KIVALINA CAUSEWAY GEOTECHNICAL REPORT, KIVALINA, ALASKA

REPORT

Submitted To: US Army Corps of Engineers, Alaska District
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August 14, 2015 **1419207**

Golder Associates

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1.0 INTRODUCTION

1.1 Project Description

Golder Associates Inc. (Golder) has been contracted by the US Army Corps of Engineers, Alaska District (USACE) to perform a subsurface exploration program for the Kivalina Evacuation Road Project in Kivalina, Alaska. The community of Kivalina is located on a barrier island that lies between the Kivalina Lagoon and the Chukchi Sea along the northwest coast of Alaska. Kivalina is located approximately 80 miles northwest of the community of Kotzebue, Alaska, and 75 miles southeast of the community of Point Hope, Alaska. The project location is depicted in the Vicinity Map, Figure 1.

The project consists of an emergency evacuation road crossing the Kivalina Lagoon. The road will incorporate a system of abutments/piers, bridge structures, causeways, and approach roads. At the time of this report, final grades, elevations, spans, and specific design details are not known.

This report provides the results of Golder's review of existing data, geotechnical site exploration, laboratory testing, and discussion of findings. This work was done in accordance with the Statement of Work (SoW) provided by USACE (Statement of Work Revision 10 February 2015 – Contract No. W911KB-13-D-0009), and with the USACE approved Quality Control Plan, Health and Safety Plan, and Geotechnical Work Plan.

1.2 Purpose and Scope

Our scope of work consisted of performing a geotechnical site investigation and characterizing the subsurface conditions for the proposed Kivalina Evacuation Road. Golder's findings and geotechnical considerations will support additional engineering design, permitting, and construction cost estimates, all of which will be developed by others. Our scope of services did not include developing geotechnical engineering designs, recommendations, or bid-ready construction documents. Golder's scope of work included:

- Reviewing readily available historical geotechnical explorations within and near the project area.
- Planning and executing a geotechnical drilling program to explore the subsurface soil and thermal conditions along the proposed road alignment up to 50 feet below grade.
- Performing Laboratory testing on samples collected during the geotechnical exploration.
- Providing results of the subsurface exploration and laboratory testing programs in a written Geotechnical Data Report.

Subsurface conditions were characterized by performing a subsurface exploration that included advancing boreholes, collecting soil samples, and laboratory testing. Based on the findings from the field study and laboratory testing, as well as our understanding of the site geology and regional seismic hazards, we are providing a discussion of our analysis.

1.3 Project Team

The Golder Project Team consisted of a Project Director, Project Manager, and Team Lead. Mr. Tom Krzewinski, PE, was Project Director and provided senior oversight for the project, while Mr. John Thornley, PE, the Project Manager, was accountable for project planning, monitoring, and closure. Mr. Ryan Campbell was the Team Lead and managed the field exploration program. Drilling services were provided by Discovery Drilling Inc. (Discovery) of Anchorage, Alaska. Logistics and billeting were provided by Remote Site Services Inc. (RSSI) of Anchorage, Alaska.

2.0 GEOTECHNICAL SITE INVESTIGATION

2.1 Subsurface Drilling and Sampling

The purpose of the drilling program was to explore the subsurface conditions within the project site to determine the physical and engineering characteristics of the soils. The drilling program was conducted between March 14, 2015 and March 21, 2015. Drilling was conducted using a track-mounted Geoprobe 6712DT drill rig, owned and operated by Discovery. A total of six (6) boreholes, identified as K15-01 through K15-06 (Permanent Borehole Numbers AP-39 through AP-44), were advanced at the site, as shown on the Borehole Location Map, Figure 2. The boreholes consisted of two 50-foot boreholes at proposed abutment locations and four 30-foot boreholes along the proposed causeway alignment for a total of 220 linear feet. Each borehole was drilled from the surface of the lagoon ice. The lagoon ice was ground fast at the time the boreholes were drilled.

Drilling was accomplished using hollow-stem auger methods. The augers used during the exploration have an inner diameter of 3.25 inches and an outer diameter of 6.625 inches. Samples were obtained using a 2.0-inch outside diameter (O.D.) split-barrel sampler driven by a 140-pound automatic hammer following the procedures outlined in the American Society of Testing and Materials (ASTM) D1586, “Standard Test Method for Penetration Test and Split Barrel Sampling of Soils.” In general, drive samples were collected at 2.5-foot intervals to 17.5 feet, and at 5-foot intervals thereafter to proposed test borehole depths, or at major soil type transitions. In the frozen near surface materials encountered in Boreholes K15-01 (AP-39) and K15-04 (AP-42) where insufficient penetration and material recovery was obtained using the equipment required by the ASTM D1586 test method, a modified penetration test was performed. The modified penetration test included a 3.0-inch O.D. split-barrel sampler and automatic drop hammer set to drop a 340-pound weight a distance of 30 inches.

Samplers were driven into the soil using a 140-pound automatic hammer free-falling a vertical distance of 30 inches. The number of hammer blows or blow counts generally required to drive the sampler in four 6-inch segments were recorded during sampling. The combined blow count for the middle two 6-inch segments is referred to as the uncorrected SPT N-value. Sampling procedures employed in the field were consistent with those described by the American Society for Testing and Materials, ASTM D1586, “Standard Test Method for Penetration Test and Split Barrel Sampling” (2011) with the exception of use of the larger spoon and hammer. Advancement of the SPT sampler was ceased when blow counts to drive the sampler reached 50 blows, in six inches, or more (refusal). Individual blow counts for each sample can be found in the Appendix A, Borehole logs.

Heave was encountered in Borehole K15-01 (AP-39) and K15-04 (AP-42) near the surface at five feet bgs and four feet bgs respectively and was controlled by using the auger wash method. This method uses water poured into the augers to increase the head pressure, to maintain bit circulation while drilling. In all

the boreholes the auger wash method was used to prevent heave. The term "AW" was recorded on the borehole log and sample summary when auger wash methods were used and is indicated on the individual borehole logs and can be found in Appendix A, Borehole Logs.

Each soil sample collected in the field was classified in accordance with ASTM D2488, "Description and Identification of Soils (Visual-Manual Procedure)." Where frozen conditions were encountered, soil samples were also classified in accordance with ASTM D-4083, "Frozen Soil Classification." Collected soil samples were handled in accordance with ASTM D4220, "Standard Practices of Preserving and Transporting Soil Samples." The borehole logs are presented in Appendix A. Boundaries between different soil types presented on the logs are approximate because actual transition between layers may be gradual.

2.1.1 Site Contamination Screening

Collected soil samples were placed in plastic bags and warmed to at least 50 degrees Fahrenheit (°F) before beginning the screening process. After about 30 minutes, the samples were screened with a Photoionization Detector (PID) to estimate the presence of volatile organic compound (VOC) levels. The PID used was equipped with a 10.2-electron-volt (eV) lamp. After warming and prior to testing, each sample was shaken or agitated for 15 seconds at the beginning and end of the vapor development period to assist volatilization. After vapor development, the PID sampling probe was inserted to about one-half the headspace depth and the highest meter reading was recorded, which was normally between two and five seconds after probe insertion. Care was taken when inserting the sampling probe into the bag to avoid uptake of any moisture or soil particles. The PID was calibrated at the beginning of every field day with 100-parts per million (ppm) isobutylene calibration gas. As stated in the project's Final Work Plan[1], soils with PID readings above 20 ppm, stained, or emitting odors were considered contaminated. Based on the field screenings, no contaminated soils were observed during the exploration.

2.1.2 Completion of Boreholes

Upon completion of drilling, a one-inch diameter, schedule 120 polyvinyl chloride (PVC) pipe was installed in select boreholes to allow for subsurface ground temperature measurements. The annular space between the PVC pipe and the sidewall of the boreholes was backfilled with non-contaminated drill cuttings. In compliance with Golder's Health and Safety plan, boreholes were not left open overnight without barriers and/or guarding. Horizontal locations were collected using Trimble Geo7x global positioning system (GPS) unit and differentially corrected by post-processing using Trimble GPS Pathfinder software. Post process position accuracy on the observations is between 0 and 50 cm. The borehole locations and elevations are presented in Table 1 below and shown on the Borehole Location

[1] Kivalina Evacuation Road Project, Final Work Plan. Submitted to USACE - Alaska District by Golder Associates Inc. March 6, 2015. Project Number 1419207

Map, Figure 2. Borehole elevations are assumed from bathymetric data provided by USACE on April 30, 2015.

Table 1: Borehole Locations and Mudline Elevations

Borehole	Northing (AK83-8F)	Easting (AK83-8F)	Latitude (WGS84)	Longitude (WGS84)	Elevation (Feet)[1]
K15-01 (AP-39)	5021268.196	1842645.871	67.73054419	-164.5427967	-2.34
K15-02 (AP-40)	5021391.276	1842782.222	67.73087171	-164.5417937	-3.38
K15-03 (AP-41)	5021535.562	1842911.126	67.73125763	-164.5408408	-2.14
K15-04 (AP-42)	5021952.875	1843319.69	67.73237149	-164.5378269	-1.85
K15-05 (AP-43)	5022472.143	1843929.111	67.73375086	-164.5333484	-1.4
K15-06 (AP-44)	5023107.386	1844698.75	67.73543656	-164.5276952	-1.77

Notes: Vertical Control is Mean Lower Low Water (MLLW = 0.0' NAVD-88)
[1] Assumed elevations from bathymetric data provided by USACE.

2.2 Subsurface Temperature Measurements

Subsurface temperatures were measured in Boreholes K15-01 (AP-39), K15-02 (AP-40), and K15-06 (AP-44) over the period of 30 days following the completion of drilling and recorded as the temperatures stabilized. Subsurface temperatures were measured using a Temperature Acquisition Cable (TAC) with sensor depth spacing of 2.5 feet from the ground surface to 20 feet bgs, and five (5) foot spacing from 20 to 50 feet bgs. Data was recorded on a TAC datalogger that was retrieved by RSSI employee Alex Hawley. Results are presented in Temperature Data Recordings, Appendix C.

2.3 Laboratory Testing

A total of 72 representative soil samples were selected for laboratory testing and tested by DOWL of Anchorage, Alaska, a USACE validated geotechnical laboratory. The laboratory testing was performed for the following purposes:

- Substantiating visual field classifications – ASTM D2488
- Classification of Soils (USCS) – ASTM D2487
- Particle-Size Analysis of Soils – ASTM D422
- Moisture Content – ASTM D2216
- Atterberg Limits – ASTM D4318
- Moisture, Ash, and Organic Matter of Peat and Other Organic Soils – ASTM D2974
- Salinity Testing – DOWL In-house procedure
    - (Place 100g of material and place in 250ml beaker. Record weight and add equal amount of distilled water and record weight again. Stir samples and let stand

overnight. Determine type of environment samples were recovered from and utilize standard most representative of environment. Stir sample and read temperature and conductivity with conductivity meter.)

Results of laboratory testing are presented in the Laboratory Test Summary, Appendix B. Select laboratory testing results are also presented on the borehole logs in Appendix A.

3.0 SITE CONDITIONS

3.1 Regional Setting

Kivalina is within the Arctic Foothills Physiographic Province, which is generally characterized by rolling hills and gentle slopes. The Community of Kivalina; however, is located on the southern end of Kivalina Island, a barrier island that separates Kivalina Lagoon on the east from the Chukchi Sea on the west. The Kivalina River and the Wulik River both flow into Kivalina Lagoon, which in turn discharges into the open sea through the Kivalik Inlet and the Sinauk Entrance.

Kivalina Island is generally less than 20 feet above sea level, is almost flat, and consists of geologically modern beach-sand deposits. Some gravel is present at each end of the island, but historically most granular construction material has been brought in from the Wulik River floodplain. We understand that the only significant source of locally available granular material is from the floodplains and deltas of the two major drainages east of the Kivalina Lagoon.

The Chukchi Sea has a major weather impact on the local climate, but because the Chukchi Sea is frozen for over half the year, Kivalina has a climate that is transitional between Maritime and Continental. The mean annual temperature is about 20°F with an average precipitation rate of less than 10 inches per year. Snowfall is on the order of three feet per year and persistent winter winds can result in significant drifting. Permafrost is present throughout the mainland area east of the Kivalina Lagoon.

Tidal influence in the Kivalina Lagoon is unknown at this time, but the nearest official tide recording station to Kivalina is located at the Red Dog Port, approximately 17 miles to the south. The mean range of tides at the Red Dog Port (9491094) is 0.66 feet from mean sea level according to the National Oceanic and Atmospheric Administration (NOAA)[2].

3.2 Regional Geology

Bedrock is seldom exposed in the project area except in isolated hills, especially those northwest of the Kivalina floodplain. These hills are topped with rock rubble and outcrops of limestone have been reported. DMA, 2007 see Section 3.3. Kisimigiuktuk Hill, the only hill in or near the project area, is rubble covered.

Although Pleistocene glaciation did not extend to the coast, it has had a major impact on the surficial geology in the Kivalina area. Sea level fluctuation has resulted in the accumulation of sandy beach deposits at various locations both offshore and inland from the presently established coastline. These deposits are similar in composition to present beach deposits, but in many cases they have been partially or totally eroded away or buried by newer fine grained material.

[2] NOAA Tide and Current Data, http://tidesandcurrents.noaa.gov/map/

The drainage patterns of the Wulik and Kivalina Rivers have controlled much of the post-glacial deposition of local sediments. Glacial deposits in the headwaters have been reworked by stream and river action and are the source of gravelly sand and sandy gravel deposits in the modern floodplains. Wind-blown silt and sand is often present as a near-surface veneer that, with surface vegetation, forms the present tundra cover. Along the eastern edge of Kivalina Lagoon, between the two rivers, a vegetation covered and tidally influenced zone extends as much as two miles inland.

Beneath one to two feet of seasonally thawed material, the mainland east of the lagoon is almost universally underlain by permafrost. Horizontally layered ice masses are common and near vertical ice wedges that have developed in soil contraction cracks often result in a surficial feature known as polygonal patterned ground. This segregated ice is generally confined to the fine-grained, organic-rich surface material, but under some conditions ice wedges have penetrated into the underlying granular material.

3.3 Existing Geotechnical Data

Golder has conducted geotechnical investigations in Kivalina since the 1990's for infrastructure development projects. Most of our in-house geotechnical data is not located near the proposed evacuation road alignment, although important information about the general subsurface conditions in the area may be applicable. Key elements from our review of historic geotechnical data near the proposed improvements are summarized below.

- **Golder Associates Inc. (Golder) Geotechnical Findings and Conceptual Recommendations, Kivalina Evacuation Road, 2013.** Golder was subcontracted by WHPacific to perform a geotechnical field exploration and provide conceptual-level geotechnical recommendations and considerations for a light-duty, double-lane unpaved roadway. Two roadway alignments, the northern and southern route, were investigated during this program. Based on probe and shallow drill hole data, the southern route was identified as the most viable for the construction of the roadway. The subsurface conditions along the southern alignment generally consisted of approximately 0.5 to 1.5 feet of unfrozen organic mat (PT) overlying approximately two to four feet of frozen silty sand (SM). Five granular material sources for construction of the roadway were also identified.
- **Duane Miller and Associates (DMA), Material Source Desktop Study, 2007.** In 2007 DMA issued a desktop investigation report on potential material targets in and around the Kivalina area. Sandy gravel and sand deposits were identified within the modern floodplains of the Wulik drainage as potential areas for aggregate material assessments. Old beach lines and associated back beach sand dunes were also identified as potential targets for unclassified granular material areas. Rock and rock rubble deposits from bedrock ridges were also identified as potential sources for crushed material.
- **DMA (and others), Permafrost and Wetlands Report, National Guard Armories, Western and Northern Alaska, 2006.** In August 2006, DMA probed for potential active layer depths at the armory in Kivalina. A 30-foot by 30-foot grid was established on the armory site and shallow hand-dug test pits were excavated at two of the grid nodes. Beneath a thin organic mat of grasses and roots, sand with trace fine gravel was

observed to a test pit termination depth of three feet. Frozen ground was not encountered with a five-foot probe in August, although permafrost is expected to be present below the five-foot depth.

- **US Army Corps of Engineers (USACE), Relocation Planning Project 2005.** In December 2005, USACE identified seven potential locations for the relocation of the Village of Kivalina. The purpose of the report was to provide residents and stakeholders with the information necessary to make an informed decision regarding the best solution for the community. Kivalina residents voted several times to choose the new village town site, but could not come to a conclusion as to where the new site would be located.
- **AKDOT & PF, Engineering Geology and Soils Report, Kivalina Airport, 1984.** In August 1984, nine boreholes were drilled in support of a runway expansion in Kivalina. The subsurface profile consisted of a surficial organic mat 0.5 feet thick, underlain by sand to 8 to 14 feet deep. An organic silt layer at least five feet thick was encountered beneath the sand. The active layer was observed at four to six feet below the ground surface and was underlain by permafrost to the depths explored.

3.4 Subsurface Conditions

Based on findings from the current geotechnical study, the subsurface conditions along the causeway alignment generally consist of three different sedimentary horizons: 1) lagoonal deposits, 2) nearshore marine deposits, and 3) outwash deposits. The majority of the soils observed in these deposits consisted of silt, organic silt, sandy silt, and silty sand. General soil properties measured in the laboratory for each sedimentary horizon is presented in Table 2. Each sedimentary horizon is discussed in detail in the following section. A geologic cross section along the proposed causeway alignment is shown in Figure 3.

Table 2: Generalized Soil Properties

		Sedimentary Horizons		
		Lagoonal Deposits	**Nearshore Deposits**	**Outwash Deposits**
USCS Soil Classification (see Note 1)		OL, ML	SP-SM, SM, ML	GW, SW-SM
Organic Content (%)	Average	7	4.5	NA
	Minimum	5.8	4	NA
	Maximum	7.5	5.1	NA
Moisture Content (%)	Average	42	26	15
	Minimum	32	11	6
	Maximum	63	53	31
Salinity (ppt)	Average	8.3	5.7	10.8
	Minimum	2.3	2.7	10.8
	Maximum	15.6	8.6	10.8

Notes: 1. Refer to Appendix A, Figure A-1 for USCS Classification abbreviations.

3.4.1 Lagoonal Deposits

Lagoonal deposits generally consist of organic-rich silts, silts with organics, and minor lenses of sand that have been deposited in protected lagoon and bay environments. Locally, the surface layer consists of very soft to firm non-plastic sandy silt ranging from 3 to 17 feet thick and thickening towards the mainland. However, silty sand was encountered at the surface in Boreholes K15-01 (AP-39) and K15-05 (AP-43). The surface layer at Borehole K15-01 (AP-39) may be part of the near shore marine horizon, as a fresh water channel located between Borehole K15-01 (AP-39) and Borehole K15-02 (AP-40) is connected to the Wulik River. Fine grained, organic-rich deposits observed near the bottom of Boreholes K15-01 (AP-39), K15-02 (AP-40), and K15-04 (AP-42) may be older Lagoonal deposits.

3.4.2 Nearshore Marine Deposits

Nearshore Marine deposits generally consist of unstructured mixtures of silty sands and sandy silts that have been reworked by grounding sea ice. Locally, Nearshore Marine deposits underlie the surface Lagoonal deposits, and are very loose to dense silty sands interbedded with sandy silt up to 46 feet thick. The Nearshore Marine deposits were the predominant soil types observed in boreholes.

3.4.3 Outwash Deposits

Generally, Outwash deposits consist of fluvial and glaciofluvial interbedded gravel and sand with minor silty lenses. These deposits tend to be well-graded sand and gravels with low fines content. Locally, these deposits are dense to very dense well-graded gravel and well-graded sand with silt and gravel. These deposits were observed near the bottom of Boreholes K15-01 (AP-39), K15-02 (AP-40), K15-05 (AP-43) and K15-06 (AP-44), and ranged in thickness from 3.5 to 12.5 feet thick. The Outwash deposits were underlain by older Pleistocene-age Lagoonal deposits.

3.4.4 Very Loose Zones

Three very loose zones were encountered during the geotechnical investigation. These very loose zones have SPT blow counts ranging from 0 to 3 blows per foot. Two of the zones are projected between Boreholes K15-01 (AP-39) and K15-02 (AP-40). The first very loose zone is located near the surface approximately 4.5 to 7 feet below mudline and coincides with the fresh water channel. The second very loose zone was encountered at a deeper depth from approximately 22 to 30 feet bgs. The third very loose zone ranges from 7 to 11 feet bgs at Borehole K15-05 (AP-43) and increases in thickness to 5 to 15 feet bgs as it approaches the mainland at Borehole K15-06 (AP-44).

3.4.5 Salinity

Salinity was measured in Boreholes K15-03 (AP-41) and K15-06 (AP-44). The salinity measurements in Borehole K15-03 (AP-41), located approximately 500 feet west of the village of Kivalina, ranged from 2.3 to 8.4 parts per thousand (ppt). No permafrost was found in this borehole. The salinity measurements in Borehole K15-06 (AP-44), located approximately 80 feet from the mainland, ranged from 5.2 to 15.6 ppt.

Permafrost was encountered in this borehole from 17 to 31 feet with salinity measurements ranging from 5.2 to 10.8 ppt. In comparison, seawater has a salinity of about 33 ppt and freezes at about 28.7°F.

3.4.6 Permafrost

Permafrost was encountered in Boreholes K15-05 (AP-43) and K15-06 (AP-44) within the underlying silty sands at approximate depths of 11 to 21 feet and 17 to 31 feet bgs, respectively. The permafrost is considered poorly-bonded. The measured moisture content in the permafrost soils ranged from 6 to 41 percent and was observed in the field to contain excess non-visible ice. The permafrost encountered in both boreholes may be considered relict permafrost. Relict permafrost is permafrost that has remained from the last sub-aerial exposure of the existing seafloor. During the Pleistocene epoch, 10,000 to 2.6 million years ago, the shallow lagoon may have been exposed to the sub aerial environment during glacial maximums. In addition, the fine grained and organic soils may have insulated the underlying permafrost even after the lagoon was inundated with seawater.

3.4.7 Free Water at Depth

Free water at depth was encountered in all of the boreholes while drilling and ranged from 3.0 to 7.0 feet bgs. See Table 3 for individual free water depths per borehole. A fresh water channel was observed flowing between boreholes K15-01 (AP-39) and K15-02 (AP-40) and appears to be an extension of the Wulik River.

Table 3: Free Water Depths Encountered at Time of Drilling

Borehole	K15-01 (AP-39)	K15-02 (AP-40)	K15-03 (AP-41)	K15-04 (AP-42)	K15-05 (AP-43)	K15-06 (AP-44)
Depth bgs (ft)	3.0	3.5	7.0	3.5	7.0	6.5

4.0 LIMITATIONS AND USE OF REPORT

This report has been prepared exclusively for the U.S. Army Corps of Engineers (USACE), Alaska District, for the Kivalina Causeway Geotechnical Project in Kivalina, Alaska. The findings, conclusions, and discussion presented in this report are based on visual inspection of the site conditions and limited subsurface exploration data. This report and related work program was prepared in a manner consistent with the level of care and skill ordinarily exercised by other members of the geotechnical engineering profession in the State of Alaska currently practicing under similar conditions and subject to the time limits and financial, physical, and other constraints applicable to the scope of work. No warranty expressed or implied is made.

The construction process is an integral design component with respect to the geotechnical aspects of a project. Geotechnical engineering is not an exact science because of the variability of natural processes. Only a very small portion of the soils that affect the performance of the project have been sampled or observed; thus, variations in subsurface conditions may be present between the shallow explorations authorized under this scope of work and unsampled areas. Variations may also occur 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. If there are significant changes to the subsurface conditions presented in this report, we should be notified so that we may review our conclusions and provide a written modification or verification of the changes.

The USACE has the responsibility to see that all future parties to the project, including the designer, contractor, subcontractors, etc., are made aware of this report in its entirety. This report contains information that may be useful in the preparation of contract specifications and contractor cost estimates. However, this report is not written as a specification document and may not contain sufficient information for this use without proper modification.

5.0 CLOSING

We appreciate the opportunity to provide this report. We are available to provide additional recommendations or comments as necessary. Please contact us at 907-344-6001 if you have questions or comments.

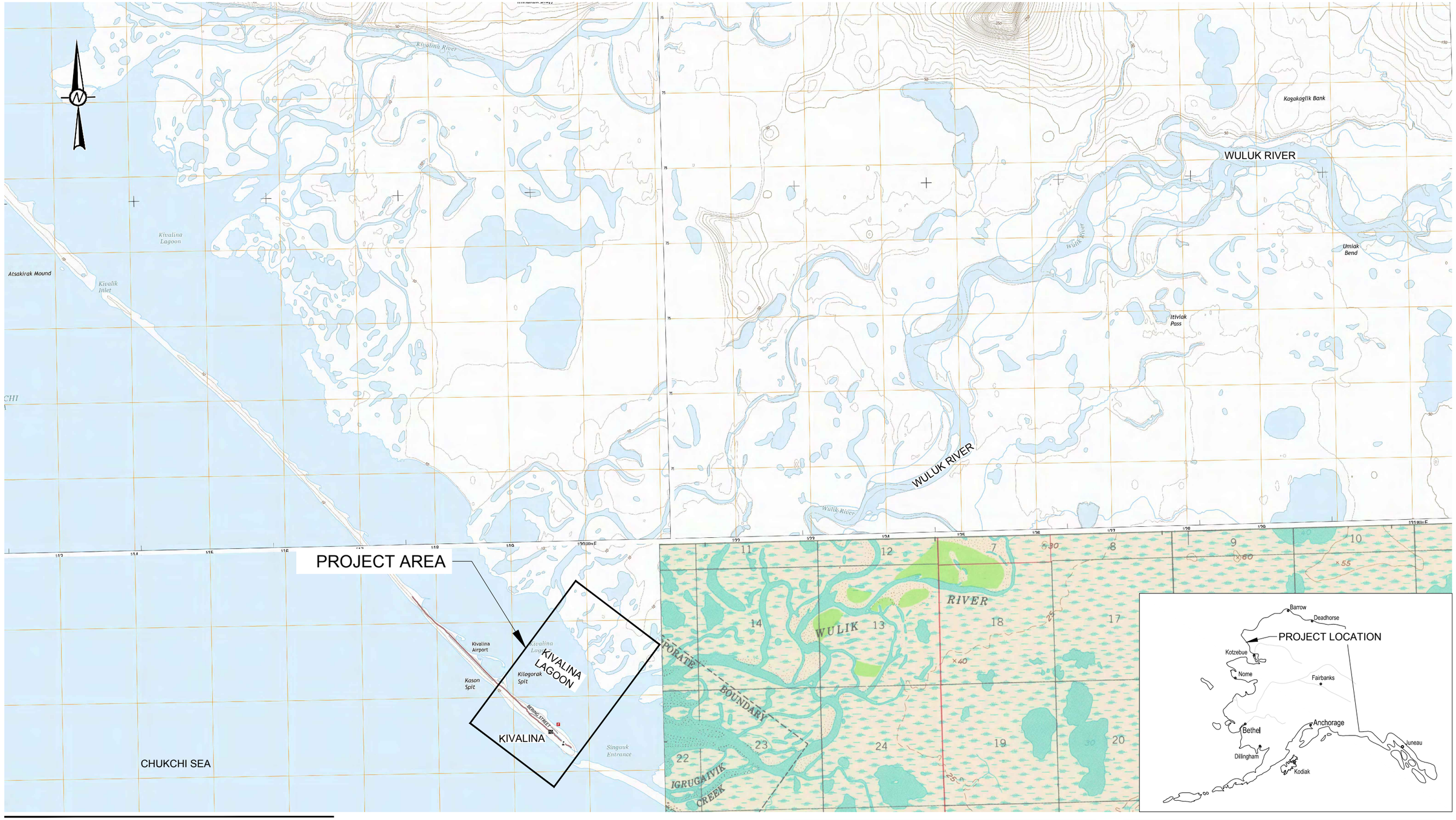
GOLDER ASSOCIATES INC.

