REPORT

QUINHAGAK SCHOOL EXPANSION – GEOTECHNICAL EXPLORATION AND RECOMMENDATIONS

Quinhagak, AK

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July 13, 2012 **113-95736**

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1.0 INTRODUCTION

This report presents the results and geotechnical engineering recommendations of the Golder Associates Inc. (Golder) exploration for the proposed expansion and infrastructure improvements for Kuinerrarmuit School in Quinhagak, Alaska. Our exploration and the findings and recommendations presented in this report were conducted in general accordance with our proposal to USKH Inc. (USKH) on October 4, 2011.

The scope of work for this project consisted of reviewing the existing geotechnical data available in the Quinhagak area, drilling and sampling geotechnical boreholes at the proposed school site, performing laboratory testing and providing geotechnical and foundation recommendations for the proposed school addition and ancillary structures.

The original school was approximately 10,000 square feet (sq-ft) with construction completed in 1981. In 1986, a 10,500 sq-ft addition to the original school was completed. The 1986 addition was connected to the original school along a common wall. We understand the proposed expansion will add an additional 20,000 sq-ft to the existing structure. The proposed addition is located to the east and south of the existing school. The ancillary support structures, at the time of our report, includes a teacher housing structure northeast of the proposed development area, a boiler building, water storage tank and a bulk fuel storage facility. We understand that a roadway for fire access is also planned around the school expansion.

Recommendations presented within this report include the school expansion and boiler building. Geotechnical recommendations for the proposed teacher housing structure are presented on a separate technical memorandum. Foundation recommendations for the proposed water storage tank and bulk fuel storage facility will be presented as an addendum to this report once civil and structural engineering designs are finalized.

2.0 FIELD EXPLORATION

The field exploration was conducted on February 9 through 16, 2012 at the planned Kuinerrarmuit School addition site in Quinhagak, Alaska. Sixteen boreholes were advanced within the proposed addition footprint to depths ranging between 20 and 49 feet below ground surface (bgs). The proposed building footprint was provided to Golder by USKH in a scaled drawing dated February 8, 2012. Borehole locations were determined in the field by measuring from fixed locations (existing building corners) with a cloth tape. Borehole locations were selected with input from USKH to develop our geotechnical understanding of the proposed addition site. Site access at the time of our fieldwork was limited in some areas due to the presence of 1 to 6 feet of snow across site decreasing toward the south. Borehole locations were cleared using a Caterpillar D6 owned and operated by the Native Village of Kwinhagak (NVK).

2.1 Existing School Observations

The foundation of the existing school consists of drilled and slurried adfreeze timber piles. During our site visit, the school seemed to be performing as expected for a foundation system approaching its design life.

Following our field exploration, we understand representatives from USKH returned to the site and noted ground surface and pile settlements on the southwestern corner of the original 1981 school. Several feet of surficial settlement of fill was reported by USKH around the piles in this area. USKH also noted at least one of the timber piles in this area appeared to have settled and may not be connected to the beam supporting the base of the existing school. Differential movements of the adfreeze piles have not been measured.

Based on previous geotechnical reports for the school foundation, we understand that 1.5 to 2-inch diameter steel access conduits were placed adjacent to the timber piles during construction. The access conduits were placed for the future addition of passive cooling if required. To prevent infiltration of water into the access conduits due to freezing of the infiltration water, conduits were often filled with diesel fuel for buildings constructed in the 1980’s. Ground temperatures were not collected at the existing school site during our initial site investigation due to diesel fuel within the conduits.

2.2 Geotechnical Exploration

The boreholes were advanced with a GeoProbe 6610T direct push machine, owned and operated by Discovery Drilling of Anchorage, Alaska. The GeoProbe was equipped with Macrocore direct push sampling equipment. The GeoProbe is a direct push hydraulic machine that utilizes static weight and percussion hammering to advance a smooth-walled rod with a leading sample barrel. The sample barrel used for the project consisted of a barrel with 2.25 inches outer diameter and 1.5 inches inner diameter. Disturbed but representative samples were collected from the boreholes with a clear PVC liner inserted in the sampler barrel. The recovered soil samples were visually classified by Golder’s on-site representative following, ASTM D2487-00 “Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System, USCS).” Visible ice was characterized and logged using ASTM D 4083-89 “Standard Practice for Description of Frozen Soils.” Representative portions of recovered samples were retained in double sealed polyethylene bags to preserve their natural moisture contents.

Closed-end 1-inch diameter, schedule 80 PVC was installed in 13 of the boreholes for future ground temperature measurements. Open-end, hand-slotted PVC pipe was installed in borehole KWN-02 for future ground water level measurements. All boreholes were backfilled with soil cuttings except boreholes KWN-12 and KWN-15. Borehole KWN-15 was observed to be frozen to depth and was backfilled with potable water. Due to a hydraulic leak on the drill-rig at borehole KWN-12, the borehole was not backfilled; however, it was marked and flagged for future monitoring and observation.

Geographic coordinates of the borehole locations were recorded in the field with a handheld GPS instrument and are provided on the borehole logs. Swing ties, measured using a cloth tape from existing structures, were also used to determine borehole locations relative to nearby structures. A site plan showing approximate borehole locations is provided in Figure 1. Borehole logs are presented in Appendix A.

2.3 In-situ Ground Temperature Collection

A Golder representative returned to Quinhagak on March 13, 2012 to measure ground temperatures in all accessible boreholes. Ground temperatures were collected approximately one month after drilling to allow for the dissipation of drilling inducted heat. Stable ground temperatures were measured using ice-bath calibrated thermistors. Thermistors were placed within the PVC conduit of the boreholes and allowed to thermally attenuate to the in-situ ground temperatures for at least 1 hour. Readings were then recorded using a switchbox and multimeter. Measured resistances were converted to degrees Fahrenheit with ice-bath calibrations applied to the field measured data.

3.0 LABORATORY TESTING

The representative soil samples retained during our site work were re-examined in our Anchorage laboratory to confirm the visual field classifications. Select soil samples were tested for natural moisture content, pore water salinity, grain size distribution, fines content (percent passing the U.S. number 200 sieve size), plasticity (Atterberg Limits) and organic content by ignition. Laboratory testing was conducted in accordance with ASTM standards except for pore water salinity.

Pore water salinity was measured by diluting the pore water with a measured amount of water. The salinity in the pore water was dispersed throughout the added water. The electrical conductivity of the water within the sample was measured and correlated to the salt concentration within the diluted sample water. The calculated salinity of the diluted sample is subtracted and the remaining saline concentration adjusted to the natural moisture content of the representative sample. Based on our testing, this method matches the ASTM standard for measurement of pore water salinity.

The soil and frozen soil classification legends are presented in Appendix A, Figures A-1 and A-2, respectively. The borehole logs are presented in Figures A-3 through A-18. Selected laboratory results are summarized on the borehole logs. A tabular summary of laboratory test results is presented in Appendix B Table B-1. Grain size distribution plots are shown in Figures B-1 and B-2. Plots of soil plasticity are presented in Figure B-3. The laboratory data presented in Appendix B should be reviewed to augment the summary laboratory data presented on the borehole logs.

4.0 REGIONAL SETTING AND CLIMATE INFORMATION

4.1 Regional Setting

Quinhagak is located on the east shore of Kuskokwim Bay, near the mouth of the Kanektok River. Gently undulating tundra terrain extends from the Kanektok River floodplain eastward to the Kilbuk Mountains and southward towards the Arolik River floodplain. The dominant landform in the area is the tundra plain that is treeless, poorly drained and typically wet during the warm season. The terrain is dotted with numerous thaw lakes and remnants of older, drained lakes are common. The natural soil deposits in the upland tundra consist of re-transported fluvial deposits of sand and gravel. Fine-grained lacustrine deposits of silt and clay are associated with tundra lakes. Along the coast, to the south and west of Quinhagak, are marine beach and tidal deposits. Tundra grasses, sedges and mosses blanket most of the natural terrain.

The Quinhagak area has been mapped within the sporadic permafrost zone (Jorgenson et al., 2008). Permafrost is typically absent beneath larger water bodies, such as beneath the Kanektok River and thaw lakebeds. Permafrost underlies much of the tundra terrain. Lakes, streams and drained thaw lakebeds may be underlain by unfrozen ground and degrading permafrost conditions may be present beneath snowdrifts or drainage areas.

4.2 Regional Climate Information

Design climate data including thawing and freezing indices for the Quinhagak area are presented in Table 1. The indices are calculated from data developed by the University of Alaska Fairbanks (UAF) Scenarios for Network for Alaska Planning (SNAP). Design indices are based on the average of the three coldest winters (freezing index) and the three warmest summers (thawing index) observed during the analysis period. Included in the table are projected climate data for years 2012 to 2042, based on the UAF SNAP data.

Table 1: Engineering Climate Indices for Quinhagak, Alaska

	1948 – 1978	1979 – 2009	2012 – 2042 (estimated)[1]
Average Air Temperature	30.9 °F	32.8 °F	35.3 °F
Average Freezing Index	2830 °F-days	2380 °F-days	1770 °F-days
Average Thawing Index	2440 °F-days	2680 °F-days	2960 °F-days
Design Freezing Index	3640 °F-days	3160 °F-days	2820 °F-days
Design Thawing Index	2780 °F-days	3090 °F-days	3760 °F-days

Note: 1) Projected by UAF SNAP, Global Climate Model ECHAM5, Emission Scenario A1B.

SNAP data were prepared by Rupp et al. (2009) and are distributed as two separate products. Historical records were calculated using the PRISM model by combining climate data from multiple meteorological records across the State of Alaska from 1901 to 2009, and modeled across the state in a manner that accounts for “variation in slope, aspect, elevation and coastal proximity” (PRISM Climate Group, 2004). Forward-looking projections were prepared from 2012 to 2042 utilizing the ECHAM5 global climate model, which was found by the SNAP group to have the highest accuracy for Alaska. We have assumed a mid-range (A1B) carbon emission scenario for the forward looking-projections.

5.0 EXISTING GEOTECHNICAL INFORMATION

The following geotechnical exploration reports were reviewed to provide a general understanding of subsurface conditions near the proposed school expansion. Foundation as-built construction records were not provided to us for review, thus final plans and specifications, for construction projects, may vary from our review of historic geotechnical reports.

- **Kuierrarmuit School –** In January 1979, R&M Consultants drilled three boreholes to depths ranging between 19.5 and 29.5 feet bgs at the site of the proposed school in Quinhagak. The subsurface conditions observed during the exploration consisted of about 1-foot of surface organics overlying 16-feet of brown silt, which was underlain by sand with trace to some gravel and silt. All boreholes were frozen throughout their exploration depths. Ground temperatures measured in one borehole had an average ground temperature of 31 degrees Fahrenheit (°F). The school was built on a foundation consisting of 12-inch diameter drilled and slurried timber adfreeze piles. A 3-foot clear space was recommended between the base of the structure and the granular fill pad constructed at the site.
- **Kuinerrarmuit School Addition –** In December 1985, Harding Lawson Associates drilled five boreholes as part of the geotechnical investigation for a 10,500 sq-ft addition of the existing school. The boreholes ranged from 21 to 40.5 feet bgs. The subsurface conditions consisted of a gravel pad underlain by ice-rich organic soils to a depth of 14 feet with silty sand and gravel to the depths explored. Surface frost was observed 1 to 3 feet bgs. An unfrozen zone was observed underlying the surface frost, 4 to 5 feet bgs. Below this unfrozen zone, well-bonded frozen conditions were observed to the depths explored with ground temperatures ranging from 30.5 to 31.0°F. During this investigation, ground temperatures were measured at the existing school. Ground temperatures near the external piles ranged from 29.8 to 30.4°F, while internal piles measured about 31.0°F. The foundation consisted of drilled and slurried timber adfreeze piles with a minimum embedment of 30 feet bgs with tip diameters of 10 to 14 inches. A 2-inch diameter steel pipe was attached to each pile for the future installation of passive cooling.
- **Washeteria and Tank Foundation –** In April 1995, Duane Miller Associates (DMA, now Golder) drilled five boreholes as part of a foundation investigation for the proposed relocation of the water plant building and water tank. The proposed location was northwest of the existing school, across the street. Three of the boreholes were within 500 feet of the existing school. The subsurface conditions consisted of peat from 3 to 4 feet bgs, with ice-rich silt to 12 feet bgs. Underlying the silt is silty sand, sandy silt and gravelly sand to the depths explored (30 feet bgs). The boreholes were frozen with ground temperatures of 31.0°F. The recommended foundation consisted of an at-grade passively cooled insulated pad. The recommended pad consisted of 4 feet of granular fill with an 8-inch layer of insulation. Three-inch diameter thermosyphons placed on 10-foot centers were recommended.
- **Quinhagak Youth Center –** In November 2002, DMA advanced four test pits as part of a foundation investigation for the proposed youth center. The youth center was located near the northwest corner of the existing school. The subsurface soils consisted of peat underlain by organic soils to depths of 1.5 to 2.5 feet bgs with gray silt observed to the depths explored in the test pits (6 feet). Bonded frozen soil was observed at depths ranging from 3 to 5.5 feet bgs. A passively cooled insulated post and pad foundation was recommended to found the youth center. The recommended pad section consisted of geotextile fabric over the existing tundra surface and a granular fill section placed to match the existing roadway grade. Four inches of insulation were recommended in the fill section with at least 12 inches of granular fill cover. Three-inch diameter

thermosyphons were recommended within the granular fill section below the insulation on 12-foot centers.

- **Qanirtuuq, Inc. Store –** In March 2010, Golder drilled five boreholes as part of a foundation investigation for the proposed new store building. The Qanirtuuq site is about 1500 feet northwest of the existing school adjacent to a drained lakebed. The boreholes were advanced between 15 and 24 feet bgs, and grab samples collected from the auger cuttings. The subsurface conditions at the site consisted of a 3.5 to 5-foot granular pad underlain by a 1 to 3-foot thick layer of peat with gray organic silt to 8 to 10 feet bgs. Poorly graded gravel was observed underlying the silt to the depths explored. Unfrozen soil was observed beneath the seasonal frost in all boreholes to the exploration depths. The recommended foundation consisted of open-end 12-inch diameter driven pipes piles installed to a depth of 35 feet bgs.

In general, subsurface conditions in undeveloped areas within Quinhagak consist of a surficial organic soil mat (peat and organic silt) ranging in depth from 1 to 14 feet bgs. Underlying the organics is mineral silt to depths ranging from 8 to 16 feet bgs. Where frozen, the mineral silts are often noted as ice-rich. Granular sands and gravels with varying fines (silt) content underlie the mineral silts to the depths explored in the previous soil investigations. Depending on the surface conditions, the soils in the Quinhagak area may be well bonded frozen, or unfrozen with a degrading permafrost condition.

6.0 SITE CONDITIONS

6.1 Surface Conditions

The proposed Quinhagak School addition consists of a 120- by 300-foot addition to the east and south of the existing school, generally extending in the north-south direction. The addition footprint covers terrain that appears to transition from relatively higher tundra surface along the northern portion of the investigation area to the margins of wetter ground on the southern portion of the investigation area. A small drainage is located within the school addition footprint entering the site at its northeast corner extending south through the center of the site and exiting near the southwest corner. The drainage area is shown in Figure 1.

6.2 Subsurface Conditions

The subsurface soil conditions underlying the school site are varied with different soil layers occurring in 2 to 5 foot sections. However, generally three distinct soil layers were encountered within each borehole. Organic soils (Pt, OL) are present near surface with underlying fine-grained soils (CL-ML, ML, SM) and granular soils at depth (SP, SW, SP-SM, SW-SM). A summary of depths and general soil conditions are presented in Table 2 for the boreholes. North to south inferred geologic cross sections of the proposed addition site are noted on the Site Map (Figure 1) and are presented in Figure 3. Each cross section shows the permafrost surface and general soil conditions.

6.2.1 Organic Surficial Soils

The surficial peat ranged in thickness from 0.5 to 2 feet bgs in boreholes KWN-01 through -03 and KWN-07 through -14. Peat was observed underlying the fill to 2 feet bgs. Peat and ice (greater than 50 percent visible ice) were observed in KWN-04 through -07 to 2 to 4 feet bgs. Borehole KWN-15 was advanced in an area with a 0.9-foot granular silty sand (SM) fill pad.

Underlying the peat and ice in KWN-05, a 2-foot layer of peat was observed to 4 feet bgs. Mineral silt (ML) was observed underlying the surficial peat in borehole KWN-02 from 1 to 1.8 feet bgs. Organic silt (OL) was observed to depths ranging from 1.8 to 5 feet bgs in boreholes KWN-01 through -04, and KWN-07 through -15. No organic silt was observed in boreholes KWN-05 and -06. A layer of mixed mineral (ML) and organic silt (OL) was observed in borehole KWN-11 from 2.8 to 7.5 feet bgs.

6.2.2 Fine-grained Mineral Soils

Mineral silt layers were observed in boreholes KWN-01 through -14 and ranged in thickness from 3 to 10.5 feet and depths that ranged from 7 to 15 feet bgs. Clayey silt (CL-ML) was observed in boreholes KWN-11 and -15 to depths from 10.5 to 14.5 feet bgs and 5 to 12.5 feet bgs, respectively. Underlying the clayey silt in KWN-15 is an organic silt (OL) layer from 12.5 to 15.5 feet bgs. Organic silt was observed underlying the mineral silt in boreholes KWN-09, -10 and -12 to a depth of 7.8, 10 and 9 feet bgs, respectively. In boreholes KWN-09, -10 and -12, mineral silt was observed underlying the organic silt from 7.8 to 10 feet bgs, 9 to 10 feet bgs and 10 to 13.5 feet bgs, respectively.

A sand (SM, SP-SM) interbed was observed from 10 to 12.5 feet bgs in boreholes KWN-01, 8.5 to 13 feet bgs in KWN-03, 10 to 11 feet bgs in KWN-06 and 10 to 11 feet bgs in KWN-10. In boreholes KWN-01, -03 and -06, the mineral silt layer continues below the sand interbed to depths ranging from 13 to 20 feet bgs. Organic silt (OL) was observed below the sand interbed in KWN-10 to a depth of 13 feet bgs.

6.2.3 Granular Soils

In general, the granular soils consisted of a mixture of silty sand (SM) and poorly and well graded sand (SP, SW), or poorly graded gravel (GP) with interbeds of mineral silt (ML). Granular soils were observed to the depths explored, without silt interbeds, in boreholes KWN-02, KWN-09 through -12, and KWN-14 through -16. Well or poorly graded sand (SW, SP), well or poorly graded sand with silt (SW-SM, SP-SM) or silty sand (SM) with mineral silt (ML) interbeds were observed in KWN-01 and KWN-03 through -08.

Mineral silt interbeds ranged in thickness from 0.7 to 2.7 feet in thickness in KWN-01 and KWN-03 through -08. An organic silt interbed was observed in borehole KWN-06 from 21.4 to 22.3 feet bgs.

A mineral silt layer (ML) was observed from 26 to 31 feet bgs and 24 to 29.5 feet bgs in boreholes KWN-04 and -13, respectively. A poorly graded gravel (GP) layer was observed from 16.5 to 20.5 feet bgs in borehole KWN-04.

6.3 Subsurface Thermal Conditions

The subsurface thermal conditions varied widely within the site, ranging from boreholes with fully frozen soil profiles to areas where up to 19 feet of unfrozen soil were observed. Ground temperature profiles are presented in Appendix C. In general, the site can be divided into two sections: permafrost and degrading permafrost.

Conditions beneath the northern portions of the proposed addition footprint are probably typical of the Quinhagak region: permafrost is present near the surface but is slightly degrading in areas of snow drifting, surface drainages and surface disturbance. A surficial drainage is present across the site and is presented in Figure 1. The southern portion of the site, in contrast, has already thermally degraded. The southern section of the site may be situated on the margins of an old, drained lakebed. It appears that a thaw bulb had formed beneath the water body and now that the lake has drained and a surficial peat layer has developed, permafrost is again building from the surface downward.

The subsurface thermal conditions discussed below are based on our field observations and ground temperature measurements. The thermal state of the soils will change throughout the year and over time.

6.3.1 Permafrost

Boreholes KWN-14 and -15 were fully frozen through their profiles with ground temperatures of 31°F and 31.5°F, respectively.

6.3.2 Degrading Permafrost

Surficial frost was observed in the majority of boreholes. The surficial frost may be a mixture of seasonal frost (active layer) and permafrost. Permafrost is defined as soil with a temperature below 32°F for two or more winters and the intervening summers. Perennially unfrozen soil layers (taliks) were observed across the site and may be open or closed. A closed talik is a zone of unfrozen soil surrounded by permafrost, above and below. An open talik only has permafrost present below the unfrozen soil zone.

Boreholes KWN-01 and -02 were terminated within unfrozen soils to the depths explored. Frozen soils were observed from ground surface to 12.5 feet bgs in KWN-01 and from ground surface to 5 feet bgs and 6 to 17 feet bgs in KWN-02 with small section of unfrozen soil was observed in KWN-02 from 5 to 6 feet bgs. Borehole KWN-16 was advanced to determine the deepest extent of the talik observed in boreholes KWN-01 and -02. The talik on the southernmost section of the site (borehole KWN-16) extended from 14 to 33 feet bgs. The unfrozen soils may extend deeper in boreholes KWN-01 and -02; however, we have inferred that the talik extends to a depth of 33 feet based on borehole KWN-16.

Boreholes KWN-03 through -04 were advanced on the southern half of the addition site adjacent a surface drainage area. A closed talik was observed in boreholes KWN-03 and -04 extending from 12.5 to 21.5 feet bgs and from 7 to 22 feet bgs, respectively.

An open talik was inferred in the remaining boreholes advanced on site (KWN-05 through -13). The thickness of the open taliks ranged from 3.5 to 8.5 feet. The observed frost depths ranged from 1 to 3.5 feet bgs and are inferred to be seasonal frost. The depth to permafrost in these boreholes ranged from 6 to 10.5 feet bgs. The deepest talik was observed in borehole KWN-05 and extended from 3.5 to 21.5 feet bgs.

Table 2 presents a summary of the depths of the general soil layers, the borehole termination depths and the depth to the base of the taliks observed in the boreholes.

Table 2: General Soil Conditions by Depth

Borehole Number	Profile Depth			Borehole Termination Depth	Depth to Deepest Frozen Soil Layer
	Surficial Organic Soils	Fine-Grained Soils	Granular Soils		
KWN-01	0 - 3 ft	3 - 20 ft	20 ft to TD	30 ft	Not Encountered
KWN-02	0 – 3.8 ft	3.8 – 10.5 ft	10.5 ft to TD	25 ft	Not Encountered
KWN-03	0 – 5 ft	5 – 18 ft	18 ft to TD	25 ft	21.5 ft
KWN-04	0 – 4.5 ft	4.5 – 15 ft	15 ft to TD	34 ft	22 ft
KWN-05	0 – 4 ft	4 – 10.5 ft	10.5 ft to TD	31.5 ft	21.5 ft
KWN-06	0 – 4 ft	4 – 13 ft	13 ft to TD	30 ft	6.5 ft
KWN-07	0 – 3 ft	3 – 7.5 ft	7.5 ft to TD	29.2 ft	9 ft
KWN-08	0 – 3.5 ft	3.5 – 7.5 ft	7.5 ft to TD	25 ft	6 ft
KWN-09	0 – 3 ft	3 – 10 ft	10 ft to TD	20 ft	7.8 ft
KWN-10	0 – 2.8 ft	2.8 – 13 ft	13 ft to TD	20 ft	6.5 ft
KWN-11	0 – 7.5 ft	7.5 – 14.5 ft	14.5 ft to TD	20 ft	10.5 ft
KWN-12	0 – 4 ft	4 – 13.5 ft	13.5 ft to TD	20 ft	8 ft
KWN-13	0 – 1.8 ft	1.8 – 10 ft	10 ft to TD	49 ft	8.5 ft
KWN-14	0 – 4.5 ft	4.5 – 14.8 ft	14.8 ft to TD	20 ft	Frozen
KWN-15	0.9 – 5 ft	5 – 15.5 ft	15.5 ft to TD	25 ft	Frozen
KWN-16*	N/A	N/A	N/A	41 ft	33 ft

Note: 1) * = Borehole was not sampled above 30 feet, layer divisions were not determined.
2) TD = Termination Depth of Borehole

A contour map of the inferred permafrost surface, based on our February 2012 field observations, is presented in Figure 2. The permafrost surface drops dramatically on the southern section of the site. The depth to permafrost presented in this figure may change throughout the year and over time. This figure is presented in order to aid in interpretation of the site thermal conditions and should not be used to predict foundation constructability.

6.4 Laboratory Test Results

Soil moisture content was measured in all recovered soil samples. Average soil moisture content, as a percentage of dry weight, was approximately 300 percent for the peat and organic silt (Pt, OL) samples, 38 percent for recovered silt (ML) samples, 22 percent for silty sand (SM) samples and 19 percent for the sand samples (SP, SW, SP-SM, SW-SM).

Atterberg Limits testing was conducted on eight fine-grained samples that were representative of samples with observed plasticity. Seven of the samples were selected from the fine-grained soil layer in each borehole and one sample was selected from a silt interbed at 27 feet bgs in borehole KWN-05. Atterberg Limits testing of mineral samples indicated the samples ranged from silty clay to silt (CL-ML, ML) with one non-plastic sample. The plasticity index of the tested samples ranged from 1 to 6. The liquid limit of the samples ranged from 20 to 34 percent moisture. Two samples had natural moisture contents within the plastic zone (KWN-12 at 4.5 feet bgs and KWN-15 at 6 feet bgs). However, the remaining samples were frozen in-situ with natural moisture contents greater than the liquid limit of these samples.

