REMOVAL ACTION SUMMARY
BEAUTY BAY MINE
KENAI FJORDS NATIONAL PARK, ALASKA

September 2006

Submitted To:
National Park Service
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31-1-11325-001

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EXECUTIVE SUMMARY

This report presents a summary of site investigations and removal actions at the Beauty Bay Mine site in Kenai Fjords National Park, Alaska. The discovery of a dead moose calf on the Beauty Bay Mine site on June 28, 1994, prompted the collection of soil and water samples in an attempt to determine if on-site hazards had been the cause of the death. The results of sampling indicated arsenic was present in mine tailings at the site at concentrations exceeding the regulatory cleanup levels. The National Park Service prepared an Engineering Evaluation/Cost Analysis (EE/CA) to establish removal action objectives and determine the most appropriate removal action. The following removal action objectives were established:

- Isolate the tailings at the site from local wildlife and the occasional human visitor. The isolation method should be resistant to degradation from climatic factors and wildlife activity.
- If possible, prevent infiltration and accumulation of water in the tailings at the site.
- If possible, stabilize the tailings to guard against their catastrophic release into Ferrum Creek during periods of high rainfall.

The EE/CA presented several removal action alternatives including

- no action,
- fencing either the perimeter of the tailings area or the entire gravel pad area,
- placing a relatively impenetrable cover over the tailings area,
- placing the tailings in a covered and lined containment cell,
- removing the tailings and shipping them to an approved disposal facility,
- on-site ex situ treatment, and
- on-site in situ treatment using solidification/stabilization (preferred alternative).

Based on a comparative analysis of the alternatives, the NPS chose as a removal action the combining of the tailings into a central location (Pond D) and on-site in situ treatment using solidification/stabilization of the tailings using a soil-cement mixture. The removal action was completed in 1998. Spalling of the surface rind has been observed during recent site visits, but the removal action objectives appear to have been met and the cap is evidently functioning as designed.

REMOVAL ACTION SUMMARY
BEAUTY BAY MINE
KENAI FJORDS NATIONAL PARK, ALASKA

1.0 INTRODUCTION

In 1994 mine tailings at the Beauty Bay Mine in Kenai Fjords National Park, Alaska were found to contain elevated levels of arsenic. A removal action was conducted in 1998 to “remove” the exposure pathway between the arsenic and the potential receptors. This Removal Action Summary provides an overview of the site conditions, decision documents, removal action activities, and subsequent observations conducted by the National Park Service (NPS) at the Beauty Bay Mine in Kenai Fjords National Park, Alaska.

Shannon & Wilson prepared this document under the direction of the NPS Alaska Regional Office. Our work was conducted in general accordance with Request No. N99224010013 and our proposal dated September 14, 2001.

1.1 Site Chronology

June 1994 - Discovery of arsenic-bearing mine tailings at the Beauty Bay mine.

July and August 1994 – NPS site visit and sampling

April 1995 – Preparation of Draft Engineering Evaluation/Cost Analysis (EE/CA)

May 1995 – NPS site visit and sampling

August 1995 - NPS and Shannon & Wilson site visit and sampling

January 1996 – Preparation of Final EE/CA

February 1996 - Preparation of Action Memorandum (AM)

July 1996 - First attempt at removal action; extremely rainy conditions precluded completion

July 1998 - Removal Action completed

August 1999 – NPS site visit to observe condition of stabilized tailings

July 2000 – NPS site visit to observe condition of stabilized tailings

August 2006 - NPS site visit to observe condition of stabilized tailings

1.2 Site Location

The site is located in south-central Alaska on the southeastern coast of the Kenai Peninsula, about 60 miles southwest of the port of Seward (Figure 1). The Beauty Bay Mine is located in Kenai Fjords National Park, about 1 mile from the beach at the head of Beauty Bay. The geographic coordinates of the site are approximately 59 degrees 33 minutes north latitude and 150 degrees 40 minutes west longitude (USGS, 1958). The mine has also been referred to as the Glass-Heifner Claims, the Earl Mount Prospect, the Knaack and Kramer Claims, or the Little Creek Mine. The site is not located on the main road system, but is accessible by boat from Seward or by floatplane from either Seward or Homer. An unusable airstrip is located approximately 0.5 miles to the southeast of the site on the Nuka River flats, adjacent to the tidewater; an unimproved dirt road leads to the site from the airstrip.

1.3 Climate

The site is located within a climatic zone dominated by maritime influences which result in small temperature variations, high precipitation, high humidity, gusty winds, and high frequency of clouds and fog. The mean minimum January temperature is 16 degrees Fahrenheit. The mean maximum July temperature is 48 degrees Fahrenheit. Annually the site receives at least 60 inches of rain (Johnson and Hartman, 1969). According to NPS personnel the site receives in excess of 6 feet of snow annually, which blankets the site from November to mid-May.

1.4 Site History

Gold was discovered at the site in 1924 and, by the end of 1925, 50 feet of adit had been advanced. In 1933 an additional 400 feet of adit was excavated. Operations ceased in 1934, and the property was idle until the claims were restaked in 1958 (Jasper, 1960). The ownership was transferred in 1965, and in 1967 the mill building was constructed and a minor amount of ore was produced (Richter, 1970). Work continued at the mine until the mid-1970s, at which time the mine was abandoned. Kenai Fjords National Park was established in 1980, and at that time the National Park Service acquired the surface rights to the site. Two unpatented federal mining claims encompassed the site, but have since lapsed.

1.5 Site Description

The site is located on the west side of Ferrum Creek at the head of Beauty Bay, at an elevation of about 200 feet above sea level (Figure 1). The surrounding area is densely vegetated with conifers and alder with extremely rugged topography; surrounding peaks are 3,500 feet above sea level within 1 mile of the coast. The site is located approximately 200 feet southwest of Ferrum Creek. The creek is about 24 to 30 feet wide and up to 3 feet deep; it has a high-velocity current that carries a moderate suspended load, reflecting upstream glacial erosion (Cieutat, et al, 1993). Flow was estimated at 400 to 500 cubic feet per minute (cfm) in a report based on a November 1959 site visit (Jasper, 1960). This same reference cites a flow of 25 to 30 cfm in "Little Creek," which is not identified on available maps of the area, but it may be the "2-meter wide stream located 100 meters west of the prospect" cited Cieutat in 1993.

