APPENDIX C – GEOTECHNICAL ANALYSIS
NAVIGATION IMPROVEMENTS
HAINES, ALASKA

GEOTECHNICAL REPORT
for the
HAINES SMALL BOAT HARBOR
HAINES, ALASKA

May 2001

1. Scope

The results of a reconnaissance study and test pit exploration for the proposed small boat harbor at Haines, Alaska are presented in this report.

The scope of the investigation was to:

1) gain a general understanding of the subsurface conditions within exploration limits with regard to dredging, 2) aid in developing criteria for planning a detailed subsurface exploration, and 3) provide preliminary recommendations relevant to the design and construction of the proposed small boat harbor.

2. Project Location and Description

Haines is located in southeast Alaska about 121 kilometers (km) northwest of Juneau at the head of Lynn Canal. The project area is located on the waterfront bordering the shore and adjacent to each side of the existing city harbor. Two areas are under consideration for the project. The area to the south of the city harbor is herein designated Portage Cove South. The proposed work at that location would consist of extending the existing seaward breakwater southward and constructing a new breakwater from shore to provide enclosure. The other area, designated Portage Cove North, would involve constructing a new harbor north of the existing city harbor. Harbor dredging and construction of breakwaters will be the primary components of the project. Proposed dredging will extend to elevations between -4.3 to -5.5 meters (m) MLLW. For reference, a Project Location Map is enclosed.

3. Field Explorations

The current exploration was conducted on 9 September 2000. Fourteen test pits were excavated; thirteen (TP-2002 through TP-2014) to the north of the existing harbor and one (TP-2001) to the south. The test pits were excavated to depths from 1.25 m to 4 m below ground surface with a tracked CAT 307 backhoe

fitted with an 0.46 m bucket. Mr. Mike Murphy of Southeast Road Builders operated the backhoe. The excavation of the test pits was supervised and logged by a geologist with the Corps of Engineers in conformance with ASTM D2488-93, "Standard Practice for Description and Identification of Soils (Visual - Manual Procedure)." Grab samples of the primary material types encountered in the test pits were obtained for laboratory testing to help in soils classification. The test pits north of the harbor were located using a cloth tape measuring perpendicularly from stationing on a previously established baseline. That baseline originated at the cable crossing sign on the north edge of the project area and extended along the high water line. Control was also provided by reference to the intersections of Front Street with Union and Dalton Streets. The test pit south of the harbor was located using the fuel storage facility and the walkway to the dock as references. The locations are shown on the enclosed Test Pit Location Map.

4. **Laboratory Testing and Soil Classification**

A testing program using the test methods listed below was established to determine the physical properties of selected soil samples. A Corps of Engineers approved laboratory performed the testing.

ASTM D 422-63 (Re-approved 1990), "Standard Test Method for Particle Size Analysis of Soils".

ASTM D 2216-92, "Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock".

ASTM D 2487-93, "Standard Test Method for Classification of Soils for Engineering Purposes (Uniform Soil Classification System)".

ASTM D 4318-95a, "Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index for Soils".

TM 5-822-5/AFM 88-7 Chapter 1, "Pavement Design for Roads, Streets, Walks, and Open Storage Areas", for determining the frost classification of the soil.

The soil descriptions and classifications contained in this report and presented on the final exploration logs are the project geologist's interpretation of the project field logs and

results of laboratory testing. The stratification lines represent approximate boundaries between soil types; actual transitions are often gradual. The test pit logs and gradation curves are enclosed.

5. Site Conditions

Geologic Setting:

Haines is located on a peninsula dividing two inlets branching from a navigable fjord called the Lynn Canal that is collocated with the Chatam Straight Fault. This fault is a strand of the Denali fault where underwater and the Chilkat fault where it extends onto land. In the Haines area, the fault separates on the west a package of metasedimentary, metavolcanic and metaplutonic rocks which have been subjected to low grade metamorphism from rocks to the east affected by high temperature and pressure events associated with the emplacement of the coast range. In the Haines area, activity has been noted on this fault although elsewhere it is considered inactive.

Southeastern Alaska lies in one of the two most seismically active zones in Alaska, a state where 6 percent of the world's shallow earthquakes have been recorded. Between 1899 and 1970, five earthquakes having magnitudes of 8 or greater have occurred in or near southeastern Alaska or in adjacent offshore areas (Lemke, 1975). In November 1987, an earthquake measuring 5.3 on the Richter scale had an epicenter at Haines. Haines lies within Seismic Zone III. It is possible that if the area is strongly shaken by an earthquake, that the harbor facilities and other man made structures in low-lying parts of the city may be the most heavily damaged. Non-engineered loose fills placed along the shore to elevate low-lying areas are expected to be subject to comparatively strong shaking. These areas are also subject to settlement, possible liquefaction, water-sediment ejection, ground fracturing, and landsliding.

Surface:

The tidal fluctuation at Haines ranges approximately from MLLW of 0.0 m and MHHW of 5.12 m on U.S. Coast and Geodetic Survey records. The proposed harbor sites are located within this intertidal zone and the subtidal zone. No bedrock was observed at the project sites.

Portage Cove South

One test pit, TP-2001 was excavated in this area. Access was difficult because of obstacles posed by a field of boulders with dimensions up to 1.5 m.

Portage Cove North

Thirteen test pits were excavated in this area. The surface is covered with silty sand, gravel, cobbles, boulders and marine vegetation. Many boulders have dimensions up to 1.5 m. The boulders are subrounded to subangular, hard, metamorphic and plutonic.

In the grassy upland area, a clay unit intersects the surface at an elevation of about 1.5 m.

Subsurface:

General

Within the intertidal zone of the areas of interest, the primary soil types encountered during the exploration or reported during dredging the city harbor are 1) diamicton, 2) interlayered silts and sands, 3) silty sand with gravel, cobbles and boulders, and 4) lean clay which locally contains gravel, cobbles and/or boulders. Diamicton is composed of poorly sorted or unsorted sediments that consist of particles from sand to boulder sizes in a matrix of fine sand, silt and/or clay. It is consolidated, typically has the appearance of concrete, and could be likened to an aggregate filled, hard mudstone. Its hardness is attributed to compression by Pleistocene glaciers. A second soil type consists of alternate layers of compacted silt and sand with minor gravel lenses that was reported during harbor dredging. A silty sand with gravel, cobbles, boulders and marine vegetation generally mantles the project areas and ranges in thickness from 0.15 m to about 1 m. A lean clay was encountered north of the existing harbor and is gray, plastic, and relatively soft to stiff.

Portage Cove South

The surfacial silty sand with gravel was encountered in TP-2001 to a depth of 1.2 m. Diamicton was encountered below the sand and became increasingly hard until refusal at 1.3 m below ground surface. The diamicton is composed of about 30% gravel, 50% sand and 20% fines.

Portage Cove North

The surfacial silty sands with gravel were typically encountered to a depth of 0.2 m on the north side of the city harbor. Lean clay with a sand fraction of less than 5% was encountered below the surfacial sand to the limit of the test pits. This clay is massive except for some thin beds of sand and shells in test pits TP-2007 and TP-2008. Boulders were embedded in the clay in five of the test pits.

6. **Discussion and Analysis**

Several circumstances pose a risk for the proposed construction of the breakwater. These include:

1) the possible presence of undiscovered bedrock,

2) the possible extended presence of diamicton at the south site,

3) the possible settlement of breakwater structures,

4) the stability of entrance channel and harbor basin side slopes.

These items are discussed below:

Bedrock: The precipitous nature of the upland topography at Haines suggests that underwater topography may be similarly irregular and that the potential in the project area for submerged rock exists. Previous work in the area of the current harbor did not encounter bedrock. The possible presence of bedrock is always a major concern during dredging operations. Its removal requires expensive underwater drilling and blasting. It would be advisable to conduct a seismic survey to confirm the absence of bedrock, the density of and distribution of sediments, as well as to delineate the occurrence(s) of diamicton. The occurrence of identified bedrock and the need to minimize its effect on project costs could influence the selection of the site and the geometry of the harbor.

Diamicton: The presence of diamicton encountered in TP-2001 is another dredging concern. Its removal is not as expensive as bedrock, but it is reported to be about 2 to 3 times that of conventional dredging. Dredging of diamicton is difficult due to its hard, dense nature and due to possibly

embedded cobbles and boulders. It is often considered dredgeble with appropriate equipment (ie, large backhoes), but slower progress or even a need to blast should be expected. As with bedrock presence, the harbor basin and entrance channel should be positioned to minimize quantities of diamicton requiring removal. Again, the dredging quantities must be accurate and sufficient geotechnical data concerning the nature of material to be removed is imperative.

Settlement: Based on field observations recorded in the central and northern project area (the Portage Cove North proposal), consideration should be given to a settlement study. Lean clay is the dominant material underlying the project area north of the existing harbor. In general, this clay is massive and extends below the limit of this exploration. (This clay only partially occurred at the current harbor site. For example, Felix Toner described a strata or pocket of firm clay in the northeast corner of the current harbor, and indicates that to the south the soils consist of interlayered silt and sand).

Stability: The side slopes of the entrance channel and harbor basin will be influenced by tidal fluctuation and wave erosion as well as soil type. These conditions should be taken into account when selecting slope angles. Another consideration is structures constructed near the top of the side slopes. These structures should be offset an adequate distance to insure stability.

7. **Recommendations**

The construction of a small boat harbor at the sites can be accomplished. However, several conditions and construction aspects should be carefully assessed. It is recommended that a detailed geotechnical exploration be performed once the final harbor site has been selected. The exploration should focus on identifying the boundaries between the shore deposits, diamicton, and bedrock, if present. It is recommended that the exploration include geophysical techniques as well as test borings and test pits. An undisturbed sample of the lean clay should be obtained from the proposed harbor site for characterization. Side slopes considered appropriate for design are 3H:1V for the shore deposits, 2H:1V for the diamicton, and 1H:4V for bedrock. For preliminary design purposes, it is recommended that structures be offset a minimum of 3.0 m from the top of dredged side slopes.

