DOWL HKM

MEMORANDUM

TO: Mr. Mark Kozak
Public Works Director
City of Kodiak

W.O. 59822

FROM: Howard K. Weston, P.E.
Manager, Geotechnical Engineering

THROUGH: Aaron R. Christie, P.E.
Civil Engineer

DATE: June 12, 2012

SUBJECT: Downtown Water, Sewer, and Storm Drain Master Plan
Test Boring Investigation

INTRODUCTION

Nine 15-foot-deep test borings were drilled in Center Street, Marine Way, Mission Road and Kashevarof Avenue on December 2, 4, and 5, 2011. The purpose of these borings was to determine the approximate depth to bedrock in support of the Downtown Water, Sewer, and Storm Drain Master Plan project.

Test borings were located in the field by taking swing tie measurements from existing features. The locations of the test borings are shown on the attached Figure A, Test Boring Location Map.

The test borings were drilled with a Mobile B-61 truck-mounted drill rig fitted with continuous flight, 8-inch diameter, hollow-stem auger. The rig is owned and operated by Denali Drilling, Inc., of Anchorage. The drilling was supervised and the samples logged by a civil engineer with our firm.

Disturbed samples were obtained at 2.5-foot intervals to a depth of 10 feet and one sample at a depth of 15 feet. The penetration test is performed by driving a 2.5-inch inside-diameter, split-spoon sampler a distance of 18 inches ahead of the auger with a 340-pound hammer falling 30 inches. The penetration resistance value shown on the test boring logs indicates the number of blows required to drive the sampler the last 12 inches. The values shown in the logs are raw data from the field and have not been adjusted for sampling equipment type or overburden pressure.

As the soil samples were recovered, they were visually classified and sealed in plastic bags to preserve the natural water content. The samples were then transported to DOWL HKM's laboratory in accordance with ASTM D4220, for further testing.

FINDINGS

The depth to bedrock was difficult to determine while drilling the test borings. The bedrock is overlain with fill composed of gravel that looks the same as the samples taken in the weathered rock. Much of the rock could be drilled with the hollow stem auger and the weathered rock broke up during sampling to a sand and gravel. The test boring logs, attached as Figures 1 through 9, show our interpretation of the soil and rock. The depth to bedrock was estimated based on drill action, sample blow counts, observation of the recovered sample, correlation with bedrock outcrops, and previous excavations by Public Works. The results of particle size distribution tests performed on selected samples follow the boring logs.

The bedrock in the study area is nearly vertically bedded and rock quality can change from soft, easily excavated rock to hard, unrippable rock in short horizontal distances. The surface of the bedrock is very irregular, so the depth to bedrock can also vary dramatically across short distances. This area of Kodiak has been extensively reworked over the years and some borings may have hit old utility excavations made into the rock and the rock surface could be much shallower a short distance away.

Test Boring 3 encountered a void between 8 and 10 feet below existing grade. It is assumed that this was an abandoned storm drain because the sampler suddenly encountered resistance at a depth of 8 feet and after 35 blows, broke through the obstruction and dropped two feet. The auger was retracted from the 7.5-foot depth and the rig moved about 3 feet away and the boring continued as Test Boring 4. The bedrock surface was interpreted to be at a depth of 14 feet in Test Boring 4. This is deeper than expected and may not be accurate.

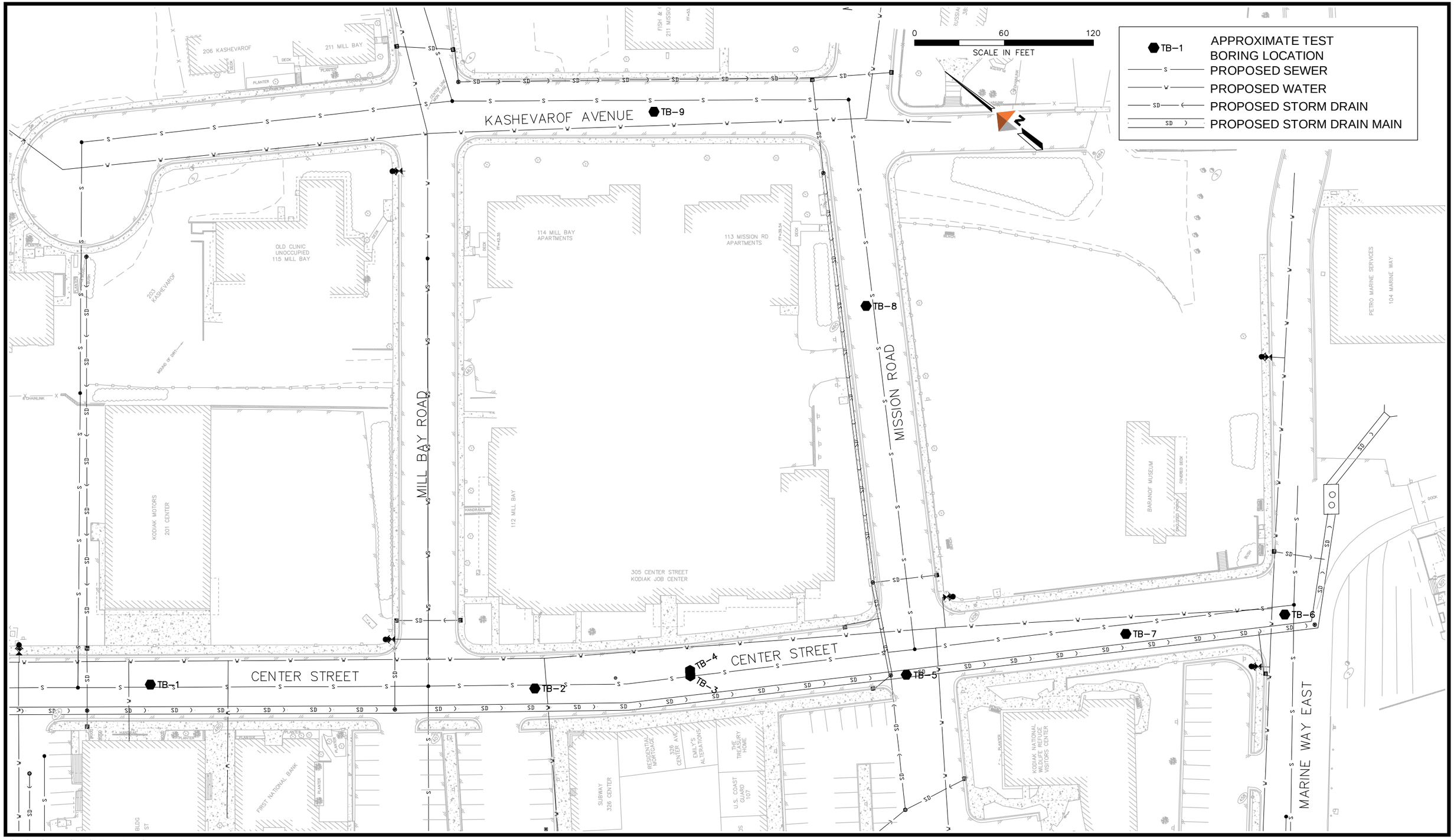
Test Boring 5 encountered bedrock at a depth of about 15 feet. This is deeper than anticipated. The adjacent Kodiak National Wildlife Visitor Center building on the southeast corner of Center Street and Mission Road is founded on shallow bedrock and bedrock outcrops can be observed in the cut on the Marine Way side of the Wildlife Visitor Center and the Baranof Museum lot. Test Boring 6 in Marine Way encountered bedrock at a depth of about 13 feet. Although this boring location is near the bedrock outcrops, this boring is believed to accurately depict a steeply dipping bedrock surface.

No environmental testing or monitoring was conducted as a part of this investigation. However, a hydrocarbon odor and sheen was noticed in Test Boring 4 below a depth of about 10 feet.

ENGINEERING ANALYSIS AND RECOMMENDATIONS

The bedrock penetrated with the hollow stem auger can be excavated with considerably more effort than required to excavate dense gravel. There are likely to be near vertical layers within the bedrock formation that cannot be excavated without the use of a large hydraulic hammer to fracture the rock. Blasting is not desirable considering the close proximity of utilities and structures. Should blasting be required, it should be performed in conformance with the City of Kodiak Standard Construction Specifications.

The construction contractor should expect a large backhoe equipped with a rock bucket and a large hydraulic hammer will be required for any rock excavation.



P:\Projects\D59822\GEO\GEO-KODIAK.dwg 2012-2-13

SCALE: AS SHOWN

DOWL HKM

Test Boring Location Map
DOWNTOWN WATER, SEWER, AND
STORM DRAIN MASTER PLAN
Kodiak, Alaska

FIGURE A

TEST BORING 1

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Graph	Soil Class	Frost Depth	Frost Class	DEPTH	
									0	**8.5" ASPHALT PAVEMENT SURFACE** (3 layers)
									0.7	
	4		1					F1		**FILL**, **POORLY GRADED GRAVEL WITH SILT AND SAND**, gray, about 35-40% sand, 10% silt, gravel angular to subangular to 2", medium sand, damp, dense to very dense
MA	2	39	2			GP GM				
	3	66/5"	3					NFS	5	**WEATHERED SHALE** classifies as **POORLY GRADED GRAVEL**, gray, about 10-15% sand, 0-5% silt, gravel subangular to 2", medium sand, damp, very dense
	2	58/3"	4							
MA	5	67/5"	5			BR			10	Hard Drilling below 12'
		50/1"	6						15	
									15.1	TD=15.1'
									20	

DEPTH (FEET)

TEST BORING COMPLETED ON 12-2-11
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊤ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-2-11
W.O. 1124.59822.01

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

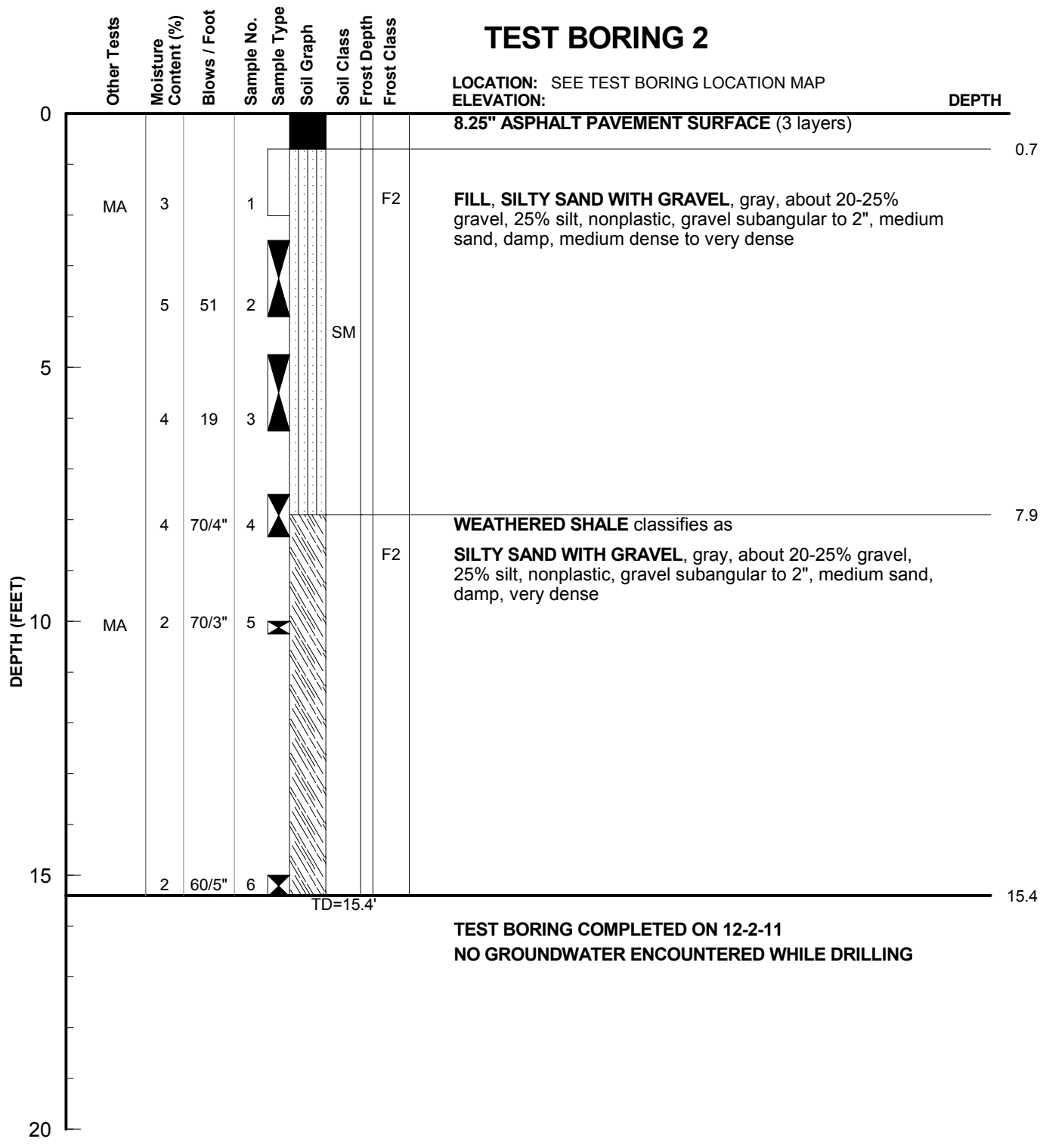
DOWL HKM

LOG OF TEST BORING 1

FIGURE 1

TEST BORING 2

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊤ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-2-11
W.O. 1124.59822.01