At the site were a mill building, several storage sheds, a bunkhouse, and the remains of another bunkhouse, located on a level pad approximately 200 feet by 225 feet in size. The pad was constructed from coarse rock, comprised of slate and graywacke with minor amounts of quartz. The milling equipment included two jaw crushers, a ball mill, and a Wilfrey concentrating table (Richter, 1970). The mine workings consisted of surface trenches and a collapsed adit.

The site is relatively level, and surface drainage appeared to be restricted to broad, shallow channels. Water was observed to drain from the now-collapsed mine adit and flowed through the site. This flow can be described as a "rill" less than 1½-feet wide (Cieutat, et al, 1993), but reportedly the flow increases during the rainy season. At the time of Shannon & Wilson's site visit in August 1995 flow from the adit was estimated at 0.02 cubic feet per second, and the pH of the water was 7.1. At this flow rate, the surface water infiltrated the ground prior to reaching the tailings ponds. No information is available regarding the maximum flow rate from mine adit. Based on the existing channel configuration, bankfull flow is anticipated to result at a flow rate of less than 1 cubic foot per minute.

1.6 Mining Geology

Gold ore was mined from at least three east-west trending, near-vertical quartz veins, ranging from 1 to 5 feet in width. The principal sulfide within the vein system was arsenopyrite ("fool's gold," FeAsS), which occurred in lenses, sheets, and irregular masses (Richter, 1970). The gold was apparently free-milling and was liberated by crushing. The veins discordantly cut massive graywacke and slate. Wallrock alteration in the vicinity of the veins consists of carbonatization and silicification (Cieutat, et al, 1993). Clay gouge and sulfate development were also noted along the vein-wallrock contact (Richter, 1970).

1.7 Surface and Groundwater

The depth to a regional groundwater aquifer is not known, although it is anticipated that the subsurface hydrology is largely controlled by the presence of the bedrock, or possibly by glacial till. In general, the rock types anticipated to underlie the site are relatively impermeable; groundwater flow within the bedrock is therefore anticipated to be limited to discontinuities (joints, fractures, and faults). Aerial photography shows the site may be mantled with a veneer of glacio-alluvial deposits; a perched groundwater table may be present above the bedrock/sediment interface. There is likely a colluvial/alluvial gravel aquifer along the base of the hillslope along Ferrum Creek.

At the time of Shannon & Wilson's visit in August 1995, water was encountered within Pond D at a depth of about 0.8 feet below the ground surface. Subsurface water was not encountered within the 1- to 1.5-foot depth explored in any of the other tailings areas. The pH of the water within the Pond D tailings pile was 4.0 at the time of our visit. The configuration of Pond D appeared to be such that rainwater accumulated within the pond, and the flow of the rainwater out of the pond is restricted by the underlying silty soil. The presence of a berm around Pond D appeared to limit the input of surface water into Pond D.

The absence of deeply incised erosion gullies or other evidence of large volumes of surface water running through the site suggests the potential for catastrophic redistributing of the tailings is low. Although snow avalanche chutes are present adjacent to the mine site, none appear to cross the site.

1.8 Previous Studies

The earliest previous investigative studies were mainly directed at characterizing the geologic conditions of the site, particularly the mining geology. In 1970, the United States Geological Survey (USGS) prepared a report describing the regional geologic conditions and ore deposit geology of the Nuka Bay area (Richter, 1970). In 1993, the USGS has recently conducted surface- water sampling of in the area of several small-scale gold mines in the Nuka Bay area (Cieutat, 1993).

Results of the 1970 USGS sampling of sediment from 44 streams draining into Nuka Bay indicated that concentrations of arsenic range from below the detection limit of 10 parts per million (ppm) to a maximum of 160 ppm. The concentration of arsenic in the panned stream sediment concentrates from Ferrum Creek, above and below the Beauty Bay Mine, was 40 ppm in both samples. Four samples of sulfide-bearing quartz vein material were collected from the underground and surface workings. The samples contained from 1,200 to 6,000 ppm arsenic.

Analyses of water samples collected during the 1993 USGS study found background metals concentrations of less than 0.05 parts per billion (ppb) silver, less than 2 ppb arsenic, less than 1 ppb cadmium, less than 1 ppb copper, 10 ppb iron, less than 1 ppb antimony, and 3 to 6 ppb zinc from waters draining areas upstream of any known mineral occurrences. A field-filtered water sample collected from the small rill exiting the mine workings at the Beauty Bay Mine contained 130 ppb arsenic and 2 ppb antimony; no iron enrichment was noted in the sample. Water samples collected from Ferrum Creek upstream and downstream of the mine site generally did not contain concentrations of metals that exceeded the local background values established by this study. The arsenic concentration in both the upstream and downstream sample was 2 ppb.

Soil and tailings were collected by the NPS and Shannon & Wilson. The concentration of arsenic in background soil samples collected from undisturbed areas in the vicinity of the mine site ranged from not greater than the laboratory detection limit to 2,890 ppm arsenic. The arsenic concentration in the tailing ponds ranges from 3,200 ppm to 50,000 ppm. The results indicated that material in an ore box adjacent to the mill building contained 257,359 ppm arsenic. Samples from the site pad (presumed waste rock) from a transect south of the Mill Building contained from 6,300 to 19,000 ppm arsenic. Material in the ore box, or elsewhere on the site where concentrations greatly exceed background, are assumed to represent a concentrate containing a high abundance of arsenopyrite. This concentrate may be the result of the milling process or the reworking of the material in the water channels on the pad. Arsenopyrite is comprised of approximately one-third arsenic; therefore, values in excess of 25 percent (250,000 ppm) could be expected in the mill concentrate samples collected from the ore box.

1.9 NPS Site Assessments

On June 28, 1994, an NPS explosives removal team visited the site; a white precipitate coating the surface of tailings pond D was noted (Figure 2; Photo 1). According to NPS personnel, the existence of the white precipitate was transient, having been observed on several of the ponds, and not during previous and subsequent site visits. No samples of the white precipitate were collected. During this visit a deceased moose calf, believed to be 1 month old, was found on the site. Apparently there was no indication of trauma, birth defects, or other blemishes or injuries noted. The presence of hoof and nose prints and kneel marks in the tailings ponds indicated that moose may have been disturbing the tailings, and potentially ingesting the material.

NPS personnel returned to the site on July 7, 1994, to obtain tissue samples from the moose calf to determine the cause of death, but it appeared that the moose had been carried off by a bear. Two samples of soil from the tailings were collected and analyzed for metals (Spencer, 1995).

