Sweetwater Uranium Facility
Kennecott Uranium Company
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Kennecott Energy

7 October 1997

Mr. Joseph J. Holonich, Chief
Uranium Recovery Branch
Division of Waste Management - Office of
Nuclear Material Safety and Safeguards
U.S. Nuclear Regulatory Commission
Washington, D.C. 20555-0001

Dear Mr. Holonich:

Subject: Kennecott Uranium Company, Sweetwater Uranium Project
Source Materials License #SUA-1350
Seventh Submittal - Final Design Tailings Management Plan

Kennecott Uranium Company is submitting with this letter *Final Design Volume I, Executive Summary.* This is the first volume of the Final Design for Tailings Management which was described in a letter dated June 11, 1997. This volume completes the submittal of the Final Design for Tailings Management.

Kennecott Uranium Company awaits your letter of acceptance of the entire submittal. If you have any questions please do not hesitate to contact me.

Sincerely yours,

Oscar Paulson
Facility Supervisor
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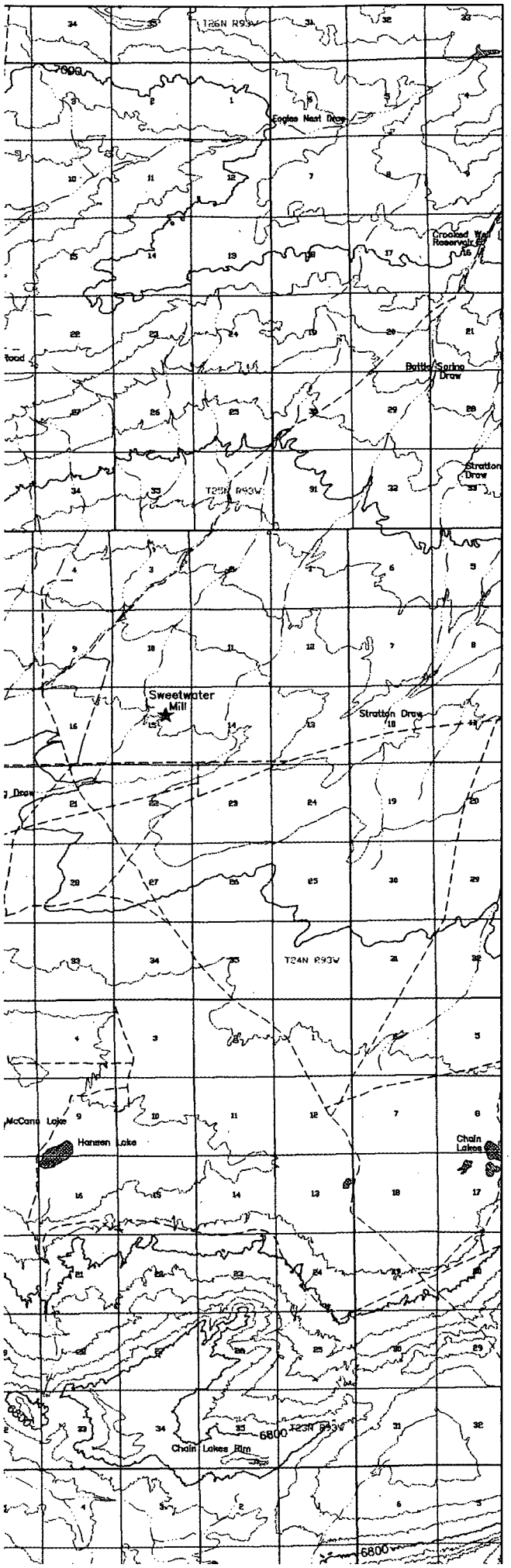
ENCLOSURE
cc: Charlotte Abrams, Project Manager - USNRC (2) - w/enc.
R. Scarano, Director NRC DRSS - Region IV - w/enc.
Glenn Dooley - w/enc.
Kent Bruxvoort - SMI
Rob Hammond - w/enc.



FINAL DESIGN
VOLUME I

EXECUTIVE SUMMARY REPORT

SWEETWATER URANIUM FACILITY
Sweetwater County, Wyoming

Source Material License
SUA-1350

Prepared For:
Kennecott Uranium Company
P.O. Box 1500
Rawlins, Wyoming 82301

Prepared By:
Shepherd Miller, Inc.
3801 Automation Way
Fort Collins, Colorado 80525

October 7, 1997

Final Design

Sweetwater Uranium Project
Source Material License
#SUA-1350

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VOLUME VI	EXISTING IMPOUNDMENT RECLAMATION PLAN
VOLUME VII	OPERATIONS PLAN

Final Design
Volume I

Executive Summary Report

Sweetwater Uranium Project
Source Material License
#SUA-1350

Prepared for:

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Prepared by:

Shepherd Miller, Inc.
3801 Automation Way, Suite 100
Fort Collins, Colorado 80525

October 7, 1997

SHEPHERD MILLER
INCORPORATED

VOLUME I

EXECUTIVE SUMMARY

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1.0 INTRODUCTION

The Sweetwater Uranium Project, Nuclear Regulatory Commission (NRC) Source Material License SUA-1350, is located in Sweetwater County, Wyoming, in the Red Desert, within the Great Divide Basin, approximately 42 miles northwest of Rawlins, (Figure 1-1). The facility includes an open pit, overburden pile, mill and associated buildings, and tailings impoundment (Figure 1-2) and is currently in standby status. The facility is owned by the Green Mountain Mining Venture and managed by Kennecott Uranium Company. It is planned to be used to mill uranium from a mine or mines on Green Mountain south of Jeffrey City, in Fremont County, Wyoming.

In July 1993 a conceptual design (Conceptual Design —Tailings Management Study, Shepherd Miller, Inc.) for new tailings impoundments and an evaporation pond to be used upon the resumption of operations was prepared and submitted to the NRC. In summary, the preferred alternative presented in the Conceptual Design consisted of excavated, lined and drained 40-acre impoundments constructed with a balanced cut and fill to create a series of partially sub-grade impoundments with earthen embankments. A 20-year project life would necessitate the construction of multiple 40-acre impoundments. The Conceptual Design presented a possible configuration of six impoundments, located north and east of the existing tailings impoundment (Figure 1-3), assuming a milling rate of 3,000 tons per day. However, the actual number of impoundments to be built over the life of the project is currently unknown. The NRC, as indicated in a letter dated April 22, 1994, found no fatal flaws in the conceptual design

Final design for the Project's tailings management includes four primary components: 1) mill water management, including recycling of tailings solution to the mill, 2) design of an evaporation pond system, 3) preparation of a reclamation plan for the existing tailings impoundment, and 4) design of a new tailings impoundment, including operational and reclamation features. The first new tailings impoundment will be located north of the existing impoundment. The evaporation ponds will be 10-acre cells, with as many built as operation of the new impoundments and reclamation of the existing impoundment requires. It is currently estimated that eight evaporation cells will be built, with contingency provided for two additional cells to the west of the eight. Drawing 1 depicts the

Project at the beginning of resumed operations, with the first new impoundment constructed, the tailings within the existing impoundment regraded, and the eight evaporation cells constructed.

Kennecott Uranium Company in a June 11, 1997 letter to the NRC requested that the Project's license be amended to be a Performance-Based License (PBL). Several operational components for the Project addressed in the final design would be performed under the PBL: mill circuit changes, tailings deposition practices, and environmental monitoring. The mill will be modified to allow recycling of tailings solution to the mill. Tailings deposition will involve discharge from multiple spigots managed to keep the tailings surface moist and promote a dense tailings mass.

The existing tailings impoundment may be used for additional tailings deposition or it may be reclaimed as soon as feasible. In either case, the tailings would be dewatered, leveled, covered with an interim cover, and monitored for settlement. After reviewing the results of settlement monitoring and other economic and environmental factors, a decision would be made to either proceed to reclamation or to modify the impoundment to make it acceptable for additional tailings deposition. The reclamation plan presented in this final design is based on the assumption that the immediate reclamation alternative would be chosen. The existing tailings would be covered below grade with the surface approximating pre-mining topography.

Reclamation of the first new impoundment will commence soon after operations in that impoundment cease. The new tailings will be dewatered and monitored for settlement. The tailings will be covered with a thick native silty sand to limit radon flux and infiltration and the cover will be topped with a layer of riprap to provide erosional stability. The west and south outslopes of the first new impoundment will also be covered with riprap; the east and north outslopes will form the interior slopes of adjacent 40-acre impoundments. At the close of project operations, the evaporation pond liners and any contaminated soils will be placed in a tailings impoundment. A diversion channel will be constructed to divert Battle Spring Draw runoff around the impoundments to protect the embankments from flood flows. Drawing 2 depicts the Project following reclamation, assuming five impoundments are built. A sixth impoundment would necessitate extension of the diversion channel.

The final design is submitted in this seven volume series as outlined below:

Volume I:	Executive Summary
Volume II:	Data Report
Volume III:	Embankment Design Report
Volume IV:	Liner Design Report
Volume V:	New Impoundment Reclamation Plan
Volume VI:	Existing Impoundment Reclamation Plan
Volume VII:	Operations Plan

Volumes II through VII are summarized in the following chapters. Volume II presents the data that were collected in support of final design. Volumes III, IV, and V present components of the new impoundment design. Volume VI details planned reclamation of the existing tailings impoundment. Volume VII addresses mill water management, design of evaporation ponds, tailings management, and environmental monitoring.

