DRAFT TECHNICAL MEMORANDUM

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CC: **Mark Yetman - Senior Project Advisor**

FROM: **Independent Peer Review Panel**
Review Team Participants: Ian Hutchison, Mike O'Kane

DATE: **August 18, 2023**

RE: **Comments and Recommendations – Gordon Lakes: Camlaren Tailings and Soil Containment Area (TSCA) Geotechnical Investigation**

1 INTRODUCTION

1.1 Scope of Review

The CIRNAC Project Technical Office (PTO) engaged the Independent Peer Review Panel (IPRP, Panel) to review the Technical Draft Report: "Gordon Lake Group – Geotechnical Services Program – TSCA Geotechnical Investigation for Dam Declassification" (Englobe, 2022b,). Along with a general review of the report, the PTO requested Panel's opinion specifically on the closure status of the dam structure.

For informational purposes the following background reports were also provided to the Panel:

- "Updated Report: Gordon Lake Group Design Basis", Stantec, 2018a, September 11.
- "FINAL - 2018 As-Built Construction – Camlaren TSCA", Stantec, 2018b, December 21.
- "Final Report: Annual 2020 Geotechnical Inspection Report – Tailings and Soil Containment Area, Camlaren Mine Site, NT", Stantec, 2021, March 30.
- "Final Report: Gordon Lake Group Geotechnical Services Program 2021 Dam Safety Review (DSR) – Tailings and Soil Containment Area", Englobe, 2022a, March 28.

1.2 Scope of IPRP Report

The following sections discuss the Panel's comments and recommendation on:

- Characteristics of the Tailings and Soil Containment Area (TSCA) (Section 2).
- Status of the TSCA (Section 3).
- Closure of the TSCA (Section 4).
- Recommendations (Section 5).
- Conclusions (Section 6).

The Panel's recommendations *are indicated in italicized text*. Where the Panel feels *strongly about a recommendation, the text is also underlined*.

2 DAM CHARACTERISITCS

2.1 As-built Condition

The Camlaren TSCA covers approximately 2.5 ha and is located on a peninsula along the East side of Goron Lake, 85 Km Northeast of Yellowknife, NT (Figure 1). A remnant of historic mining at the Gordon Lakes mine sites it is formed by a perimeter earthen dam built with sand containing traces of gravel and contains mine processing tailings overlain by contaminated soil and general mine waste. The earthen dam is generally founded on bedrock and in some areas on peat. Table 1 provides some basic information on the facility.

Dam Type	Length (m)	Maximum Height (m)	Upstream Slopes (H:V)	Downstream Slopes (H:V)
Homogenous Sand, Traces of Gravel	460 along centreline	1.5 to 5	Buttressed by tailings and soil	3.1 to 3.3

Table 1 Dam Characteristics

The TSCA was closed and covered in 2018. The outer dam slopes were stabilized, fill was placed to create a domed surface over the entire facility with slopes of approximately 4%. To limit water infiltration, a cover system was constructed consisting of a Bituminous Geomembrane (BGM) overlain with a 0.5 m thick sand layer. Erosion protection consisted of providing vegetation (willow branches) along the top of the TSCA and a coarse sand with rockfill and coco mats on the dam slopes (Figure 2).

The Panel considers features such as willow branches and coco mats are only suitable in the short term and should not be relied upon for the long-term, and questions whether sufficient vegetation can be established to provide for erosion protection in the long-term.

Lined runoff surface ditches were constructed on the northwest and south perimeters to control drainage away from the TSCA and prevent any pooling against the embankment. The ditches are lined with a BGM and covered with riprap. The BGM extends from the slopes into the ditches to prevent any water backflow into the TSCA.

Temperature profile measurements through the facility indicate temperature near the surface ranging from approximately -25°C + 20°C and steady average temperatures below the thermally active zone depth of about 5 m are near or just below the freezing point.

Englobe (2022b) proposes a Low Consequence Classification for the TSCA based on the Canadian Dam Association (CDA, 2014)[1]. The Panel supports this designation based on the discussions and information contained in the remainder of this memorandum.

Based on the 2021 Dam Safety Review (DSR) report (Englobe 2022a) instrumentation includes 4 open monitoring wells and 6 vibrating wire piezometers (VMPs) that continue to be monitored.

