U.S. Army Corps of Engineers
Alaska District
Geotechnical and Materials Section

GEOTECHNICAL FINDINGS REPORT

Entrance Channel Dredging (KOD009)
St. Paul and St. Herman Harbor (10168 & 320418)
Kodiak, Alaska

June 2012

CEPOA-EN-G-GM June 2012

MEMORANDUM FOR CEPOA-CO-O (Julie Anderson)

SUBJECT: Geotechnical Findings Report for the Entrance Channel Dredging Project, Kodiak, Alaska (KOD009) (10168 & 320418)

1. This report was requested by the U.S. Army Corps of Engineers Alaska District Construction and Operations Project Manager Julie Anderson.

2. Enclosed is the Geotechnical Findings Report for the Entrance Channel Dredging Project located at Kodiak, Alaska. Included with the report are the Project Location and Vicinity Map, Test Boring Location Maps, exploration logs, laboratory test results, and a discussion of the findings.

3. Questions should be addressed to John Rajek at 753-5695 or Marcus Palmer at 753-2665.

JAMES W. PEKAR, PE
Chief, Geotechnical Services

GEOTECHNICAL FINDINGS REPORT
Entrance Channel Dredging (KOD009)
St. Paul and St. Herman Harbor (10168 & 320418), Kodiak, Alaska

June 2012

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GEOTECHNICAL FINDINGS REPORT
Entrance Channel Dredging (KOD009)
St. Paul and St. Herman Harbor (10168 & 320418), Kodiak, Alaska

June 2012

1.0 INTRODUCTION

This report documents the results of a geotechnical site investigation performed for the planned dredging at the St. Paul and St. Herman Harbor located at Kodiak, Alaska. The scope of the investigation was to identify surface and subsurface conditions and address geotechnical concerns of the site. This report presents a summary of the findings based on site observations and results of the field exploration and laboratory testing program.

1.1 Project Description and Location

This project consists of dredging the entrance channels within the St. Paul and St. Herman Harbors at Kodiak, Alaska. St. Paul Harbor is located on Kodiak Island southwest and adjacent to the town of Kodiak. St. Herman Harbor is located between Uski Island and Near Island south of the town of Kodiak. Approximately 3,000 cubic yards of dredged material are planned for removal on the base item and an additional 7,200 cubic yards of dredged material are planned for removal under option items. Dredged material will be transported and disposed of within St. Herman Harbor at a designated disposal area. The design dredge limits for the St. Paul and St. Herman Harbors entrance channels are -16 and -12 feet mean lower low water (MLLW), respectively. A project location and vicinity map is enclosed as Figure 1.

1.2 Prior Geotechnical Investigations

A previous marine geotechnical investigation in the north entrance channel of St. Herman Harbor was conducted in 1989 by the U.S. Army Corps of Engineers, Alaska District (USACE-AD). This investigation is presented in the Kodiak Harbor General Design Memorandum dated February 1991. This study was conducted to investigate design options and develop geotechnical parameters for the development of Kodiak Harbor. Pertinent test boring information and results of a petrographic examination from the 1991 USACE-AD report is included in Appendix A and the test boring locations are shown on Figure 3 of this report.

2.0 FIELD EXPLORATION

The geotechnical site investigation for this project was conducted from 3 to 4 April 2012. A total of five test borings were drilled to depths ranging from 4.5 to 16 feet below mudline. These test borings have been designated AP-147 through AP-151.

2.1 Drilling Operations

Drilling operations were conducted on a 24 hour per day basis with a truck-mounted Mobile B-61 drill rig fitted with 4.0-inch inside diameter by 4.5-inch outside diameter HW casing and NQ-3 coring equipment. Drilling services were provided by Denali Drilling, Inc. and the LCM landing craft Cape Douglas, owned and operated by Doug Peterson, was used to access test boring locations. Photograph No.1 shows the placement of drill casing between the loading ramp and landing craft.

Photograph No.1: Drilling operations conducted on the LCM landing craft Cape Douglas.

Engineers with USACE-AD supervised the drilling and logged the tests borings. A chemist from the USACE-AD, Chemistry and Industrial Hygiene section was present during the exploration to collect samples for environmental testing. Test borings were initially advanced by driving HW steel casing into the slightly weathered bedrock with a 340 pound hammer falling 30 inches. The hammer

was operated by the driller using a rope and cathead system. The inside of the HW casing was then cleaned out with a mill tooth tri-cone bit in preparation for sampling beyond the casing's drive shoe. NQ-3 size coring equipment was used to complete the boring after casing refusal was encountered. Casing refusal was established as no observed advancement of the casing during the application of successive blows of the 340 pound hammer.

Wind and wave conditions during the drilling operations caused difficulties with the landing craft being able to maintain a fixed position over the test boring locations. Test boring AP-149, AP-150, and AP-151 had to be terminated early because the landing craft's position was moving beyond the limits of the drilling equipment.

2.2 Field Sampling

Split spoon samples were collected at the surface, 2.5 feet, and at 4.5 feet below mudline using a 2.5-inch inside diameter by 3.0-inch outside diameter sampler driven by a 340-lb hammer falling 30 inches. The hammer was operated by the driller using a rope and cathead system. The split spoon sampler was advanced either 18 or 24 inches beyond the casing or to driving refusal. The number of blows required to drive each six-inch increment is recorded on the exploration logs. Since the split spoon samples were driven into slightly weathered bedrock the blow count values do not represent values that can be correlated with similar samples collected in soil. When casing refusal was encountered the split spoon sampler was replaced with NQ-3 sized coring equipment. The NQ-3 triple-tube core barrel had an inside diameter of 1.625 inches, an outside diameter of 2.95 inches, and a length of 5 feet. The NQ-3 core barrel was advanced between two and five feet per run depending on the depth and sampling interval at which unweathered bedrock was encountered. Rock quality designation (RQD) of drilled cores were assigned in accordance with ASTM D 6032 "Standard Test Method for Determining Rock Quality Designation (RQD) of Rock Cores". Descriptions and classifications of bedrock encountered were conducted in general accordance with the engineering manual EM 1110-1-1804 Geotechnical Investigations and the technical report GL-85-3 Geotechnical Descriptions of Rock and Rock Masses.

2.3 Test Boring Location Survey

Test boring locations were surveyed using standard survey techniques by DOWL Engineers, LLC under contract with USACE-AD. Test boring coordinates are NAD83(CORS96) Alaska State Plane Coordinates, Zone 5, in US Feet. Based on a fully constrained static GPS network holding the 2003 Epoch values of OPUS DB derived stations: "NIC-4 2006" (PID BBBK44) as N 1,388,617.55', E 1,954,333.76'; "SHH-3 2009" (PID BBBk45) as N 1,382,702.24', E 1,950,183.98'; "TDB 125" (PID BBBK43) as N 1,386,072.95', E 1,950,690.54'.

Vertical control refers to the Mean-Lower-Low-Water datum (MLLW=0.0'). The MLLW values shown are based on NOAA/NOS Tidal Station 945 7292, Kodiak Island, Woman's Bay, Alaska, holding USC&GS Bench Mark SBC "No. 16 1964" as 21.42 feet. This value is from Tidal Epoch 1983-2001, published 9/12/2007 for this station. Table 1 provides a list of horizontal and vertical coordinates for the test borings and test boring location maps are included as Figure 2 and 3.

2.4 Historical Test Boring Survey Locations

To bring the 1989 test boring location data forward into the 2009 project condition survey drawing, a horizontal conversion and vertical datum shift was required. Original horizontal control for the 1989 survey was based on a 1980 Photo Mapping project by F.M. Lindsey & Associates; this project held published values on a number of NGS control points based on NAD27 ASP Zone 5 in feet as the basis of their horizontal projection. Corpscon 6.0 was used to convert this control to NAD83 ASP Zone 5 in feet for importing into the 2009 project condition survey drawing. Original vertical control for the 1989 survey was based on NOAA/NOS MLLW data "Southwest Alaska 82-2, Kodiak, Kodiak Island" published 4/8/1970 holding USC&GS Tidal benchmark: "HARBOR MASTER, 1967". A vertical datum shift of +1.61 feet was applied to all soil boring elevations to match the vertical datum of the 2009 survey, based on NOAA/NOS Tidal Station "945 7292, Kodiak Island, Womens Bay, Alaska" and referenced to MLLW based on the 1983-2001 tidal epoch. The vertical datum of shift of +1.61 feet was based on an average difference between 3 common points in both surveys. Table 1 provides the 2009 project condition survey coordinates for test boring DH-11. The elevation reported at DH-11 does not represent the current mudline elevation at that location in the St. Herman Harbor entrance channel because of dredging during the late 1990's.

