February 25, 2022

Pitquhirnikkut Ilihautiniq / Kitikmeot Heritage Society
23 Omingmak Street
Cambridge Bay (Nunavut) X0B 0C0

Attention: Ms. Sophie Pantin

Subject: Kitikmeot Heritage Society Cambridge Bay – Proposed Location Assessment (Revised)
O/Ref.: 02110045.000

Dear Ms. Pantin,

Englobe Corp. (Englobe) is pleased to provide Pitquhirnikkut Ilihautiniq / Kitikmeot Heritage Society with site selection recommendations for Lot "3A" for the above-mentioned project located in Cambridge Bay, Nunavut (the Site). The report has been prepared "As per CAN/BNQ 2501-500/2017 "Geotech Site Investigations in permafrost zones".

1 SITE OVERVIEW AND RECOMMENDATIONS

1.1 GEOLOGY

The bedrock geology of Cambridge Bay is generally comprised of Lower Paleozoic sedimentary rocks of the Arctic Platform (dolostone, limestone, sandstone, shale, intraclast conglomerate, and breccia). Bedrock outcrops are rare in and around Hamlet.

The surficial geology of the Cambridge Bay area generally comprises either glacial till vaneer or blanket, consisting of mainly sand with some gravel varying in thicknesses between 1 meter to over 5 meters in depth over the bedrock, with locally interbedded meltwater deposits.

A prior geotechnical investigation performed by Englobe at a site approximately 2km southwest of the main community revealed approximately 6 to 10 meters of gravelly sand overburden with some fines underlain by bedrock.

1.2 PERMAFROST AND CLIMATE

Cambridge Bay lies within the zone of continuous permafrost. Areas within zones of continuous permafrost generally have Mean Annual Air Temperatures (MAAT) of less than -8°C with Cambridge Bay having a MAAT of approximately -13.9°C (Climate Atlas of Canada). The active layer thickness is estimated to be approximately 1.5 m but could be more than approximately 3m in 50 years. Table 1 below shows historical and projected climate indices.

Table 1 – Climate Indices for Cambridge Bay, Nunavut

Parameter	Historical Average (1976-2005)[1]	Projected Future Average (2051-2080)[1]
Mean Annual Air Temperature (°C)	-13.9	-7.4 to -9.6
Freezing Index (C degree days)	5703	3818 to 4434
Thawing Index (C degree days)	629	938 to 1128
Annual Precipitation (mm)	186	222 to 241

1. Referenced from Climate Atlas of Canada (climateatlas.ca)

1.3 SEISMICITY

The 2015 National Building Code of Canada (the Code) stipulates that a building should be designed to withstand a minimum live load due to an earthquake.

In this regard, due to the shallow depth of the site, classification for seismic site response C (Very Dense Soil and Soft Rock) should be used for foundation supported on soil for earthquake load and effects in accordance with Table 4.1.8.4.A of the 2019 National Building Code of Canada.

Ground motion is generally given in terms of probability of exceedance, which is the likelihood of expected horizontal acceleration being exceeded during a particular period. The probability used in the 2015 National Building Code of Canada is equivalent to a 2% probability of exceedance over 50 years.

Using the 2015 National Building Code Seismic Hazard Calculation online calculator, the Peak Ground Acceleration for the Site is 0.034g, where g is 9.81 m/s2, and the Peak Ground Velocity is 0.030 m/s for an assumed site Class C and 2% probability of exceedance in 50 years. The seismic hazard is also described by spectral acceleration values at periods of 0.2, 0.5, 1.0, 2.0, 5.0, and 10.0 seconds. Spectral acceleration is a measure of ground motion that takes into account the sustained seismic energy at a particular period. The detailed spectral accelerations are attached below.

1.4 SITE DESCRIPTION

A proposed Site option was identified by the client for a preliminary site assessment for the proposed knowledge center. Figure 1 shows the proposed plan superimposed over the latest aerial photo (2020).

