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September 2, 2016

Eva Paul
Water Resources Officer
Indigenous and Northern Affairs Canada
PO Box 1500, 4923-52 St
Yellowknife, NWT
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Dear Ms. Paul;

Re. Review of interim reclamation measures for addressing ponding at Legacy Drill Sites and Cutting Sumps under 2BB-BOS1217

This document addresses TMAC Resources Inc. (TMAC's) commitment in the July 18th 2015 Indigenous and Northern Affairs (INAC) inspection report "to review practices across the circumpolar Arctic to determine if a [interim] solution [to drill-related thermokarsting] already exits". The review was conducted on behalf of TMAC by Rachel Pugh, MSc. Candidate at the University of Northern BC., and is summarized below.

1. Background

Drilling on the Hope Bay Belt property, which includes the Boston deposit, has taken place for more than 30 years under various owners. Some of the historical drill sites have depressions surrounding the drill stems/collars, allowing the ponding of water. Most of these 'ponds' are small; 30 cm to a meter in diameter and a few centimeters to 30 cm in depth. However, where intensive drilling has occurred, individual dill sites may connect, causing ponded areas to span 10+m, such as in the Boston deposit area. Also, consolidated cuttings deposition sites (initially depressions) near the Boston airstrip also pool water and may cause progressing thermokarsting. Areas of ponded water in permafrost areas can expand over time if the standing water melts the surrounding permafrost, a process analogous to thermokarsting. Smaller ponds are not anticipated to expand over time, as the small quantity of water they contain does not significantly influence the surrounding ground temperatures.

All drill holes that have been drilled on the Hope Bay Belt since TMAC's ownership of the Project have been backfilled in such a way as to prevent further ponding and thus thermokarsting. TMAC is aware of the historical drill-related ponding at Boston, and will consider reclaiming these areas by backfilling them when activity resumes at the Boston Camp. This reclamation will be influenced by the final proposed location of permanent facilities associated with the mine proposed for the area and whether a permanent road has been constructed. Boston Camp has been in care and maintenance since 2011, and neither fill material nor equipment is available to undertake the permanent reclamation

of these sites at present. TMAC expects to initiate mining in the Boston area in 2018, pending permitting, at which time equipment would be available and a quarry (from which fill material would be obtained) would be permitted.

INAC has requested that interim measures be identified for consideration at the worst-impacted sites to see if an existing solution exists prior to full reclamation in future years. Any interim measures would take into consideration the remoteness of the sites, which require either fixed wing, helicopter or possible winter overland access, and the accessibly of materials.

2. Review of Existing Practices

The review undertaken included an academic literature review, a general internet search, email and phone out-reach to Government of the Northwest Territories and Government of Yukon officials who have some experience with permafrost issues, and a discussion of findings and suggested measures with TMAC and their geotechnical consultant at SRK Consulting (Maritz Rykaart), who is familiar with the Hope Bay Project and conducts annual geotechnical inspections of the Boston site.

2.1. Academic Literature Review

Searching and reviewing potential sources of information found very little academic literature that is specific to the problem, and even less which contains any suggestion for mitigation, and none were found that contained interim mitigation measures. The academic literature review utilized the Google Scholar search tool with various key words and phrases related to thermokarsting, permafrost melt, subsidence, ponding, permafrost stabilization or rehabilitation, and mitigation measures. Most mentions of permafrost melt problems are linked to civil engineering works with roads, railroads, or buildings, and are generally focused on observing the problem or preventing the occurrence rather than successful mitigation of the problem once permafrost degradation has already occurred. Related research focused on studying the thermal regime of permafrost at disturbed sites and fully remediated sites (filled and re-vegetated). Only two papers outlining possible long-term reclamation measures were found and are discussed below:

- Ma, W., Wen, Z., Sheng, Y., Wu, Q., Wang, D., and Feng, W. 2012. Remedying embankment thaw settlement in a warm permafrost region with thermosyphons and crushed rock revetment. Can. Geotech. J. 49: 1005–1014
- Kokelj, S.V., Riseborough, D., Coutts, R., Kanigan, J.C.N. 2010. Permafrost and terrain conditions at northern drilling-mud sumps: Impacts of vegetation and climate change and the management implications. Cold Regions Science and Technology 64: 46–56

Ma et al. (2012) discuss the use of thermosyphons and a crushed rock cover, and Kokelj et al. (2010) discuss snow thickness as influenced by taller shrubs. Unfortunately, at the Hope Bay project these measures are largely not applicable or implementable. Thermosyphons are an expensive long-term solution generally used to stabilize or re-freeze permafrost around engineered structures, requiring equipment and access for installation and are not deemed appropriate for the nature or scale of the thermokarst issues at Hope Bay, nor do they constitute an interim measure. A crushed rock cover with light coloured

material (and therefore reflective of solar radiation) is discussed later in this memo, but also constitutes a final rather than interim closure measure (section 2.4).

2.2. General Internet Search

A general search of the internet, and a more focused search on other northern jurisdictions (Alaska, Northwest Territories, Yukon) which may have regulatory guidance on this issue did not recover any useful information on potential interim measures. Generally, regulatory guidance for hard rock exploration tends to suggest that measures should be taken to prevent degradation of permafrost, or to address it if it occurs, but leaves specific measures up to the proponent to generate. For oil and gas exploration, information was obtained for sump and camp-waste management, however it focuses on complete capping and monitoring of sumps, rather than interim measures.

2.3. Contact with other government expertise

Due to the lack of available information found during the academic and internet searches, efforts were made to contact persons who may have regulatory or professional experience with thermokarsting at drill sites. Government of Yukon and Government of the Northwest Territories staff with experience in mining, oil and gas, and infrastructure were approached for information or to suggest appropriate contacts. Information gained from these individuals is summarized briefly below. In general, this is a problem encountered across sectors where ground disturbance occurs in permafrost areas. Avoidance of the establishment of thermokarst ponds is preferred, or complete reclamation ultimately undertaken. Interim measures prior to complete reclamation (backfilling/capping) is not something that has been generally considered.

2.3.1. Steve Kokelj, PhD, permafrost scientist with GNWT geological survey

Dr. Kokelj was specifically asked if any interim measures, particularly those related to vegetation management or removal of ponded water might be helpful for slowing or halting the thermokarsting around the drill/sump sites. Dr. Kokelj agreed that removal of the water could be helpful, with the caveats that the water might be contaminated and the drained area might just refill. He suggested a broader look at the drainage in the area may be appropriate.

2.3.2. Don Arey, Manager of Resource Management, Beaufort/Delta Region, GNWT Lands

The Beaufort/Delta Region has a lot of experience with oil and gas exploration and therefore has been dealing with sump remediation issues for many years. He had no suggestions for interim measures, but confirmed that they do require sump remediation (capping, re-vegetation) from proponents, and that monitoring of the sumps is required. If initial efforts are seen to be failing (with ponds forming), then additional measures such as increasing the fill and extending the cap beyond the edge of the affected area might be required. Mr. Arey emailed some guidance documents regarding sump management, but a review of them found no interim measures, just full remediation (capping) and monitoring guidance. Most of these documents were produced with involvement of Department of Indian and Northern Development (DIAND, now Indigenous and Northern Affairs Canada - INAC) so it is assumed that INAC is already in possession of this information.

2.3.3. Chadwick Dyce, Senior Natural Resources Officer with Yukon Government Department of Energy Mines and Resources, Dawson, YT

Mr. Dyce works in monitoring and enforcement in the north Yukon and has experience with oil and gas drill sites. He says they have many sites with this problem but usually do not require any remediation actions and have found that they usually stabilize at a point where no further degradation occurs although a pond remains. He feels it will be an issue of increasing importance in the future. He felt pumping out the water would be a good idea if it was feasible and mentioned that remote sites lacking road access are difficult to address due to accessibility and expense.