DOWL HKM

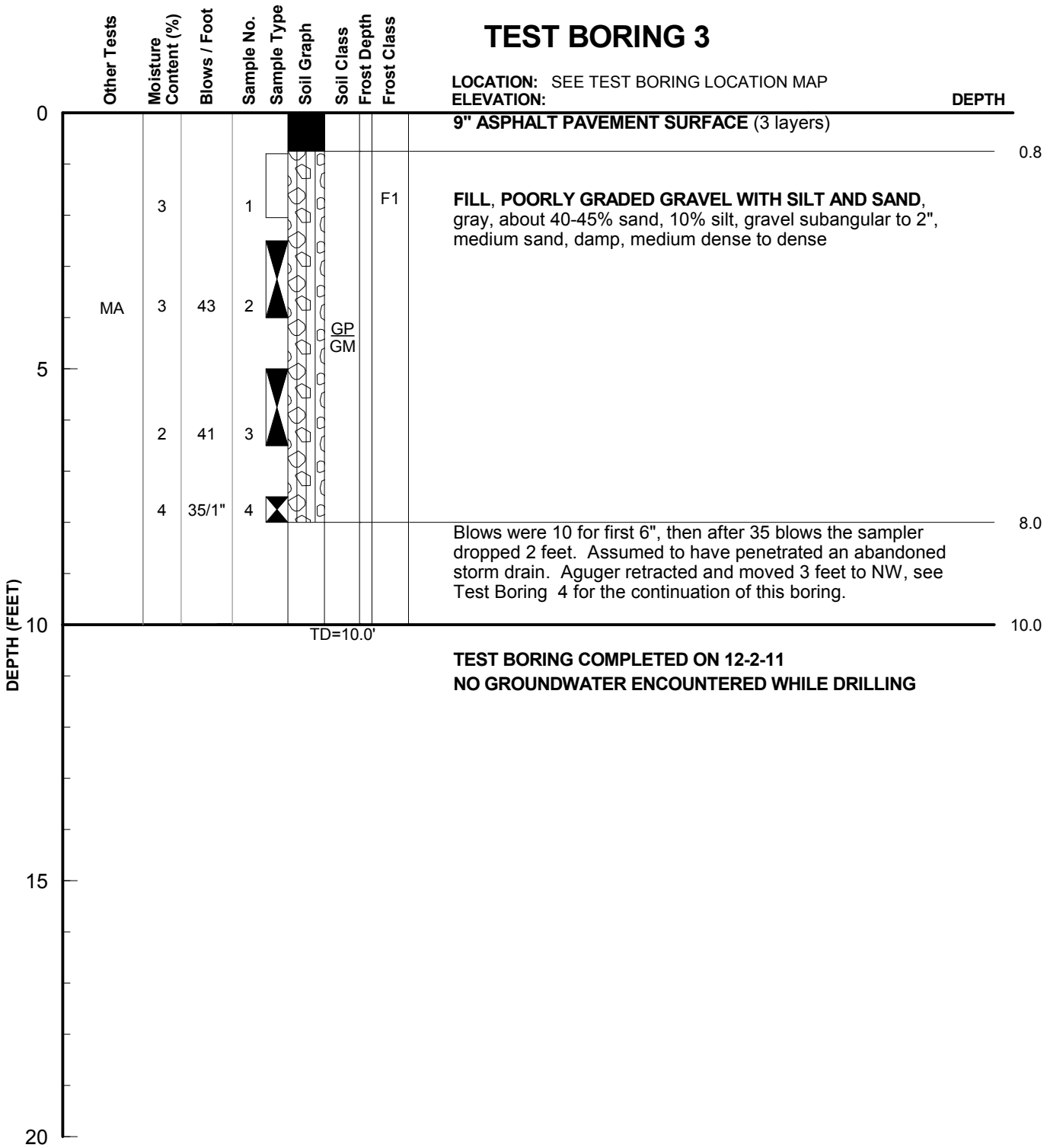
LOG OF TEST BORING 2

FIGURE 2

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

TEST BORING 3

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊡ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-2-11
W.O. 1124.59822.01

DOWL HKM

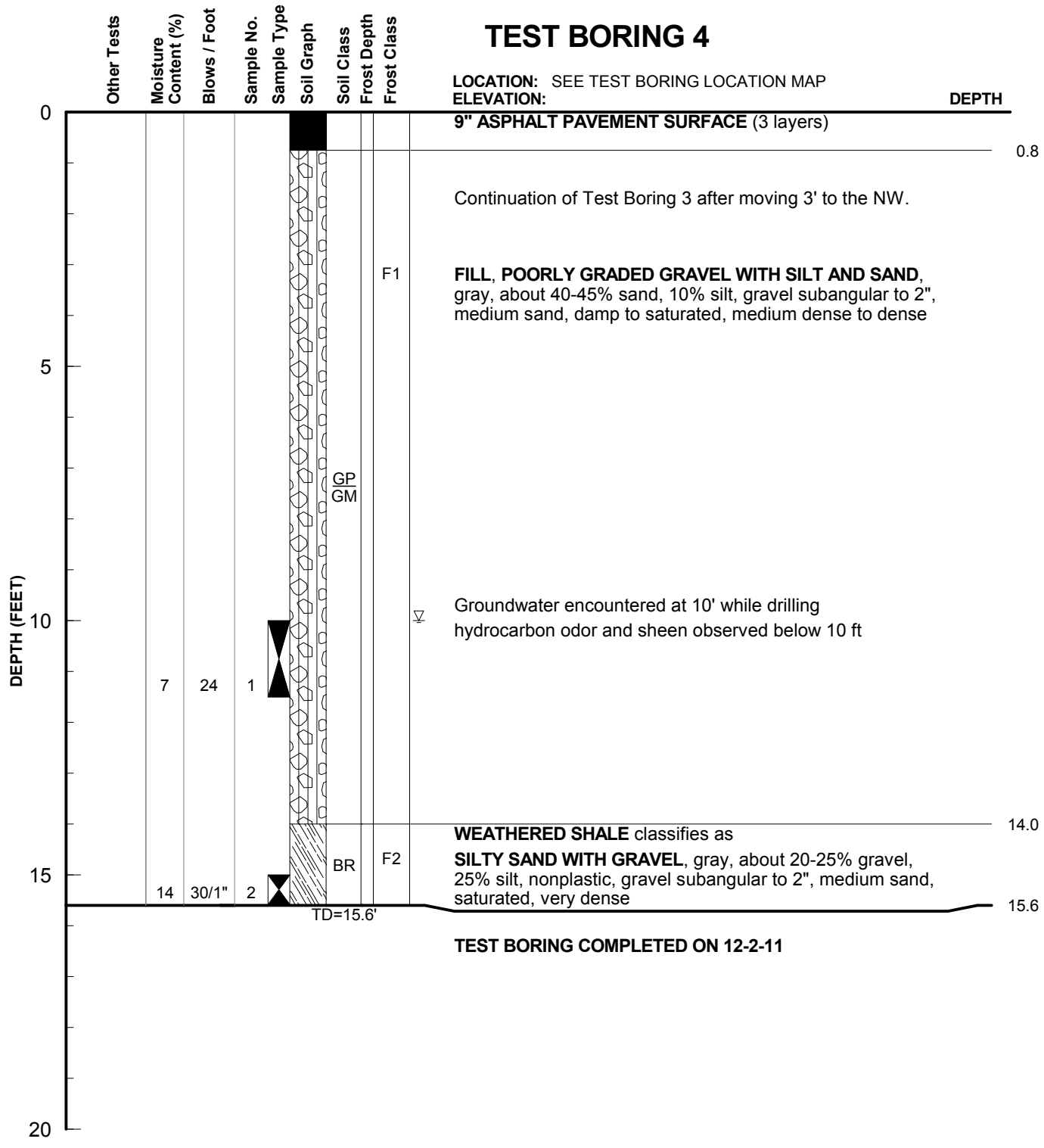
LOG OF TEST BORING 3

FIGURE 3

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

TEST BORING 4

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



KEY
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊤ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-2-11
W.O. 1124.59822.01

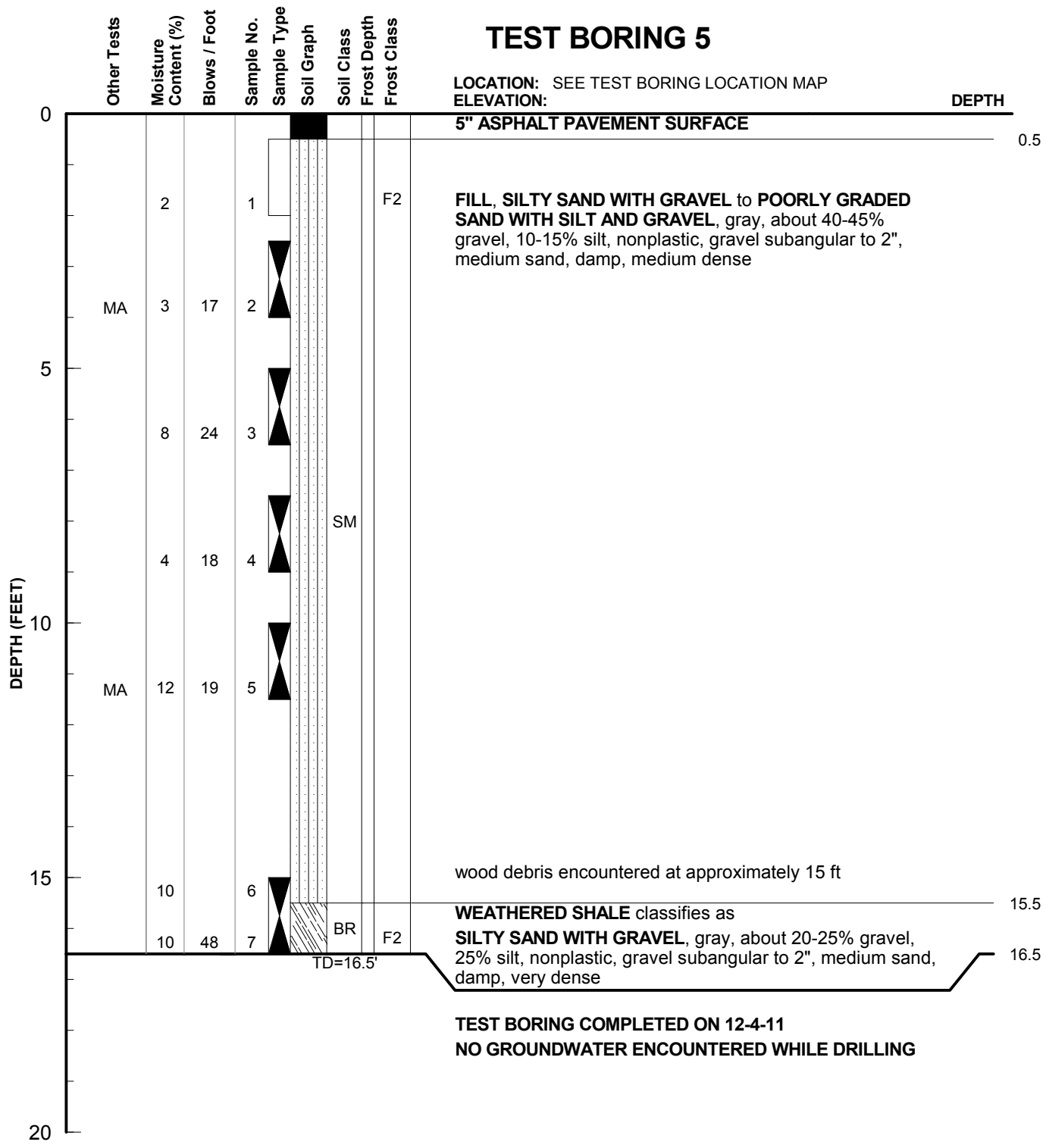
LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

DOWL HKM

LOG OF TEST BORING 4

FIGURE 4

TEST BORING 5



KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊡ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-4-11
W.O. 1124.59822.01

DOWL HKM

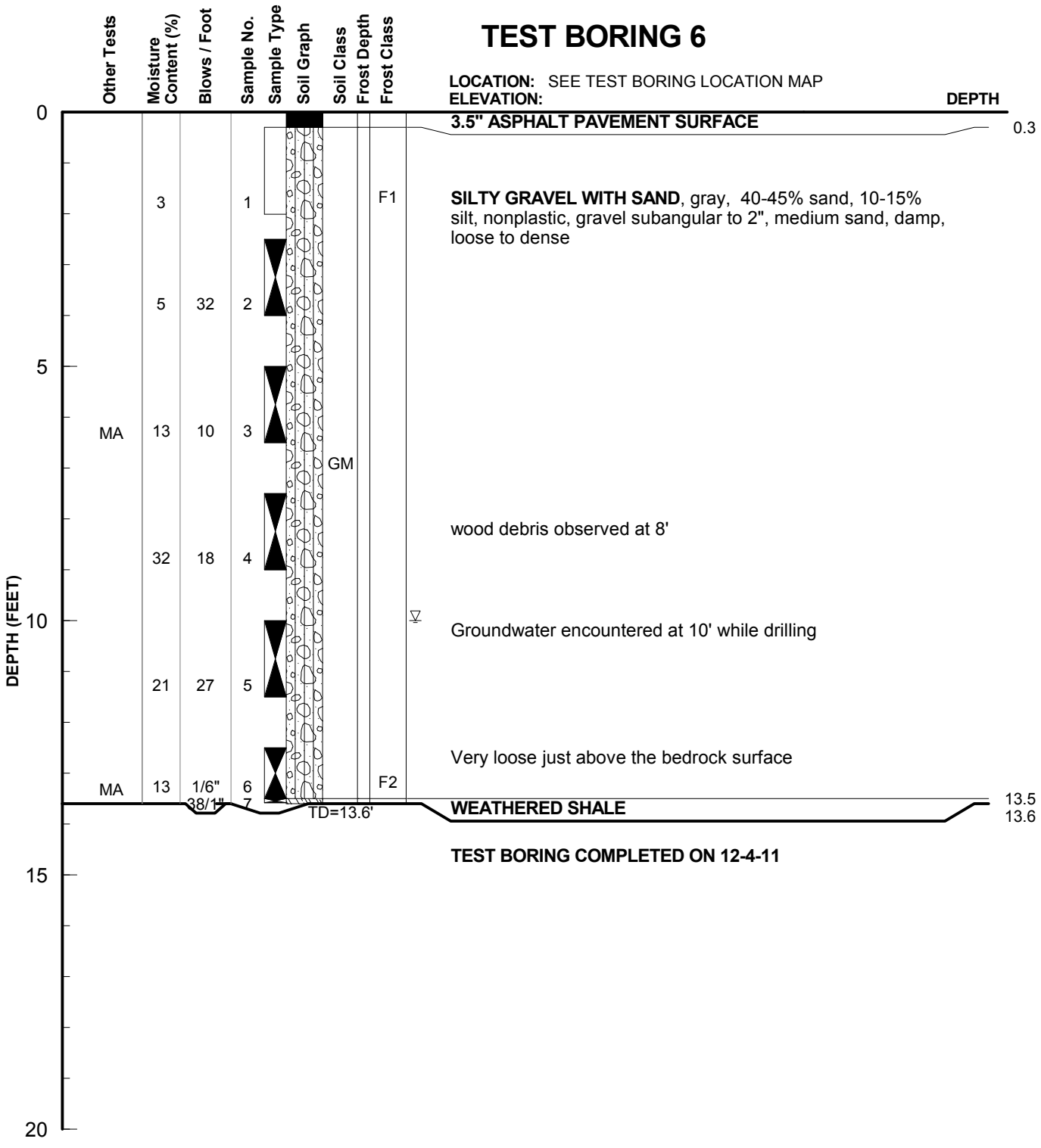
LOG OF TEST BORING 5

FIGURE 5

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

TEST BORING 6

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊤ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-4-11
W.O. 1124.59822.01