Enclosures:

1. Vicinity Map
2. Test Pit Location Map
3. Test Pit Logs (TP-2001 through TP-2014)
4. Grain-Size Distribution Curves
5. Photographs

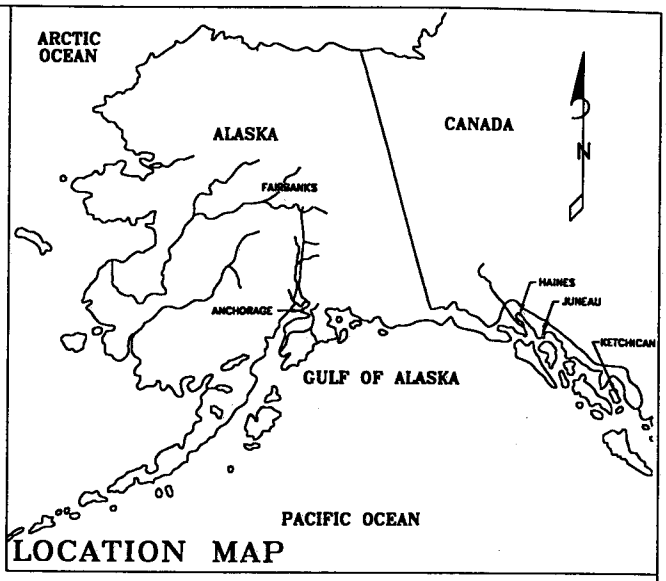
REFERENCES:

Lemke, Richard, 1975, U. S. Geological Survey Openfile Report 75-250, "Reconnaissance Engineering Geology of the Ketchikan Area, Alaska, with Special Emphasis on Evaluation of Earthquake and Other Geologic Hazards".

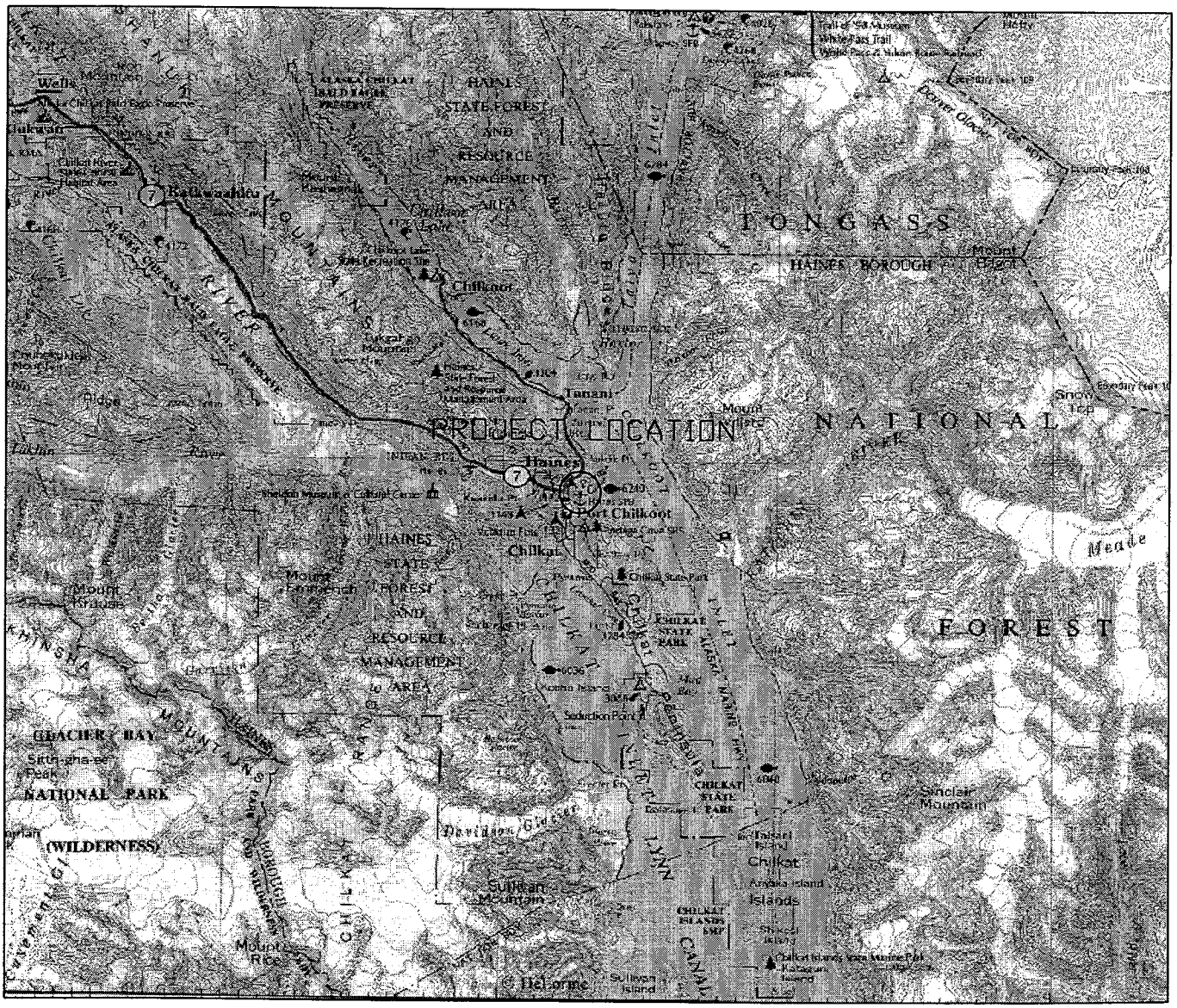
Hudson Travis, George Plafker, and Kirk Dixon, 1980, Geological Survey Circular 844, "Horizontal Offset History of the Chatham Strait Fault".

Toner, Felix J., 1957, "Subsurface Investigation, Small Boat Harbor Site Haines, Alaska". This work also reports the results of Project Aaa. 50-4-290 directed by Daniel Cole.

CORPS OF ENGINEERS



LOCATION MAP



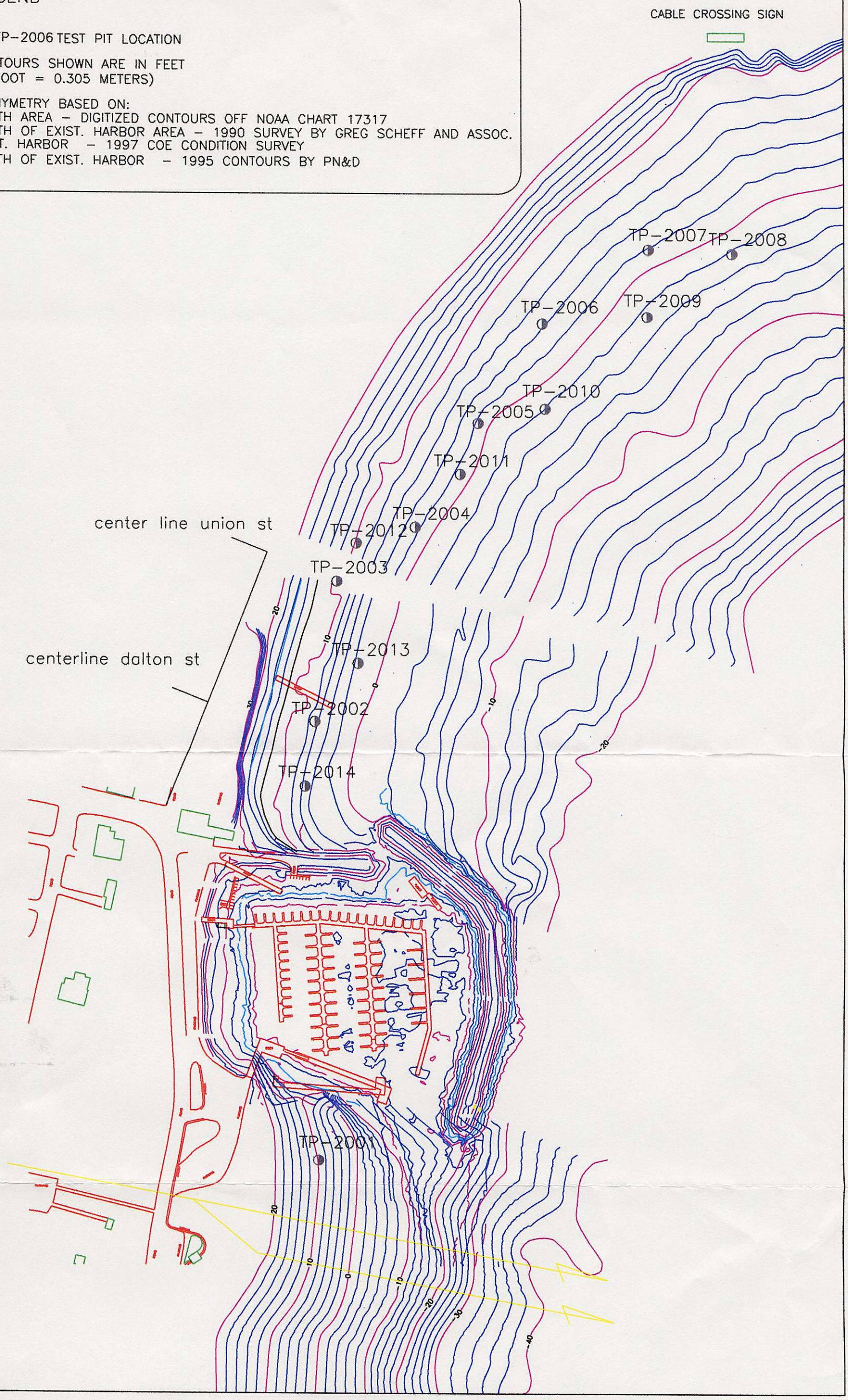
ALASKA DISTRICT CORPS OF ENGINEERS ENGINEERING SERVICES	PROJECT LOCATION MAP HAINES SMALL BOAT HARBOR HAINES, ALASKA	SCALE: N.T.S. DATE: MARCH 2001 DRAWN/RVW: JMR/CRW