Pore water salinity tests were conducted on a representative selection of recovered samples. A salinity profiles was obtained for borehole KWN-01 and selected samples tested from boreholes KWN-13 through -15. Measured salinity values from the recovered samples were ranged between 0 to 1.7 parts per thousand (ppt) and are considered negligible for geotechnical engineering purposes. The pore water salinity in a soil may contribute to a freezing point depression. As a point of reference, a pore water salinity of 10 ppt would reduce the freezing point by approximately 1°F.

7.0 DISCUSSION

7.1 Existing School Foundation

The existing school foundation, both the original school and the 1986 addition, are founded on drilled and slurried timber piles relaying on adfreeze bond for axial capacity. In our opinion, the foundation of the existing school is approaching its intended design life. However, the design life of the foundation may not represent the structure's service life.

The adfreeze piles at the site were designed to resist either frost uplift forces or creep settlement. When structural pile loads are relatively light, frost uplift force generally controls the required pile embedment. When structural loads are greater than the frost uplift force, creep settlement may control the pile embedment depth.

Frost uplift force acts on piles due to the expansion of pore water within the active layer soils during the winter months. The active layer is the zone of seasonal thermal change at the ground surface, freezing in winter and thawing in summer. The frost uplift force is a shorter-term load resisted by the adfreeze bond of the pile embedded below the active layer. The adfreeze bond is the bond between the pile surface and frozen soil surrounding the pile. The adfreeze bond capacity increases with decreased ground temperature, but the actual adfreeze bond is subject to numerous variables.

Creep settlement is a phenomenon in icy frozen soils in which the material adjacent to the pile deflects when placed under a constant stress. The adfreeze bond capacity and pile embedment in a creep analysis are based on the allowable settlement of the structure throughout its intended design life. The design life is the period of time the structure is expected to stay within its original design parameters. In terms of an adfreeze foundation, the design life is the length of time, following construction, in which the foundation settlement does not exceed the allowable foundation settlement. In general, a design life of 20 to 25 years is commonly used for schools and other village infrastructure developments. Creep is dependent on load duration; usually increased sustained loads decrease the allowable creep adfreeze bond strengths to resist creep deformations. Creep settlement generally occurs at a constant rate throughout the design life of the structure. However, creep failure of adfreeze foundations occurs when the creep settlement rate accelerates over time.

Over time and with warming climate conditions in western Alaska, two factors may increase the likelihood of foundation differential movements: increased summer thaw depths and increased ground temperatures. Increased thaw depths during summer months may accelerate permafrost degradation, particularly along southern and western facing areas of the structures. The increased ground temperatures will decrease the forces resisting frost. Since the structural loading of the piles is assumed constant and the increased ground temperatures affect the creep capacity of the adfreeze piles, downward differential foundation movements may be due to creep settlement.

Based on our site observations, significant differential movements of the foundation were not observed by our on-site representative. However, as discussed previously, subsequent site observations by USKH indicate some pile movements along the southwestern portion of the original school. Differential movements of the existing school foundation may occur in the future and a close inspection is warranted prior to freeze up, 2012.

It is our opinion that some activities be completed at the existing school site to monitor the existing foundation's performance.

- Visual inspection of the existing school foundation during summer/early fall 2012.
- Structural engineer should evaluate of the pile loads at the existing school.
- A pile cap survey of the existing school foundation tied to an external benchmark for use as a baseline if future differential foundation movements are noted.
- Cleanout the diesel and sleeve some of the existing access conduits adjacent to the foundation piles with PVC or HDPE for ground temperature measurement.
- Thermistors should be placed in the lined conduits for ground temperature measurement. The bead (sensor points) spacing on the thermistors should be between 2 and 3 feet from ground surface to the base of the piles. Thermistors should be located within the center of the existing structure, along the westernmost external wall, and at the building corners.
- The connectors for each of the thermistors should be well marked and all wired to a central location, and detailed as-built records maintained during thermistor installation.

If a Supervisory Control and Data Acquisition (SCADA) system is planned for other areas of the school, it may be beneficial to connect the ground temperature monitoring system into this system. If a SCADA system is not planned, ground temperatures should be recorded on a regular basis, monthly measurements are recommended. Ground temperatures should be measured in the fall of each year to determine the warmest ground temperatures.

7.2 Proposed School Addition Foundation

The majority of the proposed school addition site is located in an area of warming and degrading permafrost. Warming and degrading permafrost conditions occur in areas where additional heat transferred into the subsurface due to summer temperatures is not offset by the heat removed during the winter months. A layer of unfrozen soil may form between the surficial winter freeze and the underlying permafrost in these areas. Depending on the temperatures of the following winter and other conditions, the unfrozen zone may freezeback. However, if the ensuing winter conditions do not provide adequate cooling, an open talik forms. If the heat balance reverses and the heat removed is greater than the summer heat transfer, frozen ground will begin to develop at the base of the active layer with an unfrozen zone of soil below; a closed talik. Both open and closed taliks were observed in the majority of boreholes advanced at the site.

The possible foundation types for the proposed school addition consist of adfreeze drilled and slurried piling with passive cooling, passively cooled Thermo-helix piles, and driven piles with and without passive cooling. Due to the varied settlement behavior of the different foundation types, a single foundation type should be considered for the proposed school addition. The subsurface soil and thermal conditions pose two major risks to the foundation types considered for this project, differential movement and constructability.

7.2.1 Differential Movement

As discussed in the existing school foundation section, differential movements of foundations in permafrost soils are related to the imposed loads, frost forces and creep settlements. Additionally, potential for foundation differential movement exists due to degrading permafrost conditions: thaw consolidation and down-drag loads.

Thaw consolidation occurs due to the volume decrease of a soil system as it changes from a frozen to unfrozen state. The amount of expected thaw consolidation can be inferred based on moisture content and soil type. If thaw consolidation occurs at the base of a foundation, the foundation may experience thaw consolidation in two forms: the volume change due to thawing and additional settlement due to compression of the soil structure from the foundation load.

If thaw consolidation occurs along the length of the pile, the vertical movement of the soil will create a frictional load above the location of the thaw. The friction will act in a compressive direction and “downwardly drag” the pile into the subsurface. The down-drag load is in addition to the compressive structural loads on the piles and may be a significant load depending on subsurface conditions. The additional compressive load will be resisted by the capacity of the pile below the depth of thaw.

7.2.2 Constructability

Constructability methods for the different foundation systems considered feasible for this development may present varying installation costs and installation risks. Some of the installation methods may require significant expense, such as temporary casing. While others methods may require installation monitoring to verify the foundation was installed without damage.

The taliks observed on site pose risks for driven or drilled and slurried installation methods. The frozen granular soils can be very dense and stiff, relative to unfrozen or unbonded soil and may cause damage to driven piles during installation. While, frozen soils will generally maintain an open borehole annulus when a drilled and slurried pile is installed the unbonded material may slough. If significant sloughing or water infiltration occurs within the borehole annulus, temporary steel casing may be needed to ensure bonding between the pile and the frozen soil below the talik.

7.2.3 Adfreeze Drilled and Slurried Foundation Types

Adfreeze drilled and slurried timber piles form the foundation for the existing school. Steel or timber adfreeze piles are often used within the Quinhagak area. At the proposed school addition site, the warm ground temperatures, approximately 31.8°F at depth, would provide some adfreeze capacity. However, the degrading permafrost condition is expected to continue increasing the ground temperatures and increasing the thickness of the taliks. The degrading permafrost will cause decrease adfreeze bond strengths, thaw settlement and down-drag loads on the pile.

A thermosyphon may be added to decrease the potential for continued degradation of the permafrost around the pile. However, the thermosyphon would need to extend into the existing permafrost surface and “re-grow” the frozen soils in mounds adjacent of the piles. Thermosyphons this length may be very costly.

During installation of drilled and slurried piles, the annulus of the installation borehole should remain open and free of caving or sloughing soils in order to ensure bonding between the pile and the slurry. Casing the borehole would likely be required for the majority of piles at the school addition site. While casing installation methods could be used to install a drilled and slurried foundation system, the construction would be costly.

7.2.4 Thermo-helix Piles

Thermo-helix piles, designed and manufactured by Arctic Foundations, Inc. (AFI) of Anchorage, Alaska, are a foundation option. Thermo-helix piles are a carbon dioxide (CO_2) pressurized vessel that passively cools the soil surrounding the pile. The helices are generally a 2-inch wide steel band installed in a spiral on the circumference of the pile increasing the effective diameter of the pile for the adfreeze capacity, as the failure plane is extended to the edge of the helices.

These piles are installed using drilled and slurried installation methods. The Thermo-helix piles would need to be designed to remove sufficient heat to prevent further permafrost degradation. However, the constructability issues discussed in the previous section also apply to this foundation type. Casing would still be required for the majority of foundation piles.

7.2.5 Driven Piles

Driven piles consist of a steel section driven into the subsurface using vibratory or diesel impact hammer installation methods. The compressive capacity of a driven pile system is comprised of two parts. The sidewall capacity consists of the friction between the pile and the surrounding unfrozen soil. The end bearing capacity is due to the compression or bearing capacity of the soils at the tip of the pile.

Degrading permafrost conditions may cause thaw consolidation settlement and down-drag loads without the addition of passive cooling to prevent further permafrost degradation. Thus, passive cooling is recommended to retard permafrost degradation with this option. Greater heat should be removed by passive cooling than heat transferred into the subsurface during the summer months. Passive cooling should be place adjacent to the piles.

The frozen granular soils underlying the site pose a concern during installation due to the potential for pile damage during installation at the measured ground temperatures. However, potential pile damage concerns can be reduced by using a driven H-pile instead of an open-end pipe pile. H-piles generally have increased resistance to damage during driving unless larger wall thickness pipe pile sections are used.

Passive cooling should be installed adjacent to the H-piles. An open annulus can be created by welding angle iron or steel conduit to the web and web flange connection, respectively. Two angle iron or conduit sections should be attached to each pile; one for passive cooling, the other for ground temperature monitoring. Ground temperature monitoring may be needed if foundation movement is observed in the future.

Based on our field investigation, driven H-piles with passive cooling are recommended to found the proposed school addition. Geotechnical engineering recommendations are presented in the following section.

7.3 Addition Connection to Existing School

There are potential risks associated with mating the proposed school addition and the existing school along a common wall. The proximity of the proposed school may adversely affect the existing school's foundation. Differential movements between the different foundation systems may cause distress in and between the structures.

The location of the proposed school addition may cause snow drifting, roof shedding, and site drainage which may affect the thermal regime of the existing school. Differential movements or increased creep rates may occur with changes to the ground temperatures underlying the existing school. The proposed school addition and the existing school should be separated with a corridor and the area soils thermally protected. Thermal protection at the connection between the existing school and the addition should consist of passive cooling and insulation. The separation between the proposed addition and the existing school should be sufficient to allow differential movements between the two foundation systems.

7.4 Ancillary Structures – Boiler Building

We recommend that ancillary structures with loads similar to the school expansion pile loads, such as the boiler building, be constructed using the same foundation system as the proposed school addition. We should coordinate with the structural engineer regarding pile geometry and embedment depth(s) as final axial and lateral design loads for the ancillary structures are developed.

8.0 RECOMMENDATIONS

The following section discusses our geotechnical recommendations for the proposed addition. The following geotechnical recommendations should also be used to found the boiler building and other ancillary structures. Foundation recommendations for the bulk fuel facility and water tank will be presented as an addendum to this report when civil and structural engineering loads are determined. Recommendations for the proposed teacher housing were provided as a previous submittal and are presented in Appendix D.

8.1 Proposed Addition

The following discussion presents the foundation recommendations for the proposed school addition. As discussed in the previous section, we recommend the school addition be founded on driven H-piles with passive subgrade cooling.

8.1.1 Foundation Loads

Foundation loads per pile for the proposed school additions were not available at the time of our submittal. However, we have assumed loading conditions based on previous work completed for a school of similar size. The loads presented consist of total and sustained loading conditions. Total loading conditions consist of load combinations that include wind and seismic loading conditions. For geotechnical purposes, the sustained load consists of the dead load plus one-half the live load. The total and sustained structural loads assumed in our design are 50 and 30 kips, respectively. For lateral loading calculations, we have assumed a sustained lateral load of 5 kips applied 5 feet from ground surface.

The following foundation recommendations should be refined once detailed structural load information becomes available. Specifically, the pile embedment depths and internal pile stresses due to lateral loads should be confirmed.

8.1.2 Frost Uplift Forces

We have estimated the active layer to extend 4 feet bgs. The frost uplift force is calculated by multiplying the frost uplift pressure by the area of the pile within the active layer. The design frost uplift pressure used in our analysis is 30 pounds per square inch (psi). The area of the pile within the active layer is the circumscribed area (4 times the pile width) of the pile within the thickness of the active layer. The piles will need to resist the unfactored frost uplift forces presented by pile size in Table 3.

Table 3: Frost Uplift Forces

Pile Type	Frost Uplift Force
HP 12x74	70 kips
HP 14x89	82 kips

8.1.3 Design Soil Profile

Soil conditions are generally consistent among the boreholes advanced at the site. The following idealized soil profile was used as a basis for the design of the proposed addition foundation. Soil strength properties used in our axial analyses are summarized in Table 4. Moisture contents are averages of laboratory testing results. Dry unit weights were calculated from moisture content and an assumed saturated state. Friction angle and cohesion values were based on typical values for similar soils and our engineering judgment. For the purposes of our analysis, groundwater was assumed at the ground surface.

Table 4: Design Soil Profile

Depth of Layer	Soil Type	Thermal State	Moisture Content	Dry Unit Weight	Effective Unit Weight	Friction Angle	Cohesion
0 – 4 ft	Pt/OL	Active Layer	120%	40 pcf	26 pcf	-	70 psf
4 – 15 ft	ML	Mixed	40%	80 pcf	50 pcf	22°	-
15 – 50 ft	SP-SM	Mixed, frozen below 33 ft	20%	100 pcf	58 pcf	35°	-

Notes: 1) Active layer extends to 4 feet.
2) pcf = pounds per cubic foot
3) psf = pounds per square foot

The idealized soil profile has varied thermal states throughout the site. In boreholes where a talik was observed, the depth to permafrost ranged from 6 to 33 feet bgs. For the purposes of our analysis, we have assumed that the soils at the site below a depth of 33 feet are permanently frozen.

8.1.4 Axial Capacity

Due to the mixed thermal state across the site, we have modeled the axial capacity of the driven piles assuming unfrozen soil conditions. The skin friction of the soils below the active layer will provide uplift resistance against frost forces. Where frozen soil exists along the pile length, the adfreeze bond along pile sidewall may be present; however, the adfreeze bond will be larger than the frictional capacity. Assuming an unfrozen soil profile is considered conservative provided existing frozen layers remain frozen.

We calculated the pile capacity using the computer program A-Pile (Ensoft, 2007) and capacities are based on Federal Highway Administration (FHWA) calculation methods. The capacities were verified using Naval Facilities Engineering Command Design Manual 7 (NAVFAC DM7) methods. A factor of safety of 1.5 was used to calculate the frost uplift resistance. A factor of safety of 2 and 3 were used for total and sustained loading conditions, respectively.

Based on these analyses, we determined the required minimum pile embedment based on pile size, presented in Table 5. We have assumed a single pile acting without group interaction effects. If pile groups are required, we should be contacted to review our axial capacity calculations. At a minimum, the piles should be spaced at a distance equal to or greater than 3 times the maximum width of the pile.

Table 5: Minimum Pile Embedment

Pile Type	Minimum Embedment
HP 12x74	55 ft
HP 14x89	50 ft

8.1.5 Lateral Pile Resistance

Due to the mixed thermal state of the site and the potential for lateral creep with sustained lateral loads in permafrost soils, frozen and unfrozen soil conditions were used. For the frozen soil condition, an active layer thickness of 4 feet bgs was used with underlying permafrost temperatures at a constant 31.8°F. Both analyses were completed for end-of-summer thermal conditions. Frozen and unfrozen lateral design soil profiles are presented in Table 6.1 and 6.2, respectively.

Table 6.1: Frozen Lateral Design Soil Profile

Depth of Layer	Soil Type	Thermal State	Moisture Content	Dry Unit Weight	Effective Unit Weight	Friction Angle	Cohesion	K^1	E_{50}^2
0 – 4 ft	Pt/OL	Unfrozen	120%	40 pcf	26 pcf	-	70 psf		0.01
4 – 15 ft	ML	Frozen	40%	80 pcf	112 pcf	22°		1000 pci	
15 – 50 ft	SP-SM	Frozen	20%	100 pcf	120 pcf	35°	-	1000 pci	

Notes: 1) K = Modulus of subgrade reaction
2) E_{50} = Strain at 50% of maximum stress
3) pci = psi per inch

Table 6.2: Unfrozen Lateral Design Soil Profile

Depth of Layer	Soil Type	Thermal State	Moisture Content	Dry Unit Weight	Effective Unit Weight	Friction Angle	Cohesion	K^1	E_{50}^2
0 – 4 ft	Pt/OL	Unfrozen	120%	40 pcf	26 pcf	-	70 psf		0.01
4 – 15 ft	ML	Unfrozen	40%	80 pcf	50 pcf	22°	-	30 pci	
15 – 33 ft	SP-SM	Unfrozen	20%	100 pcf	58 pcf	35°	-	90 pci	
33 – 50 ft	SP-SM	Frozen	20%	100 pcf	120 pcf	35°		1000 pci	

Notes: 1) K = Modulus of subgrade reaction
2) E_{50} = Strain at 50% of maximum stress
3) pci = psi per inch

Modulus of subgrade reaction (K) and strain at 50 percent of maximum stress (E_{50}) were based on engineering judgment and published values for similar soil types. A very stiff value of K (1000 psi per inch) was used for the permafrost soils in our analyses. Some additional lateral deformation will occur due to creep of the frozen soils, if sustained lateral loads are applied to the foundation piles embedded in near surface permafrost.

The lateral resistance of the piles was calculated using the software LPile (Ensoft, 2010), as a beam on an elastic foundation. In our analysis, we have assumed that a sustained lateral load of 5 kips is applied to the head of the pile at approximately 5 feet from ground surface. Free pile head conditions are assumed. Bending of the H-pile is presented for both the strong and weak axis. The estimated deflections are at the pile cap under sustained loading conditions. Since lateral loads will most likely be transient in nature, actual deflection will be less than then those estimated by sustained loads. However, internal stresses can be developed during short-term transient loading conditions.

The internal stresses in the steel, due to the applied lateral load, for different pile geometries and frozen and unfrozen soil profiles are presented in Tables 7.1 and 7.2, respectively.

Table 7.1: Frozen Lateral Loading Stresses

Pile Type	Bending Axis	Section Area	Area Moment of Inertia	Free Head Condition		
				Deflection	Shear	Moment
HP 12x74	Weak	21.8 in^2	186 in^4	2.0 in	8.1 kips	50.3 kip-ft
HP 14x89	Weak	26.1 in^2	326 in^4	1.3 in	7.9 kips	51.9 kip-ft
HP 12x74	Strong	21.8 in^2	570 in^4	0.9 in	7.6 kips	53.6 kip-ft
HP 14x89	Strong	26.1 in^2	904 in^4	0.6 in	7.6 kips	55.0 kip-ft

Note: 1) The pile deflection discussed above is located at the pile head for a 5 kip sustained load applied 5 feet above ground surface.

Table 7.2: Unfrozen Lateral Loading Stresses

Pile Type	Bending Axis	Section Area	Area Moment of Inertia	Free Head Condition		
				Deflection	Shear	Moment
HP 12x74	Weak	21.8 in^2	186 in^4	2.4 in	7.1 kips	50.9 kip-ft
HP 14x89	Weak	26.1 in^2	326 in^4	1.6 in	6.9 kips	52.2 kip-ft
HP 12x74	Strong	21.8 in^2	570 in^4	1.0 in	6.5 kips	54.2 kip-ft
HP 14x89	Strong	26.1 in^2	904 in^4	0.8 in	6.5 kips	56.0 kip-ft

Note: 1) The pile deflection discussed above is located at the pile head for a 5 kip sustained load applied 5 feet above ground surface.

The deflections and internal pile stresses presented above were based on specific loading conditions. If loading geometry or applied load differs from the assumed conditions, pile stresses and deflections may differ from those presented.

If lateral bracing is required, it should be designed by the project structural engineer and should be located at least 6 inches from finish grade, to allow for frost related ground movement. Golder should be contacted if lateral bracing is to be attached to the pile below this level.

8.1.6 Passive Cooling

As discussed previously, passive cooling is recommended to prevent additional thaw of the permafrost soils to reduce the thaw settlements and development of down-drag loads on the piles. The amount of heat removed by the thermosyphons each winter should be greater than the heat transferred into the ground during the summer months.

The thermosyphons should be AFI thermosyphons embedded 23 feet bgs. The condenser fins of the thermosyphons should be exposed to ambient air temperatures or wind during the winter months for efficient cooling of the subsurface. Thus, the thermosyphons condensers should be placed and angled on the pile in a manner that allows the condensers to be mounted to the underside of the structure and exposed to the air and wind within the clear space. The condensers should not be located in a region of the structure where beams or other structural members will block the wind from cooling the condensers.

The thermosyphons should be installed along each pile or within 2 feet of each pile if pile groups are planned. They can be installed either in a void created by attaching angle iron to each pile or similar carrier system, or within a predrilled borehole adjacent to each pile. The diameter of the thermosyphon, the condenser size and installation procedure should be as recommended by AFI. We should be notified if our recommendations conflict with those recommended by the manufacturer to adjust our recommendations or discuss the variations.

In order to maintain the thermal state of the soils underlying the site, a minimum 3–foot clear space should be maintained between the ground surface and base of structural supports. The blow through space should be at a similar elevation to that of the existing school and designed to avoid snow drifting. If a 3-foot clear space cannot be achieved, we should be notified to verify or modify our recommendations.

Installation methods for the thermosyphons are discussed in the following section.

8.1.7 Ground Temperature Monitoring

To permit future ground temperature measurements, a closed-end 1-inch diameter Schedule 40 HDPE conduit should be installed along the length of the thermosyphon embedment and extend to two feet above finish grade. HDPE requires a thermal weld to securely close the tip. The conduit should be capped to prevent water infiltration. The temperatures along the piling can be monitored after construction using thermistors placed in the conduit.

Ground temperature monitoring of the foundation piles of the proposed addition should be used to determine a baseline for the addition following construction. If foundation movements are observed in the future, a ground temperature baseline is helpful in determining the cause of the movements.

Thermistors should be installed on the piles corner, a pile at the nominal building center, and along a pile underlying the structural separation between the existing school and the proposed addition. Thermal monitoring of the foundation piles at the proposed addition should be tied into a central location.

We can refine the ground temperature monitoring program as details of the project develop.

8.2 Addition Connection to Existing School

The thermal transition zone between the existing school and the proposed addition should be protected from warming thermal influence of the proposed addition. Passive cooling and insulation should be placed along the eastern wall of the existing school in this transition zone.

The horizontal spacing between the existing school and the proposed addition should be at least 10 feet to allow for differential movement and the transitional zone.

An AFI Flat Loop passive cooling system should be placed in a circumscribed loop around the piles on the eastern external wall of the existing school, the transitional zone between the proposed addition and the existing school. The Flat Loop system should be embedded 3 feet bgs and be placed approximately 1-foot from the outer edge of the piles. The condensers of approximately 170 sq-ft or as recommended by AFI should be installed such that the condenser is located within the prevailing wind, generally from the north in Quinhagak.

The Flat Loop system should be placed on one to three inches of a leveling course of saturated sand or sand slurry. The sand may be placed dry, the flat loop system installed and backfilled with sand slurry. Flat loop systems should be installed as recommended by AFI with the required specific quality control measures and construction procedures. If the systems are not properly installed, significant differential movements along the Flat Loop section may affect passive cooling efficiency.

Insulation should be placed in the fill above the flat loop system. Insulation should be placed above the Flat Loop system and extend 6 feet from the outer edge of the Flat Loop system on either side for a total of approximately 15 feet of insulation. After leveling the area, the 4 inches of insulation should be placed and covered with 12 inches of fill. The existing clear space between the base of the structure and the ground surface should be maintained. Insulation should have a compressive strength of 40 psi measured at 5 percent strain. Insulation should be placed such that the joints are staggered to reduce heat transfer along the insulation edges.

The project civil engineer should determine the side slope and transitional dimensions of the existing granular fill pad to the finish grade of the proposed school addition. However, for geotechnical purposes, we recommend compact granular fill final side slopes be 3H:1V (horizontal:vertical), of flatter. The site plan should prevent water and snow melt from collecting within this region and final grades should direct surface water away from the foundations. Roof drainages should also be armored at the pad grade to reduce erosion.

8.3 Seismic Design Criteria

This area is considered a relatively low seismic risk hazard. Based on site conditions observed and using historical geotechnical data, the area is considered to meet seismic site class “D” criteria as defined in the International Building Code 2009 (IBC) and US Geological Survey (USGS) databases. Seismic site class “D” is defined as “stiff soil profile” with an average Standard Penetration Test (SPT) “N” value between 15 and 50 in the upper 100 feet. The SPT data was not collected during our investigation; however, the subsurface soil and permafrost conditions meet the criteria for a stiff soil profile based on our engineering judgment.

The criteria are based on mapped spectral response acceleration for short periods (Ss) of 0.13g (Site Class “B”) and mapped spectral response accelerations for a 1-second period (S1) of 0.07g (Site Class “B”). Site coefficient factors Fa and Fv of 1.6 and 2.4, respectively, are considered appropriate to determine seismic characteristics for Site Class “D.” Based on these values, the design spectral response acceleration parameters for short period and 1-second period for Site Class “D” are 0.13g and 0.11g, respectively.

