Report #65
3/19/82

EVALUATION OF
PROPOSED TAILINGS DEPOSITION
SOUTH CELL
UNITED NUCLEAR CORPORATION
CHURCH ROCK URANIUM MILL

Raney Geotechnical Job No. 053-003

Raney Geotechnical

March 15, 1982

United Nuclear Corporation
Attention: Mr. Tom Hill
113 Sixth Street, N.W.
Albuquerque, N.M. 87102

EVALUATION OF
PROPOSED TAILINGS DEPOSITION
SOUTH CELL
United Nuclear Corporation
Church Rock Uranium Mill

Attached are five copies of the subject report. The report presents the results of our consideration of the proposed south cell usage. The purposes of our study have been to assess the geotechnical safety of the proposed usage and to develop design and operating recommenations.

Our evaluation of the proposed south cell usage has considered slope stability, settlement sensitivity, and filter compatibility. Slope stability analysis indicates factors of safety in excess of the minimums specified in NRC Guideline 3.11. Neither exploratory data nor settlement analysis indicate a significant differential settlement.

In summary, the results of our study indicate that tailings can be safely retained within the south cell area provided that a minimum 150-foot-wide sand beach is maintained.

If you have any questions regarding this letter or our report, please contact us.

Yours very truly,

RANEY GEOTECHNICAL

John M. Raney
Professional Engineer 7553
State of New Mexico

JRM/cah

Attachments

2799-B DEL MONTE STREET • WEST SACRAMENTO, CA 95691 • TELEPHONE 916/371-0434

EVALUATION OF
PROPOSED TAILINGS DEPOSITION
SOUTH CELL
UNITED NUCLEAR CORPORATION
CHURCH ROCK URANIUM MILL

INTRODUCTION

This report presents the results of our consideration of the proposed tailings deposition in the south cell area. The purposes of this study have been to assess the geotechnical impact of the proposed tailings deposition and to develop operating recommendations.

The proposed tailings deposition is a primary feature of a tailings neutralization scheme. The overall scheme includes neutralization of tailings at the mill, deposition of total tailings and cyclone overflow in the south cell, decantation of portions of accumulated solution, storage of decanted solution in the north cell area, and recycling of solution to field dilution facilities.

The topography and orientation of the south cell area and confining embankments are shown on Plate 1, Location Plan.

Authorization for this study has been provided through a consulting contract between United Nuclear Corporation and Raney Geotechnical executed on May 1, 1981. The principal contact for the study has been Tom Hill.

PURPOSE AND SCOPE

The purpose and scope of this study were developed in discussions between Messrs. Tom Hill and Deb Misra of United Nuclear Corporation and John Raney of Raney Geotechnical. In development of the scope of work, consideration was also given to specific written requests of the New Mexico State Engineers office presented in a letter of November 17, 1981.

In accomplishing the stated purpose, our specific scope has included the following:

1. A field exploratory program consisting of the drilling of 13 auger borings.
2. A laboratory testing program directed toward definition of material volume change characteristics.
3. Review of available data collected in conjunction with the construction and operation of the south cell.
4. Performance of engineering analysis consisting of: (a) a review of existing field, laboratory, and design data; (b) a review of field and laboratory data developed by this firm; (c) performance of settlement analysis; (d) development of area-capacity relationships; and (e) performance of computer slope stability analysis.
5. Preparation of this report. In addition to this report, preliminary analytical data have been presented during the course of the study.

PROPOSED CONSTRUCTION AND OPERATION

The proposed neutralization scheme has been described in detail in a letter report to the New Mexico Environmental Division from UNC, dated October 12, 1981. Under the proposed neutralization plan, the south cell area would serve as a primary storage area for tailings solids. During operation, tailings would be discharged at a rate of about 800 gallons per minute. Portions of the accumulated neutralized fluid will be decanted and pumped to the north cell area. The solution stored in the north cell would be allowed to further clarify prior to return to a dilution tank.

Tailings deposition would be accomplished along the embankment face by spiggotting. Additional solids may be placed away from the embankments as cyclone overflow. A minimum 150-foot-wide beach would be maintained without modification to the existing topography provided that the solution elevation does not exceed 6952. In practice, due to the proposed decantation, beach elevations under the continued deposition should exceed 6960 within 150 feet of embankments well in advance of a solution level on the order of 6950. It is estimated that approximately 40,000 cubic yards of beach deposited solids would be required to create a 150-foot-wide beach with a solution elevation of 6960 and a 150-foot-wide beach.

SITE CONDITIONS

The south cell is confined by the main tailings dam, the breach repair, the south cross dike, and native topography. The minimum crest elevation is approximately 6965. The maximum fluid capacity is in excess of 175 million gallons with a surface area of about 52 acres.

Following the dam breach, the south cell was isolated by the construction of the south cross dike. Prior to the breach, tailings were deposited all along the face of the main embankment and free water was commonly in contact with the embankment.

The main dam was designed as a two-zoned structure with an approximate ten-foot deep cut-off trench extending from the upstream to downstream crest in plan.[1/] Exploratory data obtained by both this firm and previous investigators appear to indicate that the main dam is more nearly a single-zone structure.[2/, 3/] The southern portion of the main embankment is built over several backfilled arroyos; the depth of the cut-off trench appears to vary. The embankment crest width is about 60 feet, with upstream and downstream slopes of 1½:1 and 2:1 (horizontal to vertical), respectively.

Portions of the main dam have been subject to two alterations. Chronologically, the first alteration was associated with a proposed embankment height raise undertaken in the Spring and Summer of 1979. The raise construction was underway when a portion of the embankment failed in July, 1979. Prior to the failure, the raise construction had included the clearings of the downstream foundation area, the placement of a tailings blanket drain from two to five feet in thickness, and the placement of several feet of engineered fill over the blanket. The second alteration is the repair of the failed embankment section. The repair is confined to about a 500-foot section of the dam at the southerly abuttment, and consists of a chimney drain and new downstream shell.

SUBSURFACE

Based upon comparisons between existing and preoperational topography, depths of retained tailings range from very shallow to in excess of 40 feet. Consistencies range from very loose in the upper five feet, to loose at greater depths.[4/]

The embankments, with the exception of the described alterations, are generally comprised of silty and sandy clays with sandstone fragments. Consistencies are generally at least stiff and permeability very low. The uniformity of consistency appears to indicate conscientious construction effort and field control.

The embankment foundation soils for most of the south cell embankments generally consist of clayey sandy silts, and silty and sandy clays. The foundation profile appears to be relatively consistent by comparison to the remainder of the overall tailings area. Where uninterrupted by arroyo cutting, immediate surface soils generally consist of slightly clayey sandy silts. These soils are typically of medium-stiff consistency. The near-surface silty soils are generally underlain by clay-dominated soils. These lower materials extend to depths in excess of 100 feet over most of the embankment alignment and are underlain by sandstone bedrock. The clayey soils are generally of medium stiff consistency and are locally moderately compressible.

For a better understanding of subsurface conditions, reference should be made to the Logs of Boring in the Appendix.

RECOMMENDATIONS

EARTHWORK

It is recommended that south cell beach areas be modified in accordance with Plate 2, Grading Plan. The primary feature of the grading plan is the constant maintenance of at least a 150-foot-wide beach. Beach modifications will be minor in the area immediately adjacent to the embankments. For the most part, material placement can be accomplished hydraulically. For a limited area adjacent to the breach repair, it is recommended that beach modifications be accomplished mechanically. There will be no compaction requirement.

We understand that some mechanical tailings movement in the beach areas of the south cell has already taken place. The existing beach level, therefore, is somewhat higher than indicated of the topographic base map of Plate 2. The recommended minimum beach dimension will be exceeded for all solution levels below elevation 6952. At no time during the deposition should cyclone overflow be discharged or directed toward the 150-foot-wide beach area.

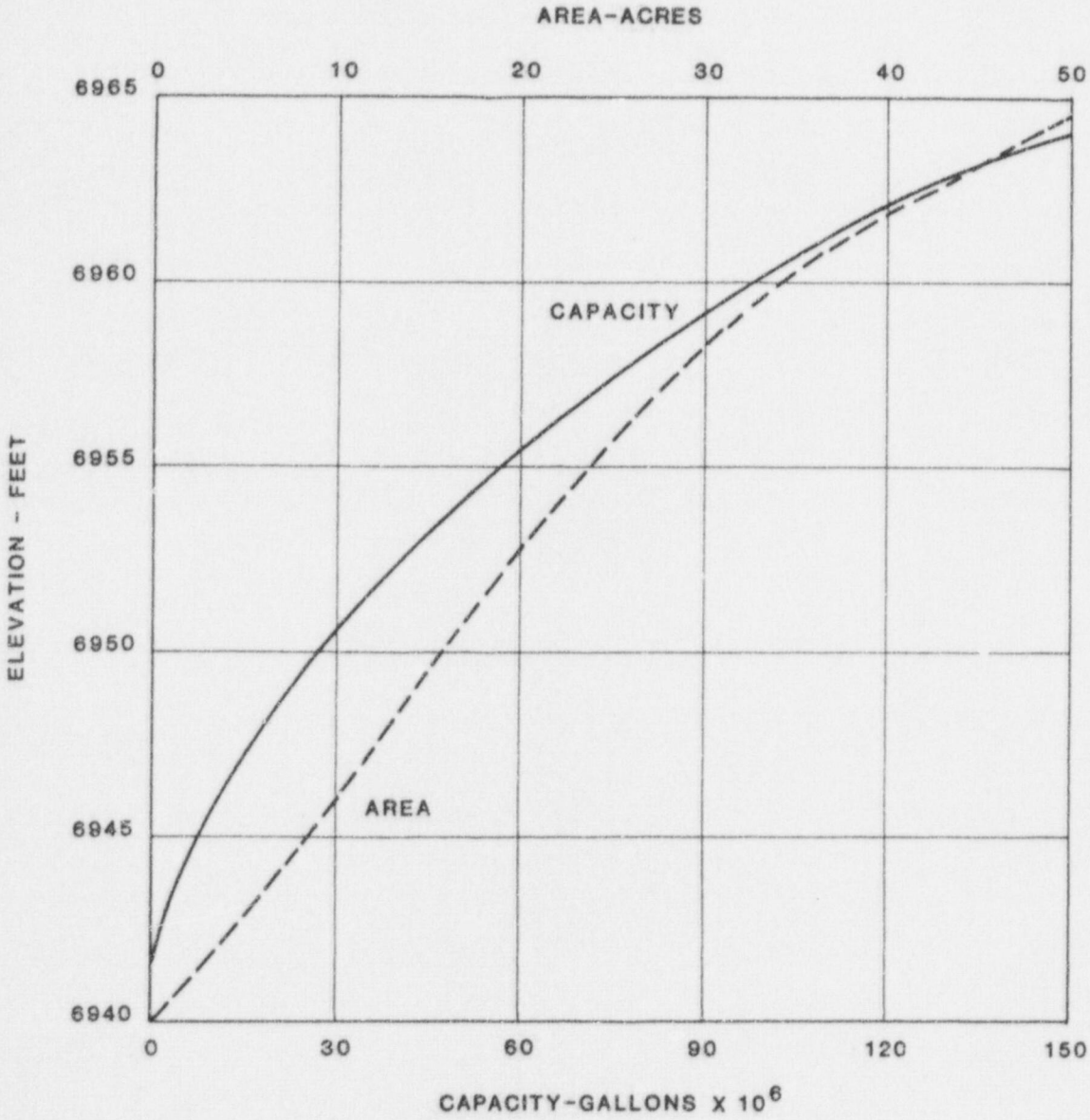
It is estimated that approximtely 40,000 cubic yards of solids will be required to achieve the grading configuration shown on Plate 2.

OPERATION

Stage vs. capacity and surface area relationships for the current topography are shown on Figure 1. The maximum recommended operating level for the beach modified south cell area is elevation 6960. At this level, a storage capacity of about 97 million gallons will be provided. Without alteration of the beach areas, a storage capacity of about 37 million gallons would be provided with a solution level at elevation 6952.

FIGURE 1

STAGE-CAPACITY CURVES



NUMBER: 1 DRAWN BY: C. Hayes DATE: 2/17/82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 2/18/82

Raney Geotechnical

The existing embankment should be subject to a regular program of visual surveillance during start up and continuing through regular operation. Attention should be paid to signs of tension cracking, slumping, erosion, and seepage. Records should be maintained and made available to the Soil Engineer. Any areas of solution encroachment into the designated beach should be repaired immediately upon detection. The low track pressure bulldozer recently purchased by UNC should be immediately available for this type of work or any other similar emergency.

Because of the importance of proper maintenance of the beach, it is recommended that a two-foot interval topography of the south cell be developed on a regular basis. A flight interval of about three months is suggested. Relocation of the discharge should be based upon consideration of the topographic data. Problem areas of solution encroachment should be modified immediately upon detection.

In accordance with NRC guidelines, the design storm series impacting the south cell shall consist of the average annual rainfall less average annual evaporation, plus the PMP, plus 40 percent of the PMP, plus the 100-year storm.[5/] The acceptable PMP is a 9.5 inch one-hour point value and the 100-year storm about 2.4 inches.[6/] The corresponding storm series is about 16 inches, acting over a south cell catchment area of about 71 acres. Figure 1 indicates ample storage capacity for the resulting approximate 31-million gallons of captured rainfall. More than two and one-half feet of wave and wave run-up freeboard would be provided during the design storm for both the initial and future phase beach modifications.

Surface water hydrology impacting, but outside the south cell catchment, is considered in a separate report prepared by Faith Engineering.

A total of 20 settlement monuments are located about the inside crown of the main embankment and south cross dike. These are S1 through S15, and SD1 through SD5. Existing survey interval and reporting procedures should be continued for these monuments. Piezometers include the Hall devices in the breach area, 300 series wells in the south cross dike, and new 500 series wells near the embankment toe.

ANALYSIS

SLOPE STABILITY

General

Three critical sections were isolated for stability analysis, one through the breach repair (Section A), one through the embankment immediately northerly of the breach repair (Section B), and one relatively near the south cross dike (Section C). The locations of these sections are shown on Plate 5, Monument, Stability and Piezometer Locations; the sections and results of the analysis are presented on Plates 7A through 7C. Loading conditions, soil strength parameters used in the analysis, and the results are discussed in the following sections.

Loading Conditions

Our analysis considered only the long-term and earthquake loading conditions. Consideration of the end-of-construction loading condition is considered unnecessary, since little new load will impact embankments and foundations. The earthquake condition was analyzed pseudostatically with an acceleration of 0.1 g. Phreatic surfaces were not established by analytical procedures but rather were conservatively located by connecting operating levels to drainage elements in the downstream toes.

Soil Properties

Most soil property data used in the analyses were derived from existing sources. New strength properties were developed for embankment engineered fill and the neutralized total tailings. The source information and soil property data have generally been agreed upon in discussions between the New Mexico State Engineers office and Raney Geotechnical. A relatively detailed discussion of soil properties is presented in the Addendum Report for the Design and Evaluation of the Central Cell Embankment Raise.[7/]

Results

Slope stability analyses were performed using the Slope-II computer program with the Simplified Bishop Method option.[8] The results indicate factors of safety in excess of the minimums suggested by the NRC.[5] The results of the analyses are presented on Plates 7A through 7C and are summarized in Table I, Stability Analysis Results.

TABLE I

STABILITY ANALYSIS RESULTS

STRUCTURE	LONG TERM	EARTHQUAKE
Section A	2.15	1.80
Section B	2.64	1.74
Section C	2.49	1.86

SETTLEMENT

General

Embankment settlement has been analyzed by comparison between observational and analytical data. We separated our consideration of embankment settlement into two categories, collapse settlement and conventional one-dimensional compression settlement.

To aid in the understanding of past settlement performance of the south cell, we have, to the extent possible, developed settlement vs. time plots for the entire life of the south cell embankment. Development of these plots required considerable judgment in the interfacing of various surveys and survey points.

The locations of the settlement monuments in conjunction with this study are shown on Plate 5. It should be noted that

the basemap for Plate 5 reflects May, 1974 topography. This method of presentation is intended to amplify the importance of conditions prior to construction.

Collapse Settlement

Collapse settlement requires the presence of relatively low density and low water content soils. Our field exploration specifically sought materials of this nature. Boring and sample locations were selected to coincide with probable locations of collapsible soils. All samples were carefully reviewed; samples which appeared to be potentially collapsible were subjected to collapse testing as described in the Appendix. The laboratory results indicate that limited amounts of soil with generally low collapse potential are present in the embankment foundation.

For the collapse mechanism to function, heretofore, dry soils must be moistened. Accordingly, we considered groundwater and operating levels about the south cell. Historic south pond operating levels were obtained by review of aerial photography and are summarized in Table II.

Little groundwater level data are available for the period prior to the embankment breach. Data since the breach do not appear to reveal any significant trends. We have summarized recent groundwater level data for the well locations shown on Plate 5; these data are presented on Table III.

Based upon our laboratory investigation and consideration of past operating levels, it is our opinion that storage of fluids to elevation 6960 will not induce settlements of a magnitude sufficient to cause embankment cracking. Exact collapse settlement magnitudes cannot be accurately assessed, but because of past foundation wetting are expected to be minor or nonexistent. The performance of neutralized solution and potentially collapsible site soils may be superior to the performance of similar materials in an acidic environment.

TABLE II

SOUTH CELL WATER SURFACE
AS DETERMINED FROM AERIAL PHOTOGRAPHY

DATE	ELEVATION	REMARKS
3/25/78	6933.8	North portion south cell
9/20/78	6944.3	
7/31/79	6954.7	
9/22/79	6952.7	Total central portion
11/6/79	6951.4	Total central portion
12/1/79	6952.6	
2/13/80	6950.9	Total central portion
4/9/80	6950.9	Confined to central area
6/3/80	6947.3	
9/27/80	6943.9	Confined to central area
10/10/80	6943.5	
12/2/80	6942.8	Confined to south central
2/24/81	6942.0	Confined to south central
4/21/81	6941.8	
6/2/81	6940.9	Confined to south central
11/15/81	--	No free water

TABLE III

SELECTED RECENT GROUNDWATER LEVELS

IDENTIFICATION	DATE	GROUNDWATER ELEVATION
22M	11/11/81	6904.67
23A	11/11/81	6888.56
333	11/25/81	6931.90
334	11/25/81	6933.59
335	11/25/81	6943.93
341	11/25/81	6947.58
510AD	12/30/81	6921.13
510D	12/30/81	6924.19
512AD	12/30/81	6908.29
512D	11/17/81 - 12/17/81	DRY
513AD	12/30/81	6887.44
513D	11/17/81 - 12/17/81	DRY
HP2211	12/30/81	6930.55
HP1905	12/30/81	6928.86
HP2236	12/30/81	6931.67
HP2235	12/30/81	6928.70

Compression Settlement

Settlement data presented on Plates 6A through 6E appear to validate laboratory test data. The effects of arroyo crossings (elimination of near-surface settlement-sensitive soils), and the effects of higher surcharge (adjacency of the breach repair and raised central cell) are clearly demonstrated.

Consolidation and Atterberg limit data for foundation engineered fill materials are summarized on Figure 2, Atterberg Limits-Consolidation Test Results

By comparing settlement data to exploratory and laboratory data it is possible to back calculate settlement parameters. In this manner, we have developed a controlling section for maximum total settlement consisting of a 30-foot layer of highly plastic silty clay. The layer appears to be reasonably normally consolidated with a virgin compression index of about 0.25. As evidenced by the slow rates of settlement in the field, values of C_v are quite small, although erratic because of the presence of sand lenses.

Future surcharge of the south cell embankments will be very slight. Conservatively assuming that sands will extend horizontally from embankment crowns at some time, a total settlement of approximately three inches may be calculated. Although storage of solution would tend to reduce effective stresses, the initial effect will probably induce some minor settlement prior to establishment of equilibrium pore pressure conditions. Estimation of this fluid-induced settlement is made difficult by variable drainage conditions.

Differential thickness of compressible soil deposits over sloping bedrock near the south abuttment have been studied by others.[2/] The failure of the embankment clearly demonstrates the importance of bedrock geometry. The breach event appears to identify the completion of primary consolidation for the embankment. Some continuing settlement of the breach repair should be

expected; however, this settlement will be uneffected by the proposed south cell usage. Calculated projected compression settlements are expected to occur over relatively long periods and should allow for plastic adjustment of the embankments.

FILTER PROPERTIES

The embankment and retained total tailings and similar new neutralized tailings are generally imcompatible as protected material and filter, respectively. That is, these materials do not fit within filter design guidelines commonly developed with D_{85} and D_{15} ratios. The filter imcompatibility is considered appropriate, however, since the function of the sand beach should be to fill potential cracks. The suitability of total tailings for this purpose could only be determined by some knowledge of crack width.

Following the breach, and during the ensuing investigation, tailing sands were observed in embankment cracks.[9/] This experience appears to demonstrate the function of a total tailings beach.

oOo

FIGURE 2

ATTERBERG LIMITS-CONSOLIDATION TEST RESULTS							
DESCRIPTION	BORING NUMBER	DEPTH FEET	NATURAL MOISTURE CONTENT (%)	LIQUID LIMIT	PLASTICITY INDEX	COEFFICIENT OF RECOMPRESSION C_{C_r}	COEFFICIENT OF VIRGIN COMPRESSION C_{C_v}
ENGINEERED FILL	T3	11.0	22.9	42.2	13.7	0.064	0.235
	T9	11.5	15.5	27.0	10.6	0.093	0.127
	T9	21.5	35.0	66.5	33.9	--	--
NATIVE SOIL DEPOSITS	T1	16.5	27.0	--	--	0.050	0.258
	T1	26.5	22.8	46.9	22.2	--	--
	T1	31.5	24.6	47.4	22.1	--	--
	T4	13.0	25.4	55.7	29.0	--	--
	T7	23.0	23.3	28.8	12.6	0.064	0.201
	T13	50.0	23.2	31.5	14.1	--	--

The following plates are attached and complete this report:

Plate 1 - Location Plan
Plate 2 - Grading Plan
Plate 3 - Embankment Foundation May 1974
Plate 4 - Topography May 1974
Plate 5 - Monument, Stability, and Piezometer Locations
Plate 6A - Monument Data S1 - S3
Plate 6B - Monument Data S4 - S7
Plate 6C - Monument Data S8 - S10
Plate 6D - Monument Data S11
Plate 6E - Monument Data S12 - S13
Plate 7A - Slope Stability Analysis, Section A
Plate 7B - Slope Stability Analysis, Section B
Plate 7C - Slope Stability Analysis, Section C

REFERENCES

1. Design of Tailings Disposal System, UNC Church Rock Uranium Mill, McKinley County, New Mexico, by Kaiser Engineers, February, 1976.

2. Stability and Integrity Assessment, Volume 3, by Sergent, Hauskins & Beckwith, dated August 31, 1979.

3. Stability and Integrity Assessment, Volume 4, by Sergent, Hauskins & Beckwith, September 4, 1979.

4. Geotechnical Consulting, North Cell Tailings Storage, United Nuclear Corporation, Church Rock, New Mexico, by Raney Geotechnical, May 21, 1981.

5. Regulatory Guide 3.11, Design, Construction and Inspection of Embankment Retention Systems for Uranium Mills, by the U.S. Nuclear Regulatory Commission, Revision 2, December, 1977.

6. Personal Communications, Jim Whiteman, dated March 19, 1981.

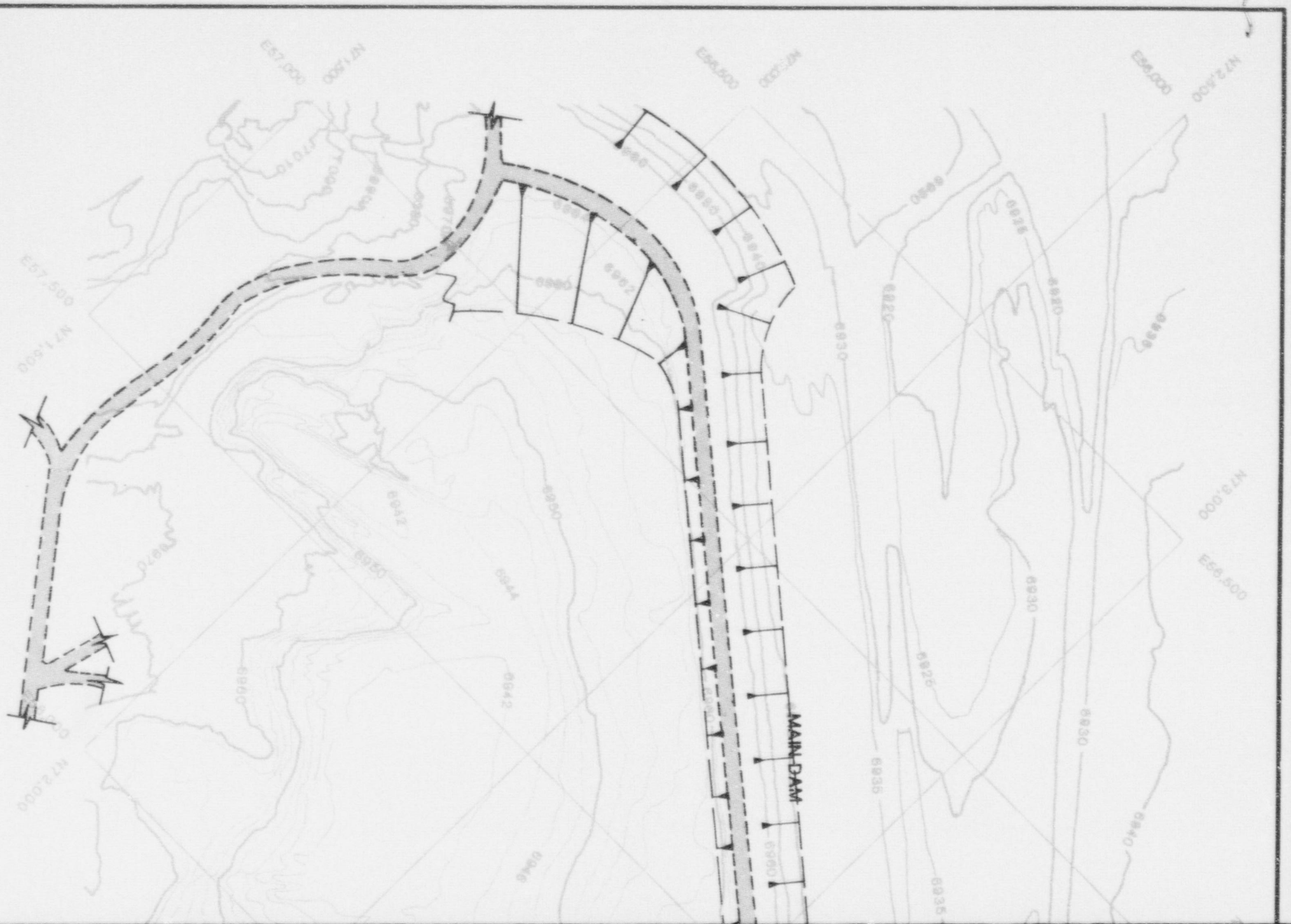
7. Addendum Report, Design and Evaluation Central Cell Embankment Raise, United Nuclear Corporation, Church Rock Uranium Mill, by Raney Geotechnical, August 24, 1981.