Ryan L. Campbell
Project Engineering Geologist

John D. Thornley, PE
Senior Geotechnical Engineer

RLC/JDT/SLA/mlp

FIGURES



REFERENCE

TOPOGRAPHIC MAPS WERE PRODUCED AND DISTRIBUTED BY USGS. 1:25,000 SCALE QUADRANGLES USED INCLUDE NOATAK C-5 OW W NE, AK (2014), NOATAK D-5 SW, AK (2014), NOATAK D-6 SE, AK (2014). 1:63,360 SCALE QUADRANGLE USED NOATAK (C-5), ALASKA (1982).

0 2000 4000
1" = 4000' FEET

CLIENT
U.S. ARMY CORPS OF ENGINEERS - ALASKA DISTRICT

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-01
DESIGNED	-
PREPARED	MSF
REVIEWED	RLC
APPROVED	JDT

PROJECT
KIVALINA CAUSEWAY

KIVALINA, AK

TITLE
VICINITY MAP

PROJECT NO.	CONTROL	REV.	FIGURE
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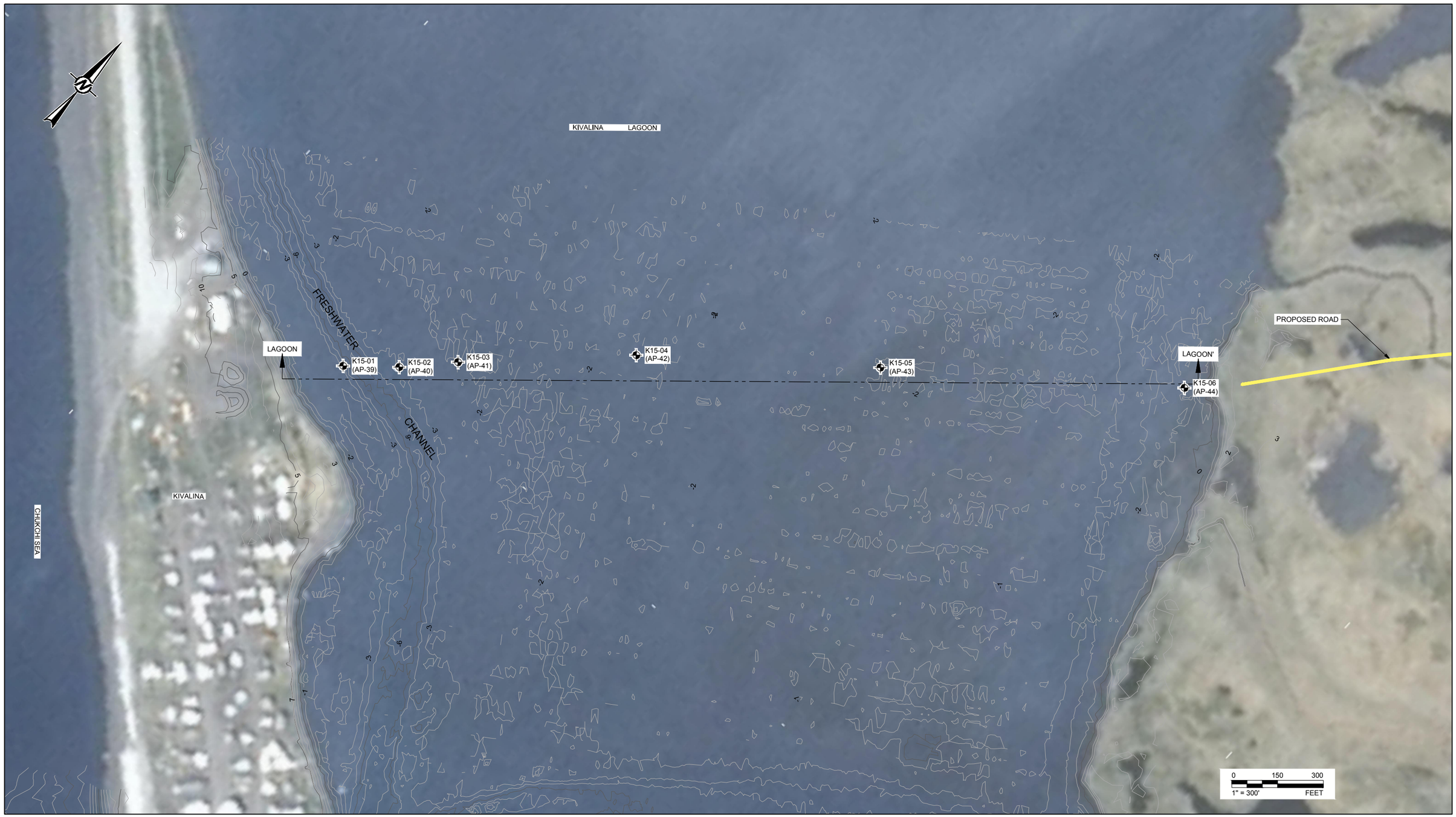

LEGEND

K15-01	2015 GOLDER BOREHOLE LOCATION AND NAME
(AP-39)	PERMANENT BOREHOLE ID

REFERENCE/NOTES

1. SPOT IMAGERY FROM 2010 WAS PROVIDED AND DISTRIBUTED BY USGS FROM 1:25,000 SCALE GEOPDF, NOATAK C-5 OW W NE, AK (2014)
2. SURFACE/BATHYMETRIC ELEVATION DATA PROVIDED BY USACE ON APRIL 30, 2015
3. VERTICAL CONTROL IS MEAN LOWER LOW WATER (MLLW=0.0') BASED ON NAVD88 LOCAL CONTROL VALUES
4. HORIZONTAL CONTROL IS AK83-8F
5. CONTOUR INTERVAL IS 1' & 5'
6. PROPOSED ROAD LOCATIONS PROVIDED BY WHPACIFIC SUMMER 2013

CLIENT
U.S. ARMY CORPS OF ENGINEERS - ALASKA DISTRICT

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-01
DESIGNED	-
PREPARED	MSF
REVIEWED	RLC
APPROVED	JDT

PROJECT
KIVALINA CAUSEWAY

KIVALINA, AK

TITLE
BOREHOLE LOCATION MAP

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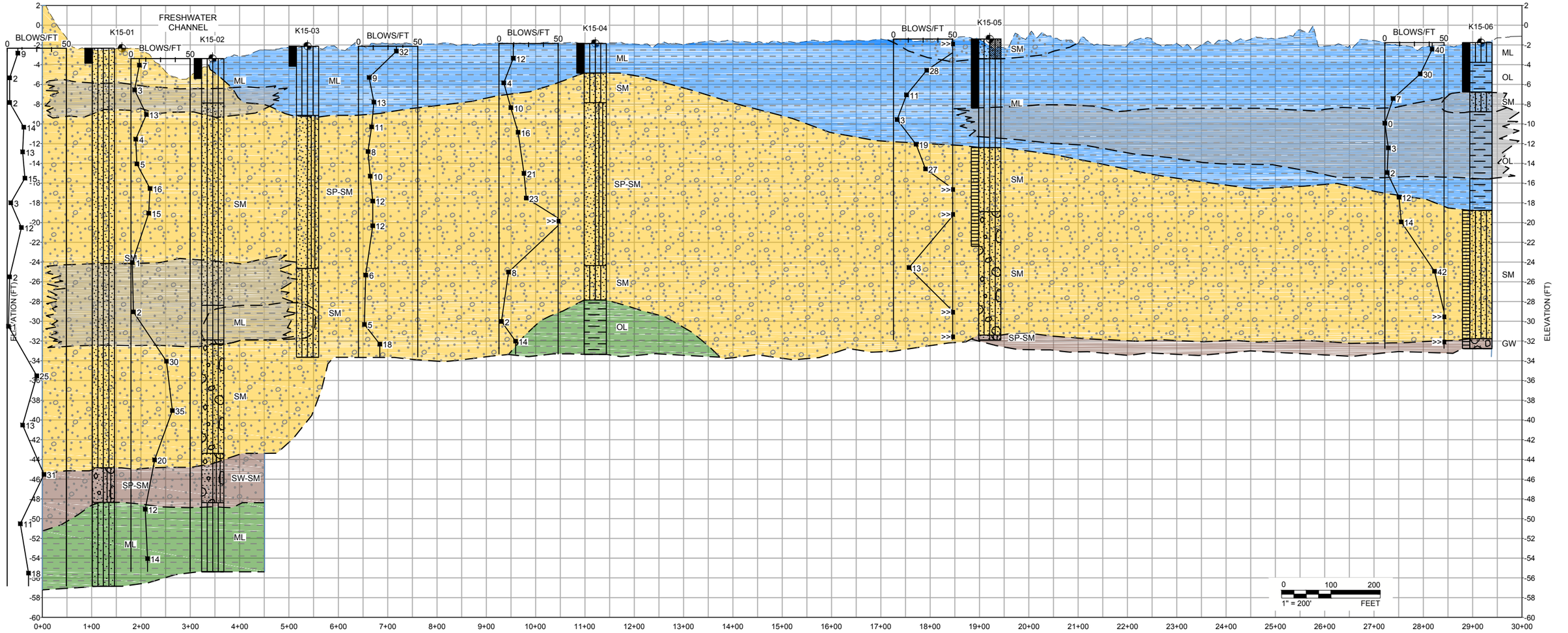
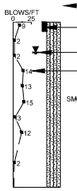


LEGEND



- BOREHOLE NAME
- ICE BONDING TYPE
- GROUNDWATER LEVEL
- UNCORRECTED BLOWS/FT
- UNIFIED SOILS CLASSIFICATION (ADAPTED FROM ASTM D2487)

ICE BONDING TYPE

- WELL BONDED
- POORLY BONDED
- UNBONDED / UNFROZEN

K15-01 (AP-39) — 2015 GOLDER BOREHOLE LOCATION AND NAME; PERMANENT BOREHOLE ID

GEOLOGICAL LEGEND

- LAGOONAL DEPOSITS
- NEARSHORE MARINE DEPOSITS
- OUTWASH DEPOSITS
- OLDER LAGOONAL DEPOSITS
- VERY LOOSE ZONES
- FINE-GRAINED MATERIAL
- COARSE-GRAINED MATERIAL

REFERENCE

SPOT IMAGERY FROM 2010 WAS PROVIDED AND DISTRIBUTED BY USGS FROM 1:25,000 SCALE GEOPDF, NOATAK C-5 OW W NE, AK (2014).

CLIENT
U.S. ARMY CORPS OF ENGINEERS - ALASKA DISTRICT

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-06-01
DESIGNED	-
PREPARED	MSF
REVIEWED	RLC
APPROVED	JDT

PROJECT
KIVALINA CAUSEWAY

KIVALINA, AK

TITLE
GEOLOGIC PLAN AND PROFILE

PROJECT NO.	CONTROL	REV.	FIGURE
1419207		A	3

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI B

1 in

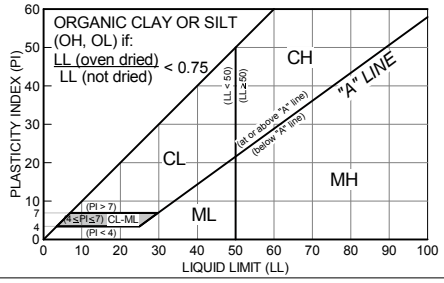
0

Path: \\Anchorage\Public\Geomatics\USACE\Kivalina\99_PROJECTS\1419207 USACE Kivalina Evac Road AK\200 REPORT\02_PRODUCTION\DWG\ | File Name: 1419207.002_Lagoon.dwg

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	



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

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 & CLAY (FINES)	SMALLER THAN #200 (0.074 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 (Diamond Bit)
HD	Heavy Duty Split Spoon (3 in. OD, 340 lb hammer)	**TW**	Thin Wall (Shelby Tube)
-BL	Brass Liners used in Split Spoon	**TP**	Thin Wall Piston Sampler
CA	Continous Core (Soil in Hollow-Stem Auger)	**MS**	Modified Shelby
GS	Grab Sample from Surface / Testpit	**MC**	Geoprobe Macro-Core
AC	Auger Charge	**RC**	Air Rotary Cuttings
AW	Auger Wash	**AG**	Auger Cuttings

LABORATORY TEST AND NOTES ABBREVIATIONS / SYMBOLS

Con	Consolidation	**PID**	Photoionization Detector	**TXCD**	Triaxial, Consolidated Drained
Dd	Dry Density	**PM**	Modified Proctor (D1557)	**TXCU**	Triaxial, Consolidated Undrained
K	Thermal Conductivity	**PP**	Pocket Penetrometer (Field)	**TXUU**	Triaxial, Unconsolidated Undrained
MA	Sieve and Hydrometer	**PTLD**	Point Load	**W_C**	Liquid Limit (LL)
NP	Non-plastic	**SA**	Sieve Analysis	**W_P**	Plastic Limit (PL)
OLI	Organic Loss	**SpG**	Specific Gravity	**Ω**	Soil Resistivity (Res.)
P200	Passing #200 Sieve (D1140)	**TC**	Thaw Consolidation/Strain	▼	Water Level
pH	Soil pH	**TV**	Torvane (Field)	▽	Water Level While Drilling

Golder Associates

SOIL CLASSIFICATION / LEGEND

Figure A-1

LIBRARY-ANC(8-5-14).GLB [ANC_SOIL_LEGEND] 10/23/14

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 distinctly 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 Inclusions are individual ice masses visible in the face of a soil mass. Inclusions 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.

RECORD OF BOREHOLE K15-01 (AP-39)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-14-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -2.34 ft
APPROX. COORDS: N: 1,842,646 E: 5,021,268

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (%) ○ W (W$_P$ 10 20 30 40 W$_L$)	GROUND TEMPERATURE (°F) (17 19 21 23 25 27 29 31 33)	NOTES: TESTS / WATER LEVELS
0	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.5 ft.										LEGEND: ● 03/23/15 00:00 ■ 03/30/15 00:00 ▲ 04/11/15 00:00 ★ 04/14/15 00:00 ⊙ 04/26/15 00:00 ✿ 05/02/15 00:00	
		0.0 - 42.5 Very loose to medium dense, wet, black, SILTY SAND; medium to coarse-grained sand, little to some silt, trace rounded gravel up to .75 inch diameter, frozen from 0-1.5' with 5% ice by volume as inclusions, well bonded (SM)		SM			1	HD	4 6 3	18/18			PID=0.4 ppm Gravel = 1%, Sand = 80%, Fines = 19%
		3 feet-Free water at depth					2	HD	1 1 1	18/18			PID=0.2 ppm
5							3	HD	1 1 1	18/18			5 feet of heave PID=0.3 ppm
							4	SS-AW	4 7 7	9/18			Restart Drill hole on 3/19/2015 PID=0.1 ppm
10							5	SS-AW	4 6 7	9/18			PID=0.1 ppm Gravel = 0%, Sand = 81%, Fines = 19%
							6	SS-AW	5 5 10 7	12/24			PID=0.1 ppm
15							7	SS-AW	5 1 2 3	12/24			PID=0.2 ppm
							8	SS-AW	6 6 6 8	13/24			PID=0.3 ppm Gravel = 4%, Sand = 70%, Fines = 26%
20		Log continued on next page											

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-3

RECORD OF BOREHOLE K15-01 (AP-39)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-14-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -2.34 ft
APPROX. COORDS: N: 1,842,646 E: 5,021,268

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40; SALINITY (ppt) △ WATER CONTENT (%) W_P w W_L 10 20 30 40	GROUND TEMPERATURE (°F) 17 19 21 23 25 27 29 31 33	NOTES TESTS WATER LEVELS
20	6.625-in. OD Hollow Stem Auger	0.0 - 42.5 Very loose to medium dense, wet, black, SILTY SAND; medium to coarse-grained sand, little to some silt, trace rounded gravel up to .75 inch diameter, frozen from 0-1.5' with 5% ice by volume as inclusions, well bonded (SM) *(Continued)* VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.5 ft.		SM			9	SS-AW	1 1 1 3	4/24		LEGEND: ● 03/23/15 00:00 ■ 03/30/15 00:00 ▲ 04/11/15 00:00 ★ 04/14/15 00:00 ⊙ 04/26/15 00:00 ✿ 05/02/15 00:00	PID=0.1 ppm
25							10	SS-AW	1 0 1 0	9/24			PID=0.3 ppm
30							11	SS-AW	12 13 12 13	24/24			PID=0.0 ppm Gravel = 4%, Sand = 48%, Fines = 48%
35							12	SS-AW	4 7 6 3	6/24			PID=0.1 ppm
40		Log continued on next page											

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-3

RECORD OF BOREHOLE K15-01 (AP-39)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-14-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -2.34 ft
APPROX. COORDS: N: 1,842,646 E: 5,021,268

DEPTH (ft)	BORING METHOD	DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	NOTES / TESTS / WATER LEVELS
40	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.5 ft. 0.0 - 42.5 Very loose to medium dense, wet, black, SILTY SAND; medium to coarse-grained sand, little to some silt, trace rounded gravel up to .75 inch diameter, frozen from 0-1.5' with 5% ice by volume as inclusions, well bonded (SM) *(Continued)*		SM		-44.8					
		42.5 - 46.0 Dense, wet, black, poorly graded SAND with silt and gravel; fine to medium-grained sand, some fine-grained gravel up to 1 inch diameter, few silt (SP-SM)		SP-SM		42.5 -48.3	13	SS-AW	19 17 14 14	9 / 24	PID=0.0 ppm Gravel = 36%, Sand = 56%, Fines = 8%
45		46.0 - 54.5 Firm to stiff, wet, black, sandy SILT; little to some fine-grained sand, trace rounded gravel up to .75 inch diameter, trace organics (ML)		ML		46.0	14	SS-AW	11 6 5 5	8 / 24	PID=0.2 ppm OLI = 4%
50							15	SS-AW	7 7 11 9	18 / 24	PID=0.0 ppm
55		Borehole completed at 54.5 ft. Notes: 1) Backfilled with cuttings 2) 340-pound hammer with 30 inch drop used for first three sample intervals 3) 1 inch Sch 120 PVC installed to depth 4) Borehole drilled from ground fast ice				-56.8					
60											

SAMPLES: UNCORRECTED BLOWS / ft ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (%) W_P W W_L (10 20 30 40)

GROUND TEMPERATURE (°F) (17 19 21 23 25 27 29 31 33)

LEGEND:
- 03/23/15 00:00
- 03/30/15 00:00
- 04/11/15 00:00
- 04/14/15 00:00
- 04/26/15 00:00
- 05/02/15 00:00

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Golder Associates

Figure A-3

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

RECORD OF BOREHOLE K15-02 (AP-40)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-19-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -3.38 ft
APPROX. COORDS: N: 1,842,782 E: 5,021,391

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40 / SALINITY (ppt) △ / WATER CONTENT (%) W_P 10 20 W 30 40 W_L	GROUND TEMPERATURE (°F) LEGEND: 03/23/15 00:00, 03/30/15 00:00, 04/11/15 00:00, 04/14/15 00:00, 04/26/15 00:00, 05/02/15 00:00 17 19 21 23 25 27 29 31 33	NOTES TESTS / WATER LEVELS
0	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 3.6 ft.											
		0.0 - 4.5 Very soft to firm, wet, black, sandy SILT; little to some fine-grained sand, frozen from 0-2' with visible ice as irregularly oriented formations, well bonded (ML)		ML			1	SS	6 6 1 1	18/24			PID=0.3 ppm
		3.5 feet-Free water at depth					2	SS	1 1 2 4	18/24			PID=0.2 ppm
						-7.9							
5		4.5 - 25.0 Very loose to loose, wet, black, SILTY SAND; fine to coarse-grained sand, little to some silt, trace to few subrounded up to 3/8 inch diameter, silt content varies with depth (SM)		SM		4.5	3	SS-AW	1 7 6 4	24/24			PID=0.3 ppm Gravel = 5%, Sand = 87%, Fines = 8%
							4	SS-AW	0 0 4 6	9/24			7.5 feet-rods fell 1' into sample interval PID=0.4 ppm
10							5	SS-AW	2 2 3 4	8/24			PID=0.1 ppm Gravel = 0%, Sand = 76%, Fines = 25%
							6	SS-AW	4 9 7 7	12/24			PID=0.0 ppm
15							7	SS-AW	7 8 7 5	14/24			PID=0.0 ppm Gravel = 9%, Sand = 82%, Fines = 9%
20		Log continued on next page											

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-4

RECORD OF BOREHOLE K15-02 (AP-40)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-19-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -3.38 ft
APPROX. COORDS: N: 1,842,782 E: 5,021,391

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ (10 20 30 40)	SALINITY (ppt) △ WATER CONTENT (%) (W_P 10 20 W 30 40 W_L)	GROUND TEMPERATURE (°F) (17 19 21 23 25 27 29 31 33)	NOTES TESTS WATER LEVELS
20	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 3.6 ft. 4.5 - 25.0 Very loose to loose, wet, black, SILTY SAND; fine to coarse-grained sand, little to some silt, trace to few subrounded up to 3/8 inch diameter, silt content varies with depth (SM) *(Continued)*		SM		-28.4	8	SS-AW	3 1 0 0	5/24	■	○		PID=0.2 ppm Gravel = 1%, Sand = 69%, Fines = 30%
25		25.0 - 28.5 Very soft to soft, wet, black, sandy SILT; some fine-grained sand, trace organics, with a very strong peat odor (ML)		ML		25.0 -31.9	9	SS-AW	3 1 1 2	18/24	■	○		20 feet-sampler fell in one blow 0.5-2 feet PID=0.3 ppm OLI = 5%
30		28.5 - 40.0 Medium dense, wet, black, SILTY SAND with gravel; medium to coarse-grained sand, trace to little rounded gravel up to 3/4 inch diameter, little silt (SM)		SM		28.5	10	SS-AW	10 15 15 12	12/24	■	○		PID=0.1 ppm Gravel = 24%, Sand = 59%, Fines = 17%
35							11	SS-AW	11 17 18 13	18/24	■	○		PID=0.0 ppm
40		Log continued on next page				-43.4								

LEGEND: ● 03/23/15 00:00 ■ 03/30/15 00:00 ▲ 04/11/15 00:00 ★ 04/14/15 00:00 ⊙ 04/26/15 00:00 ✿ 05/02/15 00:00

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Golder Associates

Figure A-4

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

RECORD OF BOREHOLE K15-02 (AP-40)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-19-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -3.38 ft
APPROX. COORDS: N: 1,842,782 E: 5,021,391

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40; SALINITY (ppt) △ WATER CONTENT (%) W_P W W_L 10 20 30 40	GROUND TEMPERATURE (°F) 17 19 21 23 25 27 29 31 33	NOTES TESTS WATER LEVELS
40	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 3.6 ft. 40.0 - 45.0 Medium dense, wet, black, well-graded SAND with silt and gravel; medium to coarse-grained sand, some fine-grained rounded gravel up to 3/4 inch diameter, few silt (SW-SM)		SW-SM		40.0	12	SS-AW	7 10 10 10	10/24		LEGEND: ● 03/23/15 00:00 ■ 03/30/15 00:00 ▲ 04/11/15 00:00 ★ 04/14/15 00:00 ⊙ 04/26/15 00:00 ✿ 05/02/15 00:00	PID=0.4 ppm Gravel = 41%, Sand = 51%, Fines = 8%
45		-48.4 45.0 - 52.0 Firm to stiff, wet, black, sandy SILT; some fine to coarse-grained sand (ML)		ML		45.0	13	SS-AW	10 5 7 7	13/24			PID=0.1 ppm
50							14	SS-AW	5 5 9 7	18/24			PID=0.2 ppm OLI = 5%
		-55.4 Borehole completed at 52.0 ft. Notes: 1) Backfilled with cuttings 2) 1 inch Sch 120 PVC installed to depth 3) Borehole drilled from ground fast ice											
55													
60													

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-4

RECORD OF BOREHOLE K15-03 (AP-41)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-20-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -2.14 ft
APPROX. COORDS: N: 1,842,911 E: 5,021,536

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (%) W_P W W_L (10 20 30 40)	GROUND TEMPERATURE (°F) (17 19 21 23 25 27 29 31 33)	NOTES / TESTS / WATER LEVELS
0	6.625-in. OD Hollow Stem Auger	0.0 - 7.0 Frozen to firm, wet, black, SILT; few to some fine-grained sand, 0.5 feet - 6 inch ice layer., well bonded visible ice as stratified formations and inclusions (ML, Vs-Vx)		ML			1	SS	4 17 15	18/18			PID=0.2 ppm
							2	SS	6 5 4 5	24/24			PID=0.1 ppm
5							3	SS	4 7 6 6	15/24			PID=0.3 ppm
		7 feet-Free water at depth				-9.1							
		7.0 - 22.5 Very loose to loose, wet, black, poorly graded SAND with silt; fine to medium-grained sand, few to little silt, trace to few fine-grained subrounded gravel, silt content varies with depth (SP-SM)				7.0	4	SS-AW	2 5 6 6	24/24			PID=0.1 ppm Gravel = 9%, Sand = 83%, Fines = 8%
10							5	SS-AW	5 6 2 1	24/24			PID=0.4 ppm
				SP-SM			6	SS-AW	3 4 6 7	12/24			PID=0.1 ppm Gravel = 3%, Sand = 85%, Fines = 12%
15							7	SS-AW	6 6 6 9	11/24			PID=0.2 ppm
							8	SS-AW	7 8 4 7	18/24			PID=0.4 ppm Gravel = 8%, Sand = 82%, Fines = 10%
20		Log continued on next page											

LEGEND:

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-5

RECORD OF BOREHOLE K15-03 (AP-41)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-20-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -2.14 ft
APPROX. COORDS: N: 1,842,911 E: 5,021,536

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ (10 20 30 40); SALINITY (ppt) △; WATER CONTENT (%) W_P W W_L (10 20 30 40)	GROUND TEMPERATURE (°F) LEGEND: (17 19 21 23 25 27 29 31 33)	NOTES / TESTS / WATER LEVELS
20	6.625-in. OD Hollow Stem Auger	7.0 - 22.5 Very loose to loose, wet, black, poorly graded SAND with silt; fine to medium-grained sand, few to little silt, trace to few fine-grained subrounded gravel, silt content varies with depth (SP-SM) *(Continued)*		SP-SM		-24.6							
		22.5 - 31.5 Loose to medium dense, wet, black, SILTY SAND; medium to coarse-grained sand, little silt, with a 1 foot layer of silt at 25 feet (SM)		SM		22.5	9	SS-AW	9 4 2 1	11/24	■ △ ○		PID=0.2 ppm
25							10	SS-AW	7 2 3 4	12/24	■ △ ○		PID=0.2 ppm Gravel = 6%, Sand = 64%, Fines = 30%
30							11	SS-AW	6 9 9 1	11/24	■ △ ○		PID=0.1 ppm Gravel = 1%, Sand = 80%, Fines = 19%
		Borehole completed at 31.5 ft.				-33.6							
35		Notes: 1) Backfilled with cuttings 2) Borehole drilled from ground fast ice											
40													