9.0 CONSTRUCTION CONSIDERATIONS

The following section discusses the constructability concerns for a driven pile with passive cooling foundation at the proposed addition site.

9.1 Site Preparation and Structural Fill

We understand that a granular fill roadway is planned for fire access around the proposed addition footprint. The roadway should be designed by the project civil engineer. Based on our geotechnical findings, the surface and surface soils within the zone of seasonal thaw should be considered compressible materials with varying amount of organics. Thus, a geotextile separation fabric should be placed between the existing tundra surface and the proposed granular fill prism. The geotextile should consist of a woven or non-woven geotextile separation fabric similar to Mirafi 500x.

Roadway fill may consist of locally obtained granular soils screened to a 3-inch minus gradation. The roadway fill should be placed in a non-frozen state in nominal 12-inch lifts, if heavy vibratory compaction equipment is used. The structural fill should be compacted to 95 percent maximum dry density as determined by the modified Proctor test (ASTM D-1557). Nominal 6-inch lifts are recommended if hand operated vibratory compaction equipment is used.

The roadway around the site should be designed to prevent the buildup of standing water in the area underlying the proposed addition footprint. Culverts should include armoring at the discharges. Culverts can impact the subsurface thermal regime thus rigid insulation should be considered under the culvert sections. We recommend coordinating with the project civil engineer on drainage culvert design once the culvert geometry and locations are determined.

Care should also be taken during construction the prevent damage to the minimize damage to the existing tundra surface. To protect the existing tundra, we have assumed construction activities will occur when the ground surface is frozen, mid to later winter. However, summer roadway fill placement may be conducted provided construction practices do not damage the tundra surface.

The surface and near surface organics will consolidate as the fill is placed. Based on our geotechnical findings, organic soils should be expected to 3 to5 feet below grade. We do not recommended removal of the organic soil prior to fill placement. However, depending on organic content, consolidation of up to 50-percent of the initial organic thickness should be expected. The organics will typically experience about one-half their total settlement during the initial summer thaw period after fill placement, but continued settlement should be expected, often differentially. The Owner should consider an annual maintenance program to re-grade the roadway fill prism to account for settlement.

9.2 Driven Pile Installation

Piles should be driven and plumb to within 1/8-inch per foot, unless specified otherwise by the structural engineer. Piles should be within 3 inches of the design locations. Other issues to consider are discussed below.

- **Driving Shoe:** A driving shoe may be used to strengthen and protect the H-pile section during installation.
- **Hammer/Pile System Acceptance and Driving Criteria:** The installation hammer selected should be sized to achieve the minimum embedment without damaging the pile. Compressive driving stresses should not exceed 90 percent of the steel yield strength. A maximum blow count for the particular pile and hammer sizes should be determined prior to starting work. We can provide further guidance and driving criteria once a pile size and an installation hammer have been selected by the design team and contractor, respectively.
- **Frozen Soil Conditions:** The contractor should be aware that frozen soils from seasonal frost and permafrost will be encountered on site. Pile driving equipment should be capable of pile installation through frost or surface and deep permafrost and provisions for pre-drilling or spudding should be included.
- **Pile Installation Inspection:** We recommend that a qualified technician or engineer be present during production driving and that complete driving logs be maintained. Complete logs should include installation blows per foot, hammer type and size, date and time of installation, hammer stroke and hammer setting. In addition, we recommend that we be given the opportunity to review the plans and specifications, prior to bidding to verify that they are in accordance with our recommendations, and the as-built records, to validate that the piles were installed in a manner consistent with our recommendations.
- **Pile Integrity Determination:** Pile Dynamic Analyzer (PDA) testing can be used to conduct real-time analyses, during installation activities, to determine if the piles were installed without damage. If PDA testing is used on the first few piles installed, the PDA testing results can be used to calibrate and verify pile installation criteria.
- **Construction Schedule:** Pile driving equipment will be utilized on this project. Consideration should be given to construction nuisances such as noise and vibrations, which may disturb the school environment.

9.3 Thermosyphon and Ground Temperature Monitoring Conduit Installation

If driven H-Pile are used, we recommend that the thermosyphons and ground temperature monitoring conduit be inserted into the voids created by welding two angle iron or steel conduit sections on either side of the web of the H-Pile section. The angle iron should be 3-inch-by-3-inch or larger and welded to the flange of the H-pile or as recommended by the project structural engineer. The steel conduit should be 1.5 to 2-inch diameter, depending on the size needed for the thermosyphons and welded to the web-flange connection of the H-pile or as recommended by the project structural engineer. The angle iron or conduit should be attached to the pile in a manner designed by the project structural engineer to resist forces during pile installation. The annulus of the angle iron or conduit should be backfilled with grout to provide a thermal connection between the thermosyphon and the ground surface.

10.0 USE OF THIS REPORT

This report has been prepared exclusively for the use of USKH for use in design of the proposed school addition in Quinhagak, Alaska. If there are significant changes in the nature, design, or location of the facilities, we should be notified so that we may review our conclusions and recommendations in light of the proposed changes and provide a written modification or verification of the changes.

There are possible variations in subsurface conditions between explorations and also with time. Therefore, inspection and testing by a qualified geotechnical engineer should be included during construction to provide corrective recommendations adapted to the conditions revealed during the work. In addition, a contingency for unanticipated conditions should be included in the construction budget and schedule.

The work program followed the standard of care expected of professionals undertaking similar work in the State of Alaska under similar conditions. No warranty expressed or implied is made.

GOLDER ASSOCIATES INC.

Heather Brooks

Heather M. Brooks, PE
Project Engineer

Richard A. Mitchells, PE
Associate and Senior Geotechnical Engineer

HMB/RAM/mlp

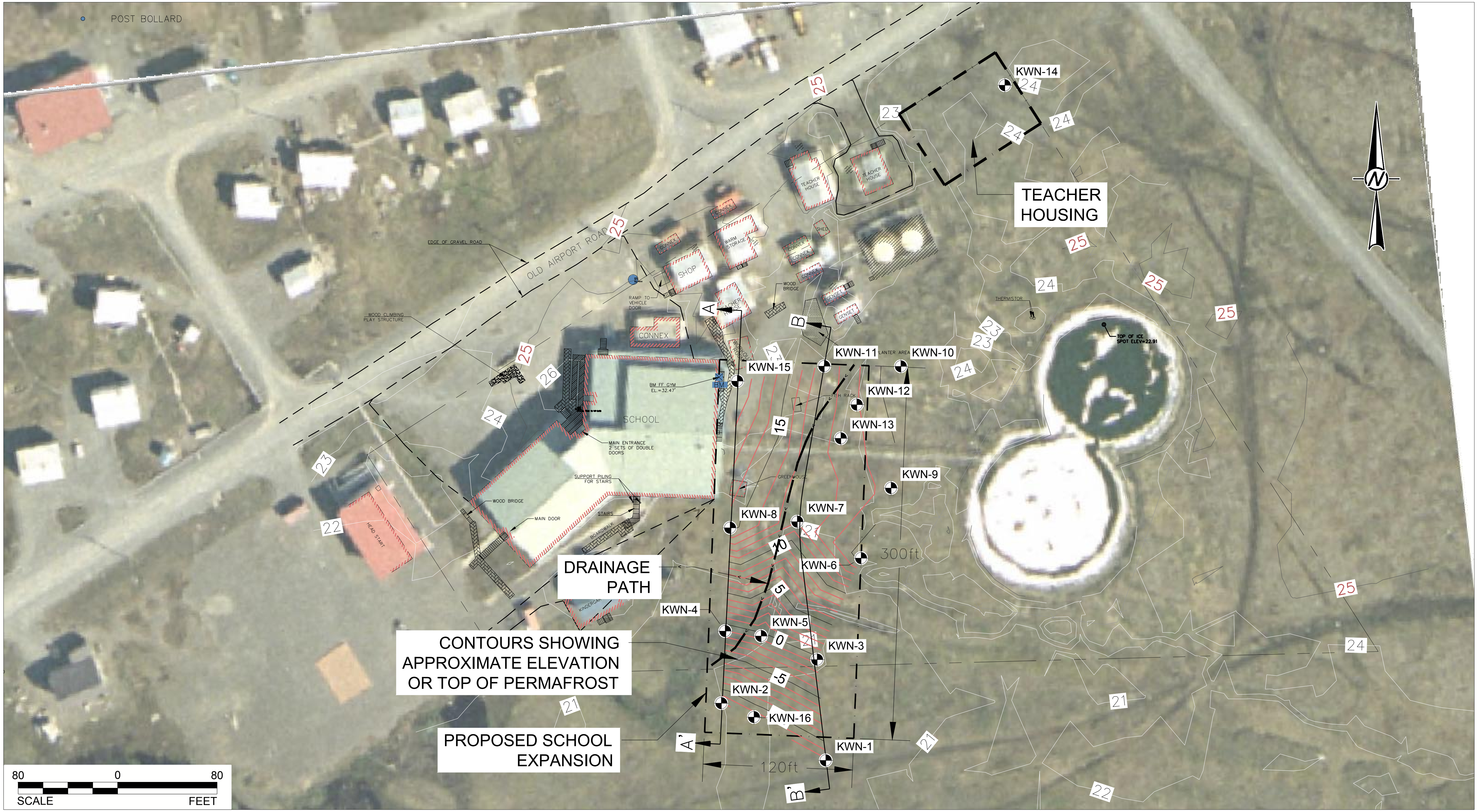
11.0 REFERENCES

Jorgenson, et al. (2008). Permafrost Characteristics of Alaska. Proceedings of the Ninth International Permafrost Conference, Fairbanks, Alaska. In Press.

PRISM Climate Group (2004). Oregon State University, http://prism.oregonstate.edu/. February 2004.

Rupp, S., Duffy. P., Olson, M., Springsteen, A., Schmidt, J., and Fresco, N. (2009). Scenarios Network for Alaska Planning. University of Alaska Fairbanks. http://snap.uaf.edu/. Accessed May 2011.

FIGURES



LEGEND

BH-1	GOLDER BOREHOLE NAME AND APPROXIMATE LOCATION

REFERENCES

1.) BASEMAP DRAWING PROVIDED BY USKH ON 2/6/2012. PROJECT NAME: QUINHAGAK SCHOOL SURVEY PERFORMED BY USKH 11/2011 THROUGH 12/2011. GROUND SURFACE ELEVATIONS FROM USKH TIN.
2.) AERIAL IMAGERY DATED JULY 27, 2007 AND PROVIDED BY ALASKA DEPARTMENT OF COMMUNITY AND REGIONAL AFFAIRS.

Golder Associates

SCALE	AS SHOWN		
DESIGN	----	----	
CADD	APG	6/19/12	
CHECK	HMB	6/19/12	
REVIEW	RAM	6/19/12	
REV.	1	6/19/12	

FILE No. Quinhagak_sitemap.dwg
PROJECT No. 113-95736

TITLE

BOREHOLE LOCATION MAP
QUINHAGAK SCHOOL EXPANSION
QUINHAGAK SCHOOL EXPANSION , ALASKA

USKH / QUINHAGAK SCHOOL / AK

FIG. 1

J:\2011 Jobs\113-95736 USKH Quinhagak School Expansion\CADD\Quinhagak_sitemap.dwg | 6/20/2012 9:57 AM | AGarrigus | ALASKA

J:\2011 Jobs\113-95736 USKH Quinhagak School Expansion\CADD\Quinhagak_sitemap.dwg | 6/20/2012 10:01 AM | AGarrigus | ALASKA

LEGEND

⊕	BH-1	GOLDER BOREHOLE NAME AND APPROXIMATE LOCATION

Golder Associates

SCALE	AS SHOWN	
DESIGN	----	----
CADD	APG	6/19/12
CHECK	HMB	6/19/12
REVIEW	RAM	6/19/12
REV.	1	6/19/12

FILE No. Quinhagak_sitemap.dwg

PROJECT No. 113-95736

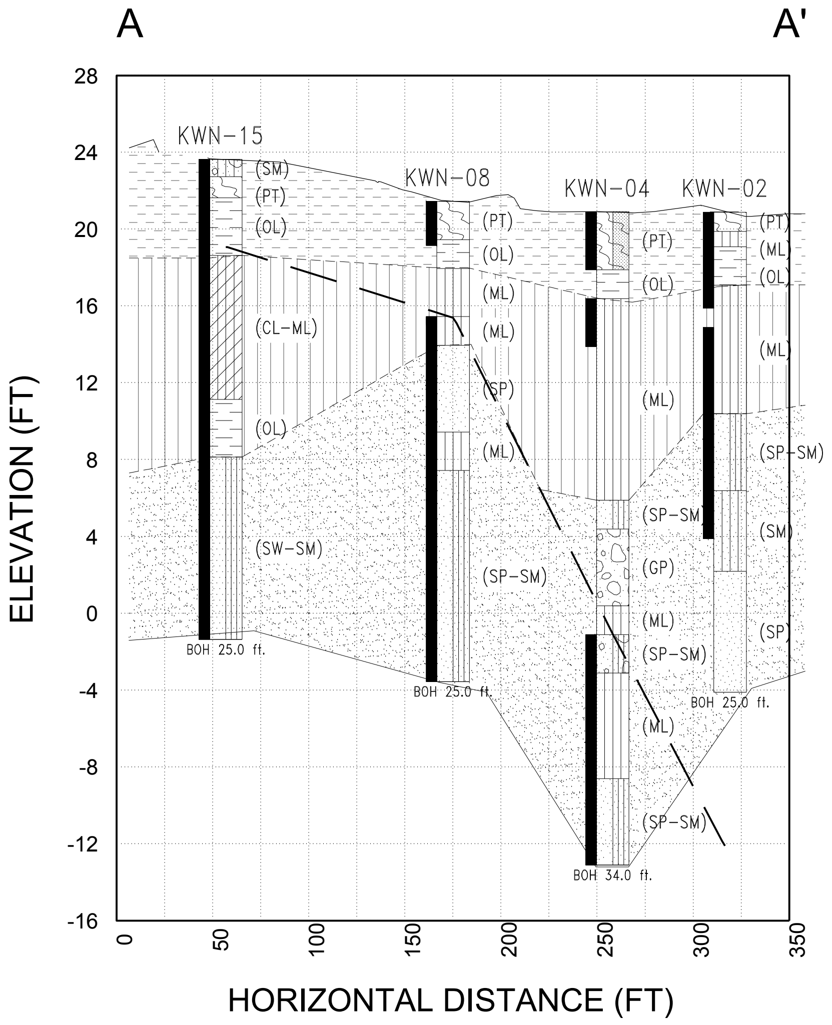
TITLE

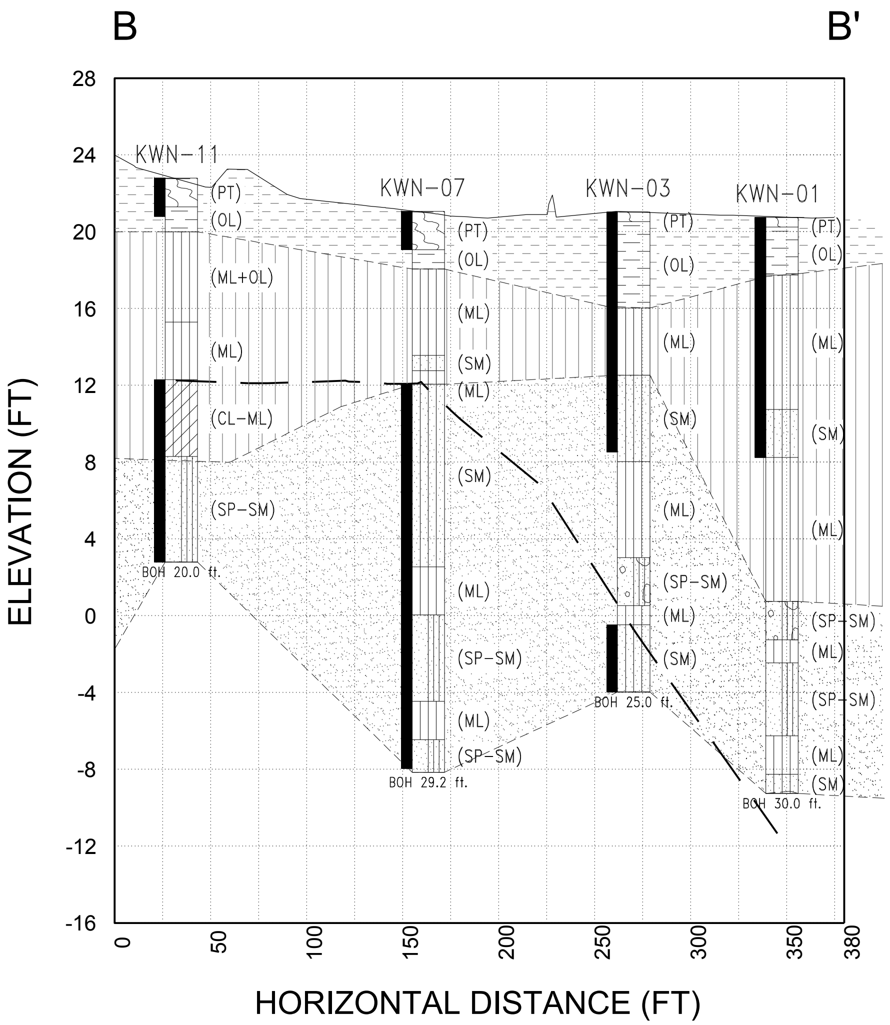
PERMAFROST CONTOUR MAP

QUINHAGAK SCHOOL EXPANSION
QUINHAGAK SCHOOL EXPANSION , ALASKA

USKH / QUINHAGAK SCHOOL / AK

FIG. 2





LEGEND

— — — INFERRED TOP OF PERMAFROST

▤ ORGANIC MATERIALS

▥ FINE GRAINED MATERIALS

▒ GRANULAR MATERIALS

HORIZONTAL SCALE

100 0 100

SCALE FEET

VERTICAL SCALE (10 X EXAGGERATION)

10 0 10

SCALE FEET

Golder Associates

SCALE	AS SHOWN	
DESIGN	----	----
CADD	APG	6/19/12
CHECK	HMB	6/19/12
REVIEW	RAM	6/19/12
REV.	1	6/19/12

FILE No. Quinhagak_sitemap.dwg

PROJECT No. 113-95736

TITLE

CROSS SECTIONS

QUINHAGAK SCHOOL EXPANSION
QUINHAGAK SCHOOL EXPANSION , ALASKA

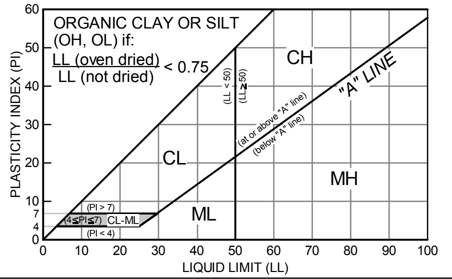
USKH / QUINHAGAK SCHOOL / AK

FIG. 3

J:\2011 Jobs\113-95736 USKH Quinhagak School Expansion\CADD\Quinhagak_sitemap.dwg | 6/20/2012 10:02 AM | AGarrigus | ALASKA

APPENDIX A
BOREHOLE LOGS

UNIFIED SOIL CLASSIFICATION (adapted from ASTM D2487)

MATERIAL TYPES	CRITERIA FOR ASSIGNING SOIL GROUP NAMES AND GROUP SYMBOLS USING LABORATORY TESTS			GROUP SYMBOL	SOIL GROUP NAMES & LEGEND		
COARSE-GRAINED SOILS >50% RETAINED ON NO. 200 SIEVE	GRAVELS >50% OF COARSE FRACTION RETAINED ON NO 4. SIEVE	CLEAN GRAVELS <5% FINES	$C_U \geq 4$ AND $1 \leq C_C \leq 3$	GW	WELL-GRADED GRAVEL	○	If soil contains ≥15% sand, add "with sand"
			$C_U < 4$ AND/OR $[C_C < 1$ OR $C_C > 3]$	GP	POORLY GRADED GRAVEL	○	
		GRAVELS WITH FINES >12% FINES	FINES CLASSIFY AS ML OR MH	GM	SILTY GRAVEL	○	
			FINES CLASSIFY AS CL OR CH	GC	CLAYEY GRAVEL	▨	
	SANDS ≥50% OF COARSE FRACTION PASSES ON NO 4. SIEVE	CLEAN SANDS <5% FINES	$C_U \geq 6$ AND $1 \leq C_C \leq 3$	SW	WELL-GRADED SAND	⁘	If soil contains ≥15% gravel, add "with gravel"
			$C_U < 6$ AND/OR $[C_C < 1$ OR $C_C > 3]$	SP	POORLY GRADED SAND	⁘	
		SANDS AND FINES >12% FINES	FINES CLASSIFY AS ML OR MH	SM	SILTY SAND	▥	
			FINES CLASSIFY AS CL OR CH	SC	CLAYEY SAND	▨	
FINE-GRAINED SOILS >50% PASSES NO. 200 SIEVE	SILTS AND CLAYS LIQUID LIMIT <50	PLASTICITY CHART 		CL	LEAN CLAY	▨	If soil contains coarse-grained soil from 15% to 29%, add "with sand" or "with gravel" for whichever type is prominent, or for ≥30%, add "sandy" or "gravelly"
				ML	SILT	▥	
				OL	ORGANIC CLAY OR SILT	☰	
	SILTS AND CLAYS LIQUID LIMIT ≥50			CH	FAT CLAY	▨	
				MH	ELASTIC SILT	▥	
				OH	ORGANIC CLAY OR SILT	▨	
HIGHLY ORGANIC SOILS		PRIMARILY ORGANIC MATTER, DARK IN COLOR, AND ORGANIC ODOR		PT	PEAT	∿	

$$C_U = \frac{D_{60}}{D_{10}} \qquad C_C = \frac{(D_{30})^2}{D_{10} \times D_{60}}$$

NOTES:
Gravels or sands with 5% to 12% fines require dual symbols (GW-GM, GW-GC, GP-GM, GP-GC, SW-SM, SW-SC, SP-SM, SP-SC) and add "with clay" or "with silt" to group name. If fines classify as CL-ML for GM or SM, use dual symbol GC-GM or SC-SM. $D_{(X\%)}$ is soil particle diameter where X% is % finer. *Optional Abbeviations:* Lower case "s" after USCS group symbol denotes either "sandy" or "with sand" while "g" denotes either "gravelly" or "with gravel"

CRITERIA FOR DESCRIBING MOISTURE CONDITION
(adapted from ASTM D2488)

DRY	ABSENCE OF MOISTURE, DUSTY, DRY TO THE TOUCH
MOIST	DAMP BUT NO VISIBLE WATER
WET	VISIBLE FREE WATER, USUALLY SOIL IS BELOW WATER TABLE

COMPONENT DEFINITIONS BY GRADATION

COMPONENT	SIZE RANGE
BOULDERS	GREATER THAN 12 in.
COBBLES	12 in. to 3 in.
GRAVEL	3 in. to #4 Sieve (4.76 mm)
COARSE GRAVEL	3 in. to 3/4 in.
FINE GRAVEL	3/4 in. to #4 (4.76 mm)
SAND	#4 (4.76 mm) to #200 (0.074 mm)
COARSE SAND	#4 (4.76 mm) to #10 (2.0 mm)
MEDIUM SAND	#10 (2.0 mm) to #40 (0.42 mm)
FINE SAND	#40 (0.42 mm) to #200 (0.074 mm)
SILT AND CLAY	SMALLER THAN #200 (0.074 mm)
SILT	0.074 mm to 0.005 mm
CLAY	LESS THAN 0.005 mm

DESCRIPTIVE TERMINOLOGY FOR PERCENTAGES (ASTM D2488)

DESCRIPTIVE TERMS	RANGE OF PROPORTION
TRACE	0 - 5%
FEW	5 - 10%
LITTLE	10 - 25%
SOME	30 - 45%
MOSTLY	50 - 100%

RELATIVE DENSITY / CONSISTENCY ESTIMATE USING STANDARD PENETRATION TEST (SPT) VALUES
(adapted from Terzaghi and Peck 1967)

COHESIONLESS SOILS (a)		COHESIVE SOILS(b)		
RELATIVE DENSITY	$(N_1)_{60}$ (blows/ft)(c)	CONSISTENCY	$(N_1)_{60}$ (blows/ft)(c)	UNCONFINED COMPRESSIVE STRENGTH (TSF)(d)
VERY LOOSE	0 - 4	VERY SOFT	0 - 2	0 - 0.25
LOOSE	4 - 10	SOFT	2 - 4	0.25 - 0.50
COMPACT	10 - 30	FIRM	4 - 8	0.50 - 1.0
DENSE	30 - 50	STIFF	8 - 15	1.0 - 2.0
VERY DENSE	OVER 50	VERY STIFF	15 - 30	2.0 - 4.0
		HARD	OVER 30	OVER 4.0

(a) Soils consisting of gravel, sand, and silt, either separately or in combination possessing no characteristics of plasticity, and exhibiting drained behavior.
(b) Soils possessing the characteristics of plasticity, and exhibiting undrained behavior.
(c) Refer to ASTM D1586 for a definition of N value. $(N_1)_{60}$ is the N value corrected for hammer energy and overburden pressure, and is detailed in ASTM D6066. N values may be affected by a number of factors including: material size, sampler size, hammer weight and type, depth, drilling method, and borehole disturbance. **N values are only an approximate guide for frozen soil or cohesive soil.**
(d) Undrained shear strength, s_u= 1/2 unconfined compression strength, U_c. Note that Torvane (TV) measures s_u and pocket penetrometer (PP) measures U_c

