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Technical Report Submission

Tlichó All-Season Road EA1617-01
Government of Northwest Territories

Natural Resources Canada

Submission to the Mackenzie Valley Review Board

October 11, 2017



Executive Summary

Summary of NRCan's review

Natural Resources Canada (NRCan) conducted a technical review to assess the completeness and technical merit of the information presented in the Government of Northwest Territories Tlicho All Season Road (TSAR) Project Description Report under the *Mackenzie Valley Resource Management Act (MVRMA)*.

Explosives

The developer has indicated that the project will require magazines for the storage of explosives. The developer has also confirmed that a licence issued under the *Explosives Act* and regulations will be required and that explosives storage will be included in an Explosives Management Plan. If the project is approved, the developer or an explosives supplier will be expected to provide more details on explosives storage in a licence application during the regulatory phase.

Permafrost

NRCan reviewed the Project Description Report (PDR) and PDR Appendices to ensure impacts on permafrost from the TASR were considered and mitigation measures were presented for the project design to ensure the integrity of the road infrastructure and minimize environmental impacts. Potential environmental impacts associated with the TASR include expanded land areas disturbed by the project and impacts on the ground thermal regime. NRCan has provided six recommendations for the Developer to include in the detailed design.

The approach taken by the Developer with respect to the road design and impact assessment including the level of baseline data collection, terrain mapping and terrain sensitivity analysis appears to be reasonable for the preliminary design stage.



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1. Introduction

Natural Resources Canada (NRCan) conducted a technical review to assess the completeness and technical merit of the information presented in the Government of Northwest Territories Tlicho All Season Road (TSAR) Project Description Report under the *Mackenzie Valley Resource Management Act (MVRMA)*. The Government of the Northwest Territories Department of Transport has submitted a proposal, outlined in its Project Description Report (PDR) to the Mackenzie Valley Review Board (MVRB) for the construction, operation and maintenance of an all season road a two lane gravel road design speed of 80 km/h and a posted speed limit of 70 km/h, approximately 94 km long. This road would allow for year-round use by commercial and private vehicles according to the size and weight limitations outlined in NWT regulations, such as the Large Vehicle Control Regulations. It will include four major bridge crossings and culverts as necessary. Traffic levels for the proposed TASR have been estimated at 20 to 40 vehicles per day. The estimate takes into account any potential traffic volumes of a metal mine north of Whatì if it were to begin production and develop a road that meets the TASR.

1.1. NRCan Mandate

NRCan seeks to enhance the responsible development and use of Canada's natural resources and the competitiveness of Canada's natural resources products. We are an established leader in science and technology in the fields of energy, forests, and minerals and metals and use our expertise in earth sciences to build and maintain an up-to-date knowledge base of our landmass. NRCan develops policies and programs that enhance the contribution of the natural resources sector to the economy and improve the quality of life for all Canadians. We conduct innovative science in facilities across Canada to generate ideas and transfer technologies. We also represent Canada at the international level to meet the country's global commitments related to the sustainable development of natural resources.

1.2. NRCan's Regulatory Role

NRCan is responsible for administering the *Explosives Act* and regulations, and pursuing the advancement of explosives safety and security technology. Our principal priority is the safety and security of the public and of all workers involved in the explosives industry in Canada. Through the Explosives Regulatory Division (ERD), NRCan provides services and support to the explosives industry, including manufacturers, importers, and distributors, of explosives.

1.3. NRCan's Participation in the Review of the Tlicho All-Season Road Project

NRCan has been participating in the technical review of the proposed Tlicho All Season Road both in the context of our regulatory role, and as an expert department with expertise in permafrost.



NRCan has participated throughout the review process and has reviewed the Project Application, the Project Description Report and the Adequacy Statement Response for the TSAR Project. NRCan provided information requests to the board in May 2017 and NRCan has reviewed the response provided by the Proponent in July 2017. NRCan did not participate in the technical meeting in August 2017 as there were no issues of concern relevant to NRCan's mandate to be discussed at the meeting. As a result of the Technical Meeting, additional documents have been made available by the Proponent for review in response to NRCan IRs.

NRCan has conducted its review of the documents submitted by the Proponent to assess impacts related to NRCan's mandate and areas of expertise have been adequately identified and evaluated.