[1] Canadian Dam Association Technical Bulletin – Application of Dam Safety Guidelines to Mining Dams, 2014

Figure 1 Camlaren Mine TSF Aerial View

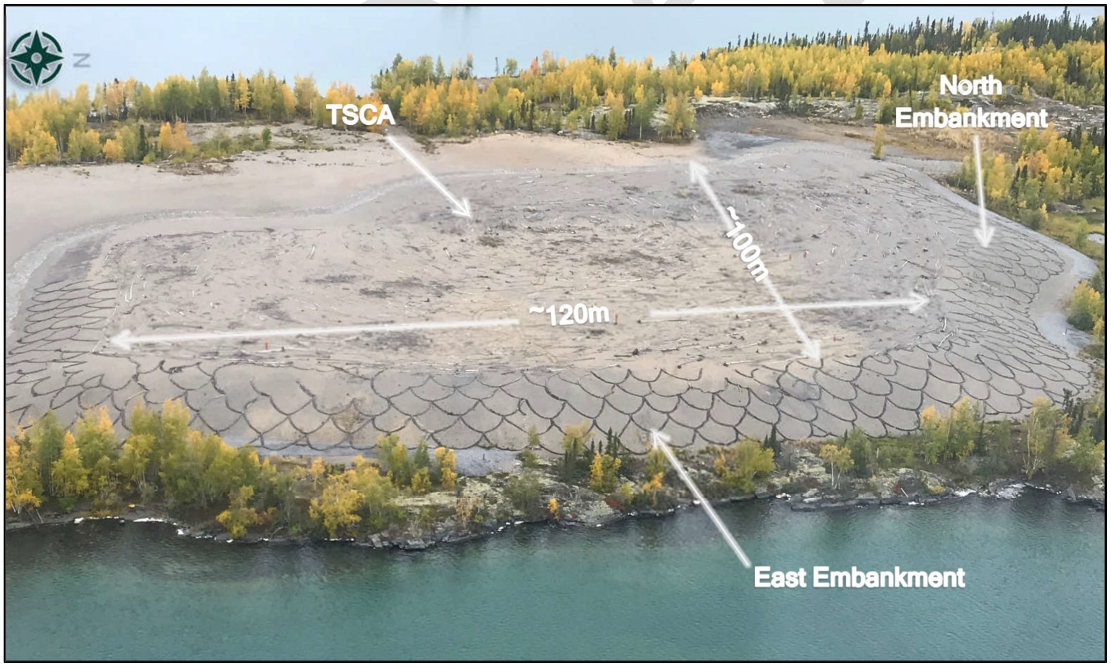

Figure 2 Camlaren Mine TSF

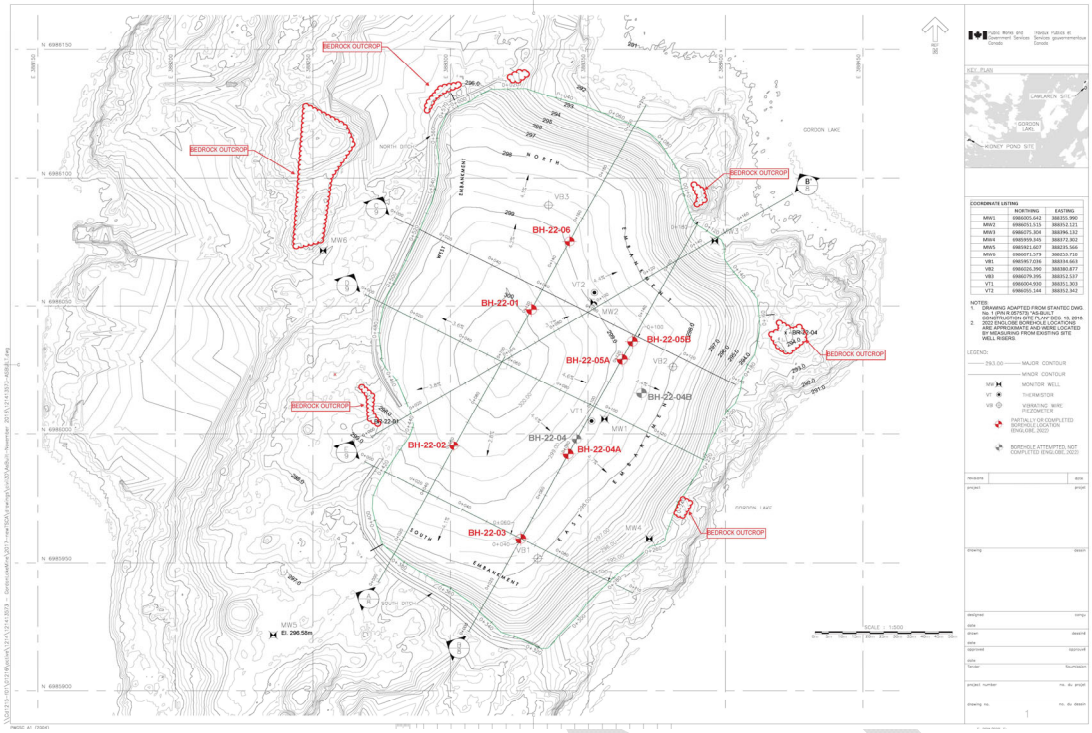