DOWL HKM

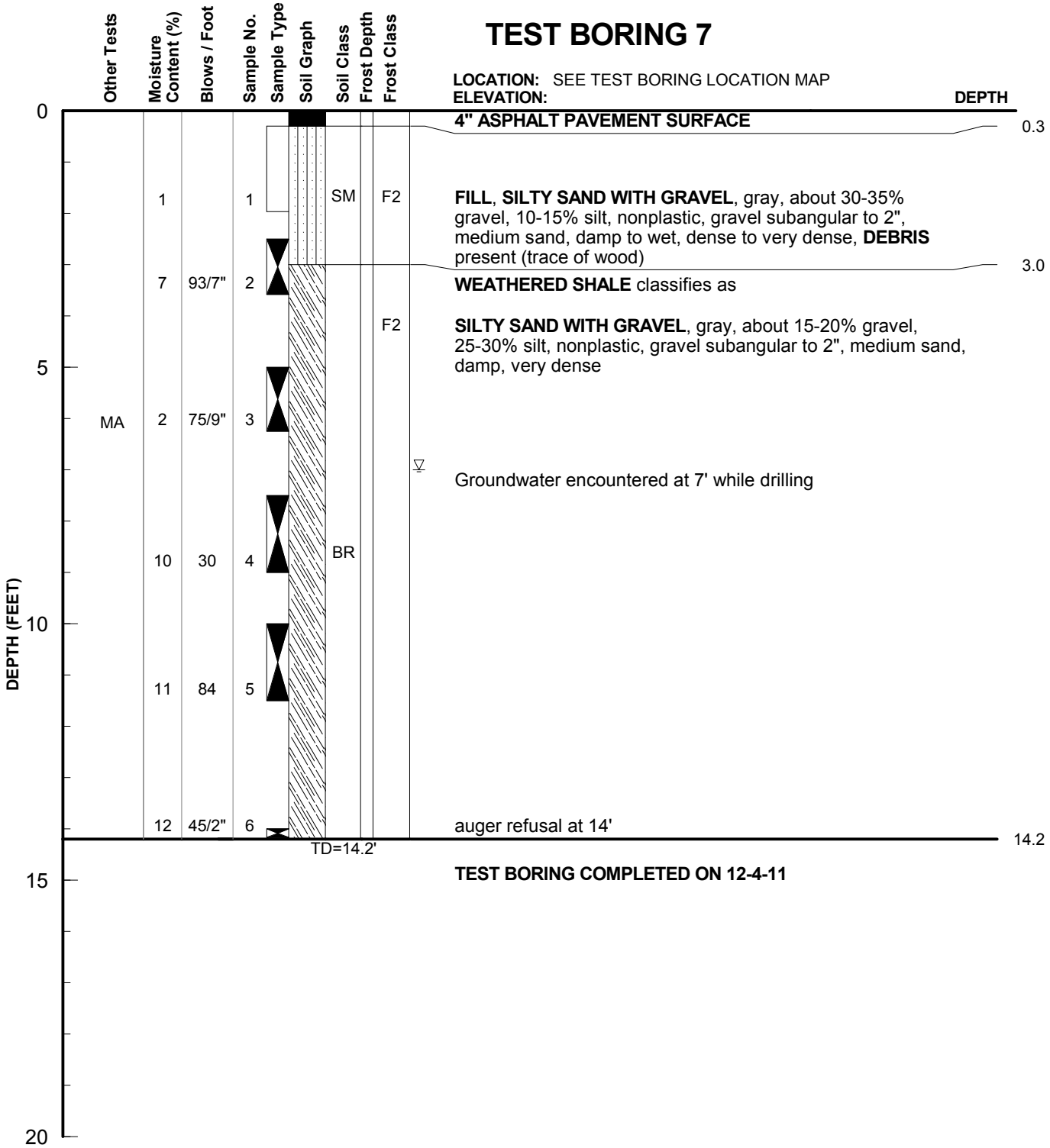
LOG OF TEST BORING 6

FIGURE 6

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

TEST BORING 7

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊤ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-4-11
W.O. 1124.59822.01

DOWL HKM

LOG OF TEST BORING 7

FIGURE 7

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

TEST BORING 8

Other Tests	Moisture Content (%)	Blows / Foot	Sample No.	Sample Type	Soil Graph	Soil Class	Frost Depth	Frost Class
	2		1					F1
MA	5	24	2			GM		
	3	61	3					F2
MA	5	61	4					
	2	71/10"	5			BR		
	5	55/5"	6					

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:

DEPTH (FEET)

0 — **6" ASPHALT PAVEMENT SURFACE** — 0.5

FILL, **SILTY GRAVEL WITH SAND**, gray, about 40% sand, 10-15% silt, nonplastic, gravel subangular to 2", medium sand, damp, medium dense

5 — 5.5

WEATHERED SHALE classifies as
SILTY SAND WITH GRAVEL, gray, about 15-20% gravel, 25-30% silt, nonplastic, gravel subangular to 2", medium sand, damp, very dense

10

15 — 15.9

TD=15.9'

20

TEST BORING COMPLETED ON 12-4-11
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊤ = Direct Push Sample
⧓ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-4-11
W.O. 1124.59822.01

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

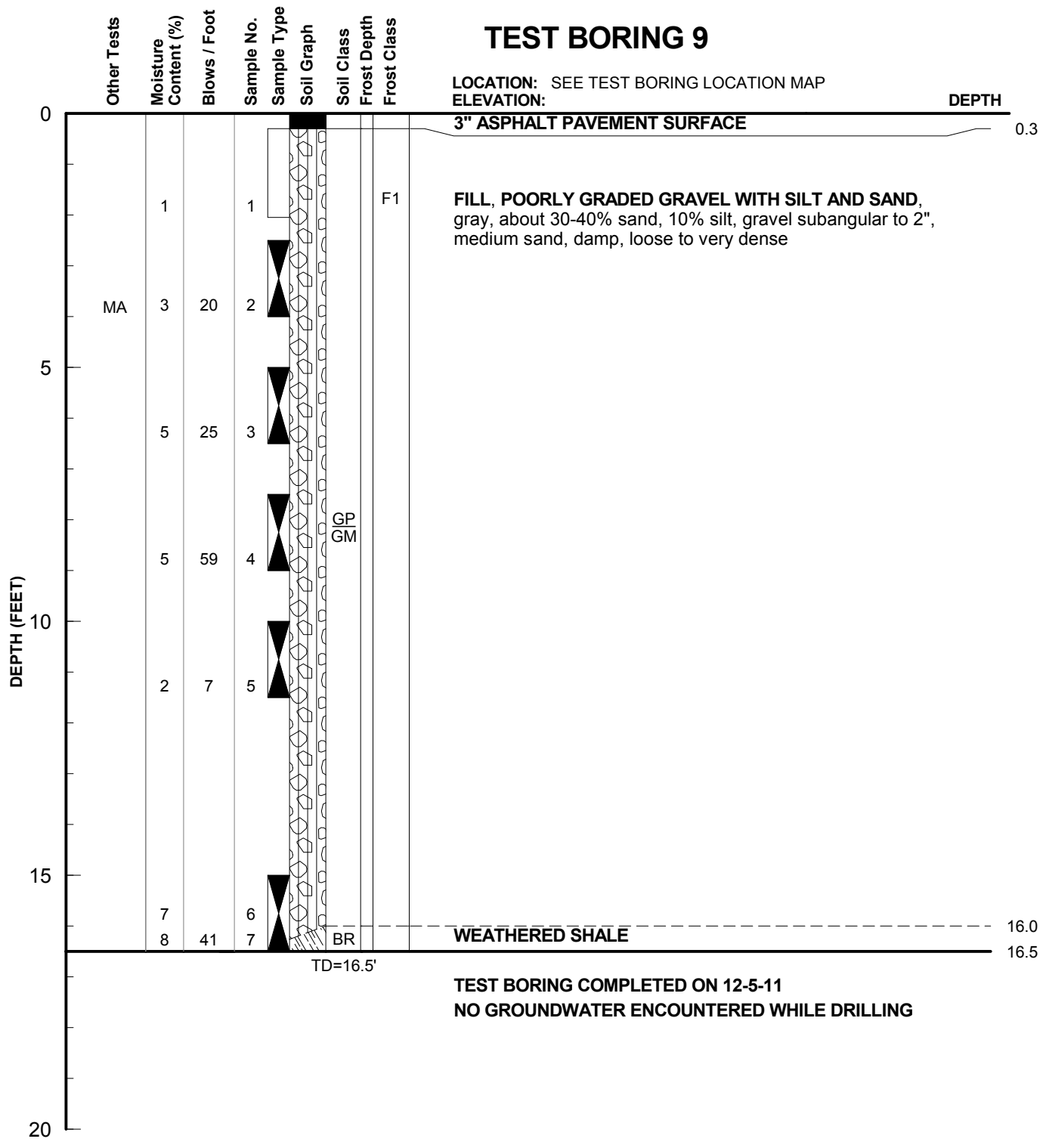
DOWL HKM

LOG OF TEST BORING 8

FIGURE 8

TEST BORING 9

LOCATION: SEE TEST BORING LOCATION MAP
ELEVATION:



TEST BORING COMPLETED ON 12-5-11
NO GROUNDWATER ENCOUNTERED WHILE DRILLING

KEY
MA = Mechanical Analysis
TD = Total Depth
□ = Grab Sample
◪ = SPT Sample
▨ = Shelby Tube - pushed
⊡ = Direct Push Sample
⊠ = 2.5" I.D. Spoon Sample
340# weight, 30" fall

DRILLING CO.: Denali Drilling, Inc.
EQUIPMENT: MOBILE B-61 Truck
OPERATOR: Seth Greer
METHOD: 8 in. OD hollow-stem auger

CLIENT: City and Borough of Kodiak
PROJECT: Downtown Master Plan
LOGGED BY: Natasha M. Hayden
TEST BORING COMPLETED: 12-5-11
W.O. 1124.59822.01

DOWL HKM

LOG OF TEST BORING 9

FIGURE 9

LOG OF EXPLORATION 59822.GPJ BLANK2.GDT 2/6/12

TEST BORING LOG - DESCRIPTIVE GUIDE

Soil Descriptions - The soil is classified visually in the field based on drill action, auger cuttings, and sample information. The recovered soil samples are classified visually again in the laboratory. The soil description on the boring log is based on an interpretation of the field and laboratory visual classifications, along with the results of laboratory particle-size distribution analyses and Atterberg Limits tests which may have been performed.

The soil classification is based on ASTM Designation D2487 "Standard Test Method for Classification of Soils for Engineering Purposes" and ASTM D2488 "Standard Practice for Description and Identification of Soils (Visual - Manual Procedure)". The soil frost classification is based on the system developed by the U.S. Army Corps of Engineers and is performed in accordance with the Departments of the Army and Air Force Publication TM 5-822-5 "Pavement Design for Roads, Streets, Walks, and Open Storage Areas". Outlines of these classification procedures are presented on the following pages.

The soil color is the subjective interpretation of the individual logging the test boring.

The plasticity of the minus No. 40 fraction of the soil is described and the fine-grained soils are identified from manual tests using the following table as a guide:

Soil Symbol	Dry Strength	Dilatancy	Toughness
ML	none to low	slow to rapid	low or thread cannot be formed
CL	medium to high	none to slow	medium
MH	low to medium	none to slow	low to medium
CH	high to very high	none	high

Plasticity Description	Criteria
Nonplastic	A 1/8" (3.2mm) thread cannot be rolled at any water content.
Low	A thread can barely be rolled and the lump cannot be formed when drier than the plastic limit.
Medium	The thread is easy to roll and not much time is required to reach the plastic limit. The thread cannot be rerolled after reaching the plastic limit. The lump crumbles when drier than the plastic limit.
High	It takes considerable time rolling and kneading to reach the plastic limit. The thread can be rerolled several times after reaching the plastic limit. The lump can be formed without crumbling when drier than the plastic limit.

Laboratory Atterberg Limits tests usually are performed on a few of the plastic soils and results are reported on the test boring log. These laboratory tests are performed in accordance with ASTM D4318 "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils."

The shape of the gravel particles is described based on this guide:

Angular: particles have sharp edges and relatively plane sides with unpolished surfaces.

Subangular: particles are similar to angular but have somewhat rounded edges.

Subrounded:	particles exhibit nearly plane sides but have well-rounded corners and edges.
Rounded:	particles have smoothly curved sides and no edges.

