KLOHN CRIPPEN

April 2, 2004

Kennecott Greens Creek Mining Company
P.O. Box 32199
Juneau, Alaska
99803-2199

Mr. Tom Zimmer
Surface Operations Manager

Dear Mr. Zimmer:

Kennecott Greens Creek Mining Company
Stage 2 Tailings Facility Expansion
Design Overview For Forest Service Submission

We are pleased to submit ten (10) copies of our report titled "Stage 2 Tailings Facility Expansion, Design Overview for Forest Service Submission".

Yours truly,

KLOHN CRIPPEN CONSULTANTS LTD.

Robert W. Chambers, P.Eng. (B.C.)
Project Manager

RWC/KAE:dl

Suite 500 – 2955 Virtual Way, Vancouver, B.C., Canada V5M 4X6 • T 604 669 3800 • F 604 669 3835 • www.klohn.com

TABLE OF CONTENTS

PAGE

TABLE OF CONTENTS
(continued)

TABLES

FIGURES

APPENDICES

TABLE OF CONTENTS
(continued)

DRAWINGS

1. INTRODUCTION

Greens Creek Mine is an underground polymetallic (zinc, silver, gold and lead) mine on northern Admiralty Island, Alaska (Drawing D-35001) that is owned and operated by Kennecott Greens Creek Mining Company (KGCMC). Mine tailings are dewatered at the mill site; about one-half of the tailings are utilized as backfill in the mine, and the remainder is transported to the Tailings Facility for storage. An incremental expansion of the Tailings Facility storage capacity, hereafter referred to as the Stage 2 Expansion, is planned between 2004 and 2007 to accommodate projected mine tailings storage requirements.

Regulatory approval for the expansion was granted after a tailings site review by the USDA Forest Service (USFS) and other Federal, State and Local Agencies. With the USFS as the lead agency, a Final Environmental Impact Statement (FEIS) was issued on October 24, 2003 with a Record of Decision (ROD) supporting the tailings disposal expansion plan. The tailings area is operated under a Waste Management Permit (WMP) issued by the Alaska Department of Environmental Conservation (ADEC) on November 7, 2003 (ADEC, 2003), and a General Plan of Operations (GPO) (KGCMC, 2004) submitted to the USFS.

This overview report provides general descriptions of the Tailings Facility site, the design conditions, the proposed expansion areas, stability analyses, construction schedules for the proposed expansion work from 2005 to 2007, and details of the proposed 2004 expansion construction. Drawing D-35002 shows the general arrangement of the Stage 2 Expansion, including the proposed locations of a new truck wash facility and new storm water retention ponds. The expansion represents approximately 60% to 70% of the total tailings capacity increase outlined in the FEIS, and will increase the capacity of the Tailings Facility (over the current pile configuration) by about 2.7 million yd^3 (about 4.7 million dry short tons).

Expansion activities planned for 2004 include construction of a new truck wash facility, rock quarrying at the proposed location for Storm Water Retention Pond No. 7 (Pond 7), construction of Step 1 of the proposed Southeast Expansion for tailings placement, and re-grading portions of the B-Road. Utility relocation in advance of 2005 construction activities could also be completed in the proposed Northeast Expansion area. Construction of the proposed Northeast and Northwest Expansion areas will likely commence in 2005 concurrently with construction of the new stormwater retention ponds. In 2006, Step 2 of the Southeast Expansion will be carried out, followed by the Southwest and Pond 6 Expansion areas in 2006 and 2007.

A preliminary timeline of the proposed expansion works is presented on Figure 4.1. The expansion plans past 2004 are estimates and could change based on the mine plan and further optimization of the tailings site, including items such as relocation of production rock to the Tailings Facility.

This report was prepared by Klohn Crippen Consultants Ltd. for the account of Kennecott Greens Creek Mining Company. The material in it reflects Klohn Crippen's best judgment in light of the information available to it at the time of preparation. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Klohn Crippen Consultants Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report.

2. GENERAL SITE DESCRIPTION AND DESIGN CONDITIONS

2.1 General

The section provides a general site characterization including physiography, climate, geology, stratigraphy, hydrology and hydrogeology, and the design basis criteria for the Stage 2 Expansion.

Also referred to in the description is the Old Tailings Facility (OTF), which was built from 1989 to 1993 and subsequently incorporated into the ETF, see Drawing D-35002.

2.2 Site Characterization

Physiography

Greens Creek Mine is partially located within the Admiralty Island National Monument, on the northern end of Admiralty Island (Drawing D-35001). Admiralty Island is part of the Alexander Archipelago, and is formed by a series of mountains that rise up to El. 4,700 ft. The terrain is characterized by steep, rugged mountain slopes and sharply incised stream valleys that were substantively formed by glacial scouring. The tailings facility is situated on a gently west-sloping bench between about El. 140 ft and El. 220 ft. It is bounded to the east by steep, rugged mountain slopes, and to the west by Hawk Inlet.

Climate

Greens Creek Mine is located in the southeastern portion of the Alaska Coastal Maritime climatic zone. The climate is characterized by cloudy skies, abundant precipitation, and moderate temperatures.

The ambient air temperature data for the tailings facility are summarized in the FEIS:

> "The air temperature at the project site is heavily influenced by the coastal marine environment, which has a moderating effect on temperature extremes. The annual average temperature at the project site ranged was between 42° [F] and 43° F between 1997 and 2000. The maximum and minimum one-hour average temperatures at the project site in 2000 were about 70° [F] and 9° F, respectively."

Local topography strongly influences the prevailing wind direction at the site. In 2000, the wind blew form the north to northeast 54% of the time and from the south to southeast 9% of the time (USDA, 2003). The average windspeed in 2000 was 11 mph, and the highest measured windspeed was 38 mph (USDA, 2003).

