RESERVATION CANYON TAILINGS IMPOUNDMENT SITE CHARACTERIZATION AND FINAL CLOSURE DESIGN

BARRICK MERCUR GOLD MINE
TOOELE COUNTY, UTAH

Prepared For:

BARRICK
MERCUR

Prepared By:

Golder Associates

JULY 1999 **VOLUME 2 OF 2** **993-2037**

APPENDIX D

LABORATORY TESTING RESULTS

SOIL CLASSIFICATION CHART

MAJOR DIVISIONS			GRAPHIC SYMBOL	GROUP SYMBOL	TYPICAL DESCRIPTIONS
COARSE GRAINED SOILS	GRAVEL AND GRAVELLY SOILS	CLEAN GRAVELS (LESS THAN 5% FINES)		GW	WELL-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
				GP	POORLY-GRADED GRAVELS, GRAVEL-SAND MIXTURES, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	GRAVELS WITH FINES (MORE THAN 12% FINES)		GM	SILTY GRAVELS, GRAVEL-SAND-SILT MIXTURES
				GC	CLAYEY GRAVELS, GRAVEL-SAND-CLAY MIXTURES
MORE THAN 50% OF MATERIAL IS LARGER THAN NO.200 SIEVE SIZE	SAND AND SANDY SOILS	CLEAN SAND (LESS THAN 5% FINES)		SW	WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
				SP	POORLY-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES
	MORE THAN 50% OF COARSE FRACTION PASSING NO.4 SIEVE	SANDS WITH FINES (MORE THAN 12% FINES)		SM	SILTY SANDS, SAND-SILT MIXTURES
				SC	CLAYEY SANDS, SAND-CLAY MIXTURES
FINE GRAINED SOILS	SILTS AND CLAYS	LIQUID LIMIT LESS THAN 50%		ML	INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY
				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
MORE THAN 50% OF MATERIAL IS SMALLER THAN NO.200 SIEVE SIZE	SILTS AND CLAYS	LIQUID LIMIT GREATER THAN 50%		MH	INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS
				CH	INORGANIC CLAYS OF HIGH PLASTICITY, FAT CLAYS
				OH	ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS
HIGHLY ORGANIC SOILS				PT	PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS.

Golder Associates Inc. Denver, Colorado			TITLE: USCS CLASSIFICATION SYSTEM		
CLIENT/PROJECT			DATE: DEC 1992	SCALE	JOB NO. 923-2484
DRAWN: BRB	CHECKED	REVIEWED	FILE	DWG. NO.	FIGURE A.1-1

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2
TABLE 1
SUMMARY OF SOIL DATA

SAMPLE TYPE	SAMPLE NUMBER	SAMPLE DEPTH (ft)	U.S.C.S. SOIL CLASSI-FICATION	DELIVERED MOISTURE (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION			SPECIFIC GRAVITY	MOIST/DEN RELATIONSHIP STANDARD PROCTOR		ADDITIONAL TESTS COMMENTS (See Notes)
						LL	PL	PI	% FINER 3/4"	% FINER #4	% FINER #200		PCF (Dry)	MOIST (%)	
	GA98 BH-4	20-22	ML	45.0	77.9	29	23	6	100	100	97	2.73			
	GA98 BH-4	40-42	CL	36.0	86.6				100	100	100				C
	GA98 BH-4	60-62													T
	GA98 BH-4	78-80	ML	30.0	90.6	29	23	6	100	100	100				C
	GA98 BH-9A	20-22	SC						100	100	35				T
	GA98 BH-9	20-40													
	GA98 BH-9	42-44	SC	28.1	94.5				100	100	16				PERM
	GA98 BH-9	60-62		24.5	99.0										
	GA98 BH-9	80-82	SM	24.4	99.8	NP	NP	NP	100	100	60				C
	GA98 BH-9	100-102		26.7	97.2										
	GA98 BH-9	122-12	CL	23.3	102.3				100	100	73				
	GA98 BH-9	142-144		23.1	99.8										
	GA98 BH-9	162-16	SC	21.0	108.1				100	100	48				
	GA98 BH-9	180-182		18.3	113.1										
	GA98 BH-9	200-20	CL-ML	23.8	104.7	29	22	7	100	100	92				C
	GA98 BH-9	220-222		23.4	104.4										
	GA98 BH-9	240-24	CL	27.2	99.3				100	100	98				
	GA98 BH-10	20-22	CL	31.7	90.4				100	100	94				
	GA98 BH-10	40-42	CL	30.3	90.5				100	100	98	2.77			PERM, C
	GA98 BH-10	60-62		28.6	92.6										
	GA98 BH-10	80-82	CL	26.0	97.4				100	100	90				

TABLE 1
SUMMARY OF SOIL DATA

SAMPLE TYPE	SAMPLE NUMBER	SAMPLE DEPTH (ft)	U.S.C.S. SOIL CLASSI-FICATION	DELIVERED MOISTURE (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS LL	PL	PI	GRAIN SIZE DISTRIBUTION % FINER 3/4"	% FINER #4	% FINER #200	SPECIFIC GRAVITY	MOIST/DEN RELATIONSHIP STANDARD PROCTOR PCF (Dry)	MOIST (%)	ADDITIONAL TESTS COMMENTS (See Notes)
	GA98 BH-10	102-104		27.4	97.3										
	GA98 BH-10	120-12	CL	24.6	100.0				100	100	83				
	GA98 BH-10	142-14	CL	21.2	99.8				100	100	52				
	GA98 BH-10	162-16	CL-ML	22.0	105.4	23	19	4	100	100	87				
	GA98 BH-10	182-18	CL	25.0	100.9				100	100	91				
	GA98 BH-10	202-204		27.5	96.8										
	GA98 BH-11	20-22	SC	25.6	95.8				100	100	49				C
	GA98 BH-11	40-42													T
	GA98 BH-11	60-62	ML	30.5	92.9	28	21	7	100	100	99	2.72			
	GA98 BH-11	80-82		26.9	95.2										
	GA98 BH-11	101-10	CL	32.0	88.6				100	100	96				C
	GA98 BH-11	120-122		25.0	99.9										
	GA98 BH-11	140-14	CL	23.8	103.3	27	18	9	100	100	90				C
	TB@CPT6	0-.5		26.7	88.0										
	TB@CPT9	0-.5		26.8	81.8										

NOTES:
LL = LIQUID LIMIT
PL = PLASTIC LIMIT
T = TRIAXIAL TEST
U = UNCONFINED COMPRESSION TEST

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2
TABLE 1
SUMMARY OF SOIL DATA

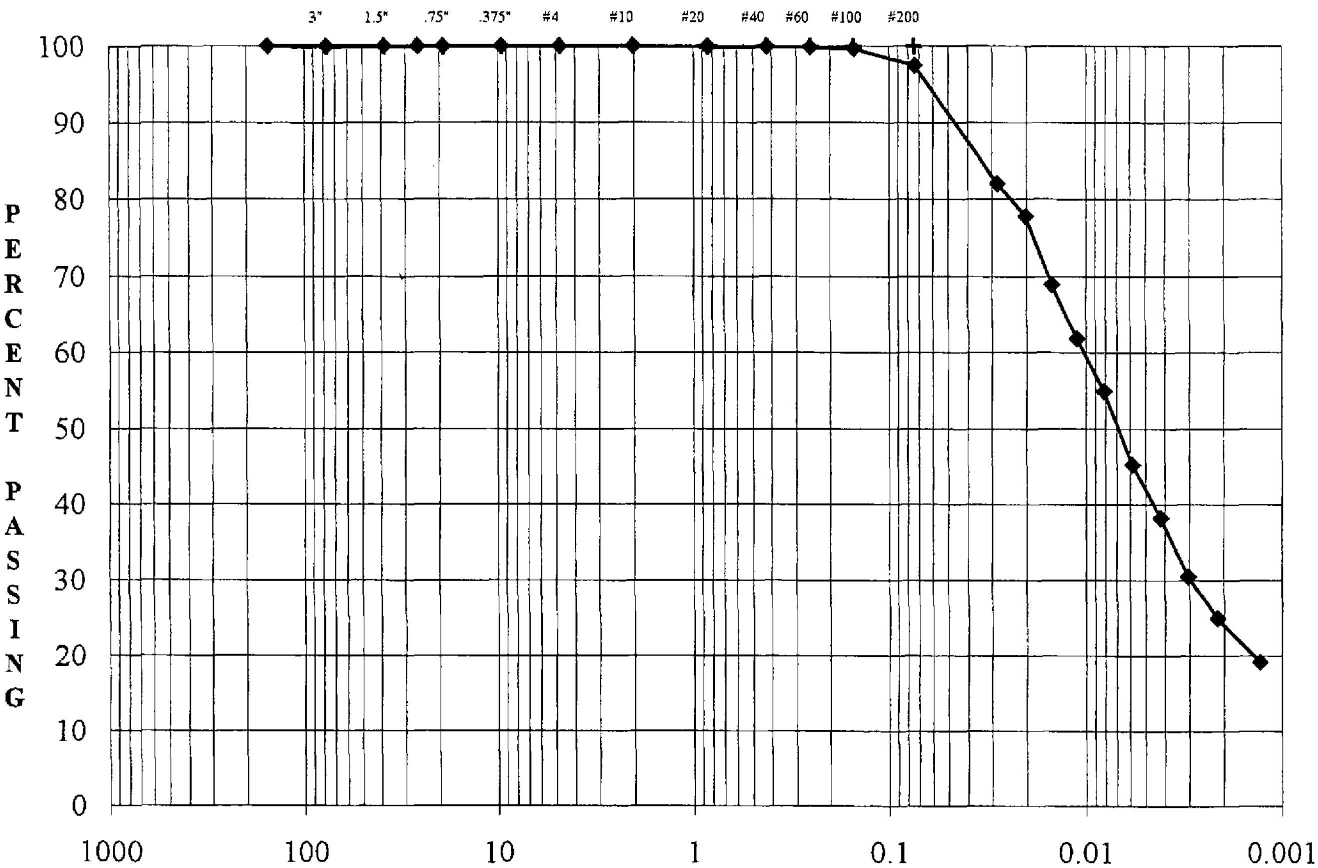
SAMPLE TYPE	SAMPLE NUMBER	SAMPLE DEPTH (ft)	U.S.C.S. SOIL CLASSI-FICATION	DELIVERED MOISTURE (%)	DRY DENSITY (PCF)	ATTERBERG LIMITS			GRAIN SIZE DISTRIBUTION			SPECIFIC GRAVITY	MOIST/DEN RELATIONSHIP STANDARD PROCTOR		ADDITIONAL TESTS COMMENTS (See Notes)
						LL	PL	PI	% FINER 3/4"	% FINER #4	% FINER #200		PCF (Dry)	MOIST (%)	

PI = PLASTIC INDEX
SL = SHRINKAGE LIMIT
C = CONSOLIDATION TEST
DS = DIRECT SHEAR TEST
PERM = PERMEABILITY

APPENDIX D-1

INDEX TESTING

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	GA98-BH4 20-22	MC (As Tested	45.0%
		LL:	29
		PL:	23
WET COLOR: DESCRIPTION:	SILT with trace fine to medium sand (ML)	PI:	6
		Gs:	2.73

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2

DATE:	02-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILINGS/UT	**SAMPLE NUMBER:** GA98-BH4
983-2344.001-2	**DEPTH (ft):** 20-22

MOISTURE CONTENT (As Tested)

Tare	TARE
Weight Wet Soil & Tare, g	0.00
Weight Dry Soil & Tare, g	0.00
Weight Tare, g	0.00
Weight Water, g	0.00
Weight Dry Soil, g	0.00
Moisture Content, %	**#DIV/0!**

PERCENT PASSING #10 SIEVE

Total Weight, g	404.30
Weight Split #10, g	404.30
Percent Passing #10	100.00%

	SIEVE	Wt. Ret., g	% Ret.	% Pass.	SIEVE	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand

SAMPLE PREPARATION FOR HYDROMETER ANALYSIS

Percent Passing #10 Sieve	100.00	Initial Wet Weight	50.00
Specific Gravity	2.73	Calculated Dry Weight	49.88
Dispersing Agent, ml, Used (40 ml $Na(PO_4)n$ per 1,000 ml H_2O)	125		

MOISTURE CONTENT (Hygroscopic - #10)

Tare	AZ		
Weight Wet Soil & Tare, g	87.26	LL:	29
Weight Dry Soil & Tare, g	87.12	PL:	23
Weight Tare, g	29.12	PI:	6
Weight Moisture, g	0.14	Gs:	2.73
Weight Dry Soil, g	58.00		
Moisture Content, %	**0.24%**		

PERCENT #10 TO #200 SIEVE CALCULATION

SEIVE	CUMUL. WT. RETAINED	CUMUL. WT. RET. CORR.	PERCENT PASSING		
#10	0.00	0.00	**100.00%**	#10	Medium Sand
#20	0.03	0.03	**99.94%**	#20	
#40	0.05	0.05	**99.90%**	#40	Fine Sand
#60	0.10	0.10	**99.80%**	#60	
#100	0.15	0.15	**99.70%**	#100	
#200	1.28	1.28	**97.43%**	#200	Fines

DATE	TIME	TIME, CUM. (min)	READING R	TEMP. T	HYD. RDG. H	PARTICLE DIAMETER	PERCENT FINER
10/01/1998	08:59	2	45.0	23.7	3.69	0.028	**82.0%**
	09:01	4	42.9	23.7	3.69	0.020	**77.8%**
	09:05	8	38.4	23.8	3.66	0.015	**69.0%**
	09:12	15	34.8	23.9	3.62	0.011	**61.9%**
	09:27	30	31.3	23.9	3.62	0.008	**54.9%**
	09:57	60	26.4	24.0	3.59	0.006	**45.3%**
	10:57	120	22.8	24.2	3.53	0.004	**38.3%**
	12:57	240	18.7	24.7	3.37	0.003	**30.4%**
	16:57	480	15.8	25.2	3.21	0.002	**25.0%**
10/02/1998	08:57	1,440	13.5	23.2	3.85	0.001	**19.2%**

% C GRVL:	**0.0%**	
% F GRVL:	**0.0%**	**0.0%**
% C SAND:	**0.0%**	
% M SAND:	**0.1%**	
% F SAND:	**2.5%**	**2.6%**
% FINES:	**97.4%**	
% TOTAL:	**100.00%**	

Wet Color:
Description: **SILT with trace fine to medium sand (ML)**

DATE:	10/02/1998
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER	983-2344.001-2	BORING NUMBER	GA 98-BH-4
PROJECT	BARRICK/MERCUR TAILINGS/UT	SAMPLE NUMBER	
DATE	9-22-98	DEPTH	20-22'

TOP

30
24
18
12
6
0

BOTTOM

SAMPLE DESCRIPTION

Slimes & silts, olive, dark tan

Sandy lense near top, f. gr. w clays & silts, olive, dark tan moist to wet,

odorous

DENSITY

DIAMETER (cm)	7.20
LENGTH (cm)	54.35
WT. TUBE & WET SAMPLE (g)	5622.1g
TUBE WT. (g)	1710.3
WET WT. OF SAMPLE (g)	3911.8
AREA (cm^2)	40.72
VOLUME (cm^3)	2212.9
WET UNIT WT. (pcf)	110.3
DRY UNIT WT. (pcf)	77.9

WATER CONTENT DETERMINATION

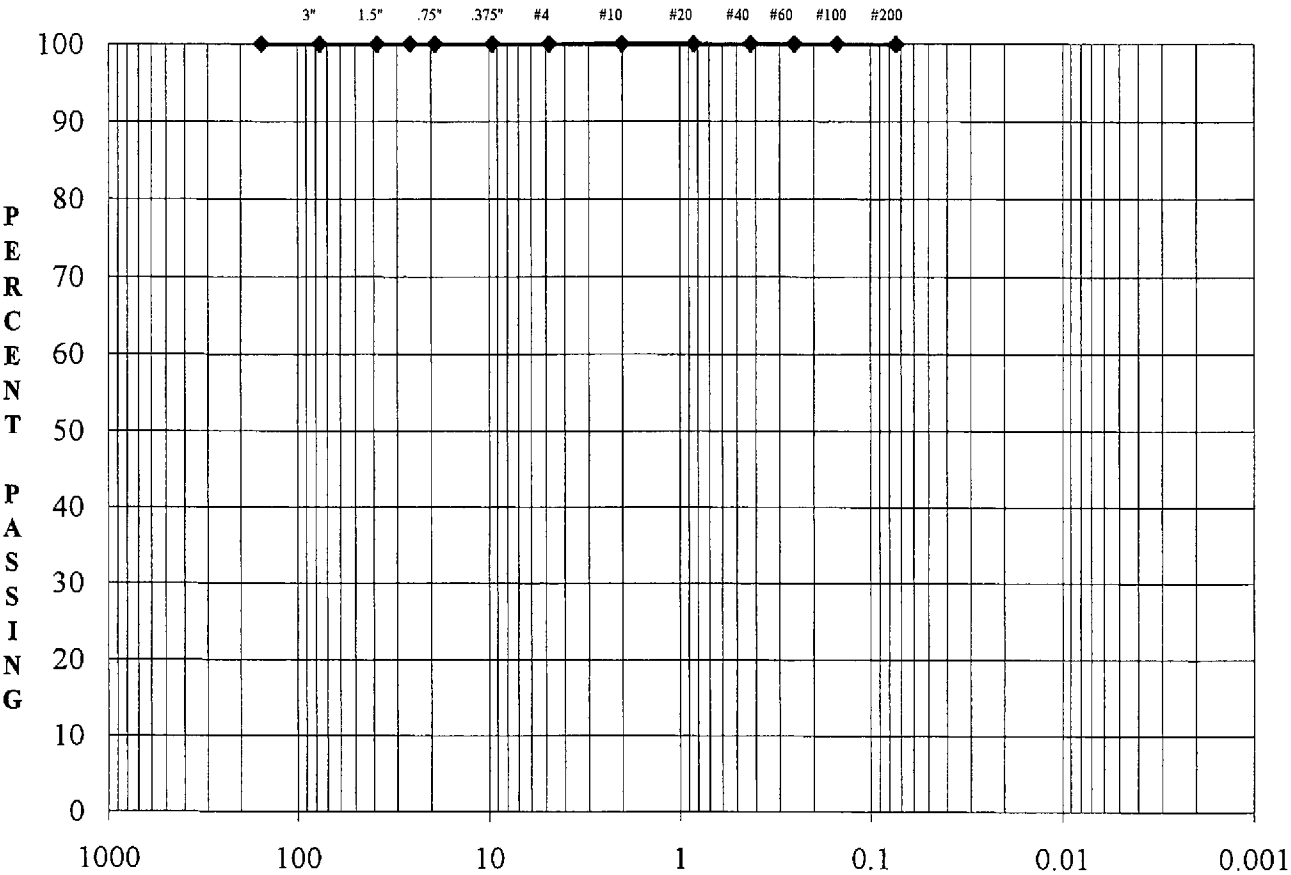
	1	2
TARE #	X-36	F-19
WET WT. & TARE (g)	205.63	175.51
DRY WT. & TARE (g)	154.82	129.25
TARE (g)	32.79	33.70
MOISTURE CONTENT (%)	41.6	48.4

45.0 % Ave

LAB WORK DONE BY: RD

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
	GRAVEL		SAND			FINES

SAMPLE #:	GA98 BH-4
DEPTH (FEET):	40-42
DESCRIPTION:	CLAY with trace fine sand (CL)

MC:	36.0%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	02-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-4**
983-2344.001-2		**DEPTH (FEET):**	**40-42**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	F26	Tare	513
Weight Wet Soil & Tare, g	293.55	Weight Soil & Tare Before Wash, g	492.94
Weight Dry Soil & Tare, g	224.49	Weight Soil & Tare After Wash, g	158.49
Weight Tare, g	32.61	Weight Tare, g	158.25
Weight Water, g	69.06	Weight Fines Lost, g	245.87
Weight Dry Soil, g	191.88	Weight Dry Soil, g	246.11
Moisture, %	**35.99%**	Fines Lost, %	**99.90%**

	SIEVE	**Wt. Ret.**	**% Ret.**	**% Pass.**	**SIEVE**	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.00	0.00%	**100.00%**	#20	
Fine Sand	#40	0.00	0.00%	**100.00%**	#40	Fine Sand
	#60	0.01	0.00%	**100.00%**	#60	
	#100	0.01	0.00%	**100.00%**	#100	
	#200	0.29	0.12%	**99.88%**	#200	
Fines	PAN	0.36	0.00%	**100.00%**	PAN	Fines

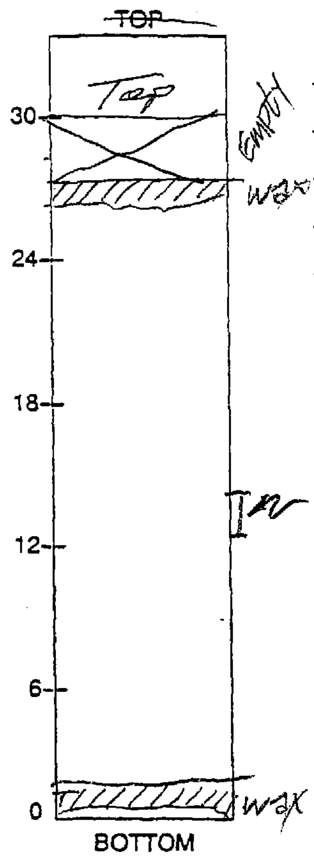
% C GRVL:	**0.0%**		Wet Color:	**CLAY with trace fine**			
% F GRVL:	**0.0%**	0.0%	Description:	**sand (CL)**			
% C SAND:	**0.0%**						
% M SAND:	**0.0%**		LL:	**NA**			
% F SAND:	**0.1%**	0.1%	PL:	**NA**		DATE:	02-Oct-98
% FINES:	**99.9%**		PI:	**NA**		TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**		REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344.001-2
PROJECT BARRICK / MERCUR TAILINGS/UT
DATE 10/05/98

BORING NUMBER GA98-BH-4
SAMPLE NUMBER
DEPTH 40-42'



SAMPLE DESCRIPTION

Slime, medium brown, wet to moist
soft to slightly firm
brown w/ some gray mottling
consolidation sample
bcm wet @ bottom

DENSITY

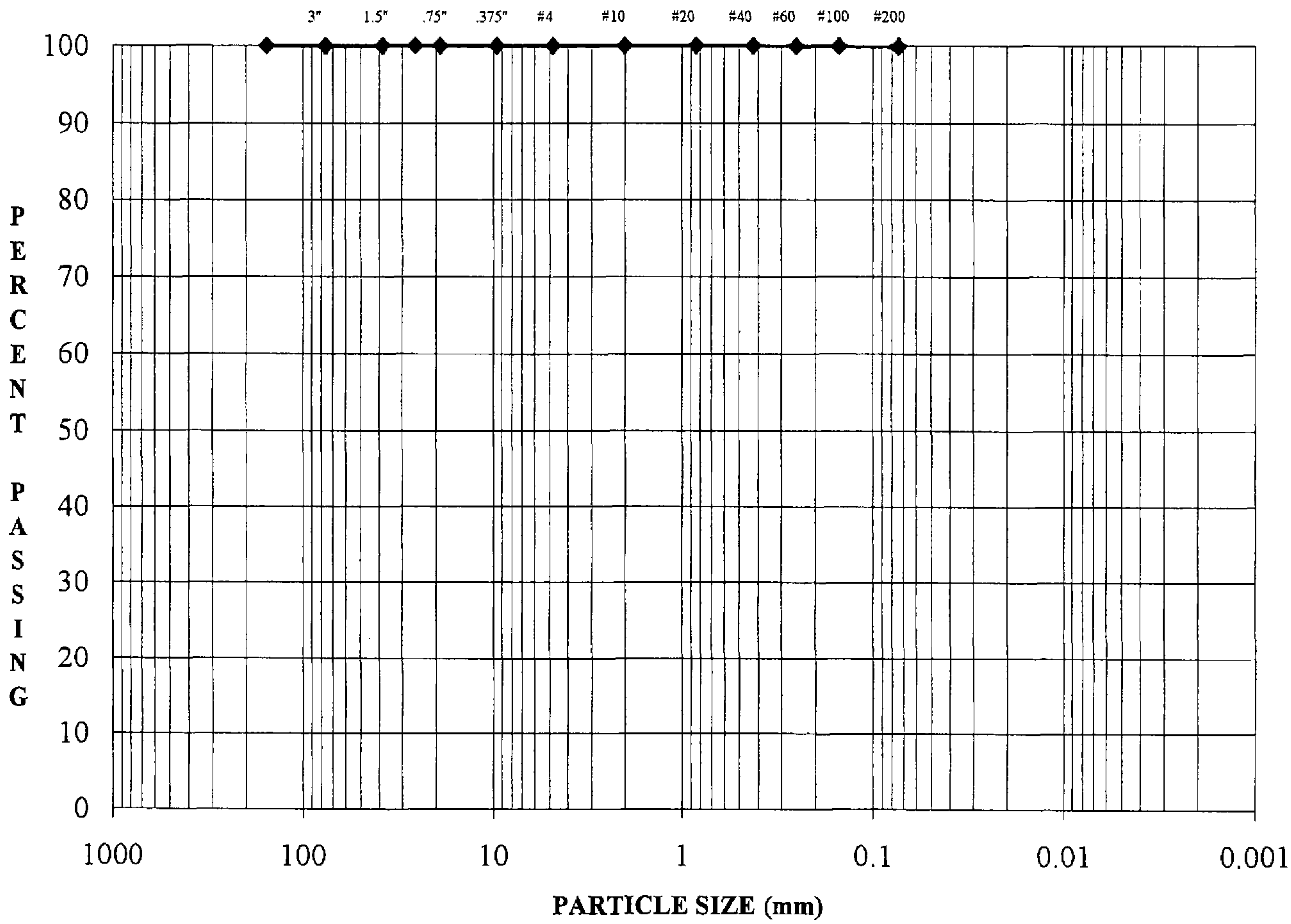
DIAMETER (cm)	7.23
LENGTH (cm)	53.5
WT. TUBE & WET SAMPLE (g)	5650.5
TUBE WT. (g)	1505.4
WET WT. OF SAMPLE (g)	4145.1
AREA (cm^2)	41.06
VOLUME (cm^3)	2196.4
WET UNIT WT. (pcf)	117.8
DRY UNIT WT. (pcf)	86.6

WATER CONTENT DETERMINATION

	1	2
TARE #	X-36	
WET WT. & TARE (g)	227.63	
DRY WT. & TARE (g)	176.05	
TARE (g)	32.79	
MOISTURE CONTENT (%)	36.0	

LAB WORK DONE BY:
APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	GRAVEL		SAND			FINES

SAMPLE #:	GA98 BH-4
DEPTH (FEET):	78-80
DESCRIPTION:	SILT with trace fine sand (ML)

MC:	30.0%
LL:	29
PL:	23
PI:	6
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	02-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	GA98 BH-4
983-2344.001-2		**DEPTH (FEET):**	78-80

MOISTURE CONTENT (Delivered Moisture) | **#200 WASH (Percent Fines)**

Tare	C5	Tare	15D
Weight Wet Soil & Tare, g	289.88	Weight Soil & Tare Before Wash, g	758.15
Weight Dry Soil & Tare, g	230.76	Weight Soil & Tare After Wash, g	158.11
Weight Tare, g	33.80	Weight Tare, g	157.02
Weight Water, g	59.12	Weight Fines Lost, g	461.26
Weight Dry Soil, g	196.96	Weight Dry Soil, g	462.35
Moisture, %	**30.02%**	Fines Lost, %	**99.76%**

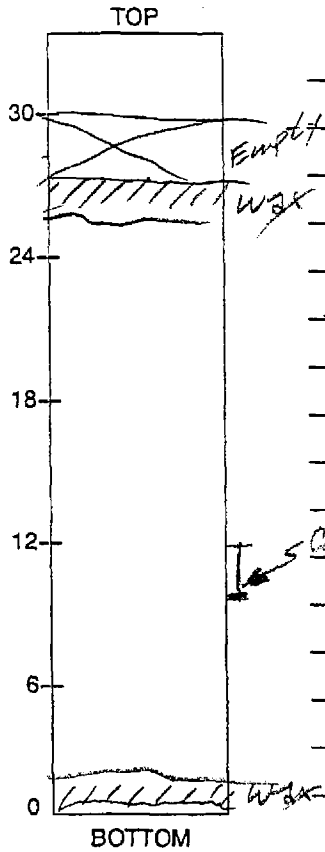
	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.00	0.00%	**100.00%**	#20	
Fine Sand	#40	0.02	0.00%	**100.00%**	#40	Fine Sand
	#60	0.23	0.05%	**99.95%**	#60	
	#100	0.57	0.12%	**99.88%**	#100	
	#200	0.96	0.21%	**99.79%**	#200	
Fines	PAN	1.07	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**SILT with trace fine sand (ML)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**29**		
% F SAND:	**0.2%**	0.2%	PL:	**23**	DATE:	02-Oct-98
% FINES:	**99.8%**		PI:	**6**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER 983-2344 001-2 BORING NUMBER GA98 BH4
PROJECT Barrick/Mercur Tailings/UT SAMPLE NUMBER
DATE 10/5/98 DEPTH 78-80



SAMPLE DESCRIPTION

Slime, medium gray gray-brown, moist
firm to slightly soft, sticky

consolidation sample
becoming red brown

DENSITY

DIAMETER (cm)	7.26
LENGTH (cm)	53.7
WT. TUBE & WET SAMPLE (g)	5826.7
TUBE WT. (g)	1629.5
WET WT. OF SAMPLE (g)	4197.2
AREA (cm^2)	41.40
VOLUME (cm^3)	2223.0
WET UNIT WT. (pcf)	117.8
DRY UNIT WT. (pcf)	90.6

WATER CONTENT DETERMINATION

	1	2
TARE #	C5	
WET WT. & TARE (g)	289.88	
DRY WT. & TARE (g)	230.76	
TARE (g)	33.80	
MOISTURE CONTENT (%)	30.0	

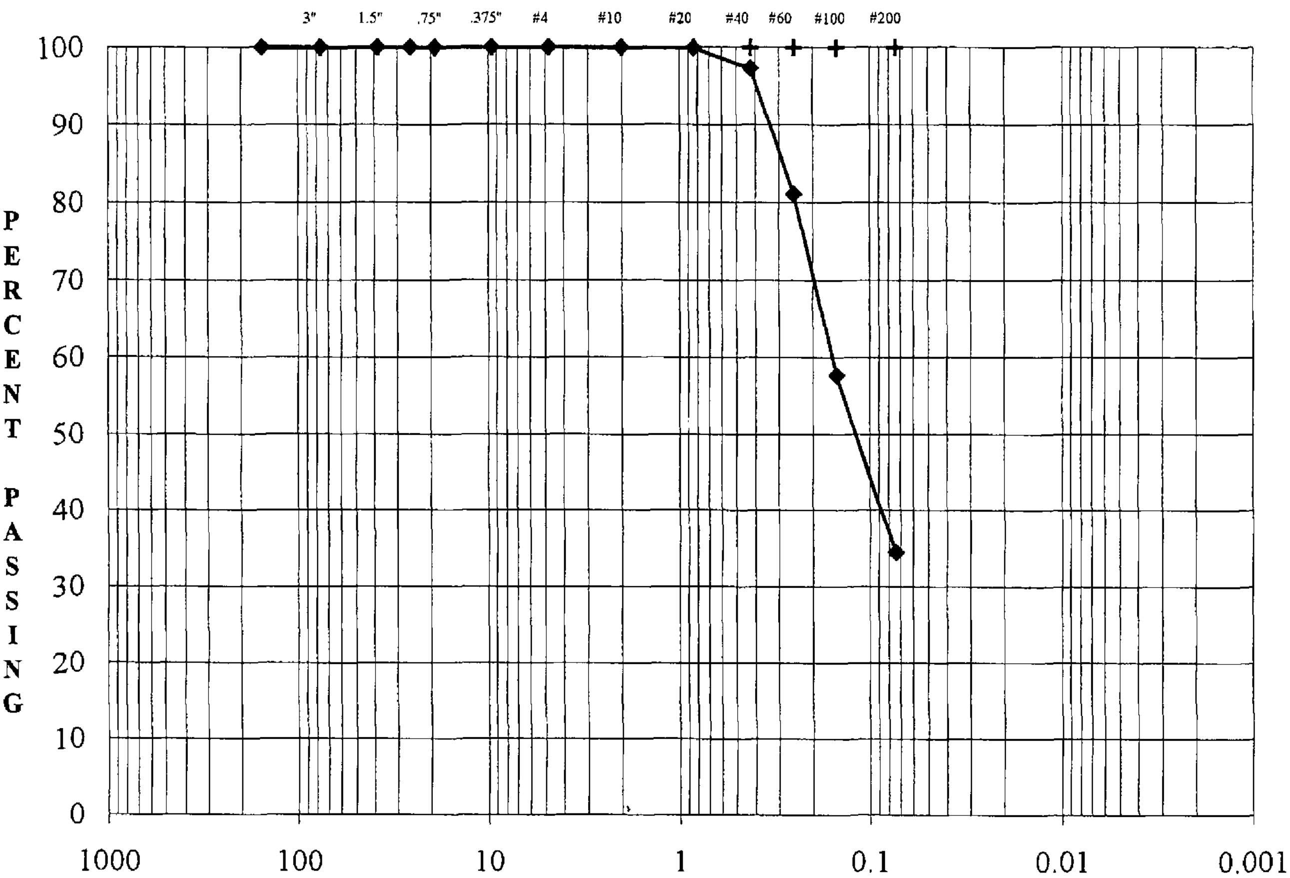
LAB WORK DONE BY:

APPROVED BY:

Need Atterbergs & 200 wash

7334.0

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	GRAVEL		SAND			FINES

SAMPLE #:	GA98 BH-9A	MC:	22.2%
DEPTH (FEET):	20-22	LL:	NA
		PL:	NA
DESCRIPTION:	Fine to medium SAND and clay (SC)	PI:	NA
		Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	27-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-9A**
983-2344.001-2		**DEPTH (FEET):**	**20-22**

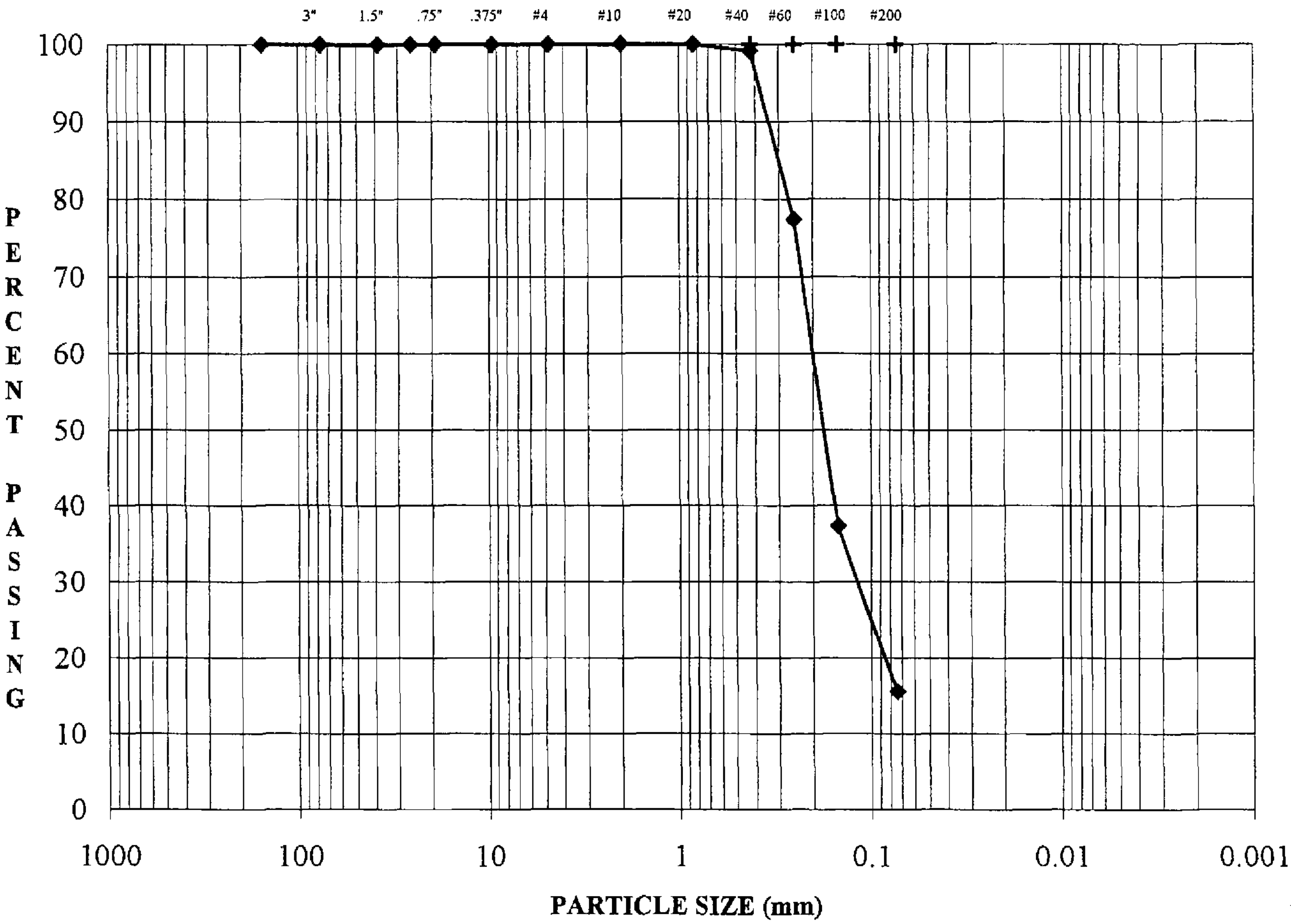
MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	X28	Tare	Z17
Weight Wet Soil & Tare, g	110.45	Weight Soil & Tare Before Wash, g	593.87
Weight Dry Soil & Tare, g	96.50	Weight Soil & Tare After Wash, g	409.67
Weight Tare, g	33.58	Weight Tare, g	190.77
Weight Water, g	13.95	Weight Fines Lost, g	111.05
Weight Dry Soil, g	62.92	Weight Dry Soil, g	329.95
Moisture, %	**22.17%**	Fines Lost, %	**33.66%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.33	0.10%	**99.90%**	#20	
Fine Sand	#40	8.71	2.64%	**97.36%**	#40	Fine Sand
	#60	62.54	18.95%	**81.05%**	#60	
	#100	139.67	42.33%	**57.67%**	#100	
	#200	216.10	65.50%	**34.50%**	#200	
Fines	PAN	219.27	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**Fine to medium SAND**		
% F GRVL:	**0.0%**	0.0%	Description:	**and clay (SC)**		
% C SAND:	**0.0%**					
% M SAND:	**2.6%**		LL:	**NA**		
% F SAND:	**62.9%**	65.5%	PL:	**NA**	DATE:	27-Oct-98
% FINES:	**34.5%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	**GRAVEL**		**SAND**			**FINES**

SAMPLE #:	**GA98 BH-9**
DEPTH (FEET):	**42-44'**
DESCRIPTION:	**Fine to medium SAND with some clay (SC)**

MC:	27.6%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	07-Oct-98
TECH:	BDM
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-9**
983-2344.001-2		**DEPTH (FEET):**	**42-44'**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	f39	Tare	75
Weight Wet Soil & Tare, g	192.75	Weight Soil & Tare Before Wash, g	769.48
Weight Dry Soil & Tare, g	158.18	Weight Soil & Tare After Wash, g	585.27
Weight Tare, g	32.98	Weight Tare, g	221.49
Weight Water, g	34.57	Weight Fines Lost, g	65.64
Weight Dry Soil, g	125.20	Weight Dry Soil, g	429.42
Moisture, %	**27.61%**	Fines Lost, %	**15.29%**

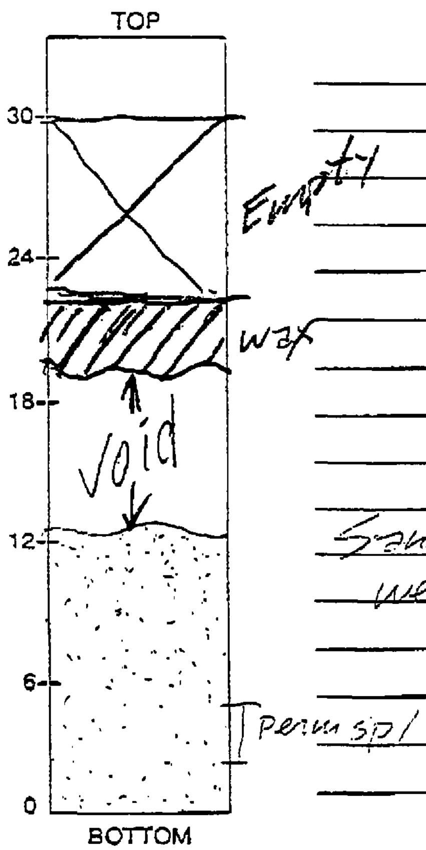
	SIEVE	**Wt. Ret.**	**% Ret.**	**% Pass.**	**SIEVE**	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.02	0.00%	**100.00%**	#10	Medium Sand
	#20	0.07	0.02%	**99.98%**	#20	
Fine Sand	#40	3.63	0.85%	**99.15%**	#40	Fine Sand
	#60	96.94	22.57%	**77.43%**	#60	
	#100	269.07	62.66%	**37.34%**	#100	
	#200	362.60	84.44%	**15.56%**	#200	
Fines	PAN	363.75	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**Fine to medium SAND with some clay (SC)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.8%**		LL:	NA		
% F SAND:	**83.6%**	84.4%	PL:	NA	DATE:	07-Oct-98
% FINES:	**15.6%**		PI:	NA	TECH:	BDM
% TOTAL:	**100.0%**		Gs:	NA	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344.001.2	BORING NUMBER	GA 98 BH9
PROJECT	Barrick/Mercur Tailings/Ut	SAMPLE NUMBER	
DATE	10/7/98	DEPTH	42-44



SAMPLE DESCRIPTION

Sand, medium gray, medium grain, wet

DENSITY

DIAMETER (cm)	7.26
LENGTH (cm)	30.35
WT. TUBE & WET SAMPLE (g)	3313.0
TUBE WT. (g)	875.7
WET WT. OF SAMPLE (g)	2437.3
AREA (cm²)	41.40
VOLUME (cm³)	1256.4
WET UNIT WT. (pcf)	121.1
DRY UNIT WT. (pcf)	94.5

WATER CONTENT DETERMINATION

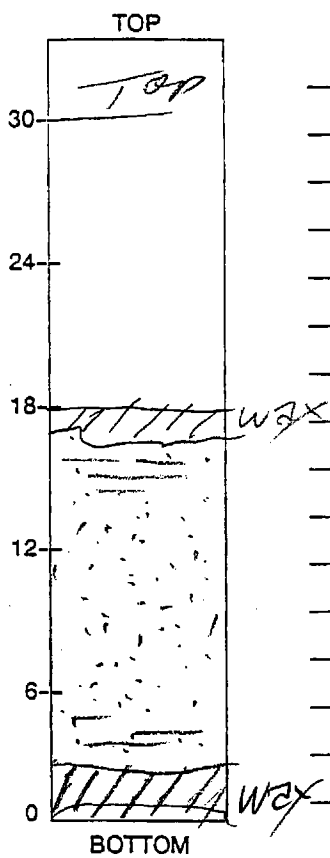
	1	2
TARE #	F39	X3
WET WT. & TARE (g)	192.75	150.71
DRY WT. & TARE (g)	158.18	124.39
TARE (g)	32.98	32.31
MOISTURE CONTENT (%)	27.6	28.6

28.1 Av

Post-it® Fax Note 7671	Date 10-26	# of pages ▶ 1
To Doug Jeneveun	From Dave Dix	
Co./Dept.	Co.	
Phone #	Phone #	
Fax #	Fax #	

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001-2	BORING NUMBER	GA98 BH9
PROJECT	Barrick/Mercur Tailings/UT	SAMPLE NUMBER	
DATE		DEPTH	60-62



SAMPLE DESCRIPTION

Sand, medium gray, moist, medium grained, w/ slime streaks, interlaminated

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	37.95
WT. TUBE & WET SAMPLE (g)	4250.2
TUBE WT. (g)	1162.0
WET WT. OF SAMPLE (g)	3088.2
AREA (cm^2)	41.17
VOLUME (cm^3)	1562.4
WET UNIT WT. (pcf)	123.3
DRY UNIT WT. (pcf)	99.0

WATER CONTENT DETERMINATION

	1	2
TARE #	F32	X19
WET WT. & TARE (g)	272.03	193.37
DRY WT. & TARE (g)	225.00	161.84
TARE (g)	32.31	32.94
MOISTURE CONTENT (%)	24.9	24.5

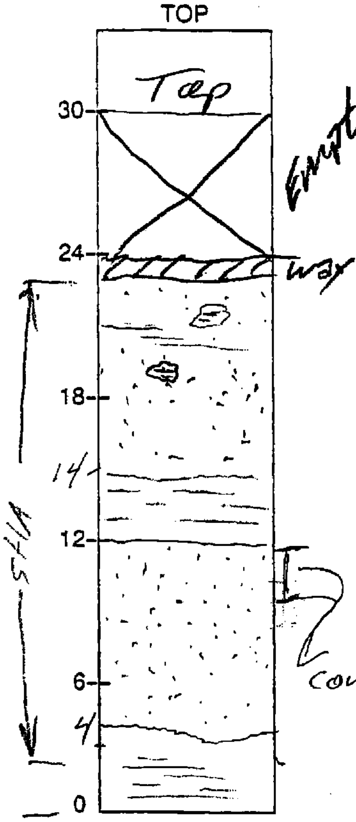
LAB WORK DONE BY: ____________________

APPROVED BY: ____________________

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER: 983-2344 001.2 | BORING NUMBER: GA 98 BH 9
PROJECT: Barrick/Mercur Tailings/Ut | SAMPLE NUMBER:
DATE: 10/12/98 | DEPTH: 80-82

TOP



BOTTOM

SAMPLE DESCRIPTION

sand, gray brown moist, slimy/w slime streaks, medium grained, slime balls common.

slime, yellow brown, moist

sand, brown, moist to wet, medium to fine grained

slime, medium brown, moist ~~to wet~~

NOTE: SHA sample represents entire interval

DENSITY

DIAMETER (cm)	7.25
LENGTH (cm)	49.20
WT. TUBE & WET SAMPLE (g)	5548.8
TUBE WT. (g)	1505.1
WET WT. OF SAMPLE (g)	4043.8
AREA (cm^2)	41.28
VOLUME (cm^3)	2031.1
WET UNIT WT. (pcf)	124.2
DRY UNIT WT. (pcf)	99.8

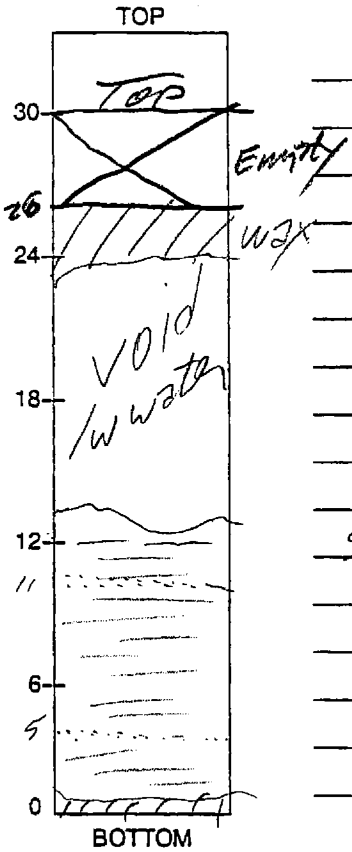
WATER CONTENT DETERMINATION

	1	2
TARE #	~~X24~~	X 31
WET WT. & TARE (g)		176.42
DRY WT. & TARE (g)		148.27
TARE (g)	~~14~~	33.12
MOISTURE CONTENT (%)		24.4

LAB WORK DONE BY:
APPROVED BY:

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER	983-2344.001,2	BORING NUMBER	GA98-BH9
PROJECT	Barrick/Marcus Tailings/UT	SAMPLE NUMBER	
DATE		DEPTH	100-102



SAMPLE DESCRIPTION

Slime medium brown, very moist to wet /w occasional sandy streaks

DENSITY

DIAMETER (cm)	7.27
LENGTH (cm)	20.75
WT. TUBE & WET SAMPLE (g)	2331.78
TUBE WT. (g)	631.57
WET WT. OF SAMPLE (g)	1700.2
AREA (cm²)	41.51
VOLUME (cm³)	861.3
WET UNIT WT. (pcf)	123.2
DRY UNIT WT. (pcf)	97.2

WATER CONTENT DETERMINATION

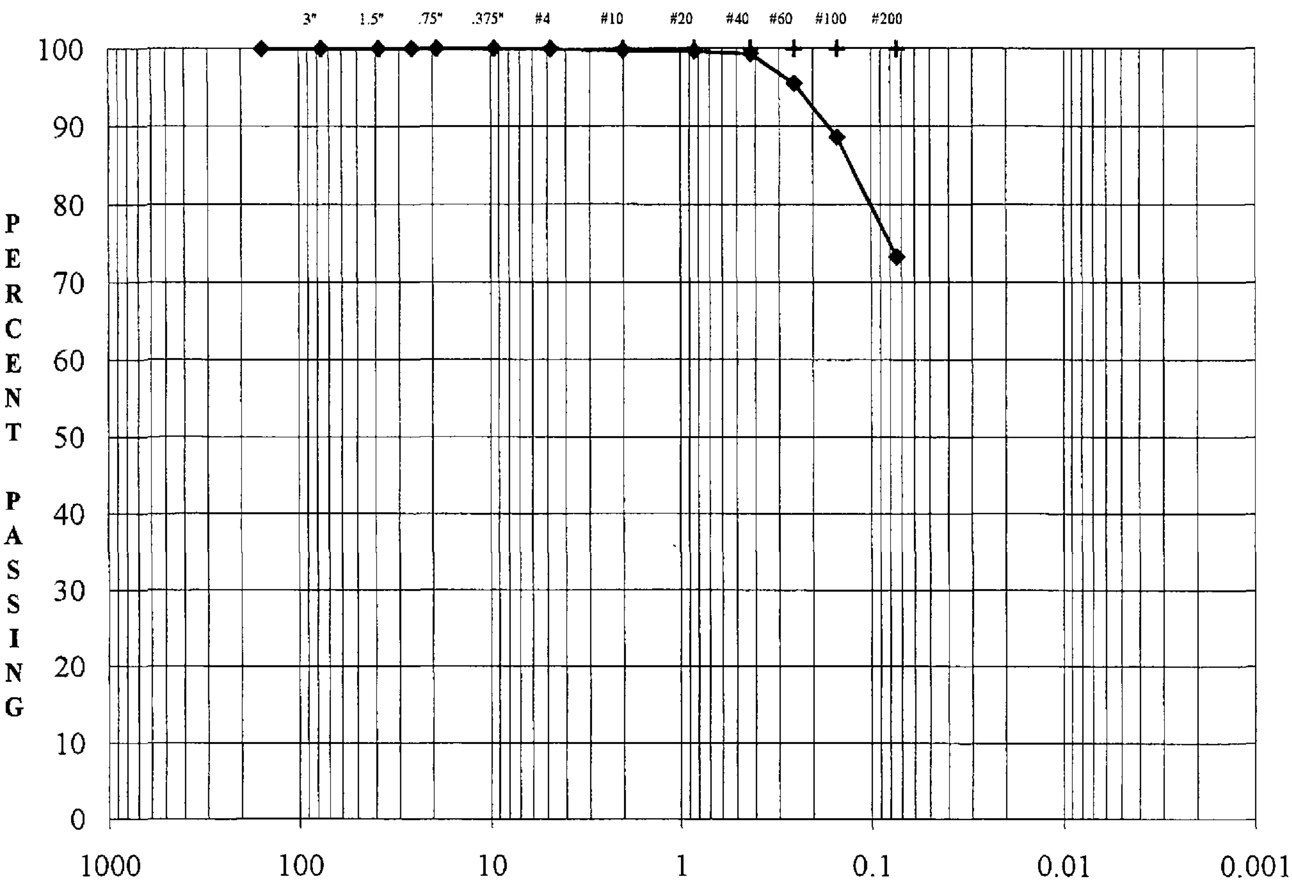
	1	2
TARE #	F25	F40
WET WT. & TARE (g)	179.24	155.52
DRY WT. & TARE (g)	148.33	129.67
TARE (g)	32.66	32.74
MOISTURE CONTENT (%)	26.7	26.7

26.7

LAB WORK DONE BY:

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #: GA98 BH-9
122-124

DESCRIPTION: CLAY with some fine to corse sand, trace fine gravel (CL)

MC:	20.1%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	29-Sep-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	GA98 BH-9
983-2344.001-2		**DEPTH (FEET):**	122-124

MOISTURE CONTENT (Delivered Moisture) | **#200 WASH (Percent Fines)**

Tare	F23	Tare	O5
Weight Wet Soil & Tare, g	186.50	Weight Soil & Tare Before Wash, g	774.88
Weight Dry Soil & Tare, g	160.86	Weight Soil & Tare After Wash, g	310.48
Weight Tare, g	33.60	Weight Tare, g	166.75
Weight Water, g	25.64	Weight Fines Lost, g	362.42
Weight Dry Soil, g	127.26	Weight Dry Soil, g	506.15
Moisture, %	**20.15%**	Fines Lost, %	**71.60%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.41	0.08%	**99.92%**	#4	Coarse Sand
Medium Sand	#10	1.06	0.21%	**99.79%**	#10	Medium Sand
	#20	1.66	0.33%	**99.67%**	#20	
Fine Sand	#40	3.50	0.69%	**99.31%**	#40	Fine Sand
	#60	22.75	4.49%	**95.51%**	#60	
	#100	57.60	11.38%	**88.62%**	#100	
	#200	135.53	26.78%	**73.22%**	#200	
Fines	PAN	144.22	0.00%	**100.00%**	PAN	Fines

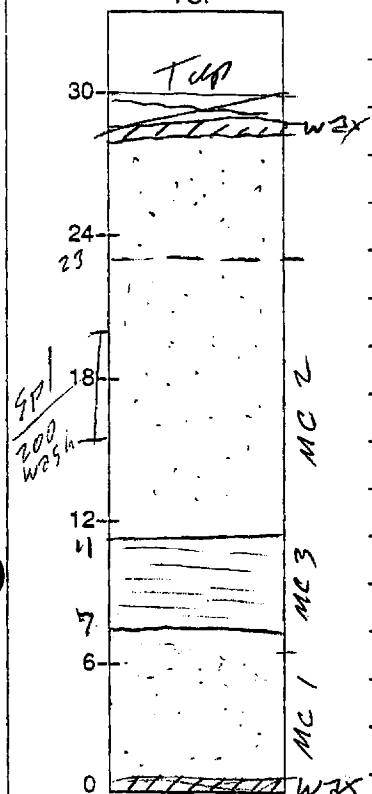
% C GRVL:	**0.0%**		Wet Color:	**CLAY with some fine to corse sand, trace fine gravel (CL)**		
% F GRVL:	**0.1%**	0.1%	Description:			
% C SAND:	**0.1%**					
% M SAND:	**0.5%**		LL:	**NA**		
% F SAND:	**26.1%**	26.7%	PL:	**NA**	DATE:	29-Sep-98
% FINES:	**73.2%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344.001-2
PROJECT Barrick/Mercur Tailings/UT
DATE 9/24
BORING NUMBER GA98 BH9
SAMPLE NUMBER
DEPTH 122-124

TOP



BOTTOM

SAMPLE DESCRIPTION

sand, olive gray, fine to medium grained very fine grained in part, part slimey

slime, olive gray moist to wet
sand, dark green-brown, fine-medium grained moist to wet

DENSITY

DIAMETER (cm)	7.27
LENGTH (cm)	55.70
WT. TUBE & WET SAMPLE (g)	6292.6
TUBE WT. (g)	1617.4
WET WT. OF SAMPLE (g)	4675.2
AREA (cm²)	41.51
VOLUME (cm³)	2312.1
WET UNIT WT. (pcf)	126.2
DRY UNIT WT. (pcf)	102.3

WATER CONTENT DETERMINATION

	1	2	~~2~~ 3
TARE #	CC1A	DD1	K23
WET WT. & TARE (g)	311.01	363.77	53.31
DRY WT. & TARE (g)	268.06	310.97	46.48
TARE (g)	84.03	84.22	21.90
MOISTURE CONTENT (%)	23.3	23.3	27.8
			slime

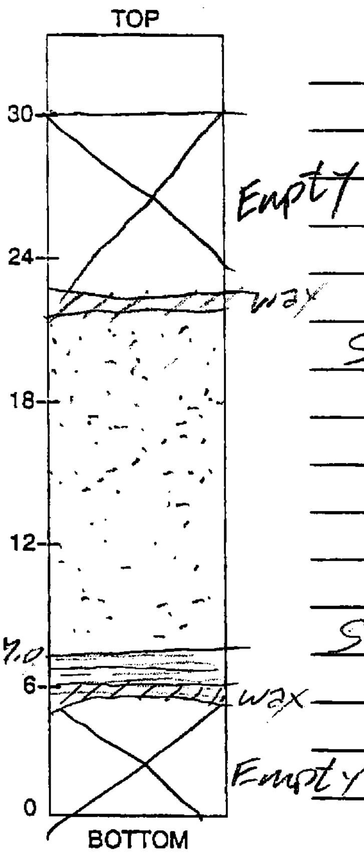
23.3%

LAB WORK DONE BY:
APPROVED BY:

8146.7 Total Tube

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-1344 001.2	BORING NUMBER	GA98 BH 9
PROJECT	Barrick/Mercur Tailings/UT	SAMPLE NUMBER	
DATE		DEPTH	142-144



SAMPLE DESCRIPTION

Sand, medium brown, wet, fine medium grained

Slime medium brown, very moist to wet soft

DENSITY

DIAMETER (cm)	7.27
LENGTH (cm)	29.30
WT. TUBE & WET SAMPLE (g)	3298.5
TUBE WT. (g)	904.4
WET WT. OF SAMPLE (g)	2394.1
AREA (cm²)	41.51
VOLUME (cm³)	1216.3
WET UNIT WT. (pcf)	122.8
DRY UNIT WT. (pcf)	99.8

WATER CONTENT DETERMINATION

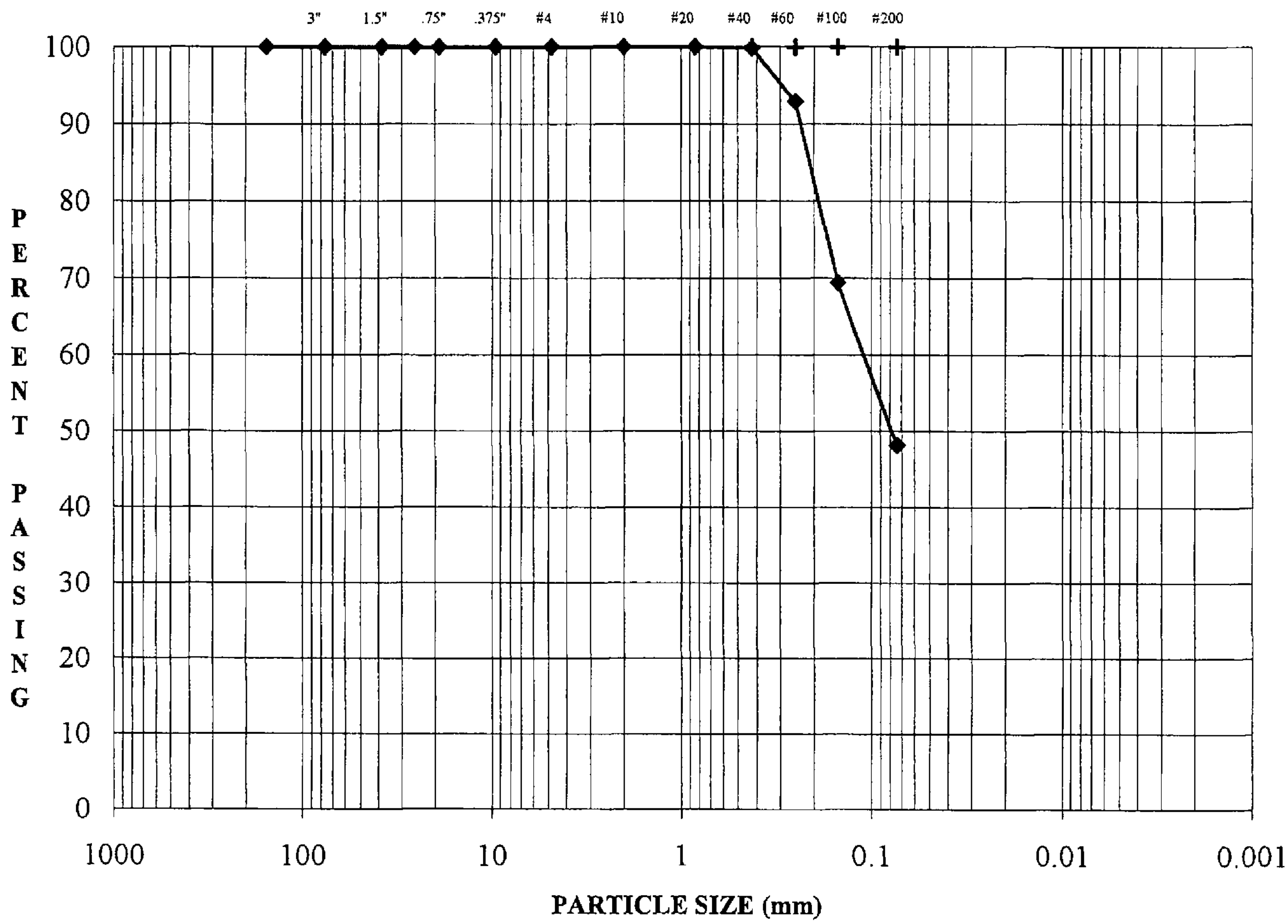
	1	2
TARE #	F17	3A
WET WT. & TARE (g)	167.10	158.85
DRY WT. & TARE (g)	142.97	134.30
TARE (g)	32.99	33.42
MOISTURE CONTENT (%)	21.9	24.3

23.1 AV

LAB WORK DONE BY:

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	GA98 BH-9	MC:	21.0%
DEPTH (FEET):	162-164	LL:	NA
		PL:	NA
DESCRIPTION:	SAND and clay (SC)	PI:	NA
		Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	29-Sep-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-9**
983-2344.001-2		**DEPTH (FEET):**	**162-164**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	METS	Tare	1
Weight Wet Soil & Tare, g	1046.30	Weight Soil & Tare Before Wash, g	1037.90
Weight Dry Soil & Tare, g	881.80	Weight Soil & Tare After Wash, g	591.23
Weight Tare, g	98.11	Weight Tare, g	217.30
Weight Water, g	164.50	Weight Fines Lost, g	304.31
Weight Dry Soil, g	783.69	Weight Dry Soil, g	678.24
Moisture, %	**20.99%**	Fines Lost, %	**44.87%**

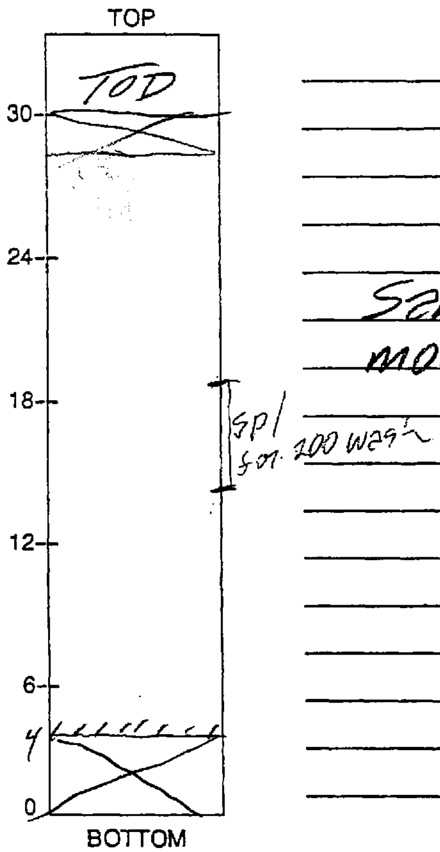
	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.05	0.01%	**99.99%**	#10	Medium Sand
	#20	0.12	0.02%	**99.98%**	#20	
Fine Sand	#40	0.89	0.13%	**99.87%**	#40	Fine Sand
	#60	48.12	7.09%	**92.91%**	#60	
	#100	207.63	30.61%	**69.39%**	#100	
	#200	351.53	51.83%	**48.17%**	#200	
Fines	PAN	374.08	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**SAND and clay (SC)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.1%**		LL:	**NA**		
% F SAND:	**51.7%**	51.8%	PL:	**NA**	DATE:	29-Sep-98
% FINES:	**48.2%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001-2	BORING NUMBER	GA98 BH9
PROJECT	Barrick/Mercur Tailings/UT	SAMPLE NUMBER	
DATE	9/25/98	DEPTH	162-164



SAMPLE DESCRIPTION

Sand, olive gray, brown, fine grained
moist to wet -

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	43.2
WT. TUBE & WET SAMPLE (g)	5051.4
TUBE WT. (g)	1325.4
WET WT. OF SAMPLE (g)	3726.0
AREA (cm²)	41.17
VOLUME (cm³)	1778.5
WET UNIT WT. (pcf)	130.7
DRY UNIT WT. (pcf)	108.1

WATER CONTENT DETERMINATION

	1	2
TARE #	69 Mets	
WET WT. & TARE (g)	1046.3	
DRY WT. & TARE (g)	881.8	
TARE (g)	98.11	
MOISTURE CONTENT (%)	21.0	

LAB WORK DONE BY:

APPROVED BY:

6899.2

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344 001.2
PROJECT Barrick/Mercur Tailings
DATE 10/13/98

BORING NUMBER GA98 BH9
SAMPLE NUMBER
DEPTH 180-182

TOP

30 Top
Empty
25.5
Wax
24

18

12

6

0 Wax
BOTTOM

SAMPLE DESCRIPTION

Sand, medium brown, very fine grained, silty moist to wet, slimey

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	54.05
WT. TUBE & WET SAMPLE (g)	6428.4
TUBE WT. (g)	1656.8
WET WT. OF SAMPLE (g)	4771.6
AREA (cm^2)	41.17
VOLUME (cm^3)	2225.7
WET UNIT WT. (pcf)	133.8
DRY UNIT WT. (pcf)	113.1

WATER CONTENT DETERMINATION

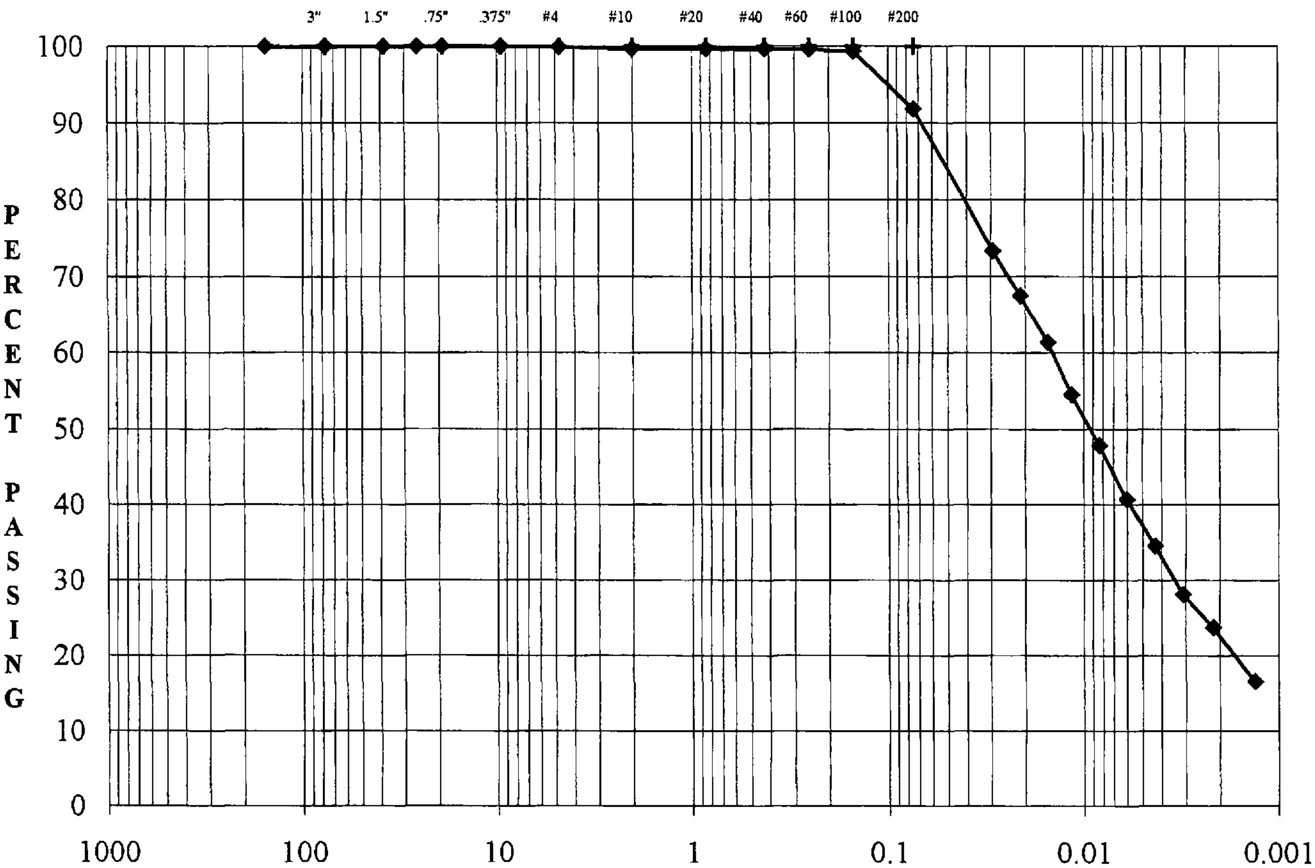
	1	2
TARE #	X9	F28
WET WT. & TARE (g)	155.89	170.38
DRY WT. & TARE (g)	136.84	149.04
TARE (g)	33.01	33.27
MOISTURE CONTENT (%)	18.3	18.4

18.3

LAB WORK DONE BY:

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	GRAVEL		SAND			FINES

SAMPLE #:	GA98-BH9 200-202
WET COLOR: DESCRIPTION:	SILTY CLAY with little fine to corse sand, trace fine gravel (CL-ML)

MC (As Tested	23.8%
LL:	29
PL:	22
PI:	7
Gs:	2.75

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2

DATE:	27-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILINGS/UT	**SAMPLE NUMBER:** GA98-BH9
983-2344.001-2	**DEPTH (ft):** 200-202

MOISTURE CONTENT (As Tested)

Tare	TARE
Weight Wet Soil & Tare, g	0.00
Weight Dry Soil & Tare, g	0.00
Weight Tare, g	0.00
Weight Water, g	0.00
Weight Dry Soil, g	0.00
Moisture Content, %	**#DIV/0!**

PERCENT PASSING #10 SIEVE

Total Weight, g	763.30
Weight Split #10, g	761.00
Percent Passing #10	99.70%

	SIEVE	Wt. Ret., g	% Ret.	% Pass.	SIEVE	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.63	0.08%	**99.92%**	#4	Coarse Sand
Medium Sand	#10	2.30	0.30%	**99.70%**	#10	Medium Sand

SAMPLE PREPARATION FOR HYDROMETER ANALYSIS

Percent Passing #10 Sieve	99.70	Initial Wet Weight	50.00
Specific Gravity	2.75	Calculated Dry Weight	49.83
Dispersing Agent, ml, Used (40 ml $Na(PO_4)n$ per 1,000 ml H_2O)	125		

MOISTURE CONTENT (Hygroscopic - #10)

Tare	S9		
Weight Wet Soil & Tare, g	120.45	LL:	29
Weight Dry Soil & Tare, g	120.14	PL:	22
Weight Tare, g	27.92	PI:	7
Weight Moisture, g	0.31	Gs:	2.75
Weight Dry Soil, g	92.22		
Moisture Content, %	**0.34%**		

PERCENT #10 TO #200 SIEVE CALCULATION

SEIVE	CUMUL. WT. RETAINED	CUMUL. WT. RET. CORR.	PERCENT PASSING	
#10	0.00	0.15	**99.70%**	#10 Medium Sand
#20	0.00	0.15	**99.70%**	#20
#40	0.02	0.17	**99.66%**	#40 Fine Sand
#60	0.06	0.21	**99.58%**	#60
#100	0.17	0.32	**99.36%**	#100
#200	3.94	4.09	**91.82%**	#200 Fines

DATE	TIME	TIME, CUM. (min)	READING R	TEMP. T	HYD. RDG. H	PARTICLE DIAMETER	PERCENT FINER
10/26/1998	07:53	2	41.4	22.7	4.01	0.029	**73.3%**
	07:55	4	38.4	22.7	4.01	0.021	**67.4%**
	07:59	8	35.3	22.7	4.01	0.015	**61.4%**
	08:06	15	31.8	22.7	4.01	0.011	**54.5%**
	08:21	30	28.4	22.8	3.98	0.008	**47.9%**
	08:51	60	24.7	22.9	3.94	0.006	**40.7%**
	09:51	120	21.5	23.1	3.88	0.004	**34.5%**
	11:51	240	18.0	23.7	3.69	0.003	**28.1%**
	15:51	480	15.3	25.2	3.21	0.002	**23.7%**
10/27/1998	07:51	1,440	12.5	22.5	4.07	0.001	**16.5%**

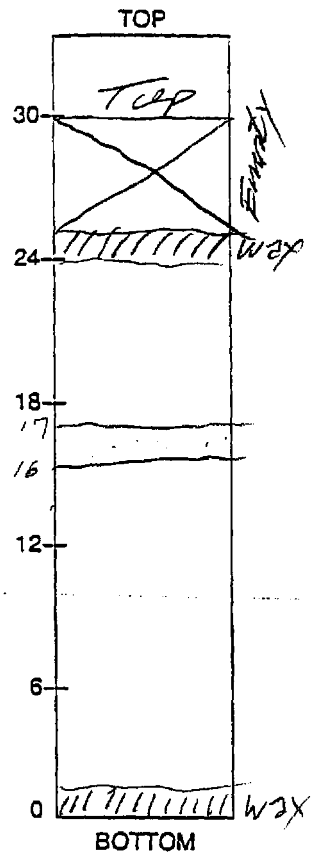
% C GRVL:	**0.0%**		
% F GRVL:	**0.1%**	**0.1%**	
% C SAND:	**0.2%**		Wet Color:
% M SAND:	**0.0%**		Description: **SILTY CLAY with little fine to corse sand, trace fine gravel (CL-ML)**
% F SAND:	**7.8%**	**8.1%**	
% FINES:	**91.8%**		
% TOTAL:	**100.00%**		

DATE:	10/27/1998
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344. 001-4
PROJECT Barrick/Mercur Tailings/UT
DATE 10/21/98
BORING NUMBER GA98 BH 9
SAMPLE NUMBER
DEPTH 200-202



SAMPLE DESCRIPTION

Slime, medium brown, moist, firm to slightly soft
sandy streak

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	55.9
WT. TUBE & WET SAMPLE (g)	6434.9
TUBE WT. (g)	1653.6
WET WT. OF SAMPLE (g)	4781.3
AREA (cm^2)	41.17
VOLUME (cm^3)	2301.3
WET UNIT WT. (pcf)	129.6
DRY UNIT WT. (pcf)	104.7

WATER CONTENT DETERMINATION

	1	2
TARE #	X 17	
WET WT. & TARE (g)	240.65	
DRY WT. & TARE (g)	200.73	
TARE (g)	33.09	
MOISTURE CONTENT (%)	23.8	

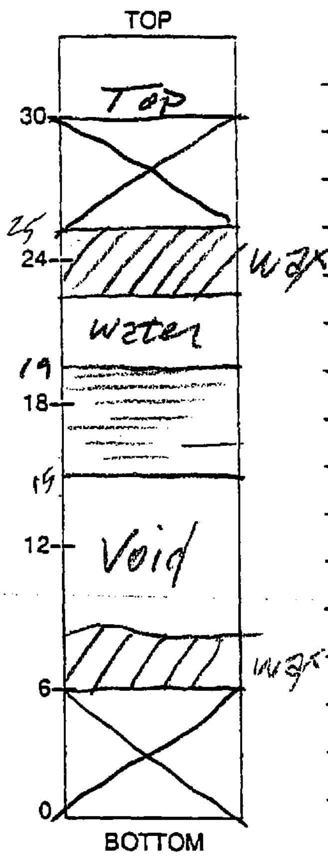
LAB WORK DONE BY:

APPROVED BY:

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER 983-2344.001.2
PROJECT Barrick/Mercury Tailing
DATE 10/13/98

BORING NUMBER GA98 BH9
SAMPLE NUMBER
DEPTH 220-222



SAMPLE DESCRIPTION

Slime, medium brown moist, soft to slightly firm -

Note: obtained weight & measurments for density from trimed sample.

DENSITY

DIAMETER (cm)	4.90
LENGTH (cm)	9.09
WT. TUBE & WET SAMPLE (g)	NA
TUBE WT. (g)	
WET WT. OF SAMPLE (g)	353.80
AREA (cm²)	18.86
VOLUME (cm³)	171.4
WET UNIT WT. (pcf)	128.8
DRY UNIT WT. (pcf)	104.4

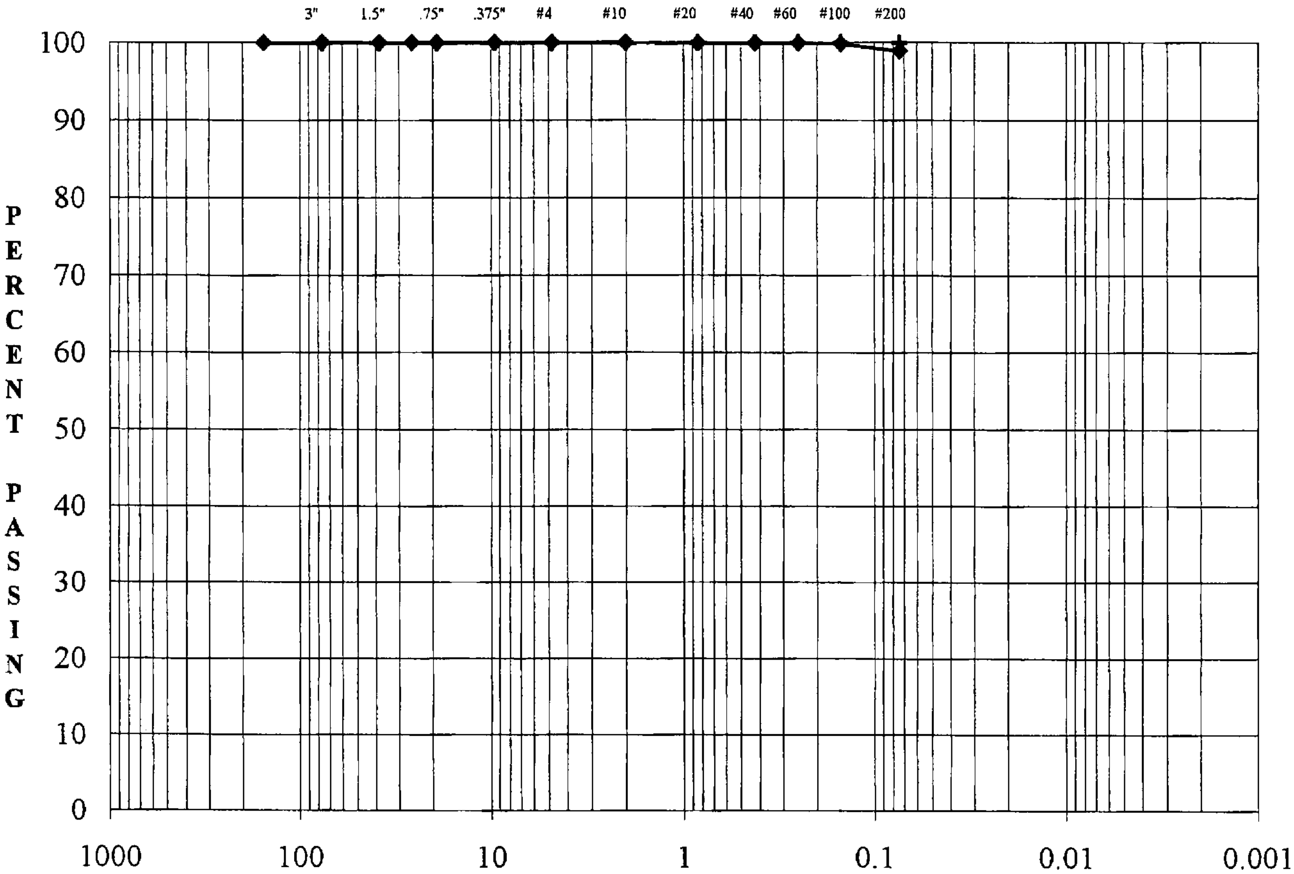
WATER CONTENT DETERMINATION

	1	2
TARE #	6A	X 10
WET WT. & TARE (g)	154.30	164.99
DRY WT. & TARE (g)	131.06	140.09
TARE (g)	31.63	33.17
MOISTURE CONTENT (%)	23.4	23.3

23.4

LAB WORK DONE BY:
APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
	GRAVEL		SAND			FINES

SAMPLE #:	GA98 BH-9	MC:	27.2%
DEPTH (FEET):	240-242	LL:	NA
		PL:	NA
DESCRIPTION:	CLAY with trace fine sand (CL)	PI:	NA
		Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	29-Sep-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-9**
983-2344.001-2		**DEPTH (FEET):**	**240-242**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	V-3	Tare	Z17
Weight Wet Soil & Tare, g	359.82	Weight Soil & Tare Before Wash, g	662.10
Weight Dry Soil & Tare, g	301.10	Weight Soil & Tare After Wash, g	201.85
Weight Tare, g	85.00	Weight Tare, g	190.46
Weight Water, g	58.72	Weight Fines Lost, g	359.48
Weight Dry Soil, g	216.10	Weight Dry Soil, g	370.87
Moisture, %	**27.17%**	Fines Lost, %	**96.93%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.08	0.02%	**99.98%**	#10	Medium Sand
	#20	0.17	0.05%	**99.95%**	#20	
Fine Sand	#40	0.20	0.05%	**99.95%**	#40	Fine Sand
	#60	0.29	0.08%	**99.92%**	#60	
	#100	0.49	0.13%	**99.87%**	#100	
	#200	3.88	1.05%	**98.95%**	#200	
Fines	PAN	11.44	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**			Wet Color:	**CLAY with trace fine sand (CL)**	
% F GRVL:	**0.0%**	0.0%		Description:		
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	NA		
% F SAND:	**1.0%**	1.0%	PL:	NA	DATE:	29-Sep-98
% FINES:	**99.0%**		PI:	NA	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	NA	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001-2	BORING NUMBER	98 BH9
PROJECT	Barrick/Mercur Tailings/Ut	SAMPLE NUMBER	
DATE	9/28/98	DEPTH	240 - 242

TOP

30
Top
24
18
Moist #2
12
6
Moist #1
0

BOTTOM

SAMPLE DESCRIPTION

Slime, medium gray, soft to s/ firm, moist

Water Content

Tare #	V-3
wt wt	359.82
Dry wt	301.10
tare wt	85.00
MC %	27.2

DENSITY

DIAMETER (cm)	7.27
LENGTH (cm)	55.50
WT. TUBE & WET SAMPLE (g)	6284.0
TUBE WT. (g)	1622.2
WET WT. OF SAMPLE (g)	4661.8
AREA (cm²)	41.51
VOLUME (cm³)	2303.8
WET UNIT WT. (pcf)	126.3
DRY UNIT WT. (pcf)	99.3

WATER CONTENT DETERMINATION

	1	2
TARE #	~~F 39~~	~~X19~~
WET WT. & TARE (g)	~~336.42~~	~~383.85~~
DRY WT. & TARE (g)	~~189.35~~	~~239.36~~
TARE (g)	~~32.97~~	~~32.93~~
MOISTURE CONTENT (%)	~~94.0~~	~~70.0~~

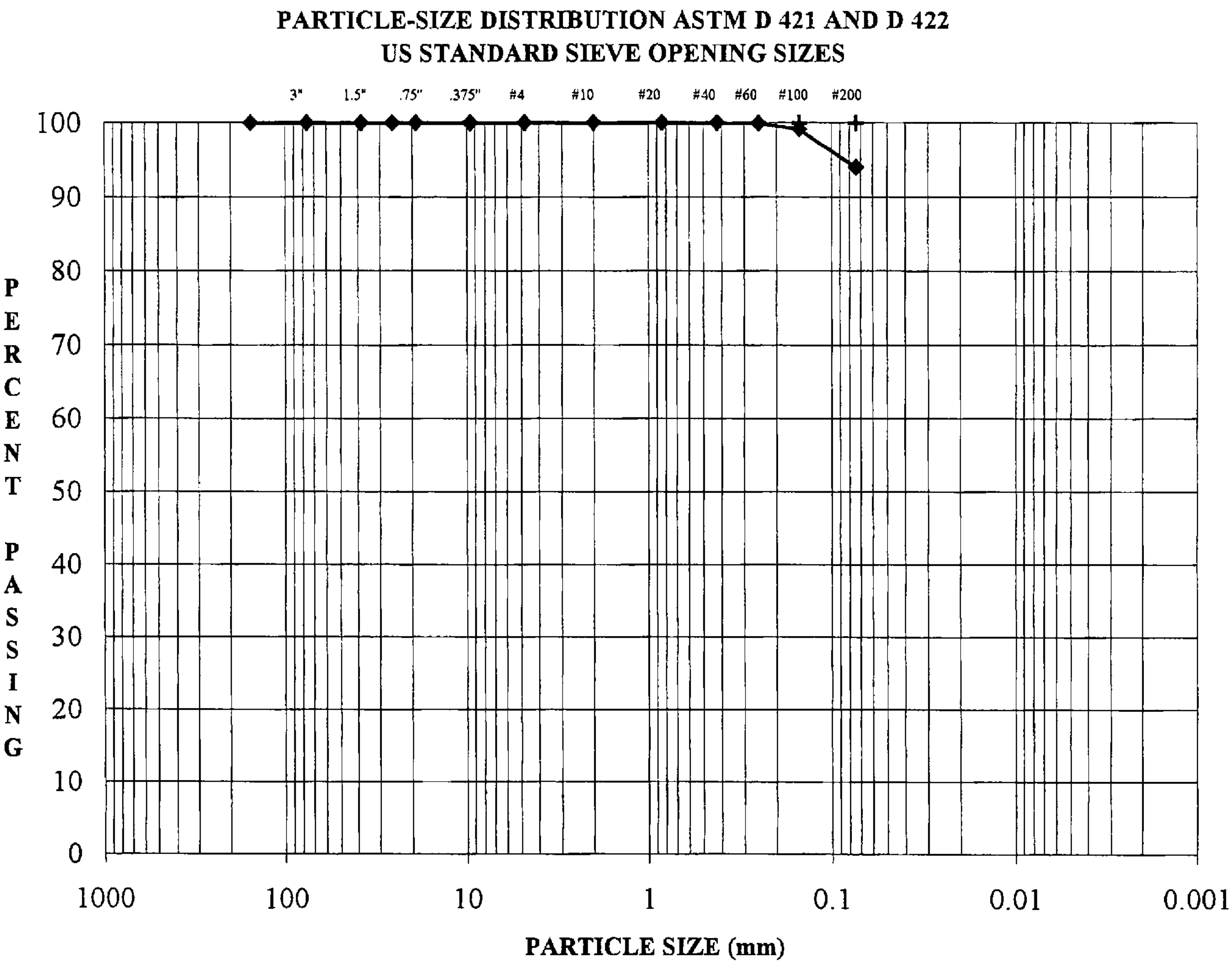
~~82.0~~ Average

Bust?

LAB WORK DONE BY: Bdm

APPROVED BY:

93670



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #: GA98 BH-10
DEPTH (FEET): 20-22
DESCRIPTION: CLAY with little fine sand (CL)

MC:	30.8%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	29-Sep-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		SAMPLE #:	GA98 BH-10
983-2344.001-2		DEPTH (FEET):	20-22

MOISTURE CONTENT (Delivered Moisture)

Tare	X9
Weight Wet Soil & Tare, g	192.91
Weight Dry Soil & Tare, g	155.41
Weight Tare, g	33.51
Weight Water, g	37.50
Weight Dry Soil, g	121.90
Moisture, %	**30.76%**

#200 WASH (Percent Fines)

Tare	15D
Weight Soil & Tare Before Wash, g	609.56
Weight Soil & Tare After Wash, g	180.76
Weight Tare, g	157.02
Weight Fines Lost, g	322.34
Weight Dry Soil, g	346.08
Fines Lost, %	**93.14%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.01	0.00%	**100.00%**	#20	
Fine Sand	#40	0.02	0.01%	**99.99%**	#40	Fine Sand
	#60	0.40	0.12%	**99.88%**	#60	
	#100	2.95	0.85%	**99.15%**	#100	
	#200	20.73	5.99%	**94.01%**	#200	
Fines	PAN	23.77	0.00%	**100.00%**	PAN	Fines

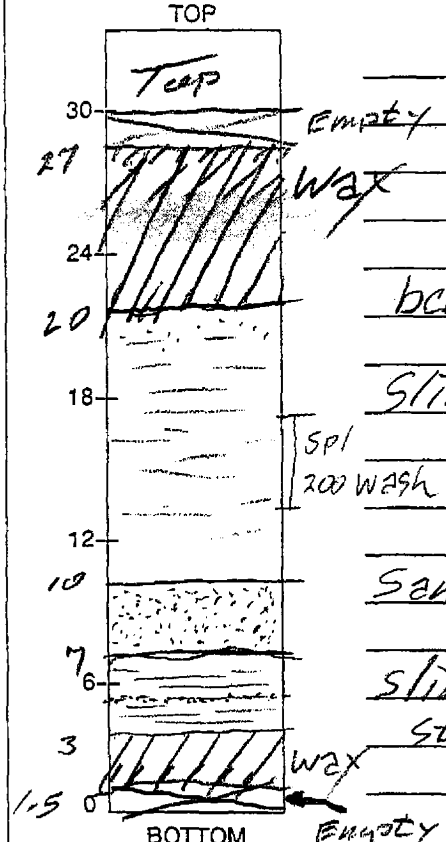
% C GRVL:	**0.0%**		Wet Color:	**CLAY with little fine**		
% F GRVL:	**0.0%**	0.0%	Description:	**sand (CL)**		
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**NA**		
% F SAND:	**6.0%**	6.0%	PL:	**NA**	DATE:	29-Sep-98
% FINES:	**94.0%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344, 001-2	BORING NUMBER	GA96 BH 10
PROJECT	Barrick/Mercur Tail/Ut	SAMPLE NUMBER	
DATE		DEPTH	20-22

TOP



BOTTOM

SAMPLE DESCRIPTION

bcom sandy @ Top

Slime, medium brown, olive - moist to wet

Sand, fine grained, medium gray, moist

slime, olive gray-brown, soft, wet thin sandy streek

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	45.61
WT. TUBE & WET SAMPLE (g)	4951.3
TUBE WT. (g)	1448.4
WET WT. OF SAMPLE (g)	3502.9
AREA (cm²)	41.17
VOLUME (cm³)	1877.7
WET UNIT WT. (pcf)	119.1
DRY UNIT WT. (pcf)	90.4

WATER CONTENT DETERMINATION

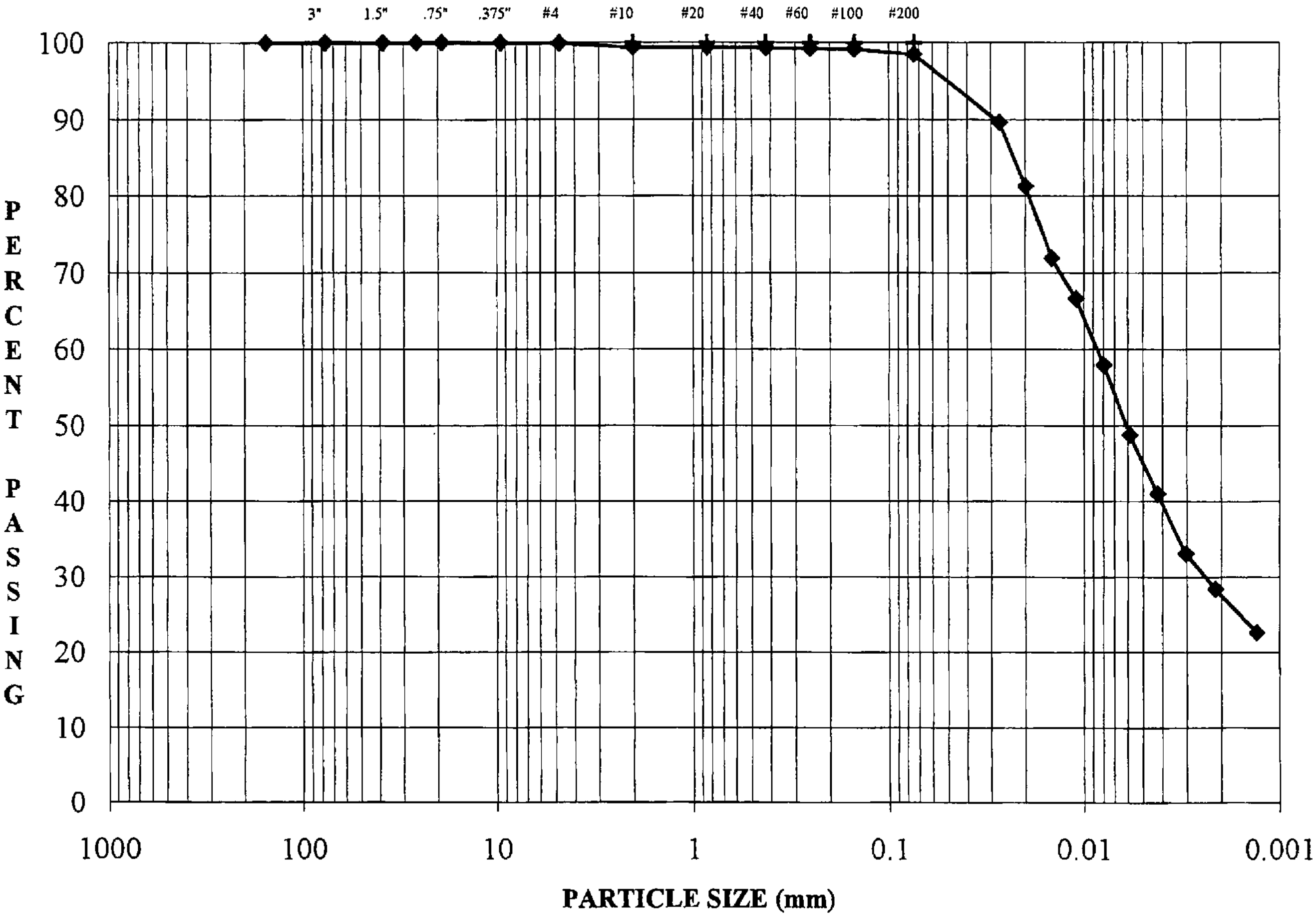
	1	2
TARE #	5-13	
WET WT. & TARE (g)	739.61	
DRY WT. & TARE (g)	599.52	
TARE (g)	158.08	
MOISTURE CONTENT (%)	31.7	

LAB WORK DONE BY: Bdm

APPROVED BY:

6803.4

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	**GRAVEL**		**SAND**			**FINES**

SAMPLE #:	**GA98-BH10 40-42**		**MC (As Tested**	**30.3%**
			LL:	**LL**
			PL:	**PL**
WET COLOR: DESCRIPTION:	**CLAY with trace fine to coarse sand, trace fine gravel (CL)**		**PI:**	**PI**
			Gs:	**2.77**

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2

DATE:	**30-Oct-98**
TECH:	**ZE**
REVIEW:	**DMD**

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILINGS/UT		**SAMPLE NUMBER:**	GA98-BH10
983-2344.001-2		**DEPTH (ft):**	40-42

MOISTURE CONTENT (As Tested)

Tare	TARE
Weight Wet Soil & Tare, g	0.00
Weight Dry Soil & Tare, g	0.00
Weight Tare, g	0.00
Weight Water, g	0.00
Weight Dry Soil, g	0.00
Moisture Content, %	#DIV/0!