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-5

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

RECORD OF BOREHOLE K15-04 (AP-42)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-14-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -1.85 ft
APPROX. COORDS: N: 1,843,320 E: 5,021,953

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40; SALINITY (ppt) △ WATER CONTENT (%) W_P W W_L 10 20 30 40	GROUND TEMPERATURE (°F) LEGEND: 17 19 21 23 25 27 29 31 33	NOTES / TESTS / WATER LEVELS
0	6.625-in. OD Hollow Stem Auger	0.0 - 3.0 Frozen, black, sandy SILT; some fine-grained sand, well bonded with approximately less than 5% visible ice by volume as inclusions (ML, Vx) VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.4 ft.		ML		-4.9	1	HD	6 6 6	18/18			PID=0.1 ppm
		3.0 - 6.0 Loose, moist to wet, black, SILTY SAND; medium to coarse-grained sand, little to some silt (SM) 3.5 feet-Free water at depth		SM		3.0	2	HD	4 3 1	18/18		53	PID=0.1 ppm 4 feet of heaving sand Gravel = 5%, Sand = 75%, Fines = 20%
5						-7.9							
		6.0 - 22.5 Medium dense to very dense, wet, black, poorly graded SAND with silt; fine to medium-grained sand, few silt, trace to few fine-grained gravel (SP-SM)				6.0	3	HD	2 3 7	18/18			PID=0.2 ppm Gravel = 0%, Sand = 91%, Fines = 8%
							4	HD	1 6 10	18/18			PID=0.3 ppm Gravel = 9%, Sand = 85%, Fines = 6%
10													Restart Drill hole on 3/21/2015
				SP-SM			5	SS-AW	6 10 11 17	18/24			PID=0.1 ppm
15							6	SS-AW	7 13 10 8	12/24			PID=0.2 ppm Gravel = 12%, Sand = 77%, Fines = 11%
							7	SS-AW	10 14 40	18/18		>>	PID=0.2 ppm
20		Log continued on next page											

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-6

RECORD OF BOREHOLE K15-04 (AP-42)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-14-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -1.85 ft
APPROX. COORDS: N: 1,843,320 E: 5,021,953

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40; SALINITY (ppt) △ WATER CONTENT (%) W_P W W_L 10 20 30 40	GROUND TEMPERATURE (°F) LEGEND: 17 19 21 23 25 27 29 31 33	NOTES / TESTS / WATER LEVELS
20	6.625-in. OD Hollow Stem Auger	6.0 - 22.5 Medium dense to very dense, wet, black, poorly graded SAND with silt; fine to medium-grained sand, few silt, trace to few fine-grained gravel (SP-SM) *(Continued)* VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.4 ft.		SP-SM		-24.4							
		22.5 - 26.0 Loose, wet, black, SILTY SAND; fine to medium-grained sand, little silt, trace fine-grained gravel, trace organics (SM) 24 feet-4 inch organic layer		SM		22.5 -27.9	8	SS-AW	10 1 7 7	16/24			PID=0.5 ppm Gravel = 4%, Sand = 72%, Fines = 24%, OLI = 4%
25		26.0 - 31.5 Very soft to stiff, wet, black, ORGANIC SILT; some fine-grained sand, little organics (OL)		OL		26.0	9	SS-AW	0 1 1 1	18/24			27.5 feet - rod sank 6 inches (sand at top of spoon) PID=0.4 ppm
30							10	SS-AW	7 4 10 8	17/24			PID=0.3 ppm OLI = 15%
		Borehole completed at 31.5 ft. Notes: 1) Backfilled with cuttings 2) 340-pound hammer with 30 inch drop used for first four sample intervals 3) Borehole drilled from ground fast ice				-33.4							
35													
40													

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-6

RECORD OF BOREHOLE K15-05 (AP-43)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-21-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -1.4 ft
APPROX. COORDS: N: 1,843,929 E: 5,022,472

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40; SALINITY (ppt) △ WATER CONTENT (%) W_P 10 20 W 30 40 W_L	GROUND TEMPERATURE (°F) LEGEND: 17 19 21 23 25 27 29 31 33	NOTES / TESTS / WATER LEVELS
0	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.7 ft.											
		0.0 - 2.0 Frozen, gray, SILTY SAND; fine-grained sand, little silt, trace fine-grained gravel, with a 4-inch thick ice lens at 0.5', well bonded with approximately 20-30% visible ice by volume as stratified formations and inclusions (SM, Vs-Vx)		SM		-3.4	1	SS	8 33 28	18/18	>>		PID=0.2 ppm Gravel = 1%, Sand = 74%, Fines = 25%
		2.0 - 11.0 Frozen from 2'-7' to very soft, moist, black, sandy SILT; little fine-grained sand, well bonded with no excess ice (ML, Nbn)		ML		2.0	2	SS	11 16 12 19	24/24			PID=0.3 ppm
5							3	SS	5 4 7 5	24/24			PID=0.5 ppm
		7 feet-Free water at depth					4	SS-AW	0 1 2 3	24/24			unfrozen at 7 feet 7.5 feet - rod sank 4-6 inches PID=0.2 ppm
10							5	SS-AW	7 10 9 9	24/24			PID=0.1 ppm
		11.0 - 17.5 Frozen, wet, black, SILTY SAND; fine to medium-grained sand, some silt, poorly bonded (SM)		SM		-12.4 11.0	6	SS-AW	9 13 14 20	24/24			Gravel = 0%, Sand = 69%, Fines = 31% PID=0.2 ppm
15							7	SS-AW	13 38/3"	9/9	>>		PID=0.2 ppm
		17.5 - 30.0 Frozen from 17.5'-21',loose to very dense, wet, black, SILTY SAND with gravel; fine to medium-grained sand, little silt, little to some subrounded gravel up to .75 inch diameter, gravel from 25-30.5', poorly bonded (SM)		SM		-18.9 17.5	8	SS-AW	11 39/4"	10/10	>>		Gravel = 16%, Sand = 67%, Fines = 17% PID=0.3 ppm
20		Log continued on next page											

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Golder Associates

Figure A-7

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

RECORD OF BOREHOLE K15-05 (AP-43)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-21-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -1.4 ft
APPROX. COORDS: N: 1,843,929 E: 5,022,472

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40; SALINITY (ppt) △ WATER CONTENT (%) W_P W W_L 10 20 30 40	GROUND TEMPERATURE (°F) LEGEND: 17 19 21 23 25 27 29 31 33	NOTES / TESTS / WATER LEVELS
20	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.7 ft. 17.5 - 30.0 Frozen from 17.5'-21',loose to very dense, wet, black, SILTY SAND with gravel; fine to medium-grained sand, little silt, little to some subrounded gravel up to .75 inch diameter, gravel from 25-30.5', poorly bonded (SM) *(Continued)*											
							9	SS-AW	9 4 9 10	12/24			PID=0.1 ppm
25				SM									25 feet - drill rig chatter
							10	SS-AW	40 30/1"	7/7		>>	Gravel = 38%, Sand = 47%, Fines = 15% PID=0.0 ppm PID=0.0 ppm
30						-31.4							
		30.0 - 30.5 Very dense, wet, black, poorly graded SAND with silt and gravel; medium to coarse-grained sand, some fine-grained gravel up to 3/4 inch diameter, few silt (SP-SM)		SP-SM		30.0 -31.9	11	SS-AW	50/6"	6/6		>>	Gravel = 46%, Sand = 48%, Fines = 6%
		Borehole completed at 30.5 ft.											
35		Notes: 1) Backfilled with cuttings 2) Borehole drilled from ground fast ice											
40													

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-7

RECORD OF BOREHOLE K15-06 (AP-44)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-21-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -1.77 ft
APPROX. COORDS: N: 1,844,699 E: 5,023,107

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	NOTES / TESTS / WATER LEVELS
0	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.5 ft.									
		0.0 - 2.0 Frozen, black, sandy SILT; little fine-grained sand, well bonded with approximately 5% visible ice by volume as irregularly oriented formations (ML, Vr)		ML		-3.8	1	SS	15 23 17 20	24/24	PID=0.1 ppm
		2.0 - 5.0 Frozen, black, ORGANIC SILT; little sand, few organics, well bonded with no excess ice (OL, Nbn)		OL		2.0 -6.8	2	SS	20 15 15 11	24/24	PID=0.1 ppm OLI = 6%
5		5.0 - 7.0 Very loose to loose, wet, black, SILTY SAND; fine to coarse-grained sand, little silt, little fine-grained gravel, with organics (SM) 6.5 feet-Free water at depth		SM		5.0 -8.8	3	SS	5 6 1 0	11/24	PID=0.0 ppm Gravel = 12%, Sand = 65%, Fines = 23%
		7.0 - 17.0 Very soft to firm, wet, black, ORGANIC SILT; little fine-grained sand, few organics (OL)		OL		7.0	4	SS-AW	1 0 0 0	4/24	7.5 feet - one blow for 2 feet PID=0.3 ppm OLI = 9%
10							5	SS-AW	0 1 2 2	24/24	10 feet - sampler fell 8 inches with wieght of rod OLI = 7%
							6	SS-AW	1 1 1 1	24/24	PID=0.4 ppm PID=0.2 ppm OLI = 6%
15							7	SS-AW	3 5 7 5	24/24	PID=0.4 ppm OLI = 8%
		17.0 - 30.0 Frozen, wet, black, SILTY SAND; fine to coarse-grained sand, little to some silt, trace to little fine-grained gravel, with organics at 17.5', poorly bonded (SM)		SM		-18.8 17.0	8	SS-AW	3 6 8 25	24/24	PID=0.5 ppm Gravel = 0%, Sand = 62%, Fines = 38%
20		Log continued on next page									

UNCORRECTED BLOWS / ft ■ (10 20 30 40)
SALINITY (ppt) △
WATER CONTENT (%) W_P W W_L (10 20 30 40)

GROUND TEMPERATURE (°F) (17 19 21 23 25 27 29 31 33)
LEGEND:
03/23/15 00:00
04/12/15 00:00
04/14/15 00:00
04/26/15 00:00
05/03/15 00:00
03/30/15 00:00

54
54

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-8

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

RECORD OF BOREHOLE K15-06 (AP-44)

PROJECT: Kivalina Causeway
PROJECT NUMBER: 1419207
LOCATION: Kivalina, AK

CLIENT: USACE
DRILLING DATE: 3-21-15
EQUIPMENT: Geoprobe 6712 DT

DATUM: NAD83, AK State Plane Zone 8, NAVD-88
APPROX. ELEVATION: -1.77 ft
APPROX. COORDS: N: 1,844,699 E: 5,023,107

DEPTH (ft)	BORING METHOD	SOIL PROFILE: DESCRIPTION	ICE BOND	USCS	GRAPHIC LOG	ELEV. / DEPTH (ft)	SAMPLES: NUMBER	TYPE	BLOWS / 6 in.	REC / ATT (in.)	UNCORRECTED BLOWS / ft ■ 10 20 30 40	SALINITY (ppt) △ WATER CONTENT (%) W_P 10 20 W 30 40 W_L	GROUND TEMPERATURE (°F) 17 19 21 23 25 27 29 31 33	NOTES TESTS WATER LEVELS
20	6.625-in. OD Hollow Stem Auger	VEGETATION: sea ice (ground fast) lagoon ICE DEPTH: 2.5 ft. 17.0 - 30.0 Frozen, wet, black, SILTY SAND; fine to coarse-grained sand, little to some silt, trace to little fine-grained gravel, with organics at 17.5', poorly bonded (SM) *(Continued)*		SM			9	SS-AW	14 17 25 7	16/24	■	△ ○		PID=0.2 ppm
25							10	SS-AW	21 50/4"	8/10	■	△ ○	>>	PID=0.1 ppm Gravel = 11%, Sand = 64%, Fines = 25%
30		30.0 - 31.0 Frozen, wet, black, well-graded GRAVEL with sand; fine-grained gravel up to 3/4 inch diameter, some fine to coarse-grained sand, trace silt, poorly bonded (GW)		GW		-31.8 30.0 -32.8	11	SS-AW	13 37/6"	12/12	■	○ △	>>	PID=0.0 ppm Gravel = 55%, Sand = 42%, Fines = 4%
35		Borehole completed at 31.0 ft.												
40		Notes: 1) Backfilled with cuttings 2) 1 inch Sch 120 PVC installed to depth 3) Borehole drilled from ground fast ice												

GROUND TEMPERATURE (°F) LEGEND:
- 03/23/15 00:00
- 04/12/15 00:00
- 04/14/15 00:00
- 04/26/15 00:00
- 05/03/15 00:00
- 03/30/15 00:00

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC BOREHOLE W/ THERMISTOR] RLCampbell 8/6/15

Golder Associates

DEPTH SCALE: 1 inch to 2.5 feet
DRILLING CONTRACTOR: Discovery Drilling Inc.
DRILLER: Derek Dell

LOGGED: R. Campbell
CHECKED: H. Weston
CHECK DATE: 5/10/2015

Figure A-8

APPENDIX B
LABORATORY DATA

DOWL

Testing Report Summary

Date Sample Recv'd: 4/6/2015

Client: Golder Associates
W.O. #: 34316
Project: USACE Kivalina Causeway
Lab #: Varies
Location: See below

All results will be posted to the website for your access and convenience. Samples will be kept for 30 days before being disposed. Please contact us if you would like the remaining material returned.

Lab ID	Sample ID	Test Performed	Test Method	Results	
324	K15-01, Sample 15, Depth 52.5-54.5'	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D4318	Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt
325	K15-02, Sample 11, Depth 0-2'			Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt
327	K15-02, Sample 3, Depth 5-7'			Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt
339	K15-03, Sample 1, Depth 0-1.5'			Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt
350	K15-04, Sample 1, Depth 1-2.5'			Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt
361	K15-05, Sample 2, Depth 2.5-4.5'			Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt
363	K15-05, Sample 4, Depth 7.5-9.5'			Liquid Limit	40
				Plastic Limit	33
				Plasticity Index	7
				USCS	Silt or Organic Silt

continued on next page

4040 B Street, Anchorage, Alaska 99503 -- 907-562-2000

DOWL

Testing Report Summary (cont'd)

Date Sample Recv'd: 4/6/2015

Client: Golder Associates
W.O. #: 34316
Project: USACE Kivalina Causeway
Lab #: Varies
Location: See below

Lab ID	Sample ID	Test Performed	Test Method	Results	
371	K15-06, Sample 1, Depth 0-2'	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils	ASTM D4318	Liquid Limit	-
				Plastic Limit	-
				Plasticity Index	Nonplastic
				USCS	Silt
374	K15-06, Sample 4, Depth 7.5-9.5'			Liquid Limit	43
				Plastic Limit	33
				Plasticity Index	10
				USCS	Silt or Organic Silt
377	K15-06, Sample 7, Depth 15-17'			Liquid Limit	----
				Plastic Limit	----
				Plasticity Index	Nonplastic
				USCS	Silt

If you have questions regarding this summary report or the test procedures, please contact us.

Maria

Maria E. Kampsen, P.E.
Laboratory Supervisor

4040 B Street, Anchorage, Alaska 99503 -- 907-562-2000

DOWL

Testing Report Summary

Date Sample Recv'd: 4/6/2015

Client: Golder Associates
W.O. #: 34316
Project: USACE Kivalina Causeway
Lab #: see below
Location: Varies

All results will be posted to the website for your access and convenience. Samples will be kept for 30 days before being disposed. Please contact us if you would like the remaining material returned.

Sample ID	Test Performed	Test Method	Organic %
K15-01 Depth 47.5-49.5' (Lab No. 323)	Moisture, Ash & Organic Matter of Peat Materials	ASTM D2974	4.1
K15-02 Depth 25-27' (Lab No. 333)			5.1
K15-02 Depth 50-52' (Lab No. 338)			4.7
K15-04 Depth 22.5-24.5' (Lab No. 357)			4.0
K15-04 Depth 29.5-31.5' (Lab No. 359)			15.2
K15-06 Depth 2.5-4.5' (Lab No. 372)			5.8
K15-06 Depth 7.5-9.5' (Lab No. 374)			8.5
K15-06 Depth 10-12' (Lab No. 375)			6.5
K15-06 Depth12.5-14.5' (Lab No. 376)			6.3
K15-06 Depth 15-17' (Lab No. 377)			7.5

Maria

Maria E. Kampsen, P.E.
Laboratory Supervisor

DOWL

Visual Classification ASTM D-2488

Test Summary Report

Reporting Worksheet

Sample Date: 4/6/2015

Client: Golder Associates | W.O.#: 34316

Project: USACE Kivalina Causeway | Lab No.: varies

Location: Varies

Lab #	Boring		Depth		Percent			Grain			Dry Str.	PI	USCS Symbol	Color	Free Water	Organics	Ice	Remarks	Moisture	
	TH	SA	From (Feet)	To (Feet)	Gravel	Sand	#200	Max	Shape	Sand									Wet Dry	%
310	K15-01	1	0	1.5	1	80	19	1/4"	-	M	M	NP	SM	Black		Trace		1.13	34.02 / 26.89	28
311	K15-01	2	2.5	4	0	80	20	S	-	M	M	NP	SM	Black		Trace		1.15	62.9 / 51.14	24
312	K15-01	3	5	6.5	5	80	15	3/8"	-	M	-	NP	SM	Black		Trace		1.16	20.8 / 16.15	31
313	K15-01	4	7.5	9	5	80	15	1/4"	-	M	M	NP	SM	Black		Trace		1.15	37.05 / 30.27	23
314	K15-01	5	10	11.5	0	81	19	S	-	M	L	NP	SM	Black		None		1.17	33.05 / 25.95	29
315	K15-01	6	12.5	14.5	0	85	15	S	-	M	L	NP	SM	Black		None		1.15	30.63 / 25.03	23
316	K15-01	7	15.0	17	0	85	15	1/4"	-	M	L	NP	SM	Black		None		1.17	26.99 / 21.42	28
317	K15-01	8	17.5	19.5	4	70	26	1/4"	-	M	L	NP	SM	Black		Trace		1.18	22.64 / 18.25	26
318	K15-01	9	22.5	24.5	0	85	15	1/4"	-	M	H	NP	SM	Black		None		1.15	24.74 / 20.12	24
319	K15-01	10	27.5	29.5	0	85	15	1/4"	-	M	L	NP	SM	Black		None		1.16	30.47 / 24.85	24
320	K15-01	11	32.5	34.5	4	48	48	1/4"	-	F/M	H	NP	SM	Black		None		1.15	26.62 / 21.17	27
321	K15-01	12	37.5	39.5	25	60	15	1"	-	F/M	L	NP	SM	Black		None		1.16	24.97 / 21.18	19
322	K15-01	13	42.5	44.5	36	56	8	1"	-	F/M	L	NP	SP-SM	Black		None		1.15	16.97 / 15.15	13
323	K15-01	14	47.5	49.5	15	35	50	1/2"	-	F/M	VH	M	CL	Gray		None		1.15	21.19 / 17.03	26
324	K15-01	15	52.5	54.5	0	5	95	S	-	F/M	H	NP	ML	Gray		None		1.17	17.62 / 13.69	31

Continued on next page

DOWL

Visual Classification ASTM D-2488

Test Summary Report (cont'd)

Reporting Worksheet

Sample Date: 4/6/2015

Client: Golder Associates

W.O.#: 34316

Project: USACE Kivalina Causeway

Lab No.: varies

Location: See below

Lab #	Boring		Depth		Percent			Grain			Dry Str.	PI	USCS	Color	Free Water	Organics	Ice	Remarks	Moisture	
	TH	SA	From	To	Gravel	Sand	-#200	Max	Shape	Sand			Symbol						Wet / Dry	%
325	K15-02	1	0	2	0	5	95	S	-	F	M	NP	ML	Black/Brown		None		1.16	15.88 / 10.19	63
326	K15-02	2	2.5	4.5	0	20	80	S	-	F	H	NP	ML	Gray		None		1.15	20.15 / 15.36	34
327	K15-02	3	5	7	5	87	8	1/4"	-	F/M	L	NP	SP-SM	Black		None		1.16	26.66 / 22.04	22
328	K15-02	4	7.5	9.5	0	50	50	S	-	F	M	NP	ML	Black		None		1.13	20.09 / 15.1	36
329	K15-02	5	10	12	0	75	25	S	-	F	L	NP	SM	Black		None		1.13	27.58 / 21.49	30
330	K15-02	6	12.5	14.5	15	50	35	1/4"	-	F/M	L	NP	SM	Black		None		1.14	17.23 / 14.64	19
331	K15-02	7	15.0	17	9	82	9	1/4"	-	F/M	L	NP	SP-SM	Black		None		1.14	36.65 / 31.08	19
332	K15-02	8	20.0	22	1	69	30	S	-	F	L	NP	SM	Black		None		1.16	15.39 / 11.55	37
333	K15-02	9	25	27	0	25	75	S	-	F	M	NP	ML	Black		None		1.17	24.07 / 17.32	42
334	K15-02	10	30	32	24	59	17	F/C	-	F/M	L	NP	SM	Black		None		1.16	28.03 / 19.57	46
335	K15-02	11	35	37	50	35	15	F/C	-	F/M	L	NP	GM	Black		None		1.15	30.79 / 27.68	12
336	K15-02	12	40	42	41	51	8	F/C	-	F/M	L	NP	SW-SM	Black		None		1.17	23.74 / 21.5	11
337	K15-02	13	45	47	20	30	50	F/C	-	F/M	H	NP	GM	Gray		None		1.17	29.56 / 22.83	31
338	K15-02	14	50	52	0	5	95	S	-	M	VH	L	ML	Gray		None		1.17	21.73 / 17.47	26
339	K15-03	1	0	1.5	0	15	85	S	-	M	M	NP	ML	Black/Brown		None		1.14	12.1 / 8.39	51

Continued on next page

DOWL

Visual Classification ASTM D-2488

Test Summary Report (cont'd)

Reporting Worksheet

Sample Date: 4/6/2015

Client: Golder Associates

W.O.#: 34316

Project: USACE Kivalina Causeway

Lab No.: varies

Location: See below

Lab #	Boring		Depth		Percent			Grain			Dry Str.	PI	USCS	Color	Free Water	Organics	Ice	Remarks	Moisture	
	TH	SA	From	To	Gravel	Sand	-#200	Max	Shape	Sand			Symbol						Wet / Dry	%
340	K15-03	2	2.5	4.5	0	15	85	S	-	M	M	NP	ML	Black/Brown		None		1.16	27.26 / 20.07	38
341	K15-03	3	5	7	5	75	20	1/4"	-	F/M	L	NP	SM	Black		None		1.15	38.15 / 31.43	22
342	K15-03	4	7.5	9.5	9	83	8	1/4"	-	F/M	L	NP	SP-SM	Black		None		1.15	25.66 / 21.74	19
343	K15-03	5	10	12	25	50	25	1/4"	-	F/M	L	NP	ML	Black/Brown		None		1.13	18.73 / 15.16	25
344	K15-03	6	12.5	14.5	3	85	12	1/4"	-	F/M	L	NP	SP-SM	Black/Brown		None		1.13	17.41 / 14.57	21
345	K15-03	7	15.0	17	5	80	15	1/4"	-	F/M	L	NP	SM	Brown		None		1.16	20.81 / 16.83	25
346	K15-03	8	17.5	19.5	8	82	10	1/4"	-	F/M	L	NP	SW-SM	Black/Brown		None		1.16	14.7 / 12.48	20
347	K15-03	9	22.5	24.5	10	60	30	1/2"	-	F/M	L	NP	SM	Black		None		1.14	15.65 / 12.47	28
348	K15-03	10	27.5	29.5	6	64	30	1/4"	-	F/M	M	NP	SM	Black		None		1.16	23.5 / 19.1	25
349	K15-03	11	29.5	31.5	1	80	19	S	-	S	M	NP	SM	Black		None		1.15	24.71 / 19.27	30
350	K15-04	1	1	2.5	5	10	85	1/4"	-	S	H	L	ML	Black		None		1.16	29.4 / 22.93	30
351	K15-04	2	3.5	5	5	75	20	1/4"	-	F/M	L	NP	SM	Black		None		1.14	28.47 / 19.06	53
352	K15-04	3	6	7.5	1	91	10	1/4"	-	F/M	L	NP	SP-SM	Black		None		1.16	13.32 / 10.98	24
353	K15-04	4	8.5	10	9	85	6	3/58'	-	F/M	L	NP	SP-SM	Black		None		1.15	17.47 / 14.76	20
354	K15-04	5	12.5	14.5	10	85	5	1/4"	-	F/M	L	NP	SP	Black		None		1.15	19.41 / 16.7	17

Continued on next page

DOWL

Visual Classification ASTM D-2488

Test Summary Report (cont'd)

Reporting Worksheet

Sample Date: 4/6/2015

Client: Golder Associates | W.O.#: 34316

Project: USACE Kivalina Causeway | Lab No.: varies

Location: See below

Lab #	Boring		Depth		Percent			Grain			Dry Str.	PI	USCS Symbol	Color	Free Water	Organics	Ice	Remarks	Moisture	
	TH	SA	From	To	Gravel	Sand	-#200	Max	Shape	Sand									Wet Dry	%
355	K15-04	6	15	17	12	77	11	1/2"	-	F/M	L	NP	SW-SM	Brown		None		1.14	20.96 / 18.05	17
356	K15-04	7	17.5	19	15	80	5	3/8"	-	F/M	L	NP	SP	Black		None		1.15	15.25 / 13.41	15
357	K15-04	8	22.5	24.5	4	72	24	3/8"	-	F/M	M	NP	SM	Black		None		1.14	27.36 / 22.51	23
358	K15-04	9	27.5	29.5	0	5	95	S	-	M	H	NP	ML	Black		None		1.16	23.93 / 16.88	45
359	K15-04	10	29.5	31.5	0	5	95	S	-	M	M	NP	ML	Black		Trace		1.15	14.29 / 10.53	40
360	K15-05	1	0.0	1.5	1	74	25	S	-	M	L	NP	SM	Black		Trace		1.15	15.66 / 11.64	38
361	K15-05	2	2.5	4.5	0	5	95	S	-	M	H	L	ML	Gray		None		1.15	23.34 / 17.99	32
362	K15-05	3	5.0	7	0	5	95	S	-	M	M	L	ML	Gray		None		1.17	21.48 / 15.52	42
363	K15-05	4	7.5	9.5	0	5	95	S	-	M	VH	L	ML	Gray		None		1.15	31.72 / 23.43	37
364	K15-05	5	10	12	0	69	31	S	-	M	L	NP	SM	Black		None		1.15	30.72 / 24.39	27
365	K15-05	6	12.5	14.5	10	50	40	3/4"	-	F/M	M	NP	SM	Black		None		1.15	18.49 / 15.05	25
366	K15-05	7	15	17	20	40	40	1/4"	-	F/M	L	NP	SM	Brown		None		1.15	26.53 / 21.69	24
367	K15-05	8	17.5	19.5	16	67	17	1/4"	-	F/M	L	NP	SM	Brown		None		1.14	24.16 / 19.98	22
368	K15-05	9	22.5	24.5	0	50	50	S	-	M	M	NP	ML	Black		None		1.16	17.12 / 13.5	29
369	K15-05	10	27.5	28.1	38	47	15	1"	-	F/M	H	NP	SM	Black		None		1.15	20.45 / 17.56	18

Continued on next page

Visual Classification ASTM D-2488

Test Summary Report

Reporting Worksheet

Sample Date: 4/6/2015

Client: Golder Associates | W.O.#: 34316

Project: USACE Kivalina Causeway | Lab No.: varies

Location: See below

Lab #	Boring		Depth		Percent			Grain			Dry Str.	PI	USCS Symbol	Color	Free Water	Organics	Ice	Remarks	Moisture	
	TH	SA	From	To	Gravel	Sand	-#200	Max	Shape	Sand									Wet / Dry	%
370	K15-05	11	30	30.5	46	48	6	3/4"	-	M	L	NP	SP-SM	Brown		None		1.14	20 / 18.07	11
371	K15-06	1	0	2	0	5	95	S	-	M	M	NP	ML	Black		None		1.14	13.72 / 9.31	54
372	K15-06	2	2.5	4.5	0	5	95	S	-	M	L	NP	ML	Black		None		1.14	18.6 / 12.98	47
373	K15-06	3	5	7	12	65	23	1/4"	-	F/M	M	NP	SM	Black		None		1.16	34.69 / 28.22	24
374	K15-06	4	7.5	9.5	0	5	95	S	-	M	H	L	ML	Gray		None		1.16	22.33 / 15.83	44
375	K15-06	5	10.0	12	0	5	95	S	-	M	VH	L	ML	Gray		None		1.15	15.97 / 11.33	46
376	K15-06	6	12.5	14.5	0	5	95	S	-	M	VH	L	ML	Gray		None		1.13	14.89 / 10.09	54
377	K15-06	7	15.0	17	0	5	95	S	-	M	H	NP	ML	Gray		None		1.16	18.93 / 14.31	35
378	K15-06	8	17.5	19.5	0	62	38	S	-	M	L	NP	SM	Black		None		1.15	22.34 / 16.15	41
379	K15-06	9	22.5	24.5	5	75	20	1/4"	-	F/M	L	NP	SM	Black/Brown		None		1.17	11.07 / 8.78	30
380	K15-06	10	27.5	28.3	11	64	25	3/8"	-	F/M	L	NP	SM	Black		None		1.14	21.45 / 16.82	30
381	K15-06	11	30	31	55	41	4	1"	-	F/M	L	NP	GW	Brown		None		1.14	11.26 / 10.66	6

If you have questions regarding this summary report or the test procedures, please contact us.