Figure 1 – Aerial Photo Overlain by Proposed Site Area

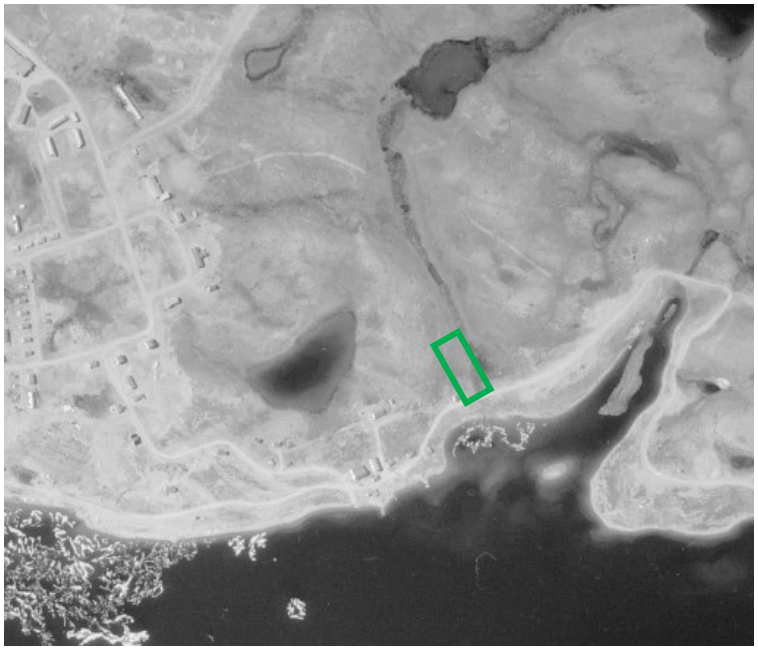


Figure 2 – Aerial Photo of Site Area (1964)

Figure 3 – Aerial Photo of Site Area (1973)

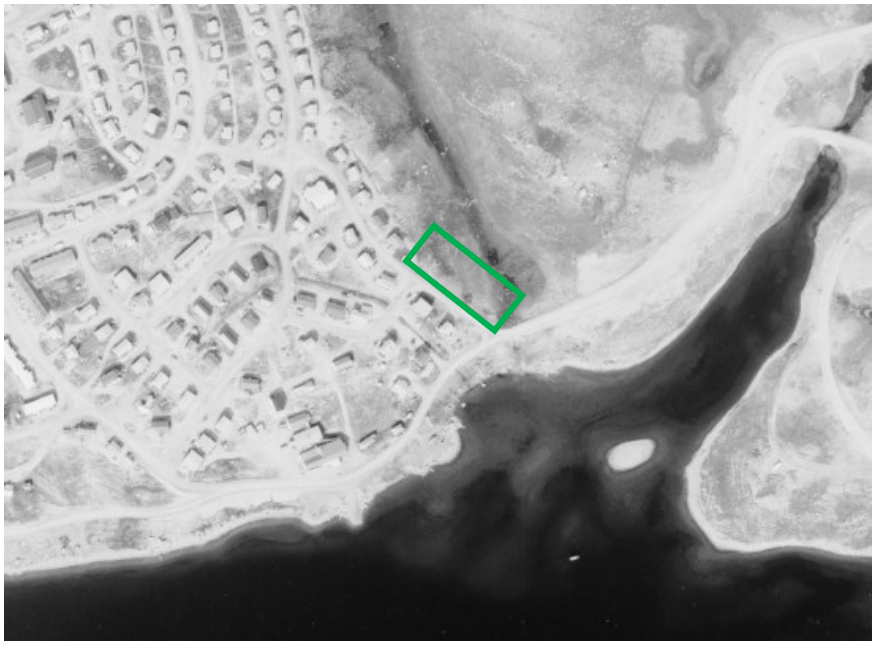


Figure 4 – Aerial Photo of Site Area (1993)

Figure 5 – Photo of Site Area, facing West (2021)

Figures 2 through 4 show historical aerial photos of the site area, which has yet to be developed. The surrounding area to the south and west was developed into residences over the lifetime of the community. Another notable development is the Canadian High Arctic Research Station (CHARS) to the north. As noted in the figures, there is a stream that runs along the north boundary of the Site, and Figure 5, which is a recent photo of the Site shows moderate ponding of water along the east portion of the Site. Additionally, there is a stream that runs along the north boundary of the Site, and water infiltrates the Site from the south. There is little to no vegetation cover throughout the Site.