Recent precipitation data from the site, as well as comparative historical data, are also summarized in the FEIS:

> "Since 1997, an automated monitoring system has collected data on the amount of precipitation at the tailings site. Between 1997 and 2000, the average annual precipitation at the site was 53.0 inches."
>
> "The precipitation levels recorded at the tailings site are consistent with other meteorological measurements in the general area. For example, the National Weather Service Climate Database reports that Angoon, on the western side of Admiralty Island, has a 40-year average annual precipitation of 42.2 inches. At the Juneau airport, annual precipitation has averaged 56.5 inches over a 51-year period of record. Auke Bay, north of Juneau, reports an annual average of 62.4 inches for a 37-year period of record. Given the surrounding records, it appears that, although the data from the tailings site are limited, they fit well with other sites within a 20 to 40 mile radius and at similar elevation."

Precipitation data from the FEIS are summarized below in Table 2.1.

Table 2.1 Greens Creek Tailings Facility Monthly Precipitation* (1997-2000)

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
Range of Maximum Daily Precipitation (in.)**	0.30 to 1.17	0.33 to 4.09	0.32 to 0.82	0.30 to 1.21	0.59 to 1.00	0.64 to 0.70	0.85 to 1.10	0.82 to 2.09	1.03 to 1.49	0.69 to 2.89	0.49 to 1.62	0.85 to 3.02
Total Monthly Precipitation*** (in.)	2.79	3.84	2.77	3.96	2.82	2.70	4.78	5.22	6.89	7.15	3.69	6.36

* The data are total precipitation (combined rain and snow).
** Recorded daily maxima from 1997 to 2000.
*** Four year monthly mean from 1997 to 2000.

In terms of monthly total precipitation, the data in Table 2.1 show that October is the wettest month (7.15 in.) and June is the driest month (2.70 in.).

Regional Geology

Admiralty Island is located in the Admiralty Subterrane of the larger Alexander Terrane. Admiralty Subterrane bedrock consists of Triassic through Ordovician sediments, meta-sediments and volcanics from 190 to 500 million years old (Ma). Bedrock in the vicinity of Greens Creek Mine generally consists of foliated Triassic (about 220 Ma) marine sediments and meta-volcanics (e.g., greywacke, argillite, phyllite, mafic tuffs, gneiss and schist). These rocks have been deformed by complex northwest-southeast striking folding and are cut by high-angle strike-slip faults and low-angle thrust faults (Apel, 1995) (Terrasat 1991).

Surficial Geology

Pleistocene glaciers deposited layers of basal till, ground moraine and outwash sediments in the valley bottoms, that are in-turn overlain by glaciolacustrine and infrequent glaciomarine sediments, colluvium and peat. Glacioestuarine or glaciomarine silt and clay have been identified at the base of eroded terrace remnants at El. 500 ft to 600 ft in

Greens Creek valley (Terrasat, 1991), indicating that a comparable amount of isostatic rebound and/or tectonic uplift has occurred. Raised beaches have also been identified at 50 ft, 100 ft, 130 ft and 160 ft elevations above sea level (Terrasat, 1991). Greens Creek valley was occupied by at least one glacial lake with associated non-marine silt and clay deposits.

The stratigraphy within the footprint of the existing tailings facility is complex and the above noted stratigraphic layers are often interlayered with each other. This is likely the result of various deposition environments including glacial, marine, and lacustrine. The generalized stratigraphy at the Tailings Facility from bottom to top is summarized as follows (Klohn Crippen, 2001a):

- Bedrock (schist, phyllite and argillite) at depths from surface outcrops to more than 140 ft. Just south of the Tailings Facility, depths to bedrock exceed 140 ft (KGCMC 1996). Bedrock is exposed at the proposed location for Pond No. 7 and in the proposed Northwest Expansion area, and at the original ground surface beneath the 2000 East expansion, beneath parts of the 2002 Southeast expansion, at Pit No. 5;

- Dense silt and sand glacial till up to 60 ft thick. This zone contains artesian water pressures (Klohn Crippen 2001a);

- Firm to very-soft lacustrine and/or marine clay and silty-clay up to about 50 ft thick. This stratum is thickest to the south and southwest of the Tailings Facility, and thins northward and in the area immediately west of the West Buttress;

- Loose to dense fluvial or shallow marine sand and gravel up to about 34 ft thick. This layer is locally absent along the north side of the OTF, 6 ft thick beneath the south side of the OTF, variably absent to over 22 ft thick beneath the east side of the OTF, and up to 33.5 ft thick to the west of the Tailings Facility. Alluvial sands in a loose to compact state were found on the south and east sides of the Tailings Facility, and in a compact to dense state west of the Tailings Facility; and,

- Amorphous to fibrous peat and organic matter. The peat was not generally stripped from beneath the footprint of the Tailings Facility, however, it was removed from beneath the footprint of the West Buttress. The peat was between about 2 ft and 18 ft thick in the drill holes to the west of the Tailings Facility.

Seismicity

Major faults and lineaments, which are potentially significant at the Greens Creek Mine, include:

- Fairweather-Queen Charlotte fault system (68.4 miles west);
- Chatham Strait fault (6.2 miles west); and,
- Coast Range mega-lineament (18.6 miles east).

A detailed seismic hazard assessment of Greens Creek Mine using both probabilistic and deterministic analyses is presented in Klohn Crippen (1998) and is summarized in Section 2.3 of this report.