Maria

Maria E. Kampsen, P.E.
Laboratory Supervisor

Conductivity Report Summary

Date Sample Recv'd: 6/9/2014

Client: Golder Associates
W.O. #: 33956
Project: USACE Kivalina Causeway
Lab #: Varies
Location: See below

Lab ID	Sample ID	Test Performed	Test Method	Parts Per Thousand (ppt)
339	K15-03, Sample 1, 0'-1.5'	Conductivity	In House Procedure	4.5
340	K15-03, Sample 2, 2.5'-4.5'			2.3
341	K15-03, Sample 3, 5'-7'			3.3
342	K15-03, Sample 4, 7.5'-9'			2.7
343	K15-03, Sample 5, 10'-12'			4.9
344	K15-03, Sample 6, 12.5'-14.5'			3.9
345	K15-03, Sample 1, 15'-17'			4.4
346	K15-03, Sample 1, 17.5'-19.5'			5.5
347	K15-03, Sample 9, 22.5'-24.5'			4.9
348	K15-03, Sample 10, 27.5'-29.5'			8.4
349	K15-03, Sample 11, 29.5'-31.5'			8.0
371	K15-06, Sample 1, 0'-2'			5.3
372	K15-06, Sample 2, 2.5'-4.5'			9.2
373	K15-06, Sample 3, 5'-7'			8.2
374	K15-06, Sample 4, 7.5'-9.5'			15.6
375	K15-06, Sample 5, 10'-12'			8.6
376	K15-06, Sample 6, 12.5'-14.5'			12.7
377	K15-06, Sample 7, 15'-17'			5.2
378	K15-06, Sample 8, 17.5'-19.5'			8.6
379	K15-06, Sample 9, 22.5'-24.5'			7.1

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4040 B Street, Anchorage, Alaska 99503 -- 907-562-2000

Conductivity Report Summary (cont'd)

		Date Sample Recv'd	6/9/2014
Client	Golder Associates	W.O. #	33956
Project	USACE Kivalina Causeway	Lab #	Varies
Location	See below		

Lab ID	Sample ID	Test Performed	Test Method	Parts Per Thousand (ppt)
380	K15-06, Sample 10, 27.5'-28.3'	Conductivity	In House Procedure	7.8
381	K15-06, Sample 11, 30'-31'			10.8

If you have questions regarding this summary report or the test procedures, please contact us.

Maria
Maria E. Kampsen, P.E.
Laboratory Supervisor

4040 B Street, Anchorage, Alaska 99503 -- 907-562-2000

DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

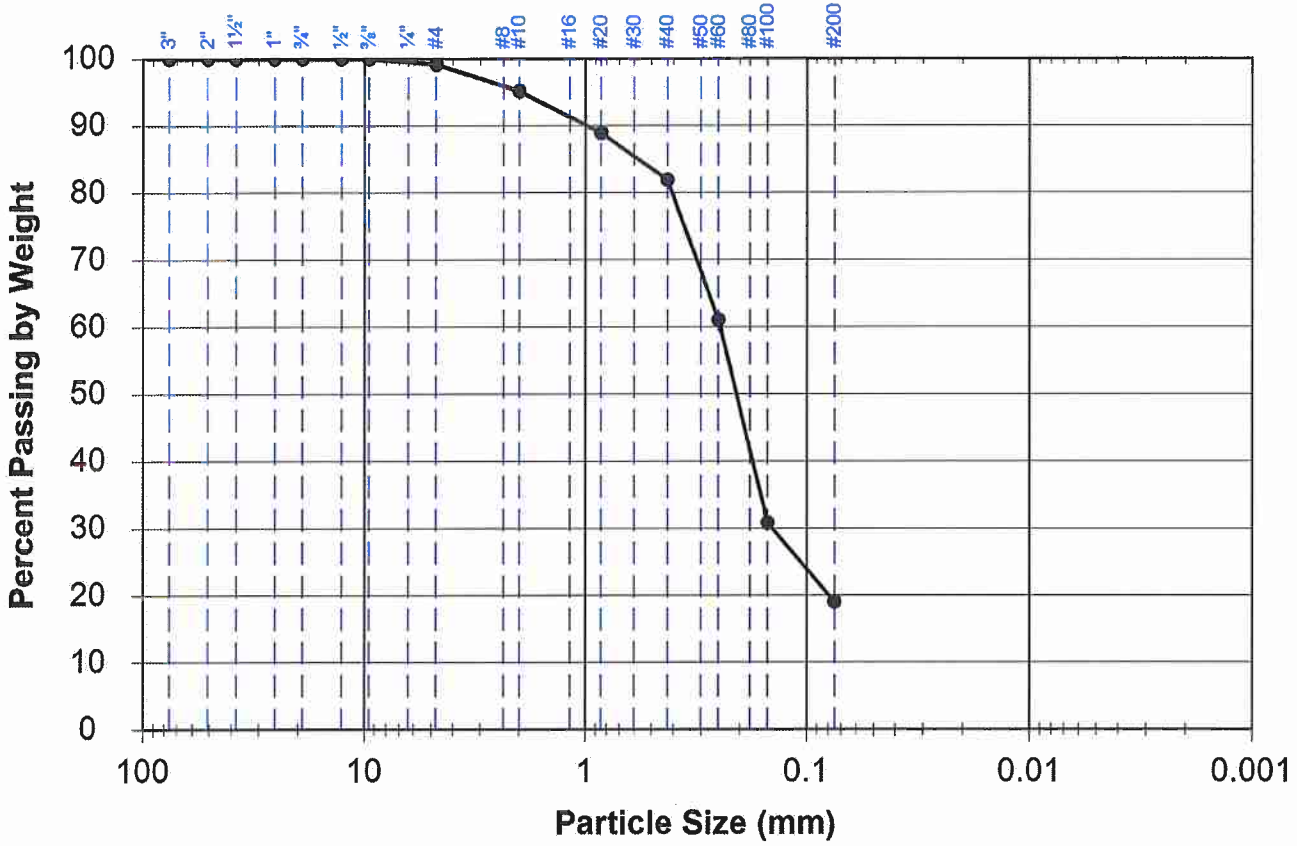
ASTM D422

Location: Test Borehole K15-01
Sample 1
Depth 0'-1.5'

Lab Number	2015-310
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: Silty Sand, SM

Frost Classification: Not Measured



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	99%	
Total Weight of Sample 725g		
#10	95%	
#20	89%	
#40	82%	
#60	61%	
#100	31%	
#200	19.1%	
Total Weight of Fine Fraction 307.6g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

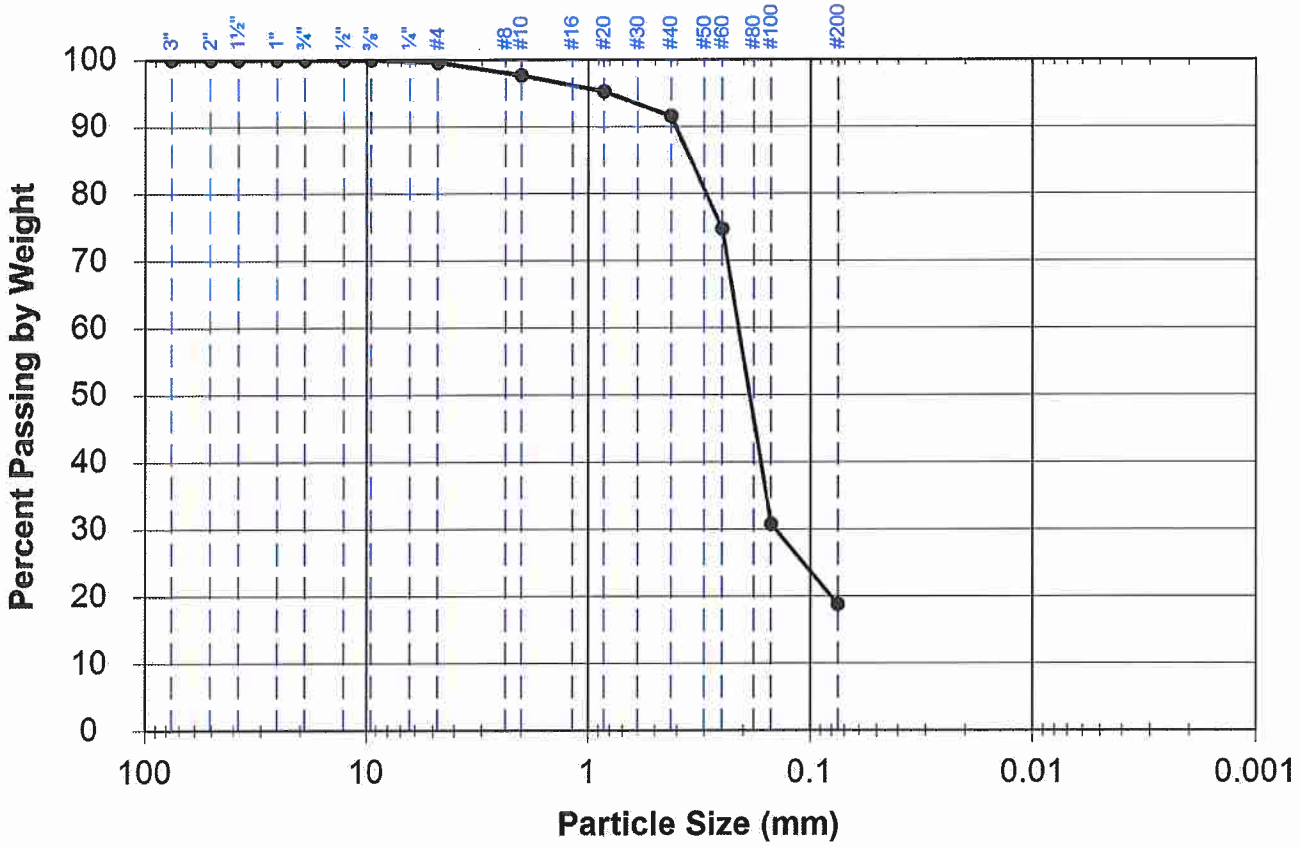
ASTM D422

Location: Test Borehole K15-01
Sample 5
Depth 10'-11.5'

Lab Number	2015-314
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Sample 292.5g		
#10	98%	
#20	95%	
#40	92%	
#60	75%	
#100	31%	
#200	18.8%	
Total Weight of Fine Fraction 291.4g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

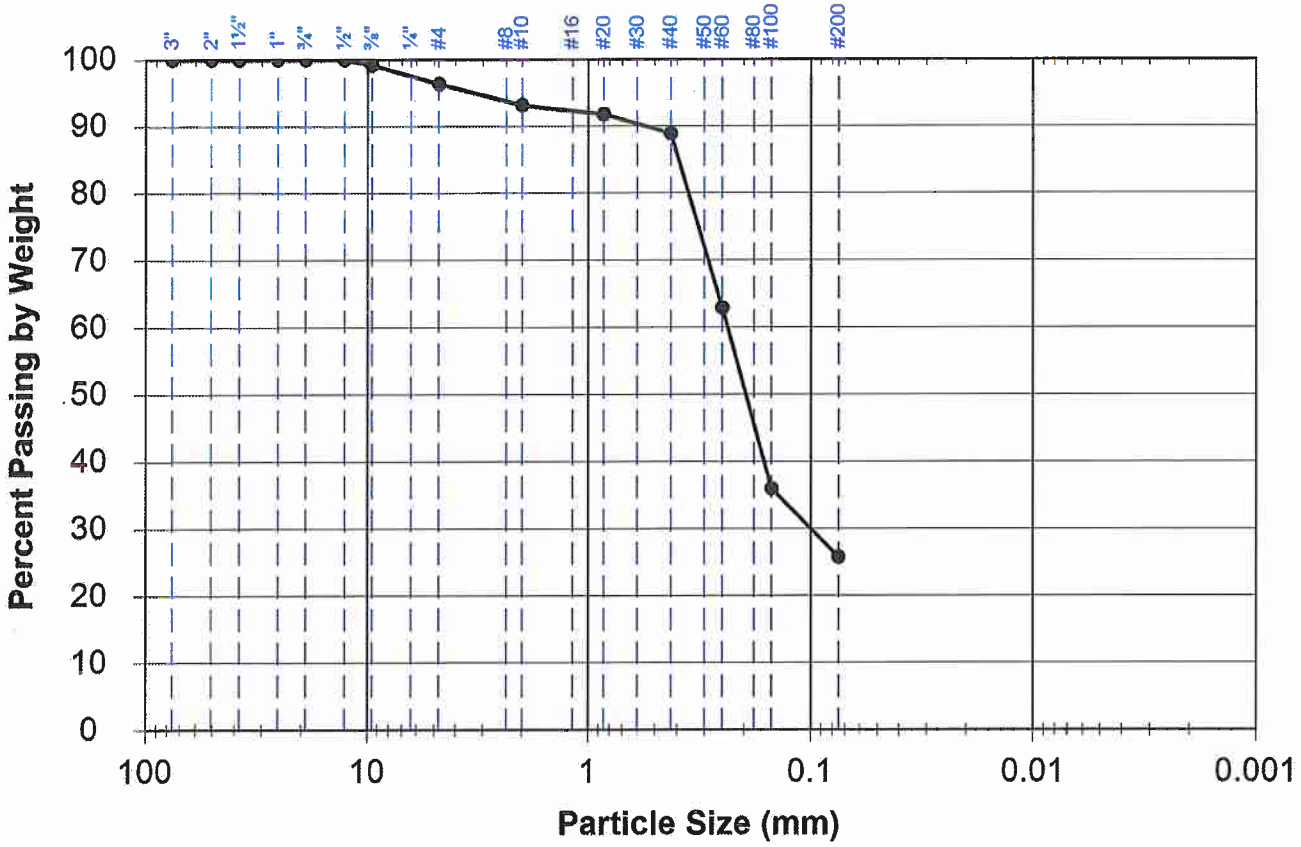
ASTM D422

Location: Test Borehole K15-01
Sample 8
Depth 17.5'-19.5'

Lab Number	2015-317
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: Silty Sand, SM

Frost Classification: Not Measured



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	99%	
#4	96%	
Total Weight of Sample 465.9g		
#10	93%	
#20	92%	
#40	89%	
#60	63%	
#100	36%	
#200	25.8%	
Total Weight of Fine Fraction 448.9g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

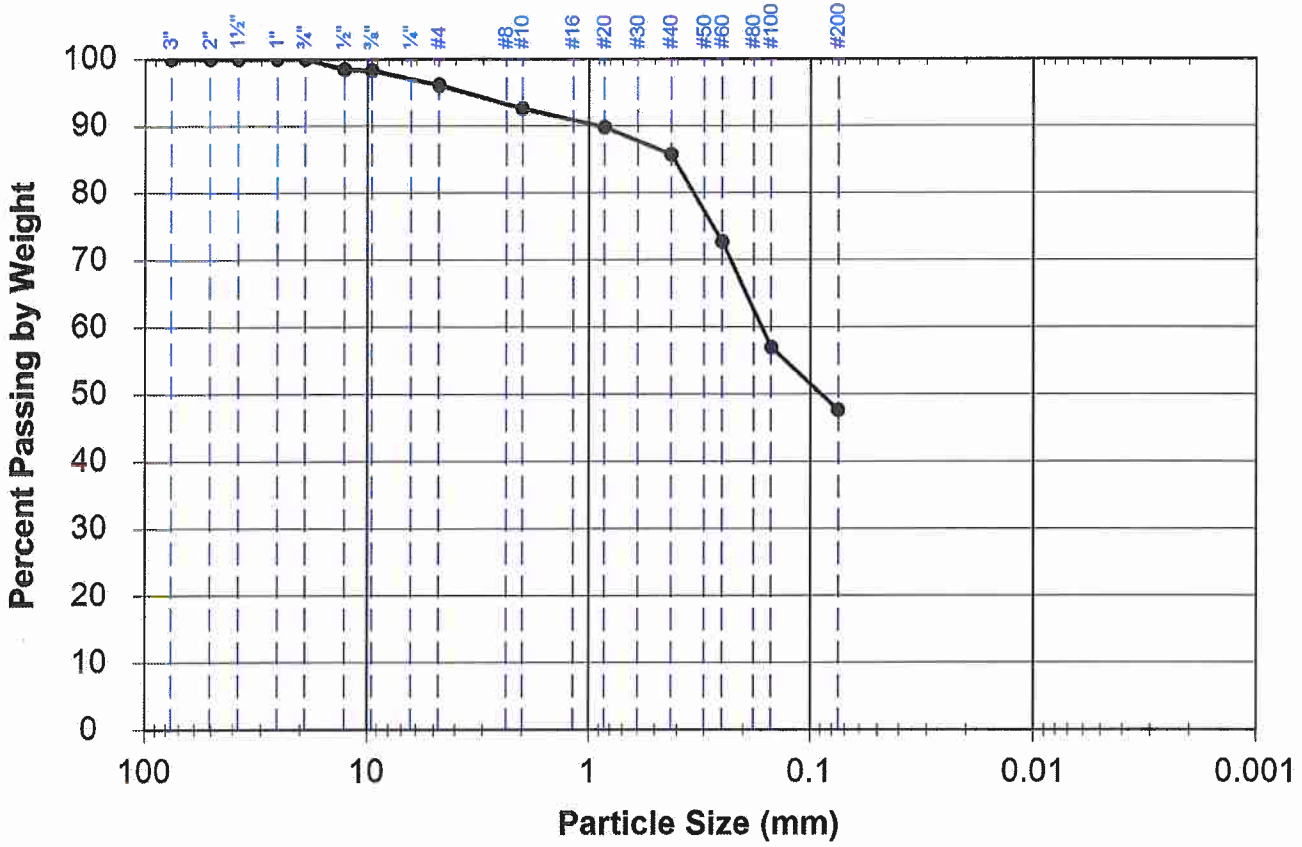
ASTM D422

Location: Test Borehole K15-01
Sample 11
Depth 32.5'-34.5'

Lab Number	2015-320
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	98%	
⅜"	98%	
#4	96%	
Total Weight of Sample 772.7g		
#10	93%	
#20	90%	
#40	86%	
#60	73%	
#100	57%	
#200	47.6%	
Total Weight of Fine Fraction 305.6g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

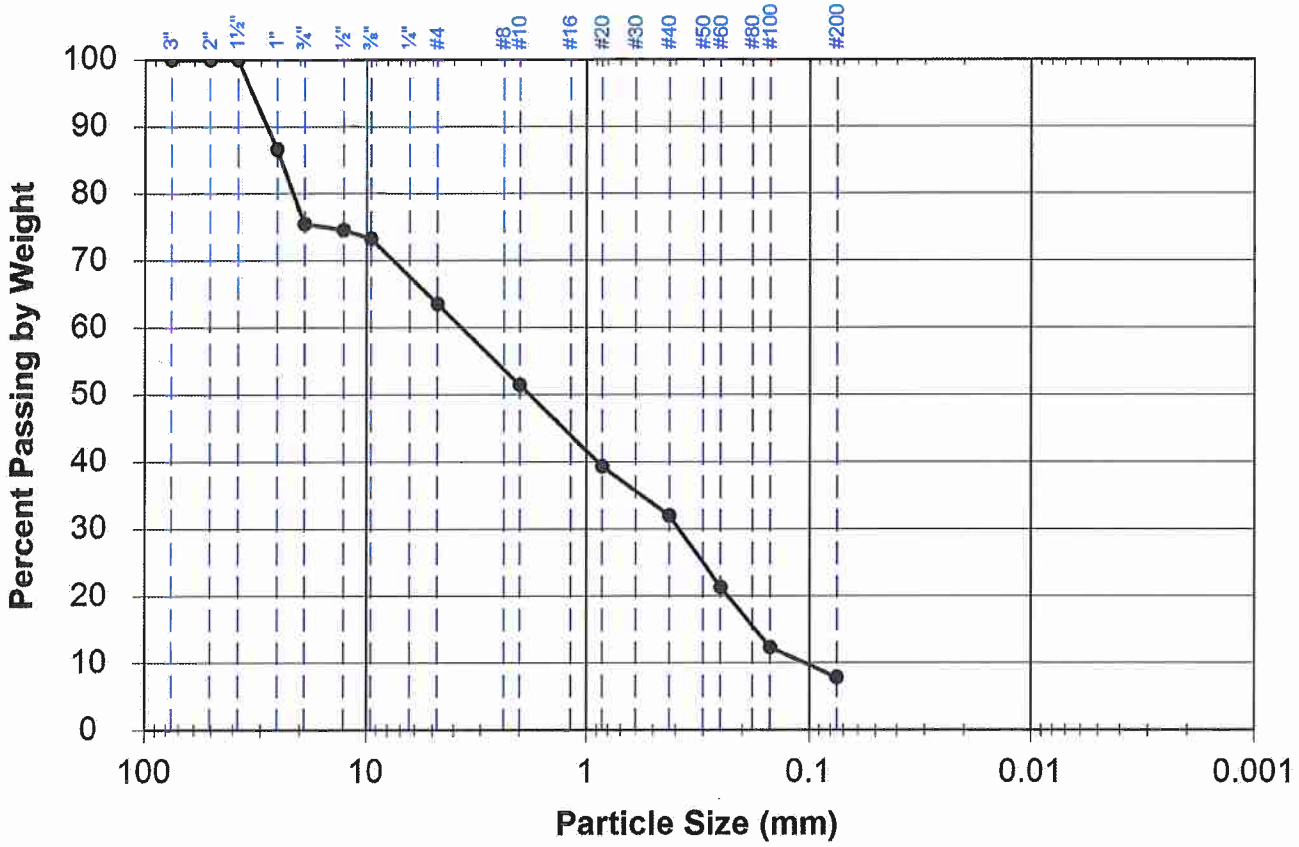
ASTM D422

Location: Test Borehole K15-01
Sample 13
Depth 42.5'-44.5'

Lab Number	2015-322
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt and Gravel, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	87%	
¾"	75%	
½"	75%	
⅜"	73%	
#4	64%	
Total Weight of Sample 508.3g		
#10	51%	
#20	39%	
#40	32%	
#60	21%	
#100	12%	
#200	7.9%	
Total Weight of Fine Fraction 322.6g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

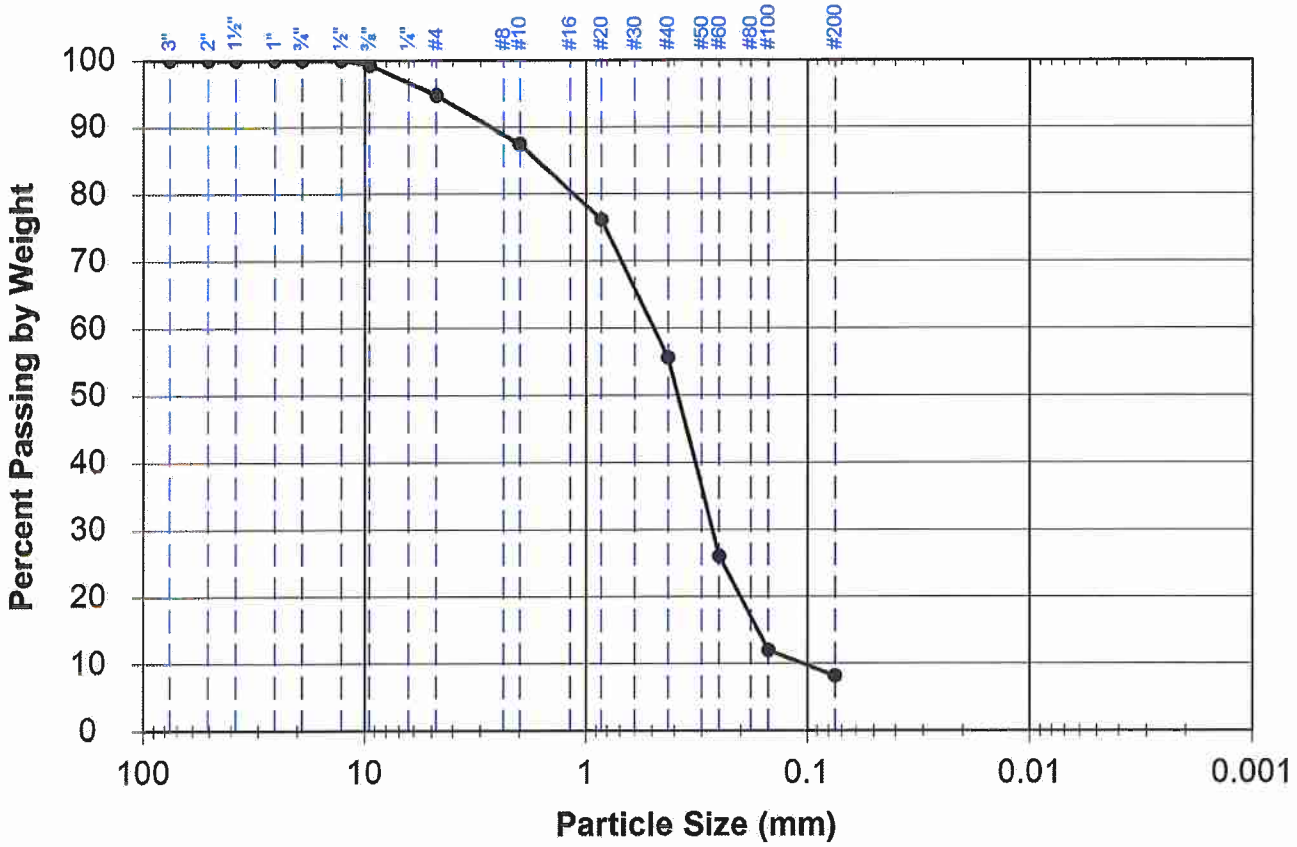
ASTM D422

Location: Test Borehole K15-02
Sample 3
Depth 5'-7'

