Giant Mine Remediation Project - Climate Change Report Review

Summary Report & Recommendations

Date: October 1, 2023
Presented to: Giant Mine Oversight Board
Prepared by: RFS Energy Consulting & Research Group Inc. (RFS Energy Consulting)

RFS ENERGY

Executive Summary

RFS Energy Consulting & Research Group Inc. (RFS Energy) was contracted by the Giant Mine Oversight Body (GMOB) in May 2023 to conduct a high-level review of the *Giant Mine Remediation Climate Change* report prepared by Golder Associates Ltd. in 2020.

The focus was to review the report through a climate adaptation and mitigation lens to identify gaps and assess the use of up-to-date metrics, best practices and climate science. In addition to this review, RFS Energy joined the June Working Group meeting during which the report was presented by the Giant Mine Remediation Project (GMRP) Project Team (the "Project Team") and where questions and concerns raised by the Working Group were addressed. Additional resources and documents were sourced and reviewed and external subject matter experts were consulted as needed throughout this process.

The information contained in this Summary Report highlights the results of this review, along with key observations, concerns and recommendations on actions that the Project Team should take to make climate change considerations for the Giant Mine more clear and transparent.

About RFS Energy

RFS Energy is a Canadian female- and Indigenous-led company specializing in clean energy & climate consulting and research services. Together the team at RFS Energy brings 50+ years of working with over 25 local and provincial governments, utilities, energy efficiency agencies and non-profit organizations across Canada. Our team's experience includes taking clean energy and climate initiatives from research, planning and procurement to in-market deployment and having worked directly with BC Hydro, FortisBC, Nelson Hydro, Energy Efficiency Alberta, SaskEnergy, Manitoba Hydro, Efficiency Manitoba, the Independent Electricity System Operator (IESO), Enbridge Gas, NB Power, and Efficiency Nova Scotia. For more information, please visit www.rfs.energy.

Project Overview

Climate change may be the biggest potential risk faced by the Giant Mine Remediation Project, and as such climate change needs to be addressed proactively by the Project Team. While some efforts - such as Golder's report - have been made to consider climate change in planning and design for Giant Mine, it seems that the potential impacts of climate change are being underestimated and that adaptive management needs to be incorporated in a more comprehensive and strategic manner.

Climate change is a rapidly evolving phenomenon, and both our understanding of its impacts and the data at our disposal are constantly changing. There is concern that climate change as a whole is not being considered or addressed for the GMRP with the appropriate level of urgency and importance - both in terms of the impacts of climate change on the project and the impacts of the project on the climate through its activities.

It is imperative that mine closure plans - particularly those involving infrastructure design - are based on the most up-to-date information available, and that decision-making processes are transparent, conservative, and founded on clear underlying assumptions. Some of these assumptions include which climate scenarios are modelled (RCP 2.6 vs RCP 8.5), how these are being weighted in relation

to each other (i.e. are they being considered with equal probability) and how climate risk is characterized (severity, probability etc.) to name a few.

Furthermore, considering the relatively new and evolving nature of climate change risk assessments, it is vital to carefully select the most relevant and appropriate framework for assessing climate risk for the GMRP, with a clear and transparent process and rationale. This is of particular importance for Giant Mine - one of the most complex remediation projects worldwide and one of the first reclamation sites to be developing a formal Perpetual Care Plan.

Key Recommendations

With this in mind, here are some best practices, guidelines and recommendations that we suggest be taken by the Project Team - within the next 6-12 months and on an ongoing basis - to make climate change considerations and strategies more clear, robust and transparent for the GMRP.

Short-term (next 6-12 months): Carry out a full and thorough climate change risk assessment for the GMRP before finalizing and submitting any further design plans.

- Leverage existing climate reviews and datasets completed for the GMRP as a starting point. Select and use a climate change risk assessment framework relevant and applicable to Giant Mine to re-assess climate risk based on IPCC's AR6.
    - RFS Energy recommends Infrastructure Canada's Climate Lens, Mining Association of Canada's Guide on Climate Change Adaptation for the Mining Sector or Environment and Climate Change Canada's Assessing Climate Change Resilience as the most applicable and recent frameworks[1].
- Complete all of the steps outlined in the protocol. Ensure that the assessment is carried out in such a way that it can be easily updated and that climate change risks can be easily re-assessed as new data becomes available. This climate change risk assessment should be considered evergreen (i.e. a living document) and the process should be considered iterative.
- Ensure that Traditional Knowledge - especially around climate change observations, risks and adaptation/resilience strategies - is included and integrated throughout the climate risk assessment process through proactive, meaningful and ongoing engagement with local Indigenous leaders, knowledge-keepers and community members. This could mean:
    - including climate data, knowledge and observations from Indigenous knowledge-holders, leaders and scientists in climate reviews and assessments (several resources exist including the Indigenous Climate Atlas or the Indigenous Climate Hub);
    - inviting Indigenous leaders and/or researchers to provide input and peer-review of key climate-related documents (such as Golder's report) being used in planning and design for the GMRP; or,
    - funding/supporting an Indigenous-led citizen science monitoring program (such as the Indigenous Guardians).

[1] PIEVC's Green is also a framework worth considering; however, we cannot comment on this as it is currently released in beta form and not accessible to the public.