2.1 Explosives Storage

The Project Description Report indicates that road construction will involve blasting and that blasting operations will require the transport and storage of explosives.

2.1.1 Summary of NRCan review

NRCan has reviewed information provided in the Project Description Report and the additional information provided by the Proponent on October 3, 2017 with respect to storage of explosives and has concluded that the Developer or an explosives supplier will require a licence issued under the *Explosives Act* for the storage of explosives. NRCan does not regulate the use of explosives and cannot comment on the potential effects of blasting.

2.1.2 Recommendations

NRCan is satisfied with the explosives storage information provided. If the project is approved, any applications submitted to NRCan's Explosives Regulatory Division for the storage of explosives will require more detailed information (i.e., type of magazine, location of explosives storage, and safety and security measures), if the project is approved.

2.1.3 Documents reviewed

Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.

Additional Information provided by the Government of Northwest Territories- via email from Stu Niven, October 3, 2017 10:38



2.2 Permafrost

2.2.1 Introduction

The proposed TASR predominately follows the route of an old overland winter road established by the military in the 1950s. The proposed TASR has been designed to meet appropriate road standards and will be primarily fill only in order to prevent permafrost degradation. Excavation within permafrost areas will be avoided whenever possible because cutting into surface vegetation can disturb the permafrost regime resulting in thaw and unstable ground. Once the geotechnical investigations have been completed, the potential borrow sources that have been identified to date will be further refined to the four to five sources that will be required for construction of the road. Efforts will be made to select borrow sources located on Territorial lands in areas that have been recently disturbed by forest fires in order to reduce the amount of disturbance related to road construction. However, there is potential for environmental impacts associated with the development of the road for all season use. This can include for example, a greater footprint and land area disturbed by the project due to clearing for a wider right-of-way, disturbance of areas that deviate from the previous route alignment, and need for granular resources from previously undisturbed areas for road embankment construction and maintenance. Additional impacts on the ground thermal regime, resulting in permafrost thaw, changes in drainage and ground instability, may occur through disturbance or changes in snow cover distribution due to the embankment. NRCan notes that the Developer has made a number of commitments for the project that will also ensure that the impacts associated with the all season road are minimised.

The approach taken by the Developer with respect to the road design and impact assessment including the level of baseline data collection, terrain mapping and terrain sensitivity analysis appears to be reasonable for the preliminary design stage. The approach is consistent with that taken for other recent approved projects such as the Inuvik to Tuktoyaktuk Highway and the road associated with the NICO mine project. Their approach is also consistent with the recommended guidelines for infrastructure and road design in permafrost regions.

A review of the proposed mitigation and anticipated environmental impacts is provided in Section 8 of the PDR of which a number of these are relevant with respect to the impacts of road construction and operation on the surrounding terrain and permafrost. In particular, the effects of climate change (i.e. warming temperatures, greater precipitation, extreme and unpredictable weather events) could have an impact on the stability of the proposed TASR from operation, maintenance, and preservation aspects, potentially resulting in negative impacts to the surrounding environment. Road stability could be impacted if the effects of climate change are not mitigated during the planning stages of construction. The design parameters and construction techniques chosen will be based on geotechnical analysis and will help in mitigating permafrost melt by avoiding shallow ice rich deposits and/or utilizing suitable techniques that will insulate the permafrost layer. Increased precipitation as a result of climate change have also been



accounted for by ensuring water crossings can compensate for the potential of increased flow and the road surface itself can accommodate increased rain events. The two most significant elements of the design are the use of non-woven geotextile between existing ground and the embankment, and maintaining minimum height, based on terrain type, to mitigate heat gain that can result in thawing of the permafrost. Table 8-3 of the PDR provides a list of potential terrain, soils and permafrost impacts and mitigations. NRCan is in general agreement with these commitments and the Developer's approach to minimizing impacts on the ground thermal regime and the potential for thawing, changes in drainage and ground instability.

With appropriate design, including the various commitments made by the Developer, it is NRCan's view that the environmental effects associated with the construction and operation of the all season road can be minimised as it relates to permafrost. NRCan offers comments and recommendations below for the developer's and MVRB's consideration for the detailed and final design of the project or subsequent monitoring and follow up plans.