SAMPLER ABBREVIATIONS

SS	SPT Sampler (2 in. OD, 140 lb hammer)	**C**	Core (Rock)
SSO	Oversize Split Spoon (2.5 in. OD, 140 lb typ.)	**TW**	Thin Wall (Shelby Tube)
HD	Heavy Duty Split Spoon (3 in. OD, 340 lb typ.)	**MS**	Modified Shelby
-BL	Brass Liners used in Split Spoon	**GP**	Geoprobe
BD	Bulk Drive (4 in. OD, 340 lb hammer typ.)	**RC**	Air Rotary Cuttings
CA	Continous Core (Soil in Hollow-Stem Auger)	**AG**	Auger Cuttings
GS	Grab Sample from Surface / Testpit		

LABORATORY TEST ABBREVIATIONS

Con	Consolidation	**P200**	Percent Fines (Silt & Clay)	**SpG**	Specific Gravity
Comp	Proctor Compaction (D698/D1557)	**pH**	Soil pH	**TC**	Thaw Consolidation/Strain
Dd	Dry Density	**PID**	Photoionization Detector	**TV**	Torvane
K	Thermal Conductivity	**PM**	Modified Proctor	**TX**	Unconfined Compression
MA	Sieve and Hydrometer Analysis	**PP**	Pocket Penetrometer	**W_C**	Liquid Limit (LL)
NP	Non-plastic	**PTLD**	Point Load	**W_P**	Plastic Limit (PL)
OLI	Organic Loss	**SA**	Sieve Analysis	**Ω**	Soil Resistivity

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SOIL CLASSIFICATION / LEGEND

Figure
A-1

FROZEN SOIL CLASSIFICATION (ASTM D4083)

1. DESCRIBE SOIL INDEPENDENT OF FROZEN STATE	CLASSIFY SOIL BY THE UNIFIED SOIL CLASSIFICATION SYSTEM				
2. MODIFY SOIL DESCRIPTION BY DESCRIPTION OF FROZEN SOIL	MAJOR GROUP		SUBGROUP		
	DESCRIPTION	DESIGNATION	DESCRIPTION		DESIGNATION
	Segregated ice not visible by eye	N	Poorly bonded of friable		Nf
			Well bonded	No excess ice	Nbn
				Excess ice	Nbe
	Segregated ice visible by eye (ice less than 25 mm thick)	V	Individual ice crystals or inclusions		Vx
			Ice coatings on particles		Vc
			Random or irregularly oriented ice formations		Vr
			Stratified or distincltly oriented ice formations		Vs
			Uniformly distributed ice		Vu
3. MODIFY SOIL DESCRIPTION BY DESCRIPTION OF SUBSTANTIAL ICE STRATA	Ice greater than 25 mm thick	ICE	Ice with soil inclusions		ICE+soil type
			Ice without soil inclusions		ICE

FROST DESIGN SOIL CLASSIFICATION (1)

FROST GROUP(2)	GENERAL SOIL TYPE	% FINER THAN 0.02 mm BY WEIGHT	TYPICAL USCS SOIL CLASS
NFS(3) [MOA NFS]	(a) Gravels Crushed stone Crushed rock	0 to 1.5	GW, GP
	(b) Sands	0 to 3	SW, SP
PFS(4) [MOA NFS]	(a) Gravels Crushed stone Crushed rock	1.5 to 3	GW, GP
[MOA F2]	(b) Sands	3 to 10	SW, SP
S1 [MOA F1]	Gravelly soils	3 to 6	GW, GP GW-GM, GP-GM, GW-GC, GP-GC
S2 [MOA F2]	Sandy soils	3 to 6	SW, SP SW-SM, SP-SM, SW-SC, SP-SC
F1 [MOA F1]	Gravelly soils	6 to 10	GM, GC, GM-GC, GW-GM, GP-GM, GW-GC, GP-GC
F2 [MOA F2]	(a) Gravelly soils	10 to 20	GW, GP GW-GM, GP-GM, GW-GC, GP-GC
	(b) Sands	6 to 15	SM, SW-SM, SP-SM, SC, SW-SC, SP-SC, SM-SC
F3 [MOA F3]	(a) Gravelly soils	Over 20	GM, GC, GM-GC
	(b) Sands, except very fine silty sands	Over 15	SM, SC, SM-SC
	(c) Clays, PI>12	--	CL, CH
F4 [MOA F4]	(a) Silts	--	ML, MH, ML-CL
	(b) Very fine silty sands	Over 15	SM, SC, SM-SC
	(c) Clays, PI<12	--	CL, ML-CL
	(d) Varved clays or other fine-grained banded sediments	--	CL or CH layered with ML, MH, ML-CL, SM, SC, or SM-SC

(1) From U.S. Army Corps of Engineers (USACE), EM 1110-3-138, "Pavement Criteria for Seasonal Frost Conditions," April 1984
(2) USACE frost groups directly correspond to frost groups listed in Municipality of Anchorage (MOA) design criteria manual (DCM), 2007; except as noted.
(3) Non-frost susceptible
(4) Possibly frost susceptible, requires lab test for void ratio to determine frost design soil classification. Gravel with void ratio > 0.25 would be NFS; Gravel with void ratio < 0.25 would be S1; Sands with void ratio > 0.30 would be NFS; Sands with void ratio < 0.30 would be S2 or F2

ICE BONDING SYMBOLS

☐	No ice-bonded soil observed
▤	Poorly bonded or friable
■	Well bonded

DEFINITIONS

Candled Ice is ice which has rotted or otherwise formed into long columnar crystals, very loosely bonded together.

Clear Ice is transparent and contains only a moderate number of air bubbles.

Cloudy Ice is translucent, but essentially sound and non-pervious

Friable denotes a condition in which material is easily broken up under light to moderate pressure.

Granular Ice is composed of coarse, more or less equidimensional, ice crystals weakly bonded together.

Ice Coatings on particles are discernible layers of ice found on or below the larger soil particles in a frozen soil mass. They are sometimes associated with hoarfrost crystals, which have grown into voids produced by the freezing action.

Ice Crystal is a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in a combination with other ice formations.

Ice Lenses are lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss and commonly in repeated layers.

Ice Segregation is the growth of ice as distinct lenses, layers, veins and masses in soils, commonly but not always oriented normal to direction of heat loss.

Massive Ice is a large mass of ice, typically nearly pure and relatively homogeneous.

Poorly-bonded signifies that the soil particles are weakly held together by the ice and that the frozen soil consequently has poor resistance to chipping or breaking.

Porous Ice contains numerous voids, usually interconnected and usually resulting from melting at air bubbles or along crystal interfaces from presence of salt or other materials in the water, or from the freezing of saturated snow. Though porous, the mass retains its structural unity.

Thaw-Stable frozen soils do not, on thawing, show loss of strength below normal, long-time thawed values nor produce detrimental settlement.

Thaw-Unstable frozen soils show on thawing, significant loss of strength below normal, long-time thawed values and/or significant settlement, as a direct result of the melting of the excess ice in the soil.

Well-Bonded signifies that the soil particles are strongly held together by the ice and that the frozen soil possesses relatively high resistance to chipping or breaking.

Golder Associates

FROZEN SOIL CLASSIFICATION / LEGEND

Figure
A-2

RECORD OF BOREHOLE KWN-01

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/10/12
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75100° N 161.89647° W

SOIL PROFILE

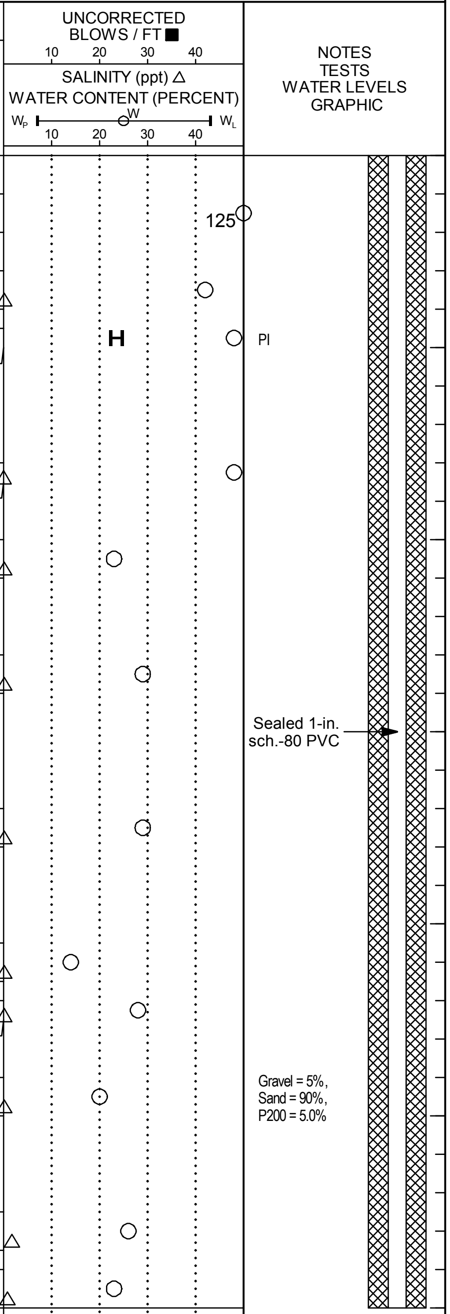
DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 0.5 Frozen, dark brown, fibrous PEAT, well bonded (PT)	PT	
0.5 - 3.0 Frozen, brown, ORGANIC SILT, few fibrous organic material, well bonded with approximately 10-15% visible ice by volume as individual ice crystals and irregularly oriented ice formations (OL, Vx-Vr)	OL	0.5
3.0 - 10.0 Frozen, gray, SILT, low plasticity, well bonded with approximately 10-30% visible ice by volume as individual ice crystals and irregularly oriented ice formations (ML, Vx-Vr)	ML	3.0
10.0 - 12.5 Frozen, gray, SILTY SAND, fine to coarse-grained sand, few silt inclusions, well bonded with approximately 10% visible ice by volume as individual ice crystals (SM, Vx)	SM	10.0
12.5 - 20.0 Moist to wet, SILT, low plasticity (ML)	ML	12.5
20.0 - 22.0 Wet, gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little subrounded gravel up to 1/2- inch diameter (SP-SM)	SP-SM	20.0
22.0 - 23.2 Wet, gray, SILT, nonplastic (ML)	ML	22.0
23.2 - 27.0 Wet, gray, poorly graded SAND with silt, fine to medium-grained sand (SP-SM)	SP-SM	23.2
27.0 - 29.0 Moist to wet, SILT with sand, few fine to medium-grained sand interbeds (ML)	ML	27.0
29.0 - 30.0 Moist to wet, gray-brown, SILTY SAND, fine to medium-grained sand, few silt inclusions (SM)	SM	29.0

Borehole completed at 30.0 ft.

Notes:
1) Borehole completed on 2/10/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 30 feet

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)
1	GP		12/12
2	GP		2/12
3	GP		6/6
4	GP		6/6
5	GP		12/12
6	GP		12/12
7	GP		12/12
8	GP		12/12
9	GP		6/6
10	GP		12/12
11	GP		12/12
12	GP		12/12



PI

Sealed 1-in. sch.-80 PVC

Gravel = 5%,
Sand = 90%,
P200 = 5.0%

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-3

RECORD OF BOREHOLE KWN-02

SHEET 1 of 1

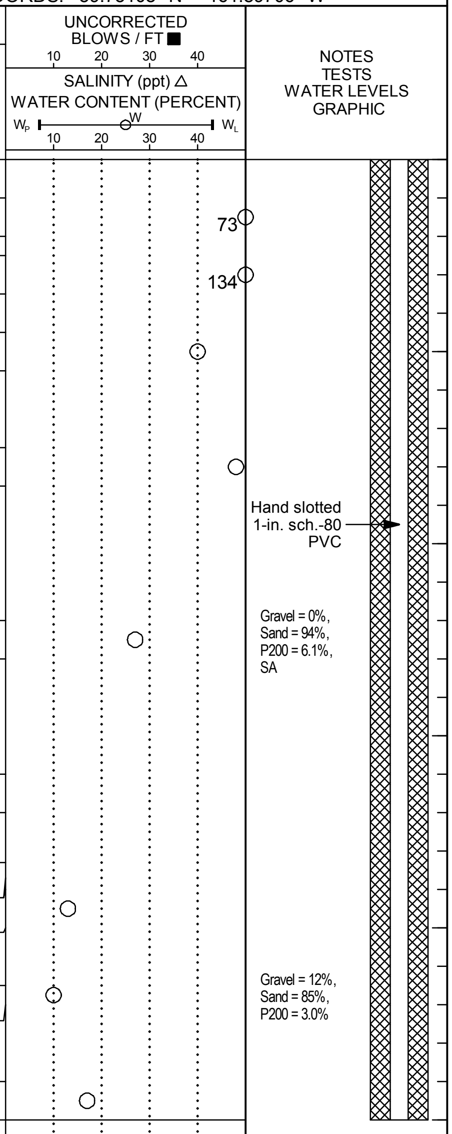
PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/10/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75108° N 161.89706° W

DEPTH (ft)	SOIL PROFILE DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0	0.0 - 1.0 Brown, PEAT, well bonded (PT)	PT	
	1.0 - 1.8 Frozen, gray-brown, SILT, low, well bonded with approximately 10% visible ice by volume as individual ice crystals and irregularly oriented ice formations (ML, Vx-Vr)	ML	1.0
	1.8 - 3.8 Frozen, brown, ORGANIC SILT, well bonded with approximately 10% visible ice by volume as individual ice crystals and irregularly oriented ice formations (OL, Vx-Vr)	OL	1.8
5	3.8 - 10.5 Frozen, gray, SILT, low to medium plasticity, 40-45% visible ice below 6 feet as stratified or distinctly oriented and irreguIary oriented ice formations, well bonded with approximately 10-15% visible ice by volume as individual ice crystals and irregularly oriented ice formations (ML, Vx-Vr)	ML	3.8
10	10.5 - 14.5 Frozen, gray, poorly graded SAND with silt, fine to medium-grained sand, well bonded with approximately 5% visible ice by volume as individual ice crystals (SP-SM, Vx)	SP-SM	10.5
15	14.5 - 18.7 Frozen, gray, SILTY SAND, fine to medium-grained sand, few silt inclusions, well bonded with approximately 5% visible ice by volume as individual ice crystals (SM, Vx) Organic silt (OL) was observed at 18.3 feet with few subrounded gravel up to 1/2- inch diameter	SM	14.5
20	18.7 - 25.0 Wet, gray, poorly graded SAND, fine to coarse-grained sand, little subrounded gravel up to 1/2- inch diameter (SP) Increased silt content noted at 22.5 feet	SP	18.7
25	Borehole completed at 25.0 ft.		

SAMPLES NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)
1	GP		12 / 12
2	GP		12 / 12
3	GP		12 / 12
4	GP		12 / 12
5	GP		12 / 12
6	GP		12 / 12
7	GP		5 / 5
8	GP		12 / 12
9	GP		6 / 6
10	GP		12 / 12



Gravel = 0%,
Sand = 94%,
P200 = 6.1%,
SA

Gravel = 12%,
Sand = 85%,
P200 = 3.0%

Notes:
1) Borehole completed on 2/10/2012
2) Borehole backfilled with thawed cuttings
3) Hand slotted 1-inch, schedule-80 PVC installed to 21 feet

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure
A-4

RECORD OF BOREHOLE KWN-03

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/10/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75119° N 161.89656° W

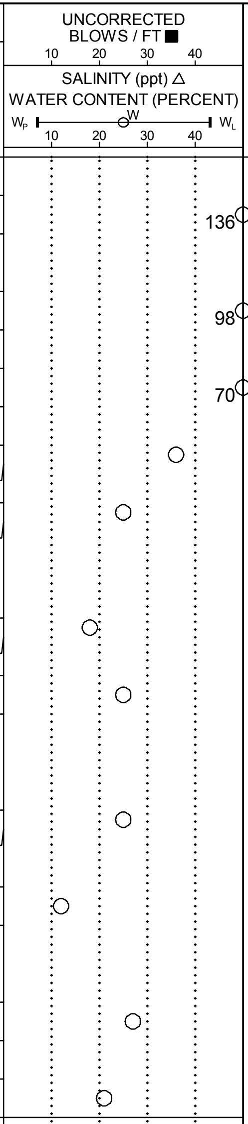
SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 0.5 Frozen, brown, PEAT and ICE, well bonded (PT)	PT	
0.5 - 5.0 Frozen, brown, ORGANIC SILT, few to little organic silt interbeds, low to medium plasticity, well bonded with approximately 5-15% visible ice by volume as individual ice crystals and irregularly oriented ice formations (OL, Vx-Vr)	OL	0.5
5.0 - 8.5 Frozen, gray-brown, SILT, low plasticity, well bonded with approximately 30-40% visible ice by volume as stratified or distinctly oriented ice formations and individual ice crystals (ML, Vs-Vx) Decreased ice content at 7 feet, well bonded excess ice (Nbe)	ML	5.0
8.5 - 13.0 Frozen, gray and brown, SILTY SAND, fine to medium-grained sand, silt content decreases below 12 feet deep, well bonded with excess ice and no excess ice (SM, Nbe-Nbn)	SM	8.5
13.0 - 18.0 Wet, gray, SILT with sand, few to little fine-grained sand, low plasticity (ML)	ML	13.0
18.0 - 20.5 Wet, gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little subrounded gravel up to 1/2- inch diameter (SP-SM)	SP-SM	18.0
20.5 - 21.5 Wet, brown, SILT, low plasticity (ML)	ML	20.5
21.5 - 25.0 Frozen, gray-brown, SILTY SAND, fine to coarse-grained sand, trace subrounded gravel up to 1/2- inch diameter, little silt, well bonded with approximately 5-10% visible ice by volume as clear individual ice crystals (SM, Vx)	SM	21.5

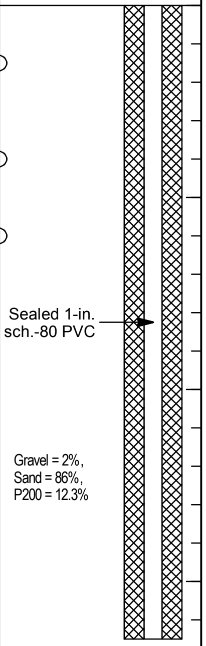
Borehole completed at 25.0 ft.

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)
1	GP		12/12
2	GP		12/12
3	GP		12/12
4	GP		6/6
5	GP		6/6
6	GP		6/6
7	GP		12/12
8	GP		6/6
9	GP		12/12
10	GP		12/12
11	GP		12/12



NOTES TESTS WATER LEVELS GRAPHIC



Gravel = 2%,
Sand = 86%,
P200 = 12.3%

Notes:
1) Borehole completed on 2/10/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 16.5 feet

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-5

RECORD OF BOREHOLE KWN-04

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/11/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75122° N 161.89697° W

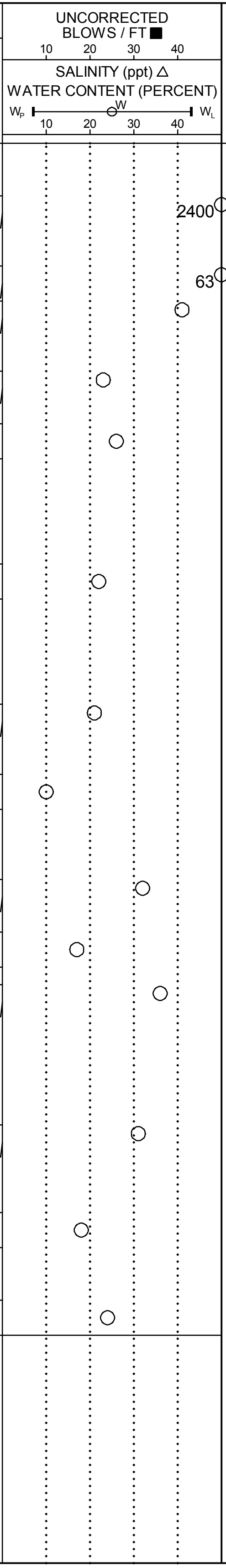
SOIL PROFILE

DESCRIPTION	USCS	ELEV. DEPTH (ft)
0.0 - 3.0 Frozen, brown, PEAT and ICE, fibrous, well bonded with approximately 50% visible ice by volume as white irregularly oriented ice formations (PT, Vr)	PT	
3.0 - 4.5 Wet, brown, ORGANIC SILT, nonplastic (OL)	OL	3.0
4.5 - 15.0 Wet, gray, SILT, no to low plasticity, well bonded (ML)	ML	4.5
15.0 - 16.5 Wet, dark gray, poorly graded SAND with silt, fine to medium-grained sand (SP-SM)	SP-SM	15.0
16.5 - 20.5 Wet, dark gray, poorly graded GRAVEL with sand, little subrounded to subangular gravel up to 1/2- inch diameter, some fine to coarse-grained sand (GP)	GP	16.5
20.5 - 22.0 Wet, gray-brown, SILT with sand, fine to medium-grained sand, nonplastic (ML)	ML	20.5
22.0 - 24.0 Frozen, gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, few subrounded to subangular gravel up to 1/2-inch diameter, well bonded with approximately 5% visible ice by volume as clear coatings on particles (SP-SM, Vc)	SP-SM	22.0
24.0 - 29.5 Frozen, gray-brown, SILT, little thin interbeds brown organic silt (OL), low, well bonded with excess ice (ML, Nbe)	ML	24.0
29.5 - 34.0 Frozen, dark gray, poorly graded SAND with silt, fine to coarse-grained sand, little subrounded to subangular gravel up to 1/2-inch diameter, well bonded with approximately 5% visible ice by volume as individual ice crystals (SP-SM, Vx)	SP-SM	29.5

Borehole completed at 34.0 ft.

SAMPLES

NUMBER	TYPE	REC/ATT (inch)
1	GP	6/6
2	GP	6/6
3	GP	6/6
4	GP	6/6
5	GP	12/12
6	GP	12/12
7	GP	6/6
8	GP	12/12
9	GP	6/6
10	GP	12/12
11	GP	6/6
12	GP	6/6
13	GP	12/12
14	GP	12/12



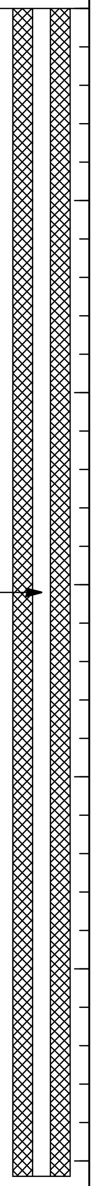
NOTES
TESTS
WATER LEVELS
GRAPHIC

Gravel = 0%,
Sand = 14%,
P200 = 85.6%

Sealed 1-in. sch.-80 PVC

Gravel = 49%,
Sand = 49%,
P200 = 2.1%

Gravel = 14%,
Sand = 79%,
P200 = 6.6%,
SA



Notes:
1) Borehole completed on 2/11/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 30.4 feet

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure
A-6

RECORD OF BOREHOLE KWN-05

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/11/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75128° N 161.89683° W

SOIL PROFILE

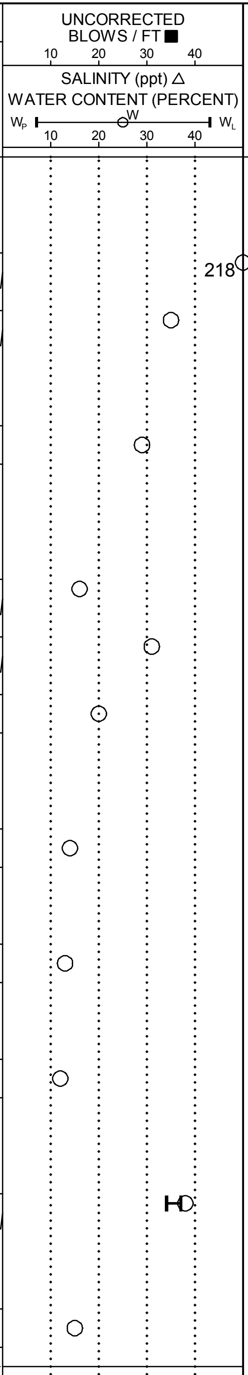
DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)
0.0 - 2.0 Frozen, brown, PEAT and ICE, well bonded with approximately 50% visible ice by volume as white irregularly oriented ice formations (PT, Vr)	■	PT	
2.0 - 4.0 Frozen, brown, PEAT, well bonded with approximately 10-20% visible ice by volume as irregularly oriented ice formations (PT, Vr)	■	PT	2.0
4.0 - 10.5 Wet, gray, SILT, no to low plasticity (ML)		ML	4.0
10.5 - 12.5 Wet, dark gray, SILTY SAND, fine to medium-grained sand (SM)		SM	10.5
12.5 - 13.5 Wet, gray and brown, SILT, few organic silt (OL) pockets, low plasticity (ML)		ML	12.5
13.5 - 16.0 Wet, dark gray, poorly graded SAND with silt, fine to coarse-grained sand (SP-SM)		SP-SM	13.5
16.0 - 22.5 Wet, dark gray, well-graded SAND, fine to coarse-grained sand, little subrounded to subangular gravel up to 3/8- inch diameter, well bonded (SW)		SW	16.0
22.5 - 25.8 Frozen, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little to some subrounded to subangular gravel up to 3/4- inch diameter, well bonded with approximately 5% visible ice by volume as individual ice crystals (SP-SM, Vx)	■	SP-SM	22.5
25.8 - 27.5 Frozen, gray-brown, SILT, low plasticity, well bonded with excess ice (ML, Nbe)	■	ML	25.8
27.5 - 31.5 Frozen, dark gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP-SM, Vx)	■	SP-SM	27.5

Borehole completed at 31.5 ft.