- Ensure that baseline assumptions for climate modelling and analysis are appropriately conservative in relation to climate change, including but not limited to:
    - Updating climate datasets to reflect AR6;
    - Considering time horizons beyond fixed timeframes (i.e. 100 years vs. an open-ended outlook that sets out to design and build with adaptation in mind;
    - Determining and using the conservative future climate scenarios (currently RCP 8.5 for air temperature for instance) for all modelling and analysis that form the basis of GMRP plans and structural designs; and,
    - Reassessing how severity, probability etc. are characterized for climate risks.
- Ensure that the climate change risk assessment team includes groups and/or individuals with a strong background and expertise in climate change, climate science and climate change risk assessments in northern regions and preferably experience with projects similar in size and scope.
- Include Working Group members as appropriate in key activities, such as risk characterization, risk identification and adaptation & mitigation strategies. This could be achieved through facilitated meetings/sessions.
- Ensure that the Working Group is appropriately engaged throughout this process, especially around key decision points such as the methodology and assumptions used. Share the climate change risk assessment results transparently, using plain and accessible language, including risks identified, how they are classified and the mitigation and adaptation strategies selected.
- Use the results of this assessment to inform and update approved designs and plans as needed. If no updates are deemed necessary, provide a clear rationale to support this decision. This assessment should clearly outline thresholds (temperature & precipitation levels, permafrost thaw etc.), trigger points and contingencies should the climate change more quickly or severely than anticipated.

Long-term (ongoing): Provide updates regularly, including on-site monitoring data or other pertinent changes to available climate data for this region.

- Incorporate a climate change risk reassessment and lens into the development of the Perpetual Care Plan. Review the baseline assessment and update it based on on-site data collected and new climate information available at that time. Update plans for monitoring and perpetual care accordingly.
- Dedicate a distinct section in GMRP's Annual Report to reporting on climate change risks, adaptation & mitigation efforts, ongoing monitoring and on-site observations and other climate strategies.
- Include a thorough update and analysis in Status of the Environment reporting that takes place every 5 years. At minimum, this should be done every 10 years so that each new IPCC Assessment Report can be incorporated and assessed in relation to the GMRP.
- Establish clear 'trigger points' or 'thresholds' to prompt a stand-alone update and reassessment of climate risks and mitigation strategies if on-the-ground monitoring shows notable differences from modelled or assumed scenarios.

Table of Contents

Background & Methodology

RFS Energy was approached by GMOB to provide a high-level review and summary of the *Giant Mine Remediation Project Climate Change* assessment prepared by Golder Associates Ltd. in 2020 for Public Services and Procurement Canada.

The intent of the review was to apply a climate change adaptation and mitigation lens to identify gaps and assess the use of up-to-date metrics, best practices and climate science, drawing from other reputable sources including external subject matter experts as needed. To provide a review of this report and recommendations related to climate change adaptation and mitigation, RFS Energy carried out the following activities:

- High-level review of Golder's Climate Change report[2]
- Attendance at the GMRP Working Group meeting held on June 8th, 2023 where the Project Team provided an overview of the report and how it was used, and answered questions
- Research, high-level review & compilation of supplementary documents and available climate change resources and tools (see Appendices A & B)
- Preliminary review of climate change assessment frameworks for mining and engineering projects (see Appendix E)
- Consultations with subject matter experts, as needed

This report summarizes the information that emerged through these activities and highlights areas of concern and key recommendations to make climate change considerations more clear and transparent for the GMRP.

Key Findings & Discussion

This section outlines the gaps, questions and areas of concern related to both the use of Golder's 2020 Climate Change Review report as the basis for surface water management engineering designs as well as a broader discussion of concerns around the overall approach to addressing climate change for the GMRP. The discussion is organized around the following 3 themes:

1. **Overall approach to climate change** - Climate change, as the most significant long-term risk to the GMRP, should be addressed more proactively and thoroughly by the Project Team.
2. **Limitations and uncertainties of climate data** - While there are inherent uncertainties associated with climate projection data, adopting a conservative approach with clear and consistent assumptions can help to de-risk the use of this data for designs & planning.
3. **Selection and use of a Climate Change Risk Assessment framework** - Climate risk assessment frameworks are also relatively new and evolving to stay up to date with climate change data. The framework chosen for the GMRP should be thorough, up-to-date and should be followed all the way through.

[2]The scope of this review was meant to be carried out at a high-level to identify potential gaps, areas of concern or points to clarify from a climate change perspective. This review did not involve an in-depth technical analysis.

1. Overall approach to climate change

There is a concern that the potential impacts of climate change are not being considered for the GMRP as seriously or thoroughly as they should or could be, for the following reasons:

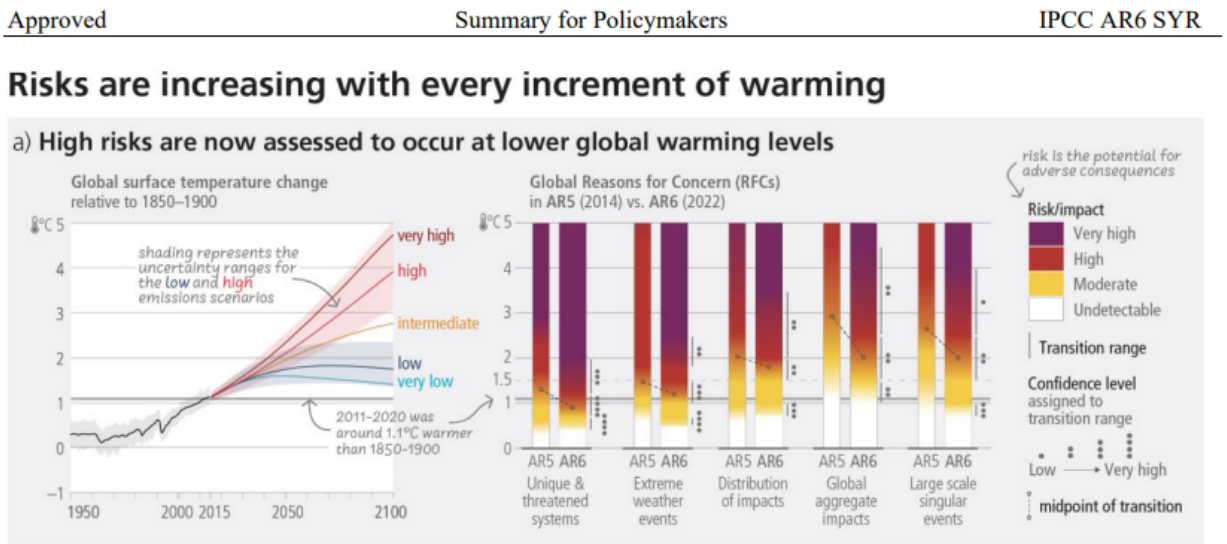
Piecemeal approach to climate change risk assessment