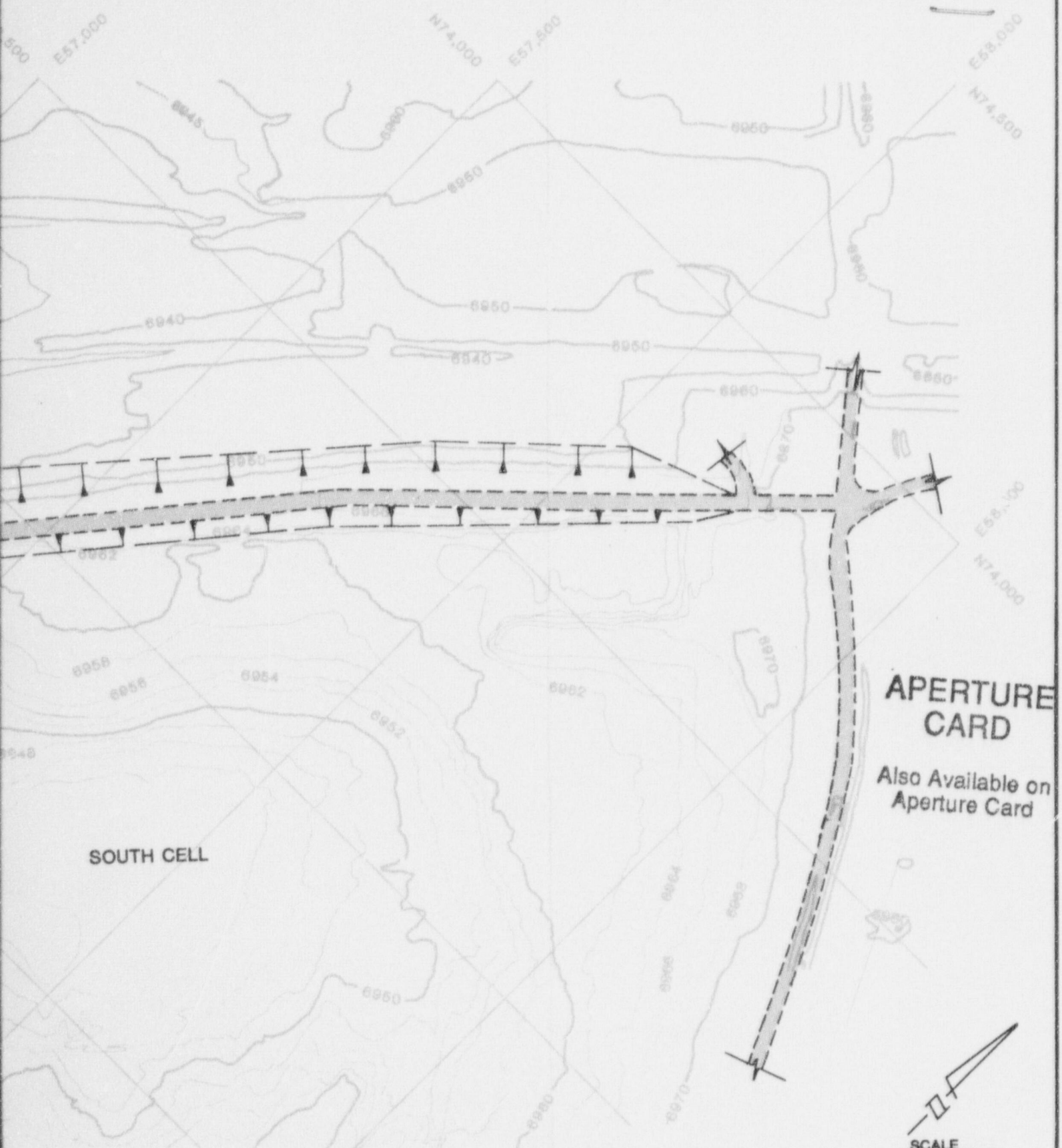
8. Slope-II, Stability Analysis, by Geo-Slope Programming, Ltd., April, 1978.

9. Failure of the Church Rock Tailings Dam, by John D. Nelson and Joseph D. Kane, Colorado State University.

PLATE NUMBER: 1 DRAWN BY: K Lohrey DATE: 3-3-02

PROJECT NUMBER: 053-003 CHECK BY: Rmm DATE: 3/8/02





LOCATION PLAN

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PLATE 1

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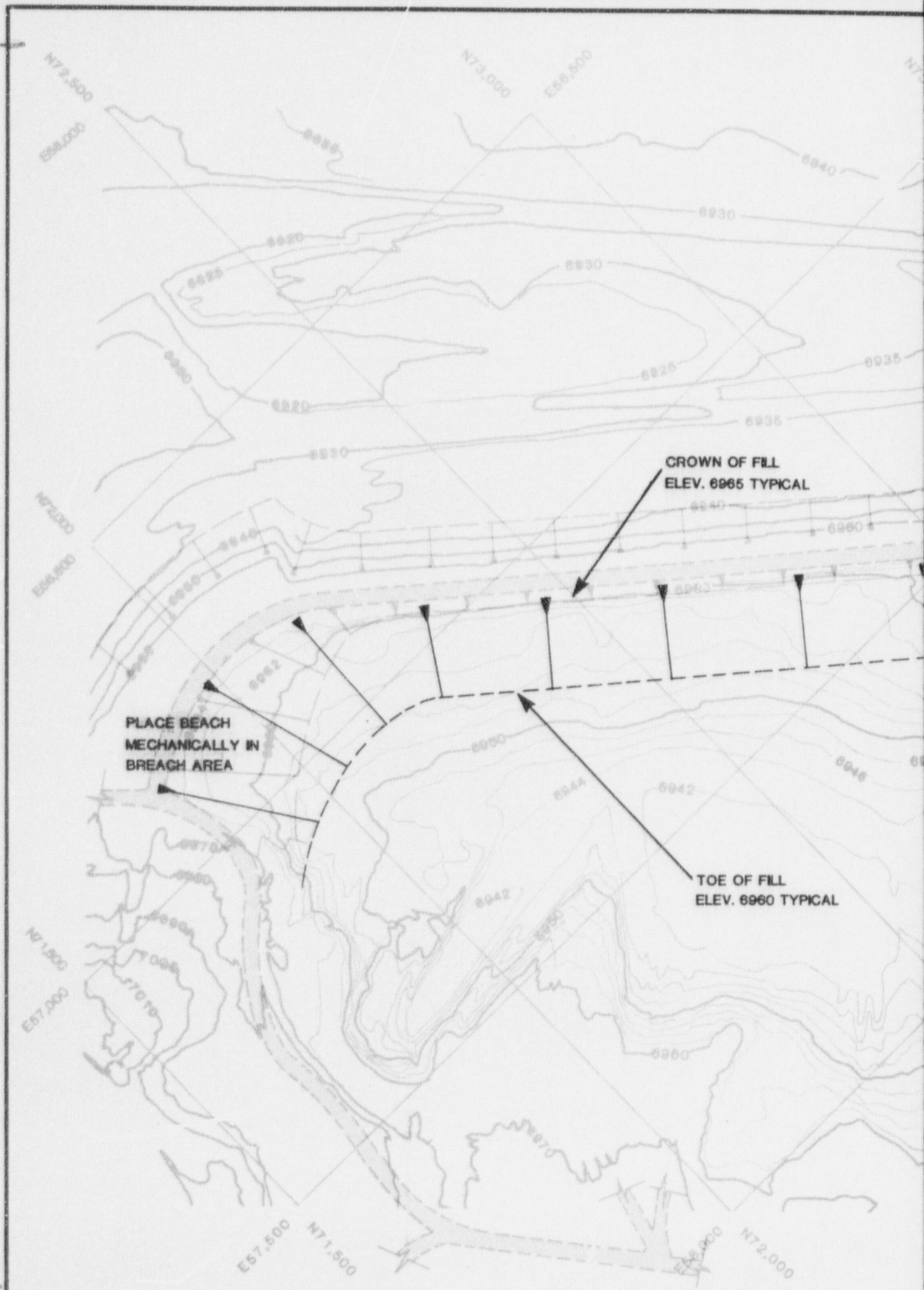

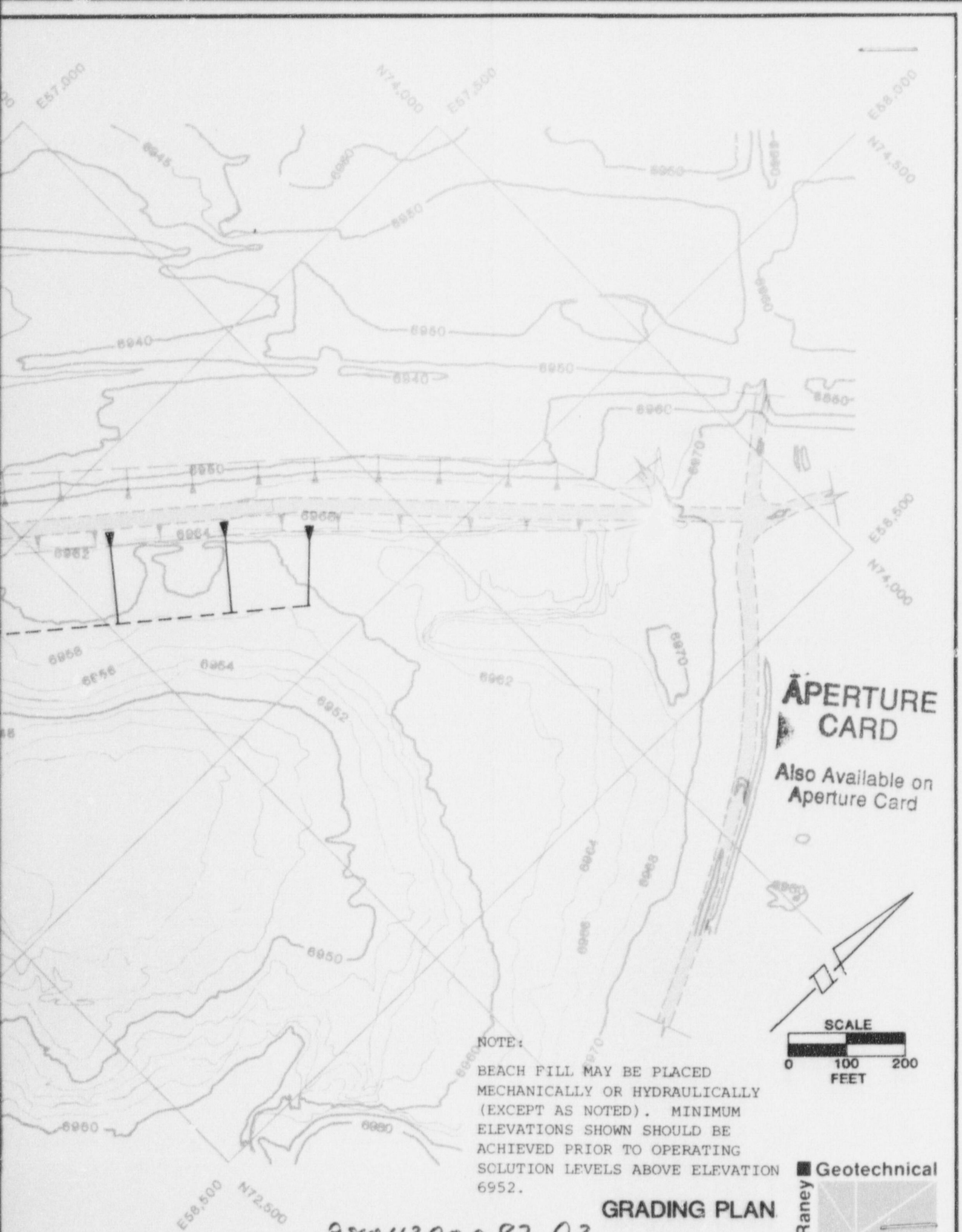

APERTURE CARD

Also Available on Aperture Card

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NOTE:

BEACH FILL MAY BE PLACED MECHANICALLY OR HYDRAULICALLY (EXCEPT AS NOTED). MINIMUM ELEVATIONS SHOWN SHOULD BE ACHIEVED PRIOR TO OPERATING SOLUTION LEVELS ABOVE ELEVATION 6952.

GRADING PLAN

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9804300087-02

PLATE 2

PROJECT NUMBER: 063-001 DRAWN BY: C. Hayes DATE: 12/16/81

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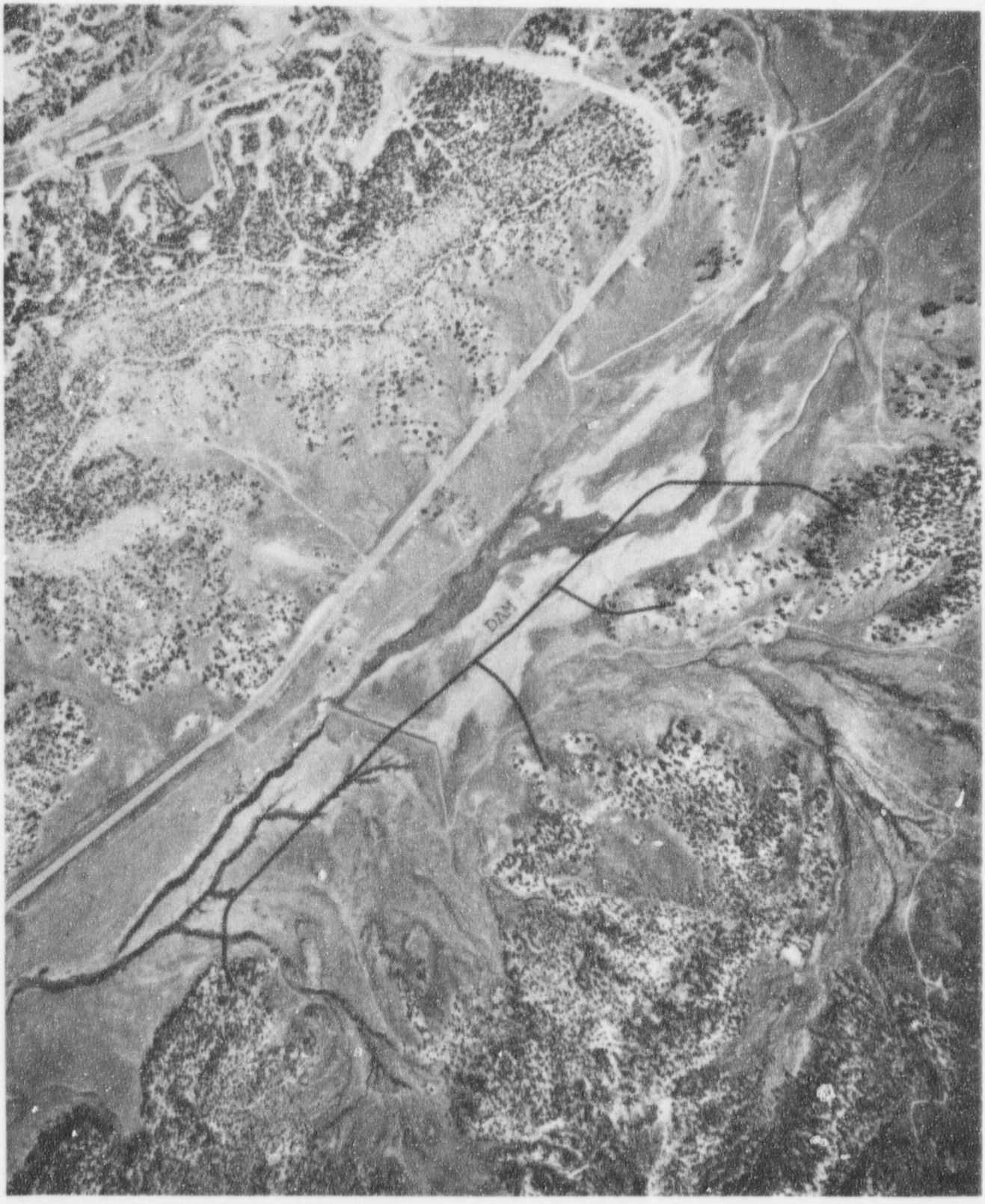

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REFERENCE: AERIAL PHOTOGRAPHY
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EMBANKMENT FOUNDATION
MAY 1974

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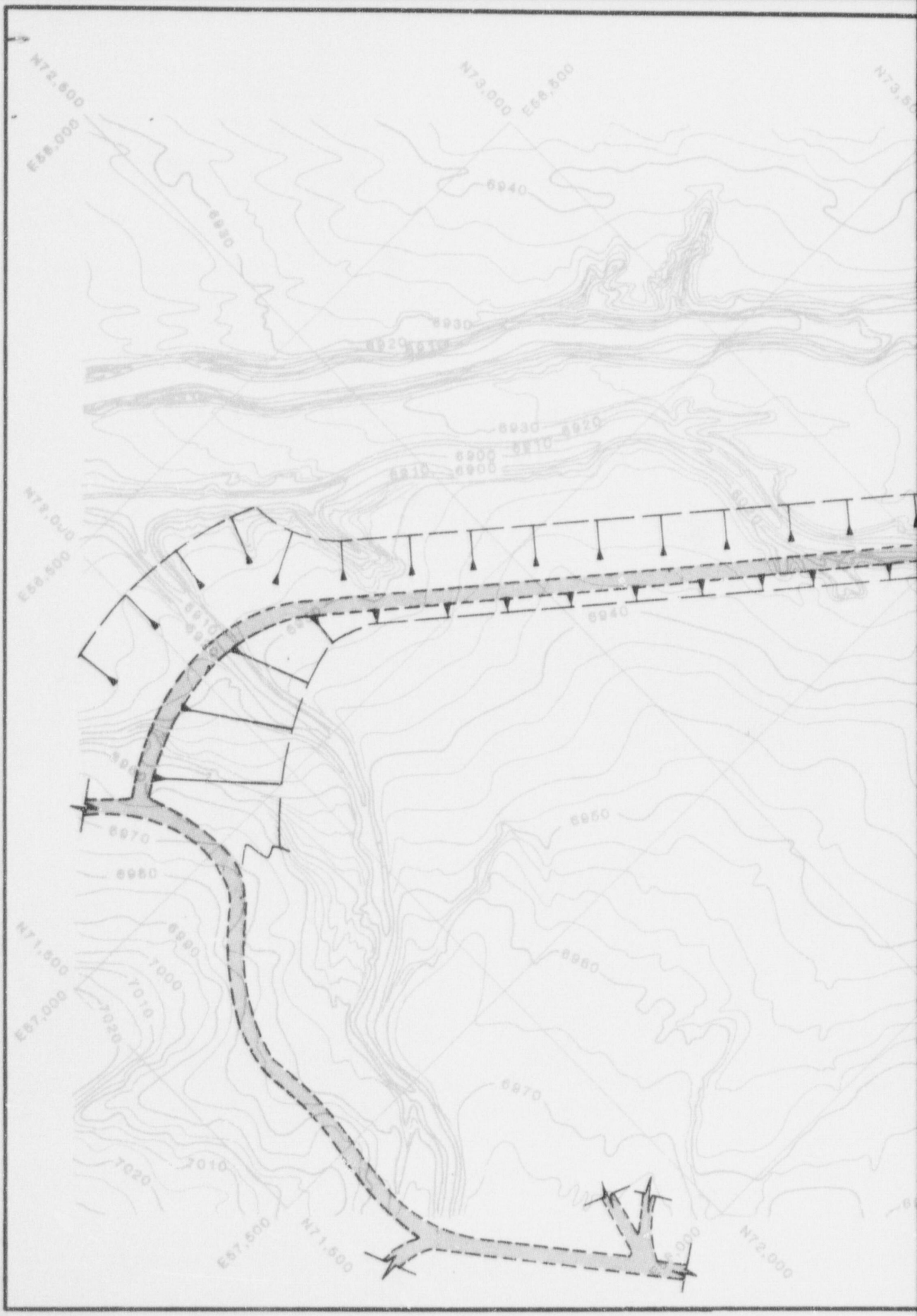
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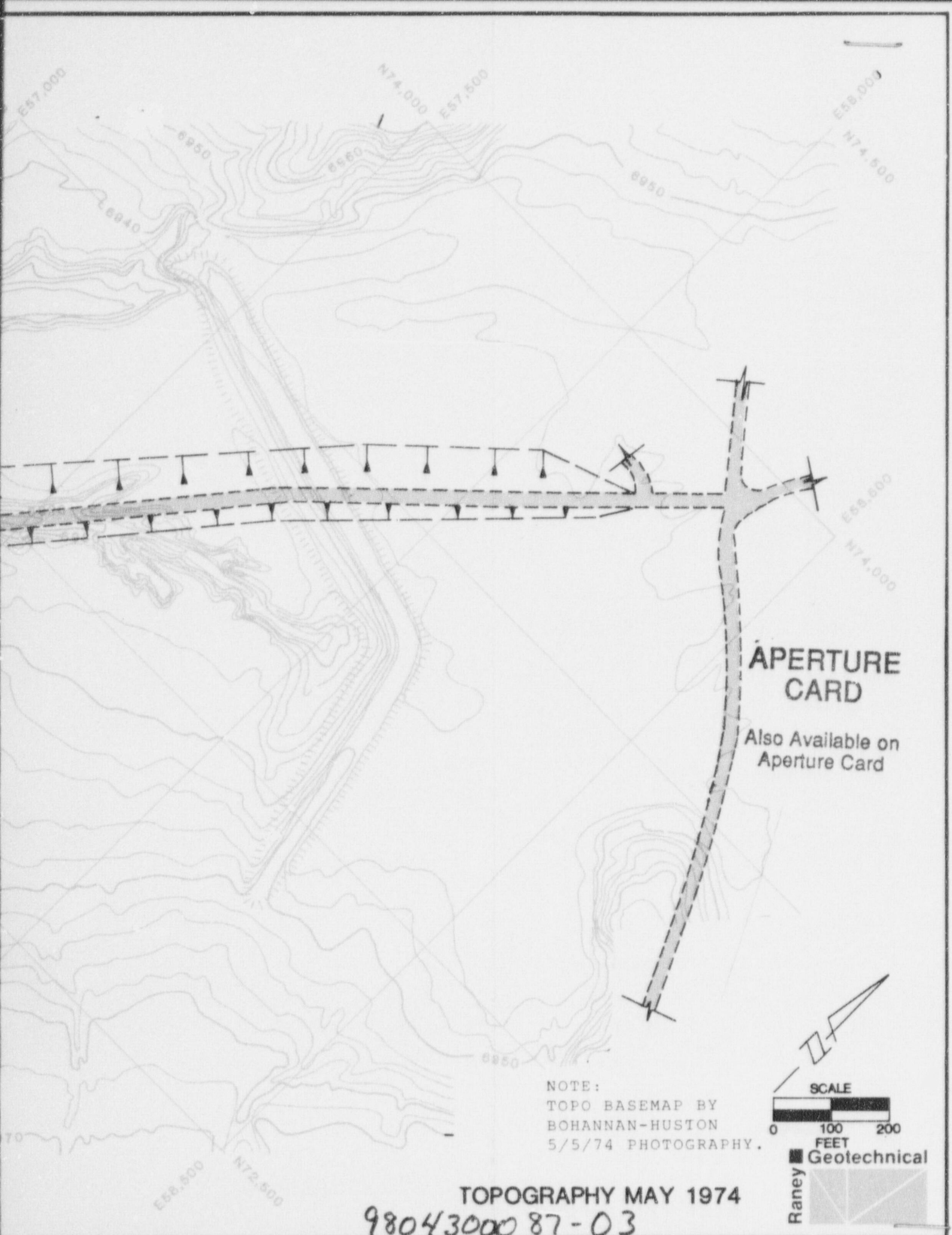

TOPOGRAPHY MAY 1974

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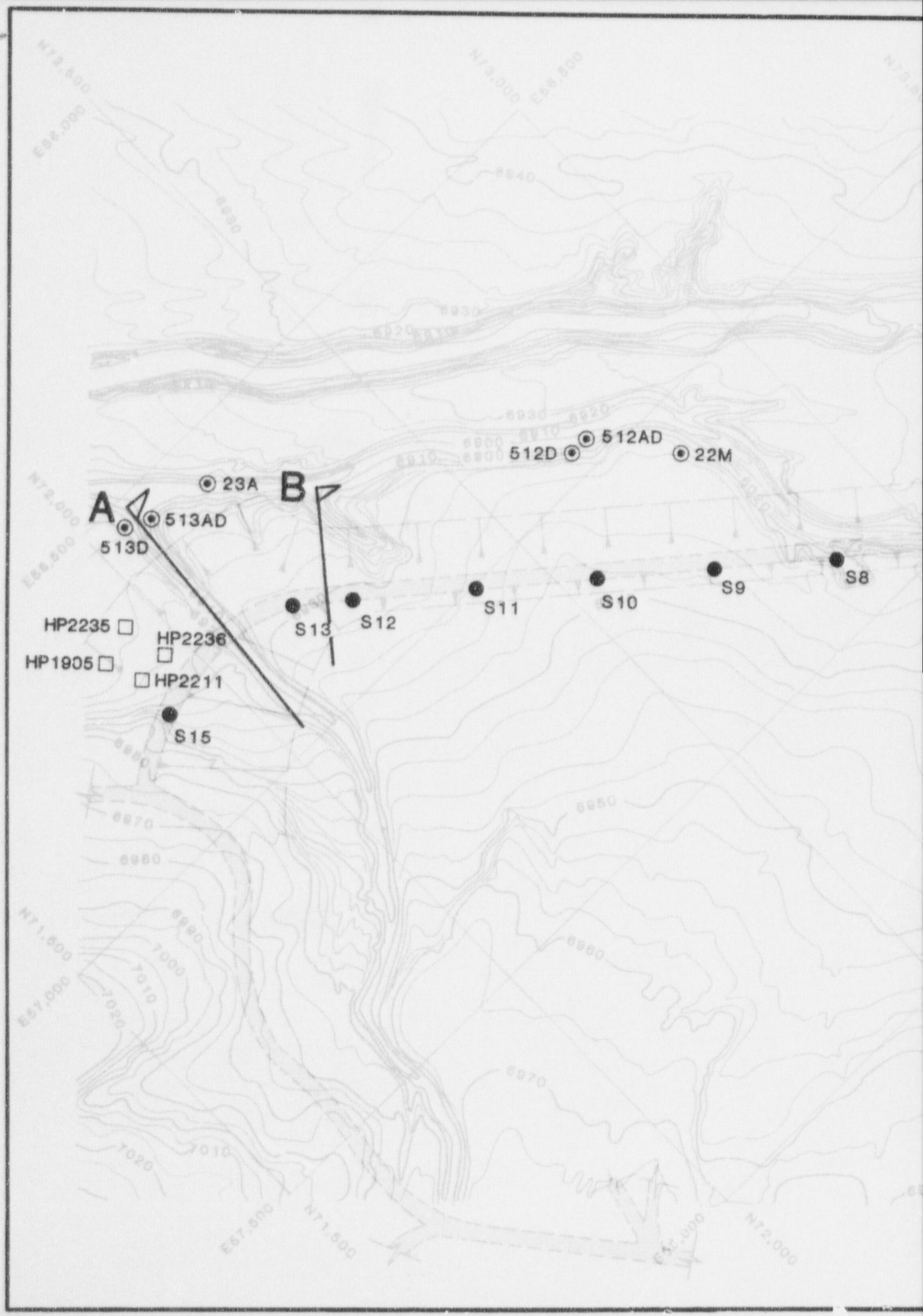
PLATE 4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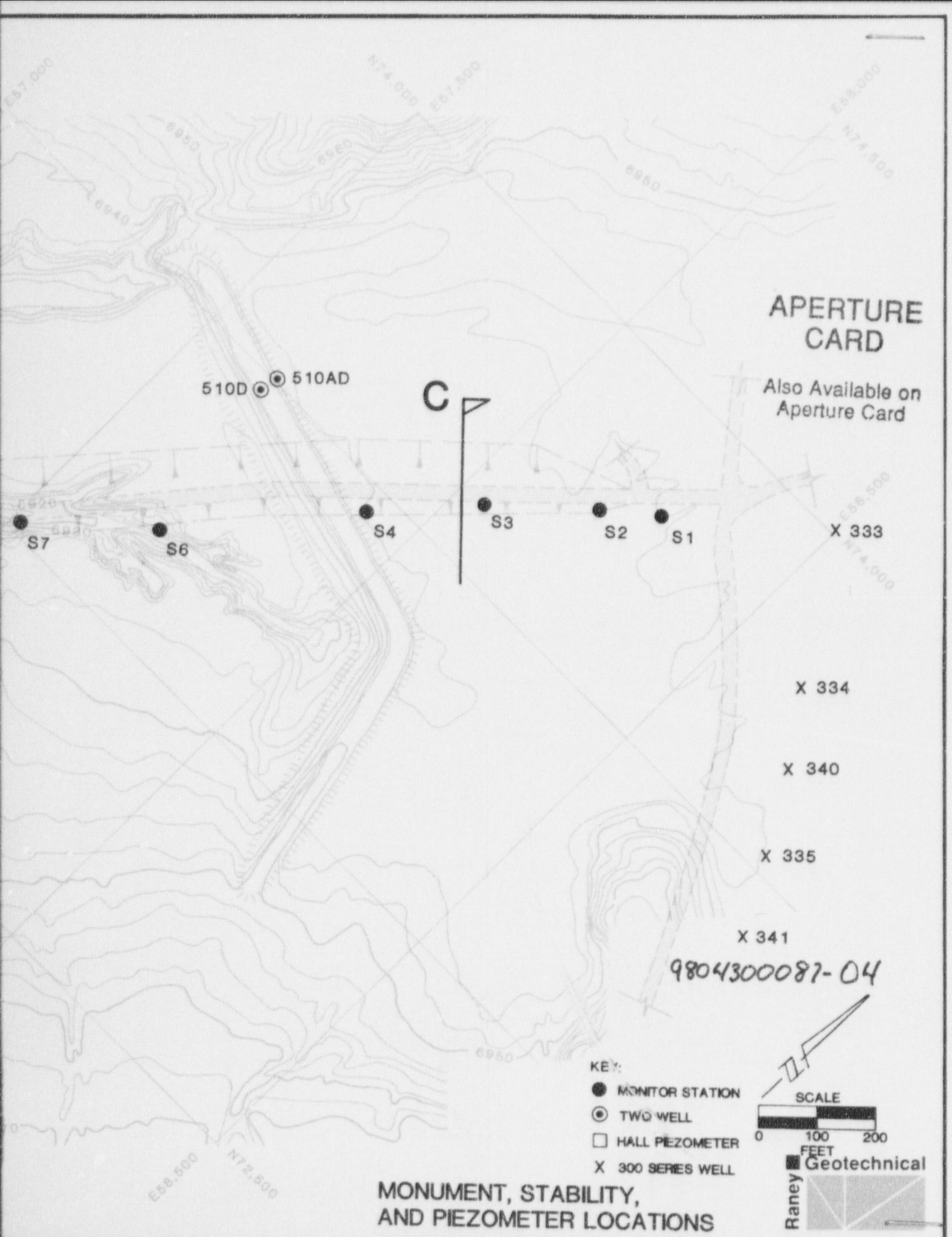
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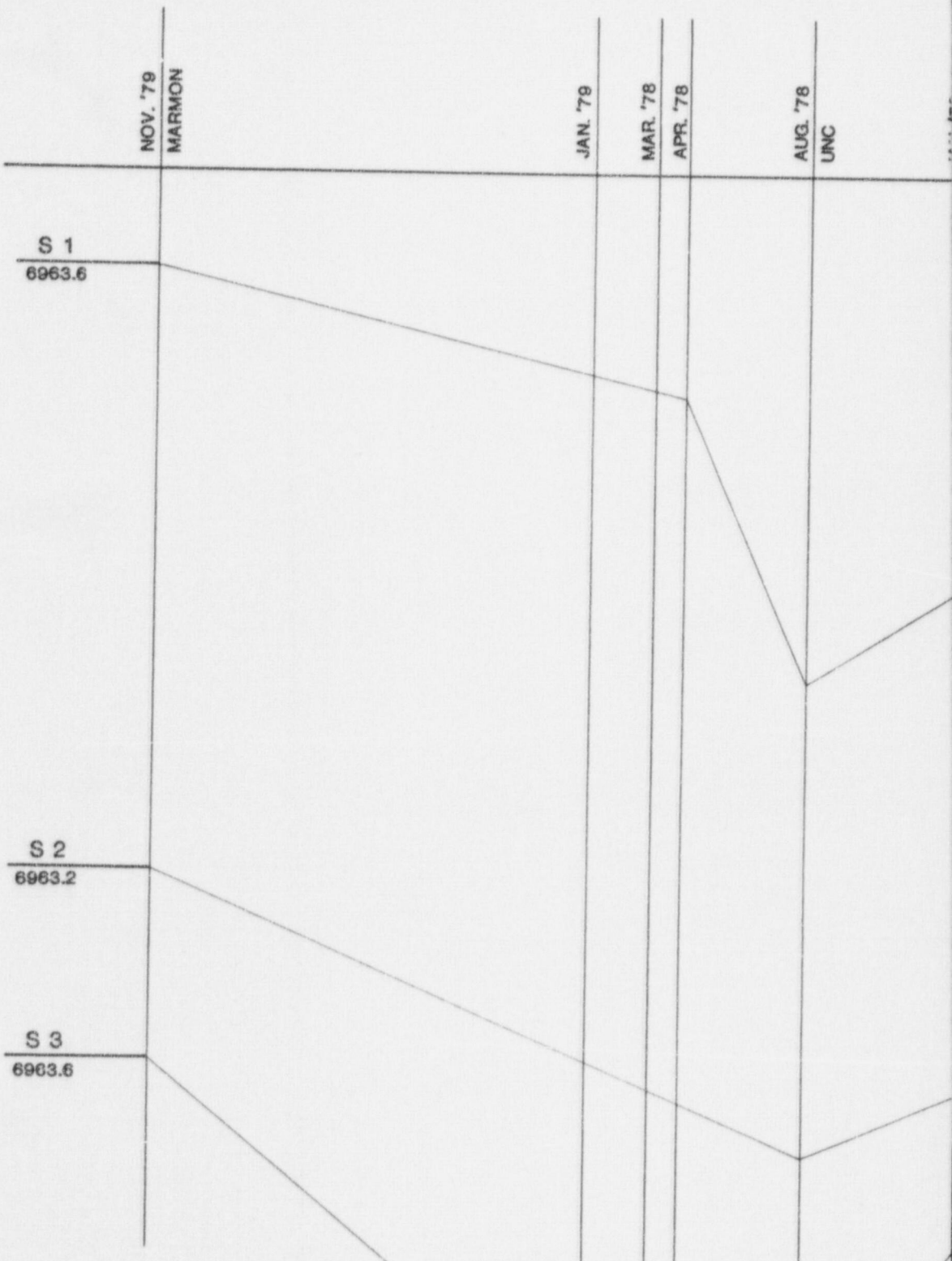
MONUMENT, STABILITY, AND PIEZOMETER LOCATIONS

