We acknowledge CIRNAC's comments regarding the proposed research and thank the Board for the opportunity to respond.

CIRNAC #1: Environmental Controls for Alternative Sampling Locations

"The Proponent requests a 100 km sampling radius around each of 13 coordinates, increased from 50 km, to allow alternative sites to be selected in the field. Although the proposal indicates streams, wetlands, eskers, thermokarst, ice lenses, and fragile terrain would be avoided, the application does not provide mapped alternative areas or measurable site-selection criteria, or proposed setbacks from waterbodies. The expanded areas may also include substantially different drainage, soil moisture, and permafrost conditions. Without defined screening criteria, it is unclear whether alternative locations would adequately avoid saturated ground, drainage features, ice-rich permafrost, thermokarst, and unstable terrain. CIRNAC recommends that the Proponent consider:"

- **Providing clear environmental criteria for selecting alternative sampling sites, including appropriate setbacks from waterbodies;**

The proposed 100 km extended radius around sampling sites this year is requested to allow for flexibility in sampling in the case that boat landing is not feasible at the original site due to weather, wildlife, etc. Site selection criteria for alternative sites will remain the same as those established for the originally proposed sites. Sites will be chosen based on observation and field assessments by Gwen Freeze, the research associate conducting the sampling. Possible sampling sites will be assessed for level and stable terrain with firm ground and will avoid any sign of saturated soils, drainage features, or waterbodies in the area, including streams, standing water, or wetlands. In the case that waterbodies exist near sampling sites, sampling will be setback a minimum of 200 meters from the nearest sign of a waterbody, which will be measurable by GPS. Site selection will also avoid areas with evidence of thermokarst and ice lenses as described below. Aboard the Adventure Canada vessel there will also be a team of naturalists and geologists with experience in Arctic terrain who can be consulted on site selection upon landing.

Alternative landing locations will be determined by Adventure Canada based on weather, sea ice, and wildlife, and therefore alternative sampling sites cannot be accurately mapped at this time. However, the above criteria will apply to any possible sampling site (original or alternative) and site selection will be done with careful assessment. In the case that an alternative landing site is visited by Adventure Canada and it does not meet the site selection criteria, sampling will not occur.

- **Describing how wetlands, drainage features, saturated ground, thermokarst, ice lenses, and unstable terrain would be identified and avoided;**

Terrain will be visually and physically examined for signs of wetlands, drainage features, saturated ground, thermokarst, ice lenses, and unstable terrain. Wetlands and saturated ground will be identified by the presence of standing water, waterlogged soils, and soil that releases water when compressed. Drainage features will be identified by surface water flow and terrain depressions or troughs that indicate water movement. Thermokarst will be identified by uneven or irregular ground, sinking land, or thaw slumps, while unstable ground may be indicated by collapsing soil or active erosion that suggest ground instability. Signs of ice lenses may include exposed ground ice in the terrain. Sampling will not proceed if any of these features are encountered in the proposed area. Furthermore, sampling will occur slowly and with careful observation. The first step of sampling is manually digging a small soil pit down to the ground ice. If at any point during sampling saturated ground, collapsing soil, or visible ice lenses are encountered, sampling will immediately stop and the sampling pit will be restored.

- **Recording the final sampling coordinates and confirm that the site-selection criteria were met.**

The final sampling coordinates will be recorded by GPS and photographs taken to confirm compliance with site-selection criteria. Although a range of drainage, soil moisture, and permafrost conditions are expected across study sites, each potential sampling site will be carefully assessed to ensure compliance with the environmental criteria described above and evaluated to ensure sampling can proceed safely.

CIRNAC #2: Borehole Depth, Closure, and Subsurface Flow

"The project summary describes 30 cm permafrost cores, while the equipment information indicates that permafrost may occur 1 to 2 metres below ground and that 31 cm drill extensions may be required. The total borehole depth and number of boreholes per site are not provided. The Project also identifies one person on site for 13 days, with sampling at each location expected to take no more than two hours. The application does not demonstrate how equipment transport, drilling, sample handling, borehole closure, and plot restoration would be completed particularly where permafrost is deeper than anticipated or field conditions shorten operations. Drill holes should be backfilled or capped, and artesian flow should be immediately plugged and permanently sealed. CIRNAC recommends that the Proponent consider:"

- **Clarifying the maximum borehole depth, diameter, and number of boreholes at each site;**

The maximum borehole depth will be no deeper than 2.1 meters. Permafrost is expected to be encountered approximately 1 meter below the surface, and while we have identified a maximum of 2 meters, we think this is unlikely at any of the sites. Once ground ice is reached, a single ground-ice core of 30 cm in length will be collected at each site. The 31 cm bit extensions will not increase the borehole depth but instead will be used to allow the drill to reach the upper layer of permafrost without widening the sampling pit above the borehole. Maximum drilling depth will remain 2.1 meters or less below the surface. The borehole diameter will be 10 cm (as per the diameter of the core bit). Borehole size is expected to therefore be 30 cm deep and 10 cm wide and occur in the upper permafrost layer.

The small soil pit above the borehole will be used to collect no more than 1 kg of soil. We had identified the sampling plot at each site to be a maximum of 3 by 3 meters, although we expect the dug soil pit to be smaller, at 1 by 1 meters or a maximum of 2 by 2 meters. Only one soil pit and borehole will be dug/drilled at each site.