Climate change has been considered and discussed at various points and stages throughout planning and design activities for the GMRP (ex: CRP, QRA, AECOM study and Golder study). However, these efforts and considerations have taken place in isolation and applied to specific plans or designs - representing a piecemeal approach.

After reviewing several background documents (listed in Appendix B), our assessment is that none of the resources presented or studies undertaken by the Project Team represent a thorough, clear or transparent climate change assessment, nor do they consider interactions between climate risks. The importance of taking a comprehensive approach is highlighted in the IPCC's AR6[3]:

- For every incremental increase of global warming, the projected climate-related risks, losses and damages escalate and become more complex and difficult to manage. We also need to consider the interaction between both climate and non-climate risks, and the potential for these risks to compound and cascade.
- Compared to AR5, the IPCC has determined in AR6 that climate-related risks are higher for any future warming scenario. AR6 states that "projected long-term impacts are up to multiple times higher than currently observed" and that "worldwide climate resilient development action is more urgent than previously assessed in AR5."

This means that even if projected climatic changes (i.e. surface-air temperatures and/or precipitation levels) do not change significantly (in other words - the climate dataset values), our understanding of the implications of these changes has - and so how we identify, assess and plan to mitigate and adapt to these risks must also change. The diagram below from IPCC AR6 helps to visualize this point - showing how higher risks are now associated with lower warming scenarios:



[3]Relevant excerpts from the IPCC's AR6 are included in Appendix B.

With each higher warming scenario, adaptation measures will be less and less effective. To counter this, the IPCC emphasizes that adaptation responses that are integrated, flexible, inclusive, are based on long-term planning, span systems and sectors and address social inequities will be the most effective. By contrast, "actions that focus on sectors and risks in isolation and on short-term gains often lead to maladaptation over the long-term, creating lock-ins of vulnerability, exposure and risks that are difficult to change."[4]

It is important to keep in mind that the IPCC is looking at global trends - and we know that climate change is happening faster and at a higher degree in northern regions - which means that impacts in the North will likely happen sooner, and will be more pronounced.

What does this mean for and how can it be applied to the GMRP? Put simply, the new information released by the IPCC could fundamentally change the starting point and baseline assumptions that feed into a climate change risk assessment for the Giant Mine. For example, when assessing the severity of a particular climate risk, the level of severity or probability may need to be stated higher than previously assessed.

Lack of meaningful discussion on climate change

There seems to have been a step missed between the Project Team compiling climate data and discussing the implications, risks and adaptation/mitigation strategies with the Working Group. Working Group members and other key stakeholders should be meaningfully engaged on climate change considerations by outlining risks, assumptions and methodologies clearly, transparently and using plain language.

Lack of clarity & transparency in information presented

The nature and way that information has been presented has contributed to an overall lack of clarity and transparency in the data itself and how it is being used. The Golder report, for instance, was presented as a climate change assessment report, whereas it was actually a climate dataset specifically for the surface water design. The report was a compilation and analysis of available literature and online tools (indicated in the report itself) - no on-site observations were included in the Golder study.

The project team referenced using the *Guide on Climate Change Adaptation for the Mining Sector* prepared by Golder for the Mining Association of Canada (MAC). This Guide was presented as the industry standard for climate change assessments in the mining industry; however, the Golder report for the Giant Mine and the Guide were both being prepared simultaneously by Golder (report released in 2020 and Guide released in 2021). Furthermore, there may be a conflict of interest around the fact that Golder developed both the report and the methodology upon which the report is based.

[4] Source: IPCC AR6

The Guide on Climate Change Adaptation outlines a 3-Stage process for assessing climate change risks and adaptation measures (see Appendix D for more detail). This framework may in fact be the most appropriate climate assessment protocol for the GMRP, and it seems to have a robust process for assessing and documenting climate risk and mitigation strategies. However, the 2020 Golder report only represents the first two activities for Stage 1 (developing a climate dataset) and not Stage 1 in its entirety as the project team implied during the call.

RECOMMENDATION #1: The project team needs to ensure that more attention, importance and due diligence is placed on the impacts of climate change on, and created by, the GMRP.

2. Limitations and uncertainties of climate data

Both climate change data and our global understanding of the related impacts is changing - and both have limitations. It is critical that the GMRP plans - especially infrastructure design - are based on the most up-to-date information and that the underlying assumptions used in decision-making are clearly stated, transparent and adequately conservative.

This includes which percentiles are selected, which climate scenarios are modelled (RCP[5] 2.6 vs RCP 8.5) and how these are being weighted (i.e. are they being considered with equal probability).

Climate science and climate change projection data is inherently uncertain (as noted by both Golder and AECOM). Our understanding of how the climate is changing and implications on different regions, infrastructure along with the significance of these changes is constantly evolving - which is why there is a global effort to update this information through the IPCC Assessment Reports that are released every 7 years.

