Appendix W

Engineering Memos

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Project name:
Marten Falls Community Access Road PD EA

Project ref:
60593122

From:
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Date:
March 13, 2024

To:
Leah Deveaux

Cc:
Katelyn Price

Memorandum

Subject: Marten Falls Community Access Road PD EA – Traffic Data Review

In support of the Marten Falls Community Access Road Preliminary Design (PD) and Environmental Assessment (EA), AECOM Canada Ltd. (AECOM) has undertaken a review of available traffic data and relevant studies for estimating the future volumes, distribution, and composition of traffic for the proposed road.

Background Information and Study Area

The Marten Falls Community Access Road is one of three proposed Ring of Fire (ROF) road projects located in northern Ontario. The road would provide an all-season access opportunity for Marten Falls First Nation community and form the first of three segments of highway connections to the ROF region. The community is currently served by a winter road for six to eight weeks per year and is otherwise only reachable by air. The Marten Falls Community Access Road will connect near the northern terminus of the existing Painter Lake Road. From there through various local roads (Painter Lake Road, Mine Road, Anaconda Road, and Esnagami Road), it will connect Highways 584 and 643 to the Ring of Fire. This will also allow for connection of Marten Falls to Nakina and other communities.

Marten Falls Community Access Road features a north-south section of approximately 170 kilometres, and an east-west section of approximately 70 kilometres. The north-south section will serve as a major route connecting to the ROF, while the east-west segment provides direct traffic service for Marten Falls First Nation.

Traffic Data

The AECOM project team was provided with background information and documents as inputs to the traffic forecasts and assumptions for Marten Falls Community Access Road. The following studies were provided and reviewed by the project team:

- *Design Considerations for the Ring of Fire Highways* – MTO (April 2023)
- *Noront Resources Eagle's Nest Access Road Traffic Study* – HATCH (August 5, 2022)

General information on existing travel patterns of the winter road connecting to Marten Falls First Nation between January and February of each year was also provided to the project team. The winter road sees approximately 30 loads (i.e., trucks with goods) each season with approximately 7 to 8 cars per day while usable.

Traffic Assumptions

Average Annual Daily Traffic

For the purpose of the Noise and Air Quality studies, AECOM is proposing to use an estimated Average Annual Daily Traffic (AADT) of 700 for the north-south section and 100 for the east-west section of the Marten Falls Community Access Road. These volumes are reflective of the anticipated peak traffic in 2046.

The estimate for the north-south segment exceeds the forecasted AADT of 500 as per the noted study prepared by HATCH. The study uses information on projected ROF mining activities, as well as intercommunity travel estimates based on Institute of Transportation Engineers (ITE) Trip Generation principles to develop the forecast, including anticipated travel to/from Webequie First Nation at the northern terminus of the ROF highway system. The estimated AADT of 700 also exceeds existing volumes from traffic counts available for nearby Highways 584 and 643, which indicate AADTs ranging between 200 and 270 in 2016 with negative historical growth trends (not accounting for potential ROF development traffic).

The east-west segment is estimated to see an AADT of 100 based on the HATCH report, which is reasonable for a community with an estimated population of 310 in 2046 (up from 252 in 2016). It is noted that the east-west segment may see some additional temporary or permanent aggregate facilities with additional truck traffic along a portion of the segment; however, this is not expected to contribute substantially to the AADT in 2046.

It is further noted that the MTO's *Design Considerations for the Ring of Fire Highways* criteria note that under unknown conditions, a conservative approach is to design to an AADT of 1000 or greater.

Table 1: Proposed AADTs for Marten Falls Community Access Road in 2046

Segment of Marten Falls Community Access Road	2046 AADT
North-South (to ROF)	700
East-West (to Marten Falls First Nation)	100

Traffic Composition

Traffic data materials were also reviewed to identify information on the future anticipated composition of traffic (i.e., auto traffic, medium trucks, and heavy trucks). Medium and heavy trucks are defined as follows:

- Medium trucks: all vehicles with two axles and six wheels designed for the transportation of cargo. Generally, the gross vehicle weight is greater than 4,500 kg but less than 12,000 kg. City buses are also included in this category.
- Heavy trucks: all vehicles with three or more axles designed for the transportation of cargo. Generally, the gross vehicle weight is greater than 12,000 kg. Intercity buses are also included in this category.

The 2046 forecast prepared by HATCH estimates 64% commercial vehicles on the north-south segment and 2.5% on the east-west segment based on anticipated ROF mining operations, as well as projected commercial vehicles associated with the connected communities. With nearly all forecasted truck traffic associated with the mine (i.e., 280 of 286 daily vehicles on the north-south segment), it can generally be assumed that mining vehicles would be classified as heavy trucks.

For a northern community of this nature, a higher ownership of light-duty trucks and medium trucks for personal and business use can generally be expected. It can be conservatively assumed that approximately 20% of vehicles not classified as heavy trucks could be classified as medium trucks. This is in line with the higher range of similar facilities noted in the Appendix of the MTO Design Considerations.

Table 2: Proposed Medium and Heavy Truck Percentages for Marten Falls Community Access Road in 2046

Segment of Marten Falls Community Access Road	2046 Medium Truck Percentage	2046 Heavy Truck Percentage
North-South (to ROF)	7%	64%
East-West (to Marten Falls First Nation)	20%	3%

It has been noted that the east-west segment of the Marten Falls Community Access Road may see some additional temporary or permanent aggregate facilities with additional truck traffic along a portion of the segment. This is expected to contribute between 10 and 20 truckloads for the delivery of aggregates during construction, as well as 5 to 10 belly dump trailers (i.e., trucks that allow for materials to be released from the bottom of the trailer using a clamshell design) for aggregate distribution per year. This is not expected to contribute substantially to the heavy truck percentage along this segment of the road in 2046.

Limited information was available on the anticipated day/night traffic distribution for the north-south and east-west segments of Marten Falls Community Access Road. The closest available Automatic Traffic Recorder (ATR) counts collected for 24 hours per day over seven days near Thunder Bay (approximately 400 kilometres southwest of Marten Falls) indicate approximately 88% daytime (i.e., 7:00 AM to 11:00 PM) traffic. However, it is recommended that conservative assumptions on day/night distribution are made due to the limited information available for estimating hourly travel patterns.