The NPS again returned to the site on August 24, 1994, and collected 22 soil samples, three mineral samples, a vegetation sample, and two samples of the water which was draining from the collapsed adit (Tetreau, 1994).

NPS visited the site on May 31 and August 29, 1995, and collected an additional 26 soil samples and seven water samples. The soil samples were collected from the tailings ponds and undisturbed areas in the vicinity of the site. Three water samples were collected from Ferrum Creek in locations upstream at the probable point of entry and downstream from the mine site. No white precipitate was present on the tailings ponds during these site visits (Anonymous, 1994).

A representative from Shannon & Wilson accompanied the NPS to the site on August 29, 1995. Shannon & Wilson observed site conditions and collected soil samples for characterization and for soil stabilization mix design testing. The characterization samples were submitted to Dr. Scott Fendorf, a soil chemist with the University of Idaho, Moscow, for arsenic speciation studies and Dr. Hsing K. Lin, hydrometallurgist with the University of Alaska, Fairbanks, for physical characterization and arsenic speciation studies.

1.10 Tailings Description

There were a series of what have been termed "tailings ponds" northwest of the mill (Figure 2). There is some question whether the ponds are true “tailings ponds," in the sense that tailings were carried to them in a water suspension. Both the small amount of water apparently available, and the small amount of water needed to operate a Wilfrey table, suggest that perhaps the ponds were used to contain tailings which had been physically transported to them by some means other than by flowing water. However, the term “tailings pond” is used as the best descriptor of the inferred contents of the ponds.

Sieve analysis of the tailings indicates they consist of fine- to coarse-grained, sand-sized granules with approximately 6 percent silt. Silt contained in the tailings was present in small clumps, and may be a byproduct of the crushing operation. A visual classification of the tailings composition shows them to be about 85 to 90 percent white quartz, 10 to 15 percent sedimentary rock fragments, with minor amounts of oxide fragments or tarnished sulfides.

Field observations indicated the tailings in ponds C, D, F, and G covered an estimated area of about 1,225 square feet (Figure 2, Photo 2). Data from a limited number of test pits excavated on August 29, 1995 suggest the thickness of the tailings in these areas ranged from a minimum of 2 inches to a maximum of about 36 inches. From the field observations and test pit data, the volume of tailings was estimated at about 61 cubic yards; based on information collected during the removal action the estimated volume of tailings at the site was increased to 73 cubic yards.

1.11 Release Mechanisms

The method of release of arsenic into the environment of the site is related to the weathering of arsenopyrite within Pond D. One of the byproducts of the weathering is sulfuric acid, which accelerates the dissolution process. Once the arsenopyrite is dissolved, the elemental constituents are mobile and are free to recombine to form secondary minerals. It is assumed that the dissociated metal cations combine with anions to form arsenic-bearing compounds. These secondary minerals apparently precipitated on the surface of the Pond D during a dry spell during the summer of 1994.

The stability of these secondary mineral precipitates in the presence of water is low; therefore, the heavy rainfall at the site and flooding of Pond D dissolved the precipitate, once again mobilizing its constituents. The presence of water containing 29 ppm arsenic within Pond D indicates that the dissolution of arsenopyrite was occurring, but without direct observation of the white crystalline precipitate it is futile to postulate its composition. Based on the high concentration of arsenic and the moderate to high potential for the presence of toxic, soluble arsenic-bearing compounds, the conservative assumption was made and the removal action was initiated.

2.0 DECISION DOCUMENTS

Shannon & Wilson prepared an EE/CA for the site in January 1996. The following objectives for the removal action were presented:

- Isolate the potentially hazardous materials (tailings) assumed to be present at the site from local wildlife and the occasional human visitor.
- If possible, prevent infiltration and accumulation of water in the tailings ponds at the site, thereby limiting the dissolution of arsenopyrite.

- If possible, stabilize the tailings to guard against their catastrophic release into Ferrum Creek during periods of high rainfall.

Based on a review of the available information pertaining to the site and a preliminary screening of potentially applicable remediation technologies, the following removal action alternatives were proposed and evaluated:

- Alternative 1 - No Action (for comparison purposes)
- Alternative 2 - Fencing either the perimeter of the tailings area or the entire gravel pad area. A 10-foot-high chain-link fence would be used to isolate the tailings area from local wildlife and from human contact.
- Alternative 3 - Place a relatively impenetrable cover over the tailings area. This cover might consist of dirt fill, geotextile membrane, or urethane spray foam.
- Alternative 4 - Place the arsenic-bearing material on site in a covered and lined containment cell.
- Alternative 5 - Remove the arsenic-bearing material and ship to an approved disposal facility.
- Alternative 6 - On-site ex situ treatment using the Cashman Process.
- Alternative 7 - On-site in situ treatment using solidification/stabilization.

An Action Memorandum was prepared in February 1996 presenting the chosen alternative. Based on the comparative analysis in the EE/CA, combining the tailings into a central location (Pond D) and solidifying/stabilizing the surface of the tailings with a concrete mixture was the recommended removal action alternative. This alternative met the removal action objectives of physically isolating the tailings from humans and wildlife, limiting infiltration of rain and meltwater, and reducing the potential for surface water transport of the tailings.

3.0 REMOVAL ACTION IMPLEMENTED

In 1996 Shannon & Wilson prepared construction specifications based on the preferred alternative described in the Action Memorandum. Linder Construction was hired by the NPS to solidify the tailings using Portland cement. In July 1996, an attempt to complete the task was aborted due to inclement weather.

Again in July 1998 Linder mobilized a field crew to the site via a barge. According to the NPS field representative, a helicopter was used to shuttle materials and equipment to the mine site. A decontamination area was set up and surface water was diverted from the area of Pond D. The surface of Pond D was scarified with a tractor-mounted roto-tiller and dry Portland cement was placed on the ground surface (Photo 3). The roto-tiller was used to blend the cement with the upper portion of the tailings and a plate compactor was used to densify the mixture (Photos 4 and 5). As the natural moisture content was sufficient to hydrate the cement no additional water was added to the mixture. Material from the Ponds C, F, and G (Figure 2) was then excavated and placed on Pond D in two 7- to 8-inch lifts; each lift was combined with cement and compacted. (Photo 6). Figure 3 shows a schematic of the solidification process. About 210 bags of cement were used during the solidification process. The upper lift was contoured to avoid ponding of surface water (Photo 7).