PLATE NUMBER: 6A DRAWN BY: KLohrey DATE: 3-2-82

PROJECT NUMBER: 053-003 CHECK BY: Ramey DATE: 3/2/82

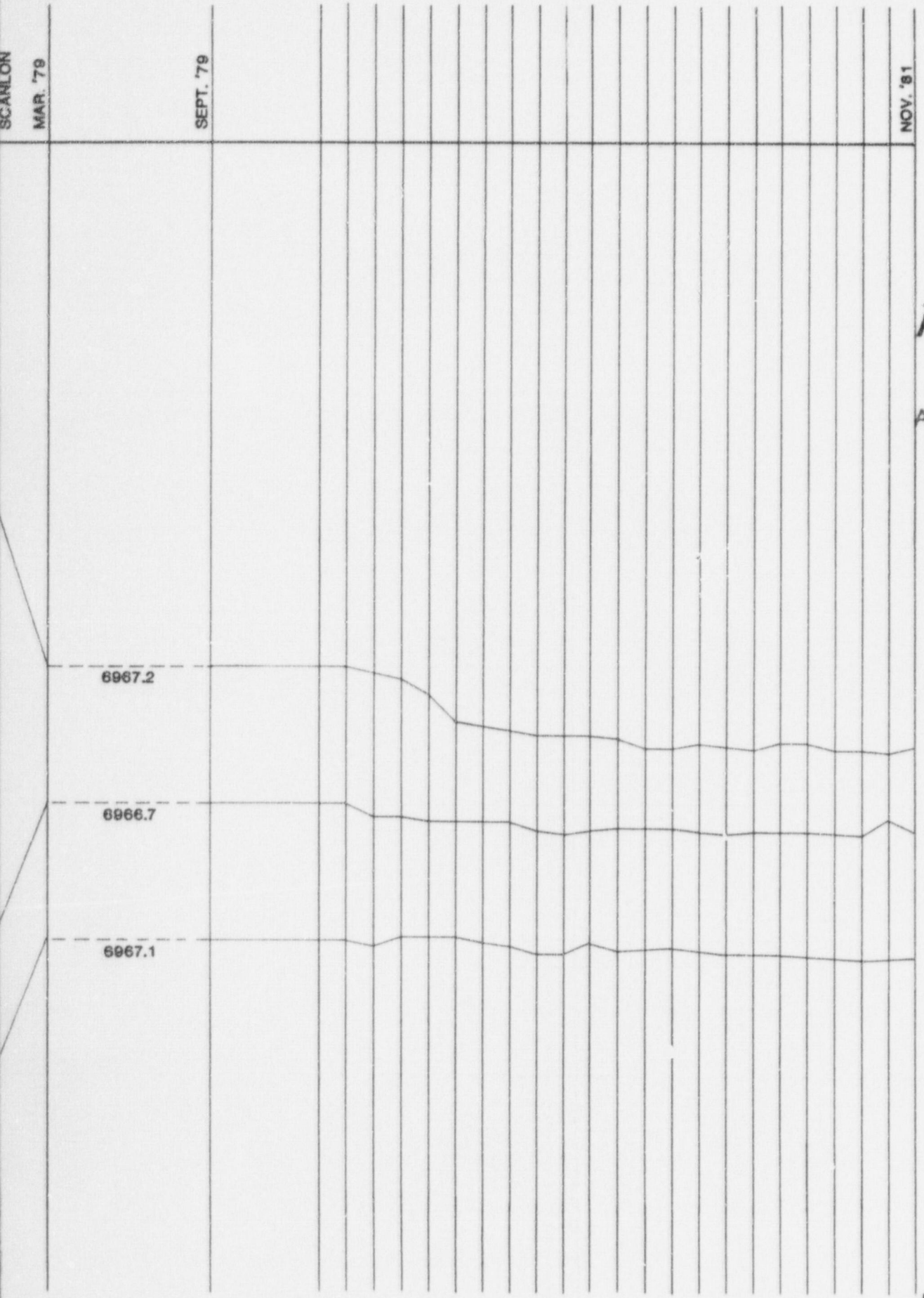


NOTES :

1. HORIZONTAL SCLAE: 0.2 = 1 MONTH
   VERTICAL SCALE: 1" = ½'

2. INCONGRUOUS DATA FROM MARCH '79 TO SEPTEMBER '79. INDICATED ELEVATIONS CORRESPOND TO SCANLON & ASSOCIATES SURVEY, SEPTEMBER '79.

3. UNAVAILABLE DATA FROM OCTOBER '79 TO DECEMBER '79, MONUMENTS S1, S2, AND S3.



MONUMENT DATA
S1 - S3

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9804300087-05

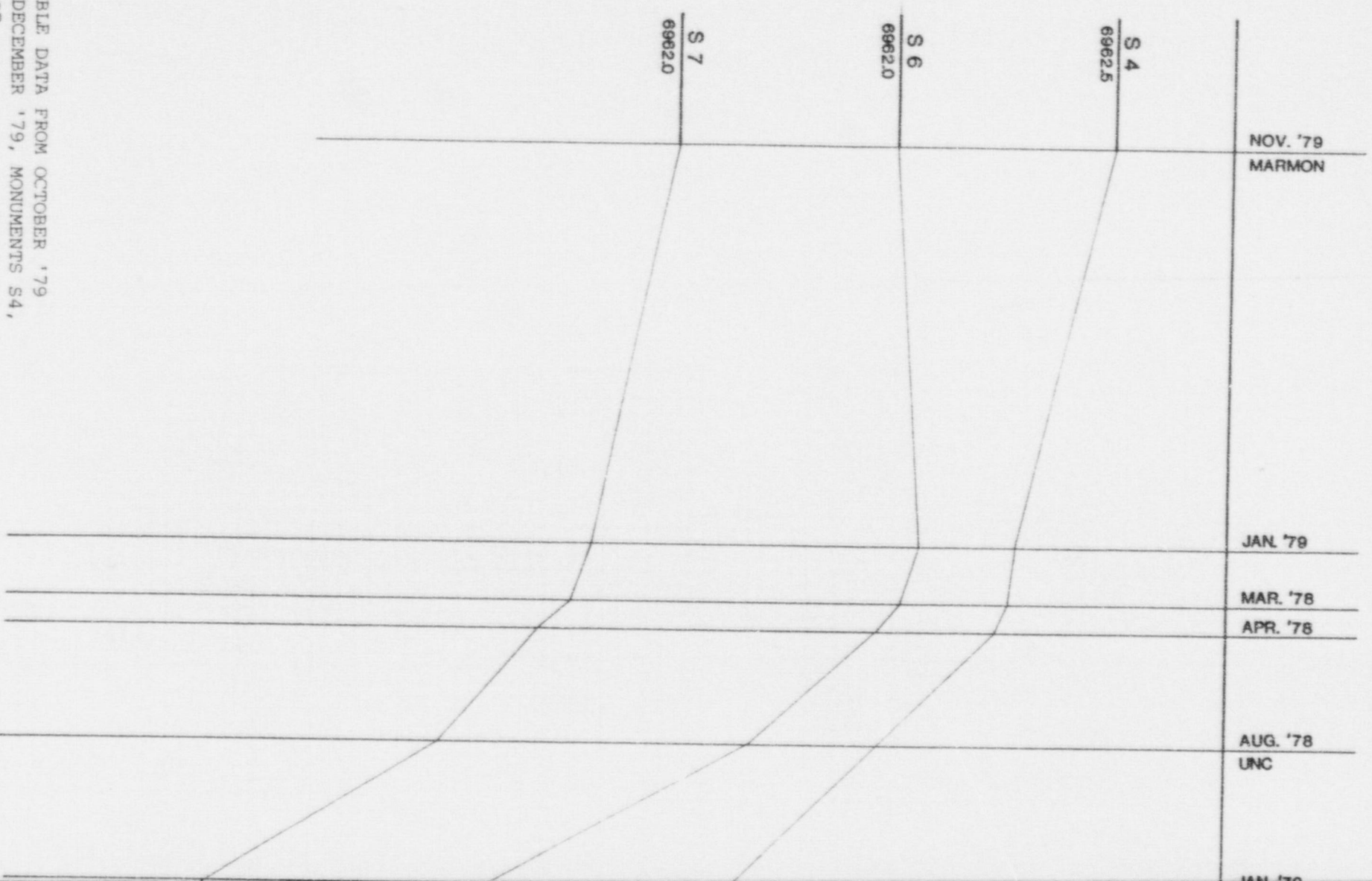
PLATE 6A

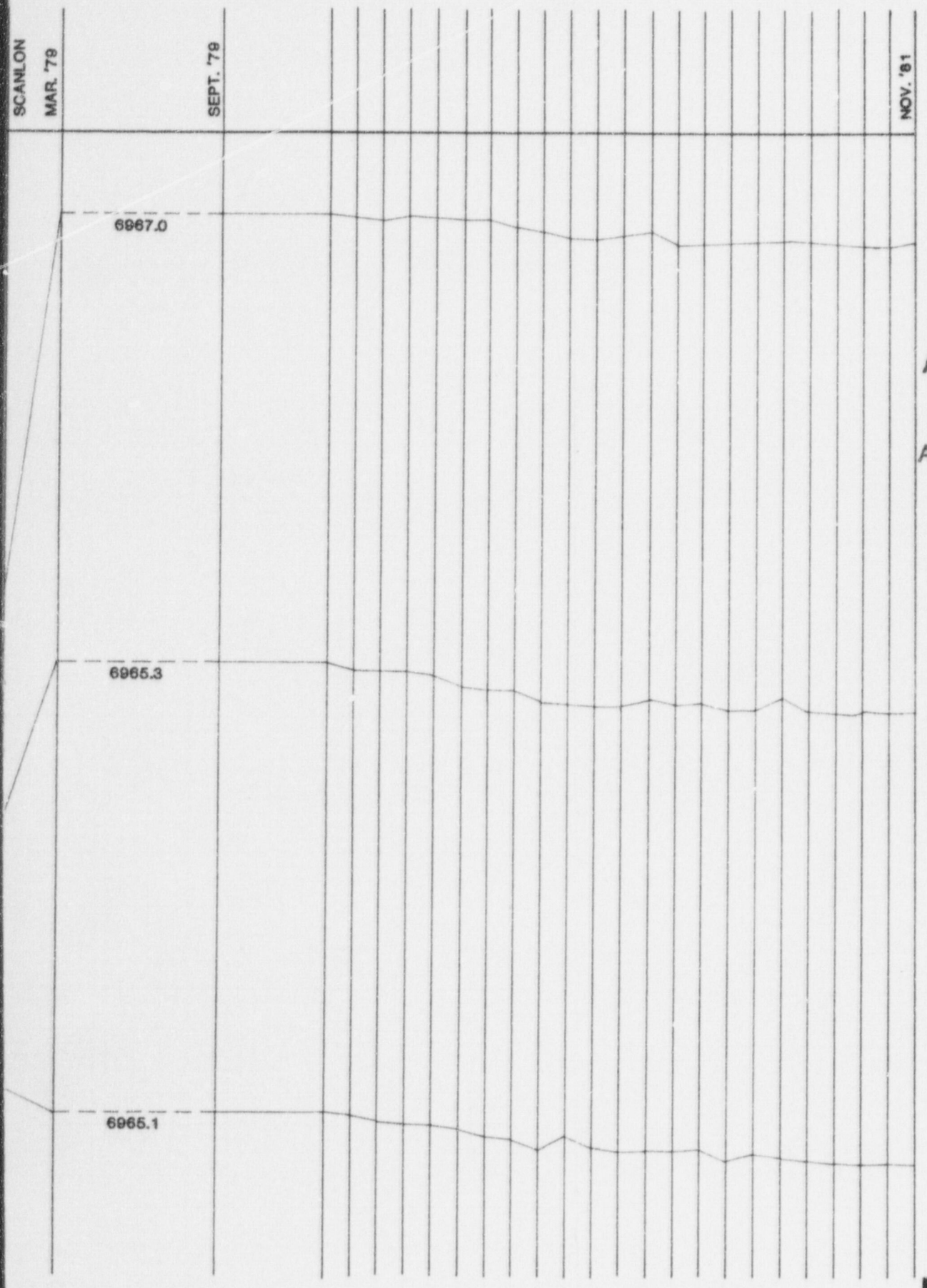
PLATE NUMBER: 6B DRAWN BY: K. Lohrey DATE: 3-2-82

PROJECT NUMBER: 053-003 CHECK BY: Ramey DATE: 3/2/82

NOTES:

1. UNAVAILABLE DATA FROM OCTOBER '79 THROUGH DECEMBER '79, MONUMENTS S4, S6, AND S7.
2. SEE NOTES ON PLATE 6A.





APERTURE CARD

Also Available on Aperture Card

MONUMENT DATA
S4 - S7

Raney Geotechnical

9804300087-06

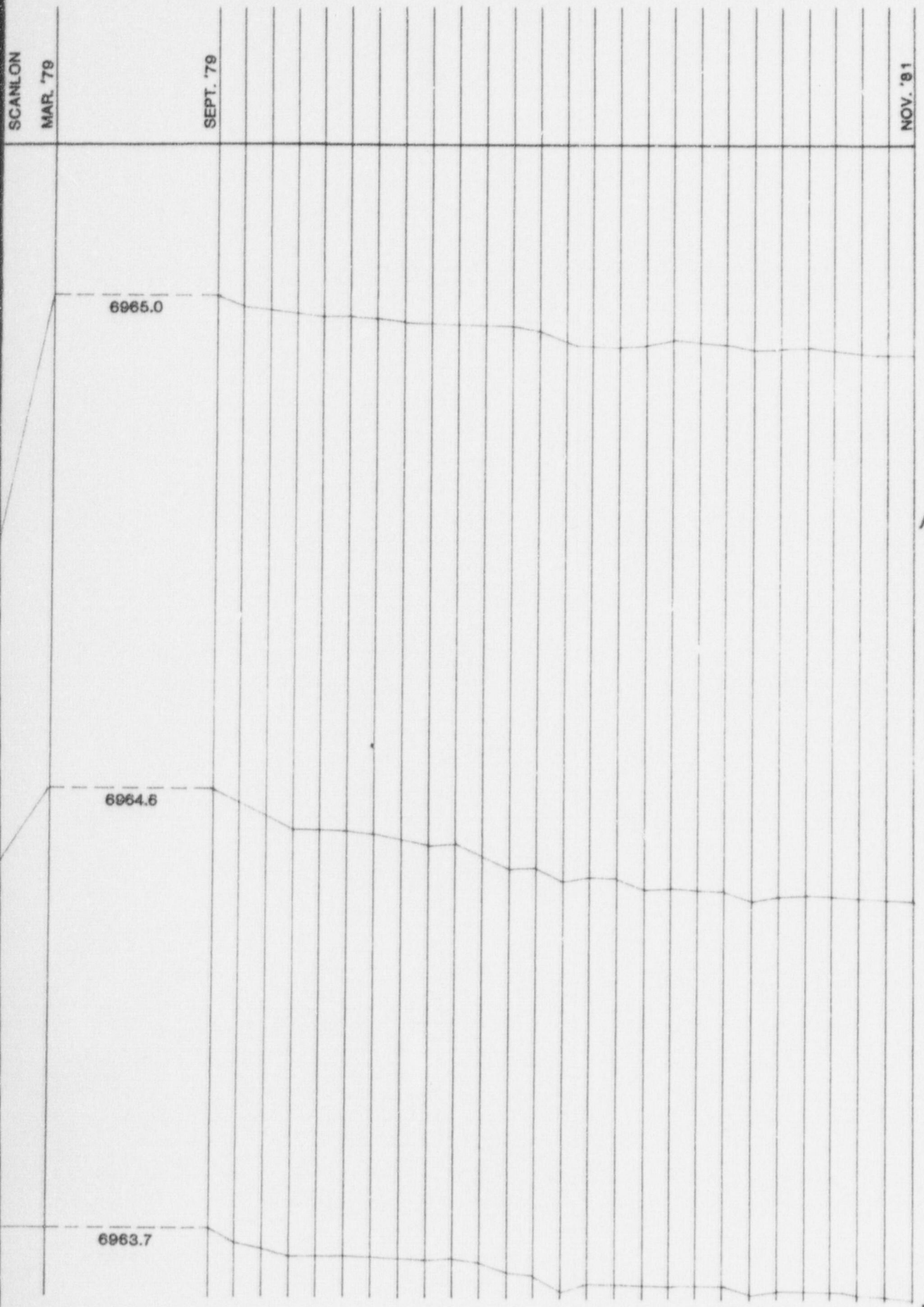
PLATE 6B

PLATE NUMBER: 6C DRAWN BY: K.L. Arvey DATE: 3-3-82

PROJECT NUMBER: 053-003 CHECK BY: [signature] DATE: 3/12/82

NOTES:

1. SEE NOTES ON PLATE 6A.



APERTURE CARD

Also Available on Aperture Card

MONUMENT DATA
S8 - S10

Raney Geotechnical

9804300087-07

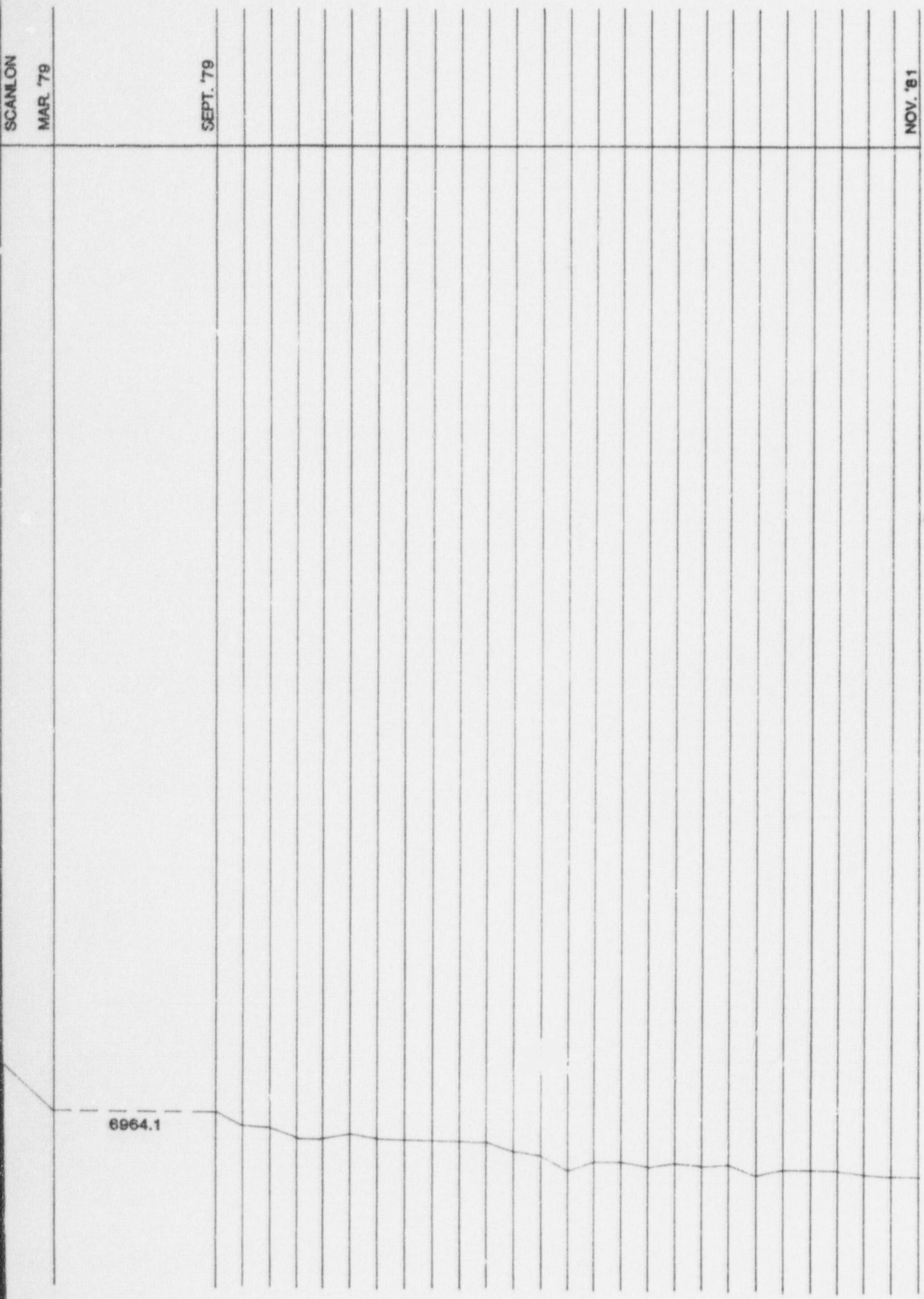
PLATE 6C

PLATE NUMBER: 6D DRAWN BY: K. Lohrey DATE: 3-3-82

PROJECT NUMBER: 053-003 CHECK BY: [signature] DATE: 3/5/82

NOTES:

1. SEE NOTES ON PLATE 6A.



APERTURE CARD

Also Available on Aperture Card

MONUMENT DATA
S11

9804300087-08

Raney Geotechnical

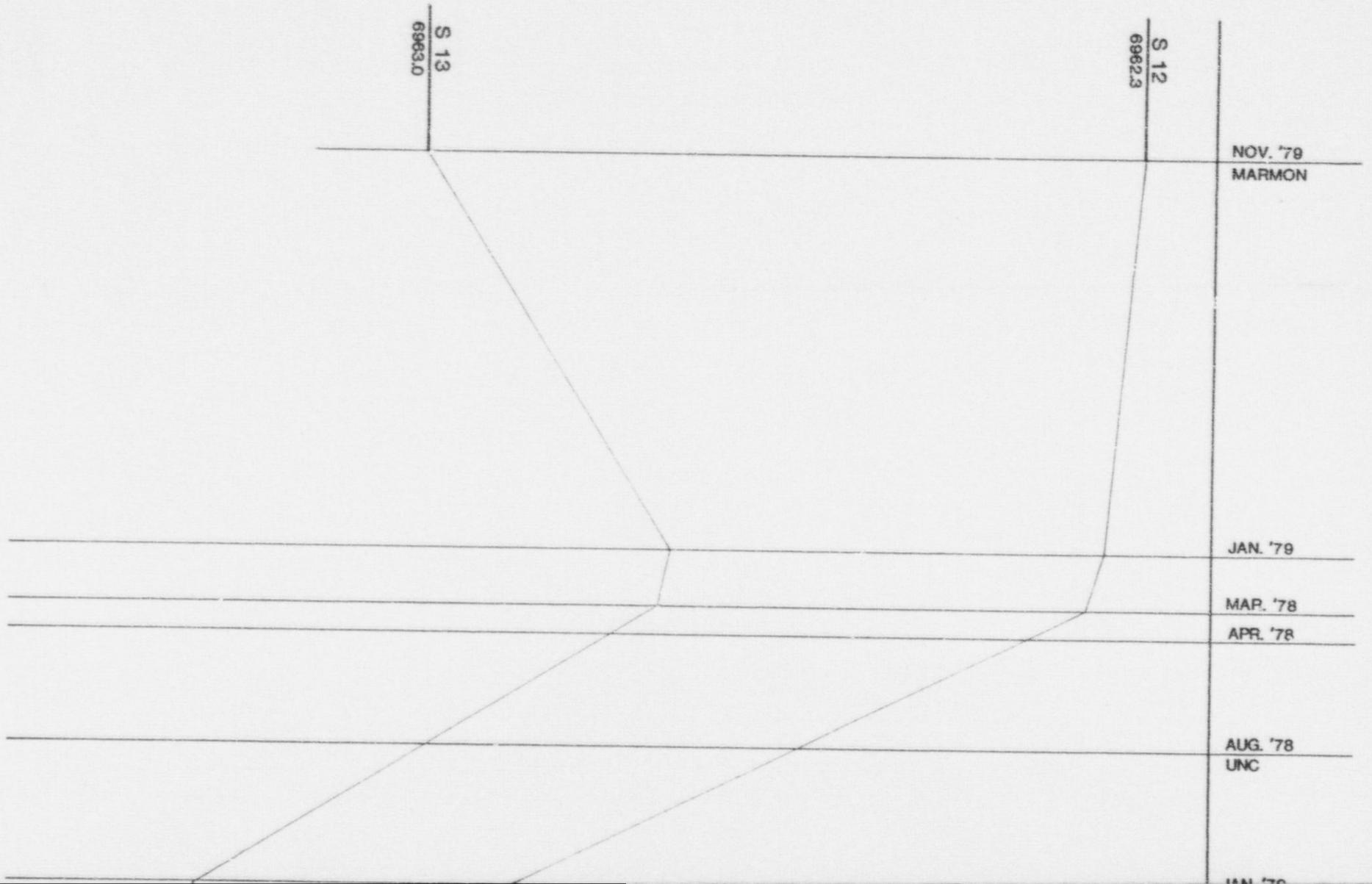
PLATE 6D

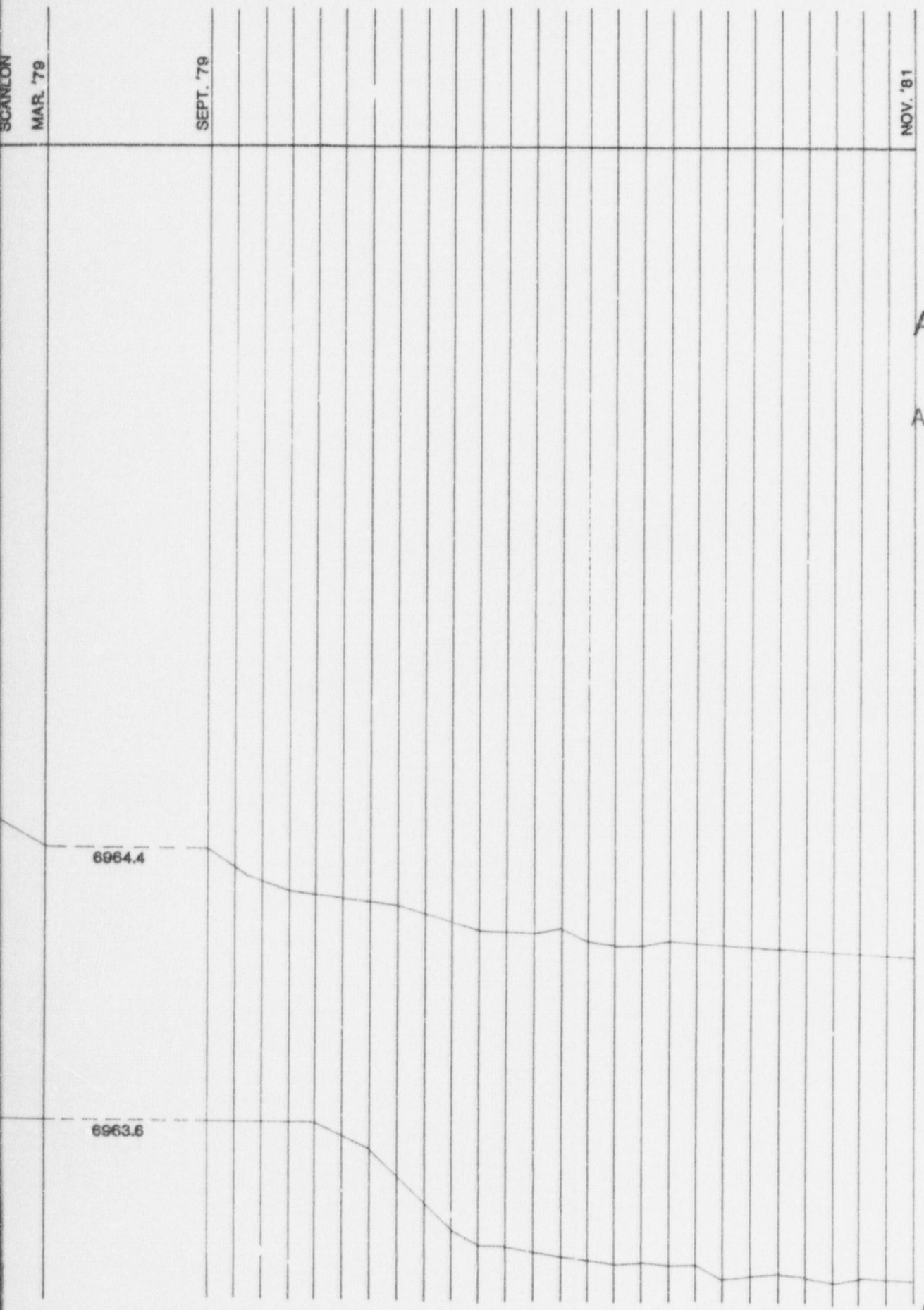
PLATE NUMBER: 6E DRAWN BY: R Lohrey DATE: 3-3-82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 3/5/82

NOTES:

1. SEE NOTES ON PLATE 6A.





MONUMENT DATA
S12 – S13

Haney Geotechnical

9804300087-09

PLATE 6E

DESCRIPTION

TAILINGS ①

ENGINEERED FILL ② ③

COMPACTED TAILINGS ⑥

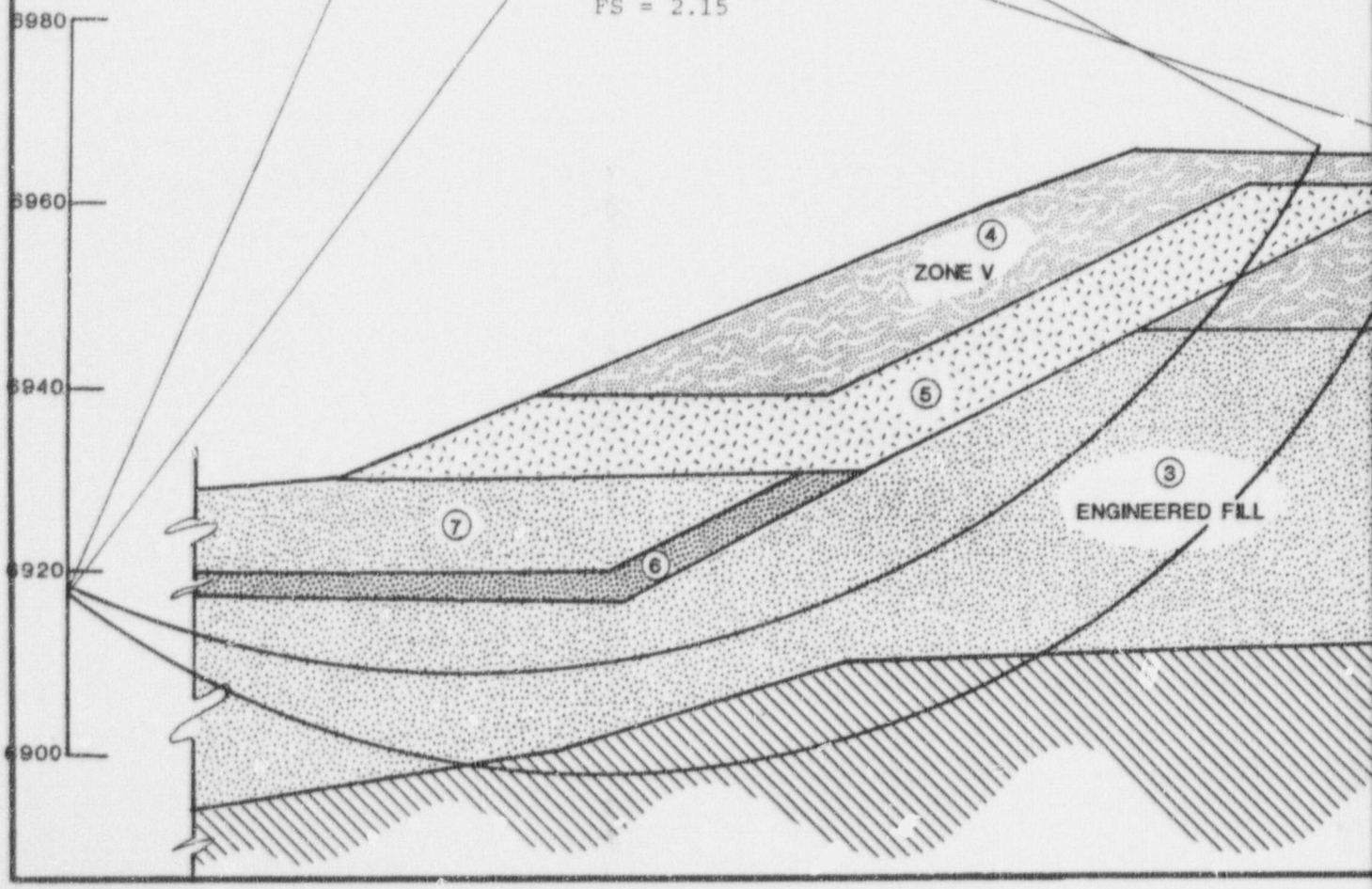
DRAIN AND FILTER ⑤

ZONE V ④

NATIVE FOUNDATION ⑧

EARTHQUAKE
FS = 1.80

LONG TERM
FS = 2.15



PROJECT NUMBER: 053-003 DRAWN BY: K. Lahrey CHECK BY: Ramm DATE: 3-11-82 DATE: 3/12/82

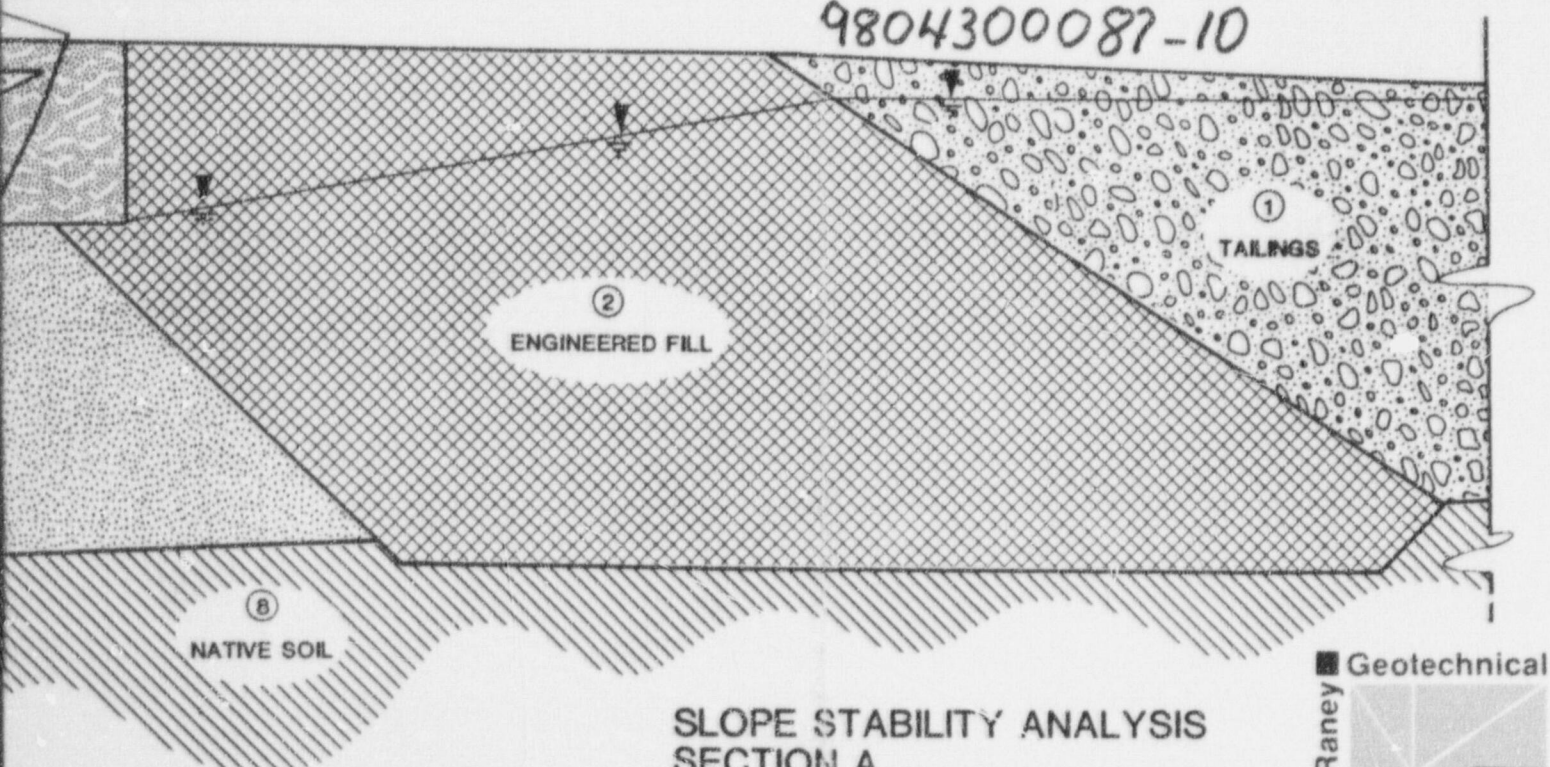
TERIAL PROPERTIES

	γ_t (PCF)	c' (PSF)	ϕ'	c (PSF)	ϕ
	120	0	36	200	16
⑦	135	450	26	270	25
	120	0	40	0	40
	120	0	30	0	30
	125	190	41	190	41
	125	400	21	400	20

NOTES:

1. EMBANKMENT CONFIGURATION DETERMINED FROM THE FOLLOWING SOURCES: KOOGLE & POULS TOPO DATED 5/5/81; BOHANNON-HUSTON TOPO DATED 5/74; KAISER ENGINEERS DESIGN REPORT DATED FEBRUARY 1976; SHB STABILITY AND INTEGRITY ASSESSMENT, VOLUME 3, DATED AUGUST 31, 1979; SHB BREACH REPAIR DESIGN DRAWINGS DATED 6/25/80; AND RANEY GEOTECHNICAL BORINGS THIS STUDY.
2. MATERIAL PROPERTIES DETERMINED FROM THE FOLLOWING SOURCES: TAILINGS AND STARTER EMBANKMENTS, THIS STUDY; NATIVE SOIL, ZONE V AND FILTER, CSI REPORT, "AS BUILT STABILITY", DATED 10/28/80; COMPACTED TAILINGS, RANEY GEOTECHNICAL REPORT, "DESIGN AND EVALUATION CENTRAL CELL EMBANKMENT RAISE, DATED AUGUST 24, 1981.
3. PHREATIC SURFACE CONSERVATIVELY ASSUMED AND BASED ON A MAXIMUM 6960 OPERATING LEVEL. HALL PIEZOMETERS PRESENTLY INDICATE HEAD LEVELS OF ABOUT 6930.
4. EARTHQUAKE ANALYSIS PERFORMED WITH TOTAL STRESS PARAMETERS AND A PSEUDO-STATIC ACCELERATION OF 0.1 g.
5. TRUE SCALE, HORIZONTAL = VERTICAL, 1" = 20'.

9804300087-10



SLOPE STABILITY ANALYSIS
SECTION A

Raney Geotechnical

PLATE 7A

PLATE NUMBER: 7B DRAWN BY: KLonney DATE: 3-10-82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 3/12/82

DESCRIPTION

TAILINGS ① ②

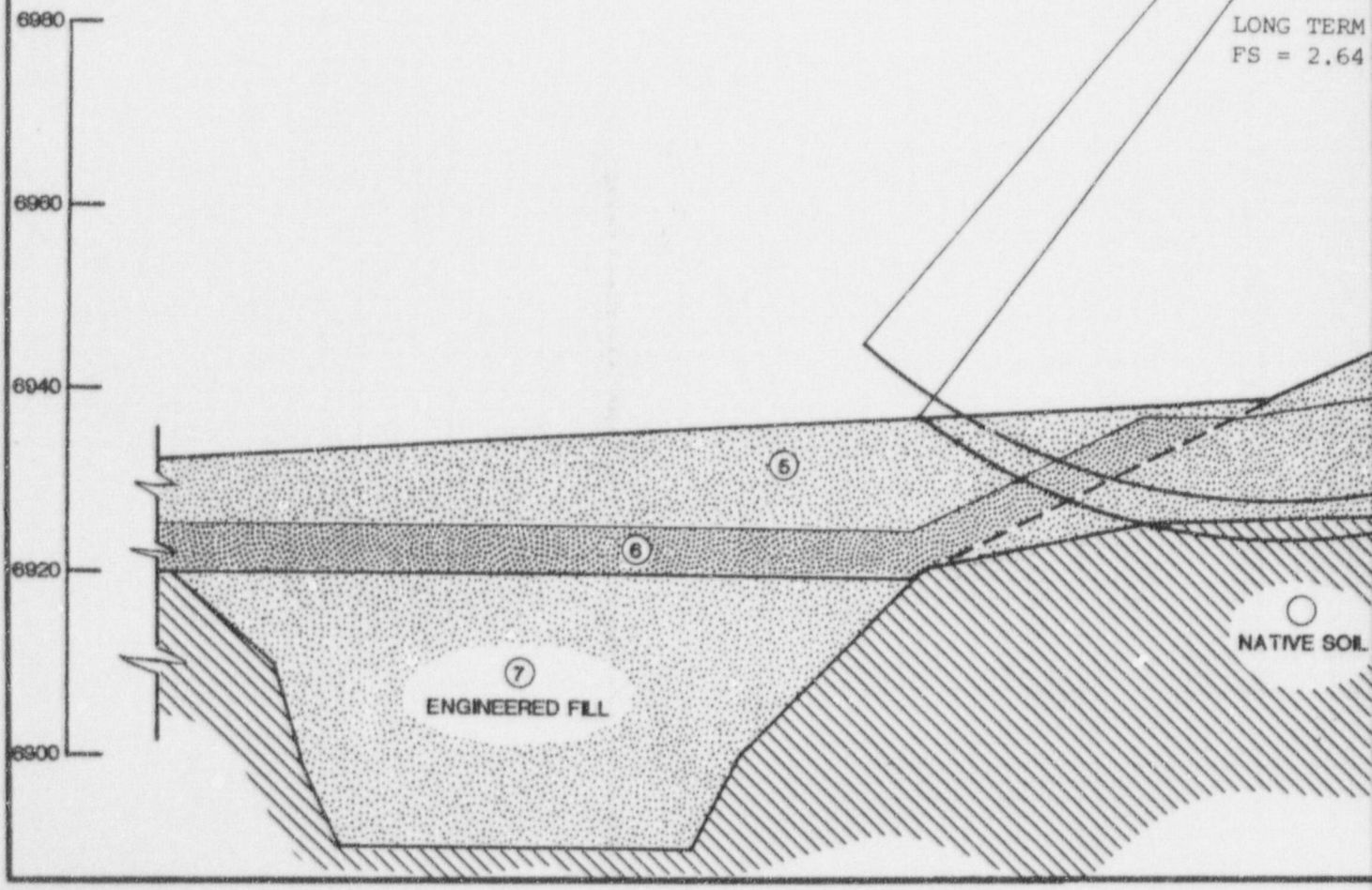
ENGINEERED FILL ③ ④ ⑨

COMPACTED TAILINGS ⑥

NATIVE SOIL ⑧

EARTHQU
FS = 1

LONG TERM
FS = 2.64



TERIAL PROPERTIES

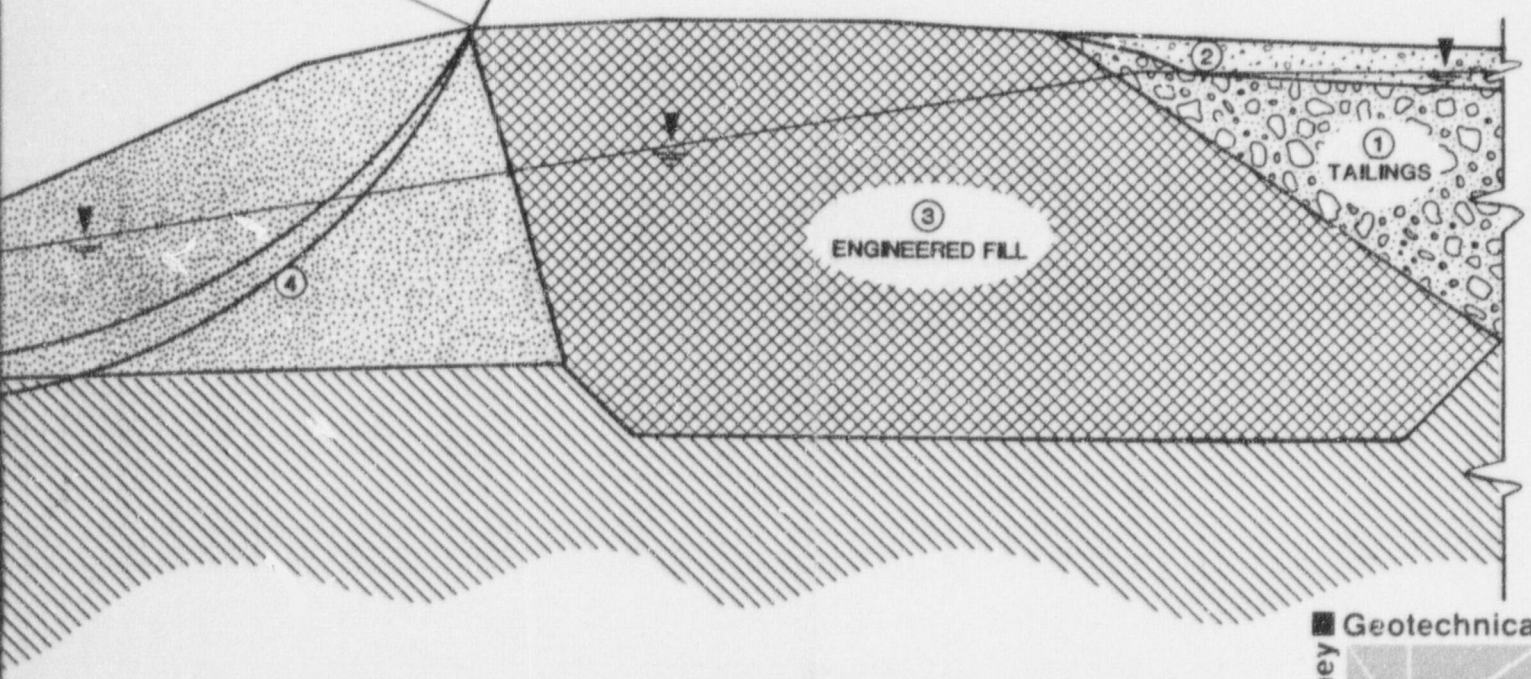
	γ_t (PCF)	c' (PSF)	ϕ'	c (PSF)	ϕ
	120	0	36	200	25
⑦	135	450	26	270	16
	120	0	40	0	40
	125	400	21	400	20

AKE
74

NOTES:

1. EMBANKMENT CONFIGURATION DETERMINED FROM THE FOLLOWING SOURCES: KOOGLE & POULS TOPO DATED 5/5/81; BOHANNON-HUSTON TOPO DATED 5/74; KAISER ENGINEERS DESIGN REPORT DATED FEBRUARY 1976; SHB STABILITY AND INTEGRITY ASSESSMENT, VOLUME 3, DATED AUGUST 31, 1979; AND RANEY GEOTECHNICAL BORINGS, THIS STUDY.
2. MATERIAL PROPERTIES DETERMINED FROM THE FOLLOWING SOURCES: TAILINGS AND STARTER EMBANKMENTS, THIS STUDY; NATIVE SOIL, ZONE V AND FILTER, CSI REPORT, "AS BUILT STABILITY", DATED 10/28/80; COMPACTED TAILINGS, RANEY GEOTECHNICAL REPORT, "DESIGN AND EVALUATION CENTRAL CELL EMBANKMENT RAISE", DATED AUGUST 24, 1981.
3. PHREATIC SURFACE CONSERVATIVELY ASSUMED AND BASED ON A MAXIMUM 6960 OPERATING LEVEL.
4. EARTHQUAKE ANALYSIS PERFORMED WITH TOTAL STRESS PARAMETERS AND A PSEUDOSTATIC ACCELERATION OF 0.1 g.
5. TRUE SCALE, HORIZONTAL = VERTICAL, 1" = 20'.

9804300087-11



Raney Geotechnical

SLOPE STABILITY ANALYSIS
SECTION B

PLATE 7B

PLATE NUMBER: 12 DRAWN BY: KLonrey DATE: 3-8-82

PROJECT NUMBER: 053-003 CHECK BY: Dunn DATE: 3/10/82

M

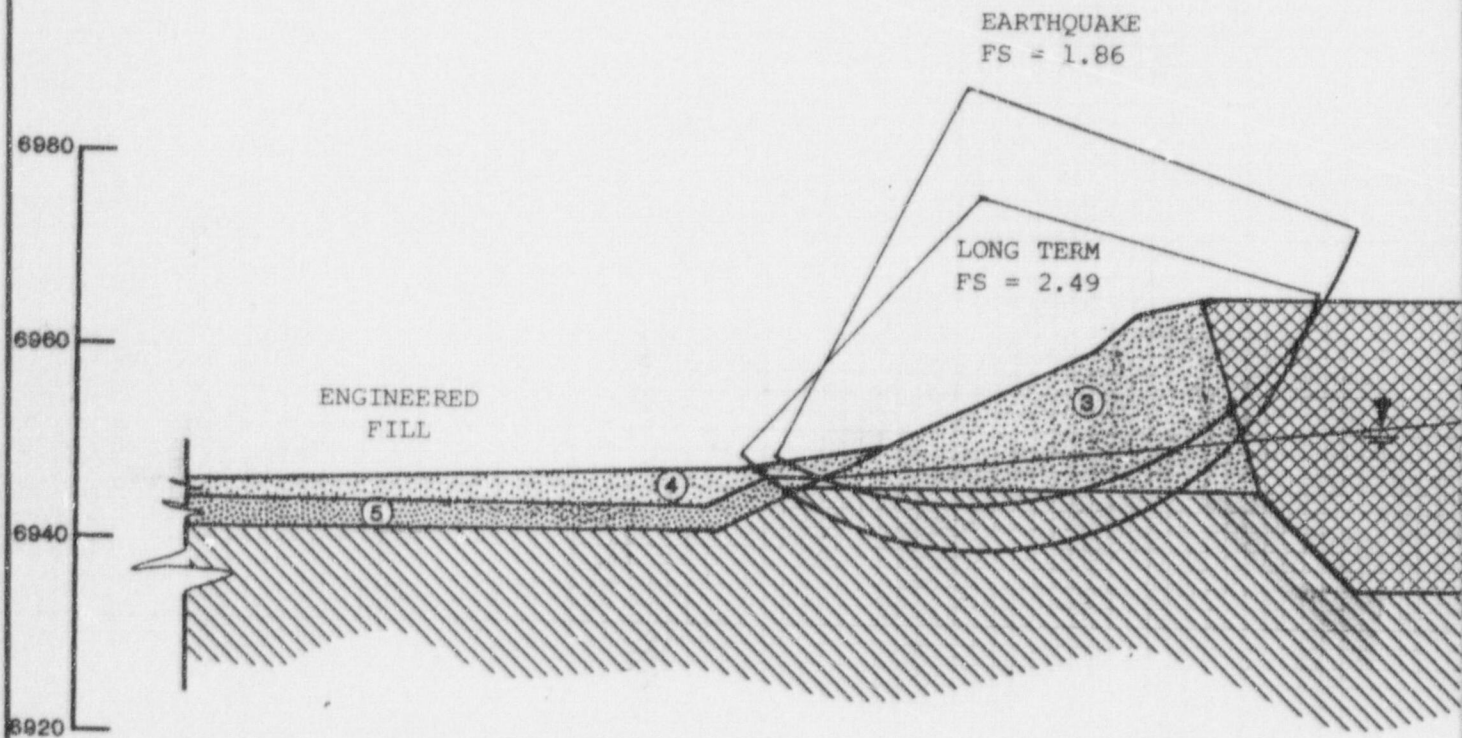
DESCRIPTION

TAILINGS (1)

ENGINEERED FILL (2) (3)

COMPACTED TAILINGS (5)

NATIVE SOIL (6)

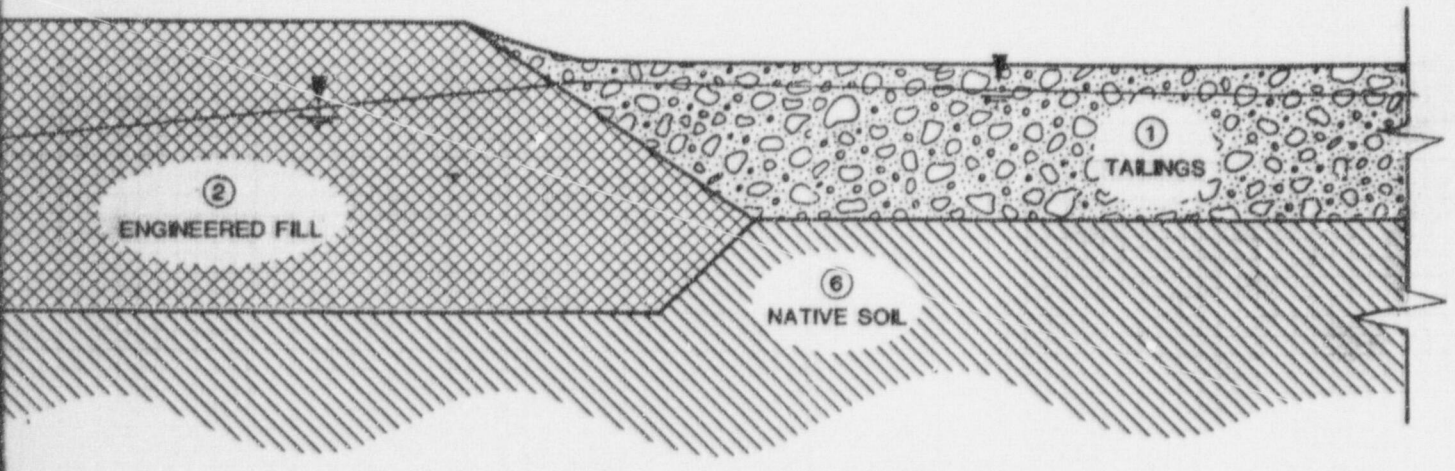


TERIAL PROPERTIES

	Yt (PCF)	c' (PSF)	φ'	c (PSF)	φ
	120	0	36	200	25
④	135	450	26	270	16
	120	0	40	0	40
	125	400	21	400	20

NOTES:

1. EMBANKMENT CONFIGURATION DETERMINED FROM THE FOLLOWING SOURCES: KOOGLE & POULS TOPO DATED 5/5/81; BOHANNON-HUSTON TOPO DATED 5/74; KAISER ENGINEERS DESIGN REPORT DATED FEBRUARY 1976; SHB STABILITY AND INTEGRITY ASSESSMENT, VOLUME 3, DATED AUGUST 31, 1979; AND RANEY GEOTECHNICAL BORINGS, THIS STUDY.
2. MATERIAL PROPERTIES DETERMINED FROM THE FOLLOWING SOURCES: TAILINGS AND STARTER EMBANKMENTS, THIS STUDY; NATIVE SOIL, ZONE V AND FILTER, CSI REPORT, "AS BUILT STABILITY", DATED 10/28/80; COMPACTED TAILINGS, RANEY GEOTECHNICAL REPORT, "DESIGN AND EVALUATION CENTRAL CELL EMBANKMENT RAISE", DATED AUGUST 24, 1981.
3. PHREATIC SURFACE CONSERVATIVELY ASSUMED AND BASED ON A MAXIMUM 6960 OPERATING LEVEL. OUR BORINGS AND 510 WELLS APPEAR TO INDICATE PRESENT FREE WATER LEVELS AROUND ELEVATION 6920.
4. EARTHQUAKE ANALYSIS PERFORMED WITH TOTAL STRESS PARAMETERS AND A PSEUDOSTATIC ACCELERATION OF 0.1 g.
5. TRUE SCALE, HORIZONTAL = VERTICAL, 1" = 20'.