The proposed Site area also lies approximately 1-2m lower relative to the surrounding properties and roads, with the site gently sloping from the southwest towards the north and east.

It must be noted that the sliding of vehicles has been an issue due to the slope of Okalik Street to the south and Nattik Street to the east. Additionally, the tight turning radius on the intersection between these two streets has been noted to cause issues for heavy truck traffic turning between these two streets.

There is a stream that runs along the north boundary of the site from west to east and releases through a culvert outlet on the east boundary of the Site. There are two culverts in the Site area, with one inlet from the south and one outlet to the east, which should release water away from the Site. Without repairs and/or improvements to the site drainage and existing culverts, increased surface ponding of water will be an issue and must be addressed for the development of the Site. Additionally, due to climate change, increased surface runoff and precipitation is projected, so addressing drainage concerns is dually important.

1.5 SITE SUITABILITY BASED ON RADAR IMAGE PROCESSING

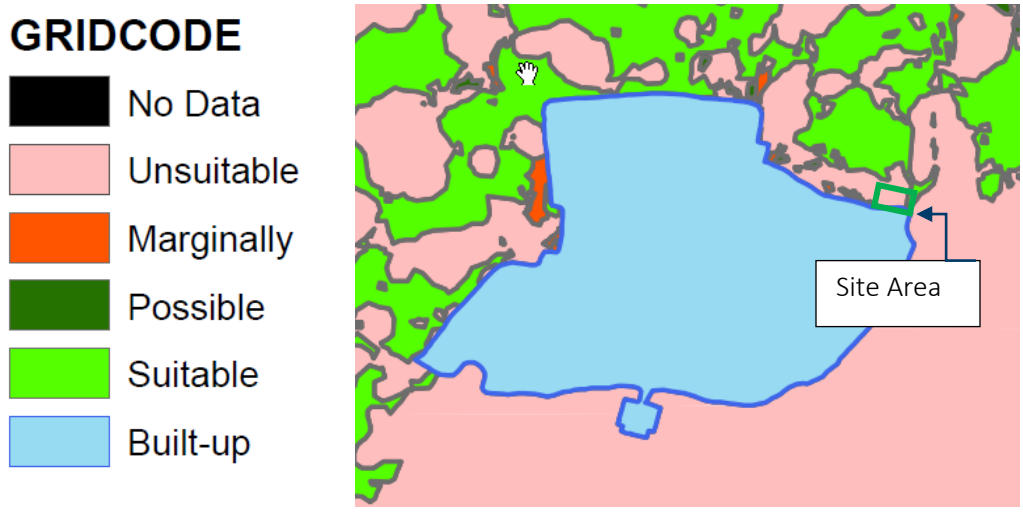
In the report "Nunavut Terrain and Soil Analysis" (3vGeomatics Inc. and BCG Engineering, 2011) accessed by Englobe, image processing of radar images on different communities throughout Northern Canada was performed to determine site suitability based on motion layers, slope and aspect, land cover classification and permafrost pictures determined through the image processing.

Based on these factors, maps were produced defining areas by suitability for development from unsuitable, marginally suitable, possibly suitable, suitable, or built-up.

The figure below roughly shows the location of the proposed Site for the proposed knowledge center with a legend regarding development suitability. The proposed Site lies mainly in what is classified as an unsuitable area based on the criteria below.

- Suitable for development – Area that is thought to be stable and available data have indicated little or no evidence of ice-rich and changing permafrost conditions. Generally consisting of terrain with exposed rock, bare soil, low vegetation, less than 4% slope, and aspect not south facing.
- Possibly suitable for development – The area is possibly stable for development; ground conditions have limited indicators of changing permafrost conditions. In some cases, due to the lack of quality remote sensing data, the presence of permafrost could not be ruled out. Generally consisting of terrain with exposed rock, bare soil, low vegetation, greater than 4% slope, and aspect not south facing.

- Marginally suitable for development – All data indicates that some ground ice is present, and the area is therefore only marginally suitable for future development. Generally consisting of terrain with low vegetation, greater than 4% slope, and includes south-facing aspects.
- Unsuitable for development – Rugged terrain, evidence of ground ice or subsidence, and surface water identified in the area. Generally consisting of terrain with wet areas, within 25 m of displacement, within 30 m of a water body, and greater than 10% slope.