According to soil density testing conducted by GeoEngineers of Anchorage (a subcontractor to Linder responsible for materials testing), the initial conditions in Pond D were 70 percent of maximum dry density with 12.9 percent moisture (Appendix A). Following the addition of the cement and compaction of the in-situ material, the maximum dry density ranged from 91 to 93 percent with a moisture content between 10.9 and 18 percent. The maximum dry density of the lifts #1 and #2 ranged from 67.7 to 77 percent with moisture contents ranging from 15.9 to 31 percent. Compaction design specifications were not met due high moisture from heavy rain and excessive silt in the material from the outlying areas. According to the GeoEngineers report, additional cement was added to the tailings to compensate for the high moisture contents.

3.1 Subsequent Site Visits

In 1999 and 2000, Linda Stromquist of the NPS visited the site to check on the condition of the tailings. She observed the surface to be smooth and with minor flakes and spall. The surface was crowned sufficiently to minimize the ponding of water. No areas were noted to have been disturbed by weather, wildlife, or humans.

In August 2006 Park Service personnel visited to the site and noted that the surface had spalled; the cap did not appear to have been disturbed by weather, wildlife, or humans. The tailings cap appears to be supporting plant growth (Photos 8 and 9). No surface water was noted in the area of the tailings.

4.0 ELIMINATION OF EXPOSURE PATHWAYS

Arsenic is the contaminant of concern at the Beauty Bay Mine. The arsenic present in the environment of the site is assumed to have originated from naturally-occurring arsenopyrite, which was mined along with the gold. The access to the arsenic-bearing fine tailings was not restricted and therefore they were subject to redistribution by heavy rainfall/surface runoff. The site is very remote, and therefore, human access to the site is limited; currently the site is posted with signs warning visitors of the potential health risks. The tailings were accessible to wildlife and, based on observations of hoof and knee marks and nose imprints, it appears that they were attractive, at least to moose. Apparently, water that accumulated within Pond D dissolved arsenopyrite and other soluble minerals, which later precipitated on the surface of the tailings during a dry period in 1994. The actual composition of the white precipitate is not known. Based on the presence of arsenic in concentrations exceeding the cleanup levels, the conservative assumption has been made that the arsenic-bearing material caused a fatal reaction in a 1-month-old moose calf. The NPS completed the removal action to eliminate exposure pathways of soil and surface water. The removal action isolated the tailings from wildlife and human visitors, minimized infiltration, eliminated the accumulation of water within Pond D, and reduced the potential for redistribution by surface water.

4.1 Receptors

The following statement is taken from the EE/CA:

> No workers are currently present at the site. A recreational cabin is located approximately 6 miles from the site. No year-round residents are known to be located in the vicinity of the site. Access to the mine is extremely limited, and the location of the mine site is not shown on USGS maps or in the NPS brochure which describes the park; therefore the site receives few visitors, estimated by the NPS at possibly 10 to 15 per year. Two valid federal mining claims currently encompass the site. There are no known users of surface water or groundwater in the vicinity of the Beauty Bay Mine. The site is located within the Kenai Fjords National Park; therefore, all of the surrounding area may be considered a sensitive environment.

According to the NPS there has been no change in the status of the site with the exception that the federal mining claims have lapsed and therefore the potential receptors remain unchanged.

4.2 Exposure Pathways

The following section presents the apparent affect the removal action has had on the various exposure pathways.

4.2.1 Groundwater

According to information presented in the EE/CA, there are no groundwater receptors within the vicinity of the site. According to the NPS observations, the solidification of the tailings appears to be limiting water infiltration through the tailings, thereby minimizing the potential for arsenic migration to the local groundwater.

4.2.2 Surface Water

Information presented in the EE/CA, indicates there has been no surface-water impact in the vicinity of the site. The removal action objective on minimizing the potential for catastrophic release of the tailings appears to have been accomplished. Although the NPS observations indicate the surface of the solidified tailings is spalling, the drainage pattern routes surface water away from the tailings. Some vegetation is taking hold on the solidified tailings, thereby further reducing the potential for redistribution of the tailings by surface water.

4.2.3 Soil Exposure

Soil exposure was the pathway of greatest concern prior to conducting the removal action at the Beauty Bay mine site. As discussed in Section 1.11, the accumulation of water in Pond D and the dissolution of arsenopyrite resulted in the potential for presence of arsenic-bearing precipitates during dry periods. The solidification of the tailings appears to have eliminated the problem of flooding in Pond D and has minimized the potential for dermal contact or ingestion of the tailings. According to the NPS there was no indication of disturbance of the cap by wildlife.

4.2.4 Air

Potential for air exposure was not considered significant prior to the removal action since the site is typically wetted or covered with snow seven months of year. The likelihood of dry, dusty conditions at the site is low. The solidification process further reduced the potential of exposure through the air pathway.

5.0 CONCLUSION

According to observations made by the NPS, the tailings in their current configuration, following the 1998 removal action, appear to be isolated from local wildlife and the occasional human visitor. The durability appears to be sufficient to attain the stated removal action objectives and the cap appears to be functioning as designed. Although the surface is spalling, there was no cracking or settlement noted, indicating the solidified mass is stable. No significant changes in the potential receptors have occurred.

To alleviate concerns about the bioavailability of arsenic in the spalling solidified mass, analytical testing could be performed. However, the release mechanism thought to be responsible for the generating arsenic-bearing precipitates has been eliminated. Analytical testing would reconfirm the presence of arsenopyrite at the site but without the release mechanism the arsenic within the arsenopyrite is believed to be relatively stable. Future site visits should concentrate on observing the physical integrity of the solidified mass, the amount and type of vegetation that is taking root, and any surface water drainage that may be compromising the edges of the solidified mass.

6.0 LIMITATIONS

The summary we have presented in this report is largely based on information collected by others; we cannot attest to its accuracy. Changes in site conditions can occur with time because of natural forces or human activity. The data presented in this report should be considered representative only of the time the data were collected. In addition, changes in government codes, regulations, or laws may occur. Because of such changes beyond our control, our observations and interpretations may need to be revised.

This report was prepared for the exclusive use of NPS and its agents in accordance with the scope of work. If it is made available to others, it should be for information on factual data only and not as a warranty of described conditions, such as those interpreted from the discussions included in this report.

SHANNON & WILSON, INC.

