

## - Preliminary Geoscientific Assessments -

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December 2018



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# 2018 Report of the NWMO Adaptive Phased Management Geoscientific Review Group (GRG) December 2018

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## Executive summary

This report provides a summary of the work completed in 2018 by the Adaptive Phased Management Geoscientific Review Group (APM-GRG; abbreviated to GRG). This year the GRG met three times by teleconference call and once during an in-person meeting in Toronto. GRG members also attended the NWMO Annual Geoscience Seminar in Toronto on June 5<sup>th</sup> and 6<sup>th</sup>, 2018, before the in-person meeting. These seminars are focused on NWMO's geoscientific research and development program and often include several presentations from international guests. The GRG were able to gain insight into the latest developments of NWMO's site characterisation program, including the Safety Case, and also received an update on the Engineering Process.

The GRG reviewed approaches, methods, criteria and findings related to broad geoscientific issues addressed by the NWMO in candidate areas underlain by crystalline rock. This included a review of the test plan for monitoring activities following drilling of the first borehole in the Ignace area, the planned content of a borehole integrated data report, the work plans for a revised lineament interpretation, an upgrading of the geological map database and discrete fracture network modelling at the Ignace site, and the findings of the revised lineament interpretation work. The GRG also provided initial feedback to the NWMO on the structure of a report concerned with the plan for Geoscientific Site Characterization at Ignace. Some terminology questions in preparation for the forthcoming review of a test plan for groundwater modelling in the Ignace area were also raised.

As in previous years, the GRG made various contributions to many geoscientific aspects and these are briefly described in this report. NWMO documented all suggestions, questions, comments in disposition tables and subsequently addressed them. The NWMO continues to provide high quality responses to all points raised by the GRG in a timely, transparent and professional manner. In the GRG members' opinion, the adopted approach follows or exceeds international practices in this phase of assessment.

The GRG's overall assessment of the progress during 2018 is again very positive. A systematic approach was adopted and executed by the NWMO, and the GRG feels that good progress was made in geoscientific site assessments. The NWMO team and its consultants have undertaken many tasks and this work was presented in high-quality documents. The review group also appreciates the careful and timely planning by NWMO to support our review work. This allowed the GRG to fulfil its mandate and carefully assess approaches, interpretations and conclusions.

Technical and scientific aspects are described in the main body of this report. A few high-level aspects are highlighted here:

- After reviewing the plan for borehole data integration and discussing with NWMO the Geoscientific Site Characterization work program at Ignace, the GRG emphasizes that the mechanical and thermal characteristics of rock units should be determined immediately after the geological characteristics, and reported before the hydrogeological and hydrogeochemical features in the integrated reports.
- The GRG recommended that fracture analyses should be carried out at one or more available quarries in the Ignace area. Such data would be highly complementary to the lineament interpretation work and the structural data acquired from boreholes. It would also be helpful for validating or testing DFN models in the near-surface realm.
- The GRG questions use of the term "Mean Life Expectancy (MLE)" and suggests replacement by less confusing and more commonly adopted terminology. The GRG considers that it is now important to update the 2013 APM Deep Geological Repository Glossary or to create at least a condensed extract for all terms in order to achieve consistency between field and borehole data. The revised glossary should be strictly followed in all future work by NWMO and their consultants.

*Geoscientific Review Group Report 2018*

- The GRG recommended inclusion of schematic geological cross-sections across the Ignace area in the work plan to upgrade the bedrock geological database for this area. The GRG also suggested that the NWMO should consider how Indigenous knowledge will be incorporated. Furthermore, the GRG recommended that the distribution of inferred overburden should be taken into account in the update of the bedrock geological database.
- An early draft of a work plan on DFN modelling was received and the GRG encouraged consideration of how the DFN will feed early into integrated work flow processes.

It is evident to and very much welcomed by the GRG that the NMWO's team has initiated work with single borehole data integration and various data interpretations in preparation for forthcoming 3D geoscientific modelling work in the Ignace area. The GRG is looking forward to the detailed data integration and interpretation reports, and eventually to an integrated 3D geoscientific model for this potential site.