2.2.2. Documents reviewed

The review focused on aspects of the project related to permafrost and terrain stability issues. The following documents were considered in the review.

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- Adequacy Statement Response EA1617-01Tlicho All-Season Road Project (13 April 2017 Report No. 1665943 Golder Associates)
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- Draft Road Alignment Geotechnical Report 2017-08-09
- DRAFT_TASR Geotechnical Investigation Borrow Sources DATA REPORT (TASR 2017 Geotechnical Investigation of Granular & Bedrock Prospects. Tetra Tech.

2.3.1 Issue 1- Embankment design options

Information on road embankment design options that accommodate the range of anticipated soil, bedrock, permafrost and hydrological conditions along the road corridor is required to ensure that the impacts of the environment as well as the impact of the environment on the project are minimized. In particular the design options show how the typical cross section could vary under a range of typical conditions within the discontinuous permafrost terrain with soil and bedrock substrate. In particular, conditions where permafrost is not present or terrain is underlain by thaw stable soil or bedrock, in contrast to permafrost soils that may be thaw unstable. In addition, design options include embankment design under dry, well drained conditions, in contrast to embankments adjacent to water bodies or wetland terrain. This information ensures that typical

conditions within discontinuous permafrost terrain along the route potential impacts can be adequately accommodated for through engineering design of the embankment.

2.3.2 Developer conclusions

The Developer will provide different design options for the final embankment design of the roadway after procurement. The designs will consider and accommodate for the range of typical conditions encountered within discontinuous permafrost terrain. This will include, for example, embankment layer depths expected to be thinner on bedrock/gravel and thicker on clay/silty substrate; geotextile is expected to be avoided on bedrock material is expected to be used for proper drainage (e.g., culverts).

For permafrost soils or thaw unstable soils, some techniques have already been considered in the PDR (Section 4.4, PR#7); for example, there will be no cutting in these locations (so the natural insulative layer of organics is not disturbed), the embankment cross-section will be thicker, and may have a layer of geotextile between native ground and embankment material. On stable soils/bedrock, roadway embankment can be thinner. In addition to these considerations, the drainage system will be designed to standards that avoid ponding water and avoid permafrost thawing. Project Co may perform thermal analyses in select locations if they require additional information in order to complete their final road design.

Embankments adjacent to waterbodies or wetland terrain are typically designed to use coarser embankment material with proper drainage; whereas embankments within dry, well-drained terrain can typically be thinner. As stated in Section 4.4.2 of the PDR, the typical highway cross section (which includes geotextile between the existing ground and the embankment; Figure 4.6) will most likely be included along the entire alignment (PR#7). This method will increase the stability of the embankment.

2.3.3 NRCan Conclusions and rationale

NRCan believes that the characterization of permafrost and terrain conditions is adequate for this stage of the design process. NRCan also agrees that additional site and thermal investigations may be required in select locations. Specific sections of the road alignment may be identified by the Developer where further investigations during detailed design will be required to confirm permafrost conditions and/or monitoring to assess changing conditions. Preservation of geotechnical boreholes and installation of temperature cables and/or thermal modelling in sensitive areas is also suggested as this would support further quantitative analysis during detailed design to determine how ground thermal conditions may change over time as well as supporting assessments of granular resource needs.

2.3.4 Recommendations

NRCAN recommends that different design options be developed following detailed geotechnical investigations that will consider and accommodate for the range of typical conditions encountered within discontinuous permafrost terrain for the final embankment design of the roadway.

NRCAN recommends that permafrost and unstable soils be identified following geotechnical investigations and that highway embankment heights be constructed and with appropriate drainage according to substrate type and drainage requirements to avoid ponding and permafrost thaw.

Field investigations should be conducted in support of detailed design, to inform the development of management plans to mitigate impacts on road operation and the surrounding terrain. Additional thermal analyses in select locations may be required to complete the final road design.