PERCENT PASSING #10 SIEVE

Total Weight, g	702.40
Weight Split #10, g	698.35
Percent Passing #10	99.42%

	SIEVE	Wt. Ret., g	% Ret.	% Pass.	SIEVE	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.87	0.12%	**99.88%**	#4	Coarse Sand
Medium Sand	#10	4.05	0.58%	**99.42%**	#10	Medium Sand

SAMPLE PREPARATION FOR HYDROMETER ANALYSIS

Percent Passing #10 Sieve	99.42	Initial Wet Weight	50.00
Specific Gravity	2.77	Calculated Dry Weight	49.64
Dispersing Agent, ml, Used (40 ml $Na(PO_4)n$ per 1,000 ml H_2O)	125		

MOISTURE CONTENT (Hygroscopic - #10)

Tare	F30
Weight Wet Soil & Tare, g	188.64
Weight Dry Soil & Tare, g	187.52
Weight Tare, g	32.86
Weight Moisture, g	1.12
Weight Dry Soil, g	154.66
Moisture Content, %	0.72%

LL:	LL
PL:	PL
PI:	PI
Gs:	2.77

PERCENT #10 TO #200 SIEVE CALCULATION

SEIVE	CUMUL. WT. RETAINED	CUMUL. WT. RET. CORR.	PERCENT PASSING		
#10	0.00	0.29	**99.42%**	#10	Medium Sand
#20	0.00	0.29	**99.42%**	#20	
#40	0.05	0.34	**99.32%**	#40	Fine Sand
#60	0.11	0.40	**99.20%**	#60	
#100	0.14	0.43	**99.14%**	#100	
#200	0.48	0.77	**98.46%**	#200	Fines

DATE	TIME	TIME, CUM. (min)	READING R	TEMP. T	HYD. RDG. H	PARTICLE DIAMETER	PERCENT FINER
10/29/1998	08:32	2	49.4	23.5	3.75	0.027	**89.6%**
	08:34	4	45.2	23.4	3.78	0.020	**81.3%**
	08:38	8	40.4	23.5	3.75	0.015	**71.9%**
	08:45	15	37.7	23.5	3.75	0.011	**66.6%**
	09:00	30	33.3	23.4	3.78	0.008	**57.9%**
	09:30	60	28.6	23.5	3.75	0.006	**48.8%**
	10:30	120	24.5	23.9	3.62	0.004	**41.0%**
	12:30	240	20.3	24.4	3.46	0.003	**33.0%**
	16:30	480	17.6	25.4	3.14	0.002	**28.4%**
10/30/1998	08:30	1,440	15.8	21.9	4.26	0.001	**22.6%**

% C GRVL:	0.0%	
% F GRVL:	0.1%	**0.1%**
% C SAND:	0.5%	
% M SAND:	0.1%	
% F SAND:	0.9%	**1.4%**
% FINES:	98.5%	
% TOTAL:	100.00%	

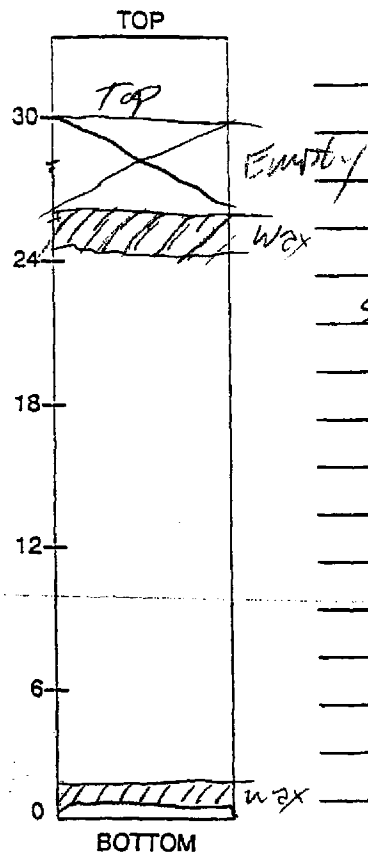
Wet Color: Description: **CLAY with trace fine to coarse sand, trace fine gravel (CL)**

DATE:	10/30/1998
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001-2	BORING NUMBER	GA 98 BH 10
PROJECT	Barrick/Mercur Tailings/ut	SAMPLE NUMBER	
DATE	10/22/98	DEPTH	40-42



SAMPLE DESCRIPTION

Slime, medium brown, redish brown, very moist, soft to slightly firm sticky

DENSITY

DIAMETER (cm)	7.26
LENGTH (cm)	53.3
WT. TUBE & WET SAMPLE (g)	5764.9
TUBE WT. (g)	1595.0
WET WT. OF SAMPLE (g)	4169.9
AREA (cm²)	41.40
VOLUME (cm³)	2206.9
WET UNIT WT. (pcf)	117.9
DRY UNIT WT. (pcf)	90.5

WATER CONTENT DETERMINATION

	1	2
TARE #	3A	2A
WET WT. & TARE (g)	246.69	308.45
DRY WT. & TARE (g)	197.32	244.31
TARE (g)	33.44	33.95
MOISTURE CONTENT (%)	30.1	30.5

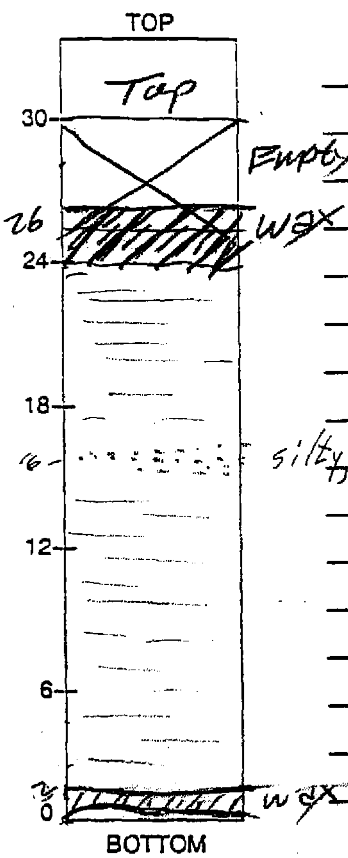
30.3

LAB WORK DONE BY:

APPROVED BY:

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001.2	BORING NUMBER	GA98 BH 10
PROJECT	Barrick/Mercury Tailings/Ut	SAMPLE NUMBER	C
DATE	10/15/98	DEPTH	60-62



SAMPLE DESCRIPTION

Slime, medium brown, yellow brown
very moist to wet, soft to slightly firm

silty, sandy streak,

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	55.50
WT. TUBE & WET SAMPLE (g)	5960.6
TUBE WT. (g)	1599.0
WET WT. OF SAMPLE (g)	4361.6
AREA (cm^2)	41.17
VOLUME (cm^3)	2284.9
WET UNIT WT. (pcf)	119.1
DRY UNIT WT. (pcf)	92.6

WATER CONTENT DETERMINATION

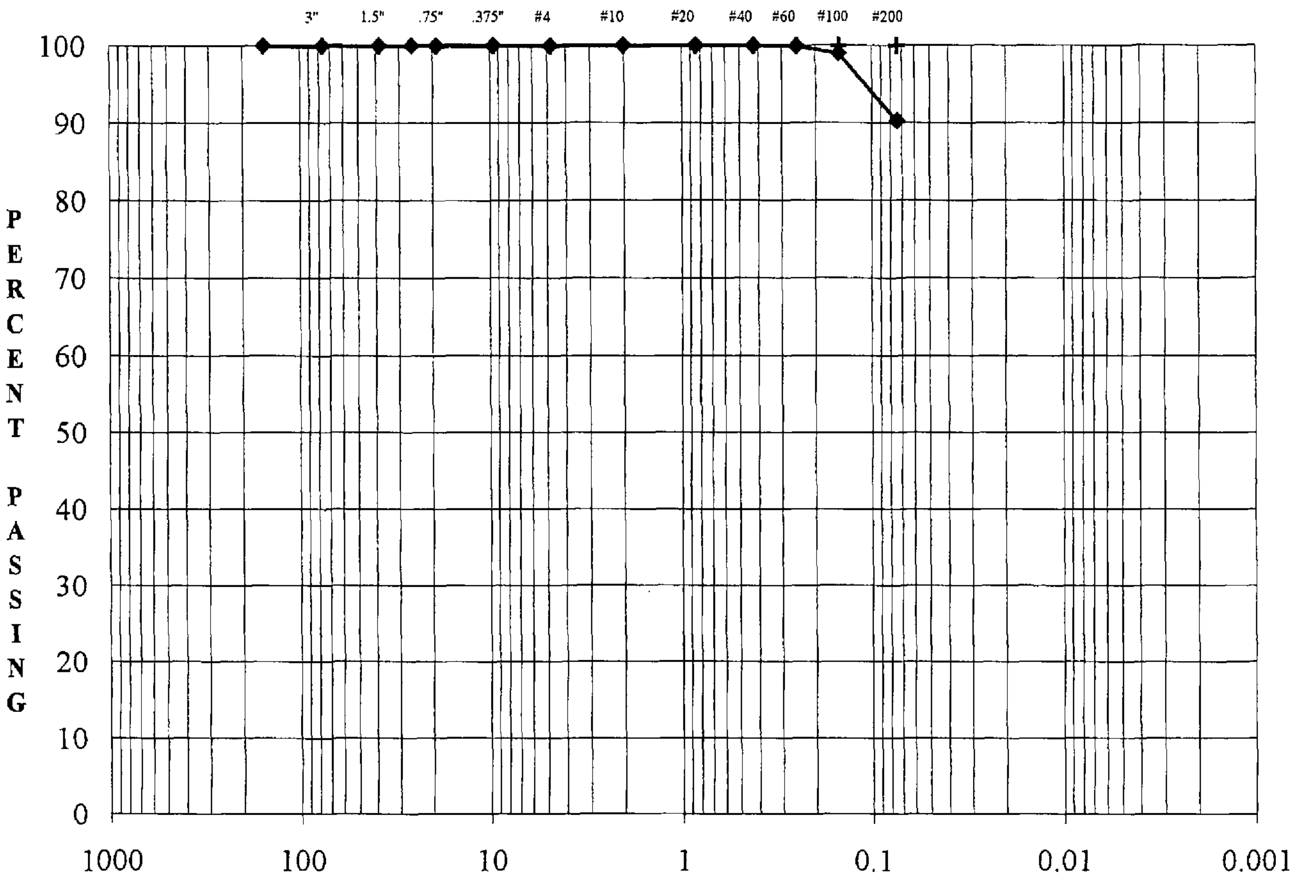
	1	2
TARE #	3A	F40
WET WT. & TARE (g)	245.72	203.95
DRY WT. & TARE (g)	198.38	166.03
TARE (g)	33.41	32.74
MOISTURE CONTENT (%)	28.7	28.4

28.6 avg

LAB WORK DONE BY: [signature]

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	GRAVEL		SAND			FINES

SAMPLE #:	GA98 BH-10	MC:	26.0%
DEPTH (FEET):	80-82	LL:	NA
		PL:	NA
DESCRIPTION:	CLAY with little fine sand (CL)	PI:	NA
		Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	02-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-10**
983-2344.001-2		**DEPTH (FEET):**	**80-82**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	Z8	Tare	O5
Weight Wet Soil & Tare, g	646.96	Weight Soil & Tare Before Wash, g	620.98
Weight Dry Soil & Tare, g	547.85	Weight Soil & Tare After Wash, g	205.41
Weight Tare, g	166.58	Weight Tare, g	166.85
Weight Water, g	99.11	Weight Fines Lost, g	321.88
Weight Dry Soil, g	381.27	Weight Dry Soil, g	360.44
Moisture, %	**25.99%**	Fines Lost, %	**89.30%**

	SIEVE	**Wt. Ret.**	**% Ret.**	**% Pass.**	**SIEVE**	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.02	0.01%	**99.99%**	#10	Medium Sand
	#20	0.06	0.02%	**99.98%**	#20	
Fine Sand	#40	0.07	0.02%	**99.98%**	#40	Fine Sand
	#60	0.23	0.06%	**99.94%**	#60	
	#100	3.54	0.98%	**99.02%**	#100	
	#200	35.18	9.76%	**90.24%**	#200	
Fines	PAN	38.62	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**CLAY with little fine sand (CL)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**NA**		
% F SAND:	**9.7%**	9.8%	PL:	**NA**	DATE:	02-Oct-98
% FINES:	**90.2%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001-2	BORING NUMBER	GA98 BH10
PROJECT	Barrick/Mercur Tailings/Ut	SAMPLE NUMBER	
DATE	10/2/98	DEPTH	80-82

TOP

SAMPLE DESCRIPTION

30 — TOP

Empty

24

wax — sandy @ Top

18

Silt, yellow brown, predominantly soft moist, part wet

12

6

slightly sandy streak

0 — wax

BOTTOM

DENSITY

DIAMETER (cm)	7.27
LENGTH (cm)	45.75
WT. TUBE & WET SAMPLE (g)	5046.6
TUBE WT. (g)	1313.6
WET WT. OF SAMPLE (g)	3733.0
AREA (cm^2)	41.51
VOLUME (cm^3)	1899.1
WET UNIT WT. (pcf)	122.7
DRY UNIT WT. (pcf)	97.4

WATER CONTENT DETERMINATION

	1	2
TARE #	Z8	
WET WT. & TARE (g)	646.96	
DRY WT. & TARE (g)	547.85	
TARE (g)	166.58	
MOISTURE CONTENT (%)	26.0	

sampled full length for Moisture & grainsize Test

LAB WORK DONE BY: Bdm

APPROVED BY:

6412.8

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344.001.2

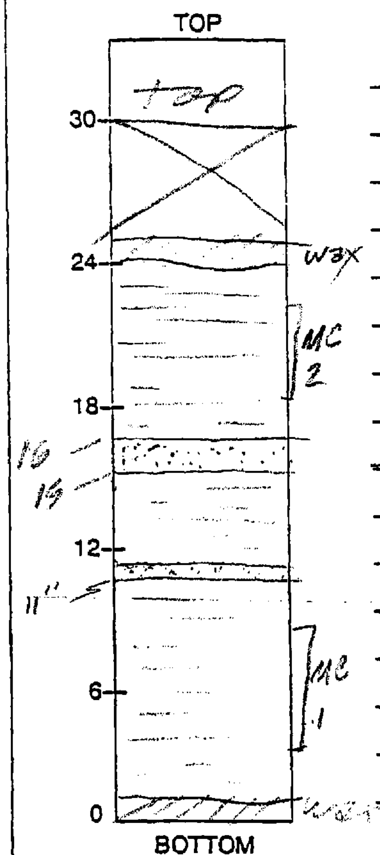
PROJECT Barrick / Mercur Tailings / UT

DATE 10/15/98

BORING NUMBER GA98-10

SAMPLE NUMBER

DEPTH ~~102-104~~ 100-102



SAMPLE DESCRIPTION

Slime, yellow, yellow brown, very moist, soft to slightly firm

Sand brown very fine grained, moist to wet

Slime, yellow yellow brown as above becoming brown

Sand brown, moist, very fine grained

Slime, brown, moist, more firm

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	51.70
WT. TUBE & WET SAMPLE (g)	5739.0
TUBE WT. (g)	1512.1
WET WT. OF SAMPLE (g)	4226.9
AREA (cm²)	41.17
VOLUME (cm³)	2128.4
WET UNIT WT. (pcf)	123.9
DRY UNIT WT. (pcf)	97.3

WATER CONTENT DETERMINATION

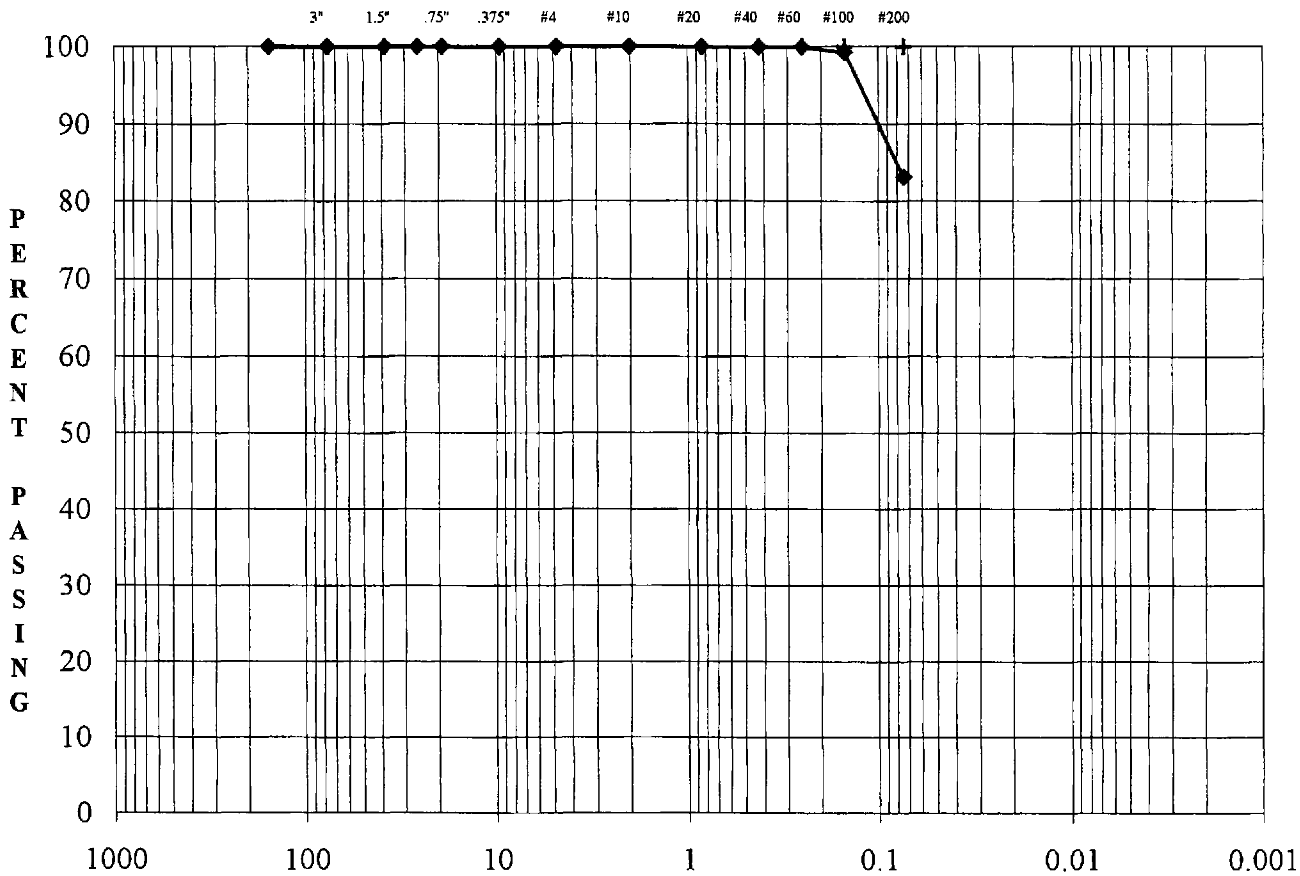
	1	2
TARE #	X 36	F 32
WET WT. & TARE (g)	177.98	144.61
DRY WT. & TARE (g)	147.16	120.44
TARE (g)	32.82	33.36
MOISTURE CONTENT (%)	27.0	27.8

27.4 % AV

LAB WORK DONE BY:

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	GA98 BH-10	MC:	24.5%
DEPTH (FEET):	120-122	LL:	NA
		PL:	NA
DESCRIPTION:	CLAY with some fine sand (CL)	PI:	NA
		Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	02-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT	**SAMPLE #:**	**GA98 BH-10**	
983-2344.001-2	**DEPTH (FEET):**	**120-122**	

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	F29	Tare	88A
Weight Wet Soil & Tare, g	212.83	Weight Soil & Tare Before Wash, g	490.15
Weight Dry Soil & Tare, g	177.56	Weight Soil & Tare After Wash, g	212.84
Weight Tare, g	33.89	Weight Tare, g	164.62
Weight Water, g	35.27	Weight Fines Lost, g	213.15
Weight Dry Soil, g	143.67	Weight Dry Soil, g	261.37
Moisture, %	**24.55%**	Fines Lost, %	**81.55%**

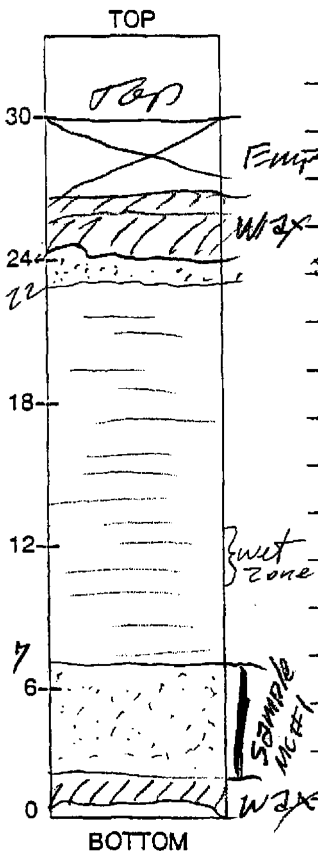
	SIEVE	**Wt. Ret.**	**% Ret.**	**% Pass.**	**SIEVE**	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.03	0.01%	**99.99%**	#20	
Fine Sand	#40	0.12	0.05%	**99.95%**	#40	Fine Sand
	#60	0.25	0.10%	**99.90%**	#60	
	#100	1.88	0.72%	**99.28%**	#100	
	#200	44.06	16.86%	**83.14%**	#200	
Fines	PAN	48.23	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**CLAY with some**		
% F GRVL:	**0.0%**	0.0%	Description:	**fine sand (CL)**		
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**NA**		
% F SAND:	**16.8%**	16.9%	PL:	**NA**	DATE:	02-Oct-98
% FINES:	**83.1%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER: 983-2344 001.2
PROJECT: Barrick/Mercur Tailings/UT
DATE: 10/2/98
BORING NUMBER: GA98 BH 10
SAMPLE NUMBER:
DEPTH: 120-122



SAMPLE DESCRIPTION

sand, olive

slime, olive gray, moist to wet

sand, olive gray, gray brown, moist fine to very fine grained

DENSITY

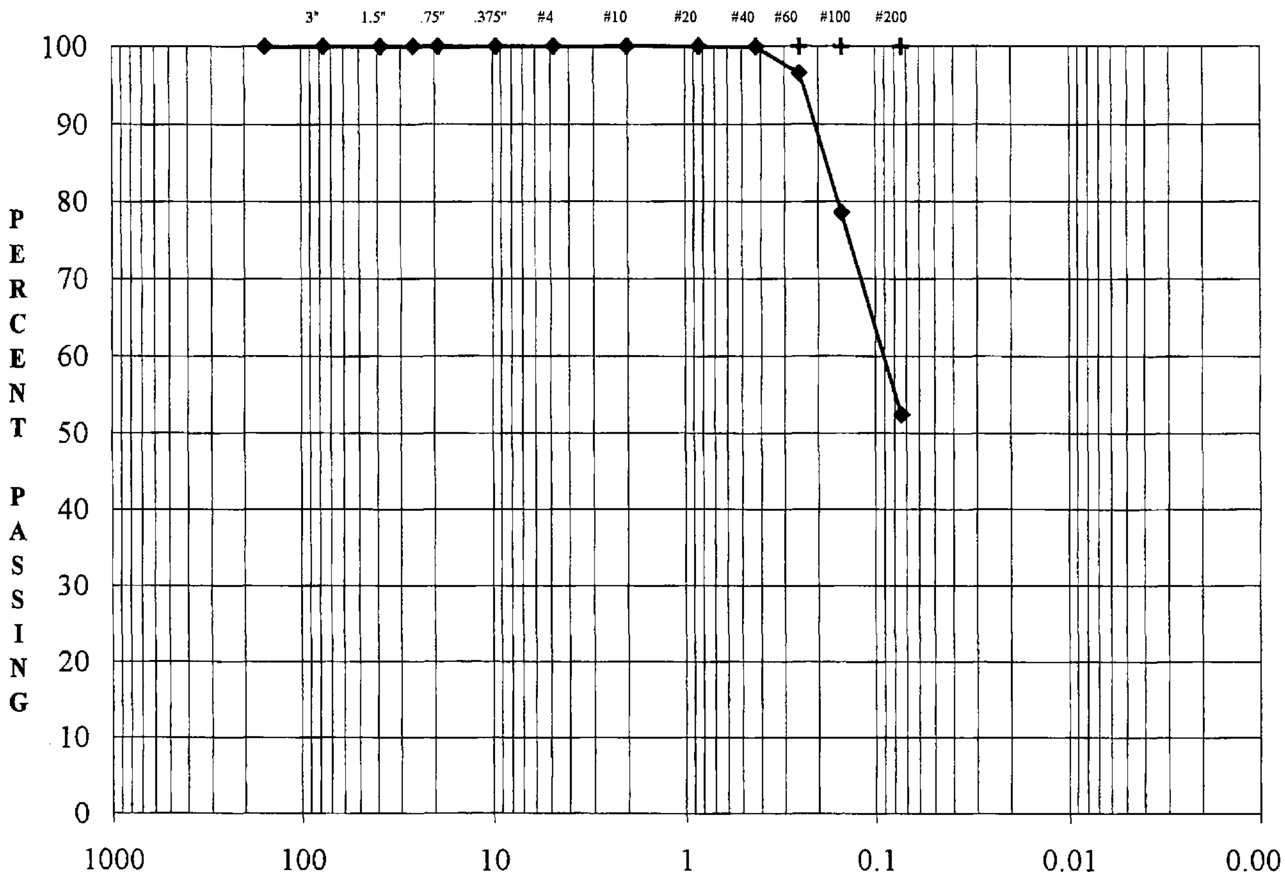
DIAMETER (cm)	7.24
LENGTH (cm)	48.75
WT. TUBE & WET SAMPLE (g)	5433.6
TUBE WT. (g)	1425.1
WET WT. OF SAMPLE (g)	4008.5
AREA (cm^2)	41.17
VOLUME (cm^3)	2007.0
WET UNIT WT. (pcf)	124.6
DRY UNIT WT. (pcf)	100.0

WATER CONTENT DETERMINATION

	1 — Sand —	2 Total Interval
TARE #	F29	U5
WET WT. & TARE (g)	212.83	762.05
DRY WT. & TARE (g)	177.56	642.71
TARE (g)	33.89	158.51
MOISTURE CONTENT (%)		24.6

LAB WORK DONE BY: Bohn
APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	**GRAVEL**		**SAND**			**FINES**

SAMPLE #:	**GA98 BH-10**
DEPTH (FEET):	**142-144**
DESCRIPTION:	**CLAY and fine sand (CL)**

MC:	**20.8%**
LL:	**NA**
PL:	**NA**
PI:	**NA**
Gs:	**NA**

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	**27-Oct-98**
TECH:	**ZE**
REVIEW:	**DMD**

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-10**
983-2344.001-2		**DEPTH (FEET):**	**142-144**

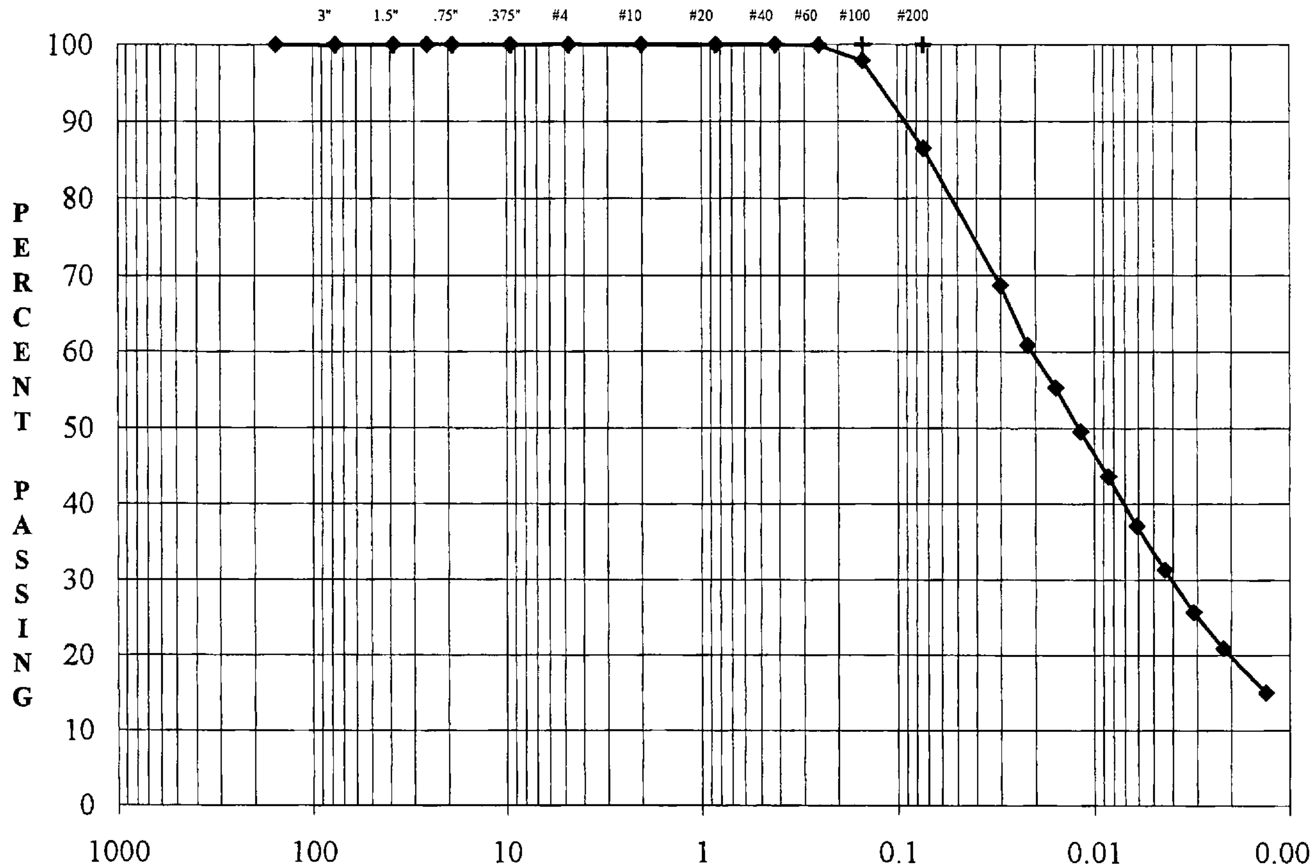
MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	F15	Tare	75
Weight Wet Soil & Tare, g	204.09	Weight Soil & Tare Before Wash, g	819.20
Weight Dry Soil & Tare, g	174.73	Weight Soil & Tare After Wash, g	469.66
Weight Tare, g	33.72	Weight Tare, g	221.52
Weight Water, g	29.36	Weight Fines Lost, g	246.54
Weight Dry Soil, g	141.01	Weight Dry Soil, g	494.68
Moisture, %	**20.82%**	Fines Lost, %	**49.84%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.07	0.01%	**99.99%**	#10	Medium Sand
	#20	0.10	0.02%	**99.98%**	#20	
Fine Sand	#40	0.30	0.06%	**99.94%**	#40	Fine Sand
	#60	16.94	3.42%	**96.58%**	#60	
	#100	105.65	21.36%	**78.64%**	#100	
	#200	235.49	47.60%	**52.40%**	#200	
Fines	PAN	248.39	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**CLAY and fine sand (CL)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**NA**		
% F SAND:	**47.5%**	47.6%	PL:	**NA**	DATE:	27-Oct-98
% FINES:	**52.4%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	GRAVEL		SAND			FINES

SAMPLE #:	GA98-BH10 162-164'	MC (As Tested	22.0%
		LL:	23
		PL:	19
WET COLOR: DESCRIPTION:	Silty CLAY with some fine sand (CL-ML)	PI:	4
		Gs:	2.74

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2

DATE:	07-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILINGS/UT	**SAMPLE NUMBER:** GA98-BH10
983-2344.001-2	**DEPTH (ft):** 162-164'

MOISTURE CONTENT (As Tested)

Tare	TARE
Weight Wet Soil & Tare, g	0.00
Weight Dry Soil & Tare, g	0.00
Weight Tare, g	0.00
Weight Water, g	0.00
Weight Dry Soil, g	0.00
Moisture Content, %	**22.0%**

PERCENT PASSING #10 SIEVE

Total Weight, g	478.20
Weight Split #10, g	478.20
Percent Passing #10	100.00%

	SIEVE	Wt. Ret., g	% Ret.	% Pass.	SIEVE	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand

SAMPLE PREPARATION FOR HYDROMETER ANALYSIS

Percent Passing #10 Sieve	100.00	Initial Wet Weight	50.00
Specific Gravity	2.74	Calculated Dry Weight	49.89
Dispersing Agent, ml, Used (40 ml Na(PO$_4$)n per 1,000 ml H$_2$O)	125		

MOISTURE CONTENT (Hygroscopic - #10)

Tare	T-5		
Weight Wet Soil & Tare, g	86.26	LL:	23
Weight Dry Soil & Tare, g	86.13	PL:	19
Weight Tare, g	28.38	PI:	4
Weight Moisture, g	0.13	Gs:	2.74
Weight Dry Soil, g	57.75		
Moisture Content, %	**0.23%**		

PERCENT #10 TO #200 SIEVE CALCULATION

SEIVE	CUMUL. WT. RETAINED	CUMUL. WT. RET. CORR.	PERCENT PASSING		
#10	0.00	0.00	**100.00%**	#10	Medium Sand
#20	0.00	0.00	**100.00%**	#20	
#40	0.00	0.00	**100.00%**	#40	Fine Sand
#60	0.06	0.06	**99.88%**	#60	
#100	1.06	1.06	**97.88%**	#100	
#200	6.73	6.73	**86.51%**	#200	Fines

DATE	TIME	TIME, CUM. (min)	READING R	TEMP. T	HYD. RDG. H	PARTICLE DIAMETER	PERCENT FINER
10/06/1998	08:02	2	38.8	22.1	4.20	0.030	**68.7%**
	08:04	4	34.9	22.0	4.23	0.022	**60.9%**
	08:08	8	32.1	22.0	4.23	0.016	**55.3%**
	08:15	15	29.2	22.0	4.23	0.012	**49.5%**
	08:30	30	26.2	22.0	4.23	0.008	**43.6%**
	09:00	60	22.9	22.1	4.20	0.006	**37.1%**
	10:00	120	19.9	22.4	4.10	0.004	**31.3%**
	12:06	240	16.7	23.5	3.75	0.003	**25.7%**
	16:00	480	13.8	25.0	3.27	0.002	**20.9%**
10/07/1998	08:00	1,440	11.8	22.0	4.23	0.001	**15.0%**

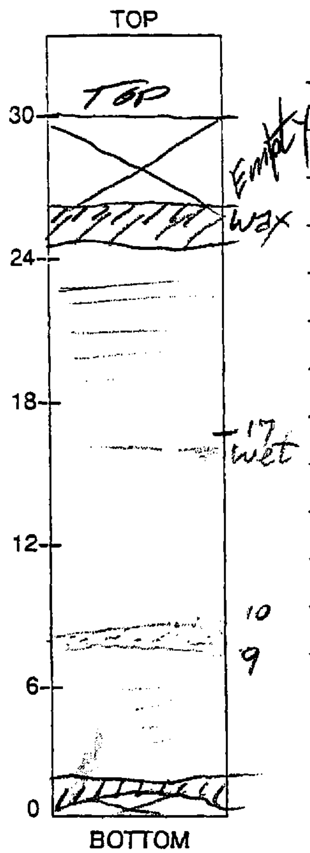
% C GRVL:	**0.0%**		
% F GRVL:	**0.0%**	**0.0%**	
% C SAND:	**0.0%**		Wet Color: **Silty CLAY with some**
% M SAND:	**0.0%**		Description: **fine sand (CL-ML)**
% F SAND:	**13.5%**	**13.5%**	DATE: 10/07/1998
% FINES:	**86.5%**		TECH: ZE
% TOTAL:	**100.00%**		REVIEW: DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001.2	BORING NUMBER	GA98-BH 10
PROJECT	Barrick/Mercur Tailings/Ut	SAMPLE NUMBER	
DATE	10/2/98	DEPTH	162-164

SAMPLE DESCRIPTION



Slime, yellow brown/w some gray mottling, soft to firm, moist, to wet in part

sandy streek -

DENSITY

DIAMETER (cm)	7.23
LENGTH (cm)	51.65
WT. TUBE & WET SAMPLE (g)	5640.5
TUBE WT. (g)	1270.4
WET WT. OF SAMPLE (g)	4370.1
AREA (cm^2)	41.06
VOLUME (cm^3)	2120.5
WET UNIT WT. (pcf)	128.6
DRY UNIT WT. (pcf)	105.4

WATER CONTENT DETERMINATION

	1	2
TARE #	7	
WET WT. & TARE (g)	538.91	
DRY WT. & TARE (g)	471.30	
TARE (g)	163.58	
MOISTURE CONTENT (%)	22.0	

sampled full length for Moisture & SHA

LAB WORK DONE BY: Bdm

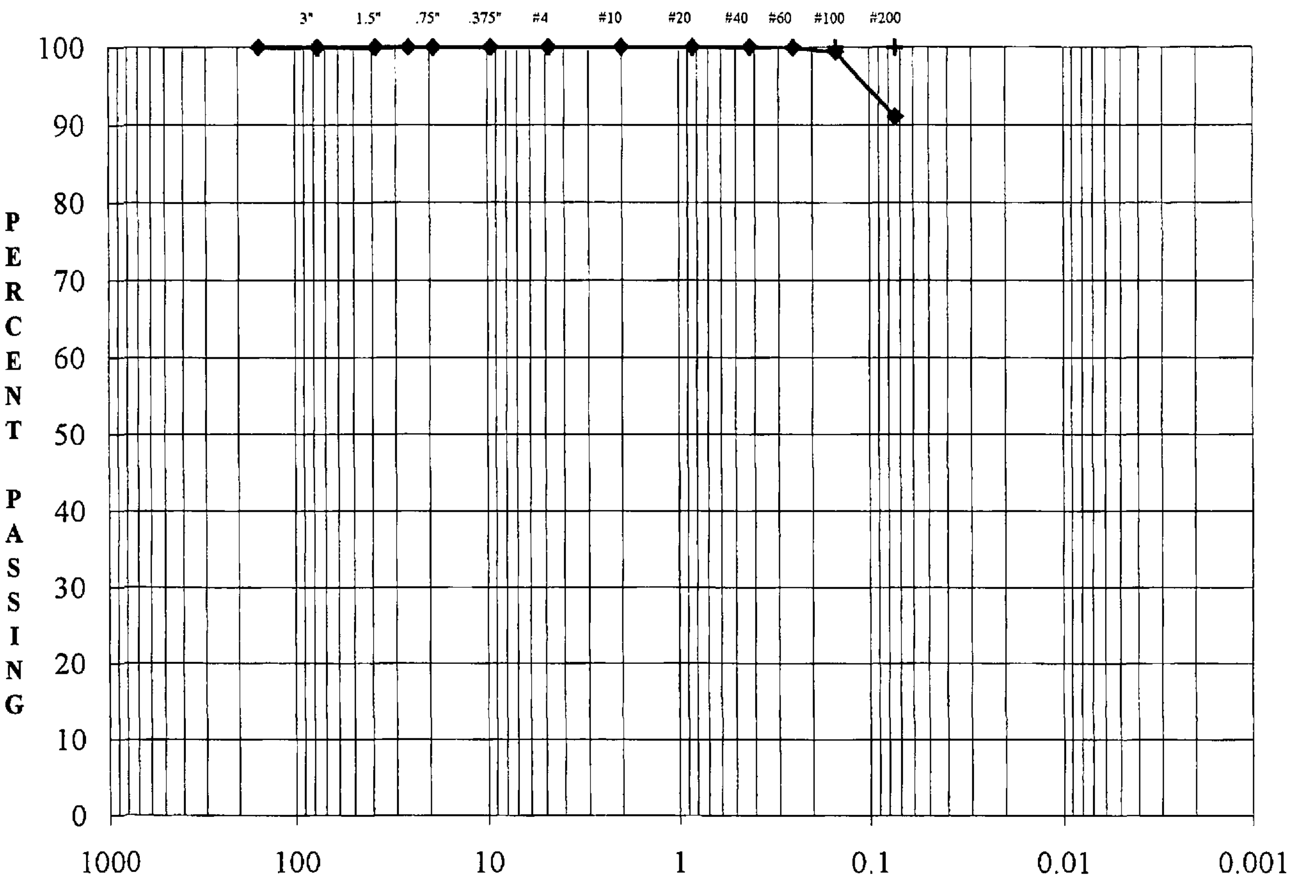
APPROVED BY:

SHA

5640.5
1270.4

7390.0
1270.4

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size
COBBLES	GRAVEL		SAND			FINES

SAMPLE #:	GA98 BH-10
DEPTH (FEET):	182-184'
DESCRIPTION:	CLAY with little fine sand (CL)

MC:	25.0%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	06-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-10**
983-2344.001-2		**DEPTH (FEET):**	**182-184'**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	F23	Tare	5-8
Weight Wet Soil & Tare, g	260.71	Weight Soil & Tare Before Wash, g	563.88
Weight Dry Soil & Tare, g	215.32	Weight Soil & Tare After Wash, g	187.00
Weight Tare, g	33.64	Weight Tare, g	157.31
Weight Water, g	45.39	Weight Fines Lost, g	295.61
Weight Dry Soil, g	181.68	Weight Dry Soil, g	325.30
Moisture, %	**24.98%**	Fines Lost, %	**90.87%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.03	0.01%	**99.99%**	#20	
Fine Sand	#40	0.07	0.02%	**99.98%**	#40	Fine Sand
	#60	0.16	0.05%	**99.95%**	#60	
	#100	1.82	0.56%	**99.44%**	#100	
	#200	28.94	8.90%	**91.10%**	#200	
Fines	PAN	29.74	0.00%	**100.00%**	PAN	Fines

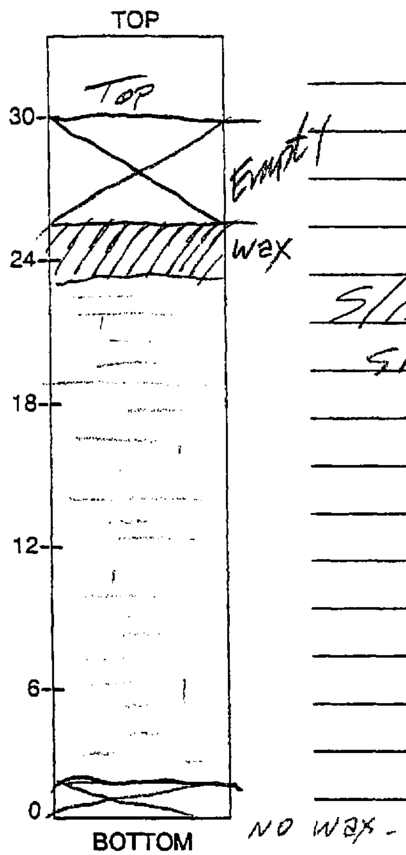
% C GRVL:	**0.0%**		Wet Color:	**CLAY with little fine sand (CL)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**NA**		
% F SAND:	**8.9%**	8.9%	PL:	**NA**	DATE:	06-Oct-98
% FINES:	**91.1%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION
AND DENSITY MEASUREMENT

JOB NUMBER 983-2344 001.2
PROJECT Barrick Mercur Tailings/Ut
DATE 10/6/98

BORING NUMBER GA98 BH10
SAMPLE NUMBER
DEPTH 182-184



SAMPLE DESCRIPTION

Slime, medium brown, moist, soft to slightly firm, blocky.

DENSITY

DIAMETER (cm)	7.26
LENGTH (cm)	52.2
WT. TUBE & WET SAMPLE (g)	5923.7
TUBE WT. (g)	1557.5
WET WT. OF SAMPLE (g)	4366.2
AREA (cm²)	41.40
VOLUME (cm³)	2160.9
WET UNIT WT. (pcf)	126.1
DRY UNIT WT. (pcf)	100.9

WATER CONTENT DETERMINATION

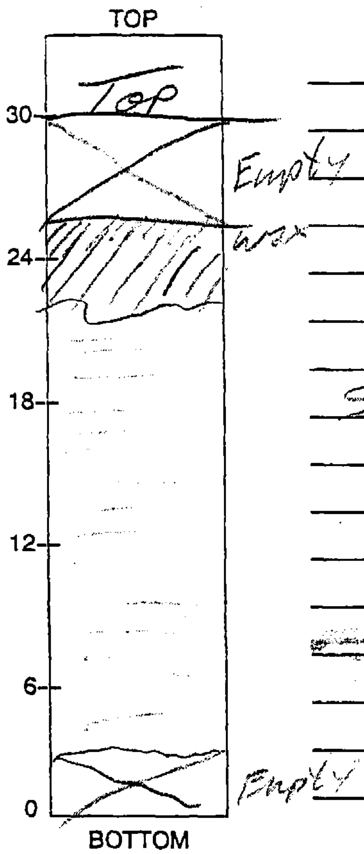
	1	2
TARE #	~~5-8~~	F23
WET WT. & TARE (g)		260.71
DRY WT. & TARE (g)		215.32
TARE (g)	~~157.25~~	33.64
MOISTURE CONTENT (%)		25.0

LAB WORK DONE BY: Bdm
APPROVED BY:

7223.7

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001.2	BORING NUMBER	GA98 BH 10
PROJECT	Barrick/Mercur Tailings/UT	SAMPLE NUMBER	
DATE	10/6/98	DEPTH	202-204



SAMPLE DESCRIPTION

Slime, medium gray brown, moist & very moist, firm

DENSITY

DIAMETER (cm)	7.26
LENGTH (cm)	45.75
WT. TUBE & WET SAMPLE (g)	5082.3
TUBE WT. (g)	1336.2
WET WT. OF SAMPLE (g)	3746.1
AREA (cm^2)	41.40
VOLUME (cm^3)	1893.9
WET UNIT WT. (pcf)	123.4
DRY UNIT WT. (pcf)	96.8

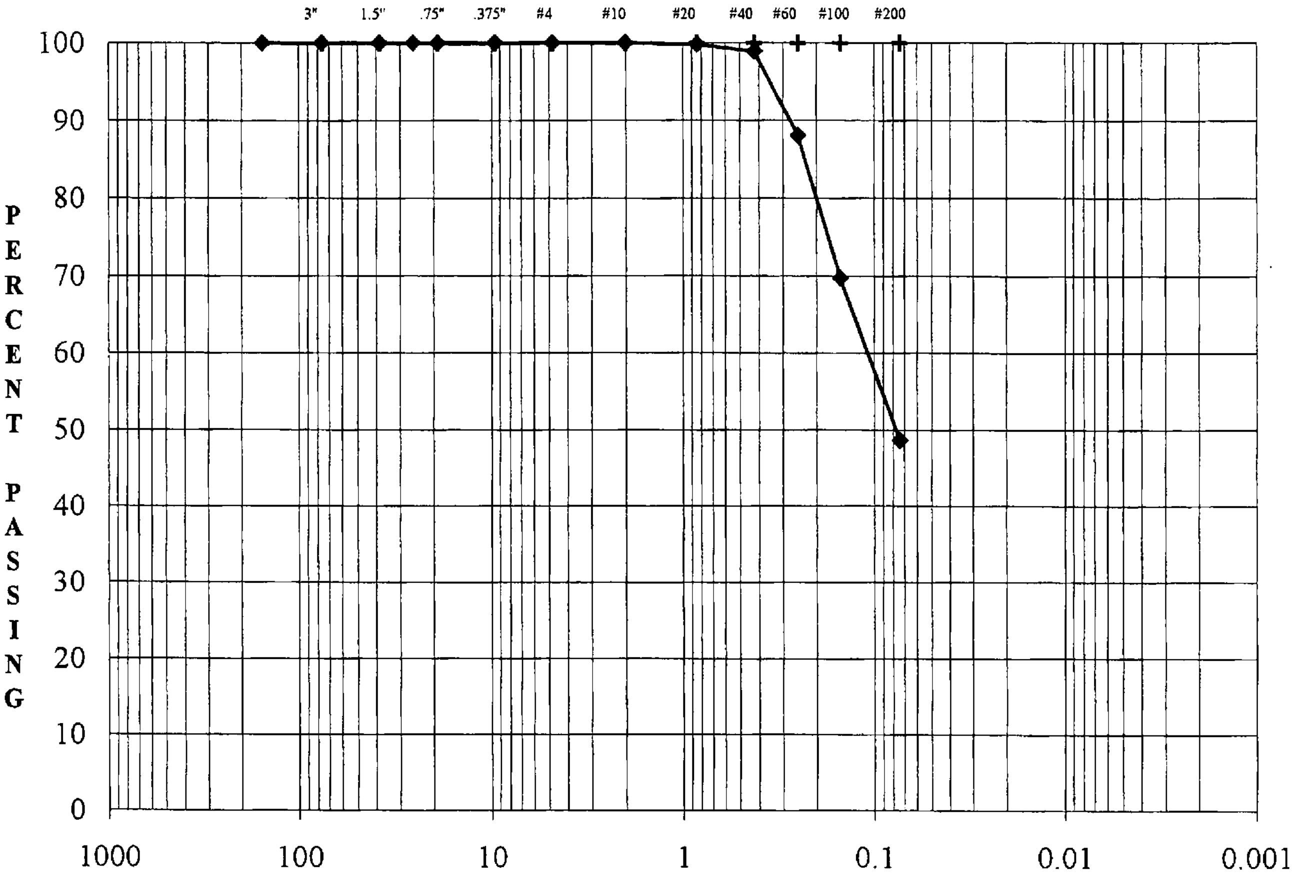
WATER CONTENT DETERMINATION

	1	2
TARE #	9A	
WET WT. & TARE (g)	198.32	
DRY WT. & TARE (g)	162.72	
TARE (g)	33.45	
MOISTURE CONTENT (%)	~~162.72~~ 27.5%	

LAB WORK DONE BY:

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	GA98 BH-11
DEPTH (FEET):	20-22
DESCRIPTION:	Fine to medium SAND and clay (SC)

MC:	26.1%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	23-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-11**
983-2344.001-2		**DEPTH (FEET):**	**20-22**

MOISTURE CONTENT (Delivered Moisture) | **#200 WASH (Percent Fines)**

MOISTURE CONTENT		#200 WASH	
Tare	9A	Tare	Q4
Weight Wet Soil & Tare, g	200.00	Weight Soil & Tare Before Wash, g	699.49
Weight Dry Soil & Tare, g	165.52	Weight Soil & Tare After Wash, g	383.18
Weight Tare, g	33.44	Weight Tare, g	155.49
Weight Water, g	34.48	Weight Fines Lost, g	203.70
Weight Dry Soil, g	132.08	Weight Dry Soil, g	431.39
Moisture, %	**26.11%**	Fines Lost, %	**47.22%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE
	6.000"	0.00	0.00%	**100.00%**	6.000"
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000" Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"
	1.000"	0.00	0.00%	**100.00%**	1.000"
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750" Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4 Coarse Sand
Medium Sand	#10	0.16	0.04%	**99.96%**	#10 Medium Sand
	#20	0.74	0.17%	**99.83%**	#20
Fine Sand	#40	4.64	1.08%	**98.92%**	#40 Fine Sand
	#60	51.28	11.89%	**88.11%**	#60
	#100	130.58	30.27%	**69.73%**	#100
	#200	221.71	51.39%	**48.61%**	#200
Fines	PAN	227.91	0.00%	**100.00%**	PAN Fines

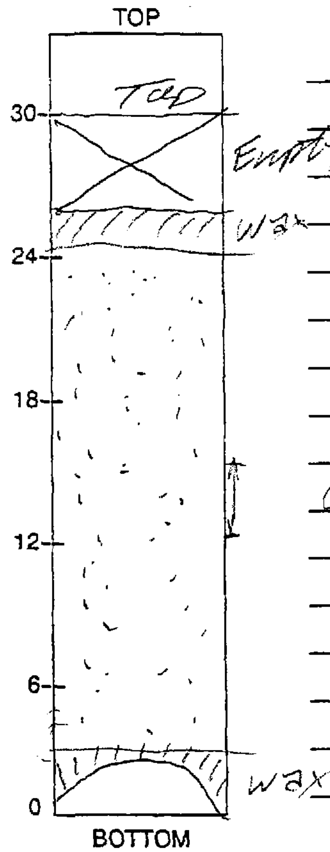
% C GRVL:	**0.0%**			Wet Color:	**Fine to medium SAND**	
% F GRVL:	**0.0%**	0.0%		Description:	**and clay (SC)**	
% C SAND:	**0.0%**					
% M SAND:	**1.0%**		LL:	**NA**		
% F SAND:	**50.3%**	51.4%	PL:	**NA**	DATE:	23-Oct-98
% FINES:	**48.6%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001.2	BORING NUMBER	GA98 BH 11
PROJECT	Barrick / Mercur Tail/Ut	SAMPLE NUMBER	
DATE	10/27	DEPTH	20 - 22

SAMPLE DESCRIPTION



sand, brown, fine grained, very moist

used 90/

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	51.5
WT. TUBE & WET SAMPLE (g)	5690.7
TUBE WT. (g)	1601.9
WET WT. OF SAMPLE (g)	4088.8
AREA (cm²)	41.17
VOLUME (cm³)	2120.2
WET UNIT WT. (pcf)	120.3
DRY UNIT WT. (pcf)	95.8

WATER CONTENT DETERMINATION

	1	2
TARE #	9A	F30
WET WT. & TARE (g)	200.00	175.48
DRY WT. & TARE (g)	165.52	146.81
TARE (g)	33.44	32.89
MOISTURE CONTENT (%)	26.1	25.2

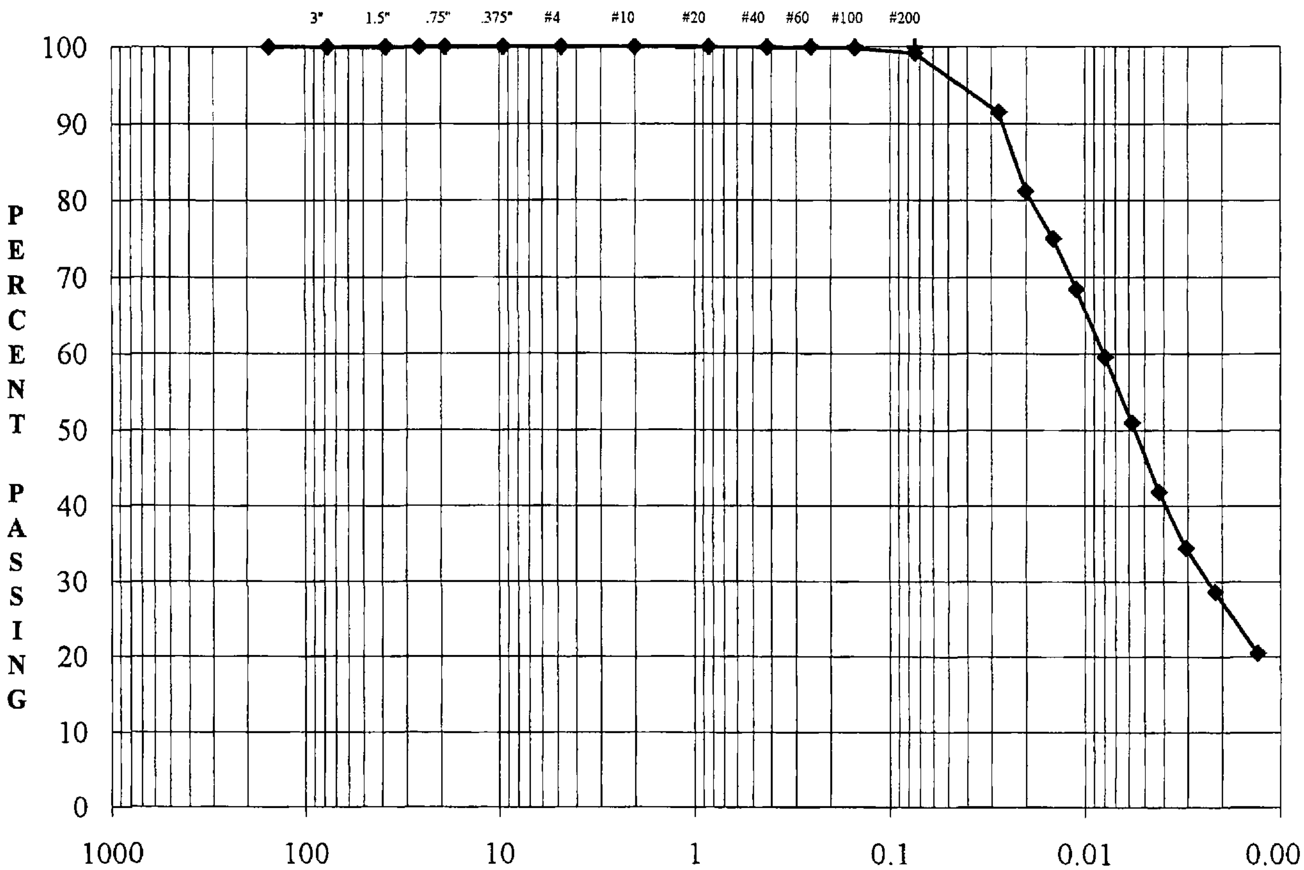
~~33.17~~

25.6 AV

LAB WORK DONE BY: Bob

APPROVED BY:

PARTICLE-SIZE DISTRIBUTION ASTM D 421 AND D 422
US STANDARD SIEVE OPENING SIZES



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	**GA98-BH11** **60-62**
WET COLOR: **DESCRIPTION:**	**SILT with trace** **fine to medium sand (ML)**

MC (As Tested	**30.5%**
LL:	**28**
PL:	**21**
PI:	**7**
Gs:	**2.72**

BARRICK/RESERVATION CANYON TAILINGS/UT
983-2344.001-2

DATE:	**02-Oct-98**
TECH:	**ZE**
REVIEW:	**DMD**

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILINGS/UT		**SAMPLE NUMBER:**	**GA98-BH11**
983-2344.001-2		**DEPTH (ft):**	**60-62**

MOISTURE CONTENT (As Tested)

Tare	TARE
Weight Wet Soil & Tare, g	0.00
Weight Dry Soil & Tare, g	0.00
Weight Tare, g	0.00
Weight Water, g	0.00
Weight Dry Soil, g	0.00
Moisture Content, %	**#DIV/0!**

PERCENT PASSING #10 SIEVE

Total Weight, g	494.40
Weight Split #10, g	494.40
Percent Passing #10	100.00%

	SIEVE	Wt. Ret., g	% Ret.	% Pass.	SIEVE	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand

SAMPLE PREPARATION FOR HYDROMETER ANALYSIS

Percent Passing #10 Sieve	100.00	Initial Wet Weight	50.00
Specific Gravity	2.72	Calculated Dry Weight	49.88
Dispersing Agent, ml, Used (40 ml $Na(PO_4)n$ per 1,000 ml H_2O)	125		

MOISTURE CONTENT (Hygroscopic - #10)

Tare	N3		
Weight Wet Soil & Tare, g	90.22	LL:	28
Weight Dry Soil & Tare, g	90.07	PL:	21
Weight Tare, g	28.04	PI:	7
Weight Moisture, g	0.15	Gs:	2.72
Weight Dry Soil, g	62.03		
Moisture Content, %	**0.24%**		

PERCENT #10 TO #200 SIEVE CALCULATION

SEIVE	CUMUL. WT. RETAINED	CUMUL. WT. RET. CORR.	PERCENT PASSING		
#10	0.00	0.00	**100.00%**	#10	Medium Sand
#20	0.02	0.02	**99.96%**	#20	
#40	0.04	0.04	**99.92%**	#40	Fine Sand
#60	0.06	0.06	**99.88%**	#60	
#100	0.07	0.07	**99.86%**	#100	
#200	0.41	0.41	**99.18%**	#200	Fines

DATE	TIME	TIME, CUM. (min)	READING R	TEMP. T	HYD. RDG. H	PARTICLE DIAMETER	PERCENT FINER
10/01/1998	08:56	2	49.7	23.9	3.62	0.027	**91.5%**
	08:58	4	44.5	24.0	3.59	0.020	**81.2%**
	09:02	8	41.4	24.0	3.59	0.014	**75.0%**
	09:09	15	38.1	23.9	3.62	0.011	**68.4%**
	09:24	30	33.6	24.0	3.59	0.008	**59.6%**
	09:54	60	29.2	24.2	3.53	0.006	**51.0%**
	10:54	120	24.6	24.3	3.49	0.004	**41.9%**
	12:54	240	20.7	24.8	3.33	0.003	**34.5%**
	16:54	480	17.6	25.3	3.17	0.002	**28.6%**
10/02/1998	08:54	1,440	14.2	23.2	3.85	0.001	**20.5%**

% C GRVL:	**0.0%**	
% F GRVL:	**0.0%**	**0.0%**
% C SAND:	**0.0%**	
% M SAND:	**0.1%**	
% F SAND:	**0.7%**	**0.8%**
% FINES:	**99.2%**	
% TOTAL:	**100.00%**	

Wet Color: Description: **SILT with trace fine to medium sand (ML)**

DATE:	10/02/1998
TECH:	ZE
REVIEW:	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344.001-2	BORING NUMBER	~~A98~~ BH-11
PROJECT	BARRICK/MERCUR TAILINGS/LT	SAMPLE NUMBER	
DATE	9-23-98	DEPTH	60-62

TOP

30
24
18
12
6
0

BOTTOM

SAMPLE DESCRIPTION

Slime w/ fine gr. sands
olive, tan
moist. to wet.
stiff

DENSITY

DIAMETER (cm)	7.15
LENGTH (cm)	55.75
WT. TUBE & WET SAMPLE (g)	5994.5
TUBE WT. (g)	1645.1
WET WT. OF SAMPLE (g)	4349.4
AREA (cm²)	40.15
VOLUME (cm³)	2238.4
WET UNIT WT. (pcf)	121.2
DRY UNIT WT. (pcf)	92.9

WATER CONTENT DETERMINATION

	1	2
TARE #	F-39	X-28
WET WT. & TARE (g)	139.34	214.07
DRY WT. & TARE (g)	114.50	171.91
TARE (g)	33.01	33.47
MOISTURE CONTENT (%)	30.5	30.5

30.5

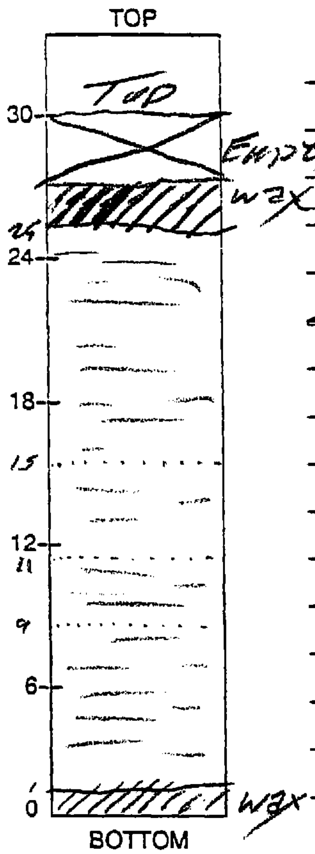
LAB WORK DONE BY: RD

APPROVED BY:

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER: 983-2344-001-2
PROJECT: Barrick/Mercur Tailings/Ut
DATE: 10/15/98

BORING NUMBER: GA98 BH 11
SAMPLE NUMBER:
DEPTH: 80-82



SAMPLE DESCRIPTION

Slime, medium brown, moist/w some wetter zones, soft to slightly firm - occasional thin sandy streaks

DENSITY

DIAMETER (cm)	7.25
LENGTH (cm)	55.92
WT. TUBE & WET SAMPLE (g)	6132.8
TUBE WT. (g)	1674.9
WET WT. OF SAMPLE (g)	4457.9
AREA (cm^2)	41.20
VOLUME (cm^3)	2303.5
WET UNIT WT. (pcf)	120.5
DRY UNIT WT. (pcf)	95.2

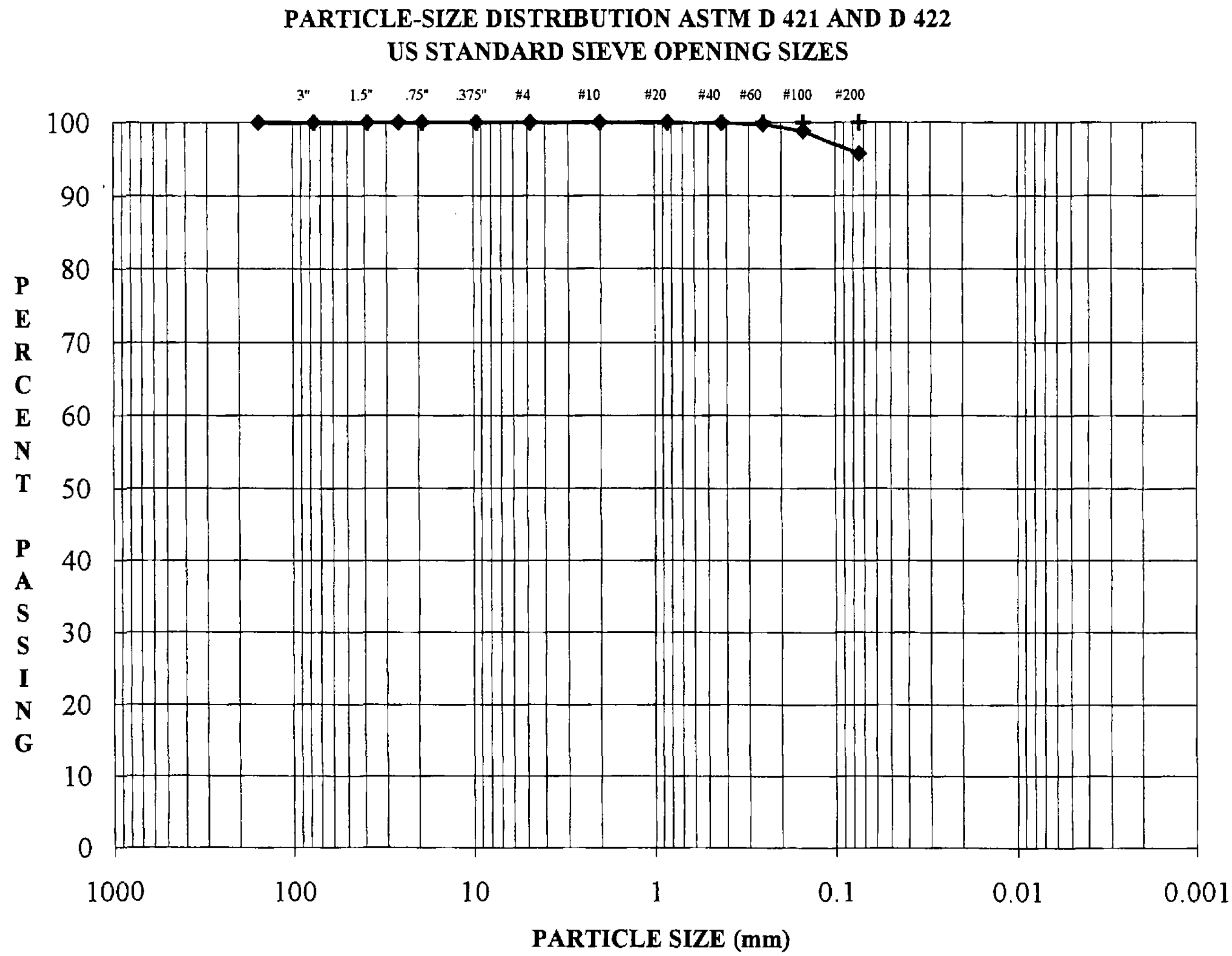
WATER CONTENT DETERMINATION

	1	2
TARE #	X 31	X 19
WET WT. & TARE (g)	218.48	235.74
DRY WT. & TARE (g)	179.59	192.24
TARE (g)	33.14	32.96
MOISTURE CONTENT (%)	26.5	27.3

26.9% AV

LAB WORK DONE BY:

APPROVED BY:



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	GA98 BH-11
DEPTH (FEET):	101-103
DESCRIPTION:	CLAY with trace fine sand (CL)

MC:	33.3%
LL:	NA
PL:	NA
PI:	NA
Gs:	NA

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	23-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	**GA98 BH-11**
983-2344.001-2		**DEPTH (FEET):**	**101-103**

MOISTURE CONTENT (Delivered Moisture)		**#200 WASH (Percent Fines)**	
Tare	F17	Tare	CC1
Weight Wet Soil & Tare, g	284.24	Weight Soil & Tare Before Wash, g	617.80
Weight Dry Soil & Tare, g	221.53	Weight Soil & Tare After Wash, g	172.51
Weight Tare, g	33.08	Weight Tare, g	156.97
Weight Water, g	62.71	Weight Fines Lost, g	330.23
Weight Dry Soil, g	188.45	Weight Dry Soil, g	345.77
Moisture, %	**33.28%**	Fines Lost, %	**95.51%**

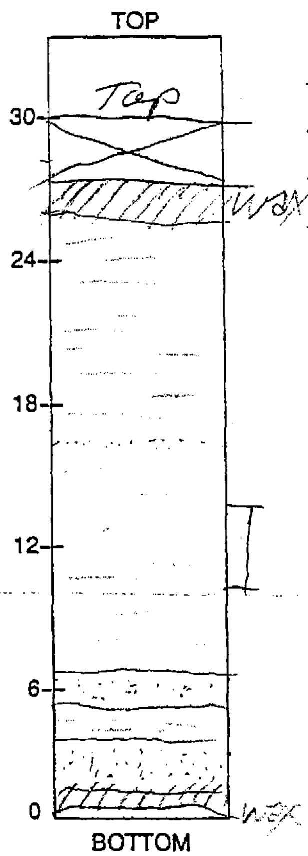
	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.02	0.01%	**99.99%**	#10	Medium Sand
	#20	0.05	0.01%	**99.99%**	#20	
Fine Sand	#40	0.18	0.05%	**99.95%**	#40	Fine Sand
	#60	0.96	0.28%	**99.72%**	#60	
	#100	3.90	1.13%	**98.87%**	#100	
	#200	14.60	4.22%	**95.78%**	#200	
Fines	PAN	15.76	0.00%	**100.00%**	PAN	Fines

% C GRVL:	**0.0%**		Wet Color:	**CLAY with trace fine sand (CL)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**NA**		
% F SAND:	**4.2%**	4.2%	PL:	**NA**	DATE:	23-Oct-98
% FINES:	**95.8%**		PI:	**NA**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344 001.2
PROJECT Barrick/Mercur Tailings/ St
DATE 10/24
BORING NUMBER GA98 BH 11
SAMPLE NUMBER
DEPTH 101 - 103



SAMPLE DESCRIPTION

slime, brown, very moist, soft to slightly firm, sticky

sandy str -

consol sample interval

sand, very fine grained w/ interlaminated slime

DENSITY

DIAMETER (cm)	7.24
LENGTH (cm)	48.0.
WT. TUBE & WET SAMPLE (g)	5118.0
TUBE WT. (g)	1412.6
WET WT. OF SAMPLE (g)	3705.4
AREA (cm²)	41.17
VOLUME (cm³)	1976.1
WET UNIT WT. (pcf)	117.0
DRY UNIT WT. (pcf)	88.6

WATER CONTENT DETERMINATION

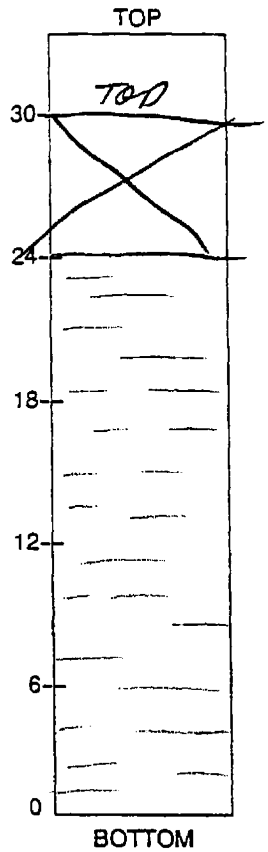
	1	2
TARE #	F 17	F 39
WET WT. & TARE (g)	284.24	182.16
DRY WT. & TARE (g)	221.53	147.14
TARE (g)	33.08	33.10
MOISTURE CONTENT (%)	33.3	30.7

32.0 AV

LAB WORK DONE BY: Bdm
APPROVED BY:

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 001.2	BORING NUMBER	GA98 BH 11
PROJECT	Barrick/Mercur Tailings/Ut	SAMPLE NUMBER	
DATE	10/7/98	DEPTH	120-122



SAMPLE DESCRIPTION

Slime, medium gray, olive gray-brown moist, sl soft to firm

DENSITY

DIAMETER (cm)	7.26
LENGTH (cm)	50.1
WT. TUBE & WET SAMPLE (g)	5587.2
TUBE WT. (g)	1437.3
WET WT. OF SAMPLE (g)	4149.9
AREA (cm²)	41.40
VOLUME (cm³)	2074.0
WET UNIT WT. (pcf)	124.9
DRY UNIT WT. (pcf)	99.9

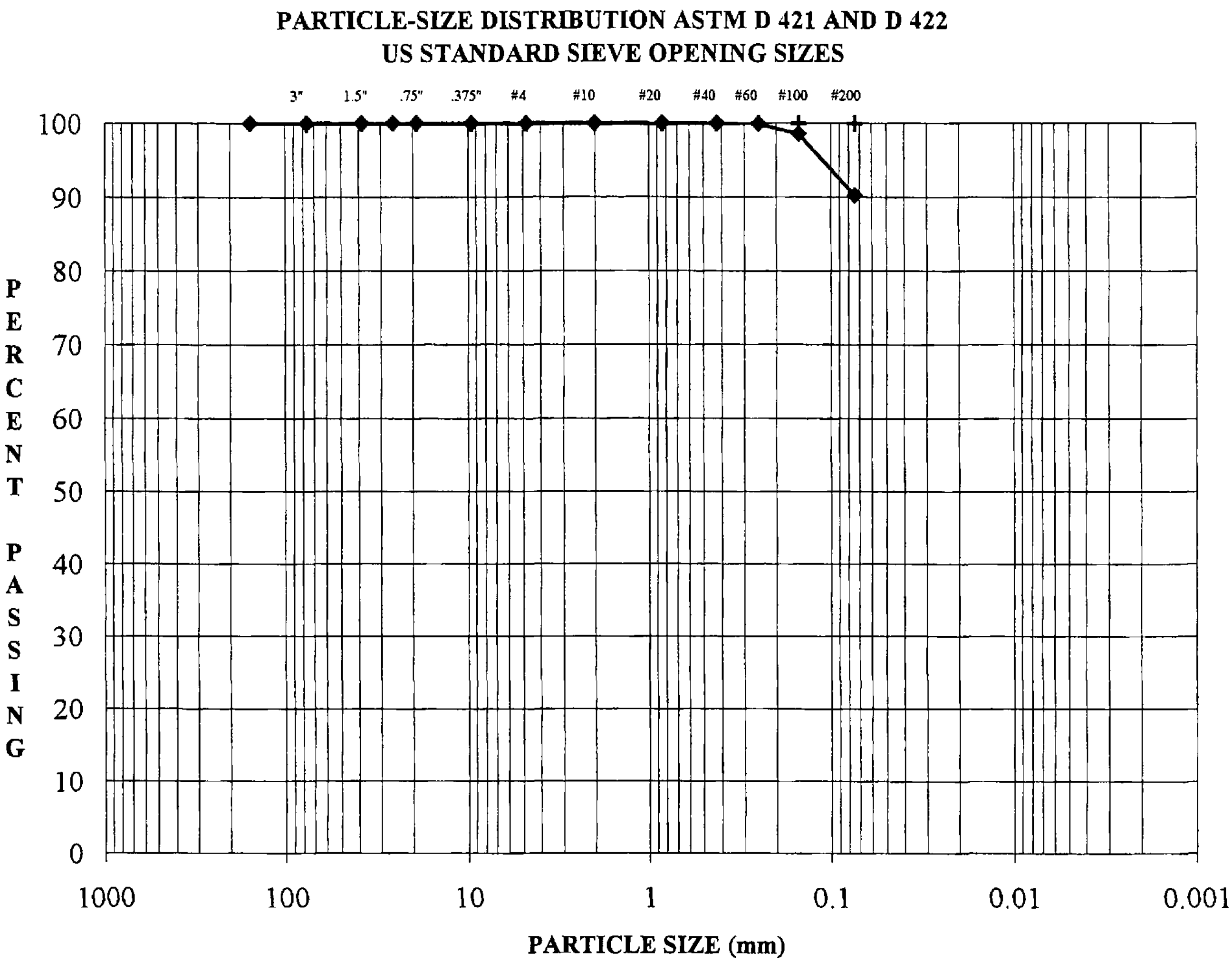
WATER CONTENT DETERMINATION

	1	2
TARE #	X17	X31
WET WT. & TARE (g)	241.46	190.12
DRY WT. & TARE (g)	199.91	158.59
TARE (g)	33.08	33.12
MOISTURE CONTENT (%)	24.9	25.1

25.0 AV MC%

LAB WORK DONE BY:

APPROVED BY:



COBBLES	GRAVEL		SAND			FINES
	Coarse	Fine	Cor	Med	Fine	Silt or Clay Size

SAMPLE #:	**GA98 BH-11**
DEPTH (FEET):	**140-142**
DESCRIPTION:	**CLAY with little fine sand (CL)**

MC:	**23.8%**
LL:	**27**
PL:	**18**
PI:	**9**
Gs:	**NA**

BARRICK/RESERVATION CANYON TAILS/UT
983-2344.001-2

DATE:	23-Oct-98
TECH:	ZE
REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

PARTICLE-SIZE ANALYSIS OF SOILS

ASTM C 117, C 136, D 421, D 422, D 1140, D 2216, D 2217

BARRICK/RESERVATION CANYON TAILS/UT		**SAMPLE #:**	GA98 BH-11
983-2344.001-2		**DEPTH (FEET):**	140-142

MOISTURE CONTENT (Delivered Moisture) | **#200 WASH (Percent Fines)**

Tare	X22	Tare	17F
Weight Wet Soil & Tare, g	233.52	Weight Soil & Tare Before Wash, g	615.39
Weight Dry Soil & Tare, g	194.95	Weight Soil & Tare After Wash, g	195.40
Weight Tare, g	33.10	Weight Tare, g	158.13
Weight Water, g	38.57	Weight Fines Lost, g	331.99
Weight Dry Soil, g	161.85	Weight Dry Soil, g	369.26
Moisture, %	**23.83%**	Fines Lost, %	**89.91%**

	SIEVE	Wt. Ret.	% Ret.	% Pass.	SIEVE	
	6.000"	0.00	0.00%	**100.00%**	6.000"	
Coarse Gravel	3.000"	0.00	0.00%	**100.00%**	3.000"	Coarse Gravel
	1.500"	0.00	0.00%	**100.00%**	1.500"	
	1.000"	0.00	0.00%	**100.00%**	1.000"	
Fine Gravel	0.750"	0.00	0.00%	**100.00%**	0.750"	Fine Gravel
	0.375"	0.00	0.00%	**100.00%**	0.375"	
Coarse Sand	#4	0.00	0.00%	**100.00%**	#4	Coarse Sand
Medium Sand	#10	0.00	0.00%	**100.00%**	#10	Medium Sand
	#20	0.05	0.01%	**99.99%**	#20	
Fine Sand	#40	0.13	0.04%	**99.96%**	#40	Fine Sand
	#60	0.34	0.09%	**99.91%**	#60	
	#100	5.36	1.45%	**98.55%**	#100	
	#200	35.98	9.74%	**90.26%**	#200	
Fines	PAN	37.34	0.00%	**100.00%**	PAN	Fines

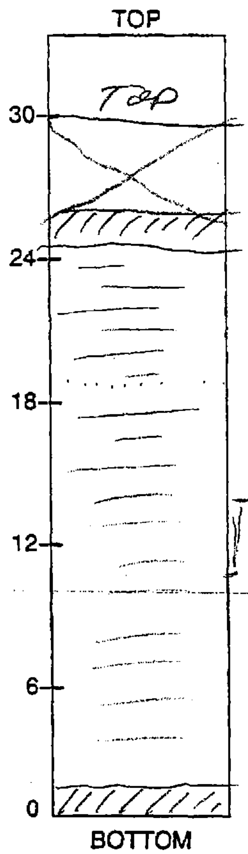
% C GRVL:	**0.0%**		Wet Color:	**CLAY with little fine sand (CL)**		
% F GRVL:	**0.0%**	0.0%	Description:			
% C SAND:	**0.0%**					
% M SAND:	**0.0%**		LL:	**27**		
% F SAND:	**9.7%**	9.7%	PL:	**18**	DATE:	23-Oct-98
% FINES:	**90.3%**		PI:	**9**	TECH:	ZE
% TOTAL:	**100.0%**		Gs:	**NA**	REVIEW:	DMD

GOLDER CONSTRUCTION SERVICES, INC.
LAKEWOOD, COLORADO

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344 001.2
PROJECT Barrick/Mercur Tailing/Ut
DATE 10/24/98

BORING NUMBER GA98 BH 11
SAMPLE NUMBER
DEPTH 140-142



SAMPLE DESCRIPTION

gray brown
Slime, moist, firm,
sandy streak

consol sel interval

DENSITY

DIAMETER (cm)	7.27
LENGTH (cm)	52.65
WT. TUBE & WET SAMPLE (g)	6051.5
TUBE WT. (g)	1573.2
WET WT. OF SAMPLE (g)	4478.3
AREA (cm^2)	41.51
VOLUME (cm^3)	2167.5
WET UNIT WT. (pcf)	127.9
DRY UNIT WT. (pcf)	103.3

WATER CONTENT DETERMINATION

	1	2
TARE #	X 22	X 15
WET WT. & TARE (g)	233.52	194.16
DRY WT. & TARE (g)	194.95	163.04
TARE (g)	33.10	32.38
MOISTURE CONTENT (%)	23.8	23.8

LAB WORK DONE BY: [illegible signature]
APPROVED BY:

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER	983-2344 021-2	BORING NUMBER	TB @ [illegible]
PROJECT	Barrick/Mercur Tailings/UT	SAMPLE NUMBER	
DATE	10/8/98	DEPTH	0 — 0.5

TOP

30
24
18
12
6 Top
0

BOTTOM

SAMPLE DESCRIPTION

Brass liner
Sand light brown moist w/ interlaminated thin slimes *

DENSITY

DIAMETER (cm)	6.19
LENGTH (cm)	14.09
WT. TUBE & WET SAMPLE (g)	971.50
TUBE WT. (g)	213.53
WET WT. OF SAMPLE (g)	757.97
AREA (cm^2)	30.09
VOLUME (cm^3)	424.0
WET UNIT WT. (pcf)	111.5
DRY UNIT WT. (pcf)	88.0

755.9

WATER CONTENT DETERMINATION

	1	2
TARE #	F32	X19
WET WT. & TARE (g)	199.70	152.60
DRY WT. & TARE (g)	165.63	126.62
TARE (g)	33.30	32.96
MOISTURE CONTENT (%)	25.7	27.7

26.7 Av

LAB WORK DONE BY: [illegible signature]

APPROVED BY:

15.21
- 1.02

1.14 .105

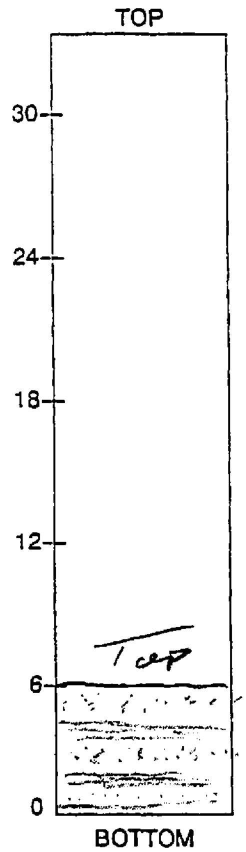
1.14 .4

1.16

SHELBY TUBE SAMPLE DESCRIPTION AND DENSITY MEASUREMENT

JOB NUMBER 983-2344 001-2
PROJECT Barrick/Mercur Tailing/Ut
DATE 10/8/98

BORING NUMBER TB @ CTP 9
SAMPLE NUMBER
DEPTH 0-5



SAMPLE DESCRIPTION

Brass Tube

Sand medium brown, w/ prominent slime lamination, moist, very friable, easily separates along bedding planes,

DENSITY

DIAMETER (cm)	6.19
LENGTH (cm)	14.70
WT. TUBE & WET SAMPLE (g)	953.4
TUBE WT. (g)	218.3
WET WT. OF SAMPLE (g)	735.1
AREA (cm²)	30.09
VOLUME (cm³)	442.4
WET UNIT WT. (pcf)	103.7
DRY UNIT WT. (pcf)	81.6

730.59

WATER CONTENT DETERMINATION

	1	2
TARE #	X 30	F 17
WET WT. & TARE (g)	200.26	191.29
DRY WT. & TARE (g)	164.48	158.11
TARE (g)	32.05	33.01
MOISTURE CONTENT (%)	27.0	26.5

26.8 Ave

15.19
.49

LAB WORK DONE BY: Eden
APPROVED BY:

APPENDIX D-2

CONSOLIDATION TESTING

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

BARRICK/MERCUR TAILINGS/UT	**SAMPLE:** GA98 BH-4	DATE	10/21/98
983-2344.001-2	40-42'	TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL		SAMPLE DATA, INITIAL		SAMPLE DATA, FINAL	
height (in)	1.330	total height (in)	1.330	total height (in)	1.055
diameter (in)	1.928	height of solids (in)	0.661	height of solids (in)	0.661
area (in^2)	2.919	height of voids (in)	0.670	height of voids (in)	0.395
volume (in^3)	3.883	void ratio	1.013	void ratio	0.597
specimen weight,wet (g)	116.12	dry density (pcf)	83.77	dry density (pcf)	105.58
specimen weight,dry (g)	85.38	moist density (pcf)	113.91	moist density (pcf)	130.46
water weight (g)	30.73				

DESCRIPTION

Brown color, CLAY with trace fine sand (CL), wet, undisturbed

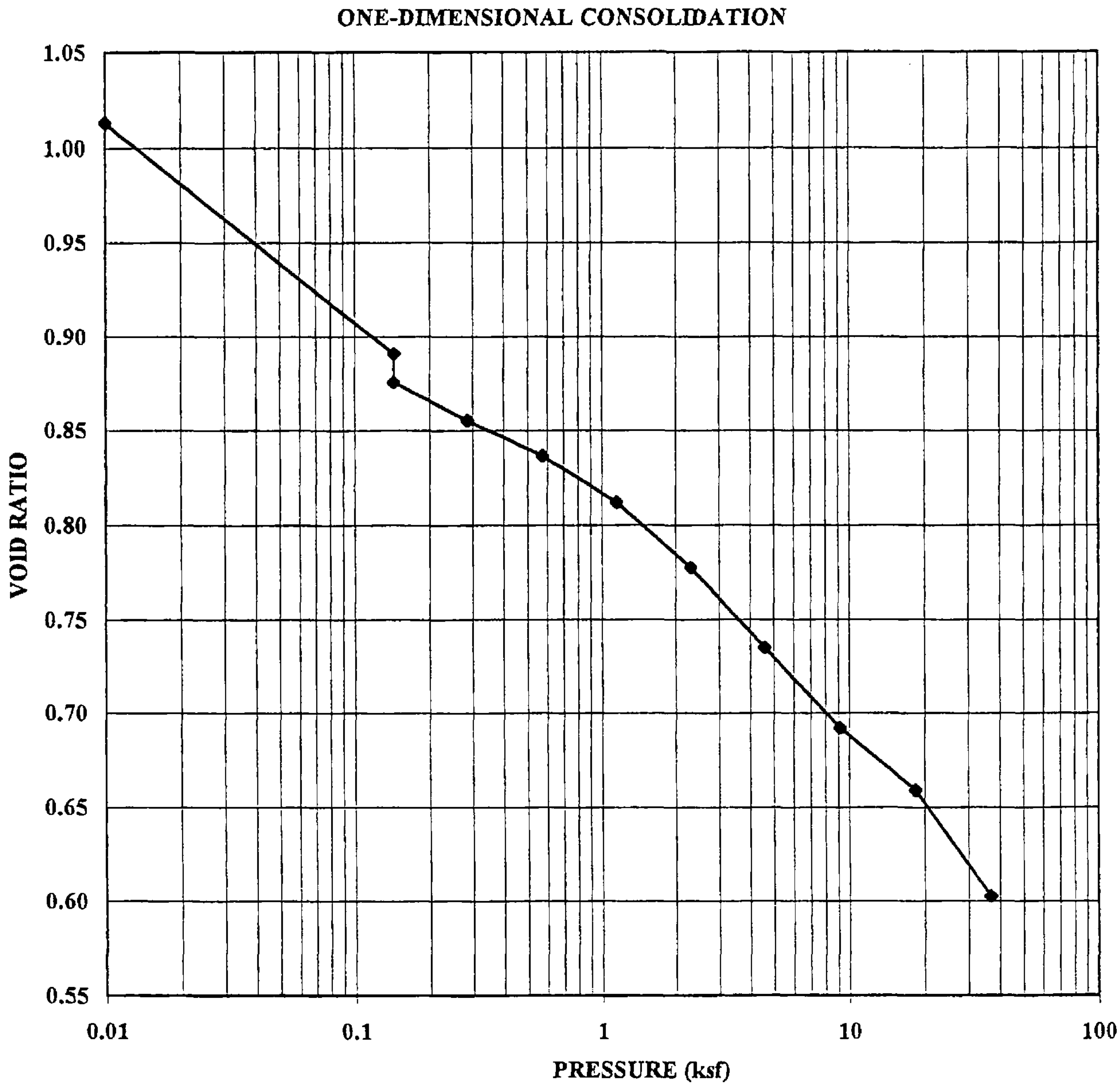
LL:	LL
PL:	PL
PI:	PI
Assumed Gs:	2.70

MOISTURE CONTENT, INITIAL		MOISTURE CONTENT, FINAL	
tare #	F-26	tare #	Q-9
wt soil&tare,moist	293.55	wt soil&tare,moist	131.32
wt soil&tare,dry	224.49	wt soil&tare,dry	111.69
wt tare	32.61	wt tare	28.38
wt moisture	69.06	wt moisture	19.63
wt dry soil	191.88	wt dry soil	83.31
% moisture	35.99%	% moisture	23.56%

PRESSURE	Final Sample	D50 Sample	t50	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)	Height	Height	TIME (min)	(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.3304	-	-	83.8	1.01	-	-	-	-	-	-
0.144	1.2451	-	-	89.1	0.89	-	-	-	-	-	-
0.144	1.2352	-	-	89.8	0.88	-	-	-	-	-	-
0.288	1.2218	1.2260	1.1017	90.8	0.86	0.6130	1.5570	0.3758	2.4243	7.23E-03	6.74E-01
0.576	1.2096	1.2158	1.0968	91.7	0.84	0.6079	1.5441	0.3696	2.3843	7.14E-03	6.66E-01
1.152	1.1934	1.2022	1.1103	93.0	0.81	0.6011	1.5268	0.3613	2.3311	6.89E-03	6.43E-01
2.304	1.1706	1.1826	1.4024	94.8	0.78	0.5913	1.5019	0.3497	2.2558	5.28E-03	4.93E-01
4.608	1.1426	1.1563	1.1833	97.1	0.74	0.5782	1.4685	0.3343	2.1566	5.98E-03	5.58E-01
9.216	1.1142	1.1283	0.9855	99.6	0.69	0.5642	1.4330	0.3183	2.0534	6.84E-03	6.38E-01
18.432	1.0925	1.1032	1.0851	101.6	0.66	0.5516	1.4011	0.3043	1.9630	5.94E-03	5.54E-01
36.864	1.0555	1.0724	0.5827	105.1	0.60	0.5362	1.3619	0.2875	1.8548	1.05E-02	9.75E-01

GOLDER ASSOCIATES INC.

LAKEWOOD, COLORADO



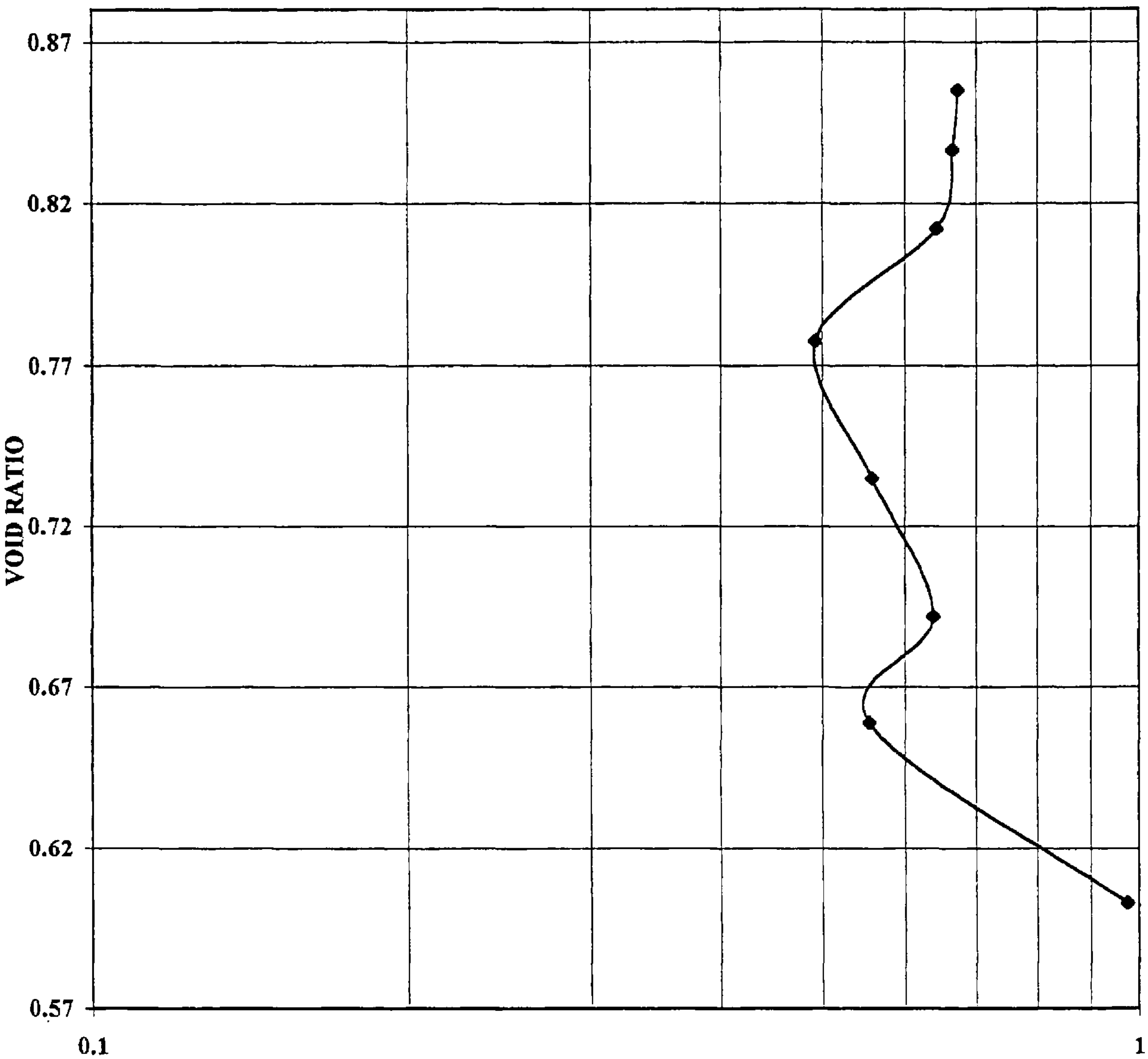
SAMPLE #:	GA98 BH-4 40-42'
DESCRIPTION:	Brown color, CLAY with trace fine sand (CL), wet, undisturbed

DATE	10/21/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #:	GA98 BH-4 40-42'
DESCRIPTION:	Brown color, CLAY with trace fine sand (CL), wet, undisturbed

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

DATE	10/21/98
TECH	ZE
REVIEW	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435

BARRICK/MERCUR TAILINGS/UT	SAMPLE: GA98- BH-4	DATE	10/20/98
983-2344.001-2	78-80'	TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.335
diameter (in)	1.926
area (in^2)	2.912
volume (in^3)	3.887
specimen weight,wet (g)	119.23
specimen weight,dry (g)	91.70
water weight (g)	27.53

SAMPLE DATA, INITIAL

total height (in)	1.335
height of solids (in)	0.711
height of voids (in)	0.623
void ratio	0.877
dry density (pcf)	89.87
moist density (pcf)	116.84

SAMPLE DATA, FINAL

total height (in)	1.025
height of solids (in)	0.711
height of voids (in)	0.314
void ratio	0.441
dry density (pcf)	117.03
moist density (pcf)	142.01

DESCRIPTION

Brown color, SILT with trace fine sand (ML), moist., undist.

LL:	29
PL:	23
PI:	6
(Assumed) Gs:	2.70

MOISTURE CONTENT, INITIAL

tare #	C-5
wt soil&tare,moist	289.88
wt soil&tare,dry	230.76
wt tare	33.80
wt moisture	59.12
wt dry soil	196.96
% moisture	30.02%

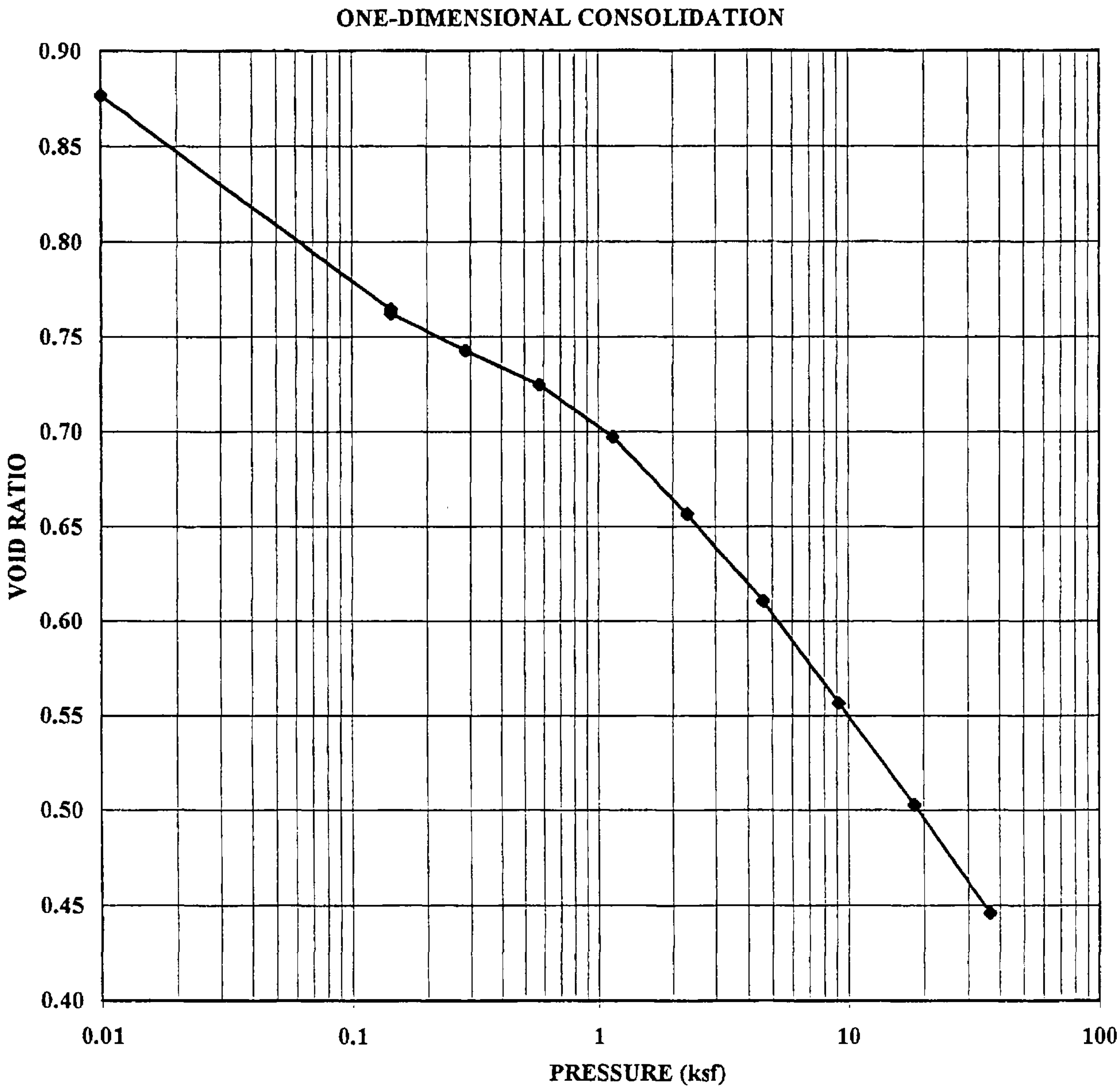
MOISTURE CONTENT, FINAL

tare #	F-30
wt soil&tare,moist	140.01
wt soil&tare,dry	121.16
wt tare	32.85
wt moisture	18.85
wt dry soil	88.31
% moisture	21.35%

PRESSURE	Final Sample	D50 Sample	t50 TIME (min)	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)	Height	Height		(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.3347	-	-	89.9	0.88	-	-	-	-	-	-
0.144	1.2507	-	-	95.5	0.76	-	-	-	-	-	-
0.144	1.2492	-	-	95.6	0.76	-	-	-	-	-	-
0.288	1.2353	1.2396	1.0784	96.7	0.74	0.6198	1.5743	0.3842	2.4785	7.55E-03	7.04E-01
0.576	1.2224	1.2267	1.1289	97.7	0.72	0.6133	1.5579	0.3762	2.4271	7.06E-03	6.59E-01
1.152	1.2030	1.2114	0.9105	99.3	0.70	0.6057	1.5385	0.3669	2.3669	8.54E-03	7.96E-01
2.304	1.1743	1.1869	0.9105	101.7	0.66	0.5935	1.5074	0.3522	2.2722	8.19E-03	7.65E-01
4.608	1.1416	1.1531	1.3288	104.6	0.61	0.5766	1.4645	0.3324	2.1448	5.30E-03	4.94E-01
9.216	1.1033	1.1173	0.9848	108.2	0.56	0.5586	1.4190	0.3121	2.0134	6.71E-03	6.26E-01
18.432	1.0651	1.0797	0.9716	112.1	0.50	0.5399	1.3712	0.2914	1.8802	6.35E-03	5.93E-01
36.864	1.0250	1.0393	1.4000	116.5	0.45	0.5196	1.3199	0.2700	1.7421	4.09E-03	3.81E-01

GOLDER ASSOCIATES INC.

LAKEWOOD, COLORADO

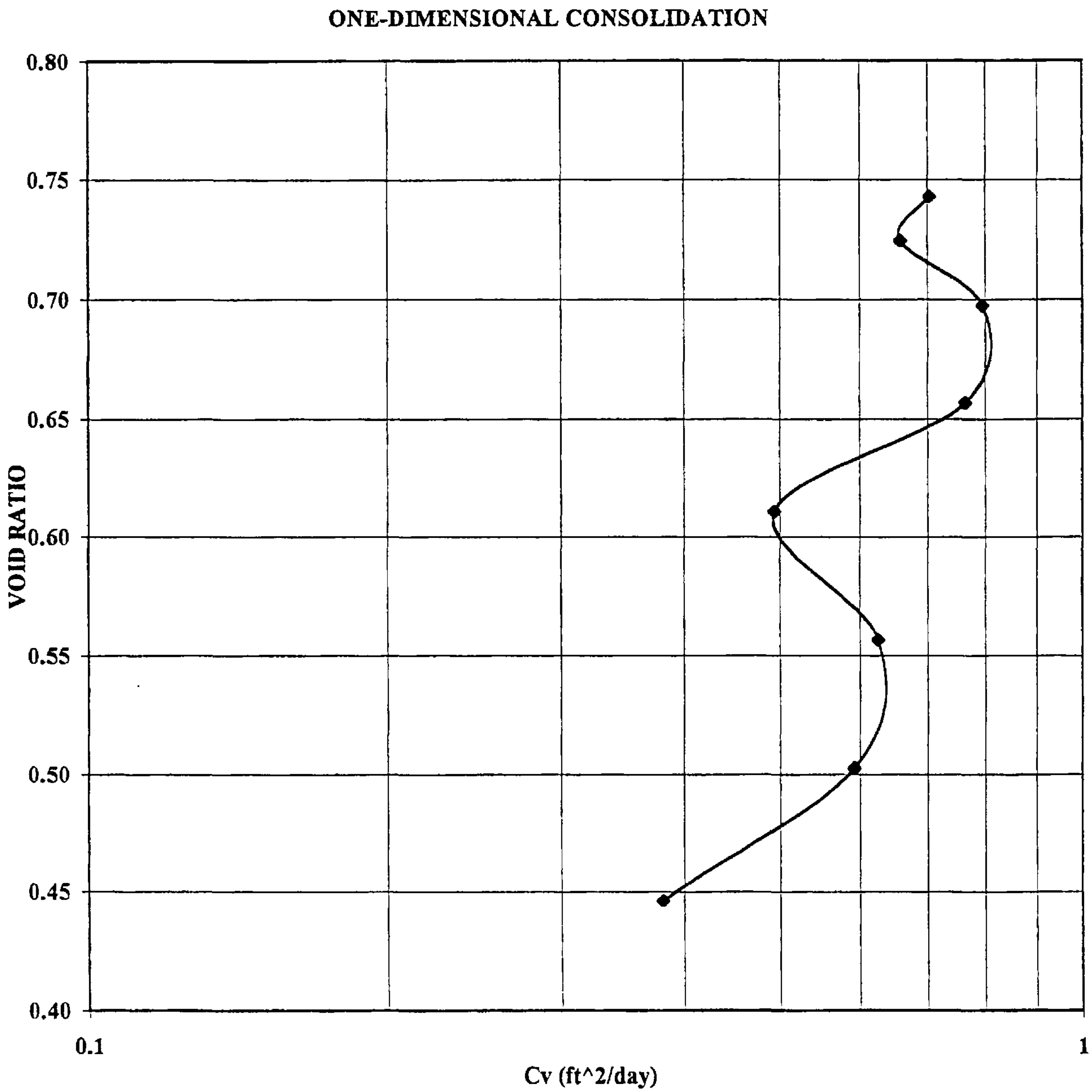


SAMPLE #:	GA98 BH-4 78-80'
DESCRIPTION:	Brown color, SILT with trace fine sand (ML), moist, undisturb.

DATE	10/20/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



SAMPLE #:	GA98 BH-4 78-80'
DESCRIPTION:	Brown color, SILT with trace fine sand (ML), moist, undisturb.

DATE	10/20/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

SAMPLE: GA98- BH-9A 20-22'

DATE	11/6/98
TECH	ZE
REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.335
diameter (in)	1.926
area (in^2)	2.912
volume (in^3)	3.889
specimen weight,wet (g)	126.19
specimen weight,dry (g)	101.96
water weight (g)	24.23

SAMPLE DATA, INITIAL

total height (in)	1.335
height of solids (in)	0.776
height of voids (in)	0.559
void ratio	0.720
dry density (pcf)	99.87
moist density (pcf)	123.61

SAMPLE DATA, FINAL

total height (in)	1.216
height of solids (in)	0.776
height of voids (in)	0.440
void ratio	0.566
dry density (pcf)	109.66
moist density (pcf)	133.33

DESCRIPTION

Fine to medium SAND and clay (SC)

LL:	LL
PL:	PL
PI:	PI
Assumed Gs:	2.75

MOISTURE CONTENT, INITIAL

tare #	Z2
wt soil&tare,moist	197.18
wt soil&tare,dry	164.72
wt tare	28.13
wt moisture	32.46
wt dry soil	136.59
% moisture	23.76%

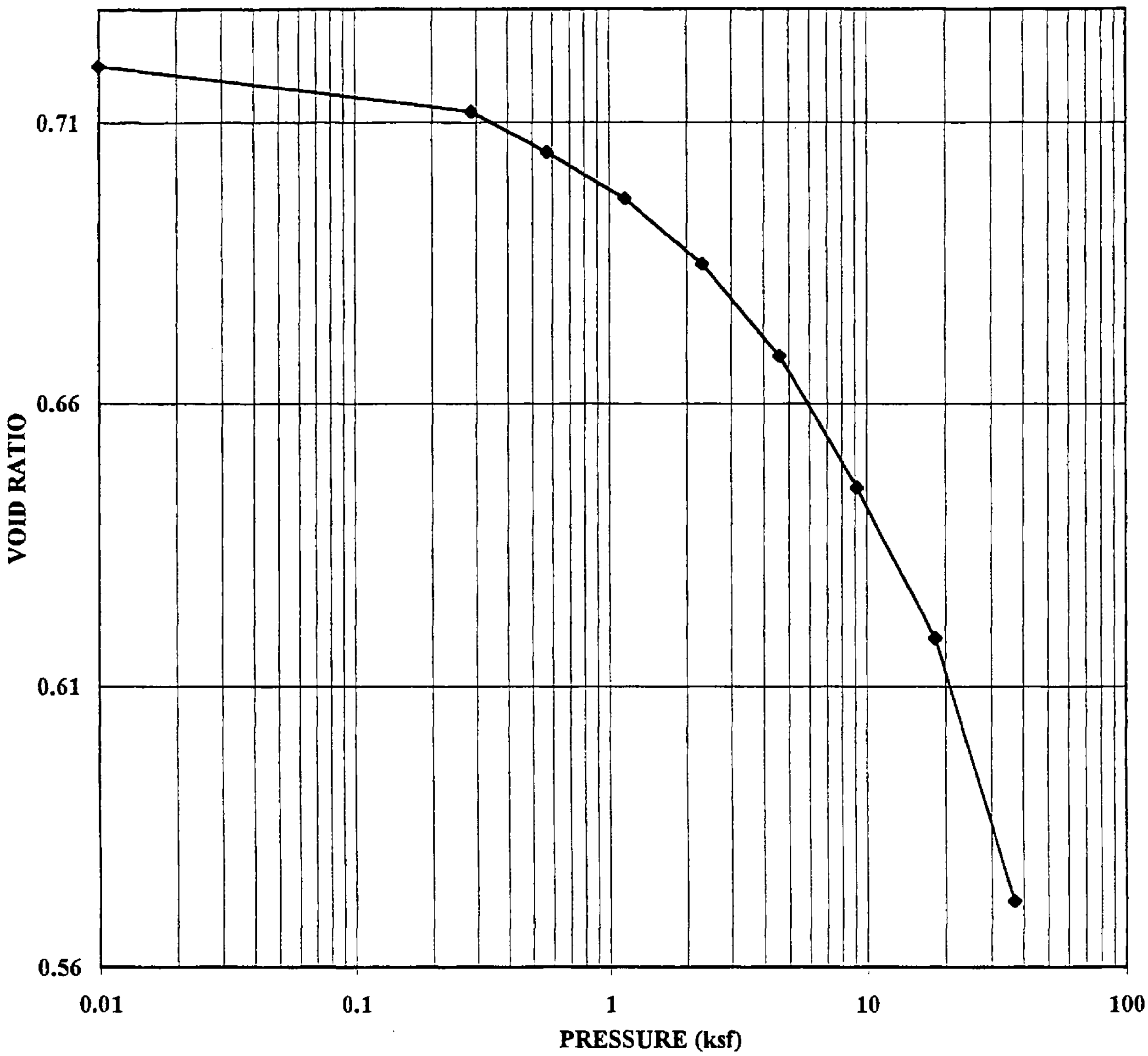
MOISTURE CONTENT, FINAL

tare #	Q6
wt soil&tare,moist	150.24
wt soil&tare,dry	128.53
wt tare	27.96
wt moisture	21.71
wt dry soil	100.57
% moisture	21.59%

PRESSURE	Final Sample	D50 Sample	t50 TIME (min)	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)	Height	Height		(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.3354	-	-	99.9	0.72	-	-	-	-	-	-
0.288	1.3246	1.3308	0.0350	100.2	0.71	0.6654	1.6901	0.4427	2.8563	2.68E-01	2.50E+01
0.576	1.3192	1.3219	0.0700	100.7	0.70	0.6609	1.6788	0.4368	2.8183	1.32E-01	1.23E+01
1.152	1.3128	1.3144	1.0000	101.1	0.70	0.6572	1.6693	0.4319	2.7867	9.15E-03	8.54E-01
2.304	1.3038	1.3089	0.0700	101.8	0.68	0.6545	1.6623	0.4283	2.7633	1.30E-01	1.21E+01
4.608	1.2911	1.2982	0.0654	102.8	0.67	0.6491	1.6487	0.4213	2.7183	1.36E-01	1.27E+01
9.216	1.2730	1.2827	0.0700	104.3	0.65	0.6413	1.6290	0.4113	2.6536	1.24E-01	1.16E+01
18.432	1.2524	1.2635	0.0780	106.0	0.62	0.6317	1.6046	0.3991	2.5747	1.08E-01	1.01E+01
36.864	1.2163	1.2364	0.1241	109.2	0.57	0.6182	1.5702	0.3822	2.4655	6.52E-02	6.09E+00

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



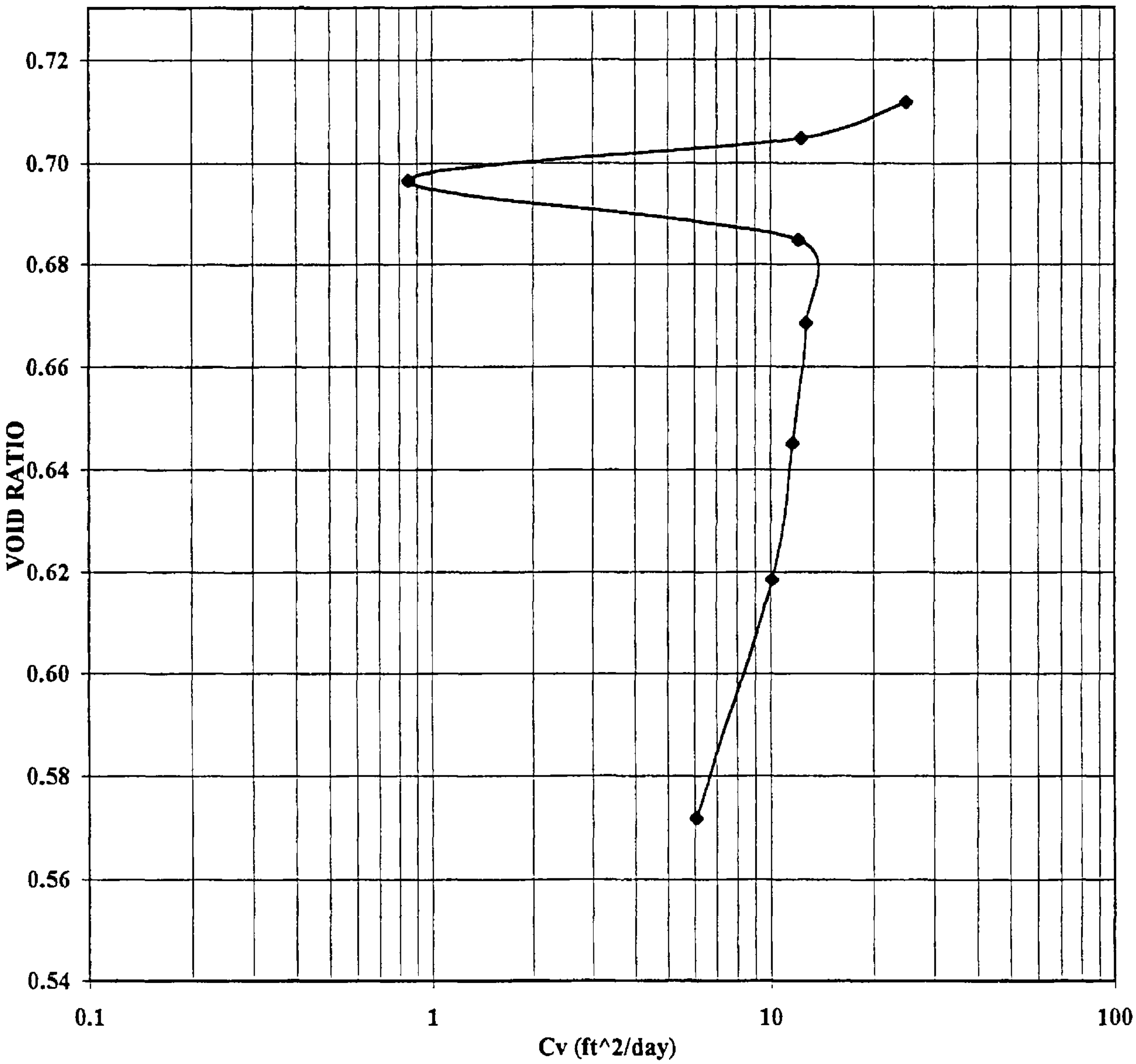
SAMPLE #:	GA98 BH9 20-22'
DESCRIPTION:	Fine to medium SAND and clay (SC)

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

DATE	11/6/98
TECH	ZE
REVIEW	DMD

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #:	GA98 BH9 20-22'
DESCRIPTION:	Fine to medium SAND and clay (SC)

DATE	11/6/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435

BARRICK/MERCUR TAILINGS/UT 983-2344.001-2	SAMPLE: GA98- BH-9 80-82'	DATE	10/8/98
		TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.337
diameter (in)	1.925
area (in^2)	2.911
volume (in^3)	3.891
specimen weight,wet (g)	130.02
specimen weight,dry (g)	102.67
water weight (g)	27.35

SAMPLE DATA, INITIAL

total height (in)	1.337
height of solids (in)	0.777
height of voids (in)	0.560
void ratio	0.721
dry density (pcf)	100.52
moist density (pcf)	127.30

SAMPLE DATA, FINAL

total height (in)	1.189
height of solids (in)	0.777
height of voids (in)	0.412
void ratio	0.531
dry density (pcf)	113.01
moist density (pcf)	133.00

DESCRIPTION

SILT and fine to medium sand, trace fine gravel (SM)

LL:	NP
PL:	NP
PI:	NP
Gs:	2.77

MOISTURE CONTENT, INITIAL

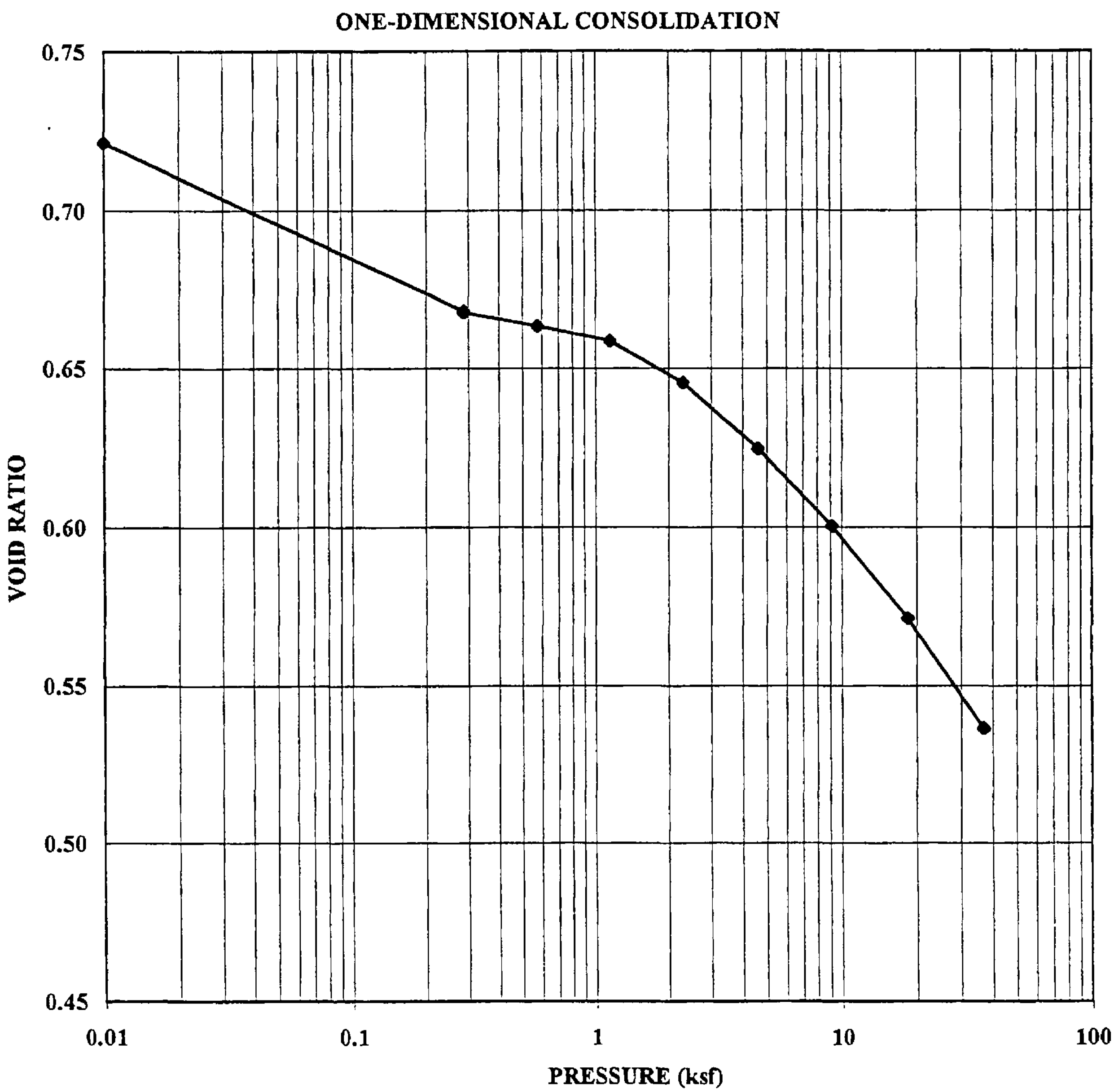
tare #	1A
wt soil&tare,moist	132.74
wt soil&tare,dry	112.06
wt tare	34.44
wt moisture	20.68
wt dry soil	77.62
% moisture	26.64%

MOISTURE CONTENT, FINAL

tare #	N5
wt soil&tare,moist	148.88
wt soil&tare,dry	130.70
wt tare	27.96
wt moisture	18.18
wt dry soil	102.74
% moisture	17.70%

PRESSURE	Final Sample	D50 Sample	t50	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)	Height	Height	TIME (min)	(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.3366	-	-	100.5	0.72	-	-	-	-	-	-
0.288	1.2909	-	-	103.6	0.67	-	-	-	-	-	-
0.288	1.2906	-	-	103.6	0.67	-	-	-	-	-	-
0.576	1.2871	1.2884	1.0272	103.9	0.66	0.6442	1.6363	0.4150	2.6775	8.56E-03	7.99E-01
1.152	1.2835	1.2845	1.3111	104.2	0.66	0.6423	1.6313	0.4125	2.6612	6.66E-03	6.22E-01
2.304	1.2734	1.2771	1.2560	105.0	0.65	0.6385	1.6219	0.4077	2.6304	6.88E-03	6.42E-01
4.608	1.2573	1.2624	0.9828	106.4	0.62	0.6312	1.6033	0.3984	2.5705	8.59E-03	8.01E-01
9.216	1.2385	1.2436	1.0620	108.0	0.60	0.6218	1.5794	0.3866	2.4944	7.71E-03	7.20E-01
18.432	1.2161	1.2217	1.1017	110.0	0.57	0.6109	1.5516	0.3731	2.4074	7.17E-03	6.69E-01
36.864	1.1890	1.1961	1.1257	112.5	0.54	0.5981	1.5191	0.3577	2.3075	6.73E-03	6.28E-01

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



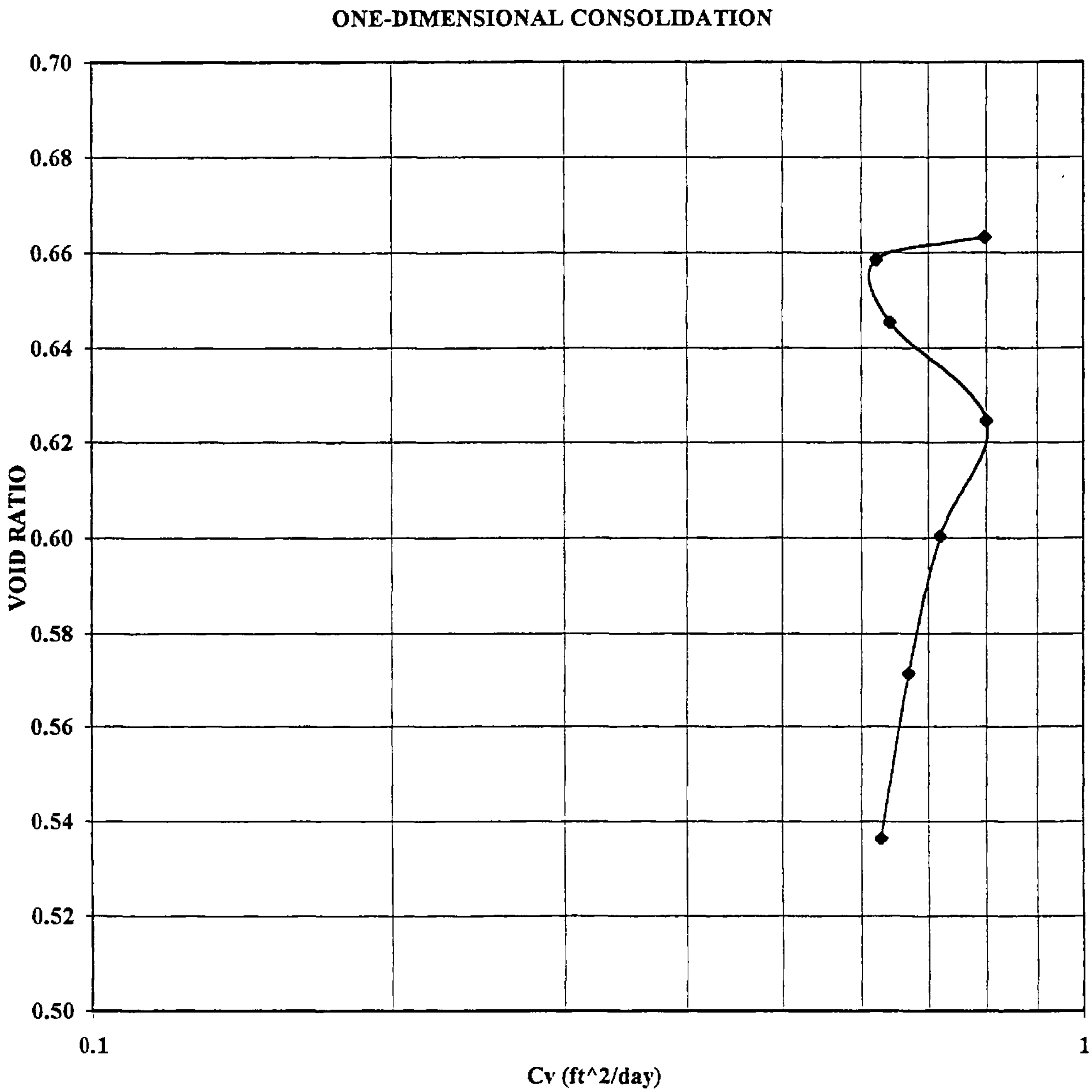
SAMPLE #: GA98 BH-9 80-82'

DESCRIPTION: SILT and fine to medium sand, trace fine gravel (SM)

DATE	10/8/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



SAMPLE #: GA98 BH-9 80-82'

DESCRIPTION: SILT and fine to medium sand, trace fine gravel (SM)

DATE	10/26/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435

BARRICK/MERCUR TAILINGS/UT	SAMPLE: GA98- BH-9	DATE	11/2/98
983-2344.001-2	200-202'	TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.330
diameter (in)	1.927
area (in^2)	2.916
volume (in^3)	3.877
specimen weight,wet (g)	130.93
specimen weight,dry (g)	105.74
water weight (g)	25.19

SAMPLE DATA, INITIAL

total height (in)	1.330
height of solids (in)	0.804
height of voids (in)	0.525
void ratio	0.653
dry density (pcf)	103.89
moist density (pcf)	128.64

SAMPLE DATA, FINAL

total height (in)	1.197
height of solids (in)	0.802
height of voids (in)	0.396
void ratio	0.494
dry density (pcf)	115.00
moist density (pcf)	138.11

DESCRIPTION

SILTY CLAY with little fine to coarse sand, trace fine gravel (CL-ML)