Table 1: Test Boring Locations

Permanent Test Boring Number	Northing	Easting	Elevation MLLW
AP-147	1,386,409.04	1,950,762.60	-14.0
AP-148	1,386,310.42	1,950,772.33	-13.5
AP-149	1,386,167.82	1,950,850.95	-13.9
AP-150	1,386,081.07	1,950,776.48	-12.8
AP-151	1,386,165.52	1,950,849.40	-14.2
DH-11	1,385,114.67	1,950,936.18	-8.29

Vertical Datum: 2009 Project Condition Survey, Mean-Lower-Low-Water (MLLW=0.0') U.S. feet
Horizontal Datum: NAD83 Alaska State Plane Zone 5 U.S. feet

3.0 LABORATORY TESTING AND SOILS CLASSIFICATION

A laboratory testing program was established to classify and determine the physical and engineering properties of the bedrock encountered on site. The program consisted of determining the relative density, absorption, and a petrographic examination of the bedrock encountered. The testing program used the latest version of the test methods found in Table 2. Laboratory test results are provided in Appendix B. Samples collected for environmental contamination testing were used to characterize the dredge material for disposal. The chemical testing results from these samples are presented separately in the trip report titled "St. Paul Harbor Sediment Investigation, Kodiak, Alaska (12-026)" dated June 2012, prepared by the USACE-AD Chemistry and Industrial Hygiene section. All samples tested were reported suitable for open water disposal.

Table 2: Laboratory Test Methods

Test Designation	Test Description
ASTM C 127	Standard Test Method for Density, Relative Density (Specific Gravity), and Absorption of Coarse Aggregates.
ASTM C 295	Standard Guide for Petrographic Examination of Aggregates for Concrete

4.0 REGIONAL GEOLOGY

The town of Kodiak is located on the eastern side of Kodiak Island approximately 100 miles from the Aleutian trough. The Kodiak Island group is geologically a continuation of the Kenai Peninsula and the Kenai Mountains with similar northeast structural trends.

The geology of the Kodiak region is generally characterized by Mesozoic and Cenozoic metamorphosed sedimentary and igneous bedrock overlain by limited Quaternary unconsolidated deposits. The bedrock of the Kodiak Islands is part of a widespread sequence of Mesozoic and Cenozoic strata that form an arc-like outcrop belt in southern Alaska (Nilsen and Moore, 1979). This outcrop belt consists of five different terrains that are separated by faults or unconformities. Northeast trending, folded, and faulted rocks underlie Kodiak Island and extend southwestward from similar trending rocks of the Kenai Peninsula.

The Cretaceous Kodiak Formation and Tertiary Ghost Rocks Formation generally underlie the northeast part of Kodiak Island. These two formations are considered part of a larger turbidite facies association, which is characterized by cyclical deposition of conglomerate, sandstone, and mudstone and shale sequences in a deep-sea fan facies depositional package (Nilsen and Moore, 1979). The Formation is estimated to be up to 16,000 feet thick and is mainly comprised of thick mudstone and shale sequences with interstratified sandstone beds and minor conglomerate. These beds have largely been metamorphosed to argillite, slate, and greywacke. The Ghost Rocks Formation crops out in a long continuous belt southeast of the Kodiak Formation. This Formation may be up to 16,000 feet thick and is characterized by sheared and highly deformed shale, argillite, and mudstone with isolated sandstone and siltstone facies. The Ghost Rocks Formation is separated from younger and older rocks by faults and contains occurrences of pillow basalts and basalt breccia.

Quaternary deposits of glacial drift, alluvium, and volcanic ash variably mantle the bedrock surface in the Kodiak area. Glacial till and outwash are widely distributed in the lower portions of the island. On uplands and steep ridges, the glacial deposits generally occur only as thin and discontinuous patches, whereas in the lowland areas of the moderate relief, a thin layer of glacial till or outwash is typically encountered. Alluvial sand and gravel deposits are found in coastal areas and occupy the valleys of major streams. In some major valleys, these alluvial deposits may range up to 500 feet thick (Jones, et al., 1978).

The Kodiak Islands are located approximately 90 miles northwest on the active zone of subduction along the Aleutian Trench, making this region prone to both volcanic and seismic activity. A coarse and dense layer of volcanic ash is generally observable in the upper soil horizons as a result of the Novarupta volcanic eruption of 1912, which deposited a thick blanket of ash over the entire island. The great Alaska Earthquake of 1964 was indicative of the strong seismicity of the region. This earthquake was the largest magnitude earthquake to affect the Kodiak area in historic time and caused widespread damage to the area. Several faults with youthful scarps also provide evidence of recent seismic activity in the area.

5.0 SITE CONDITIONS

The Entrance Channel Dredging project can be divided into three separate areas: the St. Paul Harbor entrance channel, the St. Herman Harbor north entrance channel, and the St. Herman Harbor south entrance channel. These boundaries are shown on the maps enclosed as Figures 2, 3, and 4.

5.1 Surface Conditions

St. Paul Harbor Entrance Channel
The bathymetry of the St. Paul Harbor entrance channel dredge area shows the existing mudline surface elevations range from approximately -12 feet MLLW to greater than -16 feet MLLW. The ground surface, observed within the tidal zone of the adjacent rubble mound breakwaters, was covered primarily with cobble and boulder size breakwater armor stone ranging in size from one to three feet in diameter. Samples collected at the mudline surface contained less than three inches of recent marine deposits consisting of fine-grained and coarse-grained soils with sea shells. During the setting and removal of the landing craft anchors used to support drilling operations, debris consisting of metal cables was brought to the surface within the dredge area.

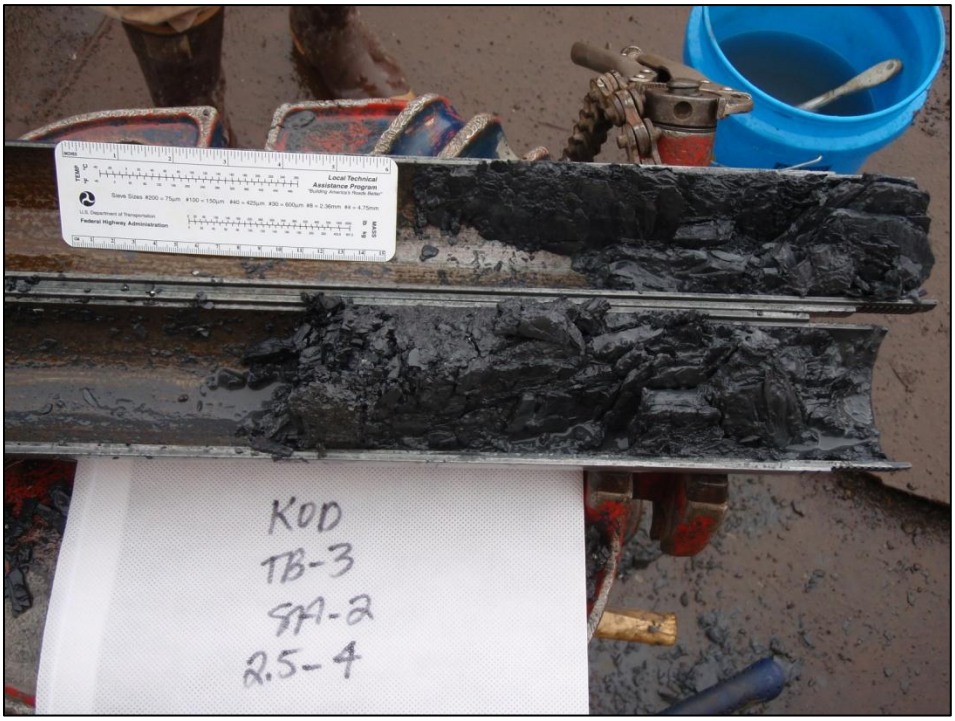
St. Herman Harbor North Entrance Channel
The bathymetry of the St. Herman Harbor north entrance channel dredge area shows the existing mudline surface elevations range from approximately zero feet MLLW along the edges to greater than -12 feet MLLW. The ground surface, observed within the tidal zone of the adjacent shore line, was covered primarily with sand, gravel, cobbles, and boulders. The surface sample collected during the 1989 exploration in test boring DH-11 consisted of six inches of well-graded gravel with silt and sand (GW-GM) with organics and shells. This surface material was removed during the 1990's dredging project.

St. Herman Harbor South Entrance Channel
The bathymetry of the St. Herman Harbor south entrance channel dredge area shows the existing mudline surface elevations range from approximately -18 feet MLLW to greater than -20 feet MLLW. The surface conditions within the St. Herman south entrance channel consists of boulder sized breakwater armor stone ranging in size from one to four feet in diameter.

5.2 Subsurface Conditions

St. Paul Harbor Entrance Channel
Bedrock was encountered at the mudline in test borings drilled in the St. Paul Harbor entrance channel dredge area. The subsurface bedrock is composed of the Kodiak formation and consists of phyllite and metagraywacke. Slightly weathered bedrock was encountered at the mudline surface to depths ranging from two to eight feet. The transition from slightly weathered bedrock to unweathered bedrock was gradual and indentified when HW casing refusal was encountered. When casing refusal was encountered the drilling operations switched to NQ-3 size coring equipment to complete the test borings.