## 1 Introduction

The Adaptive Phased Management Geoscientific Review Group (APM-GRG; abbreviated to GRG) was established by NWMO in 2012. It aims to provide independent review comments and advice on the preliminary geoscientific assessments being conducted as part of NWMO's evaluations to identify a suitable deep geological repository site in an informed and willing host community for Canada's used nuclear fuel. More specifically, the GRG provides comments on the approach, methods and criteria used, the data interpretation, and the adequacy of proposed preliminary field investigation and drilling programs to advance the understanding of the geology and increase confidence in the potential suitability of the various siting areas being considered by NWMO.

This report covers the activities of the GRG during the year 2018. Previous GRG reports were issued in December 2013, 2014, 2016 and 2017, and are publicly available on NWMO's website (APM-GRG 2013, 2014, 2016, 2017 [www.nwmo.ca](http://www.nwmo.ca)). Brief biographies of the GRG members for the 2018 term are attached to this report.

## 2 Objectives of NWMO's geoscientific preliminary assessments

The suitability of communities is assessed using a staged approach including 'Initial Screenings', 'Preliminary Assessments' and 'Detailed Site Characterization', and considers both technical and community well-being factors (NWMO 2010).

The overall preliminary assessment is conducted through a series of technical, socio-economic and cultural studies conducted in two phases over several years. Technical studies involve geoscience, engineering, transportation, environment and safety. The objective of the geoscientific suitability preliminary assessment is to assess whether candidate areas have the potential to meet NWMO's site evaluation factors (geoscientific suitability). It is conducted in two phases:

- **Phase 1 - Desktop Study:** Undertaken for all communities electing to be the focus of a preliminary assessment. This phase involves desktop studies using available geoscientific information, and a set of key geoscientific characteristics and factors that can be realistically assessed at the desktop phase of the preliminary assessment. Desktop studies for all 22 communities are completed.
- **Phase 2 - Preliminary Field Investigations:** Undertaken to further assess the potential suitability of a subset of communities selected by the NWMO. Depending on the geological setting, Phase 2 field investigations can include high resolution airborne surveys, geological mapping and initial borehole drilling.

The subset of communities advanced to Phase 2 preliminary assessment are selected based on the findings from the desktop study during Phase 1, considering technical, socio-economic and cultural considerations. It is important to note that the mandate of the GRG is exclusively focussed on the approach, methods, criteria and findings associated with the geoscientific suitability assessments. The GRG is not involved in matters pertaining to transportation and environment, and is not consulted when narrowing down the number of communities.

The status of communities involvement in NWMO's site selection process as of December 2018 is illustrated in Figure 1. There are currently five communities remaining in the site selection process. They are all in Phase 2 of the preliminary assessment, and include Ignace, Manitouwadge and Hornepayne on crystalline rock, and Huron-Kinloss and South Bruce on sedimentary rock. During 2018, the GRG reviewed geoscience reports related to the communities situated on crystalline rock, in particular the Ignace area. No review activities bearing on the two sedimentary rock sites were assigned to the GRG this year.