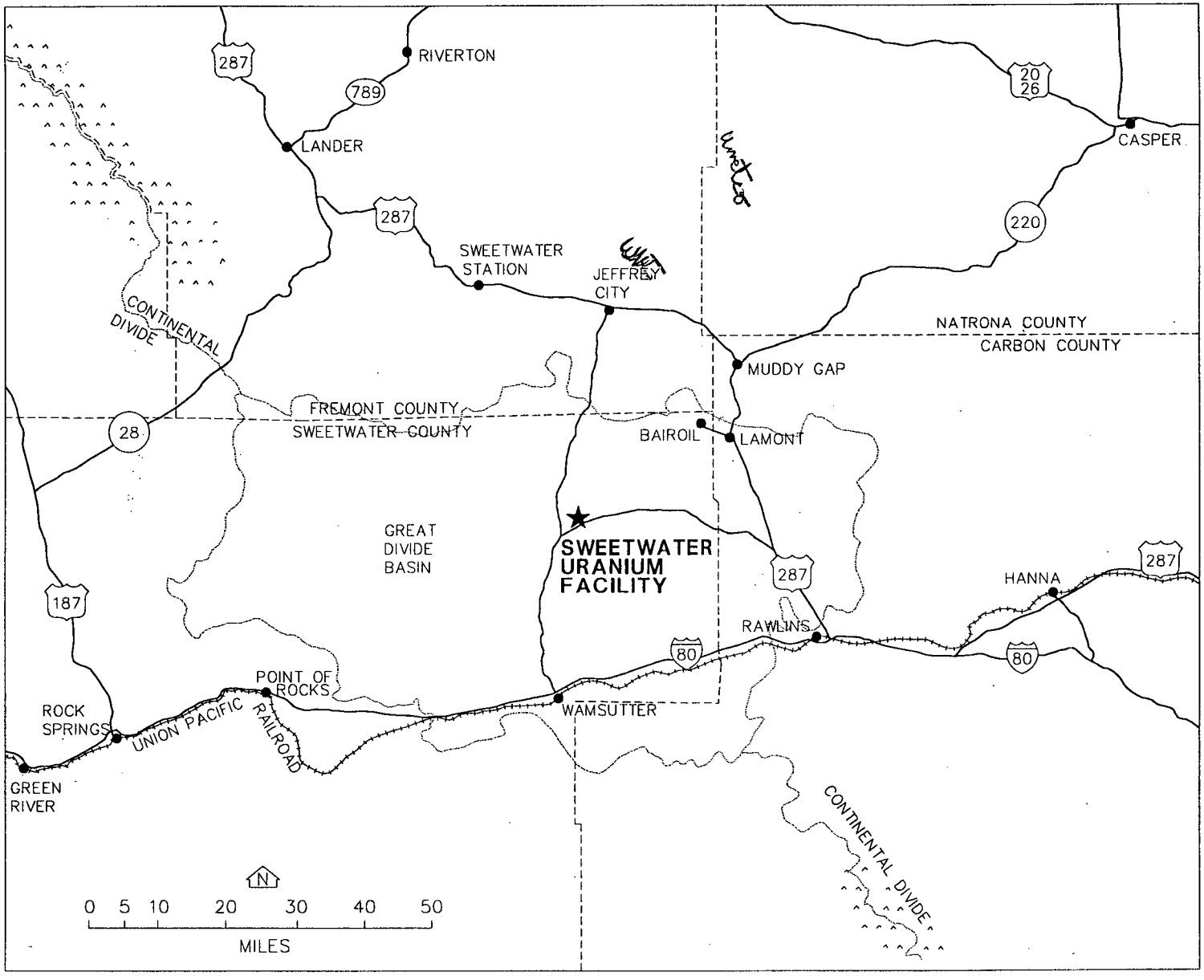

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FIGURE 1-1
LOCATION MAP

Date:	SEPTEMBER 1997
Project:	06-307
File:	06307-02

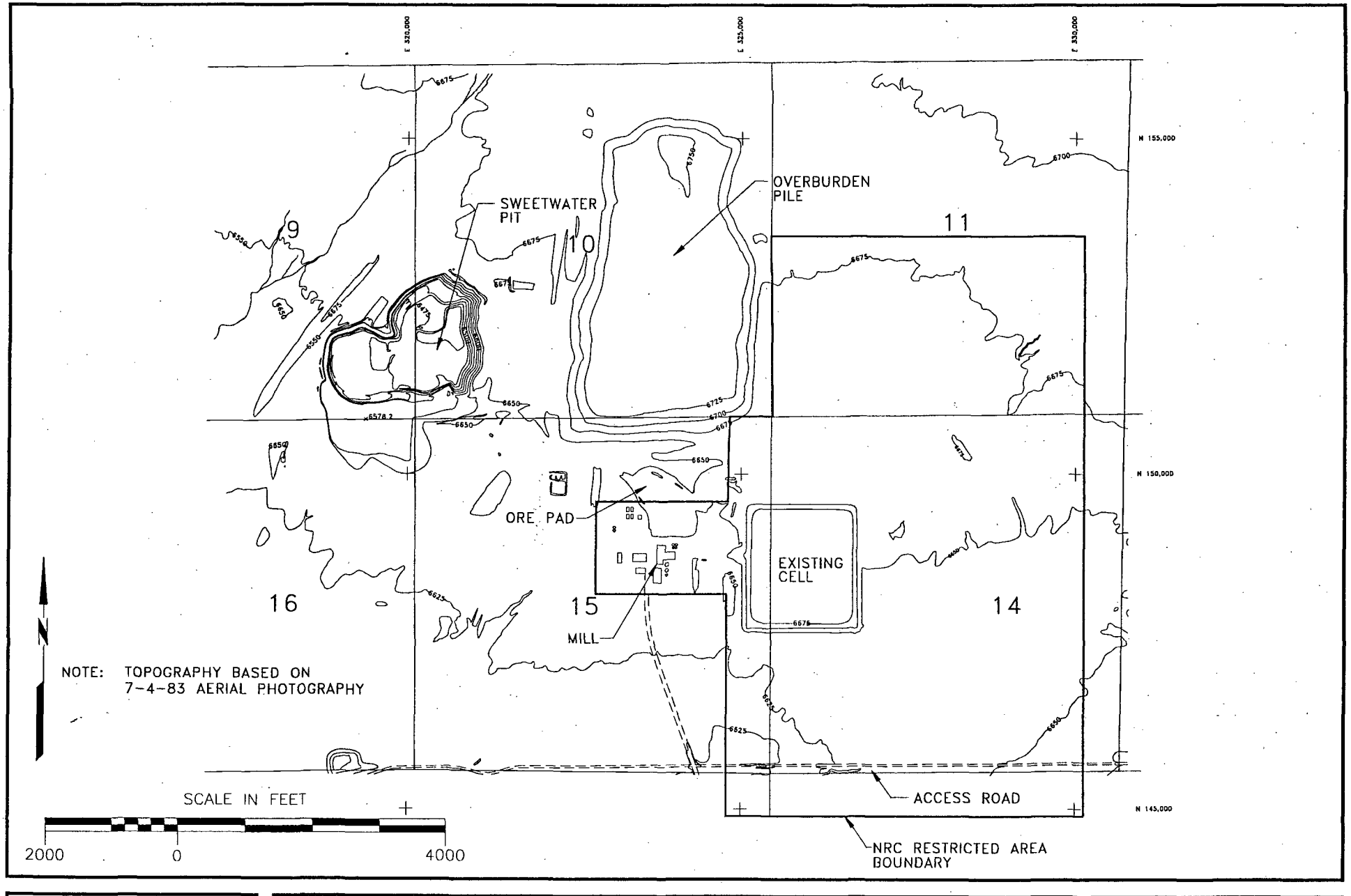

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FIGURE 1-2
SITE FACILITIES MAP