The size of gravel and sand particles is described using this guide:

	Gravel	Sand
Coarse:	Passes 3" (75 mm) sieve, retained on 3/4" (19 mm) sieve	Passes No. 4 sieve, retained on No. 10 sieve
Medium:	N/A	Passes No. 10 sieve, retained on No. 40 sieve
Fine:	Passes 3/4" (19 mm) sieve, retained on No. 4 sieve	Passes No. 40 sieve, retained on No. 200 sieve

The soil moisture is described as:

dry:	powdery, dusty, no visible moisture.
damp:	enough moisture to affect the color of the soil; moist.
wet:	water in pores but not dripping; capillary zone above water table.
saturated:	dripping wet, contains significant free water, or sampled below water table.

The subjective estimate of the density of coarse-grained soils is based on the observed drill action and on drive sample data. The guide below is used for sands with minor amounts of fine gravel; however, blowcounts can be affected strongly by gravel content, thermal state, drilling procedures, condition of equipment and performance of the test.

Standard Penetration Resistance N (blows / foot) or N (blows / 300 mm)	Soil Density
0 - 5	Very loose
6 - 10	Loose
11 - 30	Medium dense
31 - 50	Dense
More than 50	Very dense

An estimate of the consistency of fine-grained soils is based on the observed drill action and on drive sample data. The guide below is used:

Standard Penetration Resistance N (blows / foot) or N (blows / 300 mm)	Soil Consistency
0 - 2	Very soft
3 - 4	Soft
5 - 8	Firm
9 - 15	Stiff
15 - 30	Very stiff
More than 30	Hard

Soil Layer Boundaries - Generally, there is a gradual transition from one soil type to another in a natural soil deposit, and it is difficult to determine accurately the boundaries of the soil layers.

- A *diagonal line* between soil layers on the graphic boring log indicates the general region of transition from one soil layer to another.
- A *dashed diagonal line* indicates the soil boundary was detected only by a change in the recovered samples and the actual boundary may be anywhere between the indicated sample depths.
- A *horizontal line* between soil layers indicates a relatively distinct transition between soil types was observed in the recovered samples and / or by a distinct change in drill action.

Sample Interval - The sample interval is shown graphically on the test boring log and generally is accurate to about 0.5 foot (0.15 meter).

Frost Depth and Soil Temperatures - If frozen ground is encountered during drilling, the interval of frozen soil is shown graphically on the test boring log. Generally, the temperature of a few soil samples is measured and shown on the boring log. These sample temperatures only give a qualitative indication of the *in situ* soil temperatures. The temperature of samples can be influenced significantly by the ambient air temperature and friction during drilling and sampling.

Soil Moisture Content - Generally, laboratory soil moisture content tests are performed on all recovered samples. Only about 30 grams of the minus No. 4 material typically is used for the moisture content test, so results reported on the log may not reflect accurately the *in situ* moisture content of gravelly soils.

Soil Density - The soil density shown on the test boring logs generally is determined by measuring the wet weight, moisture content, and physical dimensions of relatively undisturbed specimens.

Ground Water - The depth to ground water observed during drilling generally is shown on the test boring log. The depth to ground water observed during drilling can differ significantly from the depth to the actual ground water table, particularly in fine-grained soils. When more accurate water level measurements are desired, we typically install perforated PVC pipe in a boring to monitor the ground water level.

Penetration Resistance, N - Standard penetration tests (SPT) are performed in accordance with ASTM Designation D1586 "Standard Method for Penetration Test and Split-Barrel Sampling of Soils." A modified penetration test using a 2.5-inch (63.5 mm) I.D. split spoon driven with a 340-pound (154.2 kg) hammer falling 30 inches (.76 m) is performed to obtain larger samples, particularly in gravelly soils. The boring log key describes the graphic symbols used to differentiate between sample types.

Undisturbed Samples - Undisturbed Shelby tube samples are obtained in accordance with ASTM Designation D1587, "Standard Practice for Thin-Walled Tube Sampling of Soils." Generally, 3-inch (76.2 mm) O.D. Shelby tubes are used. Relatively undisturbed liner samples are obtained in accordance with ASTM Designation D3550, "Standard Practice for Ring-Lined Barrel Sampling of Soils," except a thick-walled cutting shoe is used. Typically, the sampler is driven using a 340-pound (154.2 kg) weight falling 30 inches (.76 m). The typical brass liner has an I.D. of 2.4 inches (91 mm).

Grab Samples - Grab samples are obtained from the auger flights. The sample depth and interval indicated on the test boring log should be considered a rough approximation. The grab samples may not be representative of *in situ* soils, particularly in layered soil deposits.

CLASSIFICATION OF SOILS FOR ENGINEERING PURPOSES
ASTM DESIGNATION: D2487
Based on the Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification: Group Symbol	Soil Classification: Group Name[B]
Coarse-Grained Soils	Gravels	Clean Gravels	$Cu \geq 4$ and $1 \leq Cc \leq 3$[E]	GW	Well-graded gravel[F]
More than 50% retained on #200 sieve	More than 50% of coarse fraction retained on #4 sieve	Less than 5% fines[C]	$Cu < 4$ and/or $1 > Cc > 3$[E]	GP	Poorly graded gravel[F]
		Gravel with Fines	Fines classify as ML or MH	GM	Silty gravel [F,G,H]
		More than 12% fines[C]	Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands	Clean Sands	$Cu \geq 6$ and $1 \leq Cc \leq 3$[E]	SW	Well-graded sand[I]
	50% or more of coarse fraction passes #4 sieve	Less than 5% fines[D]	$Cu < 6$ and/or $1 > Cc > 3$[E]	SP	Poorly graded sand[I]
		Sands with Fines	Fines classify as ML or MH	SM	Silty Sand [G,H,I]
		More than 12% fines[D]	Fines classify as CL or CH	SC	Clayey Sand [G,H,I]
Fine-Grained Soils	Silts and Clays	Inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean Clay [K,L,M]
50% or more passes the #200 sieve	Liquid limit less than 50		PI < 4 or plots below "A" Line[J]	ML	Silt[K,L,M]
		Organic	Liquid limit - oven dried <0.75	OL	Organic Clay [K,L,M,N]
			Liquid limit - not dried	OL	Organic silt [K,L,M,O]
	Silts and Clays	Inorganic	PI plots on or above "A" line	CH	Fat clay [K,L,M]
	Liquid limit 50 or more		PI plots below "A" line	MH	Elastic silt [K,L,M]
		Organic	Liquid limit - oven dried <0.75	OH	Organic clay[K,L,M,P]
			Liquid limit - not dried	OH	Organic clay[K,L,M,Q]
Highly organic soils		Primarily organic matter,	dark in color, and organic odor	PT	Peat

A Based on the material passing the 3-in. (75mm) sieve.

B If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

C Gravels with 5 to 12% fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

D Sands with 5 to 12% fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

E $Cu = \frac{D_{60}}{D_{10}}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

F If soil contains $\geq$ 15% sand, add "with sand" to group name.

G If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

H If fines are organic, add "with organic fines" to group name.

I If soil contains $\geq$ 15% gravel, add "with gravel" to group name.

J If Atterberg Limits plot in hatched area, soil is a CL-ML, silty clay.

K If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant.

L If soil contains $\geq$ 30% plus No. 200, predominantly sand, add "sandy" to group name.

M If soil contains $\geq$30% plus No. 200, predominantly gravel, add "gravelly" to group name.

N PI $\geq$ 4 and plots on or above "A" line.

O PI < 4 or plots below "A" line.

P PI plots on or above "A" line.

Q PI plots below "A" line.

DESCRIPTION OF FROZEN SOILS (Visual-Manual Procedure) ASTM Designation: D4083

Part I Description of Soil Phase	Classify Soil Phase by ASTM D2487 or D2488				
Part II Description of Frozen Soil	Segregated ice is not visible by eye	N	Poorly bonded or friable	N_f	Identify by visual examination. To determine presence of excess ice, use procedures under Note 2 and hand magnifying lens as necessary. For soils not fully saturated, estimate degree of ice saturation; medium, low. Note presence of crystals or of ice coatings around larger particles.
			No excess ice	N_b	
			Well-bonded	N_{bn}	
			Excess ice	N_{be}	
	Segregated ice is visible by eye (ice 1-inch (25 mm) or less in thickness)	V	Individual ice crystal or inclusions	V_x	For ice phase, record the following when applicable: Location — Structure Orientation — Color Thickness — Size Length — Shape Spacing — Hardness Pattern of arrangement
			Ice coatings on particles	V_c	
			Random or irregularly oriented ice formations	V_r	
			Stratified or distinctly oriented ice formations	V_s	
			Uniformly distributed ice	V_u	Estimate volume of visible segregated ice present as percentage of total sample volume.
Part III Description of Substantial Ice	Ice (greater than 1-inch (25 mm) in thickness)	ICE	Ice with soil inclusions	ICE + Soil Type	Designate material as ICE (Note 3) and use descriptive terms as follows, usually one item from each group, where applicable: **Hardness**: HARD; SOFT; [of mass, not individual crystals] **Structure** (Note 4): CLEAR; CLOUDY; POROUS; CANDLED; GRANULAR; STRATIFIED **Color** (Examples): COLORLESS; GRAY; BLUE **Admixtures** (Examples): CONTAINS FEW THIN SILT INCLUSIONS
			Ice without soil inclusions	ICE	

Note 1: Frozen soils in the N group may, on close examination, indicate presence of ice within the voids of the material by crystalline reflections or by a sheen on fractured or trimmed surfaces. The impression received by the unaided eye, however, is that none of the frozen water occupies space in excess of the original voids in the soil. The opposite is true of frozen soils in the V group.

Note 2: When visual methods may be inadequate, a simple field test to aid in evaluation of the volume of excess ice can be made by placing some frozen soil in a small jar, allowing it to melt, and observing the quantity of supernatant water as a percentage of total volume.

Note 3: Where special forms of ice such as hoarfrost can be distinguished, more explicit description should be given.

Note 4: Observer should be careful to avoid being misled by surface scratches or frost coating on the ice.

DEFINITIONS

1) Ice coatings on Particles - discernible layers of ice found on or below the larger soil particles in a frozen soil mass.
2) Ice Crystal - a very small individual ice particle visible in the face of a soil mass. Crystals may be present alone or in combination with other ice formations.
3) Clear Ice - ice that is transparent and contains only a moderate number of air bubbles.
4) Cloudy Ice - ice that is translucent or relatively opaque due to the content of air or for other reasons, but which is essentially sound and impervious.
5) Porous Ice - ice that 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.
6) Candled Ice - ice that has rotted or otherwise formed into long columnar crystals, very loosely bonded together.
7) Granular Ice - ice that is composed of coarse, more or less equidimensional crystals weakly bonded together.
8) Ice Lenses - lenticular ice formations in soil occurring essentially parallel to each other, generally normal to the direction of heat loss, and commonly in repeated layers.
9) Ice Segregation - the growth of ice within soil in excess of the amount that may be produced by the in-place conversion of the original void moisture to ice. Ice segregation occurs most often as distinct lenses, layers, veins, and masses, commonly, but not always, oriented normal to the direction of heat loss.
10) Well-Bonded - a condition in which the soil particles are strongly held together by the ice so that the frozen soil possesses relatively high resistance to chipping or breaking.
11) Poorly-Bonded - a condition in which the soil particles are weakly held together by the ice so that the frozen soil has poor resistance to chipping and breaking.
12) Thaw Stable - the characteristics of frozen soils that, upon thawing, do not show loss of strength in comparison to normal, long-time thawed values nor produce detrimental settlement.

FROST DESIGN SOIL CLASSIFICATION[1]

Frost[2] Group	Kind of Soil	Percentage Finer than 0.02 mm by Weight	Typical Soil Types Under Unified Soil Classification System
NFS[3]	(a) Gravels Crushed stone Crushed rock	0 to 1.5	GW and GP
	(b) Sands	0 to 3	SW and SP
PFS[4] (MOA NFS)	(a) Gravels Crushed stone Crushed rock	1.5 to 3	GW and GP
(MOA F2)	(b) Sands	3 to 10	SW and SP
S1 (MOA F1)	Gravelly soils	3 to 6	GW, GP, GW-GM, and GP-GM
S2 (MOA F2)	Sandy soils	3 to 6	SW, SP, SW-SM, and SP-SM
F1	Gravelly soils	6 to 10	GM, GW-GM, and GP-GM
F2	(a) Gravelly soils	10 to 20	GM, GW-GM, and GP-GM
	(b) Sands	6 to 15	SM, SW-SM, and SP-SM
F3	(a) Gravelly soils	Over 20	GM and GC
	(b) Sands, except very fine silty sands	Over 15	SM and SC
	(c) Clays, PI>12		CL and CH
F4	(a) All silts		ML and MH
	(b) Very fine silty sands	Over 15	SM
	(c) Clays, PI<12		CL and CL-ML
	(d) Varved clays and other fine-grained, banded sediments		CL and ML CL, ML, and SM CL, CH, and ML CL, CH, ML and SM

1

[1] Departments of the Army and Air Force Publication TM 5-822-5/AFM 88-7, "Pavement Design for Roads, Streets, Walks, and Open Storage Areas", Table 18-2.

[2] Corps of Engineers Frost groups directly correspond to the Municipality of Anchorage soil frost classification groups, except as noted.

[3] Non Frost-Susceptible.

[4] Possibly frost-susceptible, but requires laboratory test to determine frost design soil classification.

