
	5H-1f: Make data readily available / access to data	Y	Development of a data management tool for the collection, storage, visualization, and sharing of data will be part of the final design	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
5H-1: Clear and concise communications (continued)	5H-1g: Training, awareness, competent	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities	N/A
	5H-1h: Design	Y	Efforts are being made to keep the Baseline Program design simple and easy to read	Detailed information is provided in appendices, and the executive summary will be publicly accessible
	5H-1i: Data collection	Y	The Baseline Program is being designed to identify areas where straightforward training to interested community members can be obtained via training videos or via a graded approach directly in the field (high involvement of trained personnel in Year 1, with gradual reduction in oversight in subsequent years)	N/A
	5H-1j: Strategic direction	Y	The Baseline Program is being designed with input from stakeholders and rights-holders	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
6: LOCAL KNOWLEDGE, RESOURCES, AND CONCERNS ARE IMBEDDED IN THE PROGRAM				
6F-1: Local community	6F-1a: Community involvement	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further involvement from nearby communities	N/A
	6F-1b: Involving people from the community x 3	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further involvement from nearby communities	N/A
	6F-1c: Youth involvement programs	Y	The Baseline Program design identifies opportunities for learning from the community, and sharing this knowledge with youth via involvement in sampling, school visits, etc.	N/A
	6F-1d: Community building	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further involvement from nearby communities	N/A
	6F-1e: Committed community group	For discussion	The identification of a committed community group can be included in the Baseline Program	The membership and roles of the community group would be defined based on input from the community
	6F-1f: Local training and employment x 2	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities	N/A
	6F-1g: Community sharing/input	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further input and knowledge sharing from nearby communities	N/A
	6F-1h: Who's involved	For discussion	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities	Input from the community is needed to gauge interest in level of involvement

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
6G-1: End user validation of data	6G-1a: Audit of data collected; needs to be trusted	Y	The data collected will be subject to rigorous QA/QC protocols (that will be defined as part of the Baseline Program design), and will also be reviewed annually by an external consultant to ensure data quality is acceptable and data objectives are being met	N/A
	6G-1b: Monitoring done by those interested in the activity	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities to maintain a high degree of relevance	N/A
	6G-1c: Seasonal changes weather	Y	Seasonality considerations are part of the design of the Baseline Program	N/A
	6G-1d: Boundaries? What is the impact and the footprint?	Y	Study areas for the different components of the Baseline Program are being defined as part of the design	Further input from stakeholders/rights-holders on areas of high importance for sampling as part of the Baseline Program is welcomed
6H-1: Including the community and stakeholders	6H-1a: Community inclusion (Ignace and neighbouring communities)	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further input and knowledge sharing from nearby communities	N/A
	6H-1b: Local participation in program	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further involvement from nearby communities	N/A
	6H-1c: Incorporate human observations and historical knowledge	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further involvement and knowledge sharing from nearby communities. Observations and knowledge provided during sample collection will be captured to help with the interpretation	N/A
	6H-1d: Community partners involved with data collection	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities	N/A
	6H-1e: Community input - all stakeholders	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further input and knowledge sharing from nearby communities	Many areas of investigation have been identifies as requiring further input from stakeholders/rights-holders before the Baseline Program is finalized
	6H-1f: Continuous updates and community involvement	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further input and knowledge sharing from nearby communities	N/A
	6H-1g: Consider ALL options	Y	Details of options are presented in detailed appendix tables, regardless of whether or not the option is preferred	N/A
	6H-1h: Consider current practices of hunting/trapping	Y	Efforts will be made to obtain information on preferred hunting areas and patterns to help inform sample locations	Further input from stakeholders/rights-holders on current hunting and trapping practices (locations, species, etc.) is welcomed
	6H-1i: Stakeholder oversight	Y	The Baseline Program is being designed with input from stakeholders and rights-holders, and with a high priority of identifying opportunities for further input and knowledge sharing from nearby communities	N/A
7: EDUCATION AND TRAINING TO BUILD LOCAL CAPACITY				
7A-1: Education and learning	7A-1a: Qualified worker	Partially	The Baseline Program is designed such that qualified people are always involved in sample collection. The goal is to train local community members to become the qualified personnel.	Hiring of contractors to carry out the Baseline Program will be handled by the NWMO
	7A-1b: Sample dirt for blasto *(assumed this is blastomycosis)*	N	There is currently no known method for measuring levels of blastomycosis in the environment	This can be re-evaluated during the annual reviews to determine whether new methods have emerged to measure it
	7A-1c: Wood ticks - can we get sick if bitten?	N	Although a design goal of the Baseline Program is how to account for climate change/overall picture of changing environment, the abundance of infected ticks and subsequent transmission of diseases is outside the scope of the Baseline Program	The migration of disease-carrying species due to climate change or other factors will be indirectly incorporated into the biodiversity study

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
7A-2: Learning the earth	7A-2a: Sample dirt	Y	Soil quality is a component of the Baseline Program	N/A
	7A-2b: Soil sample	Y	Soil quality is a component of the Baseline Program	N/A
7A-3: Sample training	7A-3a: Sample fish x 2	Y	Fish tissue chemistry is a component of the Baseline Program	Input from stakeholders/rights-holders on priority fishing locations and species would be beneficial to the final Baseline Program design
	7A-3b: Sample water	Y	Water quality is a component of the Baseline Program	N/A
	7A-3c: Fish sampling	Y	Fish tissue chemistry is a component of the Baseline Program	Input from stakeholders/rights-holders on priority fishing locations and species would be beneficial to the final Baseline Program design
7B-1: Nini kong Kaadinaatisiwant (where the water beings live)	7B-1a: Amphibian study frogs/turtle	For discussion	Amphibian tissue sample was considered as part of the Baseline Program. However a full study of amphibians and reptiles would be addressed as part of a separate study	Although tissue can be sampled as part of the Baseline Program, tissue concentrations can also be successfully modelled from water and soil concentrations; a study on amphibian and reptile populations would need to be considered as part of a separate biodiversity study
	7B-1b: Fish study	Y	Fish tissue chemistry is a component of the Baseline Program	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study; input from stakeholders/rights-holders on priority fishing locations and species would be beneficial to the final Baseline Program design
	7B-1c: Fish x 3	Y	Fish tissue chemistry is included in the Baseline Program	Input from stakeholders/rights-holders on priority fishing locations and species would be beneficial to the final Baseline Program design
	7B-1d: Study of insects	Y	Insects have been identified as a Secondary Valued Component of the tissue component of the Baseline Program and are thus an option for inclusion	The NWMO acknowledges that chemistry is only part of the story, and additional information will be collected as part of separate studies, including a biodiversity study
7D-1: Education	7D-1a: Hands-on learning	Y	Opportunities for training, including videos, have been identified as part of the Baseline Program design	N/A
	7D-1b: Teaching the people	Y	Opportunities for training, including videos, have been identified as part of the Baseline Program design	N/A
	7D-1c: Our relationship with the land	Y	The Baseline Program is being designed with consideration of community input and Indigenous Knowledge	N/A
7E-1: 7 Generation and the new 8th	7E-1a: Include different age groups in monitoring process	Y	The Baseline Program design identifies opportunities for learning from the community, and sharing this knowledge with youth via involvement in sampling, school visits, etc.	N/A
	7E-1b: Youth and elders learning together	Y	The Baseline Program design identifies opportunities for learning from the community, and sharing this knowledge with youth via involvement in sampling, school visits, etc.	N/A
8: TWO-WAY KNOWLEDGE SHARING				
8C-1: Ga Kina mot tii min	8C-1a: Community is presented data	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party	N/A
	8C-1b: Ga Kina mot tii min	For discussion	It is unclear what is meant by this	Clarification is required to explain what is meant by this and how it could be incorporated
	8C-1c: Who pays for our studies Joint/alone	Y	NWMO will be fully funding the Baseline Program, regardless of who is executing it	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
8C-2: Circle of knowledge	8C-2a: Elder's knowledge	Y	The Baseline Program identifies opportunities for incorporating Traditional Knowledge into the design	Input from stakeholders/rights-holders on methods of incorporating Elder's knowledge is welcomed
	8C-2b: Elder knowledge and keeper input	Y	The Baseline Program identifies opportunities for incorporating Traditional Knowledge into the design	Input from stakeholders/rights-holders on methods of incorporating Elder's knowledge is welcomed
	8C-2c: Community monitors	Y	The Baseline Program design identifies opportunities for communality involvement in the site selection and sampling process, as community monitors or otherwise	N/A
8D-1: Cooperative oversight	8D-1a: Have professionals involved (training)	Y	The Baseline Program has been designed with consideration of hiring and training local residents to complete aspects of the sampling, which would be done by qualified professionals	N/A
	8D-1b: Specialists for each category	Y	Academic experts that are leaders in their fields have shared knowledge and provided input to the preliminary design of the various components of the Baseline Program	N/A
	8D-1c: Do it together	Y	The preliminary design of the Baseline Program has been created with input from stakeholders and rights-holders, and further input is critical to the finalization of the Baseline Program	N/A
	8D-1d: Train people	Y	Opportunities for training, including videos, have been identified as part of the Baseline Program design	N/A
8E-1: Shared knowledge and transparency	8E-1a: Clear and easy to understand the data presented to us	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party	N/A
	8E-1b: Keep everything known	Y	The NWMO is sharing progress of the Project and Baseline Program as they progress. All data collected in the baseline program will be shared.	N/A
8E:-2: Diversity of knowledge	8E-2a: Monitors with different knowledge bases	Y	The Baseline Program identifies opportunities for involvement of local communities with firsthand knowledge; different people with different knowledge bases can participate in different aspects of the Baseline Program	N/A
	8E-2b: Monitors with varying cultural backgrounds	Y	The Baseline Program identifies opportunities for involvement of local communities with firsthand knowledge; different people with different backgrounds can participate in different aspects of the Baseline Program	N/A
9: ANTICIPATION OF FUTURE NEEDS AND TECHNOLOGY AND LONG TERM COMMITMENT				
9D-1: Long-term commitment to build trust	9D-1a: Be done regularly	Y	The Baseline Program is being designed with regular monitoring of the environment and on-going communication	N/A
	9D-1b: Guarantee long-term commitment	For discussion	Discussions with communities are being held to establish partnerships and determine long-term involvement	Input from the community is needed to determine what these partnerships would ideally look like
	9D-1c: Post results for community	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party	N/A
9E-1: Future technology	9E-1a: Autonomous monitoring system that actively finds new data	Partially	Consideration was given to autonomous monitors (e.g. autonomous remote water quality monitor was one option evaluated).	If any specific monitoring system is identified then this could be considered for inclusion in the Baseline Program design
	9E-1b: Use of satellite and remote technology	Y	The Baseline Program is being designed with consideration of new and emerging technologies, while ensuring that the results will be defensible and statistically sound	N/A
	9E-1c: An active monitor, like Siri or autonomous action unit (machine learning?)	Y	Methods for collecting and accessing data will be developed with consideration of new and emerging technologies	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
9F-1: Anticipation of future events	9F-1a: Chain Reactions (studying aftermath of decisions)	Y	The Baseline Program will undergo annual reviews to ensure it is relevant and collecting the desired data; it will be modified as necessary based on updated information learned from other studies (i.e., Biodiversity Study) and people (i.e., Indigenous Knowledge)	N/A
	9F-1b: What will be affected	Y	The Baseline Program is being designed to consider what components of the environment have the potential to be impacted by the Project	N/A
	9F-1c: What will happen in the future?	Y	The Baseline Program will establish existing environment conditions over multiple years so that current trends can be seen and compared to predictions for the future	N/A
	9F-1d: Year-round observation and research	Y	Some components of the Baseline Program will be monitoring year-round	N/A
	9F-1e: Willingness to make changes	Y	The Baseline Program will be reviewed annually and revised as needed	N/A
9H-1: Sustainable life-long monitoring	9H-1a: Design Stations for 50 years of continuous service	For discussion	The longevity of the monitoring stations has not been set	Input is needed from the community
	9H-1b: Understanding historic pollutants	Y	How to account for climate change/overall picture of changing environment (i.e., cumulative effects) is a design goal of the Baseline Program	N/A
	9H-1c: Sustainability funding for monitoring	Y	NWMO is committed to funding the monitoring should the site be selected	NWMO is looking to help communities set up their own monitoring capabilities (capacity building)
	9H-1d: Implication for all (population, environment, health, social)	Y	Input from discussions will be incorporated	N/A
10: ACCOUNTABILITY TO THE COMMUNITY				
10A-1: Holding each other responsible	10A-1a: Agreed upon standards	Y	The Baseline Program is being developed with consideration of approved regulatory standards, but also with input from stakeholders/rights-holders	N/A
	10A-1b: Firewood for members use wood stoves	For discussion	This is a forest management issue, but NWMO will accommodate this to the extent possible while working within the regulatory framework	Further discussion will be required to look at ways of accomplishing this while adhering to regulatory requirements
	10A-1c: Cultural based	Y	The Baseline Program is being designed with consideration of input from stakeholders/rights-holders, including ways to incorporate cultural traditions such as Ceremony	Further input from stakeholders/rights-holder on opportunities for incorporating cultural traditions is welcomed
	10A-1d: Firewood	For discussion	This is a forest management issue, but NWMO will accommodate this to the extent possible while working within the regulatory framework	Further discussion will be required to look at ways of accomplishing this while adhering to regulatory requirements
	10A-1e: Teaching culture for survival	Y	The Baseline Program is being designed to incorporate as many opportunities as possible for involvement and training of local communities, and to incorporate Indigenous Knowledge	Input on how Traditional practices and health and culture can be integrated is welcomed
10C-1: Community - the people's plan	10C-1a: Community defines what is important	Y	Input from stakeholders and rights-holders has been incorporated into the preliminary design, and will also be critical to the final design	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	10C-1b: Comprehensive community/plan engagement	Y	Input from stakeholders and rights-holders has been incorporated into the preliminary design, and will also be critical to the final design	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	10C-1c: Well though-out program (due diligence, transparency, comprehensive)	Y	The Baseline Program is being developed with consideration of stakeholder/rights-holder input, regulatory standards, statistical and scientific rigour, and all potential Project-environment interactions	N/A
	10C-1d: Length of time for study	Y	The Baseline Program is being designed to be carried out for three years, which is comprehensive for a baseline program study. It will provide the foundation for the monitoring that would be ongoing through all phases of the project.	N/A
	10H-1a: Honesty	Y	Every effort is being made to address all questions and concerns and share development of the Project and Baseline Program as they progress in the hopes of creating trust between all interested parties	N/A
	10H-1b: Transparency x 2	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party, and with maximal input from stakeholders/rights-holders	N/A

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
10H-1: Integrity	10H-1c: Decommissioning strategy and funding transparency	Indirectly	This will be part of the integrated Impact Assessment	Further discussion can be incorporated as part of the partnership discussions
	10H-1d: Share positive and negative information	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party (not hidden/secret), and with maximal input from stakeholders/rights-holders	N/A
	10H-1e: Be straight with the public	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party (not hidden/secret), and with maximal input from stakeholders/rights-holders	N/A
11: INDIGENOUS KNOWLEDGE AND LOCAL WISDOM				
11D-1: Local wisdom	11D-1a: Walleye and northern pike in Mennin	Y	Fish tissue chemistry is a component of the Baseline Program and these species can be evaluated in this waterbody	N/A
	11D-1b: Lake northwest of BH2 has northern pike	Y	This will be considered in the design of the Baseline Program	If this lake is of high importance to stakeholders/rights-holders and has the potential to be impacted by the Project, it can be sampled for northern pike and water quality
11D-2: Preservation of wildlife and forest	11D-2a: Leave timber to preserve wildlife	For discussion	This is a forest management issue, but NWMO will accommodate this to the extent possible while working within the regulatory framework	Further discussion will be required to look at ways of accomplishing this while adhering to regulatory requirements
	11D-2b: Monitor animals	Partially	The Baseline Program will evaluate wildlife tissue concentrations, but direct monitoring of wildlife will be addressed as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	11D-2c: Takes >30 yrs for forest to regrow	Indirectly	The Baseline Program will provide existing conditions in plants against which long-term data can be compared, and health will also be considered as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	11D-2d: Forest loss = wildlife loss	Partially	The Baseline Program will evaluate wildlife tissue concentrations, but direct monitoring of wildlife populations will be considered as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study
	11D-2e: Existing wildlife loss	Indirectly	How to account for climate change/overall picture of changing environment is a design goal of the Baseline Program	The contract for analyzing the data collected under the Baseline Program will include requirements for backcasting and including historic information where possible; as there is not much information available, any insight or knowledge from community members would be helpful
	11D-2f: Monitor 3rd cut health	Indirectly	The Baseline Program will provide existing conditions in plants against which long-term data can be compared, and health will also be considered as part of a separate study	The Baseline Program will aim to establish existing environmental conditions; the tissue data collected under the Baseline Program will be incorporated into the Biodiversity Study

Category and Area of Concern	Specific Concern	Addressed in Baseline Program[a]?	Rationale	Alternate Resolution/Additional Information Needed
11F-1: Cultural consultation	11F-1a: First Nation Involvement	Y	The Baseline Program has been designed with consideration of input from stakeholders/rights-holders, and hiring and training local residents to complete aspects of the sampling; NWMO is working with WLON and others to build their environmental capacity	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	11F-1b: Indigenous Rights	Y	WLON and other Indigenous groups, such as Metis, are being consulted and actively engaged as part of the development of the Baseline Program	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	11F-1c: Cultural consultation	Y	The Baseline Program is being designed with consideration of input from stakeholders/rights-holders, including ways to incorporate cultural traditions such as Ceremony	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
11G-1: First Nations	11G-1a: First Nation inclusion and education	Y	The Baseline Program has been designed with consideration of input from stakeholders/rights-holders, and hiring and training local residents to complete aspects of the sampling; NWMO is working with WLON to build their environmental capacity	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	11G-1b: Languages, communications, remote locations	For discussion	The information and data can be translated, and methods for sharing the information can be discussed	Input from the community is needed to identify preferred translations and methods for data sharing
12: CLEAR PROCESS FOR REVIEW AND TRACEABLE INPUT				
12C-1: Review and action	12C-1a: Peer review by aboriginal groups (e.g.. GCT #3)	Y	The draft Baseline Program design is being provided to stakeholders/rights-holders for input before the plan is finalized	Opportunities for further input from stakeholders/rights-holders have been identified in the design of the Baseline Program
	12C-1b: Independent studies from NWMO	For discussion	NWMO is open to further discussions on this	Further input from the community is needed to define these studies
	12C-1c: Transparency of data	Y	The Baseline Program is being designed with consideration of easy access to the data by any interested party, and with maximal input from stakeholders/rights-holders. All data collected during the program will be shared.	N/A
	12C-1d: Impacts addressed in a timely fashion	Indirectly	The Baseline Program will establish existing environmental conditions in order to provide a reference against which future data can be compared	The data will be analyzed to establish trends so that any impacts can be identified early in the process
12G-1: Clear priorities and resolution	12G-1a: Conflict resolution process (clear and easy)	For discussion	This can be incorporated into the design but further input is needed	Input from community members is required to define the goals and methods of such processes
	12G-1b: Where is the line drawn on compromise ($ and priorities/changes)	Y	The draft Baseline Program design provides recommendations for obtaining scientifically rigorous and defensible data, while trying to work within a reasonable budget	Further input is required from stakeholders/rights-holders and NWMO before the Baseline Program is finalized

Note: [a]Baseline Program - Environmental Media Baseline Program
Numbering is defined as follows: 1A-1a:
1A-1a: Category Number - broad category of concern common to groups
1A-1a: Group Letter (also identified by colour for ease of differentiation)
Group A
Group B
Group C
Group D
Group E
Group F
Group G
Group H
1A-1a: Specific area of concern unique to each group
1A-1a: Concern identified by group
Highlighting signifies opportunities for further input and clarification

APPENDIX C

CONCEPTUAL SITE MODEL

CanNorth
Canada North Environmental Services Limited Partnership
A First Nation Environmental Services Company

TECHNICAL MEMORANDUM

FINAL

Date: **October 8, 2019**

To: **Joanne Jacyk**
Nuclear Waste Management Organization

From: **Baseline Design Project Team**

Subject: **Preliminary Conceptual Site Model for Review and Input**

CanNorth Project No. 3260

Introduction

The Nuclear Waste Management Organization (NWMO) was established in 2002 with the objective of developing and implementing a plan for long-term management of Canada's used nuclear fuel. Since that time, a large amount of consultation, decision making, and studies have been undertaken. This process has included the adoption of Adaptive Phased Management (APM) as the plan, undertaking a siting process for the Deep Geological Repository (DGR) and Centre of Expertise (the Project), and conducting preliminary studies to assess the suitability of communities interested in hosting the Project. Preliminary assessments have included developing community profiles, environmental characterization, heritage, and geophysical studies and mapping, as well as stakeholder engagement in potential host communities. Five communities have been short-listed as project hosts and next steps are completing borehole drilling/testing and more detailed baseline studies in order to select a single preferred site by 2023.

On behalf of the NWMO, Canada North Environmental Services Limited Partnership (CanNorth), in collaboration with its subconsultants, is undertaking the design of an environmental baseline monitoring program (the Baseline Program) to collect data that may be used in stakeholder and first-rights engagement, risk assessment, safety assessment modelling, offset planning, and ultimately an Impact Assessment (IA) for the chosen community. The community selected by the NWMO for this program is Ignace, Ontario, also called the Northwest region. The objective is to complete the design of the Baseline Program for five environmental media (i.e., tissue samples; surface water parameters and hydrology; air quality, noise, and light; shallow groundwater; and soil quality), annual reviews of the program, and a three-year program update.

Background

The purpose of this memo is to provide a draft of the Conceptual Site Model (CSM) that will be used to develop the Baseline Program for the Project. The CSM integrates information from the various disciplines involved in the Project in order to describe the local environment and identify how the various Project components interact with one another and the environment. It is intended to be based on Project- and site-specific information. The development of a robust and solid CSM will be crucial to evaluating the feasibility of various potential sampling programs.

Development of the CSM discussed herein involved a thorough review of documents provided by the NWMO prior to April 20, 2019 related to the DGR in general and environmental work carried out in the Ignace area. It also required the application of numerous assumptions since the facility design and location have not been finalized. Any modifications to these assumptions based on updated design information are likely to impact the CSM and may affect the baseline sampling program design.

This memo provides a narrative description of the study area and existing environment for each medium (e.g., selected receptors, species of conservation concern, contaminants, release mechanisms, environmental fate and transport, etc.), summarizes the project-environment interactions in tabular format, outlines the assumptions used in the development of the CSM, and compiles the information into a graphical CSM. The CSM described herein is not a static document and will be updated as needed as the Project progresses.

The CSM has been prepared with consideration of the following five major stages of the Project (NWMO 2017):

- Construction: The site will be prepared for construction by clearing, site grading, installing fencing, installing temporary construction services, and establishing a storm water management system. The first phase of construction will be to excavate the shafts and an underground demonstration facility. The total site preparation and construction phase could be about 10 years.

- Operation: Operation will consist of receiving used nuclear fuel transported to the site, re-packaging the used fuel into long-lived containers, placing the used fuel containers in the repository, and continued underground development. These operational activities are expected to last about 40 years.

- Extended Monitoring: Following cessation of used-fuel placement activities, the placement rooms will be sealed and closed, but the access tunnels and shafts will remain open. A period of monitoring will continue for an extended period of time. For planning purposes, the period of extended monitoring is assumed to be up to 70 years. The preliminary decommissioning plan will be revised at the commencement of the extended monitoring period. Towards the end of the extended monitoring period, a detailed decommissioning plan will be prepared using information collected during the extended monitoring, and the detailed design of the shaft sealing system will be finalized.

- Decommissioning: The decommissioning of the facility will include sealing of access tunnels and shafts, and removal of surface facilities. The site will be restored to a defined end-state that will depend largely on future plans for the site (e.g., industrial, park). For planning purposes, the period of decommissioning is assumed to be 10-30 years (NWMO 2016, 2017).

- Postclosure: The postclosure period starts at the end of decommissioning, after the shafts have been sealed and the surface facilities have been dismantled. The postclosure period will last approximately one million years (NWMO 2017).

Conceptual Site Model

Study Area and Existing Environment

The NWMO has selected a potential geologically suitable area for the Project that is located approximately 40 km west of Ignace, Ontario, within the northern portion of the Revell Batholith within the Wabigoon Subprovince of the Superior Province in the Canadian Shield. The Wabigoon Subprovince is host to a series of granitic to granodioritic units that intrude metamorphosed volcanic and sedimentary rocks of greenstone belts. These greenstone belts contain a number of base metal (copper, nickel, and lead) and gold occurrences, some of which are located within a 10 km radius of the proposed Site area (Golder 2013). Granitic intrusive units in the area include the Revell, Indian Lake, White Otter Lake, and Basket Lake batholiths (Paterson Grant and Watson Limited 2013).

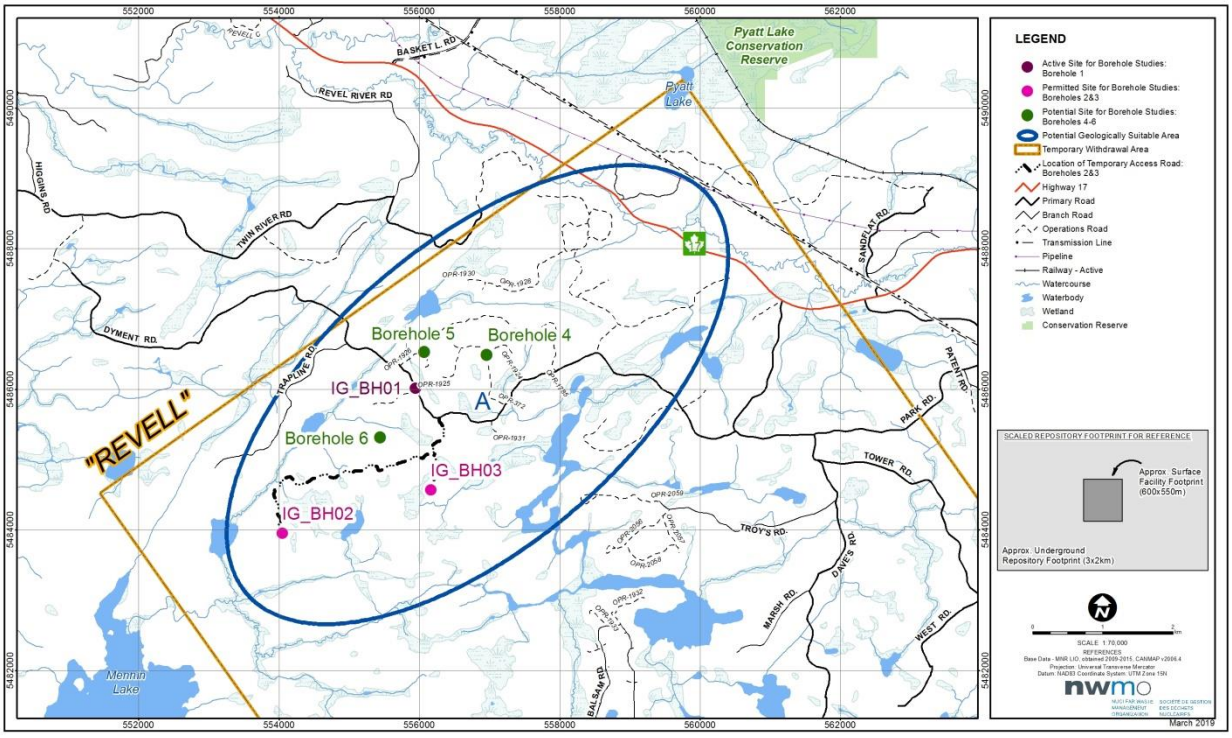
The potential geologically suitable area (Area of Interest, or AOI) is defined by an ellipse (oval) that is approximately 4.4 km by 8.7 km and extends from immediately north of Highway 17 in a southwest direction (see Figure 1). Within the AOI are two primary roads (Dyment and Trapline roads), a network of operations roads and temporary access roads constructed to support borehole drilling and logging, and several small watercourses and wetlands. Based on published maps and aerial photographs of the AOI, it is relatively flat (elevation range of ~30 m) and consists of several small lakes, streams, and wetlands; there are, however, several larger waterbodies in the area, such as Mennin Lake which is located approximately 2 km southwest of the outer extremity of the ellipse delineating the AOI, and Raleigh Lake which is approximately 20 km southeast of the AOI.