2.3.5 Documents reviewed

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- Adequacy Statement Response EA1617-01 Tlicho All-Season Road Project (13 April 2017 Report No. 1665943 Golder Associates)
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- Draft Road Alignment Geotechnical Report 2017-08-09

2.4.1 Issue 2- Embankment geotextiles

Details on embankment construction materials are required to ensure adequate design of the roadway to accommodate existing and future anticipated conditions. They are also required to evaluate the impacts of the project on the environment, and to ensure they are minimized. The road embankment will be constructed of a 200 mm coarse granular base; with an embankment height minimum of 1.5 m, and a geotextile that will be placed between the existing ground and the embankment, which will most likely be included along the entire alignment. The material properties for the embankment fill and the specifications of the geotextile and specific purpose of the geotextile is therefore required to evaluate the impact of the project on the environment. In particular, given that the coarse embankment base material can have a high hydraulic conductivity, and that subsidence beneath the embankment is possible over the medium to long term, the material properties and purpose of the geotextiles are important to minimize the impact of the project on the environment as well as the impact of the environment on the project.



2.4.2 Developer conclusions

Geotextiles placed over the ground provide extra strength to the embankment and may stop penetration of the embankment material into the ground especially when the area is wet or marshy. The actual brand and material specifications for the geotextile that will be utilized depends on various properties, such as ultimate tensile strength, permeability, UV resistance, etc. Project Co will determine the required specifications of geotextile during the detailed design phase, which follows the procurement process. The material specifications for embankment fill will also be finalized in the future by Project Co. Placing material on the base is a way to avoid water rising due to the capillary action.

2.4.3 NRCan Conclusions and rationale

In NRCans view the Developer has done a reasonable job towards identifying areas along the route likely to require the use of geotextiles to be used beneath the embankment. The use of geotextiles and its purpose is identified in the PDR. It is presently recognized that permafrost is likely present in some areas of the proposed alignment, though not necessarily encountered during preliminary geotechnical investigations (Draft Road Alignment Geotechnical Report 2017-08-09). It is further recognized that, where permafrost is encountered and/or with thaw sensitive soils, a non-woven geotextile is recommended to be placed directly on the subgrade and extend laterally into the embankment footprint from the toe of the embankment (Draft Road Alignment Geotechnical Report 2017-08-09).

2.4.4 Recommendations

NRCan recommends that geotextiles used beneath the embankment (to provide extra strength and prevent water and subsurface materials penetrating into the embankment) be based upon site conditions as evidenced by geotechnical field investigations. The specific properties of the geotextile(s) used should be appropriate to the tensile strength, permeability, and weathering resistance requirements encountered. NRCan recognizes that geotextiles may not be required across the entire route, for example where shallow and well-drained bedrock is encountered.

2.4.5 Documents reviewed

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- Draft Road Alignment Geotechnical Report 2017-08-09

2.5.1 Issue 3 – Pre-existing permafrost conditions on and off disturbed terrain

An understanding of terrain conditions on and off the existing disturbed terrain need to be factored in the context of design criteria. Permafrost, active layer, and ground ice conditions vary naturally, and also vary with time following disturbance. The proposed TASR follows a former military winter road constructed in the 1950s and used until the 1980s, and subsequently used intermittently in summer and winter by a variety of vehicles (ATVs, snowmobiles and trucks) for access. Permafrost and terrain conditions along this right-of-way can be expected to be much different than within adjacent undisturbed terrain, where no previous impact has occurred. Similarly, the response to recent fires, and to temperature conditions caused by historically warming temperatures, are also likely to differ on and off this existing right of way due to differences in vegetation cover and soil disturbance. In other areas, the proposed TASR will cross undisturbed terrain. The contrasts between these disturbed and undisturbed areas will result in terrain conditions that need to be factored into design considerations.

2.5.2 Developer conclusions

Terrain conditions off the existing disturbed terrain will likely be accommodated by following the same procedure that will be utilized in areas suspected to contain permafrost (i.e., use of geotextile and no cutting); therefore, there is already a plan in place to address the contrast between the disturbed and undisturbed areas. Project Co will address these concerns in their final design of the roadway.

Based on the findings of the terrain analysis, most of the roadway alignment follows the existing cutline or winter/summer trail. In designing the embankment roadway, the aim is not to cut the existing ground, which means vegetation will not be disturbed and soil disturbance will be minimal. In addition, movement of heavy machines will be restricted to the roadway right of way area.