Date:	SEPTEMBER 1997
Project:	06-307
File:	06307-01

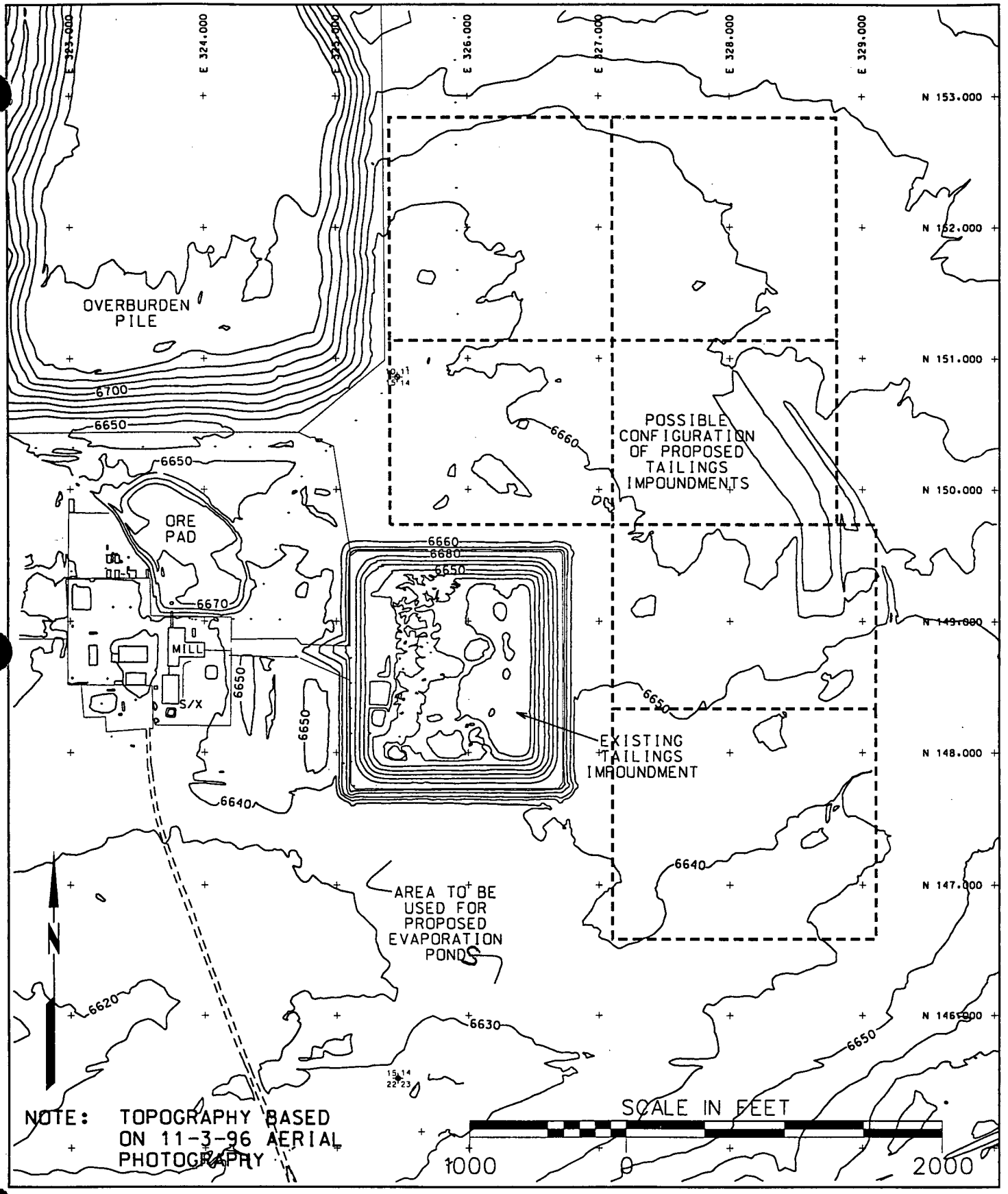

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FIGURE 1-3
CONCEPTUAL LAYOUT OF TAILINGS IMPOUNDMENTS OVER 20-YEAR PROJECT LIFE

Date:	SEPT. 1997
Project:	06-308
File:	FIGURE-1
Query:	N/A

2.0 DATA COLLECTION

Volume II presents data collected to support final design of a new tailings impoundment, reclamation of the existing tailings impoundment, and design of evaporation ponds. The new tailings impoundment will be located immediately north of the existing impoundment and the evaporation ponds will be located immediately south of the existing impoundment. The data fall into six general categories:

1) Topographic data collected for preparation of maps of the mill and tailings area and potential clay borrow areas located approximately 10 miles southwest of the mill.

2) Geotechnical and hydrological data for materials and conditions in the near vicinity of the existing tailings impoundment.

3) Radiological and geotechnical data for the existing tailings.

4) Geotechnical data for materials, located off-site, to be used in construction or reclamation of tailings impoundments.

5) Archaeological data.

6) Wildlife biology data.

Sampling programs conducted in Fall 1996 and Spring 1997 are described in Volume II. These include an aerial survey, drilling and aquifer test programs adjacent to the existing impoundment, a drilling program in the potential clay borrow areas, a drilling and cone penetrometer program in the existing tailings, and archaeological and wildlife biology surveys.

Laboratory tests were conducted on samples collected during the various drilling programs for geotechnical characterization of the foundation materials, soils, tailings, and borrow materials and radiological characterization of tailings. A description of the tests conducted and a presentation of results are provided in Volume II.

3.0 EMBANKMENT DESIGN

Volume III presents the design of the embankments for the first proposed new tailings impoundment. Specifically, the report outlines key features of the tailings impoundment embankments and provides supporting data and calculations in the Appendixes. Drawings and Specifications for construction of the embankments are also included.

Design and layout is provided for one 40-acre tailings impoundment, located immediately north of the existing tailings impoundment. Approximately 1,900,000 cubic yards of material will be moved to construct the embankments. The impoundment will have a capacity of approximately 3,000,000 cubic yards. The first impoundment is designed as it would be paired with the second, even though the impoundments would be built separately over a period of years. The crest elevation and bottom elevation of both impoundments were designed so that a balanced cut and fill would result when the second impoundment is constructed.

Figure 3-1 shows the to-be-built configuration and cut and fill quantities for the first impoundment at the close of the construction of the embankments. Figure 3-2 shows the balanced cut and fill quantities and the layout for the two-impoundment configuration which was used as a basis for design.

All interior sides will have slopes of 3.5H:1V. Temporary exterior slopes of embankments that will form the interior of a future adjacent impoundment will also be 3.5H:1V. Final exterior slopes will be graded to 5H:1V. Embankment crest widths will be 30 feet. A bench at approximately mid-depth will be 15 feet wide.

Structural integrity of the embankments was determined with regard to settlement and slope stability. The foundation soils are comprised of silty sand, silt lenses, sandstone, and claystone. The silty sand, sandstone, and claystone are relatively non-compressible and the silt lenses are thin and dry and settlement of these lenses would be minor and rapid. Phreatic surfaces for stability calculations were conservatively estimated using a seepage model assuming that no liner system would be

present. Static and pseudo-static slope stability analyses were performed. The pseudo-static stability analyses were performed based on a peak ground acceleration of 0.22g. All calculated factors of safety for operational and reclamation conditions exceeded NRC minimums of 1.5 for static conditions and 1.1 for pseudo-static conditions.