LEGEND

◑ TP-2006 TEST PIT LOCATION

CONTOURS SHOWN ARE IN FEET
(1 FOOT = 0.305 METERS)

BATHYMETRY BASED ON:
NORTH AREA – DIGITIZED CONTOURS OFF NOAA CHART 17317
NORTH OF EXIST. HARBOR AREA – 1990 SURVEY BY GREG SCHEFF AND ASSOC.
EXIST. HARBOR – 1997 COE CONDITION SURVEY
SOUTH OF EXIST. HARBOR – 1995 CONTOURS BY PN&D



ALASKA DISTRICT
CORPS OF ENGINEERS
Soils and Geology Section

TEST PIT LOCATION MAP
HAINES SMALL BOAT HARBOR
HAINES, ALASKA

SCALE: 1:300
DATE: APRIL, 2001
DRAWN/RVW: JMR/CRW

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,199 m* Easting: *717,415 m*

Top of Hole Elevation: *2.7 m*

Hole Number, Field: *TP-1*

Permanent: *TP-2001*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *1.3 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
														Surface: Boulders, cobbles, marine vegetation
0		1		F4	Grab	SM	**Silty SAND with Gravel and Cobbles**	23	47	30	76.2		6	**Gray, wet, rounded gravel and cobbles, fine to coarse sand, nonplastic fines**
1		2		F2	Grab	SM	**Silty SAND with Gravel**	33	48	19	38.1		8	**Gray, moist, subrounded to rounded gravel, fine to coarse sand, nonplastic fines, hardens to refusal (diamicton) at 1.28 m**
2														**Above test pit coordinates have been obtained from the drawing and are approximate.**
3														**Bottom of Hole 1.3 m**
4														**Elevation 1.5 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,550 m* Easting: *717,413 m*

Top of Hole Elevation: *1.5 m*

Hole Number, Field: *TP-2* Permanent: *TP-2002*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.7 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
														Surface: Boulders, cobbles, gravel, sand, marine vegetation, shells
						SM	**Silty SAND with Gravel, Cobbles and Boulders**				914.4			**Gray, moist, rounded gravel with cobbles and boulders, fine to coarse sand, nonplastic fines**
		1			Grab	CL	**Lean CLAY**							**Gray, moist, plastic fines**
1														**Elliptical shaped boulder with large axis of .51 m at 1.2 m BGS**
		2			Grab	CL	**Lean CLAY with Boulders**				508.0			**Gray, moist, plastic fines**
2														**Rounded 0.9 m boulder at 2.7 m BGS**
		3			Grab	CL	**Lean CLAY with Boulders**							**Gray, moist, plastic fines, stiff**
3														
4														**Above test pit coordinates have been obtained from the drawing and are approximate. Bottom of Hole 3.7 m Elevation -2.1 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,662 m* Easting: *717,430 m*

Top of Hole Elevation: *1.5 m*

Hole Number, Field: *TP-3* Permanent: *TP-2003*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other ☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *4.0 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
					Grab	SM	**Silty SAND with Gravel, Cobbles and Boulders**				914.4			**Surface: boulders, cobbles, gravel, sand, marine vegetation** **Gray, moist, rounded to subrounded gravel, cobbles and boulders, fine to coarse sand, nonplastic fines**
1		1												
		2			Grab	CL	**Lean CLAY**							**Gray, moist, plastic fines, stiff**
2														
		3			Grab	CL	**Lean CLAY with Boulders**				914.4			**Gray, moist, plastic fines, stiff**
3														
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 4.0 m** **Elevation -2.4 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,704 m* Easting: *717,493 m*

Top of Hole Elevation: *0.9 m*

Hole Number, Field: *TP-4*

Permanent: *TP-2004*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.4 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
0		1			Grab	SM	Silty SAND with Gravel, Cobbles and Boulders				1524.0			Surface: Boulders, cobbles, gravel, sand, marine vegetation Gray, moist, subrounded gravel with cobbles and boulders, fine to coarse sand, nonplastic fines
1		2			Grab	CL	Lean CLAY				19.1			Gray, moist (drier than samples to the east), plastic fines
2														
3		3		F4	Grab	CL	Lean CLAY	0	4	96			23	Gray, moist, LL = 30 PI = 10
4														Above test pit coordinates have been obtained from the drawing and are approximate. Bottom of Hole 3.4 m Elevation -2.4 m
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,787 m* Easting: *717,543 m*

Top of Hole Elevation: *0.0 m*

Hole Number, Field: *TP-5* Permanent: *TP-2005*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *4.0 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
		1			Grab	CL	**Lean CLAY with Boulders**				914.4			**Surface: Boulders, cobbles, gravel, sand, marine vegetation** **Green, moist, boulders, plastic fines**
1		2			Grab	CL	**Lean CLAY**							**Green, moist (drier than holes to NE), plastic fines**
2														
		3		F4	Grab	CL	**Lean CLAY**	0	4	96			31	**Green, wet, LL=36 PI=17, stiff**
3														
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 4.0 m** **Elevation -4.0 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*, *Haines, Alaska*

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,794 m* Easting: *717,726 m*

Top of Hole Elevation: *0.9 m*

Hole Number, Field: *TP-6* Permanent: *TP-2006*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.8 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
		1		F2	Grab	SM	Silty SAND with Gravel				6.4			Surface: Shells, kelp, sand ripples Gray, subrounded gravel, fine to coarse sand, moderately plastic fines
1		2		F4	Grab	CL	Lean CLAY							Gray-green, moist, plastic fines
2														
		3		F4	Grab	CL	Lean CLAY							Gray-green, moist, plastic fines
3														
4														Above test pit coordinates have been obtained from the drawing and are approximate. Bottom of Hole 3.8 m Elevation -2.9 m
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,925 m* Easting: *717,678 m*

Top of Hole Elevation: *2.1 m*

Hole Number, Field: *TP-7* Permanent: *TP-2007*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.8 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
					Grab	SP	**Poorly graded SAND with Gravel, Cobbles and Boulders**				1828.8			**Surface: Boulders, cobbles, gravel, sand, shells, marine vegetation** **Gray, moist, subrounded gravel with cobbles and boulders, fine to coarse sand, nonplastic fines**
1		1												
		2			Grab	CL	**Lean CLAY**							**Gray, moist, fine sand, plastic fines, some shells**
2														
3		3		F4	Grab	CL	**Lean CLAY**							**Gray, moist, fine sand, plastic fines**
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.8 m** **Elevation -1.7 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,922 m* Easting: *717,746 m*

Top of Hole Elevation: *-0.6 m*

Hole Number, Field: *TP-8* Permanent: *TP-2008*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.7 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
0					Grab	SM	**Silty SAND with Gravel, Cobbles and Boulders**				1828.8			**Surface: Boulders, cobbles, sand, shell fragments, marine vegetation** **Gray, wet, subrounded gravel with cobbles and boulders, fine to coarse sand, nonplastic fines**
1		1												
		2			Grab	CL	**Lean CLAY**							**Gray, wet, plastic fines, shell fragments**
2														
		3			Grab	CL	**Lean CLAY**							**Gray, wet, plastic fines, rare lenses of shell fragments**
3														
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.7 m** **Elevation -4.3 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section
EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,873 m* Easting: *717,678 m*

Top of Hole Elevation: *-0.6 m*

Hole Number, Field: *TP-9* Permanent: *TP-2009*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.5 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
0					Grab	SM	**Silty SAND with Gravel and Cobbles**				76.2			**Surface: Boulders, cobbles, gravel, shells, marine vegetation** **Gray, moist, subrounded gravel with cobbles, fine to coarse sand, moderately plastic fines**
1		1												
1					Grab	CL	**Lean CLAY**							**Gray, moist, plastic fines**
2		2												
2														
3		3			Grab	CL	**Lean CLAY**							**Gray, moist, plastic fines**
3														
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.5 m** **Elevation -4.1 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,800 m* Easting: *717,596 m*

Top of Hole Elevation: *-0.9 m*

Hole Number, Field: *TP-10* Permanent: *TP-2010*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other ☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.5 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
					Grab	SM	**Silty SAND with Gravel, Cobbles and Boulders**				1219.2			**Surface: Boulders, cobbles, sand, shells and marine vegetation** **Gray, moist, subrounded gravel with cobbles and boulders, fine to coarse sand, nonplastic fines**
1		1												
		2		F4	Grab	CL	**Lean CLAY**		3	97			30	**Gray-green, moist, plastic fines, LL = 31 PI = 12**
2														
					Grab	CL	**Lean CLAY**							**Gray-green, moist, plastic fines**
3		3												
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.5 m** **Elevation -4.4 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Page 1 of 1
Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,747 m* Easting: *717,529 m*

Top of Hole Elevation: *-0.3 m*

Hole Number, Field: *TP-11* Permanent: *TP-2011*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.8 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
0		1			Grab	SM	**Silty SAND with Gravel and Cobbles**				76.2			**Gray, moist, subrounded gravel with cobbles, fine to coarse sand, nonplastic fines**
1		2			Grab	CL	**Lean CLAY**							**Gray-green, moderately plastic fines**
2														
3		3			Grab	CL	**Lean CLAY with Boulders**				609.6			**Gray-green, moist, plastic fines**
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.8 m** **Elevation -4.1 m**
5														
6														

Surface: Boulders, cobbles, gravel, marine vegetation

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,692 m* Easting: *717,446 m*