Climate scenarios

Representative Concentration Pathways (RCPs)

RCPs describe paths to future climates based on atmospheric greenhouse gas concentrations. They represent climate futures—scenarios—extrapolated out to the year 2100, based on a range of possible future human behaviors. RCPs provide a basis for comparison and a "common language" for modelers to share their work.

The RCP values 4.5, 6.0, and 8.5 indicate projected radiative forcing values—the difference between solar energy absorbed by Earth vs. energy radiated back to space—measured in watts per square meter. RCP X projects that in 2100 the concentration of greenhouse gases will be such that each square meter of Earth will absorb X times more solar energy than it did in 1750.

- RCP 4.5 — "low" scenario. Assumes that new technologies and socioeconomic strategies cause emissions to peak in 2040 and radiative forcing to stabilize after 2100.
- RCP 6.0 — "medium" scenario. Assumes that emissions peak in 2080 and radiative forcing stabilizes after 2100.
- RCP 8.5 — "high" scenario. Emissions increase through the 21st century.

Extended Concentration Pathways (ECPs)

These scenarios allow extensions of RCPs for 2100–2300 by expanding the data series for greenhouse gas and land use. ECPs are intended to provide rough estimations of what climate and ocean systems might look like in a few centuries regardless of the driving forces of emissions (demography, policies, technology, and investment).

With this in mind - and considering that previous work was based on the most up-to-date information available *at the time* - there are concerns that the limitations of this information is not being adequately acknowledged or considered in how climate data is being used to inform design plans.

Absence of Traditional Knowledge in climate reviews & reports

Local traditional knowledge and observations around how the climate has and is changing, and the implications of these changes is a valuable lens rooted in a deep and intergenerational understanding of and connection with the land that should be meaningfully incorporated into discussions around climate change and future planning - especially in northern climates. *"Indigenous peoples were amongst the first to notice climate change and also have critical knowledges for navigating and*

[5] Representative Concentration Pathways

adapting to it."[6] A holistic approach to climate change risk, mitigation and adaptation that values both western and Indigenous science, knowledge and perspectives will result in more robust, well-thought out and long-term solutions to climate change and aligns with the recommendations in IPCC AR6 for more integrated, flexible and inclusive responses to climate change.

GMRP has committed to meaningful engagement with land rights holders, Indigenous stakeholders and the public (as outlined in the CRA Plan, the Engagement Plan and the QRA - see Appendix C). The information, studies and reports upon which the GMRP project team has based its assumptions and plans lack this important lens specifically around climate change. Traditional knowledge was not included or mentioned in either the AECOM or Golder report - either as a key source of data or an important lens in reviewing and validating this information over the long term.

Addressing limitations and uncertainty of climate data and need to stay up-to-date

Climate data continues to change and evolve - the IPCC's 6th Assessment Report was recently released and the Project Team noted during the Working Group meeting that precipitation data for Yellowknife became available in February 2023 for instance.

Due to these uncertainties, there is a strong need to stay up-to-date with this emerging data and incorporate it into existing assessments and plans. Every climate-related report relevant to the GMRP emphasizes the limitations of climate change projection data, urges caution around using the data and stresses the need to update data based on new information, for example:

> *"It should be noted that the trend analysis is subject to data quality and data availability and caution should be exercised when using these trends" (Golder, 2020)*
>
> *"The climate information presented in this brief is not based on analyses generated through this project, but rather a review of readily available information from existing sources. As climate science is continually advancing, this review should not be construed as a comprehensive and permanent characterization of historic or future climate projections and should be reviewed and revised periodically." (Wood, 2019)*

There is a clear need to acknowledge the limitations of the data currently available and de-risk this uncertainty in the context of the GMRP through clear and transparent processes and assumptions, ongoing onsite monitoring and incorporating new data into risk assessments and mitigation strategies.

Questions and concerns with underlying assumptions & interpretations of climate data

Concerns around the selection of percentiles (representing mild, medium and severe changes) and climate change scenarios (RCP 2.6 vs. 8.5) were raised by many Working Group members. As Alternatives North noted during the Working Group call: "If 50th is a low estimate AND we are not doing projections post remediation - the current estimates will be low for 2080 and even lower post remediation."

[6] Source: Indigenous Knowledges and Climate Change

Taking a conservative approach to climate modelling - such as basing projections and analyses on RCP 8.5 for the freeze program - was also recommended in the AECOM and Newmans report:

> *"For the advanced design of the Giant Mine freeze program, it is recommended that (...) the most current maximum projections for RCP 8.5 (or future equivalent) be used for all analyses. This projection is deemed conservative." (AECOM & Newmans, 2018)*

We recommend that the GMRP be more clear, transparent and conservative in the underlying assumptions that form the basis for climate modelling and data analysis.

Reconsidering time horizons used

The time horizons used for future climate change projections are shortsighted - they are currently modelled to 2100 - less than 100 years from today, and only 60+ years after project completion. Given the uncertainty around climate change projections and the variability in potential future scenarios and impacts, these time horizons are not sufficiently conservative. Extra caution and consideration should be given to planning the integrity of structures and systems being built with an open-ended outlook - in other words in perpetuity - not the next 100 years.

If modelling out to 100 years is considered 'industry standard' then we recommend that industry standard time horizons should be reconsidered and adjusted to assess risk through a climate lens, particularly when it comes to considering perpetual care as is the case with Giant Mine. While climate change projections lose accuracy beyond 100 years, it is still important to consider across a larger time horizon when planning risk and mitigation strategies.

With respect to when climate change projections and risks will be reassessed, the Project Team stated an intention to follow the timelines set out in the Environmental Assessment (independent reviews at 20-year intervals). This frequency may also be inadequate in relation to climate change - there should be ongoing - and early - review and reassessment of climate risks so that no one is caught by surprise.