Photograph No.2 shows an example of slightly weathered bedrock that was sampled with a spilt spoon sampler. Samples of slightly weathered bedrock retrieved from the split spoon sampler consisted of fractured gravel and sand size rock fragments. These broken rock fragments were caused by the split spoon sampling operation and they do not represent the existing in situ bedrock condition. Mechanical excavation using large heavy excavation equipment, ripper teeth, and hydraulic rock breakers will be required to break the slightly weathered bedrock into rock fragments that can be dredged.



Photograph No.2: Sample of slightly weathered bedrock from test boring AP-149 taken between 2.5 and 4.0 feet below the mudline.

Laboratory test results indicate the rock has a bulk specific gravity of 2.709 and absorption of 1.025 percent. A petrographic examination of rock core sampled in AP-148 was conducted by the CTL Group to evaluate the general rock composition and characteristics. The results of this examination are presented in Appendix B. Photograph No.3 shows an example of core rock recovered from test boring AP-140.

Photograph No.3: Sample of bedrock from test boring AP-150 taken between 10.0 to 13.5 feet below the mudline. Reported ASTM D 6032 Rock Quality Designation (RQD) = 0.

Generally the bedrock hardness or relative strength was identified in the field as medium hard. According to Table 3 found in the USACE Technical Report GL-85-3, this range of rock hardness correlates to an estimated minimum uniaxal compressive strength range between 1,450 and 3,645 pounds per square inch. The bedrock's stratification thickness was laminated which had a general orientation dip between vertical and 60 degrees. The rock texture was foliated and the toughness or resistance to fracture was low. Rock samples readily fracture or split along foliation planes when hit with a geologic hammer. All rock recovered during core drill was described as having a rock quality designation (RQD) value of zero which indicates a classification of rock quality as very poor.

St. Herman Harbor North Entrance Channel

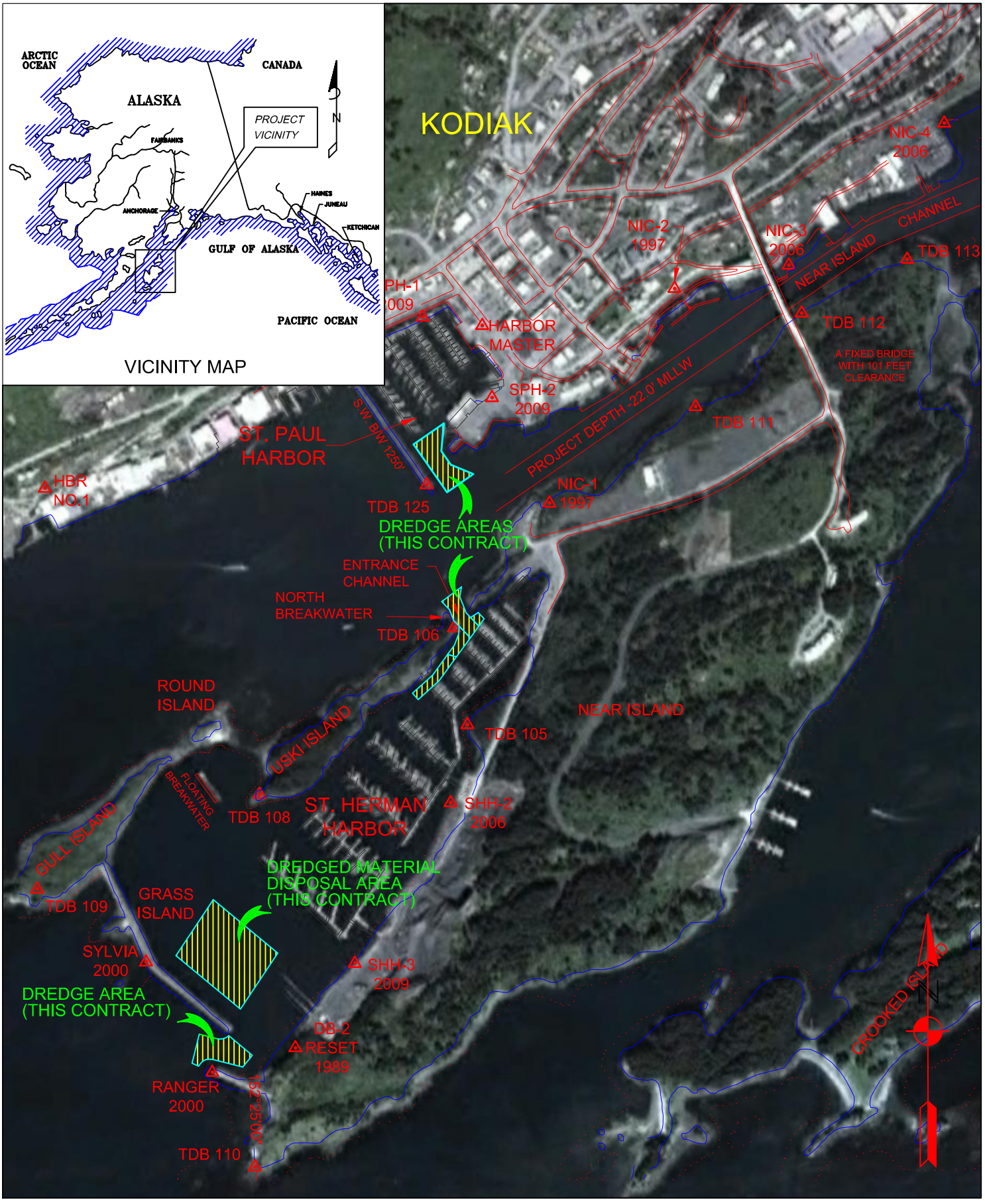
During the 1989 USACE geotechnical investigation of the St. Herman Harbor north entrance channel, one test boring was drilled to a depth of 6.1 feet below mudline, elevation -14.39 feet MLLW (2009 Survey Datum). During that investigation a six inch layer of well-graded gravel with silt, sand, organics, and shells were encountered at the surface. Below the surface layer of coarse-grained soils bedrock was encountered at an elevation of -8.79 feet MLLW (2009 Survey Datum). The north entrance channel was not completely dredged

to depth during the 1990's construction project due to the presence of bedrock that could not be removed by mechanical methods employed at the time.

Bedrock encountered in test boring DH-11 consisted of slate. The bedrock outcrop exposures located along the shoreline on the east and west sides of the St. Herman Harbor north entrance channel are typical of the bedrock encountered in test boring DH-11. The slate bedrock hardness was identified in the field as moderately hard and slightly fractured with stratification thickness of 0.125 inches near vertical joints. The maximum unbroken length of rock core recovered between a depth of 2.7 and 6.1 feet below mudline was 5 inches. A petrographic examination of rock core from DH-11 was conducted by the USACE North Pacific Division Materials Laboratory to evaluate the general rock composition and characteristics. The results of this examination are presented in Appendix B.

St. Herman Harbor South Entrance Channel

Two rubble mound breakwaters were constructed for the St. Herman Harbor south entrance channel in the late 1990's. Survey data indicates that the breakwater toes may have been over built with boulder sized armor stone which currently encroach on the entrance channel limits. The subsurface conditions within the St. Herman Harbor south entrance channel dredge area consists of boulder sized breakwater armor stone ranging in size from one to four feet in diameter and weighting between 150 and 4,000 pounds.