Top of Hole Elevation: *2.1 m*

Hole Number, Field: *TP-12* Permanent: *TP-2012*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other ☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.5 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	Grain Size %Sand	Grain Size %Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
		1			Grab	SM	**Silty SAND with Gravel and Cobbles**				76.2			**Surface: Boulders, cobbles, sand, shell fragments, marine vegetation** **Gray, moist, subrounded gravel with cobbles, fine to coarse sand, nonplastic fines, shell fragments**
1		2			Grab	CL	**Lean CLAY**							**Gray, moist, plastic fines**
2														
		3		F4	Grab	CL	**Lean CLAY with Boulders**	0	3	97	457.2		25	**Gray, moist, LL = 30 PI = 11**
3														
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.5 m** **Elevation -1.4 m**
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,596 m* Easting: *717,447 m*

Top of Hole Elevation: *0.3 m*

Hole Number, Field: *TP-13* Permanent: *TP-2013*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.4 m*

Hammer Weight:

Split Spoon I.D.:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
		1			Grab	SM	Silty SAND with Gravel, Cobbles and Boulders				1219.2			Gray, moist, subrounded gravel with cobbles and boulders, fine to coarse sand, moderately plastic fines
1														Cobble to 0.09 m at 1.07 m BGS
		2		F4	Grab	CL	Lean CLAY	4	10	86	19.1		23	Gray-green, moist, fine to coarse sand, LL = 27 PI = 9
2														
3		3			Grab	CL	Lean CLAY							Gray-green, moist, plastic fines
4														Above test pit coordinates have been obtained from the drawing and are approximate. Bottom of Hole 3.4 m Elevation -3.0 m
5														
6														

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Soils and Geology Section

EXPLORATION LOG

Project: *Haines Small Boat Harbor*
Haines, Alaska

Date: *9 Sep 2000*

Drilling Agency: ☐ Alaska District ☒ Other *Southeast Road Builders*

Elevation Datum: ☒ MSL ☐ other

Location: Northing: *825,497 m* Easting: *717,404 m*

Top of Hole Elevation: *1.2 m*

Hole Number, Field: *TP-14* Permanent: *TP-2014*

Operator: *Mike Murphy*

Inspector: *Jim Robson*

Type of Hole: ☐ other _____
☒ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater:

Depth Drilled:

Total Depth: *3.8 m*

Hammer Weight:

Split Spoon I.D:

Size and Type of Bit:

Type of Equipment: *Cat 307 with 0.46 m Bucket*

Type of Samples: *Grab*

Depth (m)	Lithology	Sample	Frozen ASTM D 4083	Frost Class. TM 5-822-5	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	Max Size (mm)	PID (ppm)	% Water	Description and Remarks
														Surface: Boulders, cobbles, gravel, wood debris
0		1			Grab	SM	**Silty SAND with Gravel, Cobbles and Boulders**				914.4			**Gray, moist, subrounded gravel with cobbles and boulders, fine to coarse sand, moderately plastic fines**
1		2			Grab	CL	**Lean CLAY with Boulders**				457.2			**Gray, moist, boulders, plastic fines**
2														
3		3		F4	Grab	CL	**Lean CLAY with Boulders**		5	95	457.2		19	**Boulder to 0.46 m at 2.7 m BGS** **Gray, moist, subrounded gravel, LL=29 PI=10**
4														**Above test pit coordinates have been obtained from the drawing and are approximate.** **Bottom of Hole 3.8 m** **Elevation -2.6 m**
5														
6														

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

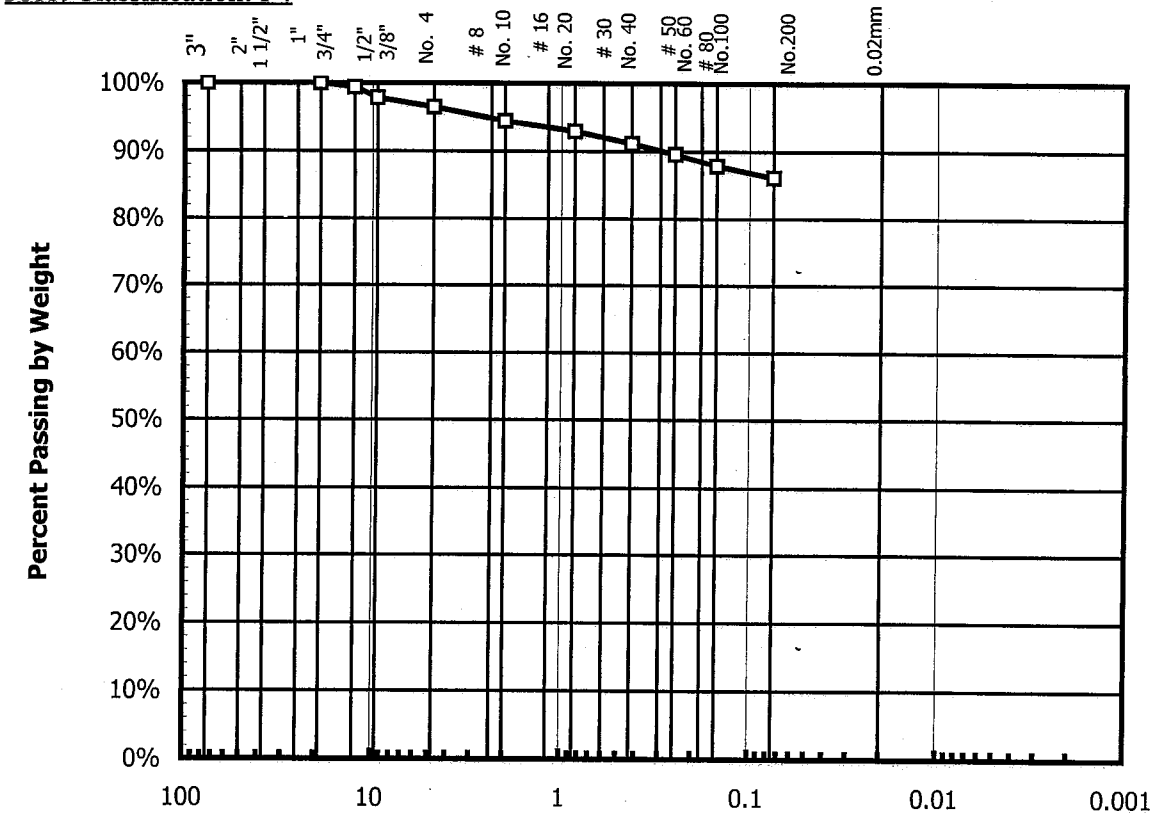
Location: Pit No. 13, SA-2 @ ~~9.0'-10.0'~~ 5.0-6.0' BP

Submitted by Client

LL = 27, PI = 9, Moisture Content = 23.4%

Engineering Classification: Lean CLAY, CL

Frost Classification: F4



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2191

Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"	100%	
1/2"	99%	
3/8"	98%	
No. 4	96%	
Total Wt. = 727.6g		
No. 8		
No. 10	94%	
No. 16		
No. 20	93%	
No. 30		
No. 40	91%	
No. 50		
No. 60	90%	
No. 80		
No. 100	88%	
No. 200	86%	
Total Wt. of Fine Fraction = 0g		
0.02 mm		

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

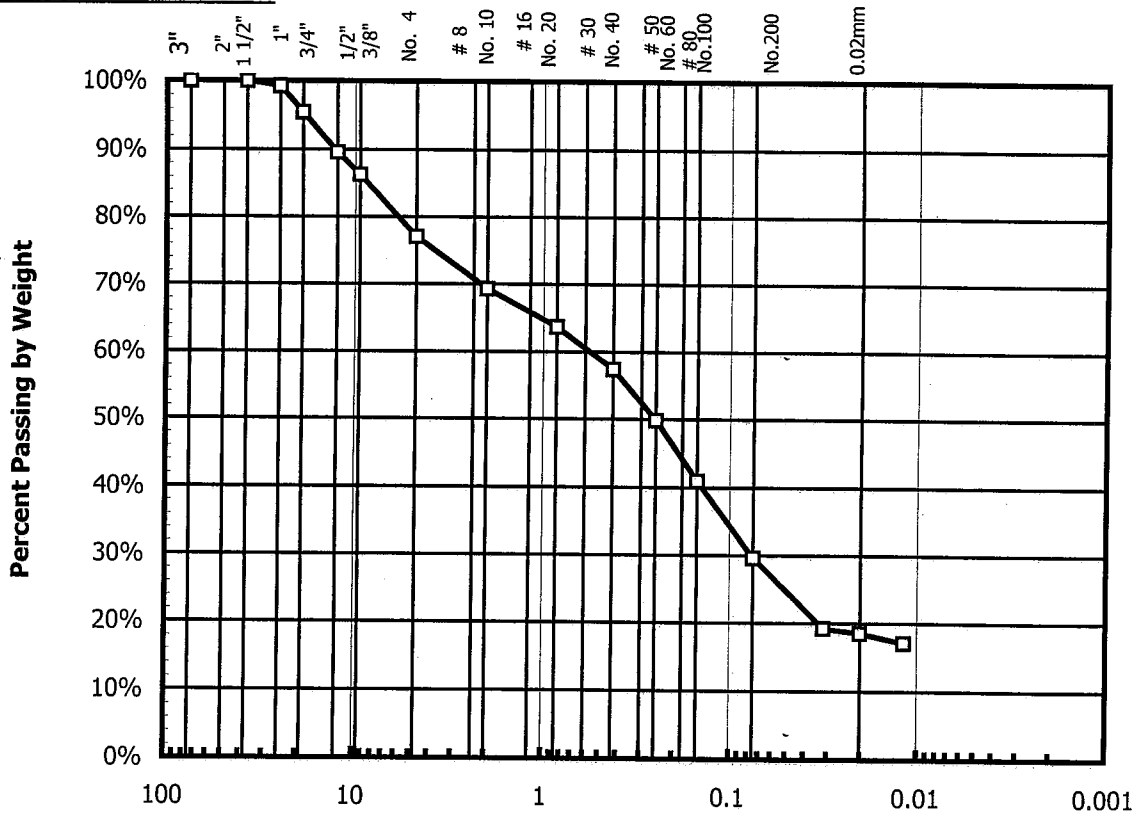
Location: Pit No. 1, SA-1 @ 1.0'-2.0'