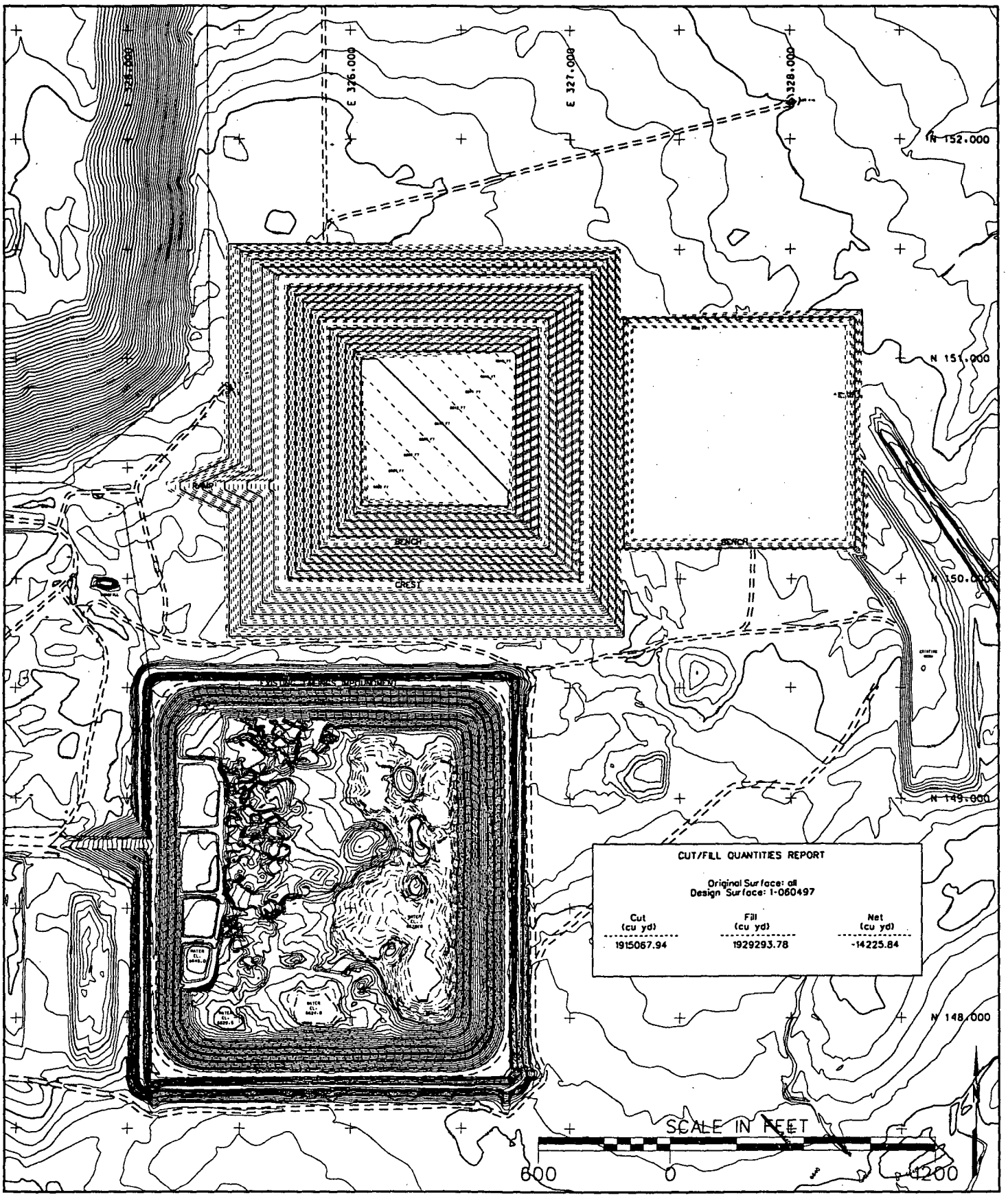

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FIGURE 3-1
CONFIGURATION OF FIRST NEW TAILINGS IMPOUNDMENT

Date:	SEPT. 1997
Project:	06-308
File:	FIGURE-L
Query:	N/A

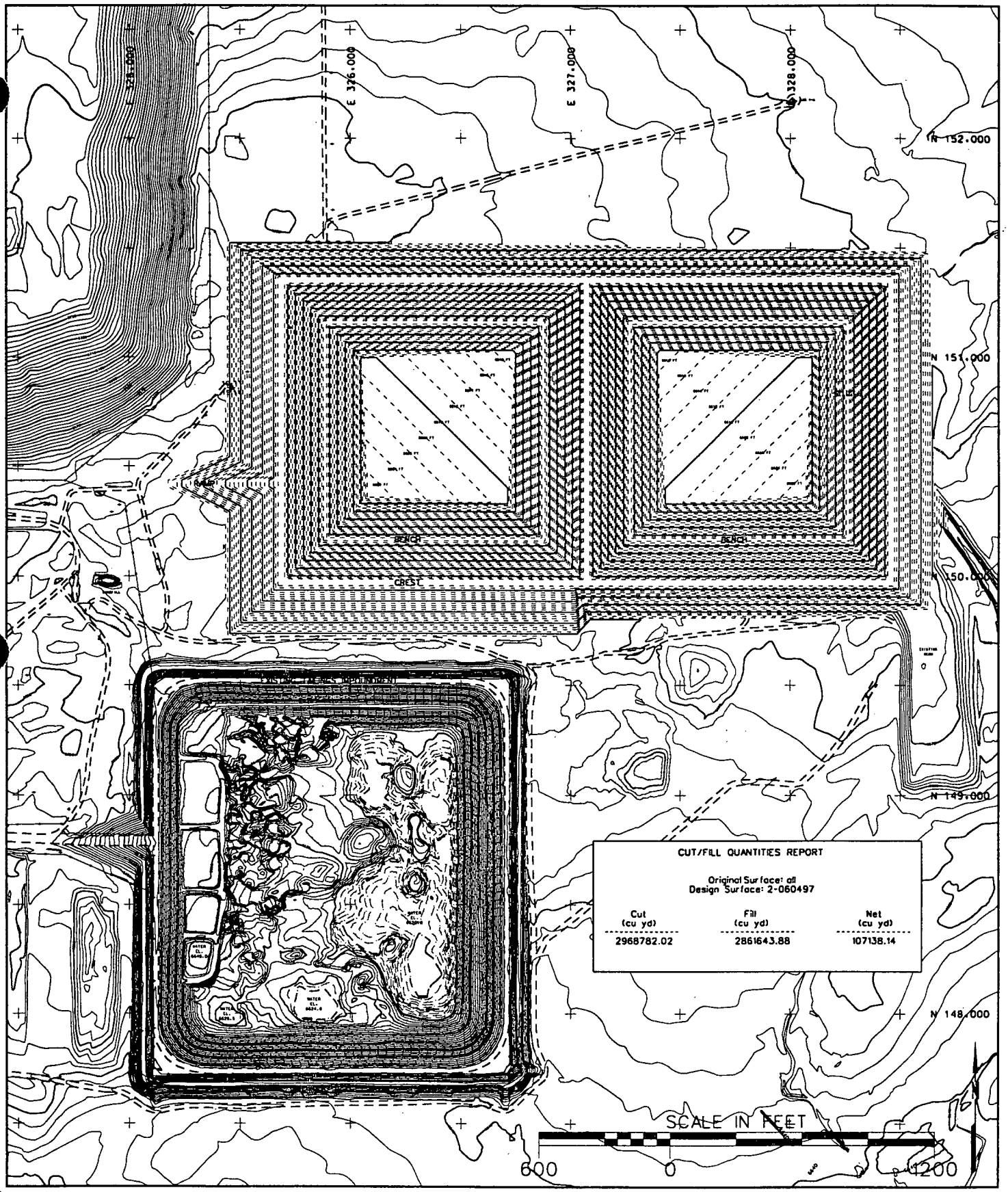

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FIGURE 3-2
DESIGN BASIS
TWO-IMPOUNDMENT CONFIGURATION

Date:	SEPT. 1997
Project:	06-308
File:	FIGURE-J
Query:	N/A

4.0 LINER DESIGN

Volume IV presents the liner system design for the proposed tailings impoundment for design approval and construction permitting. The report outlines key features of the liner system and provides supporting data and calculations in the Appendices. Drawings and Specifications for construction of the liner system are also included.

As required by 10 CFR 40, Appendix A and 40 CFR 264.221, a tailings impoundment must have a liner system with underdrain and leak detection systems. The Conceptual Design - Tailings Management Study (SMI, 1993) presented a discussion and ranking of alternatives for the new impoundment liner and selected a preferred alternative. The preferred alternative consisted of a lower three-foot thick compacted clay liner, a one-foot thick granular leak detection layer, and an upper composite liner consisting of one foot of compacted clay overlain by 60-mil HDPE.

The preferred liner design has been modified for this final design to enhance liner system performance while still achieving regulatory compliance. The liner design presented herein consists of a lower composite liner of three feet of compacted clay overlain by a 40-mil minimum HDPE synthetic liner, a leak detection layer comprised of a synthetic drainage net, and an upper 60-mil HDPE synthetic liner. This modified design provides a more reliable leak detection system, more stable side slopes, and is more economical to construct than the liner configuration presented in the Conceptual Design.

A process water recovery system (PWRS) will be constructed on the floor of the impoundment, above the liner system and below the tailings. The PWRS was designed to continuously dewater tailings during operations and additionally may assist in reclamation dewatering. The PWRS will consist of three components: 1) a highly permeable gravel layer with a pipe network to collect tailings fluids, 2) a filter layer to prevent tailings materials from clogging the gravel layer, and 3) a sump to hold fluids for pumping. No granular drainage material will be placed on the side slopes; however, slotted HDPE pipes wrapped in fabric will be placed on 50-foot centers on the side slopes to enhance tailings dewatering capabilities. Figure 4-1 presents a schematic of the liner system and PWRS in cross section. Details are shown in the design drawings in Volume IV.

Stability of the synthetic liner system was analyzed with regard to tensile forces acting on each synthetic component and holding capacity of anchor trenches. Factors of safety against tensile failure and anchor trench pullout were determined. Calculated factors of safety exceeded 1.0 in all cases. A summary of the hydraulic conductivity test results for the clay materials to be used in the lower liner is also included, demonstrating that the lower clay liner will have a hydraulic conductivity of 10^{-7} cm/sec or better.