Lack of clear plan, process or timeline for incorporating new climate data or reassessing risk

When asked at the beginning of the call whether the Project Team has current plans to incorporate the data from IPCC AR6 into their climate dataset, the initial answer was that the Project Team does not have scope to do this work. By the end of the call, a commitment was made to include AR6, and to make notes about the implications of using RCP 8.5 specifically during this exercise. It is still unclear when this will take place, how, and by whom and to what degree the concerns raised by the Working Group will be addressed.

The Project Team emphasized that each design goes through an evaluation process and that climate change risk is evaluated at this stage; however, it is not clear how, through which lens and according to what standards or metrics. The Project Team also noted that the GMRP is more advanced than most of the steps in the FCSAP[7]'s updated guidance around climate change assessments because some plans have already undergone this process and have been approved. However, it is unclear to

[7] Federal Contaminated Sites Action Plan

what degree the Mackenzie Valley Land and Water Board (MVLWB) has the appropriate and necessary expertise to evaluate climate change risks. Finally, it is still unclear how designs and plans that have already been filed, evaluated and approved through the MVLWB measure up to new guidance and frameworks that have been released post-approval.

RECOMMENDATION 2: The Project Team should put measures in place to address and de-risk the inherent limitations and uncertainties of climate science and data through transparency, conservatism and mechanisms to integrate new data and reassess risks.

3. Selection and use of Climate Change Risk Assessment framework

Guidelines, standards and frameworks for climate change risk assessments - including mitigation and adaptation strategies - for site closure and remediation projects (and for related industries including infrastructure etc.) are evolving and are still relatively new and untested. It is important to consider and select the most appropriate and relevant framework for the GMRP. The process and rationale for selecting this method should be clearly and transparently communicated.

> *"Climate change risks differ from other risks. It is often difficult or even impossible to quantify their short- or long-term probability so a conventional risk assessment that uses statistical probabilities can be ineffective. For this reason, various approaches have been developed for assessing climate change risks." (Adaptation to climate change - Guidelines on vulnerability, impacts and risk assessment, ISO 14091:2021)*

Furthermore, teams carrying out these assessments and involved in the decision-making around risk levels and mitigation strategies must have appropriate expertise and experience in climate science and climate change adaptation and mitigation. The protocol outlined by the Mining Association of Canada in its Towards Sustainable Mining initiative reflects this sentiment:

> *"As with any performance assessment tool, professional judgement is required in assessing alignment with each indicator and associated criteria. Application of this protocol will therefore require a level of expertise in auditing, systems assessment, energy and greenhouse gas (GHG) emissions management, physical climate impact management and climate change adaptation, as well as relevant regulatory regimes and requirements. This protocol is a tool to assess the level of implementation of climate change management practices in support of the TSM initiative. It is not, of itself, a guarantee of the effectiveness of climate change management activities, but is intended to create the awareness, practice and corporate culture needed to achieve success in this area."*

While several guides and frameworks were referenced by the Project Team, it is not currently clear which one is being used or why, and the overall approach has not been consistent. Many of the frameworks previously available (for instance PIEVC developed in 2008) are now outdated. This is evidenced by the release of several guides were updated and/or developed in the past 3 years:

- 2023 - The PIEVC Green Protocol (PIEVC)
- 2022 - Assessing Climate Change Resilience: Technical Guide Related to the Strategic Assessment of Climate Change (ECCC)
- 2021 - PIEVC High Level Screening Guide (PIEVC)
- 2021 - Guide on Climate Change Adaptation for the Mining Sector (Mining Association of Canada)
- 2019 - Climate Lens (Infrastructure Canada)

RECOMMENDATION #3: Climate change assessment guides and frameworks for mining remediation and infrastructure projects are relatively new and still evolving. It is important to select a climate risk assessment framework for the GMRP that is up-to-date and relevant to this project, to clearly communicate the rationale for this approach and to complete all of the steps outlined in the framework.

For a comprehensive list of climate change assessment resources, please see Appendix E. The availability of new and/or updated climate change assessment frameworks for industry presents a timely opportunity to review and reassess climate risks for the GMRP through a more robust climate lens.

Summary of Recommendations

In summary, RFS Energy has the following recommendations to make climate change considerations and strategies for the GMRP more clear, robust and transparent in both the short- and long-term.

1. **Short-term (next 6-12 months):** Carry out a full and thorough climate change assessment for the GMRP before finalizing and submitting any further design plans.

    a. Leverage existing climate reviews and datasets completed for the GMRP as a starting point. Select and use a climate change risk assessment framework relevant and applicable to Giant Mine to re-assess climate risk based on IPCC's AR6. We recommend using one of the following frameworks[8]:

        i. Infrastructure Canada's Climate Lens

        ii. Mining Association of Canada's Guide on Climate Change Adaptation for the Mining Sector

        iii. Environment and Climate Change Canada's Assessing Climate Change Resilience

    b. Complete all of the steps outlined in the selected protocol. Ensure that the assessment is carried out in such a way that it can be easily updated and that climate change risks can be easily re-assessed as new data becomes available. This climate change risk assessment should be considered evergreen (i.e. a living document) and the process should be designed to be iterative.

    c. Ensure that baseline assumptions for modelling and analysis are appropriately conservative in relation to climate change, including but not limited to:

        i. Updating climate datasets to reflect AR6 and subsequent reports released by the IPCC;

        ii. Reconsidering time horizons (i.e. planning/designing for next 100 years vs. in perpetuity);

        iii. Determining and using the conservative future climate scenarios (currently RCP 8.5 for air temperature for instance) for all modelling and analysis that form the basis of GMRP plans and structural designs; and,

        iv. Reassessing how severity, probability etc. are characterized for climate risks.

    d. Including, incorporating and valuing Traditional Knowledge throughout the climate risk assessment process with meaningful and ongoing engagement with and participation from Indigenous leaders, knowledge-holders and community members.

    e. Ensure that the climate change risk assessment team includes groups and/or individuals with a strong background and expertise in climate change, climate science and climate change risk assessments in northern regions and preferably experience with projects similar in size and scope.