Figure 3 Plan View Showing Cross Section Boring Locations and Possible Extent of Liquefiable Tailings Based on Robertson 2021

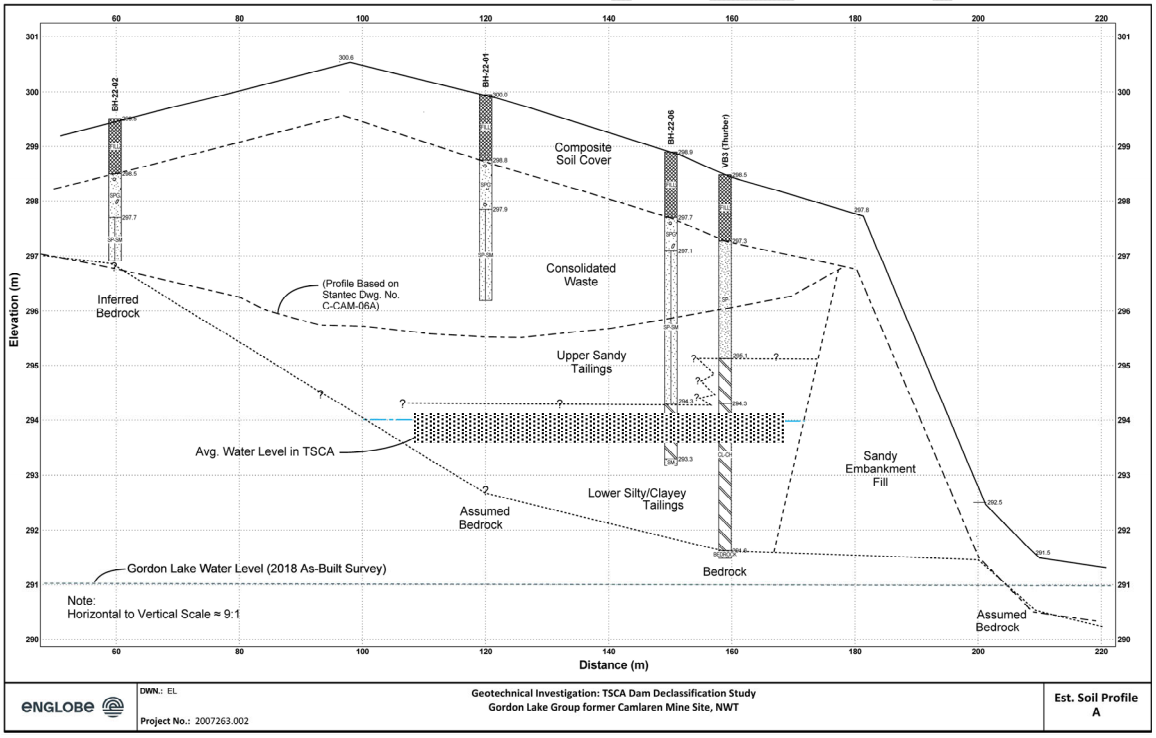

Figure 4 Cross Section View Showing Cross Section A Boring Locations and the Potential Liquefiable Zone Based on Robertson 2021