Traffic Distribution

The project team used the projected traffic volumes and travel patterns to confirm that a large volume of the heavy truck traffic on the north-south segment of Marten Falls Community Access Road will continue northward to the ROF region via the subsequent highway connection (i.e., Northern Road Link). Significantly lower volumes of trucks, and traffic in general, are shown to be headed along the east-west segment of the road connecting to Marten Falls First Nation.

Based on projected mining operations associated with the ROF from the HATCH study, no mining trucks are anticipated to use the east-west segment of Marten Falls Community Access Road. A nominal amount of commercial traffic servicing Marten Falls First Nation is projected to divert to the east-west segment, representing a very small proportion of those on the north-south segment. The forecast from the HATCH study indicates that approximately 95% of truck and commercial traffic continues to ROF by way of the Northern Link Road.

MEMORANDUM

To:	Ministry of Transportation (MTO)	**Date:**	August 17, 2023
Attention:	Paul MacInnis, Senior Advisor, Indigenous Liaison Advisor, Ministry of Mines (MINES)		
cc:	Michael Fox, Qasim Saddique, Angela Brooks, Craig Wallace and James McCutchon		
From:	Northern Road Link (NRL), Webequie Supply Road (WSR), and Marten Falls Community Access (MFCAR) Project Teams	**Project:**	NRL, WSR, MFCAR
Subject:	Proposed Peatland Road & Construction Approach		

The memo is a follow-up to the May 17, 2023, meeting between the Ministry of Transportation (MTO) and the project teams of the Webequie Supply Road (WSR), Northern Road Links (NRL and Marten Falls Community Access Road (MFCAR) regarding the design approach for the three proposed road projects in northwest Ontario. At that meeting the project teams provided information on the recommended approach to addressing open water hydrology related issues, climate change, and roadway overtopping for all three projects.

At that meeting, the project teams provided information on the recommended approach to address both design and construction challenges/risk to navigating fens, bogs and swamps (Organic Terrain) for all three projects.

The project teams are requesting MTO's acceptance and/or feedback on the recommended approach outlined in this memo for use on all three projects. The memo outlines the assumptions that were incorporated by the project teams when developing our proposed design strategy as well as the recommended construction approach for shallow and deep peatland areas for the three proposed road projects.

1 Background

1.1 Single Route Connection to Provincial Highway

NRL, WSR and MFCAR will connect to provincial roadways and the provincial highway system through a single connection at the MFCAR southern terminus. The roadways will be constructed within one of the most isolated areas in Ontario, and they will be the first all-season roads constructed within this region and the Hudson Bay lowlands.

The Ring of Fire mineral deposits are located at the northern end of the NRL Project and eastern terminus of the WSR. The development of this area is considered a critical component of the Ontario and Canada's economic future.

The Marten Falls First Nation (MFFN), Webequie First Nation (WFN) as well as potential future resource development within the Ring of Fire will be dependent upon these all-season roadways. It will be critical that there is continuous, uninterrupted, and safe access along the proposed roads as there are no other roads.

1.2 Transportation Options

In general, the serviceability and accessibility of existing winter road networks have been severely impacted by climate change and ground warming. As a result, the communities are currently experiencing diminishing winter road seasons putting pressure on the delivery of fuel, construction materials and other essential goods and services.

To address this issue, other road options have been explored within the Hudson Bay Lowlands including the Nibinamik-Webequie Community Road, TPA1B Webequie Community Supply Road, the MFFN Winter Road Realignment and the Industrial North-South Proposed Road Corridor- Cliffs Chromite Project.

If these projects are approved and the three roadways (NRL, WSR, MFCAR) are constructed, it is expected that they will form the single route connecting local communities (MFFN and WFN) as well as the Ring of Fire to the provincial highway network. Consequently, these new roads are likely to replace the existing winter roads. Additionally, it is anticipated that current flight schedules into the two remote northern airports serving WFN and MFFN will be greatly reduced as a result.

1.3 Low Tolerance for Closure

If NRL, WSR and MFCAR experience prolonged operational disruptions due to damages to the road, bridges, culverts, or other infrastructure, it will have significant adverse effects on communities and as a result, economic and financial impacts. There will be a very low tolerance for road closures and even short-term lane closures will disrupt resources operations or transportation of goods.

Repairing these remote roadways in a timely manner poses considerable challenges compared to other areas of the province, particularly if damage occurs due to settlement failure or washout caused by flooding. It is anticipated that the preferred alignment for all three roads will traverse long, continuous sections of peatland terrain.

Peatlands are the most challenging type of terrain to construct roads within, leading to higher construction costs as compared to other terrains. They also pose the greatest operational and maintenance risks such as settlement failure, permafrost degradation, and potential road overtopping/flooding. If the road sustains damages, it could take weeks or longer to repair, effectively cutting off access during that time frame.

The roadway must remain operational to maintain the supply chain connectivity for the reliable flow of goods, services and materials, community development, and the safety and security of northern communities for medical and potential emergency evacuations. Therefore, NRL, WSR and MFCAR must be designed with a conservative approach particularly within peatlands, driven by a low risk tolerance for closures or road failures.

1.4 Climate Change

Canada's northern regions are already experiencing noticeable impacts from climate change such as increasing temperatures and higher intensity and frequency of storm events. Climate change puts increased pressure on engineering designs, necessitating a more conservative approach, while requiring an increased level of engineering and investigations to further investigations to gain a deeper understanding of the terrain and anticipated conditions, ultimately reducing risks associated with climate change.

When designing in this region, engineers must account not only for the anticipated challenging ground conditions but also for the effects of climate change and the road's impact on the environment and permafrost.

1.5 Hudson Bay Lowlands/Peatlands

Ontario's Far North, home to the three projects, is situated within the vast Hudson Bay Lowlands, which is renowned for being one of the world's largest peatlands and housing one of the largest remaining undeveloped boreal forests. The terrain in this region mainly consists of poorly draining organic deposits of muskeg, featuring a high-water table typically underlain by fine-grained glacio-lacustrine clays and silts. Both the peatlands and the forest serve as crucial carbon sinks for Ontario and Canada.

Within the Hudson Bay Lowlands, bog and fen peatlands dominate the low relief terrain adjacent to the esker ridge. These peatlands exhibit characteristics such as low topographic relief, high water tables, and numerous streams and areas of standing water, which are typical of the James Bay Lowlands which forms the southern portion of the Hudson Bay Lowlands.