LL:	29
PL:	22
PI:	7
Gs:	2.75

MOISTURE CONTENT, INITIAL

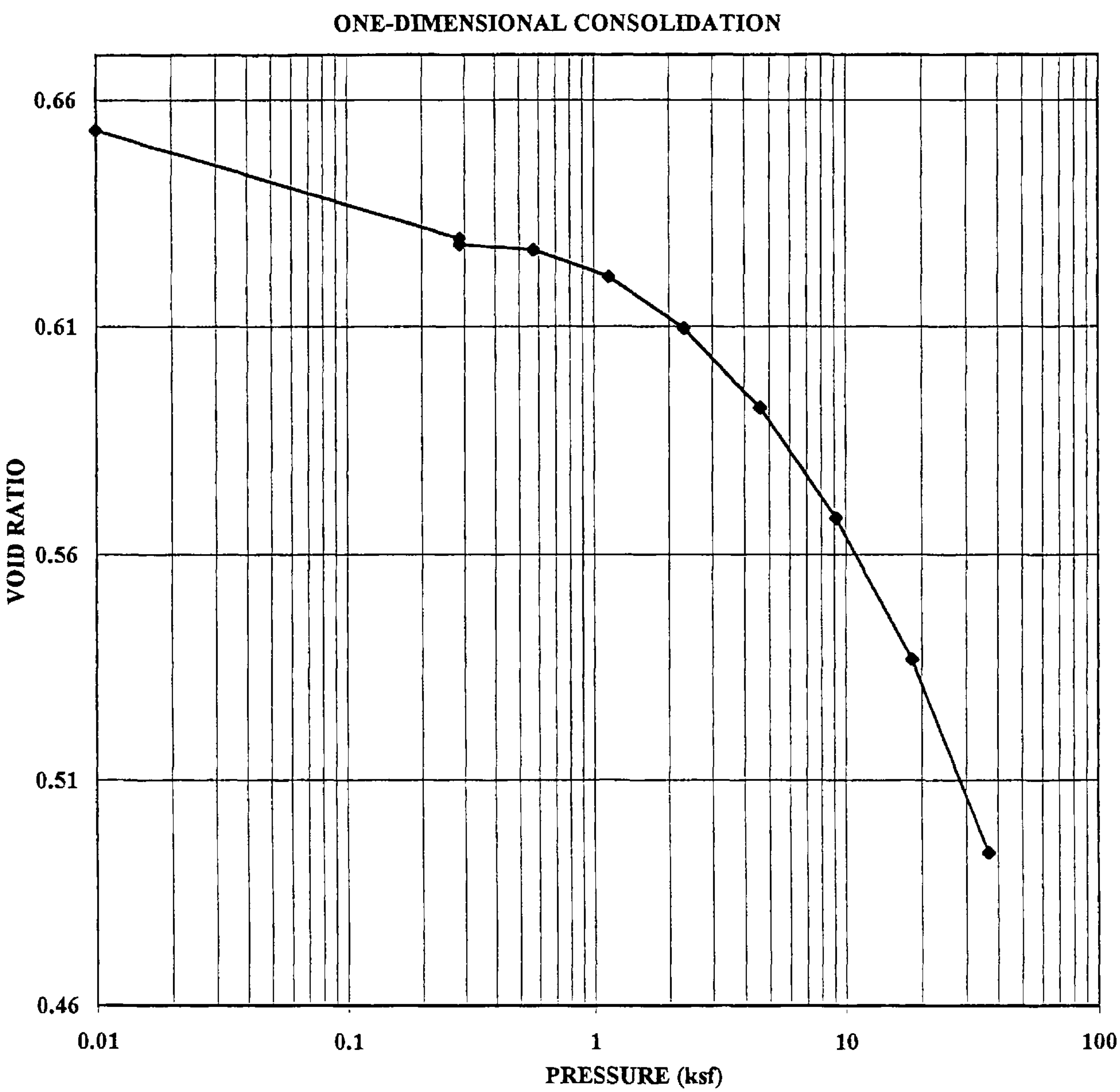
tare #	X17
wt soil&tare,moist	240.66
wt soil&tare,dry	200.73
wt tare	33.09
wt moisture	39.93
wt dry soil	167.64
% moisture	23.82%

MOISTURE CONTENT, FINAL

tare #	X28
wt soil&tare,moist	159.17
wt soil&tare,dry	138.14
wt tare	33.51
wt moisture	21.03
wt dry soil	104.63
% moisture	20.10%

PRESSURE	Final Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)				(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.3295	-	-	103.9	0.65	-	-	-	-	-	-
0.288	1.3058	-	-	105.3	0.63	-	-	-	-	-	-
0.288	1.3048	1.3158	1.7043	105.4	0.63	0.6579	1.6711	0.4328	2.7924	5.38E-03	5.02E-01
0.576	1.3038	1.3044	1.0907	105.5	0.63	0.6522	1.6566	0.4254	2.7443	8.26E-03	7.71E-01
1.152	1.2991	1.3016	0.7017	105.9	0.62	0.6508	1.6530	0.4235	2.7324	1.28E-02	1.19E+00
2.304	1.2899	1.2940	0.9333	106.6	0.61	0.6470	1.6434	0.4186	2.7009	9.50E-03	8.87E-01
4.608	1.2761	1.2828	0.9284	107.8	0.59	0.6414	1.6291	0.4114	2.6540	9.39E-03	8.76E-01
9.216	1.2566	1.2658	0.8351	109.4	0.57	0.6329	1.6076	0.4006	2.5844	1.02E-02	9.48E-01
18.432	1.2315	1.2440	1.0907	111.7	0.54	0.6220	1.5798	0.3869	2.4958	7.51E-03	7.01E-01
36.864	1.1973	1.2169	0.9128	114.9	0.49	0.6085	1.5455	0.3702	2.3886	8.59E-03	8.02E-01

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



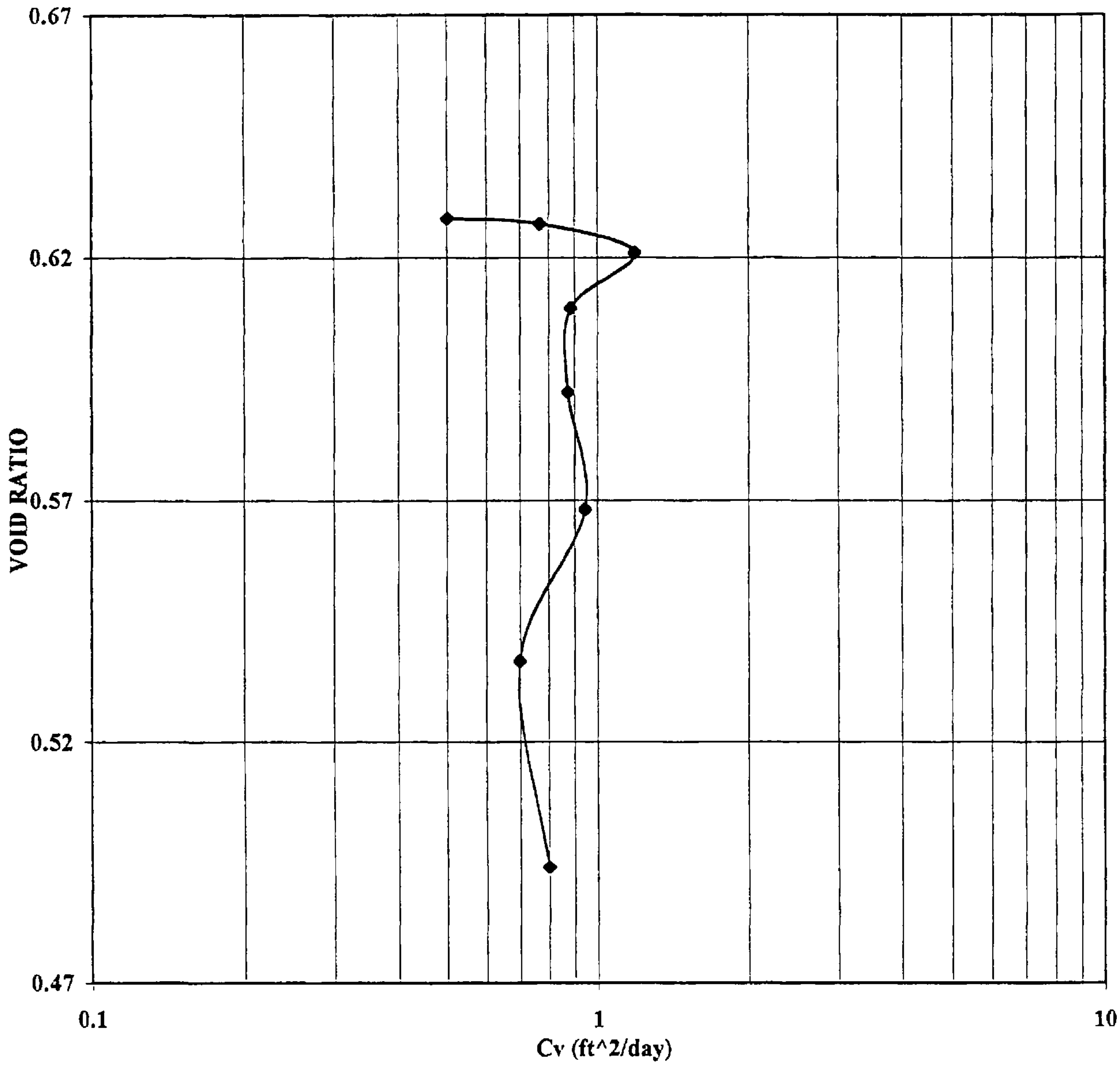
SAMPLE #:	GA98 BH-9 200-202'
DESCRIPTION:	SILTY CLAY with little fine to coarse sand, trace fine gravel (CL-ML)

DATE	11/2/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

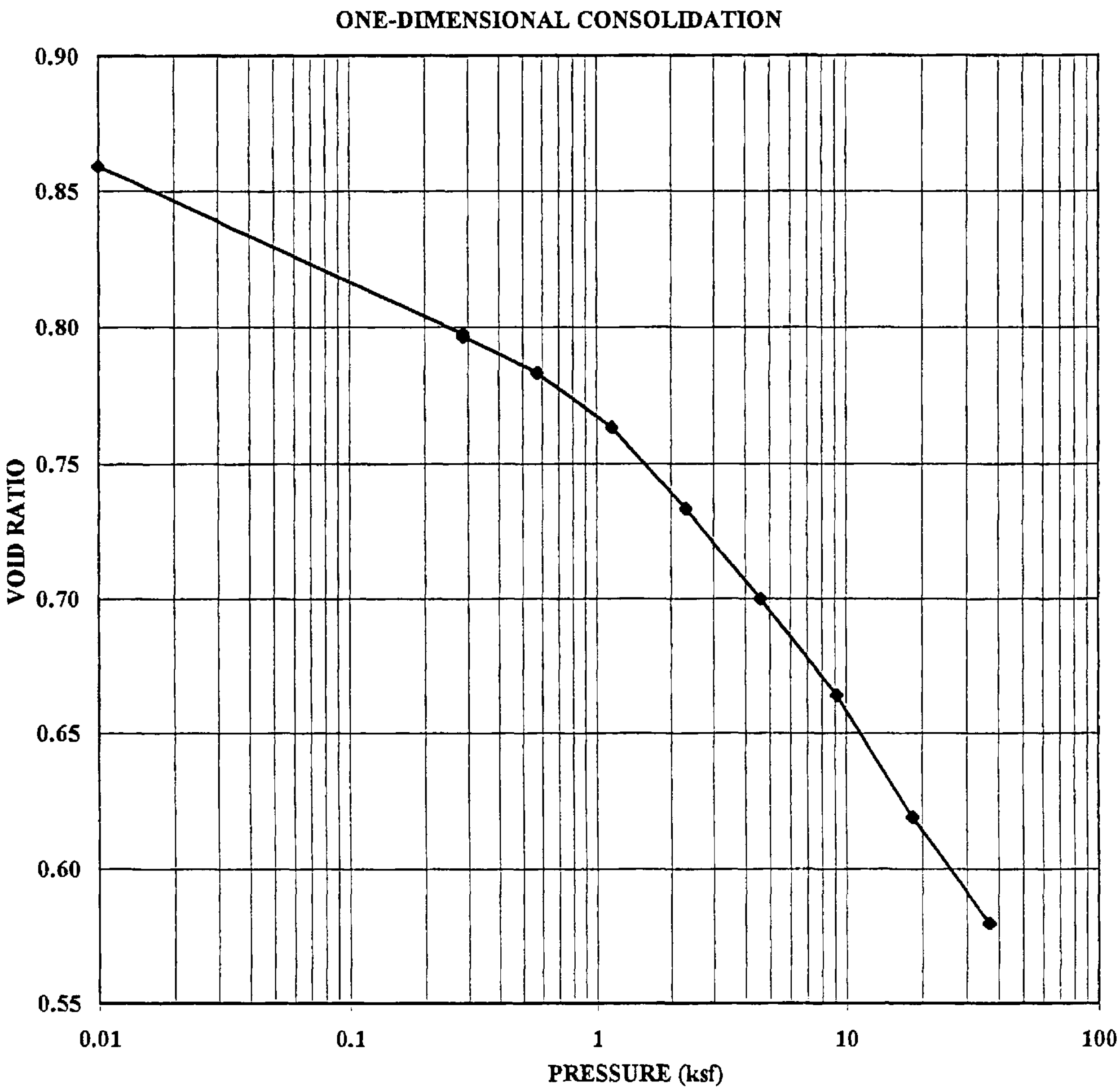


SAMPLE #:	GA98 BH-9 200-202'
DESCRIPTION:	SILTY CLAY with little fine to coarse sand, trace fine gravel (CL-ML)

DATE	11/2/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



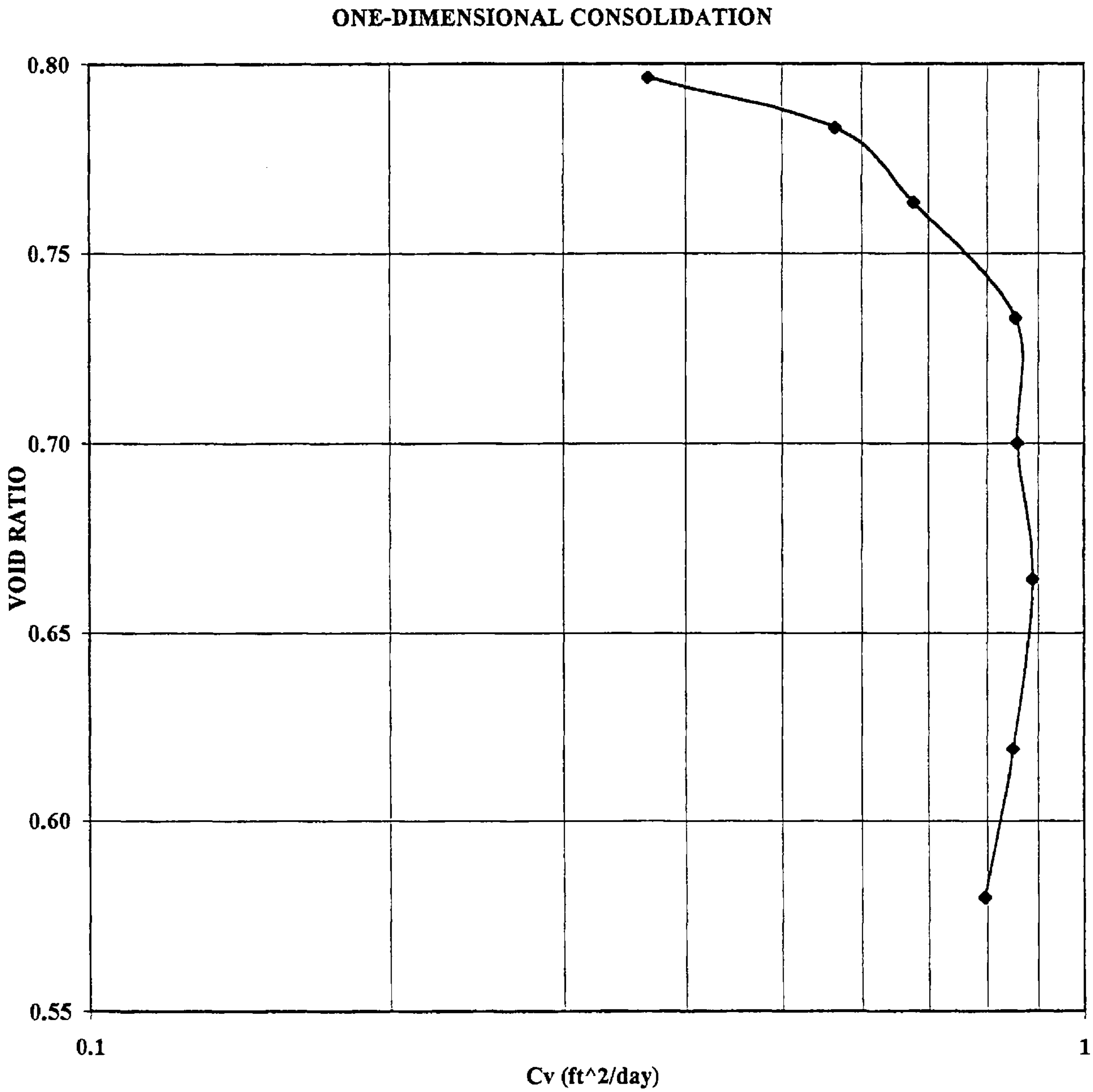
SAMPLE #: GA98 BH10
40-42'

DESCRIPTION: CLAY with trace fine to coarse sand, trace fine gravel (CL)

DATE	11/3/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



SAMPLE #:	GA98 BH10 40-42'
DESCRIPTION:	CLAY with trace fine to coarse sand, trace fine gravel (CL)

DATE	11/3/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

BARRICK/MERCUR TAILINGS/UT	SAMPLE: GA98- BH-10	DATE	11/3/98
983-2344.001-2	40-42'	TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.329
diameter (in)	1.928
area (in^2)	2.921
volume (in^3)	3.883
specimen weight,wet (g)	123.95
specimen weight,dry (g)	94.84
water weight (g)	29.11

SAMPLE DATA, INITIAL

total height (in)	1.329
height of solids (in)	0.715
height of voids (in)	0.614
void ratio	0.859
dry density (pcf)	93.05
moist density (pcf)	121.62

SAMPLE DATA, FINAL

total height (in)	1.126
height of solids (in)	0.711
height of voids (in)	0.415
void ratio	0.583
dry density (pcf)	109.31
moist density (pcf)	133.38

DESCRIPTION

CLAY with trace fine to coarse sand, trace fine gravel (CL)

LL:	LL
PL:	PL
PI:	PI
Gs:	2.77

MOISTURE CONTENT, INITIAL

tare #	X28
wt soil&tare,moist	136.43
wt soil&tare,dry	112.26
wt tare	33.52
wt moisture	24.17
wt dry soil	78.74
% moisture	30.70%

MOISTURE CONTENT, FINAL

tare #	4A
wt soil&tare,moist	147.72
wt soil&tare,dry	127.04
wt tare	33.13
wt moisture	20.68
wt dry soil	93.91
% moisture	22.02%

PRESSURE	Final Sample	D50 Sample	t50	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)	Height	Height	TIME (min)	(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.3294	-	-	93.1	0.86	-	-	-	-	-	-
0.288	1.2807	-	-	96.2	0.80	-	-	-	-	-	-
0.288	1.2800	1.3013	2.2820	96.2	0.80	0.6507	1.6527	0.4234	2.7313	3.93E-03	3.67E-01
0.576	1.2706	1.2764	1.4224	96.9	0.78	0.6382	1.6210	0.4073	2.6278	6.07E-03	5.66E-01
1.152	1.2565	1.2638	1.1654	98.0	0.76	0.6319	1.6051	0.3993	2.5763	7.26E-03	6.77E-01
2.304	1.2350	1.2454	0.8968	99.7	0.73	0.6227	1.5817	0.3878	2.5018	9.16E-03	8.55E-01
4.608	1.2114	1.2231	0.8612	101.7	0.70	0.6116	1.5534	0.3740	2.4129	9.20E-03	8.58E-01
9.216	1.1858	1.1983	0.7984	103.9	0.66	0.5992	1.5219	0.3590	2.3160	9.52E-03	8.89E-01
18.432	1.1538	1.1703	0.7962	106.7	0.62	0.5852	1.4863	0.3424	2.2091	9.11E-03	8.50E-01
36.864	1.1257	1.1390	0.8054	109.4	0.58	0.5695	1.4466	0.3243	2.0926	8.53E-03	7.96E-01

GOLDER ASSOCIATES INC.

LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION
ASTM D 2435

BARRICK/MERCUR TAILINGS/UT	SAMPLE: GA98- BH-11	DATE	11/3/98
983-2344.001-2	20-22'	TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	0.535
diameter (in)	2.500
area (in^2)	4.909
volume (in^3)	2.626
specimen weight,wet (g)	85.39
specimen weight,dry (g)	68.55
water weight (g)	16.84

SAMPLE DATA, INITIAL

total height (in)	0.535
height of solids (in)	0.310
height of voids (in)	0.225
void ratio	0.727
dry density (pcf)	99.44
moist density (pcf)	123.87

SAMPLE DATA, FINAL

total height (in)	0.489
height of solids (in)	0.310
height of voids (in)	0.180
void ratio	0.580
dry density (pcf)	108.70
moist density (pcf)	131.25

DESCRIPTION

Fine to medium SAND and clay (SC)

LL:	LL
PL:	PL
PI:	PI
Assumed Gs:	2.75

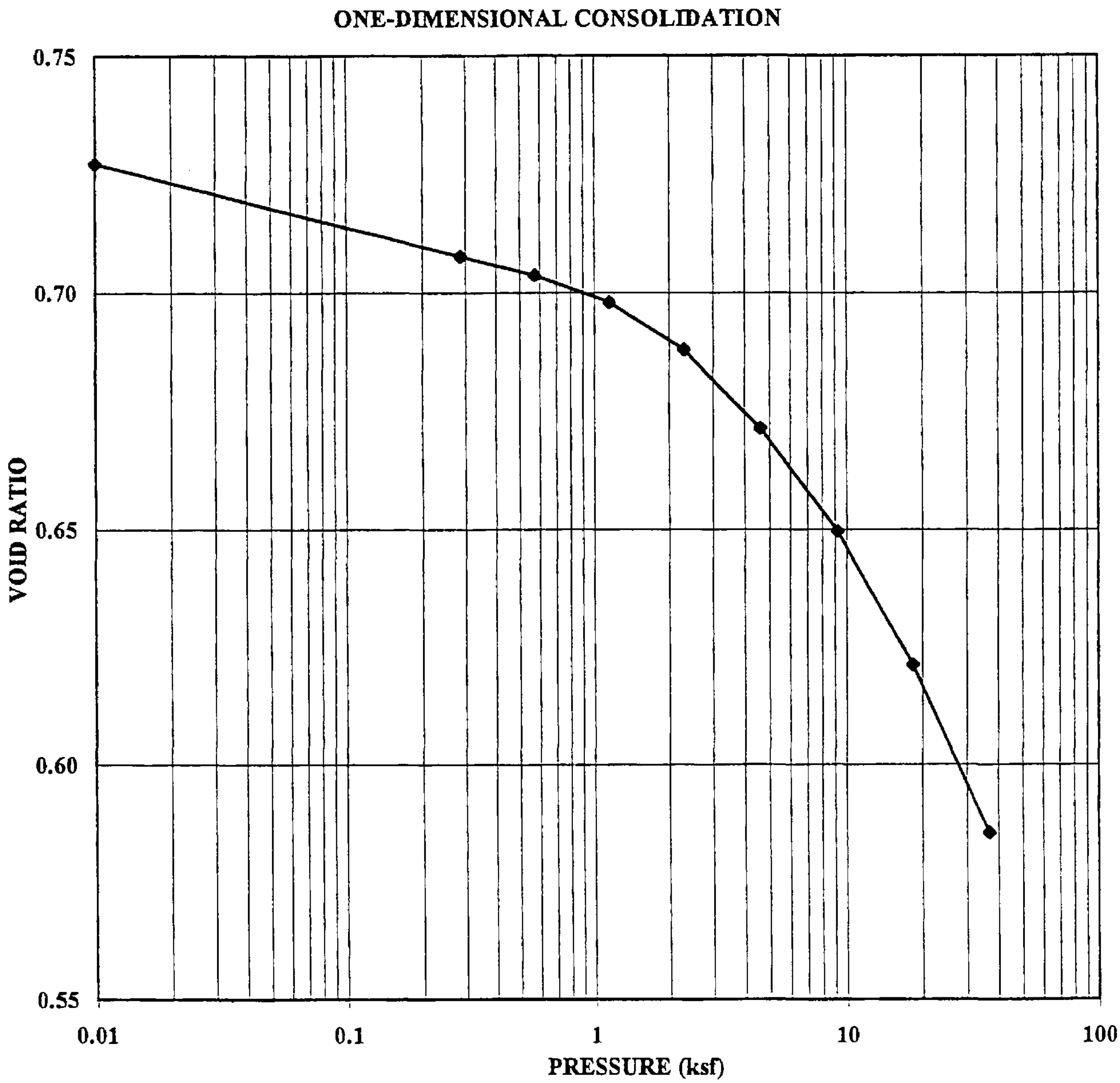
MOISTURE CONTENT, INITIAL

tare #	F32
wt soil&tare,moist	203.44
wt soil&tare,dry	169.91
wt tare	33.38
wt moisture	33.53
wt dry soil	136.53
% moisture	24.56%

MOISTURE CONTENT, FINAL

tare #	T7
wt soil&tare,moist	110.70
wt soil&tare,dry	96.59
wt tare	28.59
wt moisture	14.11
wt dry soil	68.00
% moisture	20.75%

PRESSURE	Final Sample	D50 Sample	t50	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)	Height	Height	TIME (min)	(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	0.5350	-	-	99.4	0.73	-	-	-	-	-	-
0.288	0.5271	-	-	100.5	0.71	-	-	-	-	-	-
0.576	0.5259	0.5263	1.5625	100.7	0.70	0.2631	0.6684	0.0692	0.4467	9.39E-04	8.76E-02
1.152	0.5241	0.5248	0.8521	101.1	0.70	0.2624	0.6665	0.0689	0.4442	1.71E-03	1.60E-01
2.304	0.5210	0.5218	1.1187	101.7	0.69	0.2609	0.6627	0.0681	0.4391	1.29E-03	1.20E-01
4.608	0.5159	0.5172	0.9619	102.7	0.67	0.2586	0.6569	0.0669	0.4315	1.47E-03	1.37E-01
9.216	0.5092	0.5109	1.1187	104.0	0.65	0.2554	0.6488	0.0653	0.4210	1.24E-03	1.15E-01
18.432	0.5004	0.5029	1.0203	105.8	0.62	0.2515	0.6387	0.0632	0.4080	1.31E-03	1.23E-01
36.864	0.4894	0.4923	1.1102	108.2	0.59	0.2461	0.6252	0.0606	0.3909	1.16E-03	1.08E-01



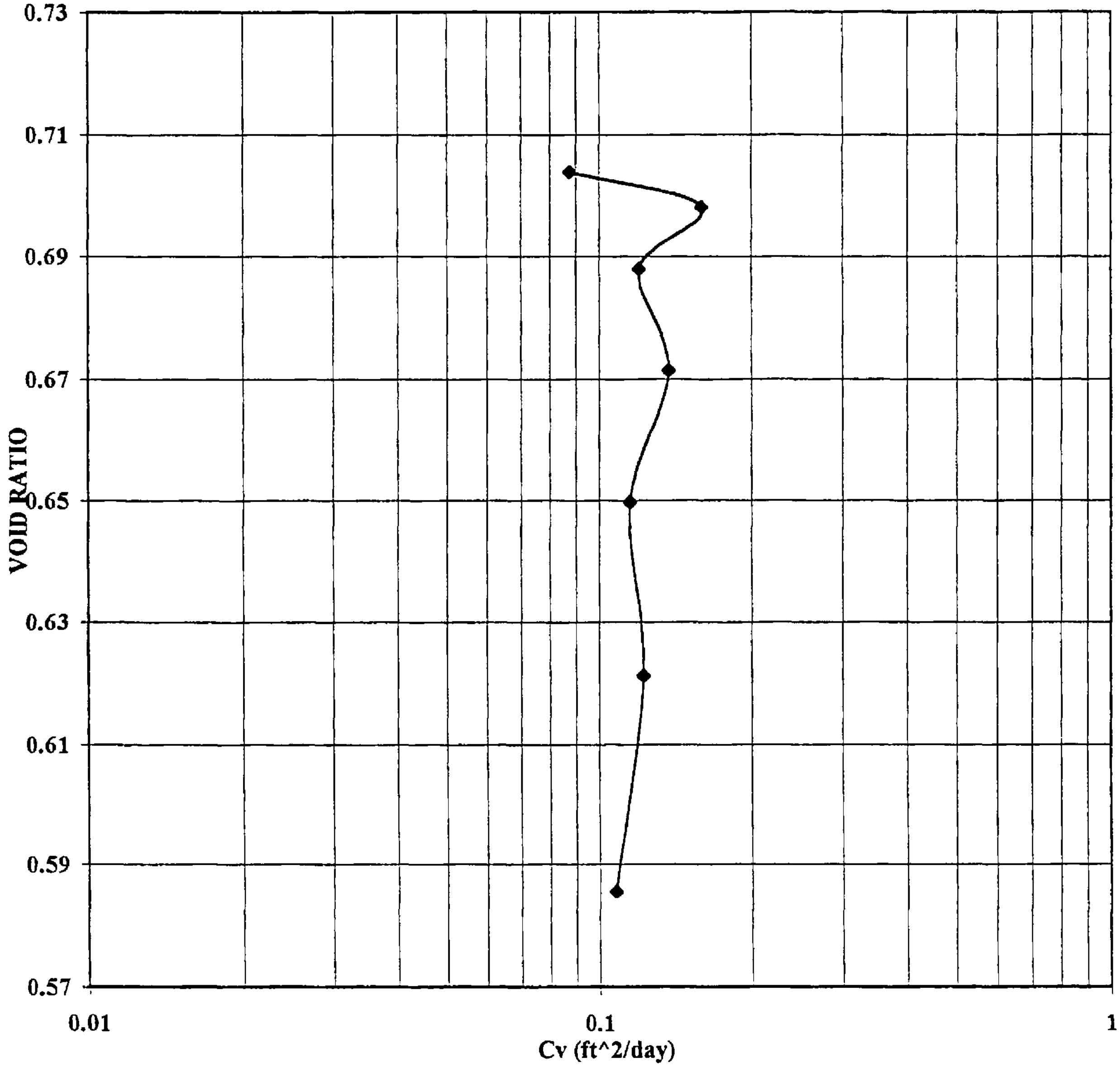
SAMPLE #:	GA98 BH11 20-22'
DESCRIPTION:	Fine to medium SAND and clay (SC)

DATE	11/3/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #: GA98 BH1 20-22'

DESCRIPTION: Fine to medium SAND and clay (SC)

DATE	11/3/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

SAMPLE: GA98- BH-11
101-103'

DATE	11/4/98
TECH	ZE
REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.000
diameter (in)	2.500
area (in^2)	4.909
volume (in^3)	4.909
specimen weight,wet (g)	156.47
specimen weight,dry (g)	117.40
water weight (g)	39.07

SAMPLE DATA, INITIAL

total height (in)	1.000
height of solids (in)	0.527
height of voids (in)	0.473
void ratio	0.899
dry density (pcf)	91.11
moist density (pcf)	121.43

SAMPLE DATA, FINAL

total height (in)	0.868
height of solids (in)	0.527
height of voids (in)	0.342
void ratio	0.649
dry density (pcf)	104.94
moist density (pcf)	127.99

DESCRIPTION

CLAY with trace fine sand (CL)

LL:	LL
PL:	PL
PI:	PI
Assumed Gs:	2.77

MOISTURE CONTENT, INITIAL

tare #	F17
wt soil&tare,moist	284.24
wt soil&tare,dry	221.53
wt tare	33.08
wt moisture	62.71
wt dry soil	188.45
% moisture	33.28%

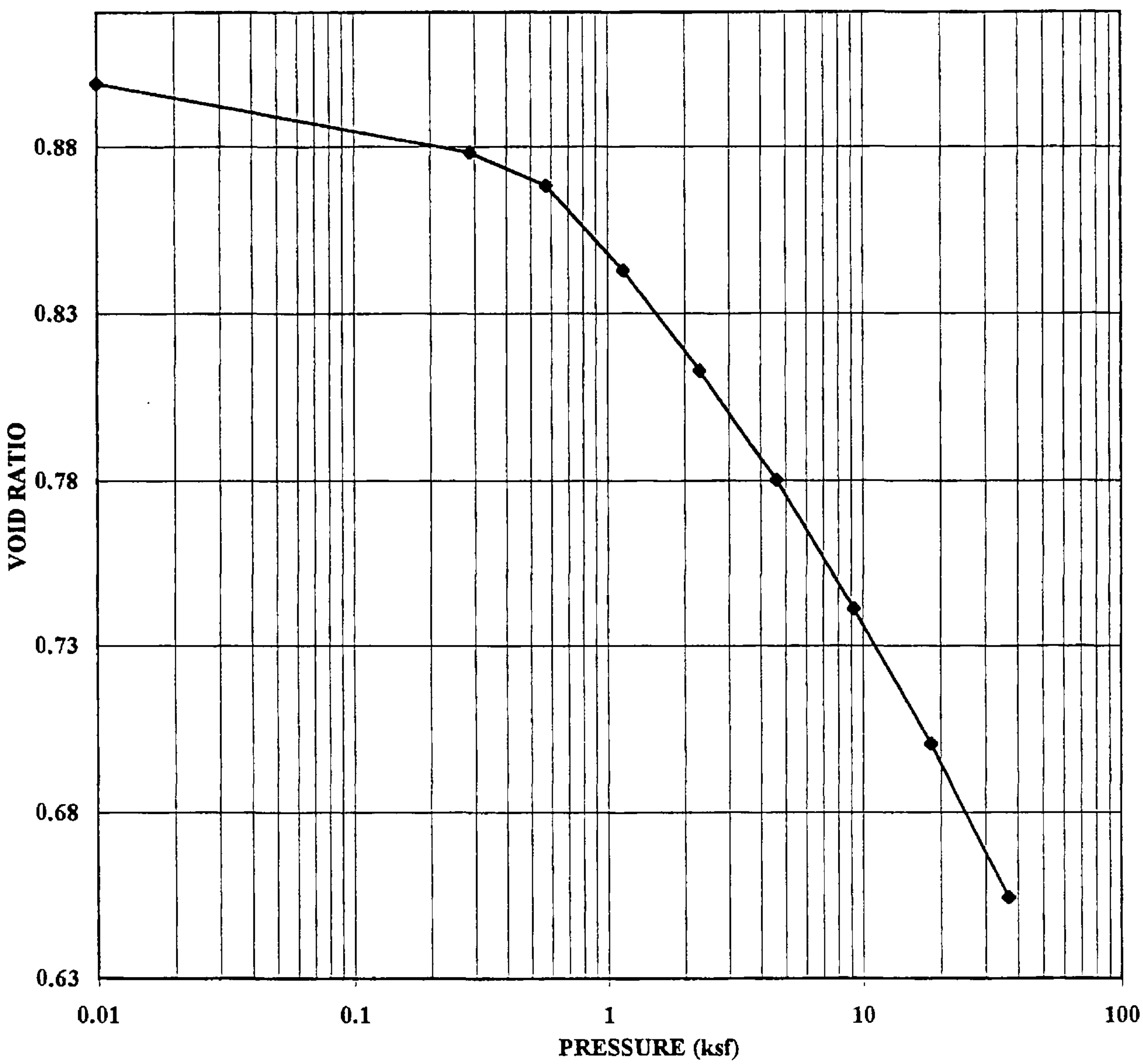
MOISTURE CONTENT, FINAL

tare #	F25
wt soil&tare,moist	178.80
wt soil&tare,dry	152.49
wt tare	32.71
wt moisture	26.31
wt dry soil	119.78
% moisture	21.97%

PRESSURE (ksf)	Final Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density (pcf)	VOID RATIO e	DRAINAGE PATH (DOUBLE DRAINAGE) H (in)	H (cm)	DRAINAGE PATH (DOUBLE DRAINAGE) H^2 (in^2)	H^2 (cm^2)	COEFFICIENT OF CONSOLIDATION Cv (cm^2/sec)	(ft^2/day)
0.010	1.0000	-	-	91.1	0.90	-	-	-	-	-	-
0.288	0.9857	0.9948	1.7918	92.0	0.88	0.4974	1.2633	0.2474	1.5960	2.92E-03	2.73E-01
0.576	0.9805	0.9846	1.4149	92.5	0.87	0.4923	1.2504	0.2424	1.5636	3.63E-03	3.39E-01
1.152	0.9671	0.9749	1.1853	93.8	0.84	0.4874	1.2381	0.2376	1.5329	4.25E-03	3.96E-01
2.304	0.9513	0.9597	1.0081	95.4	0.81	0.4798	1.2188	0.2302	1.4854	4.84E-03	4.51E-01
4.608	0.9342	0.9430	0.5000	97.1	0.78	0.4715	1.1976	0.2223	1.4343	9.42E-03	8.79E-01
9.216	0.9138	0.9254	0.2800	99.3	0.74	0.4627	1.1753	0.2141	1.3813	1.62E-02	1.51E+00
18.432	0.8924	0.9054	0.1955	101.6	0.70	0.4527	1.1498	0.2049	1.3222	2.22E-02	2.07E+00
36.864	0.8682	0.8829	0.1455	104.5	0.65	0.4415	1.1213	0.1949	1.2573	2.84E-02	2.65E+00

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

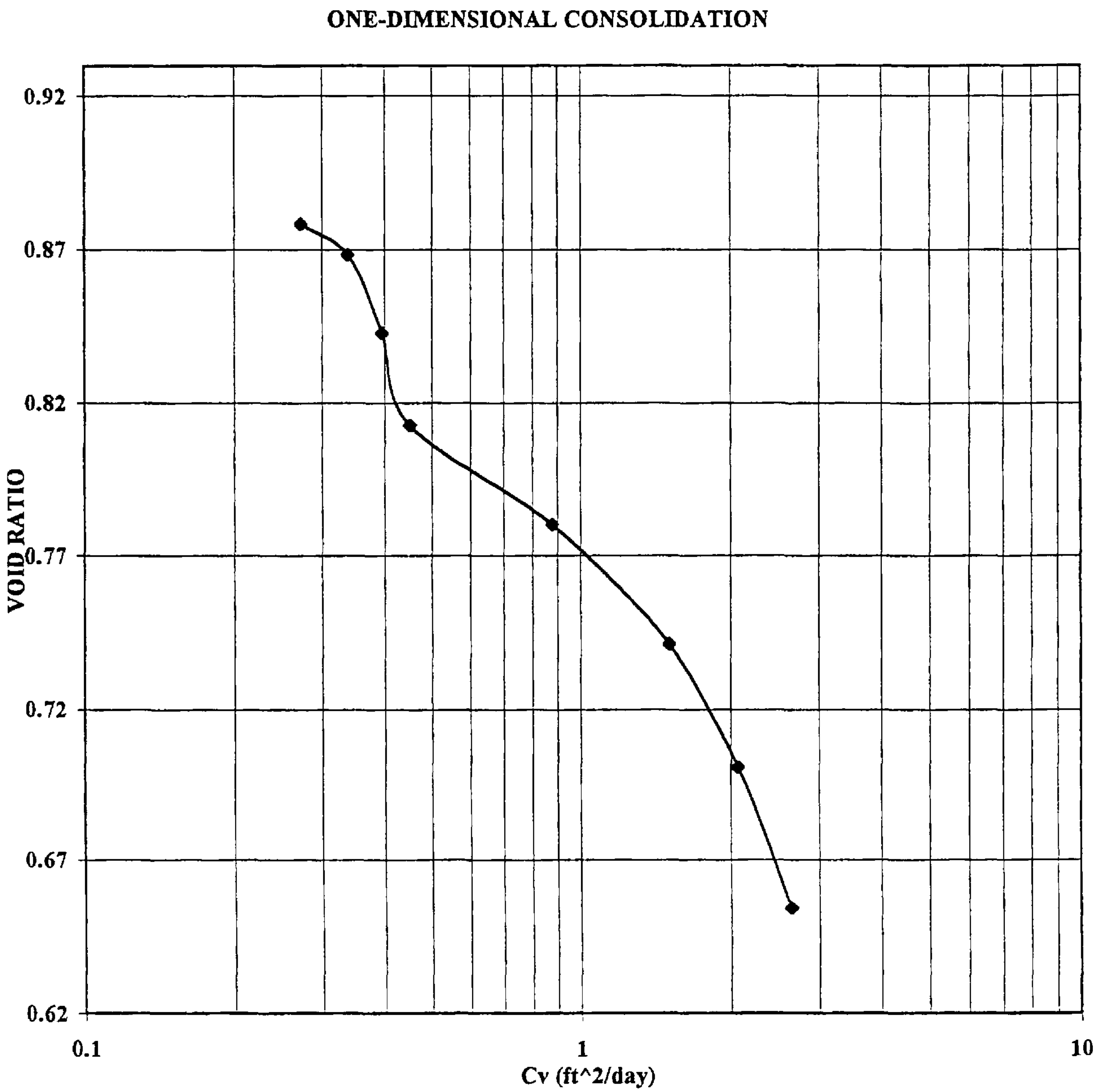


SAMPLE #:	GA98 BH11 101-103'
DESCRIPTION:	CLAY with trace fine sand (CL)

DATE	11/4/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO



SAMPLE #:	GA98 BH1 101-103'
DESCRIPTION:	CLAY with trace fine sand (CL)

DATE	11/4/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION

ASTM D 2435

BARRICK/MERCUR TAILINGS/UT	**SAMPLE:** **GA98- BH-11**	DATE	11/4/98
983-2344.001-2	**140-142'**	TECH	ZE
		REVIEW	DMD

SAMPLE DATA, GENERAL

height (in)	1.000
diameter (in)	2.500
area (in^2)	4.909
volume (in^3)	4.909
specimen weight,wet (g)	161.09
specimen weight,dry (g)	130.09
water weight (g)	31.00

SAMPLE DATA, INITIAL

total height (in)	1.000
height of solids (in)	0.584
height of voids (in)	0.416
void ratio	0.714
dry density (pcf)	100.96
moist density (pcf)	125.02

SAMPLE DATA, FINAL

total height (in)	0.900
height of solids (in)	0.579
height of voids (in)	0.321
void ratio	0.555
dry density (pcf)	111.25
moist density (pcf)	132.93

DESCRIPTION

CLAY with little fine sand (CL)

LL:	27
PL:	18
PI:	9
Assumed Gs:	2.77

MOISTURE CONTENT, INITIAL

tare #	X22
wt soil&tare,moist	233.52
wt soil&tare,dry	194.95
wt tare	33.10
wt moisture	38.57
wt dry soil	161.85
% moisture	23.83%

MOISTURE CONTENT, FINAL

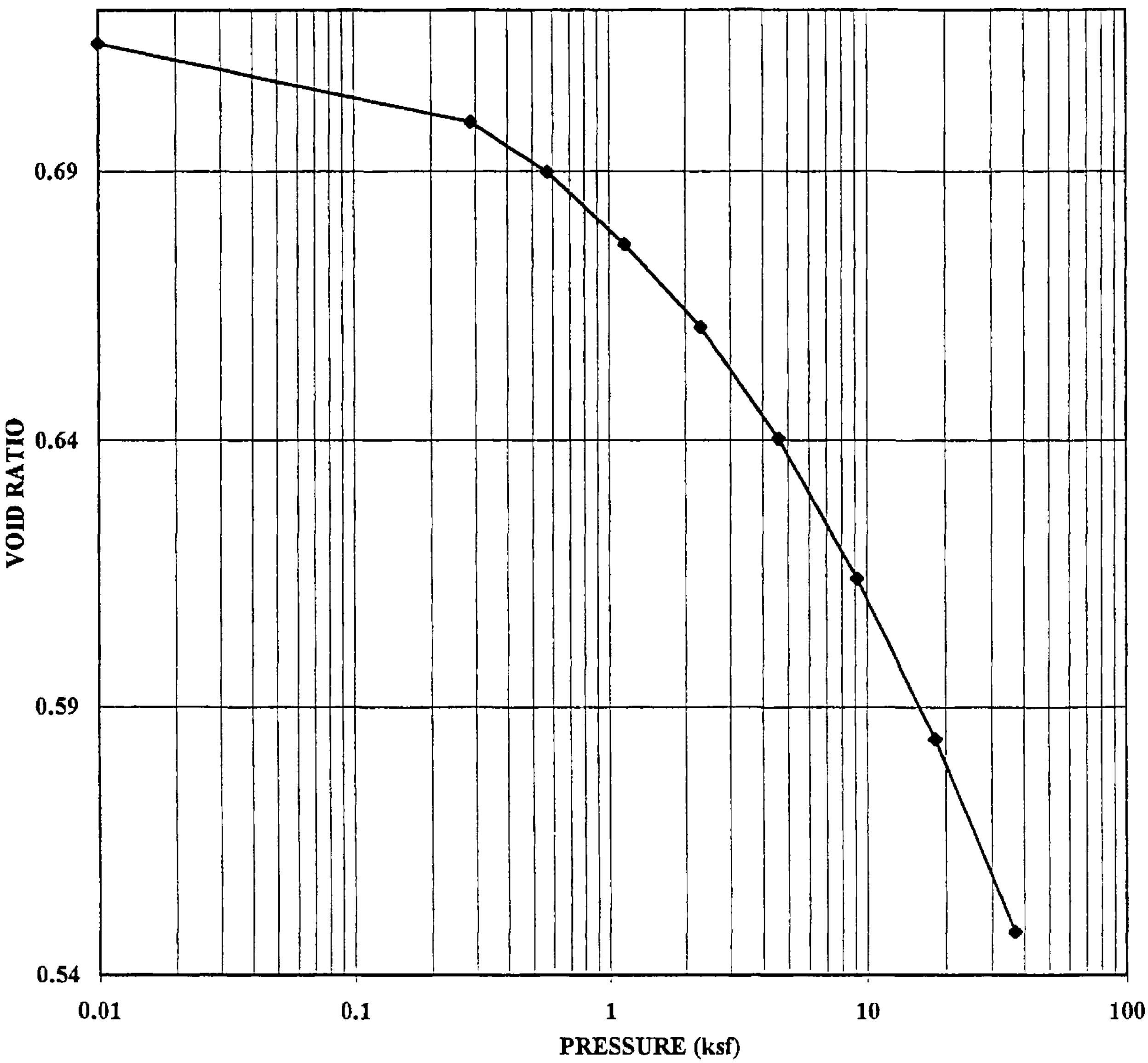
tare #	C5
wt soil&tare,moist	187.81
wt soil&tare,dry	162.70
wt tare	33.82
wt moisture	25.11
wt dry soil	128.88
% moisture	19.48%

PRESSURE	Final Sample Height	D50 Sample Height	t50 TIME (min)	Sample Density	VOID RATIO	DRAINAGE PATH (DOUBLE DRAINAGE)		DRAINAGE PATH (DOUBLE DRAINAGE)		COEFFICIENT OF CONSOLIDATION	
(ksf)				(pcf)	e	H (in)	H (cm)	H^2 (in^2)	H^2 (cm^2)	Cv (cm^2/sec)	(ft^2/day)
0.010	1.0000	-	-	101.0	0.71	-	-	-	-	-	-
0.288	0.9881	0.9926	2.1361	101.7	0.70	0.4963	1.2606	0.2463	1.5892	2.44E-03	2.28E-01
0.576	0.9827	0.9863	1.1017	102.3	0.69	0.4931	1.2526	0.2432	1.5689	4.68E-03	4.36E-01
1.152	0.9748	0.9796	1.2252	103.1	0.68	0.4898	1.2440	0.2399	1.5476	4.15E-03	3.87E-01
2.304	0.9658	0.9706	1.0000	104.1	0.66	0.4853	1.2327	0.2355	1.5195	4.99E-03	4.66E-01
4.608	0.9538	0.9609	0.3689	105.4	0.64	0.4805	1.2204	0.2309	1.4894	1.33E-02	1.24E+00
9.216	0.9386	0.9471	0.3670	107.1	0.61	0.4736	1.2028	0.2243	1.4468	1.29E-02	1.21E+00
18.432	0.9211	0.9317	0.2407	109.1	0.58	0.4658	1.1832	0.2170	1.4000	1.91E-02	1.78E+00
36.864	0.9002	0.9127	0.1955	111.7	0.55	0.4563	1.1591	0.2082	1.3435	2.26E-02	2.11E+00

GOLDER ASSOCIATES INC.

LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



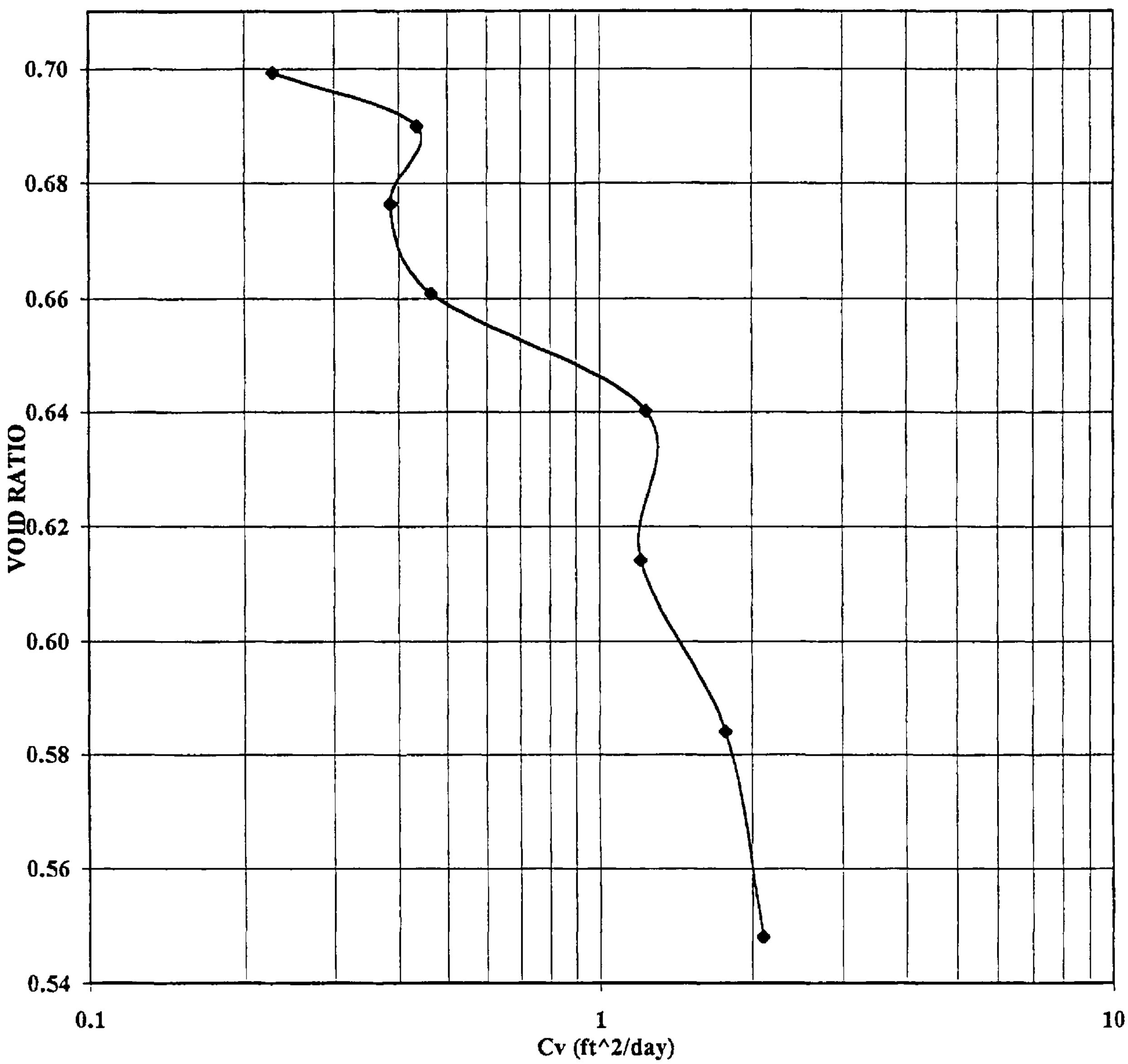
SAMPLE #:	GA98 BH11 140-142'
DESCRIPTION:	CLAY with little fine sand (CL)

DATE	11/4/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

ONE-DIMENSIONAL CONSOLIDATION



SAMPLE #:	GA98 BH1 140-142'
DESCRIPTION:	CLAY with little fine sand (CL)

DATE	11/4/98
TECH	ZE
REVIEW	DMD

BARRICK/MERCUR TAILINGS/UT
983-2344.001-2

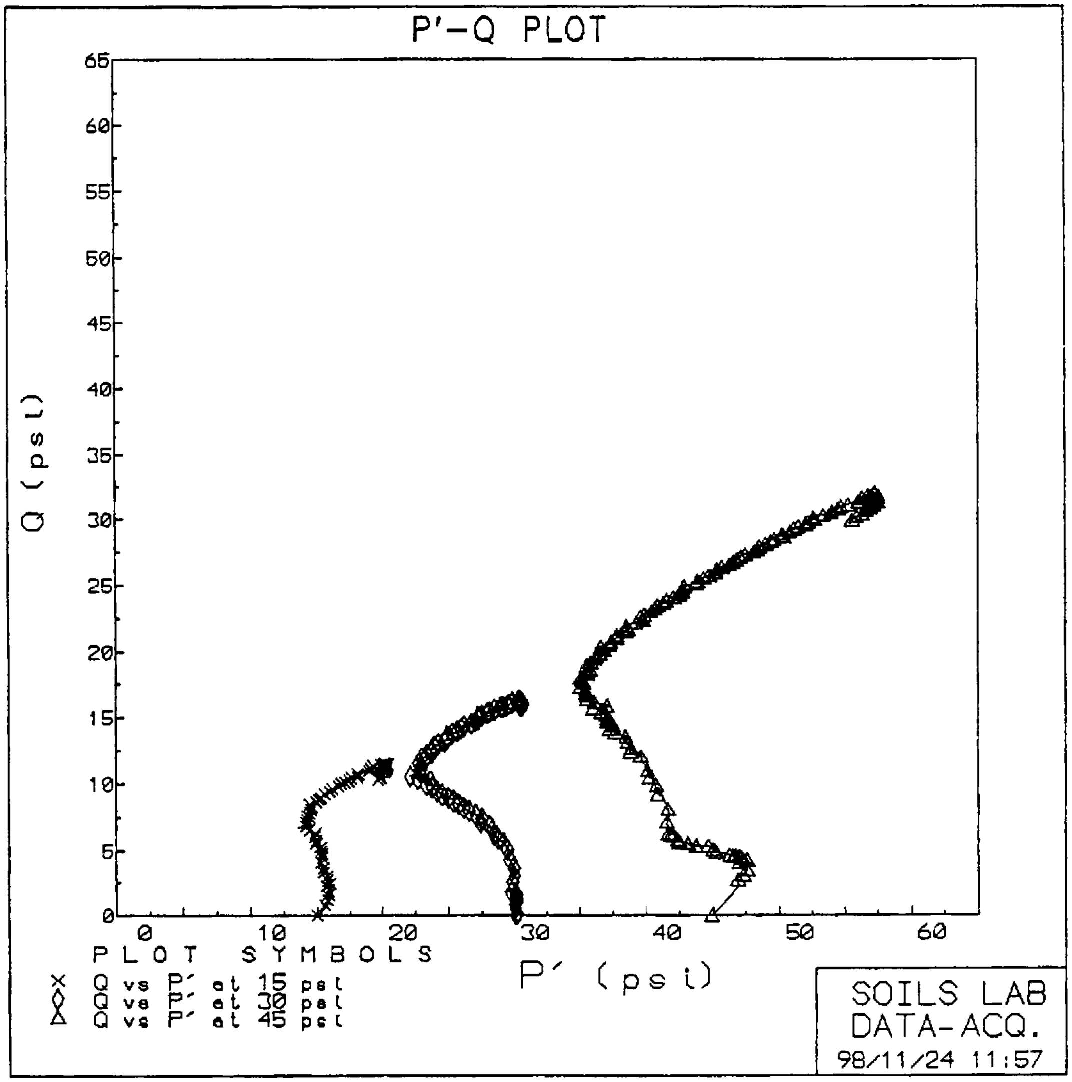
GOLDER ASSOCIATES INC.
LAKEWOOD, COLORADO

APPENDIX D-3

SHEAR STRENGTH TESTING

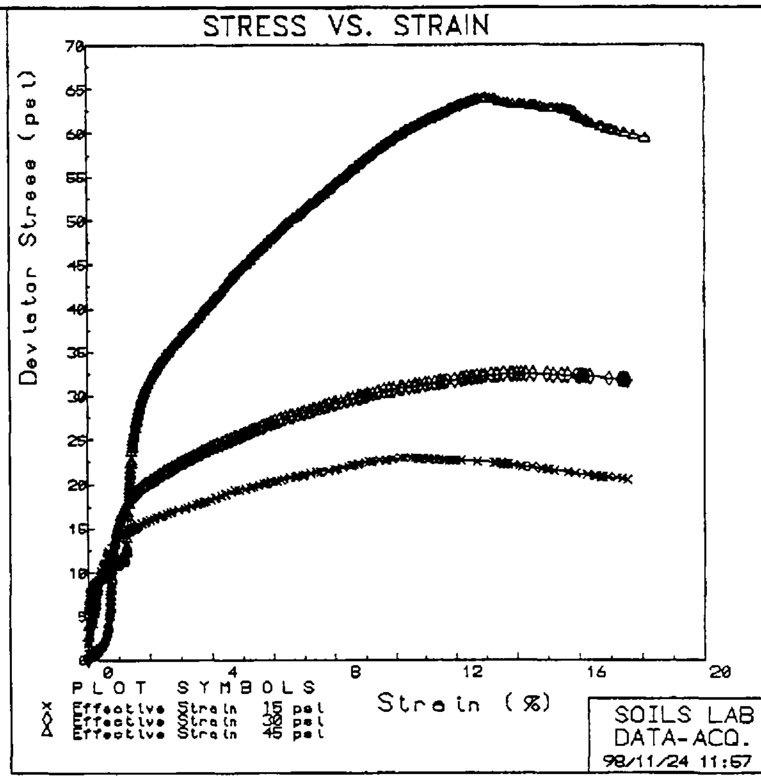
Boring Number	GA98 BH4	GA98 BH4	GA98 BH4
Sample Number	BH4	BH4	BH4
Sample Depth (ft.)	60-62	60-62	60-62
Sample Diameter (in.)	2.85	2.85	2.85
Sample Length (in.)	5.64	5.58	5.58
Dry Density (pcf)	86.7	90.2	94.2
Initial Moisture Content (%)	35.4	33.2	30.5
Final Moisture Content (%)	30.8	28.4	23.3
Strain Rate (in./min)	0.0024	0.0024	0.0024
Effective Stress (psi)	15.0	30.0	45.0
Back Pressure (psi)	85.0	70.0	55.0

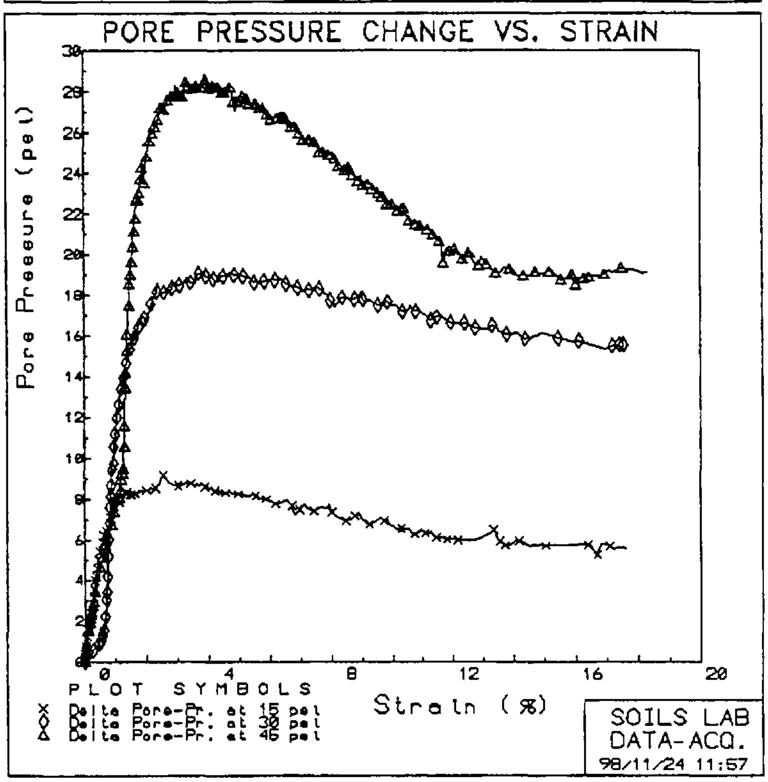
Alpha = Phi = A = C =



GOLDER ASSOCIATES INC	TITLE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
Client/Project BARRICK/MERCUR TAILINGS/UT	SAMPLE DESCR/ID GA98 BH4 60-62 — REPORT ID 2344-R2
DRAWN BDM — CHECKED DD — REVIEWED DJ	DATE NOV98 — JOB NO. 983-2344 — FIGURE --

2344BH4B 2344BH4A 2344BH4C





GOLDER ASSOCIATES INC		TITLE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST		
Client/Project BARRICK/MERCUR TAILINGS/UT		SAMPLE DESCR/ID GA98 BH4 60-62		REPORT ID 2344-R2
DRAWN BDM	CHECKED DD	REVIEWED DJ	DATE NOV98	JOB NO. 983-2344	FIGURE --

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER BH4
SAMPLE DEPTH (FEET) 60-62
BORING NUMBER GA98 BH4
EFFECTIVE STRESS (PSI) 15.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.38	0.0	100.0	100.0	0.0	0.0	15.0	15.0	0.0	15.0
1	0.7	6.43	81.2	112.6	100.0	12.6	6.5	21.2	8.6	6.3	14.9
2	1.1	6.45	91.1	114.1	100.0	14.1	7.9	21.2	7.1	7.1	14.1
3	1.5	6.48	97.7	115.1	100.0	15.1	8.4	21.7	6.6	7.5	14.2
4	2.0	6.51	103.6	115.9	100.0	15.9	8.4	22.5	6.6	8.0	14.6
5	2.4	6.54	107.6	116.5	100.0	16.5	8.7	22.8	6.3	8.2	14.6
6	2.8	6.57	112.2	117.1	100.0	17.1	8.8	23.3	6.2	8.5	14.8
7	3.3	6.60	115.5	117.5	100.0	17.5	8.8	23.8	6.3	8.8	15.0
8	3.7	6.63	118.8	117.9	100.0	17.9	8.7	24.3	6.3	9.0	15.3
9	4.1	6.66	123.4	118.5	100.0	18.5	8.5	25.1	6.6	9.3	15.8
10	4.6	6.69	127.4	119.1	100.0	19.1	8.3	25.7	6.7	9.5	16.2
11	5.0	6.72	130.7	119.5	100.0	19.5	8.3	26.2	6.8	9.7	16.5
12	5.4	6.75	134.0	119.9	100.0	19.9	8.3	26.6	6.8	9.9	16.7
13	5.9	6.78	137.3	120.2	100.0	20.2	8.0	27.2	7.0	10.1	17.1
14	6.3	6.81	140.6	120.6	100.0	20.6	7.8	27.8	7.2	10.3	17.5
15	6.7	6.84	142.6	120.8	100.0	20.8	7.5	28.3	7.5	10.4	17.9
16	7.2	6.88	145.9	121.2	100.0	21.2	7.6	28.7	7.5	10.6	18.1
17	7.7	6.91	148.5	121.5	100.0	21.5	7.6	28.9	7.4	10.7	18.1
18	8.1	6.94	151.2	121.8	100.0	21.8	7.3	29.5	7.8	10.9	18.7
19	8.5	6.98	154.5	122.1	100.0	22.1	7.0	30.2	8.1	11.1	19.1
20	9.0	7.01	157.8	122.5	100.0	22.5	7.0	30.5	8.0	11.2	19.3
21	9.5	7.05	159.7	122.7	100.0	22.7	6.9	30.8	8.1	11.3	19.4
22	9.9	7.08	161.7	122.8	100.0	22.8	6.8	31.1	8.3	11.4	19.7
23	10.4	7.12	164.4	123.1	100.0	23.1	6.5	31.6	8.5	11.5	20.0
24	10.8	7.16	163.7	122.9	100.0	22.9	6.3	31.6	8.8	11.4	20.2
25	11.3	7.19	164.4	122.9	100.0	22.9	6.4	31.5	8.6	11.4	20.0
26	11.7	7.23	165.0	122.8	100.0	22.8	6.1	31.8	9.0	11.4	20.4
27	12.1	7.26	165.0	122.7	100.0	22.7	6.0	31.7	9.0	11.4	20.4
28	12.7	7.31	165.0	122.6	100.0	22.6	6.0	31.6	9.0	11.3	20.3
29	13.2	7.35	165.0	122.4	100.0	22.4	6.4	31.1	8.7	11.2	19.9
30	13.6	7.39	164.4	122.2	100.0	22.2	5.8	31.5	9.3	11.1	20.4
31	14.1	7.42	163.7	122.0	100.0	22.0	6.0	31.1	9.1	11.0	20.1
32	14.5	7.46	163.7	121.9	100.0	21.9	5.7	31.3	9.3	11.0	20.3
33	15.0	7.50	163.0	121.7	100.0	21.7	5.7	31.0	9.3	10.9	20.2
34	15.0					21.7					
34	15.0	7.51	163.0	121.7	100.0	21.7	5.7	31.0	9.3	10.9	20.2
35	15.6	7.56	161.7	121.4	100.0	21.4	5.8	30.7	9.3	10.7	20.0
36	16.1	7.60	161.1	121.2	100.0	21.2	5.7	30.5	9.3	10.6	19.9
37	16.5	7.64	159.7	120.9	100.0	20.9	5.6	30.3	9.4	10.4	19.9
38	17.1	7.69	159.1	120.7	100.0	20.7	5.7	30.0	9.3	10.3	19.7
39	17.5	7.74	159.1	120.6	100.0	20.6	5.6	30.0	9.4	10.3	19.7

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER	BH4
SAMPLE DEPTH (FEET)	60-62
BORING NUMBER	GA98 BH4
EFFECTIVE STRESS (PSI)	30.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.38	0.0	100.0	100.0	0.0	0.0	30.2	30.2	0.0	30.2
1	0.7	6.43	32.3	105.0	100.0	5.0	2.8	32.4	27.3	2.5	29.9
2	1.1	6.45	107.6	116.7	100.0	16.7	12.5	34.4	17.7	8.3	26.0
3	1.5	6.48	122.8	118.9	100.0	18.9	15.6	33.5	14.6	9.5	24.1
4	2.0	6.51	131.4	120.2	100.0	20.2	16.9	33.5	13.3	10.1	23.4
5	2.4	6.54	138.0	121.1	100.0	21.1	18.2	33.1	12.0	10.6	22.5
6	2.8	6.56	143.9	121.9	100.0	21.9	18.2	33.9	12.0	11.0	22.9
7	3.2	6.59	149.8	122.7	100.0	22.7	18.5	34.4	11.7	11.4	23.0
8	3.6	6.62	155.8	123.5	100.0	23.5	19.0	34.7	11.2	11.8	22.9
9	4.0	6.65	161.1	124.2	100.0	24.2	18.9	35.5	11.3	12.1	23.4
10	4.4	6.68	165.7	124.8	100.0	24.8	18.9	36.1	11.3	12.4	23.7
11	4.9	6.71	170.3	125.4	100.0	25.4	19.0	36.6	11.2	12.7	23.9
12	5.3	6.74	175.6	126.1	100.0	26.1	18.9	37.3	11.3	13.0	24.3
13	5.7	6.77	180.2	126.6	100.0	26.6	18.6	38.2	11.6	13.3	24.9
14	6.2	6.80	185.5	127.3	100.0	27.3	18.8	38.7	11.4	13.6	25.0
15	6.6	6.83	189.4	127.7	100.0	27.7	18.5	39.4	11.7	13.9	25.5
16	7.1	6.87	193.4	128.2	100.0	28.2	18.2	40.2	12.0	14.1	26.1
17	7.5	6.90	197.4	128.6	100.0	28.6	18.4	40.3	11.7	14.3	26.0
18	7.9	6.93	201.3	129.1	100.0	29.1	18.0	41.2	12.2	14.5	26.7
19	8.4	6.96	205.3	129.5	100.0	29.5	17.9	41.7	12.3	14.7	27.0
20	8.8	7.00	208.6	129.8	100.0	29.8	17.8	42.2	12.4	14.9	27.3
21	9.3	7.03	212.5	130.2	100.0	30.2	17.7	42.7	12.5	15.1	27.6
22	9.7	7.07	216.5	130.6	100.0	30.6	17.6	43.2	12.6	15.3	27.9
23	10.1	7.10	219.2	130.9	100.0	30.9	17.5	43.5	12.6	15.4	28.1
24	10.6	7.14	221.8	131.1	100.0	31.1	17.5	43.7	12.7	15.5	28.2
25	11.1	7.18	225.1	131.4	100.0	31.4	17.0	44.5	13.2	15.7	28.9
26	11.5	7.21	227.7	131.6	100.0	31.6	17.0	44.8	13.2	15.8	29.0
27	11.9	7.25	230.4	131.8	100.0	31.8	16.6	45.3	13.5	15.9	29.4
28	12.3	7.28	233.0	132.0	100.0	32.0	16.6	45.6	13.6	16.0	29.6
29	12.7	7.31	235.0	132.1	100.0	32.1	16.4	45.9	13.8	16.1	29.9
30	13.1	7.35	237.6	132.3	100.0	32.3	16.3	46.2	13.8	16.2	30.0
31	13.7	7.39	240.3	132.5	100.0	32.5	16.1	46.6	14.0	16.3	30.3
32	14.1	7.43	241.6	132.5	100.0	32.5	16.1	46.5	14.0	16.3	30.3
33	14.7	7.48	242.9	132.5	100.0	32.5	16.0	46.6	14.2	16.2	30.4
34	15.2					32.4					
34	15.2	7.52	243.6	132.4	100.0	32.4	16.1	46.4	14.0	16.2	30.2
35	15.6	7.56	244.9	132.4	100.0	32.4	15.9	46.7	14.3	16.2	30.5
36	16.0	7.60	245.6	132.3	100.0	32.3	15.8	46.7	14.4	16.2	30.5
37	16.5	7.64	245.6	132.1	100.0	32.1	15.6	46.7	14.6	16.1	30.6
38	16.9	7.68	245.6	132.0	100.0	32.0	15.3	46.8	14.8	16.0	30.8
39	17.4	7.72	245.6	131.8	100.0	31.8	15.5	46.5	14.7	15.9	30.6

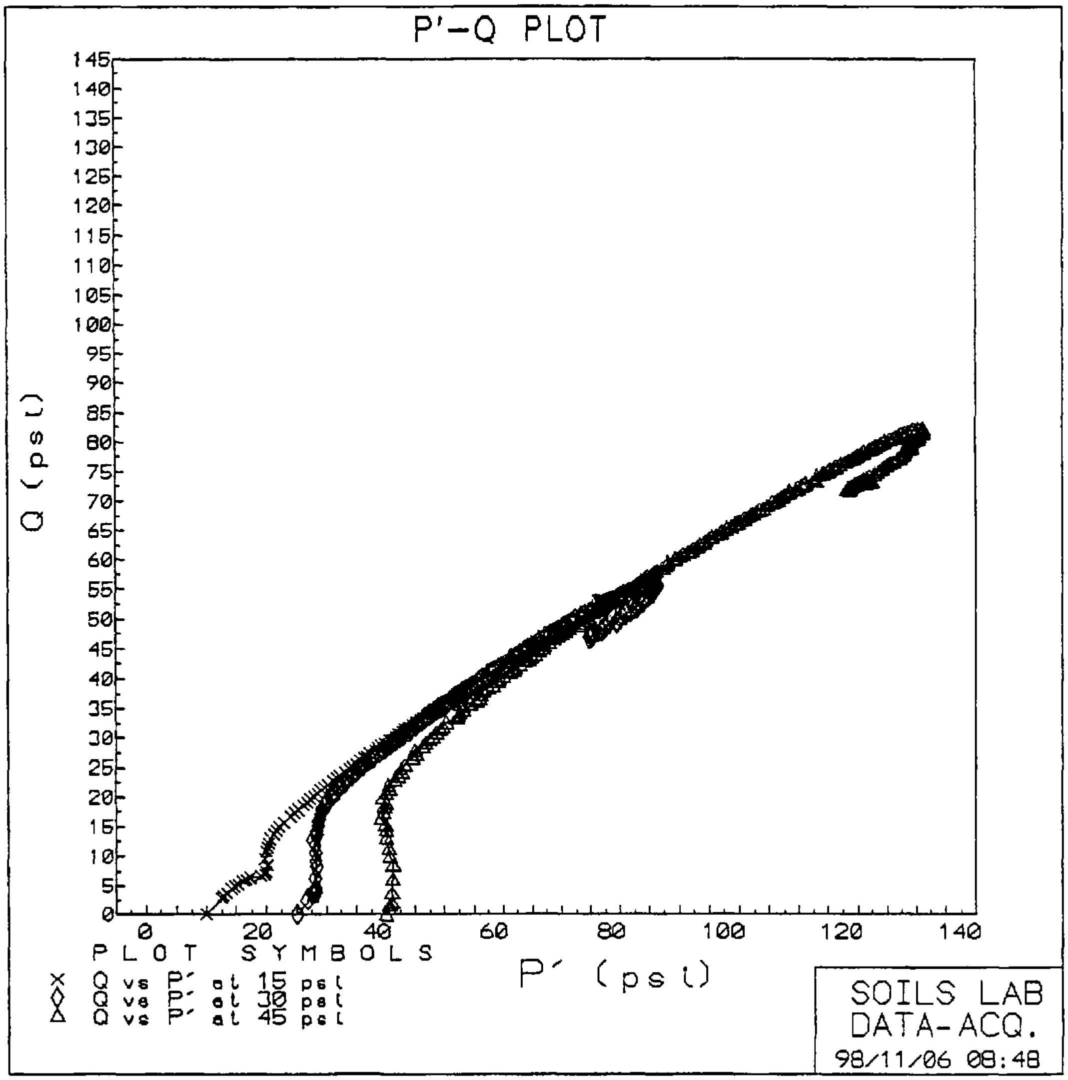
BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER	BH4
SAMPLE DEPTH (FEET)	60-62
BORING NUMBER	GA98 BH4
EFFECTIVE STRESS (PSI)	45.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.38	0.0	100.0	100.0	0.0	0.0	44.9	44.9	0.0	44.9
1	0.7	6.43	69.3	110.8	100.0	10.8	6.0	49.7	38.9	5.4	44.3
2	1.1	6.45	72.6	111.3	100.0	11.3	8.1	48.1	36.8	5.6	42.5
3	1.5	6.48	170.3	126.3	100.0	26.3	19.5	51.7	25.4	13.1	38.6
4	1.9	6.51	205.3	131.5	100.0	31.5	24.0	52.4	20.9	15.8	36.7
5	2.3	6.53	221.8	133.9	100.0	33.9	26.5	52.4	18.5	17.0	35.4
6	2.8	6.56	235.0	135.8	100.0	35.8	27.7	53.1	17.3	17.9	35.2
7	3.2	6.59	246.9	137.5	100.0	37.5	27.9	54.5	17.0	18.7	35.8
8	3.6	6.62	258.8	139.1	100.0	39.1	28.3	55.7	16.6	19.6	36.1
9	4.0	6.65	271.3	140.8	100.0	40.8	28.3	57.4	16.6	20.4	37.0
10	4.4	6.67	283.8	142.5	100.0	42.5	28.4	59.1	16.5	21.3	37.8
11	4.8	6.70	296.4	144.2	100.0	44.2	27.9	61.2	17.0	22.1	39.1
12	5.2	6.73	306.9	145.6	100.0	45.6	27.8	62.7	17.2	22.8	40.0
13	5.6	6.76	318.2	147.0	100.0	47.0	27.3	64.7	17.6	23.5	41.2
14	6.0	6.79	329.4	148.5	100.0	48.5	26.7	66.7	18.2	24.2	42.5
15	6.5	6.82	339.9	149.8	100.0	49.8	26.9	67.8	18.0	24.9	42.9
16	6.9	6.85	349.2	151.0	100.0	51.0	26.1	69.7	18.8	25.5	44.2
17	7.3	6.88	359.1	152.2	100.0	52.2	25.7	71.4	19.3	26.1	45.3
18	7.7	6.91	369.0	153.4	100.0	53.4	25.1	73.2	19.8	26.7	46.5
19	8.1	6.95	378.9	154.6	100.0	54.6	24.9	74.6	20.0	27.3	47.3
20	8.5	6.98	388.8	155.7	100.0	55.7	24.2	76.4	20.7	27.9	48.5
21	8.9	7.01	398.7	156.9	100.0	56.9	23.6	78.2	21.3	28.4	49.7
22	9.3	7.04	407.9	158.0	100.0	58.0	23.3	79.6	21.6	29.0	50.6
23	9.8	7.07	417.2	159.0	100.0	59.0	22.7	81.2	22.2	29.5	51.7
24	10.2	7.11	426.4	160.0	100.0	60.0	22.2	82.8	22.8	30.0	52.8
25	10.6	7.14	434.3	160.8	100.0	60.8	21.6	84.1	23.3	30.4	53.7
26	11.0	7.17	441.6	161.6	100.0	61.6	21.3	85.2	23.6	30.8	54.4
27	11.4	7.21	448.2	162.2	100.0	62.2	20.8	86.3	24.1	31.1	55.2
28	11.9	7.24	455.5	162.9	100.0	62.9	20.3	87.5	24.6	31.5	56.0
29	12.3	7.28	462.1	163.5	100.0	63.5	19.8	88.7	25.2	31.7	56.9
30	12.7	7.31	467.3	163.9	100.0	63.9	19.5	89.3	25.4	32.0	57.3
31	13.2	7.35	470.0	163.9	100.0	63.9	19.6	89.3	25.3	32.0	57.3
32	13.7	7.39	469.3	163.5	100.0	63.5	19.3	89.0	25.6	31.7	57.3
33	14.1	7.43	470.6	163.3	100.0	63.3	18.9	89.3	26.0	31.7	57.6
34	14.6	7.47	471.3	163.1	100.0	63.1	19.0	89.0	25.9	31.5	57.5
35	15.0	7.51	472.6	163.0	100.0	63.0	19.1	88.8	25.8	31.5	57.3
36	15.1					62.9					
36	15.1	7.51	472.6	162.9	100.0	62.9	19.2	88.6	25.7	31.5	57.2
37	15.5	7.55	473.9	162.7	100.0	62.7	18.8	88.9	26.2	31.4	57.5
38	15.9	7.59	470.6	162.0	100.0	62.0	18.6	88.3	26.3	31.0	57.3
39	16.4	7.63	467.3	161.3	100.0	61.3	18.9	87.3	26.0	30.6	56.7
40	16.8	7.67	466.0	160.8	100.0	60.8	18.9	86.7	26.0	30.4	56.3
41	17.3	7.72	464.7	160.2	100.0	60.2	19.2	86.0	25.8	30.1	55.9
42	17.8	7.76	464.7	159.9	100.0	59.9	19.3	85.5	25.6	29.9	55.6
43	18.3	7.81	463.4	159.4	100.0	59.4	19.1	85.1	25.8	29.7	55.4

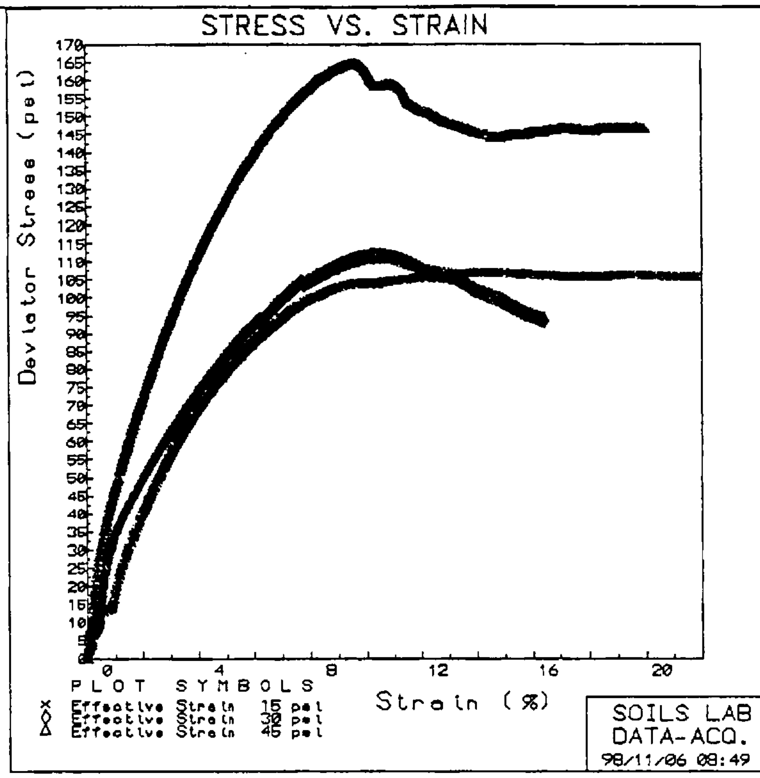
Boring Number	GA98 BH9A	GA98 BH9A	GA98 BH9A
Sample Number	BH9	BH9	BH9
Sample Depth (ft.)	20-22	20-22	20-22
Sample Diameter (in.)	2.87	2.85	2.87
Sample Length (in.)	3.95	5.52	5.56
Dry Density (pcf)	97.5	99.9	106.0
Initial Moisture Content (%)	23.1	23.1	22.2
Final Moisture Content (%)	22.9	22.6	19.5
Strain Rate (in./min)	0.0039	0.0039	0.0039
Effective Stress (psi)	15.0	30.0	45.0
Back Pressure (psi)	85.0	70.0	65.0

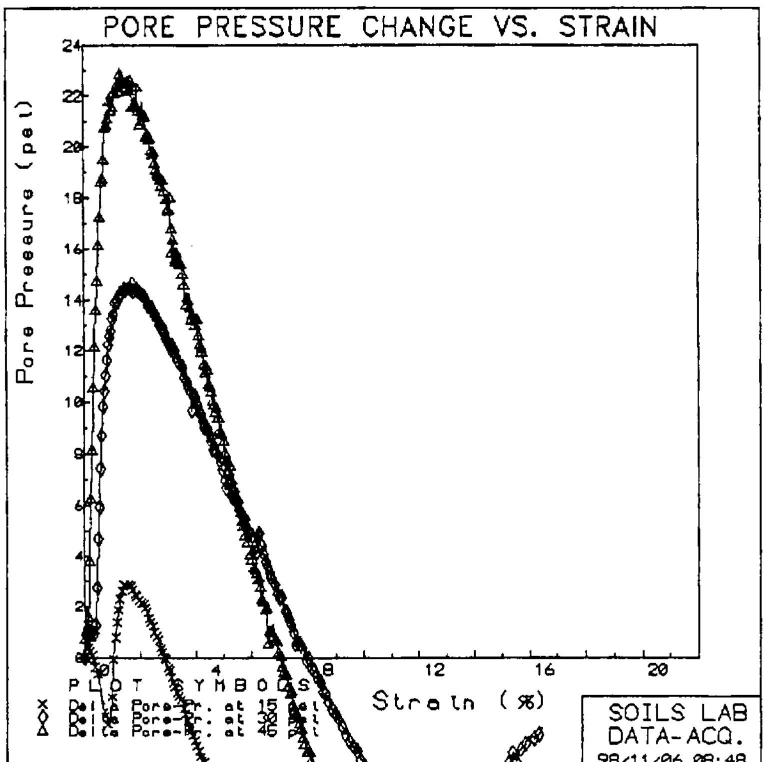
Alpha = Phi = A = C =



GOLDER ASSOCIATES INC	TITLE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST		
Client/Project BARRICK/MERCUR TAILINGS/UT	SAMPLE DESCR/ID GA98 BH9A 20-22		REPORT ID 2344-R1
DRAWN BDM CHECKED DD REVIEWED DJ	DATE NOV98	JOB NO. 983-2344	FIGURE --

2344BH98 2344BH9A 2344BH9C





GOLDER ASSOCIATES INC	TITLE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST		
Client/Project BARRICK/MERCUR TAILINGS/UT	SAMPLE DESC/ID GA98 BH9A 20-22		REPORT ID 2344-R1
DRAWN BDM · CHECKED DD · REVIEWED DJ	DATE NOV98	JOB NO. 983-2344	FIGURE --

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER BH9
SAMPLE DEPTH (FEET) 20-22
BORING NUMBER GA98 BH9A
EFFECTIVE STRESS (PSI) 15.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.49	0.0	100.0	100.0	0.0	0.0	15.0	15.0	0.0	15.0
1	1.0	6.55	119.5	118.2	100.0	18.2	-0.8	34.0	15.8	9.1	24.9
2	1.4	6.58	191.4	129.1	100.0	29.1	2.9	41.2	12.1	14.5	26.7
3	1.8	6.61	246.9	137.4	100.0	37.4	2.4	49.9	12.6	18.7	31.2
4	2.2	6.63	293.7	144.3	100.0	44.3	1.8	57.4	13.2	22.1	35.3
5	2.6	6.66	338.6	150.8	100.0	50.8	0.7	65.1	14.3	25.4	39.7
6	3.0	6.69	380.2	156.8	100.0	56.8	-0.5	72.3	15.5	28.4	43.9
7	3.4	6.72	419.1	162.4	100.0	62.4	-1.7	79.1	16.7	31.2	47.9
8	3.8	6.75	454.8	167.4	100.0	67.4	-3.0	85.4	18.0	33.7	51.7
9	4.3	6.78	487.8	172.0	100.0	72.0	-3.9	90.9	18.9	36.0	54.9
10	4.7	6.80	518.2	176.2	100.0	76.2	-5.3	96.5	20.3	38.1	58.4
11	5.1	6.83	545.9	179.9	100.0	79.9	-6.4	101.3	21.4	39.9	61.4
12	5.5	6.86	572.3	183.4	100.0	83.4	-7.6	106.0	22.6	41.7	64.3
13	5.9	6.89	596.7	186.6	100.0	86.6	-8.8	110.4	23.8	43.3	67.1
14	6.3	6.92	619.8	189.5	100.0	89.5	-10.1	114.7	25.1	44.8	69.9
15	6.7	6.95	642.3	192.4	100.0	92.4	-11.5	118.9	26.5	46.2	72.7
16	7.1	6.98	664.0	195.1	100.0	95.1	-11.8	121.9	26.8	47.5	74.4
17	7.5	7.01	683.8	197.5	100.0	97.5	-12.9	125.4	27.9	48.7	76.6
18	7.9	7.05	699.7	199.3	100.0	99.3	-13.2	127.5	28.2	49.7	77.8
19	8.3	7.08	712.9	200.7	100.0	100.7	-13.9	129.6	28.9	50.4	79.3
20	8.7	7.11	726.7	202.2	100.0	102.2	-14.5	131.7	29.5	51.1	80.6
21	9.2	7.14	737.3	203.2	100.0	103.2	-15.1	133.3	30.1	51.6	81.7
22	9.6	7.17	745.2	203.9	100.0	103.9	-15.3	134.2	30.3	51.9	82.3
23	10.0	7.21	750.5	204.1	100.0	104.1	-15.4	134.5	30.4	52.1	82.5
24	10.4	7.24	751.2	203.7	100.0	103.7	-15.5	134.2	30.5	51.9	82.3
25	10.8	7.27	760.4	204.5	100.0	104.5	-15.5	135.1	30.5	52.3	82.8
26	11.2	7.31	767.0	205.0	100.0	105.0	-15.4	135.4	30.4	52.5	82.9
27	11.6	7.34	772.9	205.3	100.0	105.3	-15.6	135.9	30.6	52.6	83.3
28	12.1	7.38	780.2	205.7	100.0	105.7	-15.6	136.4	30.6	52.9	83.5
29	12.5	7.41	784.2	205.8	100.0	105.8	-15.5	136.3	30.5	52.9	83.4
30	12.9	7.45	791.4	206.3	100.0	106.3	-15.7	137.0	30.7	53.1	83.9
31	13.3	7.48	797.4	206.6	100.0	106.6	-15.9	137.4	30.9	53.3	84.2
32	13.7	7.52	802.6	206.7	100.0	106.7	-15.6	137.4	30.6	53.4	84.0
33	14.1	7.56	807.3	206.8	100.0	106.8	-15.8	137.6	30.8	53.4	84.2
34	14.5	7.59	811.9	206.9	100.0	106.9	-15.6	137.5	30.6	53.5	84.1
35	14.9	7.63	814.5	206.8	100.0	106.8	-15.7	137.5	30.7	53.4	84.1
36	15.0					106.8					
36	15.0	7.63	815.2	206.8	100.0	106.8	-15.7	137.5	30.7	53.4	84.1
37	15.4	7.67	817.8	206.6	100.0	106.6	-15.4	137.0	30.4	53.3	83.7
38	15.9	7.71	820.5	206.4	100.0	106.4	-15.2	136.6	30.2	53.2	83.4
39	16.3	7.75	823.1	206.2	100.0	106.2	-15.0	136.3	30.0	53.1	83.2
40	16.7	7.79	825.8	206.0	100.0	106.0	-14.8	135.9	29.8	53.0	82.9
41	17.1	7.83	829.1	205.9	100.0	105.9	-14.6	135.5	29.6	52.9	82.5
42	17.6	7.87	832.4	205.7	100.0	105.7	-14.4	135.1	29.4	52.9	82.2
43	18.0	7.91	837.0	205.8	100.0	105.8	-14.4	135.2	29.4	52.9	82.3
44	18.4	7.95	841.6	205.9	100.0	105.9	-14.0	134.9	29.0	52.9	81.9
45	18.8	7.99	847.5	206.1	100.0	106.1	-13.9	135.0	28.9	53.0	82.0
46	19.2	8.03	854.1	206.3	100.0	106.3	-13.8	135.2	28.8	53.2	82.0
47	19.7	8.08	858.8	206.3	100.0	106.3	-13.9	135.2	28.9	53.1	82.1
48	20.1	8.12	861.4	206.1	100.0	106.1	-13.7	134.8	28.7	53.0	81.8
49	20.6	8.17	865.4	206.0	100.0	106.0	-13.5	134.4	28.5	53.0	81.5
50	21.0	8.21	869.3	205.9	100.0	105.9	-13.5	134.4	28.5	52.9	81.5
51	21.4	8.26	873.9	205.8	100.0	105.8	-13.5	134.3	28.5	52.9	81.4
52	21.9	8.30	877.9	205.8	100.0	105.8	-13.4	134.1	28.4	52.9	81.2

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER BH9
SAMPLE DEPTH (FEET) 20-22
BORING NUMBER GA98 BH9A
EFFECTIVE STRESS (PSI) 45.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3 psi	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.49	0.0	110.0	110.0	0.0	0.0	45.1	45.1	0.0	45.1
1	0.7	6.53	254.8	149.0	110.0	39.0	19.8	64.3	25.3	19.5	44.8
2	1.1	6.56	334.0	160.9	110.0	50.9	22.3	73.8	22.8	25.5	48.3
3	1.5	6.59	406.6	171.7	110.0	61.7	22.4	84.4	22.7	30.9	53.6
4	1.9	6.62	473.3	181.5	110.0	71.5	21.5	95.2	23.7	35.8	59.4
5	2.3	6.64	537.3	190.9	110.0	80.9	20.4	105.6	24.7	40.4	65.1
6	2.7	6.67	597.4	199.6	110.0	89.6	18.7	116.0	26.4	44.8	71.2
7	3.1	6.70	654.8	207.8	110.0	97.8	15.8	127.1	29.3	48.9	78.2
8	3.5	6.73	707.6	215.2	110.0	105.2	14.9	135.4	30.2	52.6	82.8
9	4.0	6.75	757.8	222.2	110.0	112.2	13.2	144.2	32.0	56.1	88.1
10	4.4	6.78	803.3	228.4	110.0	118.4	11.4	152.2	33.8	59.2	93.0
11	4.8	6.81	847.5	234.4	110.0	124.4	9.5	160.1	35.7	62.2	97.9
12	5.2	6.84	889.8	240.1	110.0	130.1	7.5	167.7	37.6	65.0	102.6
13	5.6	6.87	930.0	245.4	110.0	135.4	5.8	174.7	39.3	67.7	107.0
14	6.0	6.90	966.3	250.1	110.0	140.1	4.0	181.2	41.1	70.0	111.2
15	6.4	6.93	1002.7	254.7	110.0	144.7	2.5	187.3	42.6	72.3	114.9
16	6.8	6.96	1035.7	258.8	110.0	148.8	0.8	193.1	44.3	74.4	118.7
17	7.2	6.99	1065.4	262.4	110.0	152.4	-0.9	198.4	46.0	76.2	122.2
18	7.6	7.02	1093.1	265.7	110.0	155.7	-2.1	202.9	47.2	77.8	125.1
19	8.0	7.05	1118.2	268.5	110.0	158.5	-3.7	207.4	48.8	79.3	128.1
20	8.4	7.08	1140.6	271.0	110.0	161.0	-5.3	211.4	50.4	80.5	130.9
21	8.8	7.12	1158.4	272.8	110.0	162.8	-6.5	214.4	51.6	81.4	133.0
22	9.3	7.15	1174.3	274.3	110.0	164.3	-7.6	217.0	52.8	82.1	134.9
23	9.7	7.18	1182.2	274.6	110.0	164.6	-8.7	218.5	53.9	82.3	136.2
24	10.1	7.22	1166.4	271.7	110.0	161.7	-9.3	216.1	54.5	80.8	135.3
25	10.5	7.25	1148.5	268.5	110.0	158.5	-9.2	212.7	54.3	79.2	133.5
26	10.9	7.28	1157.8	269.0	110.0	159.0	-9.6	213.7	54.7	79.5	134.2
27	11.3	7.32	1149.2	267.1	110.0	157.1	-9.6	211.9	54.8	78.5	133.3
28	11.7	7.35	1123.4	262.9	110.0	152.9	-9.1	207.1	54.2	76.4	130.7
29	12.2	7.39	1117.5	261.3	110.0	151.3	-8.5	205.0	53.7	75.7	129.3
30	12.6	7.42	1111.6	259.8	110.0	149.8	-8.1	203.0	53.2	74.9	128.1
31	13.0	7.46	1105.6	258.3	110.0	148.3	-7.2	200.7	52.4	74.1	126.5
32	13.4	7.49	1103.6	257.3	110.0	147.3	-7.3	199.8	52.4	73.7	126.1
33	13.8	7.53	1099.7	256.1	110.0	146.1	-6.8	198.1	52.0	73.1	125.0
34	14.3	7.57	1097.0	255.0	110.0	145.0	-6.6	196.7	51.7	72.5	124.2
35	14.7	7.60	1096.4	254.2	110.0	144.2	-6.3	195.6	51.5	72.1	123.5
36	15.0					144.7					
36	15.0	7.63	1104.3	254.7	110.0	144.7	-6.2	196.0	51.4	72.3	123.7
37	15.4	7.67	1112.2	255.0	110.0	145.0	-6.4	196.5	51.5	72.5	124.0
38	15.8	7.71	1120.8	255.4	110.0	145.4	-6.6	197.1	51.7	72.7	124.4
39	16.3	7.75	1128.7	255.7	110.0	145.7	-6.8	197.6	51.9	72.8	124.8
40	16.7	7.79	1139.3	256.3	110.0	146.3	-6.7	198.1	51.8	73.2	124.9
41	17.1	7.82	1149.2	256.9	110.0	146.9	-7.5	199.5	52.6	73.4	126.1
42	17.5	7.86	1151.8	256.5	110.0	146.5	-7.8	199.4	52.9	73.3	126.1
43	17.9	7.90	1155.1	256.1	110.0	146.1	-8.0	199.2	53.1	73.1	126.2
44	18.3	7.94	1165.0	256.7	110.0	146.7	-8.1	199.9	53.3	73.3	126.6
45	18.8	7.99	1172.3	256.8	110.0	146.8	-8.4	200.3	53.5	73.4	126.9
46	19.2	8.03	1178.2	256.8	110.0	146.8	-8.7	200.6	53.9	73.4	127.2
47	19.6	8.07	1185.5	256.9	110.0	146.9	-8.8	200.8	53.9	73.5	127.4

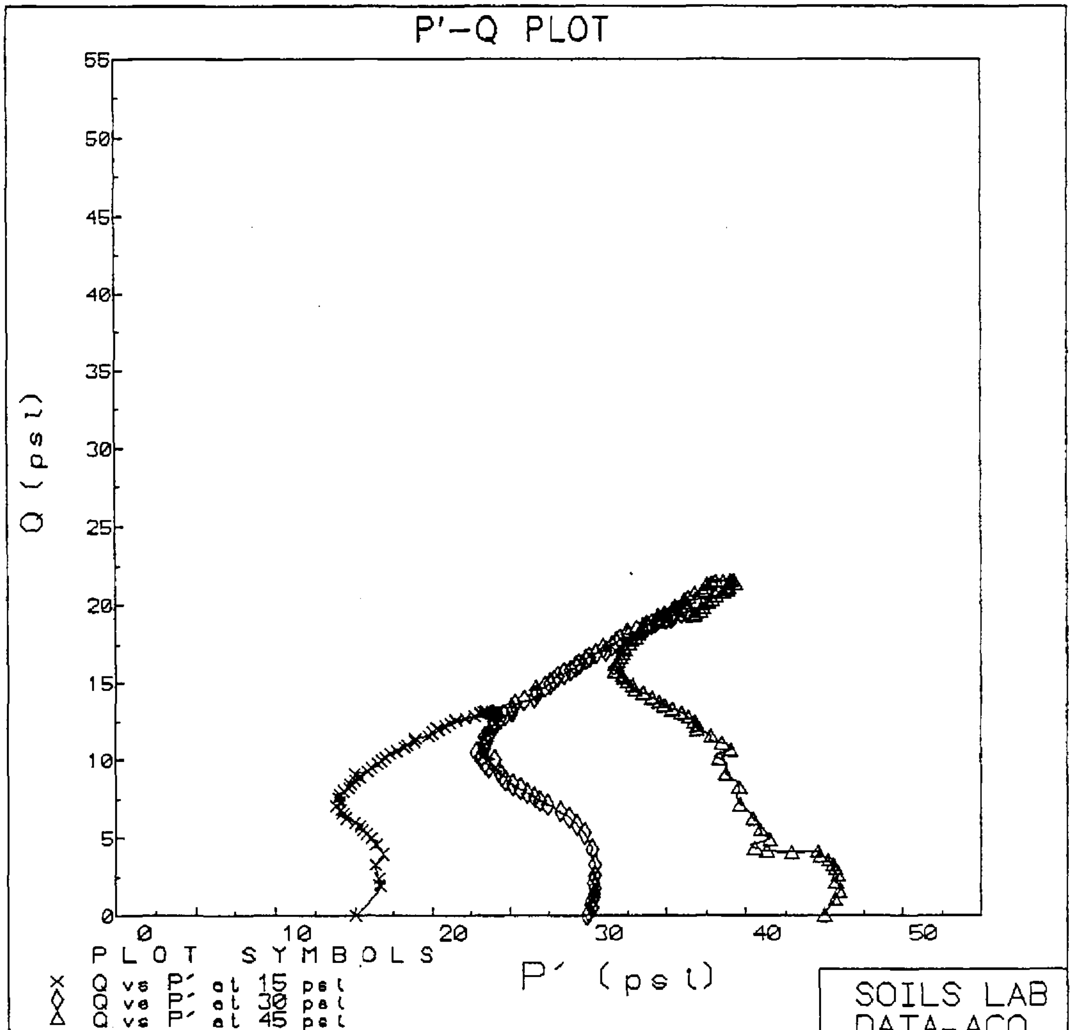
BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER BH9
SAMPLE DEPTH (FEET) 20-22
BORING NUMBER GA98 BH9A
EFFECTIVE STRESS (PSI) 30.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.38	0.0	100.0	100.0	0.0	0.0	30.0	30.0	0.0	30.0
1	0.7	6.43	171.6	126.7	100.0	26.7	10.5	46.2	19.5	13.4	32.8
2	1.1	6.45	236.3	136.6	100.0	36.6	13.9	52.8	16.2	18.3	34.5
3	1.5	6.48	279.9	143.2	100.0	43.2	14.4	58.8	15.6	21.6	37.2
4	1.9	6.51	319.5	149.1	100.0	49.1	14.4	64.7	15.6	24.5	40.2
5	2.3	6.53	356.4	154.5	100.0	54.5	13.6	70.9	16.4	27.3	43.7
6	2.7	6.56	392.1	159.8	100.0	59.8	13.1	76.7	16.9	29.9	46.8
7	3.2	6.59	425.7	164.6	100.0	64.6	12.1	82.6	18.0	32.3	50.3
8	3.6	6.62	458.8	169.3	100.0	69.3	11.0	88.3	19.0	34.7	53.7
9	4.0	6.64	489.8	173.7	100.0	73.7	10.0	93.7	20.0	36.9	56.8
10	4.4	6.67	520.1	177.9	100.0	77.9	9.0	99.0	21.0	39.0	60.0
11	4.8	6.70	549.2	181.9	100.0	81.9	7.9	104.0	22.1	41.0	63.1
12	5.2	6.73	576.9	185.7	100.0	85.7	6.8	108.9	23.2	42.9	66.1
13	5.6	6.76	603.3	189.3	100.0	89.3	5.8	113.5	24.2	44.6	68.9
14	6.0	6.79	628.4	192.6	100.0	92.6	4.6	118.0	25.5	46.3	71.7
15	6.4	6.82	647.5	195.0	100.0	95.0	4.0	121.0	26.0	47.5	73.5
16	6.8	6.85	672.6	198.2	100.0	98.2	2.9	125.4	27.2	49.1	76.3
17	7.2	6.88	695.7	201.2	100.0	101.2	1.6	129.5	28.4	50.6	78.9
18	7.6	6.91	718.2	204.0	100.0	104.0	0.6	133.4	29.5	52.0	81.4
19	8.0	6.94	727.4	204.8	100.0	104.8	-0.0	134.9	30.1	52.4	82.5
20	8.4	6.97	742.6	206.5	100.0	106.5	-0.9	137.4	30.9	53.3	84.2
21	8.9	7.00	757.1	208.1	100.0	108.1	-2.1	140.2	32.1	54.1	86.2
22	9.3	7.03	771.0	209.6	100.0	109.6	-2.8	142.5	32.8	54.8	87.6
23	9.7	7.07	782.2	210.7	100.0	110.7	-3.8	144.5	33.8	55.4	89.1
24	10.1	7.10	790.8	211.4	100.0	111.4	-4.3	145.7	34.3	55.7	90.0
25	10.5	7.13	794.7	211.4	100.0	111.4	-5.1	146.6	35.1	55.7	90.9
26	10.9	7.16	796.0	211.1	100.0	111.1	-5.8	146.9	35.8	55.6	91.4
27	11.4	7.20	792.7	210.1	100.0	110.1	-6.2	146.3	36.2	55.1	91.2
28	11.8	7.23	784.8	208.5	100.0	108.5	-6.2	144.7	36.2	54.3	90.4
29	12.2	7.27	777.6	207.0	100.0	107.0	-6.0	143.0	36.0	53.5	89.5
30	12.6	7.30	776.9	206.4	100.0	106.4	-5.9	142.3	35.9	53.2	89.1
31	13.1	7.34	776.9	205.9	100.0	105.9	-5.9	141.8	35.9	52.9	88.9
32	13.5	7.38	769.6	204.3	100.0	104.3	-6.1	140.4	36.1	52.2	88.3
33	13.9	7.41	757.8	202.2	100.0	102.2	-5.6	137.8	35.6	51.1	86.7
34	14.3	7.45	751.2	200.9	100.0	100.9	-5.1	136.0	35.1	50.4	85.6
35	14.7	7.48	745.9	199.7	100.0	99.7	-5.0	134.6	35.0	49.8	84.8
36	15.0					98.6					
36	15.0	7.51	740.6	198.6	100.0	98.6	-5.1	133.8	35.1	49.3	84.5
37	15.4	7.55	731.4	196.9	100.0	96.9	-3.8	130.7	33.8	48.5	82.3
38	15.8	7.58	722.8	195.3	100.0	95.3	-3.4	128.7	33.4	47.7	81.1
39	16.3	7.62	717.5	194.2	100.0	94.2	-3.1	127.3	33.2	47.1	80.2

Boring Number	GA98BH11	GA98BH11	GA98BH11
Sample Number	11	11	11
Sample Depth (ft.)	40-42	40-42	40-42
Sample Diameter (in.)	2.82	2.82	2.82
Sample Length (in.)	5.67	5.43	5.52
Dry Density (pcf)	90.8	92.7	92.0
Initial Moisture Content (%)	31.6	29.8	30.3
Final Moisture Content (%)	25.6	23.7	24.0
Strain Rate (in./min)	0.0031	0.0031	0.0031
Effective Stress (psi)	15.0	30.0	45.0
Back Pressure (psi)	85.0	70.0	55.0

Alpha = Phi = A = C =



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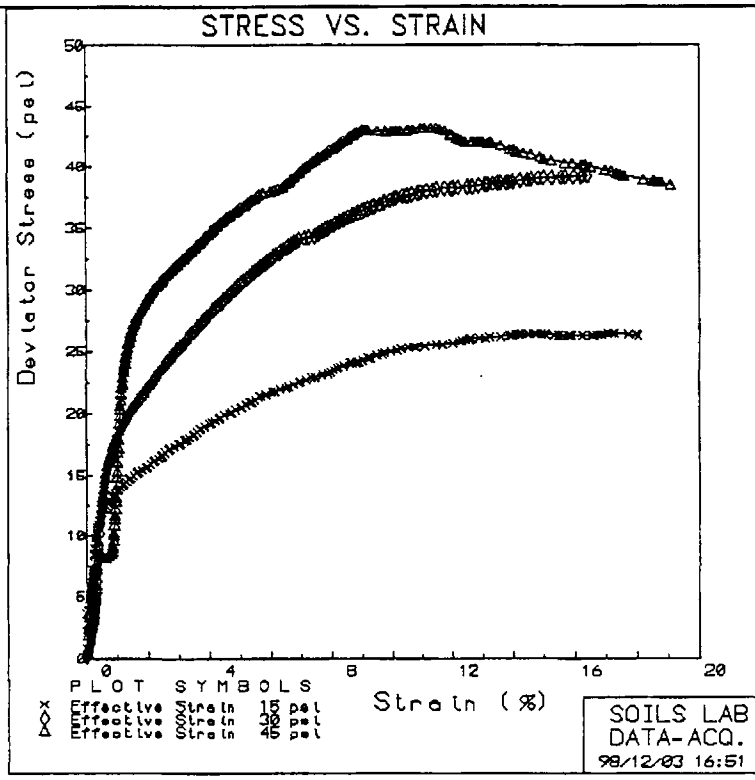
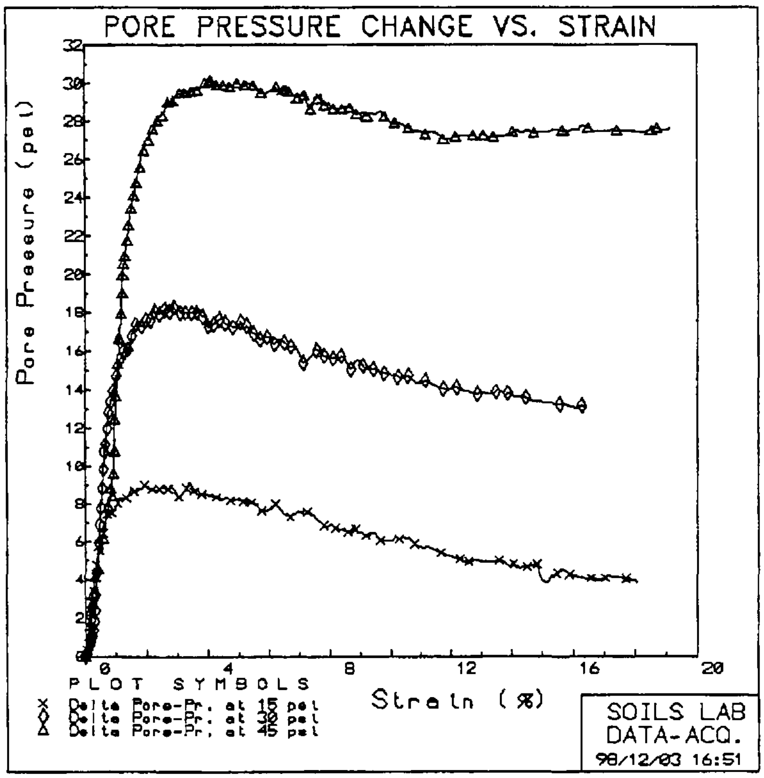
98/12/03 16:51

GOLDER ASSOCIATES INC		TITLE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST	
Client/Project BARRICK/MERCUR TAILINGS/UT		SAMPLE DESCR/ID GA98 BH11 40 to 42ft	REPORT ID 2344-R3
DRAWN BDM	CHECKED DD	REVIEWED DJ	
DATE DEC98	JOB NO. 983-2344	FIGURE --	

234411B 234411A 234411C





GOLDER ASSOCIATES INC	TITLE CONSOLIDATED UNDRAINED TRIAXIAL COMPRESSION TEST
Client/Project BARRICK/MERCUR TAILINGS/UT	SAMPLE DESCR/ID GA98 BH11 40 to 42ft REPORT ID t2344-R3

DRAWN BDM	CHECKED DD	REVIEWED DJ	DATE DEC98	JOB NO. 983-2344	FIGURE --

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER 11
SAMPLE DEPTH (FEET) 40-42
BORING NUMBER GA98BH11
EFFECTIVE STRESS (PSI) 15.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.26	0.0	100.0	100.0	0.0	0.0	15.1	15.1	0.0	15.1
1	0.7	6.30	79.9	112.7	100.0	12.7	7.1	20.6	7.9	6.3	14.3
2	1.1	6.33	88.5	114.0	100.0	14.0	8.3	20.8	6.8	7.0	13.8
3	1.5	6.36	95.1	115.0	100.0	15.0	8.8	21.2	6.2	7.5	13.7
4	2.0	6.38	100.3	115.7	100.0	15.7	8.9	21.9	6.2	7.9	14.0
5	2.4	6.41	105.6	116.5	100.0	16.5	8.7	22.8	6.4	8.2	14.6
6	2.8	6.44	110.9	117.2	100.0	17.2	9.0	23.3	6.1	8.6	14.7
7	3.2	6.47	115.5	117.9	100.0	17.9	8.6	24.3	6.5	8.9	15.4
8	3.6	6.49	120.8	118.6	100.0	18.6	8.5	25.1	6.5	9.3	15.8
9	4.1	6.52	125.4	119.2	100.0	19.2	8.4	25.8	6.6	9.6	16.2
10	4.5	6.56	130.7	119.9	100.0	19.9	8.3	26.7	6.8	10.0	16.8
11	5.0	6.59	134.7	120.4	100.0	20.4	8.2	27.3	6.9	10.2	17.1
12	5.4	6.62	139.3	121.0	100.0	21.0	8.1	28.0	7.0	10.5	17.5
13	5.9	6.65	143.2	121.5	100.0	21.5	7.6	29.0	7.4	10.8	18.2
14	6.3	6.68	146.5	121.9	100.0	21.9	7.9	29.1	7.2	11.0	18.2
15	6.7	6.71	149.2	122.2	100.0	22.2	7.3	30.0	7.8	11.1	18.9
16	7.2	6.74	153.1	122.7	100.0	22.7	7.8	30.0	7.3	11.4	18.7
17	7.6	6.77	155.8	123.0	100.0	23.0	7.2	30.9	7.9	11.5	19.4
18	8.0	6.80	159.1	123.4	100.0	23.4	6.8	31.6	8.2	11.7	19.9
19	8.5	6.84	163.7	123.9	100.0	23.9	6.6	32.4	8.5	12.0	20.4
20	9.0	6.87	166.3	124.2	100.0	24.2	6.5	32.8	8.6	12.1	20.7
21	9.4	6.91	169.6	124.6	100.0	24.6	6.4	33.2	8.6	12.3	20.9
22	9.8	6.94	172.9	124.9	100.0	24.9	6.0	34.0	9.0	12.5	21.5
23	10.3	6.98	175.6	125.2	100.0	25.2	6.1	34.1	8.9	12.6	21.5
24	10.7	7.01	177.6	125.3	100.0	25.3	6.1	34.3	9.0	12.7	21.7
25	11.2	7.05	179.5	125.5	100.0	25.5	5.7	34.8	9.4	12.7	22.1
26	11.6	7.08	180.9	125.5	100.0	25.5	5.4	35.2	9.7	12.8	22.4
27	12.1	7.12	182.8	125.7	100.0	25.7	5.2	35.6	9.9	12.8	22.8
28	12.5	7.15	185.5	125.9	100.0	25.9	4.8	36.2	10.3	13.0	23.3
29	13.0	7.19	187.5	126.1	100.0	26.1	4.9	36.2	10.1	13.0	23.2
30	13.4	7.22	188.8	126.1	100.0	26.1	4.9	36.3	10.1	13.1	23.2
31	13.9	7.27	190.8	126.3	100.0	26.3	4.7	36.6	10.3	13.1	23.5
32	14.4	7.31	192.7	126.4	100.0	26.4	4.6	36.8	10.4	13.2	23.6
33	14.8	7.35	193.4	126.3	100.0	26.3	4.8	36.6	10.3	13.2	23.4
34	15.0					26.4					
34	15.0	7.36	194.1	126.4	100.0	26.4	3.9	37.5	11.1	13.2	24.3
35	15.5	7.40	194.1	126.2	100.0	26.2	4.3	37.0	10.8	13.1	23.9
36	15.9	7.44	195.4	126.3	100.0	26.3	4.3	37.1	10.8	13.1	23.9
37	16.4	7.49	196.0	126.2	100.0	26.2	4.1	37.2	11.0	13.1	24.1
38	16.8	7.52	198.0	126.3	100.0	26.3	4.0	37.4	11.1	13.2	24.2
39	17.3	7.56	200.0	126.4	100.0	26.4	4.1	37.4	10.9	13.2	24.2
40	17.7	7.60	200.0	126.3	100.0	26.3	4.0	37.3	11.0	13.2	24.2

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER 11
SAMPLE DEPTH (FEET) 40-42
BORING NUMBER GA98BH11
EFFECTIVE STRESS (PSI) 30.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.26	0.0	100.0	100.0	0.0	0.0	29.9	29.9	0.0	29.9
1	0.7	6.30	101.0	116.0	100.0	16.0	12.0	33.9	17.9	8.0	25.9
2	1.1	6.33	118.8	118.8	100.0	18.8	15.5	33.2	14.4	9.4	23.8
3	1.6	6.36	130.7	120.6	100.0	20.6	17.0	33.5	12.9	10.3	23.2
4	2.0	6.38	139.9	121.9	100.0	21.9	17.5	34.3	12.4	11.0	23.3
5	2.4	6.41	149.2	123.3	100.0	23.3	18.0	35.2	11.9	11.6	23.6
6	2.8	6.44	158.4	124.6	100.0	24.6	18.2	36.3	11.7	12.3	24.0
7	3.2	6.46	166.3	125.7	100.0	25.7	18.0	37.6	11.9	12.9	24.7
8	3.6	6.49	174.9	126.9	100.0	26.9	18.1	38.8	11.8	13.5	25.3
9	4.0	6.52	182.8	128.0	100.0	28.0	17.3	40.6	12.6	14.0	26.6
10	4.4	6.55	190.1	129.0	100.0	29.0	17.8	41.2	12.1	14.5	26.7
11	4.8	6.58	197.4	130.0	100.0	30.0	17.2	42.7	12.7	15.0	27.7
12	5.2	6.60	204.6	131.0	100.0	31.0	17.3	43.6	12.6	15.5	28.1
13	5.7	6.63	211.2	131.8	100.0	31.8	16.7	45.0	13.2	15.9	29.1
14	6.1	6.66	217.2	132.6	100.0	32.6	16.6	45.8	13.3	16.3	29.5
15	6.5	6.69	223.1	133.3	100.0	33.3	16.5	46.8	13.4	16.7	30.1
16	6.9	6.73	229.1	134.1	100.0	34.1	16.1	47.8	13.8	17.0	30.8
17	7.4	6.76	231.7	134.3	100.0	34.3	15.8	48.4	14.1	17.1	31.3
18	7.8	6.79	237.0	134.9	100.0	34.9	15.8	49.0	14.1	17.5	31.6
19	8.3	6.82	242.3	135.5	100.0	35.5	15.6	49.8	14.3	17.8	32.0
20	8.7	6.85	246.9	136.0	100.0	36.0	15.1	50.8	14.8	18.0	32.8
21	9.1	6.88	250.8	136.4	100.0	36.4	15.2	51.1	14.7	18.2	32.9
22	9.5	6.92	254.8	136.8	100.0	36.8	15.0	51.8	14.9	18.4	33.3
23	9.9	6.95	258.8	137.2	100.0	37.2	14.8	52.4	15.1	18.6	33.7
24	10.4	6.99	262.1	137.5	100.0	37.5	14.6	52.8	15.3	18.8	34.1
25	10.9	7.02	265.4	137.8	100.0	37.8	14.3	53.4	15.6	18.9	34.5
26	11.3	7.06	268.7	138.1	100.0	38.1	14.3	53.6	15.6	19.0	34.6
27	11.9	7.10	271.3	138.2	100.0	38.2	14.0	54.1	15.9	19.1	35.0
28	12.3	7.14	273.3	138.3	100.0	38.3	14.0	54.2	15.9	19.1	35.0
29	12.8	7.17	275.3	138.4	100.0	38.4	13.8	54.5	16.1	19.2	35.3
30	13.3	7.21	278.6	138.6	100.0	38.6	13.8	54.7	16.1	19.3	35.4
31	13.7	7.25	280.5	138.7	100.0	38.7	13.8	54.8	16.1	19.3	35.4
32	14.1	7.29	282.5	138.8	100.0	38.8	13.7	55.0	16.2	19.4	35.6
33	14.6	7.33	285.2	138.9	100.0	38.9	13.5	55.3	16.4	19.5	35.9
34	15.1					39.0					
34	15.1	7.37	287.8	139.0	100.0	39.0	13.4	55.5	16.5	19.5	36.0
35	15.6	7.41	289.8	139.1	100.0	39.1	13.3	55.7	16.6	19.5	36.2
36	16.0	7.45	291.8	139.2	100.0	39.2	13.1	55.9	16.8	19.6	36.4
37	16.4	7.48	293.7	139.2	100.0	39.2	13.1	56.1	16.8	19.6	36.5

BARRICK/MERCUR TAILINGS/UT
CONSOLIDATED UNDRAINED
TRIAXIAL COMPRESSION TEST

SAMPLE NUMBER 11
SAMPLE DEPTH (FEET) 40-42
BORING NUMBER GA98BH11
EFFECTIVE STRESS (PSI) 45.0

Reading Nbr	Strain %	Area crrctd in^2	Force crrctd lbs	sigma1 psi	sigma3 psi	Deviator Stress sig1-sig3	Pore Press. psi	sig_1' psi	sig_3' psi	Q psi	P' psi
0	0.0	6.26	0.0	100.0	100.0	0.0	0.0	45.0	45.0	0.0	45.0
1	0.8	6.31	52.8	108.4	100.0	8.4	7.9	45.5	37.1	4.2	41.3
2	1.2	6.33	139.9	122.1	100.0	22.1	17.2	49.9	27.8	11.1	38.8
3	1.6	6.36	174.3	127.4	100.0	27.4	23.9	48.5	21.1	13.7	34.8
4	2.0	6.38	186.8	129.3	100.0	29.3	26.9	47.4	18.1	14.6	32.7
5	2.4	6.41	196.0	130.6	100.0	30.6	28.0	47.5	17.0	15.3	32.2
6	2.8	6.44	204.0	131.7	100.0	31.7	28.9	47.7	16.1	15.8	31.9
7	3.2	6.47	211.2	132.7	100.0	32.7	29.4	48.2	15.6	16.3	31.9
8	3.6	6.49	218.5	133.6	100.0	33.6	29.6	49.0	15.4	16.8	32.2
9	4.0	6.52	225.7	134.6	100.0	34.6	30.0	49.6	15.0	17.3	32.3
10	4.4	6.55	233.0	135.6	100.0	35.6	29.9	50.7	15.1	17.8	32.9
11	4.8	6.58	238.9	136.3	100.0	36.3	29.9	51.4	15.1	18.2	33.2
12	5.3	6.61	244.9	137.1	100.0	37.1	30.0	52.1	15.0	18.5	33.5
13	5.7	6.64	250.8	137.8	100.0	37.8	29.6	53.2	15.4	18.9	34.3
14	6.1	6.67	253.5	138.0	100.0	38.0	29.7	53.3	15.3	19.0	34.3
15	6.6	6.70	259.4	138.7	100.0	38.7	29.9	53.9	15.1	19.4	34.5
16	7.0	6.73	266.7	139.6	100.0	39.6	29.2	55.4	15.8	19.8	35.6
17	7.4	6.76	273.3	140.4	100.0	40.4	28.7	56.8	16.3	20.2	36.5
18	7.8	6.79	279.2	141.1	100.0	41.1	29.0	57.1	16.0	20.6	36.6
19	8.2	6.82	285.2	141.8	100.0	41.8	28.6	58.2	16.4	20.9	37.3
20	8.6	6.85	291.1	142.5	100.0	42.5	28.8	58.7	16.2	21.2	37.5
21	9.1	6.88	296.4	143.1	100.0	43.1	28.4	59.6	16.6	21.5	38.1
22	9.5	6.92	297.0	142.9	100.0	42.9	28.4	59.6	16.6	21.5	38.1
23	10.0	6.95	298.4	142.9	100.0	42.9	28.0	59.9	17.0	21.5	38.5
24	10.5	6.99	300.3	143.0	100.0	43.0	27.8	60.2	17.2	21.5	38.7
25	10.9	7.03	303.0	143.1	100.0	43.1	27.5	60.7	17.5	21.6	39.1
26	11.3	7.06	305.0	143.2	100.0	43.2	27.4	60.8	17.6	21.6	39.2
27	11.7	7.09	304.3	142.9	100.0	42.9	27.1	60.8	17.9	21.5	39.4
28	12.2	7.12	301.0	142.2	100.0	42.2	27.2	60.1	17.8	21.1	39.0
29	12.6	7.16	301.0	142.0	100.0	42.0	27.2	59.8	17.8	21.0	38.8
30	13.1	7.20	302.3	142.0	100.0	42.0	27.3	59.7	17.7	21.0	38.7
31	13.6	7.24	302.3	141.7	100.0	41.7	27.2	59.5	17.8	20.9	38.7
32	14.0	7.28	301.0	141.4	100.0	41.4	27.3	59.1	17.7	20.7	38.4
33	14.6	7.32	300.3	141.0	100.0	41.0	27.5	58.5	17.5	20.5	38.0
34	15.0	7.36	299.0	140.6	100.0	40.6	27.4	58.2	17.6	20.3	37.9
35	15.1					40.6					
35	15.1	7.37	299.0	140.6	100.0	40.6	27.4	58.2	17.6	20.3	37.9
36	15.7	7.42	299.0	140.3	100.0	40.3	27.5	57.8	17.5	20.1	37.7
37	16.1	7.46	299.7	140.2	100.0	40.2	27.5	57.7	17.5	20.1	37.6
38	16.5	7.49	299.7	140.0	100.0	40.0	27.6	57.4	17.4	20.0	37.4
39	16.9	7.53	299.0	139.7	100.0	39.7	27.5	57.2	17.5	19.8	37.4
40	17.4	7.58	298.4	139.4	100.0	39.4	27.5	56.9	17.5	19.7	37.2
41	17.8	7.61	298.4	139.2	100.0	39.2	27.5	56.7	17.5	19.6	37.1
42	18.4	7.67	298.4	138.9	100.0	38.9	27.5	56.4	17.5	19.5	37.0
43	19.0	7.72	297.7	138.5	100.0	38.5	27.6	56.0	17.4	19.3	36.7

APPENDIX D-4

PERMEABILITY TESTING

BARRICK/RESERVATION CANYON TAILINGS/UT

983-2344.001.2

TABLE 1

SUMMARY OF FLEXIBLE-WALL PERMEABILITY TEST RESULTS

SAMPLE NUMBER	SAMPLE DEPTH (ft)	SAMPLE LENGTH (cm)	SAMPLE DIAMETER (cm)	SAMPLE DRY DENSITY (pcf)	INITIAL MOISTURE (%)	EFFECTIVE STRESS (psi)	BACK PRESSURE (psi)	GRADIENT	AVERAGE PERMEABILITY (cm/sec)
BH-9	42-44	10.58	7.27	92.8	28.1	25	75	1	7.1×10^{-4}
BH-10	40-42	9.36	7.24	92.2	30.3	22	78	9	3.9×10^{-7}

APPENDIX E

WMCI REPORT

WATER MANAGEMENT CONSULTANTS, INC.