The land required to accommodate the Project will include an approximate footprint of 625 m x 700 m for the DGR surface facilities, and an approximate footprint of 500 m x 500 m for the offsite Excavated Rock Management Area (ERMA). Additional land will be required for access roads and potentially for a camp site. The exact location of the Project infrastructure within the AOI is currently unknown.

A series of nested study areas has been established to evaluate the effects of the Project with increasing distance from the Site (Site Study Area [SSA], Local Study Area [LSA], and Regional Study Area [RSA]). For each medium, the SSA will be identical and will be defined by the eventual property boundary of the facility, located somewhere within the AOI. The LSA and RSA for each medium are expected to largely overlap due to the interactions between media (e.g., atmospheric

deposition onto soil); however there may be a different area of focus for each medium as discussed below.

Figure 1 Area of Interest



Aquatic Environment

The Ignace area is drained by the English, Wabigoon, and Turtle rivers, which in turn make up part of the Nelson drainage system. The AOI lies within the Wabigoon watershed, which drains from Raleigh Lake northwest to Wabigoon Lake. Wabigoon Lake, in turn, drains towards the Winnipeg River and the Nelson River, which outlets at Hudson Bay. The northern portion of the area contains several small, connected waterbodies that are currently unnamed. These unnamed waterbodies collectively drain into Mennin Lake, which is located approximately 2 km southwest of the outer extremity of the ellipse delineating the AOI (Figure 1). Mennin Lake flows north into the Mennin River, and then northwest into the Wabigoon River. Other streams in the area appear to be intermittent based on exhibited intermittent subterranean flow (Tulloch 2018a).

The Ignace area contains many lakes of various sizes, 27 of which are larger than 10 km^2 and 10 of which are larger than 20 km^2, with about 18% (1,115 km^2) of the total surface area occupied by waterbodies (JDMA 2013a). The Revell Batholith contains no lakes larger than approximately 5 km^2; the largest lakes on this batholith are Revell Lake (5.1 km^2) and Mennin Lake (4.9 km^2) (JDMA 2013a). Mennin Lake is described by the Ontario Ministry of Natural Resources and Forestry (MNRF) Aquatic Resource Area data as a cool water thermal regime known to support 11 fish species (Tulloch 2018b).

Hydrology

Aerial photos indicate there has been considerable logging in the northeast region of the AOI which will influence the local hydrology, causing more runoff due to a decrease in interception and reduced infiltration. While there is a moderate change in elevation between the lowland areas with wetlands and watercourses, it is unclear whether local flooding occurs within the AOI.

Many of the waterbodies in the AOI are in headwater basins that contribute flow to Mennin Lake, with water flowing generally to the southwest. In addition, the northwest area of the AOI crosses with the ridge line between the Revell River and Mennin River basins, which both eventually go into Wabigoon Lake. Close to Mennin Lake, the surface topography appears to be very flat with multiple stream courses and wetlands criss-crossing the landscape. The largest rivers appear to be the Mennin River to the southwest of the AOI and the Revell River in the northeast section of the AOI. Given the larger flows in these two rivers, they are more likely candidates for water withdrawals and assimilating effluent discharges.

Given the topography, small drainage basins, and number of wetlands it will be important to understand the flow ranges in these streams, including whether some of them are intermittent, whether the wetland areas may be intermittent, and whether any seasonal flooding may occur. Understanding the flows will also inform the site design for water withdrawal needs and effluent discharge needs and how to effectively reduce water quality impacts. Given the location of watercourses and wetlands, there are three or four sites within the AOI that would not impinge upon watercourses or wetlands. This information will be important for the Construction, Operations, and Extended Monitoring phases of the facility.

The Atikokan and Dryden meteorological stations are located approximately 140 km southeast and 65 km west from the AOI, respectively. The Ignace area on average experiences 25 mm to 100 mm of precipitation per month and about 240 cm of snowfall per year, and therefore is unlikely to experience drought conditions that would affect local waterbodies. Local lakes and waterbodies are expected to freeze in the winter months (November to March).

More site-specific precipitation and meteorological data are required to better understand the hydrology in the AOI, especially with regards to seasonal weather patterns (rainfall and snowfall) and assess the potential for flooding and freezing near the facility. This information will also be important for stormwater and hydrology modelling to understand how much water is running off the surface facility and needs to be treated before discharge.

For the hydrological component, the LSA (LSA_{HYD}) is defined by the same boundaries of the AOI (i.e., the ellipse shown in Figure 1). Waterbody maps have confirmed the presence of many wetlands within the LSA_{HYD}. Historic and more recent flow data are not available for the streams within the LSA_{HYD}. More detailed and site-specific information on flow, floods, and wetlands are required to better characterize the LSA_{HYD} and to better understand potential interactions between surface water features and the facility.

Outside of the AOI the RSA_{HYD} is defined by covering areas downstream on the Revell River from the AOI and on Mennin Rivers below Mennin Lake. The baseline conditions on both rivers should be studied to better understand the interactions that may occur from either a water withdrawal or

effluent discharge, which are more likely to occur in these larger rivers than the small streams in the AOI.

Surface Water Parameters (Water and Sediment Quality Markers)

Few studies have been conducted to characterize the aquatic environment in the AOI and the majority have been desktop assessments, such as stream reach classifications. In 2016, some fish community information was collected from select lakes and streams in a larger study area within the Revell Batholith (Tulloch 2018a). Results illustrated that three species (white sucker, blacknose shiner, and Iowa darter) were unique to the Revell Batholith study area (i.e., were not captured in the other study areas investigated within the Ignace region). White sucker were observed at 12 of the 23 sites sampled, but it is not known if they were specifically captured within the current AOI as the AOI only overlaps with a small portion of the larger study area assessed. In 2017, aquatic habitat assessments were conducted within select areas of the AOI in support of borehole drilling and temporary access road development (Tulloch 2018b). Aquatic habitat was documented at one permanent (Mennin Lake Tributary) and two intermittent watercourses in the AOI. The Mennin Lake Tributary was considered direct fish habitat due to the permanence of the watercourse and connectivity to Mennin Lake and the intermittent streams were determined to be indirect fish habitats that act as tributaries to the main watercourse (Tulloch 2018b).

The extent of the LSA for surface water parameters (LSA_{SW}) has yet to be delineated and will depend on Project plans such as the likely location(s) of water withdrawals and effluent discharge, and whether watercourses will be directly impacted by Project infrastructure. It is anticipated that the LSA_{SW} will include waterbodies in the AOI and downstream of Mennin Lake. In addition, the LSA_{SW} may include reference waterbodies such as Cox, Spruce, or Revell lakes located upstream of the AOI within the same Wabigoon watershed.

The RSA_{SW} will incorporate lakes of significance to the communities that are participating in the stakeholder meetings being held by the NWMO. It is noted that stakeholders include rights-holders such as First Nation and Métis communities as well as other parties including local communities and regulatory agencies. The objective of sampling the regional waterbodies is to obtain baseline data on components of concern identified during the stakeholder meetings (such as water quality and invasive species) so that there are baseline data for comparison to long-term monitoring data collected during subsequent Project phases. Waterbodies near to Ignace that may be of fishing importance may include, among others, Agimak, Osaquan, Michel, and Indian lakes; however, none of these lakes are downstream of the AOI.

Hydrogeological Environment

The bedrock geology of the AOI is defined by the Revell batholith, an elongate northwest-trending pluton estimated to be 40 km in length and 10 km to 15 km in thickness. The ~2.67 billion year old batholith is heterogeneous, ranging in composition from tonalitic (plagioclase- and hornblende-rich) to granitic (potassium feldspar-rich). Other mineralogical heterogeneity within the unit occurs in the form of pegmatitic dykes and increased potassium and aluminum-rich minerals (e.g., micas) in zones of weakness. Surficial lineament density in the Revell batholith is high, but it is uncertain if these represent real bedrock structures and how far they may extend to depth (JDMA 2013b; Golder 2013).

Well records in the Ignace area only contain hydrogeological information on the overburden and shallow bedrock aquifers. From the MECP water well database, there are 120 water wells in the Ignace area, of which only 85 provide useful information regarding the aquifer, yields, and other hydrogeological parameters. None of the existing wells are within the AOI, one well is located within the LSA_{HYG} and a portion of the remainder will be within the RSA_{HYG} once that is defined. No information is available on the deep bedrock hydrogeology at the typical repository depth of approximately 500 m. Overburden aquifer wells ranged from 4.5 m to 42 m deep and shallow bedrock aquifer wells ranged from 5.5 m to 154 m deep. Aquifer tests conducted on these wells measured pumping rates of 4.5 L/min to 930 L/min for the overburden layer and 0 L/min to 206 L/min (typically 30 L/min to 40 L/min) for the shallow bedrock (Golder 2013).

The regional groundwater flow of this area typically follows the topography. In the northwest portion of the Ignace area, regional flow can be assumed to be influenced by the Wabigoon River watershed in which the flow direction is towards the northwest (Golder 2013). Limited information is available with regards to the hydrogeological properties of the deep bedrock in the Ignace area. Experience from other areas in the Canadian Shield has shown that groundwater flow in bedrock is generally confined to the shallow fractured bedrock systems. The low topographic relief of the Canadian Shield tends to result in low hydraulic gradients for groundwater movement in the shallow active region (Golder 2013). Literature references from the Whiteshell Research Area, Atikokan, and East Bull Lake reported hydraulic conductivity values between 10^{-15} m/s and 10^{-10} m/s at typical repository depths (between 400 m to 500 m) and an average near-surface value of 10^{-8} m/s.

The fracture networks in the bedrock (shallow and deep) and the bedding structure in the overburden layers will have to be evaluated to determine the site-specific hydrogeology. Hydrogeological parameters of interest include hydraulic conductivity, specific storage, primary/secondary porosity, horizontal/vertical hydraulic gradients, fracture aperture and spacing, and bulk density. The zone of influence (ZOI) of on-site mine water extraction activities should be determined in order to minimize/prevent alteration of the shallow and overall site groundwater flow regime.

The study areas for the shallow groundwater (defined as groundwater within 150 m below ground surface) sampling component of the baseline studies have not yet been fully defined but will include the following:

- LSA_{HYG} – The AOI and portions beyond the AOI that might be considered hydraulically downgradient from the facility that are most relevant to the Project interactions and where target Valued Components (VCs) can be retained. The baseline conditions of the groundwater quality, flow velocity and direction, and yield should be studied to better understand the interactions that may occur from either a groundwater withdrawal or potential chemical interactions from the facility. More detailed and site-specific information on lithology, fracture density, flow direction, hydraulic conductivity and well yields are required to better characterize the LSA_{HYD} and to better understand potential interactions between surface water features, shallow groundwater flow, and the facility.

- RSA_{HYG} – Portions of the Ignace region that stakeholders and rights-holders consider being of high importance and express concern over the potential for Project interactions.

Soil

Soil is the naturally occurring, unconsolidated mineral or organic material at least 10 cm in thickness that occurs at the earth's surface and is capable of supporting plant growth (Soil Classification Working Group 1998). Scientifically, the term "naturally occurring" for soils includes the disturbance of the surface horizons by human activities such as cultivation and logging, but not displaced materials such as stockpiled gravel or excavated rock. The definition of the soil medium for this baseline study is expanded to include soil and rock that is placed on surface as a result of excavation during construction activities (including consolidated and unconsolidated material). Environmental baseline characterization will be required to describe and characterize the distribution of existing surface terrain and associated soil quality and sensitivities within the soils LSA and RSA. Geochemical characterization will also be required to inform decisions on excavated rock and overburden placement within the SSA and ensure that storage of excavated materials is designed using best engineering practices.

Surficial soils in the study area are generally assumed to consist of the erosional-depositional products of Quaternary glacial till. Quaternary units composed largely of glacial till deposits constitute the overburden material at the site area, which is estimated to be between 0 m and 30 m thick and may contain permeable and possibly unconsolidated material. In the vicinity of the site area, approximately 70% of the land surface consists of exposed bedrock or bedrock (Revell Lake batholith) covered by only a thin mantle of unconsolidated Quaternary sediments (Golder 2013; JDMA 2013b).

The study areas for the soil sampling component of the baseline studies have not yet been fully defined but will include the following:

- LSA_{SL} – Includes the land beyond the SSA where there is potential for effects to occur from the Project and where target Valued Components (VCs) can be retained.

- RSA_{SL} – Portions of the Ignace region that stakeholders and rights-holders consider being of high importance and express concern over the potential for Project interactions.

Atmospheric Environment (Air Quality, Noise, and Light)

The local atmospheric environment is characteristic of a northern Ontario air shed, where local, regional, and national/international sources of Contaminants of Potential Concern (COPC) contribute to local air quality. Within the Ignace area, there are several industrial sources that release COPC into the air shed, including the Domtar Inc. Dryden Mill, Produits Forestiers Résolu, Ignace Sawmill, and TransCanada PipeLines Ltd.'s Station 58. These industries contribute to releases of fuel combustion by-products (i.e., CO, NO_X, SO_2, particulates) and in some cases, releases of Volatile Organic Compounds VOCs), Polycyclic Aromatic Hydrocarbons (PAHs), dioxins and furans, metals, chlorinated hydrocarbons, and sulphides. In addition, the intersecting rail corridor and Trans-Canada highway also contribute to releases of fugitive dust as well as fuel

combustion by-products. Diesel-fired power generators in remote First Nations communities also contribute to releases of fuel combustion by-products.

The LSA for air quality (LSA_{AQ}) includes the lands beyond the SSA where there is a potential for air quality effects to occur from the Project. For the purposes of this assessment, this has been defined as the lands within 10 km of the SSA, which includes the nearest community of Borups Corners. Note that there are other sources of air releases in the LSA_{AQ}, such as local industry (e.g. TransCanada Station 58), transportation (e.g., Trans-Canada Highway), and intermittent and seasonal sources (i.e., forest fires) which will contribute to the existing and future air quality conditions within this boundary.

The RSA_{AQ} includes lands beyond the LSA_{AQ} that are relevant to the assessment of long-range air quality effects of the Project on local communities. Typically, the RSA_{AQ} is set with consideration to existing air quality monitoring networks, such as those operated by the Federal and Provincial Governments (Environment and Climate Change Canada [ECCC] and the Ontario Ministry of Environment, Conservation and Parks [MECP]), in order to assist with the description of existing conditions. Given the remote location, there are no existing air quality monitoring stations within a reasonable offset from the AOI. The nearest stations that measure the types of chemical parameters typically included in an Air Quality Assessment are in Thunder Bay (approximately 250 km from the LSA_{ATM}) and Winnipeg (approximately 350 km from the LSA_{AQ}). As a result, the baseline monitoring study is intended to fill this data gap. The RSA_{AQ} has been defined as the lands within 50 km of the LSA_{AQ}, which extends to the Town of Ignace and Dryden.

The local study area for noise (LSA_{NO}) includes the lands beyond the SSA where there is a potential for noise effects to occur from the Project. For the purposes of this assessment, this has been defined as the lands within 5 km of the SSA. Note that there are other sources of noise emissions in the LSA_{NO}, such as transportation sources, which will contribute to the existing and future noise conditions within this boundary. Given the nature of noise propagation, noise emissions are not expected to extend beyond the LSA_{NO} and a regional study area for noise was not assessed.

The study area for the baseline light monitoring is restricted to the SSA given the nature of the surrounding environment (i.e., intrinsically dark). As such, local and regional study areas (LSA_{LGT} and RSA_{LGT}) were not defined.

Tissues

Obtaining and chemically analysing tissue samples is an important component of baseline studies as it provides data to be used in Human Health and Ecological Risk Assessments (HHERAs), the EA, and postclosure safety assessments. It also establishes baseline contaminant concentrations to which data from future monitoring programs can be compared.

Information characterizing habitat types in the AOI is largely based on desktop information with some ground truthing studies. In 2017, environmental studies were conducted in a central portion of the AOI that included three borehole sites, four proposed access road alignments, and areas within 120 m for buffer (Tulloch 2018a). Ecological land classification of this study area identified

15 ecosite types that are considered regionally common. The majority of the TM3 study area (89%) was comprised of undeveloped upland habitat that was almost exclusively dominated by mixes of black spruce and jack pine. Wetlands comprised 11% of the study area and were primarily black spruce dominated swamps (Tulloch 2018a).

As part of the Phase 2 assessments, trail cameras, song meters, bird point counts, amphibian breeding surveys, and an Eastern Whip-poor-will survey were conducted in the AOI; however, these data are not yet available. Thus, site-specific information on wildlife and plant species that occur in the AOI cannot be provided. High level fish, wildlife, and land use information in the Ignace region is available from the Ontario Ministry of Natural Resources and Forestry (MNRF) databases (e.g., fish community composition in larger lakes) and from community sources.

Tourism is an important industry in the region, with the area surrounding the community of Ignace containing numerous provincial parks, conservation reserves, and hunting and fishing lodges (SENES 2013). The community of Ignace website describes some of the most popular hunting targets as being moose, bear, deer, and small game such as grouse and snowshoe hare (https://www.ignace.ca). The NWMO has held several workshops with stakeholders and First Nations' rights-holders to receive input on the environmental baseline study design. Preliminary results indicate that concerns have been expressed over potential Project impacts to hunting (including deer and moose), fishing, berry and mushroom picking, wild rice, birds, and insects. The input received from these workshops has been summarized and provided to the Project Team by the NWMO, and will be considered in the preliminary feasibility report.

The NWMO is currently in the process of trying to obtain information and maps on site-specific land use. This information, if provided, will help define the study areas for the tissue sampling component of the baseline studies. As such, the study areas have not yet been fully defined but will include the following:

- LSA_{TIS} – Portions of the AOI that are most relevant to the Project interactions and contain habitat types where target Valued Components (VCs) can be retained.

- RSA_{TIS} – Portions of the Ignace region that stakeholders and rights-holders consider being of high importance and express concern over the potential for Project interactions.

Valued Components

Potential VCs to consider for the future federal EA which might have residual environmental effects:

Biological Environment	Physical Environment
• Change in populations[1] and/or tissue concentrations of: ○ Berries ○ Honey ○ Wild rice ○ Browse ○ Aquatic vegetation ○ Phytoplankton and zooplankton ○ Benthic invertebrates ○ Edible mushrooms ○ Lichen ○ Terrestrial Insects ○ Fish (various trophic levels) ○ Herptiles ○ Waterfowl ○ Terrestrial birds ○ Songbirds ○ Semi-aquatic, small, and predatory mammals ○ Moose ○ Deer	• Change in aquatic habitat • Change in surface water quantity and quality • Change in sediment quantity and quality • Change in topography • Change in surface soil characteristics and chemistry • Change in runoff characteristics (impervious area, drainage networks) during construction and then during operations • Change in overburden/shallow bedrock/deep bedrock groundwater quantity and quality • Change in surface water– groundwater interactions • Change in slope stability and water quality

[1]Note: The biological environment populations component for this contract is limited to plankton and benthic invertebrates.

It is not anticipated that all of the above-listed VCs will be sampled during the tissue samples component of the Baseline Program. Tissue types to be sampled will be a mixture of the following:

- those relevant to evaluating human exposure to COPC, such as berries, fish, and game,.;
- those relevant to addressing stakeholders and rights-holders concerns, such as fish, wild rice, and game; and
- those relevant to evaluating ecological exposure to COPC, such as browse, aquatic macrophytes, lichen, small mammals and birds, and insects.

Existing environment data will be used to create a list of species known to occur in the local and regional study areas. This information, in combination with input from the stakeholders and rights-holders, the likelihood and significance of Project interactions, and consideration of program objectives, statistical objectives, data quality objectives, data usage, and budget, will be used to select target species for the tissue samples component of the environmental baseline studies.

Potential Project Interactions

For planning purposes, a preliminary description of the Project was developed by NWMO that describes the works and activities likely to be associated with the Construction, Operation, Extended Monitoring, and Decommissioning phases. This understanding forms the basis of the baseline sampling program design. The current surface facilities layout is provided in Figure 2. To focus the baseline data collection program, the Project Team reviewed the preliminary project description to consider where the Project was likely to interact with the environment. The potential Project-Environment interactions are described in Table 1.

Figure 2 Surface facilities layout

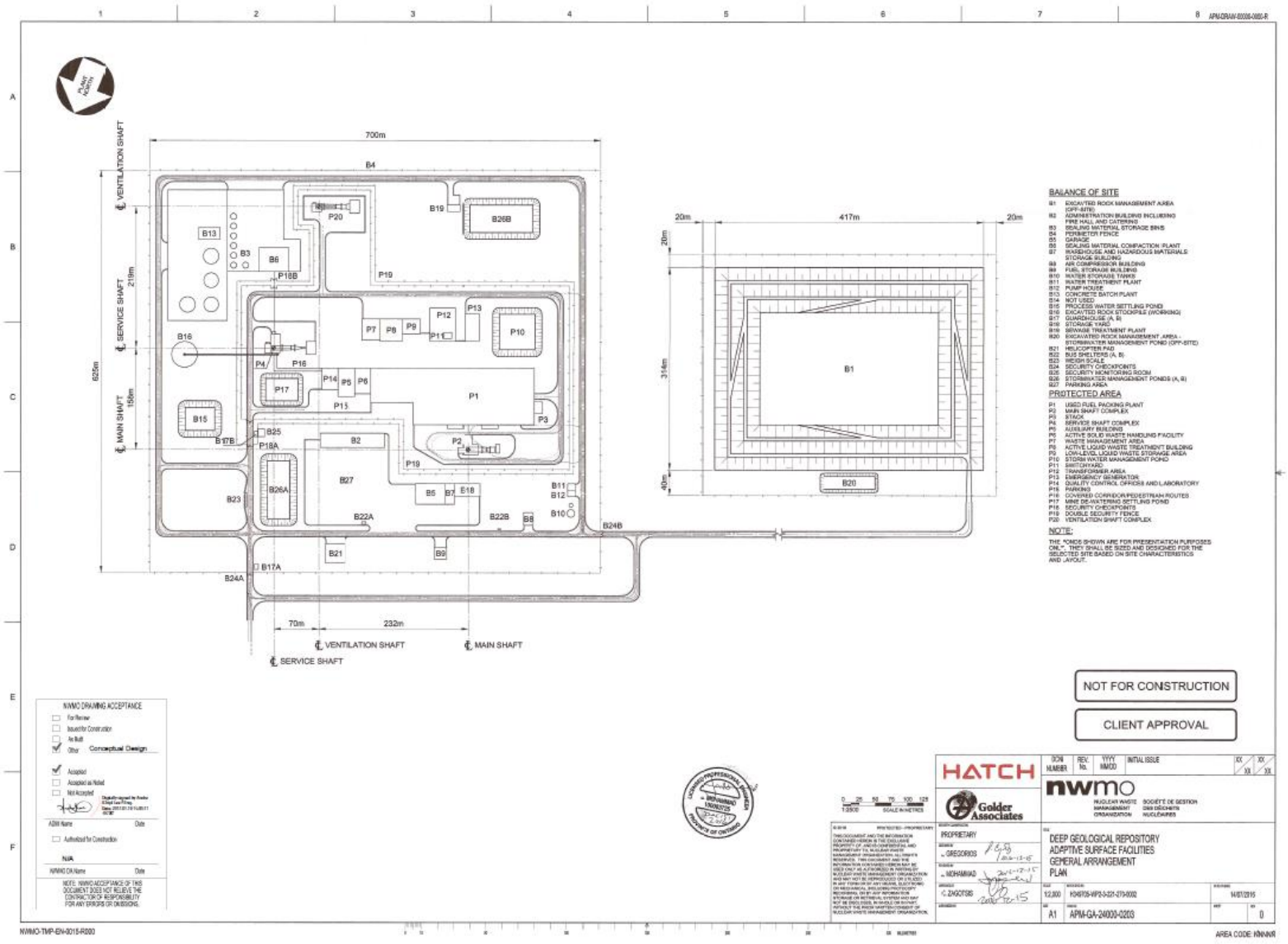


Table 1 Potential Project-environment interactions during the major stages of the Project

Project Phase	Atmospheric Environment	Aquatic Environment	Hydrogeological Environment	Soil	Tissues
Construction	– Increased release of combustion by-product emissions (primarily NOx, CO, SO_2 but also metals and PAHs) due to vehicle/ equipment exhausts and blasting – Increased release of suspended particulate matter (SPM, PM_{10} and $PM_{2.5}$) due to excavation, earth-moving, loading, hauling, dumping, blasting, vehicle travel and exhaust – Increased noise from clearing and machinery – Increased light from lighting at the site	– Water supply requirements may cause lowered water levels and volumes in the source waterbody, potentially impacting aquatic habitat (e.g., reduced flow, increased stream temperature, reducing the volume of aquatic habitat, etc.) – Dewatering could lead to a lowering of groundwater levels, causing surface water drawdown and subsequent water level alterations; this could disturb wetlands and sediments, and lead to changes in geochemical conditions that could potentially result in mobilization of minerals and contaminants – Discharge of treated effluent (sewage, dewatering, stormwater) of unknown quantity and quality to a local waterbody will impact water quantity and quality in the receiving waterbody (Understanding the volume of the effluent discharge and its quality will determine what size and types of waterbodies can be used as receiving waters) – Direct deposition of particulate or runoff containing particulates affecting surface water quality and sediment composition – Discharge of treated runoff of unknown quantity and quality from disturbed soils and off-site excavated rock pile may impact water quantity and quality in the receiving waterbody and sediment composition – Vibrations – Accidental surface releases of fuels could potentially impact surface water and sediment composition	– Dewatering could potentially cause a change in the ambient groundwater flow/transport in the overburden and shallow and deep bedrock layers – Dewatering could lead to a lowering of groundwater levels, causing surface water drawdown; a better understanding of the surface water hydrology and connection to groundwater will be important – Disturbance of fractured rock formation may increase the weathering potential of the shallow bedrock and the connection between shallow and deep bedrock through more open fractures and flow paths – There is the potential for potentiometric surface mounding beneath stormwater management ponds and excavated rock piles – Leaching of metals/minerals and residual explosives from excavated rock and soil can potentially impact the shallow aquifer system; potential for generation of acid rock drainage (ARD) due to sulfide content of the rock – Accidental surface releases of non-radiological chemicals and fuels could potentially impact the shallow aquifer via overburden/shallow bedrock infiltration – Deep groundwater release at surface could impact shallow groundwater chemistry	– Site excavation will disturb ambient overburden conditions – Changes to surface conditions may induce soil disturbance (e.g. erosion/compaction) – Soil and/or sediment disturbance, or fine particle fraction of excavated rock placed on surface may result in aqueous transport of suspended particulates – Leaching of metals/minerals and residual explosives may occur from excavated rock and soil; potential for generation of acid rock drainage (ARD) due to sulfide content of the rock – Accidental surface releases of non-radiological chemicals and fuels could potentially impact soil – Dewatering could lead to a lowering of groundwater levels, causing changes in soil moisture – Deep groundwater release at surface could impact soil chemistry	– Changes in tissue concentrations of COPC in aquatic biota from changes in sediment and surface water quality – Uptake of COPC by plant roots from soil and deposition of dust onto plant leaves – Ingestion of COPC in food (plants, fish, prey) by aquatic and terrestrial animals and biomagnification up the food chain – Soil disturbances introduced by changes in surface conditions may affect plant quantity and quality
Operation	– Increased release of combustion by-product emissions (primarily NOx, CO, SO_2) due to heating and ventilation systems, vehicle/equipment exhausts, emergency generators; – Increased release of suspended particulate matter (SPM, PM_{10} and $PM_{2.5}$) due to fugitive sources (i.e. stockpiles), concrete batching, material handling, dust collectors and ventilation systems, etc. – Potential for releases of radiation/radioactivity and other COPC from material, waste and fuel handling, preparation and storage, ventilation systems.	– Water supply requirements may cause lowered water levels and volumes in the source waterbody, potentially impacting aquatic habitat (e.g., reduced flow, increased stream temperature, reducing the volume of aquatic habitat, etc.) – Dewatering could lead to a cone of depression, causing water drawdown; a better understanding of the surface water hydrology and connection to groundwater will be important – Discharge of treated effluent (sewage, dewatering, stormwater) of unknown quantity and quality to a local waterbody will impact water quantity and quality in the receiving waterbody (Understanding the volume of the effluent discharge and its	– Dewatering could potentially cause a change in the ambient groundwater flow/transport in the overburden and shallow and deep bedrock layers – Dewatering could lead to a cone of depression, causing water drawdown. A better understanding of the surface water hydrology and connection to groundwater will be important – There is the potential for potentiometric surface mounding beneath stormwater management ponds and excavated rock piles – Accidental surface releases of non-radiological chemicals and fuels could potentially impact the shallow aquifer via overburden/shallow bedrock infiltration	– Soil and/or sediment disturbance, or fine particle fraction of excavated rock placed on surface may result in aqueous transport of suspended particulates – Leaching of metals/minerals and residual explosives may occur from waste rock and soil; potential for generation of acid rock drainage (ARD) due to sulfide content of the rock – Accidental surface releases of non-radiological chemicals and fuels could potentially impact soils – Accidental surface releases of radiological contaminants could impact soils	– Changes in tissue concentrations of COPC in aquatic biota from changes in sediment and surface water quality – Uptake of COPC by plant roots from soil and deposition of dust onto plant leaves – Ingestion of COPC in food (plants, fish, prey) by aquatic and terrestrial animals and biomagnification up the food chain