Peat deposits in the area rely on maintaining a consistent groundwater level. Any alterations to the groundwater regime within or near the road pose a significant risk to the long-term sustainability of the peat and the ecosystems dependent on that consistent groundwater condition. Proper measures need to be taken to preserve the delicate balance of this unique peatland environment and ensure its ecological integrity.

The area contains isolated pockets of permafrost or areas of ground ice and frost susceptible soil that will have to be addressed. The Hudson Bay Lowlands also have limited access to aggregate, borrow, and quarry materials required for highway construction, necessitating long-distance hauling to transport materials to the construction sites of the three projects.

1.6 Climate Resilience

Regional climate during the intended service life of the proposed road projects has the potential to induce disruptive impacts to the roadways, bridges, culverts, and other supporting infrastructure. Therefore, Climate resilience is an important consideration, given the proposed roads will serve as the single all-season connection for local communities and the fact that the region lies within areas of known permafrost.

Climate change can also have impact on peatlands. It is important that the roadway limit impacts to the peat lands even though some of the long term impacts due to climate change cannot be fully defined currently. Maintaining the groundwater regime through peatlands is critical to ensuring that the road network has a minimal environmental consequence.

A conservative approach to hydrology and climate change will increase the potential for climate resilience. Other Ontario agencies are already utilizing a conservative approach for their projects. For example, Infrastructure Ontario considers only the most conservative approach when conducting climate risk assessments for new critical infrastructure assets, such as corrections facilities. Therefore, its is recommended that a similar conservative design approach should be implemented for these projects to enhance its overall resilience.

2 Key Issues with Roadway Construction in Peatlands

Peatlands pose additional design and construction challenges due to the potential disruption of the delicate equilibrium of the ecosystem. Most groundwater movement in peatlands occurs through the upper peat layer where the peat is more fibrous and has the highest hydraulic conductivity. If the ground and surface water is not appropriately managed, water can pond on the roadway's upstream side leading to nutrient-rich water diversion and degradation of downstream vegetation and soil composition. This can also lead to degradation of permafrost given the related heat sink of the ponded water, resulting in changes to the geomorphic, hydrologic, and vegetative systems of the peatland.

Peatland's low shear strength, high compressibility, and anisotropic nature, complicates construction on peatlands. In other jurisdictions is a common practice to "float" the road through deep organic terrain by placement of a geogrid / geotextile on the peat surface followed by the placement of embankment fills. This technique significantly reduces the amount of fill placement and costing required to build the road.

Without appropriate measures to maintain the groundwater regime, water is forced upward and stored or conveyed above the peat as surface water on the upstream side of the road instead of flowing through the peat under or through the road embankment as groundwater.

The placement and compaction of granular fill without consideration for groundwater and surface water in peat lands can negatively impact surface and groundwater levels and flow patterns. For low-lying sections of peatlands not immediately adjacent to watercourse crossings, road construction can locally impact groundwater flow.

Overtopping is a concern for roadways especially in low lying areas. If the road profile is raised to reduce the likelihood of overtopping, the additional granular material to establish the higher embankment further compresses the underlying peat. Furthermore, this technique reduces the overall hydraulic conductivity and ability to conduct sub-surface flow under the road. Raising the embankment to mitigate overtopping risks results in trapped water on one side. This impedes groundwater drainage and increases the likelihood of water accumulation, leading to saturation, decreased stability, and potentially compromising the road structure. Therefore, it is critical to balance road elevation benefits with impacts to the natural hydraulic conductivity in peatland areas.

At watercourse crossings, culverts maintain surface water flows. It is anticipated that groundwater near watercourse crossings will continue to discharge into adjacent streams, ensuring its role in supporting aquatic habitats remains unaffected after road construction. To preserve the hydrologic function of wetland areas, and minimize changes in groundwater levels and flow directions, equalization culverts within the embankment to maintain surface flows and hydrologic function will be employed.

A critical concern lies in the contrast between the significance, volume, and size of peatlands between southernly Ontario and the Hudson Bay Lowlands. In lower latitudes in Ontario, peatlands generally occur in isolated pockets, while in the Hudson Bay Lowlands, peatland is a major and widespread terrain type. The existing Ontario Provincial Standards and Specifications (OPSS) and Ontario Provincial Standard Drawings (OPSD) account for the peat terrain found in the southern regions as opposed to the large expanses of peatlands within the Hudson Bay Lowlands.

The variances in thicknesses of the peatlands impacts construction; thicker peat results in more difficult construction and increased potential of groundwater concerns and requirements for mitigation to maintain the natural peatland environment. It is the peat depth and composition that will dictate the size of the embankment and assessment of groundwater mitigation.

2.1 Investigations and Activities to Date by the Projects

Existing data with respect to variations of peatlands and their behavior within the region is limited throughout the study area. However, the existing information was examined, and surficial maps, including high-level (1:100,000) scale surficial mapping conducted by the Ontario Geological Survey, were considered. Existing information was reviewed to determine the information needed to meet the requirements of provincial and federal regulators reviewing the eventual EA/IA. This includes but is not limited to photography, relevant mapping, data, and other relevant documents from work in and around the proposed road link corridor and from baseline studies and impact assessments conducted in boreal peatland northern provinces.

An example of the available surficial mapping just north of the MFCAR area is shown in Figure 1.6 below:

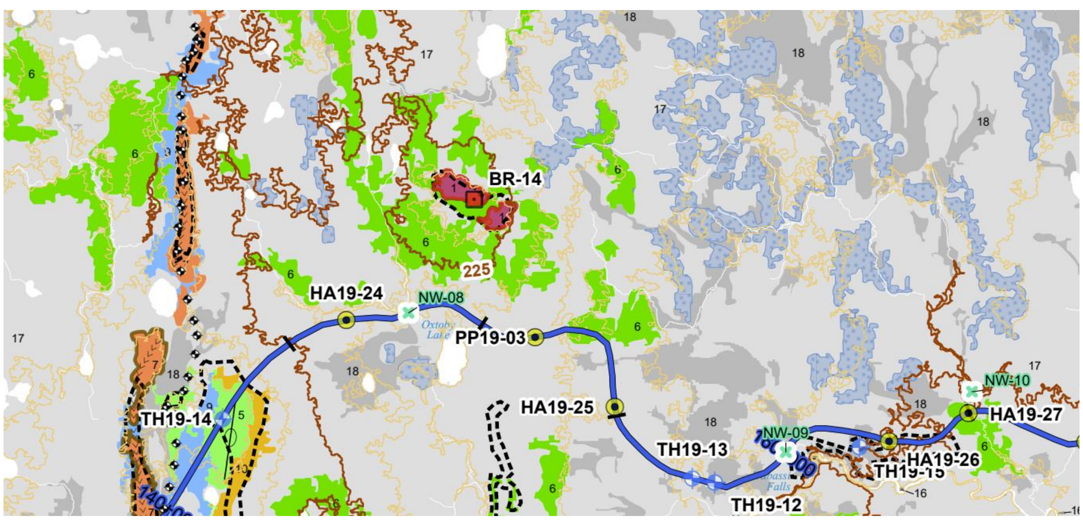

Figure 1.6 – Area Along Esker at location where alignment turns east to Marten Falls FN

The above figure illustrates the typical terrain within the Hudson Bay lowlands which is clearly dominated by organic terrain (anything light or dark grey).

After completing terrain mapping for each project, terrain types were further classified and categorized. Field investigation results were interpolated to model the variation of peat depths within terrain types. According to the Canadian Wetland Classification System (1997), peat thicknesses across the region are typically less than 5.0 m but will still require the floating road technique to be implemented. The peat thicknesses and composition will be variable along the route, especially in comparison between fen and peat bogs. Previous borehole results in the study area completed by Golder (2010) were also reviewed.

Field investigations that have been undertaken to further estimate thicknesses and composition of the organic terrain included the following:

1) Ground penetrating radar in combination with peat probes (WSR);
2) Peat probes to measure select organic terrain units (NRL); and,
3) Peat probes and hand augers (MFCAR).

The terrain types were then categorized into three rankings from most preferred (easiest to construct and managed) to least desirable. Although some investigations of the organic terrain have been undertaken, the number of investigations is currently limited and additional work should be undertaken to further define peat depths and composition.

3 Recommended Approach

The project team is recommending that NRL, WSR and MFCAR adopt a design approach for the peatlands that has been proven successful in other provinces for similar types of roads within the same latitude and terrain. Embracing this recommended approach would represent a low risk-tolerance strategy to address the potential for negative peatlands and groundwater impacts. The design approach supports the requirement to maintain the road link through all realistically (credible) extreme conditions.

To date, the approach for construction through shallow peatlands involves chasing or excavating peat areas, followed by the replacement of the excavated peat with suitable road construction materials. Deeper peat areas with depths greater than 0.6 m are left in place and embankments constructed with sound construction materials are placed on top of the peat. Over time, peat compression occurs, and as a result, the roadway must be filled to address road settlement. However, this approach, due to the poor material selection, has often resulted in peatlands' groundwater flow being impeded. After construction, from an aerial vantage, one can often observe green terrain on the upstream side and brown, dead terrain on the downstream side.

The recommended approach builds on proven methods that preserve the peatlands and local ground/surface water regimes.

3.1 Recommended Design Approach

The recommended approach is based upon successful projects with the Canadian Shield in similar terrain in Manitoba and other provinces. Based on our experience and available literature, compression, and settlement of peatlands, when loaded with roadway materials, is typically about 40%± of the original layer thickness. These compression rates have been confirmed by Ministry of Transportation in Manitoba. The ministry compared pre and post construction peat depths for several completed projects and these compression ranges were confirmed regardless of the season the road was built in. When Manitoba used more traditional construction methods where shallow peat zones were excavated, it resulted in additional excavation volumes, constructability concerns and dewatering issues.

The proposed approach, a floating road strategy, is beneficial as it minimizes disturbance to the subgrade by leaving the peat in place, which also insulates any underlying permafrost. This approach works best to preserve the bogs and fens within which peatlands are generally located. Leaving the natural insulation in place under the road, although compressed and less insulative, extends the lifespan of the underlying permafrost and reduces annual maintenance efforts. Along roads that have been constructed with peat being excavated, annual settlement magnitudes related to permafrost degradation can take the road out of service. This recommended approach also results in a more uniform rather than undulating settlement.

The proposed approach to construction within peatlands is as follows:

- Peatland material is left in situ;
- Groundwater and surface water flow will be evaluated at each location during detail design to ensure that the flow is accommodated;
- Quarried rock and/or selected granular material of higher permeability will be selected to ensure ‘free flow’ embankment fills will be placed on top of the peat;
- Sufficient material quantities will be placed to address settlement of the embankment in peatlands with study area available materials;
- Heavy, sewn geogrid to float the road will be used to ensure the permeable material does not get clogged with fines to maintain the required permeability;
- Equalization culverts 900 mm in diameter will be installed at necessary intervals to ensure that the hydraulic conductivity of peatlands in maintained.

Depending on in-situ moisture conditions, it is anticipated that most of the settlement of the peat will occur during construction and approximately 40%± of the overall peat thickness will compress. However, following construction, the peatlands will continue to settle at a much slower rate; it can take several years to reach the final compression after the initial reduction.

This approach has been proven to preserve peatlands and groundwater resources from the impacts of road construction and peat compression. For example, Manitoba has used this approach in several recent road projects under similar conditions. To confirm the design approach with continued groundwater movement, Manitoba has installed piezometers on both sides of the road prior to the construction on the outer limits of the right of way for several of these projects to allow for measurement and confirmation that the peatland and groundwater movement was unaffected. Monitoring post construction for 10 years has shown that the groundwater regime is not negatively altered as shown in the figures below taken approximately 8 years after construction. One can see that the peatlands have remained healthy and have not been impacted (ie: turned brown). Please see appendix for a potential typical drawing.

Figure 3.1a Roadway through peatland using Proposed Approach on the Rice River Road (north-eastern Manitoba)

Figure 3.1b Roadway through peatland using Proposed Approach on the Rice River Road (north-eastern Manitoba)

The groundwater study was completed from 2016 to 2019 and included monitoring of water elevations and quality. The pertinent conclusions from that study were as follows:

1. There is not a systematic increase or decrease, for example, of all piezometers on one side of a constructed site (or control site) versus the other; nor is there a pattern of piezometric levels converging or crossing over the other at only control or only constructed sites, nor on one side of a road alignment versus the other (whether control or constructed sites). The piezometer responses at all sites are driven by annual totals of precipitation over multi-year timescales; by seasonal variability in precipitation; and are also punctuated by short-duration, high intensity rainfall events.