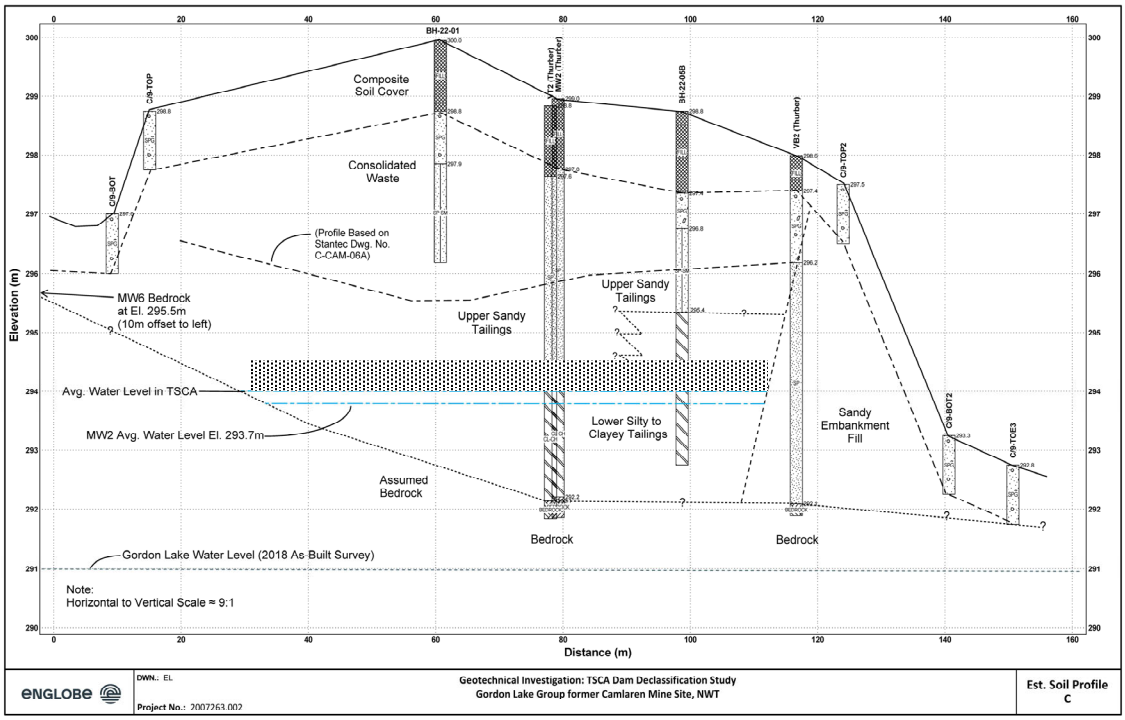

Figure 5 Cross Section View Showing Cross Section C Boring Locations and the Potential Liquefiable Zone Based on Robertson 2021

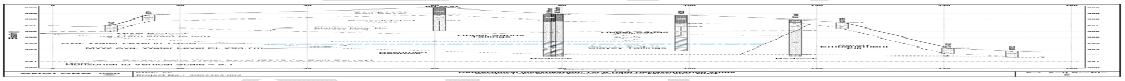

Figure 6 Undistorted Cross-section C Illustrating the Flat Nature of the TSCA

2.2 Dam Safety Review

Englobe (Englobe 2022a) completed a DSR in 2021 and concluded "there are no immediate concerns or urgent requirements for completing any major dam remediation or repair work at the site." Based on the information presented the facility meets the current and required dam stability criteria.

The constructed slope stability Factors of Safety (FOSs) for the outside dam shell ranged from 1.7 to 1.8; exceeding the CDA requirements for minimum of 1.5. The site specific seismic 2,475-year event was determined to be 0.03 g, which was indicated to be too low to reduce the static FOSs reported. The DSR identified erosion rilling on the embankment surface as the major issue that was observed, and recommended a range of surficial repairs be completed, the as-built drawings be updated, consideration be given to other methods of erosion control to encourage vegetative growth, and continuation of the annual inspection program. The DSR also recommended consideration be given to re-classify the TSCA as a "mine waste structure" instead of the current classification as a dam structure.