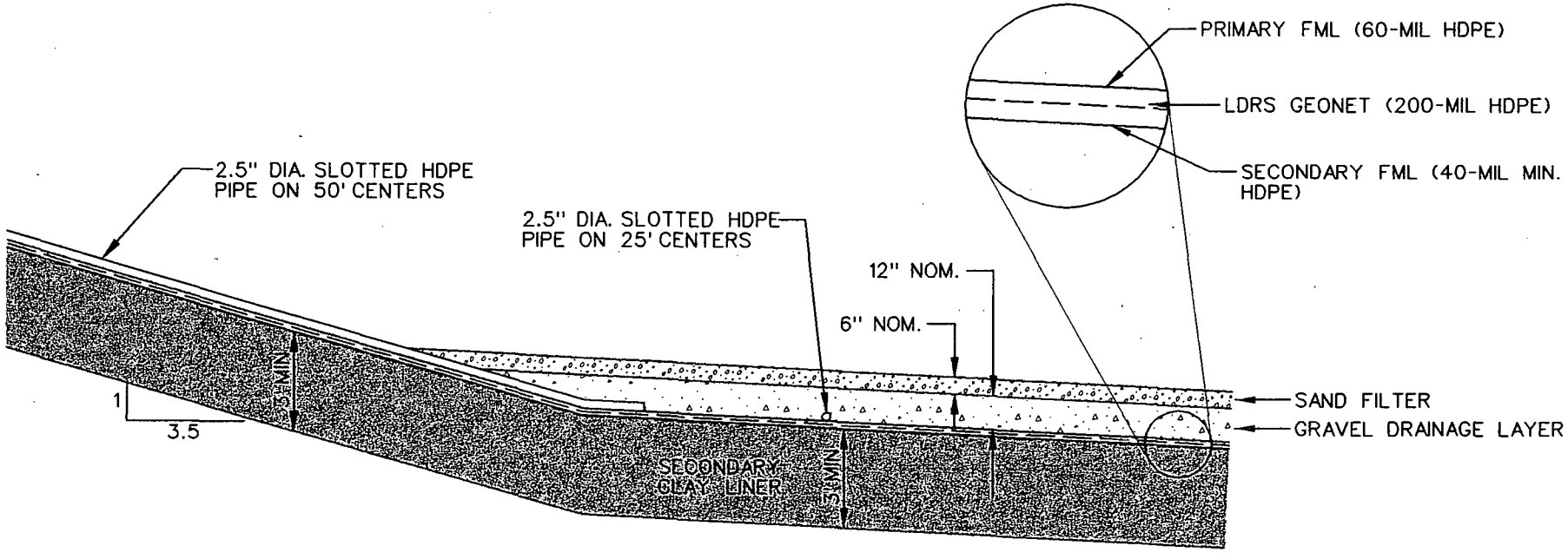

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FIGURE 4-1
TYPICAL LINER SYSTEM
CROSS SECTION

Date:	SEPT. 1997
Project:	06-308
File:	FIGURE1-1.DGN
Query:	

5.0 NEW IMPOUNDMENT RECLAMATION

Volume V presents the reclamation plan for the new first new tailings impoundment. The report outlines key features of the reclamation plan and provides supporting data and calculations in the Appendices.

Reclamation design was based on the configuration presented in the Embankment Design Report, Volume III. The expected locations of additional tailings impoundments were considered in selecting the location of the diversion channel. Last, an expected ore grade of 0.20 percent U_3O_8, assuming radiological equilibrium, was used in estimating the radium-226 content of the new tailings for radon cover design.

The first new impoundment will be reclaimed by dewatering and regrading tailings as necessary and placing a thick earthen cover constructed from on-site soils. The thick cover will limit radon flux to 20 pCi/m^2/sec or less over a 1000-year period and will reduce infiltration into the tailings to 4 percent or less of annual precipitation. The top surface and side slopes will be covered with rock to prevent erosion of the cover and side slopes. Figure 5-1 depicts the first new impoundment in cross section with its reclamation cover. It is expected that additional impoundments will be constructed to the east and to the north. The eastern and northern outslopes will become the interior slopes of other impoundments. Therefore, only the southern and western outslopes would be reclaimed with the riprap cover.

Native soils were chosen such that long-term performance requirements can be achieved. Earthen materials used in the reclamation cover will consist of non-cohesive silty sand which is not subject to damage from differential settlement, biointrusion, or freeze/thaw effects.

A diversion channel will be constructed to the north and east of the first new impoundment at the close of operations. The location of this channel was designed considering a configuration of five tailings impoundments over the life of the facility. The channel will be extended to accommodate a sixth impoundment if necessary. The channel will be a wide swale, with gentle (10H:1V) side

slopes, with a gently curved inlet to decrease the potential for erosion of the west bank opposite the confluence, and with the capacity to pass the Probable Maximum Flood (PMF). It will be unlined and located so that predicted erosion rates cannot cause lateral migration of the channel at a rate that could compromise the stability of the toe of the embankment in 1,000 years. Figure 5-2 presents the diversion channel configuration.

The estimated (+/- 25%) cost for construction of the diversion channel and reclaiming the first tailings impoundment is $5.58 million. The estimated cost for reclamation of each additional tailings impoundment is $4.18 million.

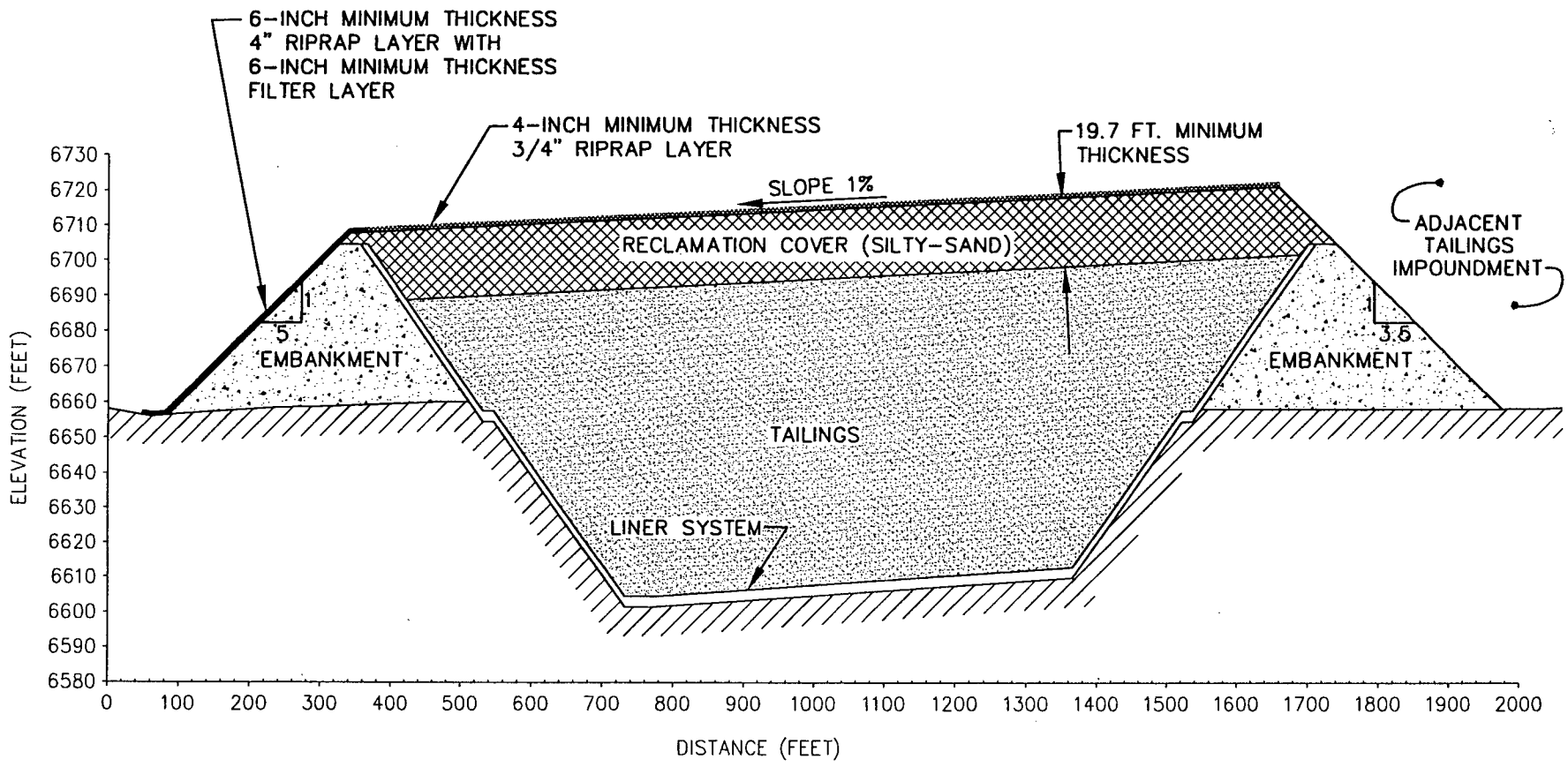

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FIGURE 5-1
RECLAMATION COVER CONFIGURATION
FOR PROPOSED TAILINGS IMPOUNDMENT