Lab Number	2015-327
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	99%	
#4	95%	
Total Weight of Sample 663.2g		
#10	87%	
#20	76%	
#40	56%	
#60	26%	
#100	12%	
#200	8.2%	
Total Weight of Fine Fraction 315.9g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

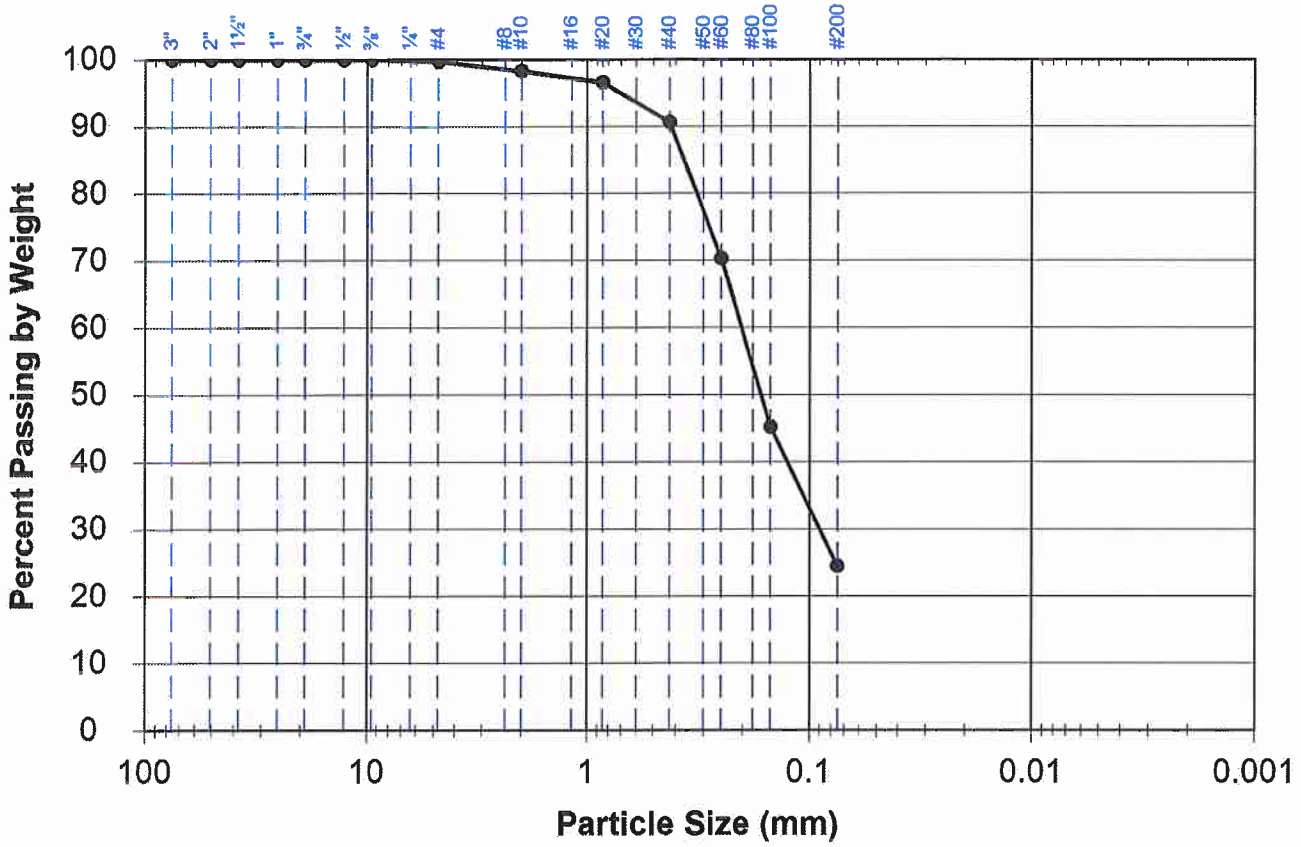
ASTM D422

Location: Test Borehole K15-02
Sample 5
Depth 10'-12'

Lab Number	2015-329
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Sample 537.6g		
#10	98%	
#20	97%	
#40	91%	
#60	70%	
#100	45%	
#200	24.5%	
Total Weight of Fine Fraction 535.5g		

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Work Order: A34316

Particle Size Distribution

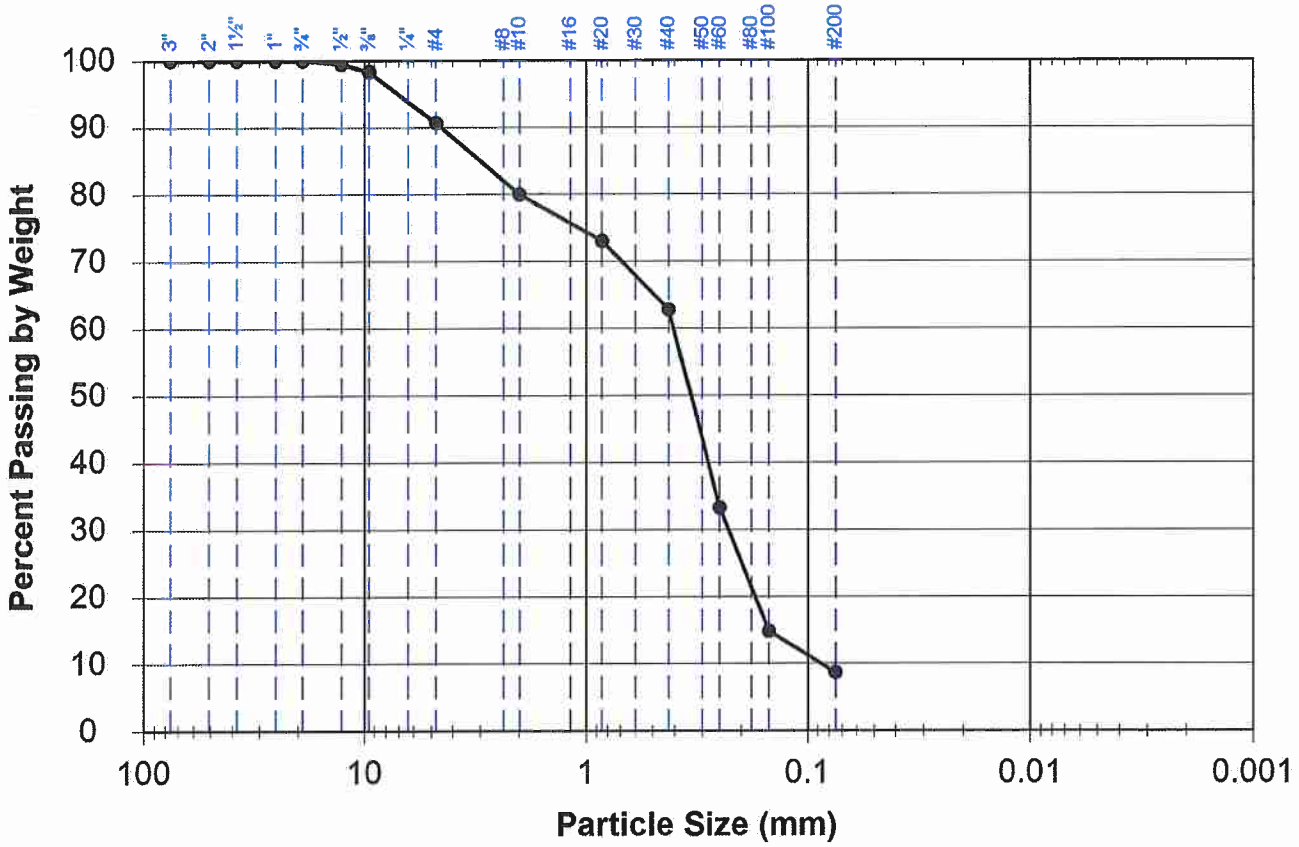
ASTM D422

Location: Test Borehole K15-02
Sample 7
Depth 15'-17'

Lab Number	2015-331
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	98%	
#4	91%	
Total Weight of Sample 553.7g		
#10	80%	
#20	73%	
#40	63%	
#60	33%	
#100	15%	
#200	8.7%	
Total Weight of Fine Fraction 501.5g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

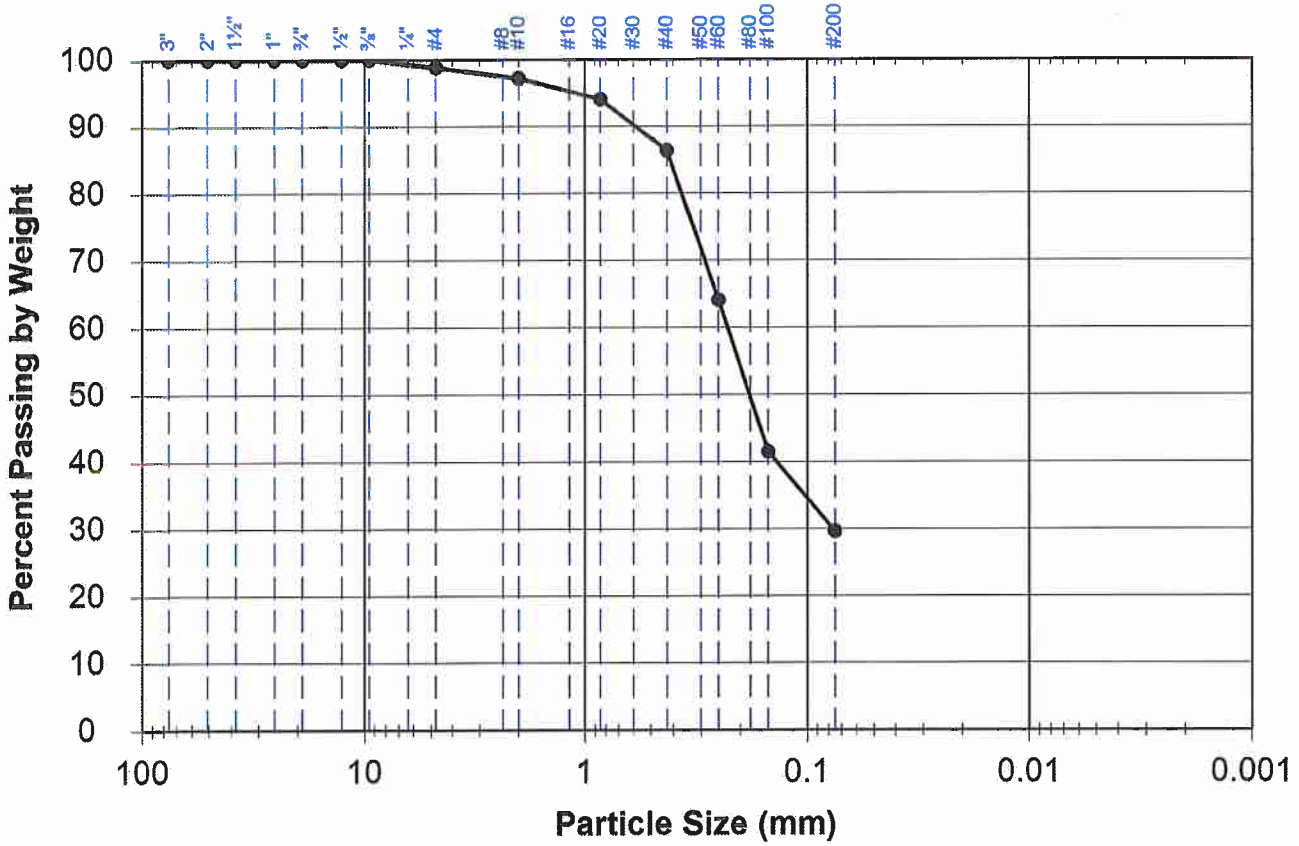
ASTM D422

Location: Test Borehole K15-02
Sample 8
Depth 20'-22'

Lab Number	2015-332
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	99%	
Total Weight of Sample 213.3g		
#10	97%	
#20	94%	
#40	86%	
#60	64%	
#100	41%	
#200	29.7%	
Total Weight of Fine Fraction 210.3g		

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Work Order: A34316

Particle Size Distribution

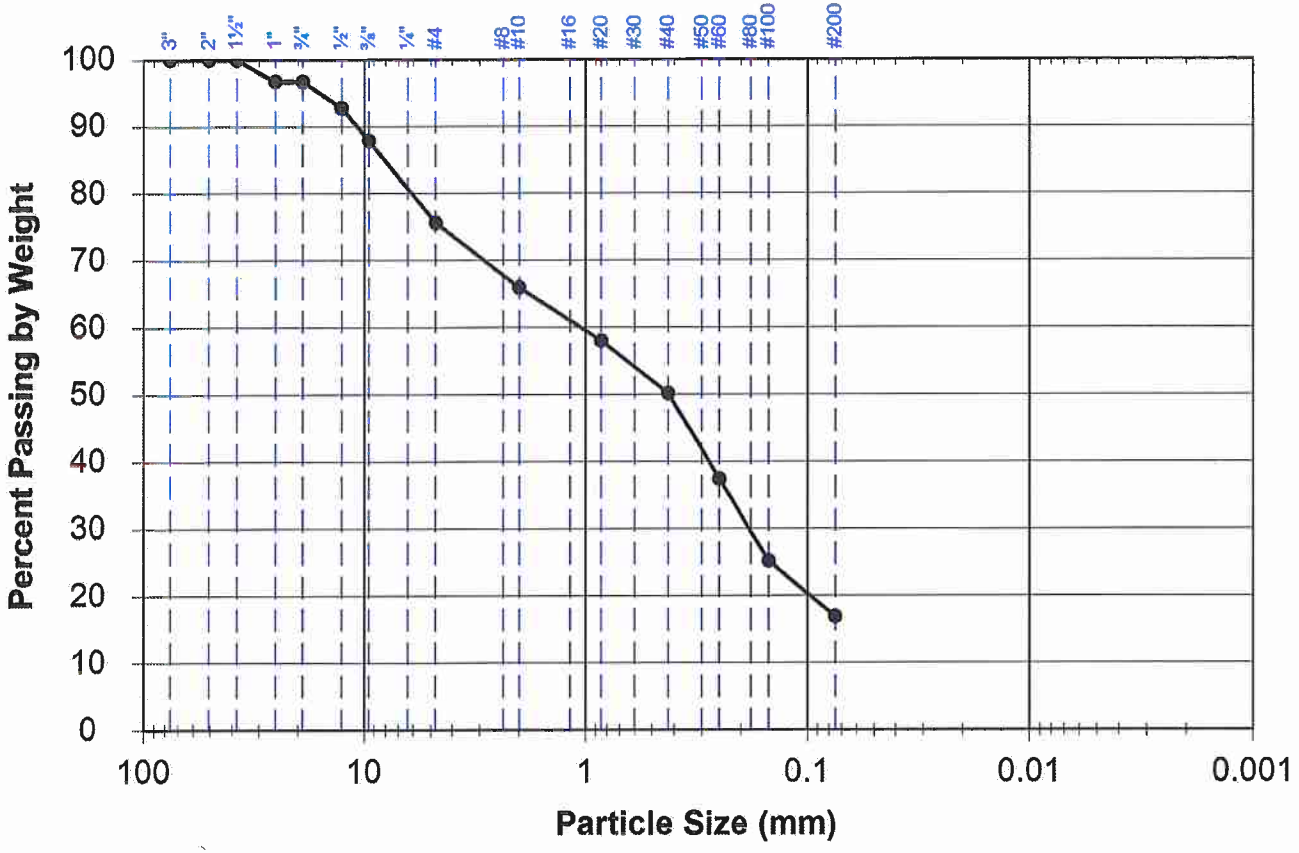
ASTM D422

Location: Test Borehole K15-02
Sample 10
Depth 30'-32'

Lab Number	2015-334
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand with Gravel, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	97%	
¾"	97%	
½"	93%	
⅜"	88%	
#4	76%	
Total Weight of Sample 744.8g		
#10	66%	
#20	58%	
#40	50%	
#60	37%	
#100	25%	
#200	16.9%	
Total Weight of Fine Fraction 561.7g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

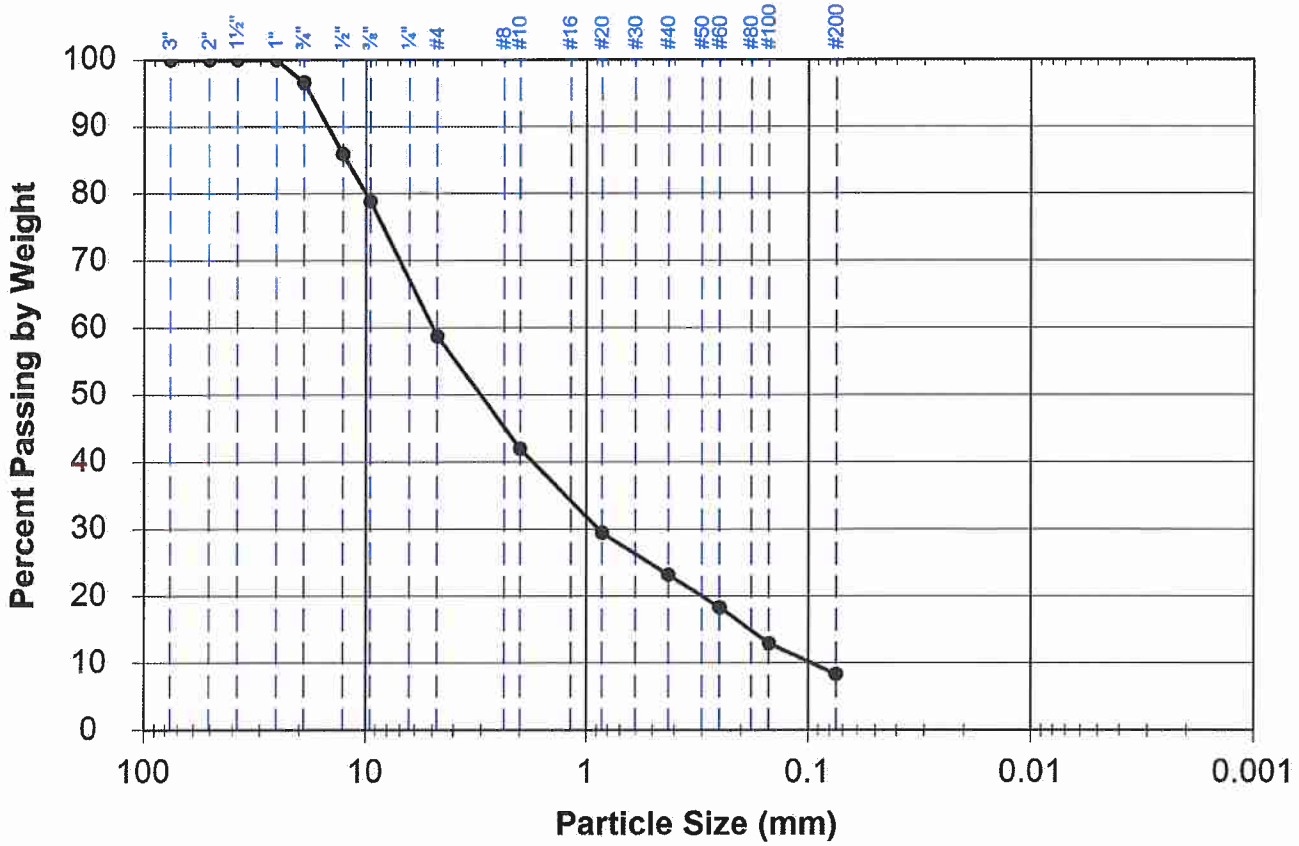
ASTM D422

Location: Test Borehole K15-02
Sample 12
Depth 40'-42'

Lab Number	2015-336
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Well Graded Sand with Silt and Gravel, SW-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	97%	
½"	86%	
⅜"	79%	
#4	59%	
Total Weight of Sample 522.3g		
#10	42%	
#20	29%	
#40	23%	
#60	18%	
#100	13%	
#200	8.3%	
Total Weight of Fine Fraction 306.4g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

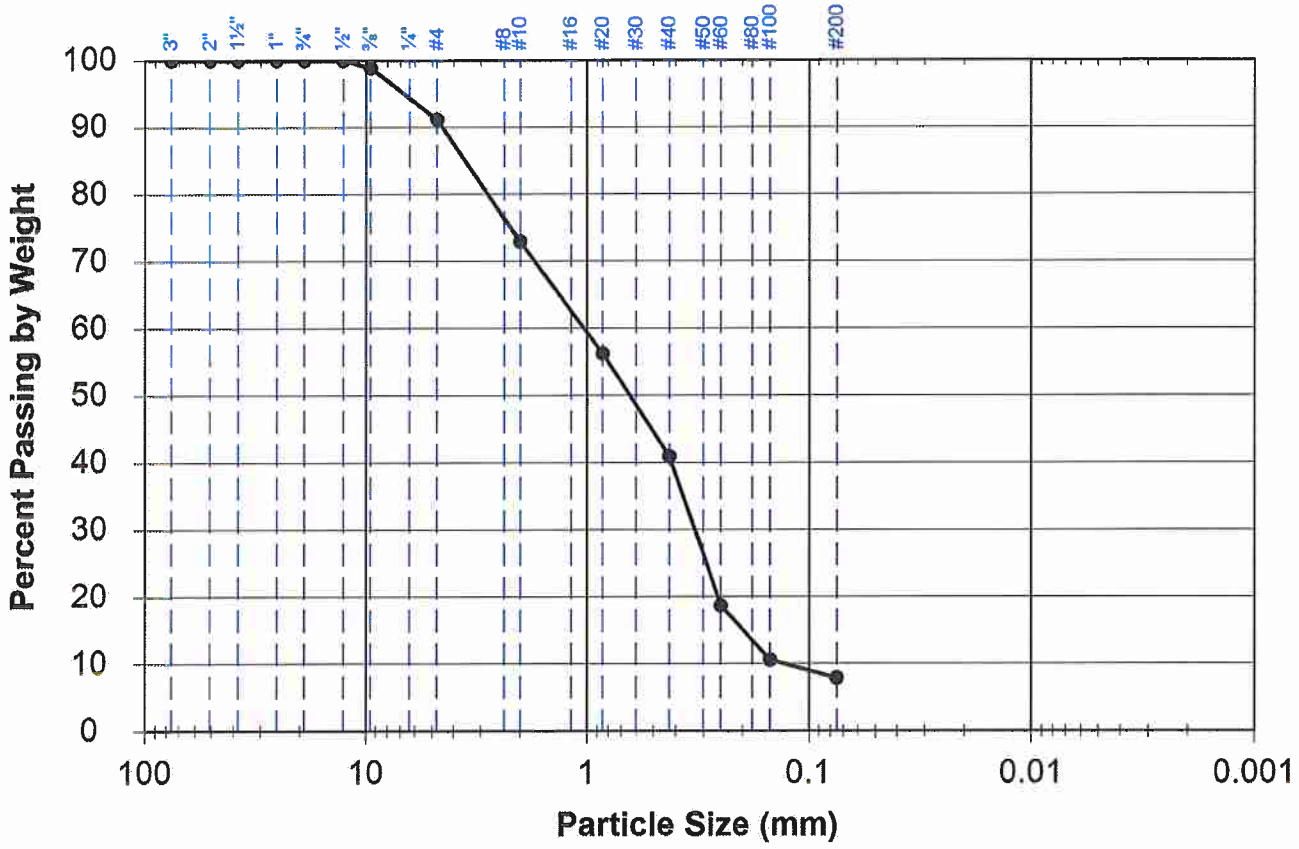
ASTM D422

Location: Test Borehole K15-03
Sample 4
Depth 7.5'-9.5'

Lab Number	2015-342
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	99%	
#4	91%	
Total Weight of Sample 614.1g		
#10	73%	
#20	56%	
#40	41%	
#60	19%	
#100	11%	
#200	7.9%	
Total Weight of Fine Fraction 558.6g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

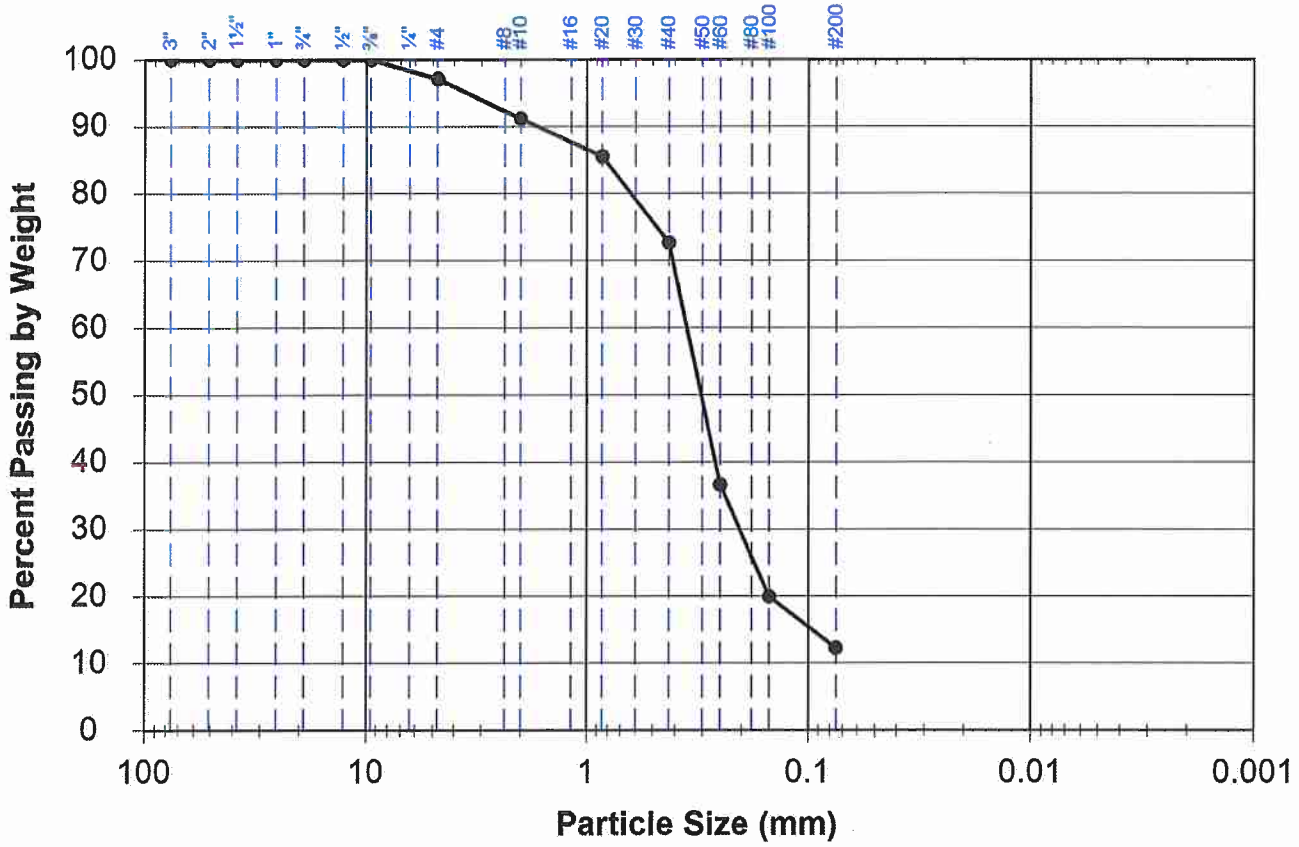
ASTM D422

Location: Test Borehole K15-03
Sample 6
Depth 12.5'-14.5'