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

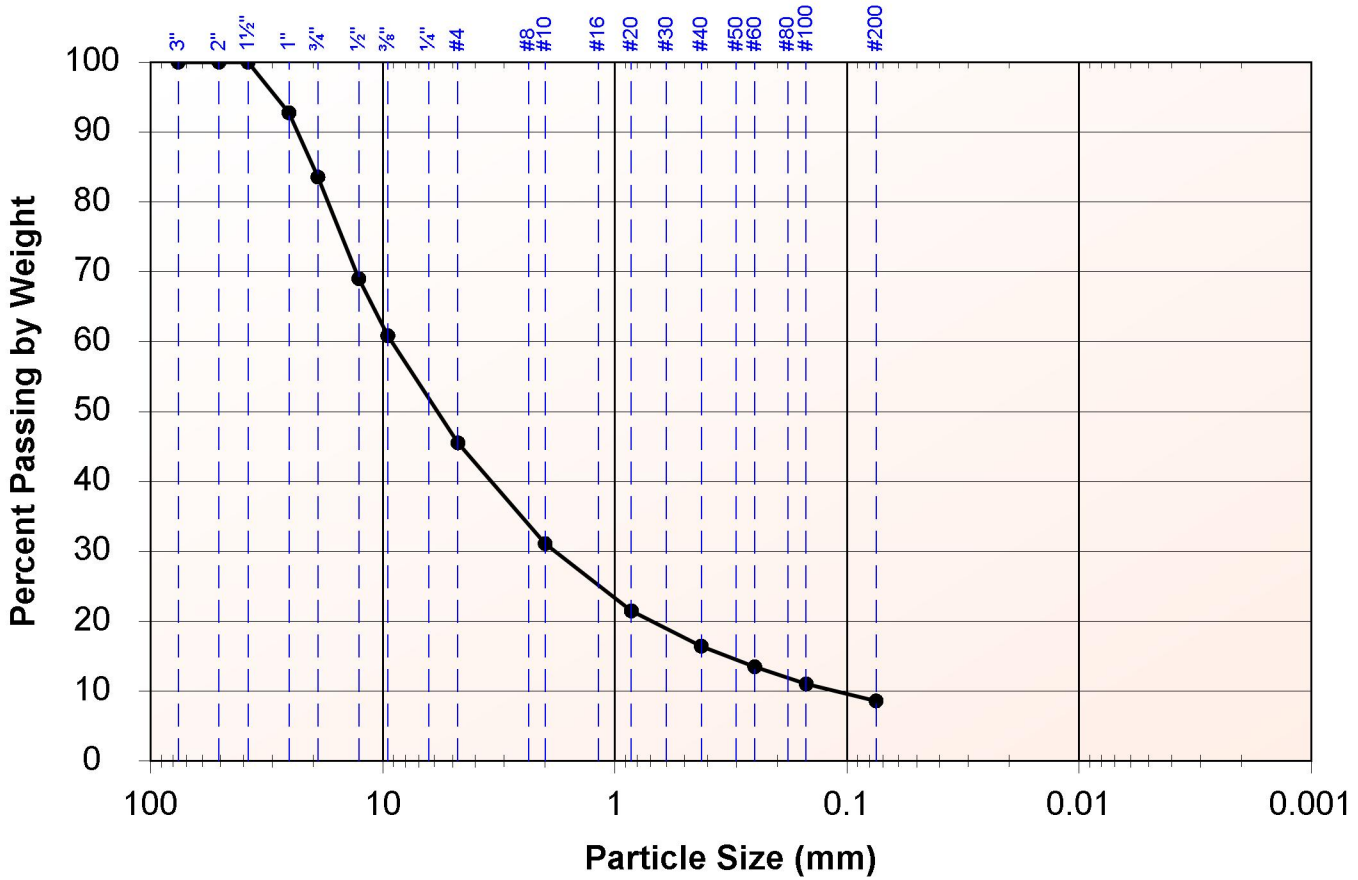
ASTM D422

Location: Test Boring 1
Sample 2
Depth 2.5'-4'

Lab Number	2011-1869
Received	12/4/2011
Reported	12/15/2011

Engineering Classification: **Poorly Graded Gravel with Silt and Sand, GP-GM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	93%	
¾"	84%	
½"	69%	
⅜"	61%	
#4	46%	
Total Weight of Coarse Fraction: 591.9g		
#10	31%	
#20	21%	
#40	16%	
#60	13%	
#100	11%	
#200	8.6%	
Total Weight of Fine Fraction: 269.2g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

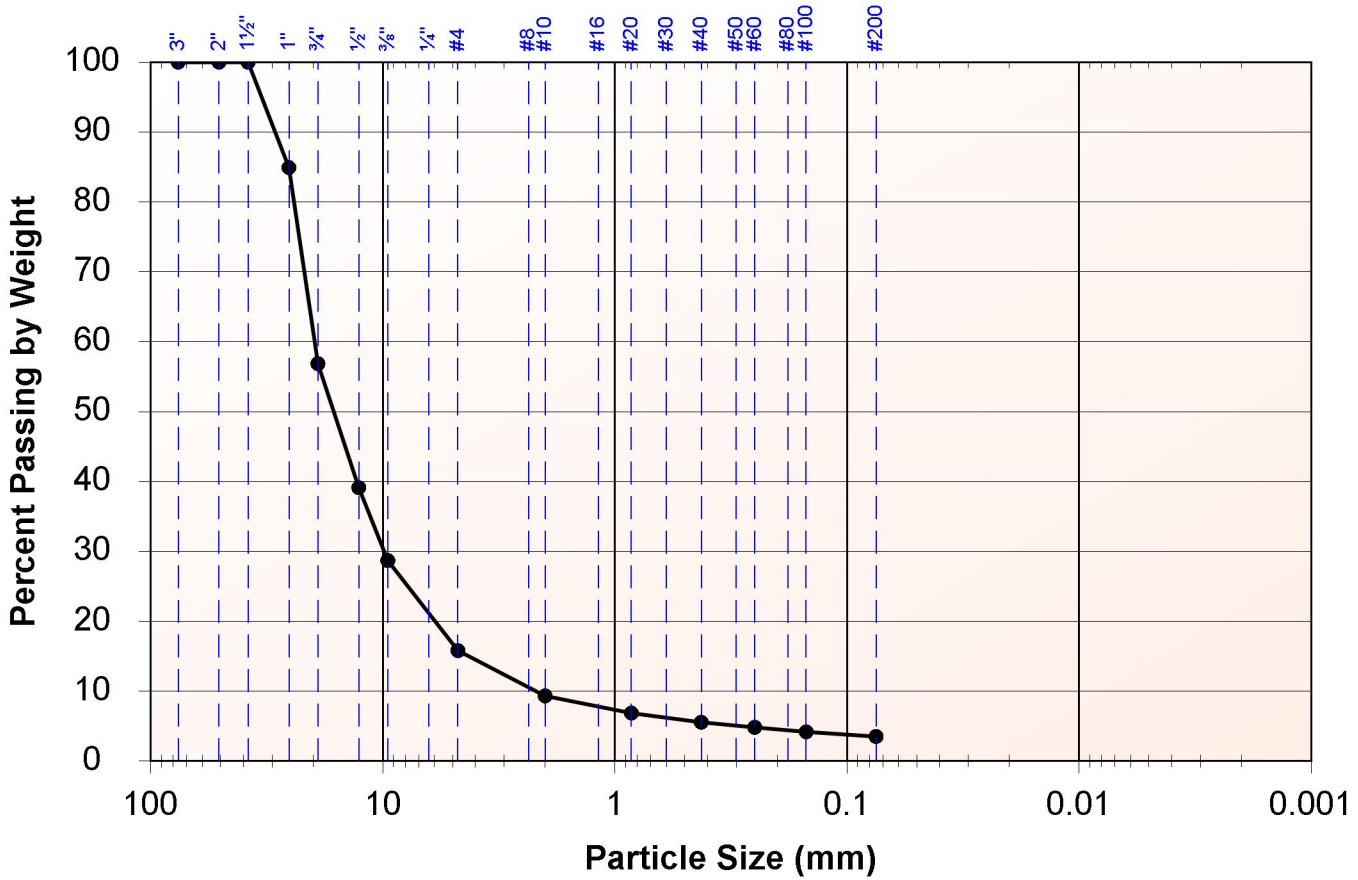
ASTM D422

Location: Test Boring 1
Sample 5
Depth 10'-11.5'

Lab Number	2010-1870
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	85%	
¾"	57%	
½"	39%	
⅜"	29%	
#4	16%	
Total Weight of Coarse Fraction: 357.9g		
#10	9%	
#20	7%	
#40	6%	
#60	5%	
#100	4%	
#200	3.5%	
Total Weight of Fine Fraction: 56.6g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

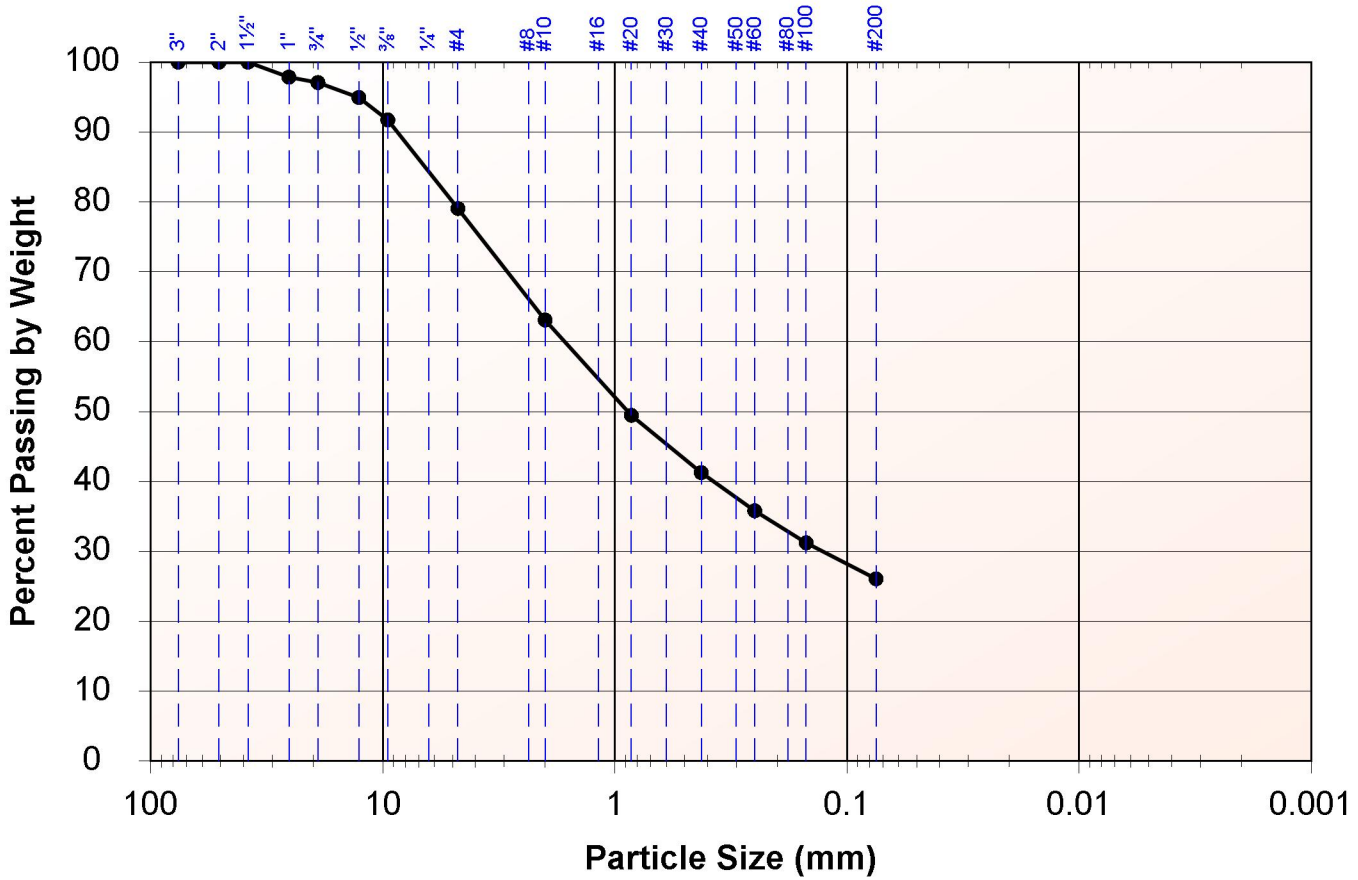
ASTM D422

Location: Test Boring 2
Sample 1
Depth 0'-2'

Lab Number	2011-1871
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	98%	
¾"	97%	
½"	95%	
⅜"	92%	
#4	79%	
Total Weight of Coarse Fraction: 3681.7g		
#10	63%	
#20	49%	
#40	41%	
#60	36%	
#100	31%	
#200	26.1%	
Total Weight of Fine Fraction: 353.2g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