Submitted by Client

PI = Non Plastic, Moisture Content = 6.3%

Engineering Classification: Silty SAND with Gravel, SM

Frost Classification: F4



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2187

Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	99%	
3/4"	95%	
1/2"	90%	
3/8"	86%	
No. 4	77%	
Total Wt. = 3591.9g		
No. 8		
No. 10	69%	
No. 16		
No. 20	64%	
No. 30		
No. 40	57%	
No. 50		
No. 60	50%	
No. 80		
No. 100	41%	
No. 200	30%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	18.5%	

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

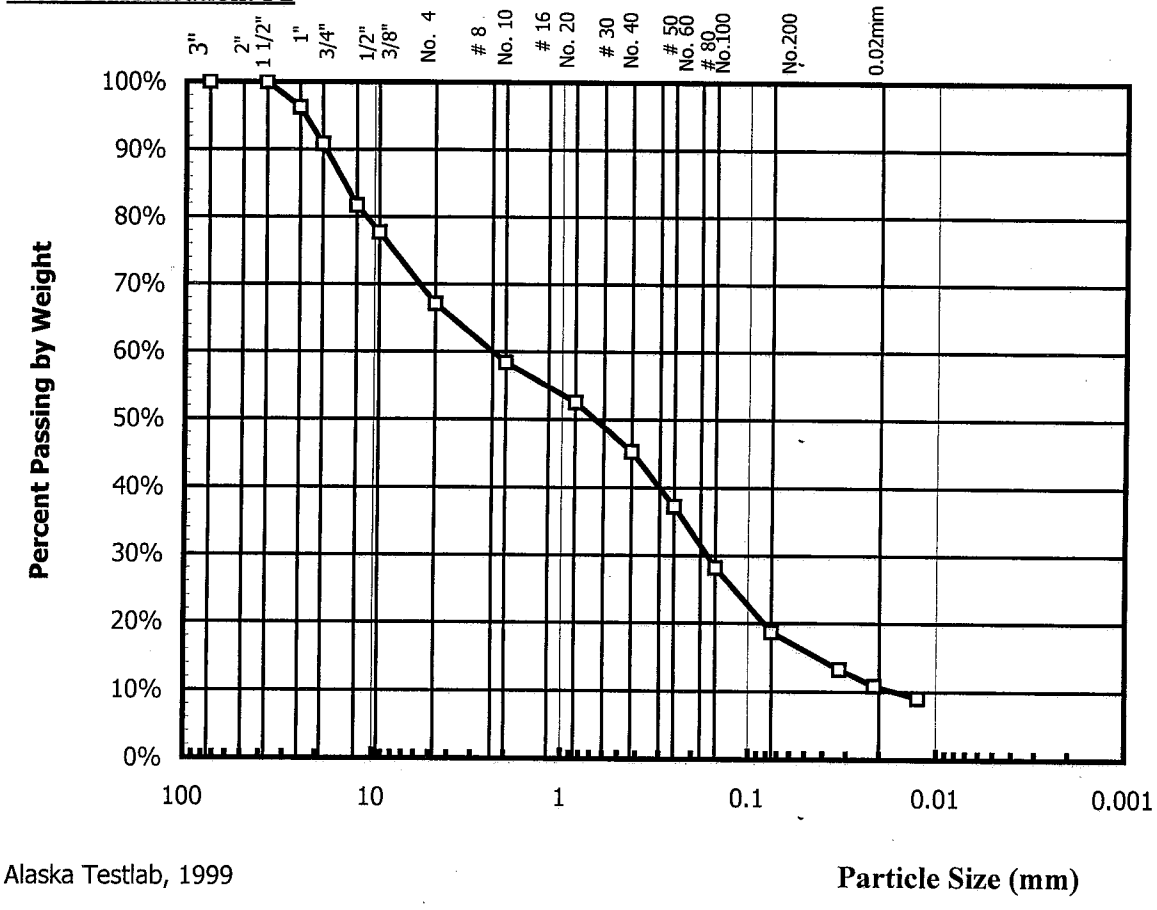
Location: Pit No. 1, SA-2 @ 3.8'-4.2'

Submitted by Client

PI - Non Plastic, Moisture Content = 7.8%

Engineering Classification: Silty SAND with Gravel, SM

Frost Classification: F2



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2186

Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"	100%	
1"	96%	
3/4"	91%	
1/2"	82%	
3/8"	78%	
No. 4	67%	
Total Wt. = 1487.2g		
No. 8		
No. 10	58%	
No. 16		
No. 20	52%	
No. 30		
No. 40	45%	
No. 50		
No. 60	37%	
No. 80		
No. 100	28%	
No. 200	19%	
Total Wt. of Fine Fraction = 0g		
0.02 mm	10.7%	

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

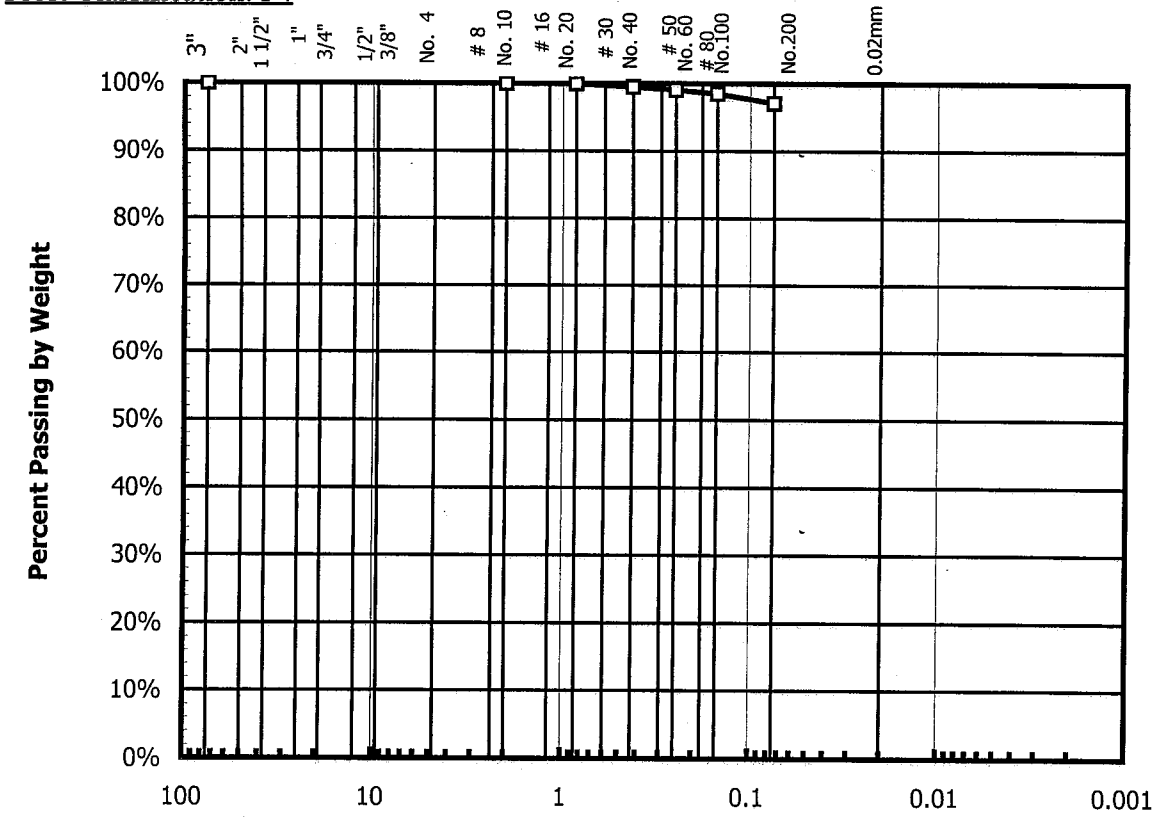
Location: Pit No. 10, SA-2 @ 4.0'-5.0'

Submitted by Client

LL = 31, PI = 12, Moisture Content = 29.9%

Engineering Classification: Lean CLAY, CL

Frost Classification: F4



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2192

Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4		
Total Wt. = 202.8g		
No. 8		
No. 10	100%	
No. 16		
No. 20	100%	
No. 30		
No. 40	99%	
No. 50		
No. 60	99%	
No. 80		
No. 100	98%	
No. 200	97%	
Total Wt. of Fine Fraction = 0g		
0.02 mm		