Hydrology

Surface water runoff from the areas adjacent to the tailings facility area flows to the south via Tributary Creek, to the north via Cannery Creek, and to the west into Hawk Inlet. Pond No. 6 collects surface water runoff from the tailings pile, perimeter collection ditches and facility underdrains for routing to the Water Treatment Plant. Pond No. 6 is also a storm water surge pond, and has an emergency spillway that is routed to the wetland southwest of the facility. The North Retention Pond collects surface contact water from the northeast portion of the Tailings Facility and routes it to Tank No. 6 or Pond No. 6.

Water in Pond No. 6 is routed to the Water Treatment Plant via Wet Well No. 1. The treated water flows through a pipeline along the west side of the tailings facility to a submerged marine diffuser near the mouth of Hawk Inlet (NPDES-002). The discharge is regulated under a National Pollutant Discharge Elimination System (NPDES) permit (USDA, 2003).

Hydrogeology

In general, groundwater flow(s) in the Tailings Facility area are influenced by the local terrain and geology, the hydraulic control structures in and around the Tailings Facility, and by incident precipitation and snowmelt (EDE, 2002) (USDA, 2003). The facility straddles a hydrological divide, with groundwater and surface water flow draining northward to Cannery Creek, southward to Tributary Creek, and westward to Hawk Inlet (EDE, 2002).

In general, the groundwater recharge area for the site is the mountain slope to the east. There is no known regional aquifer system in the tailings facility area (USDA, 2003). The groundwater moves down slope through various geological strata toward Hawk Inlet (EDE, 2002).

Groundwater in an upper, unconfined peat and sand aquifer is diverted around the tailings facility into the Tributary Creek and Cannery Creek drainages by a system of slurry walls, ditches and drains. Groundwater in the lower till and bedrock aquifer(s) flows predominantly westward under the tailings pile toward Hawk Inlet. The upper and lower aquifers are separated in some areas by a relatively low hydraulic-conductivity, discontinuous silty-clay layer (described above).

Groundwater flow within the tailings pile and in the sand aquifer beneath it is predominantly southward towards the drains and sumps at the south end of the tailings

facility, where it is collected and routed to the Water Treatment Plant (EDE, 2002). Groundwater in a bedrock high under the northwest corner of the tailings facility flows away from the high point in all directions (USDA, 2003).

2.3 Design Basis and Criteria

Design criteria for the Stage 2 expansion were developed by Klohn Crippen (2003) in consultation with KGCMC, and are detailed in this section.

Tailings Characteristics

Tailings properties are summarized in Table 2.2.

Table 2.2 Tailings Properties

PROPERTY	VALUE
Gradation	78% to 96% by weight passing No. 200 Sieve
Specific gravity of solids	3.13 to 3.50 (mean = 3.23)
Maximum dry density (standard Proctor)	120 pcf to 137 pcf (mean = 129 pcf)
Optimum moisture content (standard Proctor)	14.3% to 15.3% (mean = 14.8%)
Field Hydraulic Conductivity (measured at an in-situ density of 92% of standard Proctor optimum dry density)	2×10^{-7} cm/s

The Greens Creek Mine tailings contain varying amounts of sulfide minerals. Geochemical testing on the tailings indicates that the tailings have the potential to become acid generating, but that the lag time to acid generation is tens to hundreds of years if the tailings were exposed to oxidation (KGCMC, 1995 and Sheppard Miller Inc, 2000, USFS 2003).

Storage Volume Requirements for Stage 2 Expansion

The storage requirement for tailings and production rock in the current mine plan is estimated to be about 2.67 million cubic yards. This is equivalent to about 4.77 million

dry short tons (dst) using volume-to-mass conversion factors of 1.81 dst/cubic yard for tailings and 1.7 dst/cubic yard for all other materials.

Maximum Elevation and Slope Geometry for Tailings Facility

The maximum elevation of the tailings pile (before the proposed closure cover) is El. 330 ft. The tailings pile will be constructed with overall 3H:1V external slopes. Any closure cover constructed on the pile would raise the ultimate elevation of the facility to over El. 330 ft. The closure cover is not part of this design.

Design Factors of Safety for Geotechnical Stability

The minimum target Factors of Safety for stability analyses, to be calculated using the phreatic surface(s) provided by EDE (2003), are as follows:

- 1.5 for long-term static conditions;
- 1.3 for temporary (construction) conditions less than 1 year duration;
- 1.1 for pseudo-static conditions; if the pseudo-static safety factor is less than 1.1 a deformation analysis using the Hynes-Griffin and Franklin (1984) inertial model will be completed; and
- Greater than 1.0 for post-liquefaction.

Seismicity

A detailed seismic hazard assessment of Greens Creek Mine is presented in Klohn Crippen (1998). The design ground motion parameters are summarized in Table 2.3.

Table 2.3 Recommended Design Ground Motions at Greens Creek Mine

DESIGN CRITERION	PEAK HORIZONTAL GROUND ACCELERATION ON ROCK (g)	REPRESENTATIVE EARTHQUAKE MAGNITUDE
Operating Design Earthquake	0.15	M6.5
Maximum Design Earthquake	0.30	M7.0

Amplification of ground motion was assessed based on Seed et al. (2001).

Water Routing and Hydrology

The following operational water routing and hydrological design considerations were used in the design:

- Non-contact surface water[1] from upstream of the tailings facility to be diverted around the facility;
- Non-contact groundwater will be diverted by use of perimeter slurry walls;
- Surface and seepage water that contacts the tailings will be collected and routed to a treatment facility;
- Water collection systems (e.g., ditches, etc.) will be sized for the 100-year return period, 24-hour design storm event, ADEC (2003);
- The storm water surge ponds will be sized for at least 25 year return period, 24-hour design storm events as per the WMP; and
- The surface water routing infrastructure will be suitable for upgrading for closure conditions as required.