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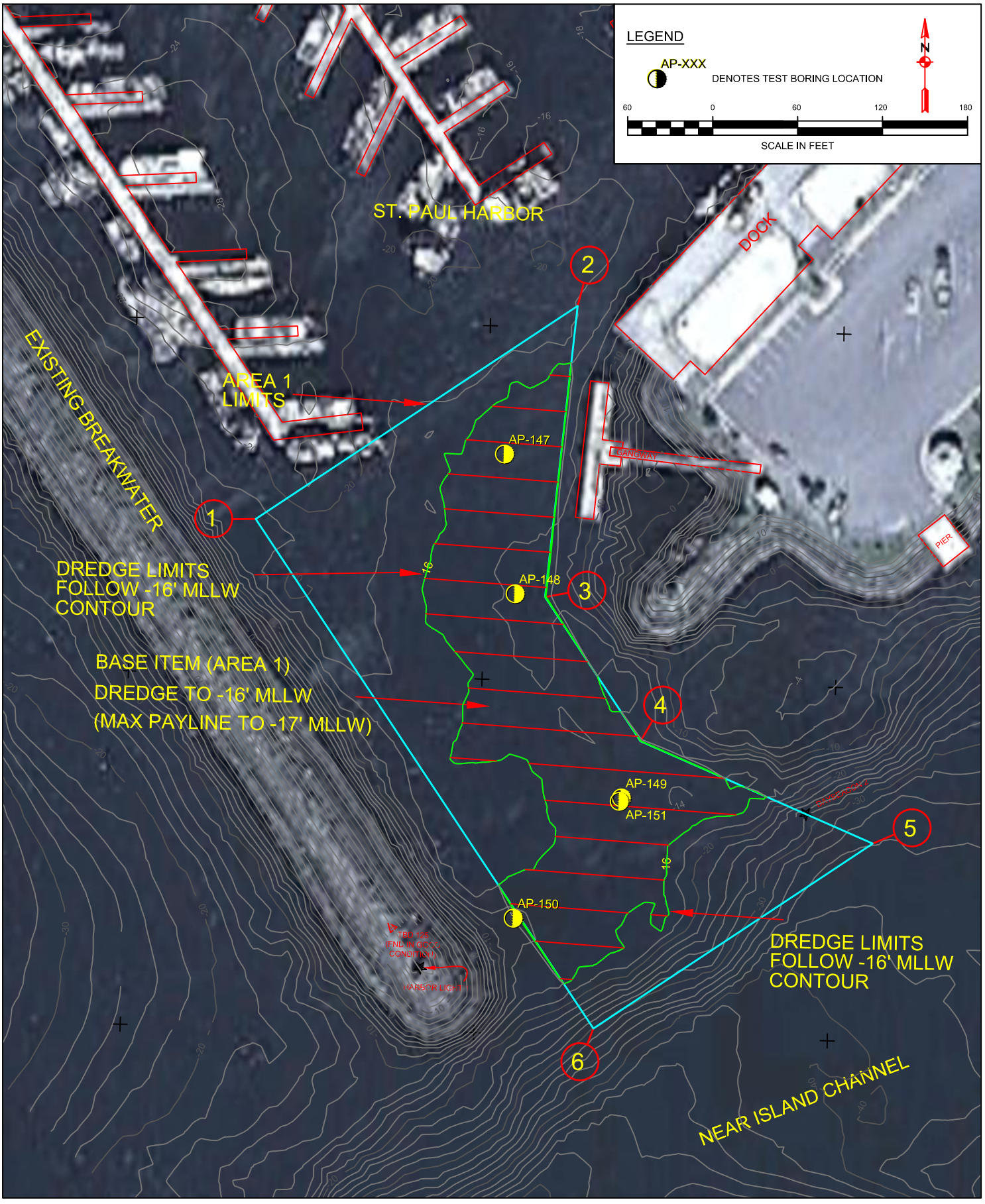
LOCATION AND VICINITY MAP
ENTRANCE CHANNEL DREDGING
KODIAK, ALASKA

SCALE: NTS
DATE: JUNE 2012
DRAWN/RVW: TTN/MDP
FIGURE 1



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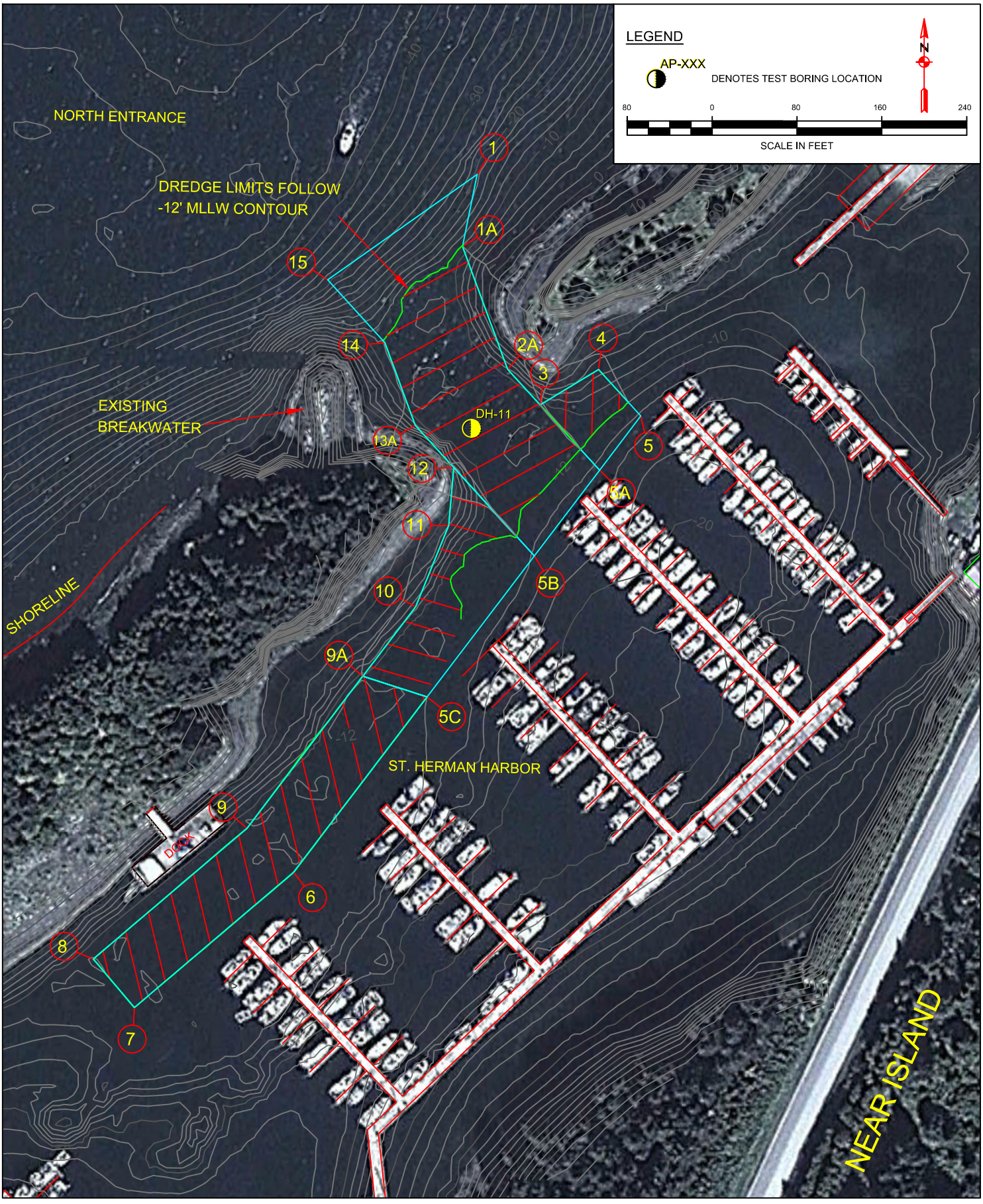
ST. PAUL HARBOR
TEST BORING LOCATION MAP
ENTRANCE CHANNEL DREDGING
ST. PAUL HARBOR, KODIAK, ALASKA

SCALE: GRAPHICAL
DATE: JUNE 2012
DRAWN/RVW: TTN/MDP
FIGURE 2



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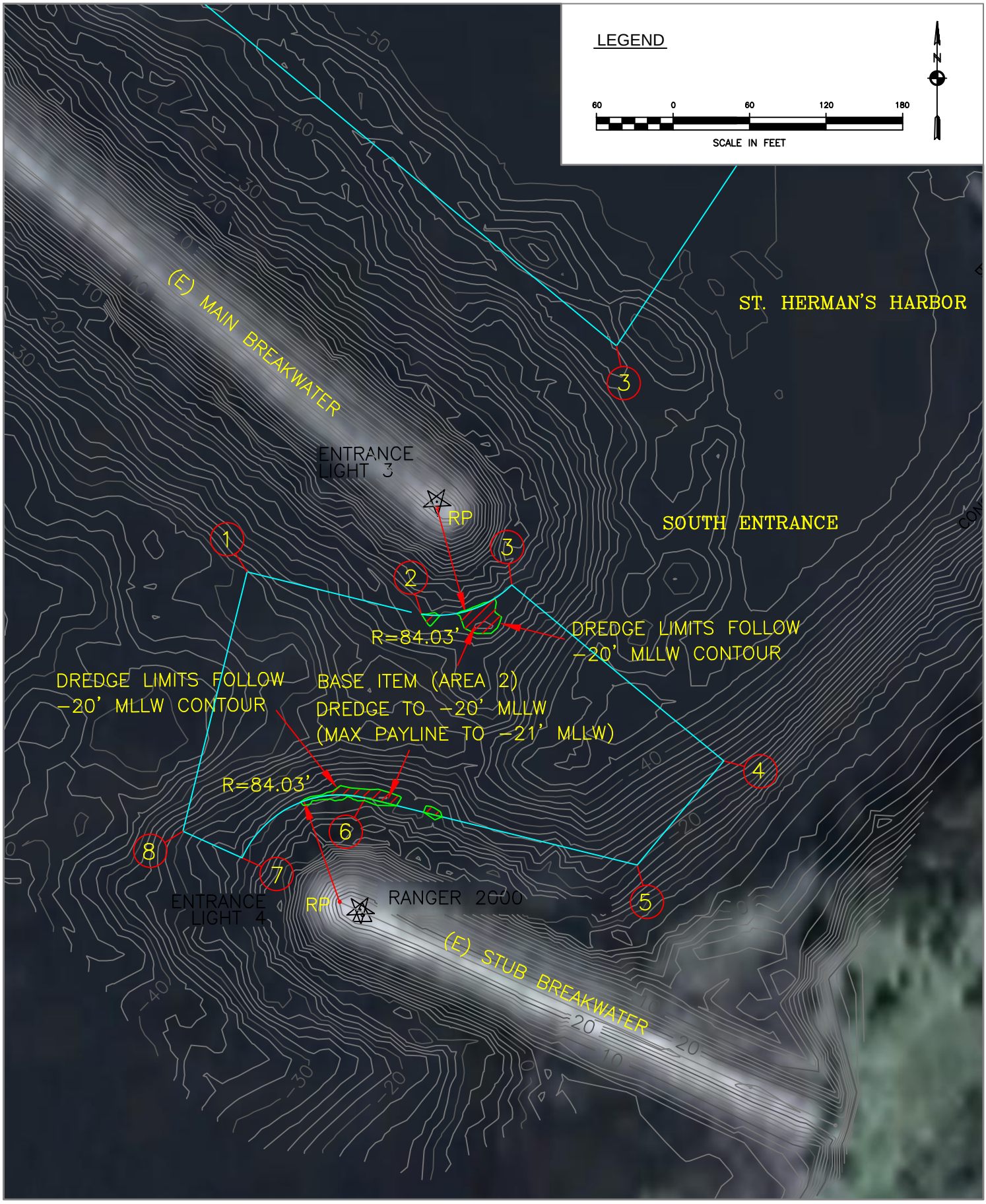
ST. HERMAN NORTH ENTRANCE CHANNEL
TEST BORING LOCATION MAP
ENTRANCE CHANNEL DREDGING
ST. HERMAN HARBOR, KODIAK, ALASKA