9804300087-12

SLOPE STABILITY ANALYSIS
SECTION C

Raney Geotechnical

PLATE 7C

APPENDIX

FIELD EXPLORATION

Field studies were directed toward identification of potentially collapsible and settlement-sensitive native soils. Foundation conditions along the downstream toe of, and beneath, the south cell embankments were explored by drilling 13 test borings. The test boring locations are shown on Plate A1, Boring Location Plan.

Exploratory information obtained by others was considered in development of the drilling program [a/], [b/], [c/], [d/], [e/] Selection of test boring locations was generally based upon pre-existing topography. Boring elevation, fill depth, and groundwater level data are summarized on Table A1, Exploratory Data.

The borings were advanced by hollow-stem augers powered by a truck-mounted CME 550. Undisturbed samples were obtained with a modified California sampler. The sampler was driven with a 140-pound hammer falling 30 inches. Modified California sampler blow count data are generally about 1.4 times higher than standard penetration sampler blow count data. A limited number of samples of cohesive soil were obtained by hydraulically pushing Pitcher tubes.

[a/] "Groundwater Discharge Plan for United Nuclear Corporation Northeast Church Rock Mill", by Science Applications Incorporated, December, 1980.

[b/] "Stability & Integrity Assessment Church Rock Tailings Dam, Church Rock, New Mexico, Volume 4, Existing Dam Stability", by Sergent, Hauskins & Beckwith, dated 9/4/79.

[c/] "Stability & Integrity Assessment Church Rock Tailings Dam, Volume 1", by Sergent, Hauskins & Beckwith, dated 7/20/79.

[d/] "Stability & Integrity Assessment Church Rock Tailings Dam, Volume 3", by Sergent, Hauskins & Beckwith, dated 8/31/79.

[e/] "United Nuclear Corporation, Tailings Pond and Dam, Church Rock Uranium Mill, Church Rock, New Mexico", by Sergent, Hauskins & Beckwith, dated 5/17/76.

TABLE A1
EXPLORATORY DATA

TEST BORING	BORING ELEVATION [a]	NATURAL GROUND ELEVATION	GROUNDWATER ELEVATION [b]	REMARKS
1	6948	6940	6917	North of Cattle Dam
2	6943	6931	6910	
3	6942	6936	6905	
4	6938	6930	6906	
5	6938	6913	--	Old Arroyo
6	6934	6906	--	Old Arroyo
7	6940	6930	6915	
8	6938	6928	--	
9	6938	6903	6902	Old Arroyo
10	6930	6903	--	Old Arroyo
11	6926	6915	6878	
12	6965	6915	--	Embankment Crest
13	6965	6925	--	Embankment Crest

[a] Determined by interpolation between contours on topographic map dated 5/5/81.

[b] Measured after drilling.

The exploratory operations were performed under the direction of an engineer from this office. Soils were classified by visual and textural examination in the field, and a complete log of each boring was maintained. Each boring was checked for the presence of free groundwater following the completion of drilling. Graphic representations of the materials encountered in the borings are presented on Plates A1-A through A1-M, Log of Boring. The nomenclature used to describe the soil types is defined on Plate A3.

LABORATORY TESTING

General

Undisturbed samples obtained during the field exploration program were subjected to various types of laboratory tests, including moisture-density determinations, unconfined compression tests, sieve/hydrometer analysis, Atterberg limit tests, consolidation tests, collapse tests, and triaxial compression tests. The laboratory tests were performed to aid in soil classification and data correlation and to provide data for evaluation of the physical behavior of the site soils during and after future south cell usage. A discussion of each type of laboratory test performed and the various test data are presented below:

Moisture-Density Tests

Moisture content and dry density determinations were performed on all physical test specimens and on appropriate other samples to allow correlation of physical test data. The results of the moisture-density determinations are presented on the boring logs.

Unconfined Compression Tests

Unconfined compression tests were performed on undisturbed samples of cohesive soil. These tests were performed to aid in assessment of soil consistency and cohesive strength. Tests were performed at a strain rate of approximately 0.05 inches per minute. The measured unconfined compressive strengths are presented on the boring logs.

Sieve/Hydrometer Analysis

Sieve/hydrometer analyses were performed on random bulk samples obtained from the flood plain and arroyo areas along the embankment toe. Grain size distribution data obtained from these tests were used in surface water hydrology studies presented under separate cover. Sieve/hydrometer analyses were also performed on a sample of neutralized total tailings obtained from the tailings discharge line in the central cell area. The results of the sieve/hydrometer analyses are presented on Plates A4-A through A4-C.

Atterberg Limits

Numerous Atterberg limit tests were performed on clayey foundation soils. The tests were performed to accurately classify the soils and to extend consolidation test data. The results of the Atterberg limit tests are presented in Plates A5-A and A5-B.

Consolidation Tests

Consolidation tests were performed on the most highly compressible site soils. The tests were performed to determine the one-dimensional compression characteristics of the subject materials, and thereby to provide data for assessment of past

and future foundation settlements. The tests were performed in Conbel pneumatic consolidometers. Samples were saturated under a nominal seating load, and incremental loads were added every 24 hours. Deflection and time rate data were obtained for each load increment. The consolidation test data are presented in the form of e vs. log p, and square root time vs. deflection (for a single representative load increment) curves on Plates A6-A through A6-C, Consolidation Test Data.

Collapse Tests

Collapse tests were performed on all samples which appeared to have collapse potential. These tests were performed in pneumatic consolidometers. Samples ranging from one to one and one-fourth inches were carefully trimmed and loaded to approximately 1500 pounds per square foot. The samples were allowed to stabilize under load for approximately 12 hours and compression readings were obtained. The stabilized samples were saturated; settlement readings were obtained 24 hours after saturation. The results of the collapse tests are presented on Table A2.

Triaxial Compression Tests

Two multi-phase consolidated undrained triaxial compression tests with pore pressure measurement were performed, one on an undisturbed embankment sample and one on a fabricated sample of neutralized total tailings. The embankment sample was tested to strengthen a weakness in the existing UNC data base. The neutralized total tailings, a new material, had never before been tested. A bulk sample of the tailings material obtained from the discharge in the central cell area was dried and fabricated by free pouring into the triaxial membrane mold. The results of the triaxial tests are presented on Plates A7-A and A7-B.

oOo

TABLE A2
COLLAPSE TESTS

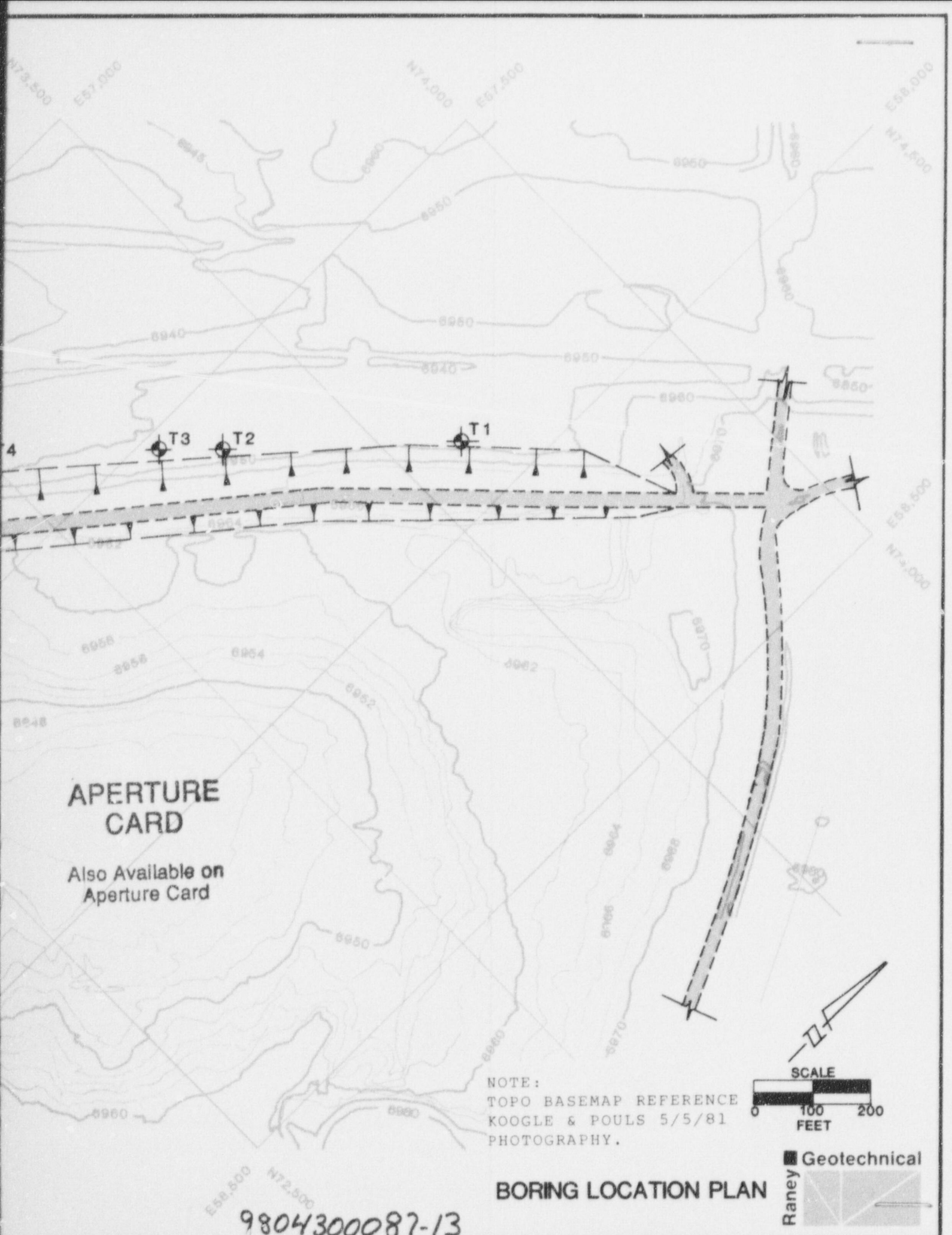
BORING NUMBER	DEPTH (FEET)	DRY DENSITY (PCF)	NATURAL WATER CONTENT (%)	VOLUME CHANGE (%)
T1	11	108	13.0	+ 0.02
T2	16	84	5.5	- 1.50
T2	16.5	74	6.1	- 3.80
T2	26	109	11.0	+ 0.39
T3	26	119	13.0	+ 4.08
T4	13	100	13.7	- 0.41
T6	32	104	15.4	- 0.16
T10	41	109	9.6	- 0.74
T11	30.5	111	2.8	- 3.52
T11	31	108	6.5	- 0.20
T12	52	89	10.7	-10.20
T12	52.5	90	5.7	- 3.83
T12	53	107	4.9	- 0.30

The following Plates are attached and complete the appendix:

A1 - Boring Location Plan
A2-A - Log of Boring, Boring 1
A2-B - Log of Boring, Boring 2
A2-C - Log of Boring, Boring 3
A2-D - Log of Boring, Boring 4
A2-E - Log of Boring, Boring 5
A2-F - Log of Boring, Boring 6
A2-G - Log of Boring, Boring 7
A2-H - Log of Boring, Boring 8
A2-I - Log of Boring, Boring 9
A2-J - Log of Boring, Boring 10
A2-K - Log of Boring, Boring 11
A2-L - Log of Boring, Boring 12
A2-M - Log of Boring, Boring 13
A3 - Unified Soil Classification System
A4-A - Grain Size Distribution
A4-B - Grain Size Distribution
A4-C - Grain Size Distribution
A5-A - Atterberg Limits Data
A5-B - Atterberg Limits Data
A6-A - Consolidation Test Data
A6-B - Consolidation Test Data
A6-C - Consolidation Test Data
A6-D - Consolidation Test Data
A7-A - Consolidated Undrained Triaxial Compression Data
A7-B - Consolidated Undrained Triaxial Compression Data

PLATE NUMBER: A1 DRAWN BY: K Lohrey DATE: 2-20-82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 2/20/82



APERTURE CARD

Also Available on Aperture Card

NOTE:
TOPO BASEMAP REFERENCE KOOGLE & POULS 5/5/81 PHOTOGRAPHY.

SCALE
0 100 200
FEET

Raney Geotechnical

BORING LOCATION PLAN

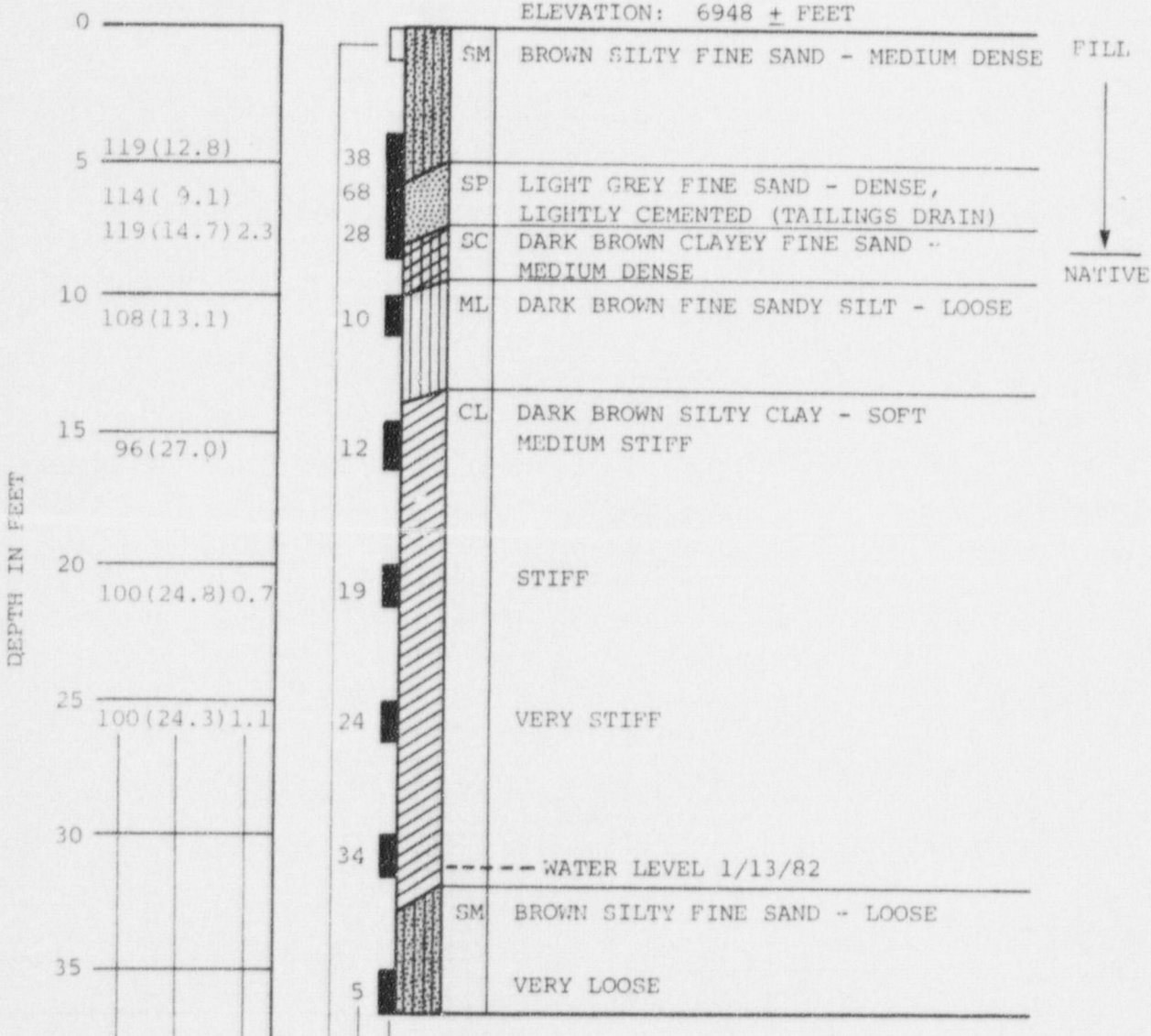
9804300087-13

PLATE A1

BORING 1

DRILLED: 1/13/82

ELEVATION: 6948 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SOIL ABBREVIATIONS DEFINED ON PLATE A-3.
3. UNDISTURBED SAMPLE OBTAINED WITH A MODIFIED CALIFORNIA SAMPLER.
4. PENETRATION RESISTANCE IN BLOWS/FOOT, 140 LB. HAMMER, 30" DROP.
5. DISTURBED BULK SAMPLE.
6. INDICATED GROUNDWATER LEVEL DETERMINED BY DIRECT MEASUREMENT FOLLOWING COMPLETION OF DRILLING.

PLATE NUMBER: A2-A DRAWN BY: STEWART DATE: 3-24-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 3/26/82

LOG OF BORING

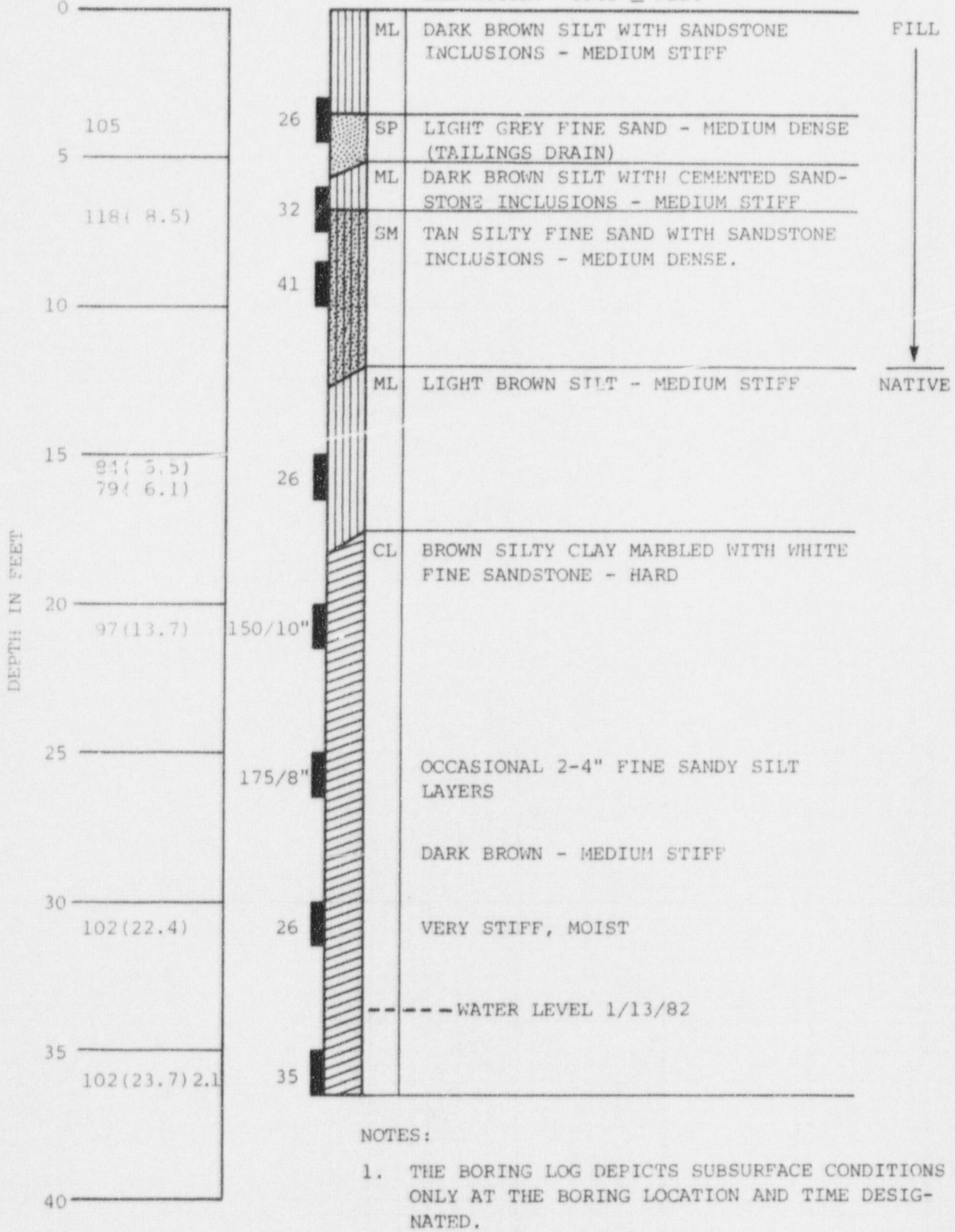
Raney Geotechnical

PLATE A2-A

BORING 2

DRILLED: 1/13/82

ELEVATION: 6943 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.

PLATE NUMBER: A2-B DRAWN BY: STEWART DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

LOG OF BORING

Raney Geotechnical

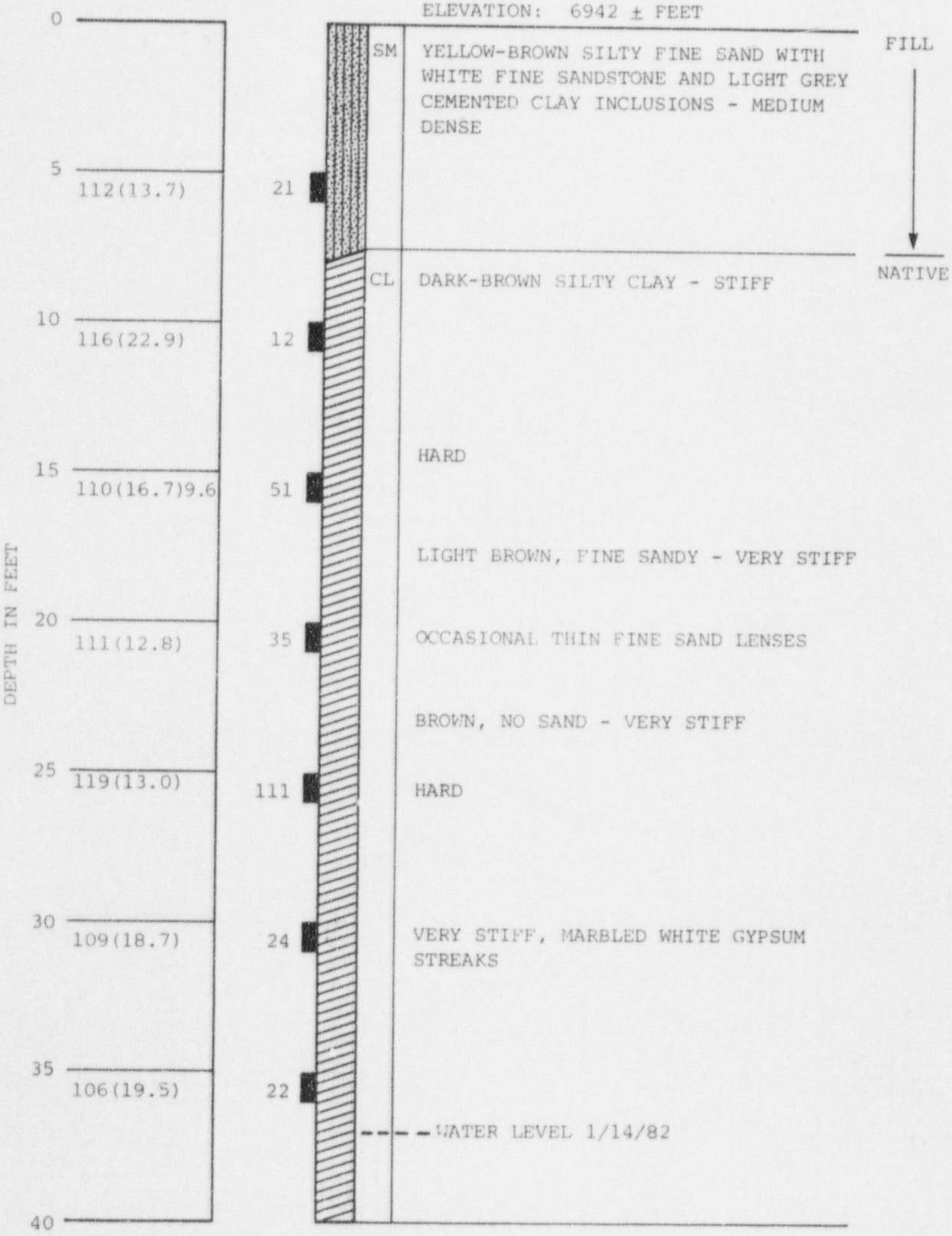
PLATE A2-B

PLATE NUMBER: A2-C DRAWN BY: STEWART DATE: 2-24-82
PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

BORING 3

DRILLED: 1/14/82

ELEVATION: 6942 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.

LOG OF BORING

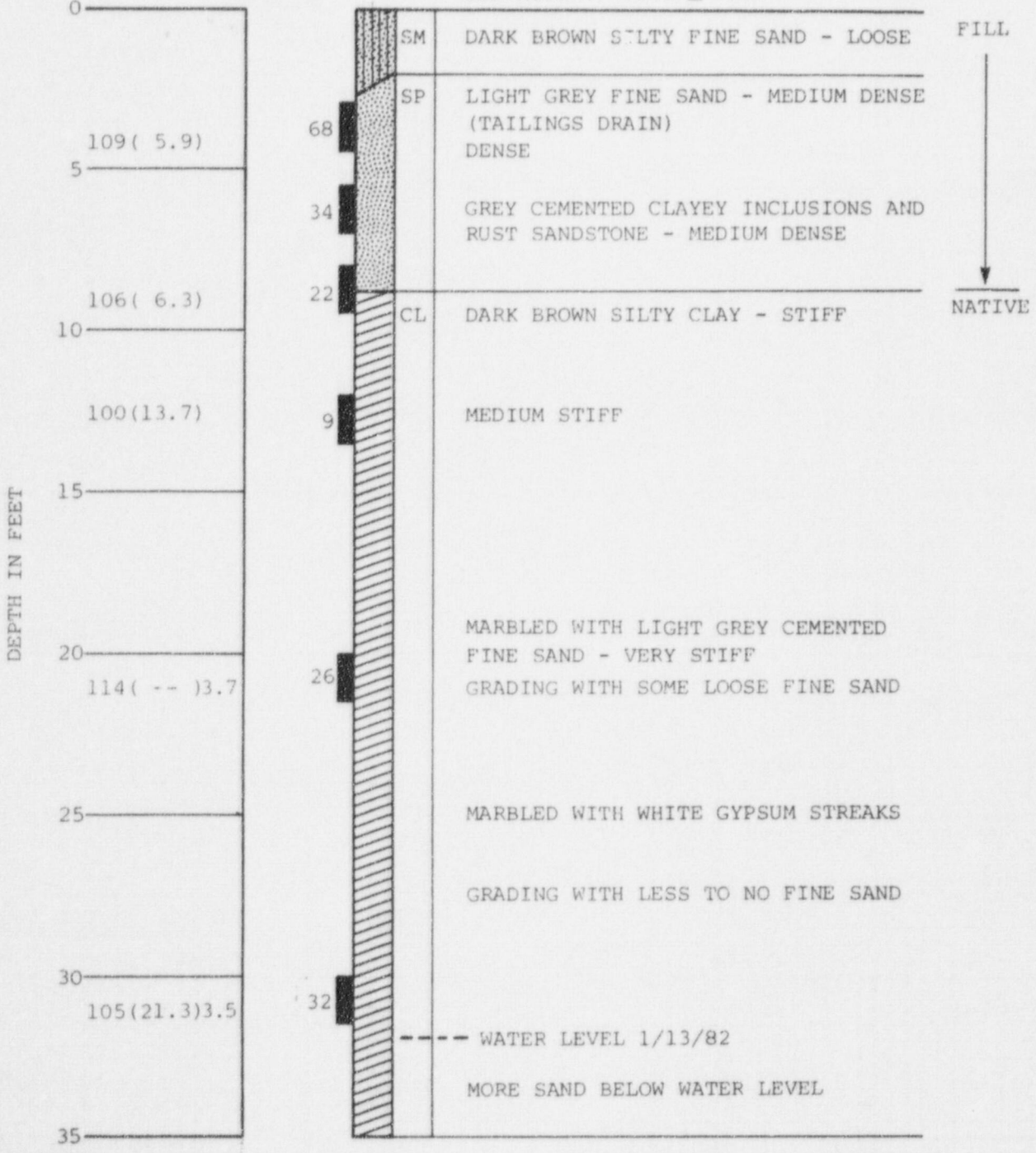
Raney Geotechnical

PLATE A2-C

BORING 4

DRILLED: 1/13/82

ELEVATION: 6938 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.