Project Phase	Atmospheric Environment	Aquatic Environment	Hydrogeological Environment	Soil	Tissues
		quality will determine what size and types of waterbodies can be used as receiving waters) – Discharge of treated runoff of unknown quantity and quality from the off-site excavated rock pile may impact water quantity and quality in the receiving waterbody – Accidental surface releases of chemicals, radionuclides and fuels could potentially impact surface water	– Accidental surface releases of radiological contaminants could potentially impact the shallow aquifer via overburden/shallow bedrock infiltration – Failure of seals in monitoring wells could lead to surface water impacts to shallow groundwater, or mixing of groundwater types – Deep groundwater release at surface could impact shallow groundwater chemistry		
Extended Monitoring	– Continued release of combustion by-product emissions (primarily NOx, CO, SO_2) due to heating and ventilation systems, vehicle/equipment exhausts, emergency generators; – Potential for releases of radiation/radioactivity from ventilation systems and other passive releases (although unlikely)	– Water supply requirements may cause lowered water levels and volumes in the source waterbody, potentially impacting aquatic habitat (e.g., reduced flow, increased stream temperature, reducing the volume of aquatic habitat, etc.) – Dewatering (if still required) could lead to a cone of depression, causing water drawdown; a better understanding of the surface water hydrology and connection to groundwater will be important – Discharge of treated effluent (sewage, dewatering, stormwater) of unknown quantity and quality to a local waterbody will impact water quantity and quality in the receiving waterbody (Understanding the volume of the effluent discharge and its quality will determine what size and types of waterbodies can be used as receiving waters) – Discharge of treated runoff of unknown quantity and quality from the off-site excavated rock pile may impact water quantity and quality in the receiving waterbody – Accidental surface releases chemicals, radionuclide and fuels could potentially impact surface water	– Dewatering could potentially cause a change in the ambient groundwater flow/transport in the overburden and shallow and deep bedrock layers – Dewatering could lead to a cone of depression, causing water drawdown. A better understanding of the surface water hydrology and connection to groundwater will be important – There is the potential for potentiometric surface mounding beneath stormwater management ponds and excavated rock piles – Accidental surface releases of non-radiological chemicals and fuels could potentially impact the shallow aquifer via overburden/shallow bedrock infiltration – Failure of seals in monitoring wells or poor abandonment of obsolete monitoring wells could lead to surface water impacts to shallow groundwater, or mixing of groundwater types	– Soil and/or sediment disturbance, or fine particle fraction of excavated rock placed on surface may result in aqueous transport of suspended particulates – Leaching of metals/minerals and residual explosives may occur from excavated rock and soil; potential for generation of acid rock drainage (ARD) due to sulfide content of the rock – Accidental surface releases of chemicals and fuels could potentially impact soils	– Changes in tissue concentrations of COPC in aquatic biota from changes in sediment and surface water quality – Uptake of COPC by plant roots from soil and deposition of dust onto plant leaves – Ingestion of COPC in food (plants, fish, prey) by aquatic and terrestrial animals and biomagnification up the food chain
Decommissioning	– Increased release of suspended particulate matter (SPM, PM_{10} and $PM_{2.5}$) due to building and shaft, underground deconstruction / de-commissioning, and vehicle equipment exhausts – Increased release of combustion by-product emissions (primarily NOx/NO_2, CO, SO_2 but also metals and PAHs) due to vehicle/ equipment exhausts. – Potential for releases of radiation/radioactivity from decommissioning and decontamination activities, ongoing operation of ventilation systems and other passive releases (although unlikely)	– Discharge of treated runoff of unknown quantity and quality from disturbed soils and off-site excavated rock pile may impact water quantity and quality in the receiving waterbody and sediment composition	– Poor abandonment of obsolete monitoring wells could lead to surface water impacts to shallow groundwater or mixing of groundwater types – Poor shaft sealing could lead to surface water impact to shallow groundwater or mixing of groundwater types	– Soil and/or sediment disturbance, or fine particle fraction of excavated rock placed on surface may result in aqueous transport of suspended particulates – Leaching of metals/minerals and residual explosives may occur from excavated rock and soil; potential for generation of acid rock drainage (ARD) due to sulfide content of the rock	– Changes in tissue concentrations of COPC in aquatic biota from changes in sediment and surface water quality – Uptake of COPC by plant roots from soil and deposition of dust onto plant leaves – Ingestion of COPC in food (plants, fish, prey) by aquatic and terrestrial animals and biomagnification up the food chain

Project Phase	Atmospheric Environment	Aquatic Environment	Hydrogeological Environment	Soil	Tissues
Postclosure	– Potential radiological and non-radiological releases over the long-term from waste in the repository after transport	– Potential radiological and non-radiological releases over the long-term from waste in the repository	– Potential radiological and non-radiological releases over the long-term from waste in the repository	– Potential radiological and non-radiological releases over the long-term from waste in the repository	– Potential radiological and non-radiological releases over the long-term from waste in the repository

Assumptions

The current set of project assumptions that have been made to develop the CSM are described below. These assumptions will be carried through the development of year 1 of the baseline sampling program:

- The Project footprint (SSA) will avoid as many waterbodies and wetlands as possible, realizing that it will likely not be possible to entirely avoid wetlands given their abundance in the AOI.

- The above ground features of the facility will consist of five ponds (three storm water management ponds, one process water settling pond, and one mine dewatering settling pond) that have been sized to accommodate a 1-in-500-year storm event. These ponds will be lined to prevent seepage to the groundwater. The mine dewatering settling pond may contain sediments, nitrogen compounds, and high salinity and uranium.

- The above ground facility will be located at higher ground surface elevations in the local topography to be sufficiently above a 1-in-500-year flood event.

- It will be possible to use a watercourse from within or adjacent to the AOI for water withdrawal. Service water will be sourced from a local waterbody and up to 90% of the used water is expected to be recycled. The total annual service water requirements for excavation and other uses will be approximately 110 million litres, while the required water supply rate for the above ground features is expected to be between 97 m^3/day to 134 m^3/day (NWMO 2016).

- Potable water will be produced on site at the water treatment plant using the fresh/fire water tank as a supply source.

- Treated effluent will be discharged during the project phases except for postclosure. On-site treated effluent from dewatering, stormwater run-off, and sewage will be discharged into a single location in the local receiving water course. The receiving waterbody is currently not known, nor is the quantity and quality of effluent; it is assumed that it would likely discharge to the Mennin River or Revell River, due to their larger size (solely based on size of river using aerial photography) and higher assimilative capacity. The amount of water discharged will be greater than the water withdrawn because of the stormwater and dewatering effluent streams. For the design of the surface water component for Year 1 of the Baseline Program, our Project Team is assuming that treated effluent will be discharged through a single discharge point into the Mennin River drainage.

- The stormwater runoff will be captured, treated, and released at the treated effluent release point. Stormwater management ponds will be appropriately designed to minimize the potential of groundwater mounding (assumed that under anticipated conditions, stormwater management ponds are not likely to influence and cause adverse effects on the local shallow groundwater flow.

- Sewage collected from the serviced buildings will be piped to an on-site sewage treatment plant for treatment to provincial standards prior to discharge with the other treated effluent streams.

- Characterization of the overburden unit is required from a desktop study. In some NWMO design reports, if the native overburden has a relatively low infiltration capacity it can be assumed that the impacts from surface water runoff infiltration into the subsurface will be minimal (i.e. additional design safety factor).

- Excavated rock, overburden and soil piles will be designed using best engineering practices. Appropriate covers, underlying pile drainage and liners, and silt curtains will be installed to minimize leaching and ARD generation. Under the anticipated project conditions, excavated rock piles are not likely to influence and cause adverse effects on the local shallow groundwater flow.

- Dewatering rates utilized during the initial construction and operations will not significantly impact off-site and regional groundwater flow regimes. Alteration of the groundwater flow regime could impact native sediments and wetland areas.

- Appropriate operational protocols will be executed during the lifespan of the DGR, and accidental surface releases of non-radiological chemicals and fuels will be prevented to the extent possible.

- Hypothetical Hydraulic Conductivity of Crystalline Rock (NWMO 2016) = 10^{-11} m/s

- Dewatering Sump Pumping Rate (NWMO 2016) = 550 m^3/day

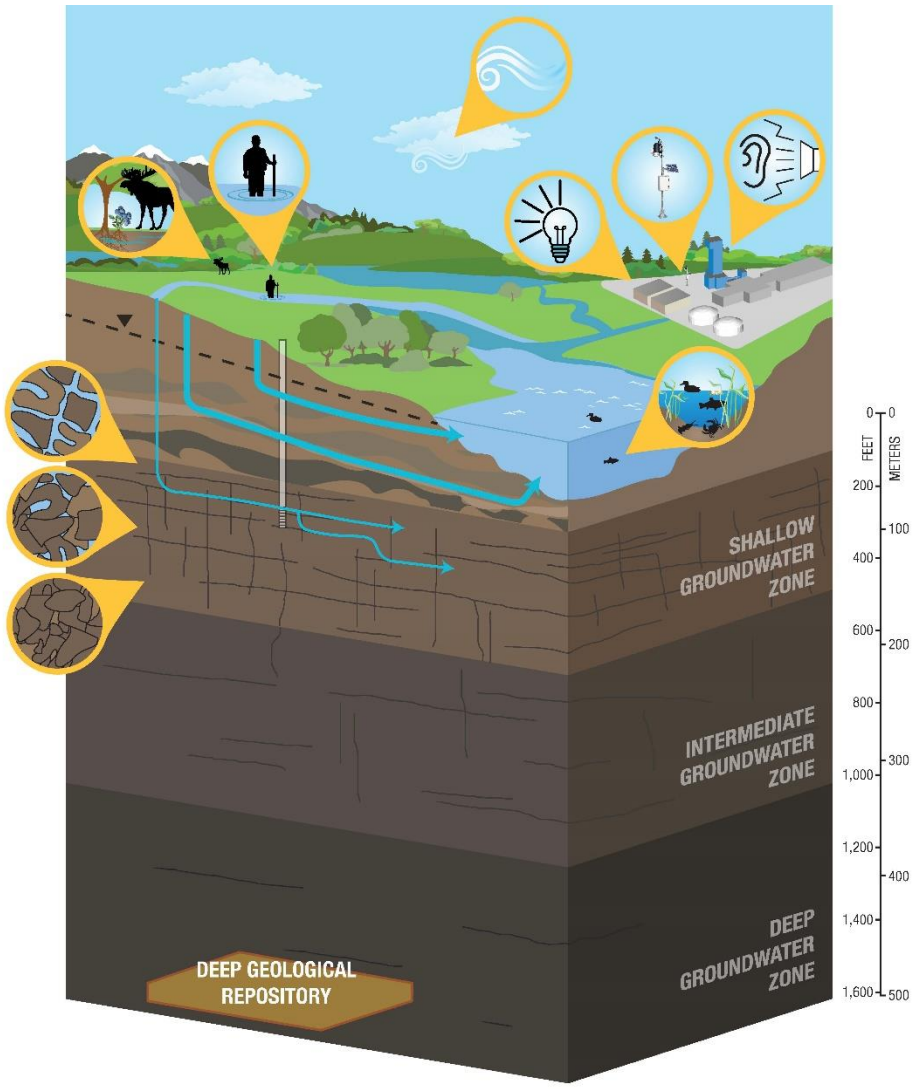
- Given the surficial geology in most of the LSA is bedrock and the high number of wetland areas, surface water does not infiltrate much and instead remains as surface flow that keeps the wetlands wet throughout the summer.

Contaminants of Potential Concern (COPC)

The COPC are discussed separately but include a range of radionuclides, metals, organic compounds, atmospheric parameters (e.g. dust), nutrients, and general chemistry parameters.

Graphical Conceptual Site Model

The figure below provides a graphical representation of the information discussed above, summarizing how the environment may potentially interact with the Project and the environmental fate and transport of possible releases from the DGR.



General Data Gaps

The design of the baseline monitoring program would be greatly aided and can be tailored to be more site-specific if the following information can be provided:

- Identify which receiving waters can assimilate the various effluent discharges from the facility.
- Identify the extent and orientation of the air shed that could be impacted from ventilation system discharges.
- Identify if any of the sites within the AOI flood seasonally or more often.
- Assess how much stormwater will be generated for the facility and the rock pile areas.
- Assess which watercourses can be used as a water supply without adversely impacting the aquatic environment and without costing too much to pump the water uphill.

- Identify abundance and likelihood of occurrence of plant, fish, and wildlife species residing in the AOI, LSA_{SW}, and RSA_{SW}.
- Refine the understanding of the magnitude and quality of the various effluent discharges.
- Better understand the size of the rock pile footprints on the land surface and the characteristics of the rocks and the water quality from erosion due to exposure to rainfall and snow
- Identification of COPC for each phase of the Project.

Additionally, data needs are summarized in Table 2. These data are required to define the site, local and regional-scale boundaries for environmental media and to inform the sampling and analytical Baseline Program design. These are all key data needs; however, much of these data needs are beyond the scope of the Baseline Program, Some parameters could be estimated from literature or proxy location through openly accessed environmental databases (e.g., Environment Canada, MNRF, etc.); however, site specific data are preferable if available. Much of the site-specific bedrock and groundwater characteristics will be collected from various programs during the next few years and integrated in a descriptive geoscientific site model (DGSM).

Table 2 Data Needs

CSM Parameter	Units
Overburden Thickness	M
Overburden Horizontal K	m/s
Overburden Vertical K	m/s
Overburden Specific Storage	1/m
Overburden Porosity	dimensionless
Overburden Lithologic Description	--
Evapotranspiration	mm/d
Runoff	m/s
Rate of capillary rise or upward flow up water into surface soil	mm/s
Surficial Shallow Aquifer Thickness	M
Surficial Shallow Aquifer Horizontal K	m/s
Surficial Shallow Aquifer Vertical K	m/s
Surficial Shallow Aquifer Specific Storage	l/m
Surficial Shallow Aquifer Porosity	dimensionless
Surficial Shallow Aquifer Lithologic Description	--
Shallow Bedrock Mean Aperture	M
Shallow Bedrock Mean Fracture Spacing	M
Shallow Bedrock Matrix Porosity	dimensionless
Shallow Bedrock Fracture Porosity	dimensionless
Shallow Bedrock Equivalent K Horizontal	m/s
Shallow Bedrock Equivalent K Vertical	m/s
Shallow Bedrock Specific Storage	l/m
Deep Bedrock Mean Aperture	M
Deep Bedrock Mean Fracture Spacing	M
Deep Bedrock Matrix Porosity	dimensionless
Deep Bedrock Fracture Porosity	dimensionless
Deep Bedrock Equivalent K Horizontal	m/s

CSM Parameter	Units
Deep Bedrock Equivalent K Vertical	m/s
Deep Bedrock Specific Storage	l/m
Site-Scale Hydraulic Gradient	dimensionless & direction
Regional-Scale Hydraulic Gradient	dimensionless & direction
Recharge/Discharge Locations (Local)	identify
Recharge/Discharge Locations (Regional)	identify
Groundwater/surface water elevations: measured at GW/SW locations on-site or in the regional watershed	m from a reference datum
Groundwater extraction rate (initial construction, within the shallow aquifer/bedrock system)	m^3/day
Groundwater extraction rate (initial construction, within the deep bedrock system)	m^3/day
Groundwater extraction rate (operations, within deep bedrock system)	m^3/day
Waterbodies for water supply (initial construction)	identify
Waterbodies for water supply (operations)	identify
Waterbodies for receiving effluent discharges (initial construction)	identify
Waterbodies for receiving effluent discharges (operations and other project stages)	identify
Waterbody characteristics within the AOI: size, aquatic presence, extent of wetland seasonally	various
Site-specific meteorological data: rainfall and snow, air temperature, relative humidity or dew point temperature, atmospheric pressure, solar radiation, wind speed and direction	various
Site-specific stream flow rate: average (seasonal) and peak flow rates	m/s
Site-specific soil infiltration rate	mm/hr
Estimation of rock extracted through construction and development	mass/time
Refined topography within the AOI	identify

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APPENDIX D

MEMORANDUM ON CONTAMINANTS OF POTENTIAL CONCERN

CanNorth
Canada North Environmental Services Limited Partnership
A First Nation Environmental Services Company

TECHNICAL MEMORANDUM

Date: **November 26, 2019**

To: **Joanne Jacyk**
Nuclear Waste Management Organization

From: **Baseline Design Project Team**

Subject: **List of Constituents of Potential Concern (COPC) for Baseline Design Program – Revision 0**

CanNorth Project No. 3260

Introduction

The Nuclear Waste Management Organization (NWMO) was established with the objective of developing and implementing a plan for long-term management of Canada's used nuclear fuel (through the construction of a Deep Geological Repository [DGR], called the Project). On behalf of the NWMO, Canada North Environmental Services Limited Partnership (CanNorth), in collaboration with its subconsultants, is undertaking the design of an environmental baseline monitoring program (Baseline Program) to collect data that may be used in stakeholder/rights holder engagement, risk assessment, modelling, offset planning, and ultimately an Impact Assessment (IA) for the chosen community. The community selected by the NWMO for this program is Ignace, Ontario, also called the Northwest region. The objective is to complete the design of the Baseline Program for environmental media (i.e., tissue samples, surface water parameters and hydrology, air quality, noise and light, shallow groundwater, and soil quality), annual reviews of the program, and a three-year program update.

The purpose of this memo is to provide information that will be used to select Contaminants of Potential Concern (COPC) that need to be considered in the Baseline Program. The COPC are selected in order to support a baseline monitoring program that would consider all stages of the Project (construction, operation, extended monitoring, decommissioning, and post-closure).

The intent of the baseline program is to define environmental conditions prior to development of the DGR so that effects of constructing and operating the DGR can be measured. Thus the list of COPC needs to be based on Project-environment interactions. Overall, the intent is to develop a COPC list for each media type that is comprehensive, yet achievable, affordable, and captures baseline information most relevant to the Project.

It is noted that there is a very low likelihood of even detecting some COPC, particularly a number of the radionuclides. Therefore there can be different sampling programs for these types of COPC than other parameters. It may also be useful to determine different tiers of priorities for characterization.

Radionuclides

Table 1 provides a complete list of radionuclides that have been associated with the DGR. The selection of which radionuclides to monitor considered whether any of the assessments to date have identified them as a priority and whether they would be expected to be present in the environment as shown in the table.

Baseline levels for a range of radionuclides was previously derived (Amiro 1992; Sheppard and Sanipelli 2011; Sheppard et al. 2011). These values are general in nature, although they are typically sourced from Canadian data. This information can be useful but needs to be augmented by site-specific information for the key radionuclides. Low background concentrations of Cl and ^{36}Cl were idenified in unfiltered water from English River, located close to Ignace, by Sheppard and Sanipelli (2011).

As noted by Amiro (1992) and Sheppard et al. (2011), previous human activities (including nuclear weapons testing) have caused environmental concentrations of some radionuclides that would not otherwise be found in appreciable quantities in nature. It is also discussed that it is likely that concentrations will change in the future due to a variety of anthropogenic processes as well as on-going decay of historical releases (e.g. Sr-90). Global concentrations of I-129 are rising as more fuel reprocessing and fuel waste packaging is done (Sheppard et al. 2011).

A large list of radionuclides were identified in Table 1. Due to the cost and difficulty obtaining samples for analysis of radionuclides different tiers were determined. Tier 1 radionuclides are the highest priority for collecting information to understand the baseline conditions. Tier 2 radionuclides are not expected to be present; however a limited number of confirmation samples would be obtained for most media, but unlikely to be sampled in tissue. Ra-226 will be analysed in groundwater and soil. Based on Table 1 the list of radionuclides to be considered in the Baseline Program includes:

Top tier: H-3, C-14, Sr-90, I-129, Cs-137, Rn-222 (air only), Ra-226 (groundwater and soil only)

Second tier: Cl-36, Co-60*, Se-79*, Ru-106*, Np-237, Pu-238, Pu-239, Pu-240, Pu-241 Am-241, Cm-244

* These radionuclides were identified as Tier 2 but are analysed with Cs-137 so would in essence become Tier 1

In addition, it is expected that the baseline monitoring program would include gross-α and gross-β. It is expected that these parameters would form part of the routine monitoring program to assess potential changes and thus the baseline levels should be characterized.

Gamma radiation will also be characterized (ground survey, passive monitoring in atmosphere).

Metals and Metalloids

Metals and metalloids may be present as a part of fuelling activities, part of the engineered barrier system or released during the project operations. A list of metals and metalloids as well as a rationale for their exclusion/ inclusion is provided in Table 2.

Nutrients

- Ammonia is used during blasting as an agent to fragment rock into useable sizes
- A sewage treatment plant constructed for workers may be a source of nutrient input into the environment.

Nutrients are listed in Table 4.

Organics (PHC, VOCs)

Water, soil, groundwater, and particulate samples can be analysed for Petroleum Hydrocarbons (PHCs) and Volatile Organic Compounds (VOCs) based on the potential release from fuelling activities (Table 3). For VOCs, of particular interest would be Benzene, Toluene, Ethylbenzene, and Xylene (BTEX), which is a by-product of fuelling activities and gasoline emissions. The baseline levels of COPC such as PHC are expected to be low but are characterized in the case of a spill.

The current monitoring program has collected substantial information on most of these COPC in surface water and sediment, thus more information is not required on this medium. In addition, these compounds are not expected to found in tissues as they readily degrade and do not bioaccumulate. Thus, they will be considered for groundwater, soil, and air quality only.

Media-Specific COPC

Air Quality Parameters

For the baseline program, the atmospheric air environment needs to characterize conventional COPC such as:

- carbon monoxide (CO)
- nitrogen oxides (NO_X)
- sulphur dioxide (SO_2)
- volatile organic compounds (VOCs)
- suspended particulate matter (SPM), particulate matter <10 microns (PM_{10}) and particulate matter <2.5 microns ($PM_{2.5}$)
- Ammonia and other nitrogen compounds can be released during the construction phase
- Particulate samples will also be analysed for appropriate radionuclides, metals and PAHs.

Surface Water and Groundwater

Characteristics such as inorganic ions (e.g. sulphate, chloride), general chemistry (e.g. pH, Total Suspended Solids [TSS], hardness, alkalinity) will be analyzed.

Some of the parameters (Dissolved Organic Carbon [DOC], hardness, pH) have the potential to be modifying factors and alter the toxicity of other COPC; therefore, it is important to understand site specific environmental conditions.

Previously, AECL found high levels of uranium in groundwater samples during their environmental monitoring for the underground research laboratory (Betcher et al. 1988). Therefore, uranium will be analysed in groundwater.

Soil

General characteristics such as grain size distribution, Total Organic Carbon (TOC), and Dissolved Organic Carbon (DOC).

Tissue Parameters

The appropriate radionuclides and metals will be analysed in tissue. Other COPC that do not bioaccumulate (e.g. sulphate) or are readily metabolized (e.g. PHC) do not need to be measured.

Consideration is given to measuring methylmercury in fish tissue based on stakeholder/rights-holder concerns regarding mercury, although there are not expected to be any Project interactions.

COPC Not Included

COPC that were identified during consultation but that do not have a Project interaction (e.g., the herbicide glyphosate) are not included. There is the potential for contaminants in the local environment from other industrial or agricultural sources (e.g., dioxins and furans, PCBs, and pesticides); however, these parameters do not have interactions with the Project and were therefore not included in the final list.

Table 1 Detailed list of radionuclides

COPC	Source of List	Priority	Rationale	Include in Monitoring Program	Comment
Radionuclides					
H-3	A, C, E, F	Y	Top contributor to dose (SENES 2012; Liberda and Leung 2018)	Y	Tier 1 – Contributes to dose, levels expected to be relatively uniform across landscape (Sheppard et al. 2011)
C-14	A, B, C, F	Y	Identified for focused modelling for post-closure (NWMO 2017)	Y	Tier 1 - Levels of C-14 will be location specific
Cl-36	B, F	Y	Identified for focused modelling for post-closure (key radionuclide for environment) (NWMO 2017)	Y	Tier 2 - Anthropogenic may be present due to fallout, limited monitoring
P-3	E				
Ar-39	E				
K-40	E				
Ca-41	B, E	Y	Identified for focused modelling for post-closure (NWMO 2017)	N	Anthropogenic
Fe-55	A, C, F				
Co-60	A, C, F	Y	Top contributor to dose (SENES 2012)	Y	Tier 2 – Can contribute to dose, Anthropogenic, limited monitoring
Ni-59	A, C, E, F				
Ni-63	A, C, E, F				
Se-79	B, E	Y	Identified for focused modelling for post-closure (key radionuclide for environment (NWMO 2017))	Y	Tier 2 – Can contribute to dose, Anthropogenic and not expected to be present naturally, limited monitoring
Kr-81	E				
Kr-85	A, C, E, F				
Sr-90	A, B, C, E, F	Y	Top contributor to dose (SENES 2012), confirmed by NWMO (28 May 2019)	Y	Tier 1 – Contributes to dose, levels can be site-specific, may be present due to fallout (much data older and may not represent current levels (Sheppard et al. 2011))
Y-90	E, F				
Zr-93	E				
Nb-93m	E				
Nb-94	A, C, E				
Mo-93	E				

COPC	Source of List	Priority	Rationale	Include in Monitoring Program	Comment
Tc-99	E				
Ru-106	A, C, F	Y	Top contributor to dose (Liberda and Leung 2018)	Y	Tier 2 - Can contribute to dose, Anthropogenic, limited monitoring
Pd-107	B, E				
Cd-113m	E				
Sn-126	B, E				
Sb-125	A, C, E, F				
Sb-126	B, E				
Te-125m	A, C, E, F				
I-129	A, B, C, E, F	Y	Primary dose contributor for post-closure (NWMO 2017)	Y	Tier 1 - Contributes to dose
Cs-134	A, C, F				
Cs-135	B, E	Y	Identified for focused modelling for post-closure (NWMO 2017)	N	Anthropogenic
Cs-137	A, C, F	Y	Top contributor to dose (SENES 2012; Liberda and Leung 2018)	Y	Tier 1 - Contributes to dose, may be present due to fallout
Ce-144	A, C, F				
Pm-147	A, C, F				
Sm-151	F			N	Anthropogenic
Eu-154	A, C, F				
Eu-155	A, C, F				
Hf-182	E				
Ta-182	E				
Pb-205	E				
Pb-210	B, E				
Bi-208	E				
Bi-210	B				
Po-210	B, E				
Rn-222	B	Y	Measure baseline levels for comparison of potential release during construction	Y	Tier 1 – need to establish baseline levels in air, can be site-specific
Ra-223	B, E				
Ra-224	E				
Ra-225	B, E				

COPC	Source of List	Priority	Rationale	Include in Monitoring Program	Comment
Ra-226	B	Y	Used to determine the potential radon release during construction	Y	Tier 1 – need to establish baseline levels, can be site-specific, only required for groundwater and soil
Ra-228	B				
Ac-225	B, E				
Ac-227	B				
Th-227	B				
Th-229	B, E				
Th-230	B, E				
Th-231	B, E				
Th-232	B, E				
Th-234	B				
Pa-231	B				
Pa-233	B, E				
U-232	E				
U-233	B, E				
U-234	A, B, C, F				
U-235	B				
U-236	B, E				
U-238	A, B, C, E, F		Identified for focused modelling for post-closure (NWMO 2017)	N	Baseline levels can be determined from analysis of uranium
Np-237	B, E	Y	Identified as key long-lived radionuclides in fuel		Tier 2 - Anthropogenic and not expected to be present naturally, limited monitoring
Pu-238	A, B, C, E, F	Y	Top contributor to dose (Liberda and Leung 2018)	Y	Tier 2 - Anthropogenic and not expected to be present naturally, limited monitoring
Pu-239	A, B, C, F	Y	Top contributor to dose (SENES 2012; Liberda and Leung 2018)	Y	Tier 2 - Anthropogenic and not expected to be present naturally, limited monitoring
Pu-240	A, B, C, E, F	Y	Top contributor to dose (SENES 2012; Liberda and Leung 2018)	Y	Tier 2 -Anthropogenic, and not expected to be present naturally limited monitoring
Pu-241	A, B, C, E	Y	Top contributor to dose (Liberda and Leung 2018)	Y	Tier 2 - Anthropogenic and not expected to be present naturally, limited monitoring
Pu-242	B, E, F				
Am-241	A, B, C, E, F	Y	Top contributor to dose (SENES 2012; Liberda and Leung 2018)	Y	Tier 2 - Anthropogenic and not expected to be present naturally, limited monitoring
Am-242m	A, C, F				

COPC	Source of List	Priority	Rationale	Include in Monitoring Program	Comment
Am-243	F				
Cm-243	F				
Cm-244	A, C, F	Y	Top contributor to dose (Liberda and Leung 2018)	Y	Tier 2 – Anthropogenic and not expected to be present naturally, limited monitoring
Gross-α			Indicator of a range of radionuclides	Y	
Gross-β			Indicator of a range of radionuclides		

Note:

Source List: A – Operation, Table 2, Table 3 (Ontario Hydro Nuclear 1993); B – Post-Closure, Table 7-25, Table 7-26 (NWMO 2017); C – Operation, Table 3.10 and 3.11 (SENES 2012); D – Operation, identified by NWMO Engineering; E – Table 1 of Amiro (1992), from Zach and Sheppard (1992); F – Accidents (Liberda and Leung 2018).