Mark S. Lockwood, C.P.G.
Principal Geologist

Reviewed by
David M. McDowell
Vice President

7.0 REFERENCES

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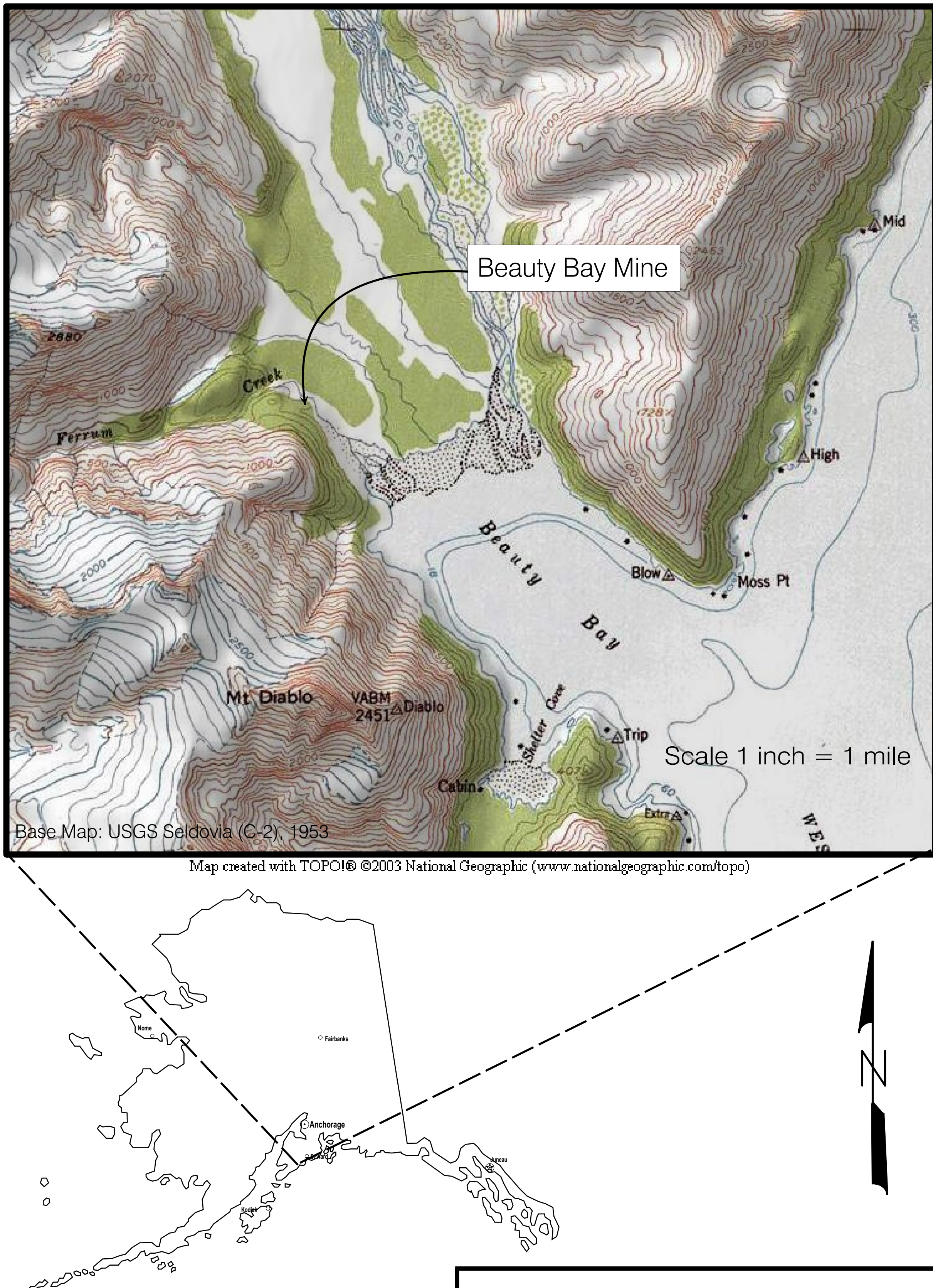

Beauty Bay Mine Removal Action Summary
Kenai Fjords National Park, Alaska

SITE LOCATION MAP

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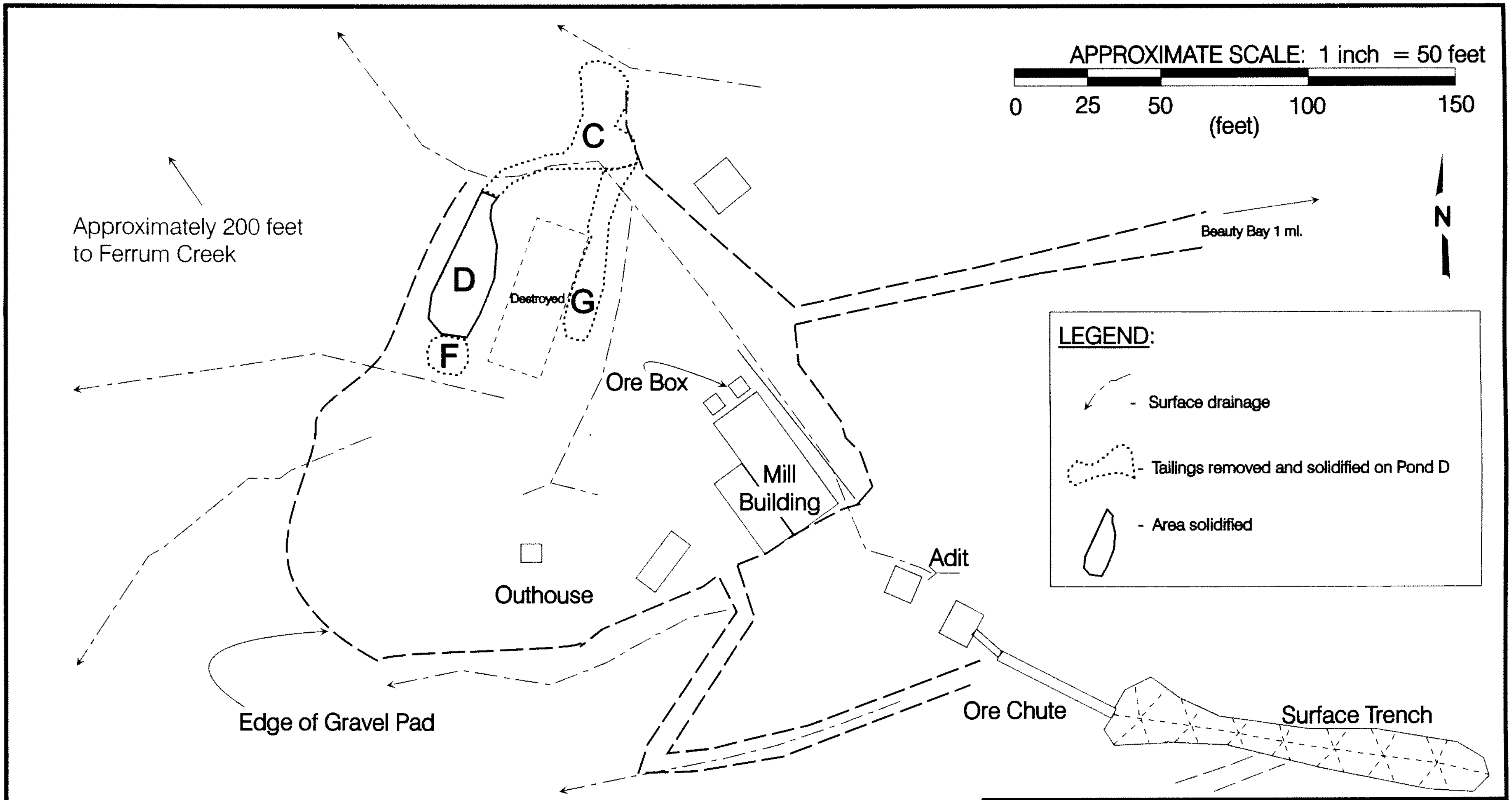
Figure 1