Lab Number	2015-344
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	97%	
Total Weight of Sample 537.3g		
#10	91%	
#20	85%	
#40	73%	
#60	37%	
#100	20%	
#200	12.3%	
Total Weight of Fine Fraction 521.3g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

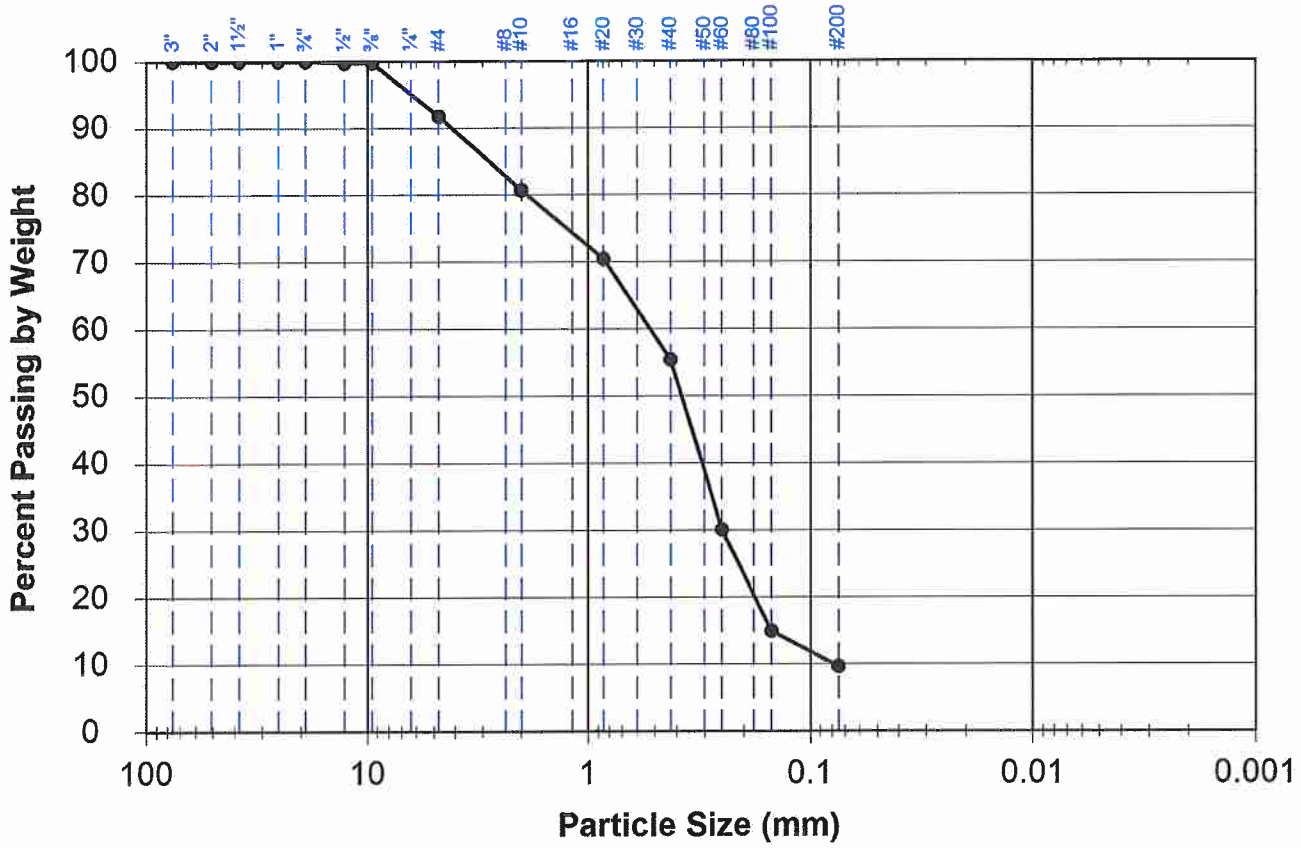
ASTM D422

Location: Test Borehole K15-03
Sample 8
Depth 17.5-19.5'

Lab Number	2015-346
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Well Graded Sand with Silt, SW-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	92%	
Total Weight of Sample 741.3g		
#10	81%	
#20	70%	
#40	55%	
#60	30%	
#100	15%	
#200	9.7%	
Total Weight of Fine Fraction 378g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

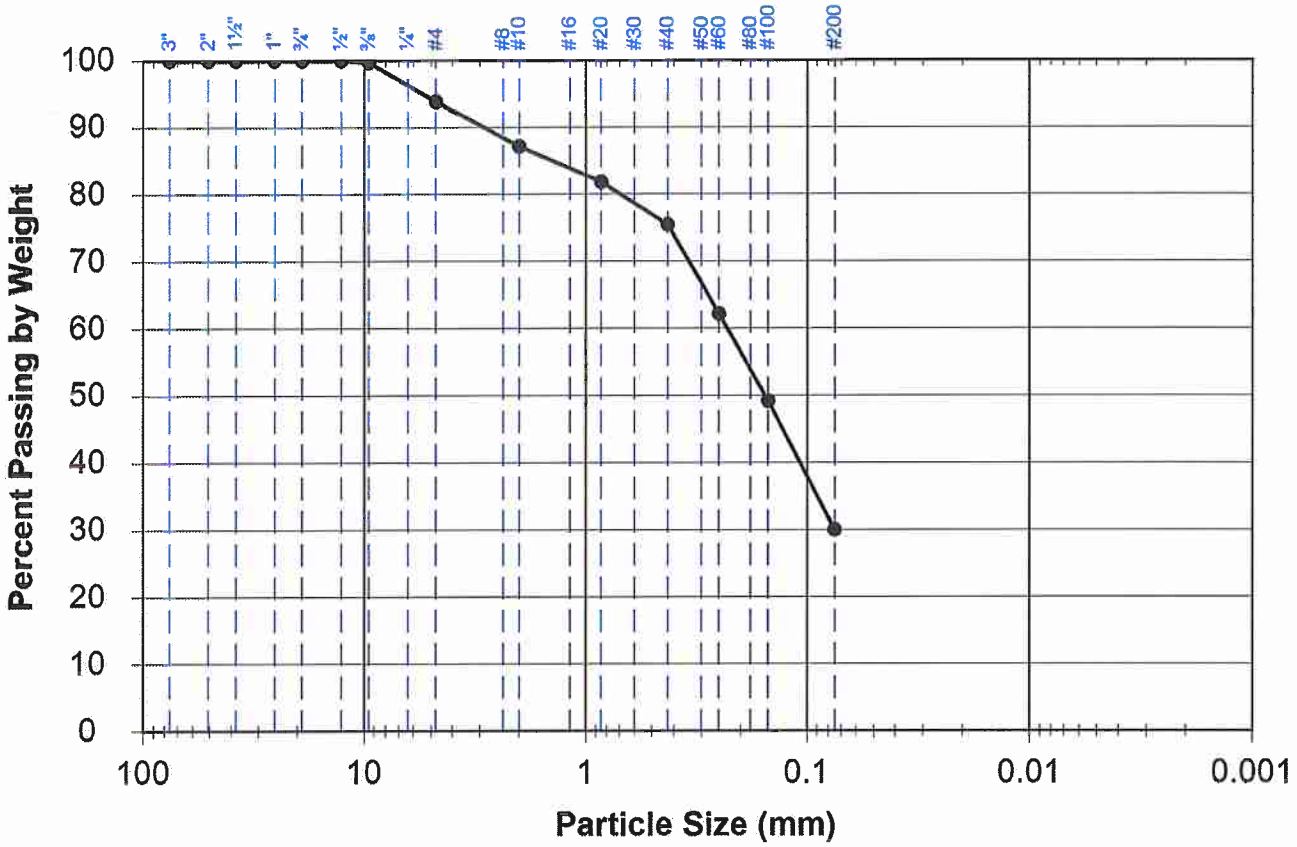
ASTM D422

Location: Test Borehole K15-03
Sample 10
Depth 27.5'-29.5'

Lab Number	2015-348
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	94%	
Total Weight of Sample 459.7g		
#10	87%	
#20	82%	
#40	75%	
#60	62%	
#100	49%	
#200	30.0%	
Total Weight of Fine Fraction 430.9g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

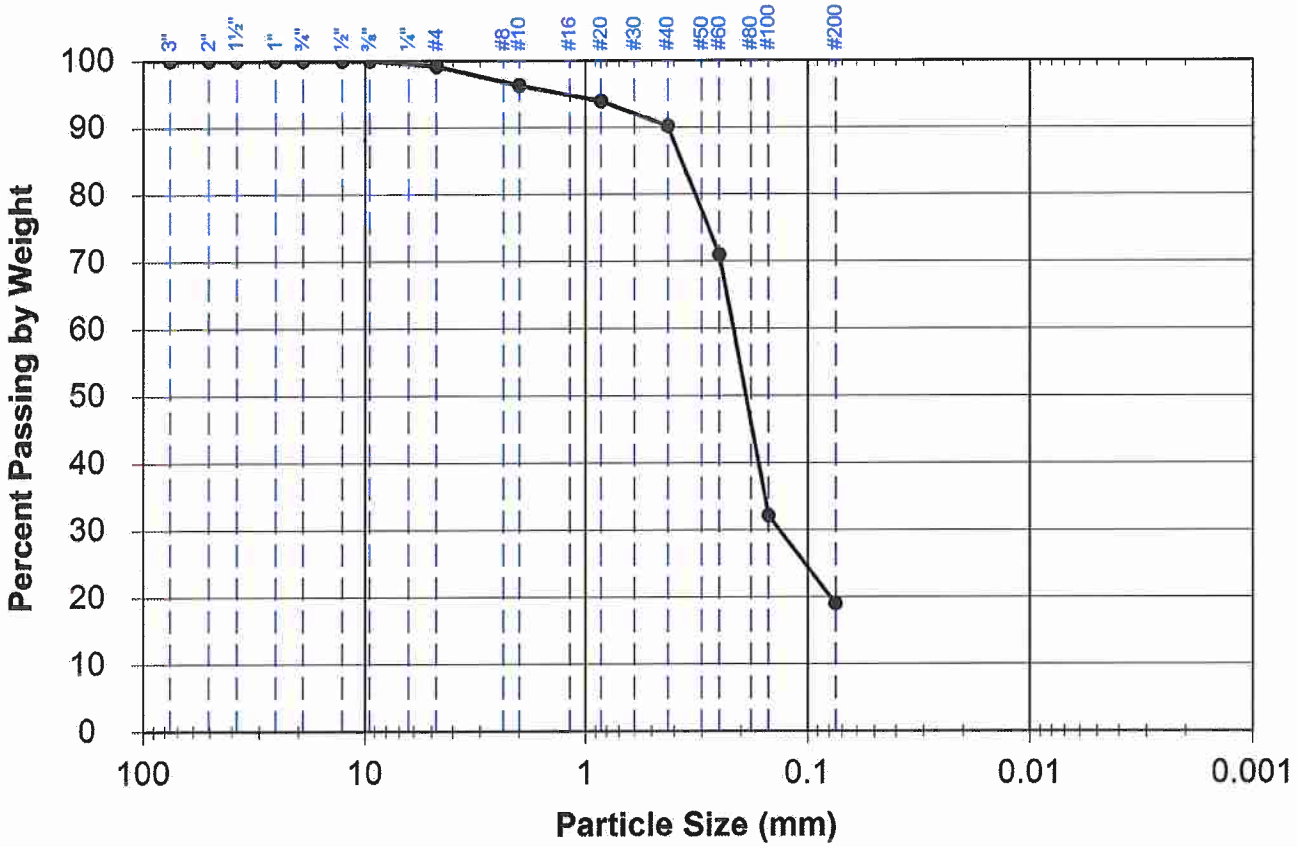
ASTM D422

Location: Test Borehole K15-03
Sample 11
Depth 29.5'-31.5'

Lab Number	2015-349
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	99%	
Total Weight of Sample 525.1g		
#10	96%	
#20	94%	
#40	90%	
#60	71%	
#100	32%	
#200	19.0%	
Total Weight of Fine Fraction 519.9g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

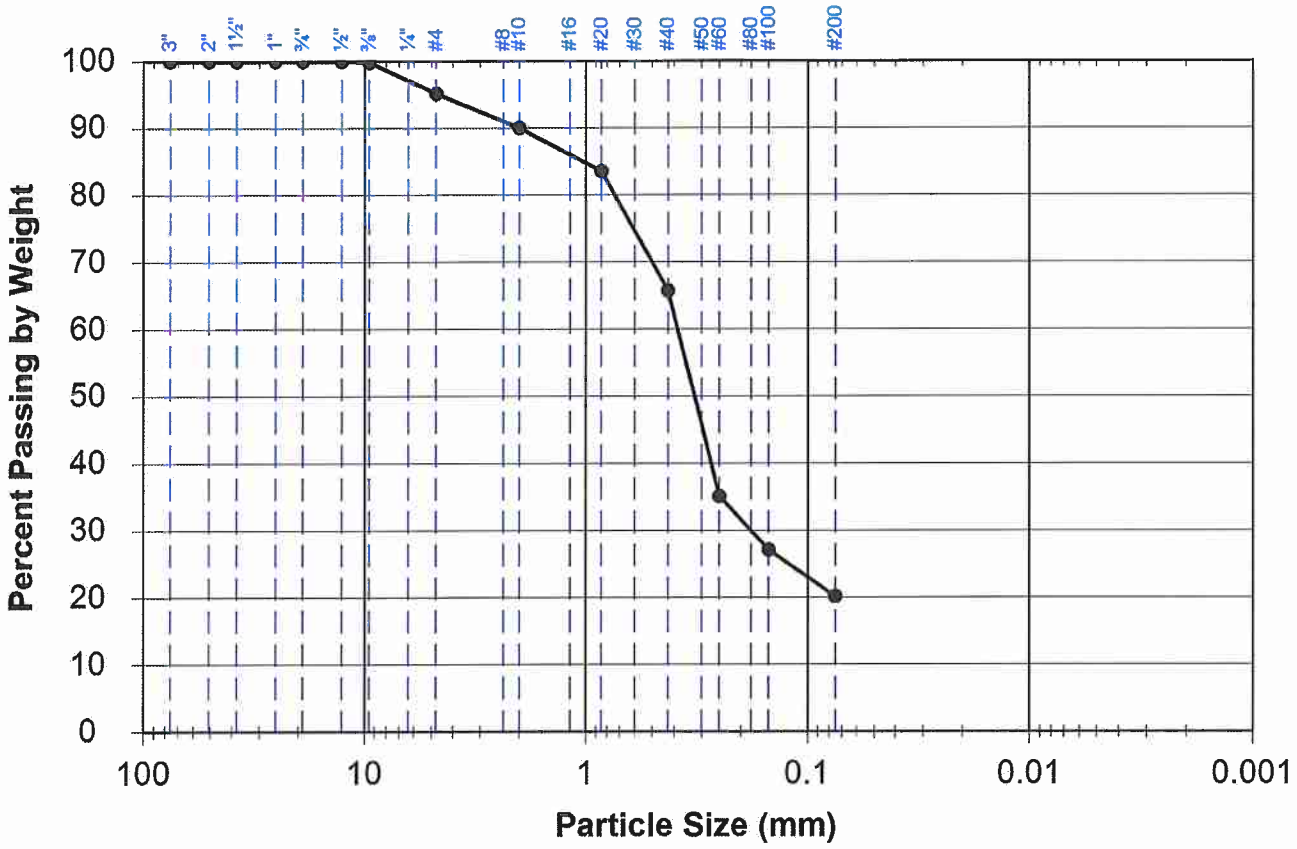
ASTM D422

Location: Test Borehole K15-04
Sample 2
Depth 3.5'-5'

Lab Number	2015-351
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	95%	
Total Weight of Sample 918.7g		
#10	90%	
#20	84%	
#40	66%	
#60	35%	
#100	27%	
#200	20.2%	
Total Weight of Fine Fraction 392.4g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

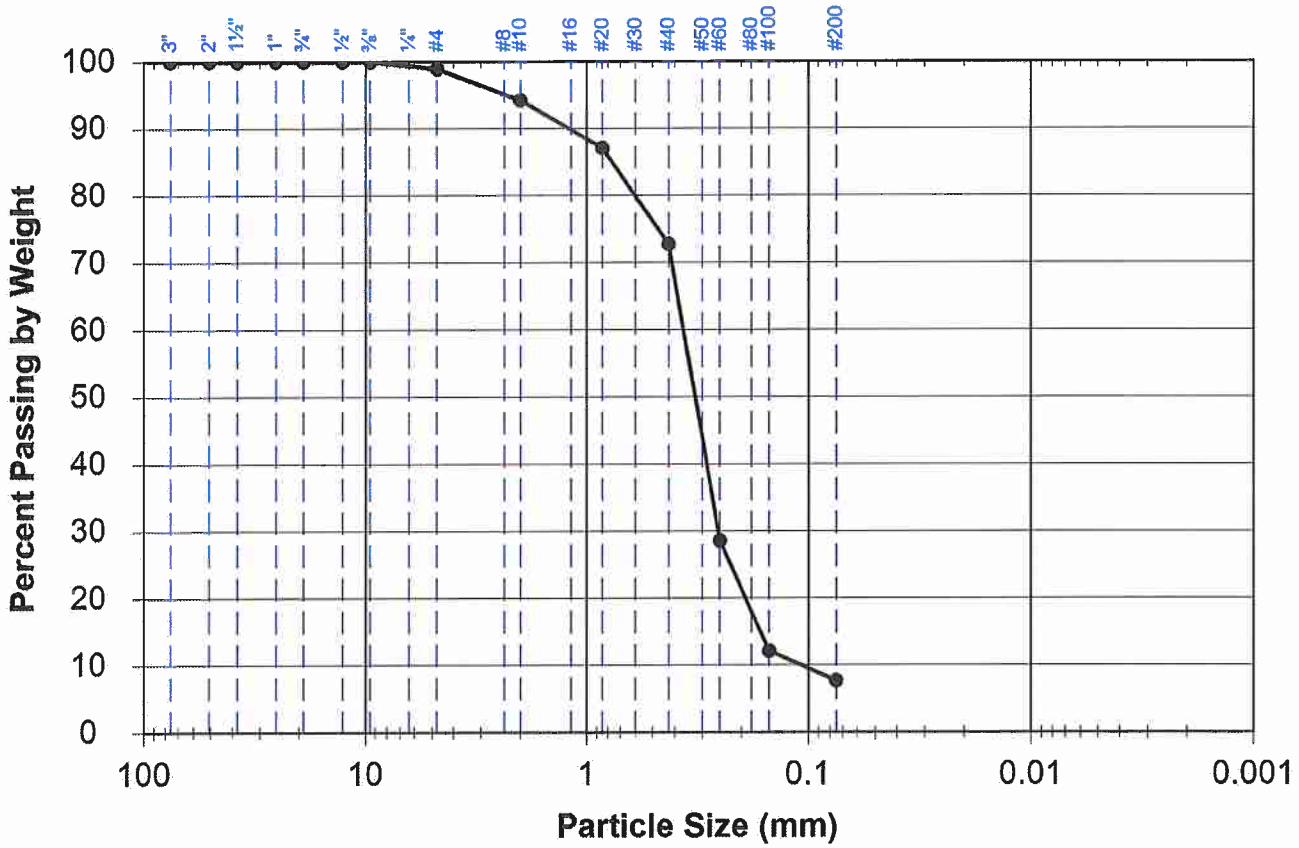
ASTM D422

Location: Test Borehole K15-04
Sample 3
Depth 6'-7.5'

Lab Number	2015-352
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	99%	
Total Weight of Sample 864.1g		
#10	94%	
#20	87%	
#40	73%	
#60	29%	
#100	12%	
#200	7.7%	
Total Weight of Fine Fraction 429.4g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

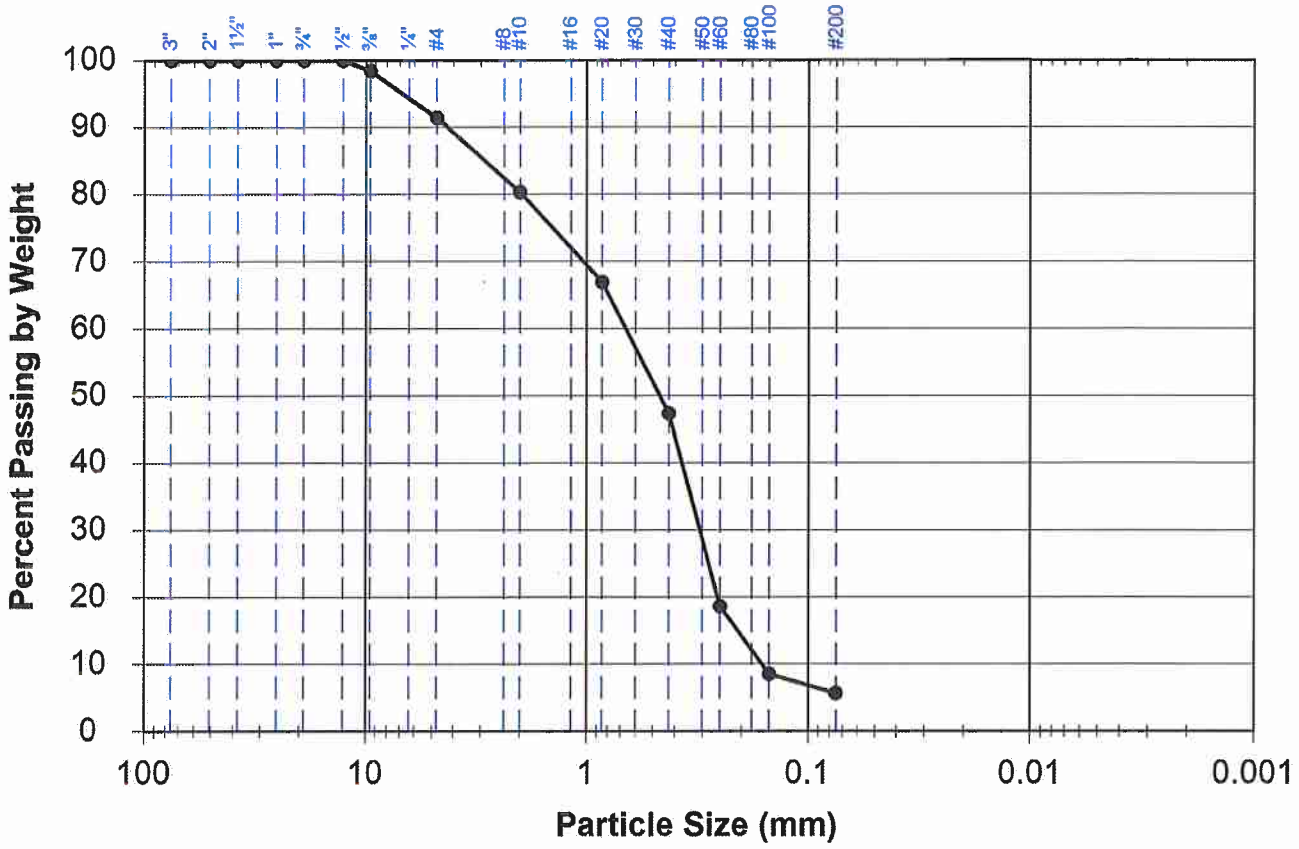
ASTM D422

Location: Test Borehole K15-04
Sample 4
Depth 8.5'-10'

Lab Number	2015-353
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	98%	
#4	91%	
Total Weight of Sample 1148.6g		
#10	80%	
#20	67%	
#40	47%	
#60	19%	
#100	9%	
#200	5.7%	
Total Weight of Fine Fraction 512.9g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

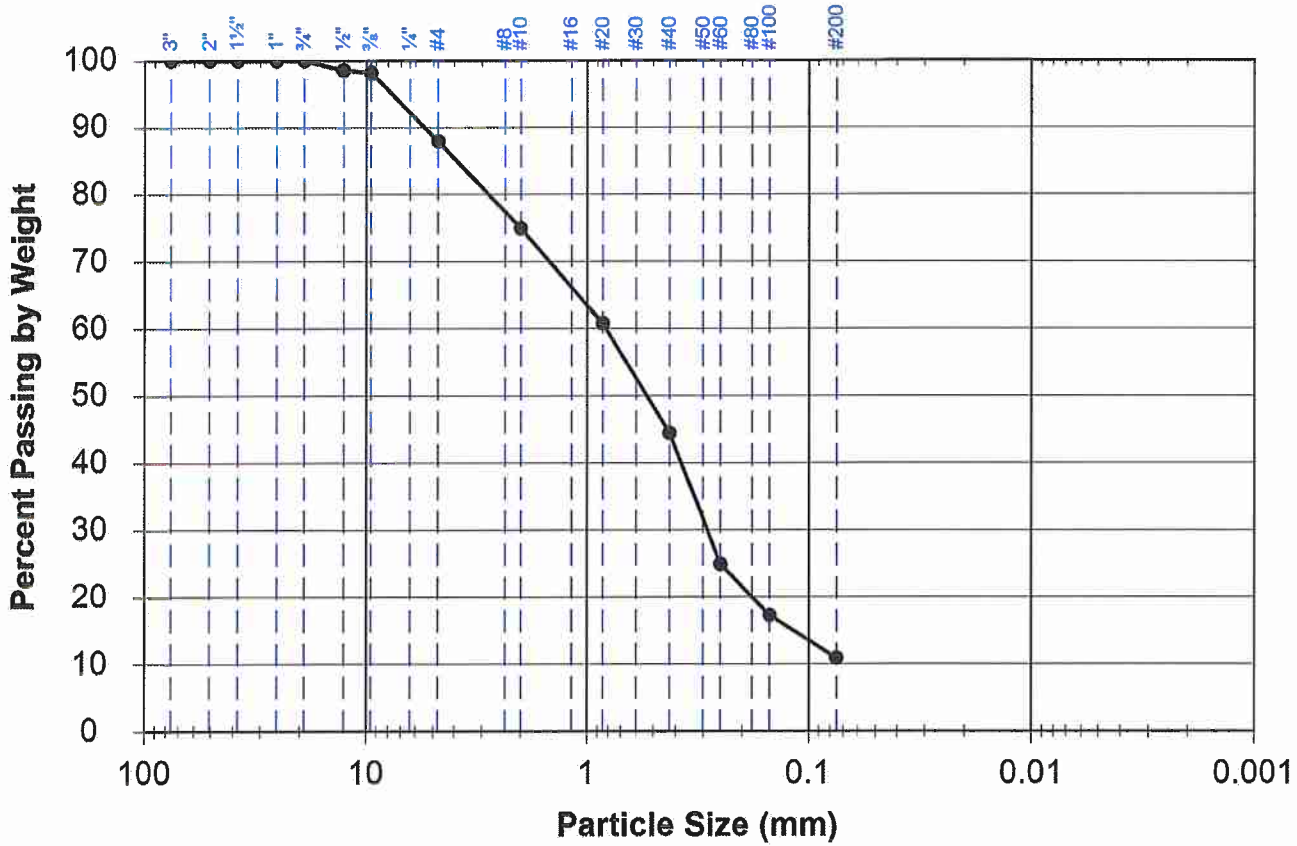
ASTM D422

Location: Test Borehole K15-04
Sample 6
Depth 15'-17'