Green shading – not identified as a priority

Orange shading – priority radionuclide selected for Baseline Program (Tier 1)

Light Orange shading – lower priority radionuclide selected for Baseline Program (Tier 2)

The list of radionuclides selected for focused modelling in NWMO (2017) was based on the radionuclides typically the most important in terms of potential radiological impact and represent a range of low-sorption to high-sorption species.

Table 2 Detailed List of Metals / Metalloids

COPC	Source of List	Rationale	COPC	Source of List	Rationale
Ag	B, E	Typical parameter – standard available	Np	E	
Am	E		Pa	E	
As	E	Typical parameter – standard available	Pb	E	Typical parameter – standard available
B	E	Typical parameter – standard available	Pd	E	
Ba	E	Typical parameter – standard available	Pr	E	
Be	E	Typical parameter – standard available	Pu	E	
Bi	B, E	Batteries, rock	Ra	E	
Br	**B, E**	**Identified as one of most important toxic stable element (Amiro 1992)**	Rb	E	
Cd	**B, E**	Typical parameter – standard available **Identified as one of most important toxic stable element (Amiro 1992)**	Rh	E	
Co		Typical parameter – standard available	Ru	E	
Cr	**E**	Typical parameter – standard available **Identified as one of most important toxic stable element (Amiro 1992)**	**Sb**	**B, E**	Typical parameter – standard available, **Identified as one of most important toxic stable element (Amiro 1992)**
Cs	**E**	**Identified as one of most important toxic stable element (Amiro 1992)**	**Se**	**B, E**	Typical parameter – standard available, **Identified as one of most important toxic stable element (Amiro 1992)**
Cu	**D, E**	Typical parameter – standard available, **Identified by Engineering as a potential COPC**	**Sm**	**E**	**Identified as one of most important toxic stable element (Amiro 1992)**
Eu	E		Sn	E	
Fe	E		Sr	E	
Gd	E		Ta	E	
Ge	E		Tb	E	
Hf	E		Tc	B, E	
Hg	**B**	Typical parameter – standard available, **Concern raised during consultation**	Te	B, E	
I	B, E		Th	E	
In	E		Ti	E	

COPC	Source of List	Rationale	COPC	Source of List	Rationale
Kr	E		Tl		Typical parameter – standard available
La	E		**U**	**E**	Typical parameter – standard available, **Can be used to determine levels of uranium isotopes and uranium series radionuclides in soil and sediment (not all media)**
Mn	E	Typical parameter – standard available	V	E	Typical parameter – standard available
Mo	**B, E**	Typical parameter – standard available, **Identified as one of most important toxic stable element (Amiro 1992), Highest HQ for post-closure (NWMO 2017 sec. 7.11.1)**	W	B, E	
Nb	E		Y	E	
Nd	E		Zn		Typical parameter – standard available
Ni	E	Typical parameter – standard available	Zr	E	Could be associated with project

Source List: A – Operation, Table 2, Table 3 (Ontario Hydro Nuclear 1993); B – Post-Closure, Table 7-25, Table 7-26 (NWMO 2017); C – Operation, Table 3.10 and 3.11 (SENES 2012); D – Operation, Identified by NWMO Engineering; E – Table 1 and Table 2 of Amiro (1992), from Zach and Sheppard (1992) and Goodwin et al. (1987), respectively.
Bold indicates elements that have been identified as being of interest

Table 3 Detailed list of organic Contaminants of Potential Concern

COPC Group	COPC[a]	Rationale	Include in Baseline Program
PAHs	Acenaphthene*, Acenaphthylene*, acridine, anthracene, benzo[a]anthracene*, Benzo[b&j]fluoranthene, Benzo[a]pyrene*, Benzo[b]fluoranthene*, Benzo[g,h,i]perylene, Benzo[k]fluoranthene*, Chrysene*, Dibenzo[a,h]anthracene*, Fluoranthene*, Fluorene*, Indeno[1,2,3-cd]pyrene*, 1-Methylnaphthalene, 2-Methylnaphthalene, Naphthalene*, Phenanthrene*, Pyrene*, Quinoline	Priority PAH used in fueling activities[b], listed in the DGR Conceptual Site Design report (NWMO 2016)	Y (surface water, tissue not required)
VOCs	Acetone, Benzene*, Bromodichloromethane, Bromoform, Bromomethane, Carbon Tetrachloride, Chlorobenzene, Chloroform, Dibromochloromethane, Dichlorobenzene, 1,2-, Dichlorobenzene, 1,3-, Dichlorobenzene, 1,4-, Dichlorodifluoromethane, Dichloroethane, 1,1-, Dichloroethane, 1,2-, Dichloroethylene, 1,1-, Dichloroethylene, 1,2-cis-, Dichloroethylene, 1,2-trans-, Dichloropropane, 1,2-, Dichloropropene, 1,3-, Ethylbenzene*, Ethylene dibromide, Hexane (n), Methyl Ethyl Ketone, Methyl Isobutyl Ketone, Methyl tert-Butyl Ether (MTBE), Methylene Chloride, Styrene, Tetrachloroethane, 1,1,1,2-, Tetrachloroethane, 1,1,2,2-, Tetrachloroethylene, Trichloroethane, 1,1,1-, Trichloroethane, 1,1,2-, Trichloroethylene, Trichlorofluoromethane, Toluene*, Vinyl chloride, Xylenes*	VOCs used in fueling activities	Y (surface water, tissue not required)
Cyanide		exceeded WQG in Tulloch monitoring	Y
PHC	PHC F1, PHC F2, PHC F3, PHC F4	PHCs used in fueling activities	Y (surface water, tissue not required)
Organochlorine insecticides[c]	DDT,DDD, Dicofol, Eldrin, Dieldrin, Chlorobenziate, Lindane, BHC, Methoxychloro Aldrin, Chlordane, Heptaclor, Endosufan, Isodrin, Isobenzan, Toxaphene, Chloro propylate	Listed in the DGR Conceptual Site Design report (NWMO 2016)	N – not expected to change as a result of project
PCBs[c]	PCB mixture	Listed in the DGR Conceptual Site Design report (NWMO 2016)	N – not expected to change as a result of project
Dioxins and Furans	Polychlorinated dibenzo-p-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs)	Not expected, activities at the site are not expected to produce these	N – not expected to change as a result of project
SVOCs	E.g., Phenols	Phenols may be used in industrial processes or in explosives	Y

Note: * - identified as a priority COPC
[a]Suite of individual chemicals analyzed by the lab may vary from the list provided
[b]PAHs used in diesel emission, diesel fuel and lubricant fuel and lubricant oil, as reported in Vieira de Souza and Corrêa (2016)
[c]COPC groups analyzed together.

Table 4 Detailed list of nutrients

COPC[a]	Rationale	Include in Monitoring Program
Sulphate	Ammonia used as a blasting agent. Other nutrients may be elevated in the environment due to the sewage treatment plant.	Y[b]
Anion and Cation Sum		Y[b]
Turbidity		Y[b]
Dissolved Organic Carbon (DOC)		Y[b]
Dissolved Calcium and Magnesium		Y[b]
Total Ammonia-N		Y[b]
Nitrogen		Y[b]
Nitrate (NO_3) and Nitrite (NO_2)		Y[b]
Total Dissolved Solids		Y[b]
Total Inorganic Carbon (TIC)		Y[b]
Total Kjeldahl Nitrogen		Y[b]
Total Organic Carbon (TOC)		Y[b]
Total Phosphorus (Colourimetric)		Y[b]
Total Suspended Solids		Y[b]

Note:
[a]This parameter is calculated, not analyzed by the lab.
[b]Part of the program, but not relevant or included for all media

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APPENDIX E

DETAILED INFORMATION ON STUDY DESIGN OPTIONS

Appendix E, Table 1

Preliminary design options for the tissue chemistry component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Option 1 - Primary VCs only												
Aquatic Piscivore Large-bodied Fish Tissue Chemistry	Characterize baseline chemistry of flora and fauna in the LSA and RSA.Data needed for IA, modelling, and to compare with future monitoring data Stakeholders and rights-holders identified fish as one of the most important VCs during NWMO consultations	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release, and/or sediments	Year 1 = Walleye 3 LSA and 4 RSA Year 2 = Northern pike 3 LSA and 4 RSA Year 3 = Lake trout/burbot 4 LSA	Year 1 = walleye from 7 locations Year 2 = northern pike from 7 locations Year 3 = lake trout/burbot from 4 locations Cost estimate assumes 5 fish/location (n = 90)	Tissue sampling will be paired with surface water sample waterbodies where applicable Targeted lethal sampling using standard fishing methods is recommended. Fish processing procedures will include fish health, length, and weight Fish ageing structures will also be collected from each fish sampled	Community members are field assistants Locations and species will be determined after further consultation with stakeholders/ rights holders on important waterbodies, harvest locations, and species of most concern.	**Radionuclides:** Gross-α, Gross-β, Sr-90, I-129, Cs-137 (Co-60, Se-79, Ru-106) **Metals (total):** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium, **Other:** Cyanide and % moisture	• 100 g minimum weight/sample needed to analyse radionuclides, metals, cyanide, and % moisture and 500 g minimum weight/sample needed to analyse the above parameters + Gross-α and Gross-β with acceptable method detection limits • Metals and % moisture will be run when sample weights cannot be achieved • Standard laboratory ICP-MS procedures completed	Standard maintenance for fishing equipment	• Local and traditional knowledge will be utilized to determine target species and locations of importance, as well as gain access and utilize traditional sampling techniques if available • Sample weight is likely large enough to analyse all COPC • Follows accepted regulatory procedures • More cost effective than including secondary VCs • Best practice during baseline studies to collect samples of traditional foods (other than fish) consumed by rights holders	• Lethal sampling is required to meet sample weight requirements for COPC analyses • Does not involve an emerging technology	Fish collection permits are required by the Ministry of Natural Resources and Forestry (MNRF)
Aquatic Benthivore Large-bodied Fish Tissue Chemistry			Year 1 = White sucker 3 LSA and 4 RSA Year 2 = Lake whitefish 4 RSA Year 3 = Cisco/Lake Sturgeon (if present) 4 LSA	Year 1 = white sucker from 7 locations Year 2 = lake whitefish from 4 locations Year 3 = cisco/lake sturgeon from 4 locations (if present) Cost estimate assumes 5 fish/location (n = 75)								
Aquatic Vegetation Macrophyte Chemistry	Characterize baseline chemistry of flora and fauna in the LSA and RSA. Data needed for IA, modelling, and to compare with future monitoring data Known traditional food/medicine source	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release, and/or sediments	Year 1 = Sedge species 3 LSA and 1 RSA Year 2 = Wild Rice/Manoomin 4 RSA Year 3 = Sweet Flag/Rat Root 2 LSA and 2 RSA	Year 1 = sedge samples from 4 locations Year 2 = wild rice/manoomin samples from 4 locations Year 3 = sweet flag (rat root/ or other) samples from 4 locations Cost estimate assumes 5 roots/location + 5 sedge shoots/location (n = 80)	Aquatic roots (sedge, wild rice, and rat root) and aquatic shoots (sedge only) in each location where harvested Where possible, aquatic macrophyte samples will be collected at waterbodies where surface water and/or fish tissue are collected				• Standard equipment maintenance • Permission should be granted before sampling program begins and proper cultural protocols should be followed when sampling these species if permission is granted		• May be difficult to obtain sample weight requirements • Sampling of certain species in large quantities may effect rights holders' harvest activities • Does not involve an emerging technology	N/A
Aquatic Waterfowl Herbivore Tissue Chemistry	Characterize baseline chemistry within the aquatic environment in the LSA and RSA. Data needed for IA, modelling, and to compare with future monitoring data Known traditional food source that is hunted within the RSA	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release, and/or sediments	1 LSA and 2 RSA	Year 1 = Canada goose or cackling goose from 3 locations Years 2 and 3 = n/a Cost estimate assumes 5 birds/location (n = 15)	Waterfowl will be hunted during the fall hunting period using steel shot	Samples will all be collected by a professional biologist with one stakeholder/one rights holder hunter. Locations and species will be determined after further consultation with stakeholders/ rights holders on important waterbodies, harvest locations, and species of most concern.			Standard equipment and maintenance		• Lethal sampling is required to meet sample weight requirements for COPC analyses • May be difficult to obtain sample weight requirements • Sampling of certain species in large quantities may effect rights holders' harvest activities • Does not involve an emerging technology • For migratory species, such as ducks, diets (and therefore chemistry) can reflect exposure to COPC outside the LSA	• Individuals are required to possess a valid federal Migratory Game Bird Hunting Permit with a Canadian Wildlife Habitat Conservation Stamp to hunt migratory birds in Canada • A special collection permit would be required if targeted outside the Ontario hunting window
Aquatic Waterfowl Omnivore Tissue Chemistry			1 LSA and 2 RSA	Year 2 = dabbling duck species (mallard, shovelers, black duck) from 3 locations Years 1 and 3 = n/a Cost estimate assumes 5 birds/location (n=30)								
Terrestrial Ungulate Tissue Chemistry	Characterize baseline chemistry within the aquatic environment in the LSA and RSA. Data needed for IA, modelling, and to compare with future monitoring data Known traditional food source that is hunted within the RSA and culturally significant; characterize baseline chemistry of moose and deer flesh and organs consumed in region. Stakeholders and rights-holders identified moose and deer as important VCs during NWMO consultations.	Uptake of COPC from aquatic and terrestrial food chain. Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release, sediments, soils, and/or air dispersion	LSA/RSA; UTMs will be collected by hunter where the animal was harvested as animals have large range	Year 1 , 2, and, 3 =10 moose (n=5) deer (n=5) Cost estimate assumes 10 samples/year (n=30)	Opportunistic samples will be retained from stakeholder/rights holders during their routine harvesting activities. Community liaisons from the stakeholder/rights holders (FNs and Metis) will be identified to help to coordinate sample collection. Harvester will be asked to submit an incisor (if available) for ageing purposes.	Stakeholders/ rights holders will be essential to the success of this VC and submitting samples voluntarily will be required.	**Radionuclides**: Gross-α, Gross-β, Sr-90, I-129, Cs-137 (Co-60, Se-79, Ru-106) **Metals (total)**: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium, **Other:** Cyanide and % moisture	• 100 g minimum weight/sample needed to analyse radionuclides, metals, cyanide, and % moisture and 500 g minimum weight/sample needed to analyse the above parameters + Gross-α and Gross-β with acceptable method detection limits • Metals and % moisture will be run when sample weights cannot be achieved • Standard laboratory ICP-MS procedures completed	Standard equipment maintenance	• High level of stakeholder and rights-holder involvement • Study areas are relevant to community members and they feel engaged (community-driven sampling) • Avoids targeted lethal sampling specifically for the baseline program • Costs are minimal	• Samples are dependant on hunting success, season, and sample submission • Strong community support and relations is needed • All relevant study areas may not be represented • Does not involve an emerging technology • Substantial sample size is required to complete all analyses	A special collection permit from either the Ministry of Environment and Climate Change or the Ministry of Natural Resources and Forestry (MNRF) may be needed as any samples gathered under "treaty rights" cannot be targeted and gifted to individuals other than immediate family
Terrestrial Ungulate Organ Chemistry				Year 1 , 2 and, 3 =20 moose liver (n=5) and kidney (n= 5) deer liver (n=5) and kidney (n=5) Cost estimate assumes 10 samples/year (n=60)								
Terrestrial Upland Game Bird Tissue Chemistry	Characterize baseline chemistry within the aquatic environment in the LSA and RSA. Data needed for IA, modelling, and to compare with future monitoring data Known traditional food source that is hunted within the RSA	Uptake of COPC from food sources, water, and/or soil through runoff, accidental surface release, air, and wind during construction a phases	1 LSA and 2 RSA	Year 1, 2, and 3 = 15 ruffed grouse/upland game bird Cost estimate assumes 5 samples/location/year (n = 45)	Biologists and stakeholders will work together to obtain samples of grouse using standard hunting methods (e.g., steel shot) during fall.	Work directly with rights holder/trappers within both the LSA and the RSA who harvest or trap for these animals.	**Radionuclides**: Gross-α, Gross-β, Sr-90, I-129, Cs-137 (Co-60, Se-79, Ru-106) **Metals (total)**: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium, **Other:** Cyanide and % moisture	• 100 g minimum weight/sample needed to analyse radionuclides, metals, cyanide, and % moisture and 500 g minimum weight/sample needed to analyse the above parameters + Gross-α and Gross-β with acceptable method detection limits • Metals and % moisture will be run when sample weights cannot be achieved • Standard laboratory ICP-MS procedures completed	Standard equipment maintenance	• Ruffed grouse known to be in the project LSA • Best practice for industry to collect samples of traditional foods (other than fish) that rights holders are consuming during baseline studies.	• Sample sizes (grams) need to be adequate for all COPC; requires lethal sampling	Upland game hunting permit is required by MNRF
Terrestrial Herbivore Small Mammal Chemistry			1 LSA and 2 RSA	Year 1 = 15 15 snowshoe hare Year 2 =15 mice/shrew Year 3 = 15 (squirrel/other) Cost estimate assumes 5 samples/location/year (n = 45)	Samples will be retained with stakeholder/rights holders during their routine harvesting activities or targeted periods. Snaring (snowshoe hare) and/or trapping methods are generally employed							Special collection permit is required
Terrestrial Vegetation Berry Chemistry			2 LSA and 3 RSA	Year 1 = 25 blueberry Year 2 = 25 cranberry Year 3 = 25 "species 3" Cost estimate assumes 5 samples/location/year (n=75)	Berries will be sampled by stakeholder/rights holders	Stakeholders/rights holders will be directly involved and their knowledge of important medicinal picking areas will be vital and should be included during the selection of the species and sampling locations				• Known to be present in both the LSA and RSA , no special equipment tools or license required to collect samples. • High level of stakeholder/rights-holder involvement as study areas/species are chosen and sampled by them. • Best practice for industry to collect samples of traditional medicines/plants that are deemed of importance to rights holders.	• Dependant on site conditions, weather, and abundance • May not be replicated in future years as dependant on climatic conditions, forest fires and forest regeneration • May be difficult to obtain minimum weight requirements to complete analyses • Plants may not exist in large quantities and are only available during certain seasons for short time periods • Obtaining samples for testing may effect traditional use, if scarce • Does not involve an emerging technology	N/A
Terrestrial Vegetation: Edible or Medicinal Plants Chemistry			1 LSA and 2 RSA	Year 1 =15 wild mushrooms (chanterelles/other) Year 2 = 15 (Labrador tea/other) Year 3 = 15 (chaga or other species) Cost estimate assumes 5 samples/location/year (n=45)	Hand grab by community members when sampling with a biologist within the regional area. Late summer early fall sampling period recommended depending on species. Rights holders including elders from these communities should be consulted and be included in the sampling of these VCs.							N/A

Appendix E, Table 1

Preliminary design options for the tissue chemistry component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Option 2 = Primary VCs + Secondary VCs (lethal methodology for both)												
Primary VCs	See Option 1											
Aquatic planktivore Small-bodied Fish Chemistry (whole body)	Characterize baseline chemistry of small-bodied fish tissue in the region; Data will be used in the IA, modelling, as well as comparison to reference locations and future monitoring data cycles	Uptake of COPC from aquatic food sources, water, and/or sediments; treated effluent, water withdrawal, dewatering, runoff, accidental surface release in drainage system	3 in LSA and 1 in RSA	Year 1 = emerald shiner/spot tail shiner from 4 locations Cost estimate assumes 5 samples/location (n=20)	Boat or backpack electrofishing, minnow traps, and box nets will be utilized to capture small-bodied fish. Minnow traps and box nets can be set up in the project area and be checked periodically while completing other surveys.	Samples will all be collected by a professional biologist with one stakeholder/one rights holder; training opportunities will be built into the program so that stakeholders/rights holders are taught to process the samples.	**Metals (total):** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium **Other:** Cyanide and % moisture	Standard laboratory ICP-MS procedures completed	Standard equipment maintenance	• Known to exist in both the LSA and RSA • Standard aquatic field methods and approach	• Sample weight is anticipated to be too small to analyse radionuclides • Substantial professional time and costs required to obtain minimum sample weights (100 g) • Does not involve an emerging technology.	Collection permits are required by the Ministry of Natural Resources and Forestry (MNRF)
Aquatic Waterfowl Piscivore Tissue Chemistry	Characterize baseline waterfowl chemistry in the region; Data can be used needed for EA and ERA modelling, and to compare with future monitoring data cycles		1 in LSA and 2 in RSA	Year 3 = merganser, loon, grebes from 3 locations Cost estimate assumes 5 samples/location (n=15)	Will work with local trapper(s)/rights holders to sample one species using standard methods (e.g., steel shot)	Rights holder/trappers who harvest or trap these animals will take part in the sampling program				High level of stakeholder/rights-holder involvement		Individuals are required to possess a valid federal Migratory Game Bird Hunting Permit with a Canadian Wildlife Habitat Conservation Stamp to hunt migratory birds in Canada. A special collection permit would be required if targeted outside the Ontario hunting window
Semi-Aquatic: Mammal Tissue Chemistry	Cultural significance; Often a traditional food source (beaver and muskrat) and/or trapped for fur; Characterize baseline chemistry of semi-aquatic mammal tissue in the region; Data will be used for the IA, modelling, as well as comparison to reference locations and future monitoring data cycles	Uptake of COPC from aquatic and terrestrial food sources, water, soil, plants and/or sediments; treated effluent, water withdrawal, dewatering, runoff, accidental surface release in drainage system	1 in LSA and 2 in RSA	Year 1 = beaver from 3 locations Year 2 = muskrat from 3 locations Year 3 =mink from 3 locations Cost estimate assumes 5 samples/location (n=45)	Hunted or trapped using standard lethal methods	Work directly with rights holder/trappers who trap for these animals Work with local trapper(s)/rights holders to determine if semi-aquatic furbearer population is sufficient in the area to obtain 15 samples of each species yearly for the project			Standard equipment maintenance	• High level of stakeholder/rights holder involvement • Best practice to collect samples of traditional species that are deemed of cultural importance to rights holders	• No radionuclides tested • Does not involve an emerging technology • May be difficult to obtain three different species	An Ontario trapping license is needed and the Fur Harvest, Fur Management, and Conservation course is required.
Aquatic/ Terrestrial Amphibian Chemistry	Characterize baseline amphibians in the region. Data can used needed for EA and ERA modelling, and to compare with future monitoring data cycles.	Uptake of COPC primarily from aquatic environment; species often sensitive to environmental contaminants and small disturbances in habitat.	1 in the LSA and 2 in the RSA	Year 1 =wood frog from 3 locations Year 2 = salamander from 3 locations Year 3 = species #3 (TBD) from 3 locations Cost estimate assumes 5 samples/location (n=45)	Standard amphibian sampling protocols and procedures	Community members are field assistants			Standard equipment maintenance	• Amphibians are often overlooked in baseline sampling programs • Species should be present in both the LSA and RSA	• No radionuclides tested • Does not involve an emerging technology • Substantial professional time and costs required to obtain minimum sample weights (100 g)	
Terrestrial Carnivore Tissue Chemistry	Characterize baseline terrestrial top carnivore in the region. Data can used needed for EA and ERA modelling, and to compare with future monitoring data cycles.	Uptake of COPC from water, soil, and food chain as top predator in the region.	LSA or RSA	Year 1, 2, and 3 = lynx, wolf, coyote Cost estimate assumes 5 samples/year (n =15) The sample size may be reduced depending on population size	Opportunistic samples will be retained from stakeholder/rights holders during their routine trapping activities Community liaisons from the stakeholder/rights holders (FNs and Metis) will be identified to help to coordinate sample collection	Work directly with rights holder/trappers who trap these animals.	**Metals (total)**: Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium **Other:** Cyanide and % moisture	Standard laboratory ICP-MS procedures completed	Standard equipment maintenance	• High level of stakeholder/rights holder involvement as working directly with trappers to obtain samples on their trap line	• No radionuclides tested • Does not involve an emerging technology • May be difficult to obtain samples	
Terrestrial Vegetation Browse Chemistry	Characterize baseline browse in the region that make up large part of the diet of ungulates (deer and moose); Data can be used for EA and ERA modelling, and to compare with future monitoring data cycles.	Uptake of COPC in browse from water, and/or soil; Uptake of COPC from runoff, accidental surface release, air, and wind dispersion during construction a phases	2 in LSA and 3 in RSA	Year 1 = willow or other from 5 locations Cost estimate assumes 5 samples/year (n=25)	Hand picked	Community members are field assistants			Standard equipment maintenance	• No special instruments are required. • Species are likely present in large quantities	• No radionuclides tested • Does not involve an emerging technology • Substantial professional time and costs required to obtain minimum sample weights (100 g)	
Terrestrial Insects	Characterize baseline insects in the region; Data will be used for ERA modelling, and to compare with future monitoring data cycles.	Uptake of COPC from soils, plants, water, air dispersion during construction activities or water releases or runoff.	2 in the LSA and 1 in the RSA	Year 1 = 15 adult dragonflies Year 1 =15 caterpillars (Total n=30)	Insect traps, netting, and hand picked	Community members are field assistants			Standard equipment maintenance	• No special instruments are required • Species are likely present in large quantities	• No radionuclides tested • Does not involve an emerging technology • Substantial professional time and costs required to obtain minimum sample weights (100 g)	
Option 3 - Primary VCs + Secondary VCs - (lethal methodology for primary VCs and non-lethal methodology for most secondary VCs)												
Primary VCs	See Option 1											
Same VCs as Option 2	See Options 1 and 2.	Aquatic/terrestrial/air dispersion through the LSA/RSA from treated effluent (from dewatering) blasting runoff, accidental surface release, construction activities.	LSA and RSA	Same as Option 2	Non-lethal sampling methods	Stakeholder/rights holders would be equally involved in both options and through all sampling phases and are essential to the success of the tissue chemistry program	**Metals (total):** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver,	TrichAnalytics analyses	Non-lethal sampling methods may consist of hair, hair follicles, scales, or soft tissue	• Emerging and novel technology through TrichAnalytics • Non-lethal for most VCs • Time/budget needed to obtain sample is reduced compared to the lethal method • Requires a smaller sample size (weight) and non-edible media (important for donated samples)	Radionuclides cannot be analysed due to the small sample size (weight)	