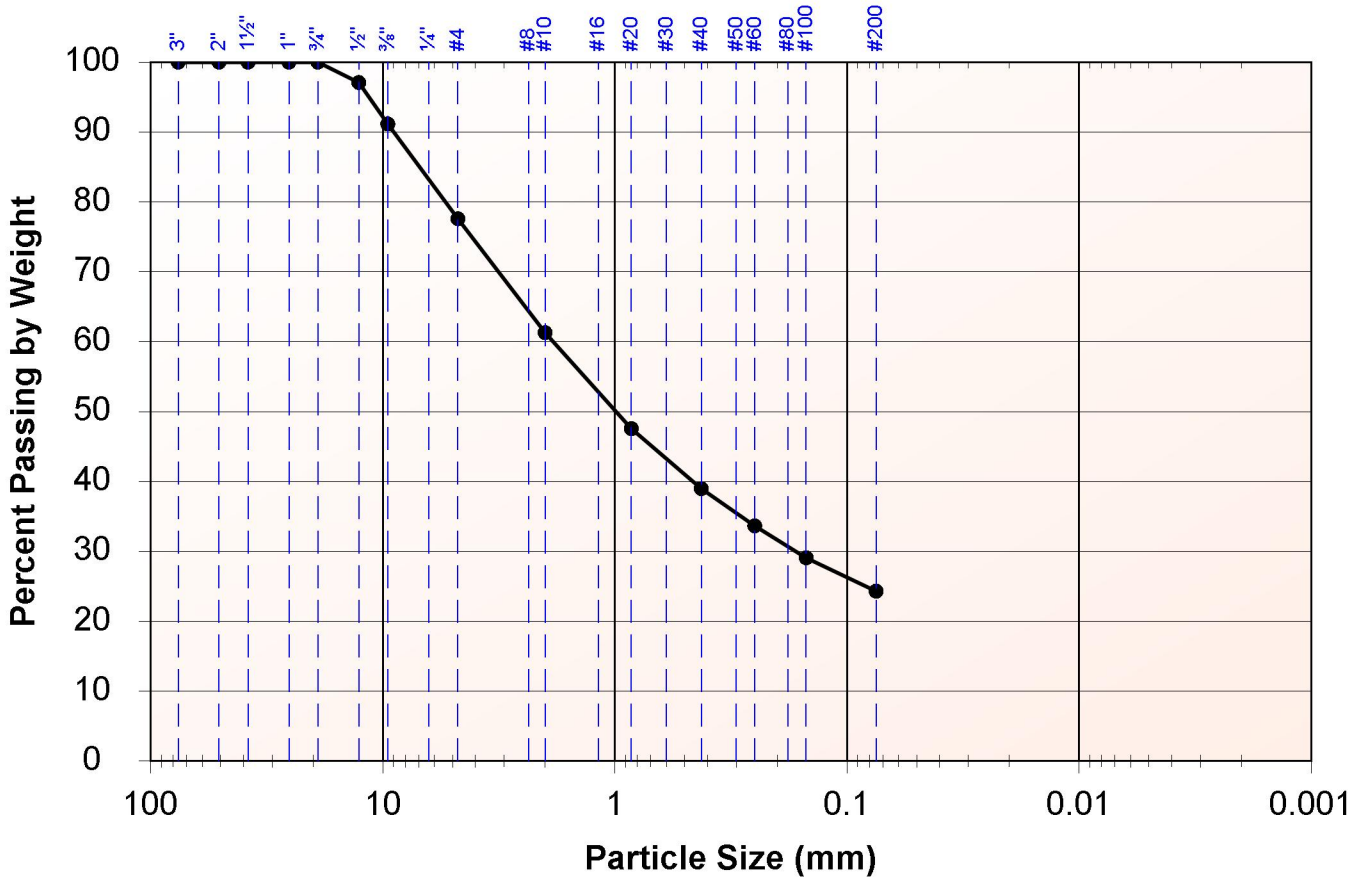
ASTM D422

Location: Test Boring 2
Sample 5
Depth 10'-11.5'

Lab Number	2011-1872
Received	12/4/2011
Reported	12/15/2011

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"	97%	
⅜"	91%	
#4	78%	
Total Weight of Coarse Fraction: 1105.9g		
#10	61%	
#20	48%	
#40	39%	
#60	34%	
#100	29%	
#200	24.3%	
Total Weight of Fine Fraction: 350.4g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

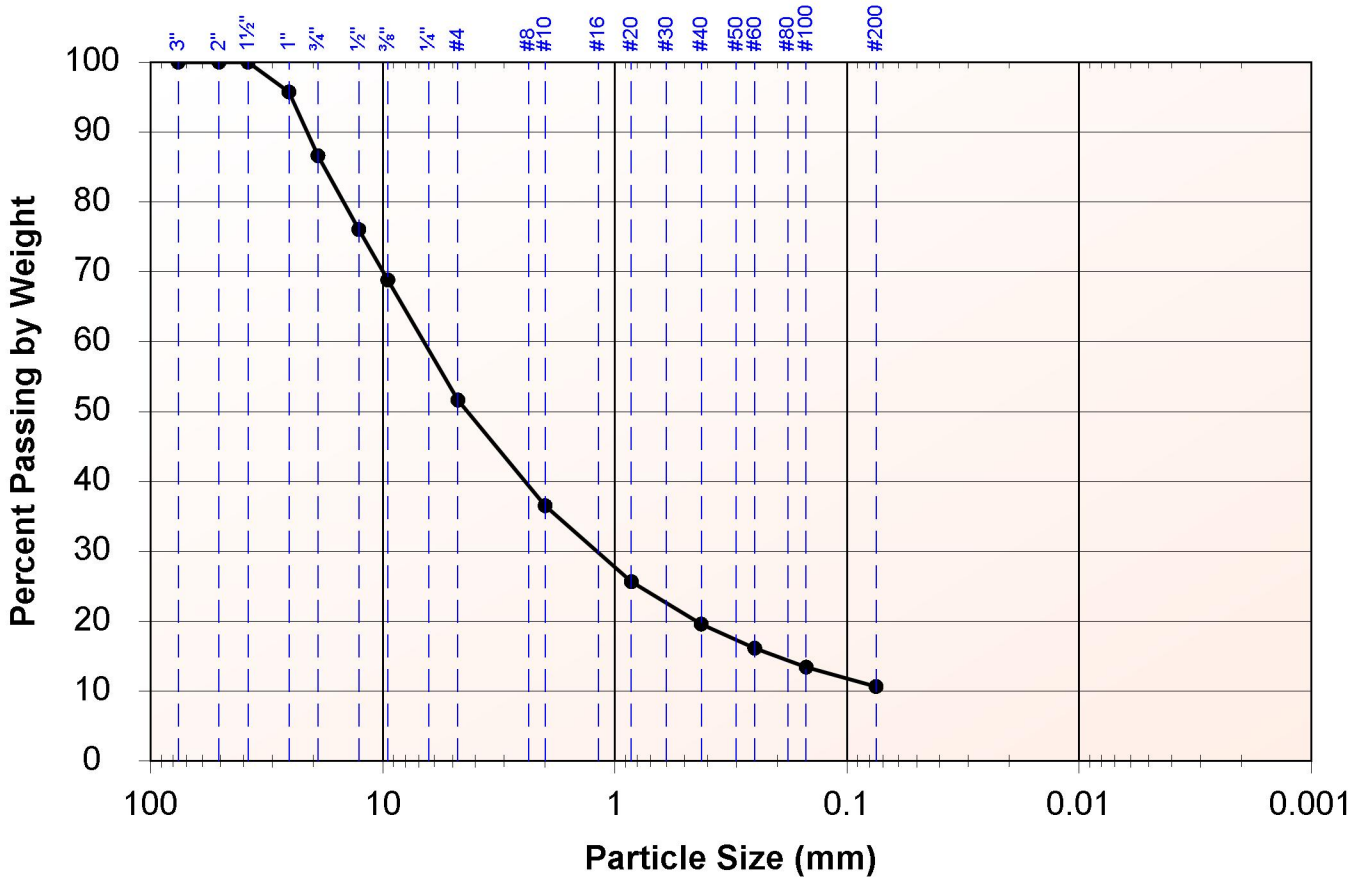
ASTM D422

Location: Test Boring 3
Sample 2
Depth 2.5'-4'

Lab Number	2011-1873
Received	12/4/2011
Reported	2/3/2012

Engineering Classification: **Poorly Graded Gravel with Silt and Sand, GP-GM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	96%	
¾"	87%	
½"	76%	
⅜"	69%	
#4	52%	
Total Weight of Coarse Fraction: 1601.7g		
#10	37%	
#20	26%	
#40	20%	
#60	16%	
#100	13%	
#200	10.7%	
Total Weight of Fine Fraction: 301.2g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

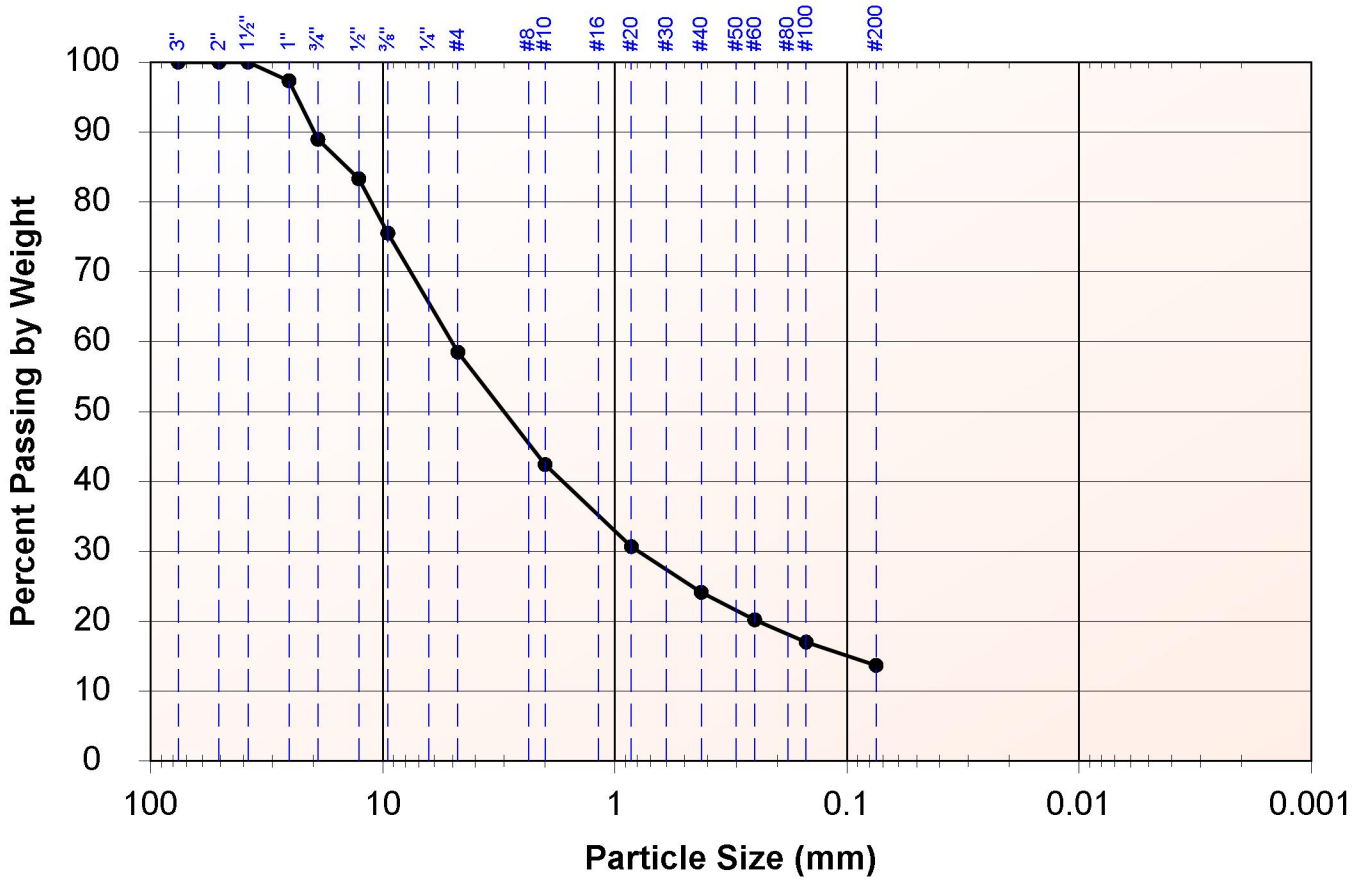
ASTM D422

Location: Test Boring 5
Sample 2
Depth 2.5'-4'

Lab Number	2011-1874
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	97%	
¾"	89%	
½"	83%	
⅜"	76%	
#4	59%	
Total Weight of Coarse Fraction: 1492.2g		
#10	42%	
#20	31%	
#40	24%	
#60	20%	
#100	17%	
#200	13.7%	
Total Weight of Fine Fraction: 304.5g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

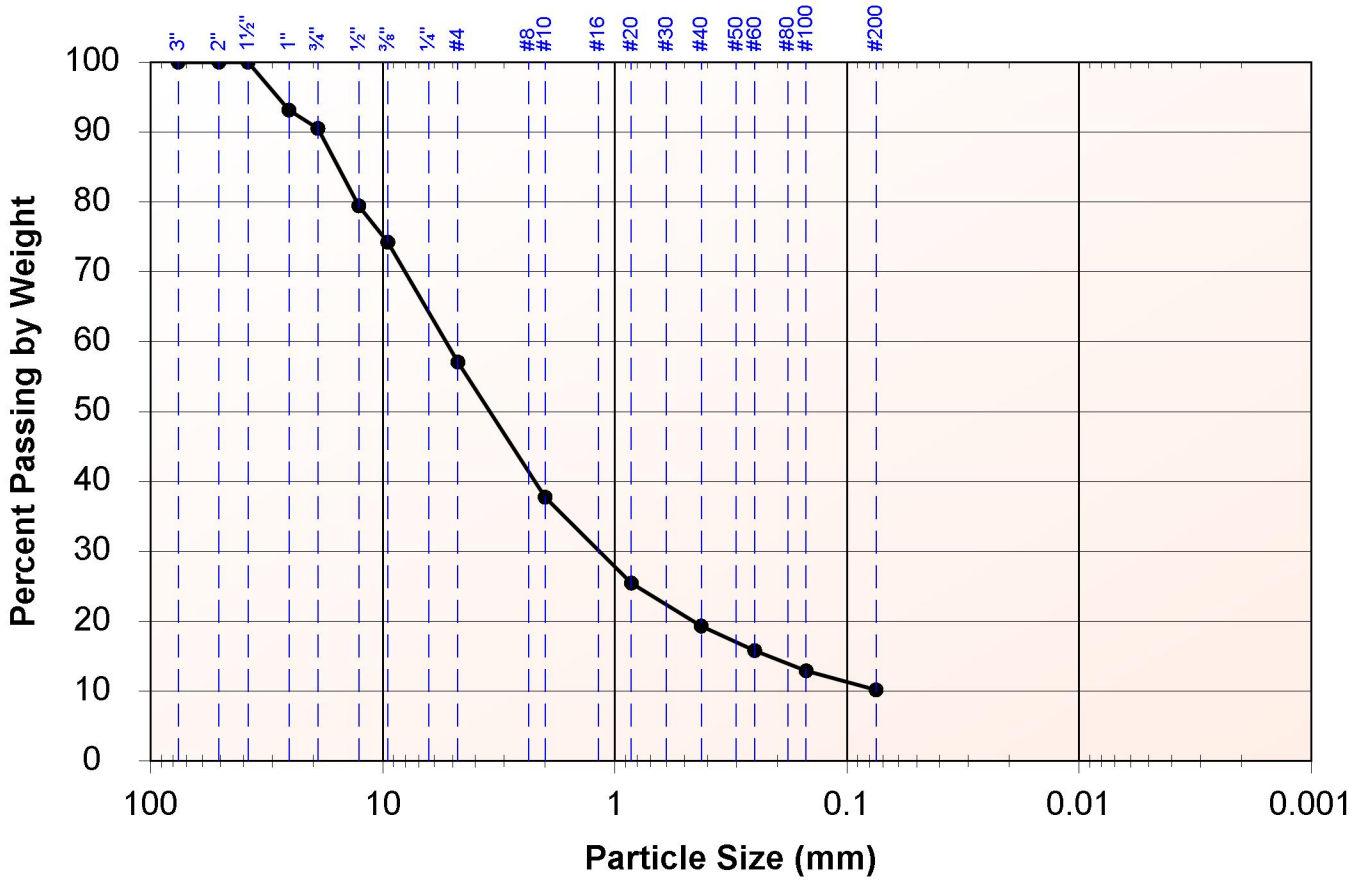
ASTM D422

Location: Test Boring 5
Sample 5
Depth 10'-11.5'