Notes:
1) Borehole completed on 2/11/2012
2) Borehole backfilled with thawed cuttings
3) No PVC installed

SAMPLES

NUMBER	TYPE	REC / ATT (inch)	NOTES TESTS WATER LEVELS
1	GP	6 / 6	
2	GP	6 / 6	
3	GP	12 / 12	
4	GP	6 / 6	Gravel = 2%, Sand = 81%, P200 = 17.8%
5	GP	6 / 6	
6	GP	12 / 12	
7	GP	12 / 12	Gravel = 10%, Sand = 87%, P200 = 2.3%, SA
8	GP	12 / 12	
9	GP	12 / 12	Gravel = 29%, Sand = 63%, P200 = 7.5%
10	GP	6 / 6	PI
11	GP	12 / 12	



DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-7

RECORD OF BOREHOLE KWN-06

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/11/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75139° N 161.89636° W

SOIL PROFILE

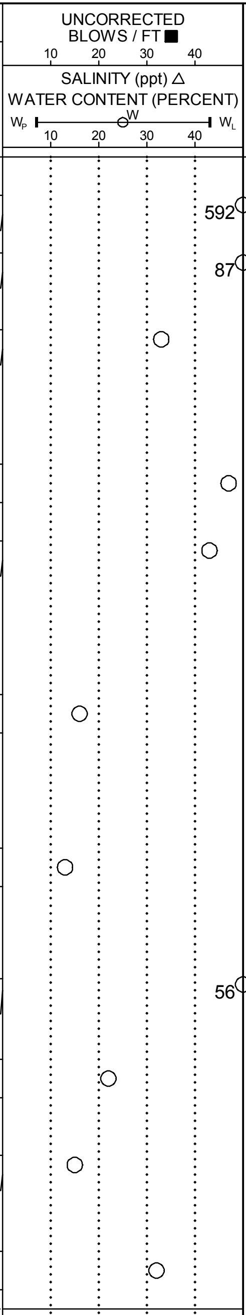
DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 4.0 Frozen, brown, PEAT and ICE, well bonded with approximately 50% visible ice by volume as white irregularly oriented ice formations (PT, Vr)	PT	
4.0 - 6.5 Wet, gray, SILT, low plasticity (ML)	ML	4.0
6.5 - 10.0 Frozen, gray, SILT, low plasticity, well bonded with approximately 10% visible ice by volume as individual ice crystals and irregularly oriented ice formations (ML, Vx-Vr)	ML	6.5
10.0 - 11.0 Frozen, dark gray, poorly graded SAND with silt, fine to medium-grained sand, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP-SM, Vx)	SP-SM	10.0
11.0 - 13.0 Frozen, gray-brown, SILT, few fine-grained sand in pockets, low plasticity, well bonded with approximately 5-10% visible ice by volume as irregularly oriented ice formations (ML, Vr)	ML	11.0
13.0 - 21.4 Frozen, dark gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc)	SP-SM	13.0
21.4 - 22.3 Frozen, brown to gray, ORGANIC SILT and SILT, low plasticity, with thin interbed of poorly graded sand with gravel (SP-SM) at 22 to 22.2 feet, well bonded with excess ice (OL, Nbe)	OL	21.4
22.3 - 27.0 Frozen, dark gray, poorly graded SAND with silt, fine to coarse-grained sand, few subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc)	SP-SM	22.3
27.0 - 29.7 Frozen, gray-brown, SILT, low plasticity, well bonded with excess ice (ML, Nbe)	ML	27.0
29.7 - 30.0 Frozen, dark gray, poorly graded SAND with silt, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP-SM, Vx)	SP-SM	

Borehole completed at 30.0 ft.

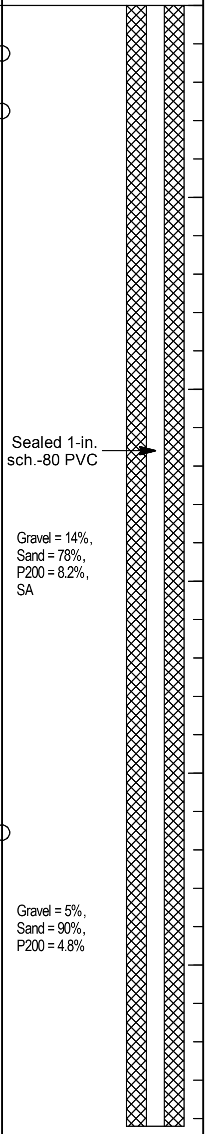
Notes:
1) Borehole completed on 2/11/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 29.2 feet

SAMPLES

NUMBER	TYPE	REC / ATT (inch)
1	GP	6 / 6
2	GP	6 / 6
3	GP	6 / 6
4	GP	12 / 12
5	GP	6 / 6
6	GP	12 / 12
7	GP	12 / 12
8	GP	3 / 4
9	GP	12 / 12
10	GP	6 / 6
11	GP	12 / 12



NOTES TESTS WATER LEVELS GRAPHIC



Gravel = 14%,
Sand = 78%,
P200 = 8.2%,
SA

Gravel = 5%,
Sand = 90%,
P200 = 4.8%

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC BOREHOLE] HBrooks 7/12/12

Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-8

RECORD OF BOREHOLE KWN-07

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/12/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75147° N 161.89672° W

SOIL PROFILE

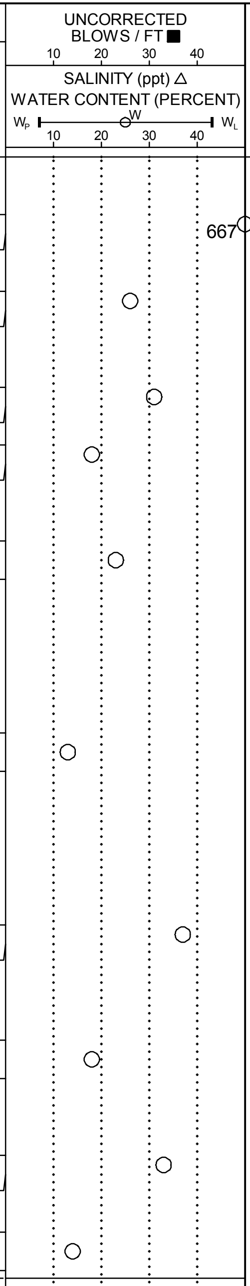
DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)
0.0 - 2.0 Frozen, brown, PEAT, fibrous, well bonded irregularly oriented ice formations (PT, Vr)	■	PT	
2.0 - 3.0 Wet, brown, ORGANIC SILT, low plasticity (OL)		OL	2.0
3.0 - 7.5 Wet, gray, SILT, trace fine-grained sand, nonplastic (ML)		ML	3.0
7.5 - 8.3 Wet, dark gray, SILTY SAND, fine to coarse-grained sand, some silt (SM)		SM	7.5
8.3 - 9.0 Wet, gray, SILT, trace fine-grained sand, nonplastic (ML)		ML	8.3
9.0 - 18.5 Frozen, dark gray, SILTY SAND, fine to medium-grained sand, little silt, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SM, Vx) Decreased silt content from 13.5 to 18.5 feet with fine to coarse-grained sand and little to some subrounded to subangular gravel up to 1/2- inch diameter	■	SM	9.0
18.5 - 21.0 Frozen, gray-brown, SILT, low plasticity, well bonded with excess ice (ML, Nbe)	■	ML	18.5
21.0 - 25.5 Frozen, dark gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little to some subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP-SM, Vx)	■	SP-SM	21.0
25.5 - 27.5 Frozen, gray-brown, SILT, little to some interbeds of fine grained sand, low plasticity, well bonded with excess ice (ML, Nbe)	■	ML	25.5
27.5 - 29.2 Frozen, dark gray, poorly graded SAND with silt and gravel, fine to medium-grained sand, little to some subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP-SM, Vx)	■	SP-SM	27.5

Borehole completed at 29.2 ft.

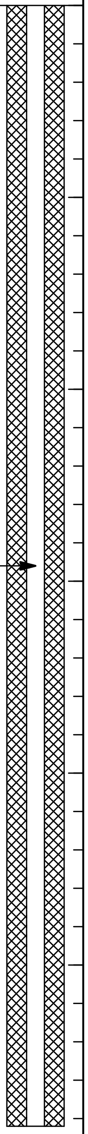
Notes:
1) Borehole completed on 2/12/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 29.2 feet

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	NOTES TESTS
1	GP		6 / 6	
2	GP		6 / 6	
3	GP		6 / 6	
4	GP		6 / 6	
5	GP		12 / 12	Gravel = 0%, Sand = 82%, P200 = 17.5%
6	GP		12 / 12	
7	GP		6 / 6	
8	GP		12 / 12	
9	GP		6 / 6	
10	GP		12 / 12	Gravel = 27%, Sand = 65%, P200 = 8.1%



NOTES TESTS WATER LEVELS GRAPHIC



Sealed 1-in. sch.-80 PVC

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Golder Associates

Figure A-9

RECORD OF BOREHOLE KWN-08

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/12/12
EQUIPMENT: Geoprobe

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75147° N 161.89700° W

SOIL PROFILE

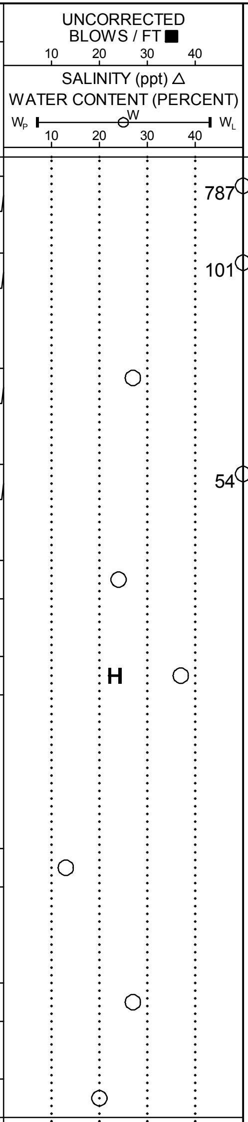
DEPTH (ft)	DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)
0.0 - 2.0	Frozen, brown, PEAT, fibrous, well bonded with approximately 30% visible ice by volume as irregularly oriented ice formations (PT, Vr)	■	PT	
2.0 - 3.5	Wet, dark brown, ORGANIC SILT, few fibrous organic material, low plasticity, well bonded (OL)		OL	2.0
3.5 - 6.0	Wet, gray, SILT, trace fine-grained sand, low plasticity (ML)		ML	3.5
6.0 - 7.5	Frozen, gray, SILT, trace fine-grained sand, low plasticity, well bonded with approximately 15-30% visible ice by volume as stratified or distinctly oriented ice formations and irregularly oriented ice formations (ML, Vs-Vr)	■	ML	6.0
7.5 - 12.0	Gray, poorly graded SAND, fine to coarse-grained sand, trace to few subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP, Vx)	■	SP	7.5
12.0 - 14.0	Frozen, gray-brown, SILT, trace fine-grained sand, medium plasticity, well bonded with approximately 20% visible ice by volume as stratified or distinctly oriented ice formations (ML, Vs)	■	ML	12.0
14.0 - 25.0	Frozen, dark gray, poorly graded SAND with silt, fine to coarse-grained sand, little to some subrounded to subangular gravel up to 3/4-inch diameter, interbeds of brown organic silt (OL), well bonded with approximately 5-15% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc) One foot interbed of SILTY SAND noted at 21.5 feet	■	SP-SM	14.0

Borehole completed at 25.0 ft.

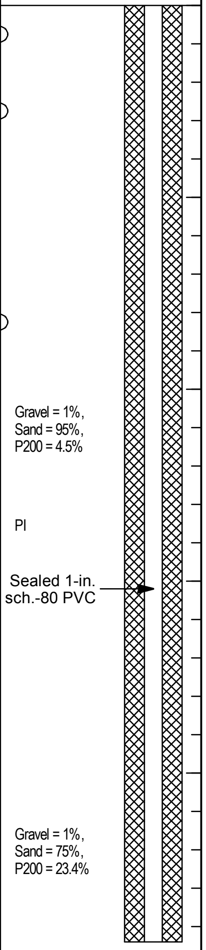
Notes:
1) Borehole completed on 2/12/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 24.4 feet

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	NOTES / TESTS
1	GP		6 / 6	
2	GP		6 / 6	
3	GP		6 / 6	
4	GP		6 / 6	
5	GP		12 / 12	Gravel = 1%, Sand = 95%, P200 = 4.5%
6	GP		12 / 12	PI
7	GP		12 / 12	
8	GP		12 / 12	Gravel = 1%, Sand = 75%, P200 = 23.4%
9	GP		12 / 12	



NOTES TESTS WATER LEVELS GRAPHIC



Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-10

RECORD OF BOREHOLE KWN-09

SHEET 1 of 1

PROJECT: Quinhagak School Expansion	CLIENT: USKH	DATUM: WGS 84
PROJECT NUMBER: 113-95736	DRILLING DATE: 2/12/12	ELEVATION: n/a
LOCATION: Quinhagak, AK	EQUIPMENT: Geoprobe	COORDS: 59.75156° N 161.89628° W

SOIL PROFILE

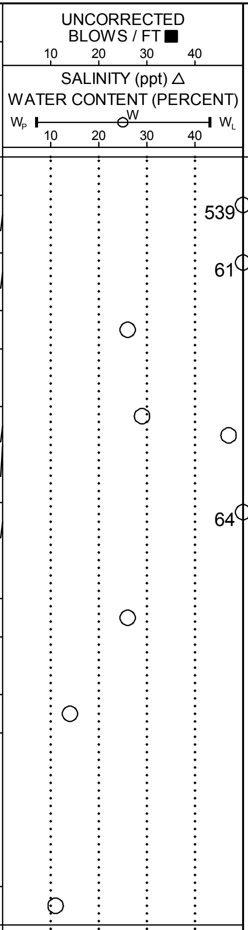
DEPTH (ft)	DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)
0.0 - 2.2	Frozen, brown, PEAT and ICE, fibrous, ice content decreases below 1-foot deep, well bonded with approximately 30-50% visible ice by volume as irregularly oriented ice formations (PT, Vr)	■	PT	
2.2 - 3.0	Dark brown, ORGANIC SILT, low plasticity, well bonded with approximately 15% visible ice by volume as irregularly oriented ice formations (OL, Vr)	■	OL	2.2
3.0 - 7.0	Wet, gray, SILT, low plasticity, poorly bonded with approximately 15% visible ice by volume as stratified or distinctly oriented ice formations (ML, Vs)		ML	3.0
7.0 - 7.8	Wet, dark brown, ORGANIC SILT, low plasticity (OL)		OL	7.0
7.8 - 10.0	Gray, SILT, low plasticity, well bonded with approximately 10% visible ice by volume as irregularly oriented ice formations (ML, Vr)	■	ML	7.8
10.0 - 20.0	Dark gray, poorly graded SAND, fine to medium-grained sand, little to some subrounded to subangular gravel up to 3/4-inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc) Interbedded layer of SILTY SAND from 12.5 to 13 feet	■	SP-SM	10.0

Borehole completed at 20.0 ft.

Notes:
1) Borehole completed on 2/12/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 19.7 feet

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	WATER CONTENT (PERCENT)
1	GP		6 / 6	539
2	GP		6 / 6	61
3	GP		12 / 12	
4	GP		6 / 6	
5	GP		6 / 6	
6	GP		6 / 6	64
7	GP		12 / 12	
8	GP		12 / 12	
9	GP		12 / 12	



NOTES / TESTS / WATER LEVELS / GRAPHIC

Sealed 1-in. sch.-80 PVC

Gravel = 1%, Sand = 95%, P200 = 4.4%

Gravel = 35%, Sand = 58%, P200 = 7.5%, SA

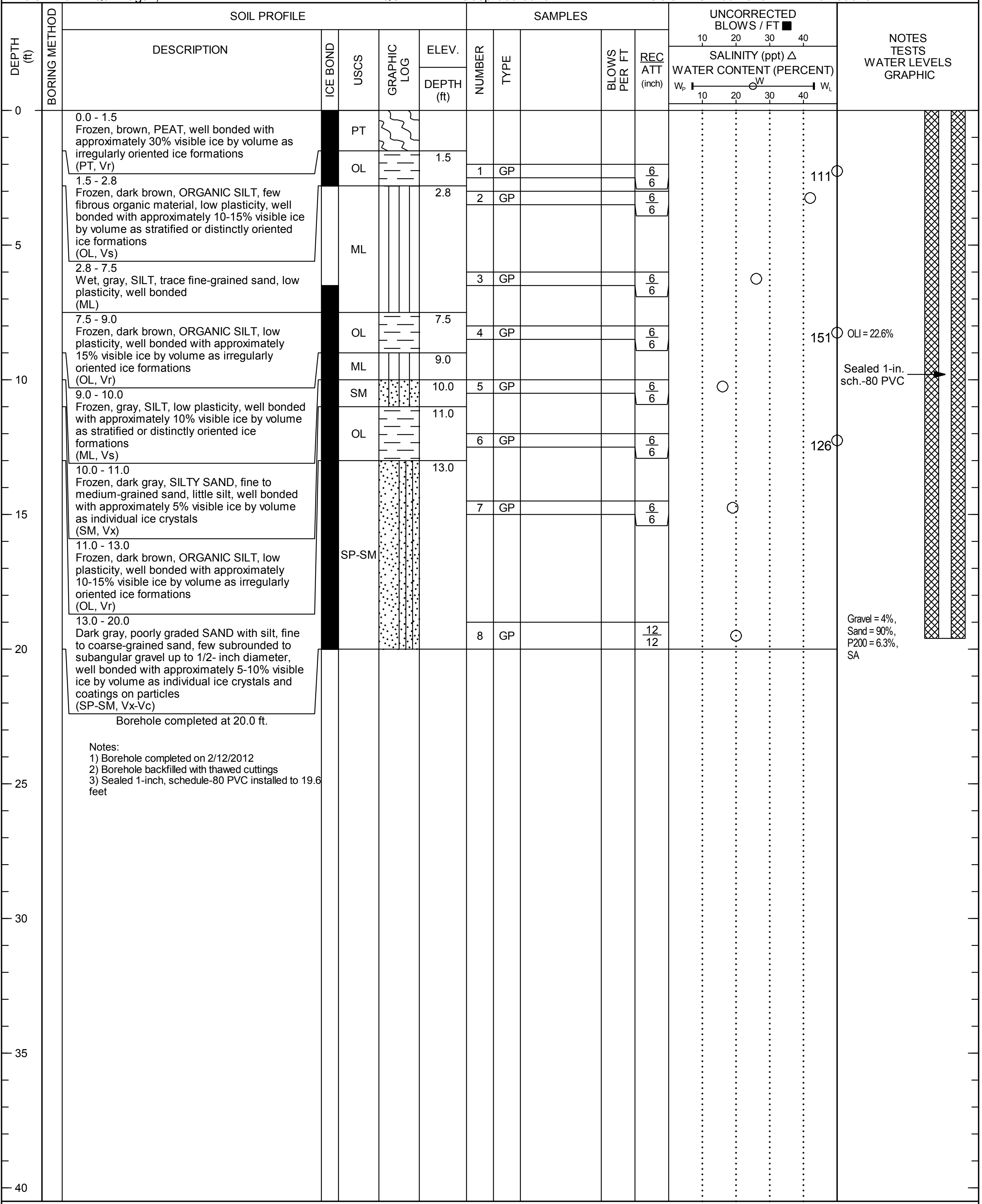
DEPTH SCALE: 1 inch to 5 feet	LOGGED: M. Hess	Figure A-11
DRILLING CONTRACTOR: Discovery Drilling	CHECKED: H. Brooks	
DRILLER: G. Erickson	CHECK DATE: 4/5/12	

Golder Associates

RECORD OF BOREHOLE KWN-10

SHEET 1 of 1

PROJECT: Quinhagak School Expansion	CLIENT: USKH	DATUM: WGS 84
PROJECT NUMBER: 113-95736	DRILLING DATE: 2/12/2012	ELEVATION: n/a
LOCATION: Quinhagak, AK	EQUIPMENT: Geoprobe 6610 DT	COORDS: 59.75181° N 161.89625° W



Description	USCS	Elev. / Depth (ft)
0.0 - 1.5 Frozen, brown, PEAT, well bonded with approximately 30% visible ice by volume as irregularly oriented ice formations (PT, Vr)	PT	
1.5 - 2.8 Frozen, dark brown, ORGANIC SILT, few fibrous organic material, low plasticity, well bonded with approximately 10-15% visible ice by volume as stratified or distinctly oriented ice formations (OL, Vs)	OL	1.5
2.8 - 7.5 Wet, gray, SILT, trace fine-grained sand, low plasticity, well bonded (ML)	ML	2.8
7.5 - 9.0 Frozen, dark brown, ORGANIC SILT, low plasticity, well bonded with approximately 15% visible ice by volume as irregularly oriented ice formations (OL, Vr)	OL	7.5
9.0 - 10.0 Frozen, gray, SILT, low plasticity, well bonded with approximately 10% visible ice by volume as stratified or distinctly oriented ice formations (ML, Vs)	ML	9.0
10.0 - 11.0 Frozen, dark gray, SILTY SAND, fine to medium-grained sand, little silt, well bonded with approximately 5% visible ice by volume as individual ice crystals (SM, Vx)	SM	10.0
11.0 - 13.0 Frozen, dark brown, ORGANIC SILT, low plasticity, well bonded with approximately 10-15% visible ice by volume as irregularly oriented ice formations (OL, Vr)	OL	11.0
13.0 - 20.0 Dark gray, poorly graded SAND with silt, fine to coarse-grained sand, few subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc)	SP-SM	13.0

Borehole completed at 20.0 ft.

Number	Type	REC / ATT	Notes
1	GP	6 / 6	
2	GP	6 / 6	
3	GP	6 / 6	
4	GP	6 / 6	OLI = 22.6%
5	GP	6 / 6	
6	GP	6 / 6	
7	GP	6 / 6	
8	GP	12 / 12	Gravel = 4%, Sand = 90%, P200 = 6.3%, SA

Sealed 1-in. sch.-80 PVC

Notes:
1) Borehole completed on 2/12/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 19.6 feet

Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-12

RECORD OF BOREHOLE KWN-11

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/12/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75181° N 161.94658° W

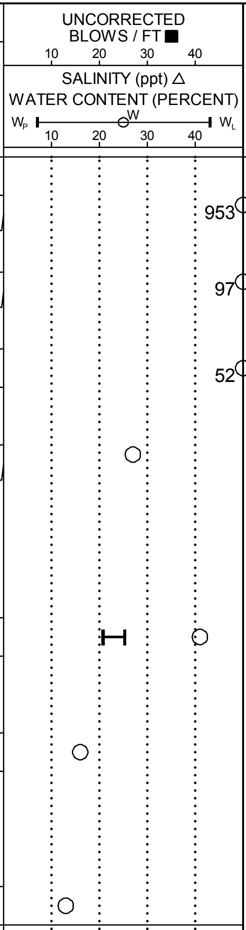
SOIL PROFILE

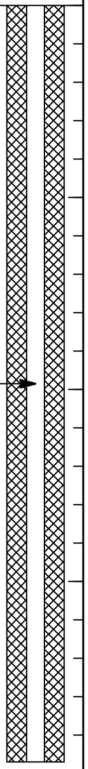
DEPTH (ft)	DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)
0	0.0 - 1.5 Frozen, brown, PEAT, fibrous, well bonded with approximately 35% visible ice by volume as irregularly oriented ice formations (PT, Vr)	■	PT	
	1.5 - 2.8 Moist, dark brown, ORGANIC SILT, trace fine to coarse-grained sand, low plasticity, well bonded (OL)		OL	1.5
5	2.8 - 7.5 Moist to wet, gray, SILT and ORGANIC SILT, low to medium plasticity, interbedded (ML+OL)		ML+ OL	2.8
10	7.5 - 10.5 Wet, gray, SILT, low plasticity (ML)		ML	7.5
	10.5 - 14.5 Gray, SILTY CLAY, low to medium plasticity, well bonded with approximately 30-35% visible ice by volume as stratified or distinctly oriented ice formations (CL-ML, Vs) Well bonded excess ice noted from 12.5 to 14.5 feet	■	CL-ML	10.5
15	14.5 - 20.0 Frozen, dark gray, poorly graded SAND with silt, fine to coarse-grained sand, trace to few subrounded to subangular gravel up to 1/2-inch diameter, trace to few silt, well bonded with approximately 5-10% visible ice by volume as individual ice crystals (SP-SM, Vx)	■	SP-SM	14.5
20	Borehole completed at 20.0 ft.			