Beauty Bay Mine Removal Action Summary
Kenai Fjords National Park, Alaska

SITE PLAN

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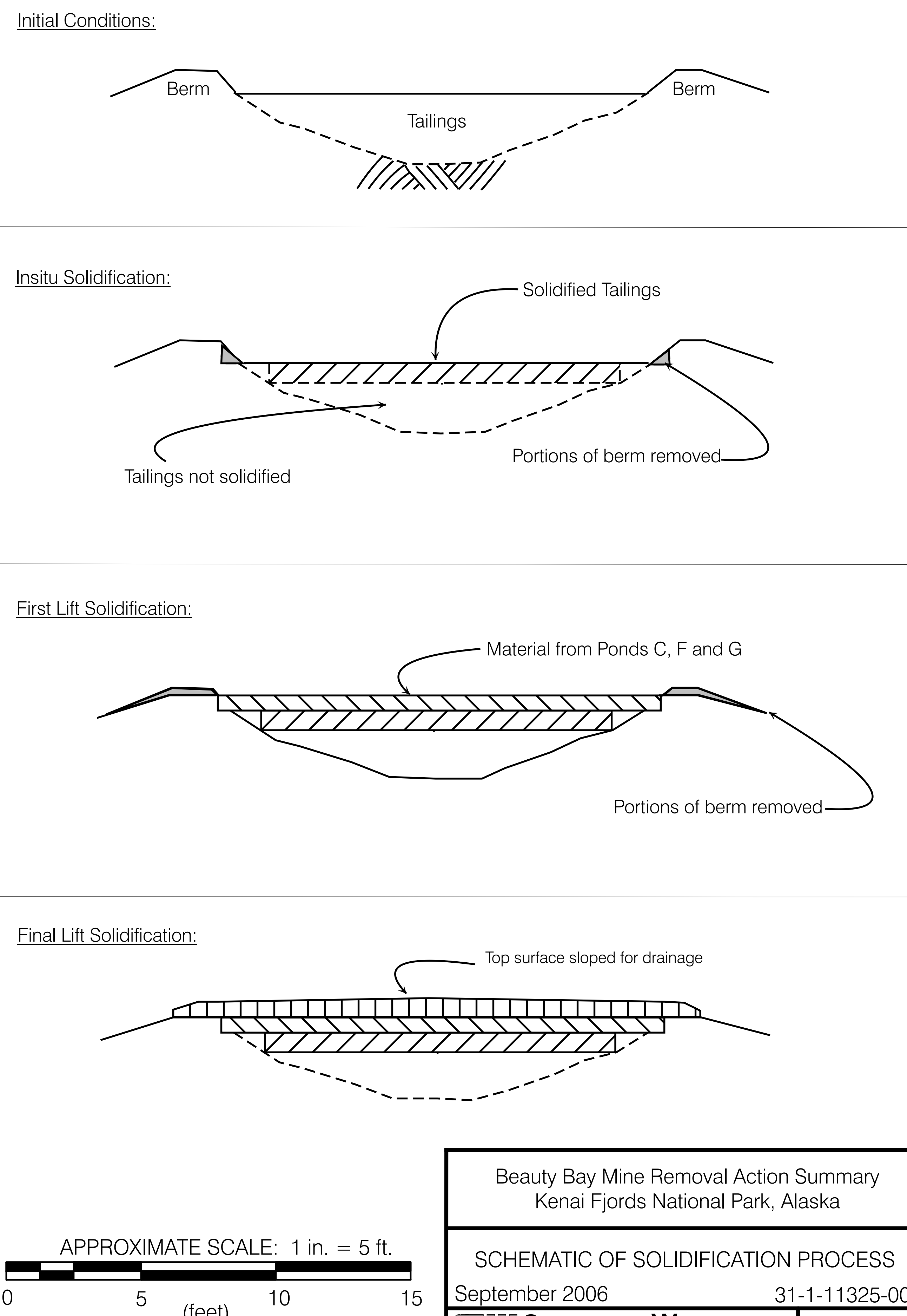
Figure 2

Figure 3



Beauty Bay Mine Removal Action Summary
Kenai Fjords National Park, Alaska

SCHEMATIC OF SOLIDIFICATION PROCESS

September 2006

31-1-11325-001

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Figure 3

Photo 1. Beauty Bay Mine tailings on June 28, 1994; note white precipitate on surface.

Photo 2. Beauty Bay Mine site looking northwest; Pond D is near center of picture - August 1995.

Photo 3. Application of Portland cement to surface of Pond D- July 1998.

Photo 4. Rototiller mixing cement with tailings.

Photo 5. Compacting tailings/cement mixture.

Photo 6. Beauty Bay Mine site looking northeast following the removal of tailings from Ponds C and G.

Photo 7. Pond D following the completion of the solidification process.

Photo 8. Pond D – August 2006; note plant growth on surface.