SCALE: GRAPHICAL
DATE: JUNE 2012
DRAWN/RVW: TTN/MDP
FIGURE 3



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ST. HERMAN SOUTH ENTRANCE
CHANNEL DREDGE AREA
ENTRANCE CHANNEL DREDGING
ST. HERMAN'S HARBOR, KODIAK, ALASKA

SCALE: GRAPHICAL
DATE: JUNE 2012
DRAWN/RVW: IJR/MDP
FIGURE 4

APPENDIX A
Exploration Logs

Exploration Logs AP-147 through AP-151..... 5 Sheets
1989 Exploration Log DH-11.....1 Sheet

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Geotechnical and Materials Section

EXPLORATION LOG

Project: Entrance Channel Dredging
St. Paul Harbor, Kodiak, Alaska

Date: 3 Apr 2012

Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling

Datum: Vertical MLLW; Horizontal ASPC Zone 5 NAD83

Location: Northing: 1,386,409 ft. Easting: 1,950,763 ft.

Top of Hole Elevation: -14.0 ft.

Hole Number, Field: TB-01

Permanent: AP-147

Operator: James Voeller and Jason Love

Inspector: John Rajek and Inocencio Roman

Type of Hole: ☒ other Rotary Wash Boring / HW Casing
☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater: Drilled Below Water

Depth Drilled: 16.0 ft.

Total Depth: 16.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D.: 2.5 in.

Size and Type of Bit: 3.875 in. Mill Tooth Tricone bit

Type of Equipment: Mobile B-61 with Cathead and Rope

Type of Samples: Drive and Core

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	% Finer 0.02mm	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
															Surface Description: Less than three inches of recent marine deposits which consisted of fine-grained and coarse-grained soils and sea shells.
0		1			2 4 12 16	Bx	Slightly weathered BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, black to gray
2		2			20 16 20 26	Bx	Slightly weathered BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, black to gray
4		3			51 38 48 56	Bx	Slightly weathered BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, black to gray
6															
8		RUN 1				NR	No Recovery								Casing refusal at 8 feet, started coring with NQ-3 core barrel, Core Run 1 had no recovery
10		RUN 2				Bx	BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, unweathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 60 degrees and vertical, black to gray, ASTM D 6032 Rock Quality Designation (RQD) = 0
12															
14															
16															Bottom of Hole 16.0 ft. Elevation -30.0 ft. Drilled Below Water PID = (Cold/Hot) Photo Ionization Detector Rock descriptions in accordance with EM 1110-1-1804 and GL-85-3 Geotechnical Descriptions of Rock and Rock Masses
18															

* Indicates Estimated Frost Classification

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Geotechnical and Materials Section

EXPLORATION LOG

Project: Entrance Channel Dredging
St. Paul Harbor, Kodiak, Alaska

Date: 3 Apr 2012

Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling

Datum: Vertical MLLW; Horizontal ASPC Zone 5 NAD83

Location: Northing: 1,386,310 ft. Easting: 1,950,772 ft.

Top of Hole Elevation: -13.5 ft.

Hole Number, Field: TB-02

Permanent: AP-148

Operator: James Voeller and Jason Love

Inspector: John Rajek and Inocencio Roman

Type of Hole: ☒ other Rotary Wash Boring / HW Casing
☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater: Drilled Below Water

Depth Drilled: 15.0 ft.

Total Depth: 15.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D.: 2.5 in.

Size and Type of Bit: 3.875 in. Mill Tooth Tricone bit

Type of Equipment: Mobile B-61 with Cathead and Rope

Type of Samples: Drive and Core

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	% Finer 0.02mm	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
0					9 9 5 21	Bx	Slightly weathered BEDROCK								Surface Description: Less than three inches of recent marine deposits which consisted of fine-grained and coarse-grained soils and sea shells. Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, black to gray
2		RUN 1				Bx	BEDROCK								Casing refusal at 2 feet, started coring with NQ-3 core barrel Kodiak Formation, phyllite and metagraywacke, medium hard, unweathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, black to gray, ASTM D 6032 Rock Quality Designation (RQD) = 0
8		RUN 2				NR	No Recovery								Core Run 2 had no recovery
8		RUN 3				Bx	BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, unweathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, vertical fractures, black to gray, RQD = 0
10		RUN 4				Bx	BEDROCK								Summary of ASTM C 295 Petrographic Observations: Rock Type: phyllite, moderately soft to locally moderately hard, no weathering observed, foliated texture, low toughness, rock readily fractures or splits along foliation planes with a blow from a hammer, several cracks and frequent microcracks are observed along foliation planes, black to dark greenish gray, RQD = 0
16															Bottom of Hole 15.0 ft. Elevation -28.5 ft. Drilled Below Water PID = (Cold/Hot) Photo Ionization Detector Rock descriptions in accordance with EM 1110-1-1804 and GL-85-3 Geotechnical Descriptions of Rock and Rock Masses

* Indicates Estimated Frost Classification

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Geotechnical and Materials Section

EXPLORATION LOG

Project: Entrance Channel Dredging
St. Paul Harbor, Kodiak, Alaska

Date: 4 Apr 2012

Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling

Datum: Vertical MLLW; Horizontal ASPC Zone 5 NAD83

Location: Northing: 1,386,168 ft. Easting: 1,950,851 ft.

Top of Hole Elevation: -13.9 ft.

Hole Number, Field: TB-03

Permanent: AP-149

Operator: James Voeller

Inspector: John Rajek

Type of Hole: ☒ other Rotary Wash Boring / HW Casing
☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater: Drilled Below Water

Depth Drilled: 4.0 ft.

Total Depth: 4.0 ft.

Hammer Weight: 340 lbs

Split Spoon I.D.: 2.5 in.

Size and Type of Bit: 3.875 in. Mill Tooth Tricone bit

Type of Equipment: Mobile B-61 with Cathead and Rope

Type of Samples: Drive and Core

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	% Finer 0.02mm	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
2		1			4 10 23 24	Bx	Slightly weathered BEDROCK								Surface Description: Less than three inches of recent marine deposits which consisted of fine-grained and coarse-grained soils and sea shells. Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 60 degrees and vertical, black to gray
4		2			40 53 88	Bx	Slightly weathered BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 60 degrees and vertical, black to gray
6															Bottom of Hole 4.0 ft. Elevation -17.9 ft. Drilled Below Water PID = (Cold/Hot) Photo Ionization Detector Rock descriptions in accordance with EM 1110-1-1804 and GL-85-3 Geotechnical Descriptions of Rock and Rock Masses Test boring had to be terminated early because wind pushed the landing craft's position beyond the limits of the drilling equipment. Moved test boring location, reset anchors, and tried to drill AP-151.
8															
10															
12															
14															
16															
18															

* Indicates Estimated Frost Classification

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Geotechnical and Materials Section

EXPLORATION LOG

Project: Entrance Channel Dredging
St. Paul Harbor, Kodiak, Alaska

Date: 4 Apr 2012

Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling

Datum: Vertical MLLW; Horizontal ASPC Zone 5 NAD83

Location: Northing: 1,386,081 ft. Easting: 1,950,776 ft.