Date:	SEPTEMBER 1997
Project:	06-308
File:	SEEP.DWG

Filename: E:\100123\DWGS\DIVER-01.dwg
Date: 06/18/1999 Time: 15:30:58.33

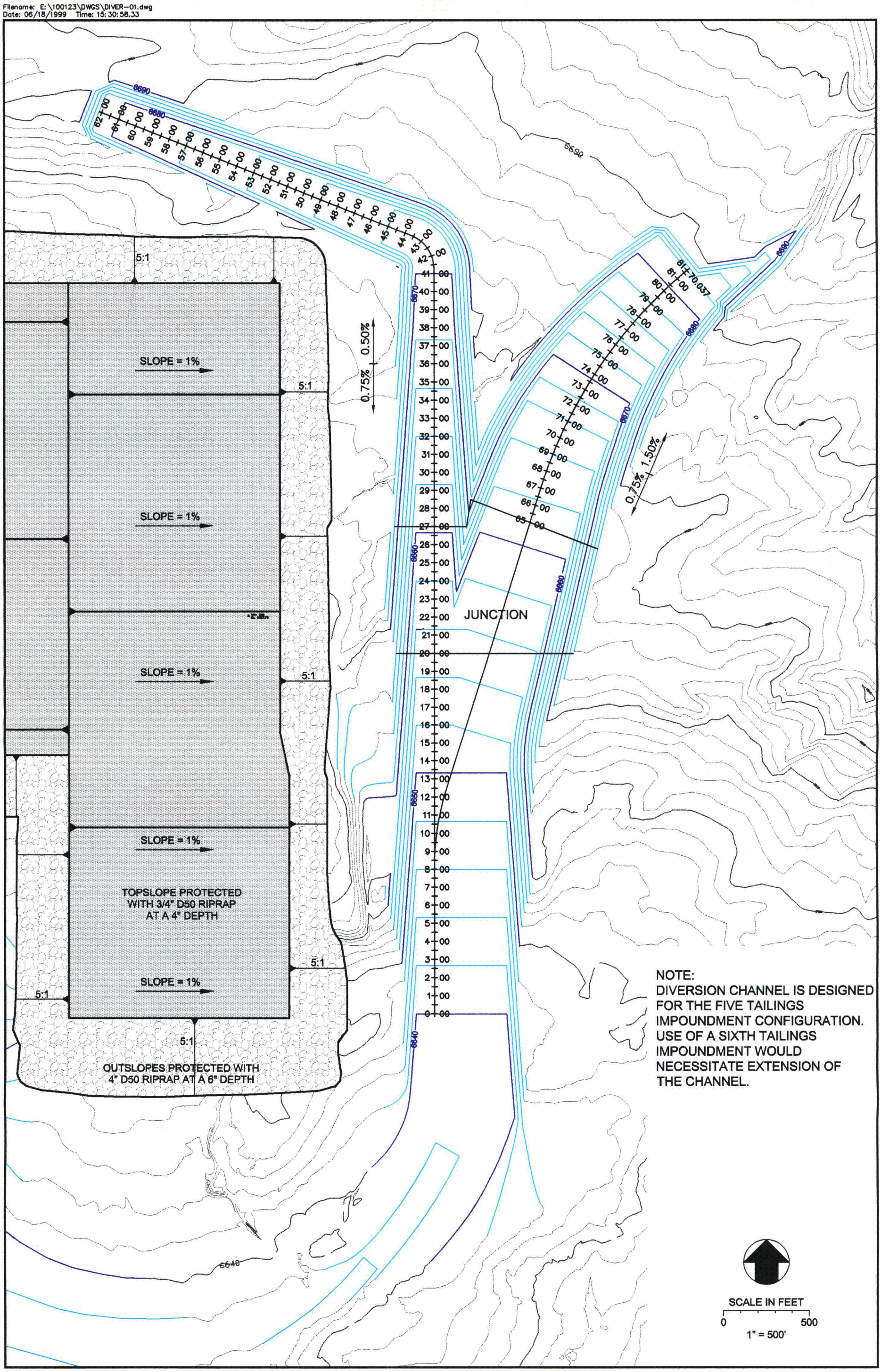

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FIGURE 5-2
DIVERSION CHANNEL CONFIGURATION

Date:	JUNE 1999
Project:	100123/014
File:	DIVER-01.DWG

6.0 EXISTING IMPOUNDMENT RECLAMATION

Volume VI presents the reclamation design for the existing tailings impoundment. Specifically, the report outlines key features of the reclamation plan, including design of a preliminary dewatering program, reclamation cover design and a pre-scoping evaluation of windblown tailings, and provides supporting data and calculations in the Appendices.

The licensee has two options for future use of the existing tailings impoundment, as depicted in Figure 6-1: (1) immediate reclamation or (2), if economic and technical considerations allow, modification for future tailings storage. Under either of the two options, the tailings must first be dewatered, leveled, covered with an interim cover, and monitored for settlement. After these four initial steps, the licensee will decide whether to proceed with reclamation or whether to make modifications necessary to allow future tailings storage. The plan submitted in detail in this document is for the first, or immediate reclamation, option. However, reclamation under the second option is conceptually addressed.

Prior to construction of the reclamation cover, or use of the existing impoundment for additional tailings storage, the tailings will be dewatered and regraded and a one-foot thick interim cover of silty sand will be placed. Tailings dewatering will be conducted in two steps: (1) removal of free water in the impoundment, and (2) installation and pumping of dewatering wells. Free water in the impoundment will be removed by direct pumping from the pond. Following removal of free water from the tailings impoundment, the tailings will be regraded to a planar surface, sloping to the southwest at 1 percent. The preliminary dewatering plan calls for installation and pumping of ten dewatering wells to dewater the saturated tailings in 18 to 24 months. Dewatering wells will likely be installed to a depth limited to ten feet above the impoundment liner and will be surrounded with a gravel filter pack. A submersible pump will be used in each well to remove water to be sent to the evaporation ponds.

The reclamation cover will consist of a single thick layer of native silty sand with an average thickness of 20 feet. The reclamation cover, as shown in Figure 6-2, will limit radon flux to much

less than 20 pCi/m^2/sec or less over a 1000-year period and will reduce infiltration into the tailings to 4 percent or less of annual precipitation. The minimum required thickness for radon attenuation is estimated to be 6.7 feet. The extra thickness is needed to contour the surface of the reclamation cover to approximate the pre-operational grade, as shown in Figure 6-3. The surface will have a vegetative cover that will allow some minor erosion to occur. However, this erosion will not be large enough to impact that portion of the cover required for radon attenuation to regulatory criterion levels. Protection of the impoundment from run-on is provided by the diversion channel to reroute flow from Battle Spring Draw.

Native soils were chosen such that long-term performance requirements can be achieved. Earthen materials used in the reclamation cover will consist of non-cohesive silty sand which is not subject to damage from differential settlement, biointrusion, or freeze/thaw effects.

A preliminary soils characterization survey was conducted in the areas adjacent to the existing tailings impoundment to identify areas that may have been impacted by windblown tailings and to estimate the extent of impacted areas. Background soil Ra-226 concentration in the mill and tailings area was estimated from sample populations within two miles of the mill and considered to be unaffected by natural uranium to be 1.54 pCi/g, rounded to 1.5 pCi/g for practical considerations of laboratory analytical precision. The surface soils showing concentrations greater than 6.5 pCi/g Ra-226 (5 pCi/g above background) were confined principally to the area within 100 meters of the impoundment, except for one region NNW of the impoundment, one upwind region southwest of the impoundment, and several areas NE of the impoundment in the downwind direction as shown in Figure 6-4. None of the soil samples collected had Ra-226 concentrations greater than 10 pCi/g.

The estimated (+/- 25%) cost for reclamation of the existing tailings impoundment for bonding purposes is $2.51 million.

A mill decommissioning and soil cleanup and verification plan was submitted with the existing impoundment reclamation plan. The estimated cost for mill area decommissioning and soil cleanup and verification is $2.34 million.