Photo 9. Close-up Pond D – August 2006

APPENDIX A

Results of Soil Density Testing
Beauty Bay, Alaska

Geo Engineers

October 2, 1998

Consulting Engineers
and Geoscientists
Offices in Washington,
Oregon and Alaska

Linder Construction, Inc.
8220 Petersburg Street
Anchorage, Alaska 99507

Attention: Stuart Barrows

Results of Soil Density Testing
Beauty Bay Mine, Alaska
File No. 0861-003-01

INTRODUCTION

GeoEngineers is pleased to present the results of soil density testing at the Beauty Bay Mine, a remote site located on the south side of the Kenai mountains approximately 35 miles southeast of Homer, Alaska. The work was conducted from July 8 through 11, 1998. Figure 1 shows the location of Beauty Bay relative to surrounding features. Figure 2 presents the site plan and relevant features. Several areas of the site were labeled by the National Park Service and Areas A, B and E are not part of this project.

PURPOSE AND SCOPE

The purpose of the project was to solidify tailings from the abandoned mine by combining the tailings with cement. The fine-grained, arsenic-bearing tailings were byproducts of the crushing process used to free fine gold from hydrothermal ore veins. Shannon & Wilson of Fairbanks, Alaska, provided a sieve description of the tailings as fine to medium sand with a maximum dry density of 118 pounds per cubic foot (pcf) and a natural moisture content of 4.5 percent. Modified Proctor testing of the cement/sand mix resulted in a maximum dry density (MDD) of 132.2 pcf at 8 percent moisture. The project specifications called for compaction of three lifts measuring 6 inches in loose thickness to a density of 95 percent MDD. Cement was to be combined through a tilling process at a concentration of six 94-pound sacks per cubic yard of tailings.

Our scope of services included testing compacted soil/cement for moisture content and density using a Seaman's nuclear soil-density gauge.

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RESULTS

An initial inspection of the site showed that the majority of tailings in Areas C, F and G consisted of less than 8 inches of silt and sandy silt. Soil in Area D was predominantly fine to medium sand up to 3 feet in thickness. First, cement was mixed into soil in Area D, then it was compacted and allowed to set up. This was followed by excavation, tilling with cement and compacting of Areas C, F and G. Soil from these areas was moved and compacted in lifts on top of the soil located in Area D. Each lift was allowed to cure prior to placement of each additional lift.

Results of our field testing indicated in-situ moisture contents in Areas C, F and G above optimum (10 to 31 percent). Compaction of these silty tailings frequently resulted in liquefaction or 'pumping' of the soil. To prevent further increases in soil moisture content, the zones of excavation and compaction were covered with clear plastic during rainy periods and at the end of each workday. Additionally, a small creek was diverted away from the construction area.

Compaction of the tailings was accomplished using a vibrating plate and rolling with a rubber-tired tractor. Approximately two to three density tests were taken per lift. The tailings compacted were siltier than soil used in the Modified Proctor Test and contained considerably more moisture. In our opinion, in terms of the desired solidification, additional of extra cement may help to compensate for soil densities below 95 percent MDD. However, we recommend that these field results be reviewed for applicability to design issues. Table 1 summarizes the compacted-soil moisture and density test results.

We appreciate the opportunity to provide geotechnical testing services to Linder Construction, Inc. during the Beauty Bay project. Please feel free to call us with any questions.

Yours very truly,

GeoEngineers, Inc.

Jeffery W. Selbig
Staff Engineer

Howard P. Thomas, P.E.
Associate

JWS:HPT:skl
Document ID: 086100301sdt.doc

Attachments

Four copies submitted

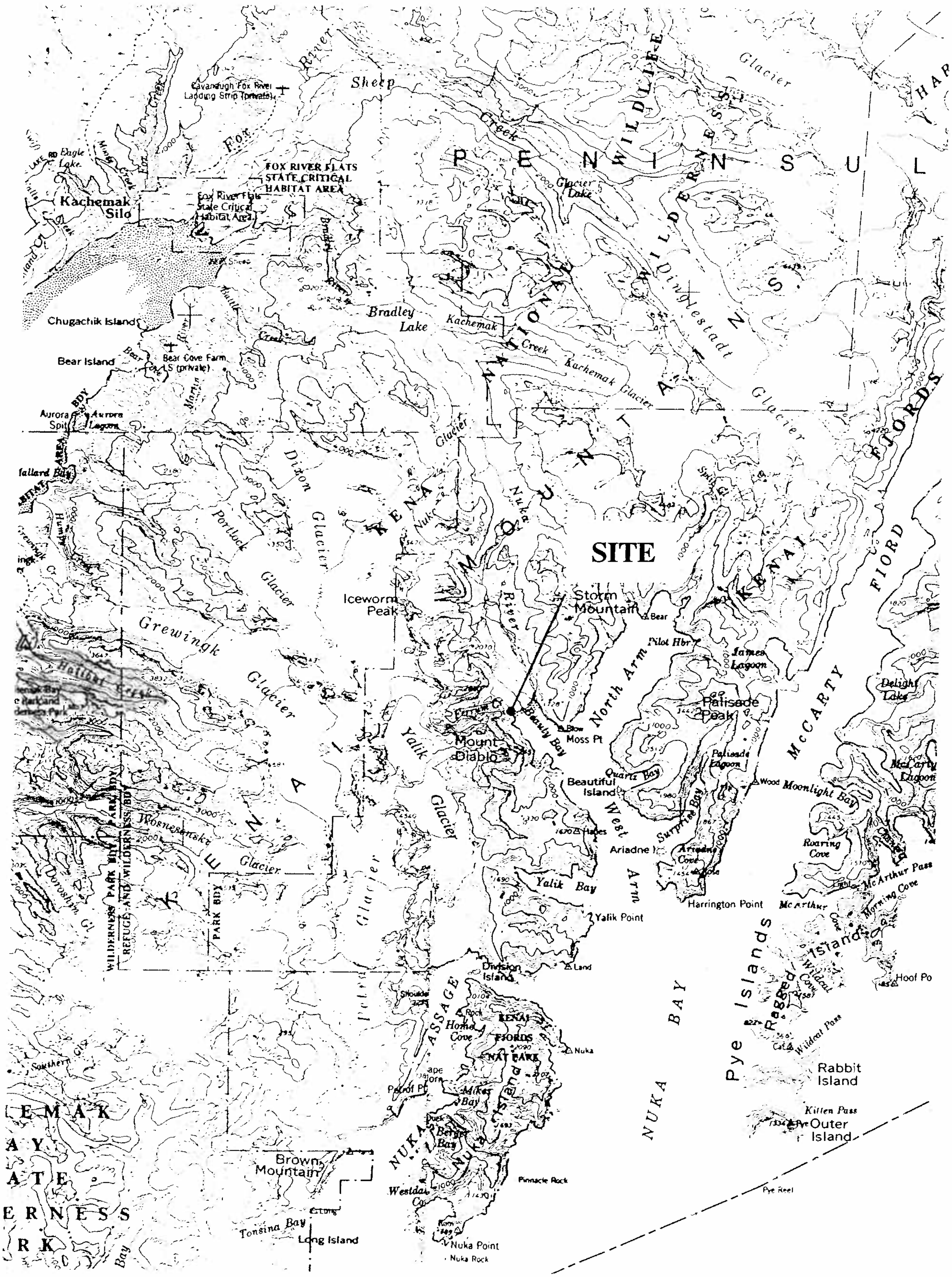
TABLE 1
SOIL MOISTURE/DENSITY TEST RESULTS - AREA D
BEAUTY BAY MINE
BEAUTY BAY, ALASKA
GEI JOB #0861-003-01