Top of Hole Elevation: -12.8 ft.

Hole Number, Field:	Permanent:	Operator:	Inspector:
TB-04	AP-150	James Voeller	John Rajek

Type of Hole: ☒ other Rotary Wash Boring / HW Casing
☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater: Drilled Below Water

Depth Drilled: 13.5 ft.

Total Depth: 13.5 ft.

Hammer Weight:	Split Spoon I.D.:	Size and Type of Bit:	Type of Equipment:	Type of Samples:
340 lbs	2.5 in.	3.875 in. Mill Tooth Tricone bit	Mobile B-61 with Cathead and Rope	Drive and Core

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	% Finer 0.02mm	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
2		1			11 17 17 13	Bx	Slightly weathered BEDROCK								Surface Description: Less than three inches of recent marine deposits which consisted of fine-grained and coarse-grained soils and sea shells. Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 80 degrees and vertical, black to gray
4		2			25 35 42 49	Bx	Slightly weathered BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 80 degrees and vertical, black to gray
6		RUN 1				Bx	BEDROCK								Casing refusal at 5 feet, started coring with NQ-3 core barrel Kodiak Formation, phyllite and metagraywacke, medium hard, unweathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 80 degrees and vertical, black to gray, ASTM D 6032 Rock Quality Designation (RQD) = 0, ASTM C 127 specific gravity = 2.709, absorption = 1.025%
10		RUN 2				Bx	BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, unweathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 80 degrees and vertical, black to gray, RQD = 0
14															Bottom of Hole 13.5 ft. Elevation -26.3 ft. Drilled Below Water PID = (Cold/Hot) Photo Ionization Detector Rock descriptions in accordance with EM 1110-1-1804 and GL-85-3 Geotechnical Descriptions of Rock and Rock Masses
16															
18															

* Indicates Estimated Frost Classification

ALASKA DISTRICT
CORPS OF ENGINEERS
ENGINEERING SERVICES

Geotechnical and Materials Section

EXPLORATION LOG

Project: Entrance Channel Dredging
St. Paul Harbor, Kodiak, Alaska

Date: 4 Apr 2012

Drilling Agency: ☐ Alaska District ☒ Other Denali Drilling

Datum: Vertical MLLW; Horizontal ASPC Zone 5 NAD83

Location: Northing: 1,386,166 ft. Easting: 1,950,849 ft.

Top of Hole Elevation: -14.2 ft.

Hole Number, Field: TB-05

Permanent: AP-151

Operator: James Voeller

Inspector: John Rajek

Type of Hole: ☒ other Rotary Wash Boring / HW Casing
☐ Test Pit ☐ Auger Hole ☐ Monitoring Well ☐ Piezometer

Depth to Groundwater: Drilled Below Water

Depth Drilled: 4.5 ft.

Total Depth: 4.5 ft.

Hammer Weight: 340 lbs

Split Spoon I.D.: 2.5 in.

Size and Type of Bit: 3.875 in. Mill Tooth Tricone bit

Type of Equipment: Mobile B-61 with Cathead and Rope

Type of Samples: Drive and Core

Depth (ft.)	Lithology	Sample Recovery	ASTM D 4083 Frozen	Frost Class. ufc3-250-01fa	Blow Count	Symbol	Classification ASTM: D 2487 or D 2488	Grain Size %Gravel	%Sand	%Fines	% Finer 0.02mm	Max Size (in.)	PID (ppm)	% Water	Description and Remarks
2		1			10 20 20 34	Bx	Slightly weathered BEDROCK								Surface Description: Less than three inches of recent marine deposits which consisted of fine-grained and coarse-grained soils and sea shells. Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 80 degrees and vertical, black to gray
4		2			51 52 54 112	Bx	Slightly weathered BEDROCK								Kodiak Formation, phyllite and metagraywacke, medium hard, slightly weathered, smooth surface texture, laminated, discontinuity spacing less than 0.5 inch, fractures dipping between 80 degrees and vertical, black to gray
6															Bottom of Hole 4.5 ft. Elevation -18.7 ft. Drilled Below Water PID = (Cold/Hot) Photo Ionization Detector Rock descriptions in accordance with EM 1110-1-1804 and GL-85-3 Geotechnical Descriptions of Rock and Rock Masses
8															Test boring had to be terminated early because wind pushed the landing craft's position beyond the limits of the drilling equipment.
10															
12															
14															
16															
18															

* Indicates Estimated Frost Classification

DEPARTMENT OF THE ARMY

North Pacific Division
U.S. Army Engineer District Alaska

EXPLORATION LOG

Project: Kodiak Alaska
St. Herman Harbor

Sheet 1 Of 1

Location Coordinates
Northing 1,385,417 Easting 810,950

Drilling Agency: [XXX] Corps of Engineers [ ] Other Alaska District

Hole Number
Field HOLE 48 Permanent DH-11

Name of Driller: Keith Mitchell

Weather: Windy, Rain

Type of Hole: [XXX] Rotary [ ] Test Pit [ ] Auger Hole

Depth To	Depth Drilled	Total Depth
7.0	6.1	13.1

Size and Type of Bit: 4"Casing Shoe / NQ

Elevation Datum: [ ] MSL [XXX] MLLW

Type of Equipment: Longyear Rotary

Number of Samples	Type of Samples	Depth to Groundwater	Date
4	SPT and Core	N/A	20 June 1989

Top of Hole Elevation	Inspector	Chief, Soils Section	Chief, Geotechnical Branch
-9.90	Bill Walker	J. Raychel	D. Thomas

Depth in Feet	% Water	Sample	Soil Legend	Classification	Max Size	Description and Remarks
0		1a 1b & Run 1	GW-GM	Well-graded GRAVEL with silt and sand		54%Gr, 40%Sa, 6%Fines 3% Organic content Black; Trace of shells Coarse to fine, angular, flat sand; Medium to fine angular, flat, elongated gravel
				Rock		Sample 1b is rock fragments; 9/33/Refusal*
		Run 2		Very dark gray, very fine-grained, moderately hard slightly fractured SLATE. Fractures to 1/8" thick, near vertical joints.		Run 1: From 0.7' to 2.7' Recovered 1½'(75%) 1' of gravel size fragments over ½' rock core with 2" maximum unbroken length. Run 2: From 2.7' to 6.1' Recovered 3.4' (100%) Maximum unbroken length was 5".
5						
10						Bottom of hole 6.1 feet Elevation -16.0 feet MLLW
						Cobbles and boulders visible on nearby shore
15						* Number of blows for each 6" increment fo 18" total
20						
25						
30						

APPENDIX B
Laboratory Testing Results

ASTM C 127 Testing Report Summary .....1 Sheet
Petrographic Examination of Rock Core St. Paul Harbor .....7 Sheets
1989 Results of Petrographic Examination .....4 Sheets

DOWL HKM

Testing Report Summary

		Date Sample Recv'd	4/12/2012
Client	USACE	W.O.	A33355
Project	Kodiak-St.Paul Harbor	Lab #	530
Location	TB-4 Run 1 5'-10'		

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

Sample ID	Test Performed	Test Method	Results	
530	Specific Gravity and Absorption of Coarse Aggregate	ASTM C127	Bulk Specific Gravity	2.709
			Bulk Specific Gravity (SSD)	2.737
			Apparent Specific Gravity	2.786
			Absorption	1.025

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

Maria

Maria E. Kampsen, P.E.
Laboratory Supervisor

Copy No. 1

Report for
U.S. Army Corps of Engineers
(Alaska District)

Project Number 156463

Petrographic Examination of Rock Core – St. Paul Harbor, Kodiak, Alaska

May15, 2012

Submitted by:
Sang Y. Lee

COA # 313577

5400 Old Orchard Road
Skokie, Illinois 60077-1030
(847) 965-7500

Austin, TX • Chicago, IL • Washington, DC

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REPORT OF PETROGRAPHIC EXAMINATION

Date: May 15, 2012

CTLGroup Project No.: 156463

Petrographic Examination of Rock Core – St. Paul Harbor, Kodiak, Alaska

A rock core sample (approximately 1.8-in. diameter and 9.5-in. long core), designated TB-2/RUN4 (Fig. 1), was received on April 17, 2012 from Mr. John Rajek of the U.S. Army Corps of Engineers, JBER, Alaska. The rock core was reportedly extracted from the above-referenced project. The rock represented by the core sample is intended to be excavated by blasting and ripping. Petrographic examination of the rock core sample, in accordance with appropriate portions of ASTM C295, was requested to evaluate general rock composition and characteristics.