2.3.4. Mohammed Idrees, P.Eng., Geotechnical Manager with Yukon Government, Transportation Engineering Branch

The transportation sector in the north experiences issues with permafrost melt and subsequent loss of ground stability in road beds. Mr. Idrees was contacted to inquire if he had any relevant information or advice on dealing with thermokarst issues. He advised that they do experience some problems and try to plan and implement projects to minimize any disturbance of the permafrost. They do their best to avoid disturbance, keep the permafrost insulated, and, if melting occurs, to direct any water away from ponding. When asked about thermosyphons he said they work but are very expensive. Given the difference between the physical natures of road building vs. exploration drilling/sumps, the conversation did not reveal any useful suggestions, however it did confirm that ponded water is problematic across sectors.

2.4. Discussion with TMAC Environmental Advisor and SRK Consulting

After the literature review and contacting of other government experts was complete, a discussion of findings and possible actions was held by Rachel Pugh with Katsky Venter, MSc., of TMAC, and one of TMAC's geotechnical consultants, Maritz Rykaart, PhD, PEng of SRK Consulting (Canada) Inc. The discussion focused on finding a solution by trying to stop the thermal erosion by targeting the causes. It was agreed that (as mentioned from the discussion with Chadwick Dyce) smaller ponds would reach equilibrium eventually; however, larger ponds may not reach equilibrium if the water presents a heat source with continued heat transfer to the permafrost. In addition, due to removal of vegetation from drilling activities and disposal of cuttings, insulation of the ground has decreased which increases the heat absorbed from solar rays and ambient weather conditions. SRK had previously reviewed the issue and found no standard available for remediation or interim management of such sites. Re-vegetation is a long-term option that is not appropriate for interim results and may not be needed once the site is fully backfilled, and thermosyphons are indeed expensive and only suggested as a last resort if conditions genuinely warrant the installation. To SRK's knowledge none of the sites at Hope Bay would warrant this strategy. In addition, thermosyphons would still require a cover layer over the affected area. SRK feels the long-term remedial option should focus on displacing the water, and backfilling the depression, ideally with a light-coloured cover, as is commonly done with capping techniques.

As an interim solution, pumping out the larger ponds and keeping them empty may reduce the summer heat source which contributes to continued permafrost degradation. However, no net environmental benefit would result from this, as even the larger ponded areas are relatively stable in size and do not pose a threat to the environment due to their

locations, which are bounded by areas of higher ground and the airstrip/road, and are located away from waterbodies. The overall rate of thermal erosion is extremely slow, and material differences would only be observable in the decadal scale. SRK has been conducting annual geotechnical inspections at the Boston site since 2007, and none of the areas in question have demonstrated any appreciable change in size over that time.

3. Conclusions

Full remedial measures for the worst-ponded areas at Boston involve filling, capping and monitoring (where necessary), to ensure long term stability. It is agreed that measures like these are intended in the future for such affected sites of the Hope Bay Project. A review seeking commonly accepted "interim" measures from other jurisdictions was largely fruitless. All identified and employed remediation measures involve the long term stabilization of such sites, as is proposed for final closure of the sites by TMAC. The possible exception is annual pumping out of the largest ponded areas to reduce possible pond expansion. Before this activity is undertaken, it is recommended that a study of whether these sites are expanding in a way that may cause greater environmental impact. Monitoring of these ponded areas is already conduced during the annual geotechnical inspections conducted by SRK Consulting Ltd. and reported to the NWB as mentioned above. Further, TMAC will demark select pond boundaries to further facilitate annual comparisons.

Should you have any questions, please contact me at John.Roberts@tmacresouces.com or 1-416-628-0216.

Regards,

M John Roberts
TMAC Vice President, Environmental Affairs

cc: Nunavut Water Board