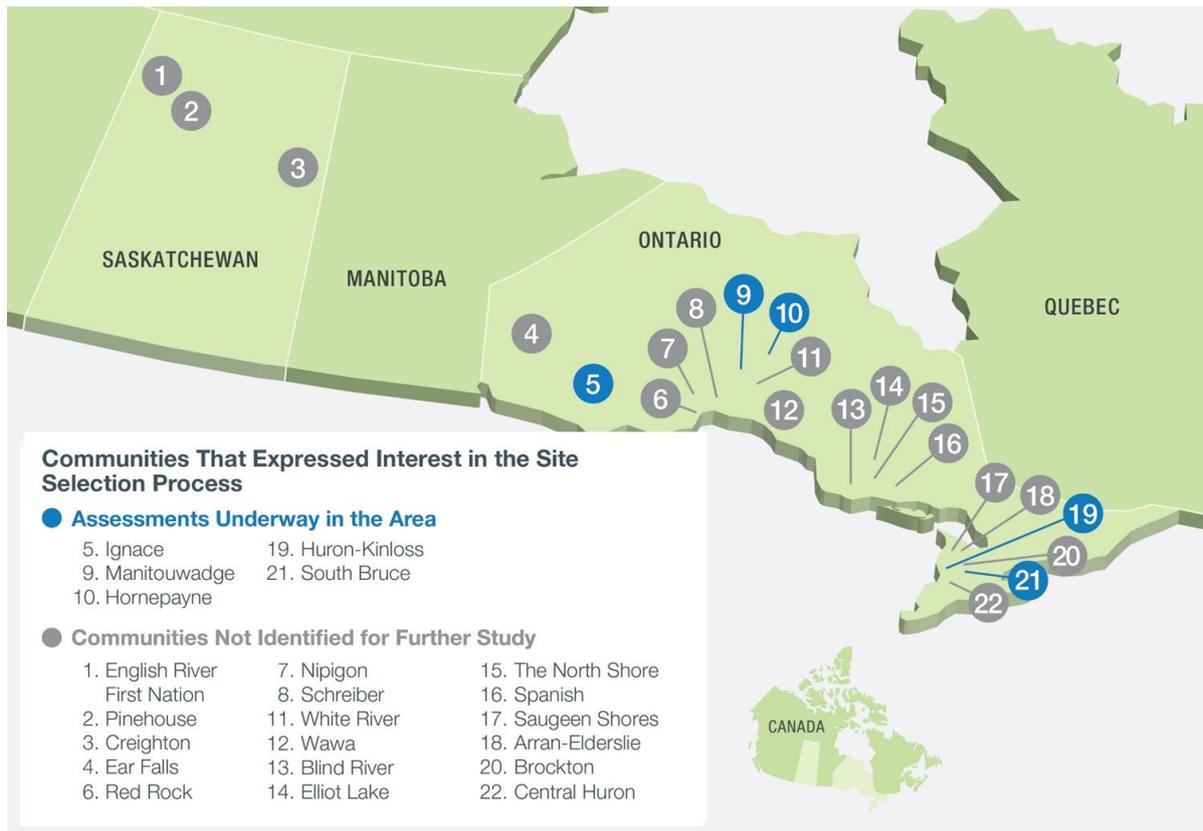


Figure 1. Communities that expressed interest in the site selection process (as of December 2018). Communities 1 to 16 are communities located on crystalline rock, and communities 17 to 22 on sedimentary rock.

### 3 GRG review activities in 2018

As the following list of activities illustrates, 2018 was another active period for the GRG with an in-person meeting in Toronto, including a visit of the Oakville engineering facility, reviews of six documents, and advisory functions on forthcoming work tasks.

#### 3.1 Meetings between GRG and NWMO

In 2018, the GRG has been involved in reviewing NWMO’s geoscientific activities in the communities remaining in Phase 2 of the preliminary assessments. Meetings with NWMO and its consultants included three teleconference calls and one in-person meeting. Specifically,

- Teleconference call on March 28, 2018.
  - Focus: Update; NWMO Planning for 2018 to 2023; supporting Geoscience Research and Development Activities
- In-Person meeting in Toronto and Oakville between June 7<sup>th</sup> and 8<sup>th</sup>, 2018 (Figure 2).
  - Focus: Geological and groundwater modelling, and Mean Life Expectancy (MLE) assessment
- Teleconference call on November 1, 2018.
  - Focus: Geoscience Site Investigations Work Flow
- Teleconference call on November 30<sup>th</sup>, 2018.
  - Focus: Introduction to the initial draft of the Geoscientific Site Characterization Plan for the Ignace area in preparation for the review by the GRG (to be completed by January 7<sup>th</sup>, 2019).

GRG members also attended the annual NWMO Annual Geoscience Seminar in Toronto on June 5<sup>th</sup> and 6<sup>th</sup>, 2018, before the in-person meeting. The GRG found it very informative and also saw great benefit in obtaining a sound understanding of the various research and development activities by the Canadian regulator (CNSC), universities and other Canadian organisations running in parallel with the site characterization. A presentation on Indigenous Knowledge was much appreciated. It was suggested to continue linking the GRG in-person meetings and Geoscience Seminars.

The GRG valued the subsequent in-person meeting and a visit to the Oakville engineering facility as it provided an opportunity to fully understand the emplacement concept pursued by NWMO. It also enhanced the GRG's ability to appreciate the complexity of the repository design and planning process.

Feedback from the GRG for consideration by the NWMO was shared following the discussions during the in-person meeting. Beyond some general observations, the feedback included comments relating to scheduling of site selection fieldwork, human resource requirements, work packages for this program (see Section 5.6), data reporting and integration including forthcoming 3D geosphere modelling.