TECHNICAL MEMORANDUM

To:	Brent Bronson
Company:	Golder and Associates, Inc.
From:	C. Filippone
Date:	January 13, 1999
Subject:	Updated Reservation Canyon draindown analysis

1.0 Introduction

Water Management Consultants, Inc. (WMCI) was retained by Golder Associates, Inc. (GAI) to conduct numerical flow modeling of draindown in the Reservation Canyon tailing impoundment at Barrick Resources' (USA) Mercur Gold Mine, located in Tooele, Utah. This study builds upon previous modeling efforts by Water Management Consultants, Inc. (WMCI, 1996) and TriTechnics (1996). Estimates of anticipated incidental flows at the tailing impoundment including seepage from the main dam seepage collection system, main dam chimney drain, levee seepage collection system and the saddle seep collection system are needed for closure planning. Estimates of water level declines within the tailing impoundment are required for compaction calculations to assist in determining the feasibility of alternative engineering controls on the surface.

The work reported here incorporates recently developed estimates of spatial variability of hydraulic conductivity within the tailing and includes estimates of flows through the clay liner underlying the impoundment in the long-term draindown projections. GAI used cone penetrometer (CPT) pore pressure dissipation methods to estimate saturated hydraulic conductivity distribution in the impoundment along five cross-sections through the tailing impoundment. The depth of the pool was also measured along these sections. Water level elevations and drain discharge records were kept from June to October 1998. Model calibration is to measured water levels and discharges from tailing embankments at two locations during the month of September 1998.

The WMCI (1996) report focused on the effect of two alternative cap designs at the impoundment with and without basal discharge on long-term discharge and draindown rates. For the saturated-unsaturated UNSAT2 simulations, WMCI input parameter values reported by TriTechnics (1996) and found that temporal variation of combined seepage rates from the main dam, main dam chimney drain, and the reclaim levee would decline from about 35 gallons per minute (gpm) to about 14 gpm after 30 years. The WMCI (1996) report concluded that a cap consisting of one foot of topsoil over two feet of subsoil was superior to one with the same cover underlain by a one foot thick clay layer. Discharge through the clay liner beneath the tailing impoundment was estimated to be about 1.17 ft/yr.

TriTechnics (1996) evaluated cap designs and estimated draindown rates and seepage flows from the main dam and the levee seepage collection system using the HELP model. HELP predicted that the upper 90 feet of tailing could dewater in about 7 to 9 years, resulting in the cessation of seepage from the main dam, and that the entire tailing mass could free drain in about 10 or 11 years.

Global Environmental Technologies (GET, 1998) presented a two-phase long-term management plan for anticipated incidental flows at the tailing impoundment including; seepage from the main dam seepage collection system; main dam chimney drain; levee seepage collection system; and, the saddle seep collection system. The plan includes recycling incidental seepage to the northwest corner of the impoundment basin and the synthetically lined East Bay impoundment during the first phase. A tailing cover and decommissioning of all facilities involved in active pumping from the incidental seepage collection points are planned for phase two.

Subsequent to the completion of the work described above, Barrick has installed flow meters to accurately measure the flow rates and seepage volumes at the main dam and levee seepage collection system. Substantially different quantities of discharge from the impoundment have been measured since then, and it has become necessary to re-evaluate previous estimations of the hydraulic parameters of the materials and the long-term behavior of the impoundment.

This report summarizes WMCI's current draindown evaluation, which is based on data obtained during CPT testing performed by GAI at the tailing impoundment and recent observations of discharge. The objectives of the study were to:

- quantify the flux of water through the clay liner and embankments, and
- estimate the temporal variation of hydraulic head distribution within the impoundment.

A variably saturated flow model, UNSAT2 (Davies and Neuman, 1983) was used to evaluate parameter estimates, draindown and seepage in cross-sections developed normal to the main dam (A-A') and the levee buttress (D-D'). The location of these profiles is indicated on Figure 1 of the main report. A three-dimensional flow model, MODFLOW (McDonald and Harbaugh, 1988), was used to analyze long-term draindown over the area of the tailing impoundment. This combination of modeling approaches allows the estimation of hydraulic parameters via calibration to existing water level and outflow data with a rigorous state of the art unsaturated flow model (UNSAT2) in two dimensions. Following calibration to existing conditions, the unsaturated flow model is used to estimate long-term draindown while incorporating physically realistic atmospheric boundary conditions. The hydraulic parameters and the liner seepage rates obtained from the unsaturated flow simulations are then built into a three-dimensional saturated flow model (MODFLOW) of the tailing impoundment for assessment of long-term draindown.

2.0 Conceptual Model

The Reservation Canyon tailing impoundment consists of approximately 20 million cubic yards of mine tailing, bounded by a main dam, saddle dam, and the levee buttress. The material in the tailing impoundment has been deposited into segregated layers over the 15-year operation of the impoundment. The crest of the original impoundment was at an elevation of 7250 ft above mean sea level (amsl). Upstream construction methods were used to elevate the crest of the dam to 7360 ft amsl using crushed limestone placed in lifts above a previously developed tailing beach. The most recently deposited tailing are still unconsolidated and lack a porous media structure. Construction of the East Bay, a synthetically lined impoundment facility designed to hold 72 million gallons of solution, was completed in 1996. The East Bay impoundment was built to facilitate water management during closure operations.

As of August 1998, tailing surface elevations sloped from about 7,337 at the beaches along the southeast and southwest sides of the impoundment to about 7,326 ft amsl in the northwest corner of the impoundment. Standing water within the impoundment at the time of the survey had a surface elevation of 7,336.7 ft amsl. This water level was maintained during the model calibration period for the month of September 1998.

With exception of inboard slopes of the upstream raises, the impoundment is lined with a six inch to one-foot thick layer of clay. This clay liner rests upon *in situ* shale or two feet of crushed shale, which overlies bedrock. The main dam and saddle dam are zoned earthen structures with a clay core and chimney drain. The base of the upstream construction is at the top of the main dam at 7,250 ft amsl. Seepage from the upstream construction berm is collected in an 800 foot long seepage collection apron located at the top of the main dam. The levee buttress does not include a clay core or chimney drain, and is intended to allow free drainage from the impoundment into a 610 foot long levee seepage collection apron and sump located at an elevation of 7,234 ft amsl.

Water is maintained in the impoundment by recirculating the discharge from the collection systems to the northwest corner of the tailing impoundment. Water collected from the levee buttress is generally routed to the East Bay impoundment. Seepage rates at both the main dam and the levee buttress have been observed to be strongly dependent on the location of slurry drops in the impoundment or if evaporation emitters are active. Flows from the main dam chimney drain and the saddle seep collection system have been observed to be small.

Climatic conditions at the tailing impoundment have been described by WMCI (1996). The same atmospheric inputs as used in the previous WMCI simulation (1996) were applied at the surface for the draindown simulation. These were synthetically generated using the HELP model for a 30-year period. For simulation projections beyond 30 years, the record was repeated. Mean temperatures and precipitation data from the Mercur site were combined with meteorological data from the Salt Lake City area representing typical weather patterns for the vicinity. Mean annual rainfall is 19.0 inches, while mean snowfall is 79.0 inches (Barrick monthly meteorological database). Adopting a 10 percent average water content for the snow, an equivalent annual precipitation of 26.9 inches is applied. Taking into account evaporation and snow sublimation during rainfall events, the overall mean net precipitation available for infiltration is estimated at 23.6 in/yr. Mean annual potential evaporation is 28.7 in/yr.

2.1 Previous work

2.1.1 Field characterization

As discussed in the introduction, several site closure studies have been conducted. These studies have made use of estimates of saturated hydraulic conductivity obtained in the field and in the laboratory during multiple phases of testing. Variability in hydraulic conductivity of the subaerial tailing proximal to the beach areas was found to range from 8.1×10^{-5} cm/sec to 2.7×10^{-3} cm/sec for nine of ten slug tests conducted by Physical Resource Engineering, Inc. (PRE) in 1993 and 1994. A tenth slug test in the subaerial tailing resulted in an estimate of 1.8 cm/sec. A value of 1.8×10^{-5} for the subaerial tailing was reported by PRE in 1989, but the method of measurement was not noted. Hydraulic conductivity estimates obtained by different measurement methods, i.e. in laboratory columns, slug testing in the field or from CPT dissipation data, can be affected both by methodology and by material properties that are a function of the scale of the measurement. For this reason it is difficult to directly compare estimates obtained by different measurement techniques. Hydraulic conductivity estimates based on in situ CPT pore pressure dissipation data interpretation by GAI in the upper subaerial tailing zone ranged from 6.7×10^{-6} cm/sec in the distal upper subaerial tailing to 4.5×10^{-5} cm/sec in the proximal unconsolidated slimes. These tests were conducted to evaluate the range of material within the tailing impoundment. The values are generally on the low end of those obtained from the proximal beach slug testing.

Tailing below the 7,213 ft amsl elevation within the impoundment were classified as bulk discharge tails in the WMCI (1996) report, and assigned a hydraulic conductivity value of 7.6×10^{-6} cm/sec as reported by PRE (1989). CPT data hydraulic conductivity values from in situ pore pressure dissipation testing for tailing in this deeper zone were estimated by GAI as 9.9×10^{-7} cm/sec for the subaqueous tailing at the deepest levels of the impoundment below approximately 7,175 ft amsl.

2.1.2 Technical approach

WMCI has adopted an approach to modeling of the tailing impoundment that combines the advantages of incorporating the nonlinear phenomena inherent to unsaturated flow processes, within a two-dimensional finite element context, with the fully saturated three-dimensional finite difference model MODFLOW for estimation of long-term water levels. Calibration of the two-dimensional main dam cross-section simulation to water levels and discharge rates observed during September 1998 was accomplished by assigning the tailing hydraulic conductivity values and spatial distributions supplied by GAI. When these parameters did not initially result in the seepage conditions observed in the field, an increasing ratio of horizontal to vertical anisotropy of those zones within the subaerial tailing was implemented. This still did not result in sufficient discharge at the main dam's solution collection system. Next, the hydraulic conductivities of the tailing zones were increased by a factor as a group and the simulations were repeated until seepage volumes corresponded with measurement data. Hydraulic parameters for materials outside the tailing were not altered from the values provided by GAI.

When a reasonable set of parameter values that reproduced measurements at the main dam and levee buttress collection systems for September 1998 at steady state was found, the steady state pressure distribution resulting from the simulation was input as the initial condition for 100-year UNSAT2 draindown simulations. For the draindown simulations, atmospheric boundaries were implemented at all surface elements except for the potential seepage faces. The resulting net seepage rates through the clay liner and recharge rates due to atmospheric conditions at the surface from UNSAT2 was incorporated into MODFLOW for a three-dimensional long-term draindown analysis.

Effectively, the simulation with MODFLOW integrates the results of the two cross-sectional UNSAT2 simulations over the entire area of the impoundment. Although this approach is considered technically sound, it is affected by the limitations of MODFLOW to deal with flow through variably saturated materials and may tend to overestimate the long-term flows out of the impoundment.

3.0 Numerical modeling

3.1 Unsaturated flow simulations

The UNSAT2 computer code has been used to model draindown in a wide range of heap leach, waste dump, and tailing piles (Guzman, Srivastava, and Beale, 1998). The model uses the Galerkin finite element method to solve the Richards equation for pore pressure, then converts this to volumetric water content according to the van Genuchten relationship. Since hydraulic conductivity is a function of saturation, the use of the UNSAT2 model allows accurate representation of flow under partially saturated conditions. When coupled with site-specific long-term synthetic atmospheric input, the model incorporates the additional effects of climatic variability. In combination with new information about the spatial distribution of hydraulic conductivity within the impoundment and measured seepage rates at the main dam and levee buttress, the revised UNSAT2 model was used to provide improved estimates of long-term draindown characteristics including water levels and outflows from the system. These estimates are then used to set boundary conditions for the three-dimensional MODFLOW simulations.

In previous modeling studies (WMCI, 1996), two cross-sections were modeled with UNSAT2. The location of cross-sections A-A' and D-D' (approximate) are shown in Figure 1. Although section D-D' is relatively close to previously simulated section B-B', it was decided to generate a new finite element grid for section D-D' which captures the details available from the recent field characterization by GAI. Figure 2 shows the two finite element grids used to model these cross-sections.

3.2 UNSAT2 model calibration

The model was calibrated to site conditions for the month of September 1998. This time period was selected because discharge rates were relatively constant, and the effect of snow guns used for enhancement of evaporation had dissipated. Figure 3 is a plot of water level elevation in the tailing reservoir from June to October 1998. Since fewer variables in operational procedures occurred in September, the September water levels exhibit significantly less fluctuation than that observed during earlier months. The average water level elevation of 7,336.7 ft was used for the modeling calibration phase. Figure 4 is a plot of pumping rates from June to September 1998. During September, the pumping rate at the main dam was approximately 200 gallons per minute (gpm). The pump-back rate from the levee buttress sump was approximately 60 gallons per minute

Hydraulic conductivity values and distributions reported by GAI for the CPT pore pressure dissipation tests were incorporated into the UNSAT2 A-A' (main dam) cross-section. Material properties for the zones surrounding the tailing including the bulk fill, run of mine, clay core and liner, chimney and bedrock, were assigned identically to those of the WMCI (1996) modeling study. Boundary conditions of unit gradient were set along the lower and left-hand (downstream) sides. For the steady state simulation, no flow boundary conditions were established along the right hand side and along the main dam surfaces away from the seepage area. The slope of the upstream construction lifts above the main dam crest at 7,250 ft was assigned seepage face boundary conditions. The tailing impoundment surface was set at constant head equal to the observed September water level of 7,336.7 ft amsl. The resulting simulation did not produce the discharges through the upstream buttress reported for the month of September 1998 at the main dam collection system.

Similarly, cross-section D-D' (levee buttress) was constructed. Material distribution as determined from the CPT characterization effort was built into the finite element grid. Material property distributions for the A-A' and D-D' unsaturated simulations are shown in the Appendix A.

Potential contribution of anisotropy within the subaerial tailing zones to the observed seepage rates was investigated. Figure 5 illustrates the seepage rates observed from the main dam buttress as a function of anisotropy. A 100:1 horizontal to vertical anisotropy ratio resulted in flows of 67 gpm at the main dam buttress, less than half of the observed rates of around 200 gpm. It was concluded that anisotropy alone could not explain the disparity between high seepage rates observed in the field and low rates predicted by the model when the in situ CPT derived hydraulic conductivity values were used.

To match observed discharges through the upstream construction buttress, hydraulic conductivity values of the tailing were increased incrementally as a group until the discharge from the model matched the reported discharge. The increase on the hydraulic conductivity values was done while maintaining the contrast of hydraulic conductivity as determined by GAI on the basis of the CPT testing and field observation. The hydraulic conductivity of the slimes or the subaqueous tailing material, was kept as measured for the following reasons. The slimes do not present a typical porous media structure, but resemble a typical dispersed colloidal emulsion. When drained, these extremely fine materials are expected to have very low hydraulic conductivity. The subaqueous tailing is believed to be significantly compacted due to the overburden pressure exerted by the overlying materials.

Figure 6 is a plot of discharge from the impoundment versus the factor by which the saturated hydraulic conductivity measurements were increased when a 10:1 horizontal to vertical anisotropy is imposed within the subaerial tailing zones. Discharge rates increase linearly as the overall tailing hydraulic conductivities are increased. A factor of 15 times the values estimated from the CPT data was found to result in the observed seepage rates around 200 gpm at the main dam seepage face.

As both Figures 5 and 6 show, basal outflows were found to be relatively unaffected by variation of hydraulic conductivity within the tailing, i.e., the unit gradient boundary condition at the bottom of the simulation domain and the hydraulic properties of the clay liner and the bedrock controlled basal seepage rates. Variation in hydraulic conductivity of the bedrock was found to have a significant effect on flow through the liner, although details of these results are not reported here.

Based on these calibration evaluations, it was concluded that except for the slimes and the subaqueous tailings, hydraulic conductivity values of 10 to 15 times those estimated from the CPT data, in combination with a 10:1 horizontal to vertical anisotropy ratio within the subaerial tailing, were reasonable. The steady state pressure distribution from the simulation was used as initial conditions for transient simulations designed to provide estimates of long-term discharge and temporal variation of hydraulic head distribution within the tailing impoundment.

Table 1 Material properties used in unsaturated flow simulations

Material description	$K_{s,x}$ (cm/sec)	$K_{s,z}$ (cm/sec)	θ_s (vol/vol)	θ_r (vol/vol)	α (1/cm)	n
1. Proximal upper subaerial tailing *	1.5e-03	1.5e-04	0.50	0.20	0.014	1.323
2. Distal upper subaerial tailing *	1.0e-03	1.0e-04	0.50	0.20	0.014	1.323
3. Proximal unconsolidated slimes	4.5e-05	4.5e-05	0.70	0.250	0.0066	1.323
4. Distal unconsolidated slimes	6.9e-06	6.9e-06	0.70	0.250	0.0066	1.323
5. Lower subaerial tailing *	1.2e-03	1.2e-04	0.37	0.150	0.016	1.768
6. Subaqueous tailing	9.9e-07	9.9e-07	0.42	0.080	0.014	1.323
7. Clay liner	2.0e-08	2.0e-08	0.37	0.286	0.002	1.590
8. Bulk fill	1.5e-04	1.5e-04	0.32	0.051	0.0163	4.360
9. Rock fill upstream	2.2e-03	2.2e-03	0.21	0.010	0.164	2.5
10. Chimney drain	3.3e-03	3.3e-03	0.27	0.033	0.119	2.450
11. Oquirrh Formation	1.4e-03	1.4e-03	0.15	0.050	0.031	3.2
12. Manning Canyon shale	3.9e-05	3.9e-05	0.15	0.050	0.014	3.2
13. Medial limestone	2.2e-03	2.2e-03	0.15	0.080	0.0140	1.323
14. Intercalated series	2.0e-4	2.e-04	0.15	0.010	0.031	3.2

*Indicates zones for which a factor of 15 and a 10:1 horizontal to vertical anisotropy in hydraulic conductivity was implemented.

3.3 Three-dimensional saturated flow simulations

Two-dimensional simulations can be used to estimate discharge from the impoundment, but a three-dimensional representation is necessary to determine the long-term variation of hydraulic heads within the impoundment. The computer code MODFLOW was used to model flow in the impoundment. MODFLOW is a finite-difference saturated flow model, which calculates the hydraulic head in each cell based upon material properties and the head in neighboring cells.

While MODFLOW does not have the capability to model unsaturated flow, it is expected that the three-dimensional model will provide an accurate representation of the temporal behavior of hydraulic head within the impoundment. This is because the boundary conditions for the saturated flow model are determined using the results from the two-dimensional unsaturated flow model. Material properties (saturated hydraulic conductivity and porosity) used in the three-dimensional model are the same as those for the unsaturated flow model except that no unsaturated flow parameters are included. A comparison of discharge rates through the main dam buttress (Figure 7), and the levee buttress (Figure 8), illustrates that the two models produce very similar results. Despite the differences between the models, the application of consistent parameters, boundary conditions and the matching of water levels over time and discharge from the system justifies the applicability of the saturated flow model to estimate the long-term draindown of the tailing impoundment.

The MODFLOW grid consists of 50 rows, 31 columns, and 11 layers for a total of 17,050 cells. The base cell area is 100 feet by 100 feet. Additional discretization was utilized in areas where higher resolution was necessary. Cells near the main dam and reclaim levee measure 50 feet by 50 feet. The base cell height is 50 feet; layer thicknesses as small as one foot were used where necessary. The lined East Bay storage pond was not included in the simulation since it is not hydraulically connected to the rest of the impoundment.

3.3.1 Model calibration

Calibration of the saturated flow model consisted primarily of determining appropriate conductances for the drains at the seepage faces and the general head boundary at the bottom of the model given the boundary conditions as computed from UNSAT2. The calibration period for the three-dimensional model was September 1998, the same as for the UNSAT2 model. While the two-dimensional models were calibrated to the measured discharge through the main dam upstream construction and levee buttress, the three-dimensional model included two additional parameters basal seepage and atmospheric interaction as determined from the unsaturated flow model. A constant head of 7,336.7 ft amsl was used to represent the standing water in the impoundment for the steady state simulation. MODFLOW's drain package was used to simulate flow through the main dam upstream construction and reclaim levee. The general head boundary package was used to simulate downward flow from the base of the impoundment.

Transient simulations were conducted for up to 100 years after closure, using the calibrated steady state results as initial conditions. It was also assumed that pump back activities onto the main impoundment would cease after closure, eliminating another source of recharge. Recharge rates in the UNSAT2 simulations were found to be close to zero when integrated over the duration of the draindown simulations because of the ability of the model to include upward flux in the unsaturated zone when net evaporative conditions exist on the surface. A comparison of water table elevations along the A-A' and D-D' cross-section shows excellent agreement with the UNSAT2.

4.0 Analysis of results

Figure 10 illustrates the results of the steady state calibration to September 1998 conditions for the A-A' and D-D' profiles. Water levels at the surface for each profile are 7,336.7 ft. Unsaturated conditions are predicted at steady state beneath the clay liner and within the main dam and both the main dam and levee buttresses. The surface of the water table slopes gently from the end of the ponded tailing (edge of the beach) to the respective seepage outflow locations for each profile. Results of the draindown simulations are presented as discharge over time for the main dam buttress (Figure 7), the levee buttress (Figure 8), and basal outflow (Figure 9).

Main Dam Buttress Seepage Rates

As shown in Figure 7, estimated seepage rates at the main dam upstream construction buttress are expected to decline rapidly during the first year of draindown. From the calibrated initial seepage rate of 182 gpm, seepages from UNSAT2 after a year decrease to approximately 62.1 gpm, after two years the seepage rate is 38.3 gpm, after three years the rate is 22.1 gpm, and after five years the rate is about 8 gpm. Seepage from the main dam buttress is predicted to cease approximately 8 years after the initiation of draindown by UNSAT2, and sometime in the fifth year by MODFLOW.

Levee Buttress Seepage Rates

Levee buttress seepage results from the D-D' UNSAT2 profile and MODFLOW are shown in Figure 8. Due to the fact that the levee has no clay liner and the collection sump is located at a lower elevation than for the main dam buttress seepage face, discharge at the levee collection sump is estimated to continue for about 13 years, five years longer than for the main dam buttress seepage. Discharge rates at the levee decline from a current level of around 60 gpm to about 42 gpm after the first year, 31 gpm after the second year, 21 gpm after the third year, to 2.5 gpm at the start of the tenth year. After year 13, no discharge was observed at the buttress levee in the Unsat2 simulations. Discharge in the MODFLOW simulations continued at negligible levels until around year 20.

Basal Seepage Rates

Estimated average seepage rates through the impoundment bottom are plotted in Figure 9. These rates result from an integration of average basal seepage from the A-A and D-D' profiles over a 50 acre area. This area was chosen due to the observation that seepage as computed by the UNSAT2 simulations occurred primarily beneath the deeper areas of the tailing impoundment, and that the area of seepage decreased as water levels decreased over the draindown period. Rates of basal seepage were seen to decay more or less exponentially over the 100 year simulation period. Loss rates at the end of the first year of draindown are predicted by UNSAT2 to be about 35 gpm over the impoundment base. At the end of 10 years basal seepage is estimated at 18 gpm. Basal seepage rate after 30 years is 9 gpm, after 50 years is 6 gpm, after 75 years is 4 gpm and after 100 years is about 3 gpm.

Distribution of basal seepage was heavily weighted in the area immediately behind the main dam throughout the 100 year simulation period. This is the area where tailing thicknesses are greatest. A high conductivity run of mine zone located between the clay core in the main dam and the tailing was found to provide a pathway for water flowing downward. The embankment zone overlies a six-inch thick clay liner at that location and an elevated seepage rate was predicted in that area.

Water Level Contour Plots

Water levels determined by MODFLOW were found to correlate very well with the predictions from the UUNSAT2 vertical profiles. The surface of the saturated tailing was found to remain more or less level as draindown progressed. As a result, water level contours are so widely spaced that plan view contour maps do not illustrate impoundment conditions as well as the vertical profiles. Figure 11 illustrates water pressure distribution within the impoundment along the A-A' profile at 10 years and 30 years after initiation of draindown. After 10 years saturated conditions exist just below the 7,250 ft main dam upstream buttress seepage outflow. After 30 years, water levels have dropped to about 7,210 ft. Water pressures in the tailing material above that level are for the most part in the –1 ft to –15 ft range (dark green), with only a small near surface portion showing pressures below –15 ft (blue). Figure 12 illustrates water pressures along the A-A' profile after 50 and 70 years. Saturated water levels within the tailing decline to about 7,175 ft 50 years after initiation of draindown, and to about 7,150 ft after 70 years. Differences in material properties are exhibited by heterogeneity in water pressures as tailing moisture content decreases. After 100 years, water levels within the impoundment have declined to 7,120 ft, about 70 feet above the clay liner.

Pressure distribution contour plots for section D-D' for 30 and 50 years after onset of draindown are presented in Appendix A. The pressure distribution indicate similar water level elevations as those reported for cross-section A-A'. Pressure contours indicate the effect of spatial variability in the material properties of the tailing materials.

Figure 13 illustrates MODFLOW water levels after one year of draindown, as an example of MODFLOW output. Also included in Figure 13 is the hydraulic head distribution computed by MODFLOW for year five of the draindown simulation. Subsequent time output showed uniform elevation drop across the impoundment, with level surface that did not exhibit significant slope.

5.0 Conclusions and recommendations

Conclusions

Current surface discharge from the impoundment is greater than predicted by previous studies. Values of saturated hydraulic conductivity estimated from CPT pore pressure dissipation tests were found to be too low to produce measured discharge rates from the main dam upstream buttress and the levee buttress in the unsaturated flow cross-section simulations. In order to calibrate to measured flow data, hydraulic conductivity values were increased slightly and a 10:1 horizontal to vertical anisotropy ratio was imposed on the three subaerial tailings zones observed to exhibit anisotropy.

Flow through the base of the impoundment was found to play a significant role in development of water levels for the entire simulation period. Basal through flow is the sole mechanism for draindown once water levels fall below the main dam upstream buttress after eight years and the levee buttress after 13 years. As indicated by the histograms of discharge into the collection system for the levee and the main dam, seepage into these structures is controlled by their elevation. In fact, seepage from the main dam collection ceases once the water level near the main impoundment falls below elevation 7,250 ft while seepage through the levee continues until the water level in its vicinity falls below elevation 7,234 ft. Seepage rates through the base decline over time and are still declining at the end of the simulation period at 100 years. Additional simulations to estimate seepage rates after 100 years, if necessary, should be conducted once that further field data become available. Typically, uncertainty in simulation results increases with length of the simulation period and decreases as a function of the data available for calibration.

A water balance analysis would make it possible to better determine the suitability of the hydraulic properties applied to the bedrock for the unsaturated simulations. The bedrock hydraulic conductivity was found to control liner seepage rates to a large extent. A concurrent record of daily meteorological conditions and an accounting of all water applied to and removed from the impoundment reservoir would make it possible to determine appropriate basal seepage values from a total water balance. For maximum accuracy, water level data over time within the tailings would also be required as a means of monitoring storage changes. Current data available to WMCI covers the period June 1998 to October 1998. Incomplete data and high variability in this short period makes the establishment of a longer period of record a prerequisite to a meaningful water budget analysis.

Recommendations

Continuous monitoring of discharge, pump back of water, and climatic conditions should be maintained so an accurate water balance analysis of the tailings impoundment can be conducted. The water balance method is an excellent means of confirming basal discharge rates obtained by other methods.

Since vertical flow into the bedrock is of paramount importance in the ultimate draindown of the impoundment, more information should be collected on the hydraulic properties of the bedrock.

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Figure 1 Site topography and location of cross-sections

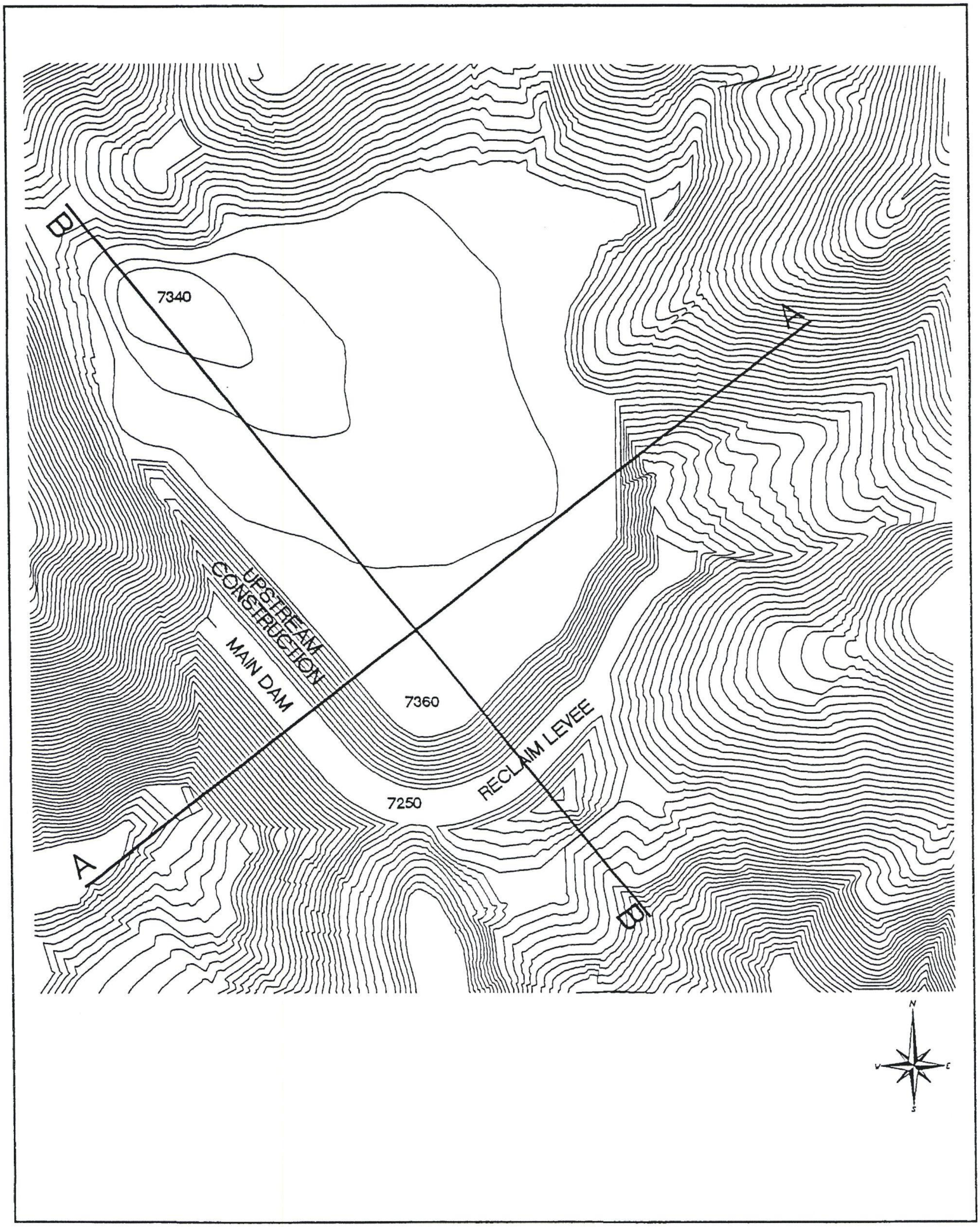

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Figure 2 Finite element grids developed for AA' and DD' profile simulations

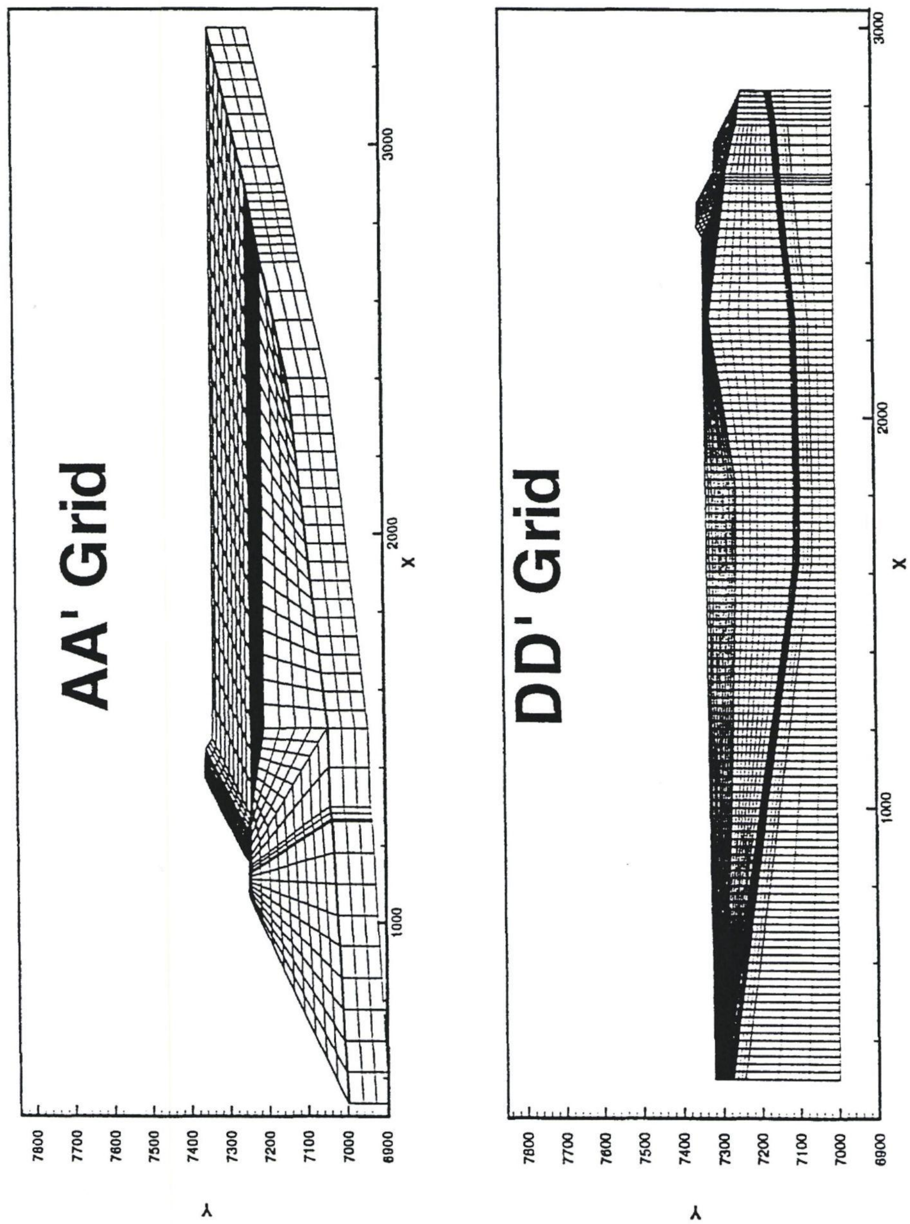

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Figure 3 Tailings impoundment pond water level elevations

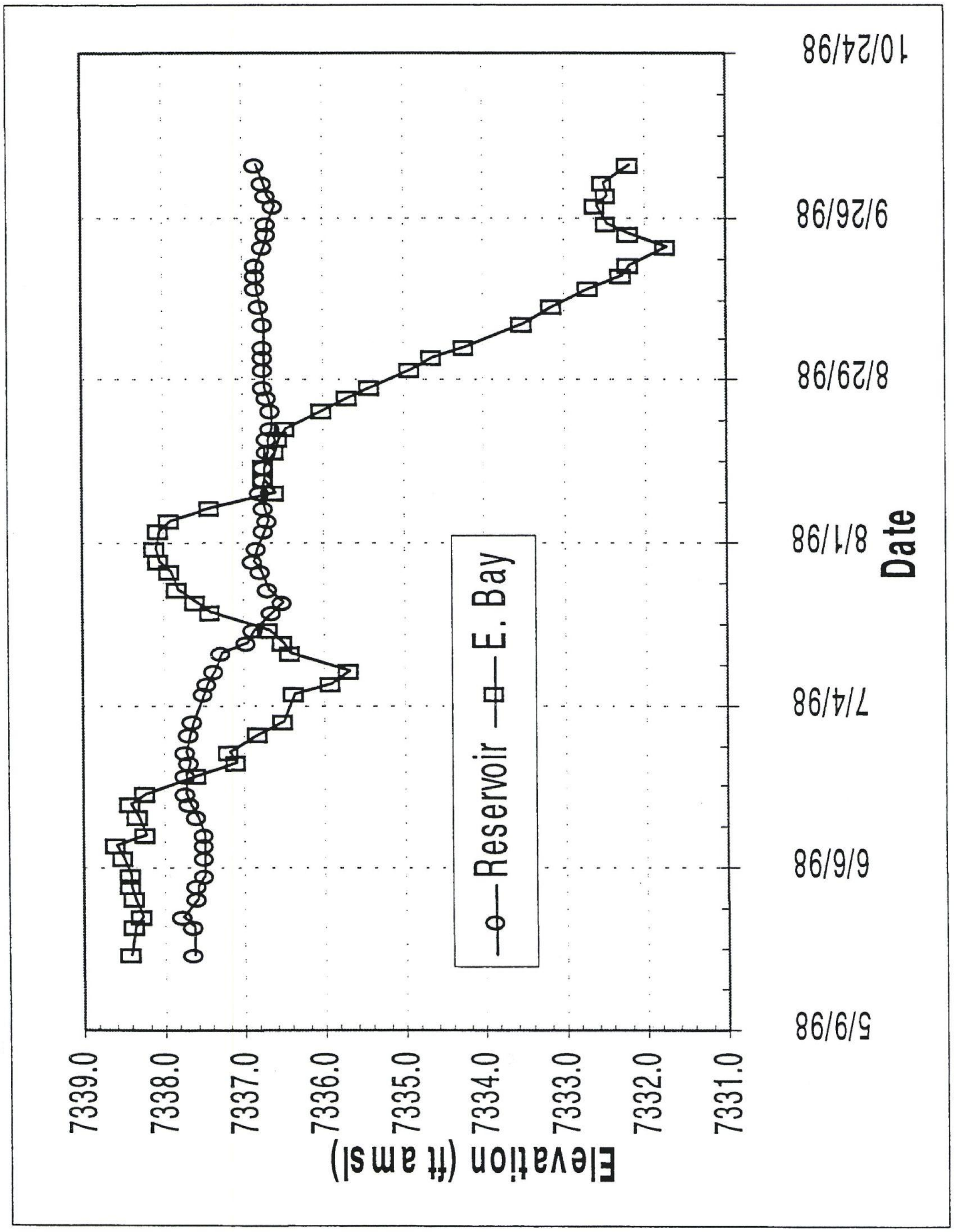

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Figure 4 Pump back rates from main dam and levee buttress collection system

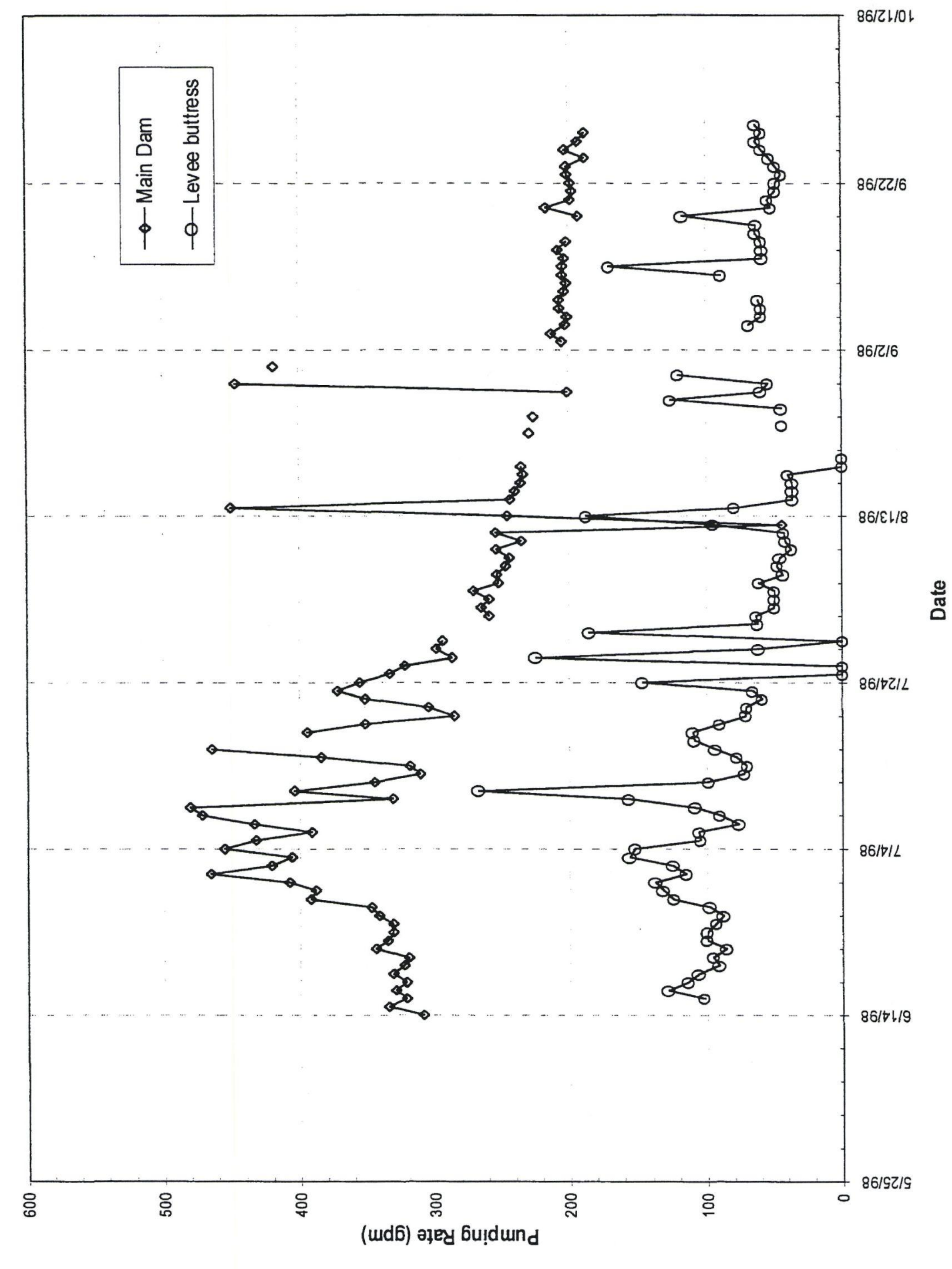

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Figure 5 Main dam and bottom outflow versus X-direction hydraulic conductivity anisotropy factor

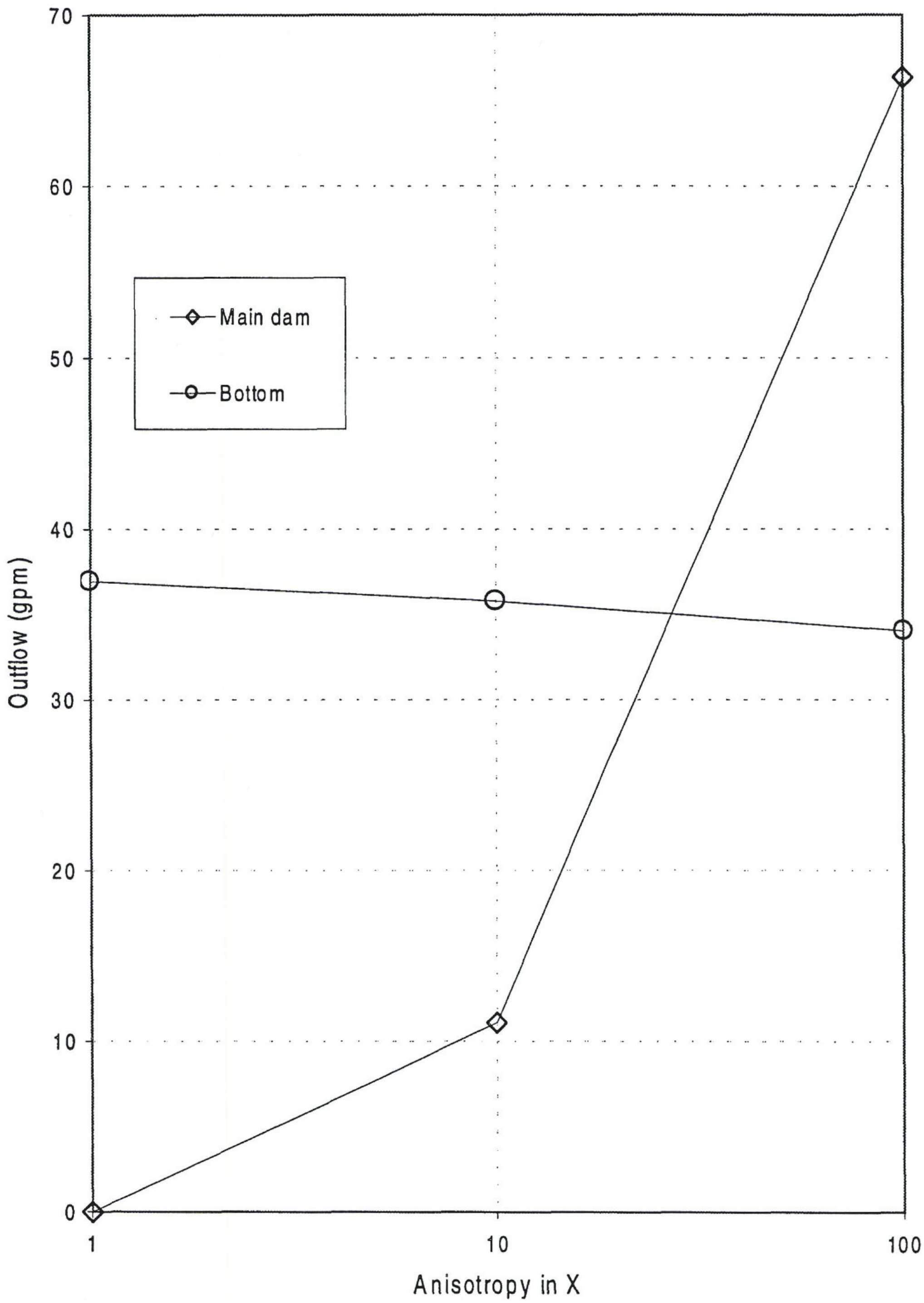

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Figure 6 Main dam and bottom outflow versus hydraulic conductivity factor (with 10:1 horizontal to

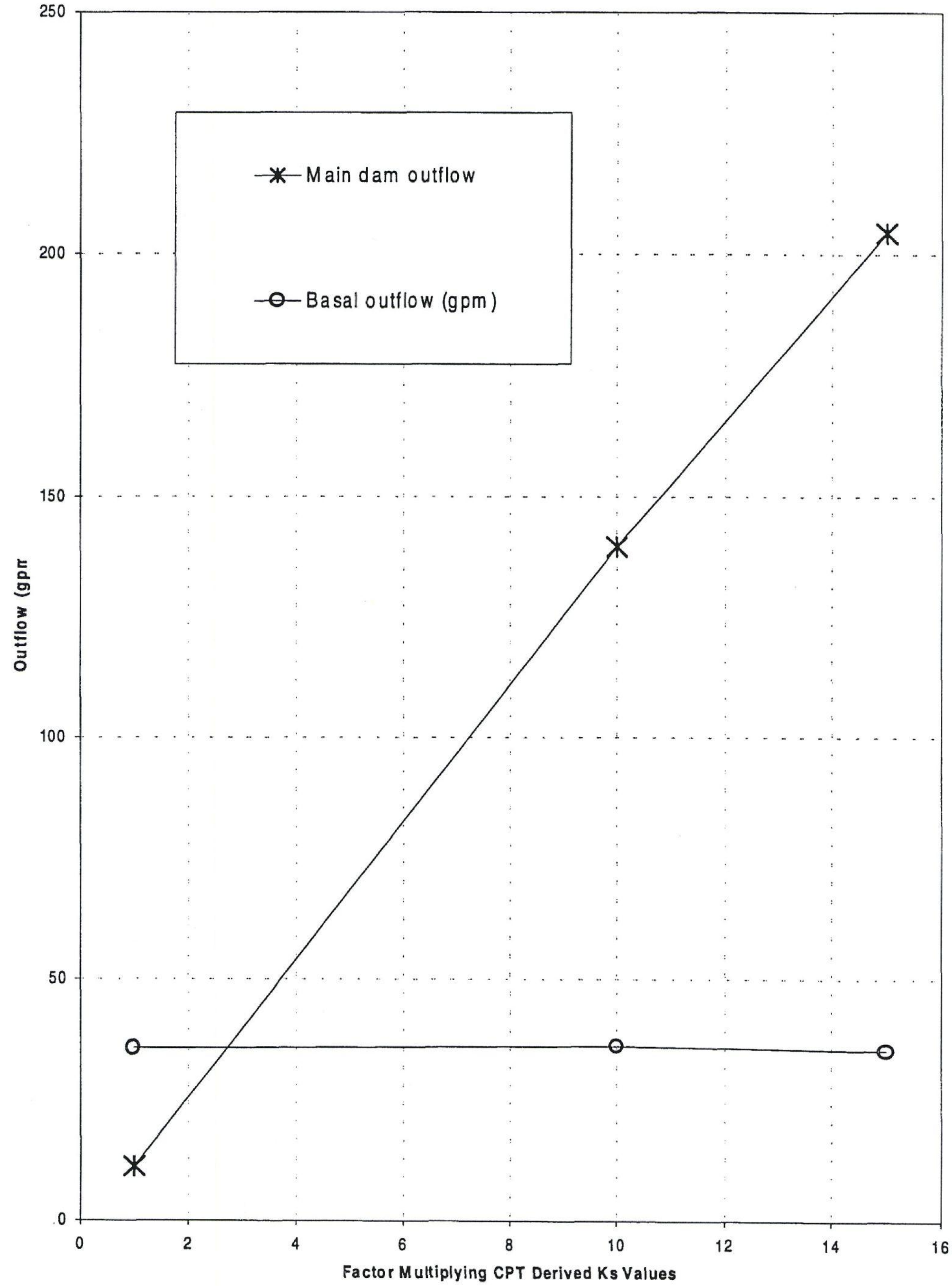

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Figure 7 Main dam seepage rates for UNSAT2 and MODFLOW during draindown

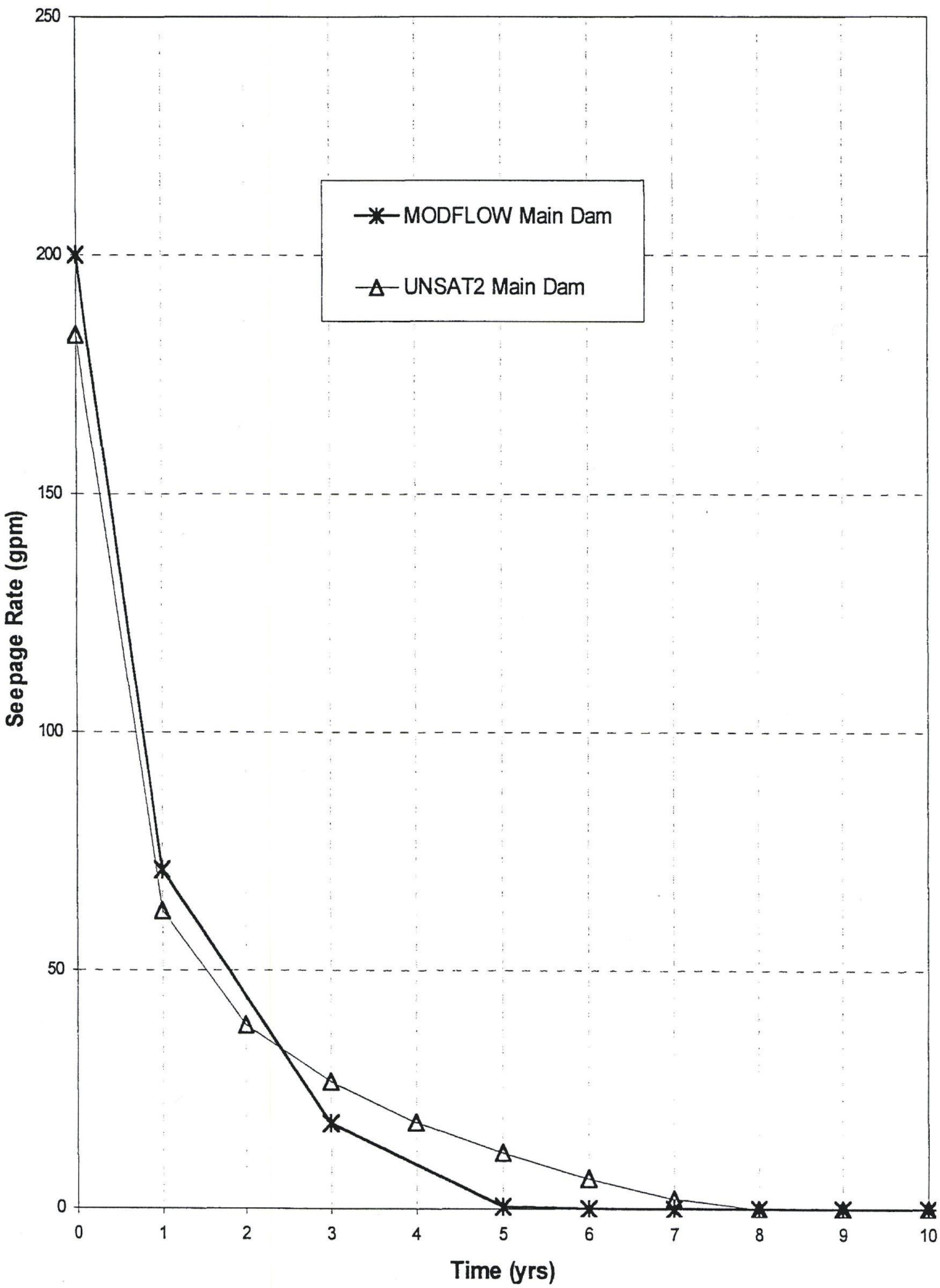

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Figure 8 Comparison of seepage at levee from Modflow and Unsat2

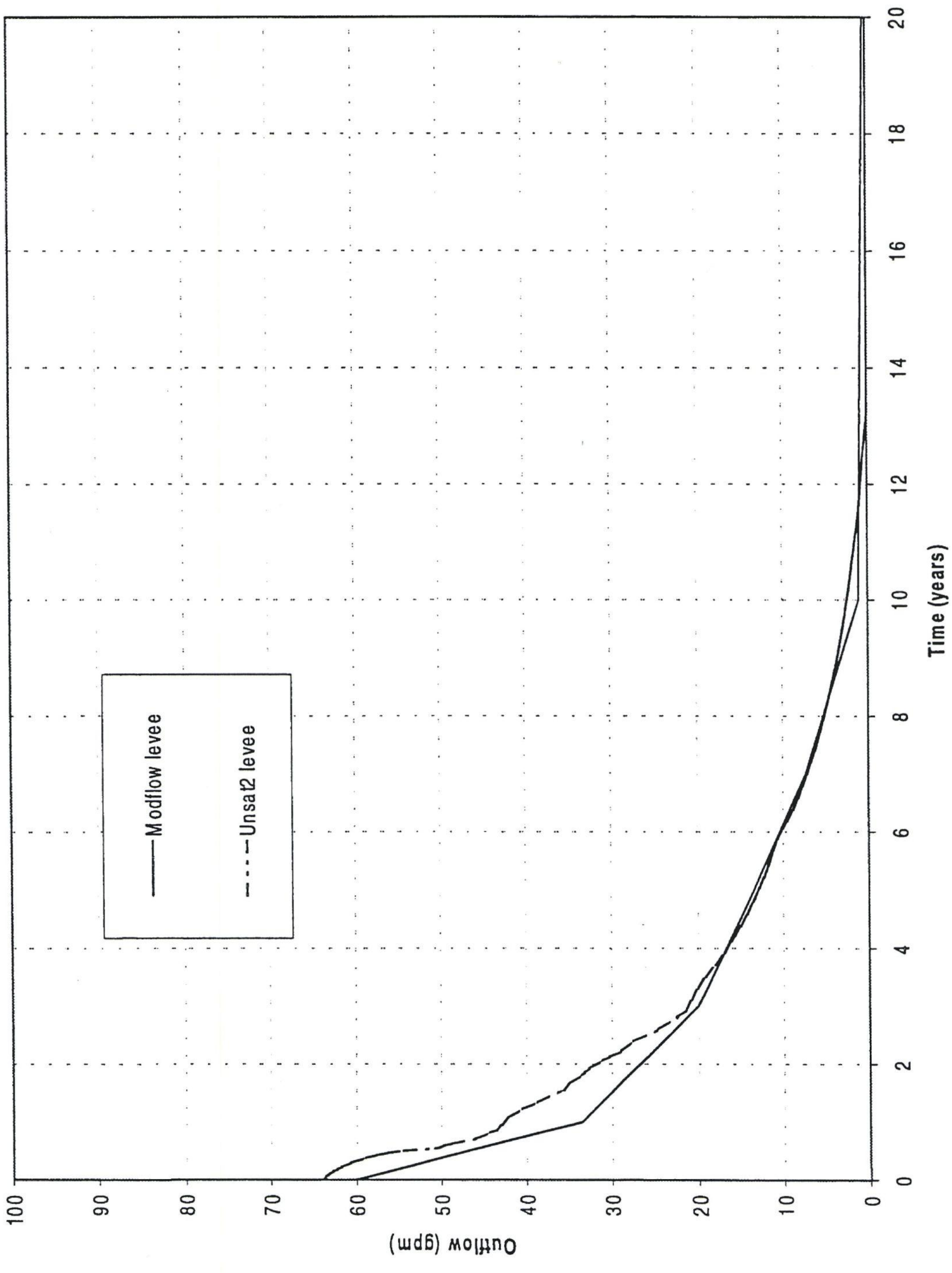

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Figure 9 Basal outflow rates

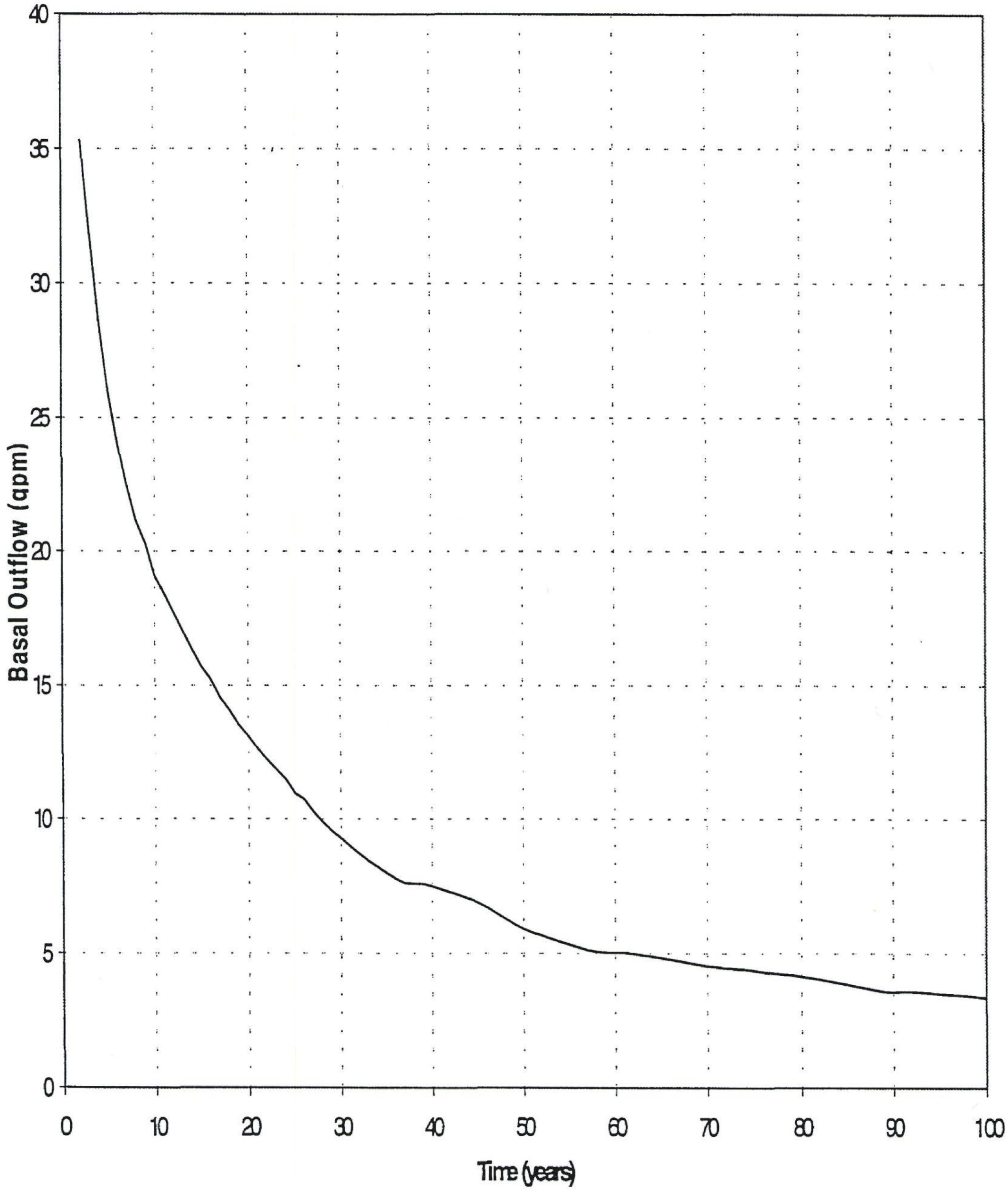

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Figure 10 Water pressures along A-A' and D-D' profiles at start of draindown

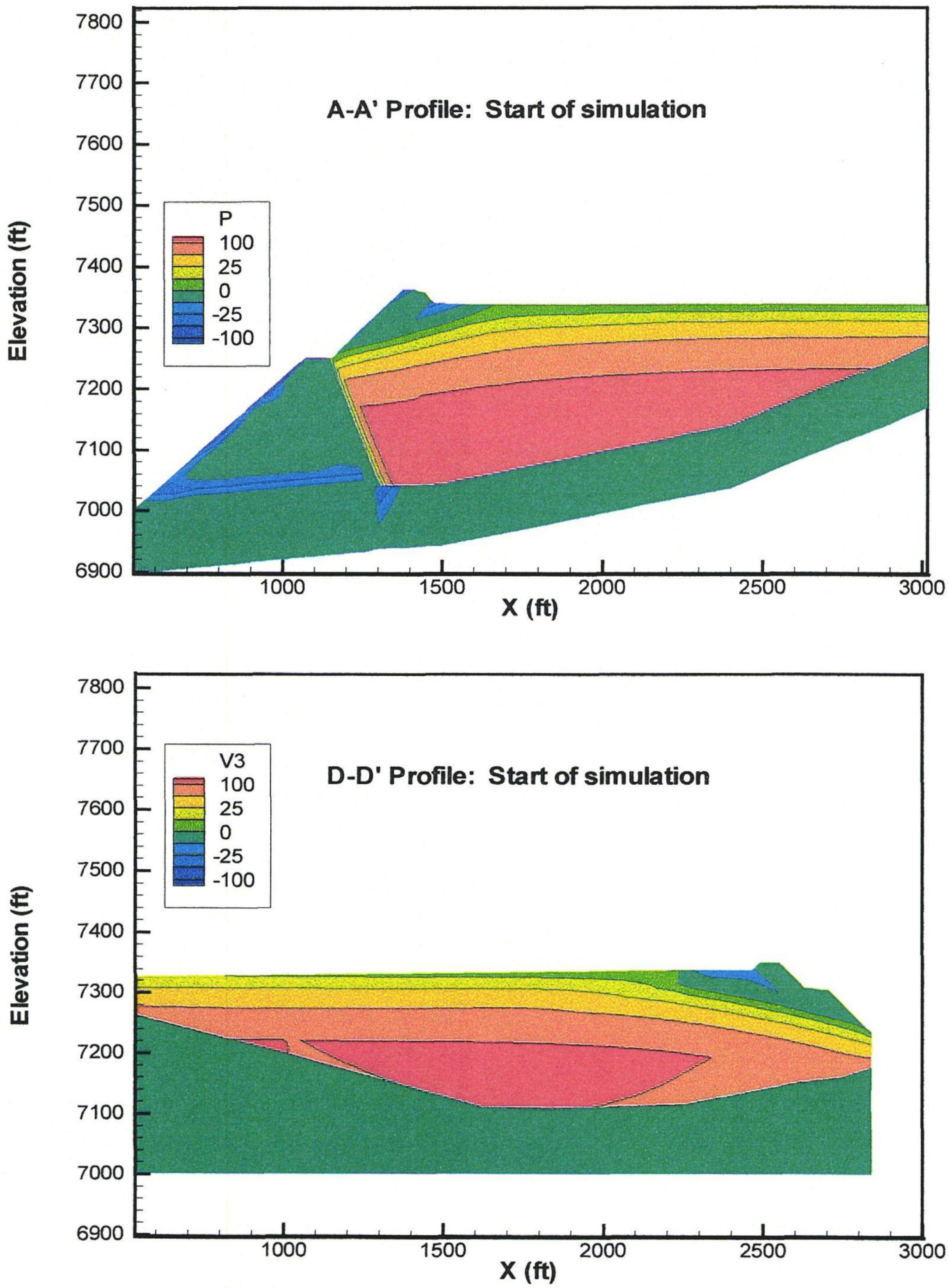

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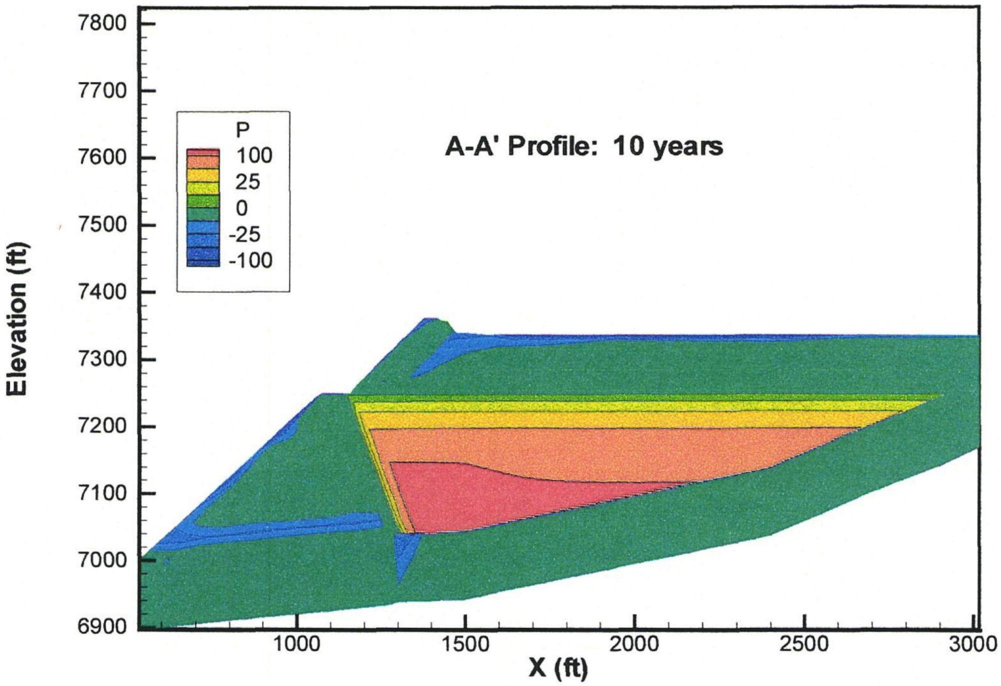
Figure 11 Water pressures along AA' profile after 10 and 30 years of draindown



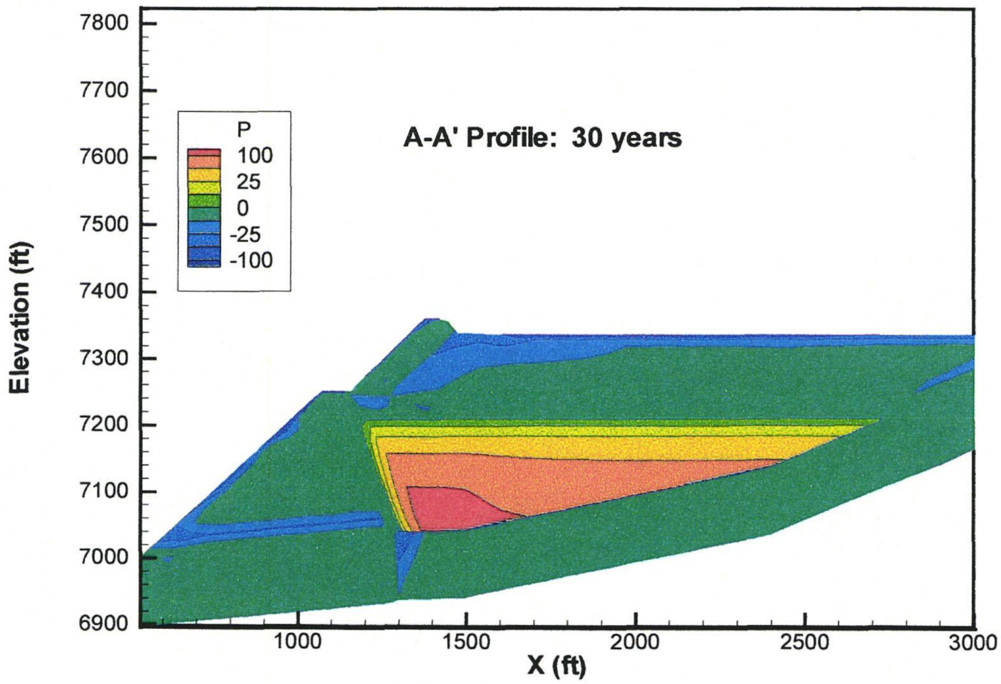


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Figure 12 Water pressures along AA' profile after 50 and 70 years of draindown

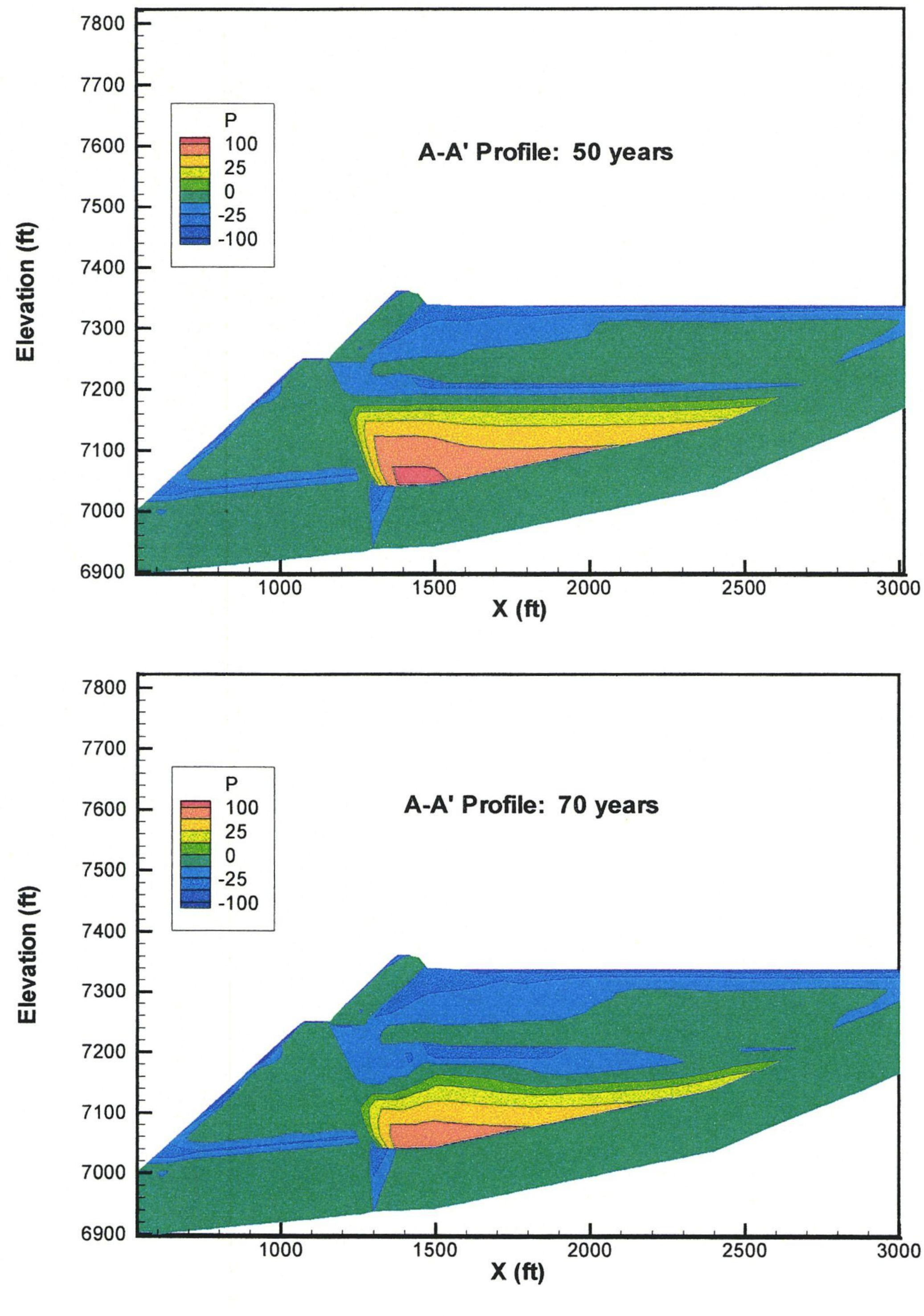

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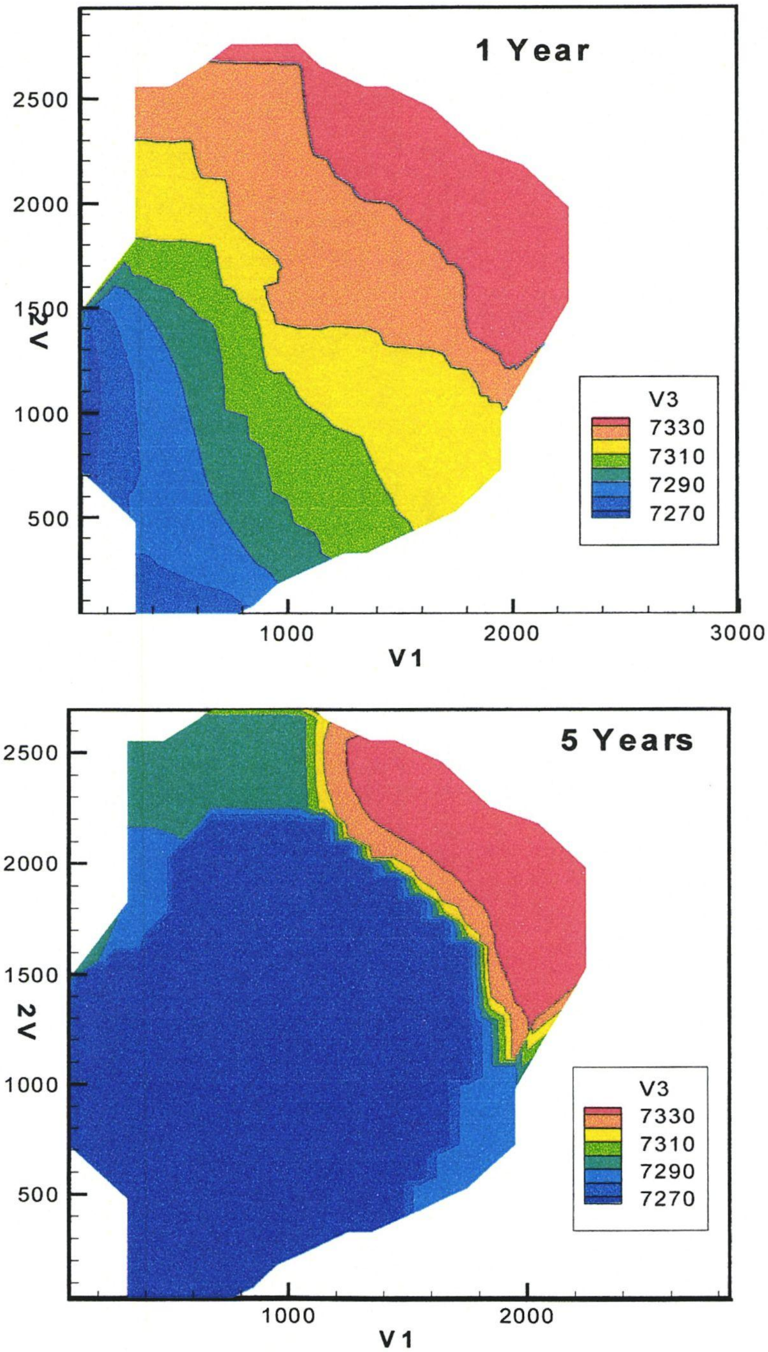
Figure 13 Water level after one and five years predicted by MODFLOW



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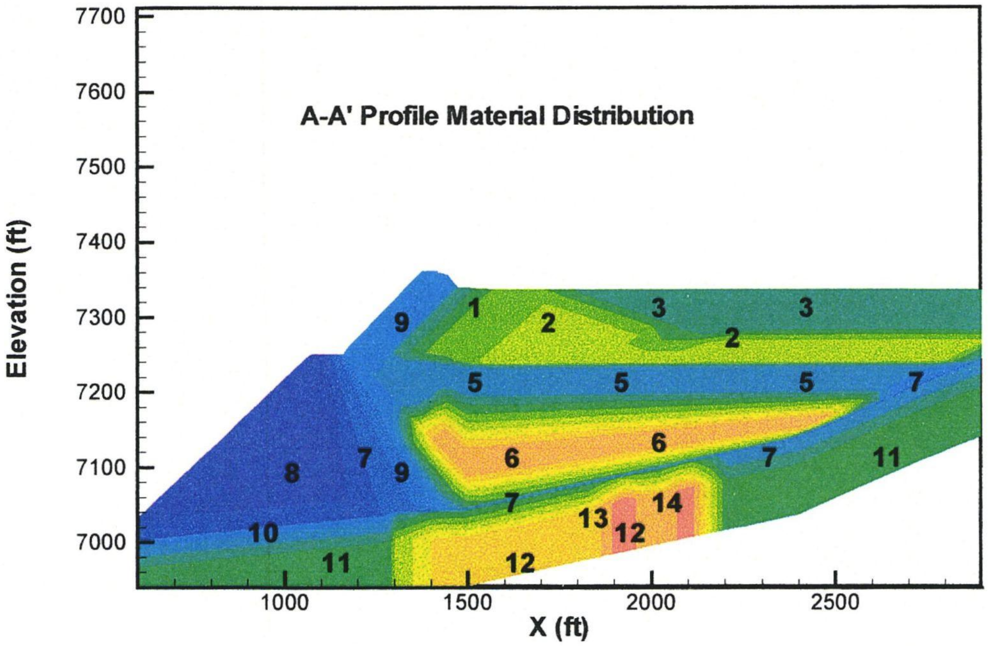
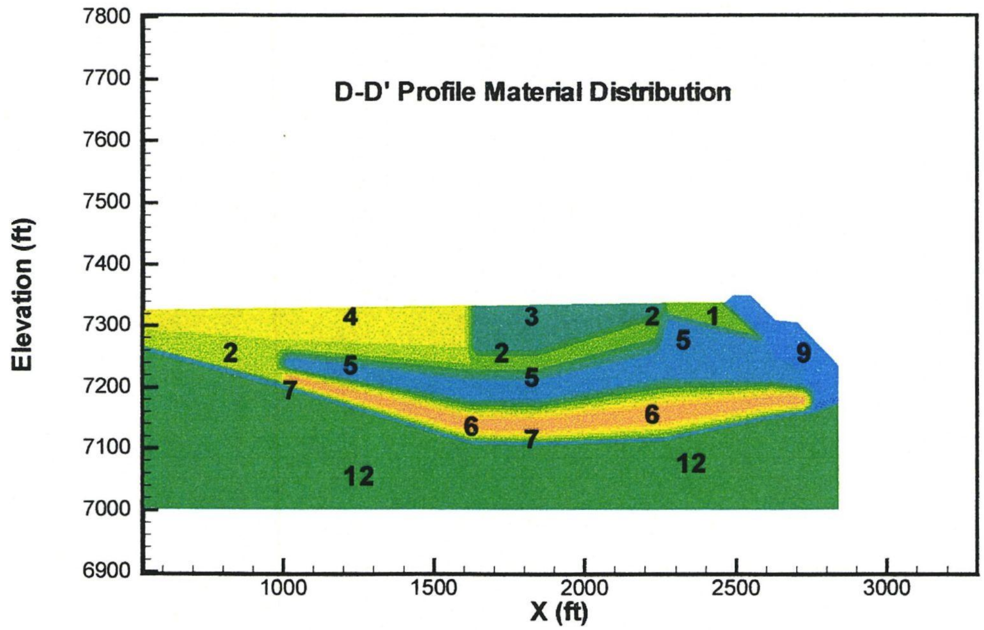
Material property distributions for sections AA' and DD'





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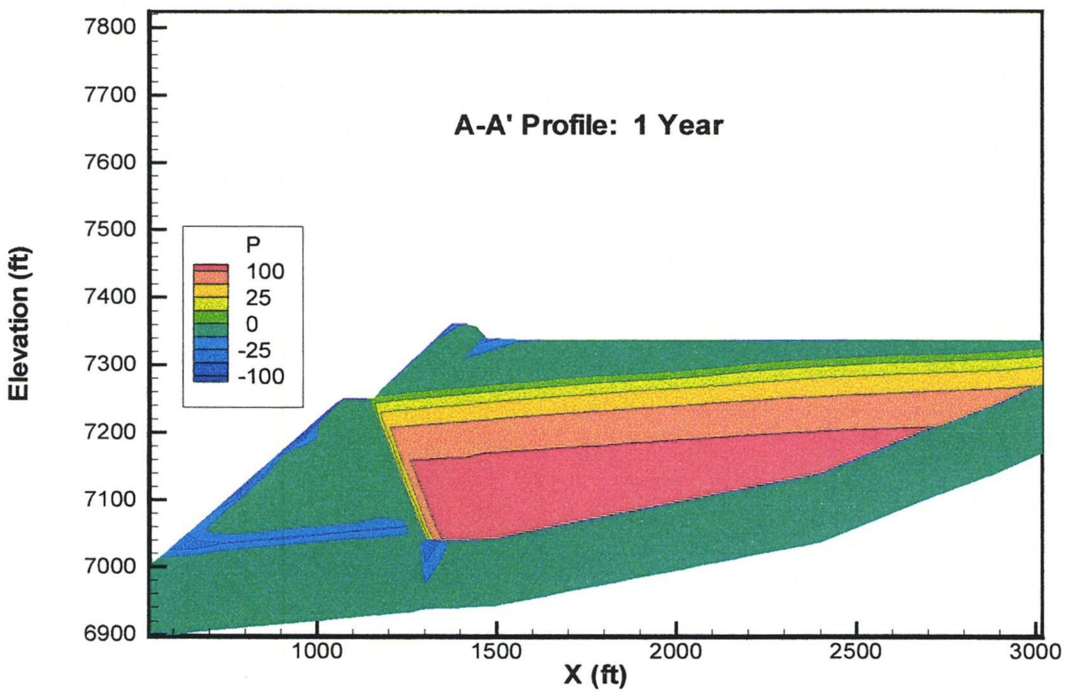
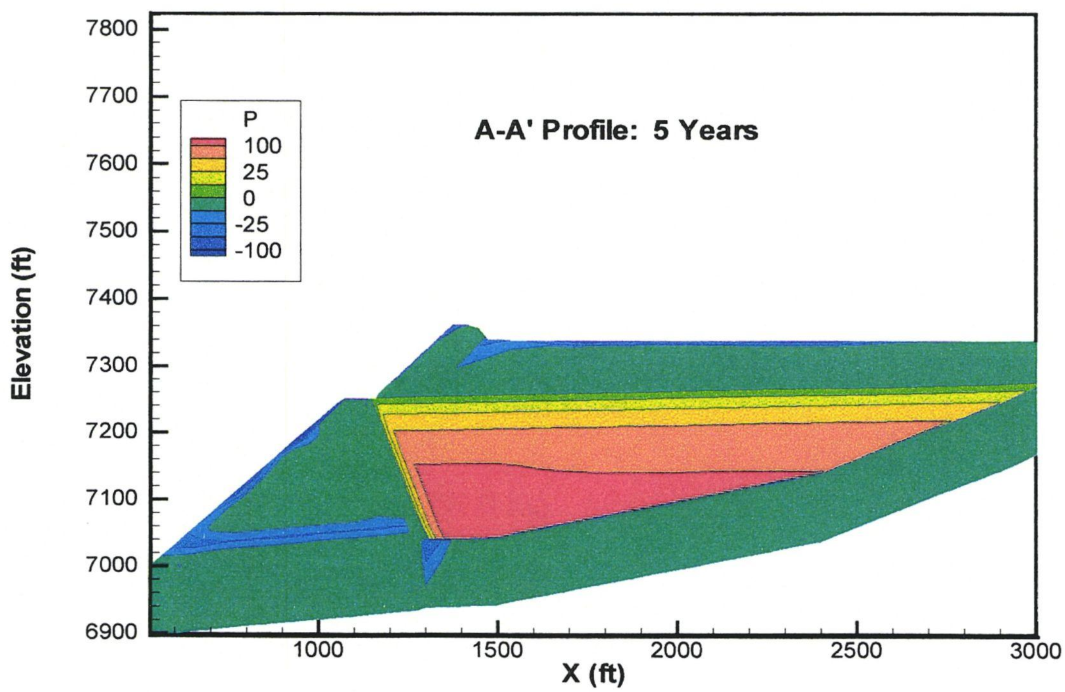
Water pressures after one and five years predicted by UNSAT2





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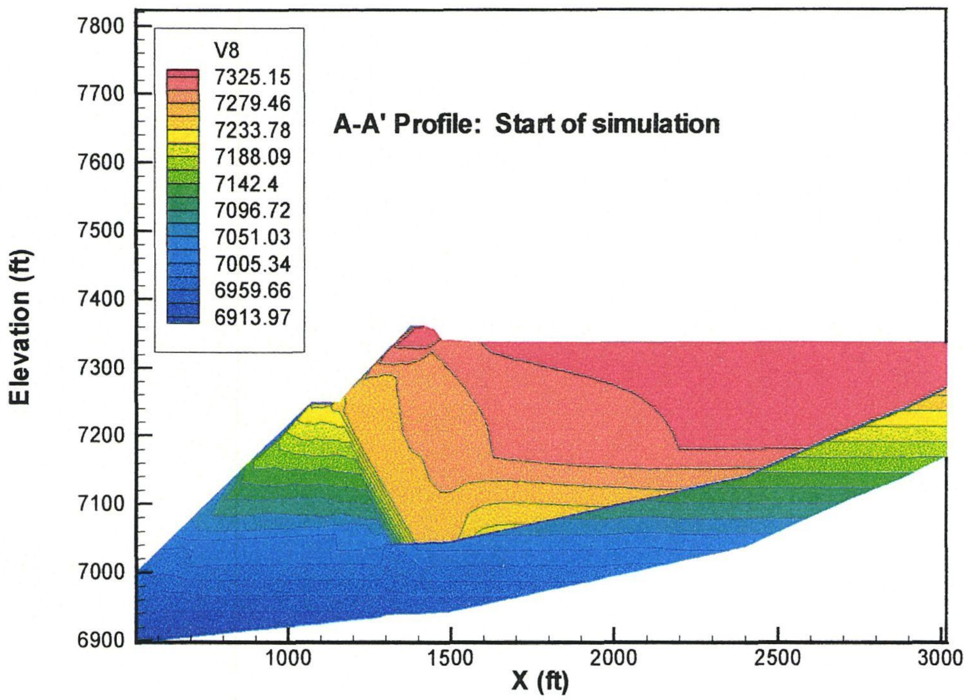
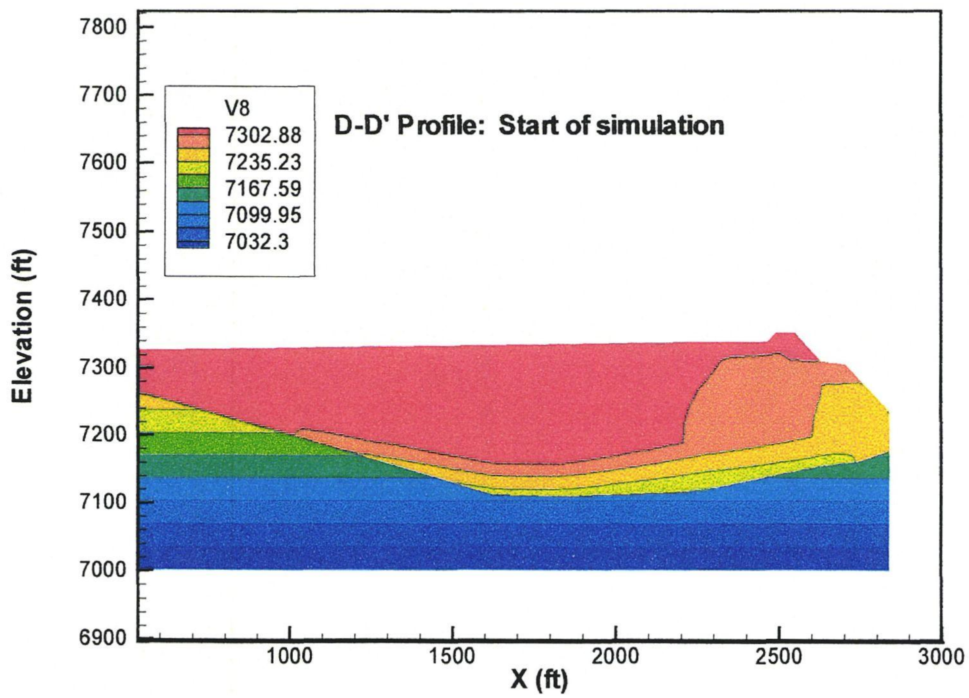
Total hydraulic head distribution at start of simulations





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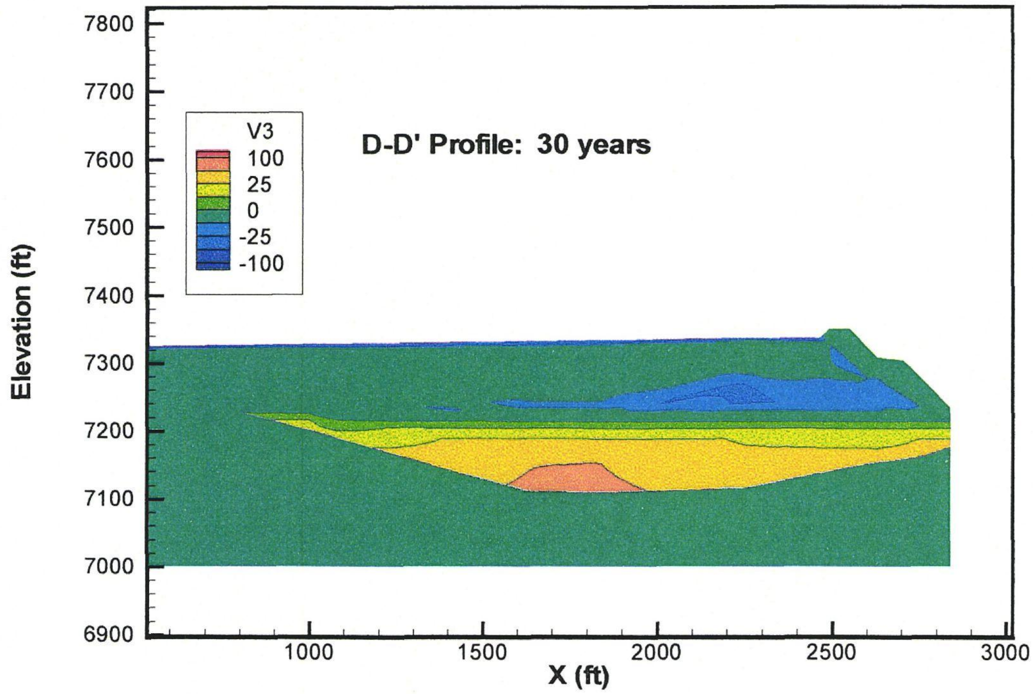
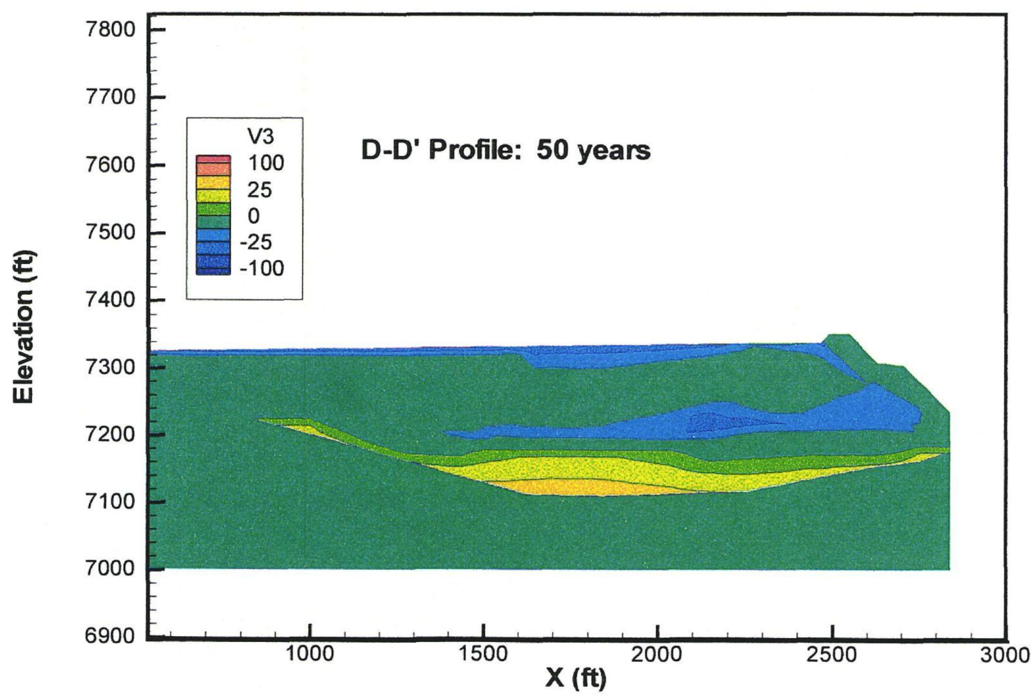
Profile DD' pressures after 30 and 50 years





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APPENDIX A

ADDITIONAL SIMULATION RESULTS

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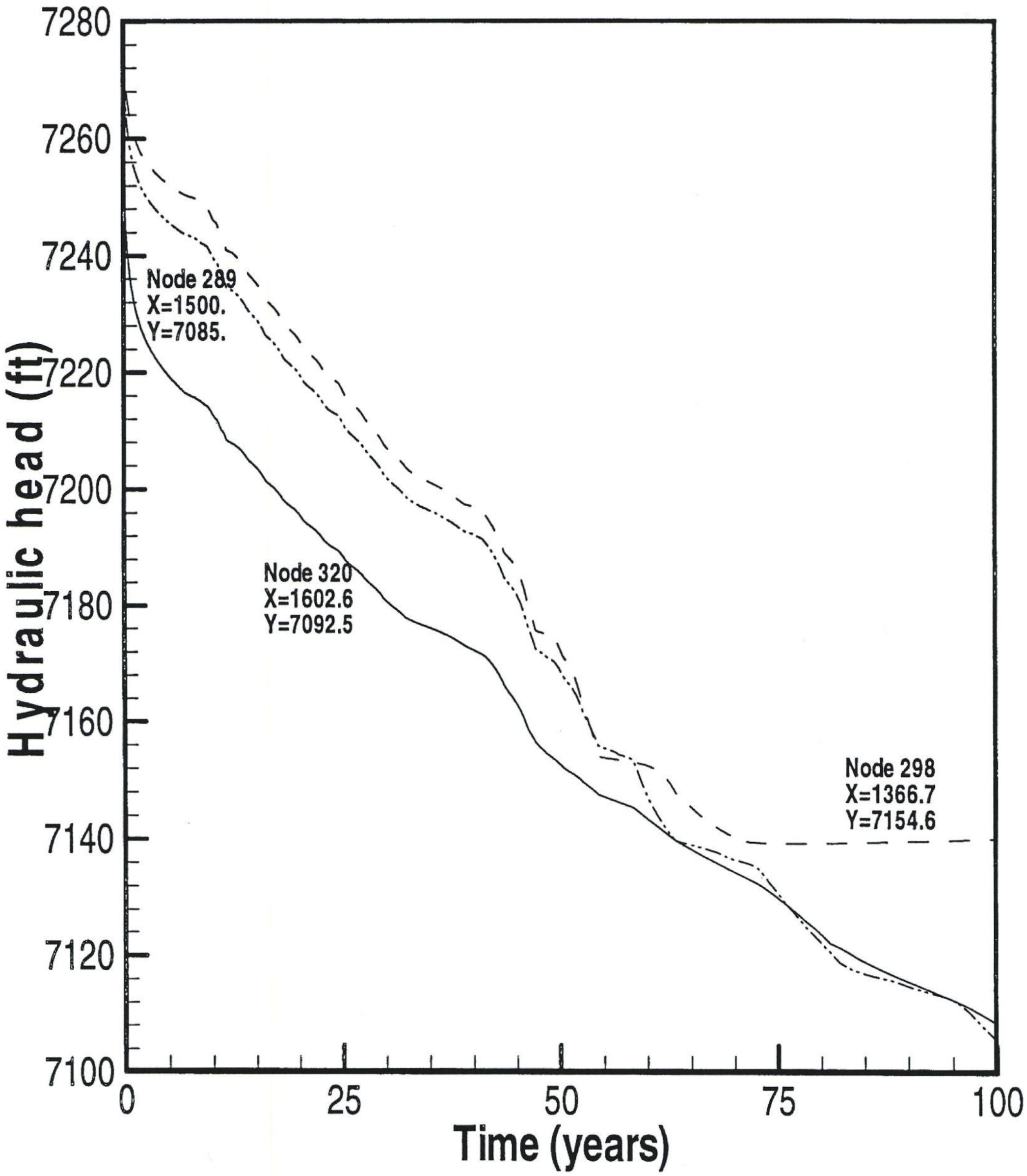
Hydraulic head versus time for three observation nodes in profile AA'



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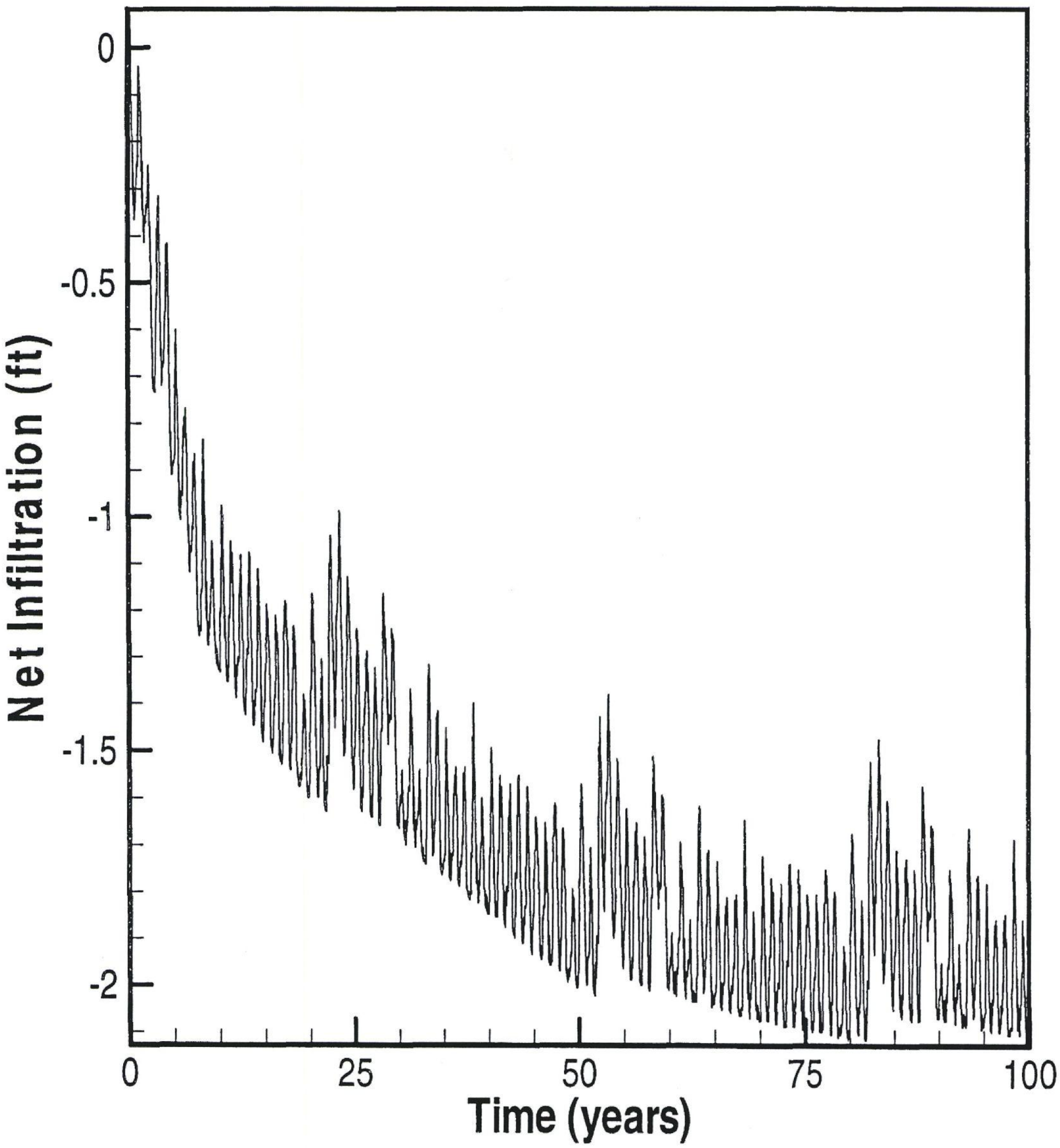
Cumulative net infiltration over 100 years



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APPENDIX F

CONSOLIDATION ANALYSES DOCUMENTATION

APPENDIX F-1

DR. ZNIDARCIC'S REPORT

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Settlement Analyses for Tailings Impoundment at Mercur Mine

by

Dobroslav Znidarcic

and

Daniel (Ta Chun) Yao

Prepared for:

Golder Associates Inc.
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December, 1998

Introduction

This report summarizes activities related to the settlement calculation for the tailings impoundment at Mercur Mine as requested by Golder Associates Inc. from Tucson, AZ. The scope of the work was defined in the letter from Golder Associates, dated August 9, 1998 (ref.: 983-2344.001-3). In addition to the interpreted field test results, we were provided with the results of the laboratory tests performed at the Golder laboratory and a slurry sample on which a seepage induced consolidation test was performed at the University of Colorado laboratory. We were also provided with a detailed map of the tailings impoundment with several cross sections on which differentiable stratigraphic units were identified for the purpose of the settlement analysis. The interpreted results of the CPT probes were also received with the interpreted pore pressure profiles currently existing at the site of each probe.