2.5.3 NRCan Conclusions and rationale

NRCan generally agrees that the characterization of permafrost and terrain conditions based on findings of the terrain analysis is adequate for this stage of the design process. NRCan also recognizes that additional geotechnical site investigations including boreholes and thermal analysis on and off the proposed right-of-way have been conducted to date (Draft Road Alignment Geotechnical Report 2017-08-09) and that additional investigations may be required in sensitive terrain, on slopes and at water crossings including where major structures may be constructed. Specific sections of the road alignment may be identified by the Developer where further investigations during detailed design will be required to confirm if permafrost is present and/or monitoring to assess changing conditions.



NRCAN anticipates that additional boreholes might be useful in better characterizing the permafrost and subsurface conditions in particularly sensitive areas including approaches to water crossings and areas where slope instability may be an issue. Preservation of geotechnical boreholes and installation of temperature cables in sensitive areas is also suggested (as recommended in the Draft Road Alignment Geotechnical Report 2017-08-09) as this would support further quantitative analysis during detailed design to determine how ground thermal conditions may change over time as well as supporting assessments of granular resource needs. It is further suggested that long-term monitoring of the roadway and embankments be conducted by qualitative and quantitative means by survey and potentially through the use of ground temperature monitoring to evaluate the long-term performance of the road.

2.5.4 Recommendations

NRCAN recommends that detailed geotechnical investigations be conducted **for the whole roadway** prior to the final design of the roadway, to characterize permafrost conditions and support quantitative analysis during detailed design, and also to form part of ongoing monitoring and management plans. Monitoring of embankment performance, which should include but not be limited to observations of cracking, sloughing, ponding, aufeis (winter icings) and vegetation changes. Additionally, where permafrost is encountered and where practical, the thermal and hydrologic regime should be monitored to ensure that the embankment performs as predicted.

2.5.5 Documents reviewed

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- Draft Road Alignment Geotechnical Report 2017-08-09

2.6.1 Issue 4 – Removal of permafrost

Permafrost is ground that remains below 0°C for two or more consecutive years. Owing to the particular properties during phase change between ice and water, considerable heat is required to melt ice within permafrost. Thus, permafrost at temperatures near and below the melting point of ice, can remain in that state for a considerable period of time. The proponent has indicated that, as a potential mitigation measure, isolated patches of permafrost can also be cleared and allowed to melt prior to construction. However, without adequate knowledge of the extent, temperature, and ground ice characteristics of the permafrost, such an approach may be unfeasible. In particular, given the time frame for construction of the TASR, the concern for disturbance of organic surfaces, and potential for construction during the winter season, it is unclear how isolated patches of permafrost can also be cleared and allowed to melt prior to construction.

2.6.2 Developer conclusions

The GNWT has clarified that it does not intend to melt isolated patches of permafrost. Under certain circumstances where it is identified that it would be better for the long term success of the road to remove isolated patches of permafrost and/or significant ice lens (because these specific patches have been identified as expecting to melt within the next 20 years and this melting will cause the road to shift in the future) Project Co will remove all *in-situ* material associated with the isolated patches of permafrost and will replace them with clean, compacted embankment material.

2.6.3 NRCAN Conclusions and rationale

NRCAN cautions the Developer on any removal of isolated patches of permafrost and/or significant ice lenses without sufficient knowledge of the depth and lateral extent of such materials. The removal of the top layer of insulative materials and/or the upper layer of ice-poor materials may expose additional ice-rich and thaw unstable materials to thermal and physical disturbance causing subsidence and lateral movement. Thaw unstable permafrost materials should only be removed following appropriate recommendations based on geotechnical and geophysical site investigations.

2.6.4 Recommendations

NRCAN recommends that any attempt to remove isolated patches of permafrost and/or significant ice lenses only be undertaken after appropriate geotechnical and geophysical investigations to confirm the extent of the permafrost and thaw unstable materials.

2.6.5 Documents reviewed

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- Draft Road Alignment Geotechnical Report 2017-08-09

2.7.1 Issue 5- Geotechnical conditions

Information on baseline terrain conditions and sensitivity, geotechnical and permafrost conditions, ground thermal conditions are required for adequate design of the highway and granular resources, impact assessment, effects of climate change on the project, and the implementation of mitigation techniques. The Developer has indicated that results from the geotechnical drilling will be incorporated into the final road design. Information on baseline terrain conditions and sensitivity along the proposed route is required to determine design

parameters for the highway and for impact assessment, and to ensure impacts of the project on the environment as well as the impact of the environment on the project are minimized. Baseline information on geotechnical and permafrost conditions is required for adequate design of the highway and for characterizing potential borrow sites. This information is also required for assessment of potential impacts and implementation of mitigation techniques. Information on ground thermal conditions is required for adequate design of the highway, assessment of impacts associated with the highway and granular resource extraction and also for determining the effects of climate change on the project.