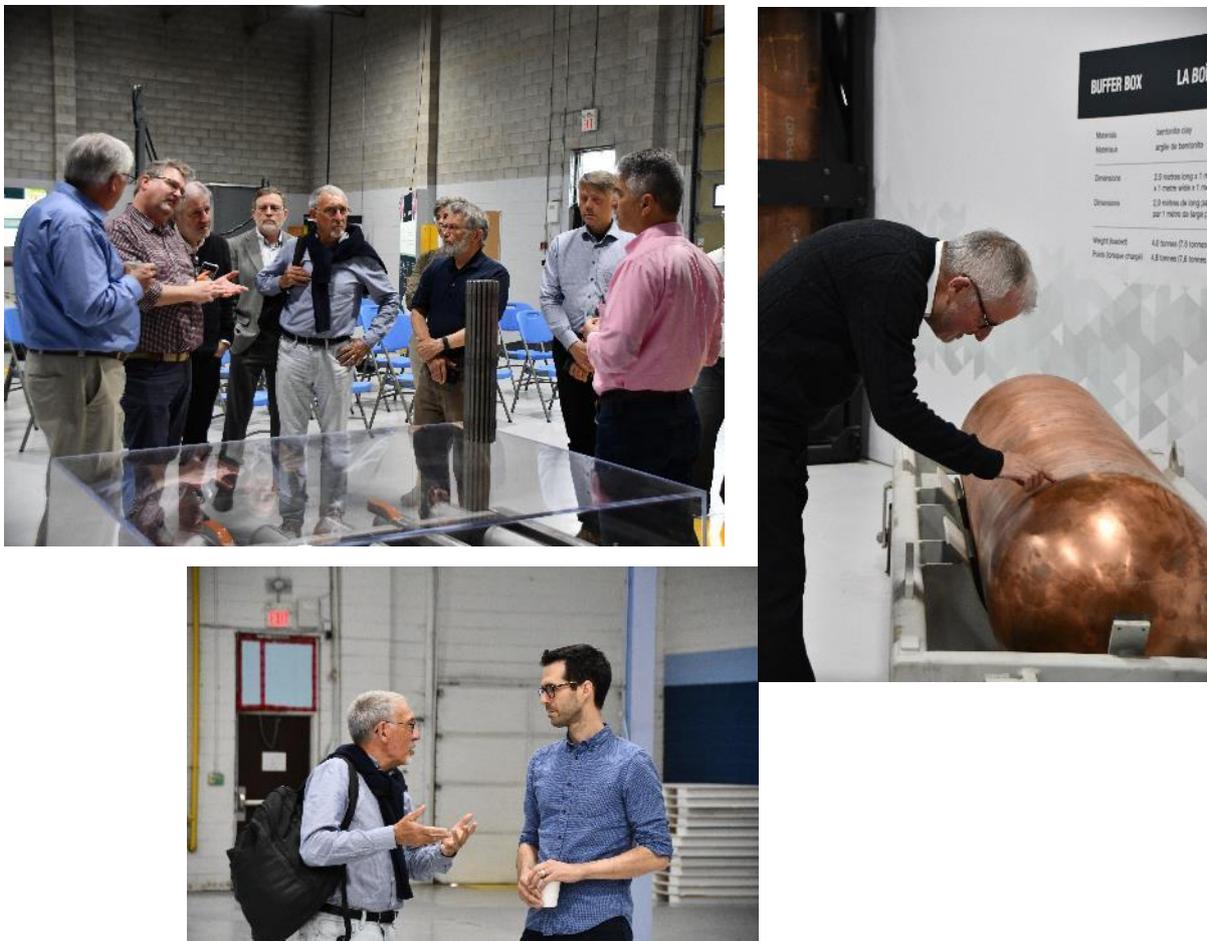


Figure 2. GRG members and NWMO staff at the Oakville facility.

### 3.2 Specific studies reviewed by the GRG

The GRG systematically reviewed approaches, methods and some findings related to the following geoscientific activities, and summarizes some comments on them in later sections of this report. Most of these activities specifically address the communities of Wabigoon Lake Ojibway Nation and Ignace, Ontario, referred to here as the 'Ignace area'.