[1] Non contact water is surface water and groundwater that has not come into contact with the tailings.

Geotechnical Properties

The design geotechnical properties of the tailings and foundation soil are summarized in Table 5.1, Section 5.

The interface friction angle between the soil and geosynthetic material will be 26° to limit the potential for interface shear slippage (Layfield Plastics, 2001 and Koerner, 1994).

The post-liquefaction undrained strength of the potentially liquefiable layers based on NCEER (1997) and Youd and Idriss (2001).

Compaction and Placement Characteristics of Tailings

Tailings placement procedures at Greens Creek Mine are provided in KGCMC's GPO (KGCMC, 2004). Tailings are currently graded and compacted to reduce surface water infiltration. Placement of tailings is sequenced to give time for construction-induced pore pressures to dissipate before additional tailings are placed. The minimum requirement for compacted in-situ density of the tailings in perimeter zones critical to pile stability is 95% of standard Proctor optimum dry density; the minimum in-situ density requirement is 90% of standard Proctor optimum dry density in the interior portions the pile.

2.4 Reclamation and Closure

The reclamation plan in the GPO (KGCMC, 2004) sets the performance standards for water quality at the tailings facility. Under the present plan, KGCMC plans to meet the criteria by placing an engineered cover on the tailings pile to minimize air and water infiltration. The final lift of tailings will be covered with a sequence of non-acid generating armoring rock, capillary breaks, compacted material and a growth media for concurrent reclamation, in compliance with the GPO (KGCMC, 2004).

3. DESCRIPTION OF STAGE 2 EXPANSION

3.1 General

This section provides a general description of the overall Stage 2 Expansion. Section 6 provides details of the 2004 work. An overall schedule for the work is discussed in Section 4. The layout of the facility after completion of the Stage 2 expansion is shown on Drawing D-35002. Hydraulic design of surface and groundwater controls was by carried out by Environmental Design Engineering (EDE) (EDE 2002).

The Stage 2 Expansion of the Tailings Facility is intended to provide surface storage capacity for tailings and production rock within the current mine plan. The expansion plan presented in this report is an overview and could change due to optimization of the tailings placement areas or changing mine storage needs. Factors that could affect the expansion footprint past 2004 are: additional water treatment facilities; mine plan changes (increases in production or mine life); and, additional volumes of material for storage in the pile (i.e., production rock). KGCMC will update this construction design report annually for approval by the USFS and ADEC prior to that year's construction activities.

The construction methods to be used in the incremental expansions planned have all been utilized in prior construction activities for the development of the Tailings Facility. Water containment and diversion, pile subdrains and collection, 3H:1V outside slopes, quarrying and installation of HDPE geomembrane liners are all established practices at the mine site. KGCMC considers use of these standard practice activities as successful and plans to use them for the continuing developments.

3.2 Tailings Placement Areas

Stage 2 Expansion construction could include development of up to five new tailings placement areas referred to as follows:

- Southeast Corner (Steps 1 and 2);
- Northeast Corner;
- Northwest Corner (Areas 1 and 2);
- Pond 6; and
- Southwest Corner.

The location of each of these areas is shown on Drawing D-35002. Drawings for each area are presented in Appendix II. The following paragraphs provide a brief description of each area.

- **Southeast Corner:** This area is an expansion to the south of the 2002 Southeast Expansion (the "Wide Corner Quarry Expansion") (Klohn Crippen, 2002). The development will require dismantling and replacement of the existing truck wash and Tank No. 6, and placement of a geomembrane liner over the area. Step 1 of this development will extend from near the existing B-Road to the existing truck wash and is described in detail in Section 6. Step 2 of this extension will eventually tie into the Pond No. 6 Expansion area.

- **Pond 6**: This will include expansion of the existing pile into Pond No. 6. Pond No. 6 water management functions will be replaced by Pond Nos. 7 and 8. Accumulated sediment and contaminated peat in Pond No. 6 will be excavated as far as practical. A drainage blanket will be placed and tied into the existing drainage blanket and discharge from Wet Well No. 2. A new wet well will be constructed at the west side of the Pond No. 6 Expansion. The design incorporates facility for future gravity drainage of the Pond No. 6 drainage blanket to the west, if this is allowed for closure.

- **Northwest Corner**: This expansion will be developed in two areas: Area 1 incorporates the southern two-thirds of the expansion area, and Area 2 incorporates additional expansion area to the north, if required.

The entire area is thought to be underlain by shallow soil and peat over bedrock. The peat and soft or unacceptable soil will be removed and the surface will be graded to achieve gravity drainage predominantly to the southwest. A HDPE geomembrane liner will be placed over the area and contact seepage waters directed via existing ditches to Wet Well No. 3. Surface runoff contact water will be routed to the containment ponds via HDPE-lined open ditches.

- **Northeast Corner**: This area is thought to be partly underlain by bedrock (the west one-third) and partly by glacial till. An excavation to remove loose sand in the foundation is proposed. A HDPE geomembrane liner will be placed over exposed bedrock and will be tied into the Northwest Expansion HDPE lining. Areas not lined with HDPE will be provided with a drainage blanket arranged to report to an extension of the existing French drain under the east side of the Tailings Facility. The Northeast Expansion will require replacement of the DB-04 water line and the water treatment plant backwash line. The North Retention Pond will be replaced by Pond No. 9. The existing slurry wall north of the Northeast Expansion will be raised and extended to the west if required. Surface contact water from the Northeast Expansion will be directed to drain by gravity to Pond No. 9 in an HDPE lined ditch.