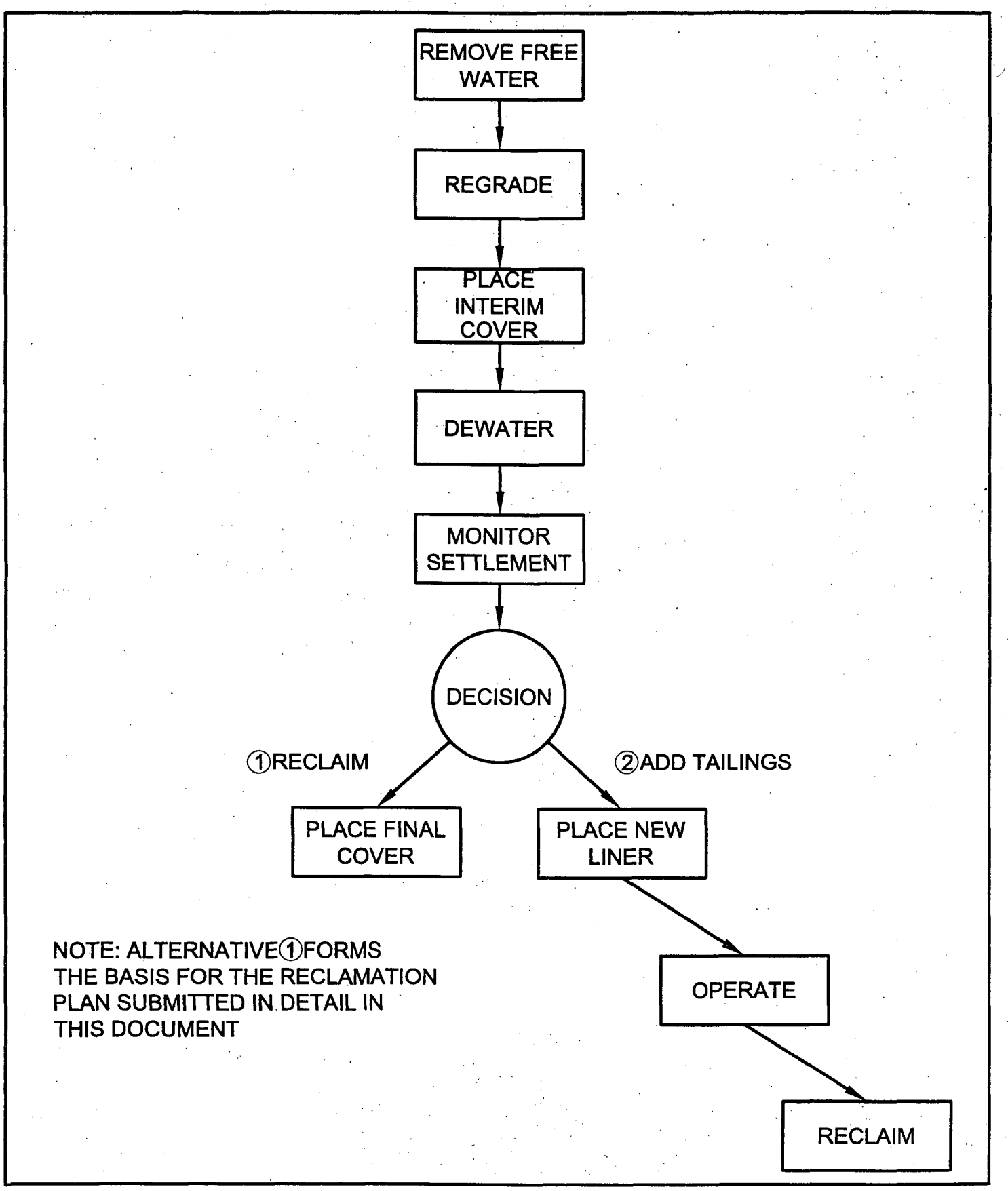

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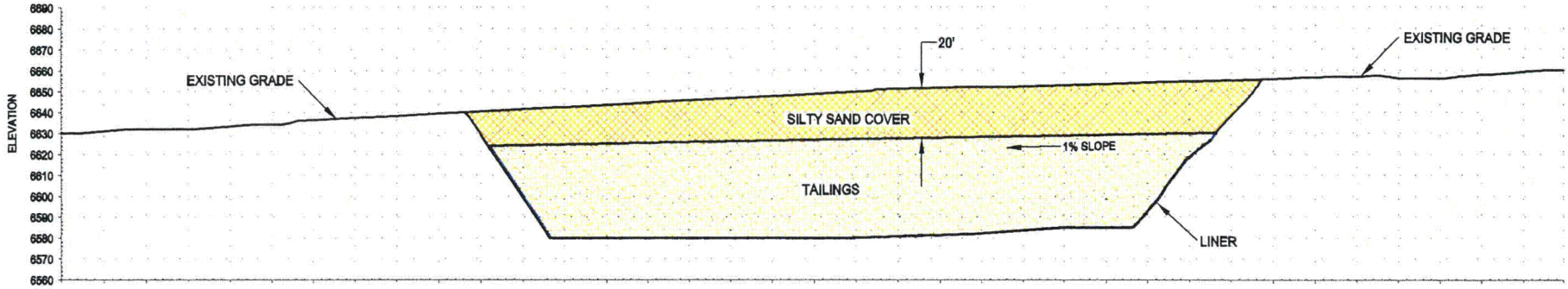
FIGURE 6-1
RECLAMATION ACTIONS FOR THE EXISTING TAILINGS IMPOUNDMENT

Date:	SEPTEMBER 1997
Project:	06-308
File:	RECLAM



SCALE IN FEET

400 0 800

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FIGURE 6-2
SCHEMATIC RECLAMATION COVER
CROSS SECTION, EXISTING TAILINGS IMPOUNDMENT