Lab Number	2011-1875
Received	12/4/2011
Reported	12/15/2011

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"	93%	
¾"	91%	
½"	79%	
⅜"	74%	
#4	57%	
Total Weight of Coarse Fraction: 2110.0g		
#10	38%	
#20	25%	
#40	19%	
#60	16%	
#100	13%	
#200	10.2%	
Total Weight of Fine Fraction: 377.3g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

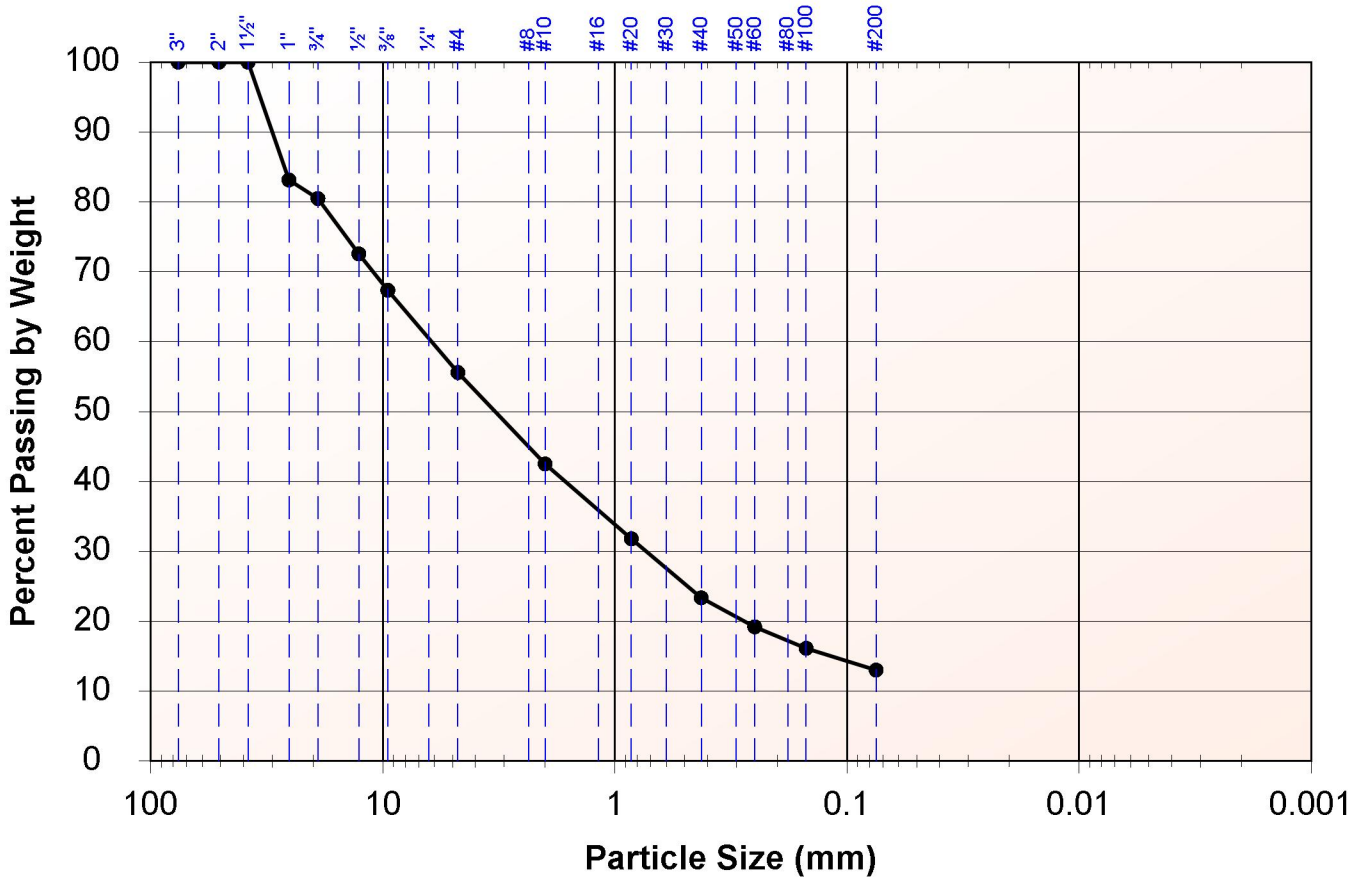
ASTM D422

Location: Test Boring 6
Sample 3
Depth 5'-6.5'

Lab Number	2011-1876
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	83%	
¾"	80%	
½"	73%	
⅜"	67%	
#4	56%	
Total Weight of Coarse Fraction: 953.3g		
#10	43%	
#20	32%	
#40	23%	
#60	19%	
#100	16%	
#200	13%	
Total Weight of Fine Fraction: 302.2g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

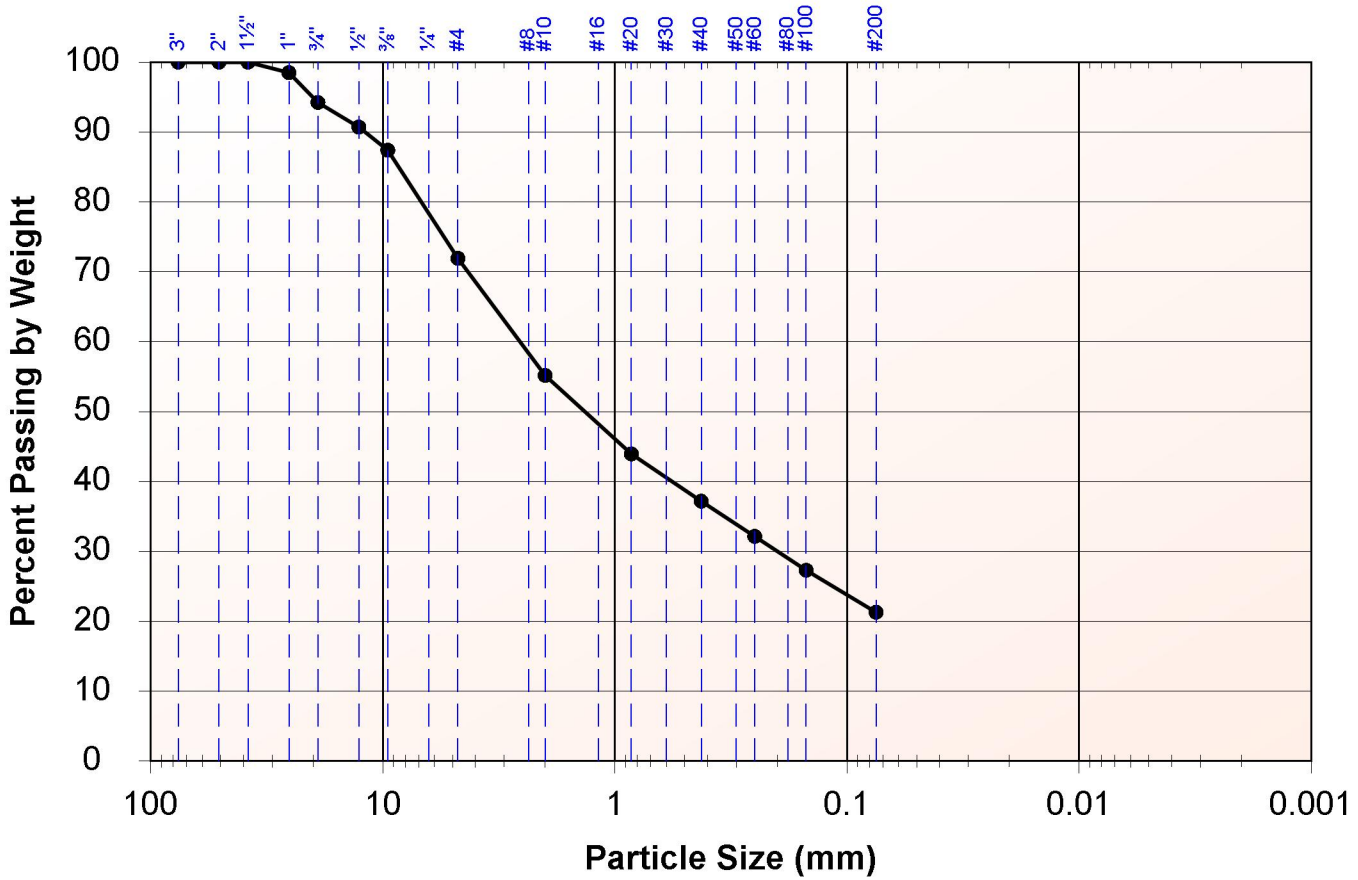
ASTM D422

Location: Test Boring 6
Sample 6
Depth 12.5'-13.5'

Lab Number	2011-1877
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	98%	
¾"	94%	
½"	91%	
⅜"	87%	
#4	72%	
Total Weight of Coarse Fraction: 1886.5g		
#10	55%	
#20	44%	
#40	37%	
#60	32%	
#100	27%	
#200	21.3%	
Total Weight of Fine Fraction: 353g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

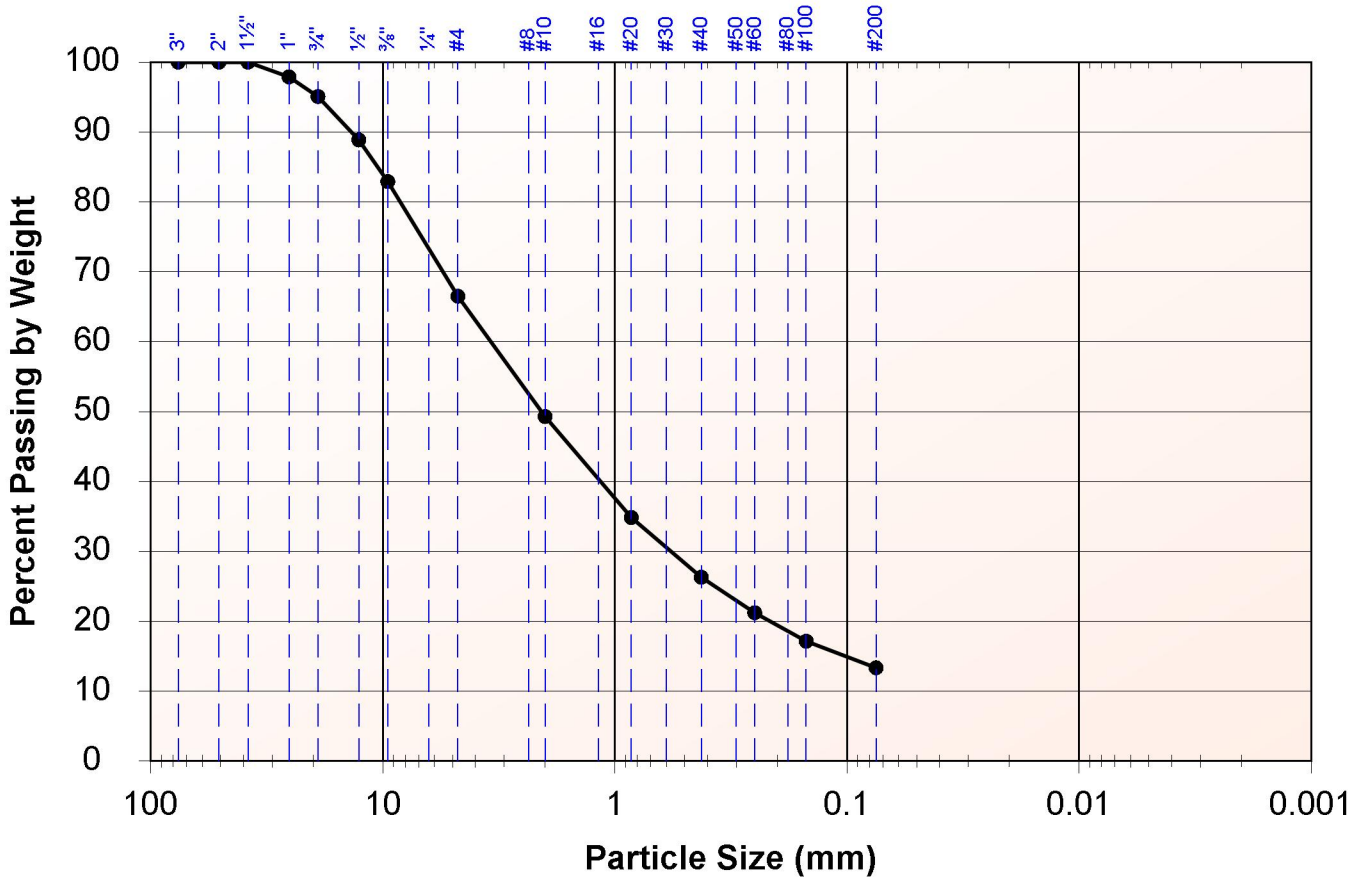
ASTM D422

Location: Test Boring 7
Sample 3
Depth 5'-6.1'