- Review of test plan WP9 concerned with monitoring activities along Borehole 1 in the Ignace

area (Section 5.1).

- Review of the approach for integrating single-borehole data, in the context of the planned geoscientific data integration report for Borehole 1 in the Ignace area (Section 5.2)
- Review of the approach and work plan, as well as the interpretation of lineaments in the Revell Batholith and surrounding greenstone belts in the Ignace area (Section 5.3).
- Review of the approach and work plan for updating the bedrock geological database for the Revell Batholith and surrounding greenstone belts in the Ignace area (Section 5.4)
- Review of work plan for DFN modelling of the Ignace area (Section 5.5)

The GRG also provided initial feedback to NWMO on the structure of a report concerned with a plan for Geoscientific Site Characterization at Ignace and raised a terminological question in preparation for the forthcoming review of a test plan for groundwater modelling in the Ignace area (Section 5.6).

## 4 Overall assessment of progress during 2018

The GRG's review process followed the same approach as in previous years:

- Prior to meetings, NWMO shared draft work plans and initial findings in technical reports, as they became available, in order to solicit review comments;
- Meetings, teleconferences and email exchanges with NWMO were held to discuss the GRG's review comments;
- GRG comments were documented and tracked in disposition tables, which, together with NWMO responses and in several cases final dispositions, were returned to the GRG to ensure that the approach to address the review comments was appropriate.

The GRG's overall contributions in 2018 focussed on the tasks listed in Section 3.2.

The GRG is again satisfied with the approach and methods adopted by the NWMO and is impressed by the progress made to-date. In particular, the GRG notes that NWMO is now in the process of preparing for 3D modelling work and expanding the initial borehole drilling program of the Phase 2 Preliminary Field Investigations in the Ignace area, by adding two more boreholes in 2019. This runs in parallel with a detailed interpretation process of Borehole 1 at Ignace. The systematic, iterative process developed and adopted by NWMO allowed the GRG to review findings and progress in detail.

The NWMO team and its consultants have again undertaken high-quality work that facilitated a carefully reviewed approach. The GRG was able to provide timely input for consideration by NWMO. Suggestions by the GRG for process improvements were considered and implemented by NWMO in a timely, transparent and professional manner. As a consequence, NWMO continues to maintain a high standard of quality work and is making steady progress in the site evaluation process. In the GRG members' opinion, the adopted approach continues to follow or exceed international practices.

## 5 GRG review comments

### 5.1 Test Plan for installation of a Westbay MP38 monitoring system in Borehole 1 at Ignace

During 2017, the GRG reviewed most of the test plans (WP1 to WP8) for the initial borehole drilling program in the Ignace area (APM-GRG, 2017). Recommendations focused on improvements around the clarity of and consistency between the plans. During 2018, the GRG continued this work with a review of the test plan (WP9) for the installation and testing of a Westbay MP38 multi-level groundwater monitoring system in Borehole 1 at Ignace (IG\_BH01).

## *5.2 Review of approach for integrating data collected from single boreholes*

The GRG reviewed the approach and rationale for integrating single-borehole data in the context of the planned geoscientific data integration report for the borehole IG\_BH01. The review work addressed the planned table of contents for the forthcoming report.

The GRG recommended to reorder the different geoscientific data sets and requested some clarification of the adopted terminology. The mechanical characteristics of rock units and the in-situ stress information should be introduced immediately after the geological characteristics; i.e., before the hydrogeological and hydrogeochemical features are presented. This issue was also raised in the context of the initial evaluation of the planning for a Geoscientific Site Characterization work program at the Ignace site (see Section 5.6.1).

Furthermore, it was recommended that attention be paid on the scale of presentation of possibly different versions of the WellCAD plots for different purposes. This is important, since the decisions made for IG\_BH01 should be followed in future borehole reports to facilitate comparisons between boreholes in the future.

The GRG advised NWMO to study examples of data presentations from deep boreholes in crystalline rocks in other countries (e.g. Finland, Sweden, Switzerland) and then to compile the best format in a template. A common template created by NWMO and their consultants should then be used for all boreholes. It is understood that this will constitute extra efforts at this stage but benefits will be derived during future work.