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	WATER CONTENT (PERCENT)	NOTES / TESTS / WATER LEVELS
1	GP		6/6	953	
2	GP		6/6	97	OLI = 15.4%
3	GP		12/12	52	
4	GP		6/6		
5	GP		12/12		PI
6	GP		12/12		Gravel = 5%, Sand = 89%, P200 = 6.7%
7	GP		12/12		

UNCORRECTED BLOWS / FT ■
SALINITY (ppt) △
WATER CONTENT (PERCENT)
W_P ⊢—○W—⊣ W_L





Notes:
1) Borehole completed on 2/12/2012
2) Borehole backfilled with thawed cuttings
3) Sealed 1-inch, schedule-80 PVC installed to 19.7 feet

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Golder Associates

Figure A-13

RECORD OF BOREHOLE KWN-12

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/13/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75172° N 161.89644° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)	SAMPLES NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	UNCORRECTED BLOWS / FT ■ 10 20 30 40 SALINITY (ppt) △ WATER CONTENT (PERCENT) W	NOTES TESTS WATER LEVELS
0		0.0 - 2.0 Frozen, brown, PEAT, fibrous, well bonded with approximately 30-40% visible ice by volume as irregularly oriented ice formations and individual ice crystals (PT, Vr-Vx)	■	PT							
		2.0 - 4.0 Moist, dark brown, ORGANIC SILT, trace fine-grained sand, low plasticity (OL)		OL	2.0	1	GP		6/6	88	
5		4.0 - 8.0 Moist to wet, gray, SILT, trace fine-grained sand, low to medium plasticity (ML)		ML	4.0	2	GP		6/6		PI
		8.0 - 10.0 Frozen, dark brown, ORGANIC SILT, low plasticity, well bonded with approximately 30% visible ice by volume as irregularly oriented ice formations and stratified or distinctly oriented ice formations (OL, Vr-Vs)	■	OL	8.0	3	GP		12/12	120	OLI = 15.5%
10		10.0 - 13.5 Frozen, gray-brown, SILT, low to medium plasticity, well bonded with approximately 25-30% visible ice by volume as irregularly oriented ice formations and stratified or distinctly oriented ice formations (ML, Vr-Vs)	■	ML	10.0	4	GP		12/12	83	
15		13.5 - 20.0 Frozen, dark gray, poorly graded SAND with silt, fine to medium-grained sand, well bonded with approximately 5% visible ice by volume as individual ice crystals (SP-SM, Vx)	■	SP-SM	13.5	5	GP		12/12		Gravel = 0%, Sand = 93%, P200 = 7.3%
20		Borehole completed at 20.0 ft.									

Notes:
1) Borehole terminated at 20 feet on 2/13/2012 due to hydraulic fluid leak from Geoprobe
2) Borehole not backfilled
3) Borehole marked with 1-inch, schedule-80 PVC

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-14

RECORD OF BOREHOLE KWN-13

SHEET 1 of 2

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/14/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75167° N 161.89644° W

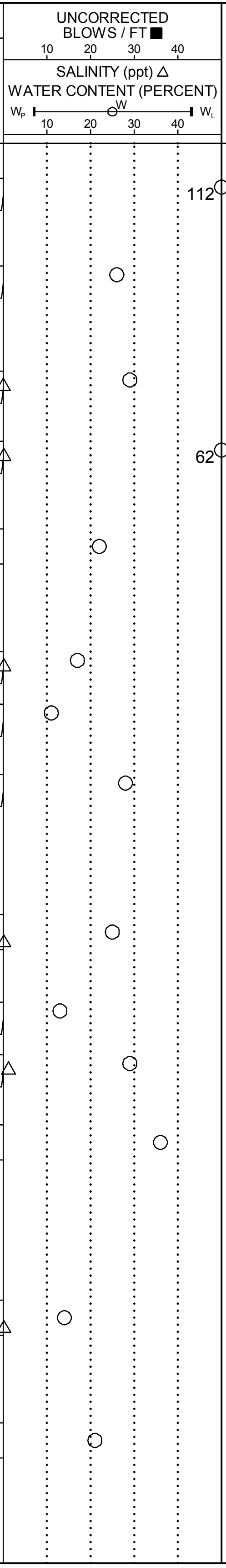
SOIL PROFILE

DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 1.0 Frozen, brown, PEAT, fibrous, well bonded with approximately 30-40% visible ice by volume as irregularly oriented ice formations and individual ice crystals (PT, Vr-Vx)	PT	
1.0 - 1.8 Moist, dark brown, ORGANIC SILT, few fibrous organic material, low plasticity (OL)	OL	1.0
1.8 - 10.0 Moist to wet, gray, SILT, trace fine-grained sand, low plasticity, poorly bonded and well bonded (ML) Poorly and well bonded with approximately 25-30% visible ice by volume as clear stratified or distinctly oriented ice formations (Vs) from 8.5 to 10 feet	ML	1.8
10.0 - 26.0 Dark gray, poorly graded SAND with silt, fine to coarse-grained sand, few subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-15% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc) Interbeds of SILTY SAND noted from 10 to 12.5 and 17.4 to 19 feet	SP-SM	10.0
26.0 - 26.5 Black, SILT, low plasticity, well bonded with no excess ice (ML, Nbn)	ML	26.0
26.5 - 31.0 Gray and brown, SILT, some interbeds of organic silt (OL), trace fine-grained sand, nonplastic, well bonded with excess ice (ML, Nbe)	ML	26.5
31.0 - 49.0 Frozen, dark gray, poorly graded SAND with silt, fine to coarse-grained sand, few to some subrounded gravel up to 3/4- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc)	SP-SM	31.0

Log continued on next page

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)
1	GP		6 / 6
2	GP		6 / 6
3	GP		6 / 6
4	GP		6 / 6
5	GP		12 / 12
6	GP		6 / 6
7	GP		6 / 6
8	GP		6 / 6
9	GP		12 / 12
10	GP		6 / 6
11	GP		6 / 6
12	GP		12 / 12
13	GP		12 / 12
14	GP		12 / 12



NOTES / TESTS / WATER LEVELS / GRAPHIC

Gravel = 0%, Sand = 80%, P200 = 19.5% (sample 5)

Sealed 1-in. sch.-80 PVC

Gravel = 7%, Sand = 87%, P200 = 6.2%, SA (sample 14)

Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-15

RECORD OF BOREHOLE KWN-13

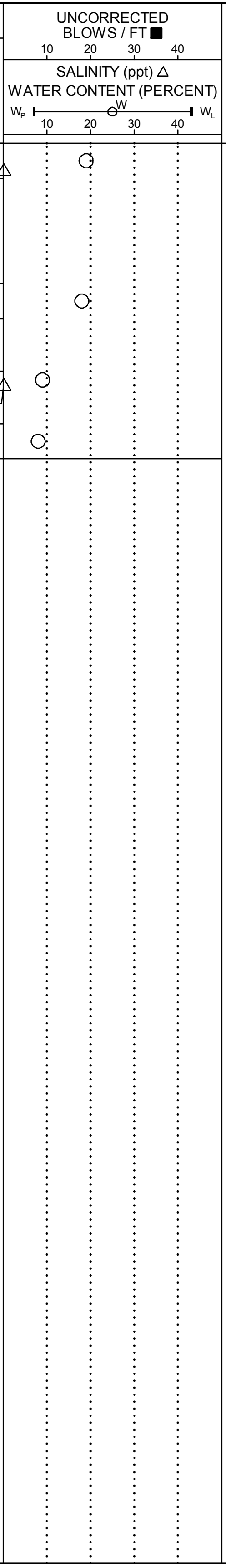
SHEET 2 of 2

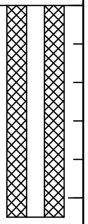
PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/14/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75167° N 161.89644° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	NOTES TESTS WATER LEVELS GRAPHIC
40		31.0 - 49.0 Frozen, dark gray, poorly graded SAND with silt, fine to coarse-grained sand, few to some subrounded gravel up to 3/4- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc) *(Continued)*					15	GP		12 / 12	
45				SP-SM			16	GP		12 / 12	
							17	GP		6 / 6	
							18	GP		12 / 12	Gravel = 45%, Sand = 51%, P200 = 3.5%
		Borehole completed at 49.0 ft.									
50		Notes: 1) Borehole terminated at 49 feet on refusal on 2/13/2012 2) Borehole backfilled with thawed cuttings 3) Sealed 1-inch, schedule-80 PVC installed to 45.5 feet									
55											
60											
65											
70											
75											
80											





DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-15

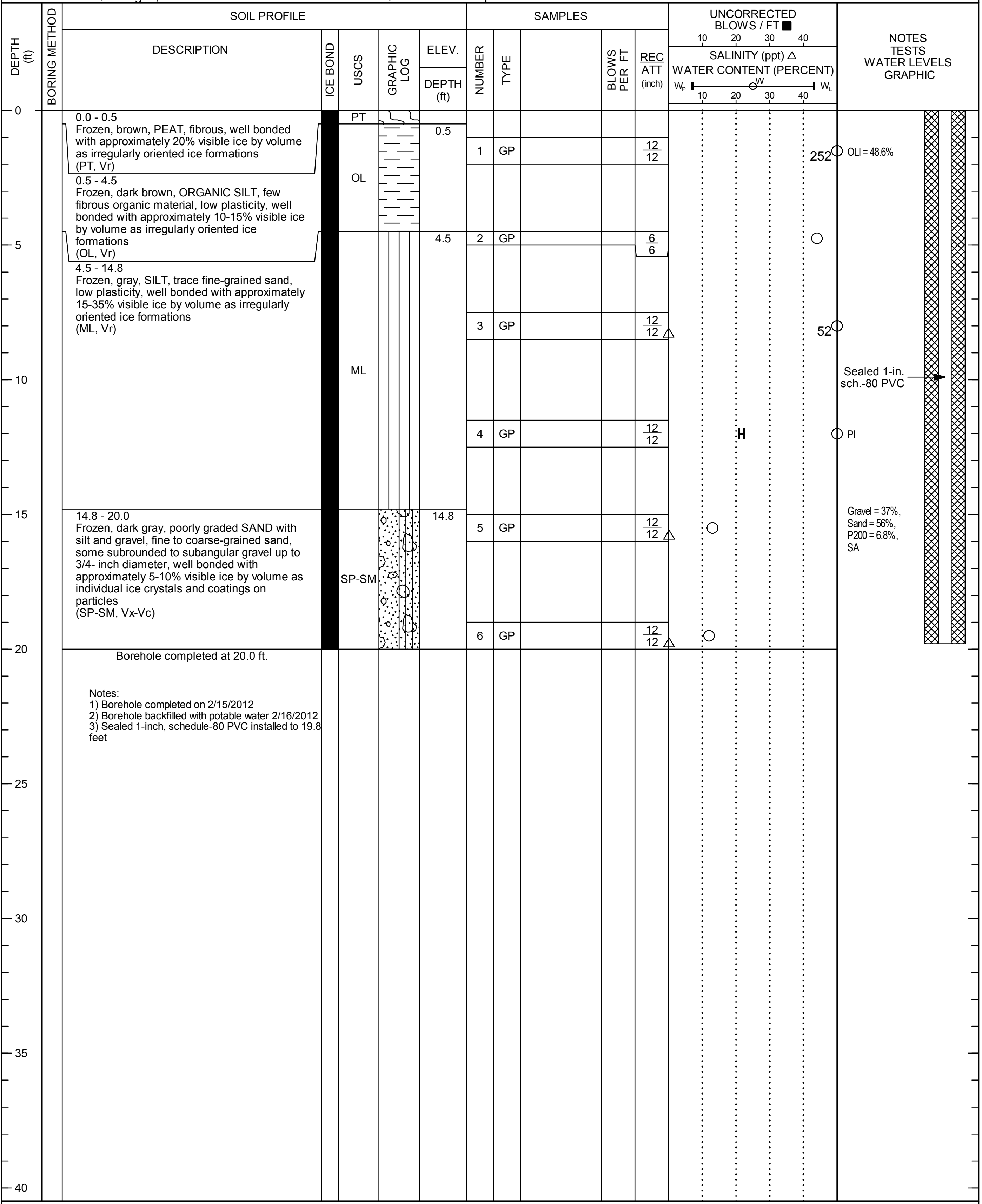
RECORD OF BOREHOLE KWN-14

SHEET 1 of 1

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/15/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75244° N 161.89575° W



DESCRIPTION	USCS	ELEV. / DEPTH (ft)
0.0 - 0.5 Frozen, brown, PEAT, fibrous, well bonded with approximately 20% visible ice by volume as irregularly oriented ice formations (PT, Vr)	PT	0.5
0.5 - 4.5 Frozen, dark brown, ORGANIC SILT, few fibrous organic material, low plasticity, well bonded with approximately 10-15% visible ice by volume as irregularly oriented ice formations (OL, Vr)	OL	4.5
4.5 - 14.8 Frozen, gray, SILT, trace fine-grained sand, low plasticity, well bonded with approximately 15-35% visible ice by volume as irregularly oriented ice formations (ML, Vr)	ML	14.8
14.8 - 20.0 Frozen, dark gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, some subrounded to subangular gravel up to 3/4- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP-SM, Vx-Vc)	SP-SM	

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	NOTES / TESTS
1	GP		12 / 12	OLI = 48.6%
2	GP		6 / 6	
3	GP		12 / 12	
4	GP		12 / 12	PI
5	GP		12 / 12	Gravel = 37%, Sand = 56%, P200 = 6.8%, SA
6	GP		12 / 12	

Borehole completed at 20.0 ft.

Notes:
1) Borehole completed on 2/15/2012
2) Borehole backfilled with potable water 2/16/2012
3) Sealed 1-inch, schedule-80 PVC installed to 19.8 feet

Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-16

RECORD OF BOREHOLE KWN-15

SHEET 1 of 1

PROJECT: Quinhagak School Expansion	CLIENT: USKH	DATUM: WGS 84
PROJECT NUMBER: 113-95736	DRILLING DATE: 2/15/2012	ELEVATION: n/a
LOCATION: Quinhagak, AK	EQUIPMENT: Geoprobe 6610 DT	COORDS: 59.75181° N 161.89694° W

SOIL PROFILE

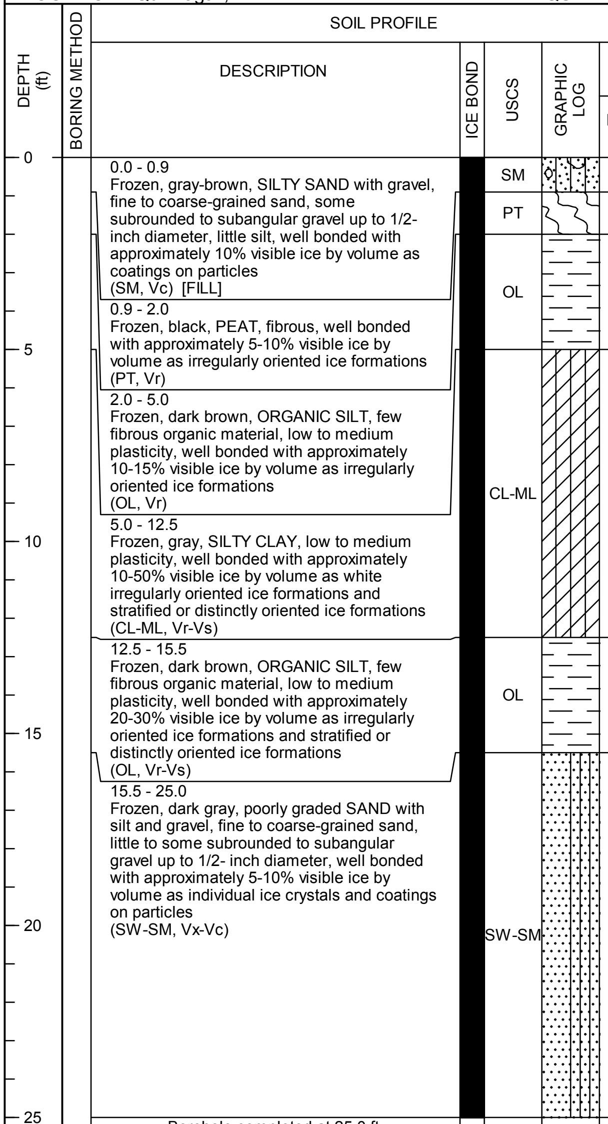
DESCRIPTION	ICE BOND	USCS	ELEV. / DEPTH (ft)
0.0 - 0.9 Frozen, gray-brown, SILTY SAND with gravel, fine to coarse-grained sand, some subrounded to subangular gravel up to 1/2-inch diameter, little silt, well bonded with approximately 10% visible ice by volume as coatings on particles (SM, Vc) [FILL]	■	SM	
0.9 - 2.0 Frozen, black, PEAT, fibrous, well bonded with approximately 5-10% visible ice by volume as irregularly oriented ice formations (PT, Vr)	■	PT	0.9
2.0 - 5.0 Frozen, dark brown, ORGANIC SILT, few fibrous organic material, low to medium plasticity, well bonded with approximately 10-15% visible ice by volume as irregularly oriented ice formations (OL, Vr)	■	OL	2.0
5.0 - 12.5 Frozen, gray, SILTY CLAY, low to medium plasticity, well bonded with approximately 10-50% visible ice by volume as white irregularly oriented ice formations and stratified or distinctly oriented ice formations (CL-ML, Vr-Vs)	■	CL-ML	5.0
12.5 - 15.5 Frozen, dark brown, ORGANIC SILT, few fibrous organic material, low to medium plasticity, well bonded with approximately 20-30% visible ice by volume as irregularly oriented ice formations and stratified or distinctly oriented ice formations (OL, Vr-Vs)	■	OL	12.5
15.5 - 25.0 Frozen, dark gray, poorly graded SAND with silt and gravel, fine to coarse-grained sand, little to some subrounded to subangular gravel up to 1/2- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SW-SM, Vx-Vc)	■	SW-SM	15.5

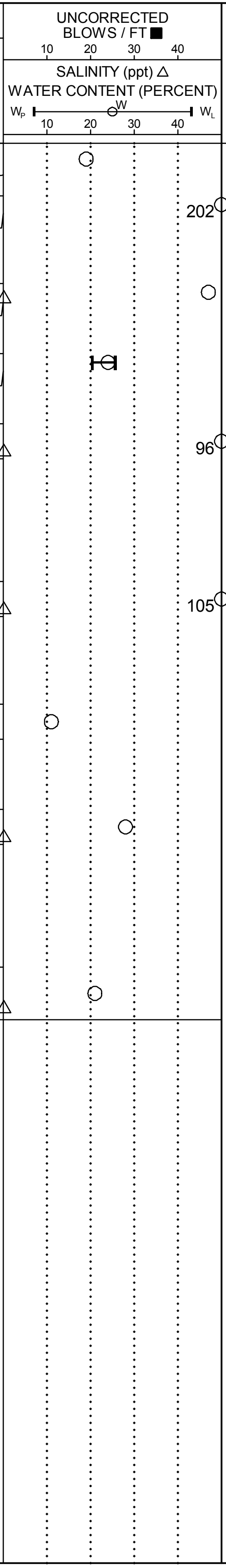
Borehole completed at 25.0 ft.

Notes:
1) Borehole completed on 2/15/2012
2) Borehole backfilled with potable water on 2/16/2012
3) Sealed 1-inch, schedule-80 PVC installed to 24.6 feet

SAMPLES

NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)
1	GP		10 / 11
2	GP		6 / 6
3	GP		6 / 6
4	GP		6 / 6
5	GP		12 / 12
6	GP		12 / 12
7	GP		12 / 12
8	GP		12 / 12
9	GP		18 / 18





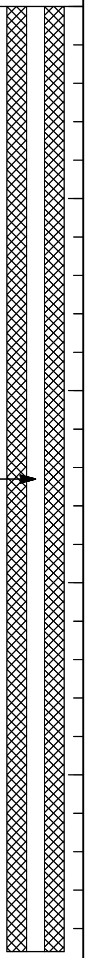
NOTES TESTS WATER LEVELS GRAPHIC

PI

Sealed 1-in. sch.-80 PVC

OLI = 12.0%

Gravel = 34%, Sand = 60%, P200 = 5.7%, SA



DEPTH SCALE: 1 inch to 5 feet	LOGGED: M. Hess	Figure A-17
DRILLING CONTRACTOR: Discovery Drilling	CHECKED: H. Brooks	
DRILLER: G. Erickson	CHECK DATE: 4/5/12	

Golder Associates

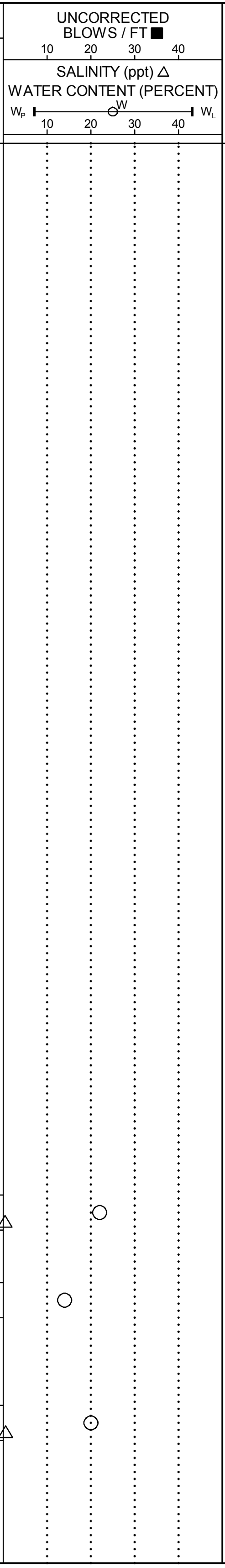
RECORD OF BOREHOLE KWN-16

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/15/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75103° N 161.89692° W

DEPTH (ft)	DESCRIPTION	USCS	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS PER FT	REC / ATT (inch)	NOTES TESTS WATER LEVELS
0	0.0 - 30.0 Borehole not sampled from 0 to 33 feet Borehole not sampled from 0 to 33 feet. See boreholes KWN-01 and KWN-02 for nearby similar (inferred) soil profiles from 0 to 33 feet. Well bonded to 14 feet. Unbonded between 14 to 33 feet.							
30	30.0 - 33.0 Wet, dark gray, poorly graded SAND with gravel, fine to coarse-grained sand, few to little subrounded to subangular gravel up to 3/8- inch diameter (SP)	SP	30.0	1	GP		12/12	
				2	GP		12/12	Gravel = 22%, Sand = 77%, P200 = 1.3%
33	33.0 - 41.0 Frozen, dark gray, poorly graded SAND with gravel, fine to coarse-grained sand, little to some subrounded to subangular gravel up to 3/4- inch diameter, well bonded with approximately 5-10% visible ice by volume as individual ice crystals and coatings on particles (SP, Vx-Vc)	SP	33.0	3	GP		12/12	



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Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure A-18

RECORD OF BOREHOLE KWN-16

SHEET 2 of 2

PROJECT: Quinhagak School Expansion
PROJECT NUMBER: 113-95736
LOCATION: Quinhagak, AK

CLIENT: USKH
DRILLING DATE: 2/15/2012
EQUIPMENT: Geoprobe 6610 DT

DATUM: WGS 84
ELEVATION: n/a
COORDS: 59.75103° N 161.89692° W

DEPTH (ft)	BORING METHOD	SOIL PROFILE DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. DEPTH (ft)	SAMPLES NUMBER	TYPE		BLOWS PER FT	REC/ATT (inch)	UNCORRECTED BLOWS / FT ■ 10 20 30 40 SALINITY (ppt) △ WATER CONTENT (PERCENT) W_P ⊢ ○W ⊣ W_L 10 20 30 40	NOTES TESTS WATER LEVELS
40			■	SP			4	GP			12/12	⊙	Gravel = 19%, Sand = 77%, P200 = 4.4%
		Borehole completed at 41.0 ft. Notes: 1) Borehole completed on 2/15/2012 2) Borehole backfilled with thawed cuttings 3) No PVC installed											
45													
50													
55													
60													
65													
70													
75													
80													

Golder Associates

DEPTH SCALE: 1 inch to 5 feet
DRILLING CONTRACTOR: Discovery Drilling
DRILLER: G. Erickson

LOGGED: M. Hess
CHECKED: H. Brooks
CHECK DATE: 4/5/12

Figure
A-18

APPENDIX B
LABORATORY TESTING RESULTS

Golder Associates

TABLE B-1: SAMPLE SUMMARY

Client:	USKH	**Project No.:**	113-95736		
Project:	Quinhagak School Expansion	**QA/QC By:**	J. Randazzo	**Date:**	3/30/2012
Location:	Quinhagak, AK	**Reviewed By:**	C. Valentine	**Date:**	4/5/2012

SAMPLING DATA							CLASSIFICATION AND INDEX TEST RESULTS											
		DEPTH (ft)									GRADATION (%)							
SAMPLE LOCATION	SAMPLE NUMBER	TOP	BOTTOM	RECOVERY (%)	SAMPLE TYPE	BLOWS PER FOOT	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRAVEL	SAND	FINES (SILT & CLAY)	ORGANIC CONTENT (%)	DESCRIPTION (USCS)	SALINITY (ppt) [$^{(d)}$ is directly meas.]	TESTS / OTHER TESTS	
KWN-01	1	1.0	2.0	100	GP		125								OL			
KWN-01	2	3.0	4.0	17	GP		42								ML	0		
KWN-01	3	4.5	5.0	100	GP		48	25	22	3					ML		PI	
KWN-01	4	8.0	8.5	100	GP		48								ML	0		
KWN-01	5	10.0	11.0	100	GP		23								SM	0		
KWN-01	6	13.0	14.0	100	GP		29								ML	0		
KWN-01	7	17.0	18.0	100	GP		29								ML	0		
KWN-01	8	20.5	21.5	100	GP		14								SP-SM	0		
KWN-01	9	22.0	22.5	100	GP		28								ML	0		
KWN-01	10	24.0	25.0	100	GP		20				5	90	5		SP-SM	0		
KWN-01	11	27.5	28.5	100	GP		26								ML	2		
KWN-01	12	29.0	30.0	100	GP		23								SM	1		
KWN-02	1	1.0	2.0	100	GP		73								ML			
KWN-02	2	2.5	3.5	100	GP		134								OL			
KWN-02	3	4.5	5.5	100	GP		40								ML			
KWN-02	4	7.5	8.5	100	GP		48								ML			
KWN-02	5	12.0	13.0	100	GP		27				0	94	6		SP-SM		SA	
KWN-02	6	16.0	17.0	100	GP										SM			
KWN-02	7	18.3	18.7	104	GP										SM			
KWN-02	8	19.0	20.0	100	GP		13								SP			
KWN-02	9	21.5	22.0	100	GP		10				12	85	3		SP			
KWN-02	10	24.0	25.0	100	GP		17								SP-SM			
KWN-03	1	1.0	2.0	100	GP		136								OL			
KWN-03	2	3.5	4.5	100	GP		98								OL			
KWN-03	3	5.5	6.5	100	GP		70								ML			
KWN-03	4	7.5	8.0	100	GP		36								ML			
KWN-03	5	9.0	9.5	100	GP		25								SM			
KWN-03	6	12.0	12.5	100	GP		18				2	86	12		SM			
KWN-03	7	13.5	14.5	100	GP		25								ML			
KWN-03	8	17.0	17.5	100	GP		25								ML			
KWN-03	9	19.0	20.0	100	GP		12								SP-SM			
KWN-03	10	22.0	23.0	100	GP		27								SM			