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

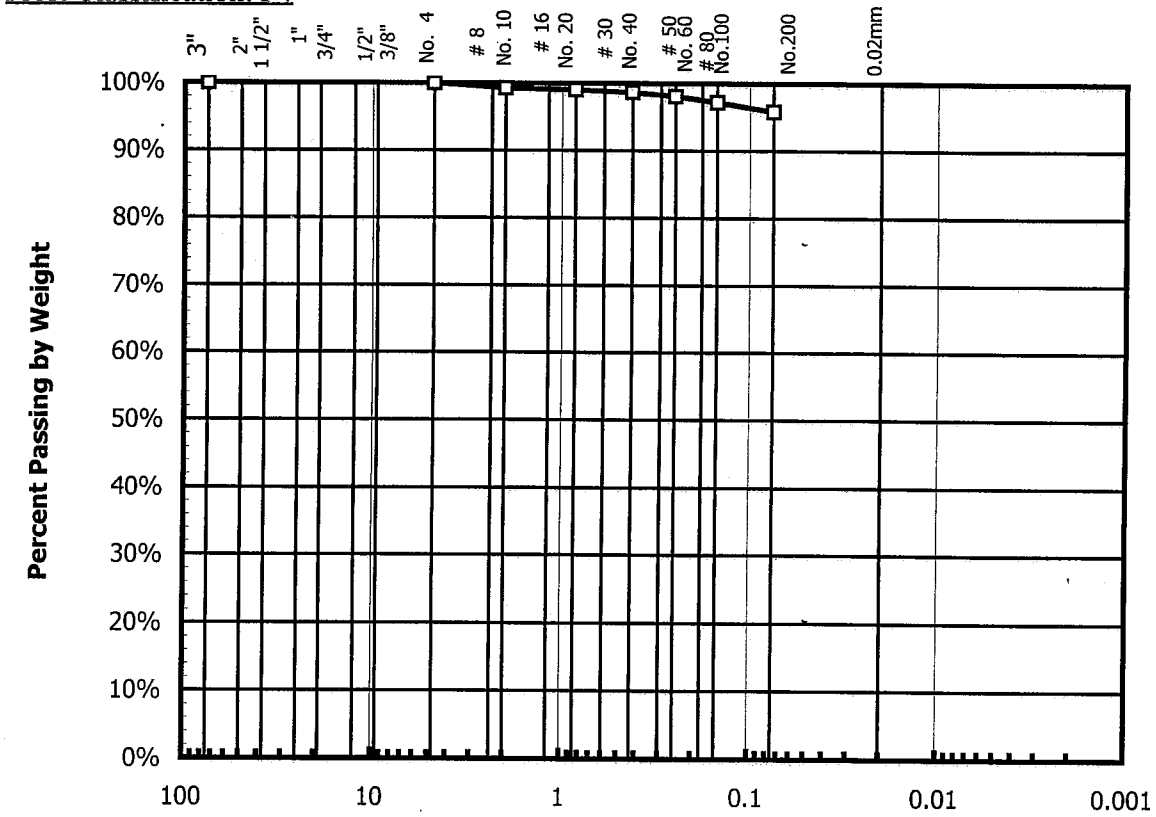
Location: Pit No. 4, SA-3 @ 9.0'-10.0'

Submitted by Client

LL = 30, PI = 10, Moisture Content = 23.2%

Engineering Classification: Lean CLAY, CL

Frost Classification: F4



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2190

Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4	100%	
Total Wt. = 237.6g		
No. 8		
No. 10	99%	
No. 16		
No. 20	99%	
No. 30		
No. 40	99%	
No. 50		
No. 60	98%	
No. 80		
No. 100	97%	
No. 200	96%	
Total Wt. of Fine Fraction = 0g		
0.02 mm		

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

PARTICLE-SIZE

DIST. ASTM D422

Location: Pit No. 5, SA-3 @ 9.0'-10.0'

Submitted by Client

LL = 36, PI = 17, Moisture Content = 30.6%

Engineering Classification: Lean CLAY, CL

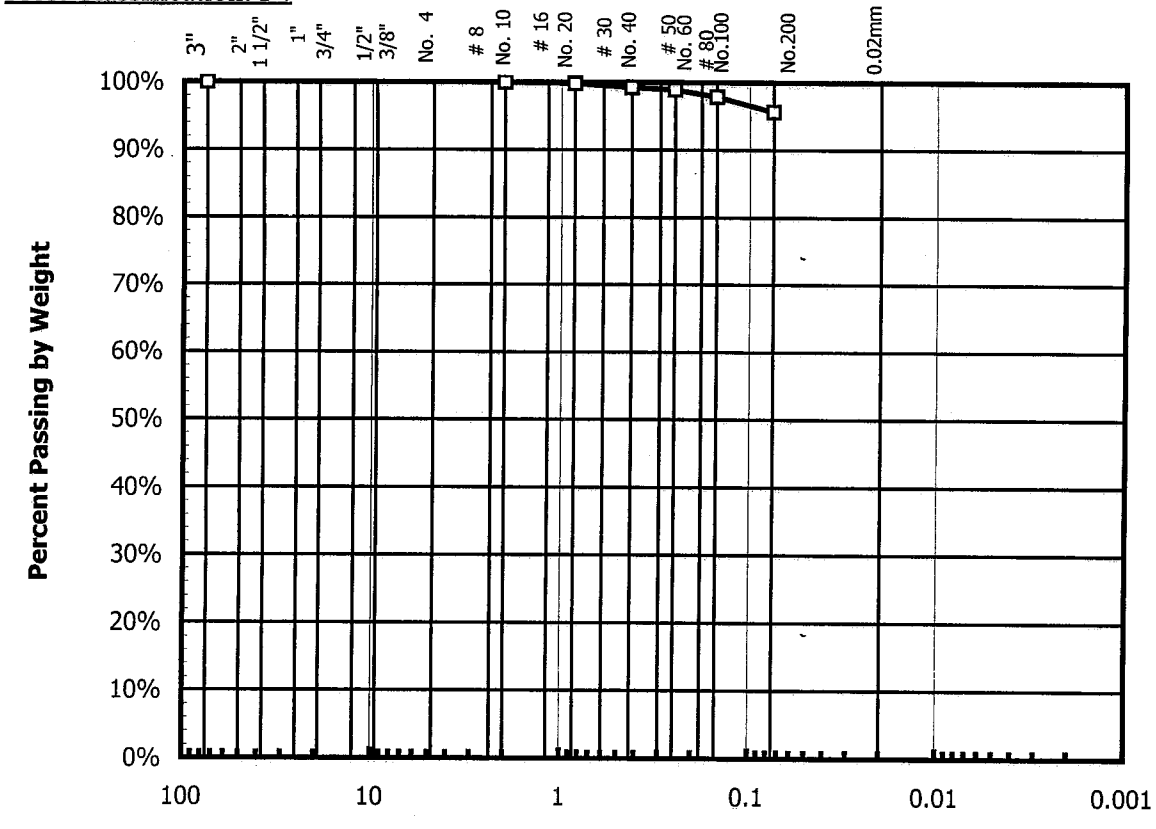
Frost Classification: F4

W.O. A29088

Lab No. 2188

Received: 10/25/00

Reported: 11/4/00



SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4		
Total Wt. = 118.8g		
No. 8		
No. 10	100%	
No. 16		
No. 20	100%	
No. 30		
No. 40	99%	
No. 50		
No. 60	99%	
No. 80		
No. 100	98%	
No. 200	96%	
Total Wt. of Fine Fraction = 0g		
0.02 mm		

© Alaska Testlab, 1999

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

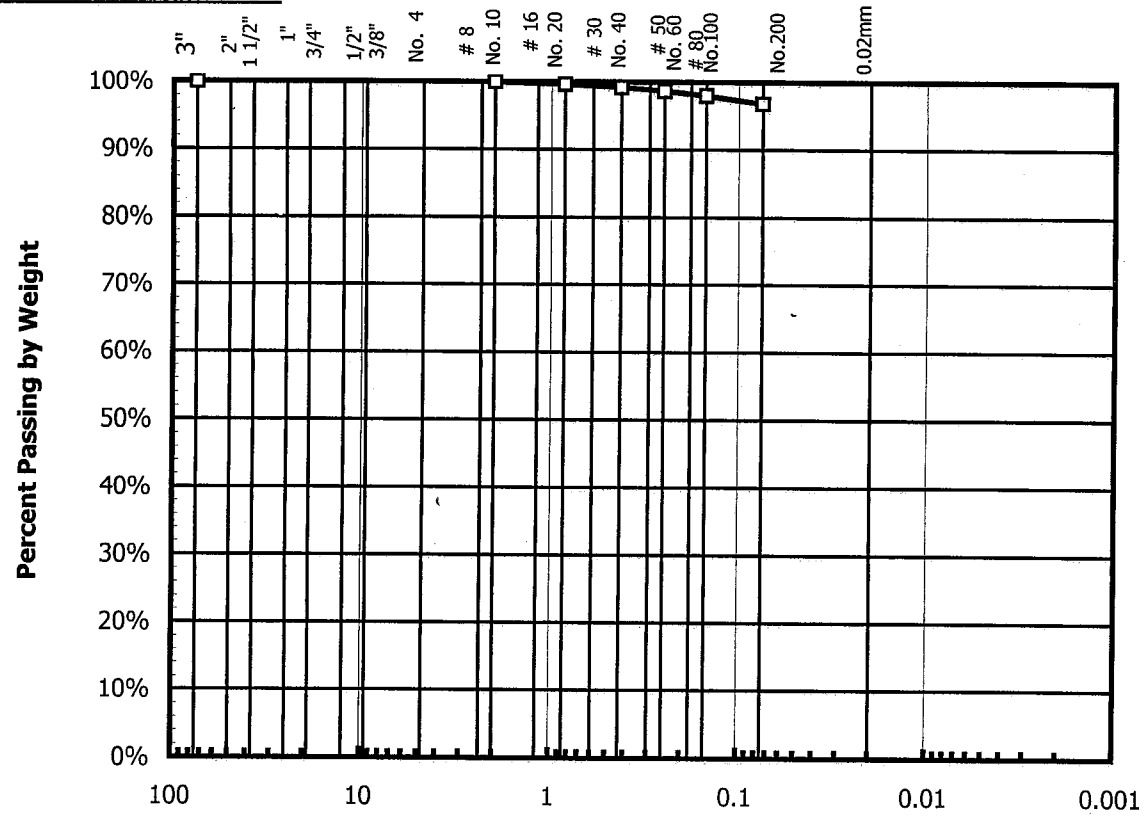
Location: Pit No. 12, SA-3 @ 9.0'-10.0'

Submitted by Client

LL = 30, PI = 11, Moisture Content = 24.5%

Engineering Classification: Lean CLAY, CL

Frost Classification: F4



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2189

Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4		
Total Wt. = 263g		
No. 8		
No. 10	100%	
No. 16		
No. 20	100%	
No. 30		
No. 40	99%	
No. 50		
No. 60	99%	
No. 80		
No. 100	98%	
No. 200	97%	
Total Wt. of Fine Fraction = 0g		
0.02 mm		