2. Water quality between stations, and within piezometer groups at individual stations, is quite similar, and typical of a low pH, bog environment.

3. Water quality is naturally low in pH due to the peat environment and samples were below the lower limit of the CCME Guidelines (6.5). Phosphorous guidelines would not apply to this bog/fen environment,

however, for comparison, concentrations would exceed the MWQSOG for streams of 0.05 mg/L. The bog/fen environment would be expected to be a nutrient sink. The CCME criteria for metals are based on pH and hardness, which is low in this environment, causing the metals criteria to be extremely low. Metals present naturally in the peat are more mobile in the low pH environment and will be present in the groundwater. At least nine metals parameters exceeded the CCME guidelines including aluminum and iron which are naturally occurring.

4. To date, small shifts in water quality and water quality types at all sites, based on data between 2016 and 2018, are relatively subtle, and are not outside of what would be deemed reasonable for a natural groundwater system.

The monitoring approach was key to prove the effectiveness of the design strategy on sections of highway through similar peatland types in eastern Manitoba. Furthermore, these monitoring wells were read again this summer and the conclusions regarding maintaining existing water levels have remained valid.

3.2 Recommended Field Investigations

Due to the complexity and risk associated with the organic terrain, field investigations and testing is recommended to improve the desk top data set to better support preliminary design. These investigations and testing help to define project risks associated with peatlands and aid in identifying areas of risk and further investigations required during detail design. WSR has already completed field investigations; NRL and MFCAR investigations are still underway.

Additional field work to support preliminary design for NRL and MFCAR is recommended to better define peat depths to support improved roadway design and aggregate quantity estimates (field testing to identify peat depths has already been completed for WSR). This would include probing and hand auger test-holes to further define peat depths and classify the peat in terms of its Von Post scale of humification. The soil classification is directly related to the in-situ permeability and compressibility of the peat. Field permeability testing will further assess peatland in-situ hydraulic conductivity.

During detail design, it is recommended that additional peatland testing/probing be conducted at closer intervals (potentially every 25 m). The specific details will be confirmed through discussions with appropriate regulatory agencies at that stage of the project.

As noted above, groundwater monitoring wells should be established along the roadway prior to construction at the edge of the roadway. It is recommended that these wells be installed in peatlands during detail design once the road alignments have been finalized with locations for specific testing sites identified in discussions with regulatory agencies. During construction additional probing to confirm peat depths is appropriate to allow for adjustments to fill requirements.

Post construction, the impact of the road on the peatlands should be monitored to confirm that the permeability of the peatlands has been maintained.

3.3 Recommended Modelling

It is recommended the information obtained from desktop and field investigations as well as data from groundwater wells be used to identify and model the local peat bog flow characteristics during detail design. This will permit assessment of the existing permeability of the original peat bogs to determine baseline hydraulic conductivities. Post construction modelling with the road in place and compressed peat matrix can be undertaken including various spacing of through culverts to maintain peatland groundwater flows.

To reduce the risk increased maintenance costs due to construction and peatlands for such a linear-infrastructure project, it is recommended an assessment to predict long-term settlement and land subsidence on peatland and underlain sedimentary layers due to road embankment during detail design. The development of a 3D groundwater flow and hydromechanical model would support the detail design team. The 3D model results, once incorporated into the design, would reduce the potential for negative impacts on peatland by the roadway. The model could also help address permafrost if a thermal component is added to understand how the local permafrost freezes during winter months and thaws during summer months. Both modeling studies are recommended during detail design stage.

3.4 Recommended Construction Approach

The project teams recommend that construction in peatland raft the roadway over peat with geogrid and placing blast rock or other suitable aggregate as noted in the design approach. This approach is important for these projects it is anticipated there will be long sections of peatlands that must be traversed, especially within the bogs and fens located throughout the study areas.

The figures below illustrate key aspects of construction through similar peatlands to show the complexity of road construction through peatland terrain.

Figure 3.3a Subgrade placement During Construction

Russian Hagglund working ahead of subgrade placement used to place sewn geotextile

Use of Use of Swamp Mats to access construction sites in frost free conditions

Figure 3.3b Swamp mat placement During Construction

Typical condition of placement of muck in frost free conditions through boggy Terrain

(Note: workers at geotextile were playing a prank and on their knees!)

Figure 3.3c Placement of material

Additional detailed assessment of the pavement/subgrade profile will be necessary during the detailed design and construction stages to effectively mitigate the impacts caused by seasonal freezing and thawing. special attention should be given to the upper approximately +/- 3 meters or the minimum frost penetration depth to ensure that non-frost susceptible materials are present in the embankment, and the subgrade is free from clayey, silty, or organic wet materials. Frost susceptible soils may be encountered during construction. It is recommended that this material either be removed and replaced or treated with select subgrade materials. It is recommended that a Non-Standard Special Provision (NSSP) be developed during detail design to address the management of ice and permafrost encountered during construction.

It is recommended that category two and three peatland areas be constructed in winter months and/or when the grade is frozen. Year-round construction may be possible where blast rock is available, however, care and attention must be paid to limit the potential for a leading edge “wave” effect. This occurs when the initial lift of rock is first placed on the geotextile.

Following construction, the peatlands will continue to settle at a much slower rate which can take several years to reach the final compression after the initial reduction. Recognizing ongoing differential settlement, it is a frequent practice to place an initial larger lift of material as in the picture above to establish the embankment and allow for the heavy equipment to advance the embankment.

When blast rock or select aggregate is placed as subgrade, the fines migrate to the top and the coarse porous stone remains at the base, enhancing the movement of water through the roadway. No additional processing of material is required post drilling and blasting. The cross culverts placed in the peat areas, with intervals confirmed during detail design based on the interpreted existing conditions and modelling, will also ensure surficial and groundwater movements will be maintained post construction. Regular maintenance is anticipated when building road embankments over peat.

It is recommended that the projects implement the rafting approach to the design and construction through peatland areas in a manner described above to maintain the groundwater regime and natural hydraulic conductivity. Although are concerns about the potential for the road to cause negative effects on peatlands, often located within bogs and fens, the proposed approach reduces this risk and has been proven to be an effective means of maintaining the natural groundwater regime.