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC_SAMPLE_SUMMARY] HBrooks 7/12/12

TABLE B-1: SAMPLE SUMMARY

Client:	USKH	**Project No.:**	113-95736		
Project:	Quinhagak School Expansion	**QA/QC By:**	J. Randazzo	**Date:**	3/30/2012
Location:	Quinhagak, AK	**Reviewed By:**	C. Valentine	**Date:**	4/5/2012

SAMPLING DATA							CLASSIFICATION AND INDEX TEST RESULTS											
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft)		RECOVERY (%)	SAMPLE TYPE	BLOWS PER FOOT	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRADATION (%)			ORGANIC CONTENT (%)	DESCRIPTION (USCS)	SALINITY (ppt) [$^{(d)}$ is directly meas.]	TESTS / OTHER TESTS	
		TOP	BOTTOM								GRAVEL	SAND	FINES (SILT & CLAY)					
KWN-03	11	24.0	25.0	100	GP		21								SP-SM			
KWN-04	1	1.5	2.0	100	GP		2400								PT			
KWN-04	2	3.5	4.0	100	GP		63								OL			
KWN-04	3	4.5	5.0	100	GP		41								ML			
KWN-04	4	6.5	7.0	100	GP		23								ML			
KWN-04	5	8.0	9.0	100	GP		26	NP	NP	NP	0	14	86		ML			
KWN-04	6	12.0	13.0	100	GP		22								ML			
KWN-04	7	16.0	16.5	100	GP		21								SP-SM			
KWN-04	8	18.0	19.0	100	GP		10				49	49	2		GP			
KWN-04	9	21.0	21.5	100	GP		32								ML			
KWN-04	10	22.5	23.5	100	GP		17								SP-SM			
KWN-04	11	24.0	24.5	100	GP		36								ML			
KWN-04	12	28.0	28.5	100	GP		31								ML			
KWN-04	13	30.5	31.5	100	GP		18				14	79	7		SP-SM		SA	
KWN-04	14	33.0	34.0	100	GP		24								SP-SM			
KWN-05	1	2.5	3.0	100	GP		218								PT			
KWN-05	2	4.0	4.5	100	GP		35								ML			
KWN-05	3	7.0	8.0	100	GP		29								ML			
KWN-05	4	11.0	11.5	100	GP		16				2	81	18		SM			
KWN-05	5	12.5	13.0	100	GP		31								ML			
KWN-05	6	14.0	15.0	100	GP		20								SP-SM			
KWN-05	7	17.5	18.5	100	GP		14				10	87	2		SW		SA	
KWN-05	8	20.5	21.5	100	GP		13								SW			
KWN-05	9	23.5	24.5	100	GP		12				29	63	8		SP-SM			
KWN-05	10	27.0	27.5	100	GP		38	37	34	3					ML		PI	
KWN-05	11	30.0	31.0	100	GP		15								SP-SM			
KWN-06	1	1.0	1.5	100	GP		592								PT			
KWN-06	2	2.5	3.0	100	GP		87								PT			
KWN-06	3	4.5	5.0	100	GP		33								ML			
KWN-06	4	8.0	9.0	100	GP		47								ML			
KWN-06	5	10.0	10.5	100	GP		43								SP-SM			
KWN-06	6	14.0	15.0	100	GP		16				14	78	8		SP-SM		SA	

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC_SAMPLE_SUMMARY] HBrooks 7/12/12

TABLE B-1: SAMPLE SUMMARY

Client: USKH		**Project No.:** 113-95736	
Project: Quinhagak School Expansion		**QA/QC By:** J. Randazzo	**Date:** 3/30/2012
Location: Quinhagak, AK		**Reviewed By:** C. Valentine	**Date:** 4/5/2012

SAMPLING DATA							CLASSIFICATION AND INDEX TEST RESULTS											
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft)		RECOVERY (%)	SAMPLE TYPE	BLOWS PER FOOT	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRADATION (%)			ORGANIC CONTENT (%)	DESCRIPTION (USCS)	SALINITY (ppt) [$^{(d)}$ is directly meas.]	TESTS / OTHER TESTS	
		TOP	BOTTOM								GRAVEL	SAND	FINES (SILT & CLAY)					
KWN-06	7	18.0	19.0	100	GP		13								SP-SM			
KWN-06	8	21.4	21.7	83	GP		56								SP-SM			
KWN-06	9	23.5	24.5	100	GP		22				5	90	5		SP-SM			
KWN-06	10	26.0	26.5	100	GP		15								SP-SM			
KWN-06	11	28.5	29.5	100	GP		32								ML			
KWN-07	1	1.5	2.0	100	GP		667								PT			
KWN-07	2	3.5	4.0	100	GP		26								ML			
KWN-07	3	6.0	6.5	100	GP		31								ML			
KWN-07	4	7.5	8.0	100	GP		18								SM			
KWN-07	5	10.0	11.0	100	GP		23				0	82	18		SM			
KWN-07	6	15.0	16.0	100	GP		13								SP-SM			
KWN-07	7	20.0	20.5	100	GP		37								ML			
KWN-07	8	23.0	24.0	100	GP		18								SP-SM			
KWN-07	9	26.0	26.5	100	GP		33								ML			
KWN-07	10	28.0	29.0	100	GP		14				27	65	8		SP-SM			
KWN-08	1	0.5	1.0	100	GP		787								PT			
KWN-08	2	2.5	3.0	100	GP		101								OL			
KWN-08	3	5.5	6.0	100	GP		27								ML			
KWN-08	4	8.0	8.5	100	GP		54								SP			
KWN-08	5	10.5	11.5	100	GP		24				1	95	5		SP			
KWN-08	6	13.0	14.0	100	GP		37	24	22	2					ML		PI	
KWN-08	7	18.0	19.0	100	GP		13								SP-SM			
KWN-08	8	21.5	22.5	100	GP		27				1	75	23		SM			
KWN-08	9	24.0	25.0	100	GP		20								SP-SM			
KWN-09	1	1.0	1.5	100	GP		539								PT			
KWN-09	2	2.5	3.0	100	GP		61								OL			
KWN-09	3	4.0	5.0	100	GP		26								ML			
KWN-09	4	6.5	7.0	100	GP		29								ML			
KWN-09	5	7.0	7.5	100	GP		47								OL			
KWN-09	6	9.0	9.5	100	GP		64								ML			
KWN-09	7	11.5	12.5	100	GP		26				1	95	4		SP			
KWN-09	8	14.0	15.0	100	GP		14								SP-SM			

TABLE B-1: SAMPLE SUMMARY

Client: USKH	**Project No.:** 113-95736		
Project: Quinhagak School Expansion	**QA/QC By:** J. Randazzo	**Date:** 3/30/2012	
Location: Quinhagak, AK	**Reviewed By:** C. Valentine	**Date:** 4/5/2012	

SAMPLING DATA							CLASSIFICATION AND INDEX TEST RESULTS											
		DEPTH (ft)									GRADATION (%)							
SAMPLE LOCATION	SAMPLE NUMBER	TOP	BOTTOM	RECOVERY (%)	SAMPLE TYPE	BLOWS PER FOOT	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRAVEL	SAND	FINES (SILT & CLAY)	ORGANIC CONTENT (%)	DESCRIPTION (USCS)	SALINITY (ppt) [$^{(d)}$ is directly meas.]	TESTS / OTHER TESTS	
KWN-09	9	19.0	20.0	100	GP		11				35	58	7		SP-SM		SA	
KWN-10	1	2.0	2.5	100	GP		111								OL			
KWN-10	2	3.0	3.5	100	GP		42								ML			
KWN-10	3	6.0	6.5	100	GP		26								ML			
KWN-10	4	8.0	8.5	100	GP		151							22.6	OL			
KWN-10	5	10.0	10.5	100	GP		16								SM			
KWN-10	6	12.0	12.5	100	GP		126								OL			
KWN-10	7	14.5	15.0	100	GP		19								SP-SM			
KWN-10	8	19.0	20.0	100	GP		20				4	90	6		SP-SM		SA	
KWN-11	1	1.0	1.5	100	GP		953								PT			
KWN-11	2	3.0	3.5	100	GP		97							15.4	OL			
KWN-11	3	5.0	6.0	100	GP		52								ML+OL			
KWN-11	4	7.5	8.0	100	GP		27								ML			
KWN-11	5	12.0	13.0	100	GP		41	25	21	4					CL-ML		PI	
KWN-11	6	15.0	16.0	100	GP		16				5	89	7		SP-SM			
KWN-11	7	19.0	20.0	100	GP		13								SP-SM			
KWN-12	1	2.0	2.5	100	GP		88								OL			
KWN-12	2	4.5	5.0	100	GP		25	27	21	6					ML		PI	
KWN-12	3	8.0	9.0	100	GP		120							15.5	OL			
KWN-12	4	11.0	12.0	100	GP		83								ML			
KWN-12	5	13.5	14.5	100	GP		22				0	93	7		SP-SM			
KWN-13	1	1.0	1.5	100	GP		112								OL			
KWN-13	2	3.5	4.0	100	GP		26								ML			
KWN-13	3	6.5	7.0	100	GP		29								ML	0		
KWN-13	4	8.5	9.0	100	GP		62								ML	0		
KWN-13	5	11.0	12.0	100	GP		22				0	80	20		SM			
KWN-13	6	14.5	15.0	100	GP		17								SP-SM	0		
KWN-13	7	16.0	16.5	100	GP		11								SP-SM			
KWN-13	8	18.0	18.5	100	GP		28								SM			
KWN-13	9	22.0	23.0	100	GP		25								SP-SM	0		
KWN-13	10	24.5	25.0	100	GP		13								SP-SM			
KWN-13	11	26.0	26.5	100	GP		29								ML	1		

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC_SAMPLE_SUMMARY] HBrooks 7/12/12

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TABLE B-1: SAMPLE SUMMARY

Client: USKH		**Project No.:** 113-95736	
Project: Quinhagak School Expansion		**QA/QC By:** J. Randazzo	**Date:** 3/30/2012
Location: Quinhagak, AK		**Reviewed By:** C. Valentine	**Date:** 4/5/2012

SAMPLING DATA							**CLASSIFICATION AND INDEX TEST RESULTS**											
SAMPLE LOCATION	SAMPLE NUMBER	DEPTH (ft)		RECOVERY (%)	SAMPLE TYPE	BLOWS PER FOOT	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT (LL) (%)	PLASTIC LIMIT (PL) (%)	PLASTICITY INDEX (PI) (%)	GRADATION (%)			ORGANIC CONTENT (%)	DESCRIPTION (USCS)	SALINITY (ppt) [$^{(d)}$ is directly meas.]	TESTS / OTHER TESTS	
		TOP	BOTTOM								GRAVEL	SAND	FINES (SILT & CLAY)					
KWN-13	12	28.0	29.0	100	GP		36								ML			
KWN-13	13	33.0	34.0	100	GP		14								SP-SM	0		
KWN-13	14	36.5	37.5	100	GP		21				7	87	6		SP-SM		SA	
KWN-13	15	40.0	41.0	100	GP		19								SP	0		
KWN-13	16	44.0	45.0	100	GP		18								SP			
KWN-13	17	46.5	47.0	100	GP		9								SP	0		
KWN-13	18	48.0	49.0	100	GP		8				45	51	4		SP			
KWN-14	1	1.0	2.0	100	GP		252							48.6	OL			
KWN-14	2	4.5	5.0	100	GP		44								ML			
KWN-14	3	7.5	8.5	100	GP		52								ML	0		
KWN-14	4	11.5	12.5	100	GP		50	22	21	1					ML		PI	
KWN-14	5	15.0	16.0	100	GP		13				37	56	7		SP-SM	0	SA	
KWN-14	6	19.0	20.0	100	GP		12								SP-SM	0		
KWN-15	1	0.0	0.9	93	GP		19								SM			
KWN-15	2	1.5	2.0	100	GP		202								PT			
KWN-15	3	4.0	4.5	100	GP		47								OL	0		
KWN-15	4	6.0	6.5	100	GP		24	26	20	6					CL-ML		PI	
KWN-15	5	8.0	9.0	100	GP		96								ML	0		
KWN-15	6	12.5	13.5	100	GP		105							12.0	OL	0		
KWN-15	7	16.0	17.0	100	GP		11				34	60	6		SW-SM		SA	
KWN-15	8	19.0	20.0	100	GP		28								SW-SM	0		
KWN-15	9	23.5	25.0	100	GP		21								SW-SM	0		
KWN-16	1	30.0	31.0	100	GP		22								SP	0		
KWN-16	2	32.5	33.5	100	GP		14				22	77	1		SP			
KWN-16	3	36.0	37.0	100	GP		20								SP	1		
KWN-16	4	40.0	41.0	100	GP		20				19	77	4		SP			

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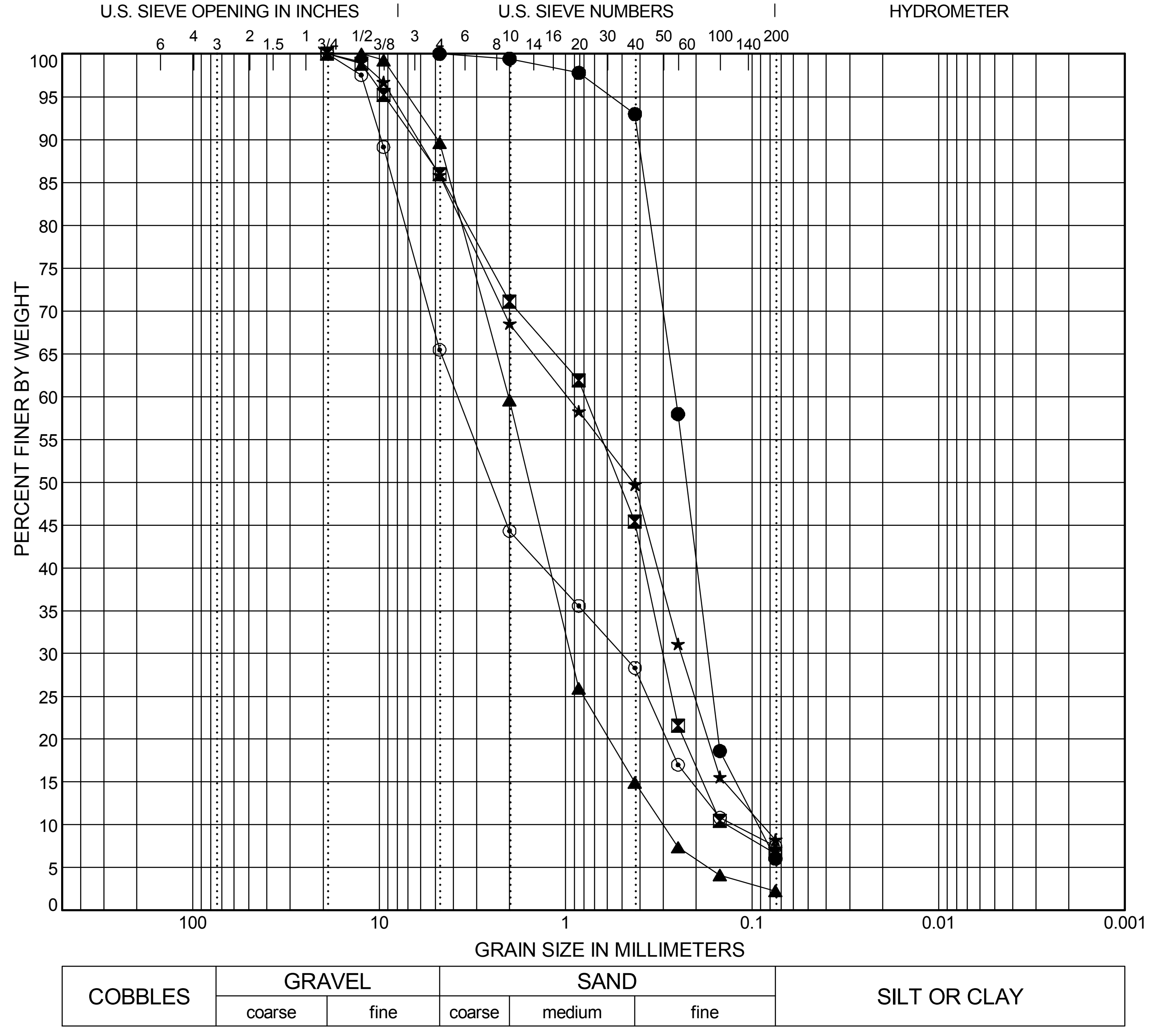
FIGURE B-1: SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s)
ASTM D 422

Client:	USKH	**Project No.:**	113-95736		
Project:	Quinhagak School Expansion	**QA/QC By:**	J. Randazzo	**Date:**	3/30/2012
Location:	Quinhagak, AK	**Reviewed By:**	C. Valentine	**Date:**	4/5/2012



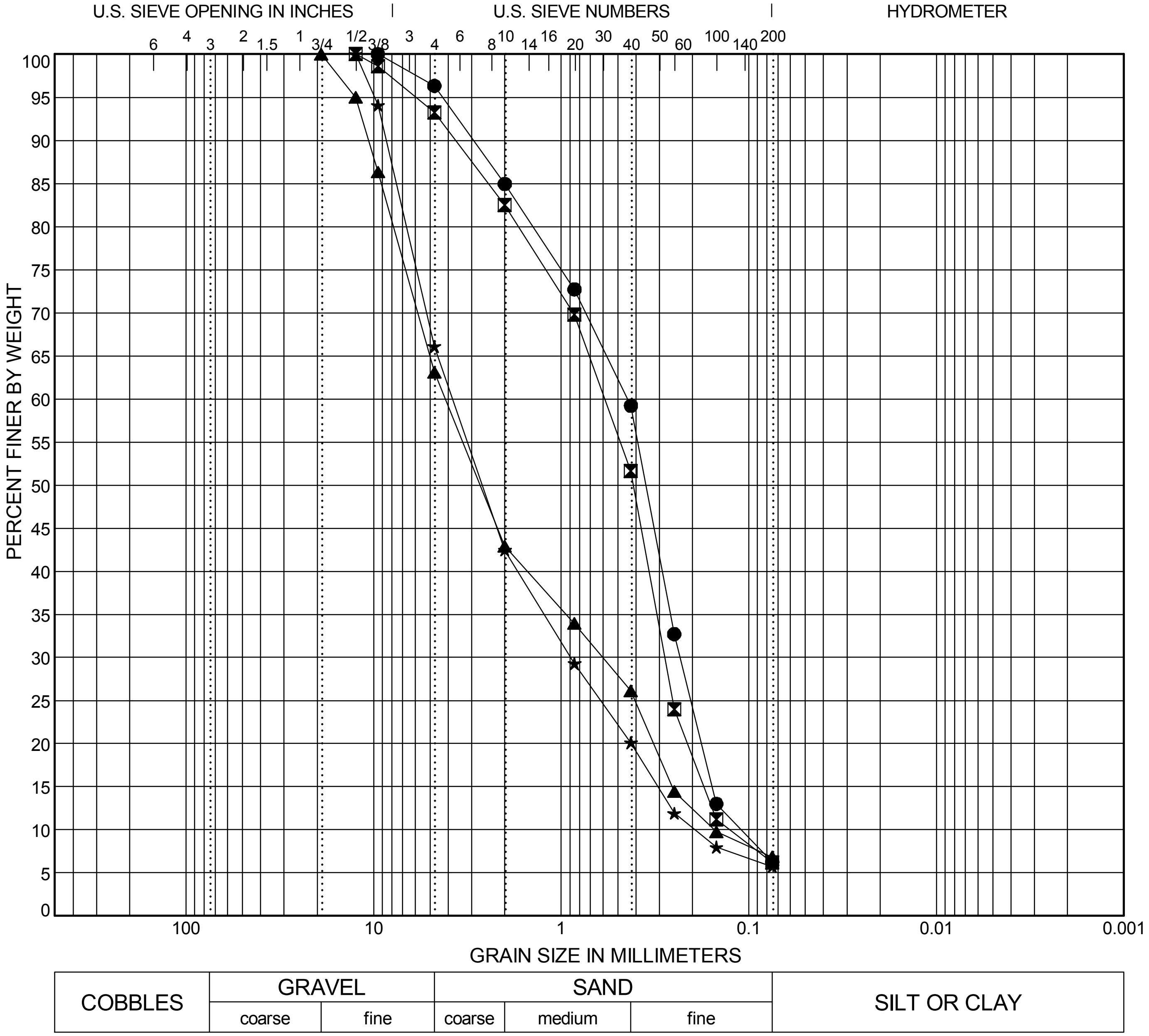
	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	% Fines	% < 0.02 mm
●	KWN-02	5	12.0	poorly graded sand with silt (SP-SM)	1.2	2.8	0.0	93.9	6.1	
⧗	KWN-04	13	30.5	poorly graded sand with silt (SP-SM)	0.8	5.7	14.1	79.3	6.6	
▲	KWN-05	7	17.5	well-graded sand (SW)	1.5	6.7	10.4	87.4	2.3	
★	KWN-06	6	14.0	poorly graded sand with silt (SP-SM)	0.7	11.1	14.1	77.6	8.2	
⊙	KWN-09	9	19.0	poorly graded sand with silt and gravel (SP-SM)	0.5	30.2	34.5	58.0	7.5	

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC LAB GRAIN SIZE] HBrooks 7/13/12

FIGURE B-2: SUMMARY OF PARTICLE SIZE DISTRIBUTION RESULTS

Reference(s)
ASTM D 422

Client:	USKH	**Project No.:**	113-95736		
Project:	Quinhagak School Expansion	**QA/QC By:**	J. Randazzo	**Date:**	3/30/2012
Location:	Quinhagak, AK	**Reviewed By:**	C. Valentine	**Date:**	4/5/2012



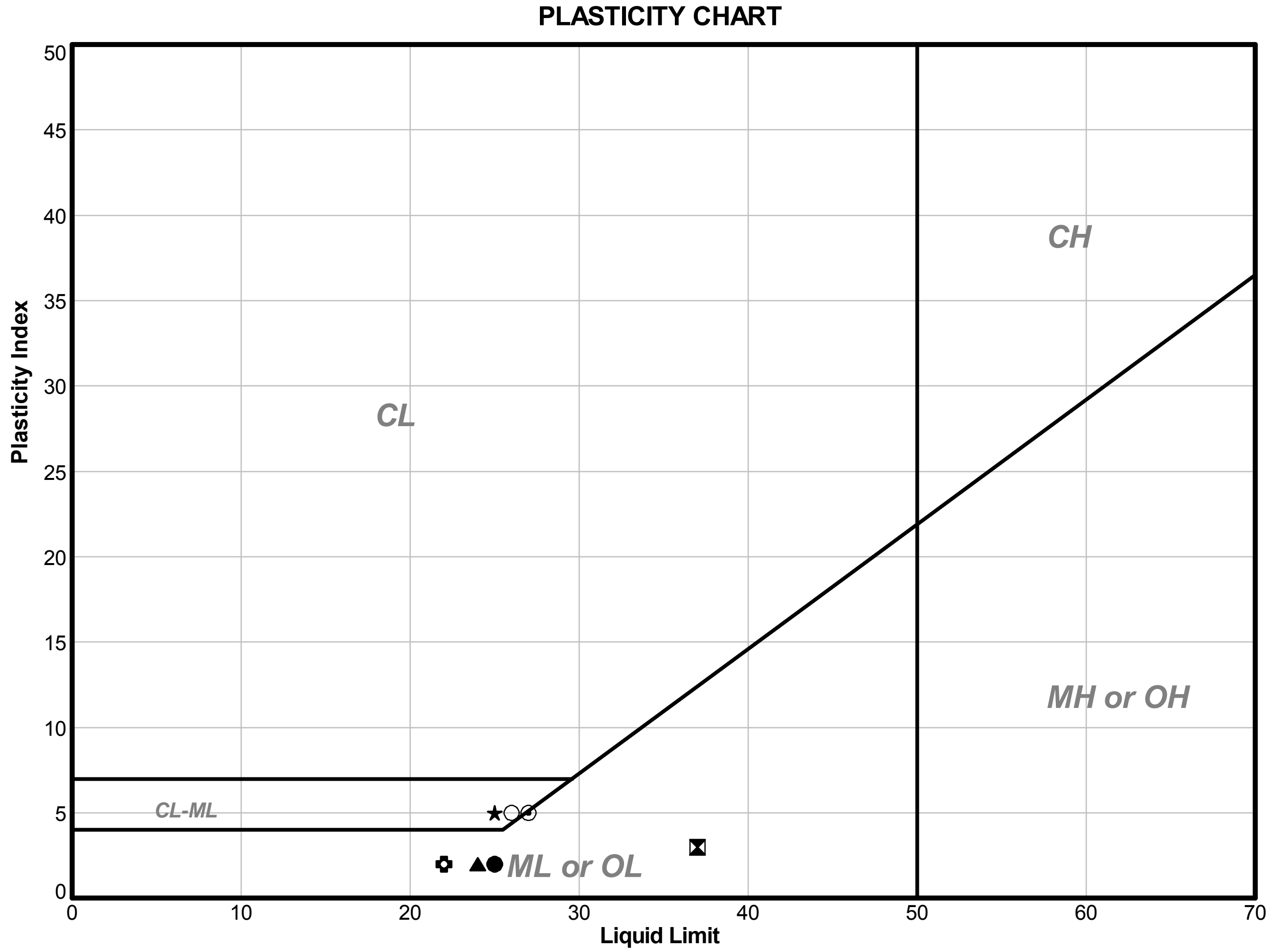
	Sample Location	Sample Number	Depth (ft)	USCS Classification	Cc	Cu	% Gravel	% Sand	% Fines	% < 0.02 mm
●	KWN-10	8	19.0	poorly graded sand with silt (SP-SM)	1.1	4.0	3.7	90.1	6.3	
☒	KWN-13	14	36.5	poorly graded sand with silt (SP-SM)	1.1	4.6	6.8	87.1	6.2	
▲	KWN-14	5	15.0	poorly graded sand with silt and gravel (SP-SM)	0.6	27.2	36.9	56.3	6.8	
★	KWN-15	7	16.0	well-graded sand with silt and gravel (SW-SM)	1.1	19.6	33.9	60.4	5.7	