- **Southwest Corner**: This small area is needed to allow full development of the Pond No. 6 Expansion area. Peat will be excavated as far as practical without undermining the Tailings Facility, and a drainage blanket and Wet Well will be constructed. The area will be enclosed by a slurry wall connecting the West Buttress slurry wall and the Saddle Dam slurry wall. Surface drainage will be via a lined ditch to the surface pond system.

3.3 Water Management

3.3.1 General

A surface water and groundwater management system for the proposed expansion area has been recommended by EDE (EDE 2002). The elements the surface water plan are shown on Figure 3.1 and may consist of the following:

- Installation of additional lined surface water ditches;

- Construction of proposed Retention Pond Nos. 7 and 8 with discharges to the water treatment facilities;
- Construction of proposed Stormwater Retention Pond No. 9 to replace the North Retention Pond;
- Raising and extending the existing northeast and west abutment slurry walls; and,
- Constructing a new slurry wall round the southwest expansion.

3.3.2 Surface Water

A series of geomembrane lined ditches has been designed to collect surface contact runoff water from the Stage 2 Expansion. The ditches will generally surround the perimeter of the toe line of the Tailings Facility, on the tailings side of a new perimeter access road. The ditches were sized to convey the peak instantaneous flow produced during a 100-year return period, 24-hour duration storm. Water in the ditches will be directed south to Pond No. 6, while it is still in service, and eventually be routed to the Pond Nos. 7, 8 and 9.

The location and perimeter outline of Pond Nos. 7 and 8 are shown on Figure 3.1. Pond No. 7 will be formed partly from a bedrock excavation in the area immediately southwest of Pond No. 6. Pond No. 8 is founded on dense sand and silty sand and will have a rock fill berm to form the containment. The interior of the new containment ponds will be lined with a synthetic liner system (e.g., 60 mil textured HDPE) to reduce the potential for seepage into the underlying strata or containment berms. The containment dykes will be constructed from compacted rock fill, and will have a 15 ft crest width, upstream slopes of 3H:1V and downstream slopes of 2.5H:1V. Drainage blankets beneath the liner systems, and a 2 ft thick service layer on top of the liner will reduce buoyancy effects. The material removed from the excavation will be used as fill for development of the site infrastructure, if possible.

Proposed Pond Nos. 7 and 8 will provide storage capacity of up to 30 acre-ft and 10 acre-ft when empty, respectively, to accommodate the runoff volume produced during the 25-yr return period, 24-hour duration design storm event. The total runoff volume reporting to the new ponds includes contributions from the mine and mill, Site 23, Site D, Hawk Inlet facility, and the tailings area. All of the proposed new ponds will have emergency overflow spillways.

3.3.3 Groundwater and Seepage Control

The groundwater catchments and drainage areas beneath the Stage 2 Expansion are shown on Figure 3.2.

The design for the Tailings Facility has relied predominantly on the presence of low permeability soils beneath the tailings pile, a series of soil-bentonite walls, drainage ditches and blanket drains beneath the pile for seepage containment. Some portions of the proposed expansion will extend into areas that have a limited thickness or no underlying low permeability native soils and shallow bedrock[2]. In such areas a low permeability synthetic liner (e.g., an 80 mil HDPE liner[3]) will be placed. Drawing D-35002 shows each expansion area and notes which areas are expected to be lined. There is low permeability soil under portions of the proposed expansion areas (specifically, the proposed Southwest and Pond 6 Expansions, and a majority of the Northeast Expansion), and the need for a lined containment these areas will be assessed in the field after surficial soil and peat has been excavated. If the continuity of the low permeability soils is found to be sporadic, an HDPE liner will be placed.

[2] The actual extent of the low permeable soils in the vicinity of ETF has been defined based on available drill hole information and will be further defined during work on the various expansion areas.
[3] An 80 mil HDPE liner was recommended for placement beneath the tailings at wide corner quarry (see KCCL 2001b).

The geomembrane liner and seepage collection system will collect infiltration through the tailings pile, and reduce the potential for co-mingling of contact water and groundwater, or groundwater contact with tailings. Prior to placement of the liner or seepage collection system, the foundation will be contoured to facilitate gravity drainage toward the drainage ditches and surface water ponds.

Soil-bentonite slurry walls will be added as needed for groundwater containment and diversion. The low-permeability slurry walls are designed to restrict groundwater in the sand and peat strata from entering the tailings containment area, as well as to contain groundwater within the tailings storage areas. The slurry wall in the Pond No. 6 Main Embankment may be extended eastward to an existing slurry wall beneath the B-Road to provide containment for the proposed new Truck Wash. The slurry wall enclosing the proposed Southwest Expansion will be tied into the existing slurry walls along the West Buttress and in the Saddle Dam. In addition, the existing slurry walls along the West Buttress and north of the Northeast Expansion will be raised and extended as needed to improve containment as the pile is developed in these areas.

3.4 Roads

As shown on Drawing D-35002, a new service road[4] will be constructed around the north and west perimeter of the proposed Northeast and Northwest Expansion and the west and south perimeter of the Southwest Expansion. The new road will be constructed on a prepared foundation, which will include removal of peat, soft soil, wood, trees, and other deleterious materials. Where the peat is too thick to remove, additional rock fill and geogrid will be placed as required.

[4] The service road will be designed for four-wheel drive vehicles and track mounted equipment to gain access to the pile for service of the ditches and other infrastructure. If a new haul road is required it will be designed at a later date.