The Panel generally concurs with the DSR findings, but questions whether current cover system performance, with respect to erosion and vegetation, can provide a sufficiently durable cover system for the long-term. Vegetation on the cover system appears to be entirely absent. Hence, evidence of erosion that is currently observed, has a high probability of continuing, and conditions will likely worsen without active annual intervention.

The nature of sandy material in this area is that it is susceptible to erosion, has relatively higher permeability, and lower nutrient content. As a result, plant available water holding capacity is limited, even with the presence of the underlying geomembrane. Quite possibly, snowmelt and rainfall transmit rapidly to the base of the overlying layer, and then moves laterally, as 'interflow', over the geomembrane and off the landform given the domed nature of the landform.

Furthermore, given the nature of the sandy material, it is quite challenging to establish vegetation when combined with the very short growing season in the temperate climate, and the long cold winters. There is a very 'tight' window for vegetation establishment and it appears that any effort to seed and revegetate the cover system has not been successful. These conditions also make it challenging for volunteer vegetation to establish.

Avoiding annual intervention in respect of erosion control measures and repair will support CDA requirements for re-classifying the TSCA as a "mine waste structure" because it will substantially enhance longevity of the geomembrane using a natural, passive, methodology (i.e., vegetation), and enhance the ability of the structure to maintain current internal pore water pressure conditions.

The Panel assumes that there is no issue with respect to soil contamination over the overlying layer inhibiting vegetation establishment; rather, it is simply a case of a lack of moisture and nutrients, coupled with the challenges of a short growing season and cold winters.

2.3 2022 Site Investigation

Englobe (2022b) performed geotechnical investigations in July/August 2022 aimed at evaluating the site's subsurface conditions to "provide a site-specific geotechnical assessment to determine whether the TSCA would be a suitable candidate for conversion to a landform structure classification and therefore being delisted as a dam structure."

This program included the following investigative work:

- A combination of auger boreholes and CPT probes were conducted at nine locations throughout the TSCA.
- Mapping was conducted of the exposed bedrock adjacent to the TSCA.
- The subsurface stratigraphy and material properties were determined from the borehole and CPT data. Properties include unit weight, effective strength, soil cohesion, liquefaction potential (from the CPT data), and average thicknesses of similar stratigraphic zones.

Figures 3 through 5 provide a plan view of the TSCA and the locations of the boring and CPT probes and the cross-sections through the facility showing the tailings, the fill and the cover system construction. The cross-sections are vertically exaggerated by a factor of 9 providing a distorted view of the facility. Figure 6 is the same cross section as on Figure 5 but without vertical exaggeration and illustrates how flat the facility actually is.

Englobe (2022) using a chart generated by PK Robertson (1990), a recognized international expert in assessing liquefaction potential in granular materials, to assess the liquefaction potential of the tailings

in the TSCA. The results indicate only one 0.6 m thick layer of tailings, classified as "sand to silty sand", could potentially be considered to be liquefiable.

The Panel notes that since the Robertson publication in 1990 significant advances have been made in establishing methods to assess liquefaction potential and there have been several major Tailings Storage Facility (TSF) failures that have provided valuable data against which the relationships have been calibrated. The current version of Figure 7 has evolved into that provided in Figure 8 with a more detailed interpretation of the condition of the assessed tailings. The indicated behavioral zones (Figure 8) include:

CC = clay like material that is contractive – this means the clay particles can contract causing increases in pore water pressure with a resulting flow liquefaction type behaviour if the material is disturbed.
CCS = clay like contractive behavior – indicates potential for flow liquefaction - also indicates sensitive clays.
CD = clay like dilative material – this means the clay particles expand when disturbed, decreasing pore pressure, and increasing the frictional strength of the material – this material is considered non-liquifiable.
SC = sand like contractive material, potentially liquefiable.
SD = sand like dilative material – considered non-liquefiable.
TC = Transitional (between sand and clay) contractive material – considered potentially liquifiable.
TD = Transitional dilative material – considered non liquifiable.

Materials considered to be potentially liquifiable would only do so if disturbed, such as during a loss of containment, i.e., complete dam failure or during a severe earthquake.