Although the site area lies within what is classified by the report as an unsuitable area, the site would be rendered suitable for development with proper improvements to the site as noted in the recommendations in Section 1.8.

1.6 BORROW MATERIAL SITES

Due to the necessity of a source of engineered fill, several borrow sites were identified through a review of the following report:

1. "Geotechnical Evaluation for Municipal Waste Facilities, Cambridge Bay, Nunavut", prepared by EBA Engineering Consultants Ltd., dated December 2006.

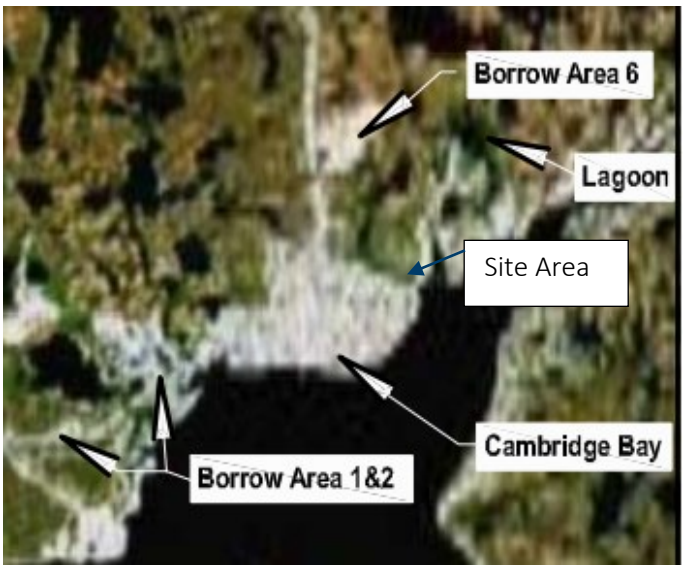


Figure 6 – Prospective Borrow Sites

After a review of these reports, several prospective borrow sites were identified in Figure 6 below.

Borrow areas 1 and 2 are located approximately 1.5 km southwest of the Hamlet of Cambridge Bay. Borrow area 6 is located approximately 1.0 km north of Hamlet. It is noted that a crusher is available within Cambridge Bay. With sufficient processing, there would be a material suitable for 75 mm minus gravel, or even 25 mm minus gravel.

Permits are required for the exploration and recovery of material from these borrow pits from the Government of Nunavut and the Hamlet of Cambridge Bay.

1.7 POSSIBLE FOUNDATION TYPES

Shallow foundations on grade overlying a thick bed of crushed gravel, buried footings founded in permafrost, or rock socket piles are considered possible foundation types for the site given the geology of the area and typical foundations used in buildings in the community. Consideration should be given to future increases in the active layer due to climate change trends, which will impact engineered fill depths and/or footing embedment depths and the use of thermosyphon systems to mitigate the impact on the permafrost.

A geotechnical investigation must be carried out to confirm the feasibility and bearing capacities of each foundation type.

1.8 RECOMMENDATIONS

The proposed site in its current state is considered feasible for development with consideration to the improvement recommendations below:

- The site elevation will need to be increased to match the surrounding areas and site grading improved to allow for access to Okalik Street to the south or Natik Street to the east, as well as to improve overall site drainage;
- A stable source of engineered fill is required for the development of the Site;
- A surveyor will be required to help assess the topography of the site, as well as the level and volume of fill required;
- Specific site grading requirements must be designed by a certified civil engineer;
- Two culverts adjacent to the Site to the south and east will need to be repaired/upgraded to discourage ponding of water onsite;
- If possible, the proposed development should be built on the western portion of the Site, to mitigate issues due to surface water runoff and ponding noted on the eastern portion of the Site;
- Due to climate change, increased surface runoff and precipitation is projected, so there is a need to address drainage concerns with increased flows in mind;
- Additionally due to potential permafrost degradation from climate change , consideration should be given to building the proposed development on deep foundations, pending a future geotechnical investigation to assess the subsurface conditions and depth of bedrock, if any; and,
- There are issues caused by the slope of the adjacent roads, the volume of traffic, and the tight turning radius of the roads to the southeast of the Site. Improvements to the road slopes are recommended to reduce the sliding of vehicles in the vicinity of the Site. Widening the turning radius of the intersection between Natik Street and Okalik Street is recommended to improve the flow of heavy traffic.