Appendix E, Table 2

Preliminary design options for the hydrology component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Hydrology General	Collection of baseline (1 year) and monitoring data (2 years) in the LSA and RSA surface water bodies pertaining to water level and flow in order to eliminate and/or mitigate impacts pertaining to the facility design, construction and operation	Seasonal flow changes from freezing and thaw based on changes in precipitation in the drainage network. Runoff from disturbed soils and off-site rock pile weathering. Water withdrawal or larger effluent discharge into the watershed from construction and/or operation in terms of erosion or affects from an increase or decrease flow in receiving waterbodies.	LSA and RSA covering areas downstream on the Revell River from the AOI, on Mennin River just below Mennin Lake, and Mennin Lake	**VC** - Physical Environment, changes in surface water runoff. Sample Frequency: Hourly if permanent stations on the Mennin and Revell River are deployed or 3 or 4 times year if individual site visits are made. For smaller streams the sites would be visited twice a year for manual flow and water level measurements. Mennin Lake should be visited at a minimum of quaetterly to take water level readings. **Sample Size** - first year for Mennin and Revell River 3 to 6 visits to develop water level discharge rating curve. For smaller streams the site visits would be once in the spring melt time period for flow measurements and once in the late summer dry season. The **frequency** of field visits and measurements can be tied in with surface water quality monitoring and other field efforts.	Small streams associated with wetland and small pond areas would have simple flow measurements made manually each spring and in the dry late summer time period for three years. Mennin Lake water levels measurements would be made manually on a quarterly basis, at minimum, for three years. Flow monitoring stations on Mennin River and Revell River would consist of a more continuous (hourly) water level sensors and periodic flow measurements to develop stage discharge rating curve for each site. An alternative to a continuous water level gauge would be to install a permanent staff gauge which can be read each field visit and used with the stage-discharge relationship. Field monitoring would follow Canadian Federal and/or Ontario Stream Assessment protocols.	Input on proposed placement of gauging stations and assistance in manual data collection (can be coordinated with fish habitat characteristics, water quality or other field sampling components)	Increase in flow (flooding), decrease in flow (drought) which may impact assimilative capacity for discharging and withdrawing for supply	N/A	Continuous water level gauges or permanent staff gauges would have ongoing maintenance for the three year duration of the baseline study. This would include checking equipment, swapping out batteries or other faulty equipment, cleaning equipment as necessary, downloading data, if telemetry is not used.	• Obtain site-specific data that will be more appropriate to use than far away ECCC monitoring stations • Gain environment data on an area not studied in detail	• Planning around weather (snow) and frost. • Coordination and learning of accessible points for measurements. • Remote nature of some sites	**Federal** – *Impact Assessment Act* , *Fisheries Act* . **Provincial** - *Public Lands Act* (MNRF Work Permit), *Ontario Water Resources Act* (Permit to Take Water (Surface water), *Clean Waters Act, Ministry of Northern Development, Mines and Forestry Act, Ministry of Natural Resources Act, Lakes and Rivers Improvement Act, Fish and Wildlife Conservation Act, Endangered Species Act, 2007* and *Beds of Navigable Water Act* .
Hydrology Meteorology	Meteorological data collection to understand site-specific weather conditions and seasonal patterns. This data will inform an understanding of flood and low flow conditions that may exist seasonally The nearest weather stations are approximately 40 to 100 km away from the AOI and may not be appropriate to use to represent site-specific conditions		LSA	**Sample Frequency:** hourly using a continuous meteorological station **Sample duration:** minimal one year, may be up to three years	Canadian Federal guidelines or Ontario provincial guidelines similar to US EPA's Meteorological Monitoring Guidance for Regulatory Modeling Applications (2000) (EPA-454/R-99-005).	Input on proposed placement of the weather station. Potential for community members as field assistants during site visits for station installation and periodic maintenance.	Intense rainfall, lack of rainfall, high air temperature. The meteorological station will measure air temperature, total precipitation (rainfall and est. of snowfall), wind direction and wind speed, relative humidity or dew point temperature, atmospheric pressure, and perhaps solar radiation.	N/A	A continuous weather station would have ongoing maintenance for the three year duration of the baseline study. This would include checking equipment, troubleshooting, calibration of instruments, swapping out batteries or other faulty equipment, cleaning equipment as necessary, downloading data, if telemetry is not used.	Obtain site-specific data that will be more appropriate to use than data from distant weather stations		N/A

Appendix E, Table 3

Preliminary design options for the surface water component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Surface water	Characterize baseline water quality in the LSA and RSA. Identified as an important component during stakeholder/rights-holder engagement. Data needed for IA, modelling, and to compare with future monitoring data	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release	LSA and Reference Areas	Sample surface water at 8 locations quarterly. Cost estimate assumes 3 samples/location + 3 QA/QC samples/quarter (n= 108/year)	At each sampling location, *in situ* limnology measurements are taken using a limnology meter (e.g., YSI multi-meter) and a water sample for chemical analyses is taken using a water sampler (e.g., Van Dorn)	Community members are field assistants with potential to conduct sampling independently once trained	***In situ* limnology:** Dissolved Oxygen, Temperature, pH, Conductivity, Redox Potential **Radionuclides:** Cl-36, Co-60, Se-79, Ru-106, Cs-137, Pu-238, Pu-239, Pu-240, Pu-241 Am-241, Cm-244, Gross-α, Gross-β **General chemistry, ions, and nutrients:** Alkalinity, Bicarbonate, Bromide, Calcium, Carbonate, Chloride, Cyanide, Fluoride, Hydroxide, Magnesium, pH, Potassium, Sodium, Specific conductivity, Sulphate, Sum of Ions, Total Dissolved Solids, Total Hardness, Total Suspended Solids, Turbidity, Ammonia as Nitrogen, Nitrate + Nitrite, Nitrate (NO_3), Total Organic Carbon, Inorganic Carbon, Dissolved Organic Carbon, Phosphorus, Total Kjeldahl Nitrogen, 5 day Biological Oxygen Demand (BOD_5), E. coli, Total Coliforms **Metals (total and dissolved):** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium	*In situ* limnology measurements and standard laboratory procedures	Standard equipment maintenance for limnology meter and water sampler	• More cost effective than inclusion of continuous remote water quality meter • Seasonal trends are captured • Follows accepted regulatory procedures	• Diurnal trends are not captured • Temporal data are limited to 4 times a year	• Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines (WQG) for the Protection of Aquatic Life • Government of Canada Federal Water Quality Guidelines (FEQG) • Ontario Ministry of Environment, Conservation and Parks Provincial Water Quality Guidelines (PWQOs) • BOD_5, suspended solids, total phosphorus, (NH_3+NH_4^+)-N concentrations - *F-5-1 Determination Of Treatment Requirements For Municipal And Private Sewage Treatment Works* and *OWR Act (R.S.O. 1990)*
				Sample surface water at 8 locations quarterly. Cost estimate assumes 3 samples/location + 3 QA/QC samples/quarter (n= 108/year) + 1 continuous remote water quality meter	At each sampling location, *in situ* limnology measurements are taken using a limnology meter (e.g., YSI multi-meter) and a water sample for chemical analyses is taken using a water sampler (e.g., Van Dorn); at 1 location a continuous remote water quality station is installed		Same as above for in *In situ* limnology and water samples COPC included in cost estimate for continuous remote water quality meter: pH, Conductivity, Turbidity, Dissolved Oxygen, Total Organic Carbon, Nitrate, and Ammonia	*In situ* limnology measurements and standard laboratory procedures; *In situ* measurements for continuous remote water quality meter	Standard equipment maintenance for limnology meter and water sampler; bi-annual maintenance required for continuous remote water quality meter	• Seasonal trends and diurnal trends (for some COPC) are captured • Water sample collection follows accepted regulatory procedures plus continuous data are collected for key water quality characterization parameters • Includes emerging and novel technology; more sensors can be installed to measure additional COPC including some dissolved metals	• Use of continuous remote water quality meter does not replace the need for the field sampling program as not all COPC can be measured, particularly radionuclides • Increased cost for the continuous remote water quality meter including annual fees and maintenance	
		Dependent on location of lake sampled; potentially the same sources as above, potentially aerial dispersion, or potentially no Project-related source but sampled for community assurance	RSA	Sample surface water at 8 waterbodies quarterly. Cost estimate assumes 1 sample/lake + 1 QA/QC sample/quarter (n=36/year)	At each sampling location, *in situ* limnology measurements are taken using a limnology meter (e.g., YSI multi-meter) and a water sample is taken for chemical analyses using a water sampler (e.g., Van Dorn)	Community members are field assistants with potential to conduct sampling independently once trained	***In situ* limnology:** Dissolved Oxygen, Temperature, pH, Conductivity, Redox Potential **Radionuclides:** H-3, C-14, Co-60, Se-79, Sr-90, Ru-106, I-129, Cs-137, Gross-α, Gross-β **General chemistry, ions, and nutrients:** Alkalinity, Bicarbonate, Bromide, Calcium, Carbonate, Chloride, Cyanide, Fluoride, Hydroxide, Magnesium, pH, Potassium, Sodium, Specific conductivity, Sulphate, Sum of Ions, Total Dissolved Solids, Total Hardness, Total Suspended Solids, Turbidity, Ammonia as Nitrogen, Nitrate + Nitrite, Nitrate (NO_3), Total Organic Carbon, Inorganic Carbon, Dissolved Organic Carbon, Phosphorus, Total Kjeldahl Nitrogen **Metals (total and dissolved):** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium	*In situ* limnology measurements and standard laboratory procedures	Standard equipment maintenance for limnology meter and water sampler	• Seasonal and spatial trends are captured • Water sample collection follows accepted regulatory procedures	• Sampling effort is more labour intensive than using surface grabs • Lower community involvement than the option presented below	• Canadian Council of Ministers of the Environment (CCME) Water Quality Guidelines (WQG) for the Protection of Aquatic Life • Government of Canada Federal Water Quality Guidelines (FEQG) • Ontario Ministry of Environment, Conservation and Parks Provincial Water Quality Guidelines (PWQOs)
					At each sampling location, a surface grab method is used to obtain water samples for chemical analyses	Sampling completed entirely by community members	Same as above with the exception of *in situ* limnology parameters	Standard laboratory procedures	None	• Entirely community-based monitoring program • Simple sampling method • Seasonal and spatial trends are captured	• Surface grabs may not be representative of the entire waterbody • Potential concerns with quality control and regulatory acceptance	

Appendix E, Table 3

Preliminary design options for the surface water component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Sediment	Characterize baseline sediment quality in the LSA. Data needed for IA, modelling, and to compare with future monitoring data	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release	LSA and Reference Areas	Sample sediment at 5 stations in 8 areas + 10% QA/QC samples (n=44/year)	At each station, composite sediment samples are collected using a core sampler (e.g., Tech-ops corer); surficial horizon (e.g., 0 to 2 cm) retained for analyses with the option of archiving deeper horizons	Community members are field assistants	**Radionuclides:** Cl-36, Co-60, Se-79, Ru-106, Cs-137, Pu-238, Pu-239, Pu-240, Pu-241 Am-241, Cm-244, Gross-α, Gross-β **General Characterization:** Moisture, Total Organic Carbon, Particle Size (5 fraction EEM) **Metals:** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium **Nutrients:** Ammonia as Nitrogen, Nitrate + Nitrite, Nitrate (NO_3), Phosphorus	Standard laboratory procedures	Standard equipment maintenance for core sampler; core tubes require acid washing between sampling trips	• Spatial variation is captured with more study areas compared to the option presented below • Follows accepted regulatory procedures • Sediment/water interface is minimally disturbed using a core sampler (thus fine particles are retained) • Pre-determined sediment horizons can be analysed	• More costly than sampling 5 areas • Use of core sampler requires greater effort to collect large samples for analysis compared to grab sampler • Core sampler cannot be used in firm substrates	• CCME Sediment Quality Guidelines (SQG) for the Protection of Aquatic Life • Ontario Ministry of Environment, Conservation and Parks Soil, Groundwater and Sediment Site Condition Standards (SCS) and Provincial Sediment Quality Guidelines
				Sample sediment at 5 stations in 5 areas + 10% QA/QC samples (n=28/year)						• Follows accepted regulatory procedures • Sediment/water interface is minimally disturbed using a core sampler (thus fine particles are retained) • Pre-determined sediment horizons can be analysed • Less costly than sampling 8 areas	• Less spatial coverage of the study area than the option presented above • Use of core sampler requires greater effort to collect large samples for analysis compared to grab sampler • Core sampler cannot be used in firm substrates	
				Sample sediment at 5 stations in 8 areas + 10% QA/QC samples (n=44/year)	At each station, composite sediment samples are collected using a grab sampler (e.g., petit ponar); surficial sediment horizon is retained for analyses		**Radionuclides:** Cl-36, Co-60, Se-79, Ru-106, Cs-137, Pu-238, Pu-239, Pu-240, Pu-241 Am-241, Cm-244, Gross-α, Gross-β **General Characterization:** Moisture, Total Organic Carbon, Particle Size (5 fraction EEM) **Metals:** Aluminum, Antimony, Arsenic, Barium, Beryllium, Bismuth, Boron, Bromine, Cadmium, Cesium, Chromium (total, trivalent, hexavalent), Cobalt, Copper, Iron, Lead, Lithium, Mercury, Manganese, Molybdenum, Nickel, Samarium, Selenium, Silver, Strontium, Thallium, Tin, Titanium, Uranium, Vanadium, Zinc, Zirconium **Nutrients:** Ammonia as Nitrogen, Nitrate + Nitrite, Nitrate (NO_3), Phosphorus		Standard equipment maintenance for grab sampler	• Spatial variation is captured with more study areas compared to the option presented below • Follows accepted regulatory procedures • Grab sampler can attain larger quantities of sediment than the core sampler • Grab sampler is better able to penetrate firm substrates than the core sampler	• More costly than sampling 5 areas • Grab sampler does not allow for distinct sediment horizons to be sampled • Sediment/water interface is disturbed and fine particles can be lost	
				Sample sediment at 5 stations in 5 areas + 10% QA/QC samples (n=28/year)						• Follows accepted regulatory procedures • Grab sampler can attain larger quantities of sediment than the core sampler • Grab sampler is better able to penetrate firm substrates than the core sampler • Less costly than sampling 8 areas	• Less spatial coverage of the study area than the option presented above • Grab sampler does not allow for distinct sediment horizons to be sampled • Sediment/water interface is disturbed and fine particles can be lost	
Chlorophyll/ Phytoplankton	Characterize baseline phytoplankton communities and chlorophyll concentrations in the LSA. Data needed for IA, modelling, and to compare with future monitoring data.	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release	LSA and Reference Areas	Install a continuous remote water quality meter at 1 station	If a continuous remote water quality meter is being installed to measure other water quality COPC (see above in surface water), then sensors can be added to monitor chlorophyll a and blue green algae	None	Chlorophyll a and blue-green algae	*In situ* measurements for continuous remote water quality meter	Bi-annual maintenance required for continuous remote water quality meter	• Seasonal and diurnal trends are captured • Combined with the surface water meter for cost savings • Can be combined with phytoplankton water sample option below	• No community involvement • Only characterizing one location in the LSA • Good approach for monitoring algal blooms, but does not provide baseline information on phytoplankton communities	N/A
				Sample phytoplankton at 8 locations quarterly. Cost estimate assumes 3 samples/location (n=96/year)	At each sampling location, a water sample is collected and submitted for laboratory analyses	Community members are field assistants with potential to conduct sampling independently once trained	Chlorophyll a, b, c; Phytoplankton taxonomic enumeration and biomass	Standard laboratory procedures	Standard equipment maintenance for sampling device	• Greater spatial coverage and breadth of data than using only the remote water quality meter • Community involvement • Combined with the water sampling program for cost savings • Can be combined with continuous meter option above • Follows accepted regulatory procedures	• Less temporal data for the two COPC measured using the remote water quality meter • More expensive than the option presented above	

Appendix E, Table 3

Preliminary design options for the surface water component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Zooplankton	Characterize baseline zooplankton communities in the LSA. Data needed for IA, modelling, and to compare with future monitoring data	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release	LSA and Reference Areas	Sample zooplankton at 8 locations quarterly Cost estimate assumes 3 samples/location (n=96/year)	At each sampling location, a zooplankton sample is collected using a tow net (e.g., Wisconsin net) and submitted for laboratory analyses	Community members are field assistants with potential to conduct sampling independently once trained	Zooplankton taxonomic enumeration and biomass	Standard laboratory procedures using a taxonomist	Standard equipment maintenance for sampling device	• Spatial variation is captured with more study areas compared to the option presented below • Follows accepted regulatory procedures	• Does not involve an emerging technology and traditional taxonomic enumeration methods could become obsolete in the distant future • More costly than sampling 5 areas	N/A
					At each sampling location, a zooplankton sample is collected using a tow net (e.g., Wisconsin net) and submitted for laboratory analyses; in addition a water sample is collected for eDNA analyses			Standard laboratory procedures using a taxonomist and creation of an eDNA barcode library (see report for more information)		• Most comprehensive dataset (spatially and taxonomically) • Side by side approach and creation of an eDNA barcode library sets up the program for efficient use of this technology during future monitoring • Field methods and traditional taxonomic methods follow accepted regulatory procedures	• More expensive to include eDNA component • eDNA analysis does not address density and biomass	
				Sample zooplankton at 5 locations quarterly. Cost estimate assumes 3 samples/location (n=60/year)	At each sampling location, a zooplankton sample is collected using a tow net (e.g., Wisconsin net) and submitted for laboratory analyses	Community members are field assistants with potential to conduct sampling independently once trained	Zooplankton taxonomic enumeration and biomass	Standard laboratory procedures using a taxonomist	Standard equipment maintenance for sampling device	• Least expensive option • Follows accepted regulatory procedures	• Does not involve an emerging technology and traditional taxonomic enumeration methods could become obsolete in the distant future • Provides less spatial coverage than sampling 8 areas	N/A
					At each sampling location, a zooplankton sample is collected using a tow net (e.g., Wisconsin net) and submitted for laboratory analyses; in addition a water sample is collected for eDNA analyses			Standard laboratory procedures using a taxonomist and creation of an eDNA barcode library (see report for more information)		• Most comprehensive dataset (spatially and taxonomically) • Side by side approach and creation of an eDNA barcode library sets up the program for efficient use of this technology during future monitoring • Field methods and traditional taxonomic methods follow accepted regulatory procedures	• More expensive to include eDNA component • eDNA analysis does not address density and biomass	
Benthic Invertebrates	Characterize baseline benthic invertebrate communities in the LSA. Data needed for IA, modelling, and to compare with future monitoring data	Treated effluent (from dewatering, sewage, and storm water), water withdrawal, blasting, runoff, accidental surface release	LSA and Reference Areas	Sample benthic invertebrates at 5 stations in 8 areas (n=40)	At each sampling location, a benthic invertebrate sample is collected using a grab sampler (e.g., Ekman dredge) and submitted for laboratory analyses	Community members are field assistants	Benthic invertebrate taxonomic enumeration and biomass	Standard laboratory procedures using a taxonomist	Standard equipment maintenance for sampling device	• Spatial variation is captured with more study areas compared to the option presented below • Follows accepted regulatory procedures	• Does not involve an emerging technology and traditional taxonomic enumeration methods could become obsolete in the distant future • More costly than sampling 5 areas	N/A
					At each sampling location, a benthic invertebrate sample is collected using a grab sampler (e.g., Ekman dredge) and submitted for laboratory analyses; in addition a water sample is collected for eDNA analyses			Standard laboratory procedures using a taxonomist and creation of an eDNA barcode library (see report for more information)		• Most comprehensive dataset (spatially and taxonomically) • Side by side approach and creation of an eDNA barcode library sets up the program for efficient use of this technology during future monitoring • Field methods and traditional taxonomic methods follow accepted regulatory procedures	• More expensive to include eDNA component • eDNA analysis does not address density and biomass	
				Sample benthic invertebrates at 5 stations in 5 areas (n=25)	At each sampling location, a benthic invertebrate sample is collected using a grab sampler (e.g., Ekman dredge) and submitted for laboratory analyses	Community members are field assistants	Benthic invertebrate taxonomic enumeration and biomass	Standard laboratory procedures using a taxonomist	Standard equipment maintenance for sampling device	• Least expensive option • Follows accepted regulatory procedures	• Does not involve an emerging technology and traditional taxonomic enumeration methods could become obsolete in the distant future • Provides less spatial coverage than sampling 8 areas	N/A
					At each sampling location, a benthic invertebrate sample is collected using a grab sampler (e.g., Ekman dredge) and submitted for laboratory analyses; in addition a water sample is collected for eDNA analyses			Standard laboratory procedures using a taxonomist and creation of an eDNA barcode library (see report for more information)		• Most comprehensive dataset (spatially and taxonomically) • Side by side approach and creation of an eDNA barcode library sets up the program for efficient use of this technology during future monitoring • Field methods and traditional taxonomic methods follow accepted regulatory procedures	• More expensive to include eDNA component • eDNA analysis does not address density and biomass	

Appendix E, Table 4

Preliminary design options for the air component of the Baseline Program.

Category	Objective/ Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Technological Options	Preferred Option	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Air	Determine the local baseline air quality conditions in the vicinity of the project site, for COPCs that may be associated with Construction, Operations, and Decommissioning	Combustion by-products *Construction* : vehicle/equipment exhausts, blasting *Operations/ Extended Monitoring* : HVAC, generators, vehicle/equipment exhausts *Decommissioning* : vehicle/equipment exhausts	SSA	Continuous sampling at one location for air quality parameters	Continuous hourly air samples	Stakeholders can participate in weekly instrument performance checks (zero/span)	Nitrogen dioxide (NO_2) nitrogen oxide (NO) oxides of nitrogen (NOx)	Chemi-luminescence	• GLN-114E (DKK-TOA Corp.) •Serinus 40 (Ecotech) • AC32e (Env. SA) • APNA-370 (Horiba) • Airpointer (recordum) • 6040 (Sabio) • T200 (Teledyne) • 42iQ (Thermo)	Teledyne T200	• weekly performance checks; • monthly calibration; • periodic leak checks • no ongoing operations requirements (system is autonomous)	• designed for autonomous use • continuous system provides robust data set • modern systems have option for telemetered results	• rack-mount - requires temperature-controlled enclosure • requires continuous connection to electrical power supply	Ontario Environmental Protection Act (Ontario Regulation 419/05); Canadian Environmental Protection Act, 1999 (Canadian Ambient Air Quality Standards (CAAQS)).
			LSA	Network of monthly samples for air quality parameters	Passive monthly exposure	Stakeholders can operate the passive monitoring program	Nitrogen dioxide (NO_2) nitrogen oxide (NO) oxides of nitrogen (NOx)	Maxxam PTC SOP-00148	Chemically-treated badge	Maxxam PASS	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after one month	• simple to deploy - no technical background is necessary • small footprint, no power required • low cost compared to reference method - greater spatial coverage possible	• not a reference method by MECP or US EPA • results are monthly averages, so cannot be compared to AQ standards (for use in tracking trends only)	
			SSA	Continuous sampling at one location for air quality parameters	Continuous hourly air samples	Stakeholders can participate in weekly instrument diagnostics and zero/span check, filter change	Sulphur dioxide (SO_2)	UV Fluorescence	• GFS-312E (DKK-TOA Corp.) •Serinus 50 (Ecotech) • AF22e (Env. SA) • APSA-370 (Horiba) • Airpointer (recordum) • 6020 (Sabio) • T100 (Teledyne) • 43iQ (Thermo)	Teledyne T100	• weekly performance checks; • quarterly calibration; • biannual flow checks • no ongoing operations requirements (system is autonomous)	• designed for autonomous use • continuous system provides robust data set • modern systems have option for telemetered results	• rack-mount - requires temperature-controlled enclosure • requires continuous connection to electrical power supply	
			LSA	Network of monthly samples for air quality parameters	Passive monthly exposure	Stakeholders can operate the passive monitoring program	Sulphur dioxide (SO_2)	Maxxam PTC SOP-00149	Chemically-treated badge	Maxxam PASS	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after one month	• simple to deploy - no technical background is necessary • small footprint, no power required • low cost compared to reference method - greater spatial coverage possible	• not a reference method by MECP or US EPA • results are monthly averages, so cannot be compared to AQ standards (for use in tracking trends only)	
			SSA	Continuous sampling at one location for air quality parameters	Continuous hourly air samples	Weekly instrument performance checks (zero/span)	Carbon monoxide (CO)	NDIR gas filter correlation	• GFS-311E (DKK-TOA Corp.) •Serinus 30 (Ecotech) • CO12e (Env. SA) • APMA-370 (Horiba) • Airpointer (recordum) • 6050 (Sabio) • T300 (Teledyne) • 48iQ (Thermo)	Teledyne T300	• weekly performance checks; • quarterly calibration; • annual flow and leak checks; • no ongoing operations requirements (system is autonomous)	• designed for autonomous use • continuous system provides robust data set • modern systems have option for telemetered results	• rack-mount - requires temperature-controlled enclosure • requires continuous connection to electrical power supply	

Appendix E, Table 4

Preliminary design options for the air component of the Baseline Program.

Category	Objective/ Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Technological Options	Preferred Option	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Air	Determine the local baseline air quality conditions in the vicinity of the project site, for COPCs that may be associated with Construction, Operations, and Decommissioning	Combustion by-products *Construction* : vehicle/equipment exhausts, blasting *Operations/ Extended Monitoring* : HVAC, generators, vehicle/equipment exhausts *Decommissioning* : vehicle/equipment exhausts	SSA	Collection of 24-h air samples	Intermittent 24-hour air samples	Stakeholders can check instrument operations prior to sample campaign	Polyaromatic hydrocarbons (PAHs)	GC/MS on filter and PUF cartridge per EPA TO-13a	PUF HVAS with: • brushed motor • brushless motor • digital timer • mechanical timer	PUF HVAS with brushless motor and mechanical timer	• calibration upon installation, after motor change, and quarterly; • operation requires on-site technician • requires periodic motor replacement depending on model	• best available method for measuring in low background • the only method approved by the MECP for ambient PAH sampling • robust equipment suitable for operation in all weather with no additional enclosure	• not an automated method - requires skilled technician on-site to do sampling • results not available until well after sample is collected • potential for sample contamination (e.g., during filter handling, shipping)	Ontario Environmental Protection Act (Ontario Regulation 419/05); Canadian Environmental Protection Act, 1999 (Canadian Ambient Air Quality Standards (CAAQS)).
			SSA	Collection of 24-h air samples	Intermittent 24-hour air samples	Stakeholders can operate VOC monitors	Volatile organic compounds (VOCs)	Gas chromatography/ Mass spectrometry (GC/MS)	• absorbent cartridge • evacuated canister	evacuated canister	• no maintenance requirements • operation simply consists of attaching the flow controller to the canister and opening it, and closing it after 24-hours	• simplest of approved methods by MECP • does not require power or batteries	• sample is not precisely timed - up to operator to keep accurate time • operator must be present to close valve at 24-hour point, or sample may be voided - no auto-shutoff	
			LSA	Network of monthly samples for air quality parameters	Passive monthly exposure	Stakeholders can operate the passive monitoring program	Polyaromatic hydrocarbons (PAHs)	GC/MS on filter and PUF cartridge per EPA TO-13a	PUF Disk Sampler	PUF Disk Sampler	• no maintenance requirements • operation simply consists of deploying PUF disk and base, and collection after one month	• simple to deploy - no technical background is necessary • small footprint, no power required • low cost compared to reference method - greater spatial coverage possible	• not a reference method by MECP or US EPA • results are monthly averages, so cannot be compared to AQ standards (for use in tracking trends only)	
			SSA	Collection of 24-h air samples	Intermittent 24-hour air samples	Stakeholders can check instrument operations prior to sample campaign	Total suspended particulate matter (TSP)	Gravimetry	HVAS with: • brushed motor • brushless motor • digital timer • mechanical timer	HVAS with brushless motor and mechanical timer	• calibration upon installation, after motor change, and quarterly; • operation requires on-site technician • requires periodic motor replacement depending on model	• best available method for measuring in low-background environment • allows for subsequent metals analysis • the only method approved by the MECP for ambient TSP sampling • robust equipment suitable for operation in all weather with no additional enclosure	• not an automated method - requires skilled technician on-site to complete sampling • results not available until well after sample is collected •increased potential for sample contamination (e.g., during filter handling, shipping)	
			LSA	Network of monthly samples for air quality parameters	Passive monthly exposure	Stakeholders can operate the passive monitoring program	Volatile organic compounds (VOCs)	Gas chromatography/ Mass spectrometry (GC/MS)	chemically-treated badge	Maxxam PASS	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after one month	• simple to deploy - no technical background is necessary • small footprint, no power required • low cost compared to reference method - greater spatial coverage possible	• not a reference method by MECP or US EPA • results are monthly averages, so cannot be compared to AQ standards (for use in tracking trends only)	

Appendix E, Table 4

Preliminary design options for the air component of the Baseline Program.