## *5.3 Lineament Interpretation in the Ignace Area*

The NWMO established a work plan and completed an in-house interpretation of lineaments in the Revell Batholith and surrounding greenstone belts in the Ignace area. These tasks were presented in separate technical reports that were reviewed by the GRG. Data sets are high-resolution airborne magnetic data flown in 2014 (SGL, 2014), and high-resolution LiDAR and orthoimagery NIR aerial data sets acquired during 2017. The new imagery data sets provide much improved surface information for the interpretation of lineaments compared to that used during the earlier Phase 2 preliminary field investigations work.

### *5.3.1 Lineament interpretation work plan*

The GRG was generally satisfied with the approach and work plan for a revised interpretation of lineaments within the Ignace area. Recommendations were made to help improve the completion of the lineament interpretation and the quality of the work plan report.

In order to reduce issues with uncertainty in lineament interpretation, the GRG noted that it will be carried out jointly by two interpreters and will undergo numerous, rigorous reviews. In this context, the GRG discussed the use of a semi-automated lineament tracing tool. The GRG also noted that the geological information gained from the attribute "width" is uncertain and recommended that it should be removed from the attributes table. Furthermore, it was suggested that it should be stated up to what scale the new lineament interpretation aims to trace lineaments. If there is no limit, it is also necessary to inform future users of this approach.

The GRG remains convinced, and advised NWMO accordingly, that future analysis of fractures in available quarries in the Ignace area would be highly complementary, bridging the scale gap between the lineament interpretation discussed in the work plan and the structural data that will be acquired from boreholes. It would also be helpful to test and validate the DFN modelling approach in the near-surface realm.

### 5.3.2 Lineament interpretation report

The GRG reviewed a draft of the lineament interpretation report for the Ignace area produced by the NWMO geoscience staff. The report described in suitably adequate detail the methodology used, which is vital for this work task. The report also presented and carried out some analysis of the results. The draft report sent for review did not contain an abstract or a conclusions section. For this reason, the GRG requested to read an updated report when written. NWMO has recently provided the final report to the GRG that includes the recommended changes.

The GRG pointed out some problems with one of the terms used to classify in a geological sense some of the interpreted lineaments. The GRG suggested use of the term “fabric-concordant” instead of “brittle-ductile”, and this recommendation has been adopted by NWMO. This issue was noted in earlier work, emphasizing the need for an updated glossary of terms to be used by NWMO and their consultants. The GRG also recommended inclusion of a statement informing the reader how lineaments identified solely from the LiDAR and orthoimagery data (referred to as surficial lineaments) were classified geologically.

Several requests were made to clarify, for example, how the azimuths of lineaments were calculated and how some aspects of the rose diagram analysis were carried out, for example, the use of length-weighted and unweighted data.

### 5.4 *Work plan for updating the bedrock geological database for the Ignace area*

The NWMO geoscience team has initiated a task to update the bedrock geological database for the Revell Batholith and greenstone belts in the Ignace area. The GRG conducted a review of the work plan for this activity. In addition to the points raised below, the GRG recommended other changes to help improve the quality of the report.

The GRG advised on better means for the integration of the lineament information (see Section 5.3.2). Furthermore, it was suggested that the evaluation of the lineaments should take place at an early stage in the work plan for the bedrock geological database (Task 2 in the work flow). The lineaments will be inferred, in part, to represent brittle structures (including faults or fault zones) and dykes, and are a key feature in the bedrock geological database; particularly as a deterministic component in the forthcoming geological and groundwater modelling activities. They will probably also have an impact on how the boundaries between different rock units are drawn.

Potential terminological problems around the use of the term “brittle-ductile” were again identified. Furthermore, the GRG emphasized that it is vital that the terminology used in the bedrock geological database is fully consistent with that developed for WP3 during the borehole drilling campaign. Ultimately, the entire approach has to be adopted to produce a spatial (3D) model for brittle deformation zones (including faults or fault zones), ductile shear zones and rock units including dykes. The same nomenclature has to be used at all dimensions of this spatial model.

The GRG recommended modification of the work plan to include the construction of at least two schematic geological cross-sections across the Ignace area. The cross-sections should be constructed by an integration of all geological information with the Phase 2 geophysical information including forward modelling work.