The service road will be constructed with a minimum 3 ft base course (ballast) thickness of processed blast rock (e.g., 6 in. minus), and capped with between 0.5 ft and 1.0 ft of surfacing material (e.g., 1.5 in. minus). The road alignment will have a maximum grade of approximately 22%, minimum top width of 19 ft, and will be constructed to blend smoothly into the existing perimeter service road. KGCMC will construct a safety barrier on the downslope side of the road.

3.5 Relocation of Services

The location of services will be confirmed by KGCMC prior to construction and relocated as required.

3.6 Disposal Quarry and Borrow Areas

The quarries, borrow, and stockpile areas for the Stage 2 Expansion are shown on Drawing D-35002 and include:

- Development of a storage area for excavated materials (topsoil and organics) that could be used for reclamation;
- Development of new quarries within bedrock ridges at the south end of the proposed lease boundary. These quarries will be used as a source of construction materials for infrastructure development, and for road construction as needed;
- Development of soil borrow areas (sand and gravel) for infrastructure development and reclamation materials storage; and,
- Other areas may be developed as approved and needed for future storage capacity expansion beyond the Stage 2 Expansion.

4. CONSTRUCTION SCHEDULE

The proposed construction schedule is outlined in Figure 4.1. This table provides a summary of the schedule to complete the overall Stage 2 Expansion. The schedule is a preliminary plan divided on a quarterly basis for the next 4 years. The planned construction and approximate in-service dates for each expansion area and the new water retention ponds are shown on this schedule. Tentative date and schedules past 2004 will be updated in the annual reports by KGCMC.

The construction schedule for 2004 is shown on Figure 4.2 and is detailed on a weekly basis to the end of the 2004 calendar year. All of the construction activities planned for 2004 are included on this schedule and show the approximate in-service dates for the proposed Southeast Expansion (Area 1) and the proposed new Truck Wash facility.

5. STABILITY ANALYSES

Stability analyses of the tailings facility at the overall Stage 2 configuration was completed using limit equilibrium methods (Bishop's Simplified, Janbu and Morganstern-Price) using the computer program Slope/W (Geo-Slope, 1998). Five sections through the pile were analyzed for static and post-liquefaction stability. The section through the Northwest Expansion was analyzed under pseudo-static conditions because there were no potentially liquefiable layers within that section. Figure 5.1 shows a plan of the tailings pile and the location of each stability section that was analyzed. Appendix II contains the results for each stability section that was analyzed.

Post-liquefaction analysis was conducted for all areas except the Northwest Expansion as discussed above. Table 5.1 shows a summary of the soil properties that were used for the static and post-liquefaction stability analyses. The tailings are divided into "old tailings" and "new tailings" to differentiate between the tailings that were placed up until 1993, and the tailings that have been placed since 1996.

Table 5.1 Summary of Material Properties used in Stability Analyses

SOIL	UNIT WEIGHT (pcf)	FRICTION ANGLE (degrees)	COHESION (psf)	POST-LIQUEFACTION UNDRAINED STRENGTH PSF (Phi = 0)
New Tailings	128	36	0	2800
Old Tailings	120	28	0	400
Gravelly Sand	120	27	0	535
Peat	67	27	0	n/a
Compacted Rock Fill	120	40	0	n/a
Silty Clay	120	30	0	n/a
Silty Sandy Till	120	33	0	n/a
Sand and Geomembrane	125	26	0	n/a
Bedrock	-	-	-	-

The analysis results are compared to design criteria listed in Section 3, in the following discussion.

The calculated static Factors of Safety exceed 1.5 for all of the sections that were analyzed. The calculated pseudo-static Factor of Safety for Section 5 (Northwest Expansion) exceeded 1.1.

The post-liquefaction analyses determined that the calculated Factors of Safety exceed 1.0 for all of the sections that were analyzed, except for Section 4. Additional site investigation and analysis of Section 4 is required to improve the current understanding of this area, as follows:

- Assess the extent and continuity of potentially liquefiable zones;
- Because the original design of the West Buttress contemplated a maximum tailings elevation of 220 ft, an assessment must be done to determine whether the current configuration can accommodate the proposed 330 ft final height.

Additional lateral support for the western portion of the pile could be required, depending upon the results of the additional assessments. This work will be completed prior to expansion in this area.

6. 2004 WORK SUMMARY

6.1 General

This section provides a summary of the design and construction to be initiated in 2004. The work includes Step 1 of the Southeast Expansion being the area uphill of the existing truck wash, grading and lining beneath the new truck wash facility, and construction of the new truck wash facility.

6.2 Southeast Expansion, Area 1

6.2.1 General

This expansion covers the area south of the Wide Corner Quarry Expansion commissioned in 2002 (Klohn Crippen, 2002) and extends the existing liner system to the south. The existing Truck Wash will be dismantled and a proposed new Truck Wash Facility to wash all vehicles in contact with tailing will be constructed. The Truck Wash building will be provided by a qualified contractor to accomplish all vehicle washing needs. Area 2, which will involve expansion west and south of the existing Truck Wash in 2006, is discussed in general terms.

The details of the assumed foundation conditions, recommendations for site investigations where the data is incomplete, excavation and grading plans, and liner or slurry wall requirements are outlined in the following sections.

6.2.2 Foundation Conditions

The natural foundation conditions in the Southeast Expansion are adequately known due to the drilling and construction in this area. Fill thicknesses in some areas are uncertain and will be confirmed by test pits. Much of this area was covered by a thin layer of peat/surficial material over bedrock before development. There is a peat spoil pile along the west margin of the Southeast Expansion that will be removed. Peat and oversized

material have been stockpiled near the proposed new truck wash pad; these will also be removed, most likely to the Pit No. 5 area.