Category	Objective/ Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Technological Options	Preferred Option	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Air	Determine the local baseline air quality conditions in the vicinity of the project site, for COPCs that may be associated with Construction, Operations, and Decommissioning	Combustion by-products *Construction*: vehicle/equipment exhausts, blasting *Operations/ Extended Monitoring*: HVAC, generators, vehicle/equipment exhausts *Decommissioning*: vehicle/equipment exhausts	SSA	Continuous sampling at one location for air quality parameters	Continuous hourly air samples	Possible for stakeholders to participate in weekly instrument performance checks	Suspended particulate matter less than 10 micron (PM10)	Gravimetry; or Beta Attenuation; or Light Scatter	intermittent samplers: • PQ100/PQ200 (BGI) • E-FRM (MetOne) • Partisol (Thermo) • TE-Wilber 10 (Tisch) continuous samplers: • FPM-222/223 (DKK-TOA) • MP101M Beta (Env. SA) • APDA-371 (Horiba) • BAM-1020/E-BAM (MetOne) • SM200 (Opsis) • T640 (Teledyne) • 5014i (Thermo) • TEOM1405 (Thermo)	Teledyne T640	• series of monthly checks (span, pump, flow, leaks) • no ongoing operations requirements (system is autonomous)	• designed for autonomous use • measures PM10 and PM2.5 simultaneously in one instrument • continuous system provides robust data set • modern systems have option for telemetered results	• rack-mount - requires temperature-controlled enclosure • requires continuous connection to electrical power supply	Ontario Environmental Protection Act (Ontario Regulation 419/05); Canadian Environmental Protection Act, 1999 (Canadian Ambient Air Quality Standards (CAAQS)).
			SSA	Continuous sampling at one location for air quality parameters	continuous hourly air samples	Stakeholders can complete weekly instrument performance checks	Suspended particulate matter less than 2.5 micron (PM2.5)	Gravimetry; or Beta Attenuation; or Light Scatter	intermittent samplers: • PQ200 (BGI) • E-FRM (MetOne) • Partisol (Thermo) • TE-Wilber 2.5 (Tisch) continuous samplers: • MP101M Beta (Env. SA) • EDM180 (Grimm) • APDA-371 (Horiba) • BAM-1020/1022 (MetOne) • SM200 (Opsis) • T640 (Teledyne) • 5030i (Thermo) • TEOM1400 (Thermo)	Teledyne T640	• series of monthly checks (span, pump, flow, leaks) • no ongoing operations requirements (system is autonomous)	• designed for autonomous use • measures PM10 and PM2.5 simultaneously in one instrument • continuous system provides robust data set • modern systems have option for telemetered results	• rack-mount - requires temperature-controlled enclosure • requires continuous connection to electrical power supply	
			LSA	Network of monthly samples for air quality parameters	Passive monthly exposure	Stakeholders can operate the passive monitoring program	Settleable particulates (dustfall)	Gravimetry (ASTM Method D1739-98/MECP DF-E3043A)	Dustfall jars		• no maintenance requirements • operation simply consists of unsealing the jar upon installation, adding the sample media (DI water and anti-freeze solution), and re-sealing upon collection after one month	• simple to deploy - no technical background is necessary • MECP-approved sampling method • small footprint, no power required • low cost compared to reference method - greater spatial coverage possible	• provides only monthly average data • results not available until well after sample is collected • samples are easily contaminated (insects, leaves)	
			SSA	Collection of 24-h air samples	Intermittent 24-hour air samples	Stakeholders can check instrument operations prior to sample campaign	metals (in TSP) • Aluminum (Al) • Antimony (Sb) • Arsenic (As) • Barium (Ba) • Beryllium (Be) • Boron (B) • Cadmium (Cd) • Calcium (Ca) • Chromium (Cr) • Cobalt (Co) • Copper (Cu) • Iron (Fe) • Lead (Pb) • Lithium (Li) • Magnesium (Mg) • Manganese (Mn) • Mercury (Hg) • Molybdenum (Mo) • Nickel (Ni) • Phosphorus (P) • Potassium (K) • Selenium (Se) • Silica (SiO_2) • Silver (Ag) • Sodium (Na) • Strontium (Sr) • Thallium (Tl) • Tin (Sn) • Titanium (Ti) • Vanadium (V) • Zinc (Z)	EPA 6010 (ICP-AES)	same as TSP	same as TSP	same as TSP	same as TSP	same as TSP	
			LSA	Network of monthly samples for air quality parameters	passive monthly exposure	Stakeholders can operate the passive monitoring program	Metals (in dustfall) (same suite as for TSP)	EPA 6010 (ICP-AES)	dustfall jars		same as dustfall	same as dustfall	same as dustfall	

Appendix E, Table 4

Preliminary design options for the air component of the Baseline Program.

Category	Objective/ Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Technological Options	Preferred Option	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Air	Determine the local baseline air quality conditions in the vicinity of the project site, for COPCs that may be associated with Construction, Operations, and Decommissioning	*Operations/ Extended Monitoring:* material, waste and fuel handling, preparation and storage, ventilation systems, passive releases *Decommissioning:* decommissioning activities, ventilation systems, passive releases	SSA	Collection of 24-h air samples	Intermittent 24-hour air samples	Stakeholders can check instrument operations prior to sample campaign	Radionuclides (in TSP): • Tier 1: Gross-α; Gross-β; Sr-90, I-129, Cs-137 •Tier 2: Cl-36, Cs-17, Se-79, Ru-106, Pu-238, Pu-239, Pu-240, Am-241, Cm-244	Neutron Activation Analysis	same as TSP		same as TSP	same as TSP	same as TSP	Nuclear Safety and Control Act; N288.4
			LSA	Network of monthly samples for air quality parameters	Passive monthly exposure	Stakeholders can operate the passive monitoring program	Radionuclides (in dustfall): • Tier 1: Gross-α; Gross-β; Sr-90, I-129, Cs-137 •Tier 2: Cl-36, Cs-17, Se-79, Ru-106, Pu-238, Pu-239, Pu-240, Am-241, Cm-244	Neutron Activation Analysis	dustfall jars	dustfall jars	same as dustfall	same as dustfall	same as dustfall	
			SSA	Monthly samples for radiological air quality parameters	Active monthly samples	Stakeholders can participate in weekly instrument performance checks	Tritium (H-3)	Beta counting in liquid scintillation detector	tritium-in-air monitor (similar to Ontario MOL)	tritium-in-air monitor (similar to Ontario MOL)	• no maintenance requirements • silica gel cells are replaced monthly	• simple to deploy and operate	• mechanical equipment involved (pump, gas meter, timer), possible breakdowns •require power and more expensive	
			LSA	Quarterly samples for radiological air quality parameters	Passive quarterly samples	Stakeholders can operate the passive monitoring program	Carbon-14	Liquid scintillation counter	soda lime pellet sampler	soda lime pellet sampler	• no maintenance requirements • operation simply consists of exposing the sample media upon installation, and re-sealing upon collection after three months	• simple to deploy and operate • small footprint, no power required • low cost - high spatial coverage possible	• results not available until well after sample is collected	
			LSA	Monthly samples for radiological air quality parameters	Passive monthly samples	Stakeholders can operate the passive monitoring program	Tritium (H-3)	Liquid scintillation counter	liquid absorber, either water or a mixture of water and ethylene glycol, in a sampling container or vial with a cap	liquid absorber, either water or a mixture of water and ethylene glycol, in a sampling container or vial with a cap	• no maintenance requirements	• simple to deploy and operate • small footprint, no power required • low cost - high spatial coverage possible	• less sensitive, less accurate and more variable compared to active sampler • high uncertainty	
			LSA	Quarterly samples for radiological air quality parameters	Passive quarterly exposure	Stakeholders can operate the passive monitoring program	Radon	Alpha track	alpha track technique; devide composed of film elements inside anti-static plastic housing; radon enters by diffusion.	alpha track technique; devide composed of film elements inside anti-static plastic housing; radon enters by diffusion.	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after three months	• simple to deploy and operate • small footprint, no power required • low cost - high spatial coverage possible	• only provide radon levels at the locations with monitors and not the entire site	
			SSA	Quarterly samples for radiological air quality parameters	Passive quarterly exposure	Stakeholders can operate the passive monitoring program	Radon	Alpha track	alpha track technique; devide composed of film elements inside anti-static plastic housing; radon enters by diffusion.	alpha track technique; devide composed of film elements inside anti-static plastic housing; radon enters by diffusion.	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after three months	• simple to deploy and operate • small footprint, no power required • low cost - high spatial coverage possible	• only provide radon levels at the locations with monitors and not the entire site	
			LSA	Quarterly samples for radiological air quality parameters	Passive quarterly exposure	Stakeholders can operate the passive monitoring program	External gamma	Optically stimulated luminescence	dosimeter badge in environmental holder	dosimeter badge in environmental holder	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after three months	• simple to deploy and operate • small footprint, no power required • low cost - high spatial coverage possible	• only provide gamma radiation levels at the locations with monitors and not the entire site	
			SSA	Quarterly samples for radiological air quality parameters	Passive quarterly exposure	Stakeholders can operate the passive monitoring program	External gamma	Optically stimulated luminescence	dosimeter badge in environmental holder	dosimeter badge in environmental holder	• no maintenance requirements • operation simply consists of unsealing the badge upon installation, and re-sealing upon collection after three months	• simple to deploy and operate • small footprint, no power required • low cost - high spatial coverage possible	• only provide gamma radiation levels at the locations with monitors and not the entire site	

See Appendix G for additional information

Appendix E, Table 5

Preliminary design options for the noise component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Noise	Determine the local baseline noise conditions in the vicinity of the project site, for COPCs that may be associated with Construction, Operations, and Decommissioning	Noise from *Construction*: vehicle/equipment exhausts, blasting, motors, pumps *Operations/ Extended Monitoring*: HVAC, motors, pumps, generators, vehicle/equipment exhausts *Decommissioning*: vehicle/equipment exhausts, motors, pumps	SSA/LSA	Measurements for noise	Continuous hourly samples (Leq) Option of Class 1 Integrating Sound Level Meter	Possible for stakeholders to assist with the noise monitoring program	Noise	IEC 61672-1:2013	• No maintenance required (short term campaign); • Spot calibration during campaigns; • No ongoing operational requirements	• Short term and continuous system provides robust data set • Data logging capabilities • Simple to deploy and operate • Cost effective	• Data can voided if taken during adverse weather conditions	Ontario Environmental Protection Act (Ontario Regulation 419/05); NPC-300 Health Canada's (HC) Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise International Standards Organization (ISO) 1996-2 Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of environmental noise levels

Appendix E, Table 6

Preliminary design options for the light component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/ Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Light	Determine the local baseline illuminance and sky glow in the vicinity of the project site, for COPCs that may be associated with Construction, Operations, and Decommissioning	Light from *Construction* : facility lighting, vehicle/equipment *Operations/ Extended Monitoring* : facility lighting, vehicle/equipment *Decommissioning* : facility lighting, vehicle/equipment	SSA	Measurements for light	Discrete campaign based samples Light Meter and Sky Quality Meter	Possible for stakeholders to assist with the illuminance monitoring program	Illuminance	CIE 150:2003	• No maintenance required (short term campaign) • No ongoing operational requirements	• Simple to deploy and operate • Cost effective • Instantaneous results • Data logging capabilities	• Sampling is dependent on meteorological and lunar conditions • Difficult to achieve repeatability due to varying conditions	Canadian Environmental Assessment Act

Appendix E, Table 7

Preliminary design options for the shallow groundwater component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Sampling/Field Methods	Sampling Frequency	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Groundwater	Hydrogeological Characterization (Hydraulic Gradient (horizontal, vertical), GW Flow Regime)		SSA, LSA, RSA	9 proposed MW locations at three depths within the SSA, LSA RSA - 120 wells were identified in the Ignace area. Need to determine which will be best to sample for RSA (aim for 7)	Synoptic GW level measurement using water level tapes. Continuous measurement using data loggers and pressure transducers (hourly frequency for a month, 4 months of the year) and barologgers (for select wells; needed to allow for data correction for barometric effects). For private wells in RSA may not be possible to monitoring water elevations in the wells due to 1) infrastructure in the well; 2) pumping of the well for water use. May be able to negotiate shutting off pumps for period of time to get accurate static water elevation from these private wells.	Manual/automated techniques. Data loggers and pressure transducers (and baro loggers) for continuous measurement. Battery operated probes and calibrated tape for manual measurements (below top of casing as the datum)	Quarterly	High level - manual measurements, download transducers	Hydraulic gradient (horizontal, vertical), GW Flow regime	N/A	Access to monitoring well locations (private wells, remote locations) Seasonal considerations (snow cover, visibility)	Both manual and automated methods should be utilized for GW level monitoring	N/A	Hydrogeological characterization based on environmental baseline studies. Key parameter to understand gradients, groundwater flow directions, possible presence of aquitard units
	Hydrogeological Characterization (Hydraulic Conductivity - Soil/Overburden (horizontal/vertical))	N/A	SSA, LSA	Little to no overburden is expected in the borehole locations; May need to locate areas with sufficient overburden to do test if possible - if not then won't be applicable anyway. There are private water wells that are completed in OB.	Lithology data from well records (use literature references for K)	Information collected from borehole/coring logs; slug or pumping tests conducted depending on overburden thickness, well placement (pumping and monitoring locations? Single well tests) Pressure transducer installation needed for hydraulic testing Will depend on well configurations and K; pump tests may not be possible.	Single	Community members are field assistants	N/A	Standard Methods - literature references for K based on lithology descriptions	none	Quick, information from existing boring data or tests done on deeper BH in area for comparison	Estimate only - not direct measurement from borehole	
					Slug tests (constant or rising head), pumping tests, type curves (AQTESOLV), grain size distribution correlations. Additional direct push tool methods? Hydraulic profile tool - Waterloo Sampler APS (not costed - likely not sufficient OB in study area to warrant).					Standard Methods - Type curve (fitting) methods available in AQTESOLV	Mobilization of electrical and hydraulic equipment (power supply, tubing, reservoir tanks (vacuum, pressure, fluid)) Access to private wells, seasonal considerations , H&S considerations	Well specific test information; use of pressure transducers for single well or cross well tests will provide conductivity of well and possible indication of connection to other wells in area	Dependent on well completions - only representative of screened interval (s); if single test only possible, then not representative of larger area, heterogeneity	Hydrogeological characterization based on environmental baseline studies conducted for mining projects in the Ignace Region (Amec Foster Wheeler 2018, Golder 2013). Additional characterization methods referenced from Singhal and Gupta (2010). Estimated hydrogeological parameter was noted in NWMO (2017).
	Hydrogeological Characterization (Hydraulic Conductivity - Bedrock (Shallow) (horizontal/ vertical))	N/A	SSA, LSA	All Shallow MW locations (upper 100 m)	Lithology data from well records (use literature references)); as part of this scope the assumption is that the wells are completed under separate scope - only testing available in previously installed and completed wells.	Information collected from borehole/coring logs;	Determined from initial testing (single event)?	Community members are field assistants	Hydraulic conductivity - Bedrock (Shallow) (horizontal/ vertical)	Standard Methods - literature references for K based on lithology descriptions	N/A	Quick, information from existing boring data or tests done on deeper BH in area for comparison	Estimate only - not direct measurement from borehole	Hydrogeological characterization based on environmental baseline studies conducted for mining projects in the Ignace Region (Amec Foster Wheeler 2018, Golder 2013). Additional characterization methods referenced from Singhal and Gupta (2010). Estimated hydrogeological parameter was noted in NWMO (2017).
					As part of this scope the assumption is that the wells are completed under separate scope - only testing available will occur in previously installed and completed wells, Pulse interference tests (single/multiple pulses), hydraulic tomography methods (slug tests or pumping at multiple wells), tracer injection tests, downhole flowmeter tests.	Information collected from borehole/coring logs; slug or pumping tests conducted depending on permeability and well placement (pumping and monitoring locations? Single well tests?) Pressure transducer installation needed for hydraulic testing Will depend on well configurations and K; pump tests may not be possible.				Standard Methods - Type curve (fitting) methods available in AQTESOLV; if tomography can be applied from multiple monitoring locations then methods from Paradis et al 2016 or similar for test configurations.	Mobilization of electrical and hydraulic equipment (power supply, tubing, reservoir tanks (vacuum, pressure, fluid)) Access to monitoring wells,	Direct well testing; Well specific test information; use of pressure transducers for single well or cross well tests will provide conductivity of well and possible indication of connection to other wells in area	Dependent on well completions - only representative of screened interval (s); if single test only possible, then not representative of larger area, heterogeneity	Hydrogeological characterization based on environmental baseline studies conducted for mining projects in the Ignace Region (Amec Foster Wheeler 2018, Golder 2013). Additional characterization methods referenced from Singhal and Gupta (2010). Estimated hydrogeological parameter was noted in NWMO (2017).

Appendix E, Table 7

Preliminary design options for the shallow groundwater component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Sampling/Field Methods	Sampling Frequency	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Groundwater	Hydrogeological Characterization (Dewatering Rate, Dewatering Impact On Ambient Conditions (Predicted Drawdown))		SSA, LSA	All Shallow MW locations (upper 100 m).	Development of numerical groundwater model (Hydrogeosphere being developed by NWMO). To be developed after determining the Site-specific hydrogeological parameters.	Data collected from shallow wells, deep wells and surface water program, all inputs for model.	One set of tests for baseline testing. Adjustable during the lifecycle of the DGR? Due to potential transient changes in GW flow regime during the DGR lifespan.		N/A	Model development, calibration, testing - conducted by NWMO	N/A	Sophisticated tool that will allow for a lot of options evaluations, predictions.	Only as good as data inputted and assumptions used to build; not direct measurements.	
					Constant rate and/or step drawdown pumping tests (with a representative monitoring well set) to assist in the decision-making. Use of real-time monitoring well data to adjust dewatering rates if necessary. Also monitoring chemistry, Redox, other to see surface water inflow from shallow intervals.	Will depend on well configurations and K; pump tests may not be possible. Standard groundwater sampling methods and or grab samples from groundwater extracted from pumping well if possible.	One set of tests for baseline testing. Adjustable during the lifecycle of the DGR? Due to potential transient changes in GW flow regime during the DGR lifespan.	Community members are field assistants	Monitoring for GW SW interactions during pump test	Will depend on well configurations and K; pump tests may not be possible. Standard Methods - Type curve (fitting) methods available in AQTESOLV; standard laboratory methods or field monitoring for groundwater chemistry if pumping is achievable.	Mobilization of electrical and hydraulic equipment (power supply, tubing, reservoir tanks (vacuum, pressure, fluid)) Access to monitoring wells; standard maintenance of pumps, sampling equipment	Direct well testing; Well specific test information; use of pressure transducers for single well or cross well tests will provide information on drawdown and possible indication of connection to other wells in area; chemistry will help to evaluate potential surface water interaction from shallow monitoring wells.	Dependent on well completions - only representative of screened interval (s); if single test only possible, then not representative of larger area, heterogeneity	Hydrogeological parameter was referenced in NWMO (2016)
	GW Quality (Dissolved Anions & Nutrients & Additional WQ Parameters)	Understanding of background ambient GW parameters. Potential changes to ambient conditions due to DGR operations and drainage from excavated rock/soil		9 proposed MW locations with monitoring at 3 depth within the SSA, LSA. Need to determine depth intervals in sampling plan to classify based on hydrostratigraphic unit.	Commonly used equipment/infrastructure installed at MWs include: -dedicated Waterra tubing (HDPE; 5/8" diameter) and foot valves -at least three well volumes purged; recommend low flow sampling methods <u>- pump selection based on depth to water</u> <u>P</u>rotocols/steps: -for metals analysis, samples were field-filtered -field parameters measured during purging: temperature, ORP, DO, EC, pH	Low-flow (if possible) sampling protocols preferred. Use of submersible, peristaltic, dedicated foot valves, or bladder pumps to extract GW from select MW locations. Field sampling plan needs to account for: equipment/field/trip blank samples, duplicate samples	Quarterly first year, semi annual to annual going forward	Community members are field assistants	Ammonia, Chloride, Cr (III, VI), Aesthetics, Conductivity, DO, Nitrate/Nitrite, Fluoride, Sulphate, Mercury, Phosphorus, pH, Reactive Chlorine species, TSS/TDS, Turbidity, Sulphur	Standard laboratory procedures	Access to monitoring well locations (private wells, remote locations) Seasonal considerations (snow cover, visibility); Highlights the need for an accurate GPS survey of MWs. Field staff might need to use GPS tracker to located MWs for future monitoring and sampling events. Standard equipment maintenance for pumps, tubing and power sources. Sample integrity considerations (refrigeration, sample coolers), travel time for samples from collection point to lab for analyses (i.e. holding times)	• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	See applicable ODWS/PWQO/CCME guideline limits
	GW Quality (Dissolved Metals)	Machinery, batteries, release from excavated rock/soil						Community members are field assistants	Al, Sb, As, Ba, Be, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Li, Mg, Mn, Mo, Ni, Se, Ag, Na, Tl, Sn, U, V, Zn					
	GW Quality (VOCs)	Metal degreasers, chemical solvents, paints						Community members are field assistants	VOCs list (see GW Analytical Reg Limits tab)			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	No VOCs expected to be detected in GW in AOI so 12 rounds of data likely more than necessary - assumed reduced sampling in years 2 and 3	See applicable ODWS/PWQO/CCME guideline limits; A list of standard analytical methods is described in Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (MECP, 2011).
	GW Quality (PAHs, Phenols (SVOCs))	Machinery, fuels, chemicals	SSA, LSA	9 proposed MW locations with monitoring at 3 depths within the SSA, LSA. Need to determine depth intervals in sampling plan to classify based on hydrostratigraphic unit.	Commonly used equipment/infrastructure installed at MWs include: -dedicated Waterra tubing (HDPE; 5/8" diameter) and foot valves -at least three well volumes purged; recommend low flow sampling methods <u>- pump selection based on depth to water</u> <u>P</u>rotocols/steps: -for metals analysis, samples were field-filtered -field parameters measured during purging: temperature, ORP, DO, EC, pH	Low-flow (if possible) sampling protocols preferred. Use of submersible, peristaltic, dedicated foot valves, or bladder pumps to extract GW from select MW locations. Field sampling plan needs to account for: equipment/field/trip blank samples, duplicate samples	Quarterly first year, semi annual to annual going forward	Community members are field assistants	PAHs/phenols/SVOC lists (see GW Analytical Reg Limits tab)	Standard laboratory procedures	Access to monitoring well locations (private wells, remote locations) Seasonal considerations (snow cover, visibility); Highlights the need for an accurate GPS survey of MWs. Field staff might need to use GPS tracker to located MWs for future monitoring and sampling events. Standard equipment maintenance for pumps, tubing and power sources. Sample integrity considerations (refrigeration, sample coolers), travel time for samples from collection point to lab for analyses (i.e. holding times)	• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	No SVOCs expected to be detected in GW in AOI so 12 rounds of data likely more than necessary - assumed reduced sampling in years 2 and 3	See applicable ODWS/PWQO/CCME guideline limits; A list of standard analytical methods is described in Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (MECP, 2011).
	GW Quality (Radionuclides)	Emplaced used fuel containers, natural radionuclide emittance from native bedrock						Community members are field assistants	Tier 1: H-3, C-14, Sr-90, I-129, Cs-137, gross-alpha, and gross-beta radionuclides, Ra-226			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures; shorter list of Radionuclides focused on representative and key radionuclides	not all compounds tested; not expected to be significant variability or detection	
												• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures; full list of radionuclides	full list of radionuclides but beyond expected key radionuclides; expensive and not necessary	See applicable ODWS/PWQO/CCME guideline limits
	GW Quality (Nitrogen (total) - determination of organic vs inorganic nitrogen)	Understanding of background ambient GW parameters. Potentially from local/regional agricultural sources?						Community members are field assistants	(Nitrogen (total) - determination of organic vs inorganic nitrogen)			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	See applicable ODWS/PWQO/CCME guideline limits; A list of standard analytical methods is described in Protocol for Analytical Methods Used in the Assessment of Properties under Part XV.1 of the Environmental Protection Act (MECP, 2011).
	GW Quality (Cyanides)	Since this a not an ore-extraction project, cyanides should not be in use during the DGR lifespan?						Community members are field assistants	Cyanides			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	
	GW Quality (Organic/Inorganic Carbon)	Additional GW analyte referenced in the ODWS/PWQO/CCME guidelines						Community members are field assistants	Organic/Inorganic Carbon			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	
	GW Quality (PHCs (F1, F2, F3, F4))	Machinery, fuels, chemicals						Community members are field assistants	PHCs list (F1, F2, F3, F4)			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	
	GW Quality (Methylmercury)	Directly related to potential excavated rock/soil drainage to other aquatic environments?						Community members are field assistants	Methylmercury			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	See applicable ODWS/PWQO/CCME guideline limits
	GW Quality (Low-Level Mercury)	Directly related to potential excavated rock/soil drainage to other aquatic environments?						Community members are field assistants	Low level mercury			• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally	See applicable ODWS/PWQO/CCME guideline limits

Appendix E, Table 7

Preliminary design options for the shallow groundwater component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Sampling/Field Methods	Sampling Frequency	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Groundwater	GW Quality at Regional Scale- starting with private wells	Understanding of background ambient GW parameters. Potential changes to ambient conditions due to DGR operations and drainage from excavated rock/soil.	RSA	RSA - 120 wells were identified in the Ignace area. Need to determine which will be best to sample for RSA (aim for 7) Need to consider the wells that fall within certain RSA coverage. will need to arrange access to fill in locations where data needs are greatest. Need to determine depth intervals in sampling plan to classify based on hydrostratigraphic unit.	Best approach would be to pull existing pump and well infrastructure and then use commonly used equipment/infrastructure in the private well: -dedicated Waterra tubing (HDPE; 5/8" diameter) and foot valves -at least three well volumes purged; recommend low flow sampling methods - pump selection based on depth to water Protocols/steps: -for metals analysis, samples were field-filtered -field parameters measured during purging: temperature, ORP, DO, EC, pH Will need to evaluate infrastructure and applicable	Low-flow (if possible) sampling protocols preferred. Use of submersible, peristaltic, dedicated foot valves, or bladder pumps to extract GW from select private locations. Will need to evaluate infrastructure and applicable equipment for the existing private wells. Field sampling plan needs to account for: equipment/field/trip blank samples, duplicate samples	Quarterly first year, semi annual to annual going forward	Community members are field assistants	Same as LSA, SSA	Same as LSA, SSA	Access to private well locations (private well access agreements) Standard equipment maintenance for pumps, tubing and power sources. Sample integrity considerations (refrigeration, sample coolers), travel time for samples from collection point to lab for analyses (i.e. holding times)	• Seasonal and spatial trends are captured • Groundwater sample collection follows accepted regulatory procedures; best practice for	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally; requires removing pump and infrastructure from private wells and loss of water to the home during sampling events	See applicable ODWS/PWQO/CCME guideline limits
					Best approach would be to pull existing pump and well infrastructure and then use commonly used equipment/infrastructure in the private well: Will need to evaluate infrastructure and applicable equipment for the existing private wells. Alternate approach will be to take sample from the existing house water system ahead of any in house treatment systems (RO, filters, tanks, etc.)	Will need to evaluate infrastructure and applicable equipment for the existing private wells. Field sampling plan needs to account for: equipment/field/trip blank samples, duplicate samples	Quarterly first year, semi annual to annual going forward	Private well owners collect samples from tap/point pre treatment from private wells				• Seasonal and spatial trends are captured • Simple collection from existing infrastructure	Quarterly Sampling may not be required for 3 years if data indicates stable results either annually or seasonally; not best practice for sampling - potential interference from existing infrastructure and pumps etc.	