All this information was considered and utilized in the settlement calculations described in this report.

The references cited in this report are included in the appendix for the convenience of the reader.

Material characteristics

A sample of the tailings from the depth of 20'-22' from the borehole GA98 BH-4 was remolded at an initial void ratio of 4.51. Preliminary tests have shown that this void ratio corresponds to the zero effective stress, or the soil formation void ratio for the material. The slurry sample was then tested in the seepage induced consolidation device and the consolidation material characteristics were obtained. Table 1 presents the analysis results for the seepage induced consolidation test in SI units, while Table 2 presents the consolidation model parameters A, B, Z, C and D in both SI and lb-ft-day units. The parameters define the void ratio - effective stress and void ratio - hydraulic conductivity relationships by following expressions (Liu and Znidarcic, 1991)

$$e = A(\sigma' + Z)^{B}$$

$$k = C\,e^{D}$$

Figures 1 and 2 present the consolidation characteristics for the sample in SI and lb-ft-day units respectively.

The seepage induced consolidation test and analysis are described in the paper by Abu-Hejleh and Znidarcic (1996) which is attached in the Appendix.

Upon reviewing all available data, it was concluded that the material characteristics obtained for the BH-4 sample are representative for the stratigraphic unit identified as "unconsolidated slimes" and should be used for calculating settlement at CPT locations 1, 3, 4 and 8. Similarly, it was concluded that the rest of the material in the impoundment should be modeled as two materials with non-linear compressibility characteristics. These characteristics were selected based on the conventional consolidation test results performed at the Golder lab and on the field data that provided information on density and pore pressure profiles. The two materials, identified as type A and B, where used to calculate settlements at CPT locations 2, 6, 9, 12 (type A) and 7, 10, 11 (type B). The sample BH-4, 20'-22', was identified as type C material. The compressibility model parameters for all three types are summarized in Table 3, and the compressibility curves are presented in Figure 3. Figure 3 demonstrates how materials A and B are much stiffer than material C, representing coarser tailings but how all three materials approach a similar void ratio at high effective stresses.

Table 1 Results of the SICT Analysis for Sample GA98 BH4, 20'-22'

```
----------------------------------------------------------
          Seepage Induced Consolidation Results :
  Unit Weight of Water                 =          9.81000 kN/m^3
  Unit Weight of Solids                =         26.78130 kN/m^3

  Initial Height of the Sample         =           .05172 m
  Void Ratio at zero effective stress =          4.51000
  Top Effective Stress                 =           .10000 kPa
  Darcian   Velocity                   =        .42550E-06 m/s
  Final Height of the Sample           =           .03540 m
  Final Bottom Effective Stress        =           .95940 kPa
----------------------------------------------------------
         Step Loading Test Results :
  Void Ratio                           =           .89530
  Effective Stress                     =        203.81000 kPa
  Permeability Coefficient             =        .58698E-08 m/s
--------------------------------------------------------
        THE OUTPUT RESULTS ARE LISTED AS FOLLOWS :
-------------------------------------------------------

              PARAMETER ESTIMATION RESULTS

       Parameter A                   =        2.37519

       Parameter B                   =        -.18349

       Parameter Z                   =          .03036 kPa

       Parameter C                   =     .83719E-08 m/s

       Parameter D                   =        3.21039

       Number of Iterations          =     6

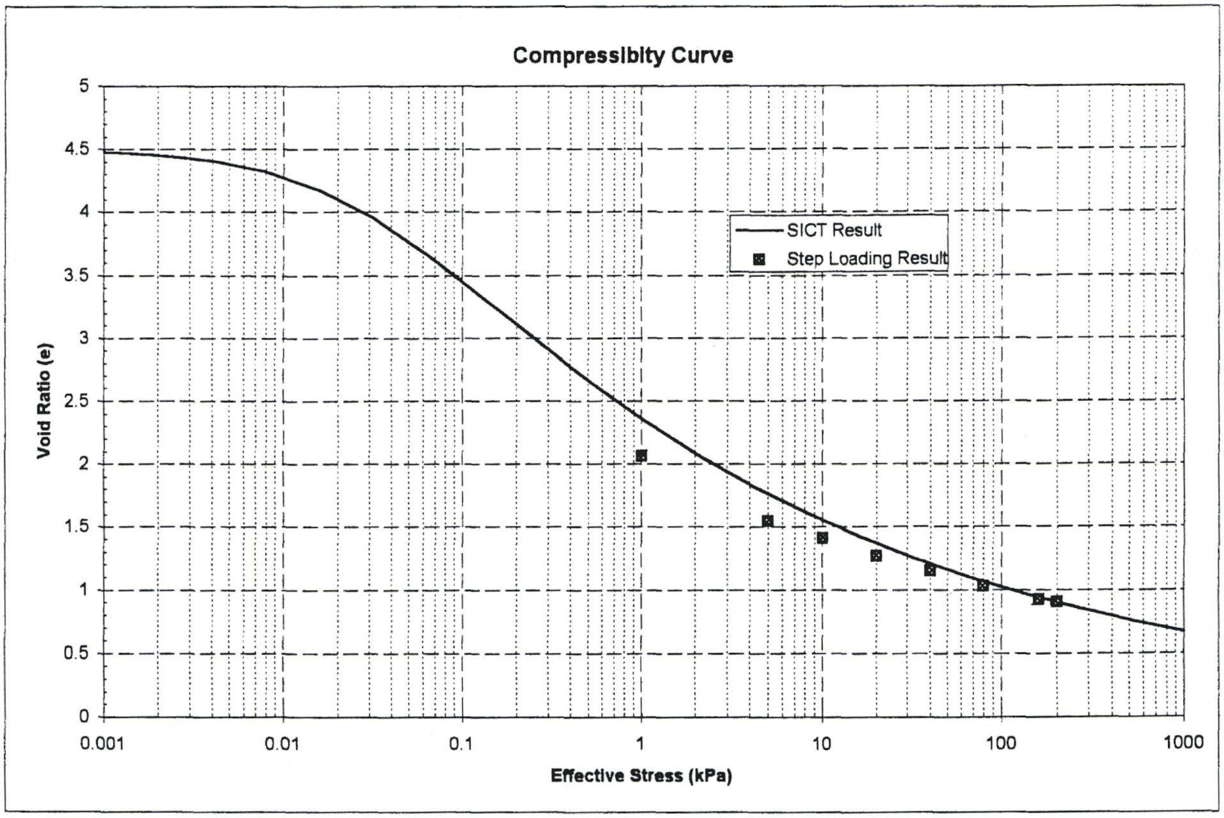
       Total Normalized Difference   =      .45803E-05

-------------------------------------------------------
```

Table 2 Consolidation Parameters for Sample GA98 BH4, 20'-22'

Parameter	A	B	Z	C	D
Value SI Units	2.38	-0.183	0.0304	$8.37*10^{-9}$	3.21
Value lb-ft-day Units	4.15	-0.183	0.634	$2.37*10^{-3}$	3.21

A= 2.3752 B= -0.18349 Z= 0.03037 kPa



Barrick Gold Mine, 20'-22', Light Brown

C= 8.3689E-09 m/s D= 3.20715

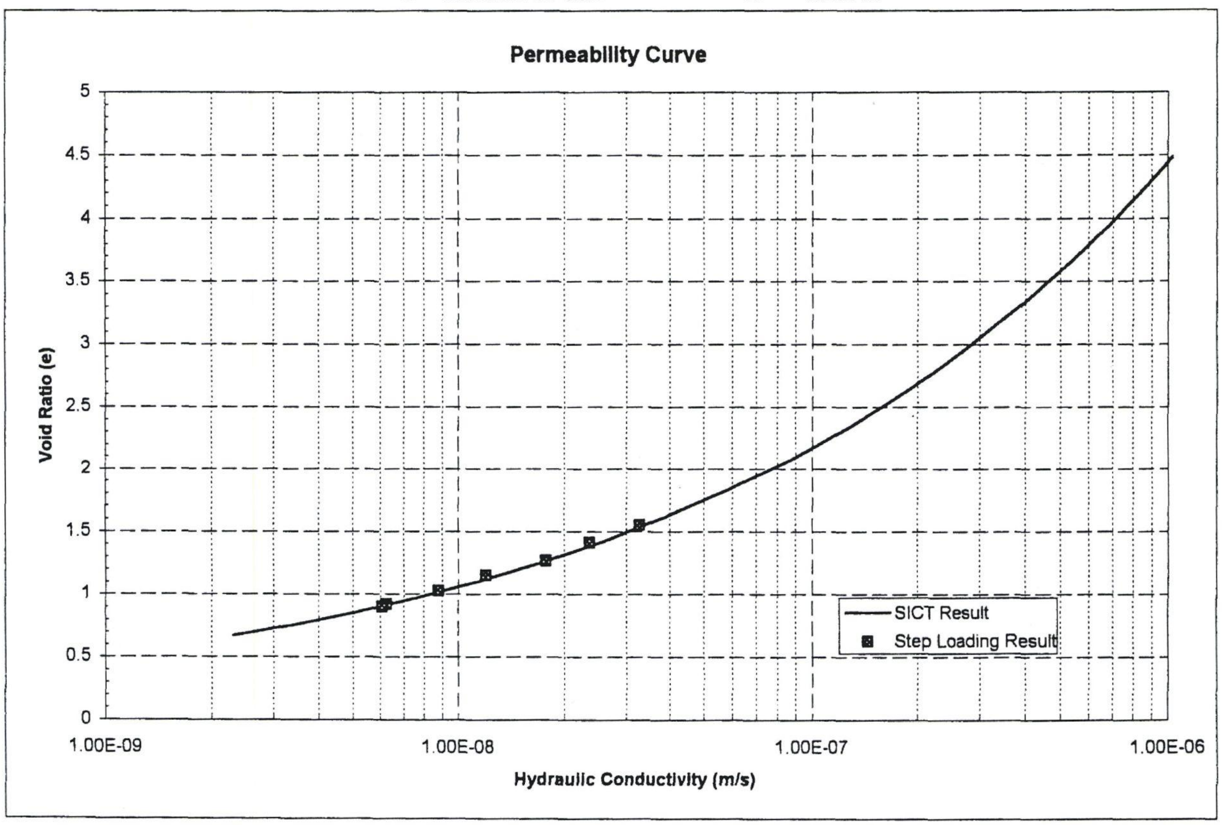
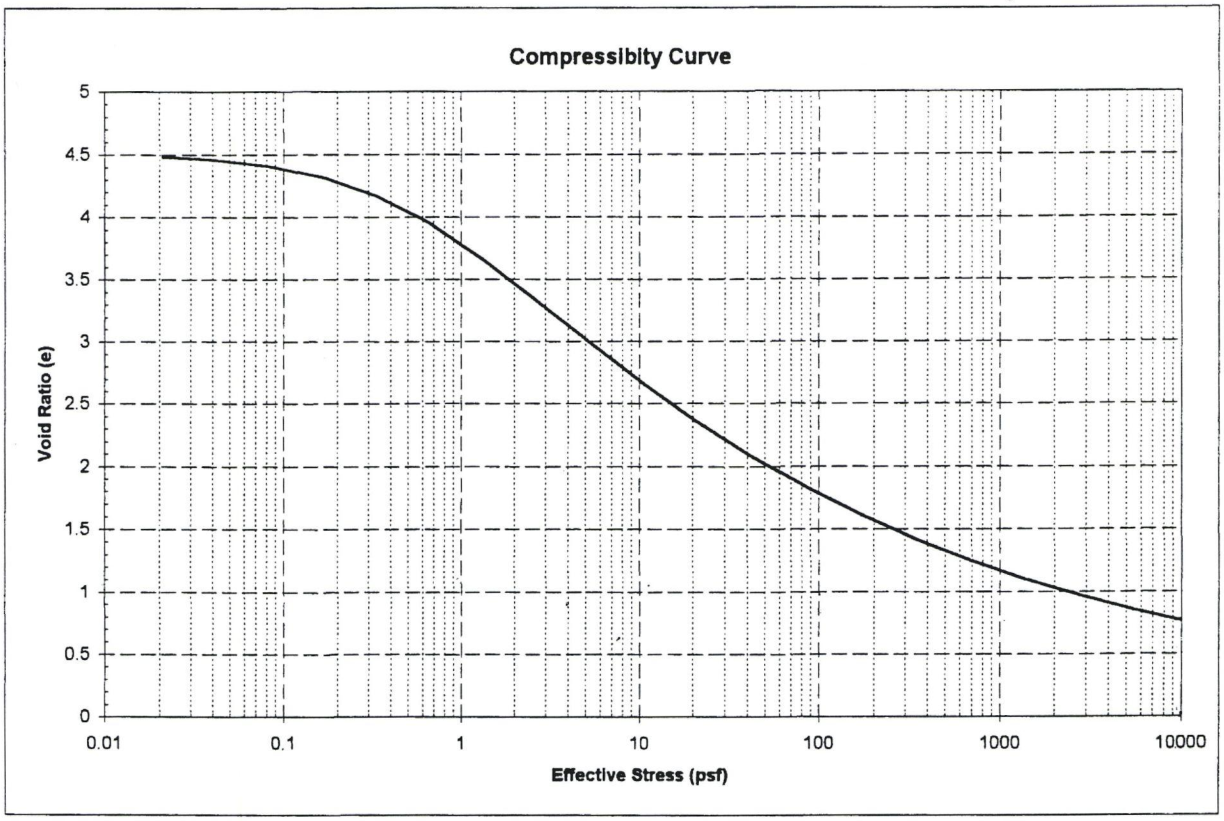


Figure 1 Consolidation Characteristics for Sample GA98 BH4, 20'-22' (SI units)

A= 4.1483 B= -0.18349 Z= 0.63407 psf



Barrick Gold Mine, 20'-22', Light Brown
C= 2.3731E-03 ft/day D= 3.21039

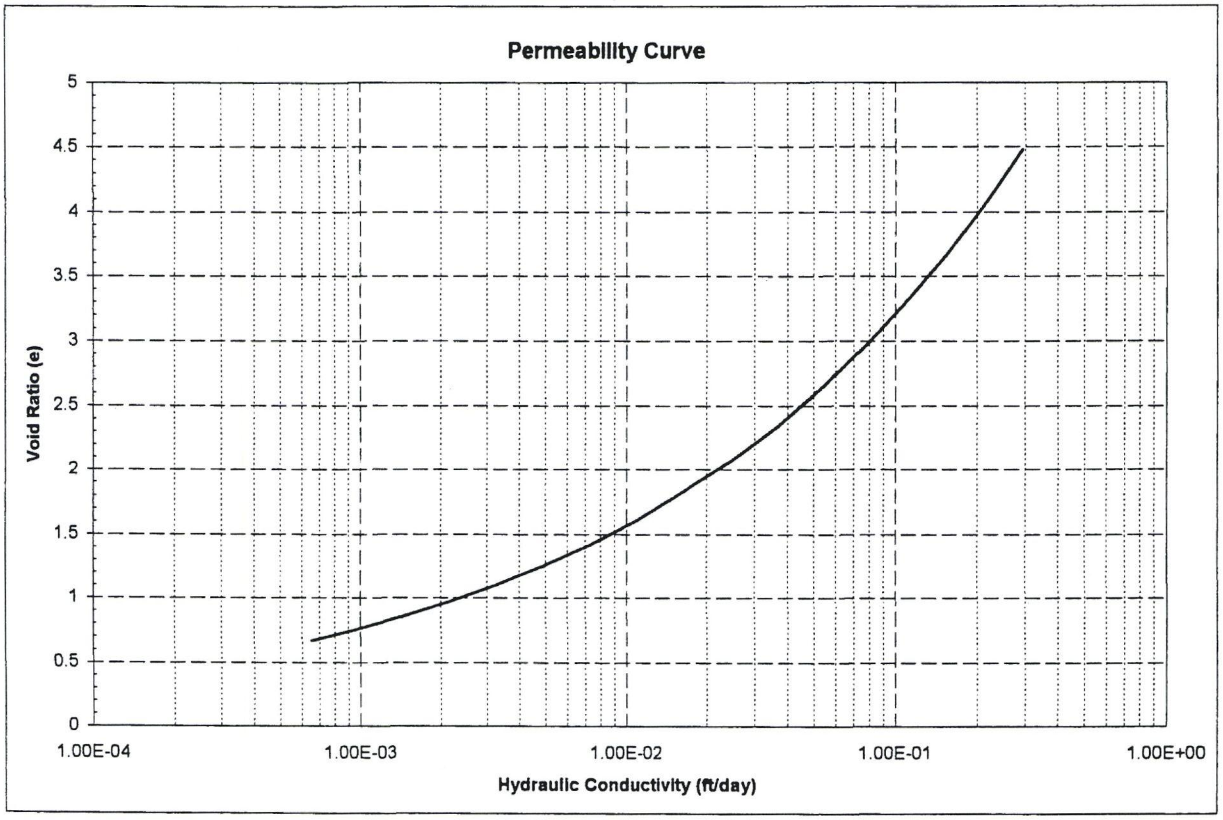


Figure 2 Consolidation Characteristics for Sample GA98 BH4, 20'-22' (lb-ft-day units)

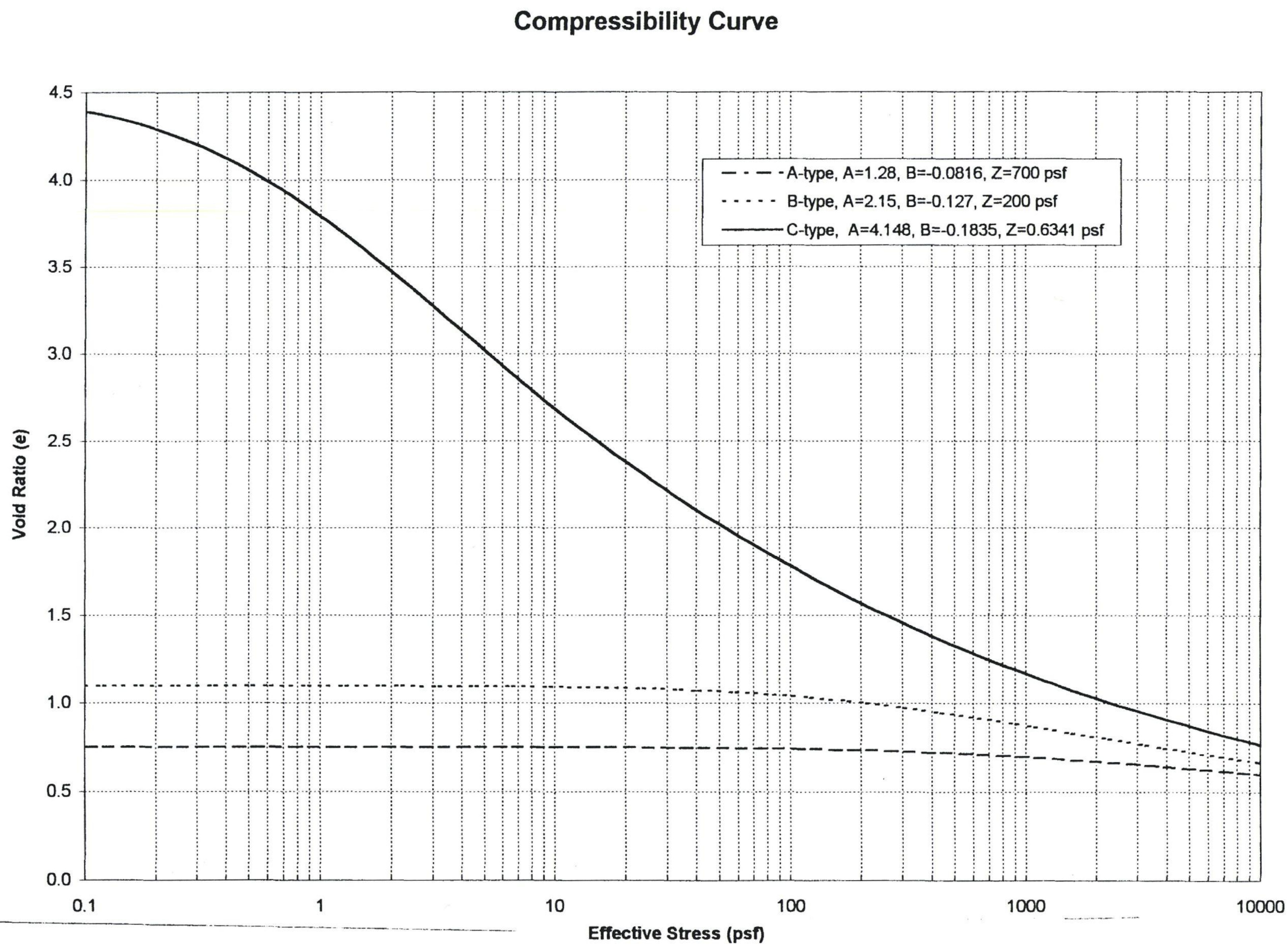


Figure 3 Compressibility Characteristics for type A, B and C material (lb-ft-day units)

Preliminary consolidation and desiccation analysis

Using the material consolidation characteristics obtained in the seepage induced consolidation test, the filling history for the CPT 4 location was modeled using the computer program CONDES (Yao and Znidarcic, 1997). The filling history modeling was followed by the self-weight consolidation and desiccation analyses. The results are presented in Figures 4 and 5. Figure 4 summarizes the height data for various scenarios. The instantaneous filling results are shown just as a benchmark case as if the total amount of the tailings at the location were deposited in an instant. The gradual filling rate is assumed to be constant over the period of 9 years, the time over which the thickness of tailings at CPT-4 location was deposited, based on the historical data provided. The effective evaporation rate of 3.3 ft/year was selected from the climatic data provided to us. Figure 5 presents the void ratio profiles for the three cases at the indicated times.

The consolidation and desiccation theories implemented into the computer program CONDES are described in the papers by Abu-Hejleh and Znidarcic (1995 and 1996). One of the essential features of the desiccation process is the creation of the desiccated crust at the tailing surface. Once the crust is formed, further evaporation is inhibited and the beneficial effect of the desiccation process is lost. The thickness of the crust and the rate of its creation depend on the relative magnitudes of the hydraulic conductivity of the slimes and the evaporation rate. For the given slime properties higher evaporation rates will create thinner crust sooner while lower evaporation rates will result in thicker crust created over a longer period of time. Thus, higher evaporation rate will be more critical in the sense that the desiccation effects will be less beneficial for slime management. For this reason, in the analysis the highest effective evaporation rate of 3.3 ft per year, representing the climatic conditions during the summer months, was assumed. It should be also noted that the effective evaporation rate is somewhat lower than the maximum evaporation rate at a site and is not at all affected by the precipitation rates. During the rainy periods there is no evaporation, but the moisture doesn't penetrate significantly into the soil, since the volume change of the soil during swelling is much smaller that during initial compression.

Several conclusions regarding the material behavior can be derived from the presented results. First, the material consolidates readily in a relatively short period of time and only a small additional settlement should be expected at the location in the absence of any external factors that will change the current condition in which the location is submerged. Second, the external factors such as loading or desiccation will affect mostly the upper 20-ft of the deposit and most of the settlement will be a consequence of the compression of this upper layer. Third, the evaporation effects at the assumed rate will produce a relatively uniform upper layer without creating a thin crust at the site.

These conclusions are supported by the field observations in which the upper 20-ft of the deposit was found to be in such a soft state that the sampling method used prevented the collection of undisturbed samples for the void ratio determination. The measured pore pressures were also consistent with the conclusion that the self-weight consolidation is almost completed.

Based on these findings we have concluded that the material consolidation is not a major issue at the site, and that the settlement analysis will be sufficient to characterize the behavior of the impoundment during and after the closure. Therefore the subsequent analyses will focus only on the settlement calculations, while an implicit assumption is made that the full consolidation will take place during any construction activity or shortly thereafter. This assumption is further justified by realizing that the preliminary analysis was performed for the type C material that clearly has the least favorable consolidation characteristics. For any other location in the impoundment, the consolidation will be even faster than demonstrated for the location CPT 4.

It should also be noted that a more detailed consolidation analysis for the impoundment is possible, but for it to be justified additional data will be necessary. These

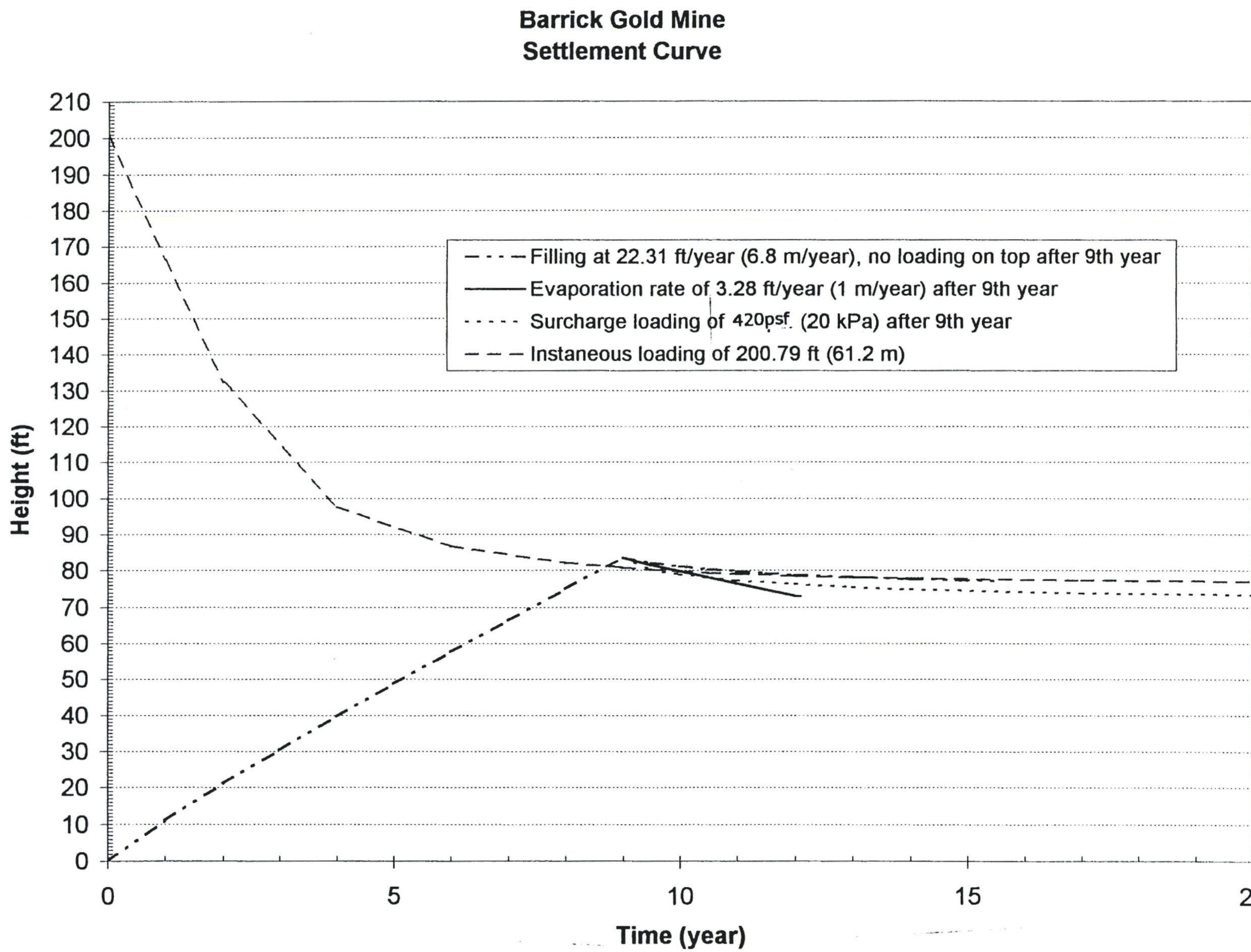


Figure 4 Height Results for Various Filling and Loading Conditions

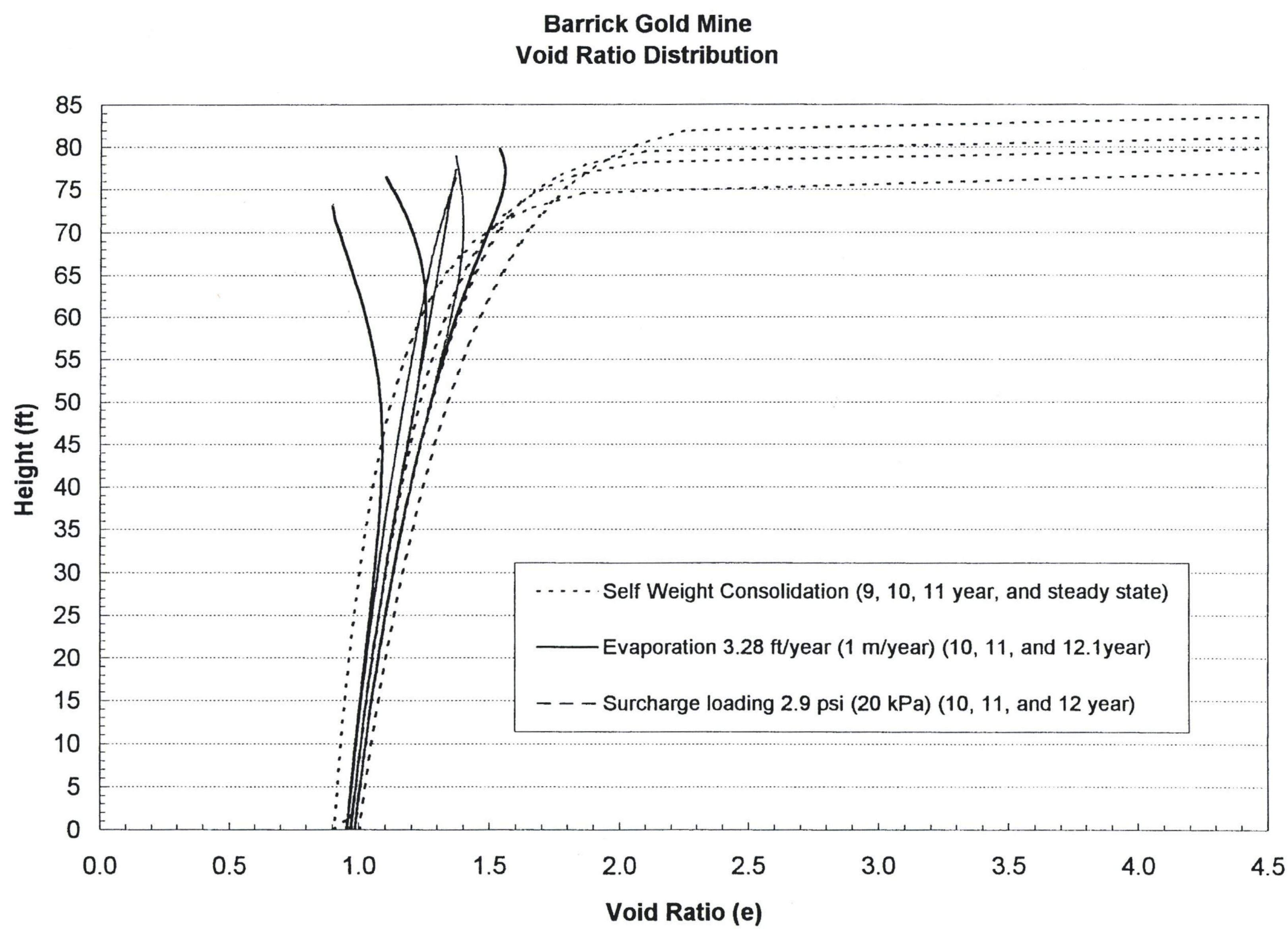


Figure 5 Void Ratio Profiles

data would require as a minimum a reliable measurement of the water content in the soft upper 20 ft of the submerged tailings and additional consolidation tests on coarser tailings samples. While such investigation is certainly possible we do not believe it to be justified for the purposes of this study.

Settlement analyses

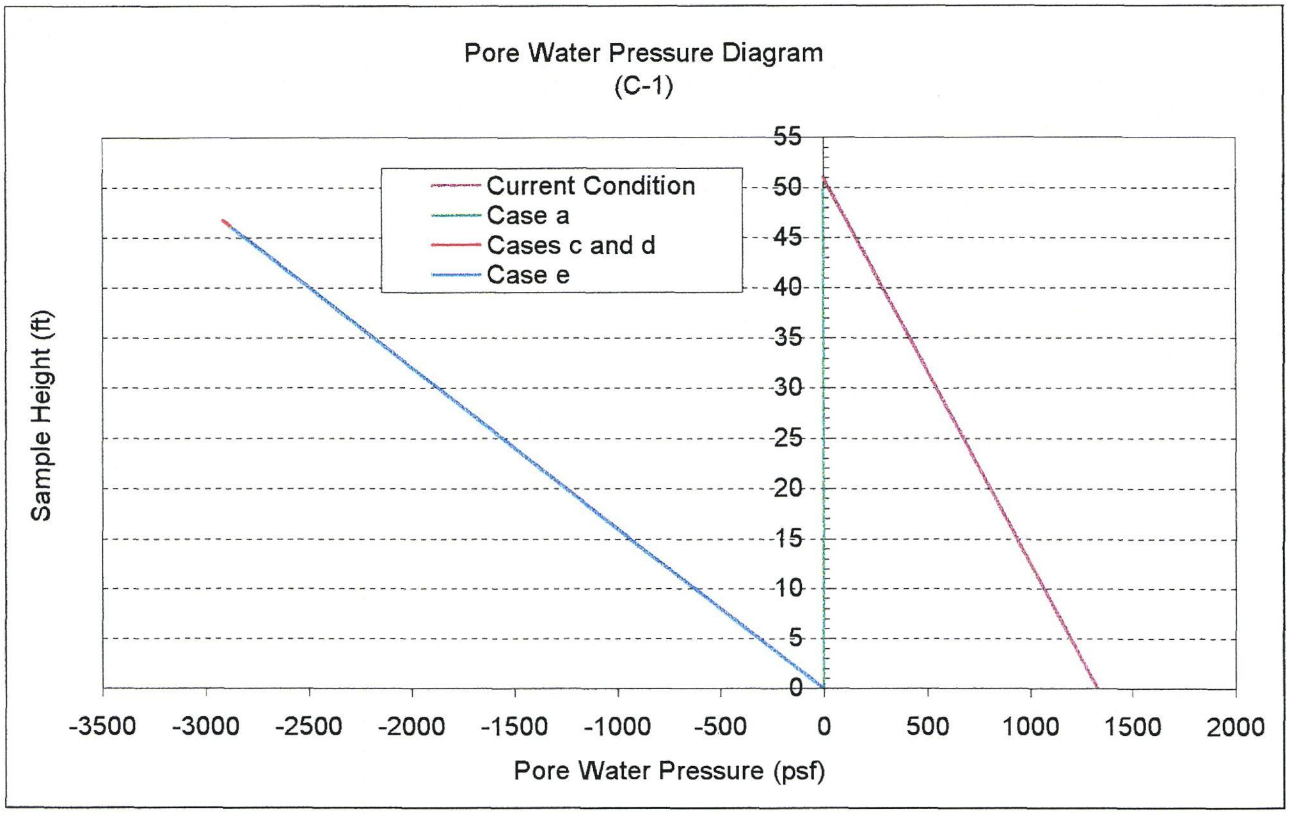
Using material characteristics that are described previously, analyses for various field conditions were performed at each CPT location. First, the current state was analyzed by considering the current pore pressure profiles obtained from the CPT data. The results of these analyses were used as the initial condition for the subsequent settlement calculations. The settlements will be created as a consequence of the changing groundwater conditions, including desiccation, and due to any additional loading produced by the cover to be placed on the tailings. The changes in the groundwater conditions were predicted by groundwater hydrological studies and were provided to us by Golder Associates.

Consequently, several settlement scenarios were analyzed. First, a case is analyzed in which all positive pore pressures were dissipated and no capillary effects are considered (case a). This is equivalent of assuming zero pore pressure at all depths. Second, full draindown with a capillary rise of 10 ft is considered for coarse grained tailings (CPT locations 2, 6, 7, 9, 10, 11 and 12), while capillary rise to the ground surface is considered for the finer material (CPT locations 1, 3, 4 and 8) (cases b and c respectively). Third, the lowering of the groundwater table to the elevation 7240 is considered with the already stated capillary effects above the water table (case d). And finally the addition of the cover is considered (case e). Figure 6 shows the pore pressure conditions considered for all the cases including the initial condition for each CPT location. The groundwater table elevations and capillary conditions were obtained from the hydrologic studies.

The results of the settlement analyses are presented in Table 4, and the corresponding void ratio profiles for each CPT location are presented in Figure 7 a to k. The void ratio profiles are provided here in order to demonstrate for each case the parts of the layers that compress the most and therefore contribute the most to the calculated settlement.

It should be noted that the results here do not explicitly present the desiccation effects. However, based on the presented analyses, the desiccation settlement can be easily predicted if the drying periods are known. For the CPT locations 1, 3, 4, and 8 any cover construction will have to be preceded by a drying period since for these locations the surface material is extremely soft preventing any construction traffic in this situation.

It should also be noted that the desiccation effects are equivalent to the lowering of the groundwater table effects and as such they are already considered in the analyses. Thus, any evaporation-generated settlements will have to be subtracted from the calculated values in order to predict the subsequent settlements. As for the rate of the evaporation generated settlements, the preliminary analyses has demonstrated that for the Barrick Mercur Mine tailings the settlement rate is equal to the effective overall yearly evaporation rate of 2.4 ft/ year, since even the extreme evaporation rate of 3.3 ft/year doesn't produce a thin crust that would diminish the desiccation effects. Thus, the total evaporative settlement can be calculated by multiplying this rate with the elapsed period of time over which the tailings will be allowed to dry. Based on the earlier presented desiccation analysis, such calculation is valid for desiccation of up to two years over which period the upper 20 ft of the slimes will be affected by the process and the resulting settlement will be up to 5 ft. This value will than have to be subtracted from the predicted settlements in Table 4 in order to obtain the subsequent settlement that will take place after cover construction and the lowering of the groundwater table.



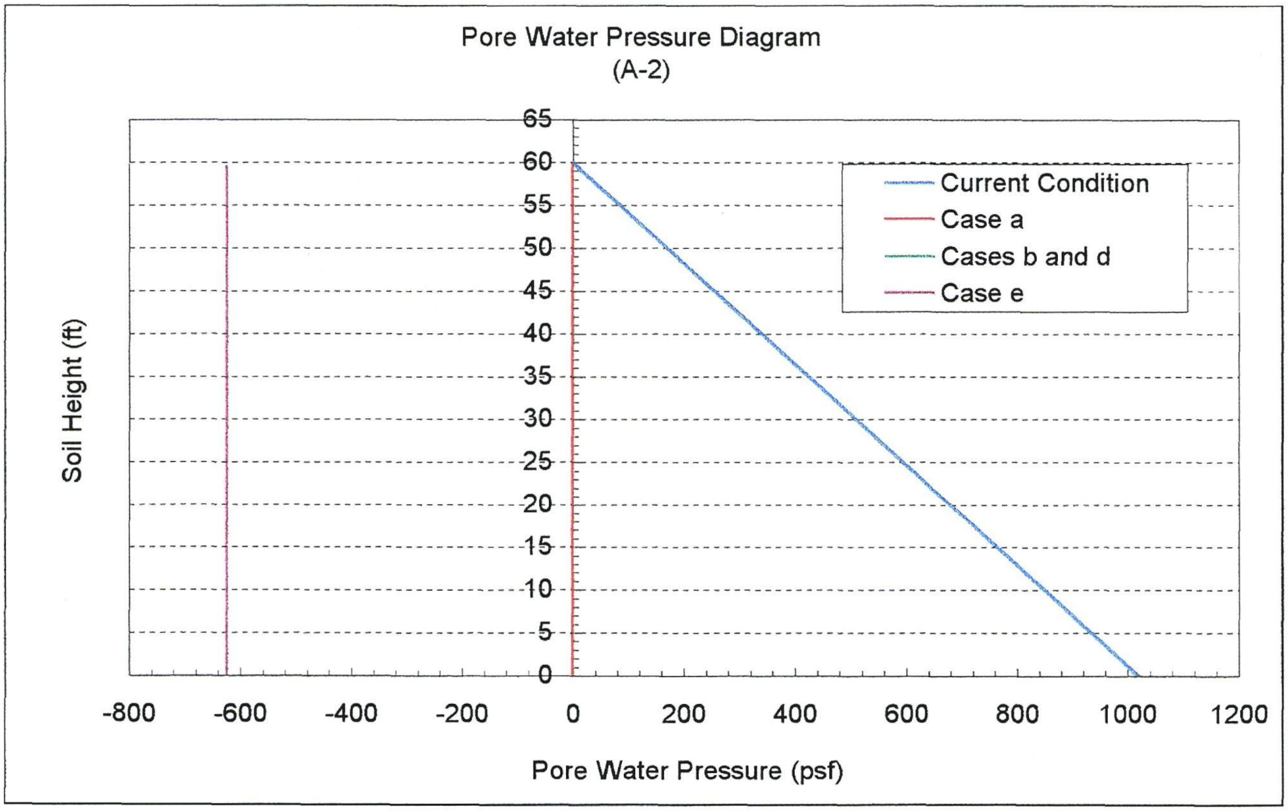
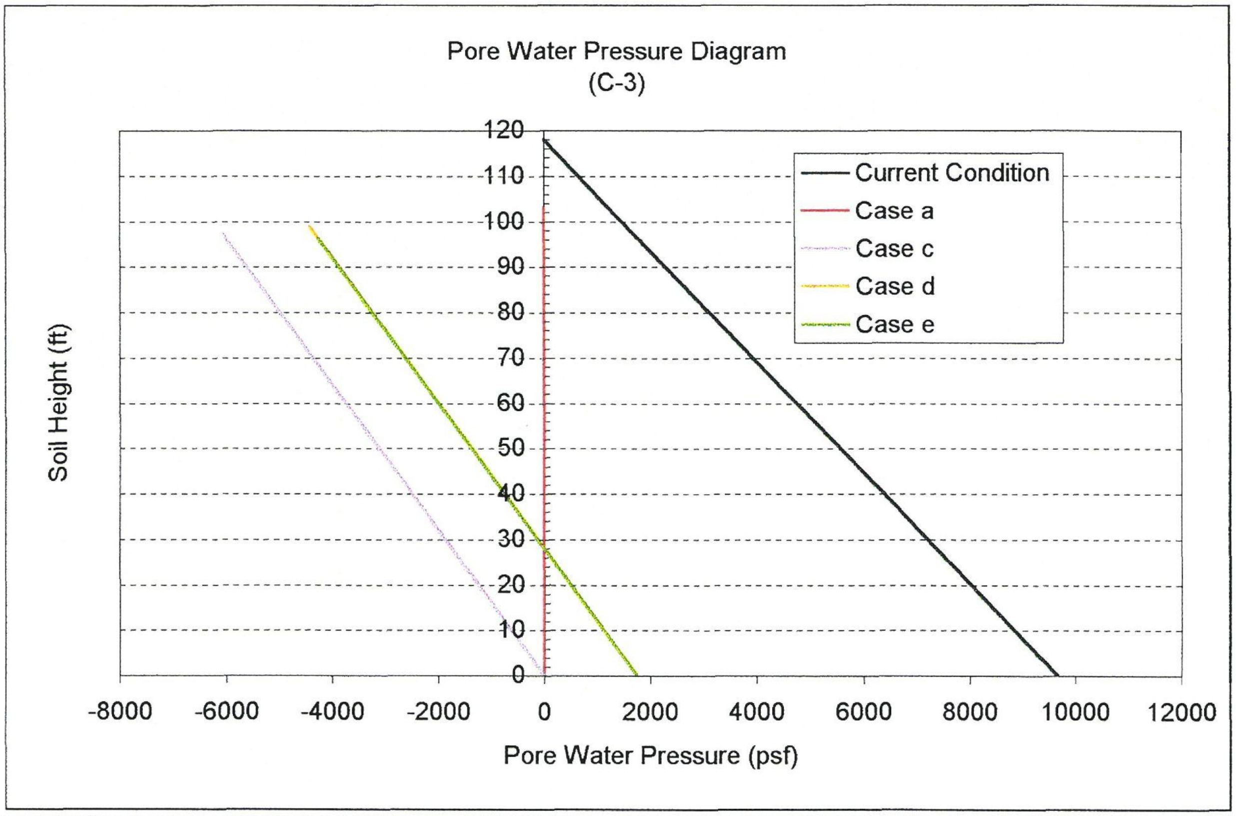
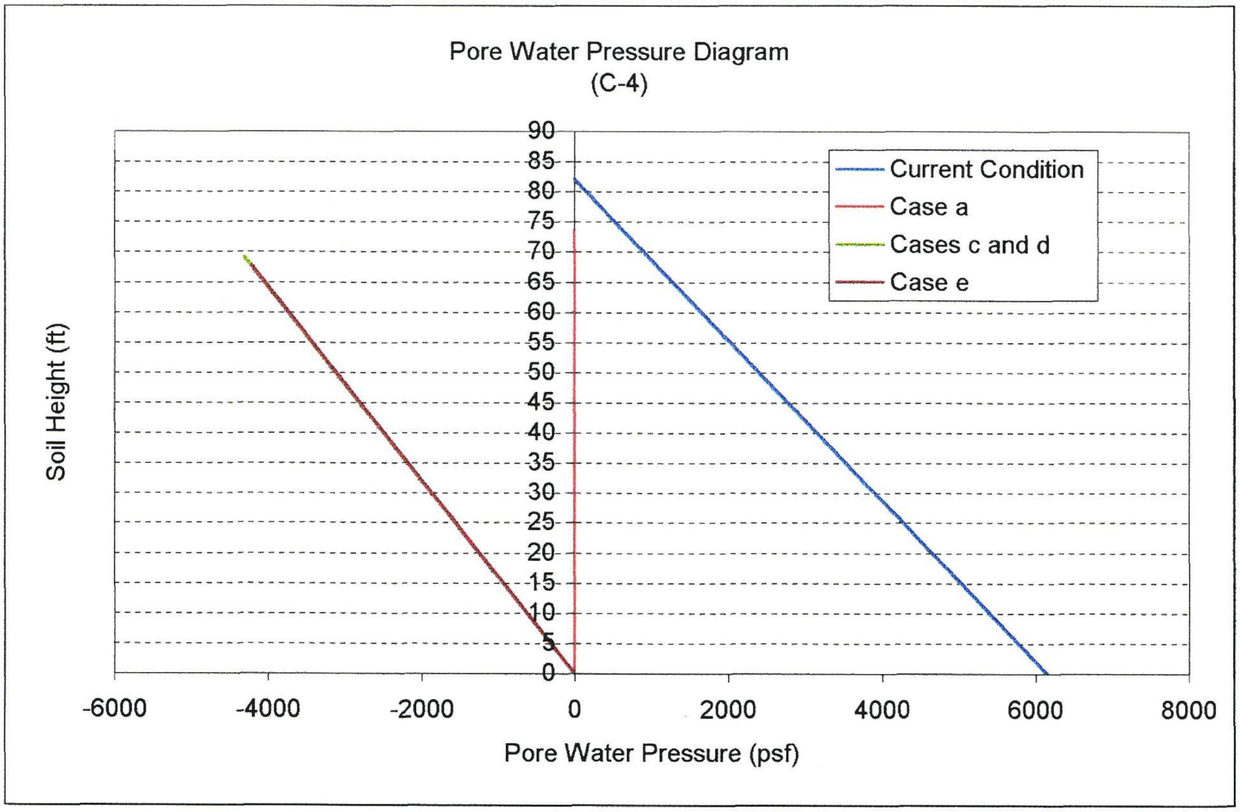


Figure 6 Pore Water Pressure Profiles for Settlement Analysis





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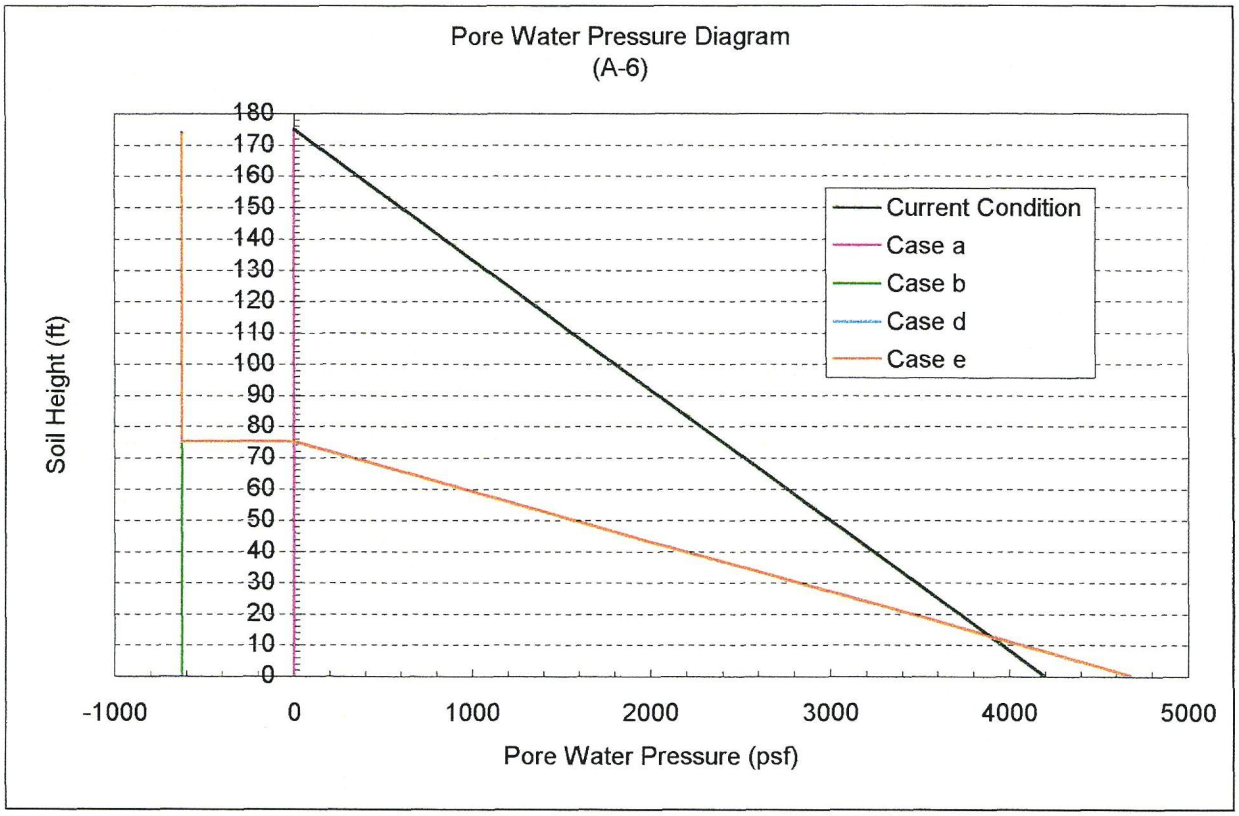

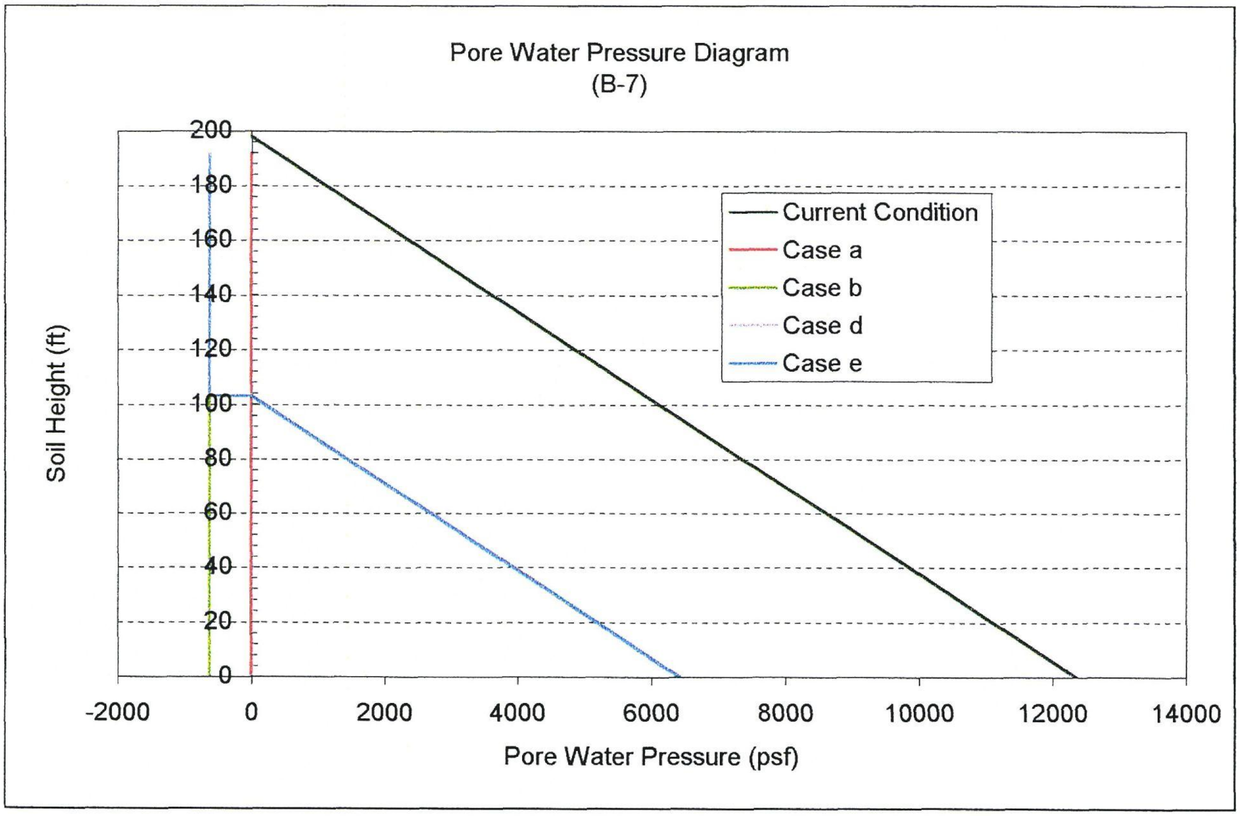

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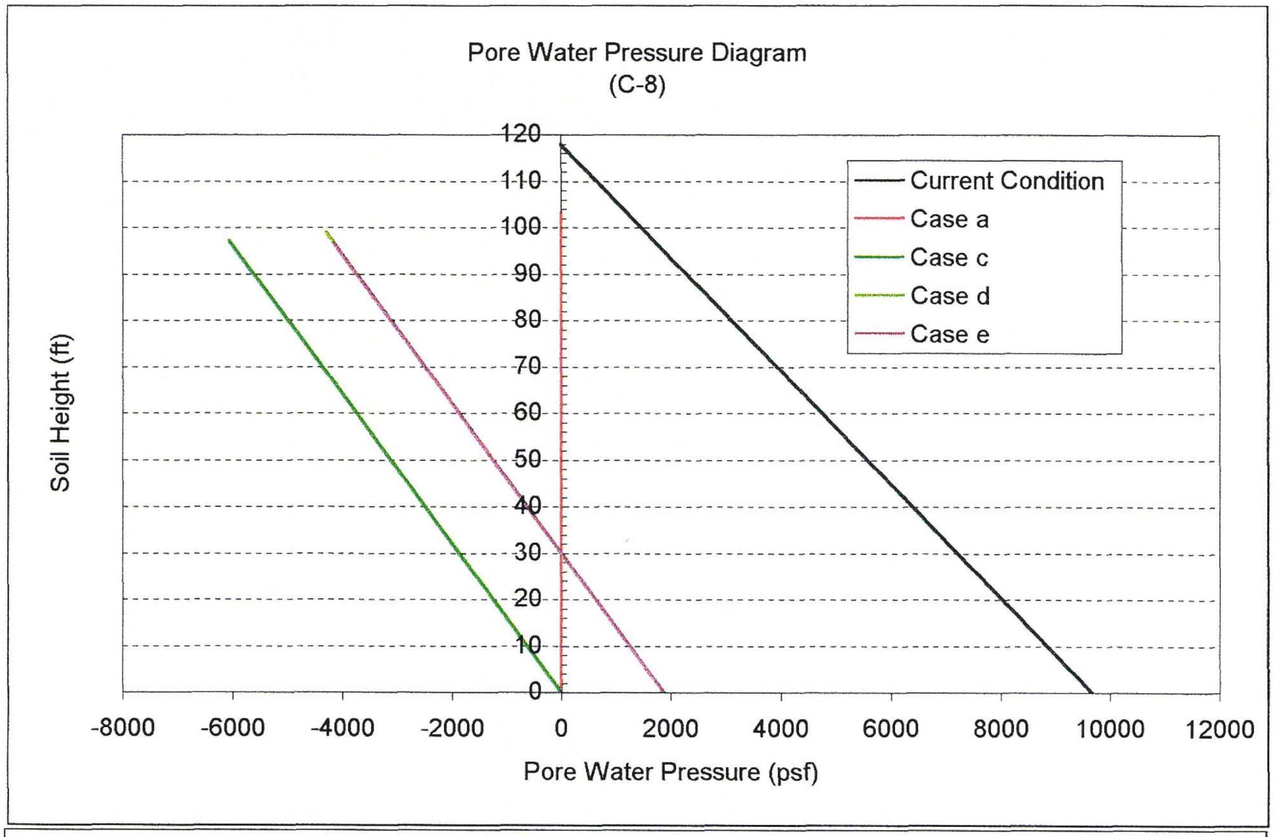

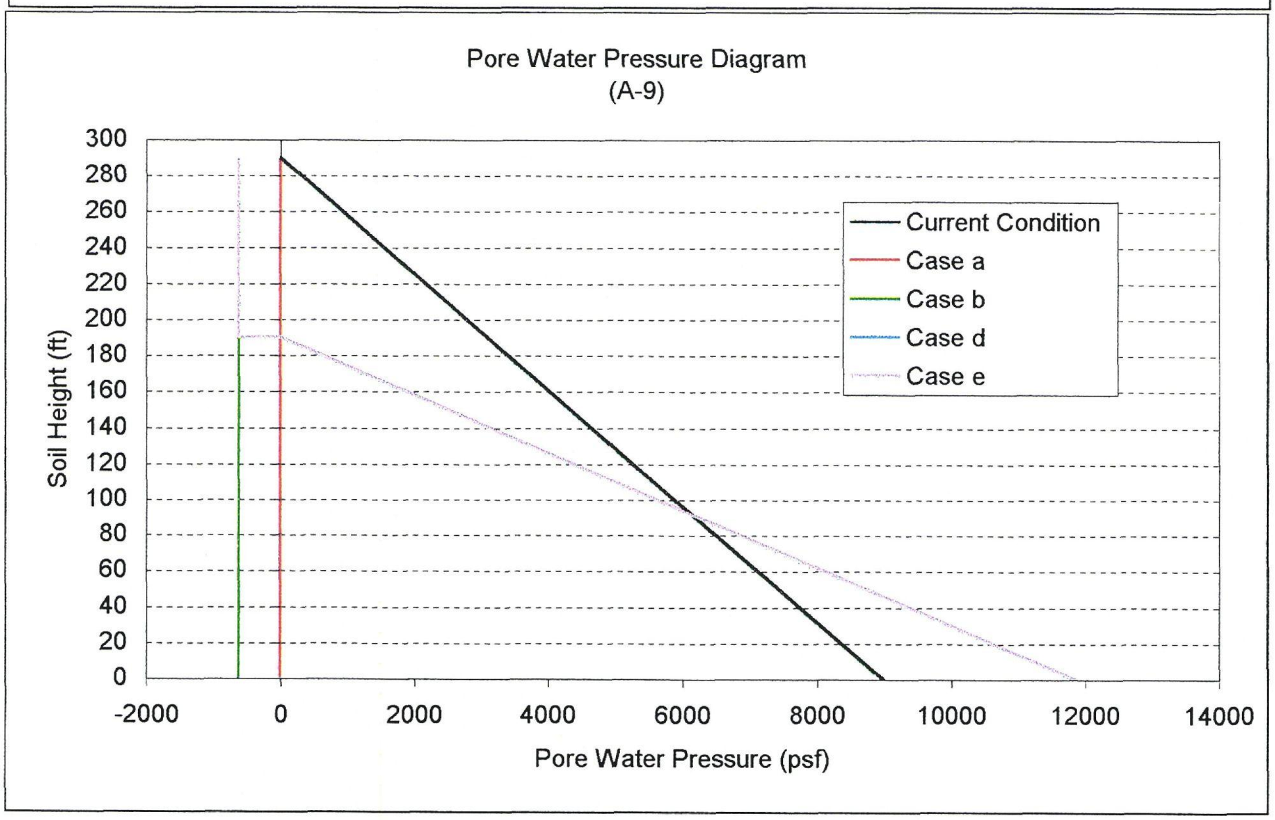

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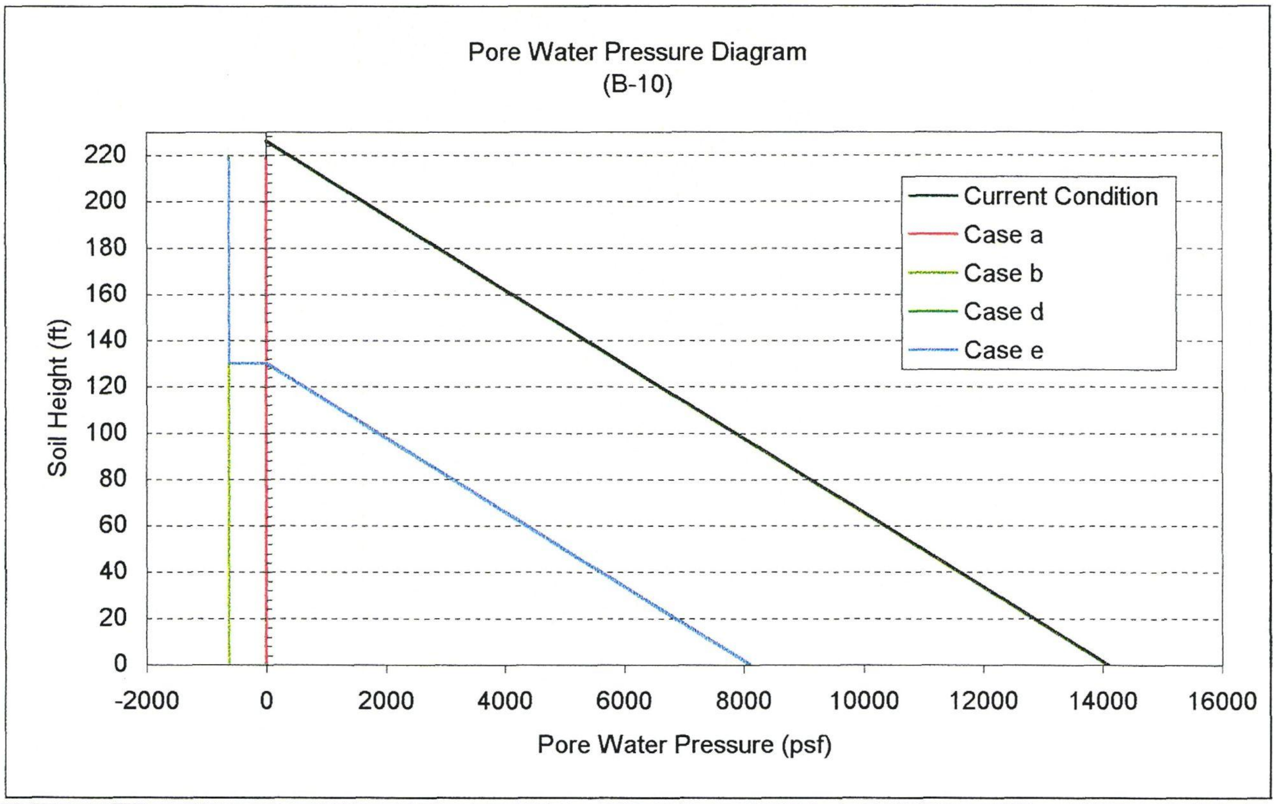

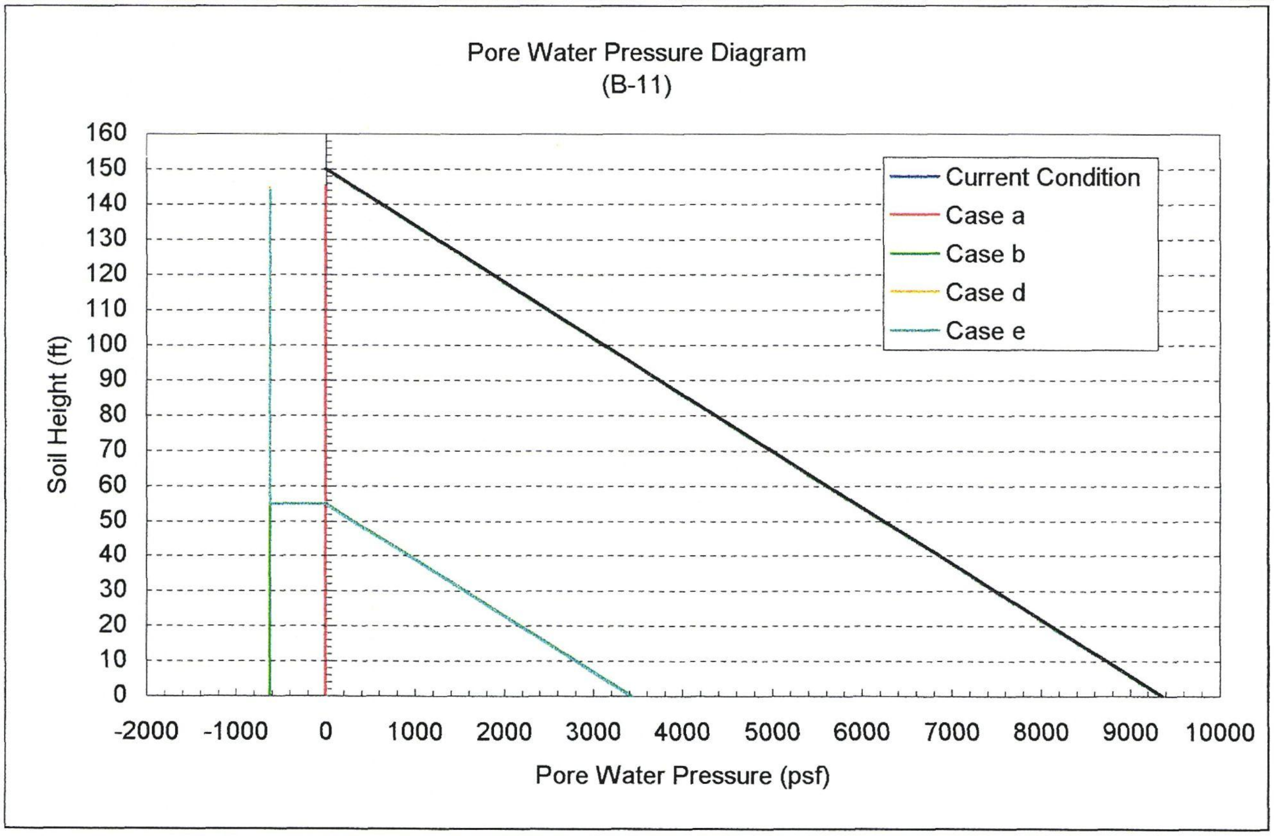

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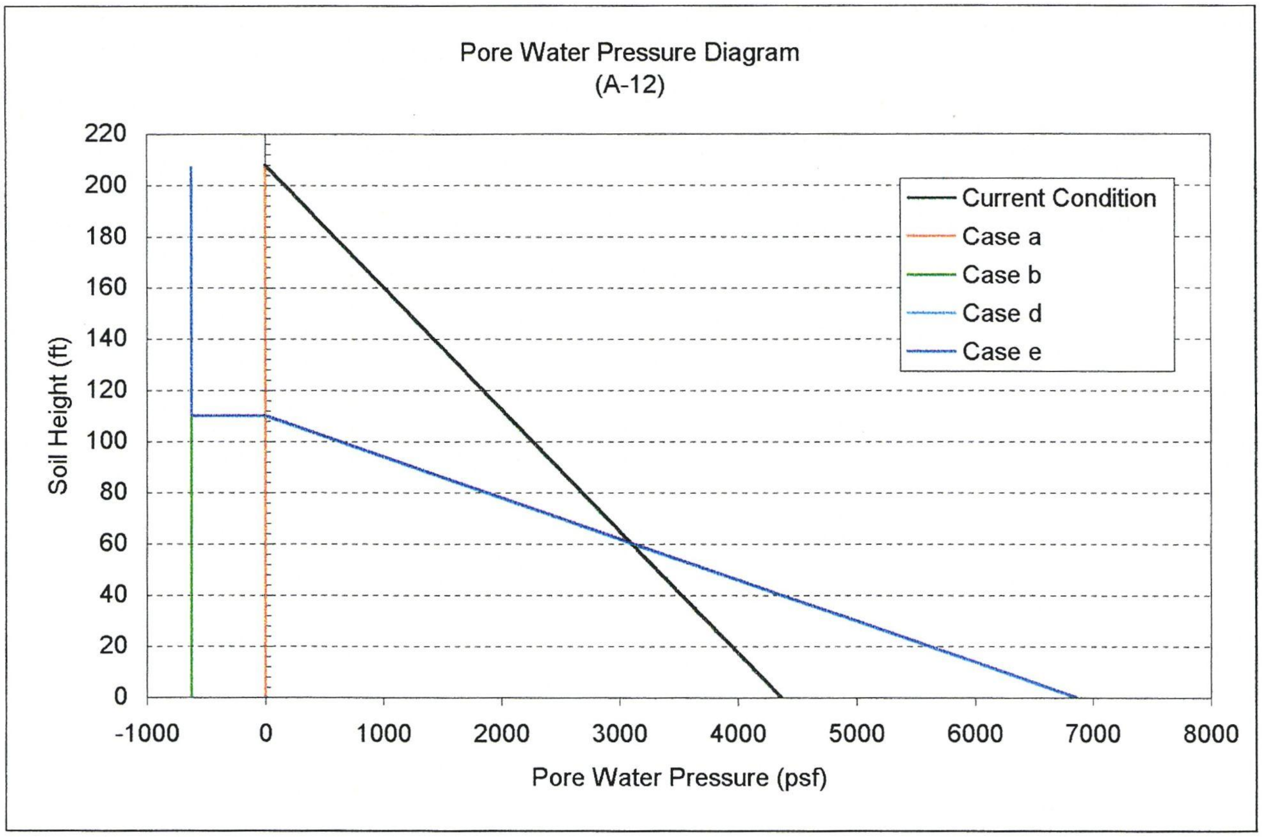

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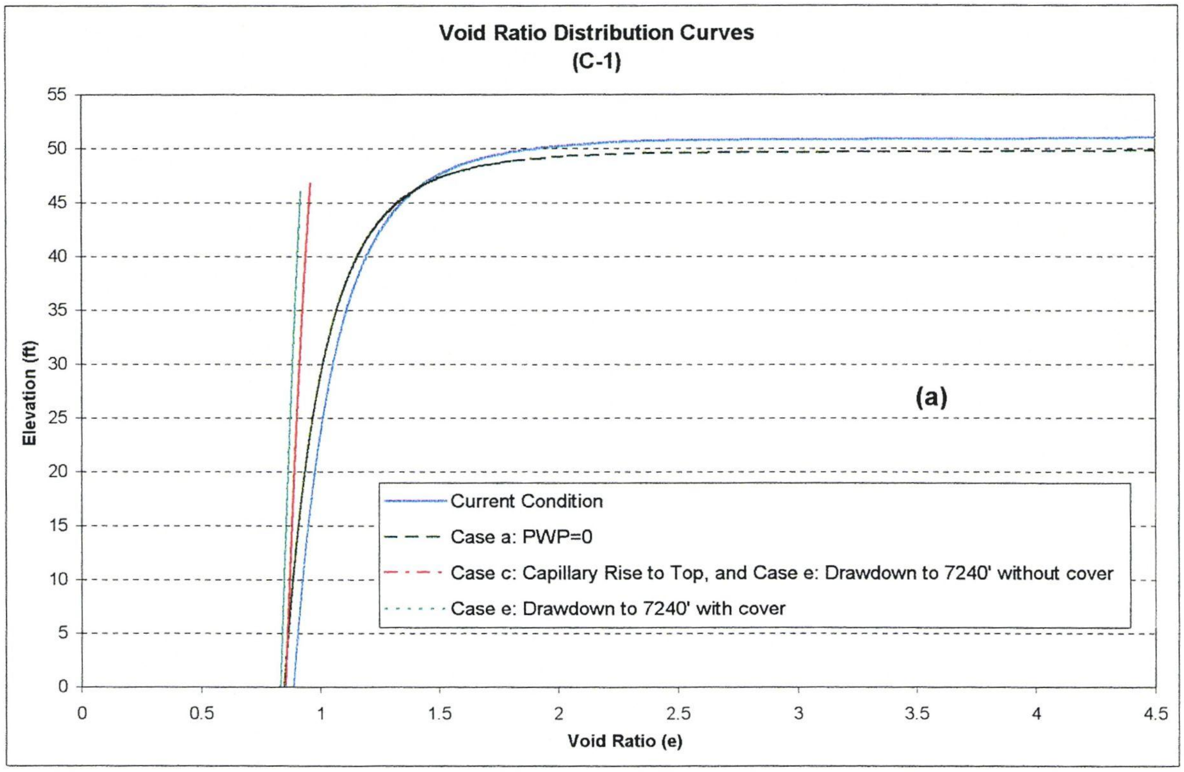


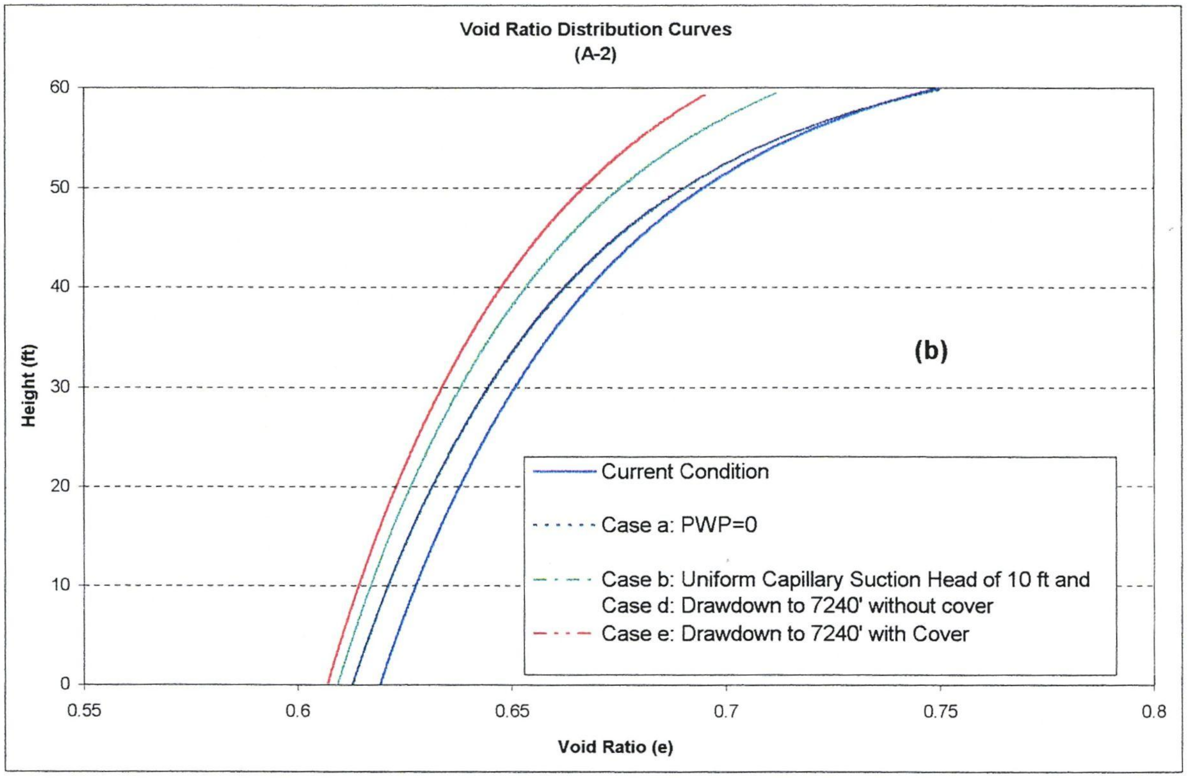
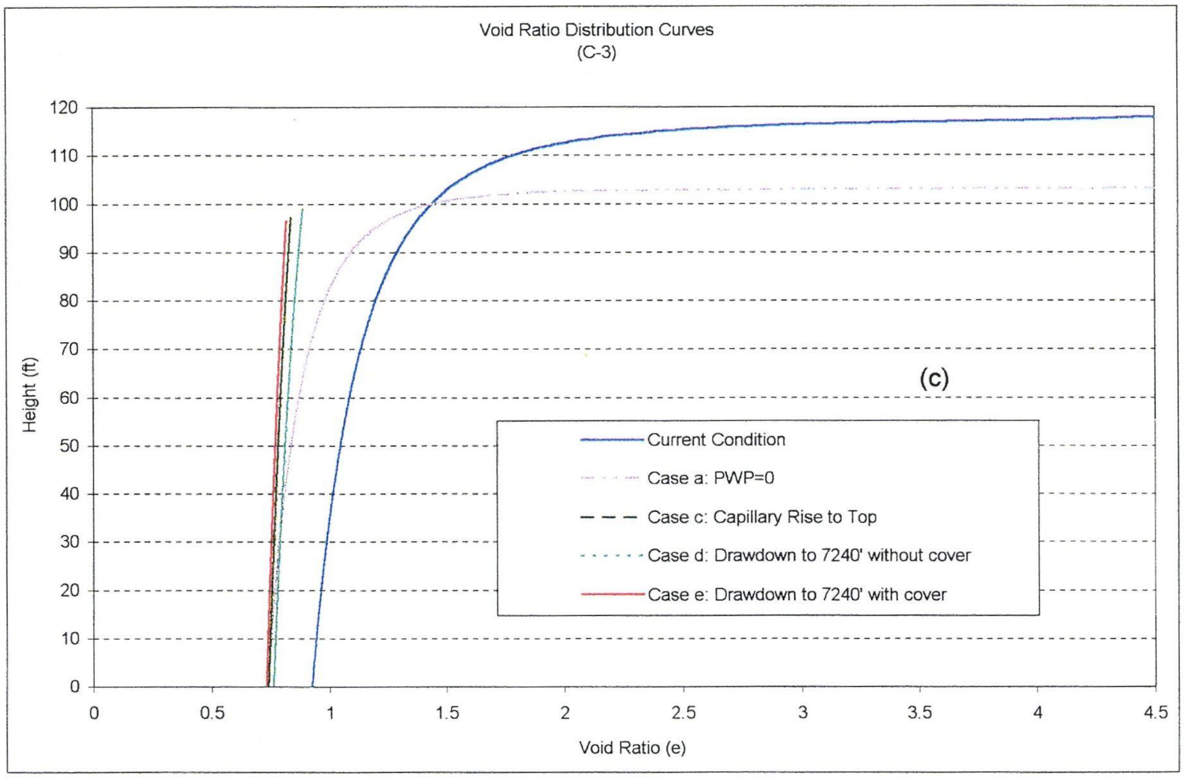


Figure 7 Void Ratio Profiles



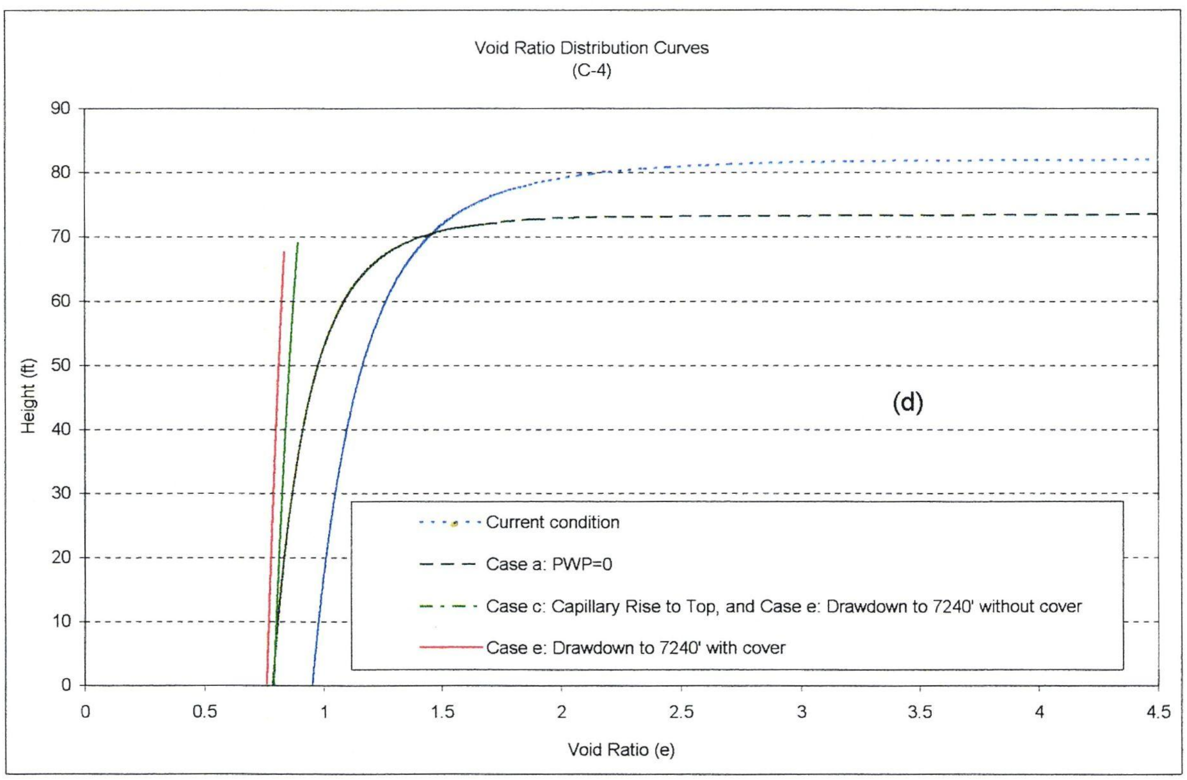
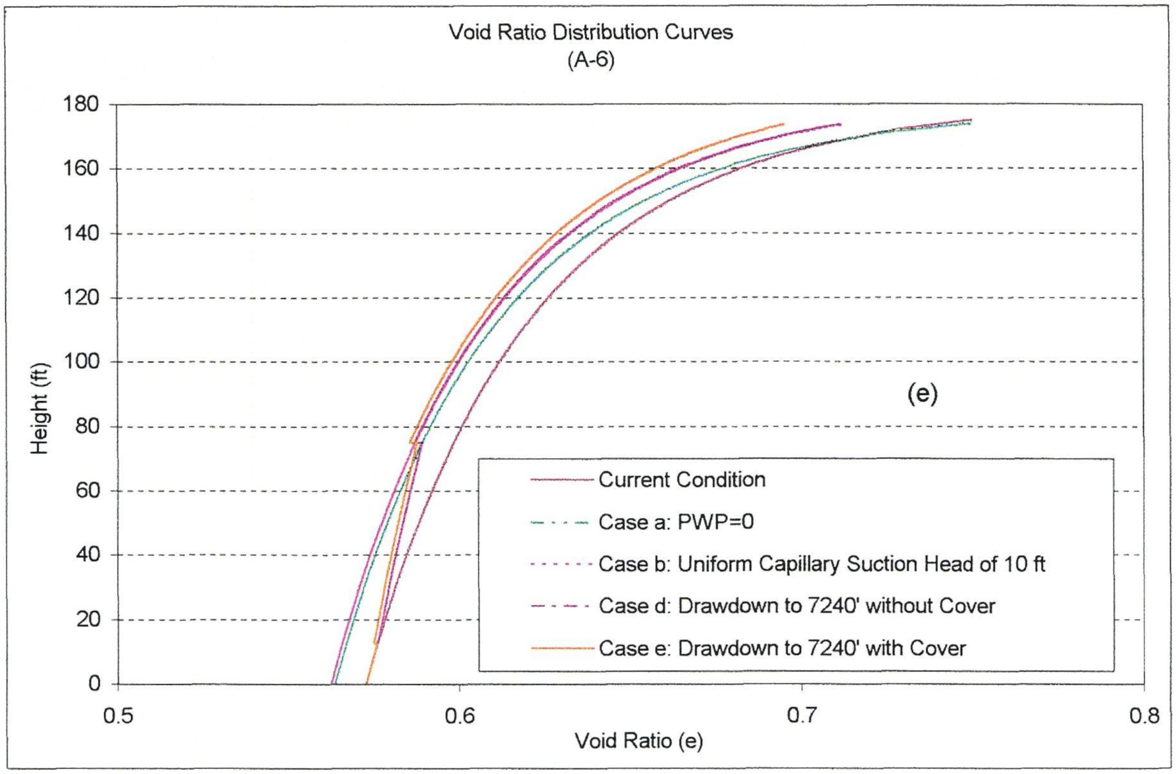
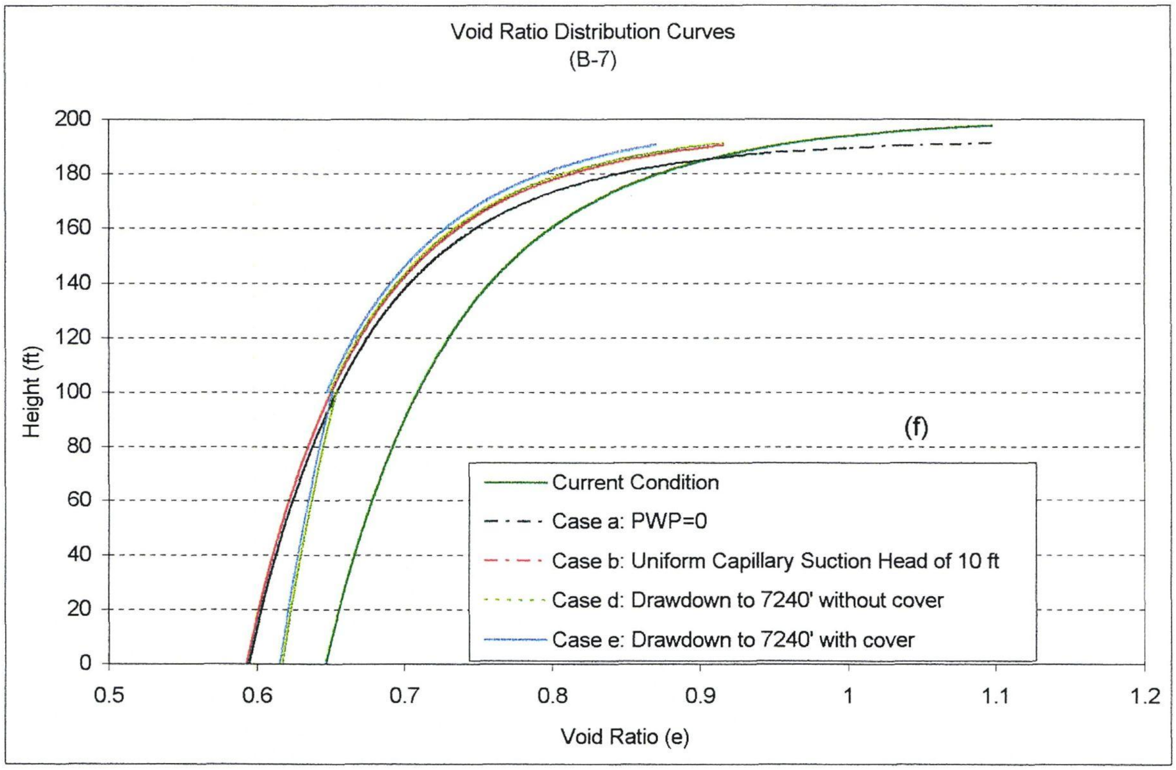


Figure 7 -continue Void Ratio Profiles





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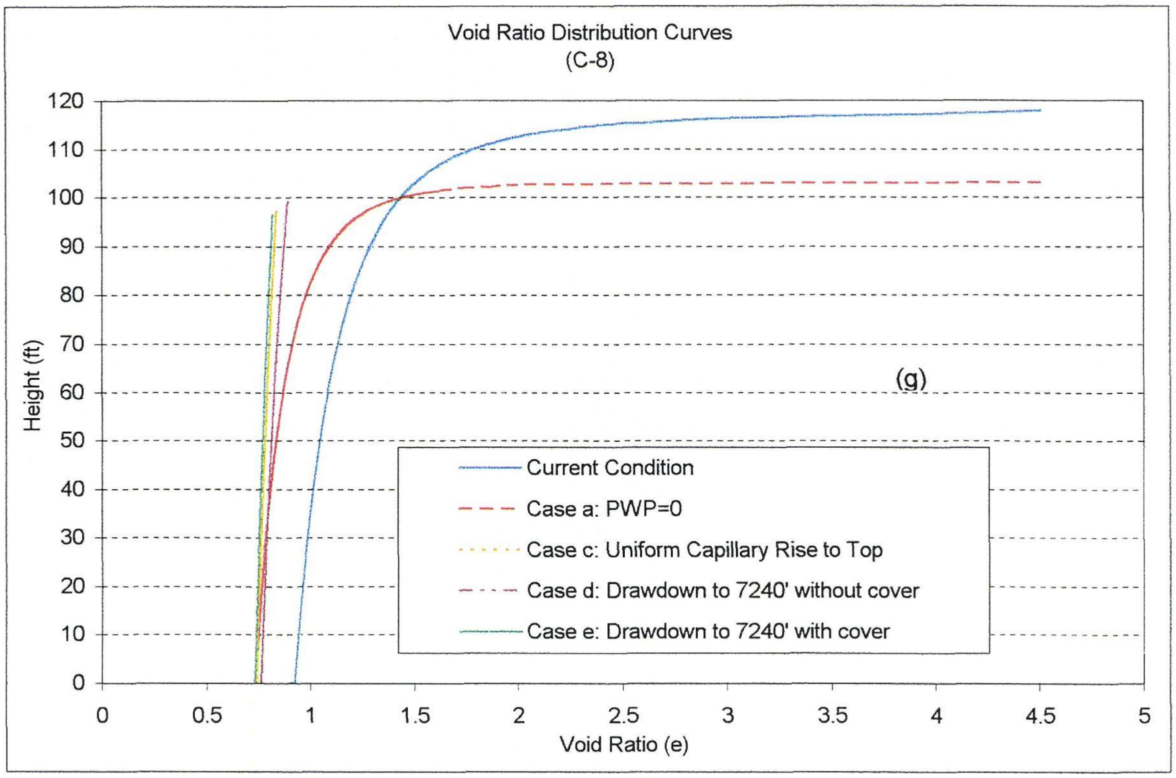

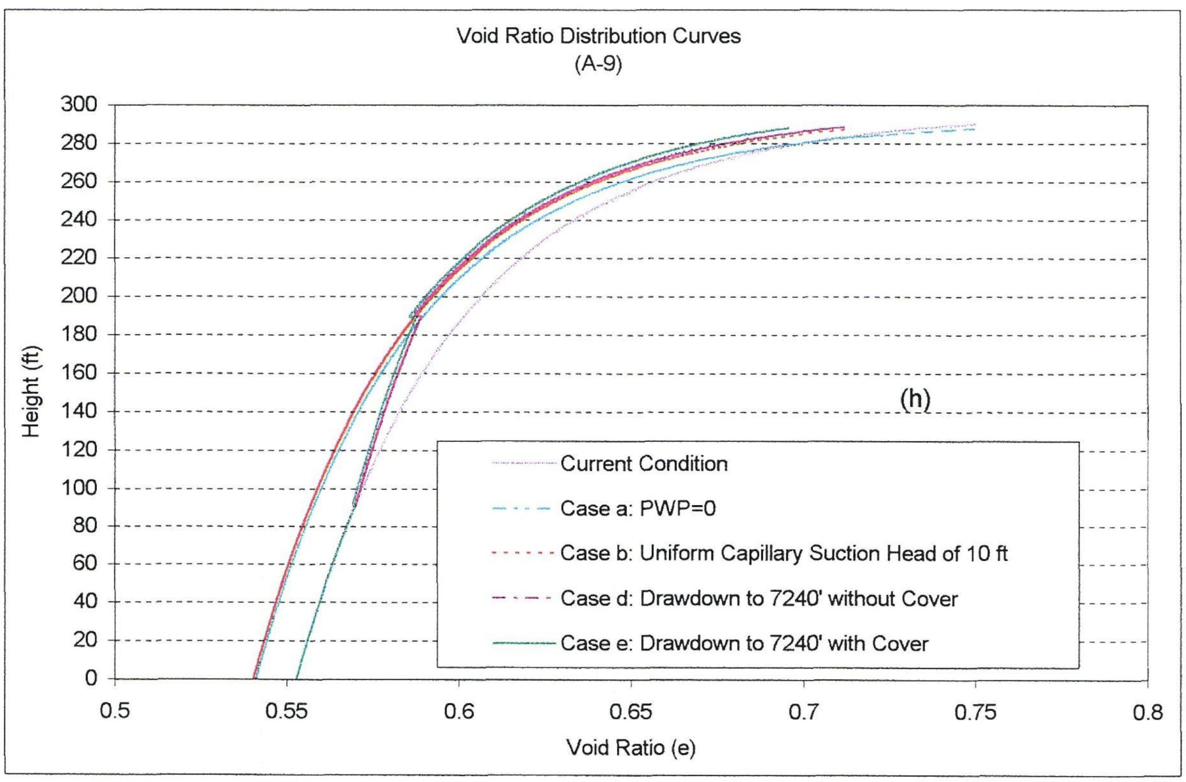

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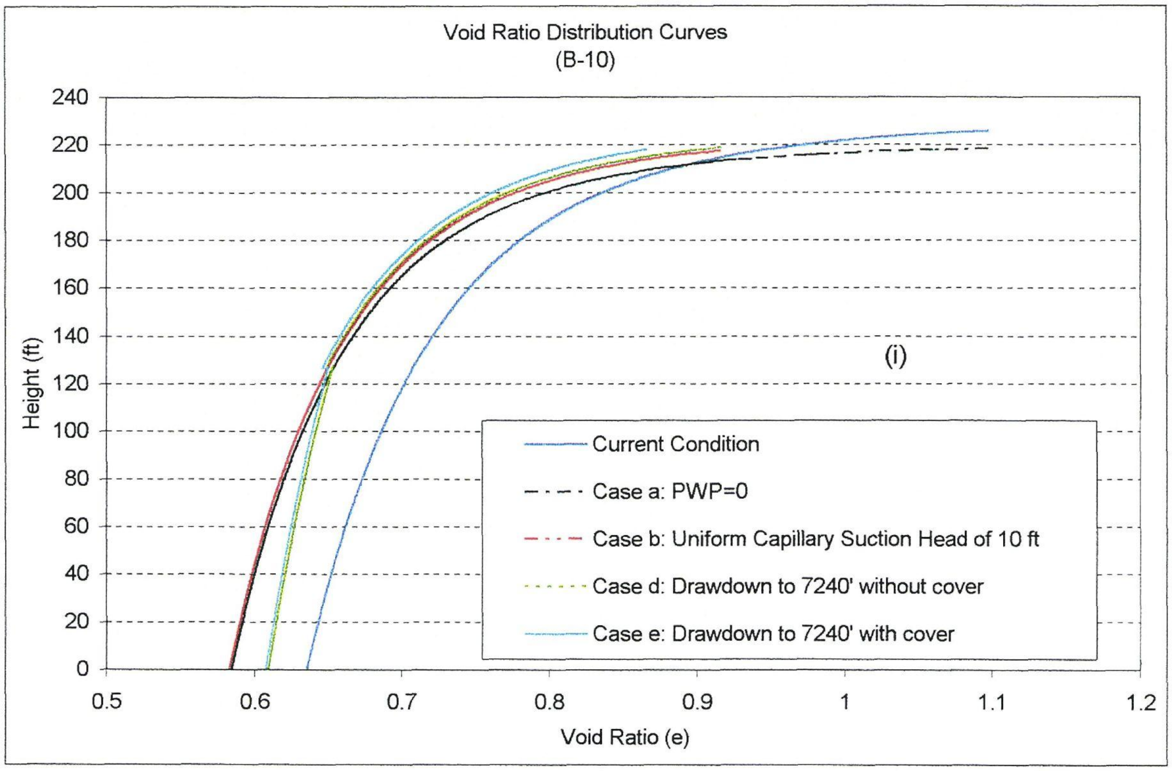

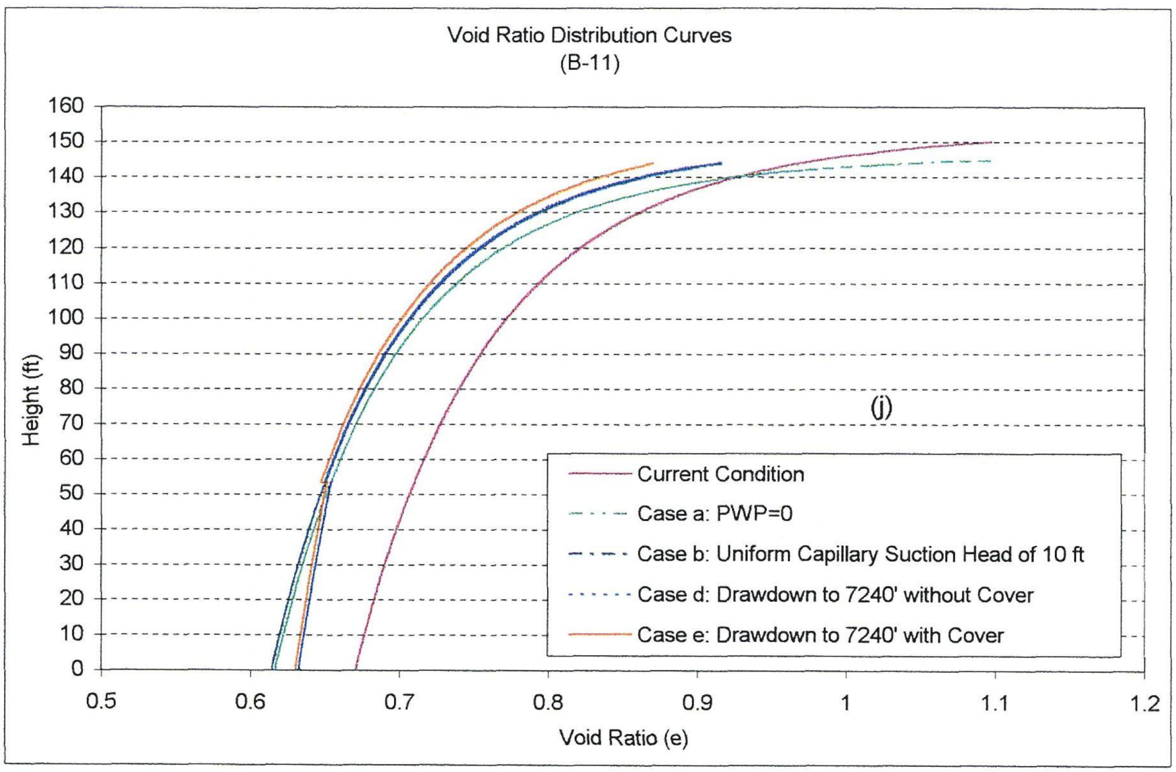

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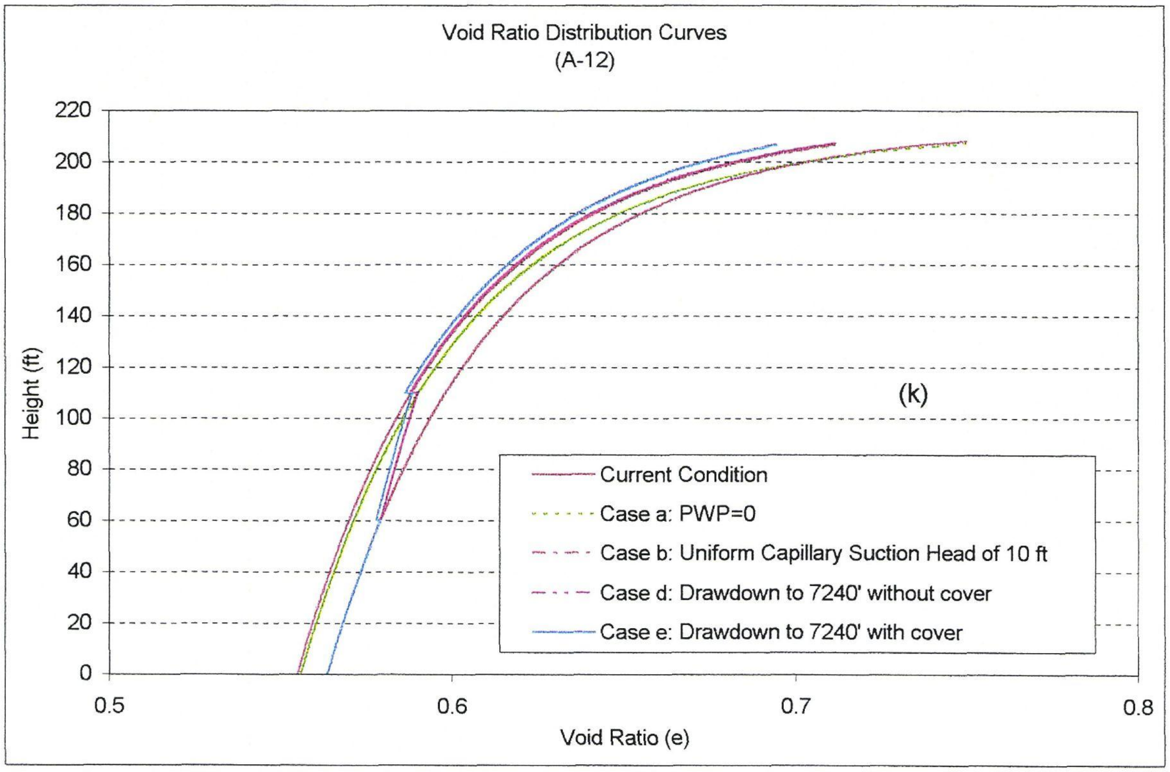

Figure 7 -continue Void Ratio Profiles

Table 3 Compressibility Parameters for Types A, B and C Material (lb-ft-day)

Parameters	A	B	Z
Units	-	-	psf
Type A	1.28	-0.0816	700
Type B	2.15	-0.127	200
Type C	4.15	-0.183	0.634

Table 4 Settlement Results

CPT No.	Soil Type	Current Depth(ft)	Settlement (ft) with Different Scenarios				
			a	b	c	d	e
1	C	51	1.2	-	4.3	4.3	5.0
2	A	60	0.2	0.5	-	0.5	0.7
3	C	118	14.9	-	20.9	19.2	21.7
4	C	82	8.5	-	12.9	12.9	14.4
6	A	175	1.0	1.5	-	1.1	1.4
7	B	198	6.6	7.7	-	6.6	7.2
8	C	118	14.9	-	20.9	19.1	21.6
9	A	290	2.1	2.6	-	1.5	1.8
10	B	226	7.5	8.6	-	7.2	7.8
11	B	150	5.1	6.1	-	5.7	6.2
12	A	208	1.0	1.5	-	0.9	1.2

Note:

a: Assuming zero pore water pressure at all depths
b: Assuming uniform 10 ft capillary suction head at all depths
c: Assuming full capillary rise from bottom to soil surface
d: Settlements with drawdown to Elev. 7240ft, without cover
e: Settlement with drawdown to Elev. 7240ft, with cover

The described desiccation effects should be considered for the CPT locations 1, 3, 4 and 8 only, as the coarser surface tailings in other locations will not be affected by the evaporation in the same manner.

It is noted here that the CPT locations 7, 10 and 11 were analyzed here with the assumption that the maximum void ratio at these locations doesn't exceed the value of 1.10. Field data indicate that at these locations the top 20 ft are in as soft state as for the CPT locations 1,3,4 and 8, and that this upper material has similar characteristics to the C type material. If that is the case, the upper 20 ft of slimes at these locations will behave similar to the locations 1,3,4 and 8, and up to 5 ft of desiccation settlement can be expected at a rate of 2.4 ft per year. However, for locations 7, 10 and 11 these settlements will be in addition to those indicated in Table 4, since the soft upper layer was not considered in the presented analyses for these locations. The main reason why the upper layer was not analyzed is the lack of reliable field data for the shallow depth and the absence of the laboratory tests for this material.

Discussion and Conclusions

The results in Table 4 demonstrate that at locations with A type material, CPT 2, 6, 9 and 12, final settlements of between 1 ft and 2 ft could be expected. These settlements are achieved by more or less uniform (with depth) compression of the layer as demonstrated in Figure 7 b, e, h and k in which the more or less uniform reduction in void ratios is demonstrated.

Locations with B type material, CPT 7, 10 and 11, will experience intermediate final settlements of between 6 ft and 8 ft. These settlements are created by the compression of the material over the whole depth of the layer, but also by the compression of the relatively softer material at the surface. This is demonstrated by the void ratio profiles in Figure 7 f, i and j. As stated earlier if the slimes at top surface at these locations have void ratios higher than the assumed value of 1.10, additional settlement of up to 5 ft due to desiccation could be expected.

Finally, extreme settlements of up to 22 ft can be expected at locations with type C material, CPT 1, 3, 4 and 8. Location CPT 1 will experience the final settlement of only 5 ft despite the presence of the C type material due to its relatively shallow depth of only 51 ft. As void ratio profiles in Figure 7 a, c, d and g demonstrate, most of the extreme settlement is concentrated in the surface layer in which the large void ratio changes are expected. Most likely a good portion of the surface layer will be compressed during the initial drying process and subsequent settlement will be reduced by this amount.

The presented results can be used for designing the final cover for the impoundment. It should be recognized in the design process that the extreme settlements for type C material carry the most uncertainty due to the lack of reliable field data on the condition of the surface portion of this material. These locations will also be affected to the greatest extend by the desiccation process and this fact should be also kept in mind when deciding on the form of the final cover as well as on the construction schedule.

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Appendix - References

Desiccation Theory for Soft Cohesive Soils

By A. Naser Abu-Hejleh[1] and Dobroslav Znidarčić,[2] Associate Members, ASCE

Abstract: A new desiccation theory is developed that provides a rational framework for the consolidation and desiccation analysis of soft fine-grained waste soils. The theory includes four consecutive segments that correspond chronologically to the phases that a soft soil layer undergoes in the field after deposition: consolidation under one-dimensional compression; desiccation under one-dimensional shrinkage; propagation of vertical cracks and tensile stress release; and desiccation under three-dimensional shrinkage. A general form of the finite strain governing equation of the overall consolidation and desiccation process is formulated. It includes the cracking function and the nonlinear constitutive relations. The experimentally obtained consolidation and desiccation characteristics for soft china clay, which are needed for the overall analysis of a given field problem, are presented. The predictions of this theory for the response of a hypothetical soft china clay layer undergoing self-weight consolidation, seepage consolidation, and desiccation due to lowering of the ground-water level or surface drying are presented and discussed.

INTRODUCTION

Significant amounts of slurried fine-grained waste soils are produced in the mining and dredging operations and deposited hydraulically in large disposal facilities. For example, more than 50,000,000 t (dry weight) of highly plastic phosphatic clays are produced annually in Florida's phosphate industry (Carrier et al. 1983). Quantities of sediments, approaching 400,000,000 m^3 are dredged annually from the navigable waterways of the United States (Poindexter and Walker 1988). These and other soft wastes have unconventional consolidation properties such as high water content, high compressibility, and low strength and permeability. Hence, densification of the waste is required either at the time of deposition or later. The densification maximizes the disposal-site capacity, stabilizes the disposal-facility structure, and allows for the reclamation of the disposal site for subsequent land use by increasing the soil shear strength and reducing the long-term settlements. Out of several densification techniques reported (Johnson et al. 1977; Mitchell 1988), desiccation due to surface drying and lowering of the ground-water level is of interest in the present paper.

Due to desiccation, the surface of the soil layer settles, and cracks initiate and propagate downward forming cracked soil columns with a desiccated surface crust. According to Blight (1988), surface drying has the effect of considerably reducing the void ratio of the deposited slurry materials and increasing the solid storage capacity of the impoundments. East et al. (1987) argued that surface drying can fully consolidate the slurry soil during the subaerial deposition (i.e., when the surface water on the top of the soil layer is removed), thus reducing the long-term settlement to a minimum. Often, the reclamation operations for soft cohesive waste-disposal sites require the development of a desiccated surface crust with an adequate strength in order to support workers and equipment (Carrier and Bromwell 1983; Johnson et al. 1977). The depth of the surface crust depends on the climatic conditions (i.e., evaporation rate), the final ground-water level, and vegetation (Mitchell 1988).

There are many reasons why a rational method to predict the response and behavior of soft cohesive soils undergoing desiccation is needed. First, the available models in the literature for the analysis of desiccation of soft soils are empirical or semiempirical. For example, Swarbrick and Fell (1992) described a semiempirical one-dimensional model of sedimentation and desiccation that includes restrictive assumptions, such as a uniform distribution of water content with depth throughout the desiccation process. The U.S. Army Engineer Waterways Experiment Station (WES) model (Cargill 1985) is also empirically based and can be used only in a limited number of field situations. Second, only a few oversimplified models for the three-dimensional shrinkage are available. For example, the Bronswijk (1988) model might be applicable only for relatively stiff soils, where small strains occur and the changes in the total vertical stresses are negligible. These conditions are unjustified for modeling three-dimensional shrinkage of soft fine-grained soils. For example, McNeilan and Skaggs (1988) reported observations for a dried-out surface of a hydraulic landfill in Los Angeles. Orthogonal desiccation crack patterns with 0.3-m width and as much as 1.5–2.1m depth were noted, and the total settlement in the softest area of the landfill from spring 1983 to spring of 1987 was 1.8 m. Third, a complete study on desiccation cracking of soft soils or a model that incorporates the desiccation cracking analysis in the transition from one-dimensional to three-dimensional shrinkage is not described in the literature. Fourth, the constitutive and cracking relations for soft fine-grained soils undergoing desiccation are not reported in the literature. For all these reasons, many researchers stressed the need for more work in the area of desiccation of soft soils (Johnson et al. 1977).

A new theory for modeling the overall consolidation and desiccation process of soft fine-grained soils after deposition was developed (Abu-Hejleh 1993). It eliminates all the stated shortcomings of existing studies. The theory was implemented in a finite-element computer program, and laboratory tests were developed to provide all the necessary desiccation constitutive relations for soft cohesive soils. The present paper describes the main components of the theory and the experimentally obtained consolidation and desiccation characteristics for soft china clay that are needed for the overall analysis. The predictions for the response of a hypothetical soft china clay layer undergoing self-weight consolidation, seepage consolidation, and desiccation due to lowering of the ground-water level or surface drying are also included.

THEORETICAL DEVELOPMENT

While the proposed desiccation theory overcomes most of the limitations of existing analyses reported in the literature, several assumptions were used in order to proceed with the

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Note. Discussion open until November 1, 1995. To extend the closing date one month, a written request must be filed with the ASCE Manager of Journals. The manuscript for this paper was submitted for review and possible publication on July 2, 1993. This paper is part of the *Journal of Geotechnical Engineering*, Vol. 121, No. 6, June, 1995. ©ASCE, ISSN 0733-9410/95/0006-0493–0502/$2.00 + $.25 per page. Paper No. 6369.