FINDINGS

The core consists entirely of phyllite, an intermediate-grade, foliated metamorphic rock consisting of fine-grained silicate minerals. The rock is mainly composed of silt-sized quartz grains, fine mica and chlorite flakes, and black organic/argillaceous materials. The rock is black to dark greenish gray, fine-grained, and moderately soft to locally moderately hard (readily scratched with a metal probe). Mineral grains in the rock are rarely coarse enough to be seen with the unaided eye. The rock is strongly foliated due to alignment of platy minerals (mainly micas, Fig. 2), and readily splits into thin pieces or sheets along the foliation planes when hit with a geologic hammer in the laboratory. No visible porosity is observed in the rock. The rock does not exhibit any significant weathering.

Other findings are presented below. Selected petrographic observations are summarized in Table 1.

- Overall toughness (resistance to fracture) of the rock is judged to be relatively low. The core as received was fractured into several smaller pieces. The rock core exhibits several cracks and frequent microcracks along the foliation planes; these likely occurred during coring or subsequent handling. As described above, the rock readily breaks or splits along the foliation planes when hit with a geologic hammer in the laboratory.

- Figure 3 presents thin-section photomicrographs showing petrographic texture of the rock. Silt-sized grains of quartz and a small amount of feldspar are scattered between wavy or layered bands of mica, chlorite, and organic/argillaceous materials. The rock exhibits a silky sheen on the foliation surfaces due to presence of the aligned micas and chlorite (typical feature of phyllite).
- Small veinlets are locally observed in the rock. The veinlets are mainly observed along the foliation planes, but some are oriented oblique to the foliation planes. The veinlets consist mainly of quartz and calcite. The veinlets are mostly short (discontinuous) and localized, and do not appear to significantly affect the overall rock properties.
- Apart from localized variations, the rock exhibits generally similar mineral assemblage, texture, and physical properties through the length of the core.

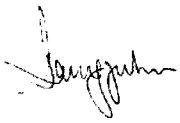
TABLE 1 SUMMARY OF PETROGRAPHIC OBSERVATIONS

Observed features	Rock Core TB-2/RUN4
Rock Type	Phyllite
Mineral composition	Silt-sized grains of quartz and a small amount of feldspar, mica and chlorite flakes, and organic/argillaceous materials
Color	Black to dark greenish gray
Grain size	Fine-grained; individual mineral grains are not visible with naked eye
Texture	Foliated
Hardness	Moderately soft to locally moderately hard; readily scratched with a metal probe
Toughness (resistance to fracture)	Low; the rock readily fractures or splits along foliation planes when hit with a geologic hammer in the laboratory
Porosity	No visible porosity
Weathering	None observed
Cracks & zones/planes of weakness	Several cracks and frequent microcracks are observed along foliation planes; cracking/microcracking likely occurred during coring or subsequent handling

METHODS OF TEST

Petrographic examination of the rock core sample was performed in accordance with the appropriate portions of ASTM C295, "Standard Guide for Petrographic Examination of Aggregates for Concrete." The sample was visually inspected and photographed, as received. Epoxy was applied to the fractures to stabilize the rock core sample. After the epoxy set, the rock core was cut in half longitudinally, and one of the halves was finely ground (lapped) to produce a flat, smooth, semi-polished finish. Freshly broken surfaces and lapped surfaces of the rock core sample were studied with the stereomicroscope at magnifications up to x45.

For thin-section study, a small rectangular block was cut from a representative body portion of the core sample, and one side of the block was lapped to produce a smooth, flat surface. The block was cleaned and dried, and the prepared surface was mounted on a ground glass microscope slide with epoxy resin. After the epoxy hardened, the thickness of the mounted block was reduced to approximately 20 μm (0.0008 in.). The resulting thin section was examined using a polarized-light (petrographic) microscope at magnifications up to 400X to study rock mineralogy and microstructure.

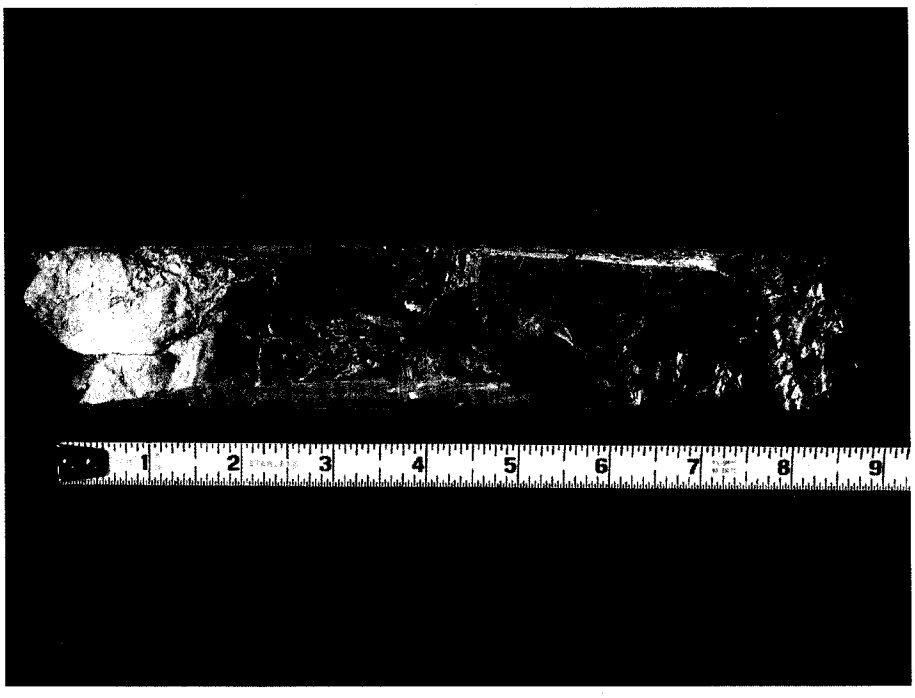


Sang Y. Lee, Ph.D., PE (Texas), PG (Indiana)
Senior Petrographer
Petrography Group

SYL

Notes:
1. Results refer specifically to the sample submitted.
2. This report may not be reproduced except in its entirety.
3. The sample will be retained for 30 days, after which it will be discarded unless we hear otherwise from you.

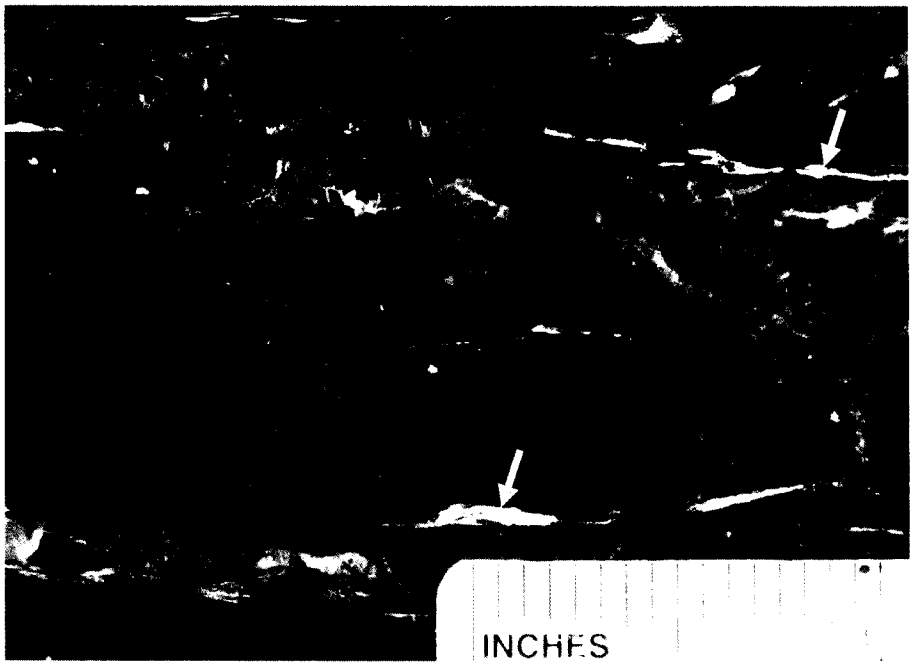
1a. Side view.



1b. Opposite side. The core was fractured into several pieces, mainly along foliation planes. The rock exhibits a silky sheen (arrows) on the foliation surfaces, typical feature of phyllite.