Appendix E, Table 8

Preliminary design options for the soil component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Soils and Unconsolidated Overburden	Baseline characterization of surficial soil quality in the SSA, LSA, and RSA, and soil and unconsolidated overburden encountered during drilling of 9 proposed shallow GW wells Data needed for comparison against future monitoring data	Chemicals, fuels, machinery, batteries, release from exposure of excavated material	SSA; LSA; RSA	Surficial soil samples will be collected at locations of plant tissue analysis in the LSA and RSA. Soil samples will also be collected at 9 proposed shallow GW well locations: sample at surface, at 15 centimeters bgs, and then at 2-meter intervals bgs.	Surficial samples - collected from top 15 cm from undisturbed areas. Borehole samples - discrete. One sampling event	Community members as field assistants	**Total metals (mg/kg)** including aluminum, antimony, arsenic, barium, beryllium, bismuth, boron, cadmium, calcium, chromium (VI), chromium (III), cobalt, copper, iron, lead, lithium, magnesium, manganese, mercury, molybdenum, nickel, phosphorus, potassium, selenium, silver, sodium, strontium, thallium, tin, titanium , uranium, vanadium, zinc, and zirconium. Plus bromine, cesium and samarium	Standard laboratory procedures	Seasonal considerations (snow cover, visibility) Sample integrity considerations (refrigeration, sample coolers), travel time for samples from collection point to lab for analyses (i.e. holding times)	Community and stakeholder involvement	Does not involve an emerging technology	ODWS/ PWQO/ CCME guideline limits
		Used nuclear fuel containers, natural radionuclide emittance from native soil	SSA; LSA; RSA	Surficial soil samples will be collected at locations of plant tissue analysis in the LSA and RSA. Soil samples will also be collected at 9 proposed shallow GW well locations: sample at surface, at 15 centimeters bgs, and then at 2-meter intervals bgs.	Surficial samples - collected from top 15 cm from undisturbed areas. Borehole samples - discrete. One sampling event	Community members as field assistants	**Top tier:** H-3, C-14, Cs-137, Sr-90, I-129, Ra-226 gross-α, and gross-β radionuclides **Second-tier:** Cl-36, Co-60, Se-79, Ru-106, Pu-238, Pu-239, Pu-240, Pu-241 Am-241, Cm-244 radionuclides (assume half as many samples)	Standard laboratory procedures				
		Natural soil quality	SSA; LSA; RSA	Surficial soil samples will be collected at locations of plant tissue analysis in the LSA and RSA. Soil samples will also be collected at 9 proposed shallow GW well locations: sample at surface, at 15 centimeters bgs, and then at 2-meter intervals bgs. In addition, field descriptions of soils (borehole logging) should be applied, including visual classification, grain size estimation, in-situ moisture content, color, soil texture, and soil type	Surficial samples - collected from top 15 cm from undisturbed areas. Borehole samples - discrete. One sampling event	Community members use portable field kits to sample for soil quality in the RSA	Inorganic nitrogen compounds (N_2, NO_3, NO_2), pH, soil moisture, Total Organic Carbon, Dissolved Organic Carbon, and grain size distribution	Standard laboratory procedures				
		Fuels, machinery	SSA; LSA; RSA	Surficial soil samples will be collected at locations of plant tissue analysis in the LSA and RSA. Soil samples will also be collected at 9 proposed shallow GW well locations: sample at surface, at 15 centimeters bgs, and then at 2-meter intervals bgs.	Surficial samples - collected from top 15 cm from undisturbed areas. Borehole samples - discrete. One sampling event	Community members as field assistants	Semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH) diesel, gasoline, and heavy oils	Appropriate methods under EPA SW-846				

Appendix E, Table 8

Preliminary design options for the soil component of the Baseline Program.

Category	Objective/Project Need	Potential Source	Study Area	VC and Sample Size/Resolution	Sampling Approach	Stakeholder Involvement	Contaminants of Potential Concern/ Endpoints	Analytical Methods	Operating/ Maintenance Requirements	Benefits	Drawbacks	Applicable Regulations/ Guidelines
Bedrock and Consolidated Overburden	Baseline characterization of the geochemical and radiological properties of bedrock and consolidated overburden encountered during drilling of 9 proposed deep GW wells. Data needed for comparison against future monitoring data.	Chemicals, fuels, machinery, batteries, release from exposure of excavated material	SSA; LSA	At 18 proposed mid-depth and deep GW well locations (up to ~100 m depth per well). Samples should be collected at 5-meter intervals up to 50 m depth, and at 10-meter intervals from 50-100 m depth. Up to 5 additional samples should be collected at key lithologic features such as contacts, veins, grain size changes, and sulfide occurrences.	Borehole samples - discrete One sampling event	Community members as field assistants	**Total metals (mg/kg)**, major and trace elements, acid generation, and leaching potential	Static Geochemical Characterization based on MEND (2009), AMIRA (2002) and INAP (2012) should include: - Acid-Base Accounting (ABA): to develop estimates of the potential for acid generation based on the balance between acid producing and acid buffering minerals; - Major and Trace Element Analysis on Solids: to determine the total amount of metals in the solid phase of the rock samples (including x-ray fluorescence and total metals analysis by total digestion for metals; EPA 3050B); and, - Net Acid Generation (NAG) Testing: to verify the acid generation potential from ABA. Approximately 50% of samples should be submitted for the following additional static testing: - Short-Term Leach Testing (shake flask extraction testing): to develop initial estimates of metal leaching from a rock sample when immersed in distilled water. A modified ASTM D3987 (standard test method for shake extraction of solid waste with water) method; and - Comprehensive Analysis of NAG leachates (NAG leach testing): to evaluate the products of the complete oxidation of minerals. - Based on the results of the static testing, approximately 10% of samples should be submitted to the laboratory for the following additional static testing and kinetic testing: - Kinetic testing: used to determine mineral reaction rates - conducted according to the method outlined in ASTM D5744-99 (standard test method for accelerated weathering of solid materials using a modified humidity cell). - Mineralogy by Qualitative X-Ray Diffraction: to identify mineral assemblages as they have a large influence on metal leaching, and mineral reaction rates. - Grain Size: to help determine metal leaching, and mineral reaction rates ASTM D422-63 (standard test method for particle-size analysis of soils) will be used.	Seasonal considerations (snow cover, visibility) Sample integrity considerations (refrigeration, sample coolers), travel time for samples from collection point to lab for analyses (i.e. holding times).	Community and stakeholder involvement	Does not involve an emerging technology	ODWS/ PWQO/ CCME guideline limits
		Used nuclear fuel containers, natural radionuclide emittance from native bedrock					**Top tier:** H-3, C-14, Cs-137, Sr-90, I-129, Ra-226, gross-alpha, and gross-beta radionuclides **Second-tier:** Cl-36, Co-60, Se-79, Ru-106, Pu-238, Pu-239, Pu-240, Pu-241 Am-241, Cm-244 radionuclides (assume half as many samples)	Provided by NWMO				
	Core logging to determine: lithological descriptions (metamorphism, alteration styles, structural relationships and fabric, mineralogy, occurrence and intensity); and ore mineralogy (sulphide types, abundance, mode of occurrence, extent of previous oxidation and an estimate of relative sulphide reactivity). This information will inform sample number and location to support the geochemical characterization program.	Geochemical reactions resulting from mineralized rocks exposed to surface, through excavation and placement on surface, thus exposure to atmosphere. Areas of high fracture density that increase exposure potential of COPC-bearing material to groundwater.	SSA; LSA	At 18 proposed mid-depth and deep GW well locations (up to ~100 m depth per well). Samples should be collected at 5-meter intervals up to 50 m depth, and at 10-meter intervals from 50-100 m depth. Up to 5 additional samples should be collected at key lithologic features such as contacts, veins, grain size changes, and sulfide occurrences.	Core/borehole samples, hand-held XRF screening, measurements, and logging of structural measurements at fractures or lineations One sampling event	Historical records; anecdotal information about metals exploration in the area; community members as field assistants	See geochemical characterization	Visual observation by geologist/geochemist	Seasonal considerations (snow cover, visibility)	• Hand-held XRF is fast and efficient method of sample screening • Trained geologists can identify heterogeneity in units, making sampling both more efficient and comprehensive • Community and stakeholder involvement	• Does not involve an emerging technology • Requires field work to be completed in temperate weather to save the cost of a core shack. • Hand-held XRF is not a highly quantitative method	ODWS/ PWQO/ CCME guideline limits
Gamma survey	Characterize the gamma radiation levels in the area	Natural gamma	SSA	The gamma radiation survey will cover a pre-defined area, meant to encompass the facility and ERMA footprints within the SSAGAM. The final survey boundaries will be defined in consultation with NWMO.	Environmental gamma radiation data will be collected through roving transects using a GPS integrated gamma radiation surveying equipment either by foot or by ATV (depending on the site terrain and access issues). Gamma radiation measurements will be taken at a distance of approximately 1 m above the ground surface. One sampling event in Year 3	Community members as field assistants	Gamma	Collected data will be mapped to ensure adequate coverage, accuracy and confirm any identified areas of radiological contamination. A reference area will also be included in the survey	Standard for this equipment	Provides background gamma radiation information		

APPENDIX F

VALUED COMPONENT CATEGORY SELECTION MATRIX FOR TISSUE SAMPLING PROGRAM

APPENDIX F

Valued Component Category selection matrix for tissue sampling program.

Valued Component (VC) Category	Example VCs that Occur in Region	Score					Baseline Measurement Priority	Rationale
		Community	HHRA	ERA	Is Sample Size Achievable?	Total		
Large-bodied Fish - Piscivore	Walleye, Lake Trout (RSA_{TIS} only), Northern Pike, Burbot	3	3	3	3	12	Primary	High cultural/stakeholder significance; First Nations Food, Nutrition and Environment Study (FNFNES) important pathway; identified in Table 2-1 of Federal Contaminated Sites Action Plan (FCSAP) and satisfies Table 7-1 of N288.6 (fish)
Large-bodied Fish - Benthivore	Lake Whitefish (RSA_{TIS} only), Cisco (RSA_{TIS} only), White Sucker, Sturgeon (RSA_{TIS} only)	3	3	3	3	12	Primary	High cultural/stakeholder significance; FNFNES important pathway; identified in Table 2-1 of FCSAP and satisfies Table 7-1 of N288.6 (fish).
Aquatic Macrophytes	Sedge Species, Wild Rice/Manoomin (RSA_{TIS} only), Rat Root/Sweet Flag (RSA_{TIS} only)	3	3	3	2	11	Primary	Manoomin and rat root/sweet flag specifically identified as culturally significant and harvested and consumed by local community members; aquatic macrophytes identified in Table 2-1 of FCSAP, satisfies Table 7-1 of N288.6 (aquatic plant species).
Aquatic Birds - Herbivores	Canada Goose, Cackling Goose, Snow Goose	3	3	3	2	11	Primary	Canada geese are hunted in the region and are a known traditional food source; FNFNES important pathway (goose); goose identified in Table 2-1 and 2-2of FCSAP.
Aquatic Birds - Omnivores	Mallard Duck	3	3	3	2	11	Primary	Ducks are hunted in the region and are a known traditional food source; FNFNES important pathway (duck); although all doses low, some of the highest calculated values were for mallard (NWMO 2017b); dabbling duck identified in Table 2-1 of FCSAP, satisfies Table 7-1 of N288.6 (bird species with aquatic habitat).
Terrestrial Berries	Blueberry, Cranberry, Raspberry	3	3	2	2	10	Primary	Mentioned repeatedly in stakeholder/rights-holder consultations (Appendix B) and important traditional food; FNFNES important pathway (strawberry, blueberries); plants is important pathway for I-129 (Sixth Safety Case).
Terrestrial Vegetation - Edible or Medicinal Use	Wild Mushrooms, Chaga, Labrador Tea	3	3	2	2	10	Primary	Mentioned repeatedly in stakeholder/rights-holder consultations (Appendix B) and important traditional food; FNFNES important pathway (strawberry, blueberries); plants is important pathway for I-129 (Sixth Safety Case).
Upland Game Birds	Ruffed Grouse	3	3	3	3	12	Primary	Mentioned repeatedly in stakeholder/rights-holder consultations (Appendix B) and known traditional food source; FNFNES important pathway (partridge); satisfies Table 2-2 of FCSAP (omnivorous bird), satisfies Table 7-1 of N288.6 (bird species with terrestrial habitat).
Small Mammals	Mice, Shrew, Squirrels, Snowshoe Hare	3	2	3	2	10	Primary	Small mammals including snow shoe hare are trapped/snared and a potential traditional food source; identified in Table 2-2 of FCSAP (e.g. vole, shrews, bat, hare), satisfies Table 7-1 of N288.6 (small mammals).
Ungulates	Moose, Whitetail Deer	3	3	3	3	12	Primary	Mentioned repeatedly in stakeholder/rights-holder consultations (Appendix B); high cultural value and known traditional food source; FNFNES important pathway; identified in Table 2-1 of FCSAP, satisfies Table 7-1 of N288.6 (large mammal).

APPENDIX F

Valued Component Category selection matrix for tissue sampling program.

Valued Component (VC) Category	Example VCs that Occur in Region	Score					Baseline Measurement Priority	Rationale
		Community	HHRA	ERA	Is Sample Size Achievable?	Total		
Semi-aquatic Mammals	Beaver, Muskrat, Mink, Otter	2	3	3	1	9	Secondary	Locally trapped and culturally significant; FNFNES important pathway (beaver); although all doses low, some of the highest calculated values were for mink, beaver and muskrat (NWMO 2017b); Table 2-1 of FCSAP recommends muskrat, mink; satisfies Table 7-1 of N288.6 (small mammal).
Large Mammals - Carnivore	Wolf, Lynx	2	2	3	2	9	Secondary	Possibly trapped for furs; lynx sometimes consumed by Elders, wolf have high cultural significance; satisfies Table 2-2 of FCSAP (carnivorous mammal).
Amphibians	Spring Peeper, Boreal Chorus Frog, Wood Frog, Grey Treefrog, Green frog, American Toad	2	1	3	2	8	Secondary	Frogs and toads identified in stakeholder/rights-holder consultations (Appendix B; comment 7B-1a); not a concern for HHRA; although all doses low, some of the highest calculated values were for northern leopard frog (NWMO 2017b); amphibian identified in Table 2-1 and Table 2-2 of FCSAP, satisfies Table 7-1 of N288.6; risks for non-radiological COPC generally assessed using environmental concentrations; concentrations can be successfully modelled based on water and soil chemistry input.
Birds - Piscivores	Merganser, Loon, Grebes, Falcons, Hawks, Eagles, Herons	1	2	3	2	8	Secondary	Not specifically mentioned in stakeholder/rights-holder consultations; although all doses low, some of the highest calculated values were for loon (NWMO 2017b; piscivorous identified in Table 2-1 of FCSAP (loon, merganser, osprey), satisfies Table 7-1 of N288.6 (bird species with aquatic habitat).
Terrestrial Vegetation - Browse	Willow, Birch, Red Osier Dogwood, Balsam	2	1	3	2	8	Secondary	Terrestrial vegetation mentioned repeatedly in stakeholder/rights-holder consultations (Appendix B) in terms of ecosystem and moose/deer health; not a HHRA concern; identified in Table 2-2 of FCSAP, satisfies Table 7-1 of N288.6 (terrestrial plant).
Small-bodied Fish - Planktivore	Emerald Shiner, Spottail Shiner, Blacknose Shiner, Iowa Darter, Longnose Dace (LSA_{TIS})	2	1	2	2	7	Secondary	Fish mentioned repeatedly in stakeholder/rights-holder consultations (Appendix B) in terms of overall protection; not a HHRA concern; identified in Table 2-1 of FCSAP, satisfies Table 7-1 of N288.6 (fish) but can be successfully modelled based on water chemistry input.
Insects	Dragonflies, Caterpillars	2	1	3	2	8	Secondary	Insects mentioned in stakeholder/rights-holder consultations (Appendix B, comments 3B-2b and 7B-1d); not a HHRA concern; identified in Table 2-2 of FCSAP, satisfies Table 7-1 of N288.6 but can be successfully modelled based on soil chemistry input.
Benthic Invertebrates	Chironomids	1	1	3	1	6	Not Required	Not identified as a concern in stakeholder/rights-holder consultations; not a concern for HHRA; identified in Table 2-1 of FCSAP, satisfies Table 7-1 of N288.6 (benthic invertebrates) but can be successfully modelled based on water chemistry/sediment input.

APPENDIX F

Valued Component Category selection matrix for tissue sampling program.

Valued Component (VC) Category	Example VCs that Occur in Region	Score					Baseline Measurement Priority	Rationale
		Community	HHRA	ERA	Is Sample Size Achievable?	Total		
Birds - Insectivores	Swallows, Flycatchers	2	1	2	1	6	Not Required	Songbirds (Canadian Jays) mentioned in stakeholder/rights-holder consultations (Appendix B, comment 1G-2d); not a concern for HHRA; swallow identified in Table 2-1 of FCSAP but can be successfully modelled based on water and soil chemistry data.
Soil Invertebrates	Worms	1	1	3	1	6	Not Required	Mentioned in stakeholder/rights-holder consultations (Appendix B, comment 3B-2c); not a concern for HHRA; identified in Table 2-2 of FCSAP, satisfies Table 7-1 of N288.6 (soil invertebrate) but can be successfully modelled based on soil chemistry input.
Honey, bees	Honey	2	2	1	1	6	Not Required	Mentioned in stakeholder/rights-holder consultations (Appendix B, comment 3B-2a); not required for an ERA; locally difficult to source.
Herptiles	Not captured in amphibians listed above (Snakes, Turtles)	2	1	2	1	6	Not Required	Amphibian and reptile study was mentioned in stakeholder/rights-holder consultation (Appendix B, comment 7B-1a); not a HHRA concern; identified in Table 2-1 and 2-2 of FCSAP but can be successfully modelled based on water and soil chemistry input.
Large Mammal - Omnivore	Black Bear	2	1	2	1	6	Not Required	No mention of consumption but bear hunting takes place and bears are generally culturally important; not a HHRA concern; identified in Table 2-2 of FCSAP (bear), satisfies Table 7-1 of N288.6 but information captured with large mammal carnivore category.

Note: Valued Component (VC) categories of aquatic primary producers (phytoplankton) and pelagic invertebrates (zooplankton) covered by surface water chemistry input; see main report for complete references.

Ranking System

Community

Rank = 1	No specific mention in stakeholder/rights holder consultation; not a known food source (Appendix B; Chan et al. 2014; CanNorth 2011, 2014, 2017a, 2018a, 2018b)
Rank = 2	Mentioned by stakeholders; potential food source; cultural importance; tourism/economic importance (Appendix B; Chan et al. 2014; CanNorth 2011, 2014, 2017a, 2018a, 2018b)
Rank = 3	Consistently brought up by stakeholders/rights holders; known traditional food source; cultural importance; tourism/economic importance (Appendix B; Chan et al. 2014; CanNorth 2011, 2014, 2017a, 2018a, 2018b)

HHRA (Human Health Risk Assessment)

Rank = 1	Not included in HHRA
Rank = 2	Included in HHRA but expected to be minor
Rank = 3	Important to HHRA (Chan et al. 2014; CCME 2016a, 2016b)

ERA (Ecological Risk Assessment)

Rank = 1	Not specifically identified in sources (CSA 2012; Environment Canada 2012a; CCME 2016b; NWMO 2017b)
Rank = 2	Identified by at least 1 source (CSA 2012; Environment Canada 2012a; CCME 2016b; NWMO 2017b)
Rank = 3	Identified by all 3 sources (CSA 2012; Environment Canada 2012a; CCME 2016b; NWMO 2017b)

Sample Size

Rank = 1	Sample weight or sample number unlikely to be sufficient to achieve meaningful results
Rank = 2	Sample weight or sample number will be sufficient to achieve meaningful results
Rank = 3	Sample weight or sample number achievable and meaningful

Total Score/Baseline Measurement Priority

10-12	Primary Target
7-9	Secondary Target
5-6	Not Required

APPENDIX G

DETAILED DESIGN INPUT FOR AIR QUALITY, NOISE, AND LIGHT MONITORING COMPONENTS

1. ATMOSPHERIC MONITORING PROGRAM – DETAILED INFORMATION

The preliminary list of COPC considered in the baseline air quality and noise monitoring program were identified in the Conceptual Site Model (see Appendix C), which are summarized in Table 1, and further separated into *Tier 1* and *Tier 2* COPC. The Tier 1 (priority) COPC list includes (a) conventional air quality contaminants that are expected to be readily measurable within the LSA_{ATM} and RSA_{ATM}, (b) key radiation/radioactivity COPC that may be of greater concern in the community, and (c) noise levels. The Tier 2 COPC list includes other contaminants that are (a) expected to be present in low-level amounts or possibly not measurable (i.e., below detection limits) in the LSA_{ATM} and RSA_{ATM} and/or (b) associated with a potential project-interaction, and (c) may be of concern with in the community. The Tier 1 COPC include conventional parameters that are the subject of provincial and national air monitoring initiatives, as well as Radiation/Radioactivity based COPC. The Tier 2 COPC include trace organics/toxics (VOCs, PAHs) and trace metals (naturally occurring or the product of local industry), and other radionuclides of interest to NWMO.

Table 1: Summary of COPC

Description	Category	Contaminant of Concern
Tier 1 COPC	Conventional Parameters	Carbon Monoxide (CO) Nitrogen Oxides (NOx) Sulphur Dioxide (SO_2) Total Suspended Particulate Matter (TSP) Suspended Particulate Matter <10 micron (PM_{10}) Suspended Particulate Matter <2.5 micron ($PM_{2.5}$)
	Radiation/Radioactivity	Tritium Carbon-14 Radon Radionuclides: Sr-90, I-129 Gross-α and Gross-β External Gamma
	Noise	Noise
Tier 2 COPC	Trace Organics and Toxics	Volatile Organic Compounds (VOCs) Polyaromatic Hydrocarbons (PAHs)
	Trace Metals	Conventional list of 31 metals (U.S. EPA Method 6010)
	Radiation/Radioactivity	Radionuclides: Cl-36, Cs-17, Se-79, Ru-106, Cs-137, Pu-238, Pu-239, Pu-240, Am-241, Cm-244

For the baseline characterization program, we are evaluating the potential to initiate a "Primary" reference method monitoring program with a "Secondary" network of off-site passive ambient air monitoring approaches within the Local Study Area and/or Regional Study Area, which would also be collocated with the reference methods for ongoing validation. The passive monitoring approaches typically consist of specially-treated sample media that are exposed to atmospheric conditions for a known period, then retrieved, and analyzed at a laboratory for the associated pollutant. This simple form of measurement would provide a means of gathering data further afield from the project site, such as locations of community or ecological interest. In addition, as passive methods do not require a specialized technical background to deploy, this could be a means of having a stakeholder group involved in the baseline measurement program.

1.1 Primary Monitoring Program

The "primary" atmospheric monitoring program is the core program that consists of sampling using accepted reference methods, endorsed by the Ontario MECP, ECCC and/or U.S. EPA. This core program is expected to be maintained throughout the life of the project and provide information on how baseline levels change over the various stages, through the use of consistent methods and an adaptive monitoring framework. The use of reference methods at a primary station will also allow for the evaluation and validation of technologies that may applied as part of the "secondary" air quality monitoring program (see Section 2). The methods under consideration for measurement of the COPC presented in Table 1 in the primary monitoring network are discussed in the following sections.

1.2 Tier 1 COPC

1.2.1 Conventional Parameters

1.2.1.1 Particulate Matter

Prior to discussing the available equipment options for the measurement of particulate matter, it is important to first distinguish between the two general types of particulate monitoring instruments that are available: *continuous* and *non-continuous* monitors. Continuous particulate monitors make use of technology that allow for particulate concentrations to be quantified internally, averaged for a desired time-step (e.g., 1-hour) and reported on an ongoing, uninterrupted basis. The use of continuous monitors would therefore allow for hourly particulate concentrations to be logged 24 hours per day, 7 days per week, resulting in a robust data set. In non-continuous particulate monitors, the particulate concentrations are established on a gravimetric basis, whereby the sample air is drawn across a pre-weighed filter, and upon completion of the sample period (e.g., 24-hours), the filter is removed and provided to a laboratory for post-weighing and any requested additional analysis (e.g., metals speciation). The main pros and cons of each type of sample method are summarized in Table 2.

Table 2: Pros and Cons of Particulate Monitoring Principles

Continuous		Non-Continuous	
Pros	**Cons**	**Pros**	**Cons**
Provide a robust data set of hourly concentrations on a 24/7 basis Concentration results available immediately (near real-time) Minimal maintenance requirements – designed to operate long-term with minimal site visits	Do not allow for subsequent analysis of metals content Often rack-mounted equipment that requires a temperature-controlled enclosure (e.g., sample trailer)	Allow for subsequent analysis of metals content High volume methods available that increase the likelihood of detectable metals content in low background areas Often self-contained stand-alone units that do not require a special enclosure	Require weekly visits from experienced field technician for filter changes, recording instrument readings, completing calibrations, maintenance When operated on NAPS schedule, only a single 24-hr sample per week is collected Increased potential for sample contamination (e.g., during filter handling, shipping) Concentration results not available until well after sampling has occurred (samples need to be compiled and sent to lab for analysis)

It is recommended that the baseline air quality monitoring program include a high-volume air sampler (HVAS) at the permanent station, for the measurement of TSP. This non-continuous technology is the only reference method for TSP from both the Ontario MECP and the U.S. EPA. We would recommend following the National Air Pollution Surveillance (NAPS) Network sampling schedule, which includes a 24-hr sample every 6th day.

An HVAS draws a large volume of sample air across a filter, which deposits more particulate on the filter than instruments that use lower flow rates. This allows for a greater likelihood of detecting particulate in environment with low particulate levels, as well as a greater chance of measuring detectable metals content if a metals scan is conducted on the filter. An HVAS instrument is also a reference method for measurement of PM_{10} and could be used if there were a need to quantify metals content in the PM_{10} size fraction. It is not expected to be necessary to operate a PM_{10} HVAS just to quantify particulate levels alone (i.e., no metals), as the more modern reference methods provide strong detection in low-level environments.