David L. Andersen, P.E., General Manager

Client: U. S. Army Corps of Engineers

Project: Haines Small Boat Harbor

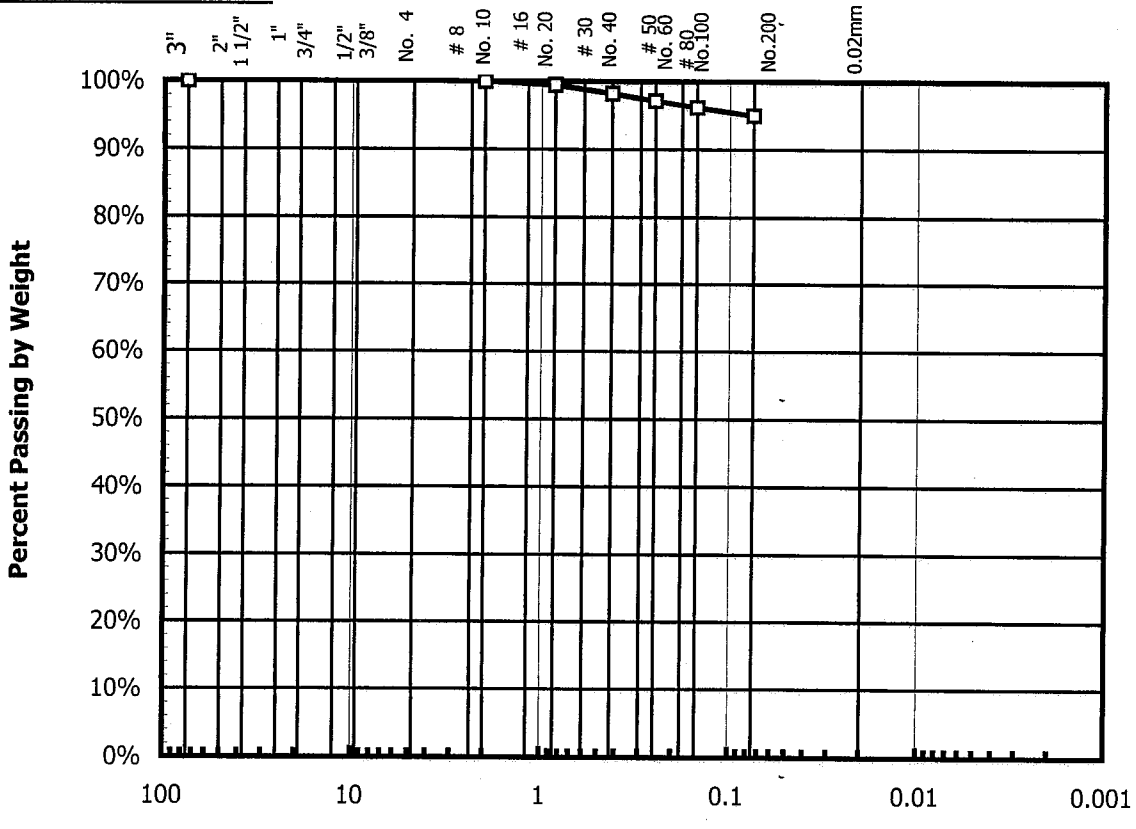
Location: Pit No. 14, SA-3 @ 11.0'-12.0'

Submitted by Client

LL = 29, PI = 10, Moisture Content = 18.6%

Engineering Classification: Lean CLAY, CL

Frost Classification: F4



© Alaska Testlab, 1999

PARTICLE-SIZE

DIST. ASTM D422

W.O. A29088

Lab No. 2193

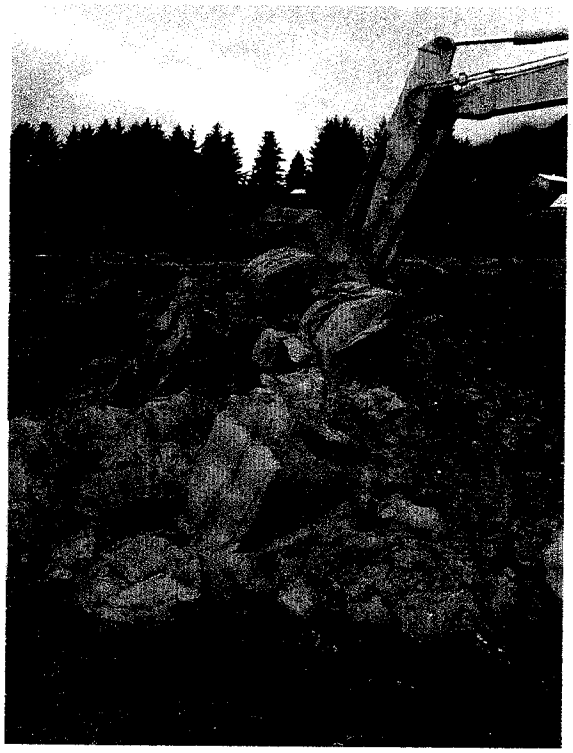
Received: 10/25/00

Reported: 11/4/00

SIZE	PASSING	SPECIFICATION
+3 in Not Included in Test = ~0%		
3"		
2"		
1 1/2"		
1"		
3/4"		
1/2"		
3/8"		
No. 4		
Total Wt. = 187.9g		
No. 8		
No. 10	100%	
No. 16		
No. 20	99%	
No. 30		
No. 40	98%	
No. 50		
No. 60	97%	
No. 80		
No. 100	96%	
No. 200	95%	
Total Wt. of Fine Fraction = 0g		
0.02 mm		

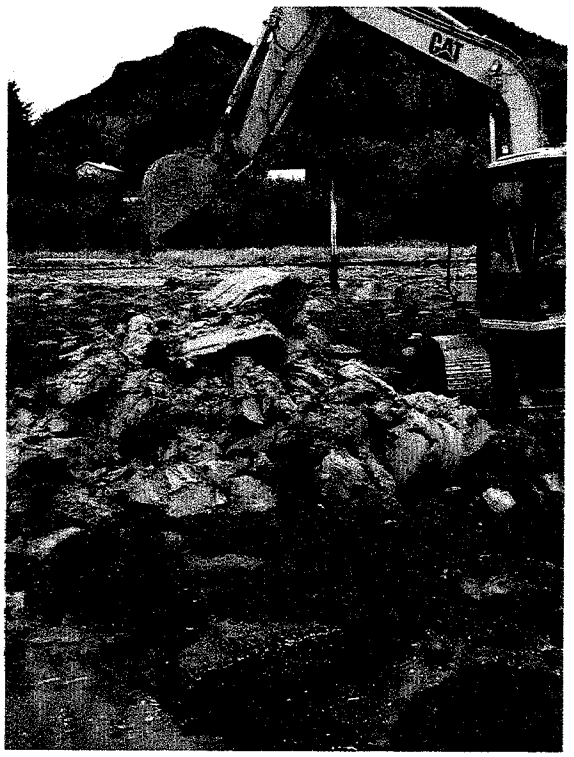
David L. Andersen, P.E., General Manager

TP-2006: Lean Clay Cuttings



TP-2007: Lean Clay Cuttings

TP-2012 Note Boulders Behind Lean Clay Cuttings



TP-2007: Boulders Overlying Lean Clay

HAINES SMALL BOAT HARBOR
IDEALIZED BREAKWATER STABILITY ANALYSIS

Introduction

The Corps of Engineers' Alaska District Hydraulic and Hydrology (H&H) section (CEPOA-EN-CW-HH) requested an idealized stability analysis for a breakwater to be constructed on clay soils at the Haines Small Boat Harbor. The results of the analysis are to be used for project planning, determining costs, and viability. This report is in response to H&H's request.

Proposed Design

Two idealized breakwater designs were used in the analysis. The first had an 8-ft wide crest and the second a 45-ft wide crest. Both breakwater crests were at an elevation of +26 MLLW. Side slopes for both intercepted the mud line at an elevation of –25 MLLW and varied from 1½h:1v to 2h:1v. For purposes of the analysis, the water level was assumed to be –4 MLLW. See Figure 1.

Material Characteristics & Engineering Properties

A test pit reconnaissance exploration was performed at the Haines Small Boat Harbor in May 2001. The purpose of that exploration was to determine the general subsurface characteristics at the site and did not specifically address soil strength parameters. Consequently, assumed unit weight and shear strength values for foundation soils were established from engineering publications based on observations during the test pit exploration.

During the test pit exploration, the clay soils encountered were removed in large blocks taking the shape of the backhoe bucket. Using the standard field test of measuring clay soil strength by indenting a sample by thumb pressure, the geologist classified the clay's consistency as stiff. Published engineering data characterizes the undrained shear strength of a stiff clay from 1000 to 2000 pounds per square foot (psf). The lower shear strength of 1000 psf was used for this analysis.

Method of Analysis and Results

The Corp of Engineers' slope stability program UTEXAS 4 was used to perform the stability analysis. The results of the program were verified by hand calculations.

Since the clay soil is below the lowest tide level a saturated unit weight was assumed. In addition, its shear strength was assumed to be constant with depth. Typical values based on past experience was used for the armor rock. Seismic considerations were not addressed.