6.2.3 Foundation Preparation

The foundation preparation for the Southeast Expansion will include the relocation of the Truck Wash (2004) and Tank No. 6 (2006). Common and rock excavation will be made to produce the grading surface. In some areas, fill (6 in. minus rockfill) will be needed to achieve the grading surface. Excavated surfaces and other surfaces will be proof-rolled and soft spots over excavated and backfilled before placing grading fill.

The grading surface for the liner system is designed to have a maximum slope of 3H:1V and a minimum slope of 2% as recommended by the USEPA guidelines (Koerner, 1994 and EPA, 2001).

A 0.5 ft layer of bedding sand will be placed on the grading surface, followed by a liner system comprising, from the bottom to top: filter cloth, 80 mil HDPE geomembrane, and a geo-composite drain layer. This configuration is similar to the liner installation completed in 2002 for the Wide Corner Quarry Expansion. A minimum 1 ft thick sand service layer, increasing to 2 ft thick on slopes steeper than 15%, will be placed over the geo-composite. Where the service layer is 1 ft thick, a further 1 ft of tailings or granular fill will be placed and lightly compacted before unrestricted travel is allowed on the lined area.

The liner will be shaped to drain south and west, with seepage water collected by perforated pipes and delivered by gravity to either Wet Well No. 4 or Pond No. 6. Perimeter ditches will run along the nominal toe of the tailings pile and between the truck wash access road and the B road. These ditches will be lined with 36 mil reinforced polypropylene. To keep the surface water separated from the underflow, the ditch lining

will not be connected to the 80 mil HDPE liner under the pile. The ditches will generally follow the grading surface profile but with an invert level about 4.5 ft above the grading surface level. Velocity breaks and possibly gabion type drops will be placed in steep sections as needed. The ditch invert elevation will drop from about El. 210 ft at the northeast corner of the Southeast Expansion to about El. 150 ft at Pond No. 6.

The liner will generally be anchored at the perimeter in a trench excavated in natural ground or in a constructed anchor berm. The liner will provide about 4 ft minimum height containment at the perimeter to reduce the likelihood of seepage exiting the perimeter over the liner.

In 2004, the ditch will be built around the Area 1 perimeter, and then routed to the northwest past the existing Truck Wash to Pond No. 6. Once the Area 2 construction is completed the ditch system can discharge directly to Pond No. 6, and eventually to Pond No. 7 by gravity flow.

6.3 Pond 7

Proposed Stormwater Retention Pond Nos. 7 and 8 will eventually replace Pond No. 6. Pond No. 7 will be incrementally excavated over three to four years starting in 2004 to provide construction and general-use quarry rock. Pond No. 8 will be constructed in 2005. Pond No. 6 will continue to operate until Pond No. 7 is commissioned. Stormwater handling capacity will be maintained during the incremental expansion periods, and the new stormwater systems will comply with the 25-year return period, 24-hour duration storm water capacity design criteria set by ADEC. The upgraded stormwater capacities will be commissioned by January 2006.

6.4 Truck Wash Facility

The Truck Wash Facility is being designed and constructed by Others, but it is included in this report for completeness. Klohn Crippen is preparing designs for the foundation and drainage control or containment from and around the proposed new Truck Wash Facility. The foundation of the new Truck Wash is within the boundary of the existing lease. The lining that is being placed for the Southeast Expansion will be extended to the concrete slab of the Truck Wash to provide containment. Seepage water will be routed into the contact water collection system for the Tailings Facility. The concrete pad for the Truck Wash Facility will be designed so that contact water and wash water drains toward the Southeast Expansion and collected in the contact water ditches.

6.5 B-Road Re-Grading

A portion of the B-Road adjacent to the proposed new Truck Wash and several hundred feet to the south will be re-graded to reduce adverse grades for loaded haul trucks coming down from the mill site, and re-aligned to provide a more favorable corner transition and camber for loaded vehicles approaching the Tailings Facility from the south. The re-alignment will be within the current right-of-way, which extends 60 feet either side of the current B-Road centerline. The earthworks will likely be done in conjunction with work for the around the new Truck Wash.

7. CONSTRUCTION INSPECTION AND MONITORING

7.1 Site Supervision

It is envisioned that the site construction will proceed in a manner similar to the 2002 work with independent contractors undertaking most of the construction, technical supervision and Quality Assurance by Klohn Crippen and Contract Management by KGCMC.

7.2 Instrumentation and Drilling

As part of the Southeast Expansion, the instrumentation hut will be relocated and the existing instrumentation beneath the Wide Corner Quarry will be extended. Additional piezometers will be installed within the Tailings Facility to monitor the pore pressures in the underdrains and beneath the geomembrane liner. Two vibrating wire piezometers will be installed in the service layer and two in the bedding layer of the Southeast Expansion Area 1. The proposed locations for the piezometers are shown in plan view on Drawing D-35023.

A series of survey monitoring points will be established around the toe and on the slope of the tailings pile as it is developed. These monitoring points will be checked for movement regularly during operation and periodically during closure.

The monitoring schedules for the instruments will be consistent with the GPO.

7.3 Site Investigation

KGCMC will continue appropriate site investigations to provide data for the design and construction past 2004, as has been the normal procedure for tailings impoundment development.

8. RECOMMENDATIONS AND CLOSING REMARKS

This report presents the design for the Stage 2 Expansion of the tailings facility and in particular, is the final design plan and drawings for the 2004 construction year. The design presented in this report is flexible enough that adjustments could be implemented as the plan unfolds in future years. The designs presented in this report are consistent with the existing safety criteria for seismic stability and water management in the tailings facility. Site investigations will be undertaken to confirm the design assumptions.