2.7.2 Developer conclusions

The Developer has provided draft geotechnical reports for major structures that include the borehole locations, depths drilled and drilling results. The Developer has also submitted the Draft Road Alignment Geotechnical Report 2017-08-09 for review.

2.7.3 NRCan Conclusions and rationale

NRCan finds that the characterization of permafrost and terrain conditions based on findings of the terrain analysis and additional geotechnical site investigations including boreholes and thermal analysis conducted to date (Draft Road Alignment Geotechnical Report 2017-08-09) to be adequate. NRCan further recognizes that additional investigations may be undertaken for specific terrain and/or drainage conditions and where major structures may be constructed.

NRCan anticipates that additional boreholes and thermal analyse may be required to characterize the permafrost and subsurface conditions in some areas. Preservation of geotechnical boreholes and installation of temperature cables may be required for monitoring purposes (as recommended in the Draft Road Alignment Geotechnical Report 2017-08-09) as this would support further quantitative analysis during detailed design to determine how ground thermal conditions may change over time. NRCan recommends that long-term monitoring of the roadway and embankments be conducted to evaluate the long-term performance of the road.

2.7.4 Recommendations

NRCan recommends that, in addition to geotechnical studies conducted to date (Draft Road Alignment Geotechnical Report 2017-08-09) that further site investigations be carried out to confirm permafrost and subsurface conditions, in particular near water crossings, on slopes and where major structures will be built, in order to support final design and also to inform development of any mitigation, management and monitoring plans. NRCan also recommends that deeper geotechnical boreholes, installation of temperature cables and geophysical surveys would be useful components of the detailed site investigations to characterize permafrost



conditions and also support quantitative analysis during detailed design and to form part of the management and potential monitoring plans.

2.7.5 Documents reviewed

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- Draft Road Alignment Geotechnical Report 2017-08-09

2.8.1 Issue 6– Borrow materials

An adequate supply of locally available granular and quarry bedrock materials is required for the construction and maintenance of the TASR embankment. Borrow materials from quarry and bedrock sources must include materials sufficient for future maintenance of the proposed road. The Proponent has indicated that the total embankment volume is currently estimated at 3,100,000 m³ for a 1.5 m thick (average) embankment, and that estimated volumes are currently adequate. Ongoing maintenance, following initial construction will be an essential component of providing a safe driving surface, and for ensuring that no significant impacts on the environment occur during the life of the road. In addition, in evaluating the impacts on proposed granular and bedrock quarry sources, future requirements of materials for maintenance of the roadway should be considered.

2.8.2 Developer conclusions

The Developer has indicated that there is enough gravel available within the preferred prospects for future maintenance to keep the roadway safe for drivers. The table located in Appendix J of the TASR PDR (PR#7) provides INF's initial estimate of available granular and bedrock prospects near the TASR. The estimated volume of these prospects exceeds INF's initial total embankment volume of 3,100,000 m³, which INF estimated as being necessary to construct the TASR. These prospects will also contain a sufficient amount of material to support future road maintenance.

INF is currently conducting geotechnical investigations at 13 preferred prospects. Once the geotechnical investigations are complete and the final reports have been produced, actual quality and quantity of granular materials available at each source will be known in addition to whether the sources are suitable from a geochemical perspective.

2.8.3 NRCAN Conclusions and rationale



NRCan supports the Developer's approach of assessing the potential amount of material to support road construction and future road maintenance through geotechnical investigations at 13 preferred prospects. NRCan is aware of the information and has reviewed the DRAFT_TASR Geotechnical Investigation Borrow Sources DATA REPORT (TASR 2017 Geotechnical Investigation of Granular & Bedrock Prospects. Tetra Tech. NRCan notes that this "Issued for Review" document is provided solely for the purpose of client review and presents the contractors interim findings and recommendations to date. Usable findings and recommendations will be provided through an "Issued for Use" document to be issued subsequently. NRCan expects that final designs be undertaken based on recommendations made in the "Issued for Use" report. At that time, the actual quality and quantity of granular materials available at each source will be known in addition to whether the sources are suitable from a geochemical perspective. In addition, Quarry Operations Plans will be developed for each quarry to prevent any possible environmental impacts.