Lab Number	2015-355
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Well Graded Sand with Silt, SW-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	99%	
⅜"	98%	
#4	88%	
Total Weight of Sample 539.4g		
#10	75%	
#20	61%	
#40	44%	
#60	25%	
#100	17%	
#200	10.9%	
Total Weight of Fine Fraction 473.3g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

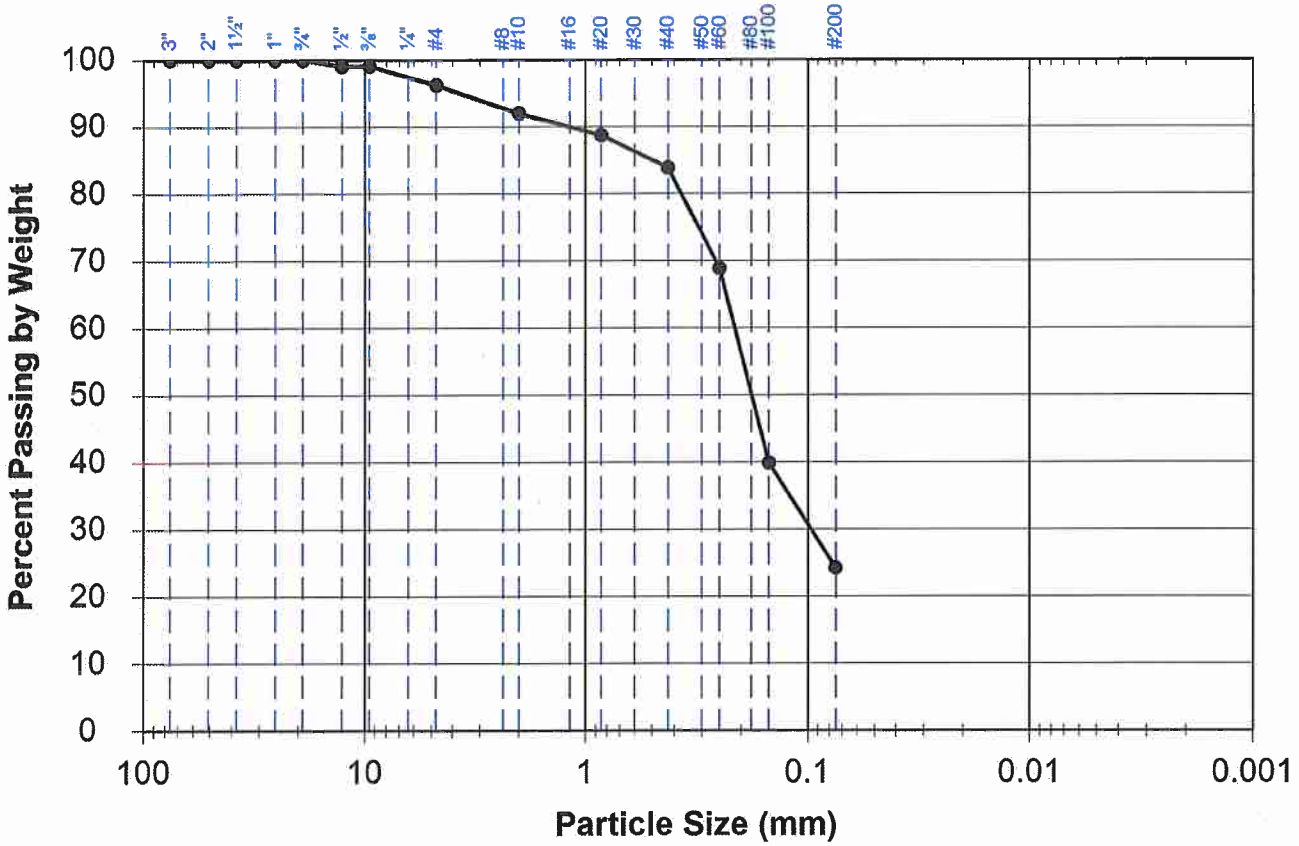
ASTM D422

Location: Test Borehole K15-04
Sample 8
Depth 22.5'-24.5'

Lab Number	2015-357
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	99%	
⅜"	99%	
#4	96%	
Total Weight of Sample 365g		
#10	92%	
#20	89%	
#40	84%	
#60	69%	
#100	40%	
#200	24.3%	
Total Weight of Fine Fraction 351.6g		

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Client: Golder Associates Inc.
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Work Order: A34316

Particle Size Distribution

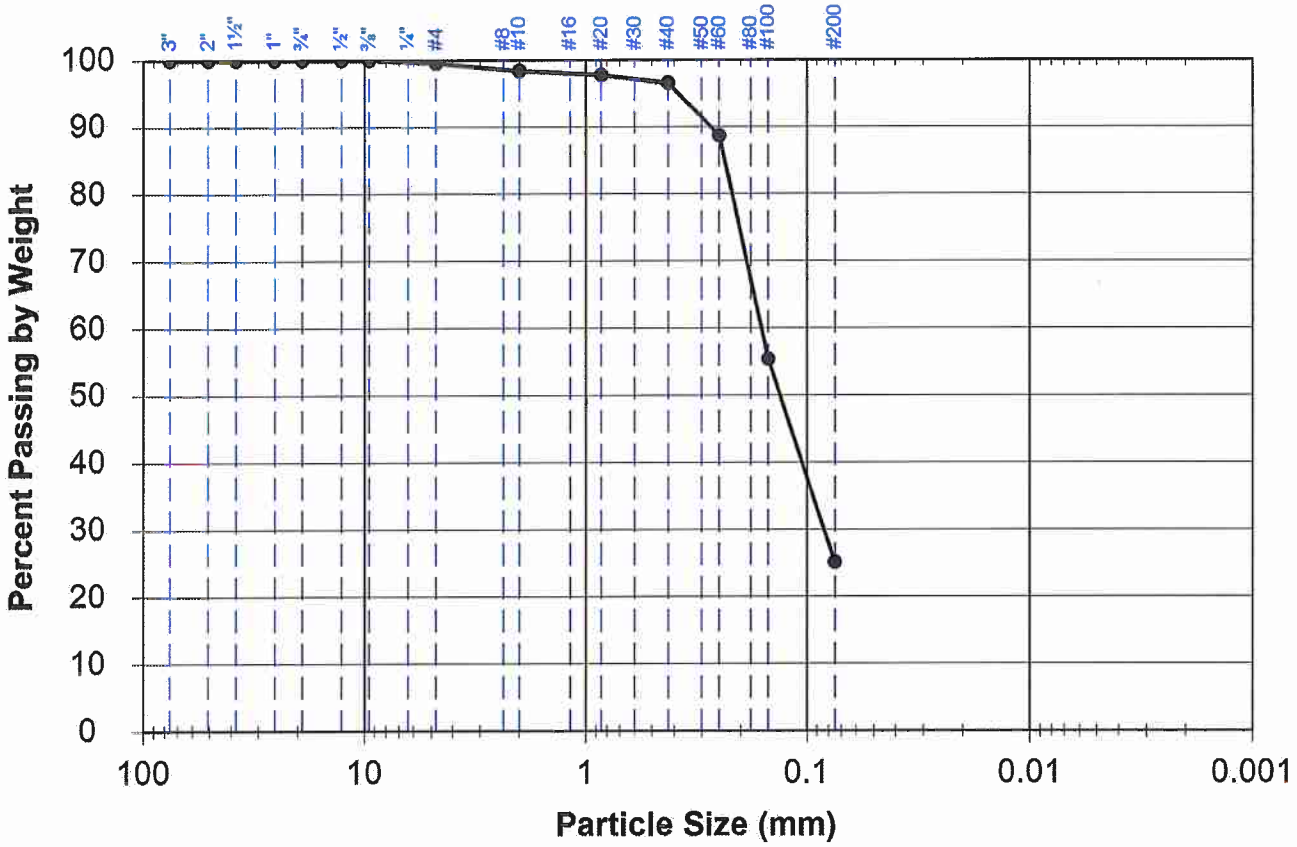
ASTM D422

Location: Test Borehole K15-05
Sample 1
Depth 0'-1.5'

Lab Number	2015-360
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	99%	
Total Weight of Sample 339.9g		
#10	98%	
#20	98%	
#40	97%	
#60	89%	
#100	55%	
#200	25.2%	
Total Weight of Fine Fraction 338.2g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

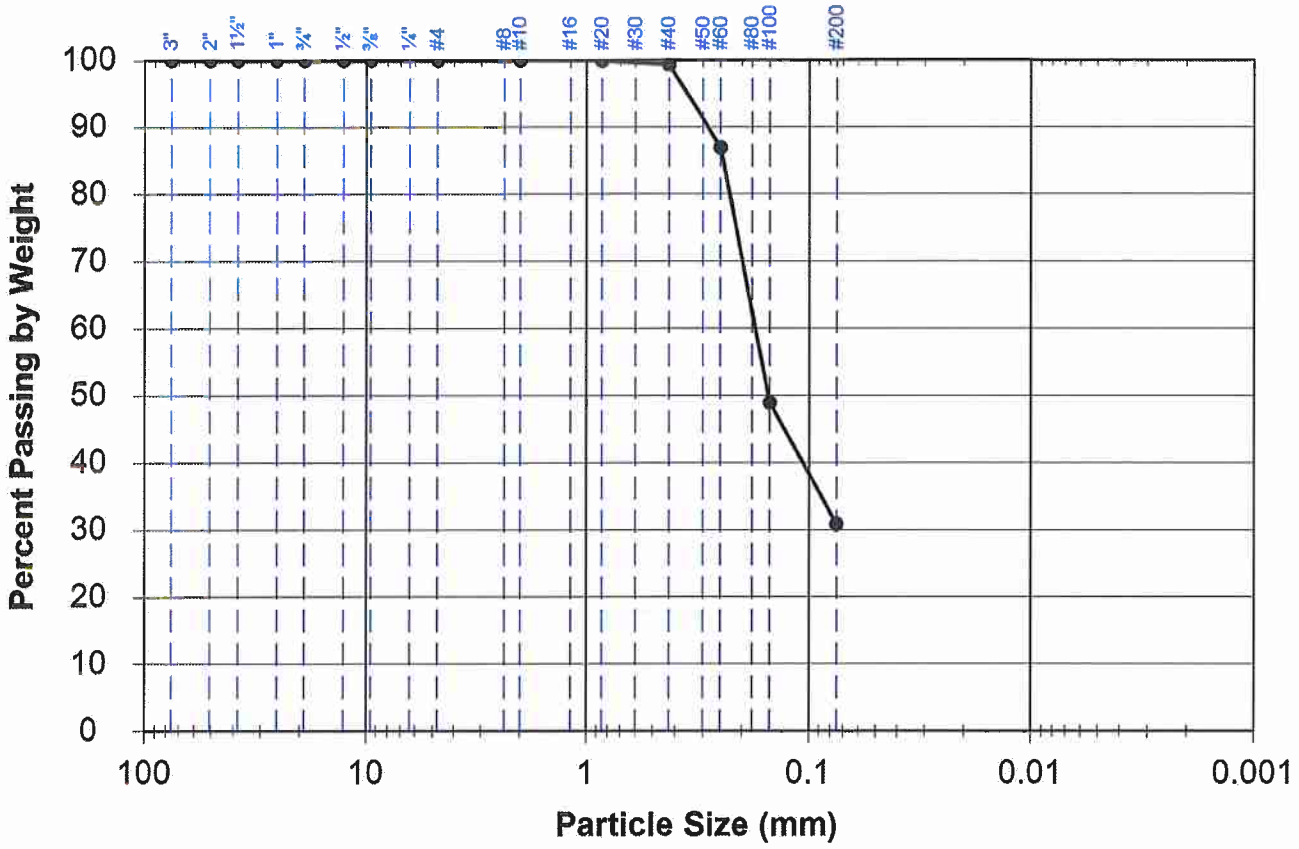
ASTM D422

Location: Test Borehole K15-05
Sample 5
Depth 10'-12'

Lab Number	2015-364
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Sample 378.2g		
#10	100%	
#20	100%	
#40	99%	
#60	87%	
#100	49%	
#200	30.9%	
Total Weight of Fine Fraction 378.2g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

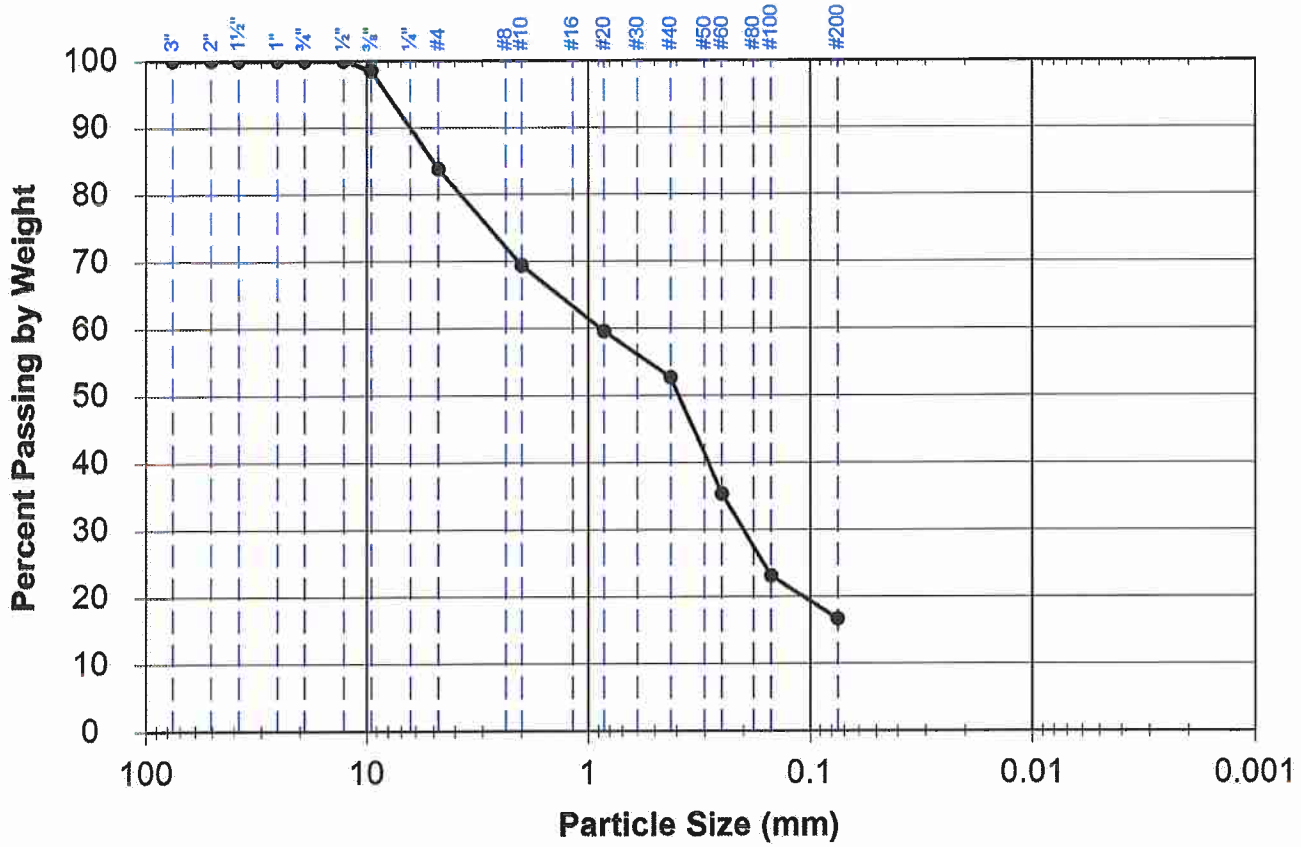
ASTM D422

Location: Test Borehole K15-05
Sample 8
Depth 17.5'-19.5'

Lab Number	2015-367
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand with Gravel, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	99%	
#4	84%	
Total Weight of Sample 394g		
#10	69%	
#20	60%	
#40	53%	
#60	35%	
#100	23%	
#200	16.7%	
Total Weight of Fine Fraction 329.7g		

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Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

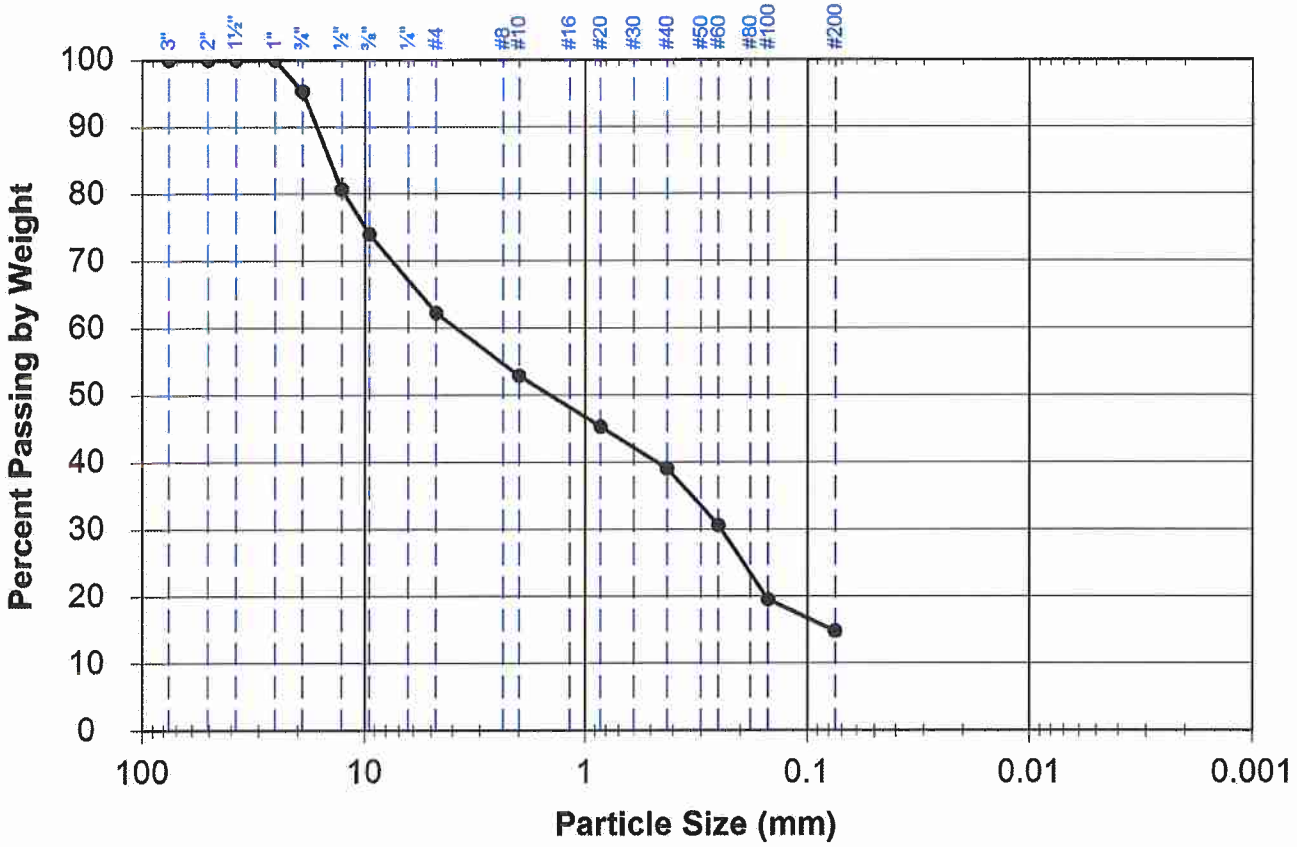
ASTM D422

Location: Test Borehole K15-05
Sample 10
Depth 27.5'-28.1'

Lab Number	2015-369
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand with Gravel, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	95%	
½"	81%	
⅜"	74%	
#4	62%	
Total Weight of Sample 280.2g		
#10	53%	
#20	45%	
#40	39%	
#60	31%	
#100	20%	
#200	14.8%	
Total Weight of Fine Fraction 174.3g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

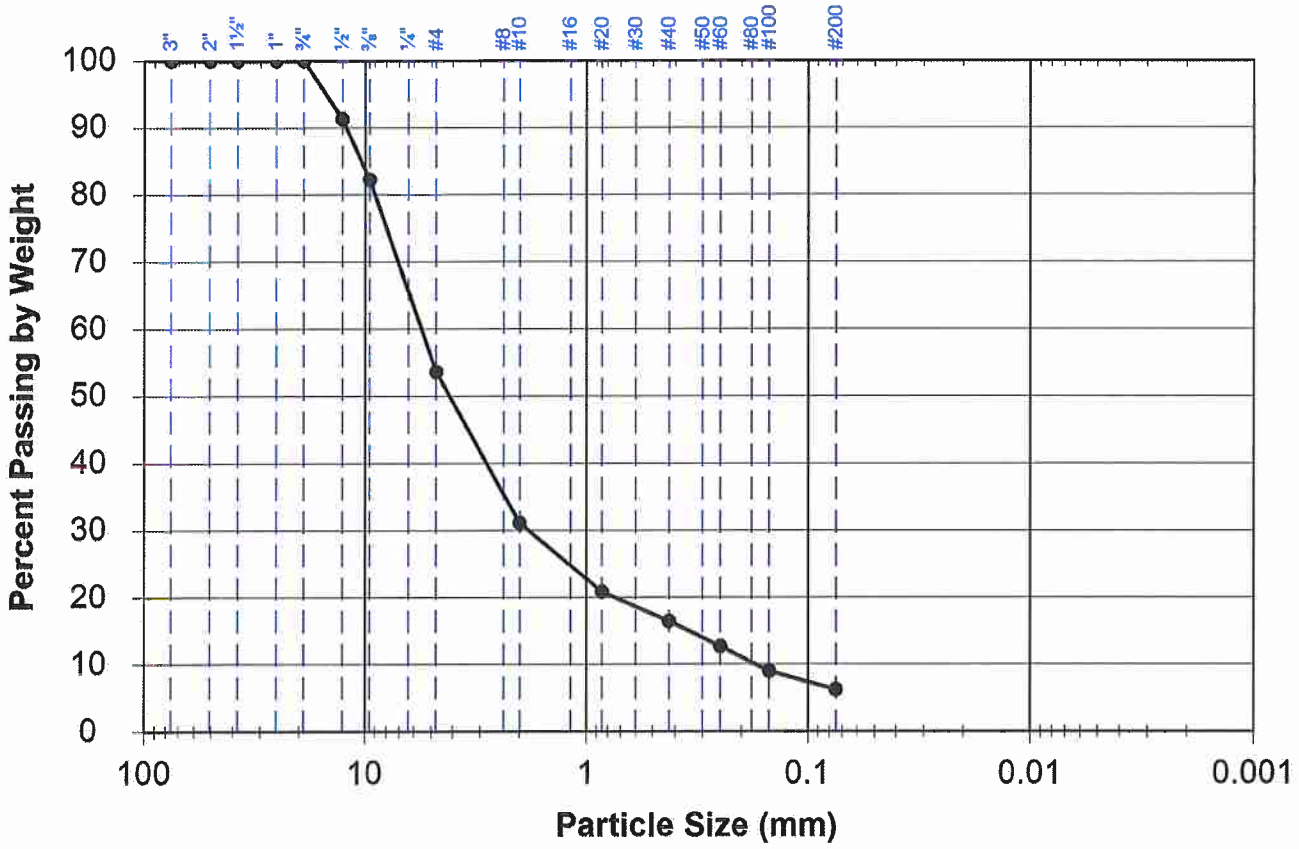
ASTM D422

Location: Test Borehole K15-05
Sample 11
Depth 30'-30.5'

Lab Number	2015-370
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Poorly Graded Sand with Silt and Gravel, SP-SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	91%	
⅜"	82%	
#4	54%	
Total Weight of Sample 253.1g		
#10	31%	
#20	21%	
#40	16%	
#60	13%	
#100	9%	
#200	6.3%	
Total Weight of Fine Fraction 135.6g		

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DOWL HKM

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Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

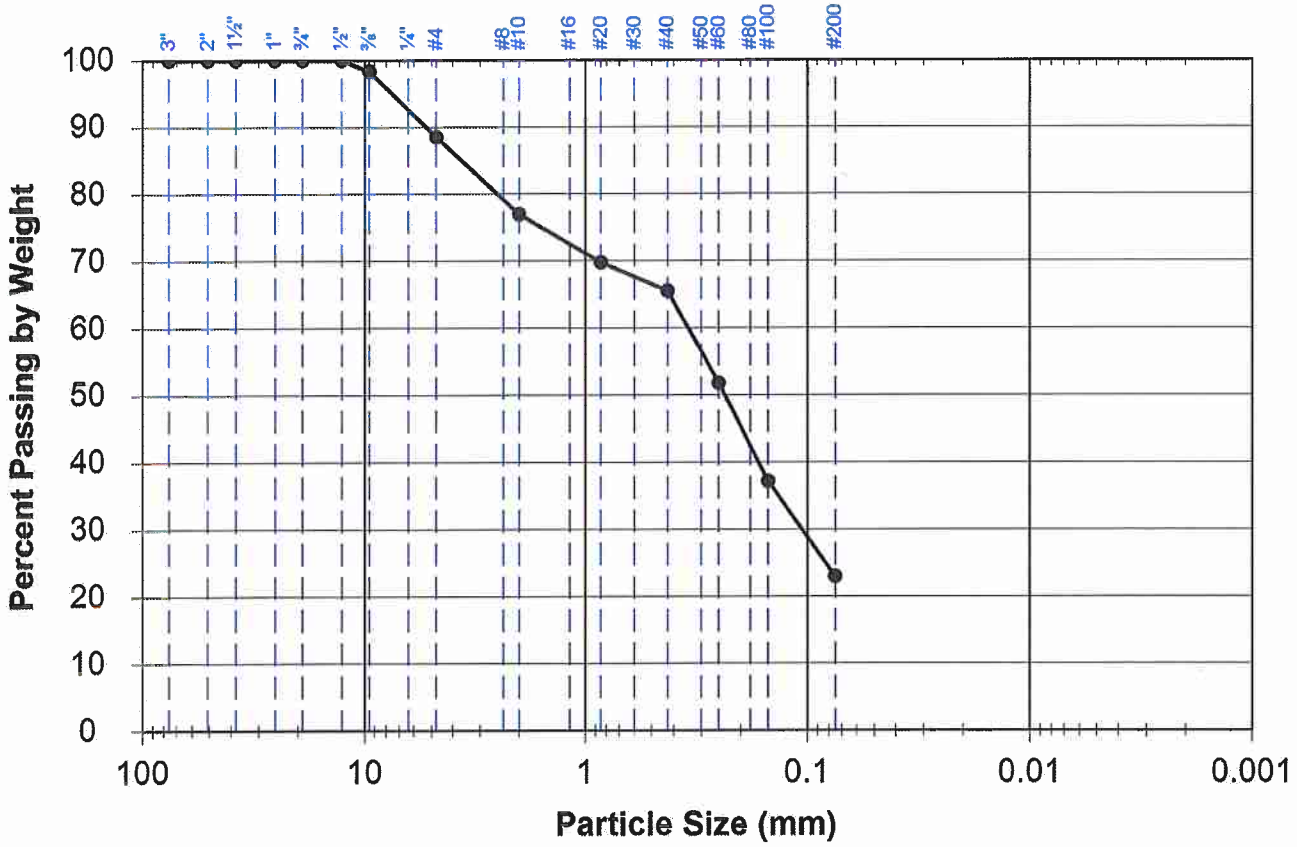
ASTM D422

Location: Test Borehole K15-06
Sample 3
Depth 5'-7'