The Stage 2 Expansion plan utilizes well established procedures and the design incorporates successful techniques used in past construction projects for the tailings area development. Given the extensive investigations to date and yearly revised site plans for work planned past 2004, KGCMC establishes the baseline for the pile expansion to fulfill the current mine plan. Recommendations for further site investigations to detail the following years construction plan will follow the same planning tasks as for the Year 2004 construction season.

If you have any questions or wish to discuss the contents of this report, please do not hesitate to call.

KLOHN CRIPPEN CONSULTANTS LTD.

Robert W. Chambers, P. Eng. (B.C.)
Project Manager

Len Murray, P.E. (Alaska)
Senior Reviewer

REFERENCES

Alaska Department of Environmental Conservation (ADEC) (2003). "*Waste Management Permit 0211-BA0001 6*", Kennecott Greens Creek Mining Company. November 7.

Apel, D.G. (1995). "*Geology of the Greens Creek Mine, Admiralty Island, Alaska"*. Abstracts of Professional Papers, Alaska Miners Association Conference, Juneau; pp. 35.

Environmental Design Engineering (EDE) (2002). "*Kennecott Greens Creek Mining Company, Stage II Tailings Expansion Hydrologic Analysis*". Engineering report submitted to KGCMC. February, 2002. 59 pages; attachments.

Environmental Design Engineering (2003). *"Kennecott Greens Creek Mine - Site Water Balance"*. Engineering report submitted to KGCMC. 48 pages; attachments.

Environmental Protection Agency (EPA) (2001). "*Code of Federal Regulations 40, Protection of the Environment, Subchapter 1 – Solids Wastes – Part 258*". August 7.

Geo-Slope International Ltd. (1998a). Slope/W Version 5.17.

Hynes-Griffin, M.E. and A.G. Franklin (1984). "*Rationalizing the Seismic Coefficient Method"*. US Army Corps of Engineers - Geotechnical Laboratory, Miscellaneous Paper GL-84-13. 37 pages.

Kennecott Greens Creek Mining Company (KGCMC) (1995). "*Kennecott Greens Creek Mine Tailings Impoundment Characterization Study*". February.

Kennecott Greens Creek Mining Company (KGCMC) (2004). "*General Plan of Operation-Appendix 3 – Tailings Impoundment, April 2004*".

Klohn Crippen Consultants Ltd. (KC) (1998). "*Kennecott Greens Creek Mine Seismic Hazard Assessment*". August.

Klohn Crippen Consultants Ltd. (KC) (1999). "*Kennecott Greens Creek Mine, Evaluation of Tailings Pile*". 36 pages; attachments.

Klohn Crippen Consultants Ltd. (KC) (2001a). "*Kennecott Greens Creek Mine – 2001 Geotechnical Investigation – Field Report*". May.

Klohn Crippen Consultants Ltd. (KC) (2001b). "*Existing Tailings Facility, Wide Corner Quarry Liner Design – Final Report*" November.

Klohn Crippen Consultants Ltd. (KC) (2002) "*Southeast Expansion Construction Summary – Final Report*" November

Klohn Crippen Consultants Ltd. (KC) (2003). "*Design Basis Memorandum*" December.

Koerner, Robert M. (1994). "*Designing With Geosynthetics*". Third Edition.

Layfield Plastics (2001). Personal Communication. August.

National Center for Earthquake Engineering Research (1997). Proceedings for NCEER Workshop of Evaluation of Liquefaction Resistance of Soils. November 19.

Seed, R.B. et al. (2001). "*Recent Advances in Soil Liquefaction Engineering and Seismic Site Response Evaluation*". From 4th Conference on Recent Advances in Geotechnical Earthquake Engineering and Soil Dynamics. March.

Sheppard Miller Inc. (2000). "*Technical Review ARD/Metals Leaching and Fresh Water Monitoring Plan, Greens Creek Mine*".

Terrasat, (1991). "*Geological and Geophysical Investigation of The Greens Creek Mine Area, Admiralty Island, Alaska"*.

Youd, T.L. and Idriss, I.M. (2001). "*Liquefaction Resistance of Soils*". Journal of Geotechnical and Geoenvironmental Engineering Volume 127, No. 4 pp 297 – 313.

U.S.D.A. Forest Service, Tongass National Forest R10-MB-482a, November 2003. Greens Creek Tailings Disposal – Final Environmental Impact Statement, Volumes I and II.

FIGURES

APPENDIX I

Stability Analysis

APPENDIX II

Expansion Area Drawings

D-35003 Stage 2 Final Configuration Plan
D-35010 Northwest Corner Excavation and Grading Plan
D-35011 Northwest Corner Road and Ditch Layout
D-35012 Northwest Corner Road and Ditch Sections
D-35013 Northeast Corner Excavation and Grading Plan
D-35014 Northeast Corner Sections and Details
D-35015 Southeast Corner, Pond 6, and Southwest Corner Grading Plan
D-35016 Southeast Corner, Pond 6, and Southwest Corner Road and Ditch Plan
D-35017 Southeast Corner Sections
D-35018 Pond 6 Sections
D-35019 Southwest Corner Sections
D-35020 Southeast Corner Grading Surface Plan
D-35021 Southeast Corner Road and Ditch Plan
D-35022 Southeast Corner Details
D-35023 Southeast Corner Instrumentation Plan
D-35032 Pond 7 Plan
D-35033 Pond 7 Sections
D-35034 Pond 7 Details
D-35035 Pond 8 Plan
D-35036 Pond 8 Sections
D-35037 Pond 8 Details
D-35038 Pond 9 Plan, Sections

DRAWINGS

D-35001 Site Location Plan

D-35002 General Arrangement

D-35023 Southeast Corner Instrumentation Plan