Based on the more recent 2021 chart, the layers that are potentially liquifiable include BH-22-06 (4.9-5.5m) and BH-22-05B (4.- 4.8 m), which would be considered contractive (see Figures 4, 5 and 8).

The Panel judges the total volume of tailings may be in the 20,000 to 40,000 m3 range based on the sections provided in the report. Furthermore, assuming worst case, the zones identified as potentially liquifiable represent continuous zones (Figures 4 and 5); the Panel's rough estimates of the volume of potentially flowable tailings appear to be approximately 10% of this volume. The relevance of these small amounts of total and potentially liquefiable tailings is discussed further in Section 4. Overall, the capacity of the TSCA is cited as 80,000 m3 (Englobe 2022a).

The Panel notes there appear to be inconsistencies between the boring shown in plan view (Figure 3) and the cross-section B (not shown) of the report and some of the plot locations on Figure 7 appear to be incorrect.

3 TSCA STATUS

The TSCA is a dam in a passive closure mode as defined by CDA (2014). It is subject to ongoing monitoring and maintenance, annual dam safety inspections and periodic DSRs. It requires an Engineer of Record (EoR) to provide technical direction and to verify whether the dam has been (MAC 2021)[2]:

- "designed in accordance with performance objectives and indicators, applicable guidelines, standards, and legal requirements; and

[2] Mining Association of Canada A Guide to the Management of Tailings facilities – Version 3.2 March 2021

- constructed and is performing throughout the life cycle in accordance with the design intent, performance objectives and indicators, applicable guidelines, standards, and legal requirements."

While Stantec Consulting Ltd. provided the prior EOR, there does not appear to be a current EOR.

The Panel has not seen any of the original approvals for the dam construction and operation, so it is not clear whether it was originally approved as a dam or a waste pile. Based on the report on the TSCA provided, it is evident that CIRNAC are treating the facility as a regulated dam.

4 TSCA CLOSURE

4.1 Criteria for a Dam

The 2007 (revised 2013) CDA Guidance states the following: "A dam is a barrier constructed for the retention of water, water containing any other substance, waste, or tailings, provided the barrier is capable of impounding at least 30,000 m^3 of liquid and is at least 2.5 m high." As noted in Section 2.1of that [CDA] guidance, if the consequences of dam operation or failure are likely to be unacceptable to the public, then a structure that is less than 2.5 m in height and less than 30,000 m^3 of impoundment can also be considered a dam if it "retains contaminated substances."

Based on the above definitions, and considering the very small amount of potential liquefiable tailings in the TSCA, it raises the question as to whether it should even be considered a dam under CDA. Obviously, further verification of the calculated tailings volumes is necessary as well as characterizing the geochemistry of the tailings so the level of contamination these pose can be further assessed in order to address the second part of the CDA requirements noted above.

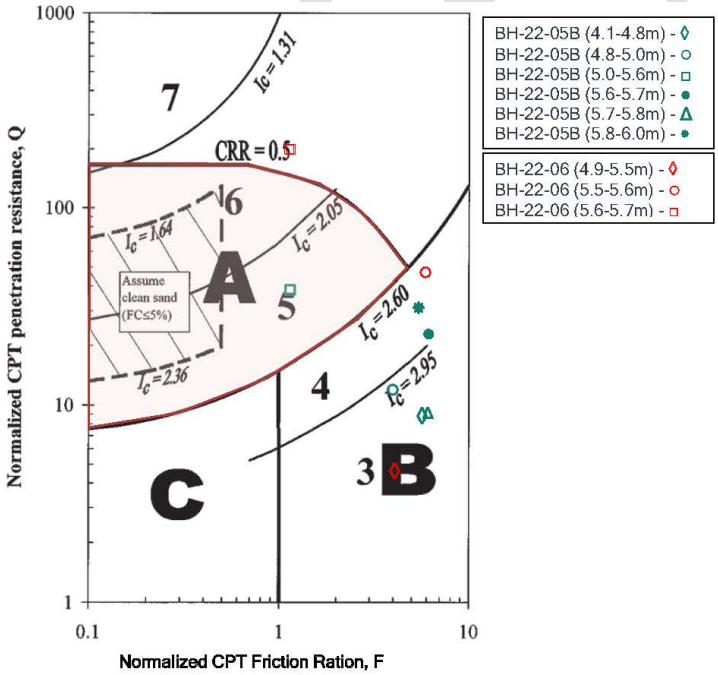

Figure 7 CPT Results Plotted by Englobe on Chart Developed by Robertson (1990)