The GRG recommended that the distribution of inferred overburden based on electromagnetic conductance measurements and orthoimagery data should be taken into account in the update of the bedrock geological database (Task 4). This may affect the interpretation of lineament densities and other scientific or engineering quantities. NWMO staff should also think about a suitable representation of this information in a printed map generated using the database.

### *5.5 Work plan for DFN modelling in the Ignace area*

The GRG reviewed the approach and preliminary work plan for the Discrete Fracture Network (DFN) modelling work plan in the Ignace area.

The GRG felt that it was not evident how the DFN modelling would be used to enhance the site characterization process, e.g., the selection of future boreholes. Furthermore, the draft work plan was difficult to understand (jargon) and did not seem to integrate well into the overall work plans. The GRG repeatedly expressed the view that the DFN modelling seemed to be treated as an add-on rather than as a tool to actively evaluate the merit of future planned borehole locations and as an integrated component of building the 3D structural model.

### *5.6 Other activities*

#### *5.6.1 Work plan for Geoscientific Site Characterization at Ignace*

A draft of the work plan for Geoscientific Site Characterization at Ignace was presented to the GRG and discussed at the two teleconferences in November 2018. The GRG was not satisfied with the planned general structure of the report, for example, with the rock mechanics and thermal models following the hydrogeology and hydrogeochemistry models. The GRG recommends a more logical sequence in which the geological model is followed by thermal and rock mechanics (or geomechanics) including in-situ stress model, followed by the hydrogeology and hydrogeochemistry models. It is possible that transport properties should also be included in an extra chapter, because geological, hydrogeological and hydrogeochemical aspects are combined to arrive at the transport model; e.g., in matrix diffusion processes. This would be in line with the structure of Finnish (e.g. Olkiluoto) and Swedish (e.g. Forsmark) site characterisation reports. The GRG has now initiated a review of the work plan to be presented to NWMO prior to January 7<sup>th</sup>, 2019.

The GRG was not convinced that the switch in adopted terminology from ‘Geomechanics’ to ‘Rock mechanics’ is justified and helpful. Rock mechanics only deals with the rock, whereas geomechanics deals with the interplay of stress and strength and the related rock behaviour, e.g., excavation damage.

#### *5.6.2 Clarification of terminology in the context of groundwater modelling*

The GRG requested NWMO to provide a detailed definition of the term “Mean Life Expectancy” (including diffusion in general, and matrix diffusion specifically) in preparation for the forthcoming review of a test plan for groundwater modelling in the Ignace area. The GRG questions the use of this term and suggests replacement by less confusing and more commonly adopted terminology.

## **6 Concluding remarks**

The GRG is satisfied with the progress made during 2018, and continues to be impressed by the systematic and consistent approach adopted by NWMO to conduct geoscientific site evaluations. NWMO has developed sound workflows for the various field and interpretation studies to ensure consistency between the many consultants involved and between many communities, which allowed the GRG to carefully assess approaches, interpretations and conclusions. On this basis, the GRG supports the overall outcomes from these studies at this stage of investigation.

As reported by the GRG to the NWMO this year, the GRG is concerned about the above identified inconsistencies in terminology. Finally, the GRG would like to see a consistent integration approach assisting in developing consistent reports and eventually full 3D models. Nevertheless, the GRG has made many suggestions for data interpretation process improvements and is pleased to report that the NWMO at all times is responding to all identified issues in a timely, highly transparent, technically sound and professional manner.

The GRG notes that the NWMO is now expanding the Phase 2 preliminary field investigations by planning two additional boreholes.

Based on the experience of its members, the GRG feels that the adopted approach and the quality of the studies by the NWMO team and its consultants continue to exceed international practices at this phase of site evaluation.

## 7 Acknowledgement

This year, NWMO decided to add a new member to the GRG. The GRG members are pleased to welcome Mr. Anders Ström, Senior Program Manager at the Nuclear Fuel department at SKB (the Swedish Nuclear Fuel and Waste Management Company). He has been actively involved in SKB's siting program since the early '90s. Amongst other expertise, he brings multidisciplinary site descriptive modelling expertise. He is also fully engaged in SKB's program for research, development and demonstration.