Test Number	Date	Soil Type	Lift Number	Thickness	Maximum Dry Density[1]	Optimum Percent Moisture[1]	Dry Density	Percent Moisture	Percent Maximum Dry Density	P/F	Notes
1	07/09/98	fine sand, no cement	in-situ	2 feet	118	4.5	82.8	12.9	70	F	Area D
2	07/09/98	fine sand, cement	in-situ	6 inches	132.2	8	101	12.6	92	F	Test Plot
3	07/09/98	fine sand, cement	in-situ	6 inches	132.2	8	102.6	18	93.6	F	added extra cement
4	07/09/98	fine sand/silt, cement	in-situ	6 inches	132.2	8	106.8	10.9	91.2	F	added extra cement
5	07/10/98	sandy silt, cement	#1	8 inches	132.2	8	87.4	31	67.2	F	added extra cement
6	07/10/98	sandy silt, cement	#1	8 inches	132.2	8	99.3	21.6	76	F	added extra cement
7	07/10/98	sandy silt, cement	#2	7 inches	132.2	8	93.7	15.8	72	F	added extra cement
8	07/10/98	sandy silt, cement	#2	7 inches	132.2	8	100.2	15.9	77	F	added extra cement

Notes:

[1]Maximum Dry Density and Optimum Moisture Content as reported by Shannon and Wilson, Inc.

P/F = passed/failed soil density test



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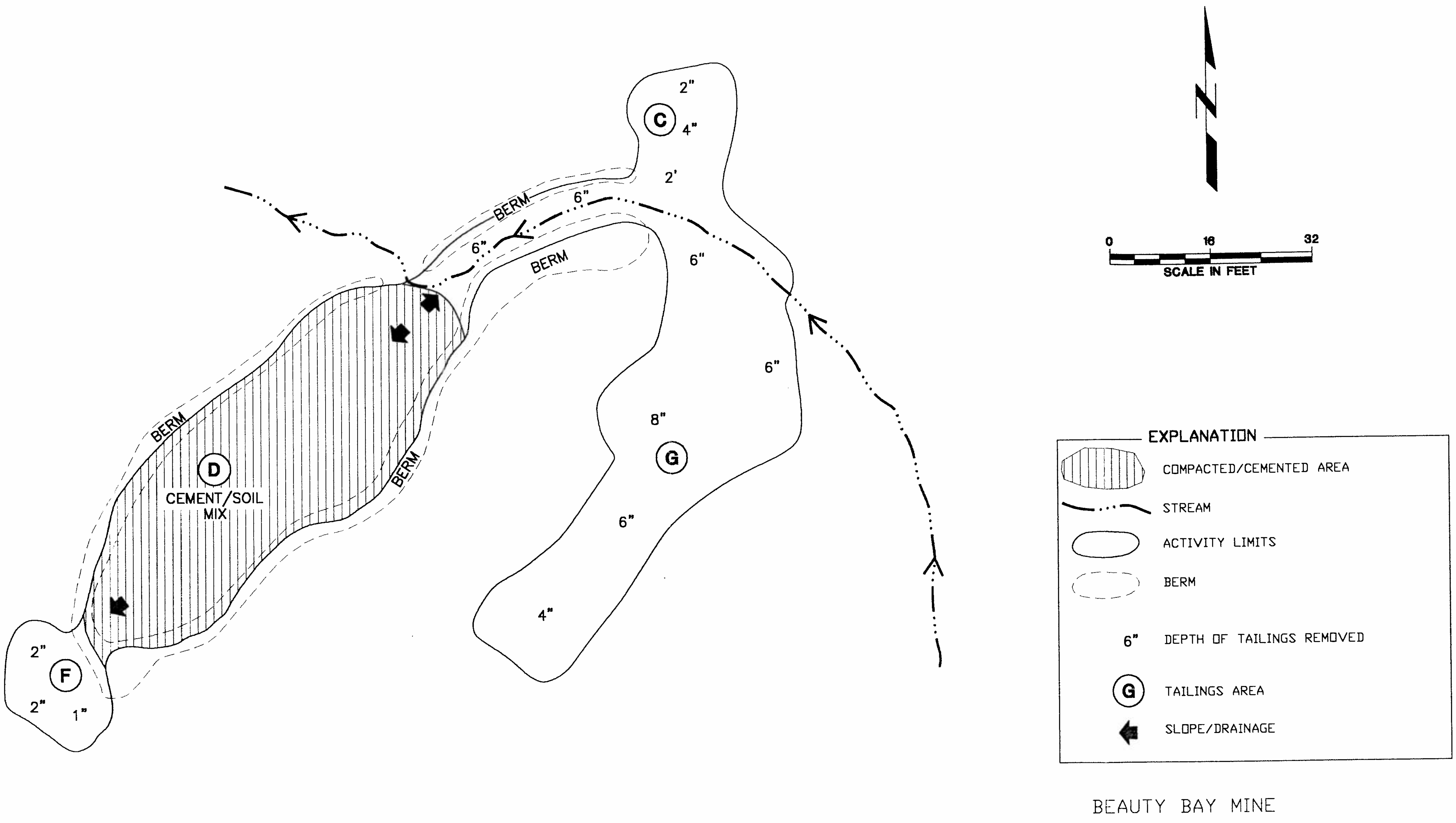
VICINITY MAP

FIGURE 1



0861-003-02JWS:DWB 08/26/98 DWG FILE: 0861-003-02-2A.DWG

References: Field sketch by GEOENGINEERS, INC.

Notes: The locations of all features shown are approximate.

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SITE PLAN

FIGURE 2