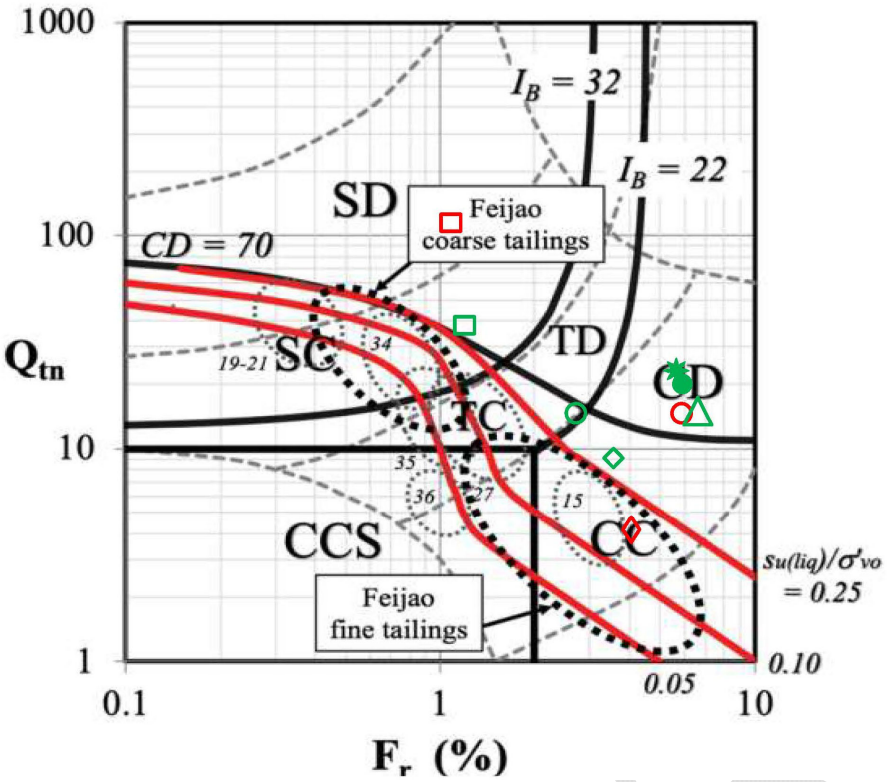

Figure 8 CPT Results Plotted by Panel on Updated Chart Developed by Robertson (2021)

It is the Panel's opinion that even though some fraction of the tailings may be potentially liquefiable, these would not affect dam safety as illustrated by the stability analyses conducted by Englobe (2022). These analyses indicate a potential failure plain would be through the dam fill material, irrespective of the strength of the tailings. Furthermore, in the event of a hypothetical catastrophic dam failure these tailings would not result a liquified tailings outflow for any significant distance, which is CDA's main concern. It is more likely, that during such a hypothetical event, which could include either a dam slope failure or deep erosion, the tailings would behave as granular fill material and be subject to slumping and/or ongoing erosion similar to what would occur in a waste pile of landform.

4.2 Reclassification as a Mine Waste Structure

Canadian Dam Association

CDA (2019)[3] indicates that "a barrier that previously impounded tailings is considered a mine waste structure if it meets all of the following criteria (subject to the further considerations that are discussed below):

1. Ponded water will not propagate a failure or uncontrolled release of contents.
2. Contents do not and cannot flow (i.e., are not fluid like) and do not rely on a barrier structure to prevent an uncontrolled release.
3. Contents do not and cannot migrate or pipe through the structure or foundation.
4. Conditions will not develop in the future that could violate the previous three criteria."

[3] Canadian Dam Association Revision to CDA Technical Bulletin: Application of Dam Safety Guidelines to Mining Dams DRAFT June 2, 2019

Based on the above guidelines the Panel agrees with Englobe (2022b) that the TSCA can be reclassified as a mine waste structure or landform.