The Ontario MECP has outlined air quality standards for PM_{10} and $PM_{2.5}$ (on a 24-hour basis), while the CCME/ECCC has a standard for $PM_{2.5}$ only (on both a 24-hour, and annual basis). There are numerous instruments approved by the Ontario MECP and U.S. EPA for measurement of PM_{10} and $PM_{2.5}$, with some being continuous and others being non-continuous. Within these instruments there are also numerous technologies

available for the quantification of particulate matter in the sample air. For instance, many of the modern instruments use beta-attenuation technology or light-scatter spectrometry to determine particulate concentrations, while others use mass-based technology such as gravimetry or an oscillating microbalance. Several options have been considered for configuring the permanent station with particulate monitors. The options included various combinations of the available equipment types (i.e., HVAS, continuous monitors, non-continuous monitors). In addition, due to the remote setting of the proposed site, options were considered that included only continuous methods for PM_{10} and $PM_{2.5}$, while operating HVAS instruments on a campaign basis, thus limiting the number of visits required by a field technician. The options that are under evaluation are summarized in Table 3.

Table 3: Particulate Monitoring Options under Evaluation for Primary Program

Scenario	HVAS			Continuous			Non-Continuous		
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$
1	▪	▪				▪			
2	▪	▪							▪
3	▪				▪	▪			
4	▪							▪	▪
5	▪				▪ †				
6	▪ ‡	▪ ‡			▪	▪			
7	▪ ‡	▪ ‡			▪ †				

Notes:
† a single entry for both PM_{10} and $PM_{2.5}$ indicates use of a dual channel or dual output device
‡ samples collected on a campaign basis (e.g., during site visits for continuous monitor maintenance)

These options were discussed with the technical team and academic advisor, and the consensus was that it is best to take advantage of continuous technology, where possible, and particularly using equipment that is capable of providing data for multiple COPC within a single instrument (i.e., both PM_{10} and $PM_{2.5}$). This suggests that scenario 5 or 7 would be the preferred approach. The various approved reference methods for PM_{10} and $PM_{2.5}$ are outlined in Table 4.

Table 4: $PM_{10}/PM_{2.5}$ Continuous Methods

Manufacturer	Model	PM_{10} Ref. Method	$PM_{2.5}$ Ref. Method	Simultaneous $PM_{10}/PM_{2.5}$	U.S. EPA Designation No.	Origin
DKK-TOA Corporation	FPM-222	•		N	EQPM-0905-156	Japan
Environnement S.A.	MP101M	•	•	Y †	EQPM-0404-151 (PM_{10}) EQPM-1013-211 ($PM_{2.5}$)	EU (France)
FAI Instruments	SWAM 5a	•	•	Y	EQPM-0912-205 (PM_{10}) EQPM-0912-204 ($PM_{2.5}$)	EU (Italy)
Grimm	EDM 180		•	Y ‡	EQPM-0311-195	EU (Germany)
Horiba	APDA-371	•	•	N	EQPM-0798-122 (PM_{10}) EQPM-0308-170 ($PM_{2.5}$)	Japan
MetOne	BAM-1020	•	•	N	EQPM-0798-122 (PM_{10}) EQPM-0308-170 ($PM_{2.5}$)	USA
MetOne	BAM-1022		•	N	EQPM-1013-209	USA
MetOne	E-BAM Plus	•		N	EQPM-1215-226	USA
Opsis	SM200	•	•	N	EQPM-0810-193 (PM_{10}) EQPM-0812-203 ($PM_{2.5}$)	EU (Sweden)
Teledyne	T640X	•	•	Y	EQPM-0516-239 (PM_{10}) EQPM-0516-238 ($PM_{2.5}$)	USA
Thermo Scientific	5014i	•	•	N	EQPM-1102-150 (PM_{10}) EQPM-0609-183 ($PM_{2.5}$)	USA
Thermo Scientific	5030i		•	N	EQPM-0609-184	USA
Thermo Scientific	TEOM 1405-DF	•	•	Y	EQPM-1013-208 (PM_{10}) EQPM-0609-182 ($PM_{2.5}$)	USA

Notes:

† simultaneous PM_{10} and $PM_{2.5}$ measurement requires an additional module (CPM Module), which is not an approved reference method for either size fraction

‡ while the unit can output the PM_{10} size fraction, it is only listed as a reference method for $PM_{2.5}$

Based on the preferred options for testing of PM_{10} and $PM_{2.5}$ (i.e., using a single instrument to measure both), the short list of equipment from Table 4 can be extracted by considering only equipment with a "Y" in the "Simultaneous $PM_{10}/PM_{2.5}$" column. Note that there are two instruments for which simultaneous PM_{10} and $PM_{2.5}$ is possible, but the technology that allows this is considered to be outside of the approved reference method. The Environnement S.A. model MP101M is a reference method for each PM_{10} and $PM_{2.5}$ (individually); however, they offer a module add-on that allows the PM_{10} monitor to output the $PM_{2.5}$ fraction using light scatter; however, this is not an approved method for $PM_{2.5}$. Similarly, the Grimm EDM 180 can output both the

PM_{10} and $PM_{2.5}$ size fractions; however, the unit is only a reference method for $PM_{2.5}$. As such, neither of these were considered in the short list.

The remaining instruments under consideration are the FAI Instruments SWAM 5a dual channel monitor, the Teledyne-Advanced Pollution Instrumentation (Teledyne-API) T640 with 640X option, and the Thermo Scientific TEOM 1405-DF Dichotomous Air Sampler. Based on professional experience, the TEOM 1405 is a somewhat dated technology that requires frequent maintenance by a skilled technician to keep online. The FAI Instruments SWAM 5a is technically a continuous method; however, it uses a magazine of pre-loaded 47-mm filters that get automatically fed to the instrument for sampling via beta-attenuation, and then fed to another magazine for removal. The intention of this design is to allow for post-analysis of the filters; however, as noted previously, it is not likely that there will be detectable metals content on the filters in a remote area, particularly with the low flow rate of this instrument. Metals content has been proposed to instead be determined using an HVAS system. In light of this, the SWAM 5a system is not recommended, as a technician would need to regularly visit the stations to reload the filter magazine with fresh filters, and remove the sampled filters, which would be discarded as they will not require post-analysis.

The Teledyne-API T640 quantifies particulates based on light-scatter technology, and when supplied with the 640X option (which is approved by the U.S. EPA), a single unit can output both PM_{10} and $PM_{2.5}$ concentrations in near real-time (1-min averages). As the instrument uses light-scatter, there is no sample media to periodically replace and so the system is very low-maintenance and intended for long-term autonomous sampling. Our technical experts have experience using the T640 for particulate measurement in the field and recommend it for its ease of use and minimal maintenance requirements. As with the continuous gas analyzers that will be discussed in following sections, the T640 is a rack-mounted unit that is intended to be installed in a temperature-controlled enclosure.

1.2.1.2 Nitrogen Oxides

The MECP outlines in its *Operations Manual for Air Quality Monitoring in Ontario* (MECP 2008) that the only acceptable method for measuring ambient Nitrogen Dioxide (NO_2) is through the use of an instrument using the *chemiluminescence* principle of measurement and makes reference to the U.S. EPA list of reference methods for allowable instrumentation. We have completed a review of the most current list of reference methods from the U.S. EPA (U.S. EPA 2018), and condensed the list as it contains many historic instruments that are no longer on the market, instruments that use analysis methods other than chemiluminescence, and instruments that have been modernized in terms of the user interface. The reduced list contains the most recent reference method technologies that are currently being marketed by the approved manufacturers. Each of the instruments under consideration include an ozone (O_3) generator that allows for the output of concentrations of nitrogen oxide (NO) and oxides of nitrogen (NO_x) in addition to NO_2. The instruments under review are summarized in Table 5.

Table 5: NO_2/NO_x Analyzers Under Evaluation

Manufacturer	Model	U.S. EPA Designation No.	Origin
DKK-TOA Corporation	GLN-114E	RFNA-0508-171	Japan
Ecotech	Serinus 40	RFNA-0809-186	Australia
Environnement S.A.	AC32e	RFNA-0118-249	EU (France)
Horiba	APNA-370	RFNA-0506-057	Japan
Recordum	Airpointer	RFNA-1194-099	EU (Austria)
Sabio	Model 6040	RFNA-0418-250	USA
Teledyne	Model T200(U)	RFNA-1194-099	USA
Thermo Environmental Inst.	Model 42i(Q)	RFNA-1289-074	USA

1.2.1.3 Sulphur Dioxide

The MECP outlines in its *Operations Manual for Air Quality Monitoring in Ontario* (MECP 2008) that the only acceptable method for measuring ambient sulphur dioxide (SO_2) is through the use of an instrument using *ultraviolet (UV) fluorescence*, and makes reference to the U.S. EPA list of reference methods for allowable instrumentation. As with NO_2, we have completed a review of the most current list of reference methods from the U.S. EPA (U.S. EPA 2018), in order to consider only the most recent approved technologies. The instruments under review are summarized in Table 6.

Table 6: SO_2 Analyzers Under Evaluation

Manufacturer	Model	U.S. EPA Designation No.	Origin
DKK-TOA Corporation	GFS-312E	EQSA-1107-168	Japan
Ecotech	Serinus 50	EQSA-0809-188	Australia
Environnement S.A.	AF22e	EQSA-0802-149	EU (France)
Horiba	APSA-370	EQSA-0506-159	Japan
Recordum	Airpointer	EQSA-0486-060	EU (Austria)
Sabio	Model 6020	RFSA-0616-237	USA
Teledyne	Model T100(U)	EQSA-0495-100	USA
Thermo Environmental Inst.	Model 43i(Q)	EQSA-0486-060	USA

1.2.1.4 Carbon Monoxide

The MECP does not outline any requirements for instrumentation measuring carbon monoxide (CO) in its *Operations Manual for Air Quality Monitoring in Ontario* (MECP 2008) ; however, the U.S. EPA does provide a list of reference methods for CO monitoring (U.S. EPA 2018). As with the other gases, the list from the U.S. EPA includes historic instruments that are no longer on the market, and so the list was condensed only to those instruments that approved manufacturers are currently marketing. The instruments under review for CO monitoring are summarized in Table 7.

Table 7: CO Analyzers Under Evaluation

Manufacturer	Model	U.S. EPA Designation No.	Origin
DKK-TOA Corporation	GFC-311E	RFCA-0907-167	Japan
Ecotech	Serinus 30	RFCA-0509-174	Australia
Environnement S.A.	CO12e	RFCA-0915-228	EU (France)
Horiba	APMA-370	RFCA-0506-158	Japan
Peak Laboratories	Model 90-170	EQCA-0814-217	USA
Recordum	Airpointer	RFCA-0981-054	EU (Austria)
Sabio	Model 6050	RFCA-0817-248	USA
Teledyne	Model T300(U)	RFCA-1093-093	USA
Thermo Environmental Inst.	Model 48i(Q)	RFCA-0981-054	USA

It should be noted that, for the most part, the same manufacturers appear on each list as providing analyzers for NO_x, SO_2 and CO. As such, there will be an advantage to selecting a single manufacturer for the three instruments, as the user interface, connections, and software will be the consistent. Based on the preferred monitor for PM_{10} and $PM_{2.5}$ (Teledyne T640), it would make sense to use the Teledyne analyzer models for NO_x, SO_2 and CO as well. Our technical experts have positive experience using Teledyne instruments in the field.

1.2.2 Radiation/Radioactivity

1.2.2.1 Radionuclides

It is expected that levels of the radionuclides of interest in air will be quite low during the baseline program (if present at all), and based on our experience at other nuclear facilities, are likely to remain difficult to detect upon operation of the facility. As such, it will be necessary to collect as large an air sample volume as possible in order to have an opportunity to detect measurable levels. It is recommended that an HVAS be used for this purpose, operated continuously for as long as is practicable (i.e., 30+ days) in the summer period when airborne particulate is typically at its highest levels. The filter from the HVAS would then be provided to the laboratory with a field and travel blank to estimate the radionuclide content of the collected sample using the approved analytical method.

1.2.2.2 Carbon-14

Carbon-14 is a COPC of interest to the radiation/radioactivity analysis and will be part of the suite of radionuclides scanned as part of the HVS samples collected as described above. Quarterly Carbon-14 measurements are being proposed as part of the primary air monitoring program. Further, Carbon-14 can be measured on an active basis in conjunction with Tritium.

We anticipate that the C-14 monitoring program will be conducted at five (5) locations (co-located with other passive monitors), with three (3) locations within the SSA and two (2) locations within the LSA_{ATM}.

1.2.2.3 Tritium

Tritium in ambient air is tested around nuclear facilities in Ontario, either by the facility operator (e.g., OPG, Bruce Power), Health Canada (historically) or the Ontario Ministry of Labour (currently). Over the years the organizations completing the monitoring have moved away from passive sampling methods due to inconsistent performance and inaccurate results. Currently, tritium in air is measured using active systems based on recommendations from the CNSC (CNSC 2019). The systems that are currently being used at nuclear facilities draws air either through a series of canisters containing silica gel, or a molecular sieve, at a low flow rate over the course of one month. Water vapour is extracted from the sample media in the laboratory and analyzed for tritium content using liquid scintillation counting. Monthly tritium measurements are being proposed as part of the primary air monitoring program.

We anticipate that the H-3 monitoring program will be conducted at five (5) locations (co-located with other passive monitors), with three (3) locations within the SSA and two (2) locations within the LSA_{ATM}.

1.2.2.4 Radon

Radon in an outdoor ambient setting is typically collected using passive long-term radon detectors. In these systems, the passive sample media is installed in a weather-protective casing that is then attached to a post or other vertical mount (e.g., tree), and exposed to the ambient air for three months. Upon retrieval, the passive sampler is returned to the laboratory for analysis, along with the field and travel blanks supplied by the manufacturer. At a minimum, radon will be measured at the permanent station; however, it can also be measured at the secondary network locations as it does not require power and can use the same vertical mount as the other passive samplers. We anticipate that the Radon monitoring program will be conducted at eight (8) locations, with six (6) locations within the SSA and two (2) locations within the LSA_{ATM}.

1.2.2.5 External Gamma

External gamma most easily measured using a dosimeter. Manufacturers typically can provide weather-proof pouches for the dosimeters for application in ambient air monitoring programs. For such a program, the dosimeter pouch is simply mounted in an open area (e.g., with the other passive samplers), exposed to the atmosphere for a period of three months, at which time it is removed, and returned to the laboratory. For this type of sampling it is important to carefully maintain travel and field blanks, as the dosimeter will continue to detect gamma during transit. We anticipate that the Radon monitoring program will be conducted at eight (8) locations, with six (6) locations within the SSA and two (2) locations within the LSA_{ATM}.

1.2.2.6 Gross-α and Gross-β

Gross-α and Gross-β will be measured from the HVAS filter, described in Section 1.2.2.1.

1.2.3 Noise

The noise baseline monitoring program would conform to standard methods and guidance outlined in the MECP's *Environmental Noise Guideline*, Health Canada's (HC) *Guidance for Evaluating Human Health Impacts in Environmental Assessment: Noise* and the International Standards Organization (ISO) *1996-2 Acoustics — Description, measurement and assessment of environmental noise — Part 2: Determination of environmental*

noise levels. A continuous monitoring program covering 1-2 week periods is anticipated on a seasonal basis in the first year, and is expected to be sufficient to characterise background noise levels in the LSA_{NO}.

To characterise the noise environment, two (2) sample locations are anticipated that would include a station within the SSA and a further station in close proximity to the major transportation sources (i.e., Trans Canada highway and CN/CP Rail). Type 1 (Class 1) integrating sound level meters would be employed that conform to the requirements of IEC 61672-1:2002, in accordance with ISO 1996-2.

1.2.4 Light

The baseline light assessment should focus on the parameters that will be of interest for the Light Impact Assessment aspect of the Environmental Assessment. The indicators of effects for light pollution generally include:

- sky glow;
- light trespass/incident light (illuminance); and
- glare.

Glare is not possible to include in a baseline study as it is a function of the installed light fixture(s), how they are oriented relative to an observer, and the specific properties of the lamp (e.g., temperature, intensity, etc.). As such, only general recommendations may be provided in an EA regarding glare (e.g., full cut-off luminaires, no horizontal-mounted lighting systems, dimming or other curfew type options).

There are guidelines for limiting light trespass based on environmental zoning classifications, which outlined by the CIE. The guideline values, measured in lux, are applicable to vertical illuminance on a property. The baseline lux values at a property may assist in defining the environmental zone; however, this should generally be obvious from the description of the setting. Nevertheless, baseline measurements are useful to collect at properties (or other locations of interest, such as natural habitat areas) in order to have a point of comparison to any predictive results or future measurement data collected at the same location. Commercial light models are able to output a predicted lux value on a defined vertical plane, provided sufficient details of the lighting design are available (e.g., proposed lamps, luminaires, building layouts and surface properties, as well as surface properties of the site lands, the lands of the sensitive properties, and the lands in between).

Light trespass is measured using a standard hand-held light meter (e.g., Extech EA33), and is measured over an imaginary vertical plane representing a receiving plane (e.g., window) at the location on interest. For planning future measurement initiatives (e.g., during construction, operations) it is beneficial to use a light meter that is also capable of measuring luminous intensity (candelas, or cd) as this can be used as an assessment of glare once the fixtures associated with the project are in place (however, as noted previously, glare cannot be measured as a component of the baseline study as it is linked specifically to project sources).

The baseline sky glow can be measured using a Unihedron Sky Quality Meter (SQM), such as the SQM-L. Sky glow is typically controlled by managing the Upward Light Ration (ULR) of the design in accordance with criteria offered by the CIE. ULR is not a baseline condition that can be measured in the field – the ULR can only be determined through calculations or modelling of the designed lighting system for the project. The measurement

of sky brightness (or sky glow), in units of magnitudes per square arcsecond, can be tracked from baseline conditions through construction and operational phases to provide a measure of how the conditions have changed as a result of the project. It should be noted though that measurements should be conducted under equivalent conditions each time, as the atmospheric conditions, seasonal phenomena, and the lunar cycle can have a significant impact upon the results. Future measurements completed in conditions that differ from the baseline condition could result in attributing impacts to the project when the difference may actually be due to the differing natural environmental conditions, which are unrelated to the project.

In general, light studies should be completed in the summer, during a period with no significant light contribution from the moon, and no significant cloud cover. Summer measurements are recommended as there is no chance for snow cover, which would increase the reflected light component. Further, there should be no contribution from the moon, which means that measurements should be taken as close as possible to the New Moon phase in the lunar calendar. Lastly, sky forecasts should be used to select a night when there is no cloud cover, as presence of clouds may also increase the presence of reflected light.

1.3 Tier 2 COPC

1.3.1 Trace Organics and Toxics

1.3.1.1 Volatile Organic Compounds (VOCs)

The Ontario MECP and U.S. EPA each designate two acceptable methods for the collection of VOC samples in ambient air: drawing ambient air through sorbent tubes (glass tubes packed with sorbent media), or drawing ambient air into an evacuated cannister under vacuum. In our experience, the latter approach is the simplest method available. The sorbent tube method requires a pump, calibrator and special handling of sample media upon sample collection (i.e., must be kept cool until received by the laboratory). The evacuated cannister method is provided by a laboratory with a calibrated flow controller, which simply needs to be attached and opened using the flow controller valve. Upon completion of the sample event (typically 24-hours), the valve is closed and the cannister is returned to the lab for analysis in accordance with U.S. EPA Method TO-15.

At this time, there is not a reference method from the Ontario MECP or U.S. EPA that allows for autonomous, continuous sampling of VOCs – both designated methods require an operator to be present to site the instrument, and open and close the valve at the beginning and end of the 24-hour sample period. As such, it is envisioned that the baseline program will involve the collection of VOC samples on a campaign basis, or will involve training local staff or a community group to complete regular sampling, field documentation and shipping of the cannisters to the lab for analysis.

1.3.1.2 Polyaromatic Hydrocarbons (PAHs)

The Ontario MECP designates two methods for the collection of PAH samples in ambient air, while the U.S. EPA designates only one. The MECP provides two methods in order to provide flexibility as to whether only non-volatile PAHs are collected, or both volatile and non-volatile PAHs are collected, based on the needs of the program. The U.S. EPA method is only for the collection of both volatile and non-volatile PAHs and is equivalent to the latter MECP method. The collection of PAH samples using the approved reference method (i.e., for both volatile and non-volatile PAHs) requires the use of a specialized HVAS. The sample media consists of a circular filter, placed in a filter holder that is in-line with a cannister that holds a glass cartridge containing a

polyurethane foam (PUF) plug. The sample air is drawn through the filter and PUF cartridge via a motor with a flow controller that maintains a constant flow rate over the 24-hour sample period. Upon completion of the sample period, the filter and PUF cartridge are shipped to a laboratory for analysis. As with the HVAS for particulates, this is a manual sampling method – a skilled operator is necessary to prepare and exchange the sample apparatus, record instrument readings, and complete calibrations and ongoing maintenance. As such, the monitoring for PAHs is being considered on a campaign basis.

1.3.2 Trace Metals

The collection of samples for trace metals does not require an additional sampling method, provided that TSP is being measured as part of the program using an HVAS. As described in Section 1.2.1.1, we are recommending that the baseline program include either regular or periodic sampling of TSP (and potentially PM_{10}) using an HVAS for this purpose. On a regular interval (currently assuming one sample per month), the laboratory will be instructed to complete an analysis of a selected HVAS filter for 31 metals according to U.S. EPA Method 6010, which uses inductively coupled plasma – atomic emission spectrometry (ICP-AES) as the analysis method.

It should be noted that for a remote setting such as the proposed site, where very low levels of metals may be expected, a 24-hour sample may not provide sufficient loading for detectable levels of metals. As such, the program may need to be adapted as results are received, to extend the sample period as necessary to be able to characterize the actual metals content and avoid simply reporting levels as below the detection limit of the laboratory instrumentation where possible.

1.3.3 Radiation/Radioactivity (Other Radionuclides)

The collection of an additional sample is not required for the added list of radionuclides of interest to the NWMO. The HVAS filter, collected as described in section 1.2.2.1, can be used for the additional scan.

2. SECONDARY MONITORING PROGRAM

The “secondary” atmospheric monitoring program will be rooted in an adaptive monitoring framework and is intended to provide broader spatial coverage to the air monitoring program, using techniques that do not require the same resources (e.g., power, enclosure, security, and technical expertise) as the reference methods used at the “primary” air quality monitoring station. Where possible, this network will make use of passive sampling methods, which simply require exposing the designated sample media to the elements for a set period of time (typically 1-3 months), then exchanging the sample media, and sending the collected samples to be analyzed at a laboratory. Generally, the use of passive techniques requires less detailed technical knowledge, skills and experience to operate, which lends to broader community involvement.

Any approaches that are used in the secondary program will also be collocated with the primary network sampling station, in order to validate the results. This approach will also allow for emerging technologies to be evaluated for potential inclusion in the secondary monitoring network. In addition to this station at the Primary monitoring location, two (2) stations are envisioned within the SSA along the fence line, and two (2) stations would be located in the LSA_{ATM} toward the north-west and south-east of the Project site. As best possible, these latter stations will be positioned close to sensitive receptors (i.e., Borrups Corners). These five (5) stations would support the passive methods noted below.

2.1 Tier 1 COPC

2.1.1 Conventional Parameters

2.1.1.1 Particulate Matter

The Ontario MECP has included a standard operating procedure for the collection of dustfall samples in its *Operations Manual for Air Quality Monitoring in Ontario* (MECP 2008). This method is often applied in remote areas where there is no access to power at the preferred monitoring locations. The method involves placing a sample jar (polymer container) in a suitable bracket that can hold the jar approximately 3 m off of the ground surface. The container is typically supplied by the lab with a screw-lid that is removed when the jar is installed for sampling and replaced at the end of the 30-day sample period. The jar is often also supplied with deionized water additive (to assist with entraining the dust), and an anti-freeze additive as applicable depending on the season. Upon completion of the sample period, the sealed container is provided to the laboratory for analysis, whereby the jar is rinsed out through a pre-weighed filter, which is then dried and post-weighed.

2.1.1.2 NO_2/NOx, SO_2

The Ontario MECP does not provide guidance for passive measurement of NO_2, NOx, SO_2 – all recommended methods require an active sampling system. Similarly, the U.S. EPA does not provide reference methods that involve passive sampling of these COPC. However, often for baseline scoping studies in remote areas it is necessary to be able to sample for these constituents where there is no access to power. This is typically addressed using chemically treated badges that are exposed to the atmosphere for a given period, before being resealed and shipped to a lab for analysis. The laboratory Bureau Veritas Canada (formerly Maxxam) offers a system that is regularly used for passive sampling of these constituents.

The Passive Air Sampling System (PASS) includes a rain head with space for three (3) passive sample cartridges to be loaded. The cartridges are loaded face-down, with the rain head acting to protect the media from the elements, and the cartridges are exposed to the atmosphere for a given period (typically 30 days). The measurement of NO_2, NOx and SO_2 each require their own individual cartridge, as they are each treated with different chemicals for sampling. There are also options for other constituents to be measured using the PASS, such as ammonia and hydrogen sulphide.

2.1.2 Radiation/Radioactivity

2.1.2.1 Other Radionuclides

A radionuclide scan would be completed intermittently on collected the dustfall samples (see section 2.1.1.1). The approach being evaluated is to complete the radionuclide analysis on the most loaded dustfall sample from the first month of sampling to determine whether detection limits can be met; if not, it would be recommended that dustfall containers be deployed for an extended period (e.g., three months) to increase the likelihood of measuring detectable amounts.

2.1.2.2 Carbon-14

In addition, carbon-14 is commonly measured by nuclear facilities passively using soda lime pellets and is the recommended approach. Using this method, the sample apparatus containing the soda lime pellets is simply exposed to the atmosphere for a period of three months to absorb CO_2 from the air. In the laboratory, the exposed pellets are titrated with acid to release the CO_2 which is then analyzed in a liquid scintillation counter to determine the carbon-14 content.

2.1.2.3 Tritium

Despite reported issues with sample accuracy and variability, tritium sampling has historically been completed using passive methods (CNSC 2019). Passive tritium samplers consist of a liquid absorber, either water or a mixture of water and ethylene glycol, in a container or capped vial. An orifice allows tritiated water to diffuse into the container/vial. The liquid absorber is placed for set exposure time and then analyzed by liquid scintillation counting. In an effort to provide greater spatial coverage, monthly passive sampling of tritium would be completed.

2.2 Tier 2 COPC

For trace organics, toxics, metals and radionuclides, we anticipate that baseline levels will be very low, if detectable at all. We anticipate that a short and intensive program would be initiated at the beginning of the program to establish if any of these COPC are measurable in the environment. Based on the results of this initial sampling effort, a more focussed program would be established to address key COPCs and resolve the spatial and temporal extents of the program.

2.2.1 Trace Organics and Toxics

2.2.1.1 Volatile Organic Compounds (VOC)

Passive methods, similar to those described in section 2.1.1.2 for NO_2/NOx and SO_2 are proposed for the secondary VOC monitoring.

2.2.1.2 Polyaromatic Hydrocarbons (PAHs)

As with the gaseous conventional parameters, the Ontario MECP and U.S. EPA do not have recommendations for passive monitoring systems for the measurement of PAHs. However, data on existing levels are often desired for remote areas. As such, passive methods have been developed for PAHs for use in remote monitoring programs. This allows average PAH concentrations to be estimated for baseline purposes, without the need for a constant electrical power supply. Outdoor passive samplers are commercially available for PAHs, which typically consist of a metal bowl (base) with a hinged metal lid. A PUF disk is placed in the bowl, and the lid, which is a larger diameter than the base closed overtop and acts to keep precipitation out while still allowing air to contact the PUF disk. Upon completion of the sample period (typically 30 days), the PUF disk is removed from the sampler and returned to the laboratory for analysis.

2.2.2 Trace Metals

The characterization of metals in dustfall does not require an additional sample device/method, provided that dustfall is being measured per section 2.1.1. As noted in that section, the dustfall that is collected is transferred to a filter upon receipt by the laboratory, and if metals speciation is required, the laboratory will complete an analysis of the dustfall filter for 31 metals according to U.S. EPA Method 6010, using ICP-AES.

2.2.3 Radiation and Radioactivity

As noted in section 2.1.2, radionuclide scan would be completed intermittently on collected dustfall samples. The approach being evaluated is to complete the radionuclide analysis on the most loaded dustfall sample from the first month of sampling to determine whether detection limits can be met; if not, it would be recommended that dustfall containers be deployed for an extended period (e.g., three months) to increase the likelihood of measuring detectable amounts.

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