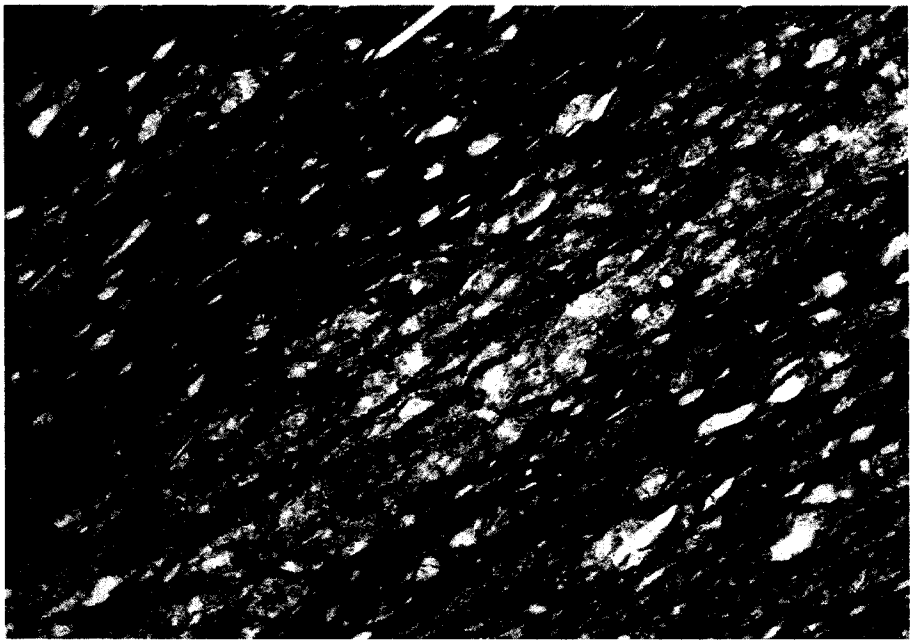
Fig. 1 Sample TB-2/RUN4 as received for examination. Scale is in inches.

2a. Full cross-sectional view. A magnified view of the designated area is shown in Fig. 2b.

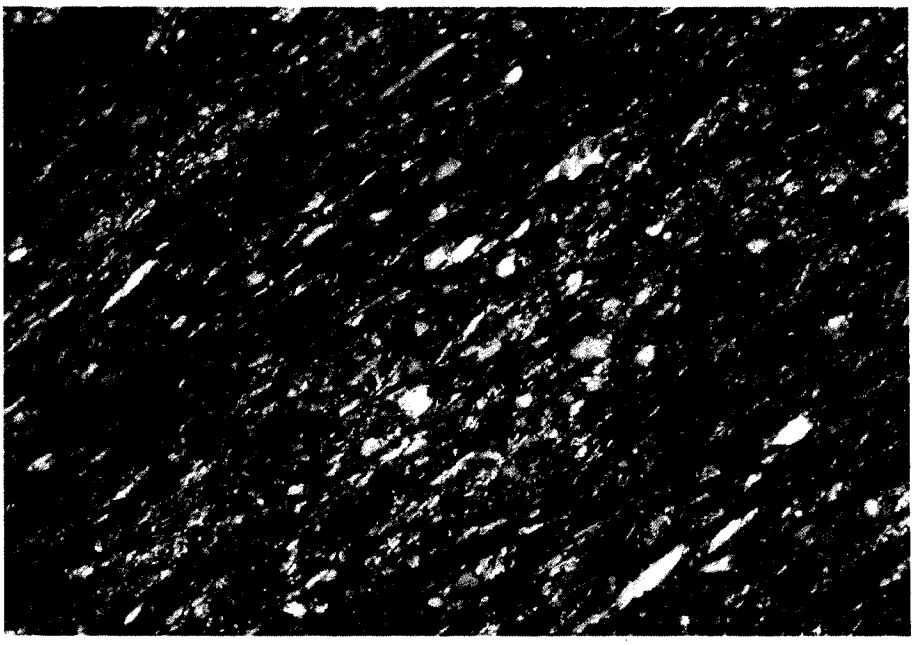


2b. Magnified view of the area designated by the red box in Fig. 2a, showing foliated texture. Several cracks/fractures are observed along the foliation planes (red arrows). White veinlets (yellow arrows) are locally observed, mainly along the foliation planes.

Fig. 2 Cut and lapped section of Sample TB-2/RUN4. Scale is in inches.



3a. Plane-polarized light mode.



3b. The same view in cross-polarized light mode. The gray granular particles are mostly quartz. The bright, elongated particles are mostly mica flakes.

Fig. 3 Thin-section photomicrographs showing foliated texture of the phyllite in Sample TB-2/RUN4. The arrows indicate the direction of foliation. Field of view is approximately 0.03 in. across.

SWDED-GL REPORT NO. 14993

RESULTS OF PETROGRAPHIC EXAMINATION

DOG BAY, KODIAK ISLAND, ALASKA - NORTH PACIFIC DIVISION LABORATORY

CORPS OF ENGINEERS

U. S. ARMY

SOUTHWESTERN DIVISION LABORATORY

DALLAS, TEXAS

NORTH PACIFIC DIVISION LABORATORY
DOG BAY, KODIAK ISLAND, ALASKA
PETROGRAPHIC EXAMINATION
SWDED-GL REPORT NO. 14993

1. REFERENCE: Reference is made to North Pacific Division Materials Laboratory test request E85899541, dated 29 Aug 89, requesting standard petrographic examination of a core sample.

2. SAMPLES: The following sample was received 29 Aug 89:

SWD NO.	MATERIAL	SOURCE
C-1911	Core Sample	Dog Bay, Kodiak Island, Alaska

3. PETROGRAPHIC REPORT:

A. C-1911. The sample consisted of very dark gray, very fine-grained, moderately hard, slightly fractured SLATE. Fractures ranged in thickness from hairline to 1/8" wide. The larger fractures were well-healed with primary quartz and secondary calcite, while the smaller fractures were well-healed only with quartz. The cleavage was parallel to the long axis of the core and was weak and slightly crenulated (small-scale folding). The rock was very slightly fissile in a non-weathered condition. Broken surfaces parallel to the cleavage were slightly shiny. Thin section examination of the rock revealed a microcrystalline to cryptocrystalline matrix consisting primarily of quartz and carbonaceous material with minor amounts of biotite and pyrite.

SOUTHWESTERN DIVISION LABORATORY, CORPS OF ENGINEERS
4815 Cass Street
Dallas, Texas 75235

SWDED-GL REPORT NO. 14993 (3 pages)

PROJECT: DOG BAY, KODIAK ISLAND, ALASKA
Feature: Petrographic Examination

Contract No.

TEST REQUEST NO.: E85899541
Dated: 29 Aug 89
Received: 11 Sep 89

From: Director
CENPD Materials Laboratory

MATERIAL:
No. and type of samples: One Core Sample
Source or other identification: CENPD-EN-G-L Sample No. 3677

Date received: 29 Aug 89

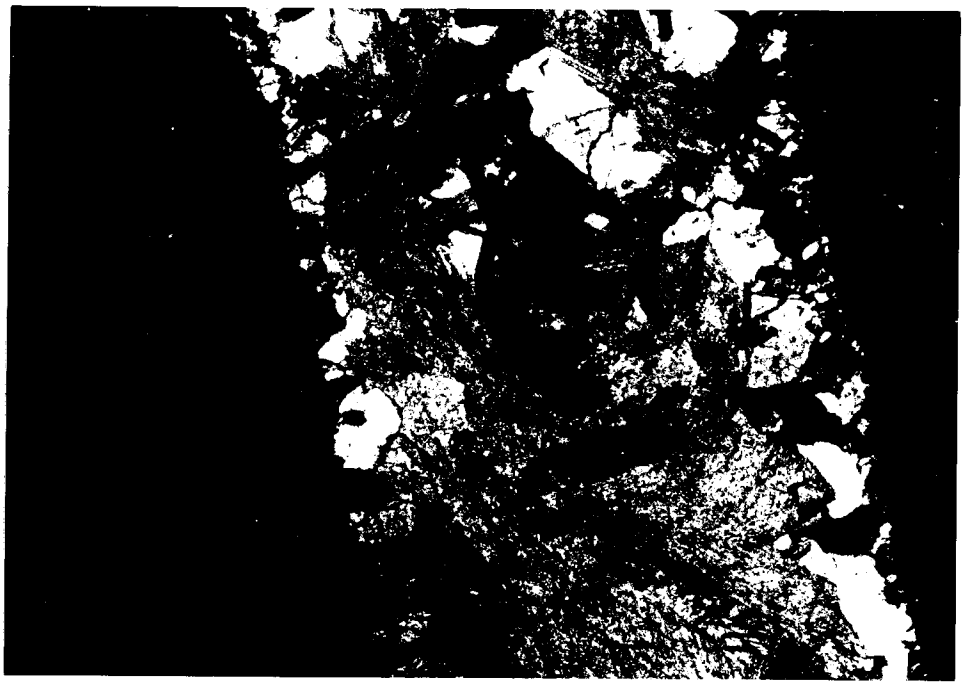
REMARKS:

SEE ATTACHED PAGES.

Report sent to:
North Pacific Division
Materials Laboratory

Copy furnished:

Date:	Name and title:	Signature
12 Sep 89	WILLIAM R. TANNER Director SWD Laboratory	Wm R Tanner



Larger fracture filled with primary quartz and secondary calcite.

Thin section perpendicular to cleavage showing preferred orienta-
of mineral grains.

PLATE 1