LOG OF BORING

Raney Geotechnical

PLATE A2-D

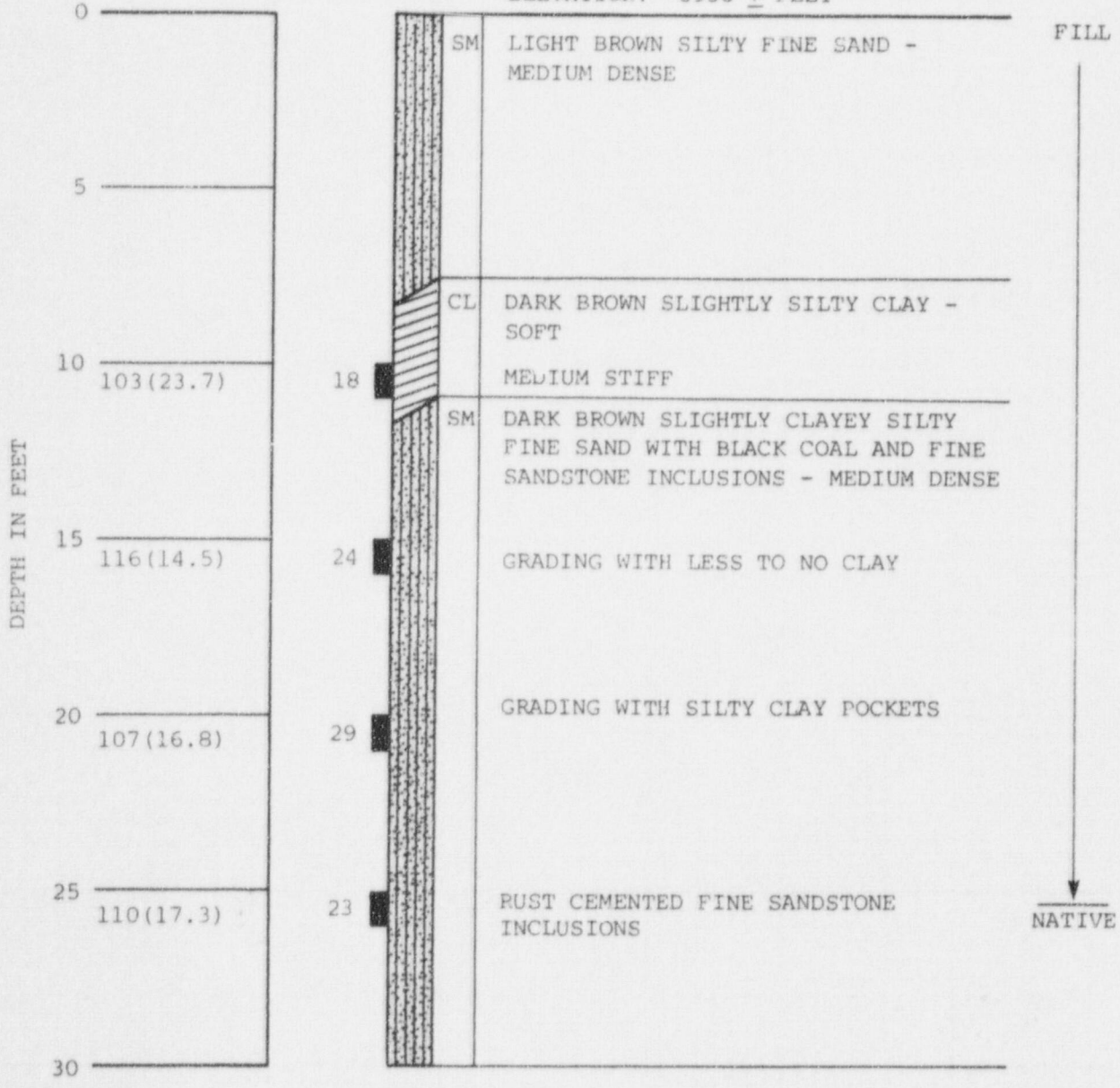
PLATE NUMBER: A2-D DRAWN BY: STEWART DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: Rumm DATE: 2/26/82

BORING 5

DRILLED: 1/15/82

ELEVATION: 6938 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.
3. NO FREE GROUNDWATER ENCOUNTERED IN BORING 5.

PLATE NUMBER: A2-E DRAWN BY: STEWART DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

LOG OF BORING

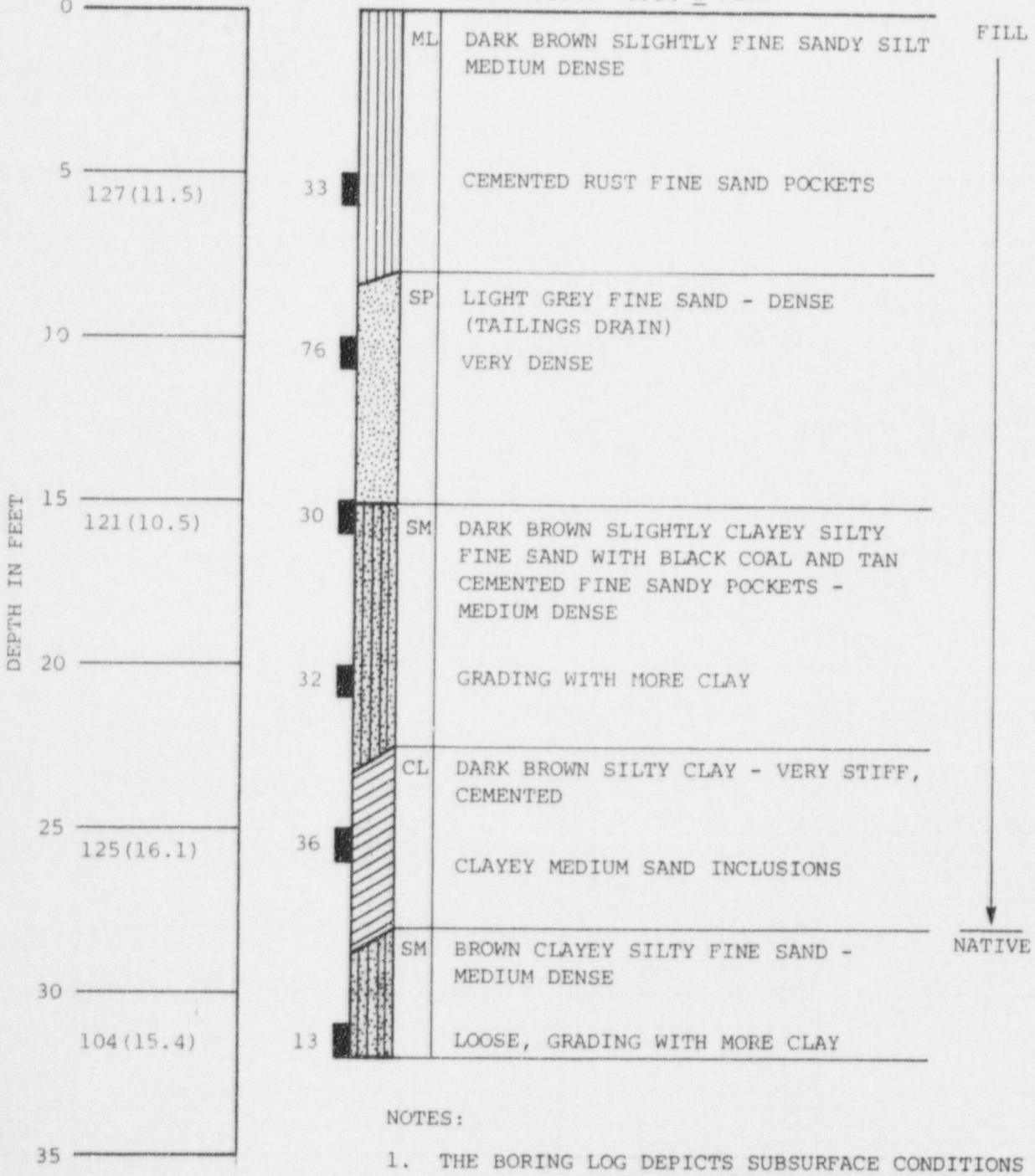
Raney Geotechnical

PLATE A2-E

BORING 6

DRILLED: 1/14/82

ELEVATION: 6934 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.
3. NO FREE GROUNDWATER ENCOUNTERED IN BORING 6.

PLATE NUMBER: A2-F DRAWN BY: Stewart DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 2/26/82

LOG OF BORING

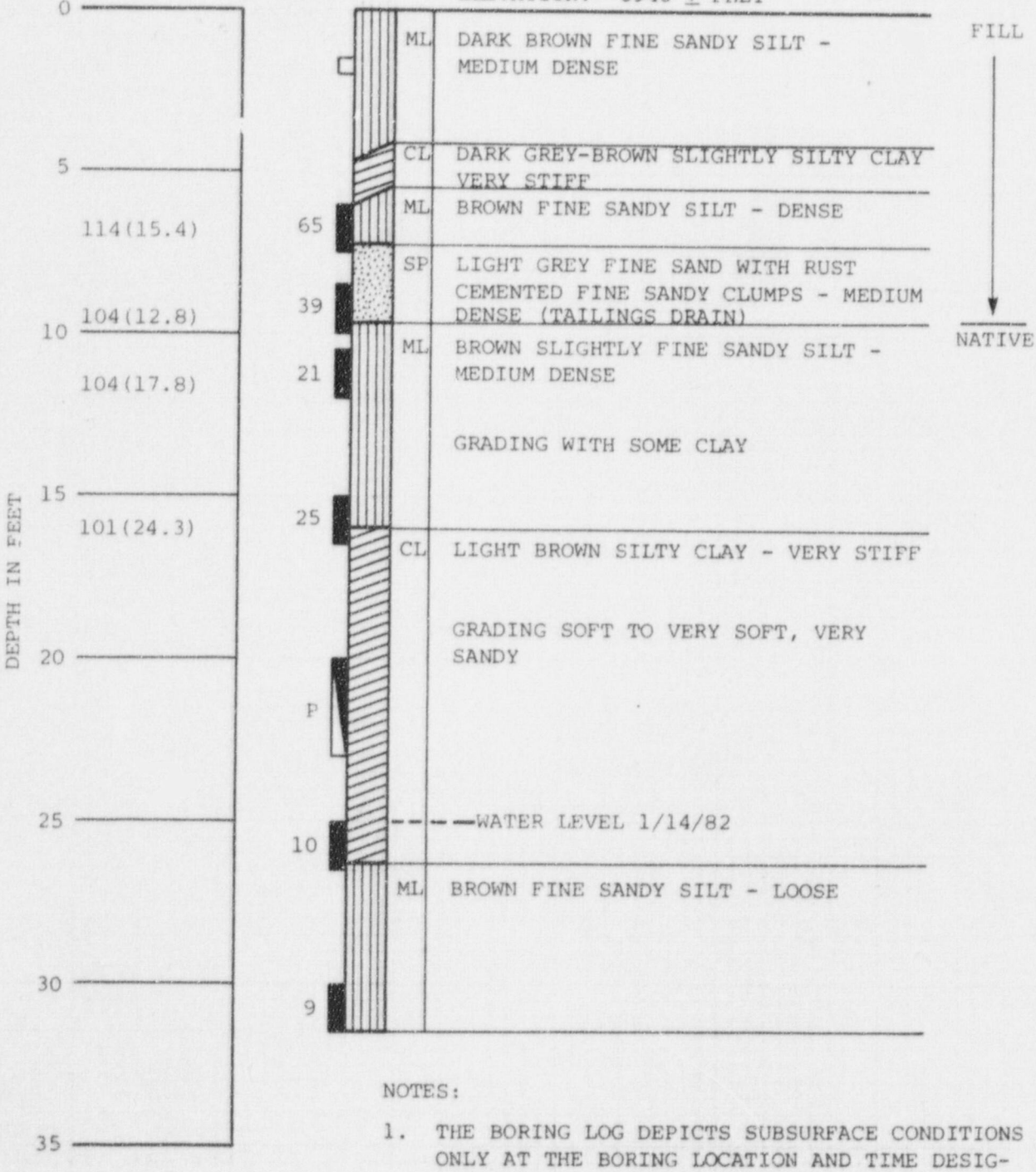
Raney Geotechnical

PLATE A2-F

BORING 7

DRILLED: 1/14/82

ELEVATION: 6940 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.
3. HYDRAULICALLY PUSHED SHELBY TUBE SAMPLE.

PLATE NUMBER: A2-G DRAWN BY: STEWART DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/24/82

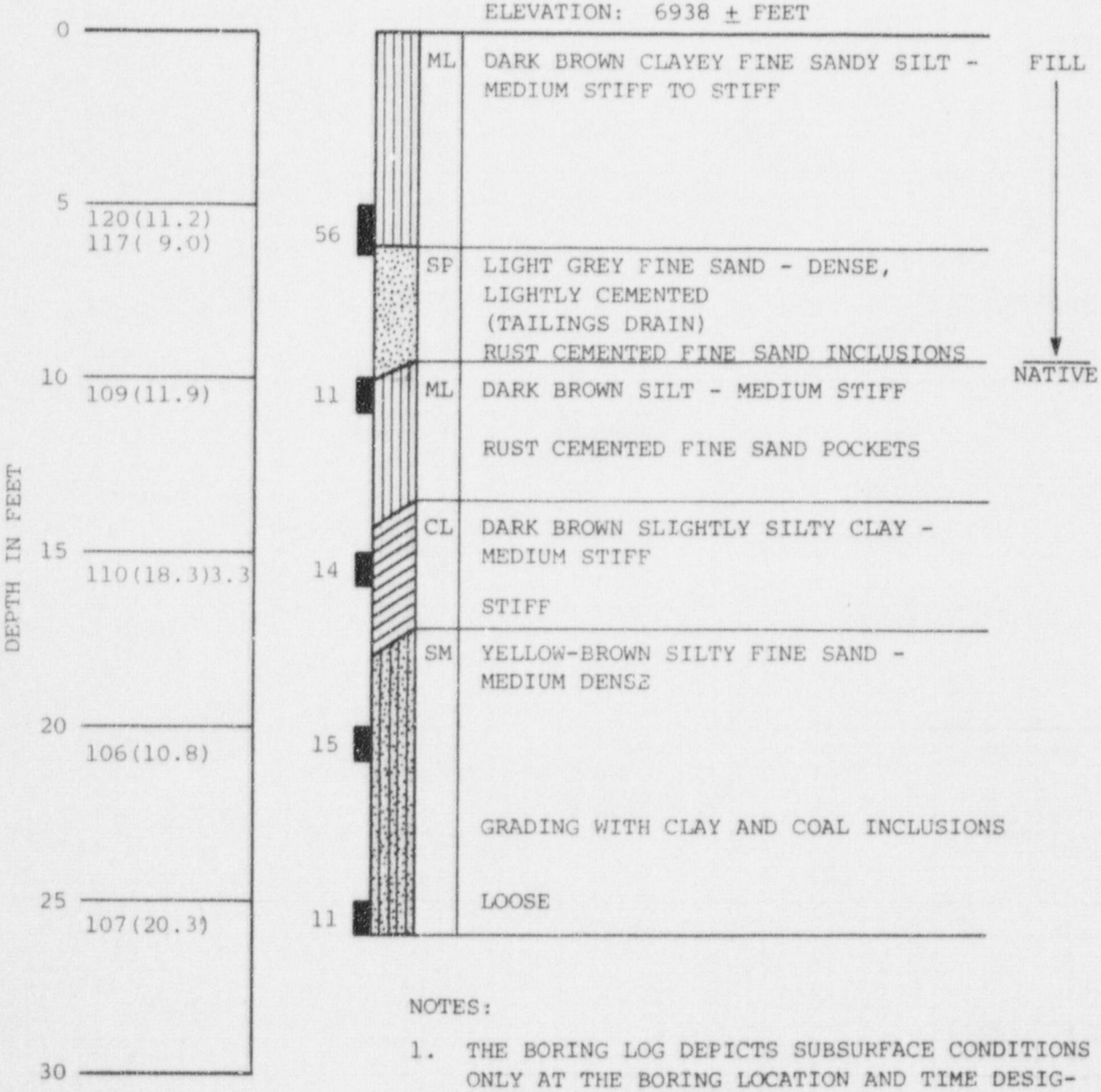
LOG OF BORING

Raney Geotechnical

BORING 8

DRILLED: 1/14/82

ELEVATION: 6938 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.
3. NO FREE GROUNDWATER ENCOUNTERED IN BORING 8.

PLATE NUMBER: A2-H DRAWN BY: STEWART DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

LOG OF BORING

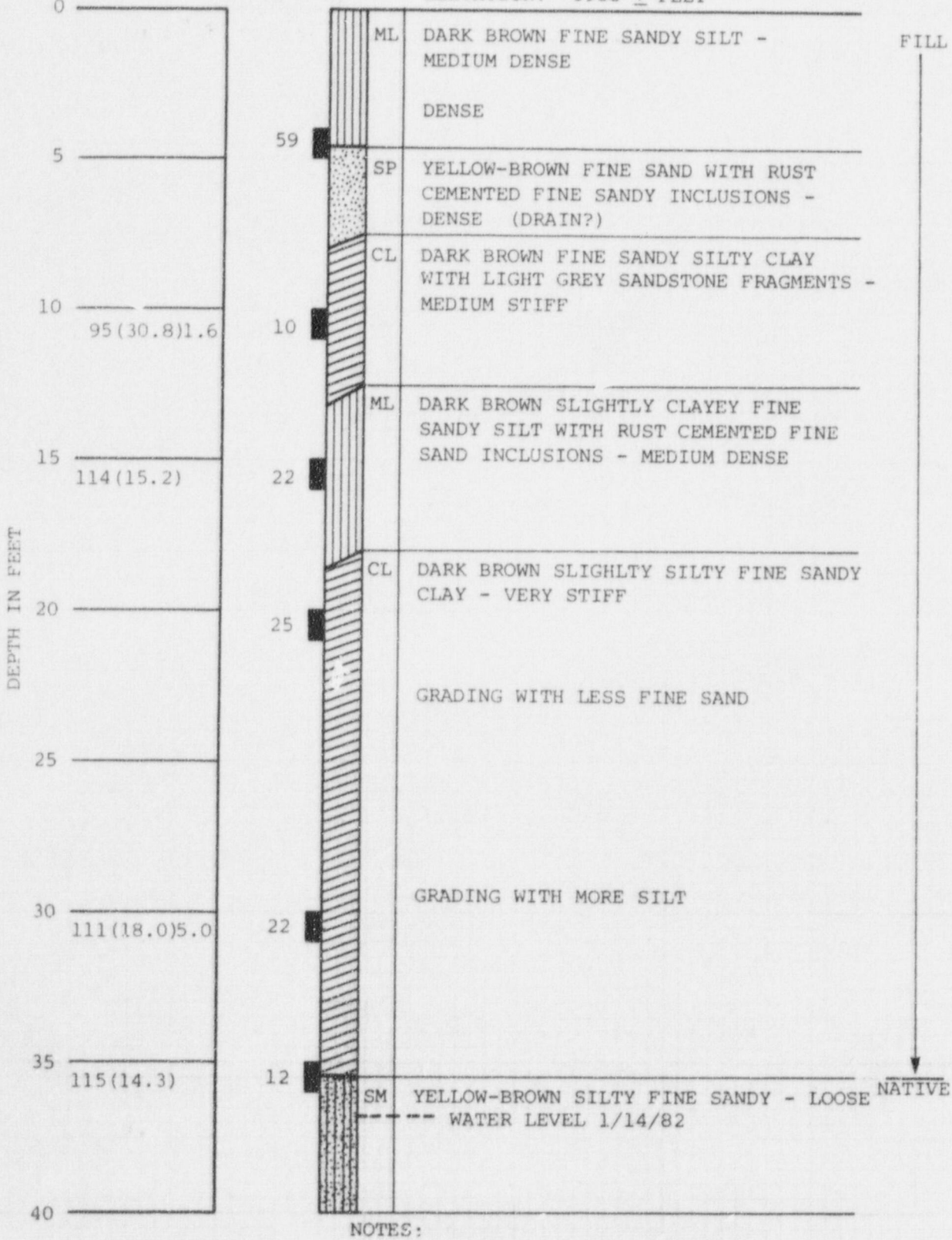
Raney Geotechnical

PLATE NUMBER: A2-I DRAWN BY: STEWART DATE: 2-24-82
PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

BORING 9

DRILLED: 1/14/82

ELEVATION: 6938 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.

LOG OF BORING

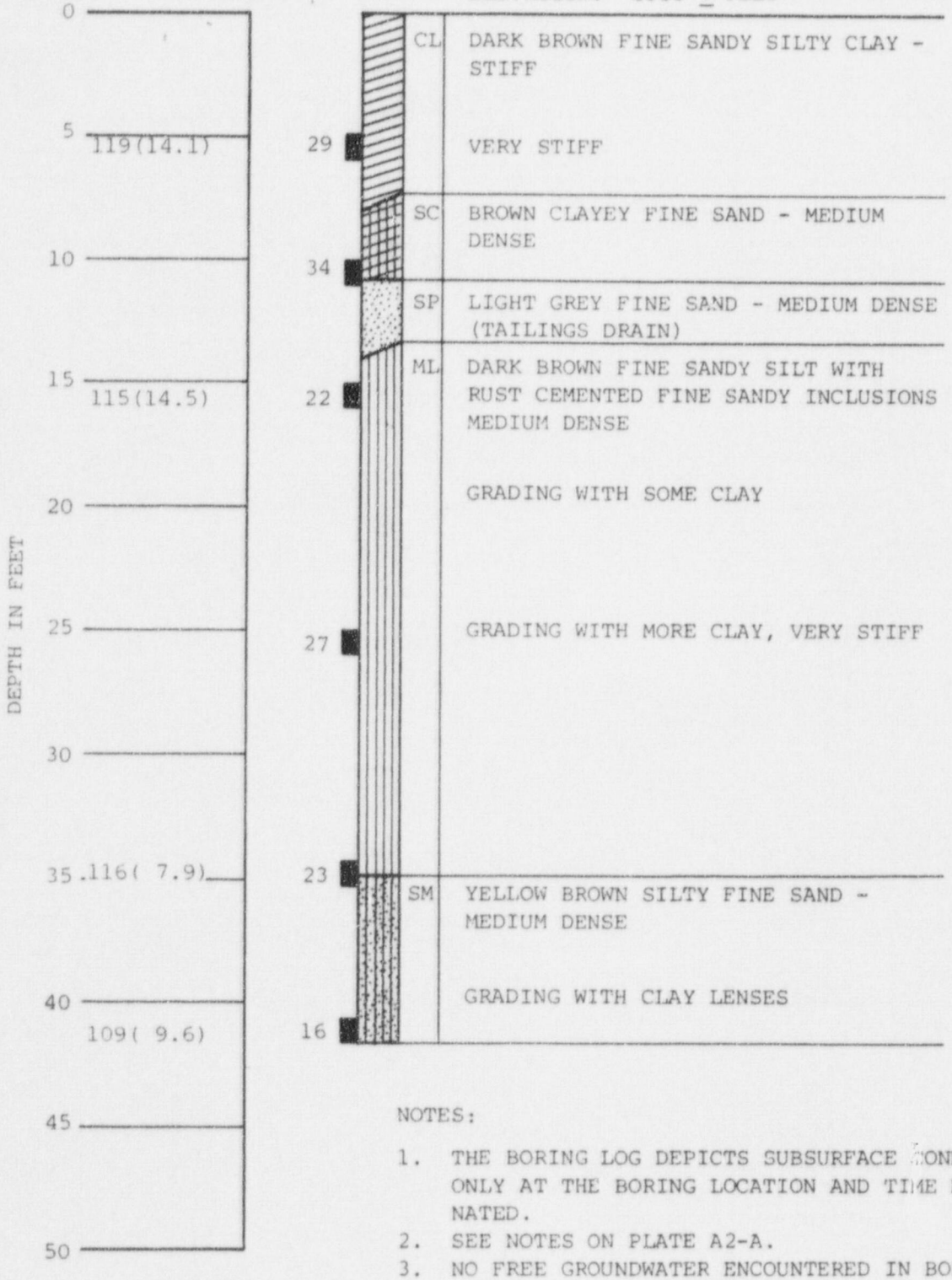
Raney Geotechnical

PLATE A2-I

BORING 10

DRILLED: 1/14/82

ELEVATION: 6930 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.
3. NO FREE GROUNDWATER ENCOUNTERED IN BORING 10.

PLATE NUMBER: A2-J
PROJECT NUMBER: 053-003
DRAWN BY: STEWART
CHECK BY:
DATE: 2-24-82
DATE: 2/26/82

LOG OF BORING

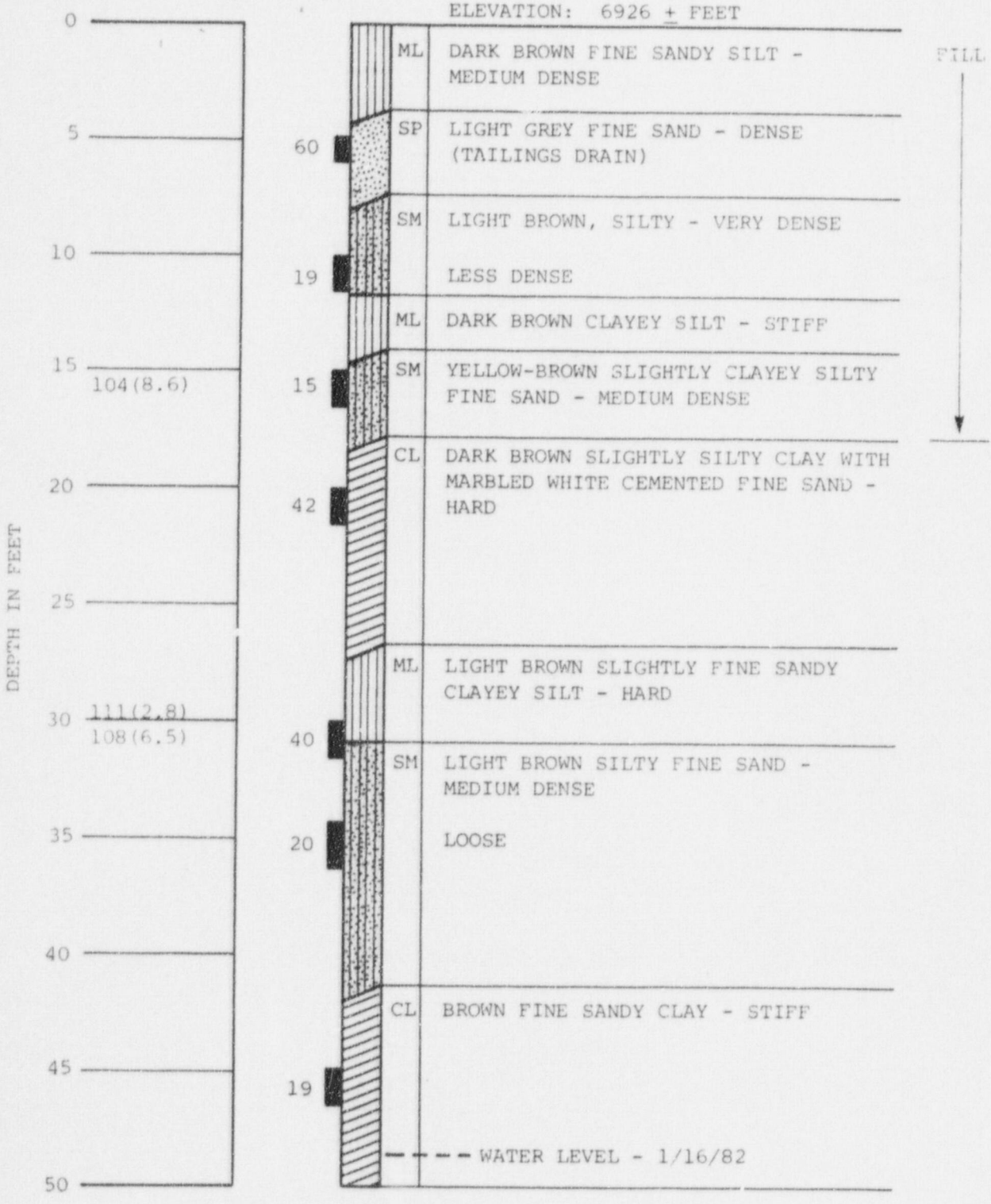
Raney Geotechnical

PLATE A2-J

BORING 11

DRILLED: 1/16/82

ELEVATION: 6926 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.