Considering each of the 4 CDA criteria it is evident that:

1. There is and will be no ponded water.
2. Mitigating factors include that there is only a small amount of potentially liquefiable tailings, a lack of any liquefaction event trigger, and the layer of tailings is relatively thin, i.e. 0.6 to 0.7 m in a roughly 2 to 4 m overall depth. As mentioned above, the failure modes which include deep erosion or slumping of the dam material could not result in a flow of the potentially liquifiable tailings, rather sloughing or erosional slurry of tailings generally mixed with fill and dam construction materials as would be expected from a failure of a waste pile.
3. There is no potential for piping through the dam since there is no driving hydraulic head. Regarding this aspect, it may also be beneficial to demonstrate, if possible, that the sand and tailings are filter combatable so no tailings migration could occur even if a large hydraulic head occurred.
4. There is no planned reuse of the TSCA and furthermore, because of its current configuration, i.e. that of a waste, pile it would not be selected for any uses that may constitute a regulated dam.

ICOLD (International Congress on Large Dams)

In terms of ICOLD Bulletin 153[4] a structure can meet the requirements of a "landform" provided it no longer poses a risk to life or the environment and a failure of the downstream slope cannot result in a flow of the impounded contents. Beyond this requirement for physical stability, the facility must be demonstrated to be chemically, ecologically, and socially stable.

The Panel notes that Englobe (2022b) has considered these ICOLD "non-geotechnical factors" in making their recommendation that a "landform closure classification be assigned" within the next 1 to 2 years.

While the Panel concurs with the approach proposed by Englobe it would be advisable to back up these conclusions with additional data and analyses to a sufficient extent that the conclusions are convincing to any stakeholder and regulatory agencies that may be involved. Also, the analyses provided should be updated to reflect the most current methods for characterizing liquefaction potential. Our associated recommendations are addressed in Section 5.

5 RECOMMENDATIONS

The Panel's recommendations include.

- *Elaborate on the characterization of the TSCA considering the following:*
  - *Update the liquefaction analyses considering the most recent developments in this field.*
  - *Refine and use the stratigraphic modeling of the TSCA to estimate the total and potentially liquifiable tailings volumes. Consider these in context with the CDA definition of a dam as discussed in Section 4.1.*
  - *Obtain geochemical data on the tailings, include acid-base accounting testing and both total and leachable mineral and metal content to address the chemical stability finding requirements.*
  - *Assess the filter compatibility between the tailings and the dam construction materials.*

[4] ICOLD, 2013 Bulletin 153 - Sustainable Design and Post-Closure Performance of Tailings Dams.

  - *Consult with an experienced biologist / revegetation expert with experience in northern soils and vegetation to assist in establishing a plan to upgrade the cover system so it is more erosion resistant and conducive to the establishment of a vegetated cover.*
- *Perform a Failure Modes Effects Analysis (FMEA) to identify any additional physical, chemical, ecologic, and social risks posed by the TSCA and assess whether any of these are significant enough to warrant mitigation or would indicate the facility cannot be considered and managed safely as a landform.*
- *Conduct the site maintenance and repairs as recommended Englobe (2022a) and implement cover system improvements developed in conjunction with a biology / revegetation expert with experience working in this region.*
- *Prepare a report, for review by regulatory agencies and stakeholders as necessary, with full justification for reclassification of the TSCA as a landform.*
- *Continue the annual inspections for several years until it can be demonstrated the TSCA is physically stable and sufficiently resilient if any erosion damage is naturally repaired. After that consider drone inspections; say every 5-years.*

6 CONCLUSIONS

The TSCA is essentially a mine waste pile and is in good condition, except possibly for the cover system. It is both advisable and possible to reclassify it as a landform and to implement an appropriate solid waste type surveillance and maintenance program. Since re-classification of mining dams is still a new and untried process, it is recommended that careful consideration be given to preparing a detailed and convincing justification for this reclassification. Also, to be considered, is that any classification performed would to some extent set a precedent for CIRNAC's many other similar small waste pile type tailings facilities. The Panel importantly recommends the existing cover system of the TSCA be improved.

This report is being submitted in draft form and will be finalized after receipt of comments from| CIRNAC.