Using engineering publications and field observations during the test pit exploration, the following soil properties were assumed for the various construction materials and in-situ conditions:

Soil Description	Weight	Friction Angle	Cohesion
Unit weight of clay, saturated	115 pcf	0 deg.	1000 psf
Unit weight of Saturated Armor Rock	126 pcf	45 deg.	0 psf
Unit weight of Emergent Armor Rock	100 pcf	45 deg.	0 psf

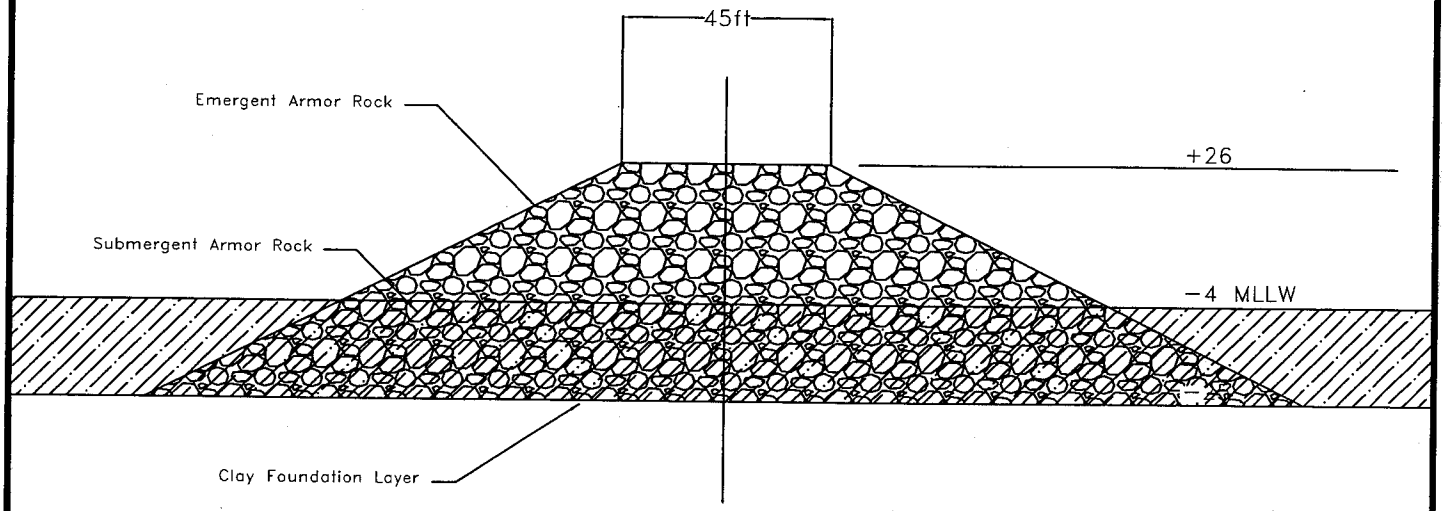
The results of the analysis indicate the clay to be capable of supporting the proposed breakwaters as currently designed. The factors of safety range from 1.3 to 1.6. A factor of safety of 1.4 was computed for 1½h:1v side slopes and 1.6 for 2h:1v side slopes. A factor of safety of 1.3, independent of the two side slopes, was computed for a 45-ft breakwater crest. A minimum value of 1.3 is normally recommended for conditions where there is no threat to human life.

Figure 2 depicts the computed failure plane for the 1½h:1v condition. Note, as expected, the failure is a deep failure within the clay foundation.

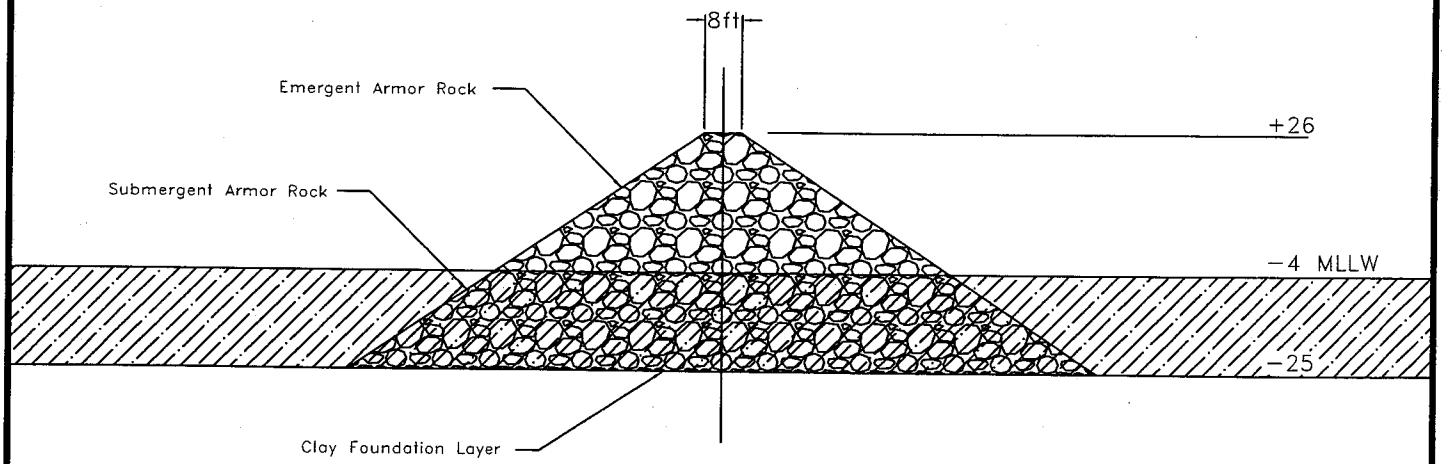
Conclusion

On the basis of the information provided by H&H and the assumed strength parameters, the slope analysis indicates the foundation clay to be capable of supporting the proposed breakwaters.

Since this analysis uses assumed values for the shear strength and unit weight of the clay foundation soils, the results are to be used for preliminary design purposes and are subject to change with additional information. A final analysis will be performed upon completion of a planned future detailed geotechnical investigation of the site. That investigation will include sampling methods to more accurately determine unit weights and strength values of the foundation materials.



2h:1v Side Slopes

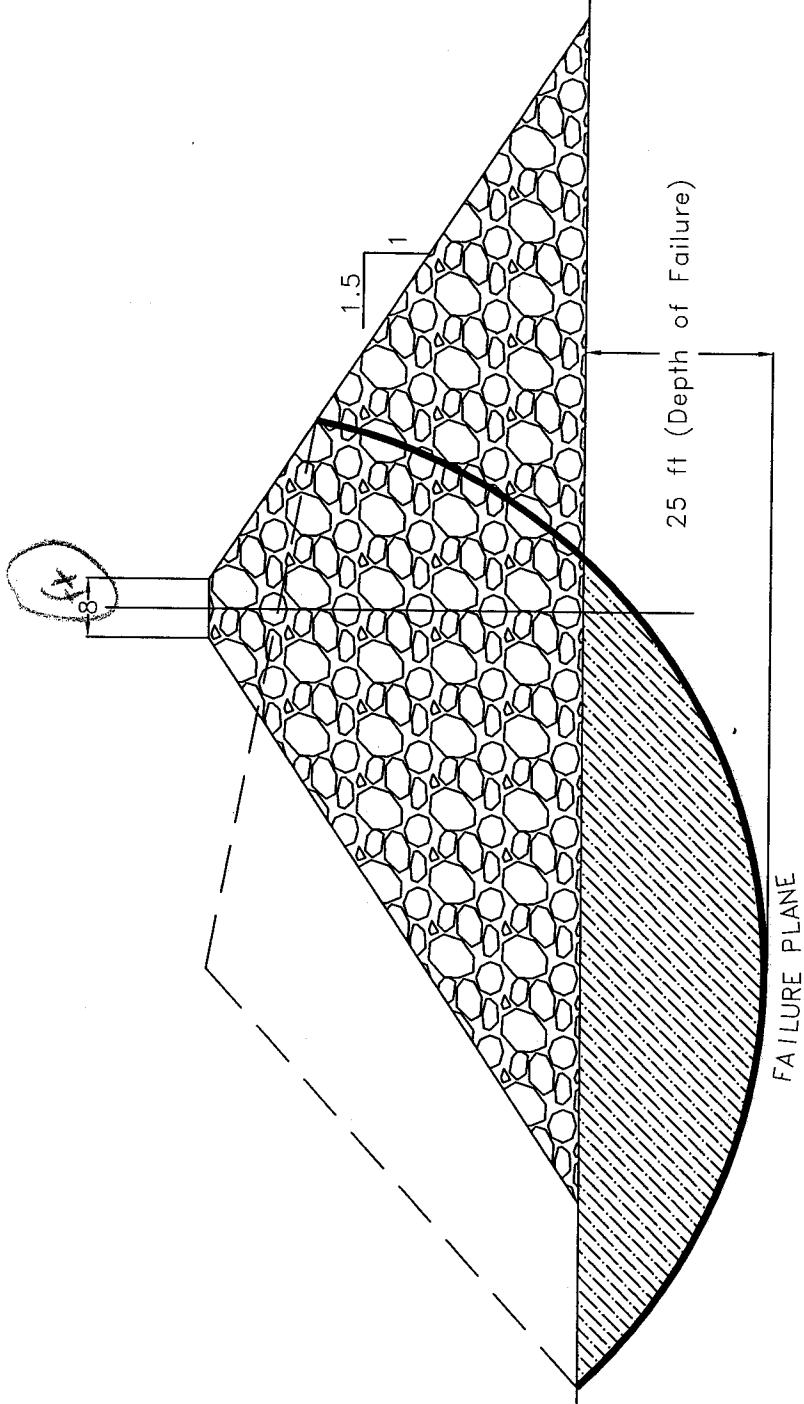


1-1/2h:1v Side Slopes

ALASKA DISTRICT CORPS OF ENGINEERS ENGINEERING SERVICES	BREAKWATER SECTIONS Haines Small Boat Harbor HAINES, ALASKA	SCALE: N.T.S. DATE: FEB. 2002 DRAWN/RVW: SCH/SCH FIGURE 1

CORPS OF ENGINEERS

U.S. ARMY



COMPUTED FACTOR OF SAFETY OF 1.4

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

COMPUTED FAILURE PLANE
Haines Small Boat Harbor
HAINES, ALASKA

SCALE: N.T.S.
DATE: FEB 2002
DRAWN/RVW: SCH/SCH
FIGURE 2