2.8.4 Recommendations

NRCan recommends that the Developer provide a complete assessment of the actual quality and quantity of granular and quarry materials available at each final identified source and whether these sources are suitable from a geochemical perspective. In particular, NRCan recommends that identification of material availability of suitable bedrock, quality granular materials, general fills and concrete aggregates be completed.

2.8.5 Documents reviewed

- Proposed Tlicho All-season Road. Project Description Report (PDR) (and related Appendices). Northwest Territories Transportation. March 2016.
- EA1617-01 Tlicho All-Season Road Information Request (Developer's) Response from GNWT to NRCAN
- DRAFT_TASR Geotechnical Investigation Borrow Sources DATA REPORT (TASR 2017 Geotechnical Investigation of Granular & Bedrock Prospects. Tetra Tech.

3. Overall conclusion

NRCan is generally satisfied with the information provided, and, within the context of the department's areas of expertise, finds the conclusions presented in the PDR and PDR Appendices to be reasonable.

NRCan appreciates the opportunity provided by the Mackenzie Valley Impact Review Board to participate in this review. We would be pleased to answer any questions regarding our comments from the Board, its staff, the Developer, or other Parties to this review.



4. Summary of NRCan's recommendations for the Government of the Northwest Territories

4.1.1 Explosives

1. NRCan is satisfied with the explosives storage information provided. Any applications submitted to NRCan's Explosives Regulatory Division for the storage of explosives will require more detailed information (i.e., type of magazine, location of explosives storage, and safety and security measures), if the project is approved.

4.1.2 Permafrost

1. For the final embankment design of the roadway, NRCan recommends that different design options be developed following detailed geotechnical investigations that will consider and accommodate for the range of typical conditions encountered within discontinuous permafrost terrain. NRCan recommends that permafrost and unstable soils be identified following geotechnical investigations and that highway embankment heights be constructed and with appropriate drainage according to substrate type and drainage requirements to avoid ponding and permafrost thaw. Field investigations should be conducted in support of this detailed design, to inform the development of management plans to mitigate impacts on road operation and the surrounding terrain. Additional thermal analyses in select locations may be required to complete the final design.
2. NRCan recommends that geotextiles used beneath the embankment (to provide extra strength and prevent water and subsurface materials penetrating into the embankment) be based upon site conditions as evidenced by geotechnical field investigations.
3. NRCan recommends that detailed geotechnical investigations be conducted for the whole roadway prior to the final design of the embankment, to characterize permafrost conditions and support quantitative analysis during detailed design, and also to form part of management and potential monitoring plans. Monitoring of embankment performance, which should include but not be limited to observations of cracking, sloughing, ponding, aufeis (winter icings) and vegetation changes. Additionally, where permafrost is encountered and where practical, the thermal and hydrologic regime should be monitored to ensure that the embankment performs as predicted.
4. NRCan recommends that any attempt to remove isolated patches of permafrost and/or significant ice lenses only be undertaken after appropriate geotechnical and geophysical investigations to confirm the extent of the permafrost and thaw unstable materials.
5. NRCan recommends that, in addition to geotechnical studies conducted to date (Draft Road Alignment Geotechnical Report 2017-08-09) that further site investigations be carried out to confirm permafrost and subsurface conditions, in particular near water crossings, on slopes and



where major structures will be built, in order to support final design and also to inform development of any mitigation, management and monitoring plans. NRCan also recommends that deeper geotechnical boreholes, installation of temperature cables and geophysical surveys would be useful components of the detailed site investigations to characterize permafrost conditions and also support quantitative analysis during detailed design and to form part of the management and potential monitoring plans.

6. NRCan recommends that the Developer provide a finalized assessment of the quality, quantity and geochemical suitability of granular and quarry materials available including identification of material availability of suitable bedrock, quality granular materials, general fills and concrete aggregates.