[8] *PIEVC's Green is also a framework worth considering; however, we cannot comment on this as it is currently released in beta form and not accessible to the public.*

f. Include and/or engage Working Group members as appropriate in key activities, such as risk characterization, risk identification and adaptation & mitigation strategies. This could be through a facilitated meeting.

g. Ensure that the Working Group is appropriately engaged throughout this process, especially around key decision points, particularly the methodology and assumptions used. Share the climate change risk assessment results transparently, using plain and accessible language, including risks identified, how they are classified and the mitigation and adaptation strategies selected.

h. Use the results of this assessment to inform and update approved designs and plans as needed. If no updates are deemed necessary, provide a clear rationale to support this decision. This assessment should clearly outline clear thresholds, trigger points and contingencies should the climate change more quickly/severely than anticipated.

2. **Long-term (ongoing):** Provide updates regularly, including on-site monitoring data or other pertinent changes to available climate data for this region.

    a. Incorporate a climate change risk reassessment into the development of the Perpetual Care Plan.

        i. Review the baseline assessment and update it based on on-site data collected and new climate information available at that time.

        ii. Update plans for monitoring and perpetual care accordingly.

    b. Dedicate a distinct section in GMRP's Annual Report to reporting on climate change risks, adaptation & mitigation efforts, ongoing monitoring and on-site observations and other climate strategies.

    c. Include a thorough update and analysis in Status of the Environment reporting that takes place every 5 years. At minimum, this should be done every 10 years so that each new IPCC Assessment Report can be incorporated and assessed in relation to the GMRP.

    d. Establish clear 'trigger points' or 'thresholds' to prompt a stand-alone update and reassessment of climate risks and mitigation strategies if on-the-ground monitoring shows notable differences from modelled or assumed scenarios.

Appendix A: Excerpts from IPCC AR6

The quotes below were taken from the International Panel on Climate Change's 6th Assessment Report (AR6).

Ref	Quote
B.2	For any given future warming level, many climate-related risks are higher than assessed in AR5, and projected long-term impacts are up to multiple times higher than currently observed (high confidence). Risks and projected adverse impacts and related losses and damages from climate change escalate with every increment of global warming (very high confidence). Climatic and non-climatic risks will increasingly interact, creating compound and cascading risks that are more complex and difficult to manage (high confidence). {Cross-Section Box.2, 3.1, 4.3, Figure 3.3, Figure 4.3} (Figure SPM.3, Figure SPM.4)
B.2.3	With further warming, climate change risks will become increasingly complex and more difficult to manage. Multiple climatic and non-climatic risk drivers will interact, resulting in compounding overall risk and risks cascading across sectors and regions.
B.4.1	The effectiveness of adaptation, including ecosystem-based and most water-related options, will decrease with increasing warming. The feasibility and effectiveness of options increase with integrated, multi-sectoral solutions that differentiate responses based on climate risk, cut across systems and address social inequities. As adaptation options often have long implementation times, long-term planning increases their efficiency. (high confidence) {3.2, Figure 3.4, 4.1, 4.2}
B.4.3	Actions that focus on sectors and risks in isolation and on short-term gains often lead to maladaptation over the long-term, creating lock-ins of vulnerability, exposure and risks that are difficult to change. For example, seawalls effectively reduce impacts to people and assets in the short-term but can also result in lockins and increase exposure to climate risks in the long-term unless they are integrated into a long-term adaptive plan. Maladaptive responses can worsen existing inequities especially for Indigenous Peoples and marginalised groups and decrease ecosystem and biodiversity resilience. Maladaptation can be avoided by flexible, multisectoral, inclusive, long-term planning and implementation of adaptation actions, with co-benefits to many sectors and systems. (high confidence) {2.3.2, 3.2}
C.1.1	Evidence of observed adverse impacts and related losses and damages, projected risks, levels and trends in vulnerability and adaptation limits, demonstrate that worldwide climate resilient development action is more urgent than previously assessed in AR5. Climate resilient development integrates adaptation and GHG mitigation to advance sustainable development for all. Climate resilient development pathways have been constrained by past development, emissions and climate change and are progressively constrained by every increment of warming, in particular beyond 1.5°C. (very high confidence) {3.4; 3.4.2; 4.1}

Appendix B: List of GMRP Resources

The list below represents the documents and studies that address climate change:

Report	Description
Perpetual Care Plan GMRP	• In development • Version 1 to be completed by 2025
Giant Mine Remediation Project: Climate Change Golder 2020	• Site-specific current and future climate data (precipitation, temperature and evapotranspiration) • Represents a climate dataset to inform surface-water design • Comparison with AECOM study and other datasets
Quantitative Risk Assessment GMRP 2020	• Includes a vulnerability assessment - followed first steps of PIEVC process • Climate change was listed in ~15 out of 134 risk scenarios identified for quantitative analysis (see below) • Most were rated as 'very unlikely' and the following rationale: *The Project has the ability to add more thermosyphons or transition to hybrids based on climate change and is required to review the project on a 20-year basis. There would also have to be a failure of the review process.* *In addition, success of an active freeze system would not be dependent on climate change.* *In combination, this sequence of events is very unlikely.* • References cited included AECOM 2018, CRP Section 5 and interviews with subject matter experts
Giant Mine Closure and Reclamation Plan Climate Resiliency Risk Review Revised Draft Report Wood 2019	• Included as an Appendix of QRA • Only a portion of the Infrastructure Canada's Climate Lens Assessment Guidance Document (Guidance) has been applied (as directed by CIRNAC) • The scope of the assessments is limited to the design, implementation and operation and maintenance, over the life-cycle of the GMRP • A risk management approach to anticipate, prevent, withstand, respond to, and recover from a climate change related disruption or impact to physical infrastructure.
Closing & Reclamation Plan GMRP 2019	Section 5.05 • Lays out long-term maintenance • Each design goes through a process where risks are identified, ranked (low, medium, high) and strategies are developed • Outlines climate change considerations that have been made in planning and design: *"The effects of climate warming have been accounted for in the freeze program design, by considering a 6.1°C increase to the mean annual air temperature over the next 100 years. This value was the upper-range global average*