Approaches that leave peat undisturbed and avoid extensive earthworks are gaining traction due to environmental concerns and the need for more economical construction solutions amidst shrinking budgets. There is an emerging focus on cost-effectiveness that encompasses waste reduction and environmental aspects, achieved through expedited consolidation, ground improvement methods, stabilization, load adjustments, and piling techniques.

It is advisable to conduct an engineering assessment of the peat's properties to better understand them and determine the most suitable approach for the specific site conditions During the detailed design phase.

4 Next Steps

It is recommended that the project teams have a follow-up meeting with MTO transportation subject matter experts to discuss the recommended approach and address any outstanding concerns.

5 References

J.D. Mollard and Associates (2010) Limited. 2022. Northern Road Link: Peat Thickness. Draft Report. 11 pp.

J.D. Mollard and Associates (2010) Limited. 2022. Terrain Implications Table. 3pp.

6 Notice to Reader

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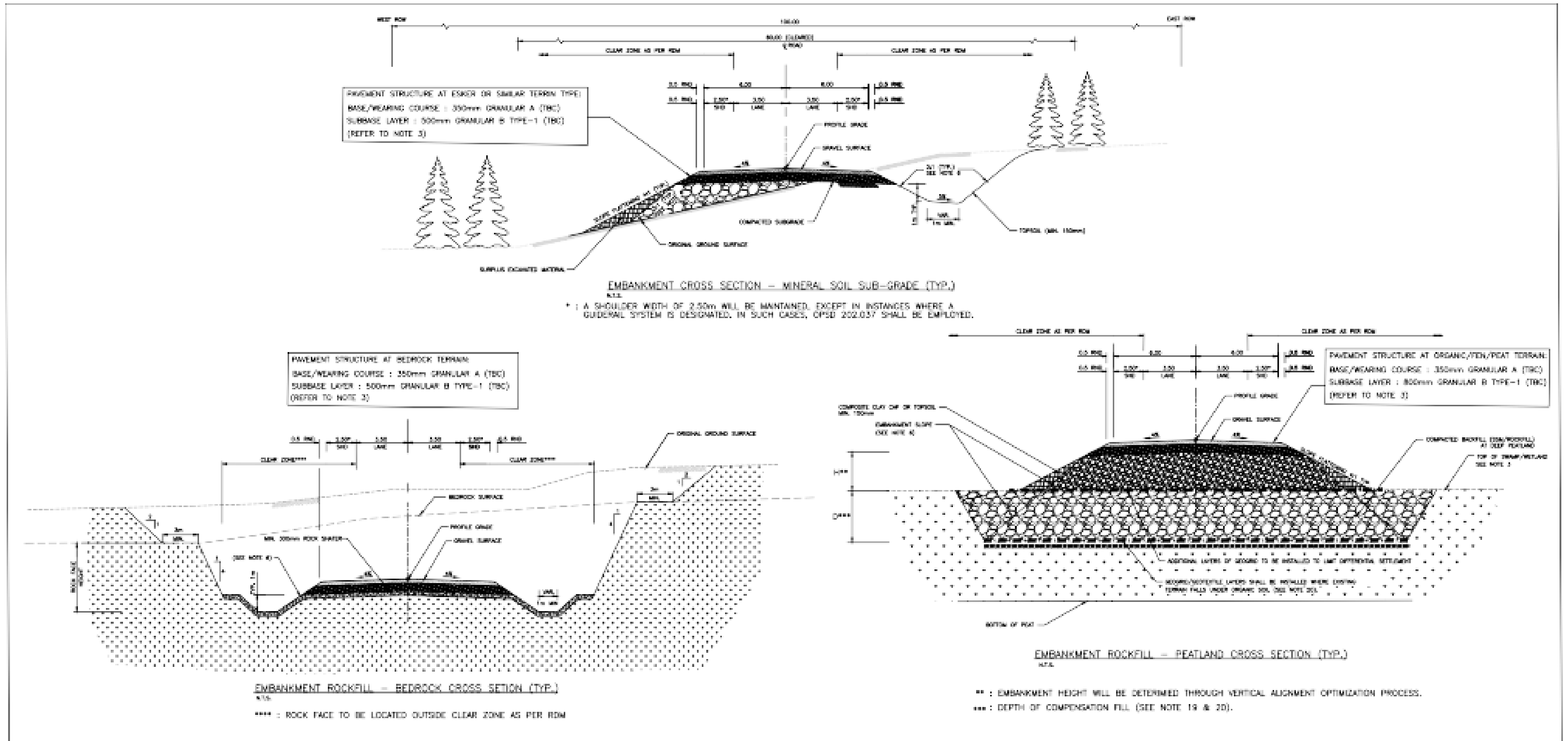
MEMORANDUM

Appendix – Typical Road Cross



PRELIMINARY DESIGN NOTES:

1. ALL TYPICAL CROSS SECTIONS TO BE READ IN CONJUNCTION WITH THE APPROPRIATE OPSD'S & MDOT'S UNLESS SPECIFIED OTHERWISE.
2. SELECT SUBGRADE MATERIAL FOR EMBANKMENT AND PAVEMENT STRUCTURE SHALL BE ACCORDING TO OPSS 1010. EARTH BORROW OR ROCK BORROW SHALL BE ACCORDING TO OPSS 212.
3. FOR CONSTRUCTION OF EMBANKMENTS OVER SWAMPS AND COMPRESSIBLE SOILS REFER TO OPSS 209.
4. GRADING TASKS, ENCOMPASSING ACTIVITIES SUCH AS EARTH/ROCK EXCAVATION AND EMBANKMENT CONSTRUCTION, AS WELL AS ROCK FACE MANAGEMENT AND THE HANDLING OF EXCAVATED SUBSTANCES, WILL BE EXECUTED FOLLOWING THE GUIDELINES OUTLINED IN OPSS 206. IN INSTANCES OF WET CONDITIONS, BACKFILL MATERIALS, EXCLUDING ROCK, CAN BE POSITIONED UP TO 600 MM ABOVE THE WATER LEVEL WITHOUT THE REQUIREMENT FOR COMPACTION. ONCE A SECURE FOUNDATION IS IN PLACE, EMBANKMENT MATERIALS SITUATED 300 MM ABOVE THE INITIAL GROUND LEVEL SHOULD BE DEPOSITED IN ACCORDANCE WITH THE STIPULATIONS SPECIFIED IN OPSS 206.
5. FOR THE STABILIZATION OF ROCK DURING CONSTRUCTION, OPSS PROV. 203 SHOULD BE FOLLOWED. FOR TRENCHING, BACKFILLING, AND COMPACTING, OPSS 401 SHOULD BE REFERRED TO.
6. TYPICAL EMBANKMENT SLOPE/FORE SLOPE TO BE 3H:1V. MINIMUM EMBANKMENT SLOPE FOR SELECT SUBGRADE SHALL BE 2H:1V AND FOR ROCKFILL SHALL BE 1.25H:1V. MINIMUM BACK SLOPE SHALL BE 2:1 OR FLATTER FOR DEPTH OF CUT UP TO 3.0m AND NOT EXCEEDING 1.5H:1V FOR DEPTH OF CUT MORE THAN 3.0m. FLATTENING SLOPE WHERE TOP OF SELECT EMBANKMENT IS LESS THAN 2.0m ABOVE ORIGINAL GROUND IS REQUIRED. FOR SLOPE FLATTENING REFER TO OPSD 202.010 AND FOR BENCHING OF SLOPES, REFER TO OPSD 208.010.
7. FOR CLEARING, GRUBBING AND REMOVAL OF SURFACE AND PILED BOULDERS REFER TO OPSS PROV. 201.
8. TO MINIMIZE THE POTENTIAL ROAD BARRIER EFFECT, MATERIALS SELECTED FOR ROAD CONSTRUCTION, ROAD ELEVATION AND EFFECT OF LOADING ON HYDRAULIC CONDUCTIVITY OF THE ROAD LAYERS SHALL BE RE-ASSESSED IN NEXT STAGE OF THE PROJECT. AS WELL, EQUALIZING CULVERTS TO FURTHER ENHANCE HYDRAULIC CONNECTIONS BETWEEN THE UPSTREAM AND DOWNSTREAM SIDES OF THE ROAD SHALL BE ASSESSED IN THE NEXT STAGE.
9. A STRATEGY SHALL BE DEVELOPED TO ADDRESS POTENTIAL FOR ROAD OVERTOPPING. RE-ASSESSED IS REQUIRED TO CONFIRM A SAFETY AND COST-EFFECTIVENESS OF OVERTOPPING AT NEXT STAGE OF PROJECT
10. IN DEEP CUT AREA, GROUNDWATER SEEPAGE (IF ANY) SHALL BE CONTROLLED AND MANAGED THROUGH ROADSIDE DRAINAGE SYSTEM.
11. FOR CONSTRUCTION OF EMBANKMENTS OVER PEATLAND AT CULVERTS WITH A DIAMETER OF LESS THAN 1500MM, THE GUIDELINES PROVIDED IN OPSD 203.040 SHOULD BE FOLLOWED. FOR CSP/RIGID PIPE CULVERTS BEDDING AND EARTH EXCAVATION REFER TO OPSD 802.030–033 OR 802.050–053.
12. PROVISION OF A RIP-RAP APRON AT INLET AND OUTLET OF WATER CROSSING CULVERTS IS REQUIRED. PROVISION OF A RIP-RAP APRON AT OUTLET OF EQUALIZING CULVERTS AT WETLAND CROSSINGS IS REQUIRED TO ALLOW FOR THE DIFFUSION OF FLOW INTO THE PEAT TO REDUCE THE POTENTIAL FOR SCOURING.
13. THE FLOW EQUALIZING IN LOW-LYING AREA SHALL BE ACHIEVED THROUGH A SERIES OF CROSS-CULVERTS PERPENDICULAR TO THE ROADWAY TO PROVIDE THE PASSAGE OF DIFFUSE SURFACE WATER FLOWS THROUGH THE ROADWAY. IN ADDITION, PROVISION OF PERMEABLE ROADBED TO ALLOW WATER TO SEEP THROUGH THE ROAD STRUCTURE IS REQUIRED.
14. THE EXACT NUMBER, SPACING AND SIZE OF THE EQUALIZATION CULVERTS SHALL BE DETERMINED DURING THE NEXT PHASE OF DESIGN WHEN MORE DATA ASSOCIATED WITH THE SITE CONDITIONS, SOIL STRATIGRAPHY, TOPOGRAPHY, PRECIPITATION, CHATCHMENT AREAS, GROUNDWATER LEVELS AND ROAD CONSTRUCTION MATERIALS ARE AVAILABLE. AT PRELIMINARY DESIGN STAGE, EQUALIZING CULVERTS AT INTERVALS OF 250 METERS, WITH A MAXIMUM SIZE NOT EXCEEDING 900mm.
15. CULVERTS SHOULD BE DESIGNED TO EFFECTIVELY MANAGE THE FLOW OF WATER, PREVENTING EXCESSIVE ACCUMULATION OR PONDING OF WATER IN UPSTREAM AREAS. CONSIDERATIONS INCLUDE PROPER SIZING, ADEQUATE INLET AND OUTLET DESIGN, EROSION AND SEDIMENT CONTROL AND REGULAR MAINTENANCE SHALL BE TAKEN.
16. THE FREEBOARD AT BRIDGE AND CULVERT CROSSINGS SHALL BE GREATER OR EQUAL TO 1.0m. THE FREEBOARD FOR PARALLEL FLOW SHALL BE EQUAL OR GREATER THAN 0.5m
17. THE MINIMUM CLEARANCE TO THE SOFFIT OF BRIDGES AND EFFECTIVE RISE OF OPEN-FOOTING CULVERTS SHALL BE 1m AND 0.3m RESPECTIVELY.