Lab Number	2015-373
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	98%	
#4	88%	
Total Weight of Sample 404.3g		
#10	77%	
#20	70%	
#40	66%	
#60	52%	
#100	37%	
#200	23.0%	
Total Weight of Fine Fraction 357.8g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

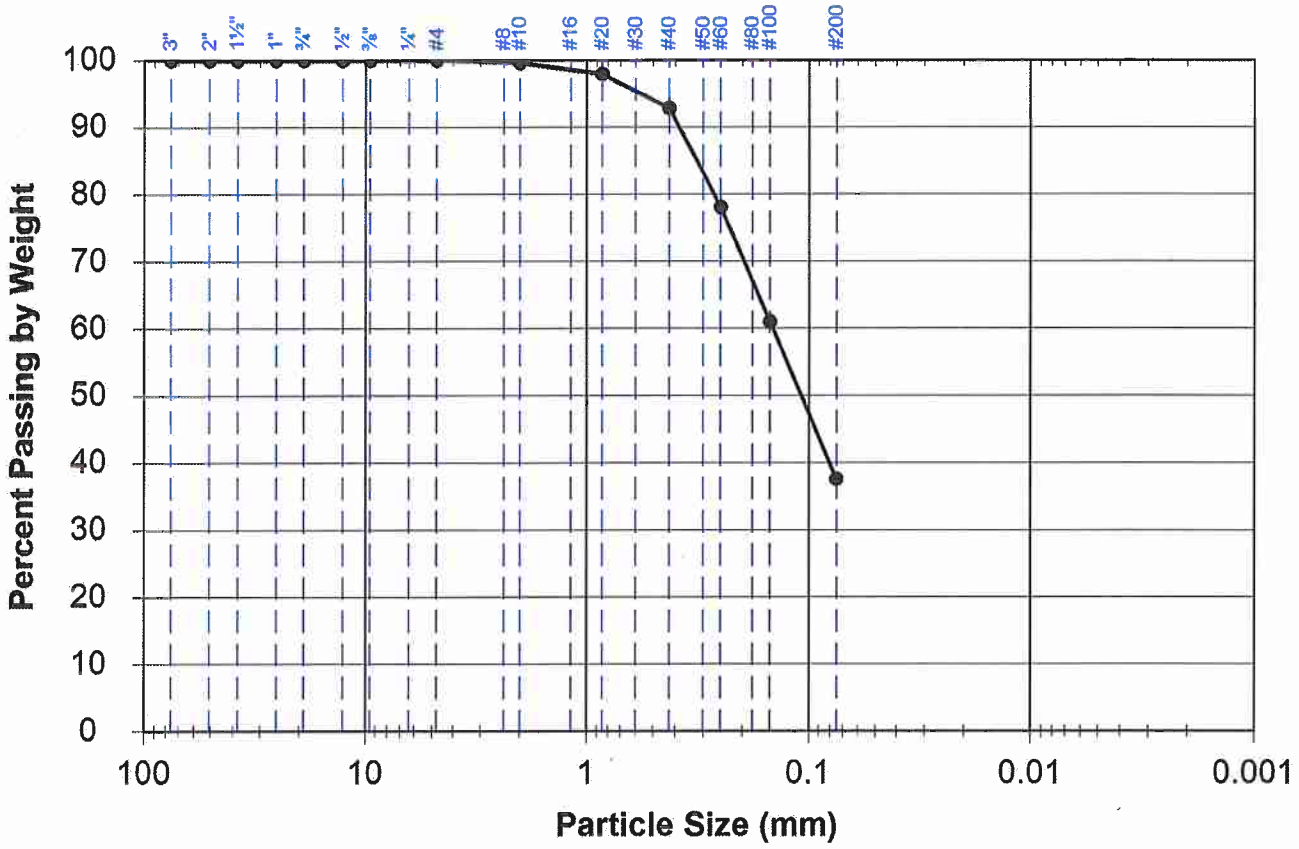
ASTM D422

Location: Test Borehole K15-06
Sample 8
Depth 17.5'-19.5'

Lab Number	2015-378
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	100%	
⅜"	100%	
#4	100%	
Total Weight of Sample 473.6g		
#10	100%	
#20	98%	
#40	93%	
#60	78%	
#100	61%	
#200	37.6%	
Total Weight of Fine Fraction 473.6g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

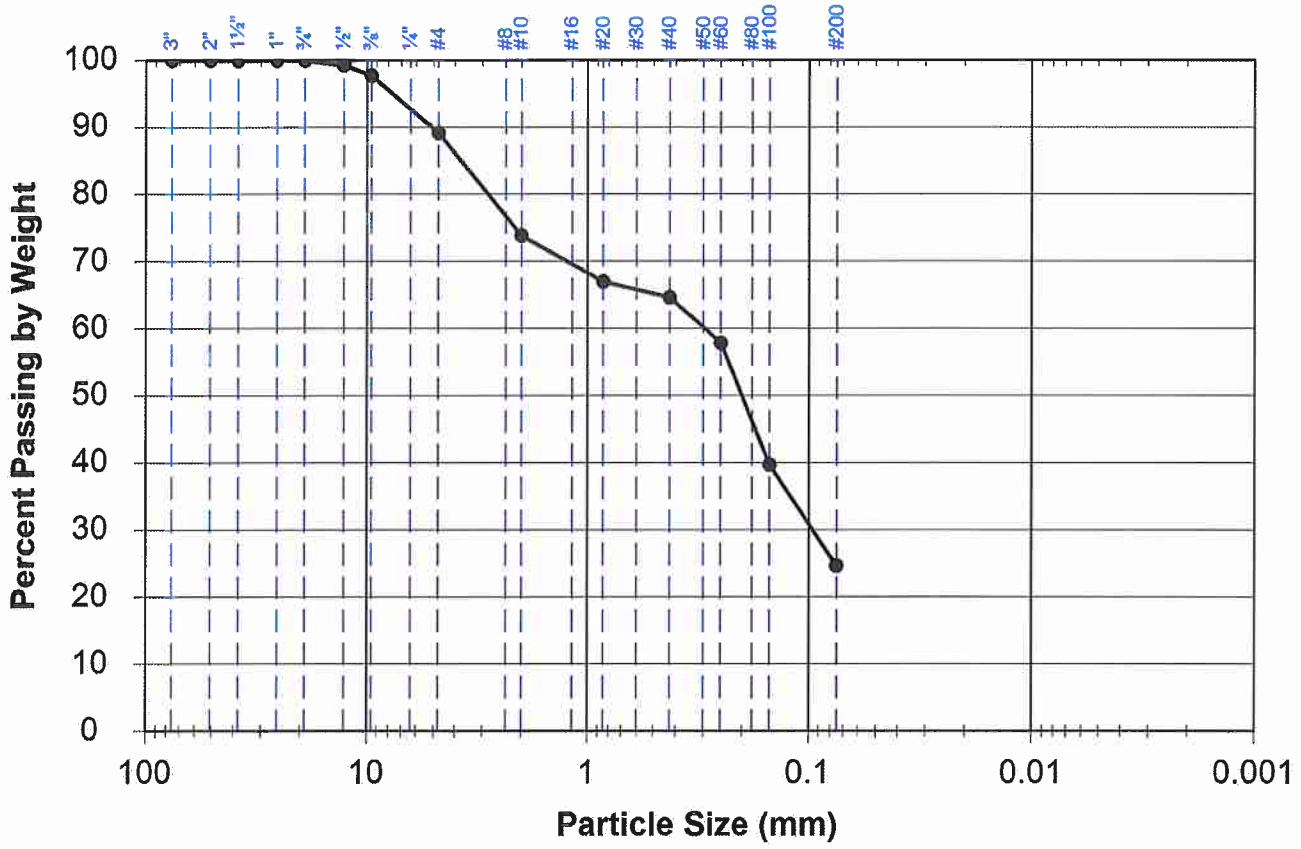
ASTM D422

Location: Test Borehole K15-06
Sample 10
Depth 27.5'-28.3'

Lab Number	2015-380
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Silty Sand, SM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	100%	
½"	99%	
⅜"	98%	
#4	89%	
Total Weight of Sample 380.8g		
#10	74%	
#20	67%	
#40	65%	
#60	58%	
#100	40%	
#200	24.7%	
Total Weight of Fine Fraction 338.9g		

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DOWL HKM

Client: Golder Associates Inc.
Project: USACE Kivalina Causeway
Work Order: A34316

Particle Size Distribution

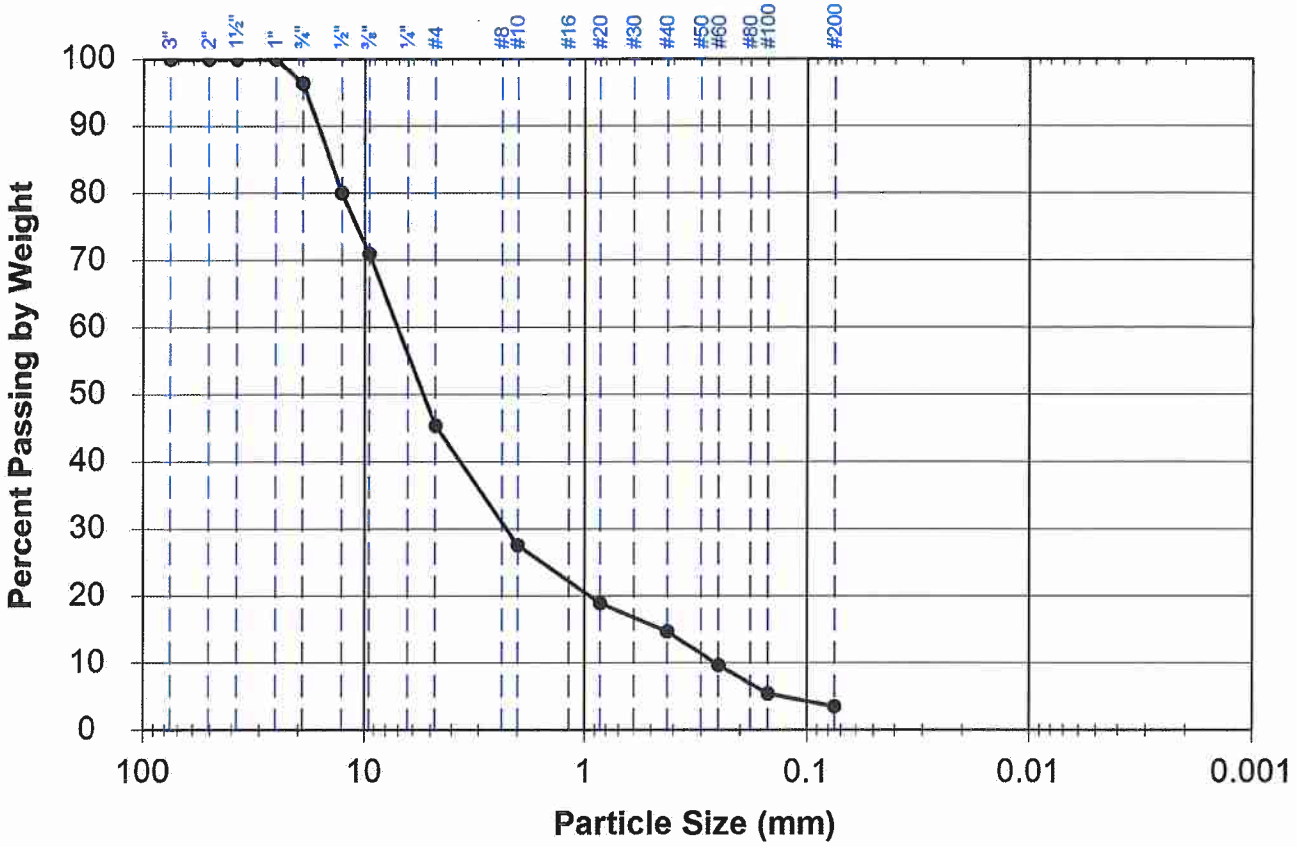
ASTM D422

Location: Test Borehole K15-06
Sample 11
Depth 30'-31'

Lab Number	2015-381
Received	4/6/2015
Reported	4/21/2015

Engineering Classification: **Well Graded Gravel with Sand, GW**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	100%	
¾"	96%	
½"	80%	
⅜"	71%	
#4	45%	
Total Weight of Sample 375.8g		
#10	28%	
#20	19%	
#40	15%	
#60	10%	
#100	5%	
#200	3.5%	
Total Weight of Fine Fraction 170.5g		

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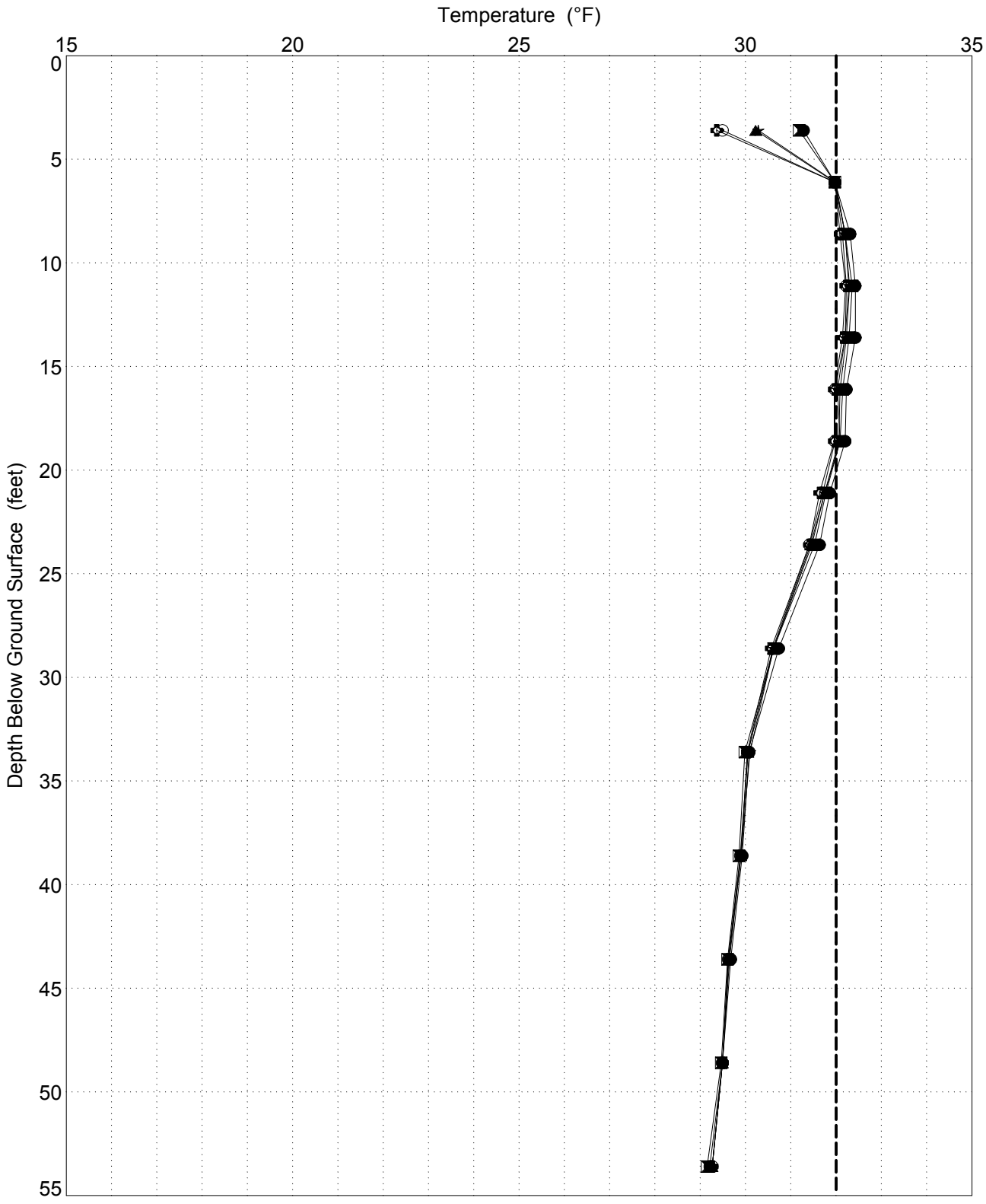
APPENDIX C
GROUND TEMPERATURE DATA



● **K15-01 (AP-39)** 03/23/15
▲ **K15-01 (AP-39)** 04/11/15
⊙ **K15-01 (AP-39)** 04/26/15
⧓ **K15-01 (AP-39)** 03/30/15
★ **K15-01 (AP-39)** 04/14/15
✪ **K15-01 (AP-39)** 05/02/15

CLIENT
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PROJECT
KIVALINA CAUSEWAY

KIVALINA, AK

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-08-06
PREPARED	RLCampbell
DESIGN	N/A
REVIEW	Howard Weston
APPROVED	John Thornley

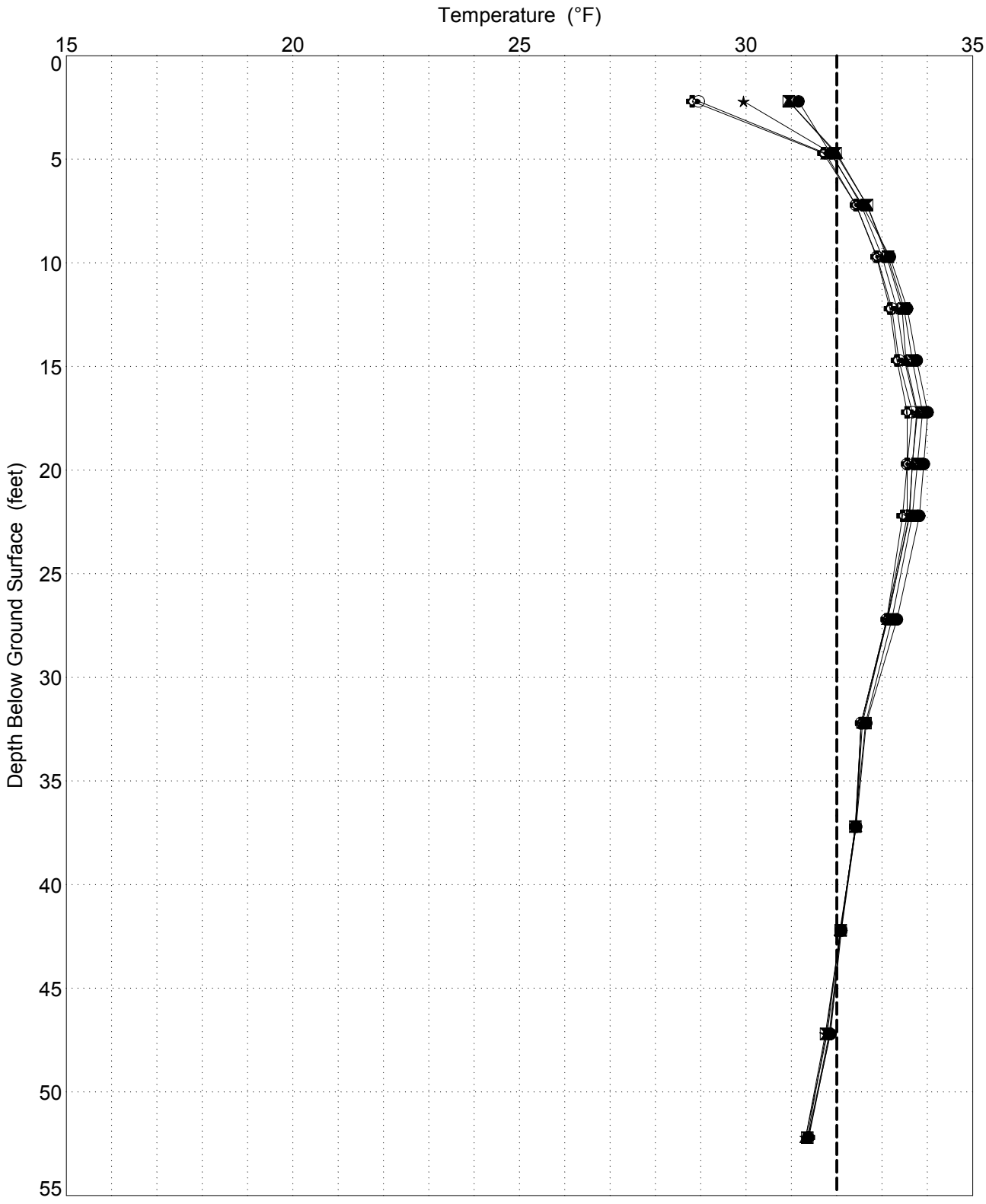
TITLE
MEASURED GROUND TEMPERATURES

PROJECT No.	CONTROL	Rev.	FIGURE
1419207		-----	C-1

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC THERMISTOR] RLCampbell 8/6/15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 1 in.



● **K15-02 (AP-40)** 03/23/15
▲ **K15-02 (AP-40)** 04/11/15
⊙ **K15-02 (AP-40)** 04/26/15
⧓ **K15-02 (AP-40)** 03/30/15
★ **K15-02 (AP-40)** 04/14/15
✪ **K15-02 (AP-40)** 05/02/15

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Golder Associates

YYYY-MM-DD	2015-08-06
PREPARED	RLCampbell
DESIGN	N/A
REVIEW	Howard Weston
APPROVED	John Thornley

PROJECT
KIVALINA CAUSEWAY

KIVALINA, AK

TITLE
MEASURED GROUND TEMPERATURES

PROJECT No.	CONTROL	Rev.	FIGURE
1419207		-----	C-2

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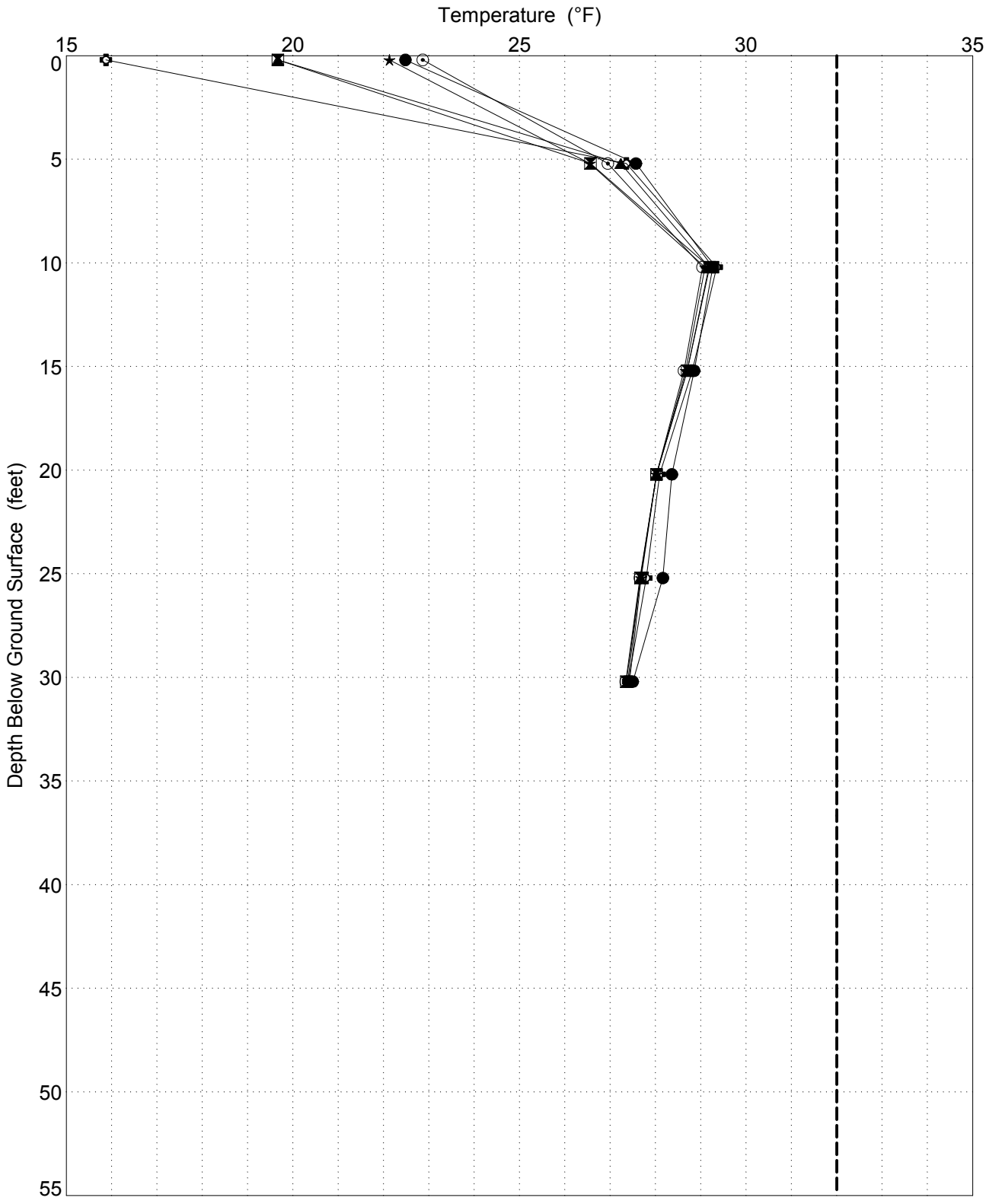

- ● **K15-06 (AP-44)** 03/23/15
- ▲ **K15-06 (AP-44)** 04/14/15
- ⊙ **K15-06 (AP-44)** 05/03/15
- ⧓ **K15-06 (AP-44)** 04/12/15
- ★ **K15-06 (AP-44)** 04/26/15
- ✿ **K15-06 (AP-44)** 03/30/15

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PROJECT
KIVALINA CAUSEWAY

KIVALINA, AK

CONSULTANT
Golder Associates

YYYY-MM-DD	2015-08-06
PREPARED	RLCampbell
DESIGN	N/A
REVIEW	Howard Weston
APPROVED	John Thornley

TITLE
MEASURED GROUND TEMPERATURES

PROJECT No.	CONTROL	Rev.	FIGURE
1419207		----	C-3

KIVALINA LOGS.GPJ LIBRARY-ANC(7-15-15).GLB [ANC THERMISTOR] RLCampbell 8/6/15

IF THIS MEASUREMENT DOES NOT MATCH WHAT IS SHOWN, THE SHEET SIZE HAS BEEN MODIFIED FROM: ANSI A

0 1 in.

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Golder Associates

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