2 CLOSING REMARKS

In summary, there should be a preliminary visual investigation and geotechnical investigation for the proposed Site to fully assess the Site for the proposed knowledge center development. It is recommended to schedule the geotechnical investigation soon to reduce schedule delays as lead times for equipment and personnel for geotechnical drilling currently can range from a month to up to several months, and geotechnical investigations are preferably performed before the ground thaw.

We trust that this letter report is satisfactory for your purposes. Please do not hesitate to contact us with any questions or if you require more information.

Yours very truly,

Englobe Corp.

Prepared By:
Jason Thai, EIT
Project Coordinator, Geotechnical

Approved By:
Kiran Prakash, M.Eng, P.Eng.
Project Manager - Geotechnical Engineer

3 REFERENCES

GEOLOGICAL SURVEY OF CANADA. 2016. SURFICIAL GEOLOGY CAMBRIDGE BAY, NUNAVUT, NTS 77-D AND PART OF NTS 77-A. AVAILABLE AT HTTPS://DOI.ORG/10.4095/297438.

PRAIRIE CLIMATE CENTRE. THE CLIMATE ATLAS OF CANADA (VERSION 2, JULY 10, 2019). HTTPS://CLIMATEATLAS.CA

3VGEOMATICS INC AND BCG EGNINEERING INC. 2010. Nunavut Terrain and Soil Analysis.

EBA ENGINEERING CONSULTANTS LTD. 2006. Geotechnical Evaluation for Municipal Waste Facilities, Cambridge Bay, Nunavut", Surficial Geology and Aggregate Resource Analysis, CAMBRIDGE BAY, NUNAVUT.

2015 National Building Code Seismic Hazard Calculation

INFORMATION: Eastern Canada English (613) 995-5548 français (613) 995-0600 Facsimile (613) 992-8836
Western Canada English (250) 363-6500 Facsimile (250) 363-6565

Site: 69.119N 105.042W **User File Reference:** Kitikmeot Heritage Society Cambridge Bay 2022-01-12 18:10 UT

Probability of exceedance per annum	0.000404	0.001	0.0021	0.01
Probability of exceedance in 50 years	2 %	5 %	10 %	40 %
Sa (0.05)	0.043	0.022	0.013	0.004
Sa (0.1)	0.061	0.033	0.021	0.006
Sa (0.2)	0.058	0.035	0.023	0.008
Sa (0.3)	0.050	0.032	0.021	0.007
Sa (0.5)	0.041	0.027	0.018	0.006
Sa (1.0)	0.025	0.016	0.011	0.003
Sa (2.0)	0.012	0.007	0.005	0.001
Sa (5.0)	0.003	0.002	0.001	0.000
Sa (10.0)	0.001	0.001	0.001	0.000
PGA (g)	0.034	0.019	0.012	0.004
PGV (m/s)	0.030	0.019	0.012	0.003

Notes: Spectral (Sa(T), where T is the period in seconds) and peak ground acceleration (PGA) values are given in units of g (9.81 m/s^2). Peak ground velocity is given in m/s. Values are for "firm ground" (NBCC2015 Site Class C, average shear wave velocity 450 m/s). NBCC2015 and CSAS6-14 values are highlighted in yellow. Three additional periods are provided - their use is discussed in the NBCC2015 Commentary. Only 2 significant figures are to be used. **These values have been interpolated from a 10-km-spaced grid of points. Depending on the gradient of the nearby points, values at this location calculated directly from the hazard program may vary. More than 95 percent of interpolated values are within 2 percent of the directly calculated values.**

References

National Building Code of Canada 2015 NRCC no. 56190; Appendix C: Table C-3, Seismic Design Data for Selected Locations in Canada

Structural Commentaries (User's Guide - NBC 2015: Part 4 of Division B)
Commentary J: Design for Seismic Effects

Geological Survey of Canada Open File 7893 Fifth Generation Seismic Hazard Model for Canada: Grid values of mean hazard to be used with the 2015 National Building Code of Canada

See the websites www.EarthquakesCanada.ca and www.nationalcodes.ca for more information