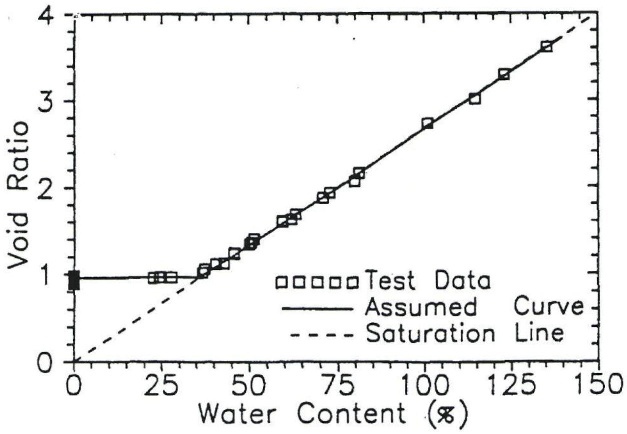

FIG. 1. Shrinkage Curve for China Clay

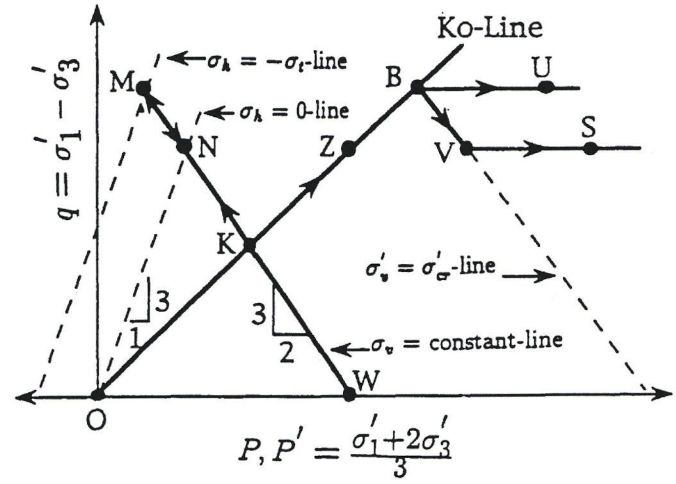

FIG. 2. Total and Effective Stress Paths during Overall Consolidation and Desiccation Process

analysis for solving this complex problem and to provide a practical approach for analyzing soft waste-disposal sites. First, the theory is based on the assumption that soft fine-grained soils undergoing desiccation remain saturated until the void ratio reaches the shrinkage limit void ratio, that is, the void ratio at which soil shrinkage is terminated. Thereafter, the desiccated soil becomes rigid and its response is not modeled in the present theory. The experimental results obtained by Bronswijk (1988) show that soils with high clay content (cohesive soils) remain staurated over a wide range of water contents during desiccation and low clay content soils show residual shrinkage; that is, the reduction in soil volume is smaller than the water volume lost during the desiccation process. Fox (1964) reported that air entered a desiccated clay sample at a suction of 1,000 kPa, whereas Yule and Ritchie (1980) gave a value of 1,500 kPa. The experimentally obtained shrinkage data, void ratio versus water content, for soft china clay are shown in Fig. 1. They suggest that soil shrinkage can be modeled with two stages: (1) normal shrinkage, where the soil remains saturated from the initial void ratio to the shrinkage limit void ratio, $e = 0.96$; and (2) zero shrinkage, where the soil does not show any volumetric change from the shrinkage limit void ratio to the end of the desiccation process. Consequently, this assumption can be justified for soft fine-grained soils, which are of primary interest in the present paper, since this type of material undergoes a large volume decrease when the moisture content is reduced (Johnson et al. 1977).

Second, the theory considers a homogeneous soil that does not vary in properties from point to point horizontally, which is a common assumption in many theories. This assumption allows for modeling a simultaneous development of desiccation cracks at different locations, which propagate vertically to the same crack depth forming cracked soil columns with equal crack spacing (Lachenbruch 1962).

Third, the soil skeleton exhibits no intrinsic time effects with incompressible water and solid phases, which is assumed in most classical small- and large-strain consolidation analyses (McVay et al. 1986). For soft soils undergoing desiccation, the presented assumptions allow for the application of the effective stress principle and allow the material constitutive relations to be a function of the void ratio only for a given stress path (Gibson et al. 1967).

Fourth, during the overall consolidation and desiccation process, the lateral and vertical planes through any point in the cracked and the uncracked soil columns are principal planes (Miller 1975). This assumption simplifies the analysis of three-dimensional shrinkage, as is discussed in subsequent sections of the present paper.

The overall consolidation and desiccation process of soft soils is modeled in the theory with four consecutive segments, which correspond chronologically to the phases that a soft soil layer undergoes in the field after deposition. These phases are consolidation under one-dimensional compression, one-dimensional shrinkage, propagation of desiccation vertical cracks with tensile stress release, and three-dimensional shrinkage. The total and effective stress paths during these four phases for a typical soil element are presented in Fig. 2. At the beginning of the consolidation process, when the effective stresses acting on the slurry soil element are zero, the element is at the effective stress state O and the total stress state W. The initial positive pore-water pressure acting on the soil element, equal to the total vertical stress, is the distance on the graph between the total stress state W and the effective stress state O. Due to consolidation and desiccation, this initial positive pore-water pressure decreases. While the stress paths are presented in the following for an element experiencing a constant total vertical stress, the theory is not restricted to this case and the analysis properly accounts for the change in the total vertical stresses throughout the consolidation-desiccation process.

In the development of this theory, it is convenient to consider the soil deformation as consisting of two components, One is associated with the change in the pore-water pressure, and the other results from the change in total stresses. The first is termed free strain, since it is the only strain component that occurs during desiccation of unconfined soil element, and the other is termed the mechanical strain. The sum of free and mechanical strains is the net strain, which arises due to change in effective stresses. Before the initiation of cracks, the net lateral strain for any soil element remains zero, and so the effective stress path during consolidation and desiccation must follow K_0 line where K_0 is the coefficient of lateral earth pressure at rest. Due to the reduction of pore-water pressure, the lateral total stress decreases, while, for illustration purposes only, the total vertical stress is assumed to remain constant. Therefore, the total stress path at this phase has a slope of $-3/2$ in the coordinate system shown in Fig. 2.

Along the total stress path WK and effective stress path OK, the pore-water pressure remains positive, and thus consolidation under one-dimensional compression takes place. Along the total stress path KM and the effective stress path KB, the pore-water pressure is negative while the soil undergoes one-dimensional shrinkage. For modeling the consolidation process, the compressibility and permeability relations are defined as

$$\sigma'_v = F_1(e); \quad k = Q_1(e) \tag{1}$$

where σ'_v = vertical effective stress; e = void ratio; and k = coefficient of permeability. The constitutive relations needed for modeling the one-dimensional shrinkage are

$$\sigma'_v = F_2(e); \quad k = Q_2(e) \tag{2}$$

Soils start cracking during one-dimensional shrinkage when total lateral tensile stress at the crack tip reaches the soil tensile strength

$$-\sigma_h = \sigma_t \tag{3}$$

where σ_h = total lateral stress; and σ_t = tensile strength. The lateral mechanical tensile strain and the corresponding total lateral tensile stress are developed during one-dimensional shrinkage, since zero net lateral strain is maintained. This type of restraint causes the development of shrinkage cracks in concrete (Penev and Kawamura 1993) and in permafrost regions (Lachenbruch 1962). Corte and Higashi (1964) used (3) to predict the development of desiccation cracks in soft soil samples. Lambe and Whitman (1969) used (3) to predict the crack depth due to lowering of the ground-water level for a normally consolidated soil layer that has a zero tensile strength. In a soil having no tensile strength, vertical desiccation cracks can open only when the total lateral stress vanishes, that is, only atmospheric pressure acts on the face of an open crack. Thus, the total stress state for this case is at N, which is on the $\sigma_h = 0$ line (Fig. 2). However, the effective stress state is at Z, where the lateral effective stress is compressive and equal to the suction (negative pore-water pressure) at the moment the cracks open. If the soil possesses some tensile strength, a larger suction is needed to create cracks. In this case, the cracking criterion is reached at the total stress state M and the effective stress state B, as shown in Fig. 2. At that point, the soil element is at the cracking void ratio e_{cr} and the cracking vertical effective stress $\sigma'_{cr} = F_2(e_{cr})$.

The lateral effective stress is equal to $K_0\sigma'_v$, and the pore-water pressure is equal to $\sigma_v - \sigma'_v$. The lateral tensile stress $-\sigma_h$ at any depth is thus related to the vertical effective stress and the total vertical stress by

$$\sigma_h = \sigma_v + (K_0 - 1)\sigma'_v \tag{4}$$

Hence, a crack at any depth, which is characterized by a total vertical stress σ_v, initiates once the void ratio at that depth is reduced enough to reach the cracking void ratio e_{cr}, which can then be related to the total vertical stress by a cracking function G

$$e_{cr} = G(\sigma_v) \tag{5}$$

The cracking function is determined from (3) and (4) and the e-σ'_v relation during one-dimensional shrinkage.

Theoretically, the cracks should develop at the surface and propagate downward simultaneously and uniformly for a homogeneous soil layer. However, reported field observations indicate that a network of more or less regularly spaced cracks develops. Their spacing and pattern is influenced by small lateral variations in material characteristics (Lachenbruch 1962; Corte and Higashi 1964). Such variations should be expected in any natural soil deposit. At the beginning of crack opening, a fracture zone of small thickness develops in the weakest points of the soil layer, where the cracks later develop, and the soil is unloaded elastically from the lateral total tensile stresses outside the fracture zone (the unfractured zone), which later forms the cracked soil column. In the fracture zone, the total lateral tensile stress starts to decrease, and once this stress drops to zero (at point N in Fig. 2), the cracks fully develop or open, and the cracked soil columns separate completely (Abu-Hejleh 1993, Hillerborg et al. 1976). The total lateral tensile stresses in the fractured and unfractured zones drop uniformly, so that no lateral and vertical shear stresses arise in the soil mass during and after the development of cracks. Therefore, the drop of total lateral tensile stresses in any vertical plane during the development of cracks can be represented by the total stress path MN in Fig. 2, where the total stress state N indicates that the cracked soil columns are free from lateral stresses. Assuming that no suction changes occur during the development of cracks, the effective stress path during the tensile stress release can be represented by BV, which is parallel to the total stresss path MN as shown in Fig. 2.

Along path MN or BV, the soil layer is unloaded, and any associated volumetric changes could be neglected. This is a realistic assumption for desiccation of soft soils, for which these unloading strains are much smaller than the large strains during loading. Furthermore, these strains are insignificant when compared to those caused by a change in suction during three-dimensional shrinkage along effective stress path VS. Neglecting the volumetric changes during the development of cracks implies that the desiccation cracks initiate and open at the same void ratio e_{cr}. Eq. (5) can be used to calculate the distribution of e_{cr} along depth characterized by total vertical stress σ_v. With the known void ratio distribution e in the soil column (from the solution of the governing equation), the cracks propagate to a depth where $e = e_{cr}$. This depth defines the horizontal boundary between the cracked ($e < e_{cr}$) and uncracked ($e > e_{cr}$) soil columns.

Neglecting the volumetric changes during the development of cracks implies also that the three-dimensional shrinkage in the cracked soil columns can be represented with the incremental isoptropic effective stress path BU shown in Fig. 2. This "free" three-dimensional shrinkage is attributed to change in suction only under a constant total vertical stress. For soil elements under different total vertical stresses, consolidation and desiccation follow the K_0 line up to cracking, and then three-dimensional shrinkage starts at different values of e_{cr} [determined by (5)] and σ'_{cr} [determined as $F2(e_{cr})$], and continues along different incremental isotropic effective stress paths. Some difference in the constitutive relations for one-dimensional shrinkage along the K_0 line and three-dimensional shrinkage along the incremental isotropic effective stress paths could be expected. One-dimensional shrinkage should produce a more dispersed structure with the parallel orientation of the particles, while during the three-dimensional shrinkage a flocculated structure could be expected, since lower shear stresses should develop at the particle interfaces. Thus, unlike the unique void ratio–vertical effective stress relation used to represent the compressibility relation along the K_0 compression line, the void ratio–vertical effective stress relations along different incremental isotropic effective stress paths are expected to be a function of the void ratio at which the three-dimensional shrinkage starts

$$\sigma'_v = F_3(e, e_{cr}) \tag{6}$$

The compressibility functional predicts only the current void ratio during three-dimensional shrinkage. Another functional, $\alpha(e, e_{cr})$, is defined to characterize the proportion of vertical and lateral deformations along the incremental isotropic effective stress paths from the beginning of three-dimensional shrinkage where $e = e_{cr}$ to a current void ratio e (e.g., from state B to state U in Fig. 2). For a soil element with a unit initial area and a unit solid volume, the three-dimensional free shrinkage reduces its volume from $1 + e_{cr}$ to $1 + e$ and the height from $1 + e_{cr}$ to $(1 + e_{cr})[1 - \varepsilon_v(e, e_{cr})]$, where $\varepsilon_v(e, e_{cr})$ is the vertical strain from the beginning of three-dimensional shrinkage. Functional $\alpha(e, e_{cr})$ is defined as the area of this element, or the volume of this element over its height

$$\alpha(e, e_{cr}) = \frac{1 + e}{(1 + e_{cr})[1 - \varepsilon_v(e, e_{cr})]} \tag{7}$$

Note that α is equal to unity (area) during consolidation and desiccation up to cracking. If e_{cr} and e can be determined at any depth during three-dimensional shrinkage and used to determine $\alpha(e, e_{cr})$, the specific area of cracks at that depth, defined as the area of cracks per unit area, can be predicted by

$$S_c(e, e_{cr}) = 1 - \alpha \tag{8}$$

Formulation of Governing Equation

The derivation of the governing equation for the overall consolidation and desiccation process follows the lines of Gibson et al. (1967). The main difference is the treatment of the desiccation process under three-dimensional shrinkage. The soil column at the origin of time $t = 0$ and the deformed soil column at some subsequent time t are shown in Figs. 3 (a and b), respectively. As shown in these figures, the vertical Lagrangian (initial) and current coordinates, designated as a_1 and ξ_1, respectively, are taken positive against the gravity from a reference datum plane, where the vertical deformations are zero; and the reference datum plane for the lateral (radial) Lagrangian and current coordinates, designated as a_2 and ξ_2, respectively, are taken from the centerline of the soil columns, where the lateral deformations are zero. The derivation is presented for an element WXYZ in the initial and deformed soil columns whose boundaries always encompass the same volume of soil solid particles. At $t = 0$, the soil element is located at the Lagrangian coordinate a_1, has unit area, a thickness of δa_1 and a void ratio of e_i. The deformed soil element at time t is located at the current coordinate ξ_1, has an area equal to α (see the definition of α), a thickness of $\delta\xi_1$, and a current void ratio of e. Since the same volume of solids is encompassed by the element in the initial and current conditions

$$\frac{\delta a_1}{1 + e_i} = \frac{\alpha\delta\xi_1}{1 + e} \tag{9}$$

Thus, for an infinitesimal element, (9) is reduced to

$$\frac{\partial a_1}{\partial \xi_1} = \frac{\alpha(1 + e_i)}{(1 + e)} \tag{10}$$

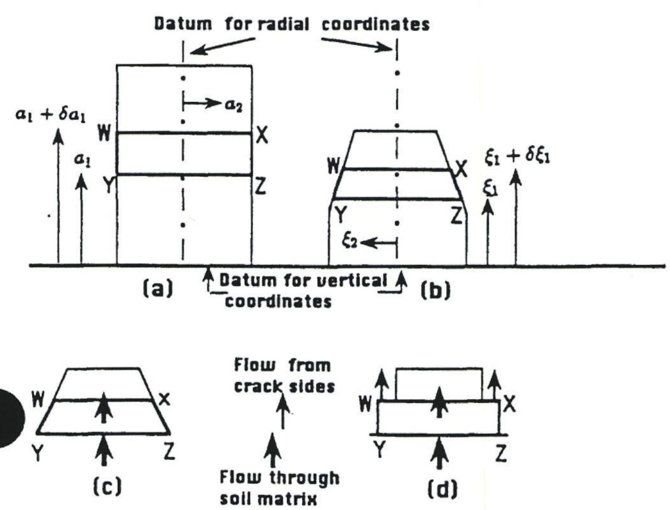

FIG. 3. Soil Element in Initial and Current Coordinate Systems

The equilibrium equation, the flow equation, the effective stress principle, and the continuity equation are used in the derivation of the governing equation.

Since no lateral shear stresses develop in the soil mass during three-dimensional shrinkage, the total vertical stresses are equal at all radii of the soil column. The vertical equilibrium equation is given as

$$\frac{\partial\sigma_v}{\partial\xi_1} = -\gamma = -\frac{\dfrac{\alpha\delta\xi_1}{1 + e}(\gamma_s + e\gamma_w)}{\alpha\delta\xi_1} = -\frac{e\gamma_w + \gamma_s}{1 + e} \tag{11}$$

where γ, γ_w and γ_s = unit weights of water-solid mixture, water phase, and solid phase, respectively. With (10), the equilibrium equation in Lagrangian coordinate system is obtained as

$$\frac{\partial\sigma_v}{\partial a_1} = -\frac{(e\gamma_w + \gamma_s)}{\alpha(1 + e_i)} \tag{12}$$

The principle of effective stress is

$$\sigma_v' = \sigma_v - u = \sigma_v - u_s - u_e \tag{13}$$

where u = pore-water pressure, which is the sum of the static pore-water pressure, u_s and the excess pore water u_e. Note that $\partial u_s/\partial\xi_1 = -\gamma_w$.

Using Darcy's Law in terms of the apparent relative velocity between the water and solid phases (Gibson et al. 1967), the flow equations in the vertical and lateral directions are given by

$$q_1 = n(v_{w1} - v_{s1}) = -\frac{k}{\gamma_w}\frac{\partial u_e}{\partial\xi_1};$$

$$q_2 = n(v_{w2} - v_{s2}) = -\frac{k}{\gamma_w}\frac{\partial u_e}{\partial\xi_2} \tag{14}$$

where q_1, q_2 = apparent relative velocities between the water and solid phases in the vertical and lateral directions, respectively; n = porosity; v_{w1} and v_{s1} = velocities of the water and solid phases in the vertical direction; and v_{w2} and v_{s2} = velocities of the water and solid phases in the lateral direction. The v_{s2} and v_{w2} are zero during consolidation and desiccation up to cracking, and are assumed equal to each other during three-dimensional shrinkage, so that the relative flow velocity between the water and solid phases in the lateral direction q_2 is always zero. Consequently, the excess pore-water pressures as well as the vertical effective stresses are equal at all radii of the cracked and uncracked soil columns. The flow equation in the vertical Lagrangian coordinate system can be obtained from (14), (13), and (10) as

$$q_1 = -k - \frac{k}{\gamma_w}\frac{\alpha(1 + e_i)}{(1 + e)}\left(\frac{\partial\sigma_v}{\partial a_1} - \frac{\partial\sigma_v'}{\partial a_1}\right) \tag{15}$$

From (6)

$$\frac{\partial\sigma_v'}{\partial a_1} = \frac{\partial\sigma_v'}{\partial e}\frac{\partial e}{\partial a_1} + \frac{\partial\sigma_v'}{\partial e_{cr}}\frac{de_{cr}}{d\sigma_v}\frac{\partial\sigma_v}{\partial a_1} \tag{16}$$

By substituting (16) and (12) in (15), q_1 can be expressed as

$$q_1 = -k + \frac{k}{\gamma_w}\frac{(e\gamma_w + \gamma_s)}{1 + e}\left(1 - \frac{\partial\sigma_v'}{\partial e_{cr}}\frac{de_{cr}}{d\sigma_v}\right)$$

$$+ \frac{k}{\gamma_w}\frac{\alpha(1 + e_i)}{(1 + e)}\frac{\partial\sigma_v'}{\partial e}\frac{\partial e}{\partial a_1} \tag{17}$$

For any values of e and e_{cr}; $\partial\sigma_v'/\partial e_{cr}$ and $\partial\sigma_v'/\partial e$ can be determined from (6), and $de_{cr}/d\sigma_v$ can be determined from (5). The $\partial\sigma_v'/\partial e_{cr}$ arises from the fact that the void ratio–effective stress relation is not a unique function for the material during three-dimensional shrinkage but depends on the void ratio at which the three-dimensional shrinkage starts. Thus, in calculating the gradient of the effective stress, the chain rules of derivatives are observed.

Finally, the continuity equation of the mixture of water and solid phases is derived for element WXYZ. This element is deforming in the space with a speed of $\partial\xi_1/\partial t$ in the vertical direction and a speed of $\partial\xi_2/\partial t$ in the lateral direction. Since the volume of solids in this element does not change with time, that is, no solid flows into or out of the element in the vertical and lateral directions, it is required that $v_{s1} = \partial\xi_1/\partial t$ and $v_{s2} = \partial\xi_2/\partial t$. Also, since $v_{w2} = v_{s2}$, there is no flow of water into or out of element WXYZ in the lateral direction. The volume of water that flows into the element shown in Fig. 3(c) through section YZ in a period of δt is

$$\alpha n(v_{w1} - v_{s1})\delta t = \alpha q_1 \delta t \tag{18}$$

and the volume of water that flows out of the element through section WX is

$$\alpha q_1 \delta t + \frac{\partial(\alpha q_1)}{\partial \xi_1}\delta\xi_1\delta t \tag{19}$$

The volume of water stored in the element over δt must equal the net change in the volume of water in the element over δt, so that

$$-\frac{\partial(\alpha q_1)}{\partial \xi_1}\delta\xi_1\delta t = \frac{\alpha\delta\xi_1}{1+e}\frac{De}{Dt}\delta t \tag{20}$$

where $(\alpha\delta\xi_1 e)/(1+e)$ = volume of water in the element; $(\alpha\delta\xi_1)/(1+e)$ = constant volume of solids in the element; and De/Dt = material derivative of the void ratio (McVay et al. 1986) that models properly the change of void ratio with time for moving soil elements

$$\frac{De}{Dt} = \frac{\partial e}{\partial t} + \frac{\partial e}{\partial \xi_1}v_{s1} + \frac{\partial e}{\partial \xi_2}v_{s2} = \frac{\partial e}{\partial t} + \frac{\partial e}{\partial a_1}\frac{\partial a_1}{\partial t} + \frac{\partial e}{\partial a_2}\frac{\partial a_2}{\partial t} \tag{21}$$

Considering (10) and that $\partial a_1/\partial t = 0$ and $\partial a_2/\partial t = 0$, the continuity equation for the water-solid mixture in the Lagrangian coordinate system can be obtained as

$$\frac{\partial(q_1\alpha)}{\partial a_1} + \frac{1}{(1+e_i)}\frac{\partial e}{\partial t} = 0 \tag{22}$$

Assuming that α is constant across $\delta\xi_1$, as shown in Fig. 3(d), the continuity equation can be simpfilied to

$$\frac{\partial q_1}{\partial a_1} + \frac{1}{\alpha(1+e_i)}\frac{\partial e}{\partial t} = 0 \tag{23}$$

It is considered in the derivation of (22) that there is no flow of water relative to the solid phase across the crack sides [see Fig. 3(c)]. This is not the case with (23) [see Fig. 3(d)], since a flow of $q_1\Delta\alpha$ is lost across the crack sides of the element, where $\Delta\alpha$ is the projected area of the element crack sides in the vertical direction. The condition represented by (22) is suitable for modeling desiccation due to lowering the ground-water level, where the downward water flow is limited to the soil matrix, and the crack sides can be considered impermeable. Since the water is lost through evaporation from both the soil layer surface as well as the crack sides, the condition represented by (23) should be reasonable for modeling desiccation due to surface drying, especially if the evaporation rate from the crack sides is close to the calculated water flux in the soil matrix near to the crack sides. For the former case, it is found that both continuity equations lead to almost identical results, and, therefore, (23) is adopted in the further analysis.

The governing nonlinear partial differential equation can be obtained by combining (17) and (23)

$$\frac{\partial}{\partial a_1}\left[k - \frac{k}{\gamma_w}\frac{(e\gamma_w + \gamma_s)}{1+e}\left(1 - \frac{\partial\sigma'_v}{\partial e_{cr}}\frac{de_{cr}}{d\sigma_v}\right)\right]$$
$$- \frac{\partial}{\partial a_1}\left[\frac{k}{\gamma_w}\frac{\alpha(1+e_i)}{(1+e)}\frac{\partial\sigma'_v}{\partial e}\frac{\partial e}{\partial a_1}\right] = \frac{1}{\alpha(1+e_i)}\frac{\partial e}{\partial t} \tag{24}$$

For the consolidation and desiccation up to cracking, $\alpha = 1$ and the void ratio–effective stress relation is a unique function for the material so that $\partial\sigma'_v/\partial e_{cr} = 0$. Applying these conditions to (24), the equation derived by Gibson et al. (1967) in the finite-strain consolidation theory is obtained

$$-\left(\frac{\gamma_s}{\gamma_w} - 1\right)\left[\frac{d}{de}\left(\frac{k}{1+e}\right)\right]\frac{\partial e}{\partial a_1}$$
$$- \frac{\partial}{\partial a}\left[\frac{k}{\gamma_w}\frac{1+e_i}{(1+e)}\frac{d\sigma'_v}{de}\frac{\partial e}{\partial a_1}\right] = \frac{1}{1+e_i}\frac{\partial e}{\partial t} \tag{25}$$

While (25) models the one-dimensional soil response during the consolidation and desiccation processes in the uncracked soil columns, (24) is the governing equation for the overall consolidation and desiccation process in the cracked and uncracked soil columns.

EXPERIMENTAL RESULTS

As stated in the theoretical development and in the derivation of the governing equation, several material functions are required in the solution process of a certain field situation. These included three pairs of compressibility and permeability relations for consolidation, desiccation under one-dimensional shrinkage, and desiccation under three-dimensional shrinkage. In addition, the cracking function G and the α functional are required. All of these constitutive and cracking functions are determined from laboratory tests that were developed earlier or from new experiments developed as a part of this research. The void ratio–effective stress and void ratio–permeability relations during the consolidation phase of the process are obtained from the seepage-induced consolidation testing and analysis (Znidarčić and Liu, 1989; Liu, 1990; Abu-Hejleh and Znidarčić, 1994).

The desiccation compressibility and permeability characteristics are obtained from a suction test in which the water is removed from the bottom of a sample in the oedometer using a flow pump to control precisely the outflow rate (Abu-Hejleh 1993). Capillary menisci develop at the sample top, creating an effective stress increase and the corresponding sample compression. Since the sample remains saturated in the test, the sample volume change is equal to the withdrawn volume of water, and this change is used to estimate the sample average void ratio at various testing times. The applied suction at the bottom of the sample is measured with a precision transducer and used to estimate the sample bottom effective stress at various testing times. For the slow withdrawal flow rate, the effective stress within the sample is uniform, and, therefore, the desiccation effective stress–void ratio relation is determined directly from the obtained test results. Desiccation compressibility characteristics along the K_0 line are obtained from samples that are laterally confined in order to produce one-dimensional shrinkage response only. Desiccation compressibility characteristics along the isotropic effective stress path (after cracking) are obtained from unconfined samples that are allowed to shrink freely in the lateral and vertical directions. To obtain material characteristics for varying cracking void ratios, several preconsolidated samples with different void ratios are prepared and then tested.

A suction test with a higher withdrawal flow rate is performed on the same material in order to produce a measureable pore pressure gradient within the sample. The generated gradient depends on the material permeability characteristics. With the known desiccation effective stress–void ratio relation, the obtained experimental results under the higher flow rate are used to evaluate indirectly the desiccation void ratio–permeability relationship. The test analysis follows the inverse problem solution algorithm equivalent to the one used in the analysis of the seepage induced consolidation test (Abu-Hejleh and Znidarčić 1994).

The obtained void ratio–effective stress relations for soft china clay during consolidation, one-dimensional shrinkage,

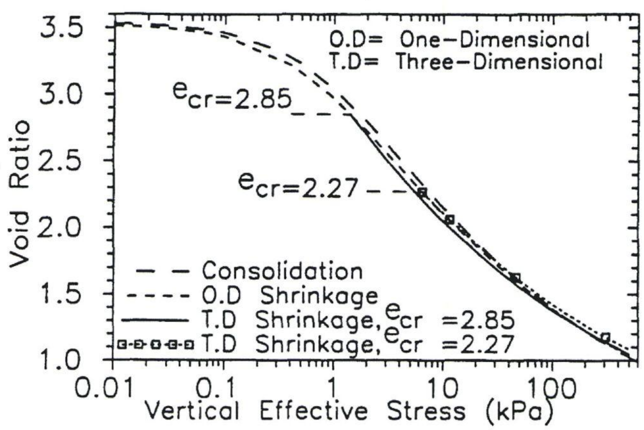

FIG. 4. Consolidation and Desiccation Compressibility Characteristics for Soft China Clay

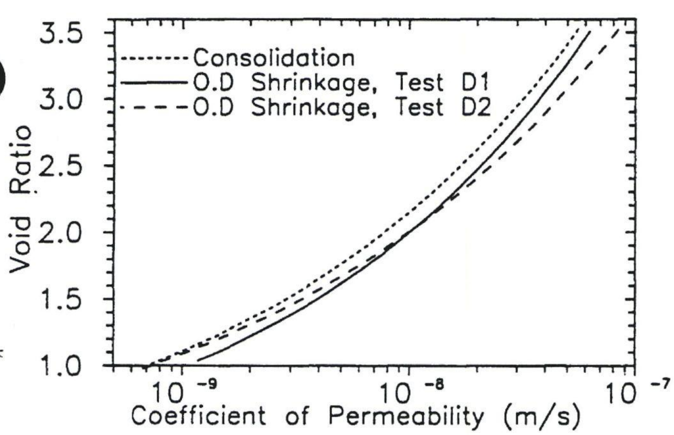

FIG. 5. Consolidation and Desiccation Permeability Characteristics for Soft China Clay

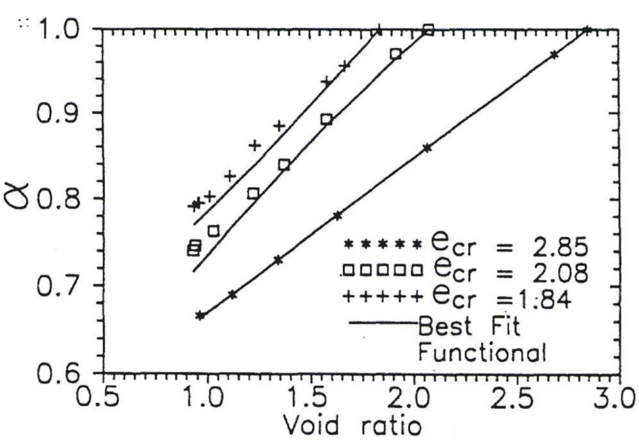

FIG. 6. Functional $\alpha(e, e_c)$ for China Clay during Three-Dimensional Shrinkage

and three-dimensional shrinkage are presented in Fig. 4. The graphical results indicate that these three relationships are very close to each other and could be assumed identical. The obtained permeability characteristics for soft china clay during consolidation and desiccation under one-dimensional shrinkage are presented in Fig. 5. Again, similar permeability characteristics during consolidation and desiccation can be noticed. While accepting that these two last conclusions lead to a simpler analysis, the obtained results for a single material should not be taken as a general rule. More tests on other soft cohesive materials should be made before general conclusions regarding their consolidation and desiccation behavior is made. The permeability during three-dimensional shrinkage is assumed to have the same permeability–void ratio relationship as during one-dimensional shrinkage. This assumption is justified by the similar compressibility characteristics for the two desiccation phases of the process.

The free shrinkage test provides the experimental data needed for the determination of functional α (Abu-Hejleh 1993). In this test, a soil sample is left to shrink vertically and laterally freely without the presence of any external constraint, and both vertical and lateral deformations are measured. Preconsolidated soil samples, with different void ratios, are prepared for this test. The experimentally obtained values of $\alpha(e, e_{cr})$ for three soft china clay samples, with three different initial void ratios, were fitted with an analytical function. Fig. 6 shows the data of α together with the fitted functional.

Finally, the evaluation of the tensile strength function and the corresponding cracking function G are needed in the analysis. The tensile strength, like the shear strength, is a function of the vertical effective stress or void ratio. Its experimental determination is quite difficult and no routine tests exist for its measurement. Thus, the tensile strength is here related to the shear strength that could be determined from routine tests. The factor F is defined as $F = \sigma_t/S_u$, where S_u is the undrained shear strength. For example, the experimentally obtained undrained shear strength–void ratio relation for china clay by Znidarčić et al. (1992) was used to estimate the tensile strength–void ratio relation as

$$\sigma_t = F10^{(1.945 - e/0.435)} \tag{26}$$

The exponential relation between the tensile strength and void ratio in (26) confirms the published data (Williams and Sibley 1992; Farrel et al. 1967). While the lower limit for F is zero, the range of unconfined compressive strength to tensile strength reported by Lau (1987) suggests that an appropriate upper limit value for F is 0.5.

To relate the development of the total lateral tensile stresses in china clay to the void ratio and the total vertical stress

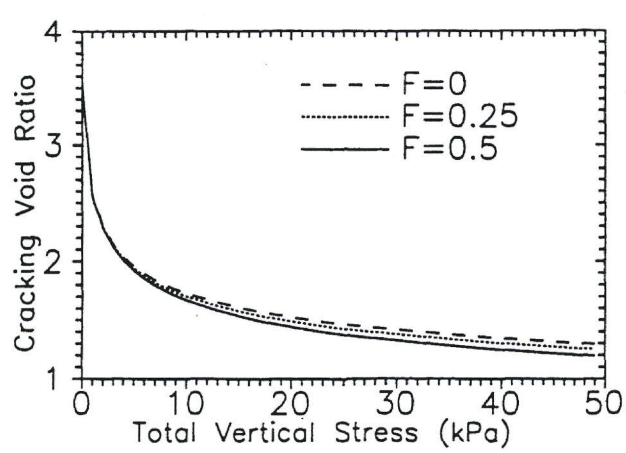

FIG. 7. Cracking Function for Soft China Clay

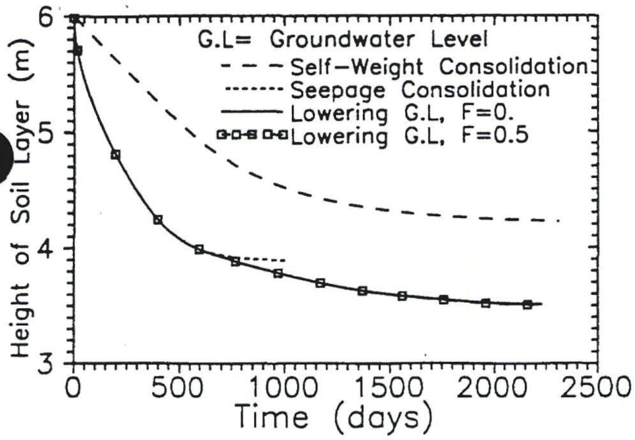

FIG. 8. Progress of Settlement with Time during Self-Weight Consolidation, Seepage-Induced Consolidation, and Lowering Ground-Water Level

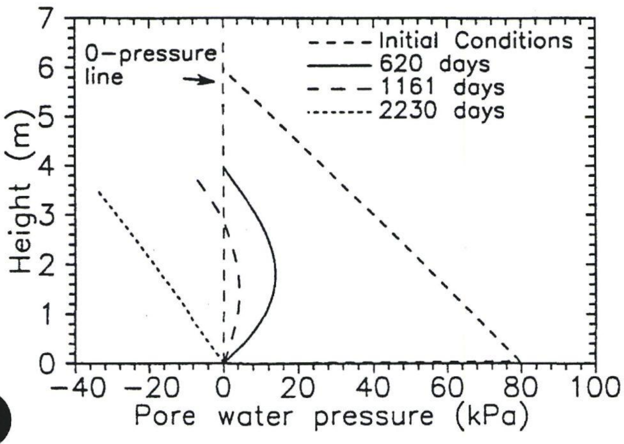

FIG. 9. Profiles of Pore-Water Pressure during Lowering Ground-Water Level

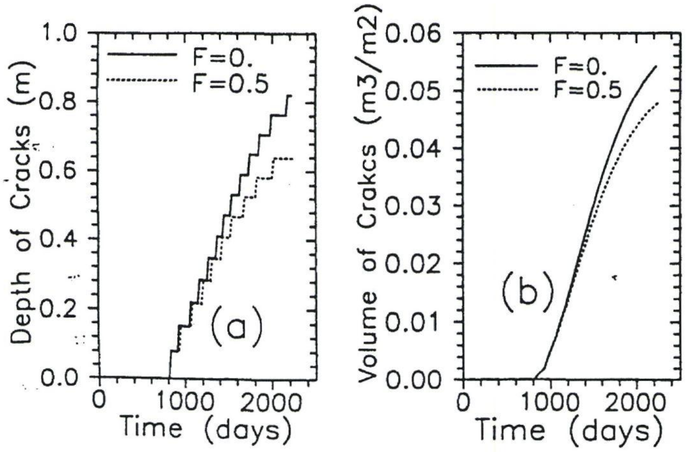

FIG. 10. Progress of (a) Crack Depth and (b) Volume of Cracks per Unit Area with Time during Lowering Ground-Water Level

only, the experimentally obtained K_0 value of 0.67 (Hutapea et al. 1992) and $e - \sigma'_v$ function during one-dimensional shrinkage are substituted in (4). Subsequently, the cracking function for china clay, $e_{cr} - \sigma_v$ relation, is obtained by substituting (26) and (4) in (3). Graphical forms of the obtained cracking functions for china clay with $F = 0$, $F = 0.25$, and $F = 0.5$ are shown in Fig. 7. Alternatively, the cracking function can be evaluated from desiccation experiments in which a soil sample is allowed to crack during the desiccation process. Since the cracking characteristics are dependent on the stress level, as (5) implies, a convenient way for obtaining these characteristics is to conduct the desiccation experiment in the geotechnical centrifuge under an increased gravity level that properly simulates the stress level in the field.

EVALUATION OF THEORY

The theory has been implemented in an efficient nonlinear finite-element computer program, called CADA (Consolidation And Desiccation Analysis). The numerical solution predicts profiles of void ratio, cracking void ratio, and total vertical stress along the vertical Lagrangian coordinate at each time step. By transforming the coordinates from Lagrangian to the current coordinates as expressed in (10), the settlement-time curve and profiles of effective stress, void ratio, pore-water pressure, and the specific area of cracks along the current depth are determined. The depth of vertical desiccation cracks is determined by the location of $e = e_{cr}$. The specific volume of cracks, defined as the volume of cracks per unit area, is evaluated by the numerical integration of the distribution of specific area of cracks along the crack depth.

A hypothetical soft china clay disposal site was used to demonstrate main features of the theory. The initial height of the soil layer is 6 m and the initial uniform distribution of void ratio corresponds to the zero effective stress void ratio for the soil, $e = 3.53$. The experimentally obtained consolidation and desiccation constitutive relations and cracking function for soft china clay are used in the analysis. Fig. 8 shows the time-settlement curves for the self-weight and seepage-induced consolidation of the layer. For the self-weight consolidation an undrained bottom boundary was assumed, and for the seepage induced consolidation a bottom drainage layer with zero pore pressure was considered. For both cases, zero effective stress void ratio, $e = 3.53$, is imposed at the top boundary throughout the process, since the soil layer surface should remain covered with water in these two scenarios. The beneficial effect of the bottom drainage layer in accelerating the rate of consolidation is evident in Fig. 8.

Lowering Ground-Water Level

Fig. 8 also presents the time-settlement curve for the case in which the downward water flow causes the lowering of the ground-water table. Initially, the boundary conditions are equal to those in the seepage-induced consolidation case. Once the upward flow at the top boundary ceases, an impervious boundary is imposed. That reflects the absence of any evaporation from, or additional infiltration into, the soil layer. Capillary suction develops at the surface with time, and the ground-water table with zero pore pressure moves downward. Ultimately, the water table reaches the bottom boundary and the hydrostatic suction distribution is established within the layer. Pore-pressure profiles are presented in Fig. 9, while the development of crack depth and specific volume with time are presented in Figs. 10(a and b). The results show that the suction will develop at the surface after 620 days and that the tensile strength, as related to the F-value, has only a slight influence on the progress of settlement as well as on the crack depth and specific volume of cracks.

Surface Drying

Surface drying is caused by the evaporation at a rate that depends on the climatic conditions at a given site. The evaporation has no effect as long as the upward surface-water flow, resulting from the self-weight consolidation of the soil layer, exceeds the evaporation rate. Once the flow rate drops below the evaporation rate, the desiccation process starts and continues until the top void ratio reaches the shrinkage limit.

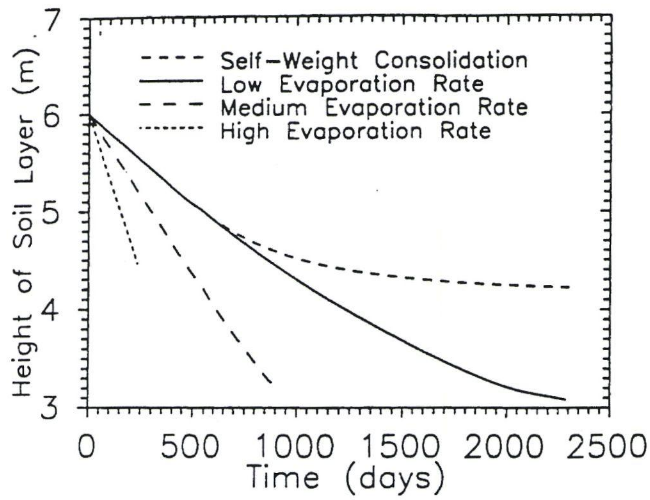

FIG. 11. Progress of Settlement with Time during Self-Weight Consolidation and Surface Drying

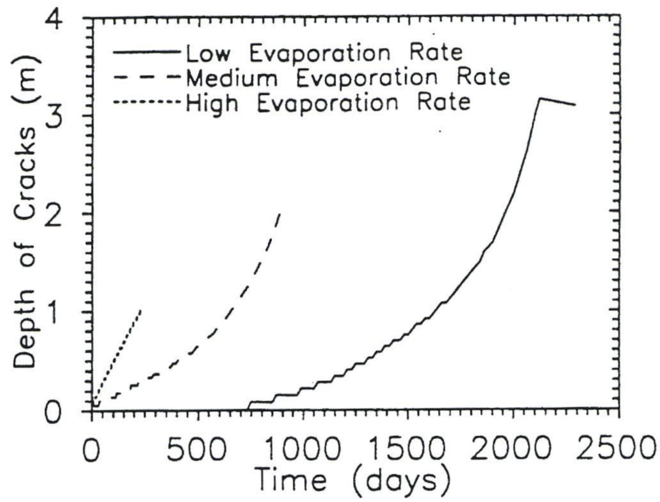

FIG. 14. Progress of Crack Depth with Time during Surface Drying

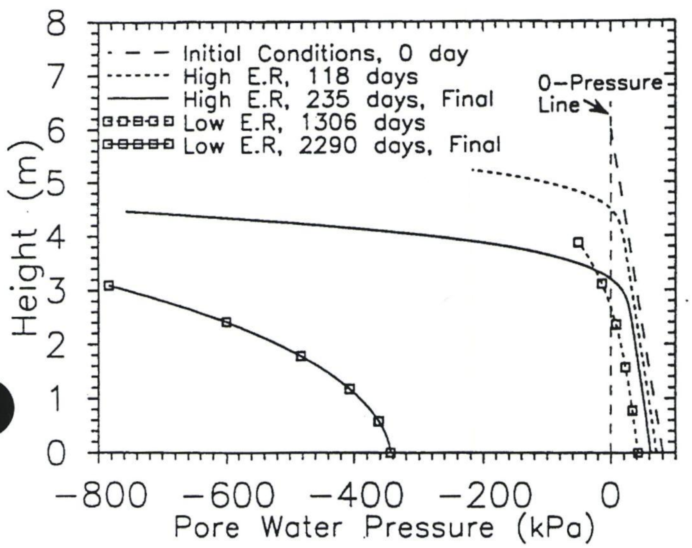

FIG. 12. Profiles of Pore-Water Pressure during Surface Drying

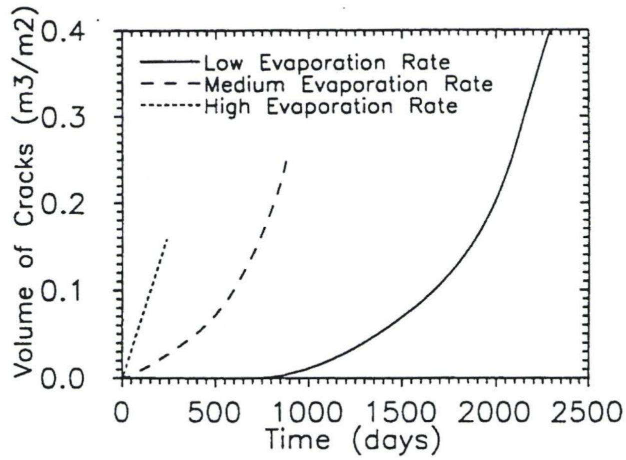

FIG. 15. Progress of Volume of Cracks with Time during Surface Drying

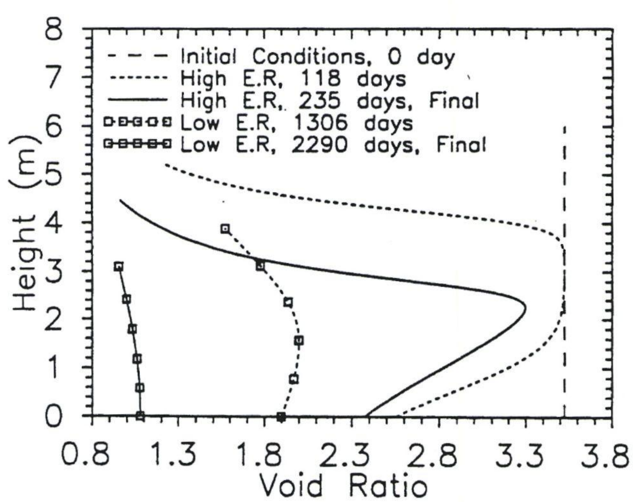

FIG. 13. Profiles of Void Ratio during Surface Drying

At that point, the soil starts to desaturate but without any associated volume change, as demonstrated in the shrinkage curve shown in Fig. 1. The present theory does not model this phase and the numerical analysis is terminated at that point. It should be noted that the actual physical process terminates as well, shortly after the shrinkage limit is reached, since the permeability of the desaturated soil at the surface is drastically reduced, creating an impervious crust that prevents further evaporation (Johnson et al. 1977).

The surface drying of the soft china clay layer is modeled with three surface evaporation rates: a low value of 1.87×10^{-8} m/s, a medium value of 4×10^{-8} m/s, and a high value of 8.5×10^{-8} m/s. The bottom boundary is assumed impervious while the top boundary has zero effective stress for the consolidation phase (as in the self-weight consolidation) and an imposed outflow rate equal to the evaporation rate in the desiccation phase. The results of the analyses are presented in Figs. 11–14. The void-ratio and pore-water pressure distributions clearly indicate the creation of a desiccated crust at the soil surface whose thickness and strength (void ratio) depend on the evaporation rafe. The slower the evaporation rate, the thicker the crust. The time settlement and the crack-depth curves demonstrate that the shrinkage limit void ratio, $e = 0.96$, is reached at the surface faster under the higher evaporation rates and that the desiccation process is terminated sooner. This might lead to the apparent paradox that the lower evaporation rate creates a larger overall compression. Again, this is easily explained by the sealing effect of the desiccated crust at the shrinkage limit. For example, as Figs. 11–13 indicate for the high evaporation rate, the desiccated crust can seal the soil surface even before the self-weight consolidation is completed, leaving a soft unconsolidated soil zone under a thin crust and preventing further dissipation of the excess pore-water pressures. Thus, the higher evaporation rates can have a detrimental effect on the overall consolidation and desiccation process.

As demonstrated in Figs. 14 and 15, the higher evaporation rate creates more-shallow cracks with smaller volume than the lower rate. Since the crack spacing is related directly to the crack depth (Lachenbruch 1962), a thin and highly fractured crust should be expected for this case, and thicker crust with more widely spaced cracks should be expected under the lower evaporation rates. The volume of cracks resulting from surface drying increase with the decrease of the evaporation rate.

CONCLUSIONS

The described desiccation theory provides a rational framework for the analysis of the overall consolidation and desiccation process of soft fine-grained soil in the field after deposition. The presented experimental results support the fundamental assumptions of the theory. The numerical analysis provides the rate of vertical and lateral deformations for a soil layer undergoing consolidation and desiccation, void-ratio and pore-water pressure distributions throughout the process, and the thickness and strength (from the void ratio) of the desiccated crust that forms at the soil surface.

The presented examples demonstrate that the theory is in qualitative agreement with the reported observation of the behavior of desiccating soil layers. The predicted relation between the evaporation rate and the thickness of the surface crust, as well as the depth and intensity of cracks are confirmed by many field observations (Mitchell 1988; Blight 1988; Johnson et al. 1977; Lachenbruch 1962; Corte and Higashi 1964). However, the quantitative verification of the theory requires additional experimental work in which a soft material is tested to obtain relevant material characteristics, and then the analysis results are compared to a well-controlled model experiment and ultimately to a field case. The centrifuge modeling technique provides an excellent tool for the confirmation, especially in terms of verifying the crack-formation mechanism. Short of an actual well-controlled field case, it is probably the only technique available to study crack development, since the field stress conditions that control crack propagation are properly simulated in the centrifuge models.

Several benefits are envisioned in applying the developed theory to analyzing various strategies in mine and dredging waste disposal. First, the theory can provide information on how to maximize simultaneously the benefits of the self-weight consolidation and desiccation for varying environmental evaporation conditions and slurry deposition rates. The second application is in predicting the strength and thickness of the desiccated crust for the final reclamation of the disposal site as well as in the intermediate stages in the staged filling operations. The third, and possibly the most beneficial, application is in providing a rational tool for evaluating possible aggressive disposal-management strategies prior to their trial implementation in the field. For example, the benefits of intermediate drainage layers sandwiched between the layers during the slurry deposition in accelerating the consolidation process and extending the influence of surface drying to larger depths inside the soil layer could be evaluated.

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APPENDIX II. NOTATION

The following symbols are used in this paper:

a_1 and a_2 = Lagrangian coordinates in vertical and lateral directions, respectively;
e = void ratio;
e_{cr} = cracking void ratio, and void ratio at beginning of three-dimensional shrinkage;
e_i = initial void ratio;
F = ratio of tensile strength to undrained shear strength;
F_1, F_2 = compressibility functions;
F_3 = compressibility functional;
G = cracking function;
K_0 = coefficient of lateral earth pressure at rest;
k = coefficient of permeability;
Q_1 and Q_2 = permeability functions;
q_1 and q_2 = apparent relative velocity between waste and solid phases in vertical and lateral directions, respectively;
S_c = specific area of cracks;
t = time;
u = pore-water pressure;
u_e = excess pore-water pressure;
u_s = static pore-water pressure;
v_{w1} and v_{w2} = velocities of water phase in vertical and lateral directions, respectively;
v_{s1} and v_{s2} = velocities of solid phase in vertical and lateral directions, respectively;
α = functional used to characterize proportion of vertical and lateral deformation during three-dimensional shrinkage;
γ, γ_w, and γ_s = unit weight of water-solid mixture, water phase, and solid phase, respectively;
δa_1, $\delta\xi_1$ = thickness of small soil element in initial and current coordinates, respectively;
δt = small time step;
$\varepsilon_v(e, e_{cr})$ = vertical free strain from beginning of three-dimensional shrinkage;
ξ_1 and ξ_2 = current coordinates in vertical and lateral directions, respectively;
σ'_{cr} = cracking vertical effective stress, and vertical effective stress at beginning of three-dimensional shrinkage;
σ_h = total lateral stress;
σ_t = tensile strength;
σ'_v = vertical effective stress; and
σ_v = total vertical stress.

Consolidation Characteristics of Phosphatic Clays

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Abstract: Reliable and convenient testing technique and analysis are used to evaluate the void ratio-effective stress and void ratio-permeability relations for several types of very soft phosphatic waste clays. The technique is based on the seepage-induced consolidation test in which a soft soil sample is subjected to a constant downward flow rate and its final consolidated height and bottom effective stress are measured as the sample reaches steady state conditions. These two data points and the measured zero effective stress void ratio represent three reliable experimental data in the low range of effective stress, where the consolidation constitutive relations are highly nonlinear. In the higher effective stress range, the loading and permeability tests are used to determine the coefficient of permeability and effective stress corresponding to a given void ratio. An efficient algorithm to describe the steady-state flow in soft soils and a parameter-estimation scheme are employed for the determination of the soil consolidation parameters needed in the finite strain consolidation theory. The laboratory data of the restricted flow test and the transient seepage-induced consolidation test and the field measurements in three phosphatic clay settling ponds confirm the results obtained from the seepage-induced consolidation testing and analysis.

INTRODUCTION

It is estimated that 30% of the world's phosphate is produced in the state of Florida, leading to the creation of large quantities of very soft, fine, and highly plastic phosphatic waste clays (McVay et al. 1986). According to Carrier et al. (1983), more than 50,000,000 t (dry weight) of such waste materials are generated annually in Florida's phosphate industry. The resulting slurry waste clay is typically pumped into large retention ponds at an initial void ratio of between 40 and 130. Within a few days to a few weeks after deposition, the sedimentation of the suspended soil particles brings the slurry clay to the zero effective stress void ratio, e_0, at which a soil is formed and the effective stress principle begins to apply. At that point, the very long consolidation process starts and might continue for decades. The soil formation void ratio, e_0, is not a material constant but depends on the initial slurry void ratio (Liu 1990). Carrier et al. (1983) listed typical values of e_0 for various fine-grained waste materials, with a value of around 30 for the phosphatic waste clays. The magnitude of densification that a deposit of soft soil undergoes during the consolidation phase is directly dependent on the soil void ratio-effective stress relation and the time-dependent progress of densification is directly dependent on the soil permeability-void ratio relation. Many computer models, based on finite strain consolidation analysis, have proven to be valuable tools in planning disposal site capacity, predicting the time at which site reclamation is technically feasible, and predicting the development of soil shear strength. However, the success of such analyses depends on the accuracy of the input data, especially the consolidation constitutive relations.

The changes of void ratio and permeability with the effective stress are very significant for soft phosphatic waste clays and other fine-grained materials, especially in the early stages of consolidation when the effective stresses are low. The direct determination of the consolidation characteristics for such soils is difficult if not impossible to achieve (Znidarčić 1982). For example, the application of a constant hydraulic gradient across a sample to measure its permeability results in a varying effective stress along the sample depth. For a very soft soil sample in the low effective stress range, this variation in effective stress produces a nonuniform void ratio distribution, and, therefore, the permeability within the sample changes significantly and can't be assumed constant. McVay et al. (1986) also concluded that the laboratory measurements for determining the permeability relationships of phosphatic clays were deficient, but that acceptable results for their compressibility relationships could be obtained from the tests. Indeed, reliable effective stress-void ratio relations for soft soils could be determined from the field measurements or laboratory tests, but only if the soil layer (or soil sample) is fully consolidated (e.g., Cargill 1986). Obtaining such data, however, requires excessive testing time for fine-grained soils. For example, Carrier et al. (1983) reported that the time needed to conduct a direct stress-controlled slurry consolidometer test on a Florida phosphatic clay sample is 6–7 months. To provide more practical and reliable methodology for the determination of the consolidation characteristics of soft soils, Znidarčić (1982) introduced the concept of the inverse solution (or indirect) approach, in which the variation of void ratio across the sample is recognized in the analysis.

Imai (1979) proposed a seepage induced consolidation test, in which, besides the self-weight of the specimen, a downward seepage force is imposed by creating a constant head difference across the specimen. The pore-water pressure within the sample is measured during the experiment and the void ratio distribution is obtained at the end of the test by slicing the specimen. From the obtained test data, the soil permeability-void ratio and effective stress-void ratio relations can be determined. Huerta et al. (1988) presented a new analysis for the seepage induced consolidation test, in which the inverse solution algorithm is adopted. While the two methods have enhanced our ability to determine the consolidation characteristics of soft soils, especially the permeability relation, they have not been widely used in practical applications. Both have some shortcomings that make their application difficult, or at least cumbersome. Imai's approach requires specialized equipment, for which the quality of the measured data is operator-dependent. In addition, the process of the determination of void ratio distribution is unreliable and may produce erroneous results. The analysis of the constant rate deformation technique sug-

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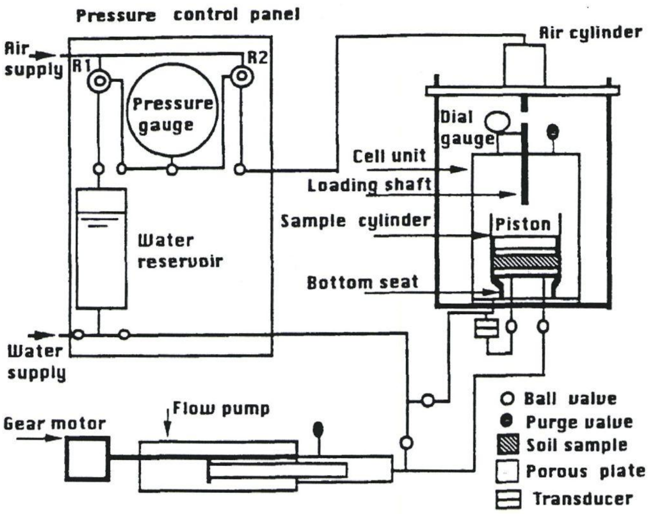

FIG. 1. Seepage-Induced Consolidation Testing Equipment

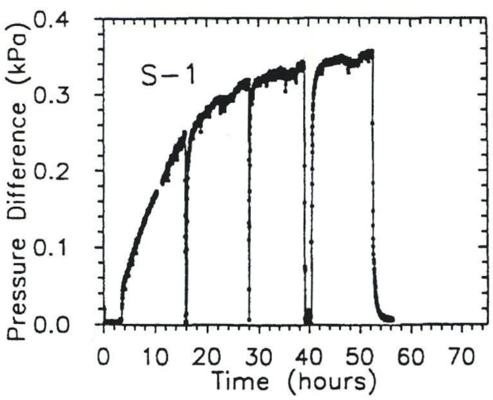

FIG. 2. Experimental Results of Seepage-Induced Consolidation Test on Sample S-1

gested by Znidarčić et al. (1986) is based on the linearized consolidation theory, which may not be appropriate for very soft, cohesive soils. In addition, the sensitivity of the developed equipment limits its application to stress levels above 1 kPa. The method proposed by Huerta et al. (1988) is the most comprehensive one, but still requires a direct measurement of the void ratio at the bottom of the sample and a precise determination of the steady-state flow rate. Both of these requirements make it a difficult and operator-dependent procedure. In addition, the associated analysis of the test results is inconvenient.

A reliable testing technique to evaluate the highly nonlinear consolidation constitutive relations of soft, cohesive soils was developed by Znidarčić and Liu (1989). The technique is based on the seepage induced consolidation test suggested originally by Imai (1979). This experiment has been enhanced and a new analysis has been developed (Abu-Hejleh and Znidarčić 1992; Znidarčić et al. 1992; Abu-Hejleh et al. 1992; and Abu-Hejleh and Znidarčić 1994). The new procedure eliminates most of the limitations of the existing methods. This paper presents the new version of the seepage induced consolidation testing and analysis and demonstrates its advantages over existing methods. Consolidation characteristics for several samples of very soft phosphatic clays obtained by the new procedure are also included. These characteristics are verified by utilizing independent experimental and field measurements.

EXPERIMENTS

The experimental part of the procedure consists of three distinct phases that all provide data for the test analysis. These include the determination of the zero effective stress void ratio, e_0, the steady-state stage of the seepage induced consolidation test, and the step loading test with the direct permeability measurements at high effective stresses.

A sufficient amount of the soft clay is thoroughly mixed at the consistency corresponding to the deposited characteristics at the beginning of the disposal. For the e_0 determination, two laboratory jars are filled with a 25 mm (1 in.) thick layer of the slurry clay and covered to prevent evaporation. The slurry clay is left for several days to settle. At the end of its consolidation, any supernatant is carefully removed and few samples are taken from the surface of the settled clay, where the effective stress is very close to zero, to determine e_0. The overall contribution of the sedimentation process in densifying the slurry clay can be estimated by the difference between the initial mixing void ratio and e_0.

The testing system for the seepage induced consolidation, step loading, and permeability tests consists of five major parts: a triaxial cell unit with a differential pressure transducer, a pressure control panel, a loading system, a flow pump, and a data acquisition system. A schematic diagram of the experimental apparatus is shown in Fig. 1. The testing system is self-contained and requires only electrical power and an air-pressure supply. The cell unit contains a transparent sample ring for housing the soft soil sample, a plastic piston, and a bottom seat that are equipped with a coarse porous plate, a loading shaft, and a dial gauge to measure the sample height. The pressure control panel has a dual purpose: to apply the necessary back pressure and to control the air pressure in the air cylinder for loading the sample in the step loading test. Two ports beneath the bottom seat connect the pore water at the bottom of the soil sample to the flow pump and to the transducer. The use of the flow pump facilitates a precise control of the flow rate through the sample. The pressure difference across the sample is measured with the precision differential pressure transducer connected to a personal computer–based data acquisition system to collect the data of pressure changes with time.

The slurry clay is poured into the transparent container and the loading piston is allowed to rest freely on top of the sample. The triaxial cell is filled with water and the entire testing system is saturated under a back pressure of 200 kPa. The slurry soil sample is left to consolidate overnight under both its own weight and the top effective stress produced by the plastic piston. Due to the piston's buoyancy, an effective stress of only 0.1 kPa is applied to the top sample boundary. This small surface load is used to prevent the creation of flow channels during the seepage induced consolidation test that would otherwise form in the sample (You 1993).

In the seepage induced consolidation test, a constant flow rate is imposed across the sample by withdrawing water from the bottom of the sample using the flow pump. Due to the downward flow of water, the sample consolidates and the resulting pressure difference across the sample increases with time. The pressure difference is continuously measured with the pressure transducer and recorded by the data acquisition system (Fig. 2). The same flow rate is maintained until the steady state condition is reached where no further consolidation takes place and the pressure difference across the sample, ΔP_s, becomes constant. The water flux across the sample, v, is constant at the steady state, and it is calculated as the imposed flow rate divided by the sample area, A_s. At that stage, the sample height, H_f, is measured and ΔP_s is used to evaluate the sample's bottom effective stress, σ_b', as

$$\sigma_b' = \sigma_0' + \gamma_w H_s(G_s - 1) + \Delta P_s \tag{1}$$

where σ_0' = effective stress produced by the loading piston; γ_w = water unit weight; G_s = specific gravity of solids; and H_s =

height of solids contained in the sample calculated as $W_d/(G_s\gamma_w A_s)$, in which W_d is the dry weight of the sample.

Once the steady-state conditions under a given flow rate are reached, the seepage-induced consolidation test with a higher flow rate can be performed. This will produce further compression of the sample and a higher pressure difference. The seepage-induced consolidation test should be performed under relatively high flow rate that will produce significant variations of void ratio and effective stress across the specimen. This provides more reliable values of v, σ'_b, and H_f for the analysis of test results. Based on experience, the flow rate should be increased from low flow rate until the resulting pressure difference is between 2 kPa and 5 kPa, and not less than 0.3 kPa or more than 10 kPa. Note that only one set of v, σ'_b, and H_f is needed for the analysis of test results.

To obtain compressibility and permeability data in the higher effective stress range, step loading and permeability tests are performed. At the conclusion of the seepage-induced consolidation test, the sample is consolidated under a large vertical effective stress, σ'_c. At the end of its consolidation, the sample height is measured and the corresponding uniform void ratio of the compressed sample, e_c, is calculated. A small downward water flux is imposed across the sample with the flow pump. The resulting pressure change across the sample is obtained and used to calculate the permeability of the sample, k_c (Aiban and Znidarčić 1989). The two tests can be repeated several times under increasing loads in order to obtain redundant data, but only one set of σ'_c, e_c, and k_c are needed for the analysis. The sample is removed from the testing apparatus and the weight of solids, W_d, is determined.

TEST ANALYSIS

An extended power function (Liu and Znidarčić 1991) is used to relate the vertical effective stress, σ'_v, to the void ratio, e

$$e = A(\sigma'_v + Z)^B \tag{2}$$

This form, representing an expanded form of a widely used power function, removes all major deficiencies of the conventional logarithmic models. Namely, the void ratio is well defined at zero effective stress and, irrespective of the stress magnitude, the void ratio never becomes negative. The conventional form of the power function is used to relate the coefficient of permeability, k, to the void ratio

$$k = Ce^D \tag{3}$$

This form describes the permeability relations for soft soils quite well, as demonstrated by Somogyi (1979) and Al Tabaa and Wood (1987). The empirical parameters A, B, C, D, and Z are the consolidation constitutive parameters to be determined for a given soil. An efficient solution describing the steady state conditions in the seepage induced consolidation test and a parameter-estimation algorithm are developed and coded in the computer program SICTA (Seepage Induced Consolidation Test Analysis). The parameters A, B, C, D, and Z are determined in program SICTA from the test results. A brief description of the overall analysis procedure follows.

The consolidation of soft phosphatic clays and other cohesive materials is properly described by the finite strain consolidation theory (Gibson et al. 1967; McVay et al. 1986). The governing equation for the process can be written in the material coordinate system as:

$$(G_s - 1)\left[\frac{d}{de}\left(\frac{k}{1+e}\right)\right]\frac{\partial e}{\partial z} - \frac{\partial}{\partial z}\left[\frac{k}{\gamma_w(1+e)}\frac{d\sigma'_v}{de}\frac{\partial e}{\partial z}\right] = \frac{\partial e}{\partial t} \tag{4}$$

where the material coordinate z is taken positive in the direction of gravity, and t = time. For the steady-state condition the right-hand side of the equation is equal to zero, since there is no further change of the void ratio with time. The equation is thus written in the form

$$(G_s - 1)\left[\frac{d}{de}\left(\frac{k}{1+e}\right)\right]\frac{de}{dz} - \frac{d}{dz}\left[\frac{k}{\gamma_w(1+e)}\frac{d\sigma'_v}{de}\frac{de}{dz}\right] = 0 \tag{5}$$

This new equation describes, together with the appropriate boundary conditions, the steady-state flow of water through a soft soil layer. Its solution gives the void ratio distribution at steady state, from which the effective stresses and layer height can be determined. It is clear from (5) that both the compressibility and permeability constitutive relations influence the steady-state void ratio distribution. Thus, the steady state in the seepage induced consolidation experiment is also an appropriate and sufficient test from which the consolidation constitutive properties can be determined. The use of the steady state, rather than the transient part of the test, has several benefits. It is easier to make reliable measurements in the steady state than during the transient part of the test. The delay in the instrumentation response, caused by the system compliance, has less effect on the quantities measured in the steady state than during the transient phase of the test. The analysis of the steady-state flow is also much simpler and involves less computational effort. The use of the steady state as the basis for the determination of the consolidation characteristics of soft soils distinguishes this method from others that are based on the analysis of transient tests (Been and Sills 1981).

At the steady-state condition in the seepage-induced consolidation test, the velocity of the sample solid phase is zero (no vertical deformation) and the apparent velocity of the water phase is constant along the sample depth and does not change with time. Hence, the steady-state apparent relative velocity between the water phase and the solid phase is the applied water flux, v. By combining the equilibrium equation, the principle of effective stress, and Darcy's Law in terms of the relative apparent velocity between the water and solid phases, an expression for v can be obtained as

$$v = \frac{k}{\gamma_w(1+e)}\frac{d\sigma'_v(z)}{dz} - \frac{k}{1+e}(G_s - 1) \tag{6}$$

Note that (6) is equivalent to (5), but the use of (6) to simulate the test is more convenient since the steady-state water flux, v, is known. The material coordinate, z, identifies the height of solids from the top of the sample, where $z = 0$, to the point of interest; note that $z = H_s$ at the bottom of the sample. The rearrangement of (6) followed by the integration from $z = 0$ to any z leads to

$$\sigma'_v(z) = \sigma'_0 + \gamma_w(G_s - 1)z + \int_0^z \frac{v\gamma_w}{k}(1+e)\,dz \tag{7}$$

The integral equation, (7), relates the vertical effective stress at any material depth z in the soil sample (or a soil layer) at steady state to the sample void ratio distribution above z. The effective stress and permeability in the integral equation are expressed in terms of the void ratio using (2) and (3). A simple iterative numerical solution for the integral equation was developed and used to describe the steady state conditions in the seepage induced consolidation test. With the known values of H_s, σ'_0, v, e_0, G_s, and γ_w, the numerical solution predicts the steady-state sample bottom effective stress, σ'_{bn}, and height, H_{fn}, for any set of parameters A, B, Z, C, and D. The numerical solution is very accurate and always stable irrespective of the degree of nonlinearity of the consolidation constitutive relations.

With the measured zero effective stress void ratio and the compressibility and permeability data in the higher effective stress range, the number of parameters needed to be estimated is reduced from five to two. Parameters B and D are chosen to be the free parameters and the other parameters are determined as

$$Z = \frac{\sigma'_c}{(e_c/e_0)^{1/B} - 1}, \quad A = \frac{e_0}{Z^B}, \quad C = \frac{k_c}{(e_c)^D} \tag{8}$$

By utilizing the steady-state results of the seepage induced consolidation test and their numerical predictions for any set of consolidation constitutive parameters, parameters B and D are determined by minimizing the objective function, Q, defined as

$$Q = \left|1 - \frac{\sigma'_{bn}}{\sigma'_b}\right| + \left|1 - \frac{H_{fn}}{H_f}\right| \tag{9}$$

An iterative parameter estimation algorithm, based on the Newton method coupled with the line search procedure (Dennis and Schnabel 1983), is used to minimize Q by calculating improved values for A, B, C, D, and Z in each successive iteration until an arbitrary small value of Q is reached. Both the efficiency of the numerical simulation of the test and the requirement that only two free parameters need to be determined prevent the parameter estimation analysis from converging to inaccurate optimized constitutive parameters. The complete analysis of any set of experimental data with the SICTA program usually requires between 3 and 20 iterations and can be completed within a few seconds on any personal computer.

The seepage-induced consolidation test with the controlled flow rate has many advantages when compared to the controlled head difference techniques (Imai 1979; Huerta et al. 1988). First, the flow pump facilitates a precise determination of the steady-state flow rates with a resolution in the range of 10^{-6} mL/s, that is four orders of magnitude better than with the conventional methods of volume change measurement (Alva-Hurtado and Selig 1981). Second, the precise control of low flow rates with the flow pump enables testing under small gradients that are easily measured with the sensitive pressure transducer. This leads to more reliable results in the low effective stress range for soft cohesive soils. Third, since the response of the transducer is essentially instantaneous, the steady-state condition will be detected as soon as it is reached in the experiment. This is a major advantage over the constant head test in which a sufficient water quantity has to be accumulated for a reliable calculation of the steady-state average flow rate. Thus, the constant head test has to be extended for some time into the steady-state regime, leading to prolonged tests.

TABLE 1. Properties of Phosphatic Clays

Sample (1)	Specific gravity (2)	Plastic limit (%) (3)	Liquid limit (%) (4)
A-1	2.6	74	318
A-9	2.82	49	233
C-1	2.92	33	114
S-1	2.71	50	198

TEST AND ANALYSIS RESULTS FOR PHOSPHATIC CLAYS

The consolidation characteristics for samples of very soft and cohesive waste phosphatic clay were determined with the presented seepage-induced consolidation testing and analysis. The samples were obtained from several phosphate mines in Florida. The specific gravity, plastic limit, and liquid limit for the samples are included in Table 1. The results of all three phases of the testing programs are summarized in Table 2, and an example of the recorded pore water pressure during the seepage induced consolidation test is given in Fig. 2. The several pressure drops noticed in Fig. 2 were caused by the resetting of the flow pump at the end of its travel distance. The data indicate that the short flow interruptions do not affect the pore pressure response significantly. The test data from Table 2 are used as the input variables for the SICTA program and the analysis results, constitutive parameters, are listed in Table 3. Graphical presentations of the obtained compressibility and permeability relations are shown in Figs. 3 and 4, respectively. The low permeability of the phosphatic clays and their high compressibility are demonstrated in these figures.

VERIFICATION RESULTS

Three types of independent measurements are used to verify the seepage-induced consolidation test and analysis results for the phosphatic clays. The obtained consolidation constitutive relations are first compared with the results of the restricted flow consolidation test which produces the same relations with a completely different testing procedure and analysis. Second, the obtained consolidation characteristics are used in the consolidation analysis to simulate the transient phase of the seepage-induced consolidation test and to predict the field conditions in several phosphatic clay settling ponds for which some direct measurements are available. The transient finite strain consolidation analysis is conducted with the CADA program (Abu-Hejleh 1993), in which an efficient, nonlinear, finite-element solution algorithm for (4) is implemented.

The testing technique and analysis procedure for the restricted flow consolidation test are documented in the report by Sills et al. (1984). In the analysis, the experimentally obtained compressibility and permeability data are fitted to the exponential curves, which correspond to linear functions in double log scale. The data from this test on sample A-9 and the fitted linear curves on double log scale plots are shown in Figs. 5 and 6, together with the obtained compressibility and permeability curves from the seepage-induced consolidation test and analysis. A good agreement between the two sets of results is noted with the only notable deviation in the low effective stress range. The data reported for the restricted flow consolidation test show substantial scatter in that range, indicating that the procedure may not be reliable for the low effective stress level. The seepage-induced consolidation test produces less ambiguous results at low effective stresses. In addition, a simpler power function is fitted to the compressibility data from the restricted flow test, while an expanded power function is used in the analysis of the seepage-induced consolidation test. Since the simple power function does not recognize the maximum void ratio for a given sample, the

TABLE 2. Experimental Results of Tests Performed on Phosphatic Clays

Sample (1)	e_0 (2)	H_0 (m) (3)	σ'_0 (kPa) (4)	v (m/s) (5)	σ'_b (kPa) (6)	H_f (m) (7)	σ_c (kPa) (8)	e_c (9)	k_c (m/s) (10)
A-1	25.93	0.046	0.10	0.147×10^{-6}	2.29	0.0230	50.00	4.68	0.798×10^{-9}
A-9	18.39	0.034	0.10	0.294×10^{-6}	2.82	0.0275	50.00	4.17	0.648×10^{-9}
C-1	13.07	0.051	0.39	0.164×10^{-6}	2.94	0.0307	29.20	4.07	0.169×10^{-8}
S-1	32.50	0.049	0.10	0.147×10^{-6}	0.474	0.0302	99.47	3.11	0.203×10^{-9}

TABLE 3. Obtained Consolidation Constitutive Parameters for Phosphatic Clays

Sample (1)	A (2)	B (3)	Z (kPa) (4)	C (m/s) (5)	D (6)
A-1	11.50	−0.230	0.029	0.625×10^{-11}	3.14
A-9	12.74	−0.285	0.277	0.361×10^{-11}	3.64
C-1	7.75	−0.191	0.065	0.429×10^{-11}	4.26
S-1	13.49	−0.319	0.064	0.384×10^{-11}	3.50

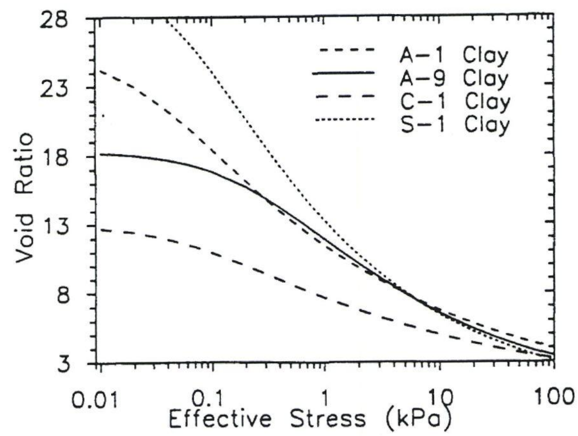

FIG. 3. Consolidation Compressibility Relations for Phosphatic Clays

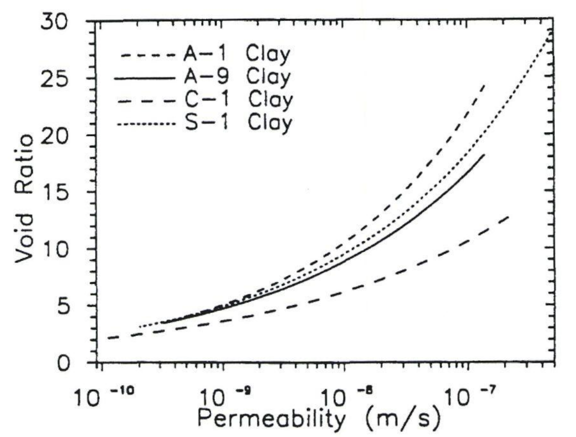

FIG. 4. Consolidation Permeability Relations for Phosphatic Clays

obtained data in the higher effective stress range are extrapolated to the low effective stress range, leading to a further disagreement between the two techniques.

In the seepage-induced consolidation test, the soil sample passes through a transient phase of consolidation before reaching the steady-state conditions. Thus, the obtained data in this phase gives the opportunity for an independent verification of the obtained consolidation characteristics in the low range of effective stresses. Note that the consolidation characteristics were obtained using only the steady state results of the seepage induced consolidation test. With the known testing conditions and measured consolidation material characteristics of the phosphatic clays, the CADA program is used to simulate the seepage induced consolidation tests. The measured test data on samples A-1 and S-1 and their numerical predictions are shown in Figs. 7 and 8. These figures show a good agreement between the test data and their numerical predictions, confirming the accuracy of the obtained consolidation characteristics of phosphatic clays in the low effective stress range.

Using the piston tube sampler, profiles of void ratio with depth were obtained from the phosphatic clay settling ponds where samples A-1, C-1, and S-1, were taken, and these are shown graphically in Figs. 9–11. In order to predict these field data numerically using the experimentally obtained consolidation characteristics and the CADA program, information that describes the boundary conditions and the slurry deposition history of the phosphatic clays is needed. It was given that the bottom surface of the settling ponds can be assumed impervious and that the phosphatic clay deposits had been covered with water. Thus, the measured zero effective stress void ratio in our laboratory is assumed for the surface of the deposits, where the effective stress is zero, and it is included in the

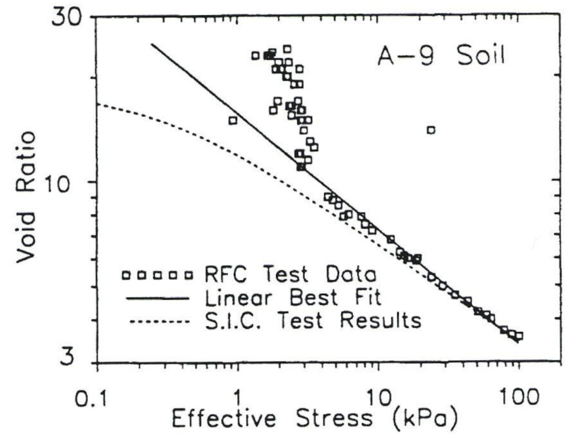

FIG. 5. Consolidation Compressibility Relation for A-9 Phosphatic Soil

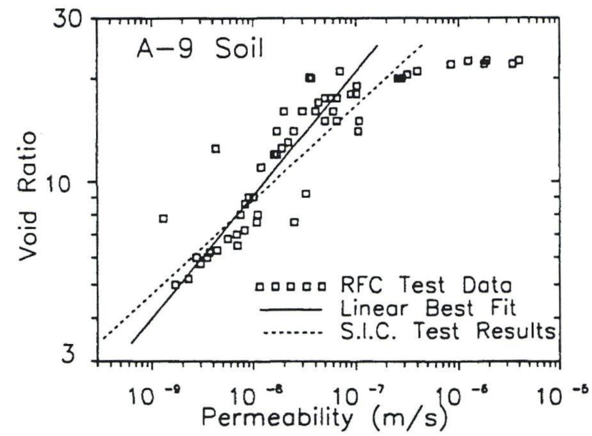

FIG. 6. Consolidation Permeability Relation for A-9 Phosphatic Soil

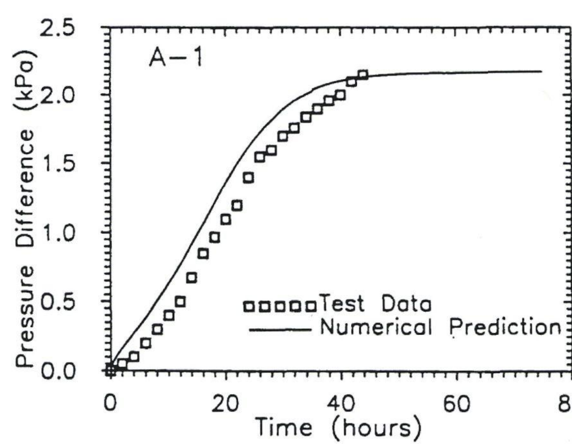

FIG. 7. Measured and Predicted Data in Seepage Induced Consolidation Test on Sample A-1

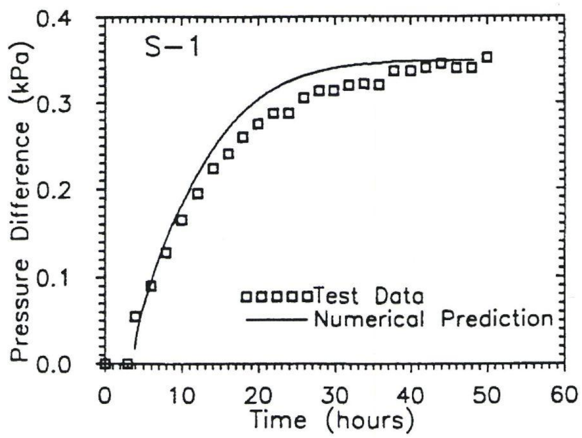

FIG. 8. Measured and Predicted Data in Seepage Induced Consolidation Test on Sample S-1

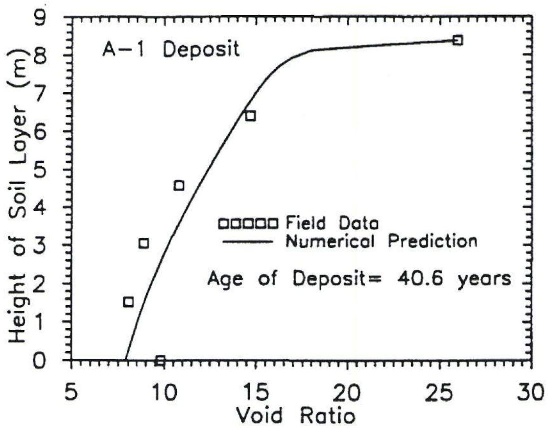

FIG. 9. Field Measurements for Void Ratio Distribution in Settling Pond A-1 and Their Numerical Predictions

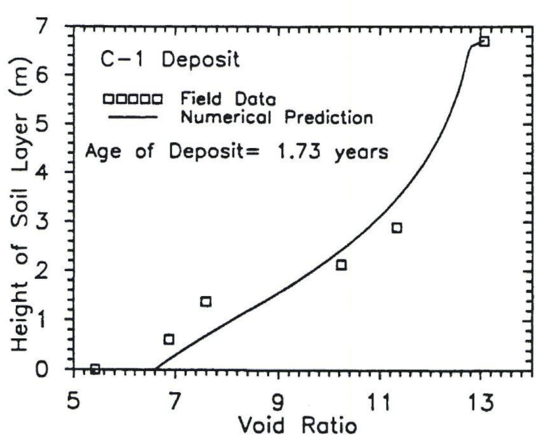

FIG. 10. Field Measurements for Void Ratio Distribution in Settling Pond C-1 and Their Numerical Predictions

presented void ratio profiles in Figs. 9–11. In addition, the e_0 value is used to represent the initial void ratio of the slurry phosphatic clays at the beginning of consolidation. For the stated boundary and initial conditions, the only source of the slurry phosphatic waste densification is the self-weight consolidation.

Since we could not obtain information on the slurry filling rates and periods, such information was either estimated or investigated with the available field data and the CADA program. The measured data of void ratio with depth were used to estimate the height of solids contained in each profile, H_s. Then, the uniform deposition rate, in terms of volume of deposited waste clay per unit area and per unit time, DR, during a filling period F is estimated as:

$$DR = H_s/F \tag{10}$$

The height of the unconsolidated slurry column, H_0, for each deposit can be calculated as $H_s(1 + e_0)$, and the corresponding filling rate is H_0/F. For example, the estimated values of H_s and H_0 for deposit S-1 are 0.516 m and 17.3 m, respectively. For each deposit, the self-weight consolidation of the unconsolidated slurry column with a total height of H_0 is modeled. The deposition conditions were simulated with the instantaneous filling and with varying uniform filling rates. A sample of the obtained settlement response for deposit S-1 is shown in Fig. 12. The graphical results indicate that the soil layer height during the self-weight consolidation could be assumed independent of the filling rate, especially when the filling rate is high. A similar result was obtained by Carrier et al. (1983). Therefore, it is assumed that the phosphatic clay conditions at the time of sampling are independent of the filling rate history and are related only to the elapsed time from the beginning of the slurry deposition operations, T_c.

The consolidation analysis results for the instantaneous filling are used to predict the void ratio profiles in the phosphatic clay deposits. The value of T_c corresponding to the sampling time, designated as the deposit age, was estimated with the measured soil layer height. For example, the age of deposit S-1 at the time of sampling is estimated as 13.13 years, since at that time the predicted soil layer height from Fig. 12 is 7.62 m, which is equal to the measured height of profile S-1 shown in Fig. 11. The void ratio profiles corresponding to the sampling time for the three phosphatic deposits are then obtained, and

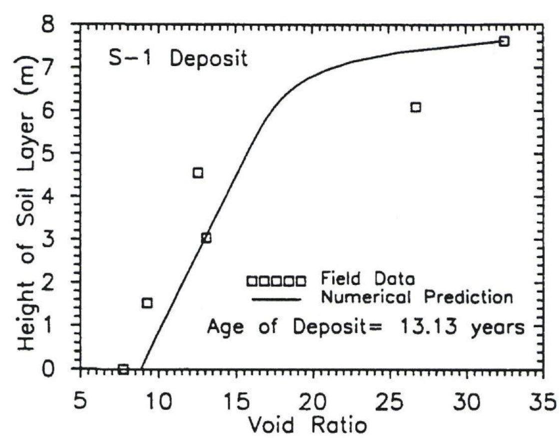

FIG. 11. Field Measurements for Void Ratio Distribution in Settling Pond S-1 and Their Numerical Predictions

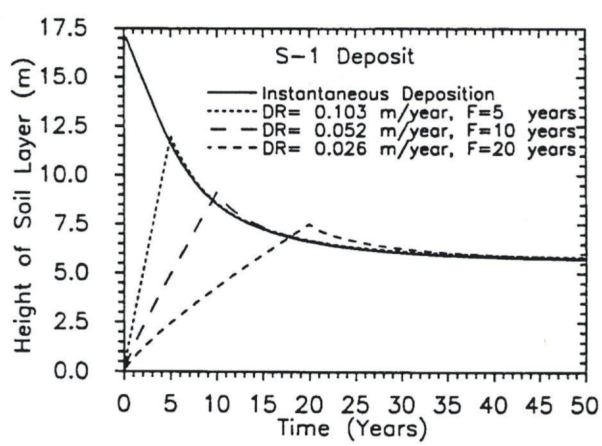

FIG. 12. Predicted Settlement-Time Curves for the Waste Clay in Settling Pond S-1 under Different Deposition Conditions

they are presented in Figs. 9–11. The graphical results show a good agreement between the measured field data of void ratio with depth and their numerical predictions. This represents further evidence of the reliability of the obtained consolidation characteristics from the seepage induced consolidation test and analysis, and supports the use of such results in the consolidation analysis of real field situations. Fig. 10 indicates that the upper portion of deposit C-1 is relatively unconsolidated, implying that this deposit was relatively young at time of sampling. This is not the case for deposits A-1 and S-1.

CONCLUSIONS

The seepage induced consolidation test and analysis provide a rational method for the determination of the consolidation constitutive relations for soft phosphatic clays and other fine-grained materials. The analysis procedure is consistent with the finite strain consolidation theory that is routinely used in the analysis of field conditions in the settling ponds at phosphate mines. The presented methodology solves the difficult problem of material characteristics determination, usually the most critical aspect of any field prediction.

The advantages of the presented methodology include the precise control of the steady-state flow rate using the flow pump, the accurate measurements of the pressure difference across the sample with the sensitive differential pressure transducer, and an efficient analysis of the test results without any restrictive assumptions. The quality of the obtained results is verified by the comparison with three types of independent measurements including the field data.

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APPENDIX II. NOTATION

The following symbols are used in this paper:

A, B, Z, C, D = consolidation constitutive parameters;
A_s = sample area;
DR = deposition rate of solid wastes;
e = void ratio;
e_c = measured void ratio in the loading test;
e_0 = zero effective stress void ratio;
F = filling period;
G_s = specific gravity of solids;
H_f = measured height of the sample in steady-state seepage-induced consolidation test;
H_{fn} = numerical prediction of H_f;
H_s = height of solids in sample or soil layer;
H_0 = initial height of unconsolidated sample or soil layer;
k = coefficient of permeability;
k_c = measured coefficient of permeability in permeability test;
Q = total normalized difference;
T_c = age of waste deposit;
v = applied water flux across sample;
W_d = dry weight of sample;
z = material coordinate;
γ_w = unit weight of water;
ΔP_s = pressure difference across sample in steady-state seepage-induced consolidation test;
σ'_b = measured bottom effective stress in steady-state seepage-induced consolidation test;
σ'_{bn} = numerical prediction of σ'_b;
σ'_c = measured vertical effective stress in loading test;
σ'_v = vertical effective stress; and
σ'_0 = vertical effective stress on top of sample.

Modeling One-Dimensional Compression Characteristics of Soils

By Jin-Chuan Liu,[1] Student Member, ASCE, and Dobroslav Znidarčić,[2] Associate Member, ASCE

Introduction

Prediction of consolidation behavior of soil deposits requires knowledge of the field condition, as well as the compressibility and permeability characteristics of the material. These characteristics are usually presented in the form of void ratio-effective stress and void ratio-permeability relationships, which are obtained experimentally.

For the purpose of the analysis, these relationships are modeled by mathematical functions that approximate the observed behavior. Various forms of these functions, ranging in complexity from constant values for compressibility and permeability to logarithmic, exponential, and power functions, have been proposed and used with greater or lesser success (Janbu 1963; Monte and Krizek 1976; Butterfield 1979; Somogyi 1979; Koppula and Morgenstern 1982; Carrier and Beckman 1984; Gibson et al. 1981; Krizek and Somogyi 1984). While experimental evidence suggests that the power-function form is appropriate for modeling the void ratio-permeability relationship (Al-Tabbaa and Wood 1987; Znidarčić and Aiban 1988), earlier proposed effective stress-void ratio models have various limitations that make them deficient in rigorous analyses. Namely, the power relation predicts an infinite void ratio for the point of zero effective stress and it cannot model the effect of overconsolidation. These problems are often circumvented by applying a fictitious effective stress at the top of the consolidating layers (Huerta et al. 1988) and by assuming different parameters for the normally consolidated and overconsolidated ranges (Butterfield 1979). While these approaches give reasonable results in most applications, the questions of a proper choice of the fictitious effective stress level and the continuity of the two functions at the preconsolidation stress region remain open.

Hardin (1989) recently proposed a $1/e$ versus $\sigma_v'^p$ model for one-dimensional, normally consolidated cohesive soils in the form

$$\frac{1}{e} = \frac{1}{e_0} + \frac{1}{S_{1-D}}\left(\frac{\sigma_v'}{P_a}\right)^p \quad (1)$$

where $1/e_0$ = intercept at $\sigma_v' = 0$, and the reciprocal slope S_{1-D} = the dimensionless stiffness coefficient for one-dimensional strain. Clearly, the void ratio is well defined at zero effective stress, since p is a positive number, and irrespective of the magnitude of the effective stress the void ratio is always positive.

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This note presents an extended power-function model that we use in our current research on consolidation of soft clays. The model overcomes the shortcomings of the earlier proposed models and has characteristics similar to those of the Hardin's model. It has the form

$$e = A(\sigma' + Z)^B \quad (2)$$

in which A and B are constants, having the usual connotation as in other power-function models, and Z is an additional soil parameter having a unit of stress. Besides removing the previously stated deficiencies, the model is capable, as will be shown later, of modeling both normally and overconsolidated soil behaviors with a continuous function and having one set of parameters.

Comparison of Models

The two models, Hardin (1989) and the extended power-function model proposed here, are compared with the published one-dimensional compression data for various soils and with the data experimentally obtained by the writers. Emphasis is given to the comparison of responses of soft materials, but some stiffer and some sensitive clays are included in the analyses as well.

The model parameters are obtained by a least-square fitting to the experimental data using the simplex method (Nelder and Mead 1965), in which the objective function in the form proposed by Arai et al. (1985) is normalized by the initial void ratio and minimized

$$\frac{\sqrt{\sum_{i=1}^{n}(e_i - \overline{e}_i)^2}}{e_{\sigma'=0}\sqrt{n}} \quad (3)$$

in which e_i = the void ratio calculated by the models for a given effective stress; $\overline{e}_i$ = the experimentally obtained void ratio for the same effective stress; and n = the number of points. The models are forced to give the initial void ratio when the effective stress is equal to zero. In this way only two of the three model parameters need to be determined in the minimization process. The same procedure was followed for both Hardin's and the extended power-function models. For the overconsolidated material, the curve-fitting to the experimental data is achieved over the entire range of stresses, and not only for the normally consolidated part. In this regard, we have deviated from the procedure recommended by Hardin (1989), but as the data will show this only proves that this model can be used to predict behavior of a wider range of soils, including overconsolidated materials. We believe this deviation is justified since only in this case can a true comparison between the two models be made.

The results are presented in Table 1 and Figs. 1–3. The table contains the values of the parameters for both models, as well as the normalized minima of the objective function (NMOF). In the normalized form, the error measure (minimum of the objective function) is not affected by the absolute value of the void ratio, thus facilitating comparison between different cases.

TABLE 1. Material Compressibility Properties

Material (1)	Source (2)	Reference (3)	Figure (4)	Hardin's Model: $e_{\sigma'=0}$ (5)	Hardin's Model: S_{I-D} (6)	Hardin's Model: ρ (7)	Hardin's Model: NMOF (8)	Extended Power-Function Model: A (9)	Extended Power-Function Model: B (10)	Extended Power-Function Model: Z (kPa) (11)	Extended Power-Function Model: NMOF (12)
Dredge clay	Canaveral Harbor	Poindexter (1987)		11.12	1.93	0.390	0.051	5.11	−0.208	0.024	0.049
Dredge clay	Canaveral Harbor	Poindexter (1987)		9.92	1.84	0.451	0.068	5.57	−0.235	0.086	0.068
Dredge clay	Canaveral Harbor	Poindexter (1987)		9.79	1.89	0.430	0.076	5.16	−0.213	0.050	0.045
Dredge clay	Canaveral Harbor	Cargill (1984)		17.00	2.59	0.351	0.112	7.68	−0.254	0.044	0.110
Dredge clay	New York Harbor	Poindexter (1987)		10.30	1.63	0.294	0.060	3.63	−0.174	0.0025	0.058
Dredge clay	Craney Island	Cargill (1984)		12.00	3.20	0.339	0.044	7.62	−0.236	0.146	0.043
Dredge clay	Charleston Harbor	Poindexter (1987)		13.62	1.69	0.421	0.027	5.57	−0.236	0.022	0.024
Dredge clay	Charleston Harbor	Poindexter (1987)		12.48	1.62	0.464	0.029	6.04	−0.254	0.058	0.050
Dredge clay	Charleston Harbor	Poindexter (1987)		12.30	1.84	0.396	0.016	5.23	−0.215	0.019	0.032
Dredge clay	Baltimore Harbor (N-1)	Znidarčić (1986)	Fig. 1	7.40	2.76	0.477	0.048	6.32	−0.224	0.492	0.016
Dredge clay	Baltimore Harbor (S-2)	Znidarčić (1986)	Fig. 1	9.60	2.41	0.465	0.065	6.80	−0.238	0.235	0.022
Dredge clay	Baltimore Harbor (N-4, N-6)	Znidarčić (1986)		7.90	2.38	0.463	0.069	5.87	−0.218	0.256	0.046
Dredge clay	Baltimore Harbor (S-4, S-6)	Znidarčić (1986)		8.50	3.23	0.490	0.079	7.52	−0.229	0.584	0.037
Mine tailing	Phosphatic clay	Somogyi et al. (1984)	Fig. 2(*a*)	15.00	3.39	0.582	0.073	13.70	−0.299	0.738	0.030
Mine tailing	Phosphatic clay	Somogyi et al. (1984)	Fig. 2(*a*)	14.00	3.29	0.557	0.038	11.42	−0.244	0.434	0.013
Mine tailing	Phosphatic clay	Scully et al. (1984)		30.00	2.22	0.348	0.047	8.25	−0.192	0.0012	0.081
Mine tailing	Phosphatic clay	Scully et al. (1984)		20.00	1.76	0.434	0.055	7.55	−0.212	0.010	0.013
Mine tailing	Phosphatic clay	Scully et al. (1984)		15.00	2.03	0.451	0.030	7.42	−0.183	0.021	0.038
Mine tailing	Gold mine (pH = 7)	Caldwell et al. (1984)		3.02	2.13	0.222	0.036	1.97	−0.096	0.012	0.055
Mine tailing	Gold mine (pH = 10.2)	Caldwell et al. (1984)		3.68	1.59	0.268	0.063	2.10	−0.130	0.014	0.026
China clay	Speswhite kaolin	Current study		8.00	1.01	0.417	0.112	3.61	−0.228	0.030	0.076
China clay	Speswhite kaolin	Current study	Fig. 2(*a*)	12.00	0.81	0.414	0.135	3.65	−0.249	0.0084	0.061
China clay	Speswhite kaolin	Current study	Fig. 2(*b*)	8.56	0.96	0.417	0.127	3.58	−0.220	0.019	0.069
China clay	Speswhite kaolin	Current study	Fig. 2(*b*)	6.00	1.05	0.472	0.121	3.56	−0.210	0.083	0.100
Field samples	Boston blue clay	Butterfield (1979)		1.19	30.02	0.956	0.001	30.00	−0.459	1,138.	0.000
Field samples	Chicago clay	Butterfield (1979)		1.51	9.70	0.721	0.008	7.81	−0.316	180.6	0.032
Field samples	Newfoundland silt	Butterfield (1979)		1.65	5.77	0.595	0.006	4.35	−0.245	52.5	0.010
Field samples	Newfoundland peat	Butterfield (1979)		35.06	13.65	0.635	0.073	82.94	−0.462	6.46	0.002
Field samples	Drammen clay (plastic)	Butterfield (1979)	Fig. 3(*a*)	1.47	9.25	0.757	0.038	7.32	−0.314	167.7	0.031
Field samples	Drammen clay (lean)	Butterfield (1979)	Fig. 3(*a*)	1.00	8.38	0.687	0.024	2.43	−0.186	118.4	0.017
Field samples	Mexico City clay	Butterfield (1979)	Fig. 3(*b*)	10.35	63.03	1.455	0.091	1.42×10^6	−1.77	788.8	0.135

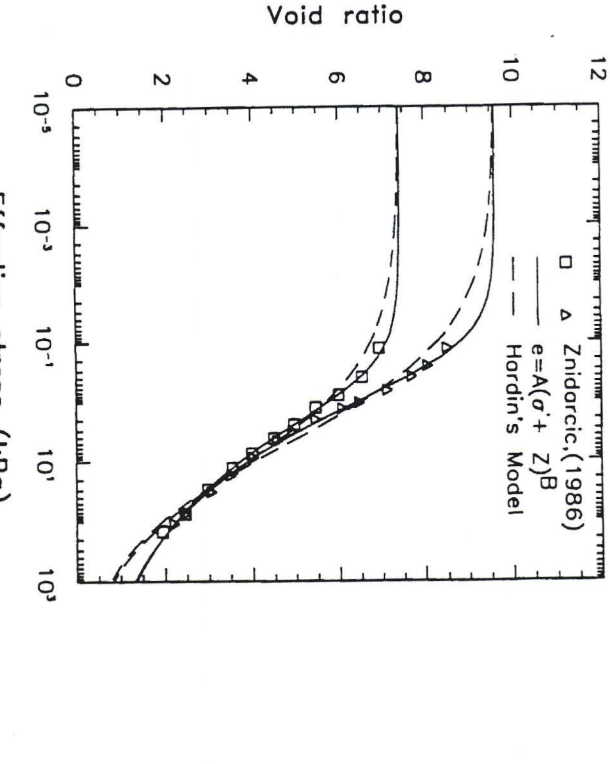

FIG. 1. Compressibility Relations of Dredged Materials from Baltimore Harbor

For Hardin's model, the value of the void ratio at zero effective stress, $e_{\sigma'=0}$, is a model parameter, while for the extended power function the same value is obtained by substituting the three parameters into the model and setting the effective stress, σ', to zero. In other words, none of the three

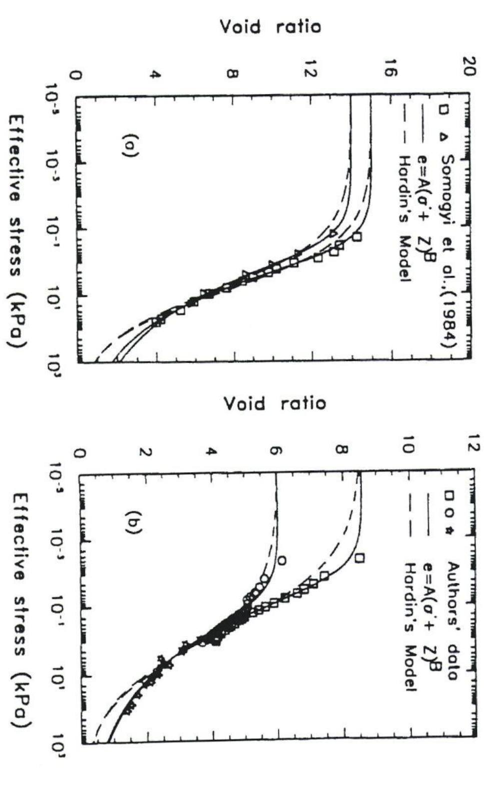

FIG. 2. Compressibility Relations of: (*a*) Phosphatic Clay; and (*b*) Speswhite Clay

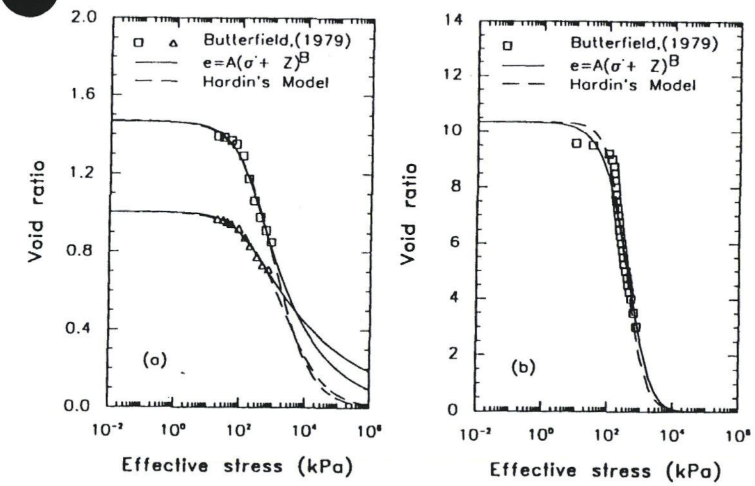

FIG. 3. Compressibility Relations of Field Samples: (*a*) Drammen Clay; and (*b*) Mexico City Clay

parameters is equal to the initial void ratio, but all three implicitly affect its value.

Figs. 1–3 demonstrate the ability of the models to predict one-dimensional compression of various materials. They represent both normally consolidated and overconsolidated samples with various values of the normalized error measure. The solid and dashed lines are used for the extended power function and Hardin's models, respectively.

Figs. 1 and 2(*a*) and (*b*) present examples of the one-dimensional compression behavior of soft soils, including dredged materials, phosphatic clays, and laboratory-prepared mixtures of speswhite kaolinite clay. Predictions from both models agree fairly well with the experimental data over the presented range of stresses. While all of these materials are normally consolidated, the experimental data indicate a flat portion of one-dimensional compression curve in the low stress range. The data in this range are scarce and probably less reliable than in the higher stress range. Still, it is evident that for the same material, the one-dimensional compression behavior in the low stress range is highly dependent on the initial void ratio. This is well illustrated in Figs. 1 and 2(*b*), where the same material was mixed with different water contents and tested. The two curves resemble behavior of overconsolidated samples, and they merge in the higher stress range. Similar behavior was observed by Martinez et al. (1987). It is evident that even the models intended exclusively for predicting soft material behavior should be able to properly model this apparent overconsolidation. The two presented models are certainly able to do so.

Fig. 3(*a*) presents the one-dimensional behavior of two samples of Drammen clay, as reported by Butterfield (1979). The two models approximate experimental results fairly well and they deviate from one another in the higher stress range, in which there is no experimental data available. This example demonstrates that both models are able to predict one-dimensional

compression behavior of overconsolidated materials using a continuous function with one set of parameters.

In Fig. 3(*b*), the models are compared with the experimental data for the sensitive Mexico City clay, as reported by Butterfield (1979). Relatively larger difference between the observed and predicted behavior is noted. In this case, Hardin's model agrees better with the experiments than the expanded power function. Both models, however, have difficulty in properly modeling the sharp curvature of the experimental data at the preconsolidation pressure. This is taken as an indication that the two models should not be used to model an overconsolidated regime of sensitive clays using a continuous function with one set of parameters. If the models were to be fitted only to the normally consolidated part of the presented data, excellent agreement would be obtained as demonstrated by Hardin (1989).

The two analytical models, Hardin's and the extended power function, remove all the major deficiencies of the conventional log-linear and power-function models. Namely, void ratio is well defined at zero effective stress; irrespective of the stress magnitude, void ratio is never negative, as is the case for the conventional log-linear model, and the models are capable of modeling one-dimensional behavior of soft soils as well as preconsolidated material. It is important that the models require only three parameters, so that their experimental determination is practicable.

The relative performance of the two models in predicting one-dimensional compression characteristics of various soils can be evaluated by comparing the normalized minima of the objective function in Table 1. The smaller the value, the better performance of the model. Though it appears that the fitting of the power function was more successful in this exercise for larger number of cases, in our opinion this does not always guarantee a superior performance. Overall the differences are insignificant, and, as demonstrated in Figs. 1–3 even in the cases when the normalized error measure is relatively high, the curves fit the experimental data quite well. It is interesting that the extended power-function model predicts relatively sharp curvature at the apparent "preconsolidation pressure" of soft materials, while Hardin's model has a smoother transition from the "overconsolidated" to "normally consolidated" regime, shown in Figs. 1–3(*a*). The opposite is true in the case of sensitive clay [Fig. 3(*b*)]. More reliable data in the very low stress range are needed to decide which of the two models is closer to the real behavior of the material.

The decision on which of the two models should be used in any particular case can be made only after both models are fitted to the same set of data and their performances can be compared for that material. It is very likely that, in most cases, the differences between the models will be much smaller than the scatter of the available data. The choice of the model will then depend more on the user's preference than on the merit of the model itself.

Conclusions

An extended power function is proposed for modeling one-dimensional compression of normally consolidated and overconsolidated soils. The function has three parameters, and a single set of these parameters is sufficient for representing void ratio-effective stress relations from zero effective stress to any desired stress level.

The model proposed by Hardin (1989) has a different form, but comparable characteristics to the model proposesd by the writers. For modeling overconsolidated behavior, a fitting process different from the one proposed by Hardin (1989) is described.

Both models may have problems in fitting data of highly sensitive clays, but from the limited comparison presented in the paper, it appears that for these cases Hardin's model is more suitable. While the two models are promising, the experiments needed for the determination of the three parameters may not be trivial. In particular, reliable measurements of soft-soil characteristics at low effective stresses is difficult. We leave the discussion of an appropriate experimental approach to a later paper.