18. WHEN CROSSING PEATLAND, IT IS IMPORTANT TO CONSIDER THE EFFECT OF CONSOLIDATION AND COMPRESSION OF THE PEAT ASSOCIATED WITH THE ROAD CONSTRUCTION (LOADING) RESULTED IN REDUCING PERMEABILITY OF THE PEAT. AS WELL, THE INCREASED HEIGHT OF THE EMBANKMENT CAN LEAD TO A FURTHER REDUCTION IN THE NATURAL HYDRAULIC CONDUCTIVITY OF THE PEAT AND UNDERLYING SOIL LAYERS. ANY ADVERSE EFFECT OF ALTERATION TO THE NATURAL GROUNDWATER FLOW DIRECTIONS AND PATTERNS SHALL BE VERIFIED IN NEXT STAGE OF THE PROJECT. TO MINIMIZE THE POTENTIAL ROAD BARRIER EFFECT IN WETLAND AREAS, IT IS NECESSARY TO RE-ASSESS THE MATERIALS SELECTED FOR ROAD CONSTRUCTION AND EQUALIZING CULVERTS TO CONFIRM HYDRAULIC CONNECTIONS BETWEEN THE UPSTREAM AND DOWNSTREAM SIDES OF THE ROAD.
19. COMPENSATION FILL THICKNESS ACCOUNTS FOR ELASTIC DEFORMATION, PRIMARY AND SECONDARY CONSOLIDATION SETTLEMENTS WITHIN THE DESIGN LIFE AS PER MTO EMBANKMENT SETTLEMENT CRITERIA.
20. INCORPORATING THE NEED TO MANAGE SETTLEMENT IN EMBANKMENT CONSTRUCTION OVER FENS AND BOGS, ALONGSIDE INSIGHTS FROM EMPIRICAL DATA REVEALING A 40% SETTLEMENT AFTER CONSTRUCTION, IT INTEGRATES A 50% CONSOLIDATION FACTOR FOR THE PEAT LAYER. THIS APPROACH AIMS TO EFFECTIVELY ADDRESS BOTH CONSOLIDATION AND THE POTENTIAL IMPACTS OF PERMAFROST THAWING. THE PROJECT WILL ALSO MAKE USE OF GEO-FABRIC/GEO-GRID REINFORCEMENT AT THE JUNCTURE BETWEEN THE FILL AND THE PEAT/COMPRESSIBLE SOIL LAYER (AS PER OPSS1860). THIS REINFORCEMENT WILL SERVE TO PROVIDE SEPARATION, ENHANCE STRUCTURAL INTEGRITY, ENSURE CONSISTENT SETTLEMENT (WITHOUT UNDULATIONS), AND CONTRIBUTE TO A REDUCTION IN THE AMOUNT OF FILL MATERIAL REQUIRED FOR THE CONSTRUCTION.
21: APPROACHES THAT LEAVE PEAT UNDISTURBED AND AVOID EXTENSIVE EARTHWORKS ARE GAINING TRACTION DUE TO ENVIRONMENTAL CONCERNS AND THE NEED FOR MORE ECONOMICAL CONSTRUCTION SOLUTIONS AMIDST SHRINKING BUDGETS. THERE IS AN EMERGING FOCUS ON COST-EFFECTIVENESS THAT ENCOMPASSES WASTE REDUCTION AND ENVIRONMENTAL ASPECTS, ACHIEVED THROUGH EXPEDITED CONSOLIDATION, GROUND IMPROVEMENT METHODS TO MINIMIZE DEFORMATIONS, STABILIZATION, LOAD ADJUSTMENTS, AND PILING TECHNIQUES. HOWEVER, IT'S IMPORTANT TO ACKNOWLEDGE THAT EVEN WITH THE INCORPORATION OF THESE METHODS, ONGOING DIFFERENTIAL SETTLEMENT AND REGULAR MAINTENANCE ARE ANTICIPATED WHEN BUILDING ROAD EMBANKMENTS OVER PEAT. DURING THE DETAILED DESIGN PHASE, IT IS ADVISABLE TO CONDUCT AN ENGINEERING ASSESSMENT OF THE PEAT'S PROPERTIES TO BETTER UNDERSTAND THEM AND DETERMINE THE MOST SUITABLE APPROACH FOR THE SPECIFIC SITE CONDITIONS.
22. ADDITIONAL DETAILED ASSESSMENT OF THE PAVEMENT/SUBGRADE PROFILE WILL BE NECESSARY DURING THE DETAILED DESIGN AND CONSTRUCTION STAGES TO EFFECTIVELY MITIGATE THE IMPACTS CAUSED BY SEASONAL FREEZING AND THAWING. SPECIAL ATTENTION SHOULD BE GIVEN TO THE UPPER APPROXIMATELY +/- 3 METERS OR THE MINIMUM FROST PENETRATION DEPTH TO ENSURE THAT NON-FROST SUSCEPTIBLE MATERIALS ARE PRESENT IN THE EMBANKMENT, AND THE SUBGRADE IS FREE FROM CLAYEY, SILTY, OR ORGANIC WET MATERIALS. IN CASES WHERE GROUND ICE OR POCKETS OF FROST-SUSCEPTIBLE SOIL ARE ENCOUNTERED WITHIN THE SPECIFIED DEPTH, THE AFFECTED MATERIAL SHOULD BE EITHER REMOVED AND REPLACED OR TREATED WITH SELECT SUBGRADE MATERIALS. IT WILL BE NECESSARY TO DEVELOP A NON-STANDARD SPECIAL PROVISION (NSSP) IN THE SUBSEQUENT PHASE TO ADDRESS THE MANAGEMENT OF ICE AND PERMAFROST DURING THE CONSTRUCTION PROCESS.
23. TO MEET THE EMBANKMENT PERFORMANCE REQUIREMENTS, THE DESIGN AND CONSTRUCTION OF EMBANKMENTS MUST ADHERE TO CERTAIN STANDARDS. FOR THIS PARTICULAR CLASS OF HIGHWAY (SECONDARY), THE MAXIMUM ALLOWABLE POST-CONSTRUCTION SETTLEMENT IS SET AT 200MM, WITH A DIFFERENTIAL SETTLEMENT RATE OF 100:1 OVER A 15-YEAR PERIOD FOLLOWING THE CONSTRUCTION OF THE PAVEMENT STRUCTURE. HOWEVER, WHEN THE EMBANKMENT IS SITUATED OVER PEATLAND, ADDITIONAL ASSESSMENT IS NECESSARY TO ADDRESS THE POTENTIAL CHALLENGES ASSOCIATED WITH SETTLEMENT. PEATLAND CONDITIONS CAN SIGNIFICANTLY IMPACT THE STABILITY AND SETTLEMENT CHARACTERISTICS OF THE EMBANKMENT, NECESSITATING A MORE THOROUGH EVALUATION AND POSSIBLY SPECIFIC MITIGATION MEASURES.