## 8 References – Documents available from [www.nwmo.ca](http://www.nwmo.ca)

NWMO, 2010. Moving Forward Together: Process for Selecting a Site for Canada's Deep Geological Repository for Used Nuclear Fuel, Nuclear Waste Management Organization.

APM-GRG, 2013. 2012-2013 Report of the NWMO Adaptive Phased Management Geoscientific Review Group (GRG).

APM-GRG, 2014. 2014 Report of the NWMO Adaptive Phased Management Geoscientific Review Group (GRG).

APM-GRG, 2016. 2015-2016 Report of the NWMO Adaptive Phased Management Geoscientific Review Group (GRG).

APM-GRG, 2017. 2017 Report of the NWMO Adaptive Phased Management Geoscientific Review Group (GRG).

## 9 Attachment - Brief biographies of the APM-GRG members

The APM-GRG is composed of five internationally recognized experts from Canada, Sweden, Switzerland, and Australia. They combine extensive multidisciplinary experience in areas relevant to the siting of deep geological repositories in both crystalline and sedimentary rock formations.



APM-GRG members (from left to right): Sandy (Alexander) Cruden, Anders Ström, Peter Kaiser (APM-GRG Chairman), Michael Stephens, and Andreas Gautschi.

### **Dr. Peter Kaiser**

Dr. Peter Kaiser, Chairman of the APM-GRG, is Professor Emeritus of Mining Engineering at Laurentian University, former Chair for Rock Engineering and Ground Control, former Director of the Rio Tinto Centre for Underground Mine Construction, and former Founding Director of the Centre for Excellence in Mining Innovation. His interests lie in geomechanics, underground excavation stability, mine design, mechanized excavation, and the applications of other emerging technologies that increase mining safety and productivity. Dr. Kaiser is a Fellow of the Canadian Academy of Engineers and a Fellow of the Engineering Institute of Canada. He is the author of more than 350 technical and scientific publications.

### **Dr. Sandy (Alexander) Cruden**

Dr. Sandy (Alexander) Cruden is a Professor and Head of the School of Earth, Atmosphere and Environment at Monash University (Australia). Dr. Cruden has more than 25 years of geoscience experience related to structural geology, analysis and characterization in both crystalline and sedimentary rock settings. Dr. Cruden completed a fault reactivation analysis and structural characterization of southwestern Ontario as part of site characterization activities for Ontario Power Generation's proposed Low- and Intermediate-Level Waste Deep Geologic Repository at the Bruce site.

**Dr. Andreas Gautschi**

Dr. Andreas Gautschi was Chief Geoscientific Advisor at the Swiss National Cooperative for the Disposal of Radioactive Waste. Since his retirement he works as an international geoscientific consultant. Dr. Gautschi has more than 30 years of geoscience experience related to the planning, co-ordination and implementation of site evaluation programs for deep geological repositories in both crystalline and sedimentary rocks. He coordinated successful geoscience activities that contributed to the selection of the Opalinus Clay formation as the preferred geologic setting for the long-term management of high-level waste in Switzerland. He still has a lectureship at ETH Zurich on Deep Geological Disposal of Radioactive Waste

**Dr. Michael Stephens**

Dr. Michael Stephens is a retired Senior State Geologist with the Geological Survey of Sweden in Uppsala. Dr. Stephens has been actively involved in the Swedish site evaluation process, including country-wide reconnaissance studies conducted in Sweden to identify potentially suitable regions for hosting a deep geological repository, geoscientific feasibility studies, and the detailed site characterization of the Forsmark site which was selected by SKB (the Swedish Nuclear Fuel and Waste Management Company) as the site for the deep geological repository for used nuclear fuel in Sweden.

**Mr. Anders Ström**

Mr. Anders Ström is Senior Program Manager within the Nuclear Fuel department at SKB (the Swedish Nuclear Fuel and Waste Management Company). His work is currently focused on co-ordination of tasks for technology development, and development of the encapsulation plant and spent fuel repository for disposal of used nuclear fuel in crystalline rock. Mr. Ström has been actively involved in SKB's siting program since the early '90s, among other things, in charge of the development of requirements on the rock for the spent fuel repository and criteria for site evaluation. During the site characterization project, he was Chief Project Manager for the multidisciplinary site descriptive modelling conducted for the two candidate sites. Since 2015, he is also in charge of SKB's program for research, development and demonstration.