ACKNOWLEDGMENT

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APPENDIX F-2

SETTLEMENT GRID OUTPUT

TABLE F-1. TOTAL THICKNESS OF TAILINGS IN FEET

	x																	
y	0	125	250	375	500	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875	2000	2125
2500	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2375	0	0	0	0	21	26	22	0	0	0	0	0	0	0	0	0	0	0
2250	0	0	0	15	37.5	46	41	26	20	0	0	0	0	0	0	0	0	0
2125	0	0	0	41	64	72	67	46	37	30	19	6	0	0	0	0	0	0
2000	0	0	37	64	81	84	82	66	51	47	43	29	21	10	0	0	0	0
1875	0	0	72	83	92	100	104	77	71	71	67	59	45	32	15	12	0	0
1750	0	0	77	85	106	121	116	117	107	97	87	78	59	50	41	34	10	0
1625	0	22	82	104	119	136	130	121	118	110	107	98	73	64	52	43	34	0
1500	0	51	112	140	153	162	151	135	129	118	112	110	98	79	61	50	34	0
1375	0	80	142	165	183	193	182	156	130	119	114	112	104	85	61	43	14	0
1250	0	111	175	196	214	218	203	172	141	130	120	115	111	81	53	14	0	0
1125	0	120	202	226	234	233	213	178	147	137	132	117	102	73	35	0	0	0
1000	0	145	227	251	255	244	223	188	152	142	132	132	90	59	13	0	0	0
875	0	180	263	271	270	248	223	193	163	153	143	133	94	55	16	0	0	0
750	0	201	288	287	275	254	223	193	168	163	155	143	100	76	17	0	0	0
625	0	201	299	287	275	250	224	195	174	169	160	145	106	82	57	0	0	0
500	0	201	288	282	265	245	228	195	185	180	170	151	122	98	0	0	0	0
375	0	201	270	268	257	247	222	196	186	176	162	152	123	99	0	0	0	0
250	0	201	249	249	239	228	210	197	180	167	157	149	124	0	0	0	0	0
125	0	141	171	175	182	185	186	162	145	118	97	71	50	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Main Dam

Levee Dam

TABLE F-2. TOTAL SETTLEMENT DUE TO FULL DRAINDOWN AND SOIL COVER SURCHARGE

Main Dam

	X-Coordinates																	
Y-Coordinates	0	125	250	375	500	625	750	875	1000	1125	1250	1375	1500	1625	1750	1875	2000	2125
2500	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2375	0.0	0.0	0.0	0.0	2.3	2.9	2.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2250	0.0	0.0	0.0	1.6	4.1	5.0	4.5	2.9	2.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2125	0.0	0.0	0.0	4.5	7.0	7.9	7.4	5.0	4.1	3.3	2.9	0.9	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.0	0.0	0.3	3.8	8.3	12.5	12.2	9.9	7.7	7.3	6.7	4.5	3.3	1.6	0.0	0.0	0.0	0.0
1875	0.0	0.0	0.7	0.8	9.1	18.9	19.6	14.5	12.2	11.0	10.4	9.2	7.0	5.0	2.3	1.9	0.0	0.0
1750	0.0	0.2	0.7	0.8	10.5	22.8	21.9	22.1	18.4	15.1	13.5	12.1	9.2	7.8	6.4	5.3	1.6	0.0
1625	0.0	0.5	0.7	0.9	11.8	25.7	24.5	22.8	20.3	17.1	16.6	15.2	11.3	9.9	8.1	6.7	5.3	0.0
1500	0.0	0.8	1.1	1.4	10.4	20.5	19.1	17.1	19.0	19.9	18.9	18.5	16.5	13.3	10.3	8.4	5.7	0.0
1375	0.0	1.1	1.5	1.7	6.8	12.4	11.7	10.0	16.0	21.6	20.7	20.3	18.9	15.4	11.1	7.8	2.5	0.0
1250	0.0	1.2	1.8	2.0	8.0	14.0	13.0	11.0	17.3	23.6	21.8	20.9	20.2	14.7	9.6	2.5	0.0	0.0
1125	0.0	1.5	2.1	2.3	8.7	14.9	13.6	11.4	18.1	24.9	24.0	21.3	18.5	13.3	6.4	0.0	0.0	0.0
1000	0.0	1.8	2.3	2.6	9.4	15.4	14.1	11.9	14.5	18.1	16.8	16.8	11.5	7.5	1.7	0.0	0.0	0.0
875	0.0	2.0	2.6	2.7	9.8	15.5	13.9	12.0	11.1	11.3	10.5	9.8	6.9	4.0	1.2	0.0	0.0	0.0
750	0.0	2.0	2.9	2.9	10.0	15.8	13.9	12.0	11.4	12.0	11.4	10.5	7.4	5.6	1.3	0.0	0.0	0.0
625	0.0	2.0	3.0	2.9	10.0	15.6	14.0	12.2	11.8	12.4	11.8	10.7	6.4	1.8	0.5	0.0	0.0	0.0
500	0.0	2.0	2.8	2.7	7.2	8.7	8.1	6.9	8.9	11.9	10.3	9.1	2.6	0.8	0.0	0.0	0.0	0.0
375	0.0	2.0	2.6	2.5	2.2	2.1	1.9	1.7	1.6	3.8	3.5	3.3	1.1	0.8	0.0	0.0	0.0	0.0
250	0.0	2.0	2.3	2.3	2.1	2.0	1.8	1.7	1.5	1.4	1.3	1.3	1.1	0.0	0.0	0.0	0.0	0.0
125	0.0	1.3	1.5	1.5	1.6	1.6	1.6	1.4	1.2	1.0	0.8	0.6	0.4	0.0	0.0	0.0	0.0	0.0
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Levee Buttress

APPENDIX G

EXISTING EMBANKMENT STABILITY ANALYSES

APPENDIX G-1

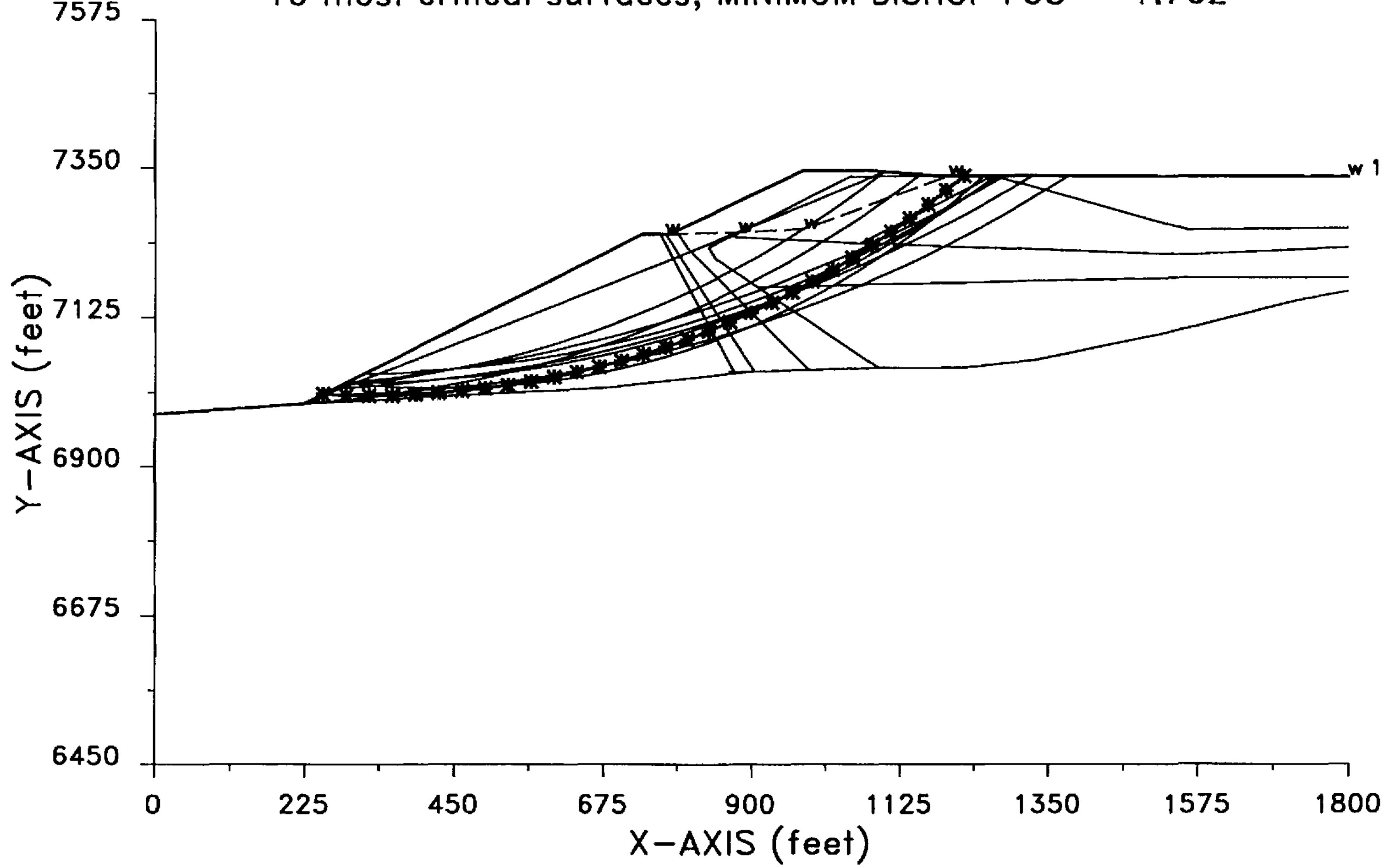
STATIC STABILITY OUTPUT

MOST CRITICAL MAIN DAM OUTPUT

MD_EC2 1-12-99 14:21

CURRENT COND. STABILITY ANALYSIS

10 most critical surfaces, MINIMUM BISHOP FOS = 1.762



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*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*             using the                 *
*          Method of Slices             *
*                                       *
*        Copyright (C) 1992 Ä 95        *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.105               95 Ä 1318   *
*****************************************
```

Problem Description : EXISTING STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

14 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	7206.3	72.7	7210.0	1
2	72.7	7210.0	128.4	7237.9	2
3	128.4	7237.9	162.3	7238.4	2
4	162.3	7238.4	169.3	7238.4	3
5	169.3	7238.4	189.2	7237.6	4
6	189.2	7237.6	235.0	7235.2	5
7	235.0	7235.2	419.0	7236.0	10
8	419.0	7236.0	568.6	7299.0	5
9	568.6	7299.0	632.6	7300.8	5
10	632.6	7300.8	721.0	7345.0	5
11	721.0	7345.0	886.8	7341.0	5
12	886.8	7341.0	893.8	7338.5	5
13	893.8	7338.5	1009.8	7337.9	6
14	1009.8	7337.9	1400.0	7334.4	7

26 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	816.8	7339.0	893.8	7338.5	6
2	732.4	7301.4	816.8	7339.0	6
3	1009.8	7337.9	1400.0	7334.4	7

4	893.3	7278.2	1009.8	7337.9	8
5	1009.8	7337.9	1400.0	7262.1	8
6	732.4	7301.4	893.3	7278.2	9
7	893.3	7278.2	1400.0	7221.2	9
8	587.8	7232.0	732.4	7301.4	9
9	189.2	7237.6	201.4	7202.9	4
10	235.0	7235.2	299.4	7192.3	5
11	587.8	7232.0	732.4	7301.4	9
12	374.3	7200.0	419.0	7236.0	5
13	528.7	7232.0	587.8	7232.0	9
14	498.9	7214.1	528.7	7232.0	9
15	498.9	7214.1	526.0	7194.9	5
16	72.7	7210.0	162.3	7205.2	1
17	162.3	7205.2	169.3	7204.6	1
18	169.3	7204.6	201.4	7202.9	1
19	201.4	7202.9	299.4	7192.3	1
20	374.3	7200.0	526.0	7194.9	10
21	526.0	7194.9	1400.0	7182.7	10
22	299.4	7192.3	584.2	7156.1	1
23	584.2	7156.1	898.0	7142.9	1
24	898.0	7142.9	1076.2	7117.6	1
25	1076.2	7117.6	1179.5	7111.3	1
26	1179.5	7111.3	1400.0	7108.8	1

ISOTROPIC Soil Parameters
----

10 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	0
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	112.0	115.0	.0	36.00	.000	.0	1
7	112.0	122.0	500.0	.00	.000	.0	1
8	112.0	122.0	710.0	.00	.000	.0	1
9	112.0	124.0	9000.0	.00	.000	.0	1
10	112.0	128.0	2300.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 10 coordinate points

****

PHREATIC SURFACE,

****

Point No.	x-water (ft)	y-water (ft)
1	162.30	7238.40
2	189.20	7237.60
3	235.00	7235.20
4	419.00	7236.00
5	570.00	7222.00
6	635.00	7245.00
7	700.00	7247.00
8	880.00	7293.00
9	1000.00	7336.70
10	1400.00	7336.70

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 300.0 ft
and x = 425.0 ft

Each surface terminates between x = 850.0 ft
and x = 1000.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

11.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 64 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	356.03	7235.73
2	365.16	7229.58
3	374.43	7223.66
4	383.85	7217.98
5	393.40	7212.52
6	403.08	7207.30
7	412.89	7202.32
8	422.82	7197.59
9	432.86	7193.10
10	443.01	7188.86
11	453.26	7184.87
12	463.61	7181.13
13	474.04	7177.65
14	484.56	7174.42
15	495.15	7171.46
16	505.81	7168.76
17	516.54	7166.32
18	527.32	7164.15
19	538.16	7162.24
20	549.03	7160.60
21	559.95	7159.22
22	570.89	7158.12
23	581.86	7157.28
24	592.85	7156.72
25	603.84	7156.42
26	614.84	7156.40
27	625.84	7156.65
28	636.83	7157.17
29	647.80	7157.95
30	658.75	7159.01
31	669.67	7160.34
32	680.55	7161.93
33	691.39	7163.79
34	702.18	7165.92
35	712.92	7168.32
36	723.60	7170.97
37	734.20	7173.89
38	744.73	7177.07
39	755.18	7180.51
40	765.54	7184.20
41	775.81	7188.15
42	785.98	7192.34
43	796.04	7196.79
44	805.99	7201.48
45	815.82	7206.42

46	825.52	7211.60
47	835.10	7217.01
48	844.54	7222.66
49	853.84	7228.54
50	862.99	7234.64
51	871.98	7240.97
52	880.82	7247.52
53	889.50	7254.28
54	898.00	7261.26
55	906.33	7268.44
56	914.49	7275.83
57	922.45	7283.41
58	930.23	7291.19
59	937.82	7299.15
60	945.21	7307.30
61	952.39	7315.63
62	959.37	7324.14
63	966.13	7332.81
64	970.06	7338.11

**** Simplified BISHOP FOS = 2.094 ****

The following is a summary of the TEN most critical surfaces

Problem Description : EXISTING STABILITY ANALYSIS

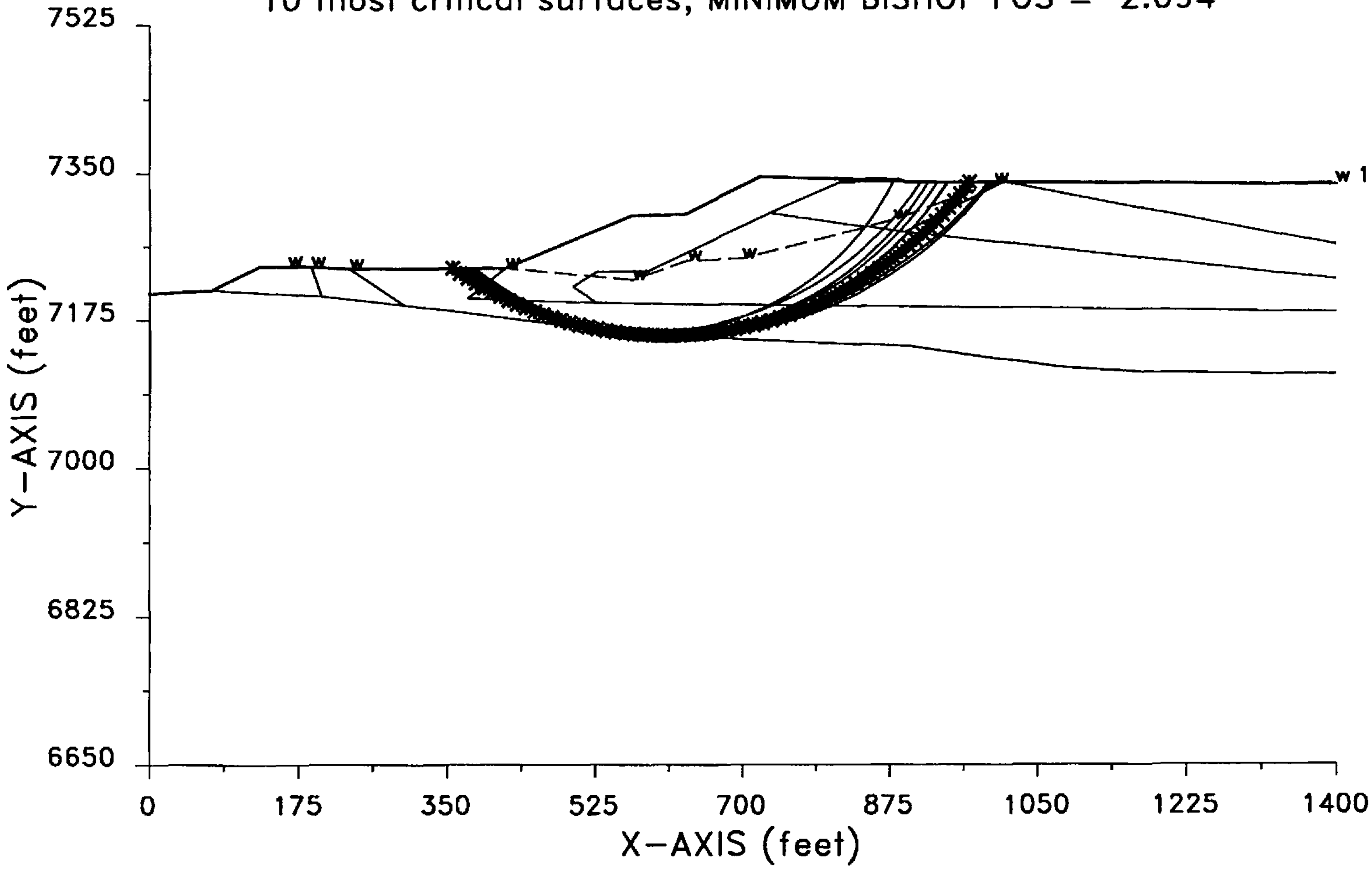
	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	2.094	610.13	7603.18	446.75	356.03	970.06	1.121E+09
2.	2.103	588.34	7483.39	325.13	377.59	880.91	7.511E+08
3.	2.118	629.06	7615.88	460.57	368.97	995.86	1.154E+09
4.	2.123	619.13	7594.42	437.26	368.97	973.80	1.084E+09
5.	2.127	606.45	7540.22	383.46	373.28	932.19	9.336E+08
6.	2.129	604.87	7524.68	367.55	377.59	921.52	8.828E+08
7.	2.130	616.97	7538.25	383.03	381.90	943.61	9.237E+08
8.	2.134	620.64	7630.86	473.15	360.34	992.52	1.202E+09
9.	2.137	613.99	7548.24	391.79	377.59	944.84	9.539E+08
10.	2.138	583.37	7554.32	393.92	351.72	912.98	9.818E+08

* * * END OF FILE * * *

MOST CRITICAL LEVEE BUTTRESS OUTPUT

SD_EC2 1-12-99 14:31

EXISTING STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 2.094



XSTABL File: MD_EC2   1-12-99   14:21

```
*******************************************
*              X S T A B L                *
*                                         *
*        Slope Stability Analysis         *
*               using the                 *
*            Method of Slices             *
*                                         *
*         Copyright (C) 1992 Ä 95         *
*   Interactive Software Designs, Inc.    *
*        Moscow, ID 83843, U.S.A.         *
*                                         *
*           All Rights Reserved           *
*                                         *
*  Ver. 5.105                95 Ä 1318    *
*******************************************
```

Problem Description : CURRENT COND. STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

----

11 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	6979.0	223.8	6995.0	1
2	223.8	6995.0	733.8	7250.0	2
3	733.8	7250.0	760.8	7250.0	2
4	760.8	7250.0	769.1	7250.0	3
5	769.1	7250.0	775.1	7250.0	4
6	775.1	7250.0	978.8	7345.0	5
7	978.8	7345.0	1071.6	7345.0	5
8	1071.6	7345.0	1145.0	7340.0	5
9	1145.0	7340.0	1179.1	7337.0	5
10	1179.1	7337.0	1266.3	7337.0	6
11	1266.3	7337.0	1800.0	7334.4	7

30 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	1052.3	7335.0	1179.1	7337.0	6
2	867.7	7245.3	1052.3	7337.0	6
3	1266.3	7337.0	1560.4	7255.0	8
4	1560.4	7255.0	1800.0	7257.0	8
5	867.7	7245.3	1066.4	7235.1	9
6	1066.4	7235.1	1266.3	7337.0	8

7	1066.4	7235.1	1560.4	7218.1	9
8	1560.4	7218.1	1800.0	7228.6	9
9	834.7	7229.3	867.7	7245.3	9
10	834.7	7229.3	845.9	7212.0	5
11	845.9	7212.0	908.6	7170.2	5
12	908.6	7170.2	1560.4	7183.2	10
13	1560.4	7183.2	1800.0	7183.2	10
14	775.1	7250.0	788.8	7250.0	4
15	788.8	7250.0	802.4	7229.0	5
16	908.6	7170.2	1092.6	7047.6	5
17	802.4	7229.0	986.6	7044.9	4
18	769.1	7250.0	903.8	7042.7	3
19	760.8	7250.0	873.3	7042.0	2
20	1726.9	7149.4	1800.0	7162.5	1
21	1571.0	7109.4	1726.9	7149.4	1
22	1329.6	7059.5	1571.0	7109.4	1
23	1220.1	7048.2	1329.6	7059.5	1
24	1092.6	7047.6	1220.1	7048.2	1
25	986.6	7044.9	1092.6	7047.6	1
26	903.8	7042.7	986.6	7044.9	1
27	873.3	7042.0	903.8	7042.7	1
28	865.6	7042.5	873.3	7042.0	1
29	680.7	7018.7	895.6	7042.5	1
30	223.8	6995.0	680.7	7018.7	1

ISOTROPIC Soil Parameters
----

10 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	0
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	112.0	115.0	.0	36.00	.000	.0	1
7	112.0	122.0	500.0	.00	.000	.0	1
8	112.0	122.0	710.0	.00	.000	.0	1
9	112.0	124.0	9000.0	.00	.000	.0	1
10	112.0	128.0	2300.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 5 coordinate points

****

PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	769.10	7250.00
2	880.00	7252.00
3	980.00	7257.00
4	1200.00	7336.70
5	1800.00	7336.70

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 200.0 ft and x = 450.0 ft

Each surface terminates between x = 1100.0 ft and x = 1500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

35.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)
****
Negative effective stresses were calculated at the base of a slice. This warning is usually reported for cases where slices have low self

weight and a relatively high "c" shear strength parameter. In such cases, this effect can only be eliminated by reducing the "c" value.
****

USER SELECTED option to maintain strength greater than zero

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 31 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	251.72	7008.96
2	286.70	7007.57
3	321.69	7007.06
4	356.69	7007.43
5	391.67	7008.68
6	426.60	7010.82
7	461.47	7013.83
8	496.26	7017.73
9	530.93	7022.49
10	565.47	7028.14
11	599.86	7034.65
12	634.07	7042.03
13	668.09	7050.26
14	701.89	7059.36
15	735.45	7069.30
16	768.74	7080.08
17	801.76	7091.70
18	834.47	7104.15
19	866.86	7117.43
20	898.90	7131.51
21	930.57	7146.40
22	961.86	7162.08
23	992.75	7178.54
24	1023.21	7195.78
25	1053.22	7213.78
26	1082.78	7232.54
27	1111.85	7252.03
28	1140.42	7272.25
29	1168.47	7293.18
30	1195.98	7314.81
31	1222.77	7337.00

**** Simplified BISHOP FOS = 1.762 ****

The following is a summary of the TEN most critical surfaces

Problem Description : CURRENT COND. STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.762	324.48	8394.91	1387.86	251.72	1222.77	1.118E+10
2.	1.769	-12134.12	39726.95	34984.92	243.10	1102.64	8.246E+10
3.	1.782	304.12	8689.68	1663.58	286.21	1272.28	1.216E+10
4.	1.793	159.81	9297.37	2282.39	268.97	1327.83	1.677E+10
5.	1.801	130.06	8692.62	1699.30	225.86	1157.07	1.170E+10
6.	1.804	141.38	8591.46	1575.46	277.59	1102.00	8.145E+09
7.	1.805	281.81	8845.19	1806.31	312.07	1275.64	1.193E+10
8.	1.806	60.80	9516.18	2500.16	286.21	1285.90	1.579E+10
9.	1.811	431.77	8230.80	1213.36	286.21	1252.11	1.026E+10
10.	1.812	249.39	9131.13	2122.17	251.72	1381.60	1.849E+10

* * * END OF FILE * * *

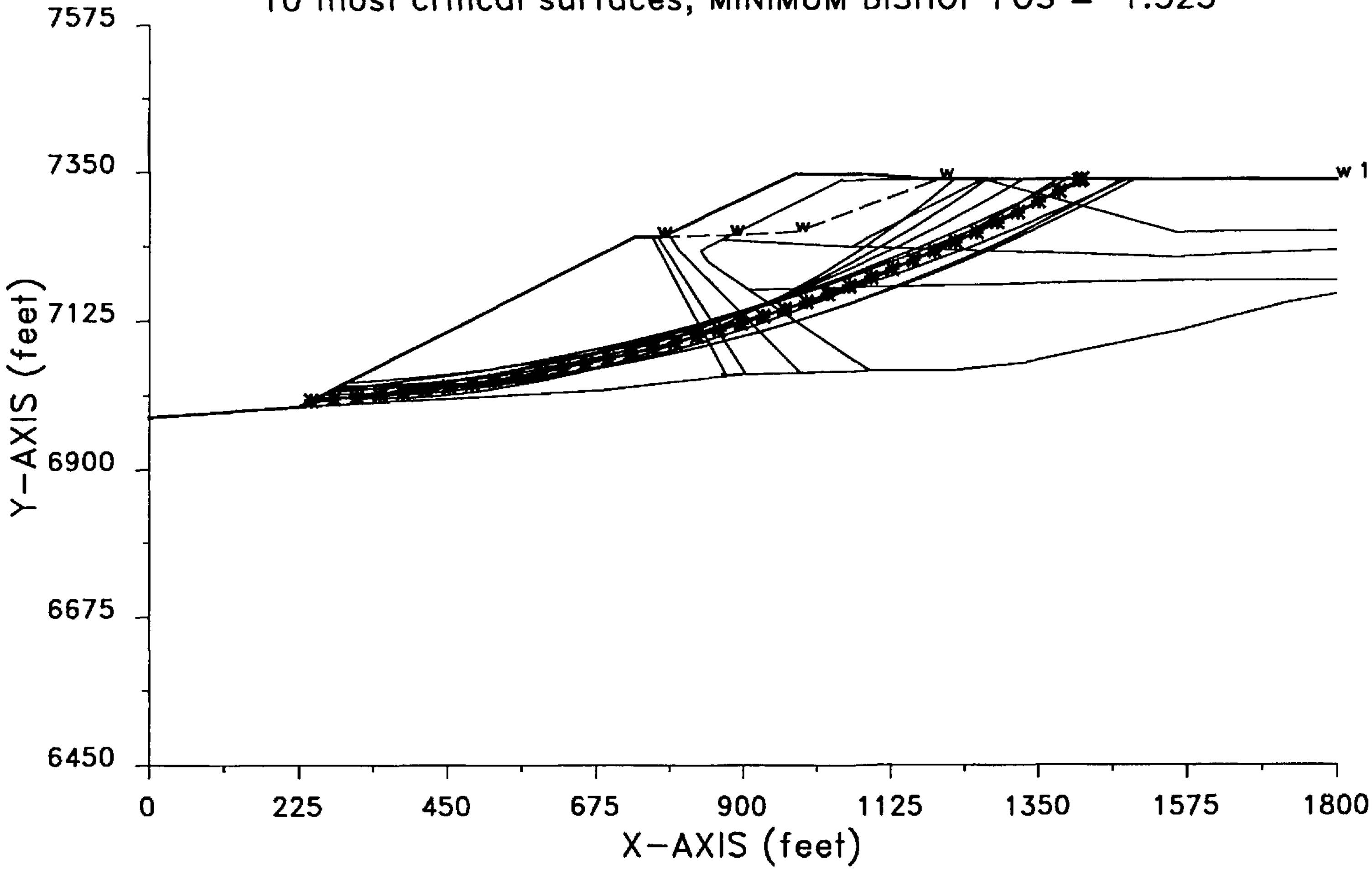
APPENDIX G-2

PSEUDOSTATIC STABILITY

MOST CRITICAL MAIN DAM OUTPUT

MD_EP2 1-12-99 14:24

CURRENT COND. STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 1.323



XSTABL File: SD_EP2   1-12-99   14:34

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****************************************
*              X S T A B L              *
*                                       *
*       Slope Stability Analysis        *
*             using the                 *
*          Method of Slices             *
*                                       *
*        Copyright (C) 1992 Ä 95        *
*   Interactive Software Designs, Inc.  *
*       Moscow, ID 83843, U.S.A.        *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.105                95 Ä 1318  *
****************************************
```

Problem Description : EXISTING STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

---

14 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	7206.3	72.7	7210.0	1
2	72.7	7210.0	128.4	7237.9	2
3	128.4	7237.9	162.3	7238.4	2
4	162.3	7238.4	169.3	7238.4	3
5	169.3	7238.4	189.2	7237.6	4
6	189.2	7237.6	235.0	7235.2	5
7	235.0	7235.2	419.0	7236.0	10
8	419.0	7236.0	568.6	7299.0	5
9	568.6	7299.0	632.6	7300.8	5
10	632.6	7300.8	721.0	7345.0	5
11	721.0	7345.0	886.8	7341.0	5
12	886.8	7341.0	893.8	7338.5	5
13	893.8	7338.5	1009.8	7337.9	6
14	1009.8	7337.9	1400.0	7334.4	7

26 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	816.8	7339.0	893.8	7338.5	6
2	732.4	7301.4	816.8	7339.0	6
3	1009.8	7337.9	1400.0	7334.4	7

4	893.3	7278.2	1009.8	7337.9	8
5	1009.8	7337.9	1400.0	7262.1	8
6	732.4	7301.4	893.3	7278.2	9
7	893.3	7278.2	1400.0	7221.2	9
8	587.8	7232.0	732.4	7301.4	9
9	189.2	7237.6	201.4	7202.9	4
10	235.0	7235.2	299.4	7192.3	5
11	587.8	7232.0	732.4	7301.4	9
12	374.3	7200.0	419.0	7236.0	5
13	528.7	7232.0	587.8	7232.0	9
14	498.9	7214.1	528.7	7232.0	9
15	498.9	7214.1	526.0	7194.9	5
16	72.7	7210.0	162.3	7205.2	1
17	162.3	7205.2	169.3	7204.6	1
18	169.3	7204.6	201.4	7202.9	1
19	201.4	7202.9	299.4	7192.3	1
20	374.3	7200.0	526.0	7194.9	10
21	526.0	7194.9	1400.0	7182.7	10
22	299.4	7192.3	584.2	7156.1	1
23	584.2	7156.1	898.0	7142.9	1
24	898.0	7142.9	1076.2	7117.6	1
25	1076.2	7117.6	1179.5	7111.3	1
26	1179.5	7111.3	1400.0	7108.8	1

ISOTROPIC Soil Parameters
----

10 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	0
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	112.0	115.0	.0	36.00	.000	.0	1
7	112.0	122.0	500.0	.00	.000	.0	1
8	112.0	122.0	710.0	.00	.000	.0	1
9	112.0	124.0	9000.0	.00	.000	.0	1
10	112.0	128.0	2300.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 10 coordinate points

****

PHREATIC SURFACE,

****

Point No.	x-water (ft)	y-water (ft)
1	162.30	7238.40
2	189.20	7237.60
3	235.00	7235.20
4	419.00	7236.00
5	570.00	7222.00
6	635.00	7245.00
7	700.00	7247.00
8	880.00	7293.00
9	1000.00	7336.70
10	1400.00	7336.70

A horizontal earthquake loading coefficient
of .100 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced
along the ground surface between x = 300.0 ft
and x = 425.0 ft

Each surface terminates between x = 850.0 ft
and x = 1000.0 ft

Unless further limitations were imposed, the minimum elevation
at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

11.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined
within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

****
-- WARNING -- WARNING -- WARNING -- WARNING -- (# 48)
****
Negative effective stresses were calculated at the base of a slice. This warning is usually reported for cases where slices have low self weight and a relatively high "c" shear strength parameter. In such cases, this effect can only be eliminated by reducing the "c" value.
****

USER SELECTED option to maintain strength greater than zero

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 65 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	368.97	7235.78
2	378.12	7229.68
3	387.41	7223.80
4	396.84	7218.14
5	406.41	7212.71
6	416.10	7207.50
7	425.92	7202.54
8	435.85	7197.80
9	445.89	7193.31
10	456.03	7189.06
11	466.28	7185.05
12	476.61	7181.29
13	487.03	7177.77
14	497.54	7174.51
15	508.12	7171.49
16	518.77	7168.74
17	529.48	7166.23
18	540.25	7163.99
19	551.07	7162.00
20	561.93	7160.27
21	572.83	7158.80
22	583.76	7157.59
23	594.72	7156.64

24	605.70	7155.96
25	616.69	7155.54
26	627.69	7155.38
27	638.69	7155.48
28	649.69	7155.85
29	660.67	7156.48
30	671.63	7157.37
31	682.57	7158.52
32	693.48	7159.94
33	704.35	7161.61
34	715.18	7163.54
35	725.96	7165.74
36	736.68	7168.19
37	747.34	7170.89
38	757.94	7173.85
39	768.46	7177.06
40	778.90	7180.52
41	789.26	7184.23
42	799.52	7188.19
43	809.69	7192.39
44	819.75	7196.84
45	829.70	7201.52
46	839.54	7206.44
47	849.26	7211.59
48	858.85	7216.97
49	868.31	7222.58
50	877.64	7228.42
51	886.82	7234.48
52	895.86	7240.75
53	904.74	7247.24
54	913.46	7253.94
55	922.03	7260.84
56	930.42	7267.95
57	938.64	7275.26
58	946.69	7282.76
59	954.55	7290.45
60	962.23	7298.33
61	969.72	7306.39
62	977.01	7314.62
63	984.10	7323.03
64	990.99	7331.60
65	995.86	7337.97

**** Simplified BISHOP FOS = 1.354 ****

The following is a summary of the TEN most critical surfaces

Problem Description : EXISTING STABILITY ANALYSIS

FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)

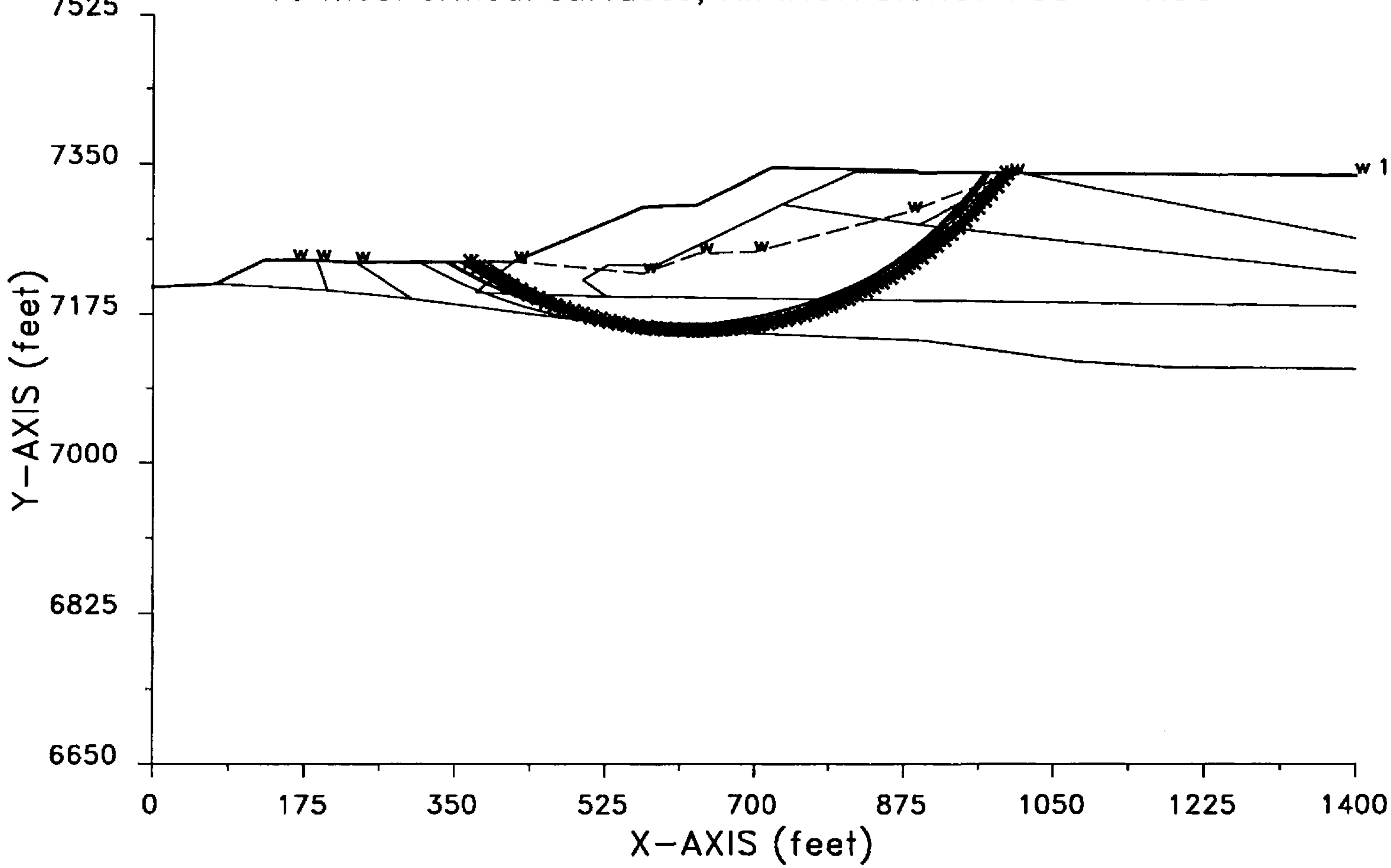
1.	1.354	629.06	7615.88	460.57	368.97	995.86	1.161E+09
2.	1.366	610.13	7603.18	446.75	356.03	970.06	1.124E+09
3.	1.369	620.64	7630.86	473.15	360.34	992.52	1.208E+09
4.	1.370	611.46	7663.96	505.41	343.10	997.41	1.326E+09
5.	1.380	619.13	7594.42	437.26	368.97	973.80	1.089E+09
6.	1.391	589.60	7722.45	562.18	308.62	999.68	1.550E+09
7.	1.393	628.91	7620.23	461.67	373.28	994.45	1.171E+09
8.	1.398	630.11	7608.25	449.97	377.59	989.20	1.131E+09
9.	1.399	631.57	7574.18	417.93	386.21	976.46	1.027E+09
10.	1.403	603.08	7667.50	506.30	338.79	987.67	1.336E+09

* * * END OF FILE * * *

MOST CRITICAL LEVEE BUTTRESS OUTPUT

SD_EP2   1-12-99   14:34

EXISTING STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 1.354



XSTABL File: MD_EP2   1-12-99   14:24

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*****************************************
*                X S T A B L            *
*                                       *
*       Slope Stability Analysis        *
*             using the                 *
*          Method of Slices             *
*                                       *
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*****************************************
```

Problem Description : CURRENT COND. STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

11 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	6979.0	223.8	6995.0	1
2	223.8	6995.0	733.8	7250.0	2
3	733.8	7250.0	760.8	7250.0	2
4	760.8	7250.0	769.1	7250.0	3
5	769.1	7250.0	775.1	7250.0	4
6	775.1	7250.0	978.8	7345.0	5
7	978.8	7345.0	1071.6	7345.0	5
8	1071.6	7345.0	1145.0	7340.0	5
9	1145.0	7340.0	1179.1	7337.0	5
10	1179.1	7337.0	1266.3	7337.0	6
11	1266.3	7337.0	1800.0	7334.4	7

30 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	1052.3	7335.0	1179.1	7337.0	6
2	867.7	7245.3	1052.3	7337.0	6
3	1266.3	7337.0	1560.4	7255.0	8
4	1560.4	7255.0	1800.0	7257.0	8
5	867.7	7245.3	1066.4	7235.1	9
6	1066.4	7235.1	1266.3	7337.0	8

7	1066.4	7235.1	1560.4	7218.1	9
8	1560.4	7218.1	1800.0	7228.6	9
9	834.7	7229.3	867.7	7245.3	9
10	834.7	7229.3	845.9	7212.0	5
11	845.9	7212.0	908.6	7170.2	5
12	908.6	7170.2	1560.4	7183.2	10
13	1560.4	7183.2	1800.0	7183.2	10
14	775.1	7250.0	788.8	7250.0	4
15	788.8	7250.0	802.4	7229.0	5
16	908.6	7170.2	1092.6	7047.6	5
17	802.4	7229.0	986.6	7044.9	4
18	769.1	7250.0	903.8	7042.7	3
19	760.8	7250.0	873.3	7042.0	2
20	1726.9	7149.4	1800.0	7162.5	1
21	1571.0	7109.4	1726.9	7149.4	1
22	1329.6	7059.5	1571.0	7109.4	1
23	1220.1	7048.2	1329.6	7059.5	1
24	1092.6	7047.6	1220.1	7048.2	1
25	986.6	7044.9	1092.6	7047.6	1
26	903.8	7042.7	986.6	7044.9	1
27	873.3	7042.0	903.8	7042.7	1
28	865.6	7042.5	873.3	7042.0	1
29	680.7	7018.7	895.6	7042.5	1
30	223.8	6995.0	680.7	7018.7	1

ISOTROPIC Soil Parameters

----

10 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	0
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	112.0	115.0	.0	36.00	.000	.0	1
7	112.0	122.0	500.0	.00	.000	.0	1
8	112.0	122.0	710.0	.00	.000	.0	1
9	112.0	124.0	9000.0	.00	.000	.0	1
10	112.0	128.0	2300.0	.00	.000	.0	1

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 5 coordinate points

****

PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	769.10	7250.00
2	880.00	7252.00
3	980.00	7257.00
4	1200.00	7336.70
5	1800.00	7336.70

A horizontal earthquake loading coefficient
of .100 has been assigned

A vertical earthquake loading coefficient
of .000 has been assigned

A critical failure surface searching method, using a random
technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced
along the ground surface between x = 200.0 ft
and x = 450.0 ft

Each surface terminates between x = 1100.0 ft
and x = 1500.0 ft

Unless further limitations were imposed, the minimum elevation
at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

35.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined
within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