LOG OF BORING

Raney Geotechnical

PLATE A2-K

PLATE NUMBER: A2-K DRAWN BY: Stewart DATE: 2-24-82
PROJECT NUMBER: 053-003 CHECK BY: Burn DATE: 2/26/82

BORING 12

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

DRILLED: 1/15/82
ELEVATION: 6965 ± FEET

NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATE A2-A.
3. NO FREE GROUNDWATER ENCOUNTERED IN BORING 12.

LOG OF BORING

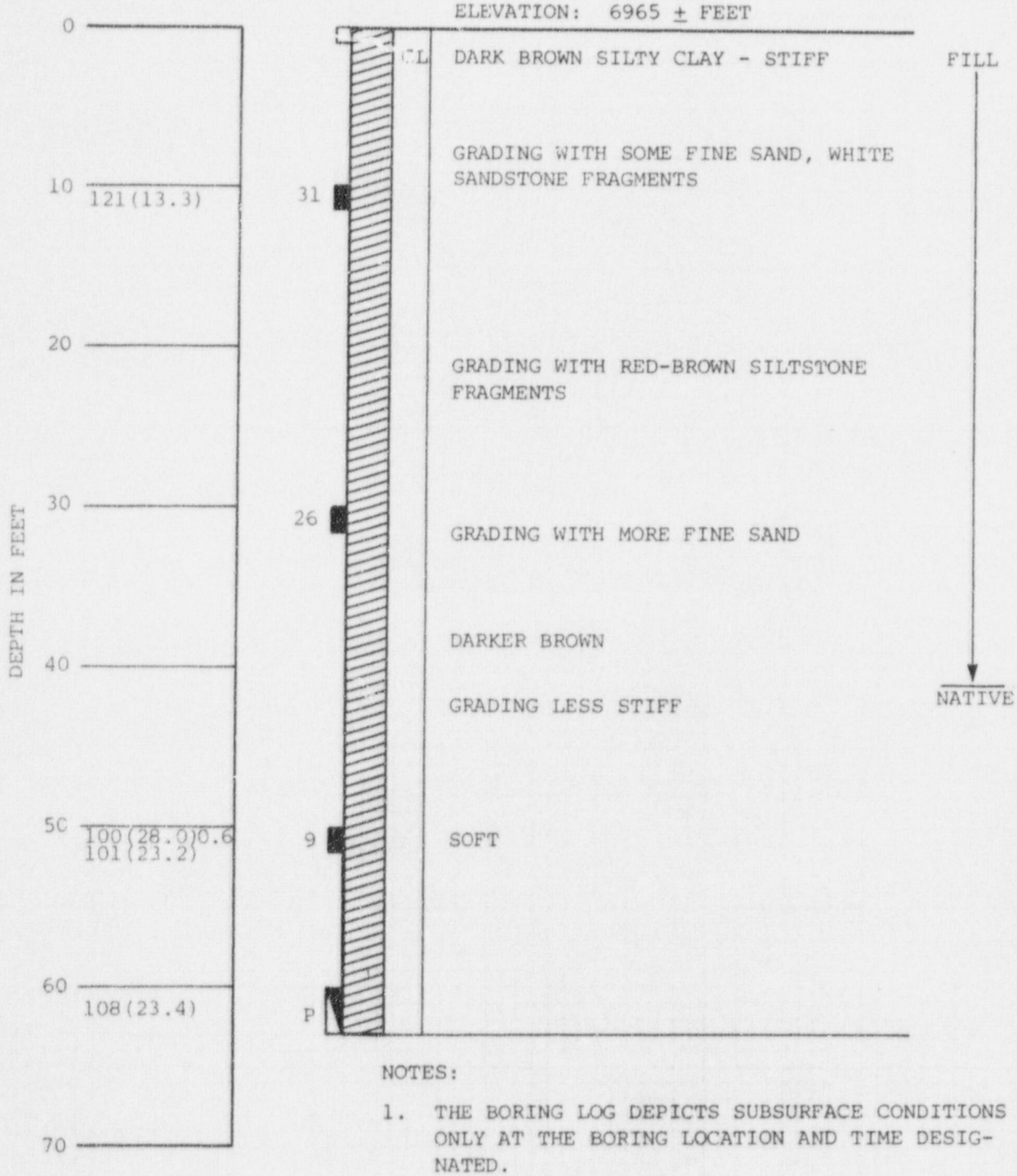
Raney Geotechnical

PLATE A2-L

BORING 13

DRILLED: 1/16/82

ELEVATION: 6965 ± FEET



NOTES:

1. THE BORING LOG DEPICTS SUBSURFACE CONDITIONS ONLY AT THE BORING LOCATION AND TIME DESIGNATED.
2. SEE NOTES ON PLATES A2-A AND A2-G.
3. NO FREE GROUNDWATER ENCOUNTERED IN BORING 13.

PLATE NUMBER: A2-M DRAWN BY: STEWART DATE: 2-24-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 2/26/82

LOG OF BORING

Raney Geotechnical

PLATE A2-M

GRAPH	LETTER	DESCRIPTION	MAJOR DIVISIONS		
	GW	WELL-GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES	CLEAN GRAVELS (LITTLE OR NO FINES)	GRAVEL AND GRAVELLY SOILS	COARSE GRAINED SOILS MORE THAN 50% LARGER THAN NO. 200 SIEVE
	GP	POORLY-GRADED GRAVELS, GRAVEL SAND MIXTURES, LITTLE OR NO FINES			
	GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES	SANDS WITH APPRECIABLE AMOUNT OF FINES	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE	
	GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES			
	SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES	CLEAN SAND (LITTLE OR NO FINES)	SANDS AND SANDY SOILS	
	SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES			
	SM	SILTY SANDS SAND-SILT MIXTURES	SANDS WITH APPRECIABLE AMOUNT OF FINES	MORE THAN 50% OF COARSE FRACTION PASSING NO. 4 SIEVE	
	SC	CLAYEY SANDS, SAND-SILT MIXTURES			
	ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY	LIQUID LIMIT LESS THAN 50	SILTS AND CLAYS	FINE GRAINED SOILS MORE THAN 50% SMALLER THAN NO. 200 SIEVE
	CL	INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS			
	OL	ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY			
	MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS	LIQUID LIMIT GREATER THAN 50	SILTS AND CLAYS	
	CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS			
	OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS			
	PT	PEAT, HUMAS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS	HIGHLY ORGANIC SOILS		

UNIFIED SOIL CLASSIFICATION SYSTEM

Raney Geotechnical

PLATE A-3

PLATE NUMBER: A4-A DRAWN BY: K Lohrey DATE: 3-1-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 3/1/82

PERCENT COARSER

SYMBOL	LOCATION	DEPTH	UNIFIED CLASSIFICATION	DESCRIPTION
———	*	SURFACE	ML	BROWN SLIGHTLY CLAYEY FINE SANDY SILT
– – – –	**	SURFACE	SM	LIGHT BROWN SILTY FINE SAND

U.S. STANDARD SIEVE SIZE

12" 6" 2" 1-1/2" 3/4" 3/8" #4 #8 #16 #30 #40 #60 #100 #200

0 10 20 30 40 50 60 70 80 90 100

100 90 80 70 60 50 40 30 20 10 0

PERCENT FINER

GRAIN SIZE IN MILLIMETERS

1000 100 10 1 0.1 0.01 0.001

BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

*750 ± FEET SOUTHWEST OF STREAM CONTROL POINT, FROM CROWN OF ARROYO

**800 ± FEET SOUTHWEST OF STREAM CONTROL POINT, FROM ARROYO BOTTOM

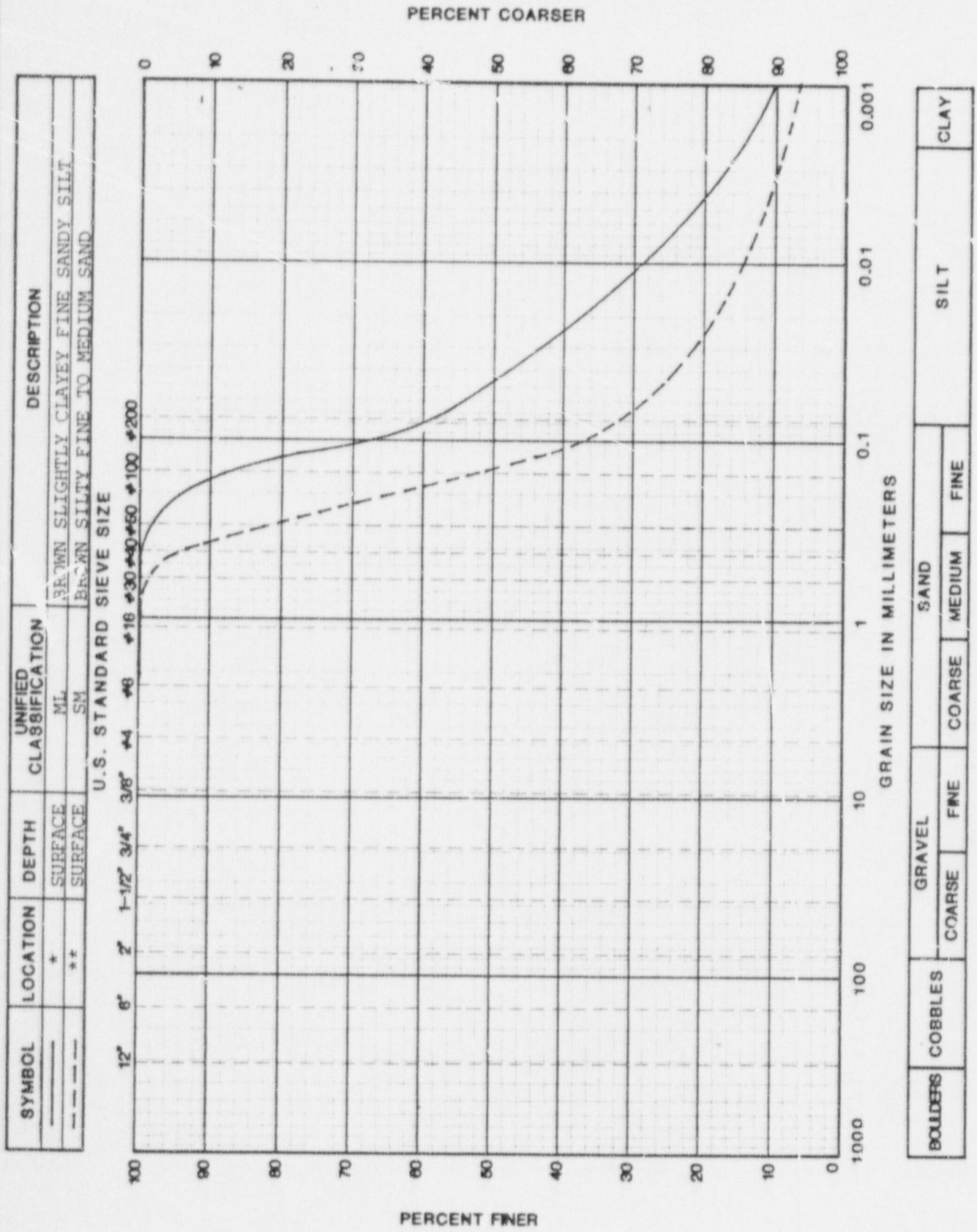
Raney Geotechnical

GRAIN SIZE DISTRIBUTION

PLATE A4-A

PLATE NUMBER: A4-B DRAWN BY: K Lowrey DATE: 3-1-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 3/1/82



SYMBOL	LOCATION	DEPTH	UNIFIED CLASSIFICATION	DESCRIPTION
———	*	SURFACE	ML	BROWN SLIGHTLY CLAYEY FINE SANDY SILT
– – – –	**	SURFACE	SM	BROWN SILTY FINE TO MEDIUM SAND

*1150 ± FEET SOUTHWEST OF STREAM CONTROL POINT, FROM MID-HEIGHT OF ARROYO SIDEWALL

**775 ± FEET SOUTHWEST OF CONTROL POINT IN FLOOD PLANE AREA BETWEEN DAM AND ARROYO

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GRAIN SIZE DISTRIBUTION

PLATE A4-B

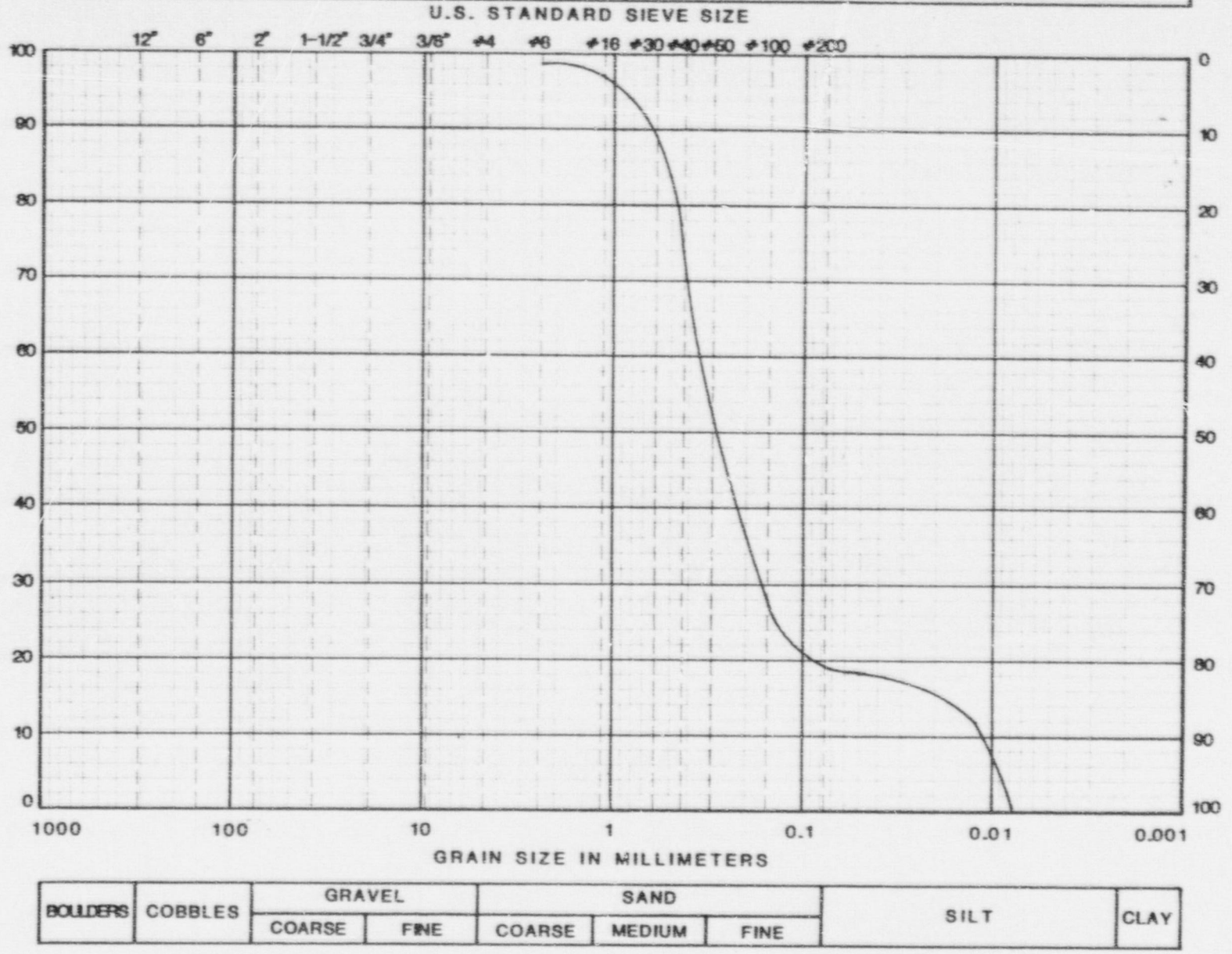
PLATE NUMBER: A4-C DRAWN BY: K. Lohrey DATE: 3-1-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 3/2/82

SYMBOL	LOCATION	DEPTH	UNIFIED CLASSIFICATION	DESCRIPTION
	*		SM	NEUTRALIZED TOTAL TAILINGS

GRAIN SIZE DISTRIBUTION

*BULK SAMPLE OBTAINED FROM DISCHARGE IN CENTRAL CELL AREA



BOULDERS	COBBLES	GRAVEL		SAND			SILT	CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE		

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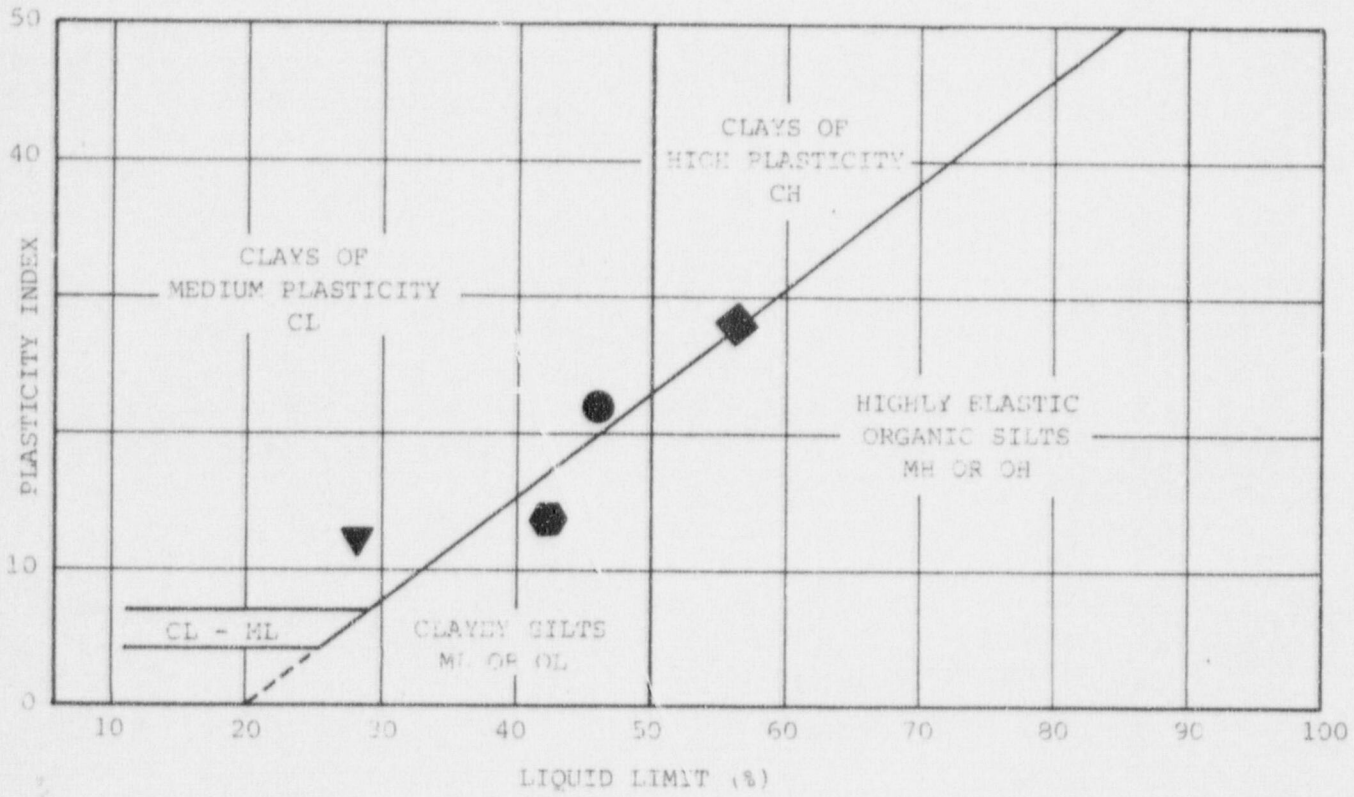
PLATE A4-C

PLATE NUMBER: A5-A DRAWN BY: K Lohrey DATE: 2-26-82

PROJECT NUMBER: 053-003 CHECK BY: Raney DATE: 3/1/82



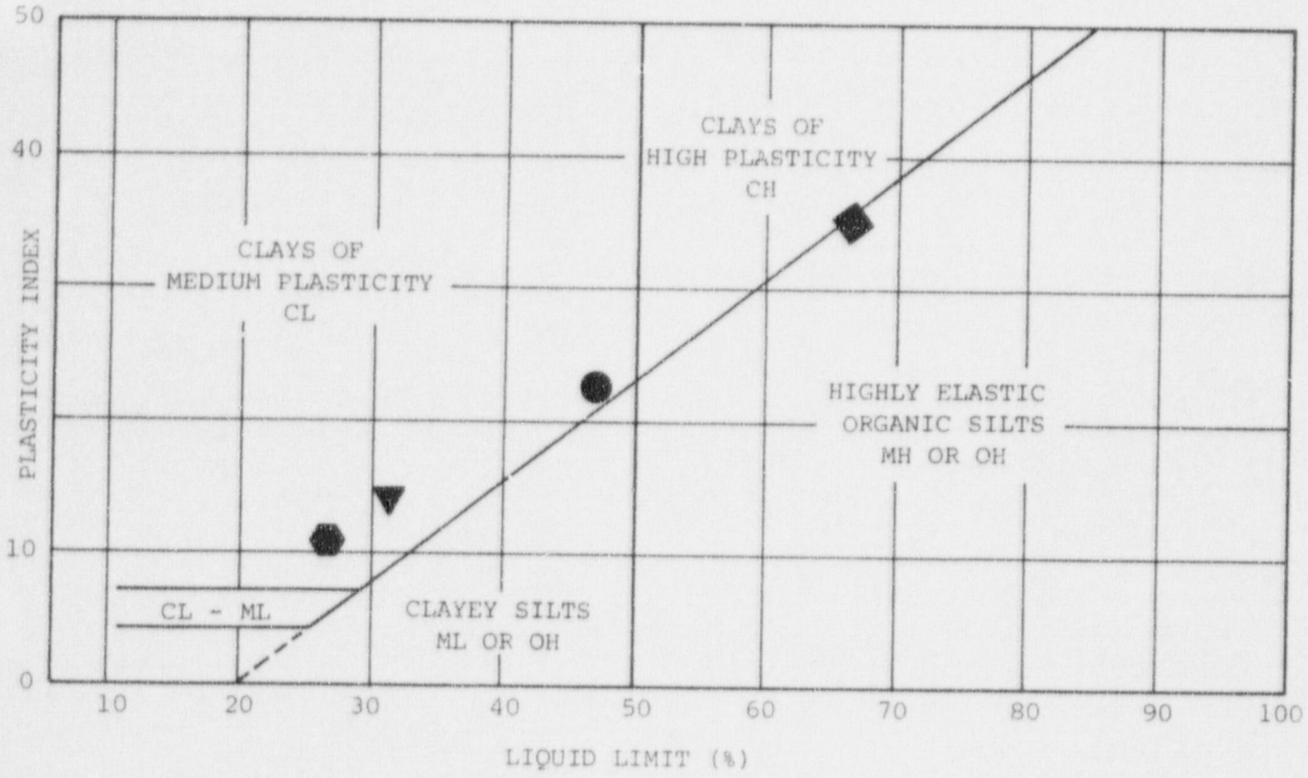
CLASSIFICATION TEST RESULTS						
SYMBOL	BORING NUMBER	DEPTH FEET	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SOIL CLASSIFICATION
●	T1	26.5	46.9	24.7	22.2	CL
⬢	T3	9.5	42.2	28.5	13.7	ML
■	T4	13.0	55.7	26.7	29.0	CH
▼	T7	23.0	28.8	16.2	12.6	CL

ATTERBERG LIMITS DATA

Raney Geotechnical

PLATE NUMBER: A5-B DRAWN BY: K. Lowrey DATE: 2-26-82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 3/1/82



CLASSIFICATION TEST RESULTS

SYMBOL	BORING NUMBER	DEPTH FEET	LIQUID LIMIT	PLASTIC LIMIT	PLASTICITY INDEX	SOIL CLASSIFICATION
●	T1	31.5	47.4	25.3	22.1	CL
⬢	T9	11.5	27.0	16.4	10.6	CL
■	T9	21.5	66.5	32.6	33.9	CH
▼	T13	50.0	31.5	17.4	14.1	CL

ATTERBERG LIMITS DATA

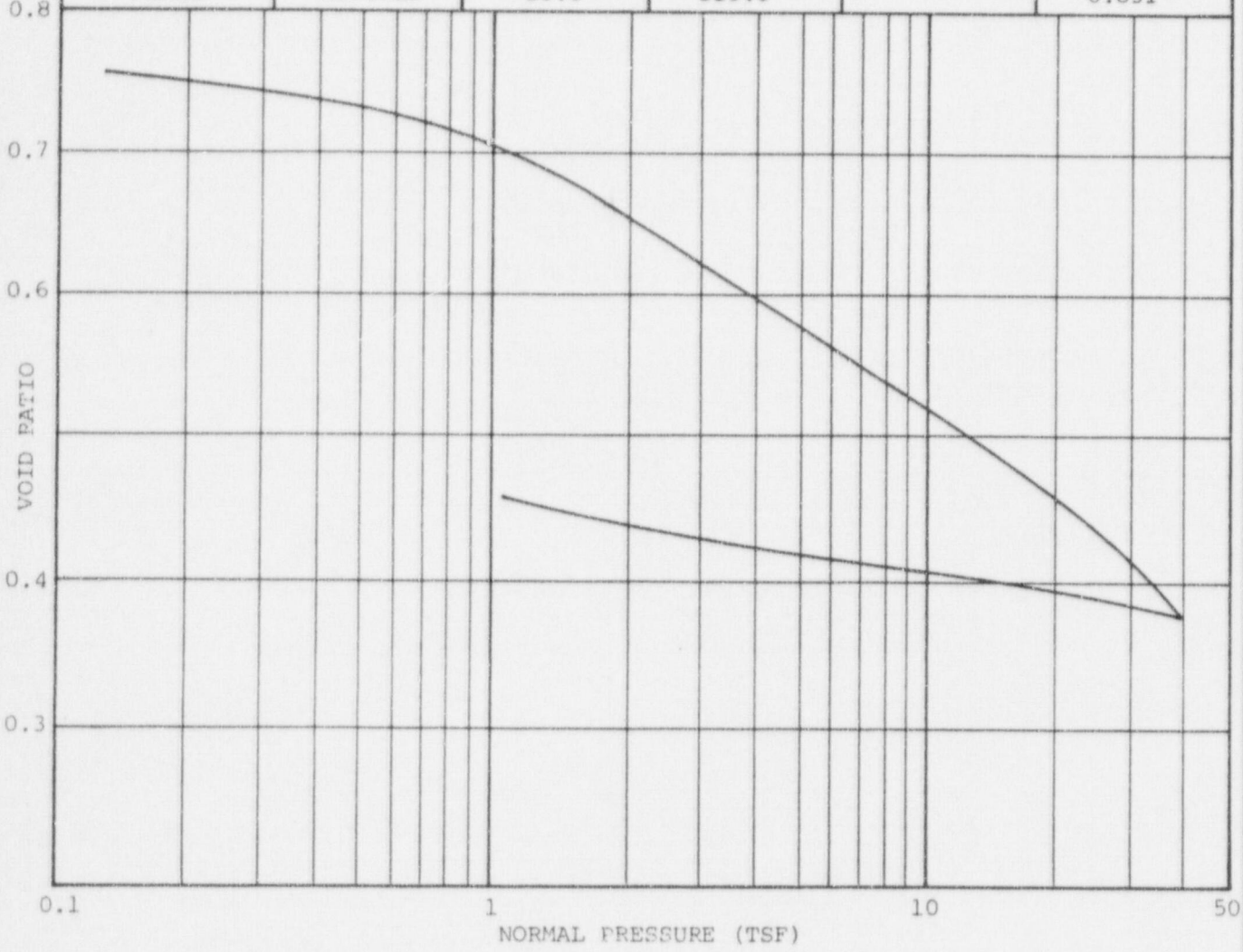
Raney Geotechnical

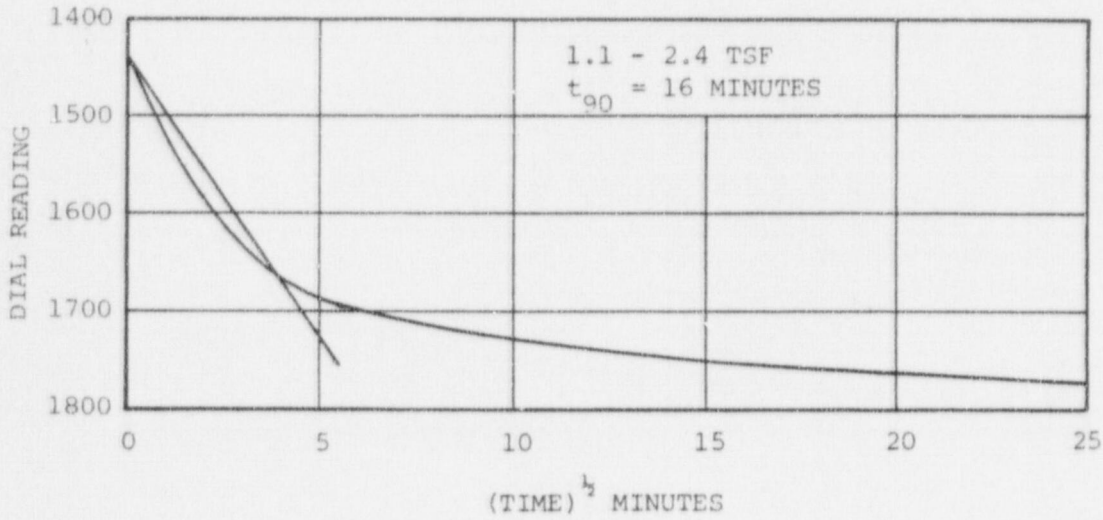
PLATE A5-B

PROJECT NUMBER: 05E-003 DRAWN BY: STEWART DATE: 2-13-82

PLATE NUMBER: A6-A CHECKED BY: Raney DATE: 2/15/82

BORING 1 DEPTH 16.5'	SPECIFIC GRAVITY	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT SATURATION	HEIGHT (INCHES)
INITIAL	2.70	27.0	95.9	96.4	1.000
FINAL	ASSUMED	20.0	115.5	--	0.831