	temperature as provided by multi-century stabilization scenarios published by the IPCC"
Climate Change Review AECOM and Newmans 2018	• Technical memorandum • Used to inform Freeze-design

Risks that are directly or indirectly related to climate change from QRA:

#	Detail
6	Climate change effects are underestimated and there is greater flooding than predicted. Baker Creek floods and leaks into the underground.
47	Climate change results in a thawing of ground conditions causing a weakened layer in the foundation of the dams leading to a loss of content.
57	Passive freeze system fails (example: due to climate change, inability to maintain -5°C) leading to loss of arsenic trioxide containment with potential release to mine pool increasing volume and concentration of water requiring treatment.
58	Natural event (example: wildfire) and/or accident damages the passive cooling system thermosyphons leading to system failure and loss of arsenic trioxide containment with potential release to mine pool increasing volume and concentration of water requiring treatment.
59	Unplanned thaw results in failure of the freeze system causing degraded rock quality. Crown pillar and sill pillar failure fractured during freezing causes increased permeability of rock mass increasing groundwater capture, allowing high concentration arsenic contaminated water to reach mine pool
60	Climate change modelling is not conservative enough and climate warms up more than expected and the passive freeze program fails. No active freeze back-up is in place.
61	Climate change modelling is not conservative enough and climate warms up more than expected and both passive and active freeze programs fail.
62	The freeze program fails (e.g., insufficient thermosyphons) and arsenic trioxide is released through fractures and into the environment.
63	The passive freeze fails (e.g., due to climate change) and it is too hard in terms of engineering and cost to shift from passive to active freezing
122	Water treatment plant shuts down (example: pump failure) and access to Yellowknife is cut off (example: forest fire, flooding) and needed personnel, fuel, and supplies are not available.
128	Equipment fails (examples: water treatment plant, underground pumps) during a time that Yellowknife is cut off (e.g., forest fire), local workers are not adequately trained to respond, no response can be made from the south.
130	Equipment fails (example: water treatment plant, underground pumps) during a forest fire (example: water treatment plant, thermosyphons burn), and the site cannot be accessed to respond.

Appendix C: Inclusion of Traditional Knowledge

Excerpt from GMRP's 2019 Engagement Plan:

4.3.2 Traditional Knowledge

The consideration and incorporation of Traditional Knowledge has been integrated into project planning and activities through the consultation and engagement processes we undertake with First Nations and Indigenous groups on various project works, as well as the overall Closure and Reclamation Plan. The Project team is committed to continuing to incorporate traditional knowledge into our implementation strategy as part of the remediation plan.

The GMRP supported Trailmark consulting company in 2018 to carry out a Traditional Knowledge study with the YKDFN at the Giant Mine site. The goal of this work is to ensure that YKDFN knowledge, values, risk perceptions, and understanding of damage and impacts to past and current land use is incorporated into the Project, that upcoming or future reclamation plans are aligned with YK Dene values and will support future land use aspirations. Furthermore, this work will help support the ongoing, proactive inclusion of Traditional Knowledge elements into mine management and risk assessment throughout the remediation of Giant Mine. A detailed report of this study will be included in subsequent versions of this Plan.

Understanding and incorporating YKDFN traditional and local Indigenous knowledge, along with YKDFN perceptions and values is an important component to include in these processes to assist in preparation for fulfilling the requirements for water licensing and is essential for consultation. Refer to Appendix A, 2.0 for a detailed overview of the GMRP's history of engagement and incorporation of Traditional Knowledge.

The NSMA are currently undertaking a Traditional Knowledge Study. This study is not specifically focused on the Giant Mine; however, once complete, the Project is committed to incorporate input from the NSMA into the GMRP where possible.

Excerpt from GMRP's QRA RE concerns around climate change raised by YKDFN:

***YKDFN-1**: I look at the whole QRA. I see how this fits. But there are three risks that over-ride all of this:*

1. *A natural event (earthquake).*
2. *Electricity requirements. Comes back to climate change. Increase in need as we are faced with climate change. Use of diesel generators add insult to injury. Some of us want to get into the power business.*
3. *Loss of control of the site - over responsibility due to colonization (21st century). Change in how we govern ourselves. We are starting to see a change in character of Yellowknife (crime, behaviour, way of thinking). We are going to see a huge change.*

Appendix D: Guide on Climate Change Adaptation for the Mining Sector

Below are the 3 Stages outlined in the Guide on Climate Change Adaptation for the Mining Sector:

Stage 1: Climate Change Risk Assessment

- Establish baseline climate conditions based on observed climate conditions for the site.
- Develop projected future climate conditions for the site using accepted modelling tools and approaches.
- Identify vulnerabilities by identifying infrastructure components, operations both on and off-site, ecosystem impacts and relationships to reclamation, and potential impacts on human health that interact with climate.
- Assess both direct and indirect risks associated with climate change for vulnerable infrastructure and operations.
- Identify potential opportunities that may arise from changing climate conditions.