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC LAB GRAIN SIZE] HBrooks 7/13/12

FIGURE B-3: LIQUID LIMIT, PLASTIC LIMIT AND PLASTICITY INDEX

Reference(s)
ASTM D 4318

Client:	USKH	**Project No.:**	113-95736		
Project:	Quinhagak School Expansion	**QA/QC By:**	J. Randazzo	**Date:**	3/30/2012
Location:	Quinhagak, AK	**Reviewed By:**	C. Valentine	**Date:**	4/5/2012

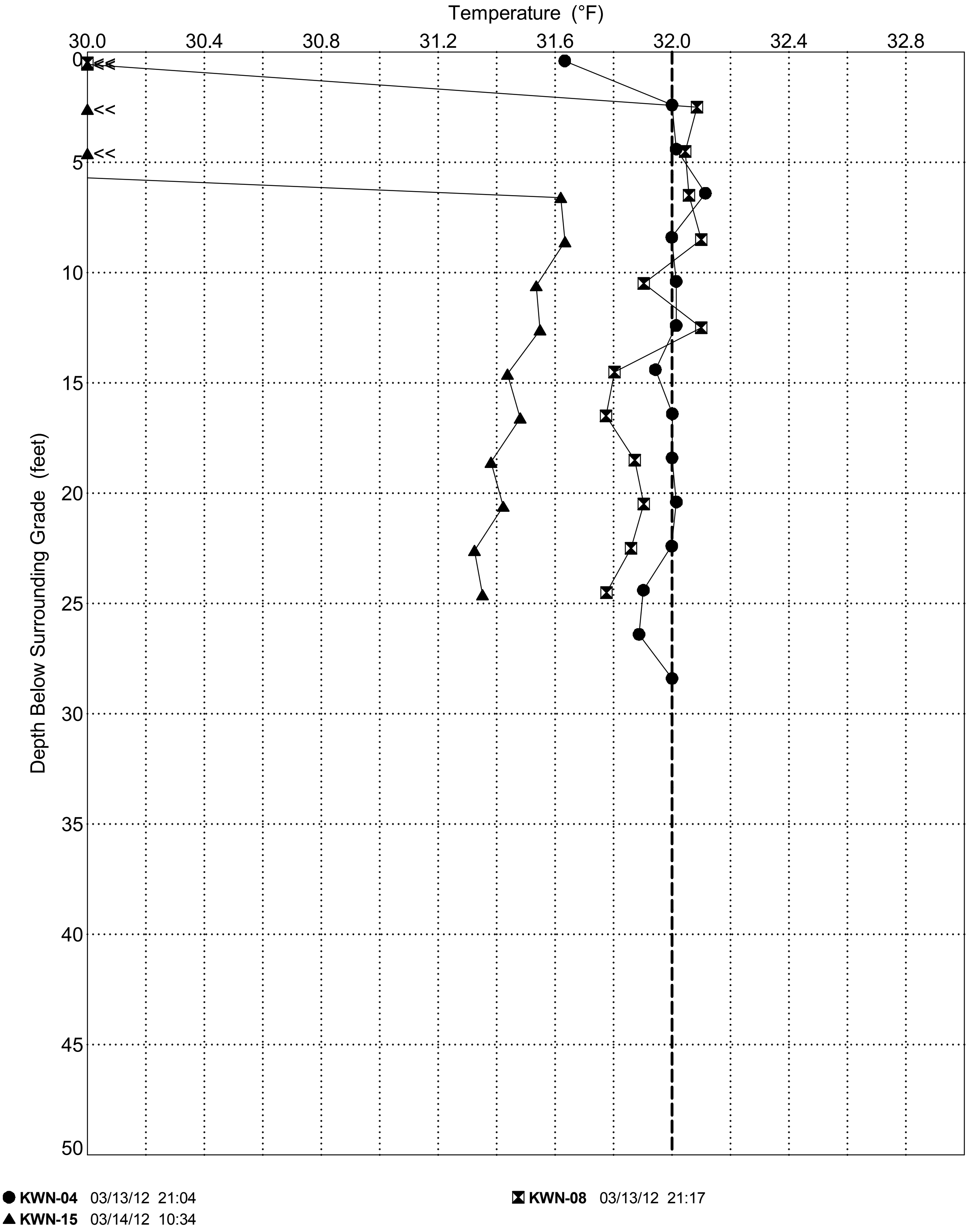


NOTE: NP - NON-PLASTIC RESULT

	Sample Location	Sample Number	Depth (ft)	Bottom (ft)	Liquid Limit (%)	Plastic Limit (%)	Plasticity Index	USCS	Natural Moisture Content (%)	Liquidity Index
●	KWN-01	3	4.5	5.0	25	22	3	ML	48	8.6
☒	KWN-05	10	27.0	27.5	37	34	3	ML	38	1.4
▲	KWN-08	6	13.0	14.0	24	22	2	ML	37	7.6
★	KWN-11	5	12.0	13.0	25	21	4	CL-ML	41	4.9
⊙	KWN-12	2	4.5	5.0	27	21	6	ML	25	0.7
✿	KWN-14	4	11.5	12.5	22	21	1	ML	50	29.1
○	KWN-15	4	6.0	6.5	26	20	6	CL-ML	24	0.6

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC LAB ATTERBERG CASAGRANDE MULTI (10)] HBrooks 7/12/12

APPENDIX C
MEASURED GROUND TEMPERATURES



113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC THERMISTOR] HBrooks 7/12/12

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FILE No. 113-95736 QUINHAGAK SCHOOL.GPJ

PROJECT No. 113-95736

SCALE	NOT TO SCALE	
DESIGN	N/A	
CADD	MMH	07/12/12
CHECK	HMB	07/12/12
REVIEW	RAM	07/12/12
REV.	0	

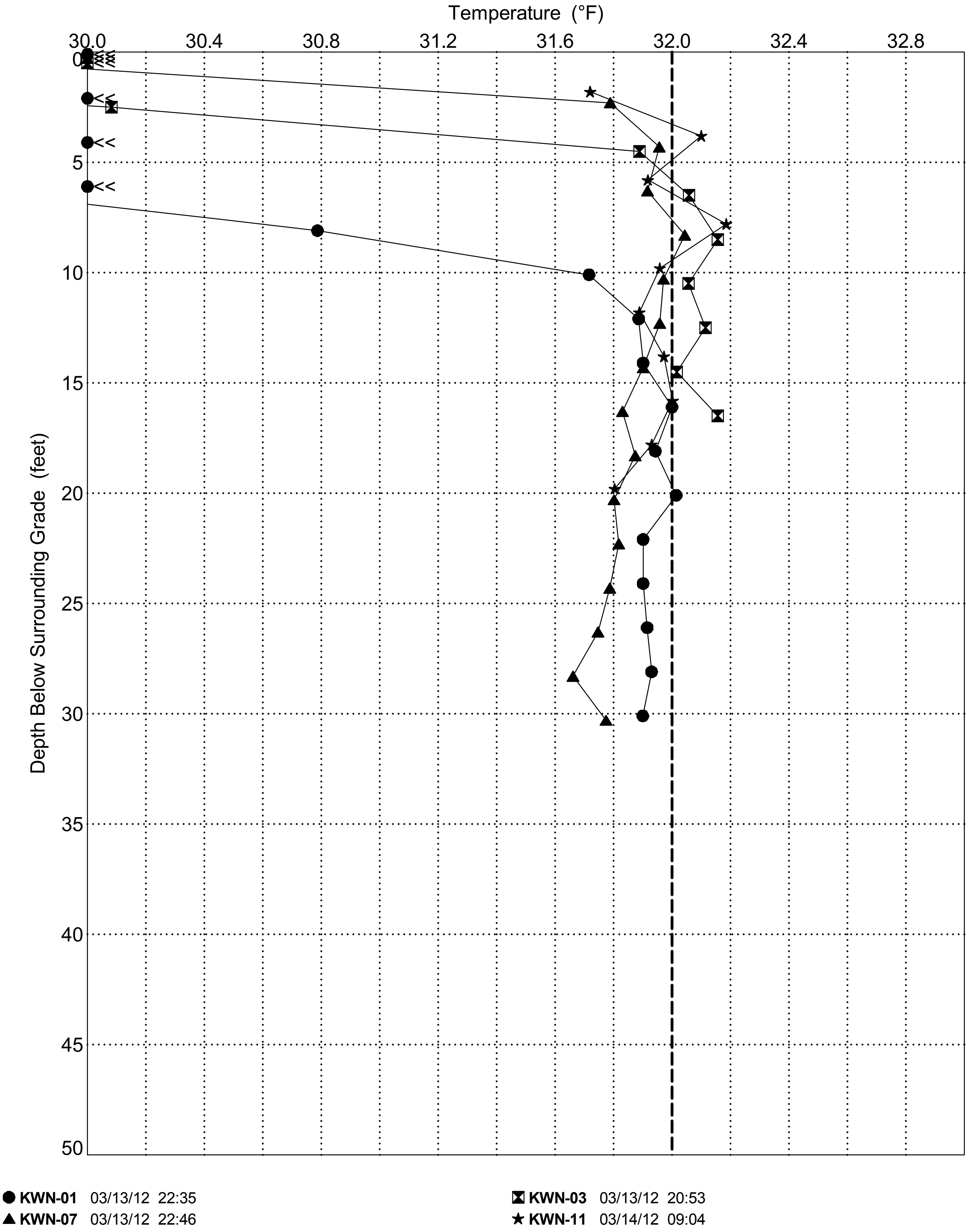
TITLE

MEASURED GROUND TEMPERATURES

QUINHAGAK SCHOOL EXPANSION
QUINHAGAK, AK

USKH/QUINHAGAK SCHOOL/AK

FIG. **C-1**



113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC THERMISTOR] HBrooks 7/12/12

Golder Associates

SCALE	NOT TO SCALE	
DESIGN	N/A	
CADD	MMH	07/12/12
CHECK	HMB	07/12/12
REVIEW	RAM	07/12/12
REV.	0	

FILE No. 113-95736 QUINHAGAK SCHOOL.GPJ

PROJECT No. 113-95736

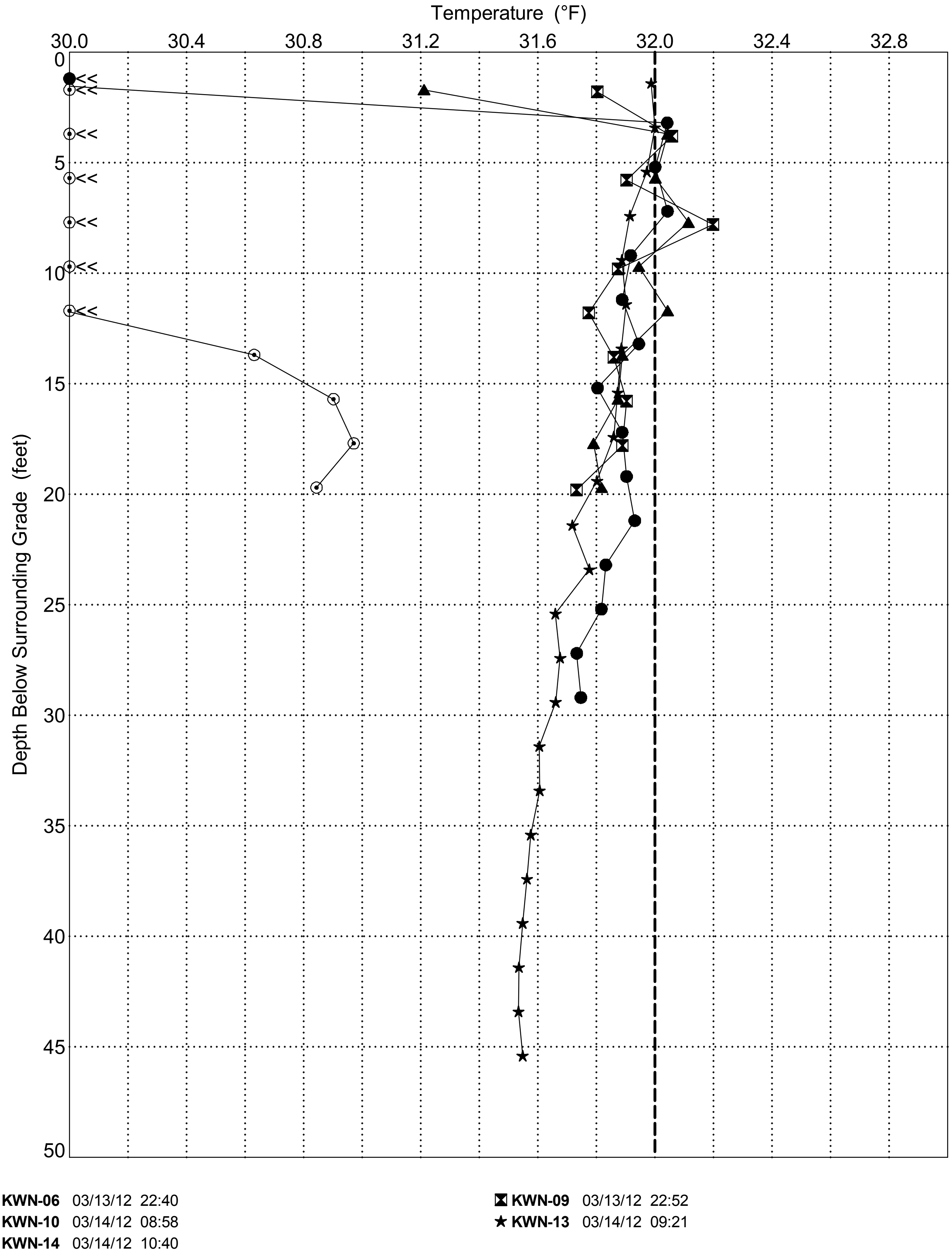
TITLE

MEASURED GROUND TEMPERATURES

QUINHAGAK SCHOOL EXPANSION
QUINHAGAK, AK

USKH/QUINHAGAK SCHOOL/AK

FIG. C-2



Golder Associates

SCALE	NOT TO SCALE		
DESIGN	N/A		
CADD	MMH	07/12/12	
CHECK	HMB	07/12/12	
REVIEW	RAM	07/12/12	
REV.	0		

FILE No. 113-95736 QUINHAGAK SCHOOL.GPJ

PROJECT No. 113-95736

TITLE

MEASURED GROUND TEMPERATURES

QUINHAGAK SCHOOL EXPANSION
QUINHAGAK, AK

USKH/QUINHAGAK SCHOOL/AK

FIG. **C-3**

113-95736 QUINHAGAK SCHOOL.GPJ LIBRARY-ANC(6-4-12).GLB [ANC THERMISTOR] HBrooks 7/12/12

APPENDIX D
TEACHER HOUSING RECOMMENDATIONS

TECHNICAL MEMORANDUM

Date: April 27, 2012 **Project No.:** 113-95736
To: Dale Smythe **Company:** USKH
From: Heather M. Brooks, PE HMB and Richard A. Mitchells, PE RAM
RE: **QUINHAGAK TEACHER HOUSING**

This memorandum presents the results of the site exploration conducted by Golder Associates Inc. (Golder) for the proposed teacher housing structure in Quinhagak, Alaska. This exploration was completed during our exploration of the proposed school addition site. Our services were completed in general accordance with our proposal to you dated October 4, 2011 and our revised cost estimate dated November 8, 2011.

We understand that the proposed teacher housing will consist of a 4-plex structure. We understand the preferred foundation for the structure is drilled and slurried timber piles. Expected structural loads on the piles were provided for our information via an email from Mr. Frank Thompson, PE dated April 25, 2012. We understand that the total dead load on the piles is 11.5 kips (sum of floor and roof dead loads) with a floor live load of 9 kips. For the purposes of our analysis the sustained load on the piles will be 16 kips per pile. The sustained load is the total dead load and one-half of the expected live load.

1.0 SITE AND SUBSURFACE CONDITIONS

Borehole KWN-14 was advanced to a depth of 20 feet below ground surface (bgs) at the location of the proposed teacher housing structure. Subsurface conditions were bonded and frozen soil with 6-inches of surface peat (Pt). Underlying the peat was a layer of low plasticity organic silt (OL) to 4.5 feet bgs. A layer of low plasticity mineral silt was observed underlying the organic silt to 14.8 feet bgs. Poorly graded sand with silt and gravel (SP-SM) was observed below the silt to the depth explored in this borehole.

Ground temperatures were measured in the boreholes after the dissipation of drilling induced heat approximately 4 weeks following drilling. Ground temperatures below the depth of seasonal influence at the teacher housing site were approximately 31 degrees Fahrenheit (°F), or colder.

2.0 RECOMMENDATIONS

Based on our geotechnical findings and our discussions of the nature of the proposed teacher housing structure, we offer the following geotechnical considerations. Geotechnical findings and recommendations for the proposed school addition structure will be provided in a separate submittal. Plans and specifications based on these recommendations should be reviewed by Golder to confirm the design meets the intent of our recommendations.

2.1 Site Preparation

We have assumed that the natural surface vegetation (tundra) will remain intact and undisturbed under and around the proposed teacher housing structure. If a granular fill pad is planned at the site, we should be notified so we can revise our recommendations.

2.2 Foundation Piles

We understand that a drilled and slurried timber pile foundation is the preferred foundation system for the proposed teacher housing structure. The piles will be installed in dry augered holes and backfilled with sand-water slurry. The clear blow-through space beneath the structure should be at least three feet or higher to allow the cold winter condition to maintain ground temperatures.

2.2.1 Foundation Embedment

The minimum pile embedment below ground surface (bgs) for an adfreeze pile design using drilled and slurried methods is controlled by the creep settlement or frost jacking forces.

Creep settlement consists of the pile settlement over the life of the structure due to the movement of the ice bonded material under the sustained load. The relatively light sustained structural loads on the pile are not expected to control the required embedment of the foundation piles to maintain creep related settlements below acceptable limits.

The frost uplift force is caused by the expansion and migration of pore water within the active layer. Significant frost uplift forces can be developed in areas with fine-grained soils capable of ice lens formation. Ice lenses form in areas with finer-grained soil, water supply, and a slow freezing front, which is the case in this area of Quinhagak. The frost force is calculated by multiplying the surface area of the pile within the active layer by the frost uplift pressure expected acting at the soil/pile interface. We estimated the active layer to extend to 5 feet bgs.

Generally, a frost uplift pressure of 40 pounds per square inch (psi) is used. A bond break (visqueen wrap) is recommended on the piles for the proposed teacher housing. Thus, a frost uplift pressure of 20 psi was used as the basis for our analysis. The calculated frost uplift force for 10 and 12-inch diameter square un-treated timber piles are 48 and 58 kips, respectively.

For this analysis, we have assumed the foundation piles will consist of 10 or 12-inch nominal square rough sawn structural timber piles. We have assumed a constant ground temperature of 31°F below 8 feet bgs. To resist the frost uplift force, the minimum embedment is 25 feet bgs or a minimum of 10 feet of embedment into the sand/gravel layer, whichever is deeper for each pile size. A factor of safety of 1.5 against frost uplift forces was used in this analysis.

The pile will resist lateral loads by acting as a cantilever above the active layer. In summer months, the point of fixity should be assumed 5.5 feet bgs. In winter months, the point of fixity should be assumed at ground surface.

To reduce the frost uplift force, a three layer wrap of a minimum 10 mil. polyethylene sheeting (Visqueen) should be securely attached to the perimeter of the each pile for the uppermost 5 feet of embedment and 6-inches above finish grade. The Visqueen should be stapled or taped to the pile after wrapping.

2.2.2 Pile Installation Considerations

Piles should be placed in pre-augered holes and slurried back with a mixture of potable water and sand/gravel slurry aggregate. The holes should be at least 6 inches greater than the widest dimension of the pile, 20 inches for the 10-inch pile and 24-inches for the 12-inch pile. The diameter of the hole must be large enough to allow proper positioning of the pile. To allow undisturbed freezeback of the adfreeze bond, the piles should not be loaded until the ground temperature of the lower half of the pile reaches 31.5°F or colder.

If the holes are drilled when the ground surface is thawed, the holes may need to be cased to prevent sidewall caving or to control water infill. Use of a concrete vibrator on all sides of the pile during slurry placement is required. The depth of the hole should be measured to verify that the design depth has been achieved. The pile should be installed so that it is plumb and in proper position. The pile should be held firmly in place by blocking until the pile meets freezeback criteria.

2.2.3 Slurry

Slurry used for backfill should consist of a mixture of sand and potable water. Brackish water and drilling tailings should not be used in the slurry. At the time of placement, the slurry should not be colder than 35°F nor warmer than 45°F.

A gravelly sand, sand or silty sand mixture should be used to make the slurry. Materials used for the slurry should be checked for salinity prior to use. If the salinity of the sand is greater than 4 parts per thousand (ppt), the material should be washed to reduce its salinity of an alternative source should be used. The sand and gravel used to make the slurry should have 100 percent of material passing the ¾-inch sieve and less than 20 percent passing the US number 200 sieve by weight. The granular soil mixture used to mix the slurry must be in an unfrozen state prior to mixing with potable water to form the slurry. Local sand and gravel can be used for slurry if it meets the criteria presented above.

The annulus of the hole should be filled in 3 to 4-foot lifts with sand-water slurry and densified between each lift. The slurry should be mixed above grade in a concrete mixer (or similar) to a consistency with an equivalent 4 to 6-inch slump.

2.2.4 Ground Temperature Monitoring

To permit temperature measurements in the slurry, a closed-end 1-inch diameter Schedule 40 HDPE or steel conduit should be installed to the bottom of each pile hole and extend to two feet above finish grade. HDPE requires a thermal weld to securely close the tip. The conduit should be capped to prevent water infiltration. HDPE conduit should not be glued. The temperatures along the piling can be monitored after construction using thermistors placed in the pipe.

Given the warm ground temperatures measured at the teacher housing site, the mixed thermal state of the school addition site and warming climate conditions expected in the area, it is likely that ground temperatures at the site will continue to warm. In order to maintain the resistance to frost uplift forces if warming temperatures occur, passive cooling may be required in the future to maintain the ground temperature of each pile. To add passive cooling to each pile, a closed-end 2-inch diameter steel pipe extending to the bottom of each pile hole and extending to 6 to 12-inches above finish grade should be installed with each pile. If the conduit is installed, the addition of passive cooling may be inserted inside the conduit at a later date, if necessary.

2.3 Site Inspection

A qualified geotechnical engineer or technician should be on-site during pile installation to verify the piles meet embedment criteria and installation recommendations. We recommend Golder review as-built records to confirm the piles were installed in accordance with project documents and our recommendations.

3.0 USE OF THIS REPORT

This memot has been prepared for the use of USKH for the proposed teacher housing structure in Quinhagak, Alaska as discussed in this report. If there are any significant changes in the nature, design, or location of the facilities, we should be notified so that we may review our conclusions and recommendations in light of the proposed changes and provide a written modification or verification of the changes.

There are possible variations in subsurface conditions, ground temperatures and thermal states, and ground water levels between explorations and also with time. Therefore, observations and testing by a qualified geotechnical professional should be included during construction to provide corrective recommendations adapted to the conditions revealed during the work.

Unanticipated soil conditions are commonly encountered and cannot fully be determined by a limited number of explorations of soil samples. Such unexpected conditions may results in additional project costs in order to construct the project as designed. Therefore, a contingency for unanticipated conditions should be included in the construction budget and schedule.

The work program followed the standard of care expected of professionals undertaking similar work in the State of Alaska under similar conditions. No warranty expressed or implied is made.

At Golder Associates we strive to be the most respected global group of companies specializing in ground engineering and environmental services. Employee owned since our formation in 1960, we have created a unique culture with pride in ownership, resulting in long-term organizational stability. Golder professionals take the time to build an understanding of client needs and of the specific environments in which they operate. We continue to expand our technical capabilities and have experienced steady growth with employees now operating from offices located throughout Africa, Asia, Australasia, Europe, North America and South America.

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