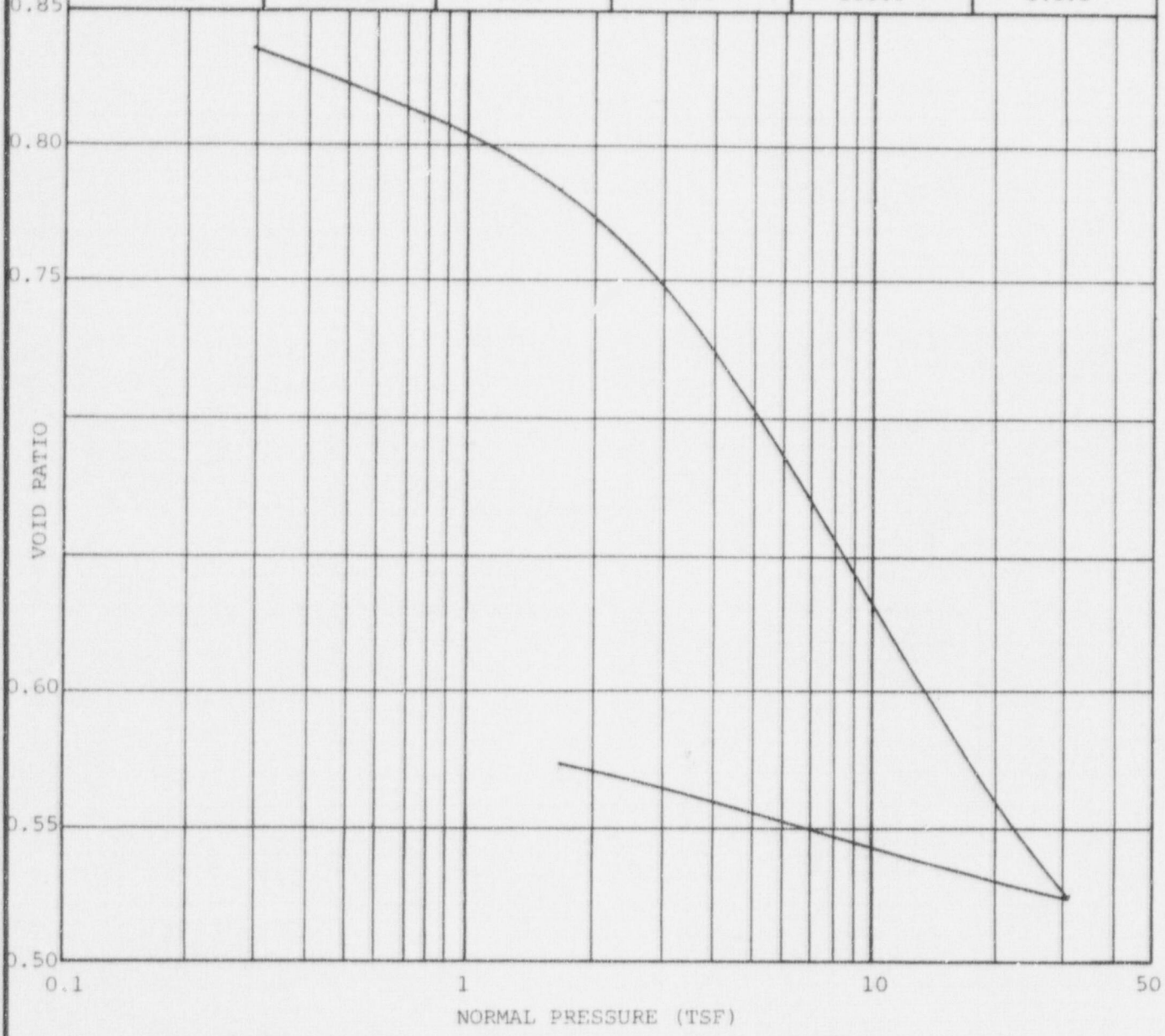


CONSOLIDATION TEST DATA

Raney Geotechnical

PLATE A6-A

BORING 3 DEPTH 11'	SPECIFIC GRAVITY	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT SATURATION	HEIGHT (INCHES)
INITIAL	2.75	22.9	97	82.5	1.250
FINAL	ASSUMED	20.8	109	100.0	1.068



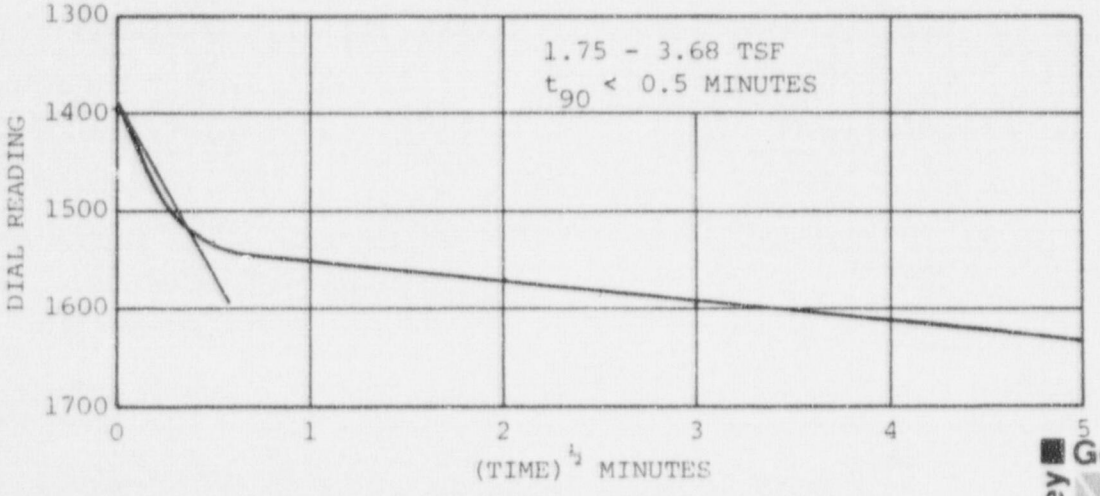


PLATE NUMBER: A6-B DRAWN BY: K Lahrey DATE: 2-23-82

PROJECT NUMBER: 053-003 CHECK BY: Penny DATE: 2/23/82

CONSOLIDATION TEST DATA

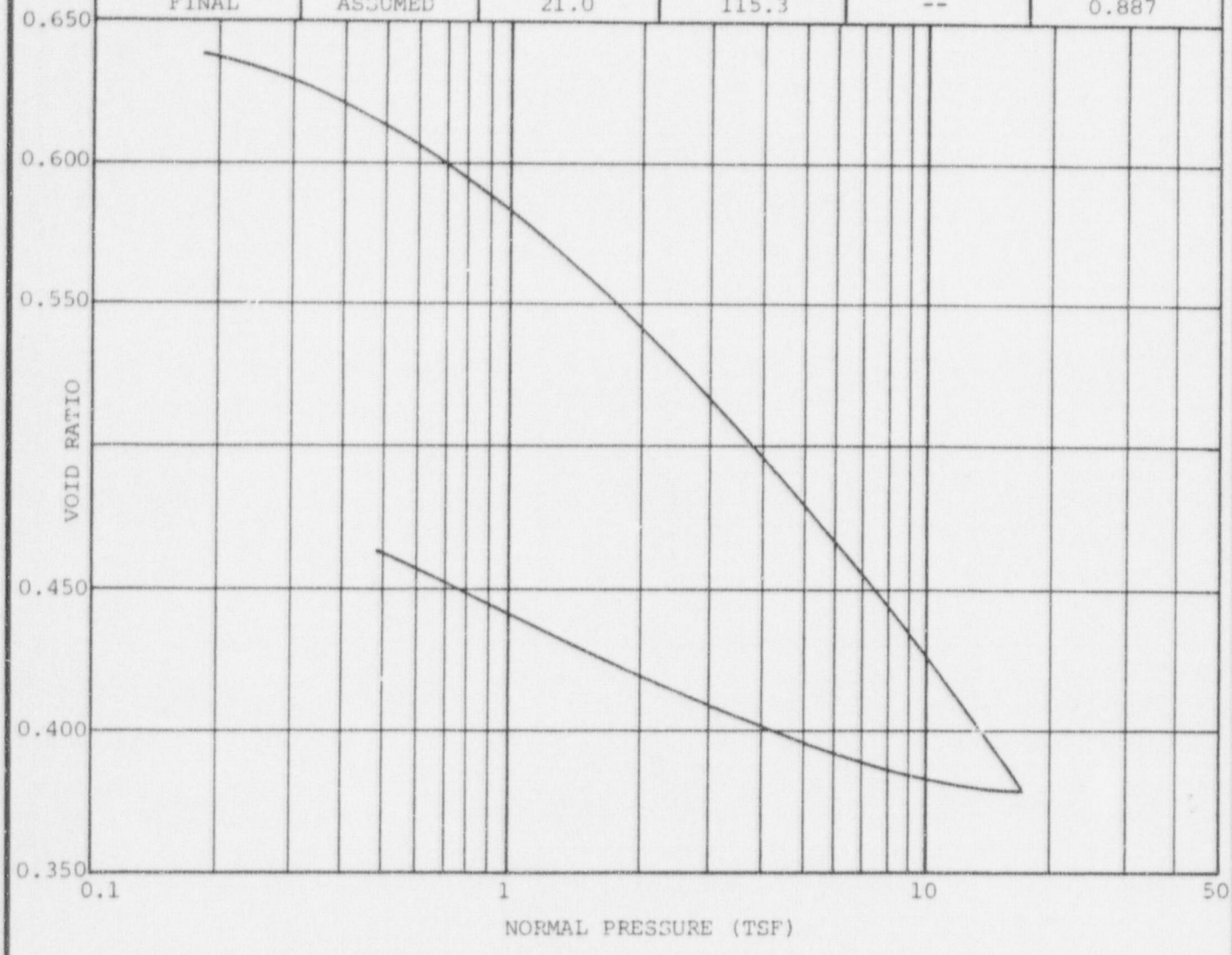
Raney Geotechnical

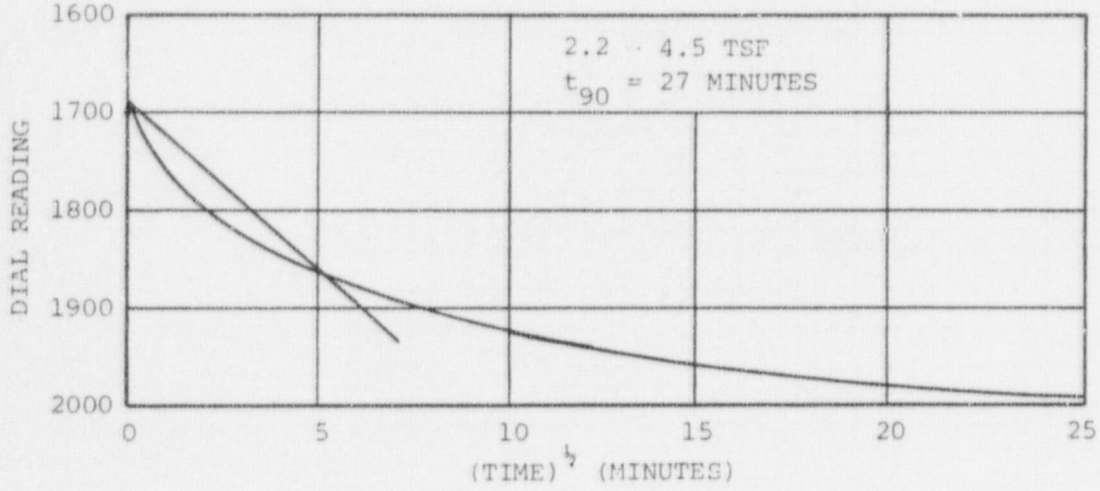
PLATE A6-B

PROJECT NUMBER: 253-003 DRAWN BY: STEWART DATE: 2-12-92

PLATE NUMBER: A6-C CHECKED BY: Raney DATE: 2/16/92

BORING 7 DEPTH 23'	SPECIFIC GRAVITY	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT SATURATION	HEIGHT (INCHES)
INITIAL	2.70	24.3	101.2	101.2	1.000
FINAL	ASSUMED	21.0	115.3	--	0.887





CONSOLIDATION TEST DATA

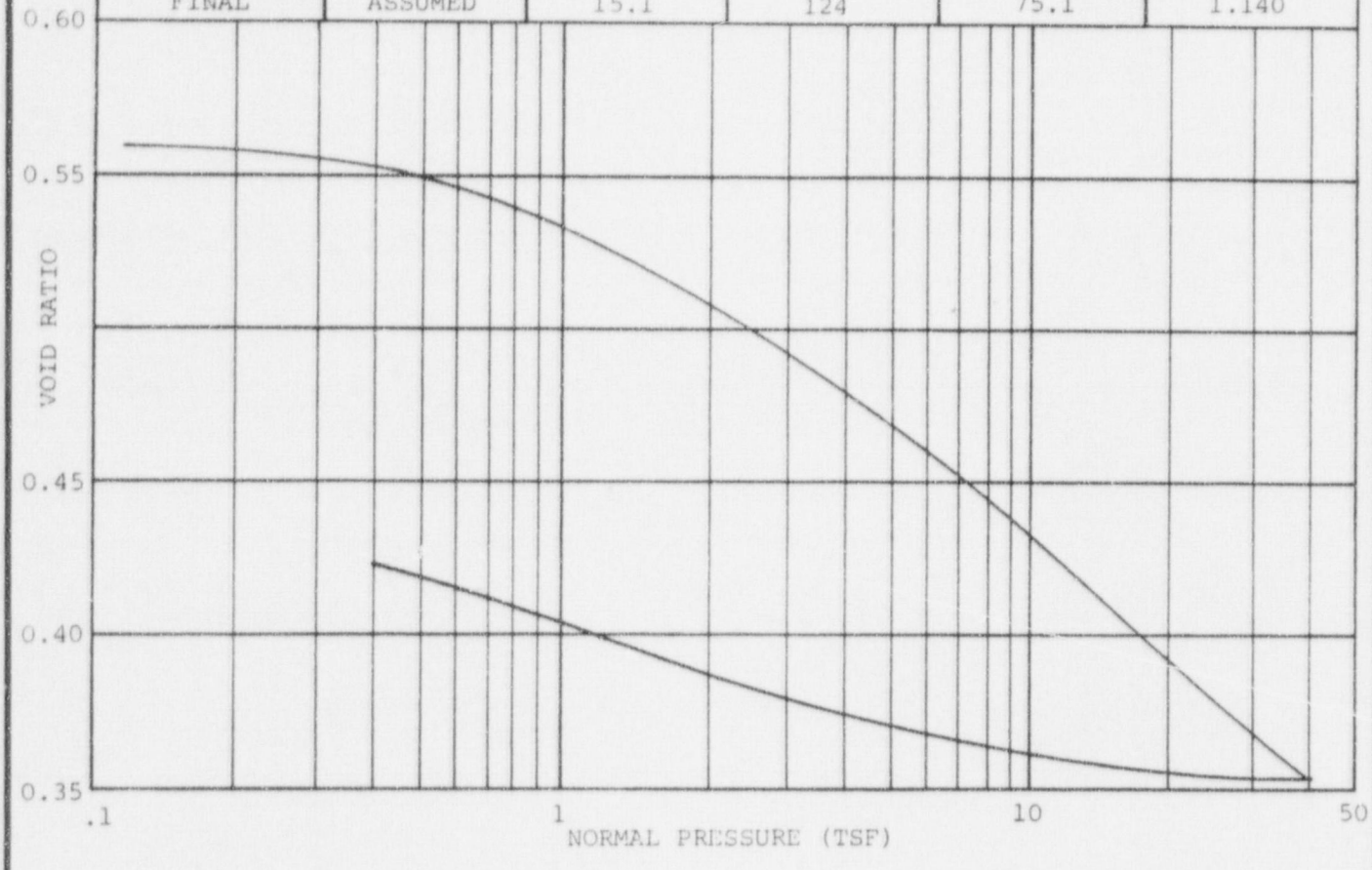
Raney Geotechnical

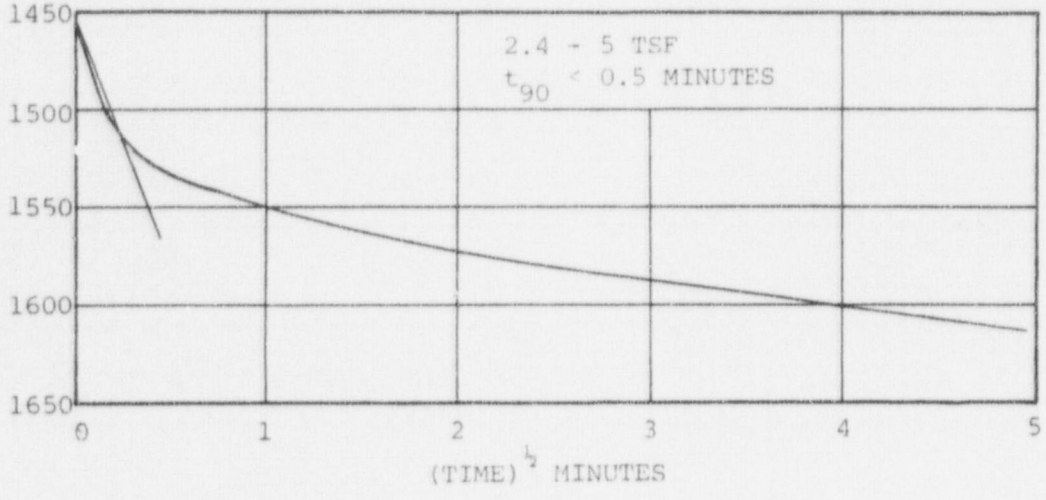
PLATE A6-C

PROJECT NUMBER: 053-003 DRAWN BY: K Lowrey DATE: 2-26-82

PLATE NUMBER: A6-D CHECKED BY: Kenney DATE: 3/1/82

BORING 9 DEPTH 11.5'	SPECIFIC GRAVITY	MOISTURE CONTENT (%)	DRY DENSITY (PCF)	PERCENT SATURATION	HEIGHT (INCHES)
INITIAL	2.70	15.5	111	97.0	1.250
FINAL	ASSUMED	15.1	124	75.1	1.140





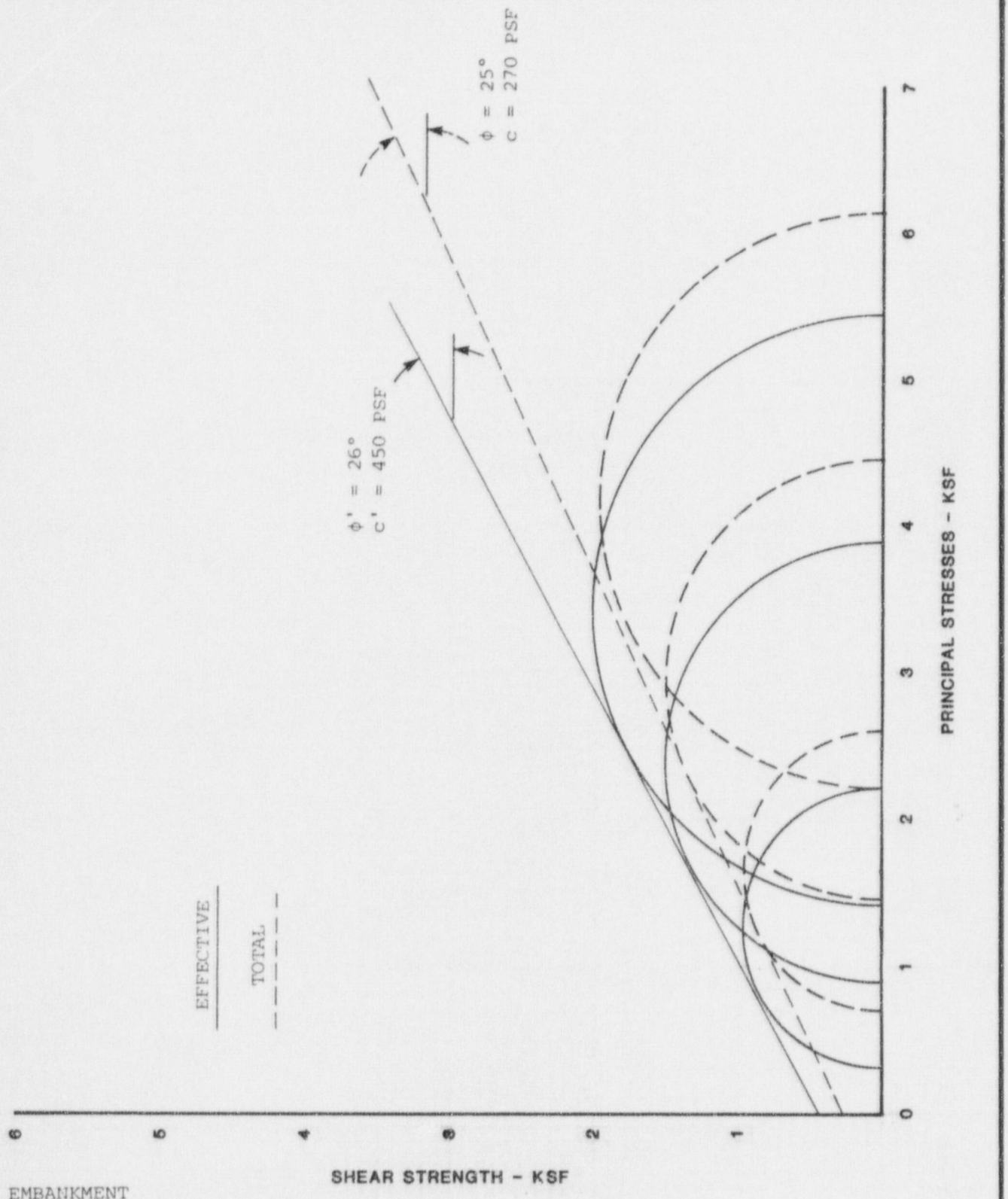
CONSOLIDATION TEST DATA

Raney Geotechnical

PLATE A6-D

PLATE NUMBER: A7-A DRAWN BY: K Lohrey DATE: 3-2-82

PROJECT NUMBER: 053-003 CHECK BY: Bumm DATE: 3/6/82



EMBANKMENT

SAMPLE T13 - 2II TESTED MULTIPHASE; γ_d = 127 PCF, W/C = 15.4%

EFFECTIVE STRESS PARAMETERS DETERMINED BY STRESS PATH

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION DATA

Raney Geotechnical

PLATE A7-A

PLATE NUMBER: A7-B DRAWN BY: K Lohrey DATE: 3-3-82

PROJECT NUMBER: 053-003 CHECK BY: [illegible] DATE: 3/4/82

CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION DATA

NEUTRALIZED TOTAL TAILINGS; γ_d = 100 PCF, W/C = 28.8%

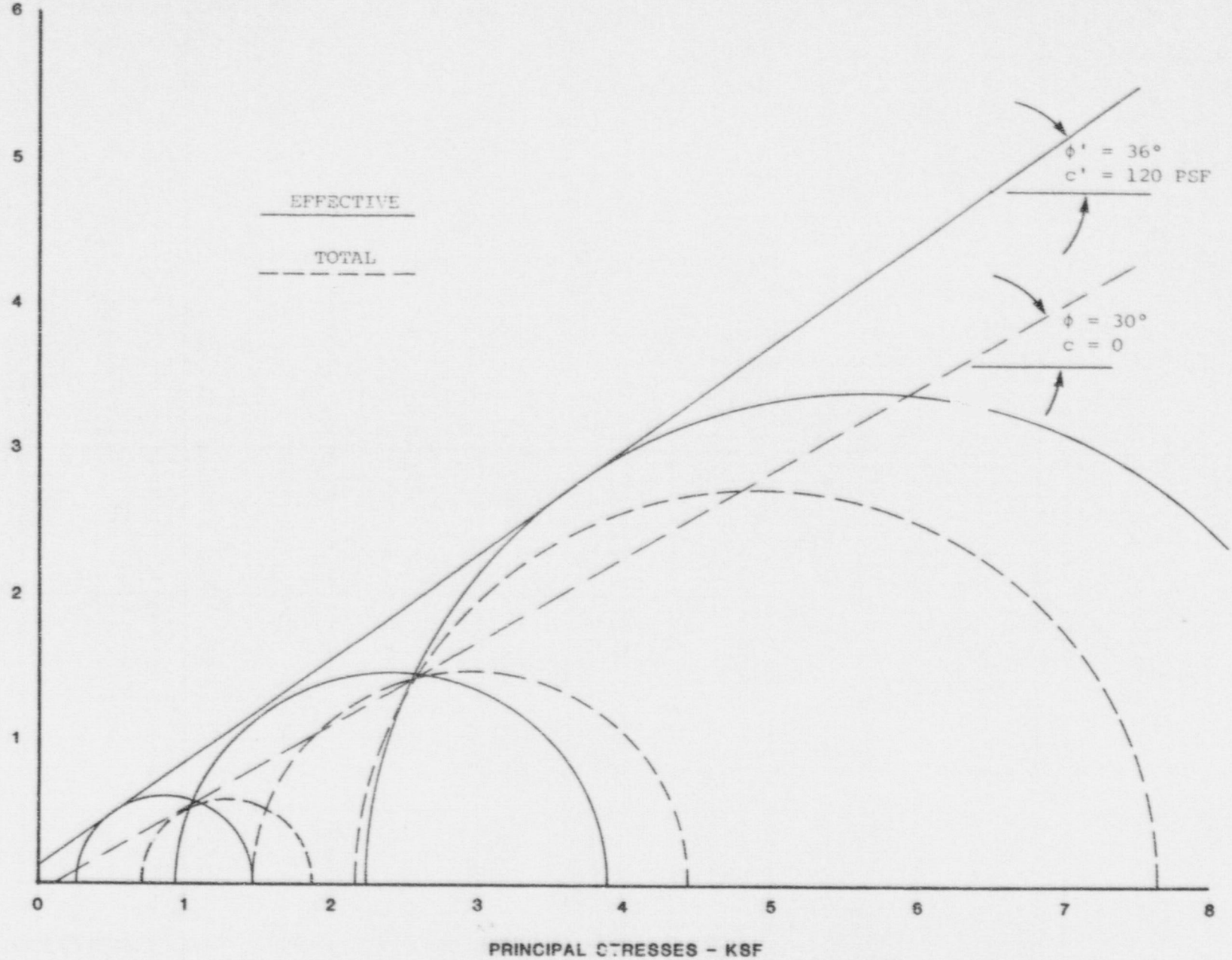


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PLATE A7-B