Stage 2: Developing Adaptation Pathways

- Identify potential adaption measures to address risks or opportunities.
- Develop potential adaptation pathways that describe different options to address the risks or opportunities, including the timing (short, medium, or long-term) of implementation of adaptation measures such as upgrades to infrastructure, and the implementation of other adaption measures such as changes to operation, maintenance, or surveillance activities.
- Apply decision analysis tools to help inform the final selection of the preferred adaptation pathway, taking into account the potential benefits and costs (financial and non-financial) of each adaptation pathway assessed.
- Conduct sensitivity analysis to test the robustness and validity of the outcomes of the decision analysis against various biases and assumptions.
- Select the preferred adaptation pathways and identify the triggers and thresholds for further actions.

Stage 3: Implementing of Adaptation Pathways

- Design and implement the selected adaptation pathways.
- Conduct surveillance to inform future reviews of and potential updates to projections of future climate conditions, the climate change risk assessment, and the decision analysis of the selected adaptation pathway.
- Implement an adaptative management process to address uncertainty associated with climate change projections, to proactively respond to unexpected changes in climate conditions beyond those projected and to take additional action in response to observed threshold values.

Appendix E: Climate Change Assessment Frameworks

Below is a list of potential protocols that could be relevant for the GMRP:

Framework / Organization	Year Released	Excerpt / Description
The PIEVC Green Protocol Public Infrastructure Engineering Vulnerability Committee (PIEVC)	2023 (BETA release)	• Outlines a process to assess infrastructure component responses to climate change impacts, • Considers the broader social and environmental systems within which the infrastructure component is situated • Meant to assist owners, operators & professionals to effectively incorporate climate change adaptation into design, development & management of existing and planned infrastructure and its surrounding env *The PIEVC Green Protocol may be considered a supplemental annex to the full PIEVC Protocol or PIEVC High Level Screening Guide.*
Assessing Climate Change Resilience: Technical Guide Related to the Strategic Assessment of Climate Change Environment and Climate Change Canada (ECCC)	2022	Provides proponents of projects that may require a federal impact assessment with additional guidance on how to consider a project's resilience to climate change. *This document supplements the Strategic Assessment of Climate Change (SACC).*
Federal Contaminated Sites Action Plan - new 'conceptual' guidance on climate change Government of Canada	2022	10-step decision-making framework to reduce environmental and human health risks from known federal contaminated sites and associated fed financial liabilities, while focusing on the highest priority sites.
PIEVC High Level Screening Guide PIEVC	2022	• Approach for undertaking vulnerability, risk, and resilience assessments • Flexible enough to be applied to full assets or systems, to a single element of infrastructure, or to an entire portfolio of numerous assets. • Results in the characterization and ranking of climate risk scenarios and the identification of those scenarios of highest priority for adaptation planning or more comprehensive analysis.
Guide on Climate Change Adaptation for the Mining Sector Mining Association of Canada / Golder	2021	Climate change adaptation framework for the mining sector. Outlines a 3-stage approach to • Increase the resilience of mines, reducing the potential for impacts and the need for more costly adaptation measures later in the life cycle. • Take advantage of climate change opportunities for improved mine management, such as longer growing

		seasons that can help enhance revegetation and reclamation activities.
Towards Sustainable Mining: Climate Change Protocol Mining Association of Canada	2021	A Tool for Assessing Climate Change Performance to facilitate continual performance improvements in the mining sector related to the management of climate-related risks and opportunities, including associated mitigation and adaptation strategies, target-setting and reporting.
The PIEVC Engineering Protocol PIEVC	2008	The Protocol systematically reviews historical climate information and projects the nature, severity and probability of future climate changes and events. It also establishes the adaptive capacity of an individual infrastructure as determined by its design, operation and maintenance. It includes an estimate of the severity of climate impacts on the components of the infrastructure (e.g., deterioration, damage or destruction) to enable the identification of higher risk components and the nature of the threat from the climate change impact. This information can be used to make informed engineering judgments on what components require adaptation as well as how to adapt them -- for example, design adjustments, changes to operational or maintenance procedures.
ISO 14091 Adaptation to climate change — Guidelines on vulnerability, impacts and risk assessment	2021	Risk assessment to provide a basis for climate change adaptation planning, implementation, and monitoring and evaluation for any organization, regardless of size, type and nature. • For responses to be delivered at the necessary pace and scale, it is important that risk assessment approaches are systematic and replicable, permitting learning within and between assessments as new knowledge, technology and experience arise. • Adaptation is usually more effective when initiated at an early stage of project development, and when undertaken as a planned process. • Climate change risks differ from other risks. It is often difficult or even impossible to quantify their short-or long-term probability so a conventional risk assessment that uses statistical probabilities can be ineffective. For this reason, various approaches have been developed for assessing climate change risks.
ISO 31000 Risk Management Guidelines	2021	Provides principles, a framework and a process for managing risk. It can be used by any organization regardless of its size, activity or sector. Not specific to climate change.
Climate Change Adaptation Plan	2021	This is Transport Canada's own internal climate change adaptation plan for 2021/2022 - included as an example

Transport Canada		here rather than a framework.
ENVISION Institute for Sustainable Infrastructure	N/A	The framework provides a flexible system of criteria and performance objectives to aid decision makers and help project teams identify sustainable, resilient, and equitable approaches during the planning, design, and construction that will continue throughout the project's operations, maintenance, and end-of-life phases.
SuRe: The Standard for Sustainable and Resilient Infrastructure Global Infrastructure Basel (GIB)	N/A	• Establish a common understanding of sustainable and resilient infrastructure between project developers, financiers, public sector institutions and end-users • Improve the quality of projects so they are built on sustainable and resilient principles • Help investors identify responsible investment opportunities.