Lab Number	2011-1878
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	98%	
¾"	95%	
½"	89%	
⅜"	83%	
#4	67%	
Total Weight of Coarse Fraction: 1188.9g		
#10	49%	
#20	35%	
#40	26%	
#60	21%	
#100	17%	
#200	13.4%	
Total Weight of Fine Fraction: 389.5g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

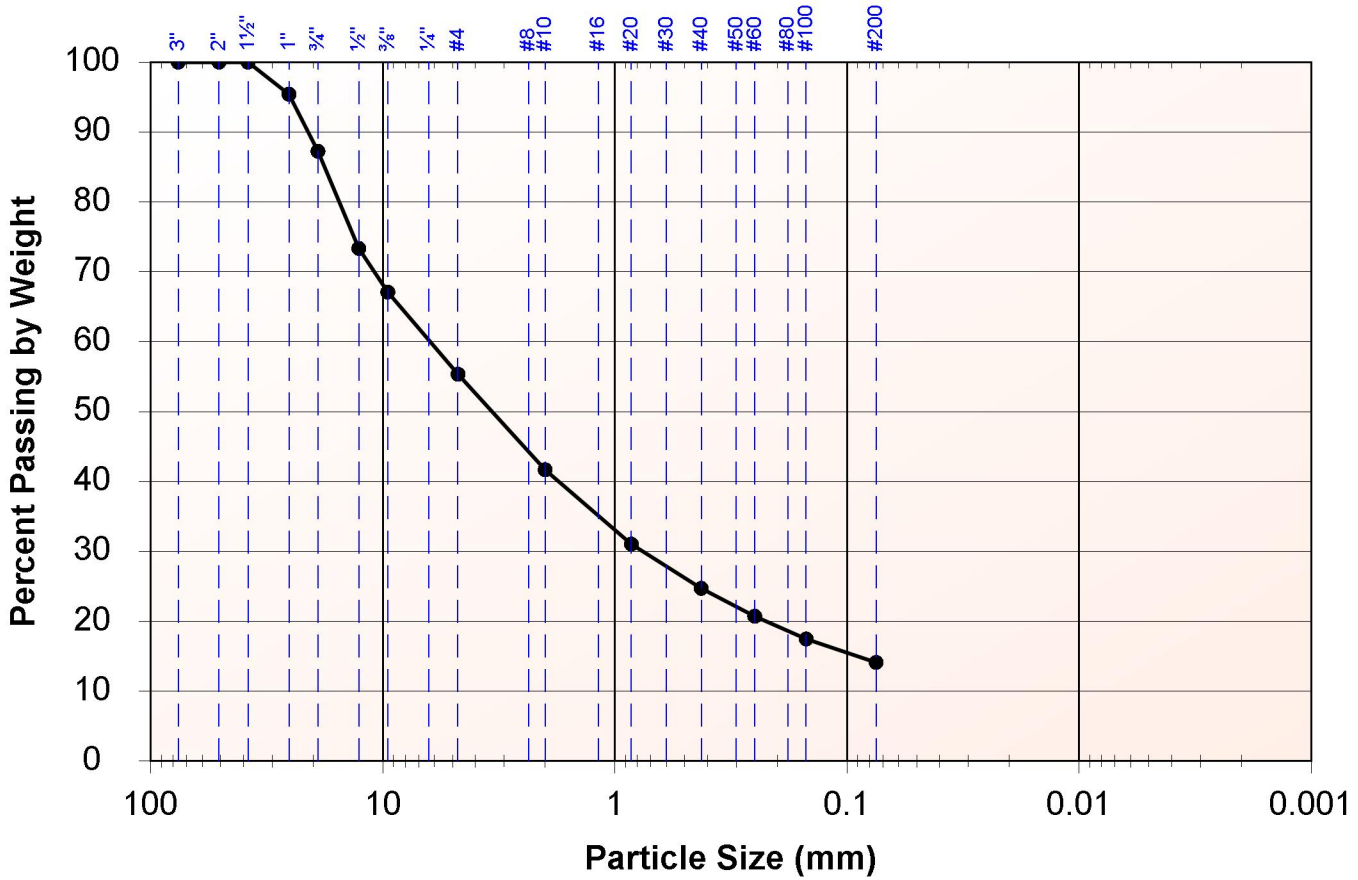
ASTM D422

Location: Test Boring 8
Sample 2
Depth 2.5'-4'

Lab Number	2011-1880
Received	12/4/2011
Reported	12/15/2011

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

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	100%	
1"	95%	
¾"	87%	
½"	73%	
⅜"	67%	
#4	55%	
Total Weight of Coarse Fraction: 1125.1g		
#10	42%	
#20	31%	
#40	25%	
#60	21%	
#100	17%	
#200	14.1%	
Total Weight of Fine Fraction: 331g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

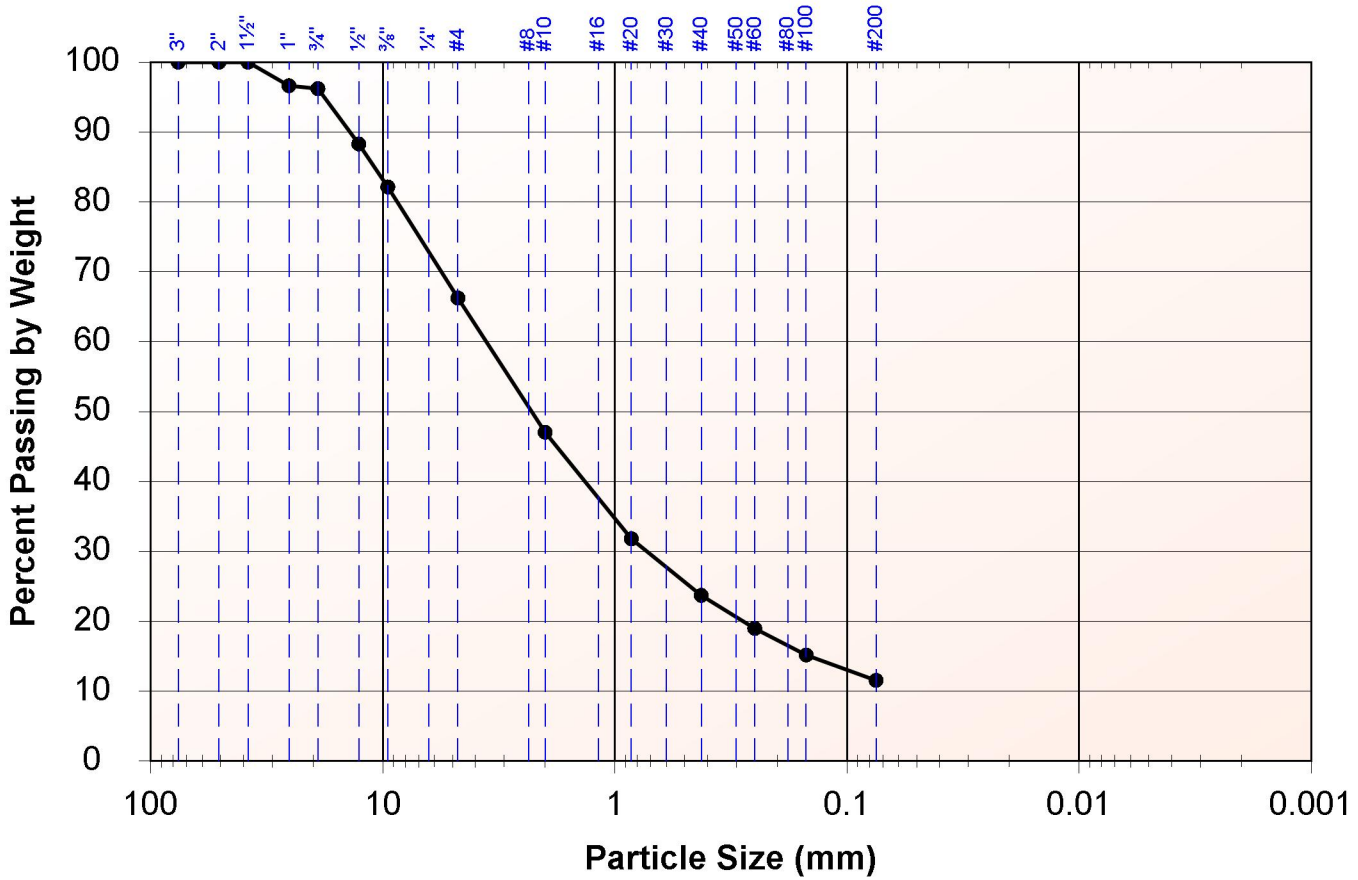
ASTM D422

Location: Test Boring 8
Sample 4
Depth 7.5'-9'

Lab Number	2011-1881
Received	12/4/2011
Reported	12/15/2011

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"	97%	
¾"	96%	
½"	88%	
⅜"	82%	
#4	66%	
Total Weight of Coarse Fraction: 1899.3g		
#10	47%	
#20	32%	
#40	24%	
#60	19%	
#100	15%	
#200	11.5%	
Total Weight of Fine Fraction: 301.2g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953

DOWL HKM

Client: City of Kodiak
Project: Downtown Kodiak MP
Work Order: D59822

Particle Size Distribution

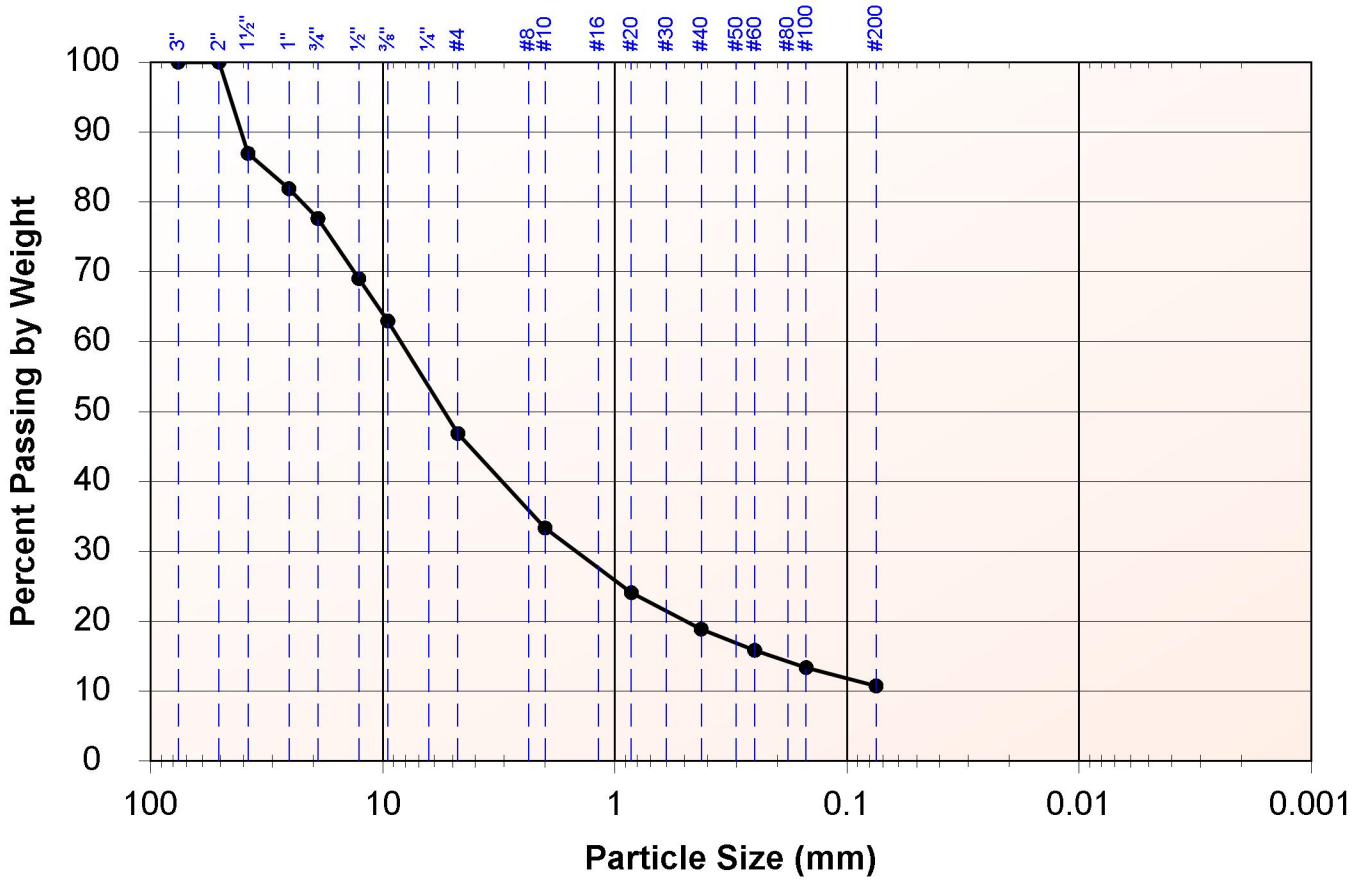
ASTM D422

Location: Test Boring 9
Sample 2
Depth 2.5'-4'

Lab Number	2011-1882
Received	12/4/2011
Reported	12/15/2011

Engineering Classification: **Poorly Graded Gravel with Silt and Sand, GP-GM**

Frost Classification: **Not Measured**



Size	Passing	Specification
3"	100%	
2"	100%	
1½"	87%	
1"	82%	
¾"	78%	
½"	69%	
⅜"	63%	
#4	47%	
Total Weight of Coarse Fraction: 1211.6g		
#10	33%	
#20	24%	
#40	19%	
#60	16%	
#100	13%	
#200	10.8%	
Total Weight of Fine Fraction: 413.9g		

Maria E. Kampsen, P.E • 4041 B Street • Anchorage • Alaska • 99503 • 907/562-2000 • Fax 907/563-3953