Date:	SEPTEMBER 1997
Project:	06-308
File:	TYP-XSEC

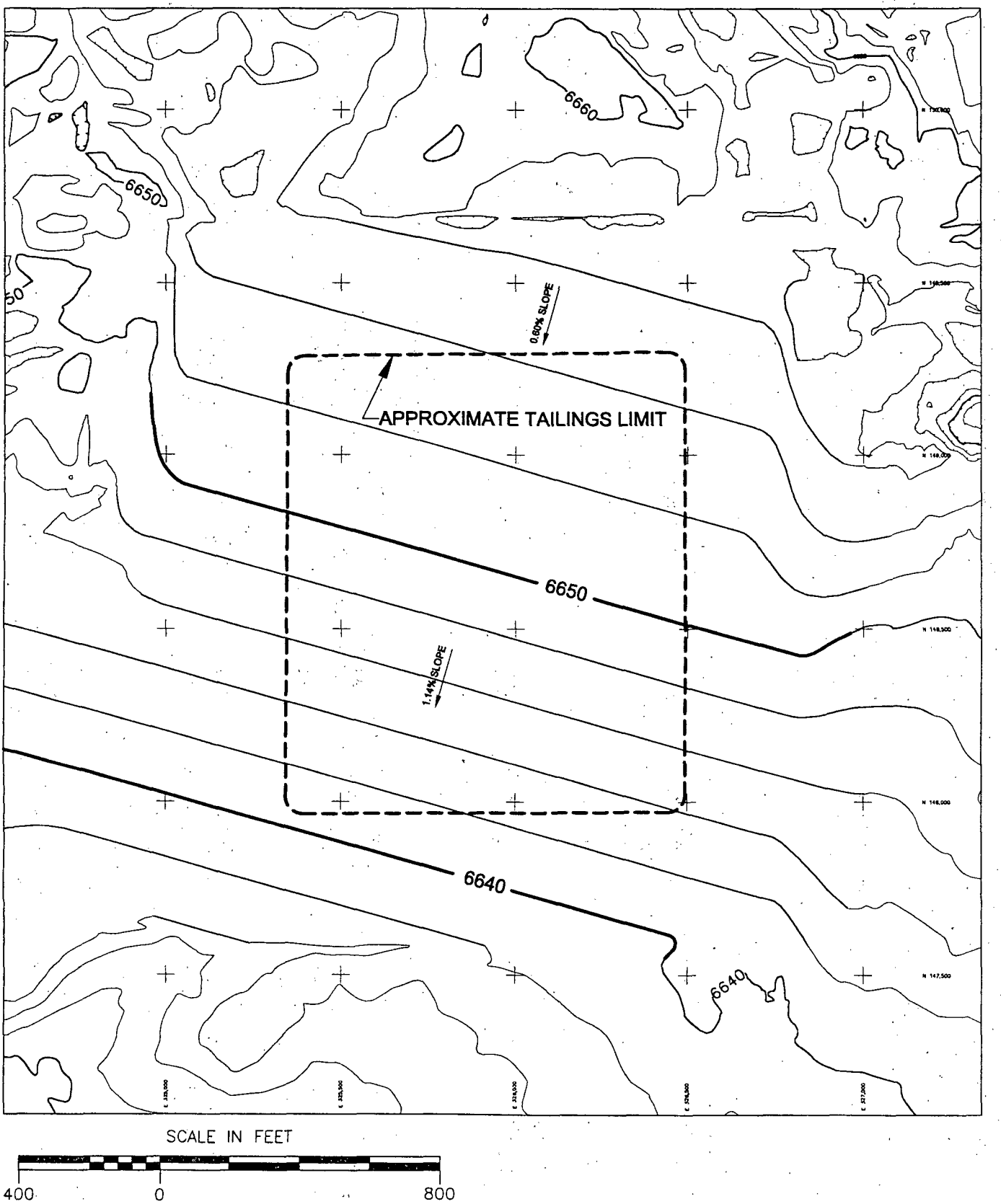

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FIGURE 6-3
RECLAMATION SURFACE CONFIGURATION

Date:	SEPTEMBER 1997
Project:	06-308
File:	PLANVIEW

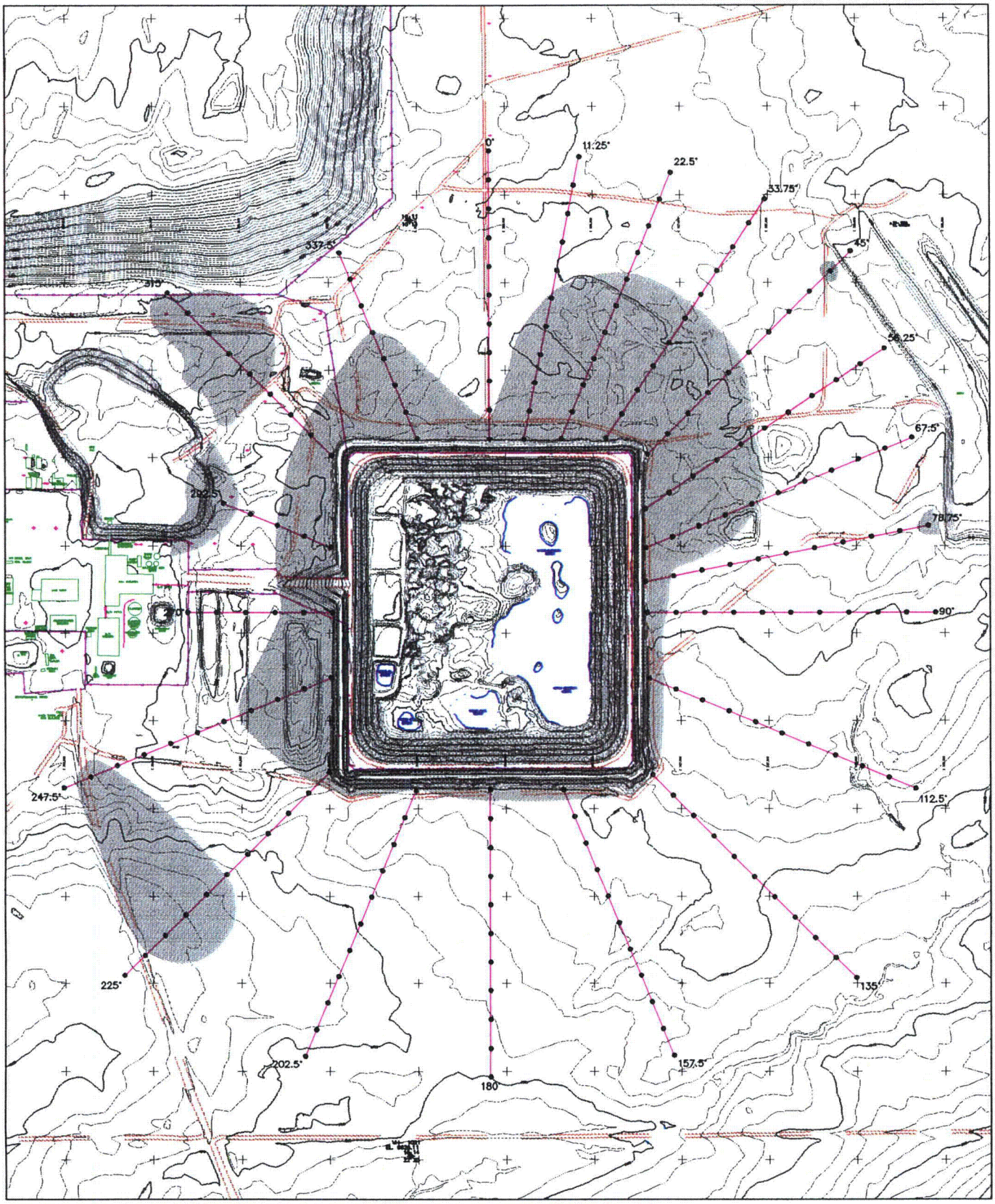

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FIGURE 6-4
RESULTS OF WINDBLOWN
PRE-SCOPING SURVEY

Date:	SEPTEMBER 1997
Project:	06-308
File:	RADIAL

7.0 OPERATIONS PLAN

Volume VII addresses four operational issues for resumed operations at the Sweetwater Uranium Project. First, management of fluids in the mill and tailings circuit is discussed, a report prepared by M3 Engineering and Technology Corporation is included as an appendix, and evaluation of tailings fluid disposal alternatives is included as an appendix. Second, design, operation and reclamation of evaporation ponds to dispose tailings fluid is presented. Drawings and Specifications for construction of the evaporation ponds and a pond water balance are included as appendices. Third, tailings deposition management, including normal operations and special considerations, is addressed. Fourth, the Project's environmental monitoring program is summarized.

Management of the mill circuit water balance will be performed under a Performance-Based License and mill operations may be modified as required. The amount of fluid pumped to the tailings impoundment may be minimized through three proposed changes to the mill. A fresh water recycle loop is proposed for the grinding circuit in which 64 gpm can be returned to the semi-autogenous grinding mill. The water balance is also proposed to be managed so that 251 gpm of tailings fluid is recycled to the leach and counter-current decantation circuits (45 gpm and 206 gpm, respectively). Last, slurry pump seals are proposed to be modified from wet gland packing to mechanical seals, thereby saving 20 gpm of required mill water. The expected mill and tailings water balance will result in 146 gpm of tailings fluid to be evaporated. The mill water balance with these proposed changes is depicted in Figure 7-1.

Evaluation of treatment and land application, and treatment and surface water discharge alternatives for tailings fluid disposal was performed. Both alternatives were rejected primarily for regulatory reasons, but also because of high treatment costs. In each case, State permits would be extremely difficult to receive and meeting NRC regulations would be costly. A third disposal alternative, deep well injection, was also evaluated. The projected costs for deep well injection are similar to projected costs for evaporation ponds. However, regulatory and operational issues would be more complex for deep well injection, and deep well injection costs would likely be more unpredictable. For these reasons, evaporation of tailings fluids was selected as the best disposal alternative.

Neutralization of the tailings solution was also evaluated and rejected because of its high cost and limited benefit.

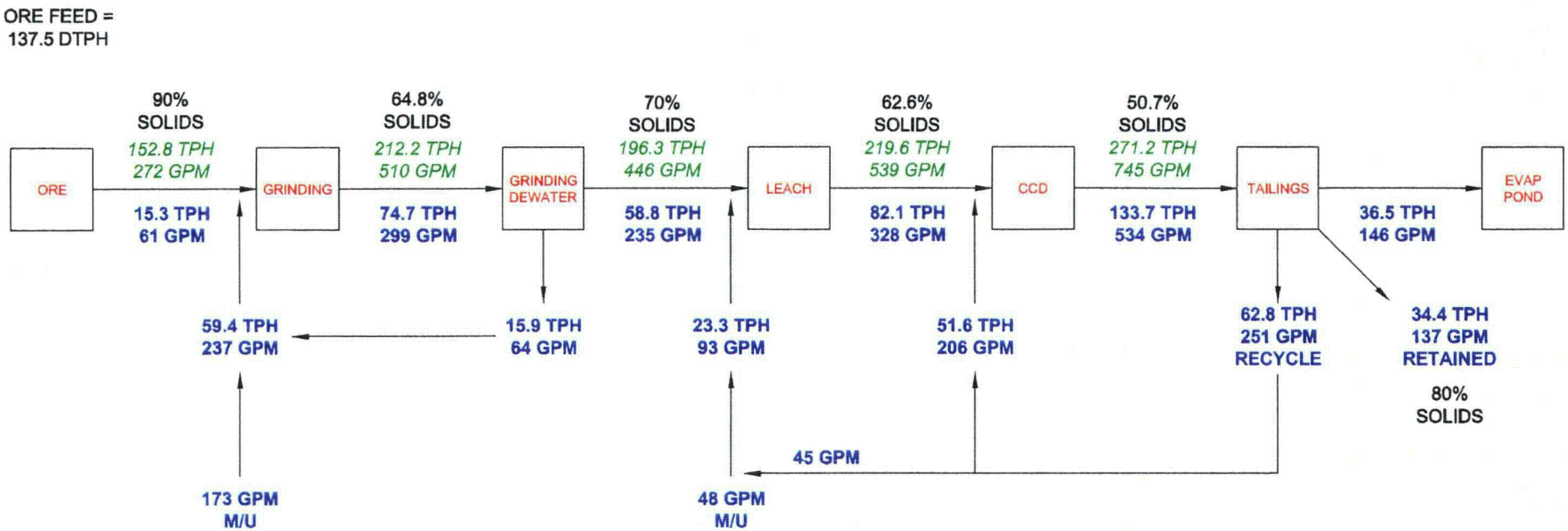
Evaporation ponds are designed to be 10 acres in area and lined with a double synthetic liner with attendant leak detection. A 10-pond configuration is presented, in which the ten adjacent ponds are located immediately south of the existing tailings impoundment. However, evaporation pond water balance calculations indicate that only eight ponds would be needed during operation of the first new tailings impoundment. The ponds are designed to be modular; only ponds required for operations would be constructed. Inclusion of ten ponds in the design layout, with the expectation that only required ponds would be constructed, provides operational flexibility for the licensee to construct ponds as needed. Slope stability analysis of the embankments was performed and safety factors for static and pseudo-static stability exceeded NRC-recommended levels of 1.5 and 1.1, respectively.

Tailings operations will be managed under an expected Performance-Based License. Standard Operating Procedures will guide normal and special operations and will be retained on site. Tailings will be discharged from the east embankment crest of the first new tailings impoundment in multiple spigots at 50- to 80-foot spacing. Tailings lines would extend from the main delivery line down the side slope and over the bottom of the impoundment. Holes perforated in the top of the tailings lines would allow the tailings to discharge where desired with controlled energy. Individual spigots, or banks of spigots, will be operated to keep the tailings beach moist to limit the potential for windblown tailings and to limit radon flux, to allow a denser tailings mass, and to control the location of the free pool. Parallel delivery lines, flanged pipe sections, tailings dump points, and isolation valves will allow operational flexibility and responsiveness for seasonal and shutdown operational concerns.

Environmental monitoring for the Project will be performed under the expected Performance-Based License. Standard Operating Procedures for environmental monitoring (termed Environmental Procedures, or EPs) have been developed and will be retained on site. The environmental monitoring program is summarized in this report, including standby and operational monitoring

under NRC, DEQ, and EPA regulations and includes the tailings impoundments, evaporation ponds, tailings fluid, the diversion channel, surface water, ground water, air, soil, sediment, and vegetation. Monitoring and Point of Compliance wells are proposed for the first new impoundment and for the evaporation ponds.

A fence will be located around the crest of the first new tailings impoundment and the toe of the evaporation ponds, as depicted in Drawing 1. The fence will be maintained during operations.



NNN.N SLURRY FLOW
NNN.N WATER FLOW

SHEPHERD MILLER
INCORPORATED

FIGURE 7-1
MILL AND TAILINGS WATER BALANCE

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