- **Explaining how boreholes would be backfilled or capped and how the original ground profile and drainage would be restored;**

Dug soil pits will be backfilled using the materials removed during sampling. Upon excavation, soil layers (surface, organic, and mineral layers) will be kept separate on tarps to ensure that soil is returned in their original order during backfilling to properly restore the ground profile and minimize disruption to local drainage to the greatest extent possible. Following backfilling, the surface layer will be restored to be level with the surrounding terrain to prevent the formation of depressions that could affect drainage.

Considering that drilled boreholes will be 30 cm deep and 10 cm wide, the volume of disrupted ground-ice material will be minimal. Any drill cuttings created during core removal will be placed in the borehole during backfilling. The material that will fill the borehole will be the soil from the deepest depth of the excavation process. No permanent caps or structures will be left in the hole or at the sampling site upon restoration.

- **Providing contingency measures for groundwater, artesian flow, unstable ground, equipment difficulties, adverse weather, or shortened landing periods.**

In the case that groundwater, artesian flow, unstable ground, or other unsuitable conditions are encountered during sampling, sampling will immediately cease and the site will be restored as above. Although artesian flow is not expected considering the relatively shallow depth of the borehole (maximum 2.1 m below the surface), it will be immediately plugged to the best of our abilities and backfilled with the excavated material.

If equipment difficulties arise, issues will be troubleshooted where it is safe to do so. However, if equipment challenges compromise safety or may negatively impact the site, sampling will stop, all equipment will be removed, and the site will be restored. In the event of adverse weather or sea conditions, as well as shortened landing period risks, sampling will not proceed. Prior to sampling each site, Gwen Freeze will discuss with Adventure Canada regarding the day's conditions and if there may be any factors that affect the planned landing duration. Sampling will only occur if there is sufficient time and safe working conditions to properly collect samples and restore the site post-sampling. If landings are unexpectedly shortened during field work, priority will be given to proper site restoration rather than sample collection. Should permafrost be deeper than expected, only active layer soil and bryophyte samples will be collected, and the drill will not be used to collect a permafrost core. Boreholes will not exceed 2.1 meters in depth.

Gwen Freeze will be travelling with Adventure Canada on their Into and Out of the Northwest Passage trips. Their *Ocean Victory* vessel will transport her and the equipment between the thirteen proposed sites. Upon landing at each potential sampling site by zodiac, equipment will be transported by foot from the landing site to sampling sites using carrying equipment. This will be done by Gwen and with the help of other Adventure Canada staff if needed. All drilling equipment is handheld and battery operated and can be carried to the sampling sites. Collected samples (bryophyte, soil, and/or permafrost core) will be carried from the sampling site back to the landing site and then back to the ship by zodiac.

CIRNAC #3: Drilling Method and Water Use

"The application identifies a Hilti DD 150-U-22 diamond core drill with a 10 cm-diameter, 37 cm-long SPX-A Speed core bit and extensions to access permafrost expected 1 to 2 metres below ground. However, the application estimates no water use and does not identify drilling fluids, a cooling medium, or a method for managing cuttings. It is unclear whether drilling would be wet or dry, how thermal disturbance and borehole stability would be controlled, and whether water or sediment-laden slurry would be generated. If water is required, the declared water use and associated authorization requirements may need to be considered. CIRNAC recommends that the Proponent consider:"

- **Clarifying whether wet or dry drilling would be used and describing the proposed cooling, cuttings-removal, and core-recovery methods;**

Samples will be collected using dry drilling and no external cooling will be used for drilling. Considering that one borehole of 10 cm x 30 cm will be drilled at each site, only a small amount of drill cuttings is expected to be created. Any drill cuttings produced will be returned to the borehole during back-filling and restoration. Use of dry drilling, the small samples size, and short drilling duration will limit generation of any water or sediment-laden slurry and thermal disturbance. Borehole stability is not expected to be an issue given the small size of boreholes and immediate site restoration. Cores will be recovered either by withdrawing the drill with the core retained in the bit, or, if the core is released from the bit, by using a core recovery tool (core grabber) to retrieve the sample from the borehole.

- **Providing the technical basis demonstrating that the selected drill and core bit are suitable for the anticipated permafrost and active-layer conditions;**

The Hilti DD 150-U-22 core drill with a 10 cm diameter SPX-A Speed core bit is suitable for this work and similar setups have been successfully used for this purpose (e.g., Wilhelm et al., 2011 https://doi.org/10.1139/w11-004). We have selected this setup intentionally, as we believe: 1) it is the safest option for handheld operation by one person, 2) the core bits are most suitable across a range of frozen ground conditions, and 3) the core barrel design is least likely to get stuck in shallow core drilling. With respect to the first point, safe operation is a paramount consideration and the electronic gears and active torque control of the Hilti DD 150-U-22 drill provide improved safety over gas powered auger systems. With respect to the second point, the SPX-A Speed core diamond drill bit is most likely to be able to cut through both coarse-grained and fine-grained material with varying levels of ground ice, whereas auger flights with carbide cutting teeth (e.g., SIPRE coring flights) operate optimally in ice-rich fine-grained soils. Given we expect to encounter a range of conditions, we have chosen the SPX-A Speed core bit as a versatile option. With respect to the third point, given the barrel of the SPX-A Speed core bit does not have any exterior annular flights (which are present on other permafrost/ice coring augers, such as SIPRE barrels), the risk of getting the barrel stuck in the ground is greatly decreased. This is an important consideration given the short sampling window at each location. We accept that coring may not be successful at each site, but believe we have selected the tool to give us the best chance at success across sites.

- **If water or drilling additives would be used, identify the source, quantity, containment, and disposal method.**

No water or drilling additives will be used.