```
***********************************************************************
    --  WARNING  --  WARNING  --  WARNING  --  WARNING  --  (# 48)
***********************************************************************
Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter.  In such
cases, this effect can only be eliminated by reducing the "c" value.
***********************************************************************
```

USER SELECTED option to maintain strength greater than zero

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 37 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	243.10	7004.65
2	278.03	7006.84
3	312.94	7009.47
4	347.80	7012.53
5	382.63	7016.03
6	417.41	7019.96
7	452.13	7024.32
8	486.80	7029.12
9	521.41	7034.34
10	555.95	7040.00
11	590.42	7046.09
12	624.80	7052.60
13	659.11	7059.55
14	693.32	7066.92
15	727.44	7074.72
16	761.46	7082.94
17	795.38	7091.58
18	829.18	7100.65
19	862.87	7110.14
20	896.44	7120.05
21	929.89	7130.37
22	963.20	7141.11
23	996.37	7152.27
24	1029.41	7163.83
25	1062.29	7175.81
26	1095.03	7188.20
27	1127.60	7200.99

28	1160.02	7214.19
29	1192.27	7227.79
30	1224.35	7241.79
31	1256.25	7256.19
32	1287.96	7270.99
33	1319.50	7286.18
34	1350.84	7301.77
35	1381.98	7317.74
36	1412.92	7334.10
37	1416.90	7336.27

**** Simplified BISHOP FOS = 1.323 ****

The following is a summary of the TEN most critical surfaces

Problem Description : CURRENT COND. STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.323	84.66	9809.21	2809.03	243.10	1416.90	2.290E+10
2.	1.326	-200.91	10830.23	3854.56	234.48	1426.61	2.918E+10
3.	1.331	159.81	9297.37	2282.39	268.97	1327.83	1.641E+10
4.	1.332	249.39	9131.13	2122.17	251.72	1381.60	1.809E+10
5.	1.340	219.61	9700.85	2687.89	260.34	1497.06	2.418E+10
6.	1.341	304.12	8689.68	1663.58	286.21	1272.28	1.191E+10
7.	1.342	29.17	10050.50	3038.78	277.59	1395.63	2.159E+10
8.	1.347	324.48	8394.91	1387.86	251.72	1222.77	1.092E+10
9.	1.348	288.94	9429.42	2407.56	277.59	1478.14	2.122E+10
10.	1.350	109.40	10225.72	3200.58	294.83	1485.43	2.448E+10

* * * END OF FILE * * *

APPENDIX H

LIQUEFACTION AND POST-LIQUEFACTION ANALYSIS

APPENDIX H-1

LIQUEFACTION ANALYSIS

APPENDIX H-1

Assessment Of Liquefaction Potential

The liquefaction analysis procedures employed during this investigation rely upon the estimation of the cyclic resistance ratio (CRR) of the in situ soils and compares that value to the cyclic stress ratio (CSR) imposed by the design earthquake to compute a factor of safety. The CRR has been computed from three independent methods that all utilize the cone penetrometer testing with pore pressure measurements (CPTU) or the seismic cone penetration testing (SCPT) data. The analysis is spreadsheet oriented and summary output for the three CPT soundings located nearest to the embankments (i.e. those tailings which constitute the foundation materials for the upstream constructed buttresses) are included in this appendix.

The CSR is defined as the ratio of the cyclic shear stress acting on a horizontal plane to the initial (pre-earthquake) effective vertical stress. The CSR that will induce liquefaction, which is equal to the CRR, is found from empirical curves that relate the estimated CSR from sites that have versus have not liquefied. The CSR is a function of the relative density and fines content of the soil as deduced from SPT, CPT, SCPT, and/or laboratory testing. The empirical curves are based on a magnitude 7.5 earthquake to yield the cyclic resistance ratio for a magnitude 7.5 earthquake ($CRR_{7.5}$). Lower magnitude earthquakes (i.e. shorter duration and fewer shear stress cycles) require a larger peak acceleration to induce liquefaction. The earthquake scaling factors applied are from Andurs and Stokoe, 1997 (*in* Youd and Idriss, 1977) and are as follows:

TABLE H-1

LIQUEFACTION POTENTIAL SPREADSHEET SUMMARY
CPT-6

DEPTH (ft)	UNIT WEIGHT (pcf)	Qc (tsf)	Qt (tsf)	Fs (tsf)	Rf%	DYNAMIC PWP (tsf)	EQUIL. PWP (ft)	TOTAL STRESS (tsf)	EFFECTIVE STRESS (tsf	CSR 0.16	r_d
5	125.00	7.95	7.96	0.06	0.01	0.10	1.52	0.31	0.27	0.12	0.99
10	125.00	9.52	9.58	0.04	0.00	0.41	3.06	0.63	0.53	0.12	0.98
15	125.00	10.09	10.18	0.06	0.01	0.63	4.56	0.94	0.80	0.12	0.96
20	125.00	11.31	11.44	0.08	0.01	0.85	6.10	1.26	1.07	0.12	0.95
25	125.00	11.15	11.33	0.08	0.01	1.22	7.59	1.56	1.33	0.12	0.94
30	125.00	12.39	12.64	0.09	0.01	1.67	9.14	1.88	1.60	0.11	0.92
35	125.00	16.49	16.77	0.13	0.01	1.86	10.63	2.19	1.86	0.11	0.89
40	125.00	15.29	15.69	0.14	0.01	2.67	12.18	2.51	2.13	0.10	0.85
45	125.00	15.41	15.93	0.13	0.01	3.47	13.67	2.81	2.39	0.10	0.81
50	125.00	19.29	19.74	0.16	0.01	3.02	15.21	3.13	2.66	0.09	0.77
55	125.00	30.75	31.02	0.29	0.01	1.79	16.71	3.44	2.92	0.09	0.73
60	125.00	30.77	31.28	0.29	0.01	3.42	18.25	3.76	3.19	0.08	0.68
65	125.00	23.01	23.92	0.24	0.01	6.07	19.75	4.07	3.45	0.08	0.64
70	125.00	25.88	26.90	0.29	0.01	6.84	21.29	4.38	3.72	0.07	0.60
75	125.00	30.59	31.43	0.37	0.01	5.58	22.78	4.69	3.98	0.07	0.57
80	125.00	33.29	33.96	0.48	0.02	4.47	24.33	5.01	4.25	0.07	0.55
85	125.00	39.29	40.02	0.55	0.02	4.82	25.82	5.32	4.51	0.07	0.54
90	125.00	47.12	47.74	0.67	0.02	4.14	27.39	5.63	4.78	0.06	0.52
95	125.00	37.12	38.43	0.54	0.02	8.72	29.68	5.94	5.02	0.06	0.51
100	125.00	43.69	44.90	0.60	0.02	8.03	33.18	6.26	5.22	0.06	0.50
105	125.00	54.76	55.48	0.81	0.02	4.81	36.91	6.57	5.42	0.06	0.50
110	125.00	48.63	49.77	0.88	0.02	7.64	40.75	6.88	5.61	0.06	0.50
115	125.00	59.98	60.91	1.04	0.02	6.21	44.48	7.19	5.80	0.06	0.50
120	125.00	66.62	67.64	1.03	0.02	6.76	48.20	7.50	6.00	0.07	0.50
125	125.00	56.59	57.57	0.82	0.02	6.56	52.05	7.82	6.19	0.07	0.50
130	125.00	51.05	51.93	0.68	0.01	5.90	55.78	8.13	6.38	0.07	0.50
135	125.00	46.33	47.64	0.66	0.02	8.68	59.63	8.44	6.58	0.07	0.50
140	125.00	38.32	40.28	0.61	0.02	13.09	63.35	8.75	6.77	0.07	0.50
145	125.00	29.06	32.09	0.40	0.01	20.20	67.20	9.07	6.97	0.07	0.50

LIQUEFACTION POTENTIAL BASED ON BLOW COUNT CORRELATIONS

DEPTH (ft)	N_{60} (blows/ft.)	C_N	$N_{1(60)}$ (blows/ft)	FINES (%)	α	β	$N_{1(60)cs}$ (blows/ft)	$CRR_{7.5}$ N	FS_N
5	3.06	2.59	6.50	20.00	3.61	1.08	10.63	0.12	0.96
10	3.81	1.45	5.45	20.00	3.61	1.08	9.50	0.10	0.87
15	4.03	1.17	4.70	20.00	3.61	1.08	8.69	0.10	0.82
20	4.50	1.00	4.50	20.00	3.61	1.08	8.47	0.10	0.82
25	4.45	0.90	4.04	20.00	3.61	1.08	7.98	0.09	0.79
30	4.97	0.82	4.02	20.00	3.61	1.08	7.95	0.09	0.79
35	6.60	0.76	4.98	30.00	4.08	1.12	9.67	0.11	0.98
40	6.12	0.71	4.34	45.50	4.79	1.18	9.91	0.11	1.04
45	6.19	0.67	4.11	50.00	5.00	1.20	9.93	0.11	1.10
50	7.72	0.63	4.87	50.00	5.00	1.20	10.84	0.12	1.26
55	12.09	0.60	7.23	50.00	5.00	1.20	13.68	0.15	1.69
60	12.09	0.58	7.03	50.00	5.00	1.20	13.44	0.15	1.74
65	9.16	0.55	5.06	50.00	5.00	1.20	11.08	0.12	1.53
70	10.29	0.53	5.48	50.00	5.00	1.20	11.58	0.13	1.71
75	12.09	0.52	6.22	50.00	5.00	1.20	12.47	0.14	1.96
80	13.16	0.50	6.57	50.00	5.00	1.20	12.88	0.14	2.08
85	15.45	0.48	7.46	50.00	5.00	1.20	13.95	0.15	2.31
90	18.38	0.47	8.65	50.00	5.00	1.20	15.38	0.17	2.60
95	14.52	0.46	6.68	50.00	5.00	1.20	13.02	0.14	2.25
100	17.00	0.45	7.63	50.00	5.00	1.20	14.15	0.16	2.54
105	21.34	0.44	9.44	50.00	5.00	1.20	16.33	0.18	2.90
110	19.13	0.43	8.30	50.00	5.00	1.20	14.97	0.16	2.56
115	23.31	0.43	9.93	50.00	5.00	1.20	16.92	0.19	2.88
120	25.71	0.42	10.81	50.00	5.00	1.20	17.97	0.20	3.04
125	22.07	0.41	9.13	50.00	5.00	1.20	15.96	0.17	2.65
130	20.15	0.41	8.20	50.00	5.00	1.20	14.85	0.16	2.44
135	18.41	0.40	7.38	50.00	5.00	1.20	13.86	0.15	2.25
140	15.30	0.40	6.05	50.00	5.00	1.20	12.26	0.13	1.98
145	11.67	0.39	4.55	50.00	5.00	1.20	10.46	0.11	1.68

LIQUEFACTION POTENTIAL BASED ON DIRECT APPLICATION OF CPT

DEPTH (ft)	q_{c1} (tsf)	q_{c1N}	$(q_{c1N})_{cs}$	n	C_Q	Q	F	Ic	Kc	$CRR_{7.5}$ CONE	FS_{cone}	FSavg
5	17.12	14.69	42.53	0.75	1.97	24.62	1.10%	2.37	2.93	0.09	0.76	
10	13.60	14.84	59.59	0.75	1.67	14.60	0.55%	2.64	4.25	0.11	0.91	0.87
15	11.76	12.04	48.09	0.75	1.27	11.06	0.82%	2.70	4.40	0.09	0.78	0.83
20	11.31	10.71	38.71	0.75	1.01	9.64	0.99%	2.76	4.23	0.08	0.71	0.78
25	10.15	9.17	35.92	0.75	0.85	8.06	1.17%	2.84	4.51	0.08	0.70	0.74
30	10.01	8.50	39.66	0.75	0.74	7.37	1.10%	2.82	4.76	0.08	0.74	0.78
35	12.44	10.21	42.90	0.75	0.66	9.03	1.01%	2.71	4.45	0.09	0.79	0.86
40	10.86	8.65	37.14	0.75	0.59	7.47	1.32%	2.78	4.63	0.08	0.78	0.92
45	10.23	7.88	35.47	0.75	0.54	6.71	1.29%	2.84	4.73	0.08	0.81	0.97
50	12.17	9.14	37.45	0.75	0.50	7.87	1.22%	2.77	4.48	0.08	0.87	1.09
55	18.39	13.44	41.24	0.75	0.47	12.04	1.40%	2.61	3.75	0.08	0.95	1.28
60	17.90	12.91	40.55	0.75	0.44	11.56	1.44%	2.64	3.89	0.08	1.00	1.34
65	12.72	8.94	36.36	0.75	0.41	7.71	1.48%	2.76	4.50	0.08	1.02	1.30
70	13.79	9.51	35.09	0.75	0.39	8.28	1.62%	2.74	4.24	0.08	1.07	1.40
75	15.75	10.68	34.93	0.75	0.37	9.33	1.80%	2.69	3.97	0.08	1.14	1.55
80	16.63	11.11	36.26	0.75	0.35	9.66	1.95%	2.62	3.82	0.08	1.19	1.64
85	18.98	12.46	37.08	0.75	0.34	11.00	1.89%	2.56	3.46	0.08	1.23	1.76
90	22.17	14.37	36.57	0.75	0.32	12.84	1.98%	2.50	3.01	0.08	1.25	1.83
95	17.09	10.96	31.06	0.75	0.31	9.59	2.01%	2.69	3.70	0.08	1.20	1.82
100	19.59	12.40	33.24	0.75	0.30	10.96	1.85%	2.64	3.61	0.08	1.24	1.93
105	24.23	15.24	38.35	0.75	0.29	13.61	2.02%	2.47	3.03	0.08	1.30	1.99
110	21.11	13.14	36.40	0.75	0.29	11.59	2.40%	2.50	3.14	0.08	1.26	1.98
115	25.55	15.76	37.73	0.75	0.28	14.11	2.38%	2.43	2.79	0.08	1.26	2.06
120	28.01	17.16	37.74	0.75	0.27	15.49	2.01%	2.42	2.69	0.08	1.25	2.11
125	23.41	14.23	37.44	0.75	0.27	12.51	1.90%	2.52	3.19	0.08	1.24	1.97
130	20.78	12.53	40.00	0.75	0.26	10.76	1.84%	2.57	3.66	0.08	1.26	1.83
135	18.58	11.12	39.13	0.75	0.25	9.40	1.92%	2.61	3.91	0.08	1.24	1.74
140	15.16	9.01	34.67	0.75	0.25	7.42	2.09%	2.71	4.25	0.08	1.17	1.57
145	11.33	6.68	30.50	0.75	0.24	5.29	1.84%	2.85	4.76	0.08	1.11	1.44

TABLE H-2

LIQUEFACTION POTENTIAL SPREADSHEET SUMMARY
CPT-9

DEPTH (ft)	UNIT WEIGHT (pcf)	qc (tsf)	qt (tsf)	Fs (tsf)	Rf%	DYNAMIC PWP (tsf)	EQUIL. PWP (ft)	Vs (fps)	TOTAL STRESS (tsf)	EFFECTIVE STRESS (tsf)	r_d	CSR 0.16
5	125.00	10.52	10.53	0.05	0.01	0.09	2.97	394.74	0.31	0.22	0.99	0.15
10	125.00	8.66	8.73	0.04	0.01	0.47	5.59	416.36	0.63	0.46	0.98	0.14
15	125.00	11.78	11.88	0.05	0.00	0.69	7.73	437.27	0.94	0.70	0.96	0.14
20	125.00	12.85	13.02	0.06	0.01	1.15	9.58	458.89	1.26	0.96	0.95	0.13
25	125.00	8.00	8.31	0.08	0.01	2.08	11.09	479.80	1.56	1.22	0.94	0.13
30	125.00	11.95	12.21	0.13	0.01	1.72	12.41	501.42	1.88	1.49	0.92	0.12
35	125.00	17.11	17.41	0.16	0.01	1.97	13.51	522.33	2.19	1.77	0.89	0.11
40	125.00	17.29	17.74	0.19	0.01	3.02	14.51	543.94	2.51	2.05	0.85	0.11
45	125.00	24.36	24.64	0.24	0.01	1.88	15.38	564.86	2.81	2.33	0.81	0.10
50	125.00	25.72	26.01	0.27	0.01	1.99	16.24	586.47	3.13	2.63	0.77	0.10
55	125.00	27.89	28.28	0.30	0.01	2.62	17.05	607.39	3.44	2.91	0.73	0.09
60	125.00	34.83	35.22	0.38	0.01	2.62	17.92	629.00	3.76	3.20	0.68	0.08
65	125.00	43.56	43.92	0.50	0.01	2.37	18.82	649.92	4.07	3.48	0.64	0.08
70	125.00	46.64	47.05	0.55	0.01	2.75	19.84	671.53	4.38	3.76	0.60	0.07
75	125.00	34.15	34.92	0.50	0.02	5.12	20.94	692.45	4.69	4.04	0.57	0.07
80	125.00	26.81	28.00	0.45	0.02	7.90	22.22	714.06	5.01	4.32	0.55	0.07
85	125.00	34.12	35.08	0.54	0.02	6.41	23.62	734.98	5.32	4.58	0.54	0.06
90	125.00	36.51	37.44	0.60	0.02	6.23	25.24	756.59	5.63	4.85	0.52	0.06
95	125.00	24.04	25.95	0.43	0.02	12.71	27.01	777.50	5.94	5.10	0.51	0.06
100	125.00	29.66	31.46	0.45	0.02	11.99	29.04	799.12	6.26	5.35	0.50	0.06
105	125.00	46.18	47.48	0.85	0.02	8.69	31.21	820.03	6.57	5.59	0.50	0.06
110	125.00	57.12	58.27	1.01	0.02	7.66	33.69	841.65	6.88	5.83	0.50	0.06
115	125.00	52.00	53.38	0.89	0.02	9.22	36.30	862.56	7.19	6.08	0.50	0.06
120	125.00	51.64	53.34	1.00	0.02	11.33	39.13	883.48	7.50	6.28	0.50	0.06
125	125.00	77.47	78.63	1.26	0.02	7.71	42.28	905.09	7.82	6.50	0.50	0.06
130	125.00	73.66	74.97	1.10	0.02	8.75	45.54	926.01	8.13	6.70	0.50	0.06
135	125.00	73.70	74.72	1.04	0.02	6.76	49.11	947.62	8.44	6.91	0.50	0.06
140	125.00	66.26	67.80	0.91	0.02	10.27	52.78	968.54	8.75	7.10	0.50	0.06
145	125.00	53.91	56.21	0.70	0.01	15.36	56.71	990.15	9.07	7.30	0.50	0.06
150	125.00	70.23	72.49	0.88	0.01	15.02	60.70	1011.06	9.38	7.48	0.50	0.07
155	125.00	84.22	86.37	0.98	0.01	14.34	64.95	1032.68	9.69	7.67	0.50	0.07
160	125.00	77.48	80.30	0.89	0.01	18.60	69.19	1053.59	10.00	7.84	0.50	0.07
165	125.00	48.51	53.13	0.56	0.01	30.78	73.65	1075.21	10.32	8.02	0.50	0.07
170	125.00	32.89	38.43	0.41	0.01	36.95	78.03	1096.12	10.63	8.19	0.50	0.07
175	125.00	34.11	39.90	0.47	0.01	38.57	82.57	1117.74	10.94	8.37	0.50	0.07
180	125.00	30.84	36.39	0.43	0.01	36.99	86.96	1138.65	11.25	8.54	0.50	0.07
185	125.00	24.95	30.16	0.34	0.01	34.71	91.45	1160.26	11.57	8.72	0.50	0.07
190	125.00	27.57	33.28	0.34	0.01	38.07	95.70	1181.18	11.88	8.89	0.50	0.07
195	125.00	31.28	37.46	0.42	0.01	41.24	99.95	1202.79	12.20	9.08	0.50	0.07
200	125.00	29.61	35.98	0.42	0.01	42.49	103.88	1223.71	12.50	9.26	0.50	0.07

LIQUEFACTION POTENTIAL BASED ON BLOW COUNT CORRELATIONS

DEPTH (ft)	N_m (blows/ft.)	C_N	$N_{1(60)}$ (blows/ft)	FINES (%)	α	β	$N_{1(60)cs}$ (blows/ft)	$CRR_{7.5}$ N	FS_N
5	4.08	2.88	10.89	50.00	5.00	1.20	18.07	0.21	1.38
10	3.46	1.58	5.68	50.00	5.00	1.20	11.82	0.13	0.91
15	4.71	1.25	5.69	50.00	5.00	1.20	11.83	0.13	0.95
20	5.14	1.06	5.55	50.00	5.00	1.20	11.66	0.13	0.97
25	3.21	0.94	3.05	50.00	5.00	1.20	8.66	0.10	0.76
30	4.79	0.85	3.98	50.00	5.00	1.20	9.77	0.11	0.89
35	6.79	0.78	5.25	50.00	5.00	1.20	11.30	0.12	1.08
40	6.85	0.72	4.89	50.00	5.00	1.20	10.87	0.12	1.11
45	9.65	0.67	6.45	50.00	5.00	1.20	12.74	0.14	1.37
50	10.19	0.64	6.53	50.00	5.00	1.20	12.83	0.14	1.46
55	10.99	0.60	6.59	50.00	5.00	1.20	12.91	0.14	1.58
60	13.62	0.58	7.84	50.00	5.00	1.20	14.41	0.16	1.87
65	16.85	0.55	9.25	50.00	5.00	1.20	16.10	0.18	2.36
70	18.10	0.53	9.61	50.00	5.00	1.20	16.53	0.19	2.57
75	13.50	0.51	6.93	50.00	5.00	1.20	13.32	0.14	2.10
80	10.71	0.50	5.31	50.00	5.00	1.20	11.37	0.12	1.86
85	13.49	0.48	6.46	50.00	5.00	1.20	12.75	0.14	2.14
90	14.40	0.47	6.75	50.00	5.00	1.20	13.10	0.14	2.24
95	9.59	0.46	4.39	50.00	5.00	1.20	10.26	0.11	1.80
100	11.78	0.44	5.21	50.00	5.00	1.20	11.26	0.12	2.01
105	18.08	0.44	7.85	50.00	5.00	1.20	14.42	0.16	2.58
110	22.20	0.43	9.45	50.00	5.00	1.20	16.34	0.18	2.91
115	20.34	0.42	8.52	50.00	5.00	1.20	15.22	0.16	2.67
120	20.20	0.41	8.28	50.00	5.00	1.20	14.93	0.16	2.63
125	29.74	0.40	11.99	50.00	5.00	1.20	19.38	0.22	3.53
130	28.36	0.40	11.29	50.00	5.00	1.20	18.55	0.21	3.34
135	28.51	0.39	11.13	50.00	5.00	1.20	18.36	0.20	3.22
140	25.68	0.39	9.94	50.00	5.00	1.20	16.93	0.19	2.96
145	21.10	0.38	8.03	50.00	5.00	1.20	14.64	0.16	2.47
150	27.22	0.38	10.23	62.08	5.00	1.20	17.27	0.19	2.91
155	32.51	0.37	12.07	75.00	5.00	1.20	19.48	0.21	3.27
160	30.21	0.37	11.11	75.00	5.00	1.20	18.33	0.20	3.02
165	19.25	0.36	7.01	75.00	5.00	1.20	13.41	0.15	2.17
170	13.21	0.38	4.75	75.00	5.00	1.20	10.70	0.12	1.72
175	13.70	0.36	4.87	75.00	5.00	1.20	10.85	0.12	1.73
180	12.39	0.35	4.36	75.00	5.00	1.20	10.24	0.11	1.62
185	10.02	0.35	3.49	75.00	5.00	1.20	9.19	0.10	1.45
190	11.07	0.34	3.82	75.00	5.00	1.20	9.58	0.10	1.50
195	12.56	0.34	4.29	75.00	5.00	1.20	10.15	0.11	1.58
200	11.89	0.34	4.02	75.00	5.00	1.20	9.83	0.11	1.52

LIQUEFACTION POTENTIAL BASED ON DIRECT APPLICATION OF CPT

DEPTH (ft)	q_{c1} (tsf)	q_{c1N}	$(q_{c1N})_{cs}$ (tsf)	n	C_Q	Q	F	Ic	Kc	$CRR_{7.5}$ Cone	FS_{cone}
5	28.29	26.98	61.22	0.53	2.92	26.36	0.64%	2.40	2.78	0.10	0.70
10	14.23	14.63	56.32	0.66	1.75	13.72	0.63%	2.66	4.23	0.10	0.69
15	14.24	14.86	57.18	0.75	1.41	13.79	0.55%	2.67	4.16	0.10	0.72
20	13.88	13.66	50.62	0.75	1.10	12.55	0.71%	2.72	4.10	0.09	0.71
25	7.60	7.01	31.39	0.75	0.91	5.94	1.46%	2.93	4.74	0.08	0.60
30	9.92	8.52	32.91	0.75	0.78	7.34	1.68%	2.82	4.33	0.08	0.64
35	13.22	10.95	37.04	0.75	0.68	9.73	1.43%	2.70	3.96	0.08	0.71
40	12.36	9.88	34.89	0.75	0.61	8.70	1.58%	2.73	4.18	0.08	0.74
45	16.27	12.57	39.31	0.75	0.55	11.25	1.42%	2.60	3.56	0.08	0.82
50	16.48	12.47	39.68	0.75	0.51	11.11	1.43%	2.60	3.63	0.08	0.87
55	16.73	12.25	38.54	0.75	0.47	10.91	1.48%	2.60	3.71	0.08	0.92
60	20.06	14.39	39.05	0.75	0.44	13.00	1.46%	2.53	3.24	0.08	0.99
65	23.91	16.74	39.98	0.75	0.41	15.31	1.56%	2.47	3.02	0.08	1.07
70	24.76	17.05	41.12	0.75	0.39	15.60	1.63%	2.44	2.89	0.08	1.15
75	17.54	11.88	38.24	0.75	0.37	10.53	1.93%	2.58	3.67	0.08	1.19
80	13.29	8.84	35.40	0.75	0.35	7.58	2.24%	2.69	4.36	0.08	1.20
85	16.34	10.68	35.31	0.75	0.33	9.32	2.25%	2.63	3.87	0.08	1.23
90	17.11	11.08	34.76	0.75	0.32	9.65	2.31%	2.61	3.70	0.08	1.25
95	11.00	7.03	28.29	0.75	0.31	5.85	2.27%	2.81	4.49	0.07	1.18
100	13.12	8.25	29.93	0.75	0.30	7.00	1.93%	2.77	4.23	0.07	1.23
105	20.03	12.47	34.80	0.75	0.29	11.04	2.32%	2.54	3.33	0.08	1.29
110	24.30	14.98	35.51	0.75	0.28	13.48	2.28%	2.45	2.73	0.08	1.30
115	21.77	13.31	35.67	0.75	0.27	11.83	2.19%	2.50	3.12	0.08	1.29
120	21.16	12.80	35.62	0.75	0.26	11.36	2.49%	2.51	3.29	0.08	1.28
125	31.22	18.73	38.96	0.75	0.26	17.12	2.23%	2.36	2.55	0.08	1.32
130	29.33	17.49	37.92	0.75	0.25	15.88	2.01%	2.43	2.77	0.08	1.29
135	28.78	16.99	38.31	0.75	0.24	15.28	1.96%	2.44	2.74	0.08	1.29
140	25.64	15.08	36.75	0.75	0.24	13.44	1.85%	2.53	3.18	0.08	1.26
145	20.51	11.96	35.14	0.75	0.23	10.46	1.81%	2.64	3.72	0.08	1.23
150	26.39	15.29	37.75	0.75	0.23	13.74	1.65%	2.50	3.14	0.08	1.25
155	31.26	18.00	39.01	0.75	0.23	16.39	1.37%	2.40	2.53	0.08	1.25
160	28.49	16.33	38.98	0.75	0.22	14.82	1.37%	2.43	2.60	0.08	1.24
165	17.85	10.08	35.83	0.75	0.22	8.88	1.36%	2.66	4.04	0.08	1.19
170	11.82	6.70	33.48	0.75	0.22	5.66	1.47%	2.80	5.00	0.08	1.15
175	12.13	6.84	33.80	0.75	0.21	5.80	1.62%	2.77	4.97	0.08	1.15
180	10.67	6.10	30.10	0.75	0.21	4.97	1.69%	2.85	4.97	0.08	1.10
185	8.70	4.85	24.26	0.75	0.21	3.62	1.83%	2.97	5.00	0.07	1.02
190	9.50	5.27	26.36	0.75	0.20	4.09	1.64%	2.93	5.00	0.07	1.04
195	10.68	5.90	29.19	0.75	0.20	4.77	1.81%	2.87	4.97	0.07	1.06
200	10.01	5.50	27.20	0.75	0.20	4.36	1.72%	2.90	4.97	0.07	1.04

LIQUEFACTION POTENTIAL BASED ON SHEAR WAVE VELOCITY

DEPTH (ft)	V_{s1} (fps)	Y	$CRR_{7.5}$ Vs	$FS_{seismic}$	FSavg
5	641.64	157.91	0.13	0.91	
10	520.47	153.33	0.09	0.66	0.81
15	487.95	143.07	0.08	0.59	0.74
20	471.67	141.22	0.07	0.56	0.72
25	464.05	160.57	0.07	0.56	0.66
30	460.49	150.53	0.07	0.58	0.70
35	459.81	139.51	0.07	0.61	0.77
40	461.07	142.69	0.07	0.65	0.86
45	463.66	131.20	0.07	0.70	0.96
50	467.41	131.06	0.07	0.76	1.03
55	471.85	132.73	0.07	0.83	1.11
60	477.11	128.32	0.08	0.90	1.26
65	482.74	126.02	0.08	0.99	1.44
70	489.02	124.83	0.08	1.10	1.56
75	495.48	136.43	0.08	1.20	1.53
80	502.51	147.50	0.09	1.29	1.49
85	509.60	143.98	0.09	1.36	1.57
90	517.19	144.56	0.09	1.44	1.61
95	524.78	163.43	0.09	1.53	1.55
100	532.83	160.76	0.10	1.62	1.62
105	540.82	145.49	0.10	1.68	1.83
110	549.26	139.46	0.11	1.75	1.96
115	557.58	145.50	0.11	1.82	1.94
120	566.05	149.21	0.12	1.90	2.03
125	574.93	138.58	0.12	1.99	2.21
130	583.65	145.22	0.13	2.09	2.22
135	592.76	146.64	0.14	2.21	2.22
140	601.67	156.45	0.15	2.36	2.22
145	610.96	167.17	0.17	2.57	2.16
150	620.01	157.45	0.19	2.86	2.31
155	629.41	150.27	0.22	3.37	2.46
160	638.53	154.03	0.30	4.47	2.17
165	647.87	178.19	-0.49	-7.20	1.71
170	657.10	194.86	-0.97	-14.32	1.50
175	666.51	196.00	-0.31	-4.53	1.42
180	675.57	205.20	-0.04	-0.59	1.35
185	684.85	219.19	0.02	0.30	1.27
190	693.74	217.44	0.05	0.72	1.28
195	702.80	214.11	0.07	0.99	1.31
200	711.43	220.17	0.08	1.18	1.28

TABLE H-3

LIQUEFACTION POTENTIAL SPREADSHEET SUMMARY
CPT-12a

DEPTH (ft)	UNIT WEIGHT (pcf)	Qc (tsf)	Qt (tsf)	Fs (tsf)	Rf%	DYNAMIC PWP (tsf)	EQUIL. PWP (ft)	TOTAL STRESS (tsf)	EFFECTIVE STRESS (tsf)	r_d	CSR 0.16
5	125	19.48	19.48	0.24	0.01	-0.02	1.77	0.31	0.26	0.99	0.12
10	125	10.80	10.84	0.06	0.01	0.25	3.39	0.60	0.49	0.98	0.12
15	125	7.46	7.58	0.05	0.01	0.81	5.13	0.91	0.75	0.97	0.12
20	125	8.12	8.29	0.06	0.01	1.10	6.93	1.23	1.01	0.95	0.12
25	125	7.83	8.07	0.07	0.01	1.63	8.67	1.53	1.26	0.94	0.12
30	125	11.44	11.73	0.10	0.01	1.89	10.46	1.85	1.52	0.92	0.12
35	125	14.84	15.14	0.15	0.01	2.01	12.20	2.16	1.78	0.89	0.11
40	125	17.24	17.59	0.20	0.02	2.33	14.00	2.48	2.04	0.85	0.11
45	125	23.23	23.55	0.24	0.01	2.12	15.74	2.78	2.29	0.81	0.10
50	125	25.58	26.04	0.25	0.01	3.07	17.54	3.10	2.55	0.77	0.10
55	125	25.82	26.30	0.27	0.01	3.20	19.28	3.41	2.81	0.73	0.09
60	125	42.17	42.31	0.42	0.01	0.91	21.07	3.73	3.07	0.69	0.09
65	125	45.66	46.00	0.46	0.01	2.24	22.81	4.03	3.32	0.65	0.08
70	125	37.45	38.27	0.36	0.01	5.47	24.61	4.35	3.58	0.61	0.08
75	125	34.86	35.72	0.43	0.01	5.73	26.35	4.66	3.84	0.57	0.07
80	125	28.28	29.54	0.46	0.02	8.40	28.15	4.98	4.10	0.55	0.07
85	125	32.56	33.95	0.52	0.02	9.21	29.88	5.29	4.35	0.54	0.07
90	125	33.56	34.88	0.52	0.02	8.75	31.68	5.60	4.61	0.53	0.07
95	125	32.22	33.80	0.55	0.02	10.56	33.42	5.91	4.87	0.51	0.06
100	125	54.34	55.45	0.65	0.02	7.43	35.22	6.23	5.13	0.50	0.06
105	125	62.71	63.63	0.67	0.01	6.11	36.96	6.54	5.38	0.50	0.06
110	125	52.20	53.70	0.80	0.02	9.98	38.75	6.85	5.64	0.50	0.06
115	125	47.95	49.71	0.80	0.02	11.77	40.49	7.16	5.90	0.50	0.06
120	125	58.18	59.87	0.93	0.02	11.30	42.23	7.47	6.15	0.50	0.06
125	125	60.80	62.61	1.03	0.02	12.11	44.03	7.79	6.41	0.50	0.06
130	125	35.68	38.68	0.62	0.02	20.04	45.77	8.09	6.67	0.50	0.06
135	125	22.81	26.72	0.31	0.01	26.06	47.62	8.42	6.94	0.50	0.06
140	125	26.28	30.21	0.33	0.01	26.18	49.31	8.72	7.18	0.50	0.06
145	125	32.37	36.32	0.37	0.01	26.32	51.10	9.04	7.44	0.50	0.06
150	125	30.25	34.29	0.33	0.01	26.87	52.84	9.35	7.70	0.50	0.06
155	125	21.85	26.33	0.24	0.01	29.85	54.64	9.66	7.96	0.50	0.06
160	125	20.12	25.00	0.24	0.01	32.51	56.38	9.97	8.21	0.50	0.06
165	125	21.17	26.15	0.31	0.01	33.22	58.18	10.29	8.47	0.50	0.06
170	125	21.11	26.21	0.33	0.02	34.00	59.91	10.60	8.73	0.50	0.06
175	125	20.79	26.08	0.32	0.02	35.27	61.68	10.91	8.98	0.50	0.06

LIQUEFACTION POTENTIAL BASED ON BLOW COUNT CORRELATIONS

DEPTH (ft)	N_{60} (blows/ft.)	C_N	$N_{1(60)}$ (blows/ft)	FINES (%)	α	β	$N_{1(60)cs}$ (blows/ft)	$CRR_{7.5}$ N	FS_N
5	5.99	2.63	14.71	20.00	3.61	1.08	19.50	0.13	1.01
10	4.20	1.52	6.74	20.00	3.61	1.08	10.89	0.12	0.97
15	2.99	1.21	3.59	20.00	3.61	1.08	7.49	0.09	0.70
20	3.26	1.03	3.35	20.00	3.61	1.08	7.23	0.08	0.69
25	3.14	0.92	2.90	20.00	3.61	1.08	6.74	0.08	0.67
30	4.60	0.84	3.79	20.00	3.61	1.08	7.70	0.09	0.75
35	5.94	0.77	4.59	28.50	4.01	1.11	9.12	0.10	0.90
40	6.85	0.72	4.93	44.00	4.72	1.18	10.54	0.12	1.08
45	9.18	0.68	6.23	50.00	5.00	1.20	12.48	0.14	1.33
50	10.05	0.64	6.47	50.00	5.00	1.20	12.77	0.14	1.43
55	10.16	0.61	6.20	50.00	5.00	1.20	12.44	0.14	1.48
60	16.36	0.59	9.54	50.00	5.00	1.20	16.44	0.18	2.11
65	17.67	0.56	10.02	50.00	5.00	1.20	17.02	0.19	2.30
70	14.64	0.54	7.97	50.00	5.00	1.20	14.57	0.16	2.09
75	13.73	0.53	7.24	50.00	5.00	1.20	13.69	0.15	2.07
80	11.25	0.51	5.73	50.00	5.00	1.20	11.88	0.13	1.85
85	12.85	0.49	6.31	50.00	5.00	1.20	12.57	0.14	2.01
90	13.26	0.48	6.37	50.00	5.00	1.20	12.64	0.14	2.06
95	12.78	0.47	5.95	50.00	5.00	1.20	12.15	0.13	2.04
100	21.15	0.45	9.57	50.00	5.00	1.20	16.49	0.19	2.92
105	24.31	0.44	10.78	50.00	5.00	1.20	17.94	0.20	3.20
110	20.34	0.43	8.81	50.00	5.00	1.20	15.58	0.17	2.70
115	18.72	0.42	7.92	50.00	5.00	1.20	14.51	0.16	2.52
120	22.53	0.41	9.31	50.00	5.00	1.20	16.17	0.18	2.84
125	23.51	0.41	9.57	50.00	5.00	1.20	16.48	0.18	2.90
130	14.02	0.40	5.62	50.00	5.00	1.20	11.74	0.13	2.04
135	9.16	0.39	3.58	50.00	5.00	1.20	9.29	0.10	1.61
140	10.55	0.38	4.04	50.00	5.00	1.20	9.85	0.11	1.70
145	12.99	0.38	4.89	50.00	5.00	1.20	10.87	0.12	1.87
150	12.15	0.37	4.51	60.83	5.00	1.20	10.42	0.11	1.80
155	8.78	0.36	3.20	73.75	5.00	1.20	8.84	0.10	1.54
160	8.08	0.36	2.90	75.00	5.00	1.20	8.48	0.09	1.48
165	8.50	0.35	3.01	75.00	5.00	1.20	8.61	0.09	1.50
170	8.48	0.35	2.95	75.00	5.00	1.20	8.54	0.09	1.49
175	8.35	0.34	2.87	75.00	5.00	1.20	8.44	0.09	1.47

LIQUEFACTION POTENTIAL BASED ON DIRECT APPLICATION OF CPT

DEPTH (ft)	q_{c1} (tsf)	q_{c1N}	$(q_{c1N})_{cs}$ (tsf)	n	C_Q	Q	F	Ic	Kc	$CRR_{7.5}$ CONE	FS_{cone}	Fsavg
5	51.60	84.71	105.69	0.75	4.82	83.88	1.18%	2.00	1.82	0.37	2.98	1.23
10	17.45	21.16	57.16	0.75	1.89	20.22	0.82%	2.55	3.52	0.10	0.81	1.00
15	8.94	9.30	43.79	0.75	1.33	8.33	0.98%	2.78	4.80	0.09	0.71	0.73
20	8.34	8.00	37.41	0.75	1.05	6.97	1.28%	2.85	4.81	0.08	0.67	0.68
25	7.22	6.56	30.79	0.75	0.88	5.49	1.54%	2.97	4.84	0.08	0.64	0.68
30	9.43	8.08	36.99	0.75	0.76	6.96	1.28%	2.85	4.74	0.08	0.69	0.73
35	11.47	9.52	40.64	0.75	0.68	8.34	1.46%	2.72	4.53	0.08	0.74	0.83
40	12.41	9.95	37.88	0.75	0.61	8.73	1.90%	2.72	4.33	0.08	0.76	0.94
45	15.76	12.28	39.12	0.75	0.56	10.97	1.76%	2.63	3.76	0.08	0.81	1.02
50	16.46	12.49	37.55	0.75	0.52	11.20	1.60%	2.64	3.74	0.08	0.84	1.09
55	15.76	11.64	37.13	0.75	0.48	10.32	1.59%	2.66	3.94	0.08	0.88	1.26
60	24.58	17.73	43.25	0.75	0.45	16.21	1.40%	2.46	2.99	0.09	0.99	1.51
65	25.88	18.42	42.53	0.75	0.42	16.93	1.51%	2.46	2.85	0.09	1.04	1.65
70	20.40	14.23	39.71	0.75	0.40	12.89	1.44%	2.59	3.55	0.08	1.08	1.66
75	18.40	12.63	39.27	0.75	0.38	11.26	1.69%	2.60	3.75	0.08	1.15	1.57
80	14.41	9.72	35.26	0.75	0.36	8.45	2.09%	2.66	4.10	0.08	1.14	1.50
85	15.99	10.59	34.31	0.75	0.35	9.32	2.16%	2.63	3.84	0.08	1.16	1.57
90	16.12	10.56	34.69	0.75	0.33	9.22	2.09%	2.63	3.86	0.08	1.19	1.65
95	15.01	9.68	34.87	0.75	0.32	8.38	2.38%	2.67	4.16	0.08	1.22	1.72
100	24.58	15.63	39.90	0.75	0.31	14.15	1.94%	2.51	3.17	0.08	1.31	1.98
105	27.82	17.51	40.65	0.75	0.30	15.94	1.67%	2.46	2.80	0.08	1.33	2.17
110	22.62	14.07	37.02	0.75	0.29	12.63	2.14%	2.51	3.23	0.08	1.28	2.05
115	20.29	12.48	35.01	0.75	0.28	11.07	2.26%	2.57	3.53	0.08	1.25	1.92
120	24.04	14.61	35.73	0.75	0.27	13.15	2.15%	2.50	3.14	0.08	1.26	2.04
125	24.74	14.92	35.59	0.75	0.26	13.45	2.17%	2.49	3.06	0.08	1.26	2.03
130	14.29	8.55	29.06	0.75	0.25	7.33	2.05%	2.77	4.29	0.07	1.18	1.67
135	8.91	5.26	26.00	0.75	0.24	4.22	1.77%	2.92	4.97	0.07	1.13	1.41
140	10.08	5.90	27.41	0.75	0.24	4.82	1.69%	2.89	4.84	0.07	1.15	1.44
145	12.19	7.07	31.12	0.75	0.23	5.96	1.51%	2.83	4.69	0.08	1.20	1.52
150	11.24	6.48	29.93	0.75	0.23	5.34	1.46%	2.86	4.82	0.07	1.19	1.46
155	7.98	4.55	22.77	0.75	0.22	3.48	1.48%	3.00	5.00	0.07	1.09	1.33
160	7.22	4.09	20.44	0.75	0.22	3.05	1.62%	3.04	5.00	0.07	1.06	1.28
165	7.48	4.20	21.02	0.75	0.21	3.15	1.99%	3.02	5.00	0.07	1.07	1.28
170	7.35	4.10	20.50	0.75	0.21	3.03	2.14%	3.03	5.00	0.07	1.06	1.27
175	7.14	3.95	19.76	0.75	0.20	2.88	2.11%	3.04	5.00	0.07	1.05	1.26

Earthquake Magnitude, M	Magnitude Scaling Factor
5.5	2.80
6.0	2.10
6.5	1.60
7.0	1.25
7.5	1.00
8.0	0.80
8.5	0.65

The design seismic event, as discussed in Section 6.2 of this report, is a Magnitude 7.5 earthquake imposing a peak ground acceleration (a_{max}) of 0.16g. Seed and Idriss (1971) formulated the following equation for the calculation of the CSR induced by the earthquake for the depth:

$$CSR = 0.65 \bullet (a_{\max} / g) \bullet \left(\frac{\sigma}{\sigma'}\right) \bullet r_d$$

The factor r_d was computed from the following relations:

$r_d = 1.0 - 0.00765(z)$ for $z < 9.15$m

$r_d = 1.174 - 0.0267(z)$ for $9.15 < z < 23$m

$r_d = 0.744 - 0.008(z)$ for $23 < z < 30$m

$r_d = 0.5$ for $z > 30$m

where z is the depth below the ground surface in meters.

The vertical total stress (σ_v) and vertical effective vertical stress (σ_v') were computed from average unit weights from laboratory testing and from equilibrium pore pressure conditions in the tailings as assessed from the CPTU.

The cyclic resistance ratio (CRR) was assessed from the following methods;

- Correlation of CPT data with standard penetration resistance blow counts and use of empirical blow count versus CRR curves. The curve for $CRR_{7.5}$ based on SPT blow count is represented mathematically by the equation:

$$CRR_{7.5} = \frac{0.048 - 0.004721x + 0.0006136x^2 - 0.00001673x^3}{1 - 0.1248x + 0.009578x^2 - 0.0003285x^3 + 0.000003714x^4}$$

  where x is the blow count estimated from the cone tip resistance corrected for fines content (Youd and Idriss, 1997).

- Direct application of cone tip resistance and use of recently developed empirical cone tip resistance versus $CRR_{7.5}$ curves. The curve for $CRR_{7.5}$ based on cone tip resistance is represented mathematically by:

$$If\left(q_{c1N}\right)_{cs} < 50 \longrightarrow CRR_{7.5} = 0.833\left[\left(q_{c1N}\right)_{cs}/1000\right] + 0.05$$

$$If\, 50 \le \left(q_{c1N}\right)_{cs} < 160 \longrightarrow CRR_{7.5} = 93\left[\left(q_{c1N}\right)_{cs}/1000\right]^3 + 0.08$$

  where $(q_{c1N})_{cs}$ is the stress corrected and normalized (stress with respect to atmospheric pressure) cone tip resistence which is also corrected for fines content (Youd and Idriss, 1997).

- Use of shear wave velocity (for sounding CPT-9) to estimate $CRR_{7.5}$ based on recently developed curves. The curves for $CRR_{7.5}$ based on shear wave velocity is represented mathematically by:

$$CRR_{7.5} = 0.03\left(V_{S1}/100\right)^2 + 0.9/\left(V_{S1c} - V_{S1}\right) - 0.9/V_{S1c}$$

  where V_{S1} is the stress corrected and normalized shear wave velocity and:

  V_{s1c}=220 m/s for sands and gravels with fines contents less than 5%
  V_{s1c}=210 m/s for sands and gravels with fines contents of about 20%

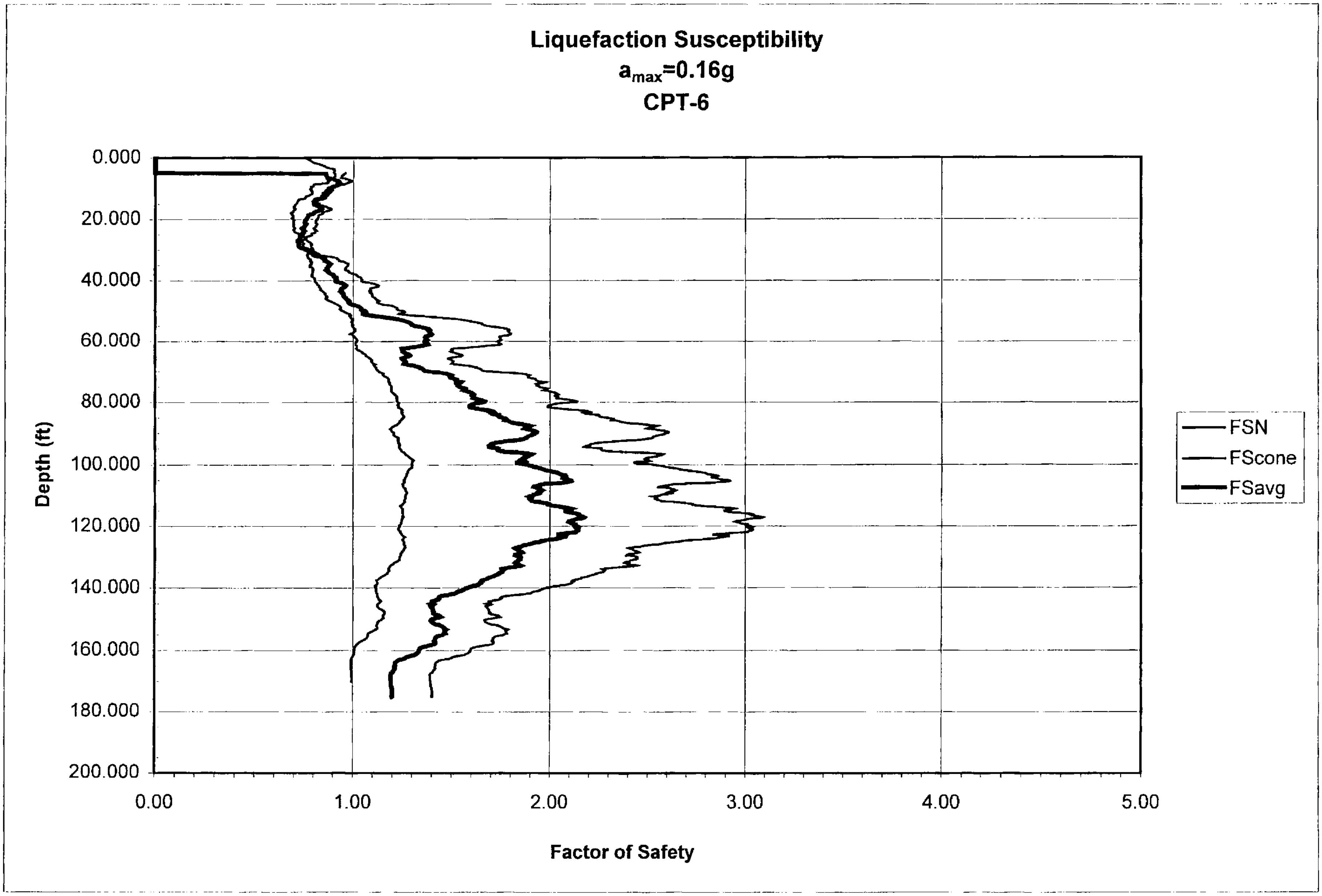
  V_{s1c}=200 m/s for sands and gravels with fines contents greater than 35%

  Where V_{s1c} is the critical value of V_{s1}, which separates contractive and dilative behavior (Youd and Idriss, 1997).

The shear wave velocity method consistently yields the most conservative CRR. Also note that the middle term goes to infinity as V_{S1} approaches V_{s1c} and then becomes very negative at slightly higher values of V_{S1}.

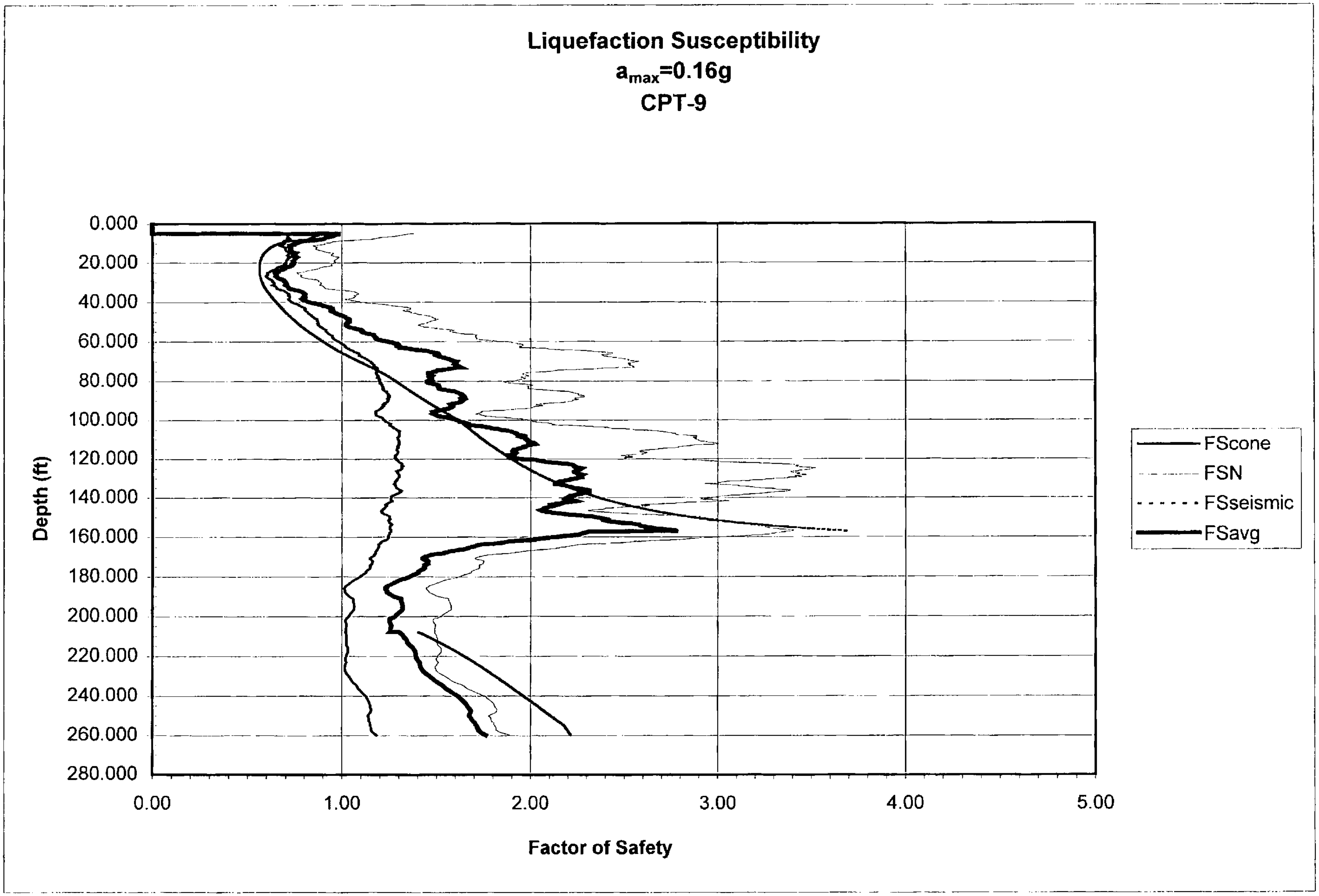
The results of the liquefaction potential analyses for CPT soundings located near the embankments (i.e. CPT-6, CPT-9 and CPT-12) are shown graphically in this appendix Figures (H-1 through H-3) and the locations of the soundings are shown on Drawing 1. It should be noted that these boring locations are all located outside the footprints of the embankments and therefore do not have the benefit of consolidation from the embankment materials. As a result, the analyses provided herein are considered conservative with respect to liquefaction potential of the foundation materials upon which the upstream raises are constructed. These Figures show that the upper 40 to 60 feet of tailings have Factors of Safety (FOS) below 1.0 indicating liquefaction during the design earthquake. The liquefaction potential has been assessed for the conditions encountered at the time of the site investigation. As the tailings drain and the phreatic level lowers, the zone of potential liquefaction is reduced for two reasons. First, the unsaturated tailings above the water table are not susceptible to liquefaction; and secondly, the lower phreatic surface increases the effective stress and limits the depth of potential liquefaction. Figures H-4 and H-5 indicate that if the phreatic surface is lowered to 33 feet below the tailings surface at the Main Dam (27 feet for the Levee Buttress) the tailings will not be susceptible to liquefaction. Based on the draindown modeling presented in Section 7.0, the embankments will not be susceptible to liquefaction after one year of draindown after the supernatent solution has been removed. The impact of liquefaction on the embankment stability is assessed utilizing residual strength values for the liquefied portion of the tailings (see Appendix H-2).

FIGURE H-1



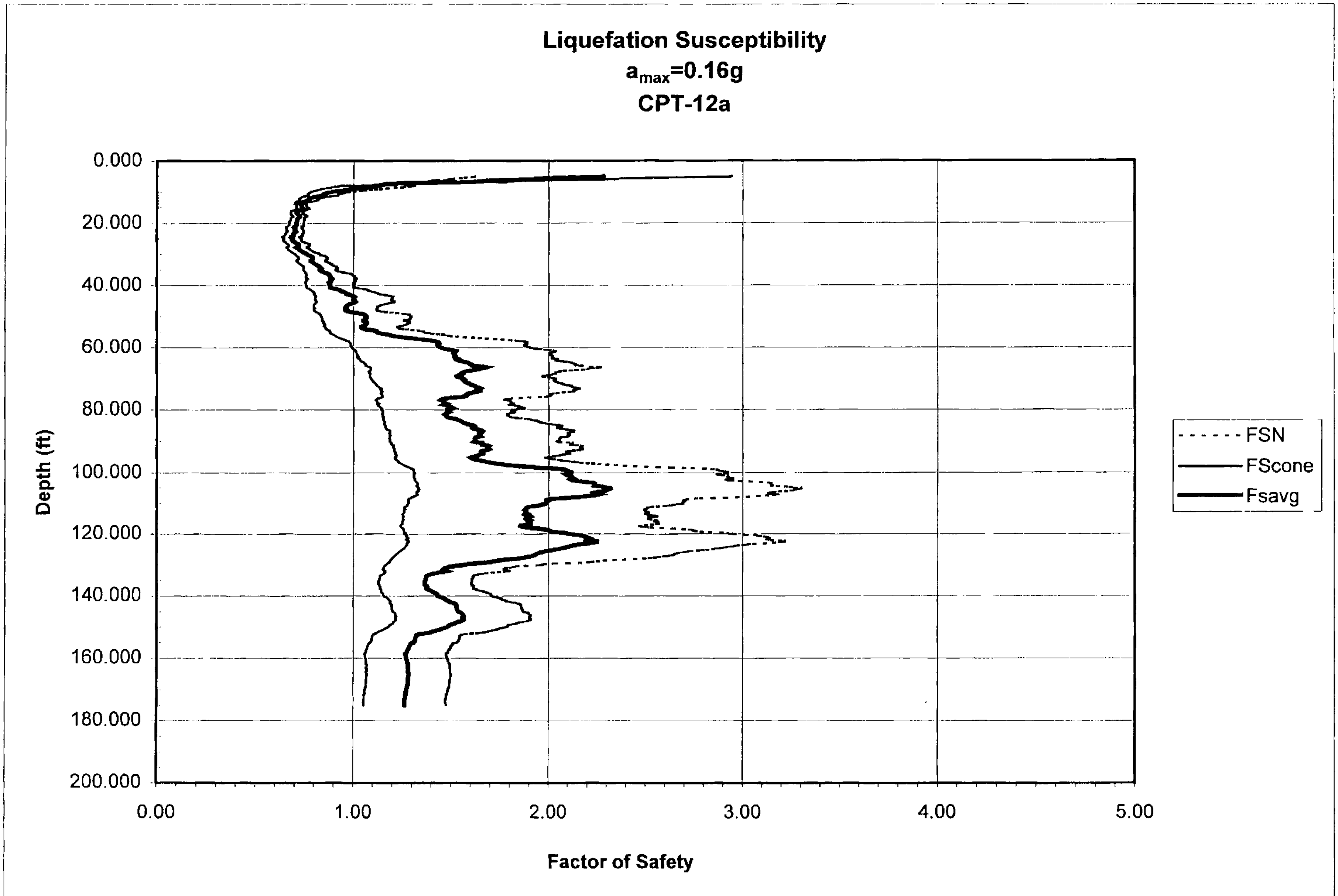
Liquefaction Susceptibility
a_{max}=0.16g
CPT-6
0.000
20.000
40.000
60.000
80.000
100.000
120.000
140.000
160.000
180.000
200.000
Depth (ft)
0.00
1.00
2.00
3.00
4.00
5.00
Factor of Safety
FSN
FScone
FSavg

FIGURE H-2



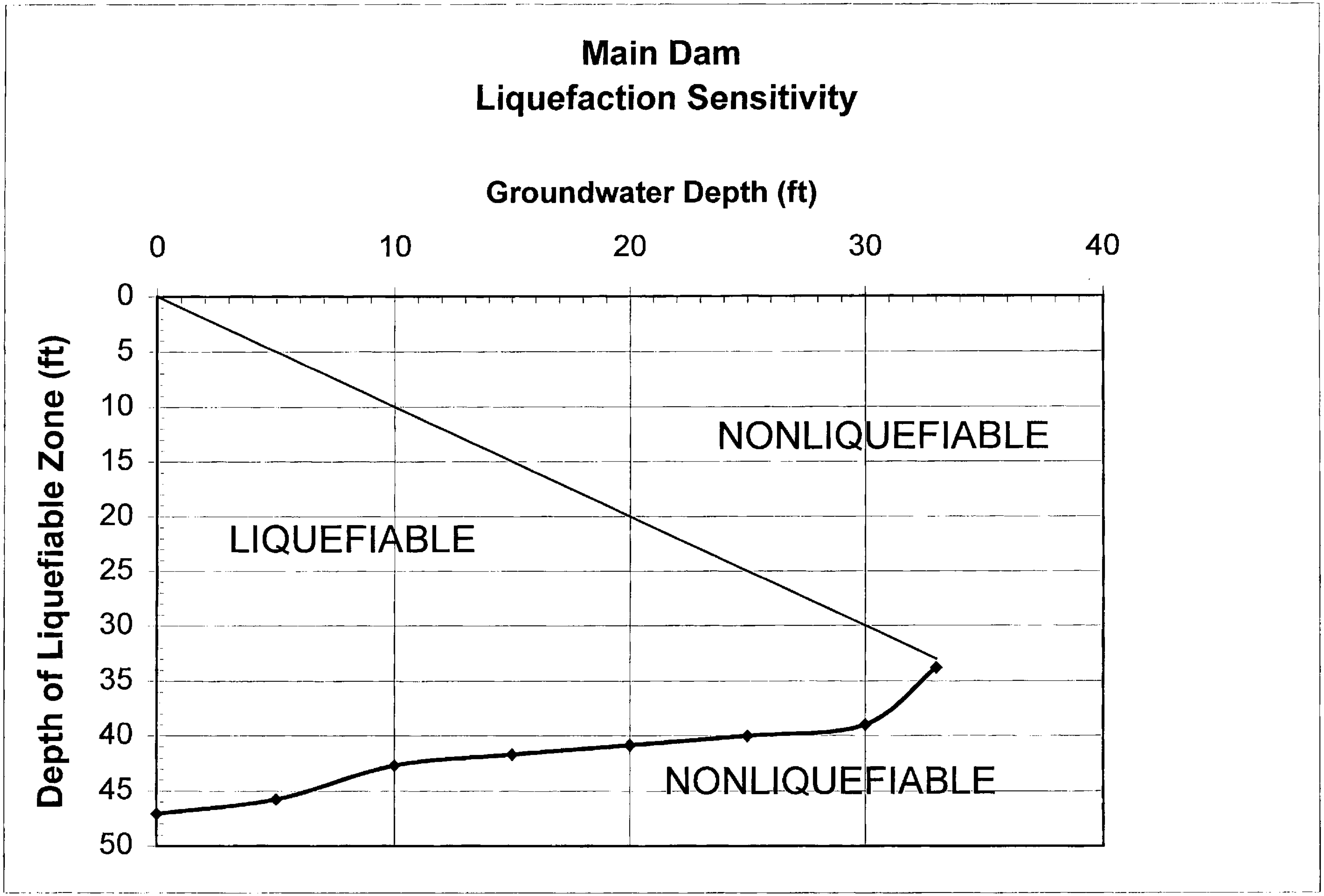
Liquefaction Susceptibility
a_{max}=0.16g
CPT-9
0.000
20.000
40.000
60.000
80.000
100.000
120.000
140.000
160.000
180.000
200.000
220.000
240.000
260.000
280.000
Depth (ft)
0.00
1.00
2.00
3.00
4.00
5.00
Factor of Safety
FScone
FSN
FSseismic
FSavg

FIGURE H-3



Liquefation Susceptibility
a_{max}=0.16g
CPT-12a
Depth (ft)
0.000
20.000
40.000
60.000
80.000
100.000
120.000
140.000
160.000
180.000
200.000
0.00
1.00
2.00
3.00
4.00
5.00
Factor of Safety
FSN
FScone
Fsavg

FIGURE H-4



Main Dam
Liquefaction Sensitivity
Groundwater Depth (ft)
0
10
20
30
40
Depth of Liquefiable Zone (ft)
0
5
10
15
20
25
30
35
40
45
50
NONLIQUEFIABLE
LIQUEFIABLE
NONLIQUEFIABLE

FIGURE H-5

Levee Buttress
Liquefaction Sensitivity

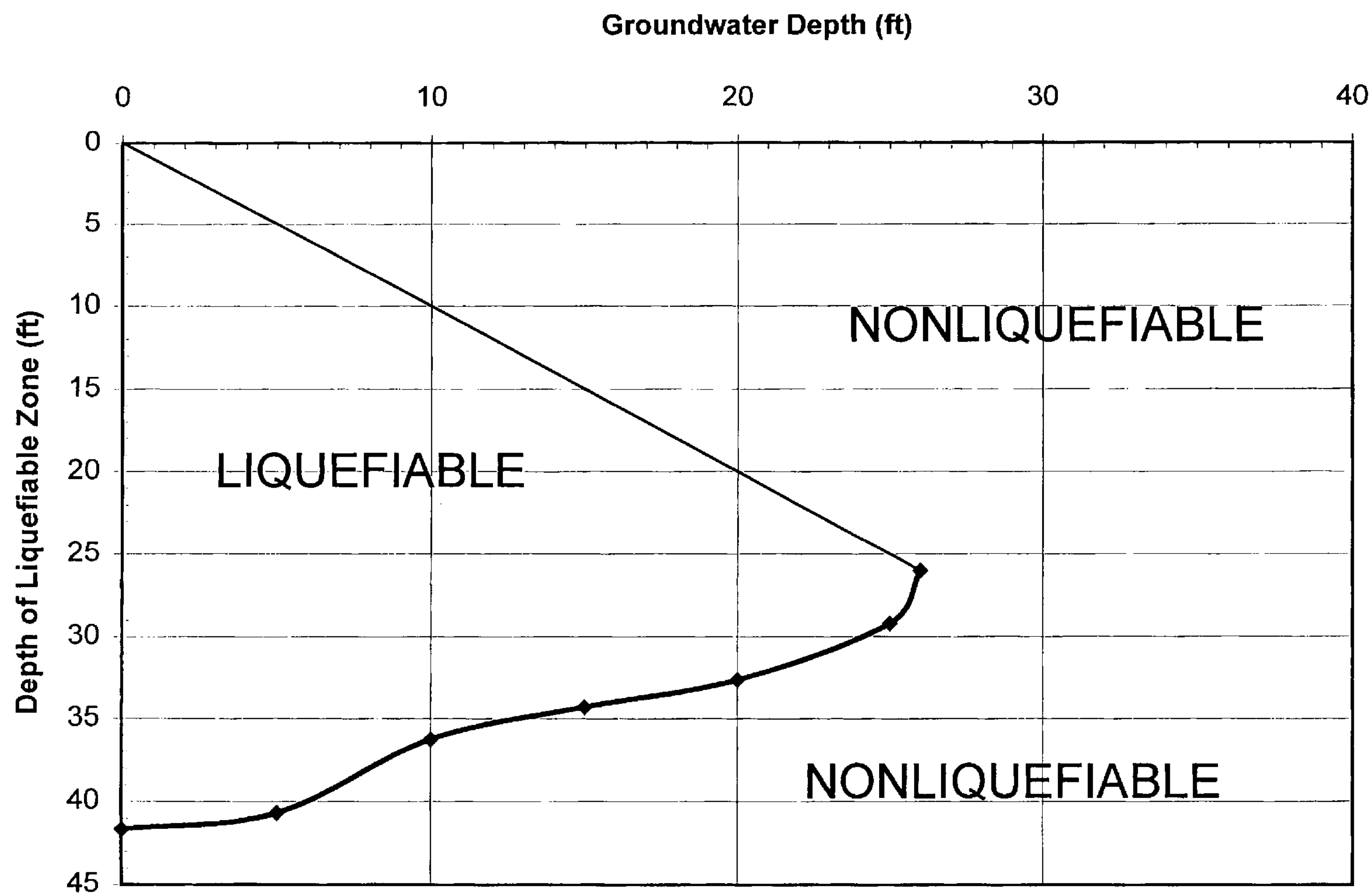


TABLE H-1

LIQUEFACTION POTENTIAL SPREADSHEET SUMMARY
CPT-6

DEPTH (ft)	UNIT WEIGHT (pcf)	Qc (tsf)	Qt (tsf)	Fs (tsf)	Rf%	DYNAMIC PWP (tsf)	EQUIL. PWP (ft)	TOTAL STRESS (tsf)	EFFECTIVE STRESS (tsf	CSR 0.16	r_d
5	125.00	7.95	7.96	0.06	0.01	0.10	1.52	0.31	0.27	0.12	0.99
10	125.00	9.52	9.56	0.04	0.00	0.41	3.06	0.63	0.53	0.12	0.98
15	125.00	10.09	10.18	0.06	0.01	0.63	4.56	0.94	0.80	0.12	0.96
20	125.00	11.31	11.44	0.08	0.01	0.85	6.10	1.26	1.07	0.12	0.95
25	125.00	11.15	11.33	0.08	0.01	1.22	7.59	1.56	1.33	0.12	0.94
30	125.00	12.39	12.64	0.09	0.01	1.67	9.14	1.88	1.60	0.11	0.92
35	125.00	16.49	16.77	0.13	0.01	1.86	10.63	2.19	1.86	0.11	0.89
40	125.00	15.29	15.69	0.14	0.01	2.67	12.18	2.51	2.13	0.10	0.85
45	125.00	15.41	15.93	0.13	0.01	3.47	13.67	2.81	2.39	0.10	0.81
50	125.00	19.29	19.74	0.16	0.01	3.02	15.21	3.13	2.66	0.09	0.77
55	125.00	30.75	31.02	0.29	0.01	1.79	16.71	3.44	2.92	0.09	0.73
60	125.00	30.77	31.28	0.29	0.01	3.42	18.25	3.76	3.19	0.08	0.68
65	125.00	23.01	23.92	0.24	0.01	6.07	19.75	4.07	3.45	0.08	0.64
70	125.00	25.88	26.90	0.29	0.01	6.84	21.29	4.38	3.72	0.07	0.60
75	125.00	30.59	31.43	0.37	0.01	5.58	22.78	4.69	3.98	0.07	0.57
80	125.00	33.29	33.96	0.48	0.02	4.47	24.33	5.01	4.25	0.07	0.55
85	125.00	39.29	40.02	0.55	0.02	4.82	25.82	5.32	4.51	0.07	0.54
90	125.00	47.12	47.74	0.67	0.02	4.14	27.39	5.63	4.78	0.06	0.52
95	125.00	37.12	38.43	0.54	0.02	8.72	29.68	5.94	5.02	0.06	0.51
100	125.00	43.69	44.90	0.60	0.02	8.03	33.18	6.26	5.22	0.06	0.50
105	125.00	54.76	55.48	0.81	0.02	4.81	36.91	6.57	5.42	0.06	0.50
110	125.00	48.63	49.77	0.88	0.02	7.64	40.75	6.88	5.61	0.06	0.50
115	125.00	59.98	60.91	1.04	0.02	6.21	44.48	7.19	5.80	0.06	0.50
120	125.00	66.62	67.64	1.03	0.02	6.76	48.20	7.50	6.00	0.07	0.50
125	125.00	56.59	57.57	0.82	0.02	6.56	52.05	7.82	6.19	0.07	0.50
130	125.00	51.05	51.93	0.68	0.01	5.90	55.78	8.13	6.38	0.07	0.50
135	125.00	46.33	47.64	0.66	0.02	8.68	59.63	8.44	6.58	0.07	0.50
140	125.00	38.32	40.28	0.61	0.02	13.09	63.35	8.75	6.77	0.07	0.50
145	125.00	29.06	32.09	0.40	0.01	20.20	67.20	9.07	6.97	0.07	0.50

DEPTH (ft)	LIQUEFACTION POTENTIAL BASED ON BLOW COUNT CORRELATIONS								
	N_{60} (blows/ft.)	C_N	$N_{1(60)}$ (blows/ft)	FINES (%)	α	β	$N_{1(60)cs}$ (blows/ft)	$CRR_{7.5}$ N	FS_N
5	3.06	2.59	6.50	20.00	3.61	1.08	10.63	0.12	0.96
10	3.81	1.45	5.45	20.00	3.61	1.08	9.50	0.10	0.87
15	4.03	1.17	4.70	20.00	3.61	1.08	8.69	0.10	0.82
20	4.50	1.00	4.50	20.00	3.61	1.08	8.47	0.10	0.82
25	4.45	0.90	4.04	20.00	3.61	1.08	7.98	0.09	0.79
30	4.97	0.82	4.02	20.00	3.61	1.08	7.95	0.09	0.79
35	6.60	0.76	4.98	30.00	4.08	1.12	9.67	0.11	0.98
40	6.12	0.71	4.34	45.50	4.79	1.18	9.91	0.11	1.04
45	6.19	0.67	4.11	50.00	5.00	1.20	9.93	0.11	1.10
50	7.72	0.63	4.87	50.00	5.00	1.20	10.84	0.12	1.26
55	12.09	0.60	7.23	50.00	5.00	1.20	13.68	0.15	1.69
60	12.09	0.58	7.03	50.00	5.00	1.20	13.44	0.15	1.74
65	9.16	0.55	5.06	50.00	5.00	1.20	11.08	0.12	1.53
70	10.29	0.53	5.48	50.00	5.00	1.20	11.58	0.13	1.71
75	12.09	0.52	6.22	50.00	5.00	1.20	12.47	0.14	1.96
80	13.16	0.50	6.57	50.00	5.00	1.20	12.88	0.14	2.08
85	15.45	0.48	7.46	50.00	5.00	1.20	13.95	0.15	2.31
90	18.38	0.47	8.65	50.00	5.00	1.20	15.38	0.17	2.60
95	14.52	0.46	6.68	50.00	5.00	1.20	13.02	0.14	2.25
100	17.00	0.45	7.63	50.00	5.00	1.20	14.15	0.16	2.54
105	21.34	0.44	9.44	50.00	5.00	1.20	16.33	0.18	2.90
110	19.13	0.43	8.30	50.00	5.00	1.20	14.97	0.16	2.56
115	23.31	0.43	9.93	50.00	5.00	1.20	16.92	0.19	2.88
120	25.71	0.42	10.81	50.00	5.00	1.20	17.97	0.20	3.04
125	22.07	0.41	9.13	50.00	5.00	1.20	15.96	0.17	2.65
130	20.15	0.41	8.20	50.00	5.00	1.20	14.85	0.16	2.44
135	18.41	0.40	7.38	50.00	5.00	1.20	13.86	0.15	2.25
140	15.30	0.40	6.05	50.00	5.00	1.20	12.26	0.13	1.98
145	11.67	0.39	4.55	50.00	5.00	1.20	10.46	0.11	1.68

DEPTH (ft)	LIQUEFACTION POTENTIAL BASED ON DIRECT APPLICATION OF CPT											
	q_{c1} (tsf)	q_{c1N}	$(q_{c1N})_{cs}$	n	C_Q	Q	F	Ic	Kc	$CRR_{7.5}$ CONE	FS_{cone}	FSavg
5	17.12	14.69	42.53	0.75	1.97	24.62	1.10%	2.37	2.93	0.09	0.76	
10	13.60	14.84	59.59	0.75	1.67	14.60	0.55%	2.64	4.25	0.11	0.91	0.87
15	11.76	12.04	48.09	0.75	1.27	11.06	0.82%	2.70	4.40	0.09	0.78	0.83
20	11.31	10.71	38.71	0.75	1.01	9.64	0.99%	2.76	4.23	0.08	0.71	0.78
25	10.15	9.17	35.92	0.75	0.85	8.06	1.17%	2.84	4.51	0.08	0.70	0.74
30	10.01	8.50	39.66	0.75	0.74	7.37	1.10%	2.82	4.76	0.08	0.74	0.78
35	12.44	10.21	42.90	0.75	0.66	9.03	1.01%	2.71	4.45	0.09	0.79	0.86
40	10.86	8.65	37.14	0.75	0.59	7.47	1.32%	2.78	4.63	0.08	0.78	0.92
45	10.23	7.88	35.47	0.75	0.54	6.71	1.29%	2.84	4.73	0.08	0.81	0.97
50	12.17	9.14	37.45	0.75	0.50	7.87	1.22%	2.77	4.48	0.08	0.87	1.09
55	18.39	13.44	41.24	0.75	0.47	12.04	1.40%	2.61	3.75	0.08	0.95	1.28
60	17.90	12.91	40.55	0.75	0.44	11.56	1.44%	2.64	3.89	0.08	1.00	1.34
65	12.72	8.94	36.36	0.75	0.41	7.71	1.48%	2.76	4.50	0.08	1.02	1.30
70	13.79	9.51	35.09	0.75	0.39	8.28	1.62%	2.74	4.24	0.08	1.07	1.40
75	15.75	10.68	34.93	0.75	0.37	9.33	1.80%	2.69	3.97	0.08	1.14	1.55
80	16.63	11.11	36.26	0.75	0.35	9.66	1.95%	2.62	3.82	0.08	1.19	1.64
85	18.98	12.46	37.08	0.75	0.34	11.00	1.89%	2.56	3.46	0.08	1.23	1.76
90	22.17	14.37	36.57	0.75	0.32	12.84	1.98%	2.50	3.01	0.08	1.25	1.83
95	17.09	10.96	31.06	0.75	0.31	9.59	2.01%	2.69	3.70	0.08	1.20	1.82
100	19.59	12.40	33.24	0.75	0.30	10.96	1.85%	2.64	3.61	0.08	1.24	1.93
105	24.23	15.24	38.35	0.75	0.29	13.61	2.02%	2.47	3.03	0.08	1.30	1.99
110	21.11	13.14	36.40	0.75	0.29	11.59	2.40%	2.50	3.14	0.08	1.26	1.98
115	25.55	15.76	37.73	0.75	0.28	14.11	2.38%	2.43	2.79	0.08	1.26	2.06
120	28.01	17.16	37.74	0.75	0.27	15.49	2.01%	2.42	2.69	0.08	1.25	2.11
125	23.41	14.23	37.44	0.75	0.27	12.51	1.90%	2.52	3.19	0.08	1.24	1.97
130	20.78	12.53	40.00	0.75	0.26	10.76	1.84%	2.57	3.66	0.08	1.26	1.83
135	18.58	11.12	39.13	0.75	0.25	9.40	1.92%	2.61	3.91	0.08	1.24	1.74
140	15.16	9.01	34.67	0.75	0.25	7.42	2.09%	2.71	4.25	0.08	1.17	1.57
145	11.33	6.68	30.50	0.75	0.24	5.29	1.84%	2.85	4.76	0.08	1.11	1.44

TABLE H-2

LIQUEFACTION POTENTIAL SPREADSHEET SUMMARY
CPT-9

DEPTH (ft)	UNIT WEIGHT (pcf)	qc (tsf)	qt (tsf)	Fs (tsf)	Rf%	DYNAMIC PWP (tsf)	EQUIL. PWP (ft)	Vs (fps)	TOTAL STRESS (tsf)	EFFECTIVE STRESS (tsf)	r_d	CSR 0.16
5	125.00	10.52	10.53	0.05	0.01	0.09	2.97	394.74	0.31	0.22	0.99	0.15
10	125.00	8.68	8.73	0.04	0.01	0.47	5.59	416.36	0.63	0.46	0.98	0.14
15	125.00	11.78	11.88	0.05	0.00	0.69	7.73	437.27	0.94	0.70	0.96	0.14
20	125.00	12.85	13.02	0.06	0.01	1.15	9.58	458.89	1.26	0.96	0.95	0.13
25	125.00	8.00	8.31	0.08	0.01	2.08	11.09	479.80	1.56	1.22	0.94	0.13
30	125.00	11.95	12.21	0.13	0.01	1.72	12.41	501.42	1.88	1.49	0.92	0.12
35	125.00	17.11	17.41	0.16	0.01	1.97	13.51	522.33	2.19	1.77	0.89	0.11
40	125.00	17.29	17.74	0.19	0.01	3.02	14.51	543.94	2.51	2.05	0.85	0.11
45	125.00	24.36	24.64	0.24	0.01	1.88	15.38	564.86	2.81	2.33	0.81	0.10
50	125.00	25.72	26.01	0.27	0.01	1.99	16.24	586.47	3.13	2.63	0.77	0.10
55	125.00	27.89	28.28	0.30	0.01	2.62	17.05	607.39	3.44	2.91	0.73	0.09
60	125.00	34.83	35.22	0.38	0.01	2.62	17.92	629.00	3.76	3.20	0.68	0.08
65	125.00	43.56	43.92	0.50	0.01	2.37	18.82	649.92	4.07	3.48	0.64	0.08
70	125.00	46.64	47.05	0.55	0.01	2.75	19.64	671.53	4.38	3.76	0.60	0.07
75	125.00	34.15	34.92	0.50	0.02	5.12	20.84	692.45	4.69	4.04	0.57	0.07
80	125.00	28.81	28.00	0.45	0.02	7.90	22.22	714.06	5.01	4.32	0.55	0.07
85	125.00	34.12	35.08	0.54	0.02	6.41	23.62	734.98	5.32	4.58	0.54	0.06
90	125.00	36.51	37.44	0.60	0.02	6.23	25.24	756.59	5.63	4.85	0.52	0.06
95	125.00	24.04	25.95	0.43	0.02	12.71	27.01	777.50	5.94	5.10	0.51	0.06
100	125.00	29.66	31.46	0.45	0.02	11.99	29.04	799.12	6.26	5.35	0.50	0.06
105	125.00	46.18	47.48	0.85	0.02	8.69	31.21	820.03	6.57	5.59	0.50	0.06
110	125.00	57.12	58.27	1.01	0.02	7.66	33.69	841.65	6.88	5.83	0.50	0.06
115	125.00	52.00	53.38	0.89	0.02	9.22	36.30	862.56	7.19	6.06	0.50	0.06
120	125.00	51.64	53.34	1.00	0.02	11.33	39.13	883.48	7.50	6.28	0.50	0.06
125	125.00	77.47	78.63	1.26	0.02	7.71	42.28	905.09	7.82	6.50	0.50	0.06
130	125.00	73.66	74.97	1.10	0.02	8.75	45.54	926.01	8.13	6.70	0.50	0.06
135	125.00	73.70	74.72	1.04	0.02	6.76	49.11	947.62	8.44	6.91	0.50	0.06
140	125.00	66.26	67.80	0.91	0.02	10.27	52.76	968.54	8.75	7.10	0.50	0.06
145	125.00	53.91	56.21	0.70	0.01	15.36	56.71	990.15	9.07	7.30	0.50	0.06
150	125.00	70.23	72.49	0.88	0.01	15.02	60.70	1011.06	9.38	7.48	0.50	0.07
155	125.00	84.22	86.37	0.98	0.01	14.34	64.95	1032.68	9.69	7.67	0.50	0.07
160	125.00	77.46	80.30	0.89	0.01	18.60	69.19	1053.59	10.00	7.84	0.50	0.07
165	125.00	48.51	53.13	0.56	0.01	30.78	73.65	1075.21	10.32	8.02	0.50	0.07
170	125.00	32.89	38.43	0.41	0.01	36.95	78.03	1096.12	10.63	8.19	0.50	0.07
175	125.00	34.11	39.90	0.47	0.01	38.57	82.57	1117.74	10.94	8.37	0.50	0.07
180	125.00	30.84	36.39	0.43	0.01	36.99	86.96	1138.65	11.25	8.54	0.50	0.07
185	125.00	24.95	30.16	0.34	0.01	34.71	91.45	1160.26	11.57	8.72	0.50	0.07
190	125.00	27.57	33.28	0.34	0.01	38.07	95.70	1181.18	11.88	8.89	0.50	0.07
195	125.00	31.28	37.46	0.42	0.01	41.24	99.95	1202.79	12.20	9.08	0.50	0.07
200	125.00	29.61	35.98	0.42	0.01	42.49	103.88	1223.71	12.50	9.26	0.50	0.07

LIQUEFACTION POTENTIAL BASED ON BLOW COUNT CORRELATIONS

DEPTH (ft)	N_{60} (blows/ft.)	C_N	$N_{1(60)}$ (blows/ft)	FINES (%)	α	β	$N_{1(60)cs}$ (blows/ft)	$CRR_{7.5}$ N	FS_N
5	4.08	2.88	10.89	50.00	5.00	1.20	18.07	0.21	1.38
10	3.46	1.58	5.68	50.00	5.00	1.20	11.82	0.13	0.91
15	4.71	1.25	5.69	50.00	5.00	1.20	11.83	0.13	0.95
20	5.14	1.06	5.55	50.00	5.00	1.20	11.66	0.13	0.97
25	3.21	0.94	3.05	50.00	5.00	1.20	8.66	0.10	0.76
30	4.79	0.85	3.98	50.00	5.00	1.20	9.77	0.11	0.89
35	6.79	0.76	5.25	50.00	5.00	1.20	11.30	0.12	1.08
40	6.85	0.72	4.89	50.00	5.00	1.20	10.87	0.12	1.11
45	9.65	0.67	6.45	50.00	5.00	1.20	12.74	0.14	1.37
50	10.19	0.64	6.53	50.00	5.00	1.20	12.83	0.14	1.46
55	10.99	0.60	6.59	50.00	5.00	1.20	12.91	0.14	1.58
60	13.62	0.58	7.84	50.00	5.00	1.20	14.41	0.16	1.87
65	16.85	0.55	9.25	50.00	5.00	1.20	16.10	0.18	2.36
70	18.10	0.53	9.61	50.00	5.00	1.20	16.53	0.19	2.57
75	13.50	0.51	6.93	50.00	5.00	1.20	13.32	0.14	2.10
80	10.71	0.50	5.31	50.00	5.00	1.20	11.37	0.12	1.86
85	13.49	0.48	6.46	50.00	5.00	1.20	12.75	0.14	2.14
90	14.40	0.47	6.75	50.00	5.00	1.20	13.10	0.14	2.24
95	9.59	0.46	4.39	50.00	5.00	1.20	10.26	0.11	1.80
100	11.78	0.44	5.21	50.00	5.00	1.20	11.26	0.12	2.01
105	18.08	0.44	7.85	50.00	5.00	1.20	14.42	0.16	2.58
110	22.20	0.43	9.45	50.00	5.00	1.20	16.34	0.18	2.91
115	20.34	0.42	8.52	50.00	5.00	1.20	15.22	0.16	2.67
120	20.20	0.41	8.28	50.00	5.00	1.20	14.93	0.16	2.63
125	29.74	0.40	11.99	50.00	5.00	1.20	19.38	0.22	3.53
130	28.36	0.40	11.29	50.00	5.00	1.20	18.55	0.21	3.34
135	28.51	0.39	11.13	50.00	5.00	1.20	18.36	0.20	3.22
140	25.68	0.39	9.94	50.00	5.00	1.20	16.93	0.19	2.96
145	21.10	0.38	8.03	50.00	5.00	1.20	14.64	0.16	2.47
150	27.22	0.38	10.23	62.08	5.00	1.20	17.27	0.19	2.91
155	32.51	0.37	12.07	75.00	5.00	1.20	19.48	0.21	3.27
160	30.21	0.37	11.11	75.00	5.00	1.20	18.33	0.20	3.02
165	19.25	0.36	7.01	75.00	5.00	1.20	13.41	0.15	2.17
170	13.21	0.36	4.75	75.00	5.00	1.20	10.70	0.12	1.72
175	13.70	0.36	4.87	75.00	5.00	1.20	10.85	0.12	1.73
180	12.39	0.35	4.36	75.00	5.00	1.20	10.24	0.11	1.62
185	10.02	0.35	3.49	75.00	5.00	1.20	9.19	0.10	1.45
190	11.07	0.34	3.82	75.00	5.00	1.20	9.58	0.10	1.50
195	12.56	0.34	4.29	75.00	5.00	1.20	10.15	0.11	1.58
200	11.69	0.34	4.02	75.00	5.00	1.20	9.83	0.11	1.52

LIQUEFACTION POTENTIAL BASED ON DIRECT APPLICATION OF CPT

DEPTH (ft)	q_{c1} (tsf)	q_{c1N}	$(q_{c1N})_{cs}$ (tsf)	n	C_Q	Q	F	Ic	Kc	$CRR_{7.5}$ Cone	FS_{cone}
5	28.29	26.98	61.22	0.53	2.92	26.36	0.64%	2.40	2.78	0.10	0.70
10	14.23	14.63	56.32	0.66	1.75	13.72	0.63%	2.66	4.23	0.10	0.69
15	14.24	14.86	57.18	0.75	1.41	13.79	0.55%	2.67	4.16	0.10	0.72
20	13.88	13.66	50.62	0.75	1.10	12.55	0.71%	2.72	4.10	0.09	0.71
25	7.60	7.01	31.39	0.75	0.91	5.94	1.46%	2.93	4.74	0.08	0.60
30	9.92	8.52	32.91	0.75	0.78	7.34	1.68%	2.82	4.33	0.08	0.64
35	13.22	10.95	37.04	0.75	0.68	9.73	1.43%	2.70	3.96	0.08	0.71
40	12.36	9.88	34.89	0.75	0.61	8.70	1.58%	2.73	4.18	0.08	0.74
45	16.27	12.57	39.31	0.75	0.55	11.25	1.42%	2.60	3.56	0.08	0.82
50	16.48	12.47	39.68	0.75	0.51	11.11	1.43%	2.60	3.63	0.08	0.87
55	16.73	12.25	38.54	0.75	0.47	10.91	1.48%	2.60	3.71	0.08	0.92
60	20.08	14.39	39.05	0.75	0.44	13.00	1.48%	2.53	3.24	0.08	0.99
65	23.91	16.74	39.98	0.75	0.41	15.31	1.56%	2.47	3.02	0.08	1.07
70	24.76	17.05	41.12	0.75	0.39	15.60	1.63%	2.44	2.89	0.08	1.15
75	17.54	11.88	38.24	0.75	0.37	10.53	1.93%	2.58	3.67	0.08	1.19
80	13.29	8.84	35.40	0.75	0.35	7.58	2.24%	2.69	4.38	0.08	1.20
85	16.34	10.68	35.31	0.75	0.33	9.32	2.25%	2.63	3.87	0.08	1.23
90	17.11	11.08	34.76	0.75	0.32	9.65	2.31%	2.61	3.70	0.08	1.25
95	11.00	7.03	28.29	0.75	0.31	5.85	2.27%	2.81	4.49	0.07	1.19
100	13.12	8.25	29.93	0.75	0.30	7.00	1.93%	2.77	4.23	0.07	1.23
105	20.03	12.47	34.80	0.75	0.29	11.04	2.32%	2.54	3.33	0.08	1.29
110	24.30	14.98	35.51	0.75	0.28	13.48	2.28%	2.45	2.73	0.08	1.30
115	21.77	13.31	35.67	0.75	0.27	11.83	2.19%	2.50	3.12	0.08	1.29
120	21.16	12.80	35.62	0.75	0.26	11.36	2.49%	2.51	3.29	0.08	1.28
125	31.22	18.73	38.96	0.75	0.26	17.12	2.23%	2.36	2.55	0.08	1.32
130	29.33	17.49	37.92	0.75	0.25	15.88	2.01%	2.43	2.77	0.08	1.29
135	28.78	16.99	38.31	0.75	0.24	15.28	1.96%	2.44	2.74	0.08	1.29
140	25.64	15.08	36.75	0.75	0.24	13.44	1.85%	2.53	3.18	0.08	1.26
145	20.51	11.96	35.14	0.75	0.23	10.46	1.81%	2.64	3.72	0.08	1.23
150	26.39	15.29	37.75	0.75	0.23	13.74	1.65%	2.50	3.14	0.08	1.25
155	31.26	18.00	39.01	0.75	0.23	16.39	1.37%	2.40	2.53	0.08	1.25
160	28.49	16.33	38.98	0.75	0.22	14.82	1.37%	2.43	2.60	0.08	1.24
165	17.65	10.06	35.83	0.75	0.22	8.88	1.36%	2.66	4.04	0.08	1.19
170	11.82	6.70	33.48	0.75	0.22	5.66	1.47%	2.80	5.00	0.08	1.15
175	12.13	6.84	33.80	0.75	0.21	5.80	1.62%	2.77	4.97	0.08	1.15
180	10.87	6.10	30.10	0.75	0.21	4.97	1.69%	2.85	4.97	0.08	1.10
185	8.70	4.85	24.26	0.75	0.21	3.62	1.83%	2.97	5.00	0.07	1.02
190	9.50	5.27	26.36	0.75	0.20	4.09	1.64%	2.93	5.00	0.07	1.04
195	10.68	5.90	29.19	0.75	0.20	4.77	1.61%	2.87	4.97	0.07	1.06
200	10.01	5.50	27.20	0.75	0.20	4.36	1.72%	2.90	4.97	0.07	1.04

LIQUEFACTION POTENTIAL BASED ON SHEAR WAVE VELOCITY

DEPTH (ft)	V_{s1} (fps)	Y	$CRR_{7.5}$ Vs	$FS_{seismic}$	FSavg
5	641.64	157.91	0.13	0.91	
10	520.47	153.33	0.09	0.66	0.81
15	487.95	143.07	0.08	0.59	0.74
20	471.87	141.22	0.07	0.56	0.72
25	464.05	160.57	0.07	0.56	0.68
30	460.49	150.53	0.07	0.58	0.70
35	459.81	139.51	0.07	0.61	0.77
40	461.07	142.69	0.07	0.65	0.86
45	463.66	131.20	0.07	0.70	0.96
50	467.41	131.06	0.07	0.76	1.03
55	471.85	132.73	0.07	0.83	1.11
60	477.11	128.32	0.08	0.90	1.26
65	482.74	126.02	0.08	0.99	1.44
70	489.02	124.83	0.08	1.10	1.56
75	495.48	136.43	0.08	1.20	1.53
80	502.51	147.50	0.09	1.29	1.49
85	509.60	143.98	0.09	1.36	1.57
90	517.19	144.56	0.09	1.44	1.61
95	524.78	163.43	0.09	1.53	1.55
100	532.83	160.76	0.10	1.62	1.62
105	540.82	145.49	0.10	1.68	1.83
110	549.26	139.46	0.11	1.75	1.96
115	557.58	145.50	0.11	1.82	1.94
120	566.05	149.21	0.12	1.90	2.03
125	574.93	138.58	0.12	1.99	2.21
130	583.65	145.22	0.13	2.09	2.22
135	592.76	146.64	0.14	2.21	2.22
140	601.67	156.45	0.15	2.36	2.22
145	610.96	167.17	0.17	2.57	2.16
150	620.01	157.45	0.19	2.86	2.31
155	629.41	150.27	0.22	3.37	2.48
160	638.53	154.03	0.30	4.47	2.17
165	647.97	178.19	-0.49	-7.20	1.71
170	657.10	194.86	-0.97	-14.32	1.50
175	666.51	196.00	-0.31	-4.53	1.42
180	675.57	205.20	-0.04	-0.59	1.35
185	684.85	219.19	0.02	0.30	1.27
190	693.74	217.44	0.05	0.72	1.28
195	702.80	214.11	0.07	0.99	1.31
200	711.43	220.17	0.08	1.18	1.28

TABLE H-3

LIQUEFACTION POTENTIAL SPREADSHEET SUMMARY
CPT-12a

DEPTH (ft)	UNIT WEIGHT (pcf)	Qc (tsf)	Qt (tsf)	Fs (tsf)	Rf%	DYNAMIC PWP (tsf)	EQUIL. PWP (ft)	TOTAL STRESS (tsf)	EFFECTIVE STRESS (tsf)	r_d	CSR 0.16	LIQUEFACTION POTENTIAL BASED ON BLOW COUNT CORRELATIONS: N_{60} (blows/ft.)	C_N	$N_{1(60)}$ (blows/ft)	FINES (%)	α	β	$N_{1(60)cs}$ (blows/ft)	$CRR_{7.5}$ N	FS_N
5	125	19.48	19.48	0.24	0.01	-0.02	1.77	0.31	0.26	0.99	0.12	5.99	2.63	14.71	20.00	3.61	1.08	19.50	0.13	1.01
10	125	10.80	10.84	0.06	0.01	0.25	3.39	0.60	0.49	0.98	0.12	4.20	1.52	6.74	20.00	3.61	1.08	10.89	0.12	0.97
15	125	7.46	7.58	0.05	0.01	0.81	5.13	0.91	0.75	0.97	0.12	2.99	1.21	3.59	20.00	3.61	1.08	7.49	0.09	0.70
20	125	8.12	8.29	0.06	0.01	1.10	6.93	1.23	1.01	0.95	0.12	3.26	1.03	3.35	20.00	3.61	1.08	7.23	0.08	0.69
25	125	7.83	8.07	0.07	0.01	1.63	8.67	1.53	1.26	0.94	0.12	3.14	0.92	2.90	20.00	3.61	1.08	6.74	0.08	0.67
30	125	11.44	11.73	0.10	0.01	1.89	10.46	1.85	1.52	0.92	0.12	4.60	0.84	3.79	20.00	3.61	1.08	7.70	0.09	0.75
35	125	14.84	15.14	0.15	0.01	2.01	12.20	2.16	1.78	0.89	0.11	5.94	0.77	4.59	28.50	4.01	1.11	9.12	0.10	0.90
40	125	17.24	17.59	0.20	0.02	2.33	14.00	2.48	2.04	0.85	0.11	6.85	0.72	4.93	44.00	4.72	1.16	10.54	0.12	1.08
45	125	23.23	23.55	0.24	0.01	2.12	15.74	2.78	2.29	0.81	0.10	9.18	0.68	6.23	50.00	5.00	1.20	12.48	0.14	1.33
50	125	25.58	26.04	0.25	0.01	3.07	17.54	3.10	2.55	0.77	0.10	10.05	0.64	6.47	50.00	5.00	1.20	12.77	0.14	1.43
55	125	25.82	26.30	0.27	0.01	3.20	19.28	3.41	2.81	0.73	0.09	10.16	0.61	6.20	50.00	5.00	1.20	12.44	0.14	1.48
60	125	42.17	42.31	0.42	0.01	0.91	21.07	3.73	3.07	0.69	0.09	16.36	0.59	9.54	50.00	5.00	1.20	16.44	0.18	2.11
65	125	45.66	46.00	0.46	0.01	2.24	22.81	4.03	3.32	0.65	0.08	17.67	0.56	10.02	50.00	5.00	1.20	17.02	0.19	2.30
70	125	37.45	38.27	0.36	0.01	5.47	24.61	4.35	3.58	0.61	0.08	14.64	0.54	7.97	50.00	5.00	1.20	14.57	0.16	2.09
75	125	34.86	35.72	0.43	0.01	5.73	26.35	4.66	3.84	0.57	0.07	13.73	0.53	7.24	50.00	5.00	1.20	13.69	0.15	2.07
80	125	28.28	29.54	0.46	0.02	8.40	28.15	4.98	4.10	0.55	0.07	11.25	0.51	5.73	50.00	5.00	1.20	11.88	0.13	1.85
85	125	32.56	33.95	0.52	0.02	9.21	29.88	5.29	4.35	0.54	0.07	12.85	0.49	6.31	50.00	5.00	1.20	12.57	0.14	2.01
90	125	33.56	34.88	0.52	0.02	8.75	31.68	5.60	4.61	0.53	0.07	13.26	0.48	6.37	50.00	5.00	1.20	12.64	0.14	2.06
95	125	32.22	33.80	0.55	0.02	10.56	33.42	5.91	4.87	0.51	0.06	12.78	0.47	5.95	50.00	5.00	1.20	12.15	0.13	2.04
100	125	54.34	55.45	0.65	0.02	7.43	35.22	6.23	5.13	0.50	0.06	21.15	0.45	9.57	50.00	5.00	1.20	16.49	0.19	2.92
105	125	62.71	63.63	0.67	0.01	6.11	36.96	6.54	5.38	0.50	0.06	24.31	0.44	10.78	50.00	5.00	1.20	17.94	0.20	3.20
110	125	52.20	53.70	0.80	0.02	9.98	38.75	6.85	5.64	0.50	0.06	20.34	0.43	8.81	50.00	5.00	1.20	15.58	0.17	2.70
115	125	47.95	49.71	0.80	0.02	11.77	40.49	7.16	5.90	0.50	0.06	18.72	0.42	7.92	50.00	5.00	1.20	14.51	0.16	2.52
120	125	58.18	59.87	0.93	0.02	11.30	42.23	7.47	6.15	0.50	0.06	22.53	0.41	9.31	50.00	5.00	1.20	16.17	0.18	2.84
125	125	60.80	62.61	1.03	0.02	12.11	44.03	7.79	6.41	0.50	0.06	23.51	0.41	9.57	50.00	5.00	1.20	16.48	0.18	2.90
130	125	35.68	38.68	0.62	0.02	20.04	45.77	8.09	6.67	0.50	0.06	14.02	0.40	5.62	50.00	5.00	1.20	11.74	0.13	2.04
135	125	22.81	26.72	0.31	0.01	26.06	47.62	8.42	6.94	0.50	0.06	9.16	0.39	3.58	50.00	5.00	1.20	9.29	0.10	1.61
140	125	26.28	30.21	0.33	0.01	26.18	49.31	8.72	7.18	0.50	0.06	10.55	0.38	4.04	50.00	5.00	1.20	9.85	0.11	1.70
145	125	32.37	36.32	0.37	0.01	26.32	51.10	9.04	7.44	0.50	0.06	12.99	0.38	4.89	50.00	5.00	1.20	10.87	0.12	1.87
150	125	30.25	34.29	0.33	0.01	26.87	52.84	9.35	7.70	0.50	0.06	12.15	0.37	4.51	60.83	5.00	1.20	10.42	0.11	1.80
155	125	21.85	26.33	0.24	0.01	29.85	54.64	9.66	7.96	0.50	0.06	8.78	0.36	3.20	73.75	5.00	1.20	8.84	0.10	1.54
160	125	20.12	25.00	0.24	0.01	32.51	56.38	9.97	8.21	0.50	0.06	8.08	0.36	2.90	75.00	5.00	1.20	8.48	0.09	1.48
165	125	21.17	26.15	0.31	0.01	33.22	58.18	10.29	8.47	0.50	0.06	8.50	0.35	3.01	75.00	5.00	1.20	8.61	0.09	1.50
170	125	21.11	26.21	0.33	0.02	34.00	59.91	10.60	8.73	0.50	0.06	8.48	0.35	2.95	75.00	5.00	1.20	8.54	0.09	1.49
175	125	20.79	26.08	0.32	0.02	35.27	61.68	10.91	8.98	0.50	0.06	8.35	0.34	2.87	75.00	5.00	1.20	8.44	0.09	1.47

DEPTH (ft)	LIQUEFACTION POTENTIAL BASED ON DIRECT APPLICATION OF CPT: q_{c1} (tsf)	q_{c1N}	$(q_{c1N})_{cs}$ (tsf)	n	C_Q	Q	F	Ic	Kc	$CRR_{7.5}$ CONE	FS_{cone}	Fsavg
5	51.60	84.71	105.69	0.75	4.82	83.88	1.18%	2.00	1.82	0.37	2.98	1.23
10	17.45	21.16	57.16	0.75	1.89	20.22	0.82%	2.55	3.52	0.10	0.81	1.00
15	8.94	9.30	43.79	0.75	1.33	8.33	0.98%	2.78	4.80	0.09	0.71	0.73
20	8.34	8.00	37.41	0.75	1.05	6.97	1.28%	2.85	4.81	0.08	0.67	0.68
25	7.22	6.56	30.79	0.75	0.88	5.49	1.54%	2.97	4.84	0.08	0.64	0.68
30	9.43	8.08	36.99	0.75	0.76	6.96	1.28%	2.85	4.74	0.08	0.69	0.73
35	11.47	9.52	40.64	0.75	0.68	8.34	1.46%	2.72	4.53	0.08	0.74	0.83
40	12.41	9.95	37.88	0.75	0.61	8.73	1.90%	2.72	4.33	0.08	0.76	0.94
45	15.76	12.28	39.12	0.75	0.56	10.97	1.76%	2.63	3.76	0.08	0.81	1.02
50	16.46	12.49	37.55	0.75	0.52	11.20	1.60%	2.64	3.74	0.08	0.84	1.09
55	15.76	11.64	37.13	0.75	0.48	10.32	1.59%	2.66	3.94	0.08	0.88	1.26
60	24.58	17.73	43.25	0.75	0.45	16.21	1.40%	2.46	2.99	0.09	0.99	1.51
65	25.88	18.42	42.53	0.75	0.42	16.93	1.51%	2.46	2.85	0.09	1.04	1.65
70	20.40	14.23	39.71	0.75	0.40	12.89	1.44%	2.59	3.55	0.08	1.08	1.66
75	18.40	12.63	39.27	0.75	0.38	11.26	1.69%	2.60	3.75	0.08	1.15	1.57
80	14.41	9.72	35.26	0.75	0.36	8.45	2.09%	2.66	4.10	0.08	1.14	1.50
85	15.99	10.59	34.31	0.75	0.35	9.32	2.16%	2.63	3.84	0.08	1.16	1.57
90	16.12	10.56	34.69	0.75	0.33	9.22	2.09%	2.63	3.86	0.08	1.19	1.65
95	15.01	9.68	34.87	0.75	0.32	8.38	2.38%	2.67	4.16	0.08	1.22	1.72
100	24.58	15.63	39.90	0.75	0.31	14.15	1.94%	2.51	3.17	0.08	1.31	1.98
105	27.82	17.51	40.65	0.75	0.30	15.94	1.67%	2.46	2.80	0.08	1.33	2.17
110	22.62	14.07	37.02	0.75	0.29	12.63	2.14%	2.51	3.23	0.08	1.28	2.05
115	20.29	12.48	35.01	0.75	0.28	11.07	2.26%	2.57	3.53	0.08	1.25	1.92
120	24.04	14.61	35.73	0.75	0.27	13.15	2.15%	2.50	3.14	0.08	1.26	2.04
125	24.74	14.92	35.59	0.75	0.26	13.45	2.17%	2.49	3.06	0.08	1.26	2.03
130	14.29	8.55	29.06	0.75	0.25	7.33	2.05%	2.77	4.29	0.07	1.18	1.67
135	8.91	5.26	26.00	0.75	0.24	4.22	1.77%	2.92	4.97	0.07	1.13	1.41
140	10.08	5.90	27.41	0.75	0.24	4.82	1.69%	2.89	4.84	0.07	1.15	1.44
145	12.19	7.07	31.12	0.75	0.23	5.96	1.51%	2.83	4.69	0.08	1.20	1.52
150	11.24	6.48	29.93	0.75	0.23	5.34	1.46%	2.86	4.82	0.07	1.19	1.46
155	7.98	4.55	22.77	0.75	0.22	3.48	1.48%	3.00	5.00	0.07	1.09	1.33
160	7.22	4.09	20.44	0.75	0.22	3.05	1.62%	3.04	5.00	0.07	1.06	1.28
165	7.48	4.20	21.02	0.75	0.21	3.15	1.99%	3.02	5.00	0.07	1.07	1.28
170	7.35	4.10	20.50	0.75	0.21	3.03	2.14%	3.03	5.00	0.07	1.06	1.27
175	7.14	3.95	19.76	0.75	0.20	2.88	2.11%	3.04	5.00	0.07	1.05	1.26

APPENDIX H-2

POST-LIQUEFACTION STABILITY ANALYSIS

	Subject Mercur Mine, Reservation Canyon Tailings	Made by TJW	Job No 983-2344.002-3
Golder Associates	Post- Earthquake Residual Strength	Checked by SV	Date 1/7/99
	Based on Seed & Harder, 1990	Approved by BRB	Sheet No 1 of 3

OBJECTIVE:

Liquefaction analyses at the Reservation Canyon Tailings Facility indicate that a portion of the tailings are susceptible to liquefaction during the design seismic event. The post liquefaction stability of the embankment was assessed to evaluate if there would be significant consequences to liquefaction. The strength of the liquefied tailings was assessed from established procedures presented by Seed and Harder, 1990.

METHOD:

The factor of safety against liquefaction is computed using methods in Youd and Idriss, 1997.

- If FS<1.0 Soils will liquefy. Use undrained residual strength assessed from Seed and Harder, 1990, Figure 11. The cone tip resistance is correlated to blow count ($N_{1(60)}$) values using curves provided by Seed and De Alba, 1986. The Seed and De Alba curves are modified in terms of soil type index (Ic) rather than mean grain size. The Ic is related to mean grain size as follows:

Mean Grain Size (mm)	Soil Type Index (Ic)
1	1
0.35	1.3
0.15	1.6
0.055	1.9
0.025	2.2
0.01	2.5

$N_{1(60)}$ is corrected for fines content (i.e. $N_{1(60)cs}$) as assessed from laboratory testing using recommendations by Seed and Harder, 1990.

- If 1.0<FS<1.4 soils will develop some residual excess pore pressure. The relationship presented by Marcuson and Hynes, (1989), Figure 10, which relates the residual excess pore pressure ratio as a function of the factor of safety was used. In order to model the residual excess pore pressure ratio using the computer software program XSTABL, a reduced friction angle was applied for tailings with 1.0<FS<1.4. The static total stress friction angle (ϕ) was estimated from:

$$\phi = \arctan\left(\frac{Su}{\sigma_v'}\right)$$

where:
Su=undrained shear strength assessed from CPT data
σ_v'=vertical effective stress based on in situ pore pressures

The reduced friction angle (ϕ_r) was computed so that the shear strength, assuming in situ stress conditions, was equal to the shear strength assuming partial excess pore pressures utilizing the static total stress friction angle (ϕ) (see attached Reduced Friction Angle Worksheets).

- If FS>1.4 Use in situ shear strength as assessed from CPT data .

CPT soundings CPT-9 and CPT-12 are located at the Main Dam and Saddle Dam, respectively, maximum cross-sections. The liquefaction susceptibility and the post liquefaction stability are based on CPT data from these soundings.

CALCULATIONS:

For CPT-9

0'-60' FS<1.0

	Subject Mercur Mine, Reservation Canyon Tailings	Made by TJW	Job No 983-2344.002-3
Golder Associates	Post- Earthquake Residual Strength	Checked by SV	Date 1/7/99
	Based on Seed & Harder, 1990	Approved by BRB	Sheet No 2 of 3

Determine strength from
Figure 11. Subdivide into three, 20 foot thick sublayers. From laboratory testing typical fines content 35 %.

Sublayer Interval	$N_{1(60)}$ is corrected for fines content	Post liquefaction Undrained Shear Strength (psf)
0 ft. – 20 ft.	11	400
20 ft. – 40 ft.	7	200
40 ft. – 60 ft.	9	250

60'-100' 1.0<FS<1.4
The average undrained shear strength over this interval = 4786 psf
The vertical effective stress @ 80 ft. (i.e. mid height) =9416 psf
So:
ϕ=arctan(4786/9416)
ϕ=27 degrees

The average factor of safety over this interval is taken to be 1.2. The corresponding excess residual pore pressure (Ru) from Marcuson et.al. (1989) is 0.3. The reduced friction angle (ϕr) for the interval from 60' to 100 is 21 degrees (see attached Reduced Friction Angle Worksheet).
ϕr=21 degrees

100'-160' FS>1.4
The average undrained shear strength from CPT data is 9600 psf. Use 100% of that value since this material is dense, dilative lower subaerial tailings.
Su=9600 psf

160'-260 1.0<FS<1.4
Interval consists of subaqueous tailings (ST). Material has high fines content but low plasticity. May be subject to partial pore pressure increase.

The average undrained shear strength over this interval = 3414 psf
The vertical effective stress @ 210 ft (i.e. mid height) =20,332 psf
So:
ϕ=arctan(3414/20,332)
ϕ=9 degrees

The average factor of safety over this interval is taken to be 1.3 (see Figures H-1 through H-3). The corresponding excess residual pore pressure (Ru) from Marcuson et.al. (1989) is 0.2. The reduced friction angle (ϕr) for the interval from 160' to 260 is 7.4 degrees (see attached Reduced Friction Angle Worksheet).
ϕr=7.4 degrees

For CPT-12
0'-60' FS<1.0

Determine strength from Figure 11. Subdivide into three, 20 foot thick sublayers. From laboratory testing typical fines content 35 %. Equivalent blow counts are virtually the same as those determined in CPT-9. For consistency use same values.

Sublayer Interval	$N_{1(60)}$ is corrected for fines content	Post liquefaction Undrained Shear Strength (psf)
0 ft. – 20 ft.	11	400

20 ft. – 40 ft.	6	200
40 ft. – 60 ft.	8	250

60'-100' 1.0<FS<1.4
The average undrained shear strength over this interval = 5228 psf
The vertical effective stress @ 80 ft. (i.e. mid height) =8240 psf
So:
ϕ=arctan(5228/8240)
ϕ=32 degrees

The average factor of safety over this interval is taken to be 1.4 (see figures H-1 through H-3). The corresponding excess residual pore pressure (Ru) from Marcuson et.al. (1989) is 0.15. The reduced friction angle (ϕr) for the interval from 60' to 100 is 28.75 degrees(see attached Reduced Friction Angle Worksheets).
ϕr=28.75 degrees

100'-135' FS>1.4
The average undrained shear strength from CPT data is 7454 psf. Use 100% of that value since this material is dense, dilative lower subaerial tailings.
Su=7454 psf

135'-175' 1.1<FS<1.4
The average undrained shear strength over this interval = 2450 psf
The vertical effective stress @ 155 ft. (i.e. mid height) =15960 psf
So:
ϕ=arctan(2450/15960)
ϕ=9 degrees

The average factor of safety over this interval is taken to be 1.25. The corresponding excess residual pore pressure (Ru) from Marcuson et.al. (1989) 0.23. The reduced friction angle (ϕr) for the interval from 135' to 175 is 7.2 degrees (see attached Reduced Friction Angle Worksheets).
ϕr=7.2 degrees

CONCLUSIONS/RESULTS:

Limit equilibrium, post liquefaction stability analyses indicate a minimum factor of safety of 1.16 for the Main Dam and 1.2 for the Levee buttress for the design earthquake. The design earthquake consists of a magnitude 7.5 earthquake generating a peak bedrock acceleration of 0.16g.. A factor of safety of 1.0 is considered acceptable for the analyses employed.

REFERENCES:

Marcuson, W.F., Hynes, M.E., and Franklin, A.G., 1989, Evaluation and Use of Residual Strength in Seismic Analysis of Embankments, Earthquake Spectra, Vol. 6, No. 3

Robertson, P.K., 1998, Oral Communication.

Seed, R.B., Harder, L.F., 1990, SPT-Based Analysis of Cyclic Pore Pressure Generation and Undrained Residual Strength, in Volume 2 Memorial Symposium Proceedings, ed. J. M. Duncan.

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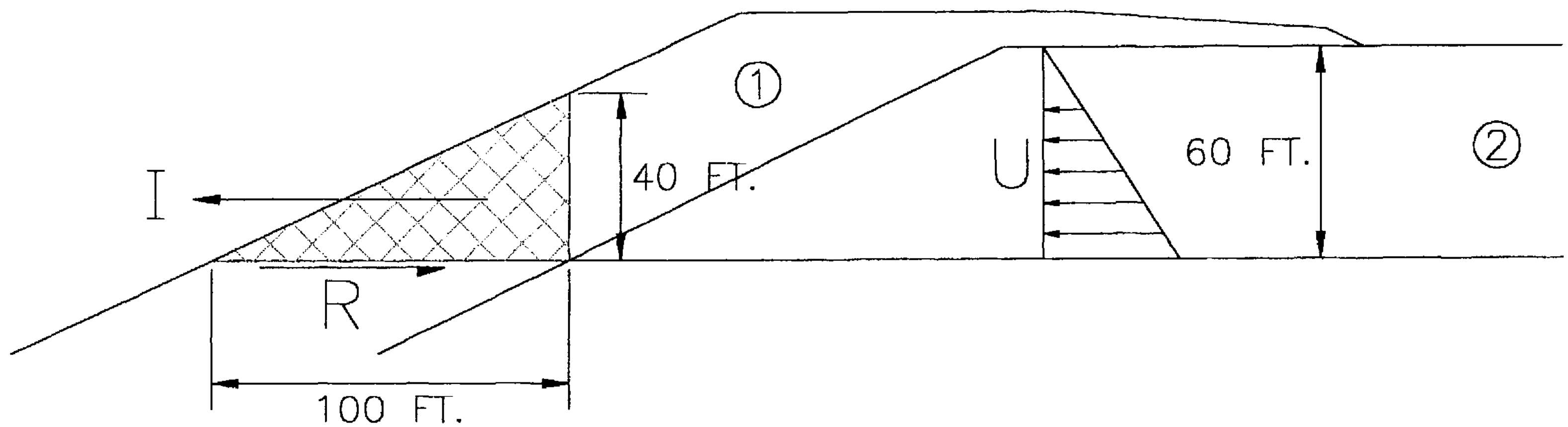

FACTOR OF SAFETY= 1.06

SOIL UNIT	MATERIAL TYPE	UNIT WEIGHT (pcf)	COHESION (PSF)	FRICTION ANGLE (degrees)
①	EMBANKMENT ROCKFILL	130	0	40
②	LIQUEFIED TAILINGS	100	0	0

CLIENT/PROJECT
BARRICK RESOURCES (USA)-MERCUR MINE
RESERVATION CANYON TAILINGS
PRELIMINARY CLOSURE DESIGN
BARRICK

Golder Associates
Tucson, Arizona

TITLE
HYDRODYNAMIC STABILITY ANALYSIS

DRAWN	CHECKED	REVIEWED	DATE	SCALE	FILE NO.	JOB NO.	DWG NO./REV.NO.	FIGURE
MJG, CAN	TJW	BRB	FEB 1999	N.T.S.	HDYNAMIC	983-2344		H-2-1

CPT-9
Proximal Upper Subaerial Tailings
Reduced Friction Angle Worksheet

Effective unit weight (pcf) 58
Ko 0.45

Depth	Vertical Effective Stress σ_1'	Horizontal Effective Stress σ_3'	Total Stress Friction Angle (ϕ)	α $45+\phi/2$	Factor of Safety	Residual Excess Pore Pressure Ratio	Residual Horizontal Effective Stress $\sigma_3'r$	Shear Strength (τ), with partial pore pressure increase	Shear Strength (τ), in situ, static	Reduced Friction Angle (ϕr)	α $45+\phi/2$
(feet)	(psf)	(psf)	degrees	degrees		Marcuson & Hynes, 1989	(psf)	(psf)	(psf)	degrees	degrees
80	4240	1908	27	58.5		0	1908.0	1413	1413	27.00	58.5
80	4240	1908	27	58.5	2.6	0.01	1888.9	1399	1399	26.81	58.4
80	4240	1908	27	58.5	2.4	0.02	1869.8	1385	1385	26.63	58.3
80	4240	1908	27	58.5	2	0.05	1812.6	1343	1343	26.06	58.0
80	4240	1908	27	58.5	1.6	0.08	1755.4	1300	1300	25.48	57.7
80	4240	1908	27	58.5	1.55	0.1	1717.2	1272	1272	25.09	57.5
80	4240	1908	27	58.5	1.4	0.15	1621.8	1201	1201	24.09	57.0
80	4240	1908	27	58.5	1.3	0.2	1526.4	1131	1131	23.07	56.5
80	4240	1908	27	58.5	1.22	0.25	1431.0	1060	1060	22.01	56.0
80	4240	1908	27	58.5	1.19	0.3	1335.6	989	989	20.91	55.5
80	4240	1908	27	58.5	1.125	0.4	1144.8	848	848	18.62	54.3
80	4240	1908	27	58.5	1.1	0.5	954.0	707	707	16.17	53.1
80	4240	1908	27	58.5	1.05	0.7	572.4	424	424	10.83	50.3
80	4240	1908	27	58.5	1.02	0.8	381.6	283	283	7.48	48.7
80	4240	1908	27	58.5	1.01	0.9	190.8	141	141	3.96	47.0

CPT-12
Proximal Upper Subaerial Tailings
Reduced Friction Angle Worksheet

Effective unit weight (pcf)	52.6
Ko	0.45

Depth (feet)	Vertical Effective Stress σ_1' (psf)	Horizontal Effective Stress σ_3' (psf)	Total Stress Friction Angle (ϕ) degrees	α 45+ϕ/2 degrees	Factor of Safety	Residual Excess Pore Pressure Ratio Marcuson & Hynes, 1989	Residual Horizontal Effective Stress $\sigma_3'r$ (psf)	Shear Strength (τ), with partial pore pressure increase (psf)	Shear Strength (τ), in situ, static (psf)	Reduced Friction Angle (ϕr) degrees	α 45+ϕ/2 degrees
80	4208	1893.6	32	61		0	1893.6	1810	1810	32.00	61.0
80	4208	1893.6	32	61	2.6	0.01	1874.7	1792	1792	31.79	60.9
80	4208	1893.6	32	61	2.4	0.02	1855.7	1774	1774	31.58	60.8
80	4208	1893.6	32	61	2	0.05	1798.9	1720	1720	30.96	60.5
80	4208	1893.6	32	61	1.6	0.08	1742.1	1665	1665	30.30	60.2
80	4208	1893.6	32	61	1.55	0.1	1704.2	1629	1629	29.87	59.9
80	4208	1893.6	32	61	1.4	0.15	1609.6	1539	1539	28.76	59.4
80	4208	1893.6	32	61	1.3	0.2	1514.9	1448	1448	27.59	58.8
80	4208	1893.6	32	61	1.22	0.25	1420.2	1358	1358	26.40	58.2
80	4208	1893.6	32	61	1.19	0.3	1325.5	1267	1267	25.15	57.6
80	4208	1893.6	32	61	1.125	0.4	1136.2	1086	1086	22.52	56.3
80	4208	1893.6	32	61	1.1	0.5	946.8	905	905	19.68	54.8
80	4208	1893.6	32	61	1.05	0.7	568.1	543	543	13.15	51.6
80	4208	1893.6	32	61	1.02	0.8	378.7	362	362	9.34	49.7
80	4208	1893.6	32	61	1.01	0.9	189.4	181	181	5.02	47.5

Subaqueous Tailings
Reduced Friction Angle Worksheet

Effective unit weight (pcf) 63
Ko 0.45

Depth	Vertical Effective Stress σ_1'	Horizontal Effective Stress σ_3'	Total Stress Friction Angle (ϕ)	α $45+\phi/2$	Factor of Safety	Residual Excess Pore Pressure Ratio	Residual Horizontal Effective Stress $\sigma_3'r$	Shear Strength (τ), with partial pore pressure increase	Shear Strength (τ), in situ, static	Reduced Friction Angle (ϕr)	α $45+\phi/2$
(feet)	(psf)	(psf)	degrees	degrees		Marcuson & Hynes, 1989	(psf)	(psf)	(psf)	degrees	degrees
195	18958	8531.1	9	49.5		0	8531.1	1562	1562	9.00	49.5
195	18958	8531.1	9	49.5	2.6	0.01	8445.8	1547	1547	8.92	49.5
195	18958	8531.1	9	49.5	2.4	0.02	8360.5	1531	1531	8.84	49.4
195	18958	8531.1	9	49.5	2	0.05	8104.5	1484	1484	8.61	49.3
195	18958	8531.1	9	49.5	1.6	0.08	7848.6	1437	1437	8.37	49.2
195	18958	8531.1	9	49.5	1.55	0.1	7678.0	1406	1406	8.21	49.1
195	18958	8531.1	9	49.5	1.4	0.15	7251.4	1328	1328	7.81	48.9
195	18958	8531.1	9	49.5	1.3	0.2	6824.9	1250	1250	7.40	48.7
195	18958	8531.1	9	49.5	1.22	0.25	6398.3	1172	1172	6.98	48.5
195	18958	8531.1	9	49.5	1.19	0.3	5971.8	1094	1094	6.57	48.3
195	18958	8531.1	9	49.5	1.125	0.4	5118.7	937	937	5.71	47.9
195	18958	8531.1	9	49.5	1.1	0.5	4265.6	781	781	4.83	47.4
195	18958	8531.1	9	49.5	1.05	0.7	2559.3	469	469	2.99	46.5
195	18958	8531.1	9	49.5	1.02	0.8	1706.2	312	312	2.02	46.0
195	18958	8531.1	9	49.5	1.01	0.9	853.1	156	156	1.03	45.5

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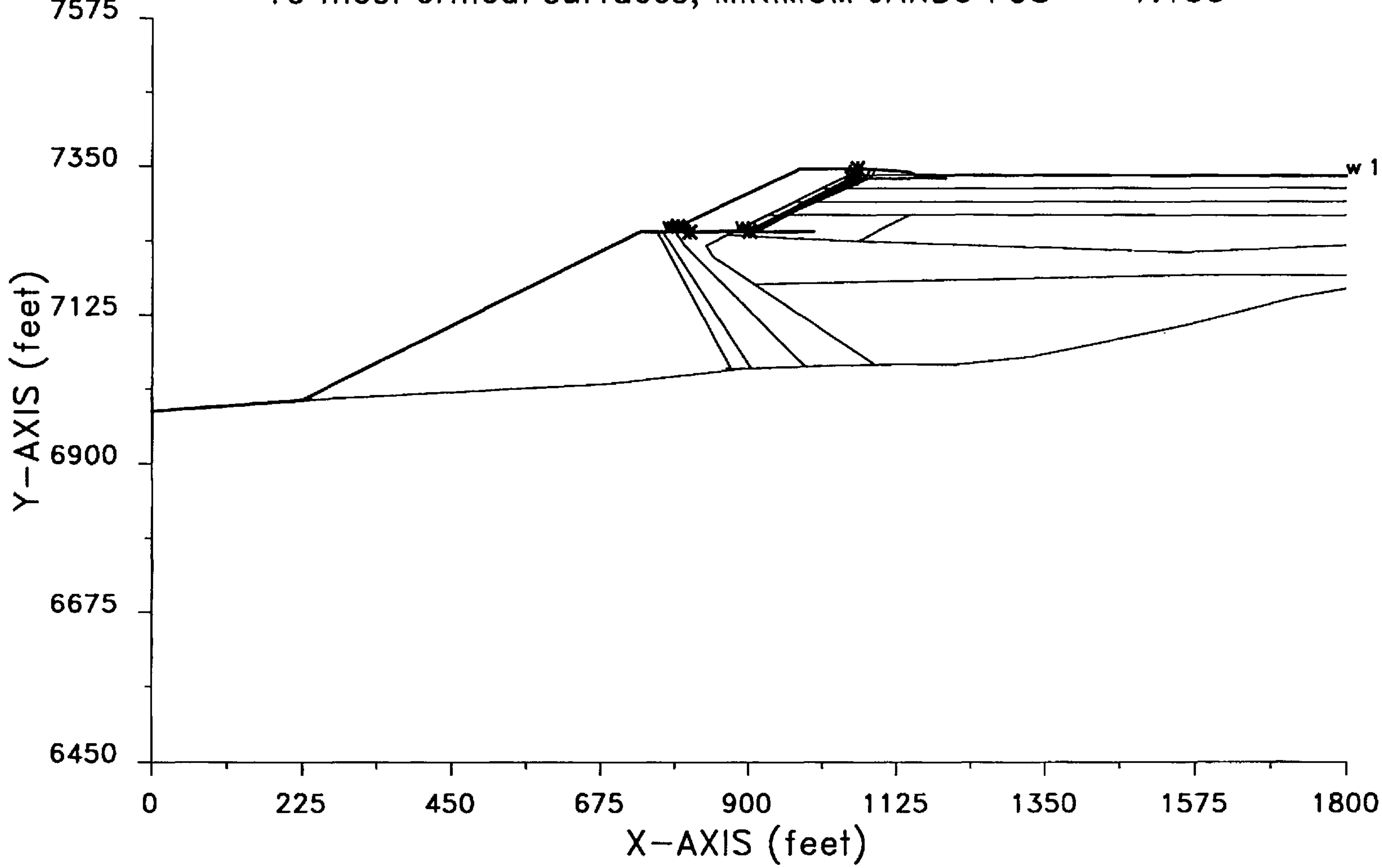
POST LIQUEFACTION STABILITY ANALYSIS
10 most critical surfaces, MINIMUM JANBU FOS = 1.133



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*              using the                *
*           Method of Slices            *
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Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

10 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	6979.0	223.8	6995.0	1
2	223.8	6995.0	733.8	7250.0	2
3	733.8	7250.0	760.8	7250.0	2
4	760.8	7250.0	769.1	7250.0	3
5	769.1	7250.0	775.1	7250.0	4
6	775.1	7250.0	978.8	7345.0	5
7	978.8	7345.0	1071.6	7345.0	5
8	1071.6	7345.0	1142.5	7340.0	5
9	1142.5	7340.0	1153.3	7335.0	5
10	1153.3	7335.0	1800.0	7333.4	6

35 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	1052.3	7335.0	1153.3	7335.0	6
2	1011.2	7315.0	1052.3	7335.0	6
3	1011.2	7315.0	1800.0	7315.0	12
4	970.0	7295.0	1011.2	7315.0	12
5	970.0	7295.0	1800.0	7295.0	13
6	928.8	7275.0	970.0	7295.0	13
7	928.8	7275.0	1146.3	7275.0	7
8	1146.3	7275.0	1800.0	7273.4	8
9	867.7	7245.3	928.8	7275.0	7
10	1066.4	7235.1	1146.3	7275.0	8

11	867.7	7245.3	1066.4	7235.1	9
12	1066.4	7235.1	1560.4	7218.1	9
13	1560.4	7218.1	1800.0	7228.6	9
14	834.7	7229.3	867.7	7245.3	9
15	834.7	7229.3	845.9	7212.0	5
16	845.9	7212.0	908.6	7170.2	5
17	908.6	7170.2	1560.4	7183.2	10
18	1560.4	7183.2	1800.0	7183.2	10
19	775.1	7250.0	788.8	7250.0	4
20	788.8	7250.0	802.4	7229.0	4
21	908.6	7170.2	1092.6	7047.6	5
22	802.4	7229.0	986.6	7044.9	4
23	769.1	7250.0	903.8	7042.7	3
24	760.8	7250.0	873.3	7042.0	2
25	1726.9	7149.4	1800.0	7162.5	1
26	1571.0	7109.4	1726.9	7149.4	1
27	1329.6	7059.5	1571.0	7109.4	1
28	1220.1	7048.2	1329.6	7059.5	1
29	1092.6	7047.6	1220.1	7048.2	1
30	986.6	7044.9	1092.6	7047.6	1
31	903.8	7042.7	986.6	7044.9	1
32	873.3	7042.0	903.8	7042.7	1
33	865.6	7042.5	873.3	7042.0	1
34	680.7	7018.7	895.6	7042.5	1
35	223.8	6995.0	680.7	7018.7	1

ISOTROPIC Soil Parameters

----

13 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	1
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	115.0	115.0	400.0	.00	.000	.0	0
7	122.0	122.0	.0	21.00	.000	.0	1
8	122.0	122.0	710.0	.00	.000	.0	0
9	124.0	124.0	9000.0	.00	.000	.0	0
10	128.0	128.0	.0	7.40	.000	.0	1
11	115.0	115.0	230.0	.00	.000	.0	0
12	115.0	115.0	200.0	.00	.000	.0	0
13	115.0	115.0	250.0	.00	.000	.0	0

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 6 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	769.10	7250.00
2	775.10	7250.00
3	788.80	7250.00
4	880.00	7250.00
5	1052.30	7335.00
6	1800.00	7335.00

A critical failure surface searching method, using a random technique for generating sliding BLOCK surfaces, has been specified.

The active and passive portions of the sliding surfaces are generated according to the Rankine theory.

1000 trial surfaces will be generated and analyzed.

3 boxes specified for generation of central block base

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

Length of line segments for active and passive portions of sliding block is 71.0 ft

Box no.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Width (ft)
1	800.0	7250.0	850.0	7250.0	2.0
2	900.0	7250.0	1000.0	7250.0	2.0
3	1050.0	7330.0	1200.0	7330.0	2.0

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED JANBU METHOD * * * * *

The 10 most critical of all the failure surfaces examined are displayed below - the most critical first

Failure surface No. 1 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	792.59	7258.16
2	810.56	7249.78
3	901.37	7250.97
4	1056.73	7330.51
5	1061.22	7335.00
6	1065.88	7345.00

** Corrected JANBU FOS = 1.133 ** (Fo factor = 1.056)

Failure surface No. 2 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	792.12	7257.94
2	807.10	7250.95
3	900.28	7249.26
4	1063.85	7329.92
5	1068.93	7335.00
6	1073.53	7344.86

** Corrected JANBU FOS = 1.137 ** (Fo factor = 1.055)

Failure surface No. 3 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	788.69	7256.34
2	801.22	7250.50
3	908.79	7250.88
4	1057.03	7330.95
5	1061.09	7335.00
6	1065.75	7345.00

** Corrected JANBU FOS = 1.139 ** (Fo factor = 1.057)

Failure surface No. 4 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	789.19	7256.57
2	805.19	7249.11
3	911.75	7249.39
4	1053.97	7329.36
5	1059.61	7335.00
6	1064.28	7345.00

** Corrected JANBU FOS = 1.145 ** (Fo factor = 1.060)

Failure surface No. 5 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	789.98	7256.94
2	806.04	7249.46
3	903.15	7249.87
4	1075.66	7330.63
5	1080.03	7335.00
6	1084.28	7344.11

** Corrected JANBU FOS = 1.151 ** (Fo factor = 1.052)

Failure surface No. 6 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	794.83	7259.20
2	814.74	7249.91
3	906.40	7249.04
4	1059.27	7330.52
5	1063.76	7335.00
6	1068.42	7345.00

** Corrected JANBU FOS = 1.152 ** (Fo factor = 1.059)

Failure surface No. 7 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	788.61	7256.30
2	800.38	7250.81
3	900.17	7249.39
4	1083.68	7330.32
5	1088.37	7335.00
6	1092.35	7343.54

** Corrected JANBU FOS = 1.155 ** (Fo factor = 1.049)

Failure surface No. 8 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	789.18	7256.57
2	803.61	7249.84
3	912.76	7249.20
4	1061.73	7330.25
5	1066.48	7335.00
6	1071.14	7345.00

** Corrected JANBU FOS = 1.157 ** (Fo factor = 1.059)

Failure surface No. 9 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	797.90	7260.63
2	819.04	7250.78
3	909.15	7250.79
4	1054.66	7329.15
5	1060.51	7335.00
6	1065.18	7345.00

** Corrected JANBU FOS = 1.160 ** (Fo factor = 1.060)

Failure surface No.10 specified by 6 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	791.30	7257.55
2	807.50	7250.00
3	904.42	7250.38
4	1075.06	7329.10
5	1080.96	7335.00
6	1085.17	7344.04

** Corrected JANBU FOS = 1.161 ** (Fo factor = 1.052)

The following is a summary of the TEN most critical surfaces

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

	Modified JANBU FOS	Correction Factor	Initial x-coord (ft)	Terminal x-coord (ft)	Available Strength (lb)
1.	1.133	1.056	792.59	1065.88	4.779E+05
2.	1.137	1.055	792.12	1073.53	4.887E+05
3.	1.139	1.057	788.69	1065.75	4.935E+05
4.	1.145	1.060	789.19	1064.28	5.105E+05
5.	1.151	1.052	789.98	1084.28	5.076E+05
6.	1.152	1.059	794.83	1068.42	4.994E+05
7.	1.155	1.049	788.61	1092.35	5.093E+05
8.	1.157	1.059	789.18	1071.14	5.193E+05
9.	1.160	1.060	797.90	1065.18	4.901E+05
10.	1.161	1.052	791.30	1085.17	5.084E+05

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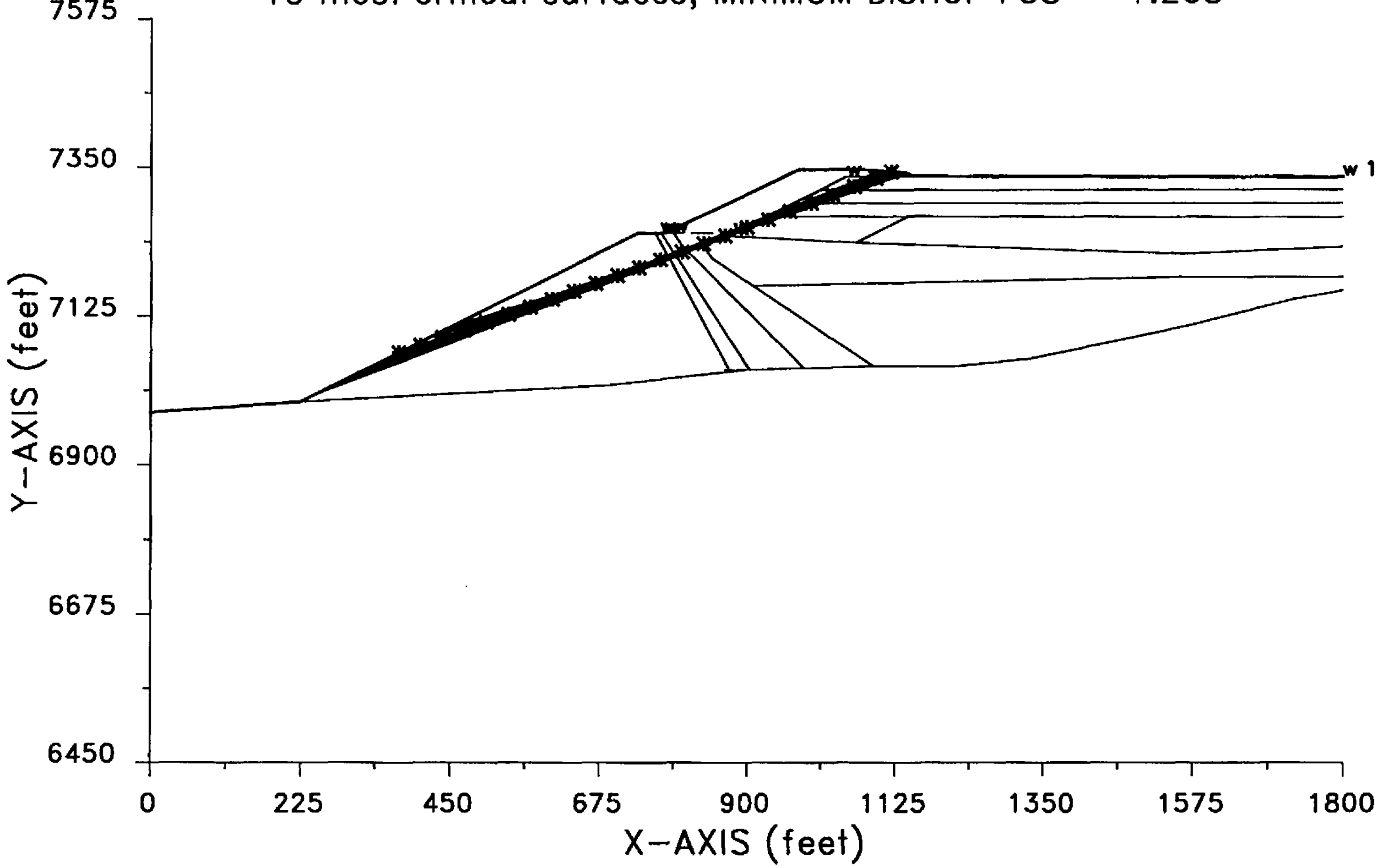
POST LIQUEFACTION STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 1.268



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*        Slope Stability Analysis       *
*              using the                *
*           Method of Slices            *
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*                                       *
*  Ver. 5.105               95 Ä 1318   *
*****************************************
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Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

10 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	6979.0	223.8	6995.0	1
2	223.8	6995.0	733.8	7250.0	2
3	733.8	7250.0	760.8	7250.0	2
4	760.8	7250.0	769.1	7250.0	3
5	769.1	7250.0	775.1	7250.0	4
6	775.1	7250.0	978.8	7345.0	5
7	978.8	7345.0	1071.6	7345.0	5
8	1071.6	7345.0	1142.5	7340.0	5
9	1142.5	7340.0	1153.3	7335.0	5
10	1153.3	7335.0	1800.0	7333.4	6

35 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	1052.3	7335.0	1153.3	7335.0	6
2	1011.2	7315.0	1052.3	7335.0	6
3	1011.2	7315.0	1800.0	7315.0	12
4	970.0	7295.0	1011.2	7315.0	12
5	970.0	7295.0	1800.0	7295.0	13
6	928.8	7275.0	970.0	7295.0	13
7	928.8	7275.0	1146.3	7275.0	7

8	1146.3	7275.0	1800.0	7273.4	8
9	867.7	7245.3	928.8	7275.0	7
10	1066.4	7235.1	1146.3	7275.0	8
11	867.7	7245.3	1066.4	7235.1	9
12	1066.4	7235.1	1560.4	7218.1	9
13	1560.4	7218.1	1800.0	7228.6	9
14	834.7	7229.3	867.7	7245.3	9
15	834.7	7229.3	845.9	7212.0	5
16	845.9	7212.0	908.6	7170.2	5
17	908.6	7170.2	1560.4	7183.2	10
18	1560.4	7183.2	1800.0	7183.2	10
19	775.1	7250.0	788.8	7250.0	4
20	788.8	7250.0	802.4	7229.0	4
21	908.6	7170.2	1092.6	7047.6	5
22	802.4	7229.0	986.6	7044.9	4
23	769.1	7250.0	903.8	7042.7	3
24	760.8	7250.0	873.3	7042.0	2
25	1726.9	7149.4	1800.0	7162.5	1
26	1571.0	7109.4	1726.9	7149.4	1
27	1329.6	7059.5	1571.0	7109.4	1
28	1220.1	7048.2	1329.6	7059.5	1
29	1092.6	7047.6	1220.1	7048.2	1
30	986.6	7044.9	1092.6	7047.6	1
31	903.8	7042.7	986.6	7044.9	1
32	873.3	7042.0	903.8	7042.7	1
33	865.6	7042.5	873.3	7042.0	1
34	680.7	7018.7	895.6	7042.5	1
35	223.8	6995.0	680.7	7018.7	1

ISOTROPIC Soil Parameters

----

13 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	1
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	115.0	115.0	400.0	.00	.000	.0	0
7	122.0	122.0	.0	21.00	.000	.0	1
8	122.0	122.0	710.0	.00	.000	.0	0
9	124.0	124.0	9000.0	.00	.000	.0	0
10	128.0	128.0	.0	7.40	.000	.0	1
11	115.0	115.0	230.0	.00	.000	.0	0
12	115.0	115.0	200.0	.00	.000	.0	0
13	115.0	115.0	250.0	.00	.000	.0	0

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 6 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	769.10	7250.00
2	775.10	7250.00
3	788.80	7250.00
4	880.00	7250.00
5	1052.30	7335.00
6	1800.00	7335.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 200.0 ft
and x = 450.0 ft

Each surface terminates between x = 1100.0 ft
and x = 1500.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

35.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 24 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	372.41	7069.31
2	405.52	7080.66
3	438.61	7092.08
4	471.67	7103.55
5	504.72	7115.07
6	537.75	7126.66
7	570.76	7138.30
8	603.74	7150.00
9	636.71	7161.75
10	669.66	7173.56
11	702.58	7185.43
12	735.49	7197.36
13	768.37	7209.34
14	801.24	7221.38
15	834.08	7233.47
16	866.91	7245.62
17	899.71	7257.83
18	932.49	7270.09
19	965.25	7282.41
20	997.99	7294.79
21	1030.70	7307.22
22	1063.40	7319.71
23	1096.07	7332.26
24	1120.20	7341.57

****   Simplified BISHOP FOS =   1.268   ****

The following is a summary of the TEN most critical surfaces

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.268	-6192.27	26260.63	20283.04	372.41	1120.20	2.887E+10

2.	1.269	-2928.44	18122.98	11521.35	450.00	1131.71	1.450E+10
3.	1.284	-7835.86	31901.52	26145.41	424.14	1128.62	3.323E+10
4.	1.291	-10299.62	39949.55	34558.80	432.76	1142.64	4.518E+10
5.	1.302	-2617.38	16756.65	10130.45	415.52	1121.49	1.420E+10
6.	1.317	-7980.63	30478.79	24858.63	346.55	1110.58	3.685E+10
7.	1.328	-12134.12	39726.95	34984.92	243.10	1102.49	6.195E+10
8.	1.351	-11636.91	40113.21	35167.48	303.45	1120.96	6.126E+10
9.	1.365	-10400.39	36085.44	30958.75	312.07	1102.15	4.861E+10
10.	1.369	-8961.22	32487.07	27089.31	277.59	1115.91	5.032E+10

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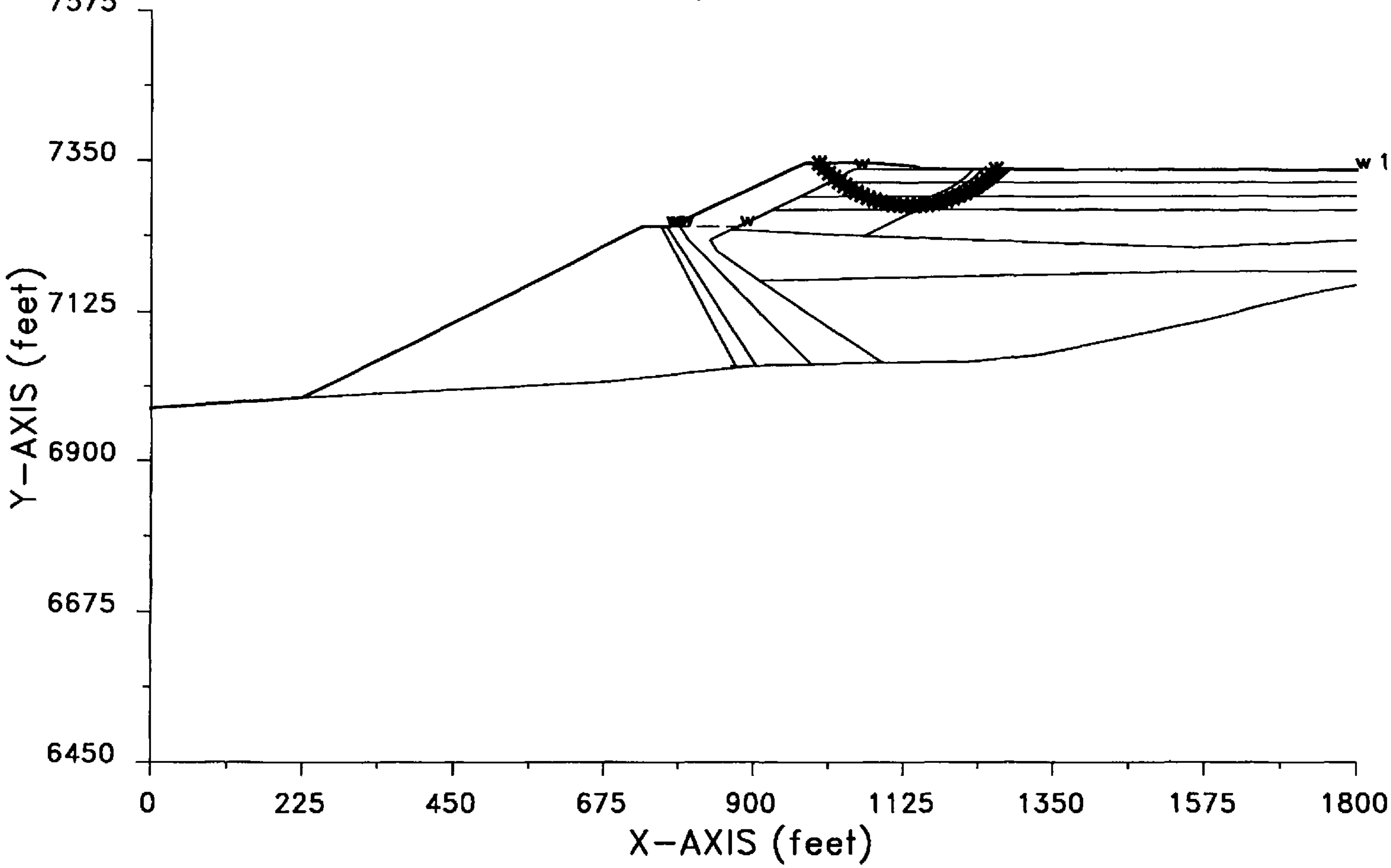
POST LIQUEFACTION STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 1.509



XSTABL File: MD_LC6   1-07-99   16:01

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*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*              using the                *
*           Method of Slices            *
*                                       *
*         Copyright (C) 1992 Ä 95       *
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*                                       *
*  Ver. 5.105                 95 Ä 1318 *
*****************************************
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Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

----

10 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	6979.0	223.8	6995.0	1
2	223.8	6995.0	733.8	7250.0	2
3	733.8	7250.0	760.8	7250.0	2
4	760.8	7250.0	769.1	7250.0	3
5	769.1	7250.0	775.1	7250.0	4
6	775.1	7250.0	978.8	7345.0	5
7	978.8	7345.0	1071.6	7345.0	5
8	1071.6	7345.0	1142.5	7340.0	5
9	1142.5	7340.0	1153.3	7335.0	5
10	1153.3	7335.0	1800.0	7333.4	6

35 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	1052.3	7335.0	1153.3	7335.0	6
2	1011.2	7315.0	1052.3	7335.0	6
3	1011.2	7315.0	1800.0	7315.0	12
4	970.0	7295.0	1011.2	7315.0	12
5	970.0	7295.0	1800.0	7295.0	13
6	928.8	7275.0	970.0	7295.0	13
7	928.8	7275.0	1146.3	7275.0	7

8	1146.3	7275.0	1800.0	7273.4	8
9	867.7	7245.3	928.8	7275.0	7
10	1066.4	7235.1	1146.3	7275.0	8
11	867.7	7245.3	1066.4	7235.1	9
12	1066.4	7235.1	1560.4	7218.1	9
13	1560.4	7218.1	1800.0	7228.6	9
14	834.7	7229.3	867.7	7245.3	9
15	834.7	7229.3	845.9	7212.0	5
16	845.9	7212.0	908.6	7170.2	5
17	908.6	7170.2	1560.4	7183.2	10
18	1560.4	7183.2	1800.0	7183.2	10
19	775.1	7250.0	788.8	7250.0	4
20	788.8	7250.0	802.4	7229.0	4
21	908.6	7170.2	1092.6	7047.6	5
22	802.4	7229.0	986.6	7044.9	4
23	769.1	7250.0	903.8	7042.7	3
24	760.8	7250.0	873.3	7042.0	2
25	1726.9	7149.4	1800.0	7162.5	1
26	1571.0	7109.4	1726.9	7149.4	1
27	1329.6	7059.5	1571.0	7109.4	1
28	1220.1	7048.2	1329.6	7059.5	1
29	1092.6	7047.6	1220.1	7048.2	1
30	986.6	7044.9	1092.6	7047.6	1
31	903.8	7042.7	986.6	7044.9	1
32	873.3	7042.0	903.8	7042.7	1
33	865.6	7042.5	873.3	7042.0	1
34	680.7	7018.7	895.6	7042.5	1
35	223.8	6995.0	680.7	7018.7	1

ISOTROPIC Soil Parameters

13 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	1
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	115.0	115.0	400.0	.00	.000	.0	0
7	122.0	122.0	.0	21.00	.000	.0	1
8	122.0	122.0	710.0	.00	.000	.0	0
9	124.0	124.0	9000.0	.00	.000	.0	0
10	128.0	128.0	.0	7.40	.000	.0	1
11	115.0	115.0	230.0	.00	.000	.0	0
12	115.0	115.0	200.0	.00	.000	.0	0
13	115.0	115.0	250.0	.00	.000	.0	0

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 6 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	769.10	7250.00
2	775.10	7250.00
3	788.80	7250.00
4	880.00	7250.00
5	1052.30	7335.00
6	1800.00	7335.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 1100.0 ft
and x = 1300.0 ft

Each surface terminates between x = 900.0 ft
and x = 1000.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

10.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 32 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	1265.52	7334.72
2	1258.35	7327.74
3	1250.81	7321.18
4	1242.92	7315.04
5	1234.69	7309.35
6	1226.16	7304.13
7	1217.36	7299.39
8	1208.30	7295.15
9	1199.02	7291.42
10	1189.55	7288.22
11	1179.91	7285.54
12	1170.14	7283.41
13	1160.27	7281.83
14	1150.32	7280.79
15	1140.34	7280.32
16	1130.34	7280.40
17	1120.36	7281.03
18	1110.43	7282.23
19	1100.58	7283.97
20	1090.85	7286.26
21	1081.25	7289.08
22	1071.84	7292.44
23	1062.62	7296.32
24	1053.63	7300.70
25	1044.90	7305.58
26	1036.46	7310.94
27	1028.32	7316.76
28	1020.53	7323.02
29	1013.09	7329.71
30	1006.04	7336.80
31	999.40	7344.27
32	998.82	7345.00

**** Simplified BISHOP FOS =   1.509 ****

```
**********************************************************************
**                                                                  **
**  Out of the    900 surfaces generated and analyzed by XSTABL,   **
**       575 surfaces were found to have MISLEADING FOS values.     **
**                                                                  **
**********************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.509	1136.72	7459.78	179.52	1265.52	998.82	1.783E+07
2.	1.517	1145.40	7472.33	196.92	1286.21	995.21	2.138E+07
3.	1.523	1138.53	7464.71	186.62	1272.41	995.35	1.956E+07
4.	1.545	1145.21	7477.19	200.47	1286.21	994.71	2.187E+07
5.	1.571	1119.29	7441.45	154.46	1231.03	998.78	1.393E+07
6.	1.582	1138.45	7474.80	198.68	1279.31	987.97	2.281E+07
7.	1.593	1125.36	7455.16	169.60	1244.83	996.35	1.635E+07
8.	1.659	1139.94	7488.60	207.64	1279.31	990.04	2.336E+07
9.	1.661	1148.77	7498.50	213.85	1286.21	999.74	2.223E+07
10.	1.676	1141.48	7494.01	215.25	1286.21	986.31	2.556E+07

* * * END OF FILE * * *

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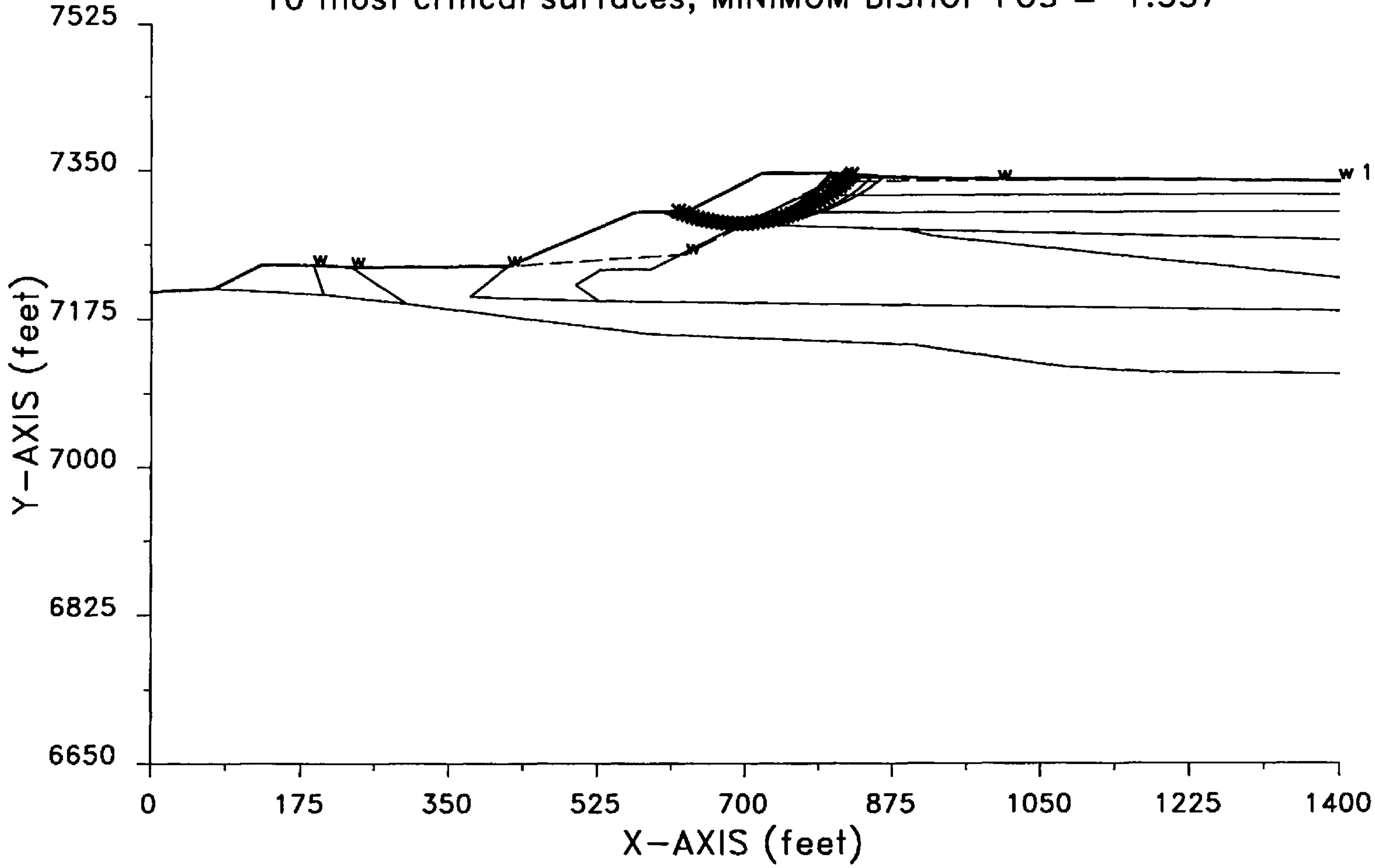
POST LIQUEFACTION STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 1.557



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*****************************************
*               X S T A B L             *
*                                       *
*        Slope Stability Analysis       *
*               using the               *
*            Method of Slices           *
*                                       *
*         Copyright (C) 1992 Ä 95       *
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*                                       *
* Ver. 5.105                  95 Ä 1318 *
*****************************************
```

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

14 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	7206.3	72.7	7210.0	1
2	72.7	7210.0	128.4	7237.9	2
3	128.4	7237.9	162.3	7238.4	2
4	162.3	7238.4	169.3	7238.4	3
5	169.3	7238.4	189.2	7237.6	4
6	189.2	7237.6	235.0	7235.2	5
7	235.0	7235.2	419.0	7236.0	11
8	419.0	7236.0	568.6	7299.0	5
9	568.6	7299.0	632.6	7300.8	5
10	632.6	7300.8	721.0	7345.0	5
11	721.0	7345.0	798.9	7345.0	5
12	798.9	7345.0	894.2	7339.0	5
13	894.2	7339.0	1009.9	7337.9	6
14	1009.9	7337.9	1400.0	7334.4	6

28 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	816.8	7339.0	894.2	7339.0	6
2	771.9	7319.0	816.8	7339.0	6
3	771.9	7319.0	1400.0	7319.0	12

4	727.0	7299.0	771.9	7319.0	12
5	727.0	7299.0	1400.0	7299.0	13
6	696.1	7285.2	727.0	7299.0	13
7	696.1	7285.2	888.2	7278.2	9
8	888.2	7278.2	1400.0	7265.9	8
9	888.2	7278.2	922.8	7271.1	9
10	922.8	7271.1	1400.0	7221.0	9
11	189.2	7237.6	201.4	7202.9	4
12	235.0	7235.2	299.4	7192.3	5
13	587.8	7232.0	696.1	7285.2	9
14	374.3	7200.0	419.0	7236.0	5
15	528.7	7232.0	587.8	7232.0	9
16	498.9	7214.1	528.7	7232.0	9
17	498.9	7214.1	526.0	7194.9	5
18	72.7	7210.0	162.3	7205.2	1
19	162.3	7205.2	169.3	7204.6	1
20	169.3	7204.6	201.4	7202.9	1
21	201.4	7202.9	299.4	7192.3	1
22	374.3	7200.0	526.0	7194.9	10
23	526.0	7194.9	1400.0	7182.7	10
24	299.4	7192.3	584.2	7156.1	1
25	584.2	7156.1	898.0	7142.9	1
26	898.0	7142.9	1076.2	7117.6	1
27	1076.2	7117.6	1179.5	7111.3	1
28	1179.5	7111.3	1400.0	7108.8	1

ISOTROPIC Soil Parameters

----

13 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	1
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	115.0	115.0	400.0	.00	.000	.0	0
7	122.0	122.0	.0	28.75	.000	.0	1
8	122.0	122.0	710.0	.00	.000	.0	0
9	124.0	124.0	7454.0	.00	.000	.0	0
10	128.0	128.0	.0	7.20	.000	.0	1
11	115.0	115.0	230.0	.00	.000	.0	0
12	115.0	115.0	200.0	.00	.000	.0	0
13	115.0	115.0	250.0	.00	.000	.0	0

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 7 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	189.20	7237.60
2	235.00	7235.20
3	419.00	7236.00
4	630.00	7250.00
5	800.00	7335.00
6	1000.00	7336.00
7	1400.00	7336.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 600.0 ft and x = 700.0 ft

Each surface terminates between x = 800.0 ft and x = 900.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

6.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 39 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	620.69	7300.46
2	626.25	7298.22
3	631.88	7296.15
4	637.58	7294.26
5	643.33	7292.56
6	649.14	7291.05
7	654.99	7289.73
8	660.89	7288.59
9	666.81	7287.65
10	672.76	7286.90
11	678.74	7286.35
12	684.73	7285.98
13	690.72	7285.82
14	696.72	7285.84
15	702.72	7286.06
16	708.71	7286.48
17	714.68	7287.08
18	720.62	7287.88
19	726.54	7288.88
20	732.42	7290.06
21	738.26	7291.44
22	744.05	7293.00
23	749.79	7294.75
24	755.47	7296.68
25	761.09	7298.80
26	766.63	7301.10
27	772.10	7303.57
28	777.48	7306.22
29	782.77	7309.05
30	787.97	7312.04
31	793.07	7315.21
32	798.06	7318.53
33	802.95	7322.02
34	807.72	7325.66
35	812.37	7329.45
36	816.89	7333.39
37	821.28	7337.48
38	825.54	7341.71
39	826.98	7343.23

****   Simplified BISHOP FOS =   1.557   ****

****

**   **

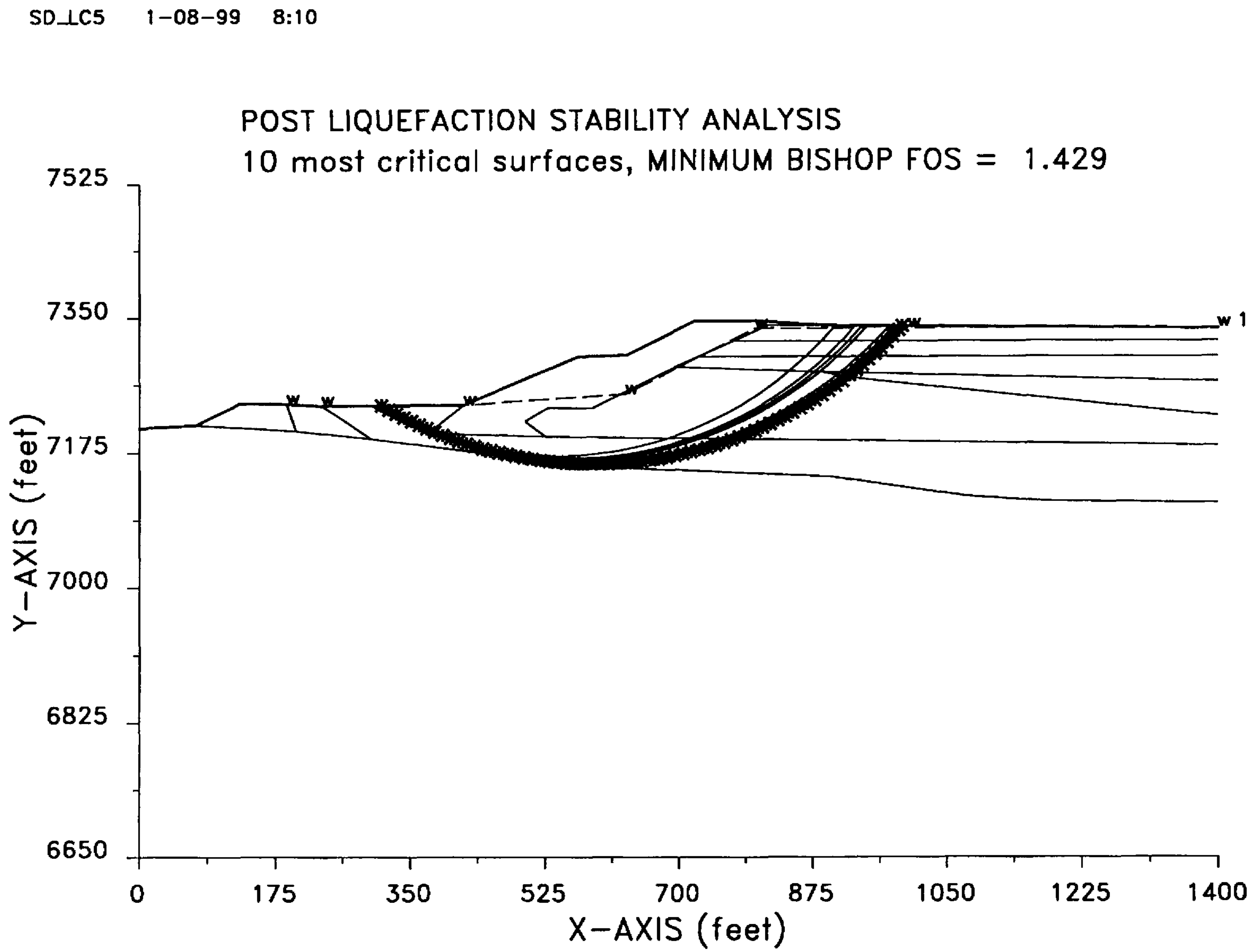
```
**  Out of the    900 surfaces generated and analyzed by XSTABL,   **
**       82 surfaces were found to have MISLEADING FOS values.     **
**                                                                 **
*******************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.557	692.98	7471.21	185.41	620.69	826.98	4.775E+07
2.	1.592	678.06	7496.80	211.83	600.00	824.25	6.083E+07
3.	1.604	690.20	7426.50	140.56	627.59	804.38	3.619E+07
4.	1.611	692.03	7511.27	225.04	613.79	840.75	6.031E+07
5.	1.677	697.41	7436.07	148.34	634.48	813.68	3.704E+07
6.	1.679	677.67	7443.29	158.17	610.34	801.23	4.633E+07
7.	1.682	676.84	7496.10	209.40	603.45	820.06	6.127E+07
8.	1.704	708.66	7537.84	251.88	624.14	866.08	6.494E+07
9.	1.707	713.68	7484.43	199.12	634.48	852.32	4.870E+07
10.	1.714	703.29	7465.38	177.52	634.48	831.99	4.426E+07

* * * END OF FILE * * *


SD_LC5 1-08-99 8:10
POST LIQUEFACTION STABILITY ANALYSIS
10 most critical surfaces, MINIMUM BISHOP FOS = 1.429
7525
7350
7175
7000
6825
6650
Y-AXIS (feet)
0
175
350
525
700
875
1050
1225
1400
X-AXIS (feet)
w 1

XSTABL File: SD_LC5   1-08-99   8:10

```
******************************************
*              X S T A B L               *
*                                        *
*        Slope Stability Analysis        *
*              using the                 *
*           Method of Slices             *
*                                        *
*         Copyright (C) 1992 Ä 95        *
*   Interactive Software Designs, Inc.   *
*        Moscow, ID 83843, U.S.A.        *
*                                        *
*           All Rights Reserved          *
*                                        *
*  Ver. 5.105                 95 Ä 1318  *
******************************************
```

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES
----

14 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	7206.3	72.7	7210.0	1
2	72.7	7210.0	128.4	7237.9	2
3	128.4	7237.9	162.3	7238.4	2
4	162.3	7238.4	169.3	7238.4	3
5	169.3	7238.4	189.2	7237.6	4
6	189.2	7237.6	235.0	7235.2	5
7	235.0	7235.2	419.0	7236.0	11
8	419.0	7236.0	568.6	7299.0	5
9	568.6	7299.0	632.6	7300.8	5
10	632.6	7300.8	721.0	7345.0	5
11	721.0	7345.0	798.9	7345.0	5
12	798.9	7345.0	894.2	7339.0	5
13	894.2	7339.0	1009.9	7337.9	6
14	1009.9	7337.9	1400.0	7334.4	6

28 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	816.8	7339.0	894.2	7339.0	6
2	771.9	7319.0	816.8	7339.0	6
3	771.9	7319.0	1400.0	7319.0	12

4	727.0	7299.0	771.9	7319.0	12
5	727.0	7299.0	1400.0	7299.0	13
6	696.1	7285.2	727.0	7299.0	13
7	696.1	7285.2	888.2	7278.2	9
8	888.2	7278.2	1400.0	7265.9	8
9	888.2	7278.2	922.8	7271.1	9
10	922.8	7271.1	1400.0	7221.0	9
11	189.2	7237.6	201.4	7202.9	4
12	235.0	7235.2	299.4	7192.3	5
13	587.8	7232.0	696.1	7285.2	9
14	374.3	7200.0	419.0	7236.0	5
15	528.7	7232.0	587.8	7232.0	9
16	498.9	7214.1	528.7	7232.0	9
17	498.9	7214.1	526.0	7194.9	5
18	72.7	7210.0	162.3	7205.2	1
19	162.3	7205.2	169.3	7204.6	1
20	169.3	7204.6	201.4	7202.9	1
21	201.4	7202.9	299.4	7192.3	1
22	374.3	7200.0	526.0	7194.9	10
23	526.0	7194.9	1400.0	7182.7	10
24	299.4	7192.3	584.2	7156.1	1
25	584.2	7156.1	898.0	7142.9	1
26	898.0	7142.9	1076.2	7117.6	1
27	1076.2	7117.6	1179.5	7111.3	1
28	1179.5	7111.3	1400.0	7108.8	1

ISOTROPIC Soil Parameters
----

13 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Unit Weight Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Pore Pressure Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	1
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	115.0	115.0	400.0	.00	.000	.0	0
7	122.0	122.0	.0	28.75	.000	.0	1
8	122.0	122.0	710.0	.00	.000	.0	0
9	124.0	124.0	7454.0	.00	.000	.0	0
10	128.0	128.0	.0	7.20	.000	.0	1
11	115.0	115.0	230.0	.00	.000	.0	0
12	115.0	115.0	200.0	.00	.000	.0	0
13	115.0	115.0	250.0	.00	.000	.0	0

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 7 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	189.20	7237.60
2	235.00	7235.20
3	419.00	7236.00
4	630.00	7250.00
5	800.00	7335.00
6	1000.00	7336.00
7	1400.00	7336.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 300.0 ft
and x = 425.0 ft

Each surface terminates between x = 900.0 ft
and x = 1000.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

11.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -30.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * *   SIMPLIFIED BISHOP METHOD   * * * * *

The most critical circular failure surface
is specified by 69 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	312.93	7235.54
2	322.46	7230.04
3	332.10	7224.74
4	341.84	7219.63
5	351.68	7214.72
6	361.62	7210.01
7	371.66	7205.50
8	381.78	7201.20
9	391.99	7197.10
10	402.27	7193.21
11	412.64	7189.52
12	423.08	7186.05
13	433.58	7182.79
14	444.15	7179.74
15	454.78	7176.90
16	465.46	7174.28
17	476.20	7171.88
18	486.98	7169.69
19	497.80	7167.73
20	508.66	7165.98
21	519.55	7164.45
22	530.48	7163.14
23	541.42	7162.06
24	552.39	7161.19
25	563.37	7160.55
26	574.36	7160.12
27	585.36	7159.92
28	596.36	7159.95
29	607.36	7160.19
30	618.35	7160.66
31	629.32	7161.35
32	640.29	7162.26
33	651.23	7163.39
34	662.15	7164.74
35	673.03	7166.31
36	683.89	7168.11
37	694.70	7170.12
38	705.47	7172.35
39	716.20	7174.79
40	726.87	7177.46
41	737.49	7180.33
42	748.04	7183.43
43	758.53	7186.73

44	768.96	7190.25
45	779.31	7193.97
46	789.58	7197.91
47	799.77	7202.05
48	809.88	7206.39
49	819.89	7210.94
50	829.81	7215.69
51	839.64	7220.64
52	849.36	7225.79
53	858.97	7231.13
54	868.48	7236.67
55	877.87	7242.39
56	887.14	7248.31
57	896.30	7254.41
58	905.32	7260.70
59	914.22	7267.16
60	922.99	7273.81
61	931.62	7280.63
62	940.11	7287.62
63	948.46	7294.79
64	956.66	7302.12
65	964.71	7309.61
66	972.61	7317.27
67	980.35	7325.08
68	987.93	7333.05
69	992.51	7338.07

**** Simplified BISHOP FOS = 1.429 ****

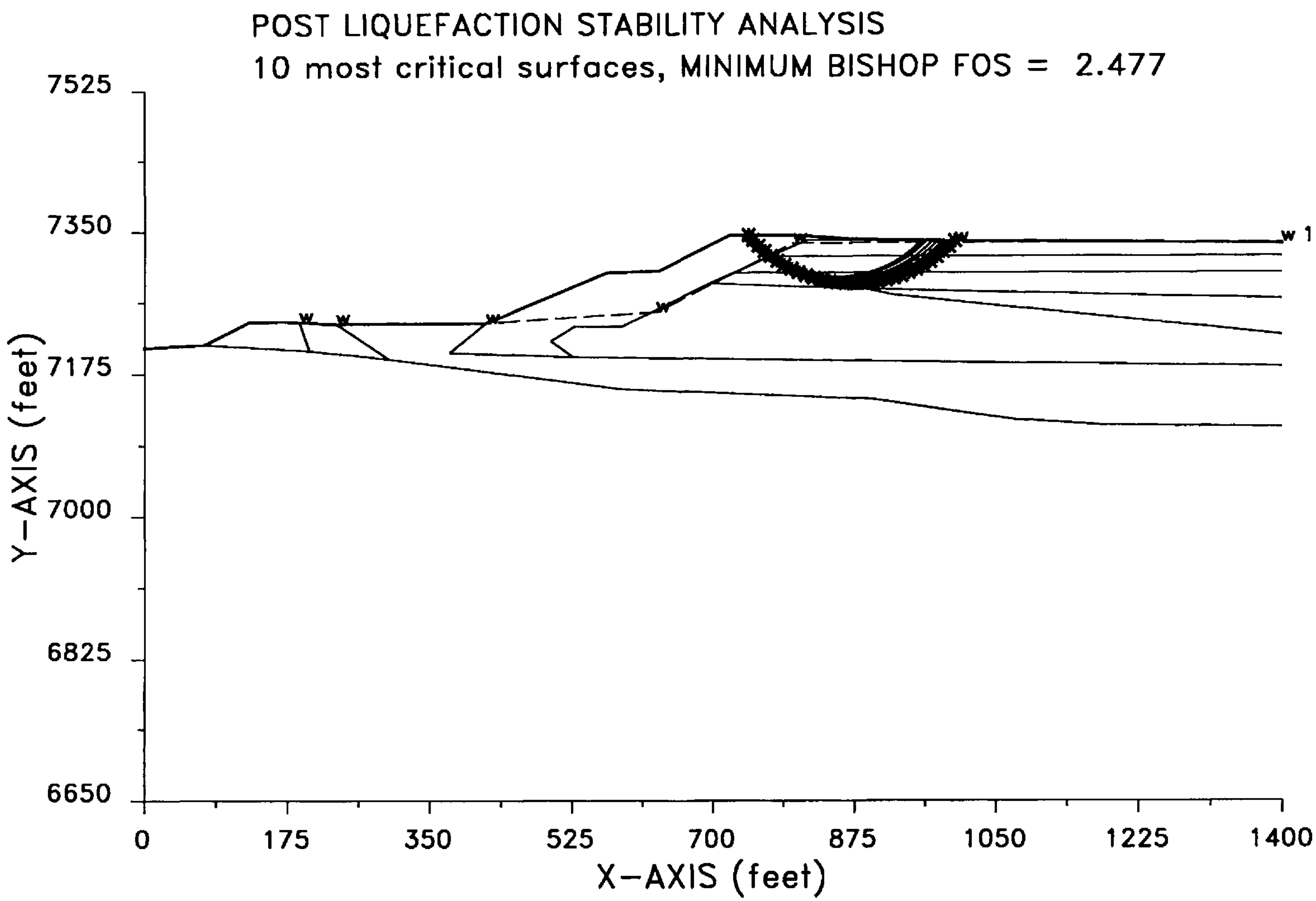
The following is a summary of the TEN most critical surfaces

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.429	589.55	7703.94	543.98	312.93	992.51	1.007E+09
2.	1.437	556.21	7660.86	494.36	304.31	931.52	8.856E+08
3.	1.437	563.50	7674.01	509.38	304.31	946.61	9.260E+08
4.	1.437	578.82	7696.51	534.34	308.62	975.84	9.861E+08
5.	1.437	584.80	7695.54	534.33	312.93	981.93	9.868E+08
6.	1.443	540.90	7646.13	476.10	300.00	904.84	8.334E+08
7.	1.446	591.63	7700.26	539.67	317.24	991.37	1.001E+09
8.	1.449	560.35	7672.95	506.87	304.31	940.41	9.194E+08
9.	1.451	565.66	7669.88	504.72	308.62	946.92	9.203E+08
10.	1.454	590.10	7716.70	555.28	312.93	996.01	1.037E+09

* * * END OF FILE * * *

SD_LC6   1-08-99   8:11



XSTABL File: SD_LC6   1-08-99   8:11

```
*****************************************
*              X S T A B L              *
*                                       *
*        Slope Stability Analysis       *
*              using the                *
*           Method of Slices            *
*                                       *
*        Copyright (C) 1992 Ä 95        *
*   Interactive Software Designs, Inc.  *
*        Moscow, ID 83843, U.S.A.       *
*                                       *
*          All Rights Reserved          *
*                                       *
*  Ver. 5.105                95 Ä 1318  *
*****************************************
```

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

SEGMENT BOUNDARY COORDINATES

14 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	.0	7206.3	72.7	7210.0	1
2	72.7	7210.0	128.4	7237.9	2
3	128.4	7237.9	162.3	7238.4	2
4	162.3	7238.4	169.3	7238.4	3
5	169.3	7238.4	189.2	7237.6	4
6	189.2	7237.6	235.0	7235.2	5
7	235.0	7235.2	419.0	7236.0	11
8	419.0	7236.0	568.6	7299.0	5
9	568.6	7299.0	632.6	7300.8	5
10	632.6	7300.8	721.0	7345.0	5
11	721.0	7345.0	798.9	7345.0	5
12	798.9	7345.0	894.2	7339.0	5
13	894.2	7339.0	1009.9	7337.9	6
14	1009.9	7337.9	1400.0	7334.4	6

28 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	816.8	7339.0	894.2	7339.0	6
2	771.9	7319.0	816.8	7339.0	6
3	771.9	7319.0	1400.0	7319.0	12

4	727.0	7299.0	771.9	7319.0	12
5	727.0	7299.0	1400.0	7299.0	13
6	696.1	7285.2	727.0	7299.0	13
7	696.1	7285.2	888.2	7278.2	9
8	888.2	7278.2	1400.0	7265.9	8
9	888.2	7278.2	922.8	7271.1	9
10	922.8	7271.1	1400.0	7221.0	9
11	189.2	7237.6	201.4	7202.9	4
12	235.0	7235.2	299.4	7192.3	5
13	587.8	7232.0	696.1	7285.2	9
14	374.3	7200.0	419.0	7236.0	5
15	528.7	7232.0	587.8	7232.0	9
16	498.9	7214.1	528.7	7232.0	9
17	498.9	7214.1	526.0	7194.9	5
18	72.7	7210.0	162.3	7205.2	1
19	162.3	7205.2	169.3	7204.6	1
20	169.3	7204.6	201.4	7202.9	1
21	201.4	7202.9	299.4	7192.3	1
22	374.3	7200.0	526.0	7194.9	10
23	526.0	7194.9	1400.0	7182.7	10
24	299.4	7192.3	584.2	7156.1	1
25	584.2	7156.1	898.0	7142.9	1
26	898.0	7142.9	1076.2	7117.6	1
27	1076.2	7117.6	1179.5	7111.3	1
28	1179.5	7111.3	1400.0	7108.8	1

ISOTROPIC Soil Parameters
----

13 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Constant (psf)	Water Surface No.
1	150.0	150.0	9000.0	35.00	.000	.0	1
2	125.0	125.0	.0	35.00	.000	.0	1
3	125.0	125.0	.0	35.00	.000	.0	1
4	118.0	123.0	288.0	30.00	.000	.0	1
5	130.0	135.0	.0	40.00	.000	.0	1
6	115.0	115.0	400.0	.00	.000	.0	0
7	122.0	122.0	.0	28.75	.000	.0	1
8	122.0	122.0	710.0	.00	.000	.0	0
9	124.0	124.0	7454.0	.00	.000	.0	0
10	128.0	128.0	.0	7.20	.000	.0	1
11	115.0	115.0	230.0	.00	.000	.0	0
12	115.0	115.0	200.0	.00	.000	.0	0
13	115.0	115.0	250.0	.00	.000	.0	0

1 Water surface(s) have been specified

Unit weight of water = 62.40 (pcf)

Water Surface No. 1 specified by 7 coordinate points

****
PHREATIC SURFACE,
****

Point No.	x-water (ft)	y-water (ft)
1	189.20	7237.60
2	235.00	7235.20
3	419.00	7236.00
4	630.00	7250.00
5	800.00	7335.00
6	1000.00	7336.00
7	1400.00	7336.00

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 900.0 ft
and x = 1000.0 ft

Each surface terminates between x = 635.0 ft
and x = 750.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

10.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 30 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	1000.00	7337.99
2	992.88	7330.98
3	985.36	7324.38
4	977.47	7318.23
5	969.24	7312.55
6	960.70	7307.36
7	951.87	7302.66
8	942.78	7298.49
9	933.47	7294.85
10	923.96	7291.75
11	914.29	7289.22
12	904.48	7287.24
13	894.58	7285.83
14	884.62	7285.00
15	874.62	7284.75
16	864.62	7285.08
17	854.67	7285.99
18	844.78	7287.47
19	834.99	7289.52
20	825.34	7292.13
21	815.85	7295.30
22	806.56	7299.01
23	797.51	7303.25
24	788.71	7308.01
25	780.21	7313.27
26	772.02	7319.01
27	764.18	7325.22
28	756.72	7331.87
29	749.65	7338.95
30	744.26	7345.00

**** Simplified BISHOP FOS = 2.477 ****

```
*********************************************************************
**                                                                 **
**  Out of the    900 surfaces generated and analyzed by XSTABL,  **
**       605 surfaces were found to have MISLEADING FOS values.    **
**                                                                 **
*********************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : POST LIQUEFACTION STABILITY ANALYSIS

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	2.477	875.31	7457.42	172.66	1000.00	744.26	1.828E+07
2.	2.511	872.19	7455.30	168.42	993.10	744.94	1.740E+07
3.	2.527	862.87	7440.78	150.04	972.41	747.51	1.427E+07
4.	2.529	868.75	7451.34	163.14	986.21	745.07	1.656E+07
5.	2.536	865.87	7446.71	156.99	979.31	746.37	1.542E+07
6.	2.558	872.07	7459.43	171.41	993.10	744.43	1.779E+07
7.	2.563	860.50	7438.47	145.11	965.52	749.61	1.317E+07
8.	2.588	855.99	7434.04	140.29	958.62	747.61	1.280E+07
9.	2.590	856.81	7436.62	144.00	962.07	745.90	1.358E+07
10.	2.595	865.36	7455.78	171.17	989.66	734.94	1.986E+07

* * * END OF FILE * * *

APPENDIX I

SOIL COVER STABILITY ANALYSES

Golder Associates	Subject Mercer Mine, Reservation Canyon	Made by MJG	Job No 993-2037
	Maximum and Minimum Lift	Checked by	Date 7/15/99
	Thickness of the Tailings Cover	Approved by	

OBJECTIVE:

- Estimate maximum recommended initial lift thickness for various tailings strength conditions and degrees of draindown through a limit equilibrium stability analysis.
- Estimate minimum equipment setback distances from the edge of the initial lift.
- Estimate maximum recommended lift height for subsequent lifts.
- Estimate minimum recommended initial lift thickness for the anticipated tailings strength conditions at the time they are covered. The ability of the initial lift to support construction equipment was evaluated with and without geosynthetic reinforcement.
- Define criteria in terms of tailings strength and depth to water to provide guidance as to when cover placement can occur.

METHOD:

- Maximum lift thickness evaluated using limit equilibrium, 2-dimensional stability analysis program (XSTABL). Total stress strength parameters were developed for the tailings and a total stress analysis was performed. An undrained shear strength was computed for the tailings as a function of the vertical effective stress, at midheight of the layer, prior to loading. The influence of negative pore pressures was included in the estimate of the vertical effective stress. A friction angle of 35-degrees was applied for the cover material. Using XSTABL (Sharma, 1995), four initial lift scenarios were considered. Lift thickness was varied between 3 and 10 feet and profile end slopes between 1.5H:1V and a 3H:1V. For each slope geometry, the shear strength is defined for the upper 5 feet that yields a factor of safety (FOS) equal to 1.5. All failures involved only the upper 5-feet of tailings. The depth to the static water level that is associated with that shear strength is also provided in Table I-2. The shear strength that yields a FOS equal to 1.5 is the estimated minimum shear strength necessary to place an initial lift of cover material over the tailings surface without generating a potentially unmanageable mudwave.

- Setback distances were defined using XSTABL line load feature. A uniform load, representative of a loaded haul truck, of 500 psf was applied to the initial lift and moved from the crest until a factor of safety of 1.5 was reached to determine the minimum equipment setback distance.

- Utilizing the three initial lift thickness' (3, 5, and 10 ft.), a maximum lift height was determined for a second lift placed on top of an initial lift of cover material. XSTABL was used to determine the overall stability of subsequent lifts of cover material on top of an initial lift. The water level was maintained at the tailings surface and tailings shear strengths were maintained at the levels applied in the initial lift thickness analyses.

- Estimate minimum recommended initial lift thickness for the anticipated tailings strength conditions at the time they are covered. The strength of the tailings at the time they are covered was estimated from the settlement modeling conducted by Prof. Znidarcic and CPT data. Prof. Znidarcic estimated that the tailings at the surface will reach a void ratio of approximately 1.0 after 2 years of desiccation. Results of CPT indicate that tailings slimes with void ratios of 1.0 have an undrained shear strength of approximately 200 psf. The ability of the initial lift to support construction equipment was evaluated with and without geosynthetic reinforcement. The minimum lift thickness to prevent equipment wheel loads from punching through the cover was estimated for haulage equipment. Four different pieces of haulage equipment were considered; two types of scrapers (CAT 657E and CAT 631E), and two types of articulated trucks (CAT

D400E and CAT D300E). Dozers are anticipated to be used to push the fill material within the equipment setback distance, and are not as likely to puncture the initial lift as the haulage equipment. Calculations are based on a method given by TENSAR (1987).

CALCULATIONS:

Output from the XSTABL stability analyses performed to determine maximum initial lift thickness, minimum equipment setback distance, and maximum subsequent lift height is provided in this Appendix.

The following equations were used to calculate the minimum lift thickness: From TENSAR, 1987.
Effective contact radius of haulage equipment tires:

$$R = \sqrt{P/p\pi}$$

Where;
P= wheel load, lbs
p= tire inflation pressure, psi

TABLE I-1. HAULAGE EQUIPMENT PROPERTIES

Equipment Type	Gross Machine Weight Loaded (lbs)	Tire Inflation Pressure (psi)	Wheel Load (lbs)
CAT 657E Scraper	271,270	80	69,174
CAT 631E Scraper	187,090	55	45,837
CAT D400E Articulated Truck	144,512	48	24,567
CAT D300E Articulated Truck	106,695	58	18,672

Bearing capacity of tailings:

Without geogrid:
$q_u=N_cS_u=3.1xS_u$ (slimes)
$q_u=N_cS_u=8xS_u$ (sands)

With geogrid:
$q_r=N_cS_u=6.2xS_u$ (slimes)
$q_r=N_cS_u=16xS_u$ (sands)

Where;
N_c=bearing capacity factor (based on TENSAR (1987), and NAVFAC (1971))
S_u=undrained shear strength of tailings (200 psf=1.39 psi for slimes; 299 psf=2.08 psi for sands)

Minimum lift thickness to prevent puncture:

Without geogrid:

$$z_u = \frac{R}{\sqrt{\frac{1}{1-q_u/p}-1}}$$

With geogrid:

$$z_u = \frac{R}{\sqrt{\frac{1}{1-q_r/p}-1}}$$

CONCLUSIONS/RESULTS:

Stability analyses show that an initial lift thickness of 3 ft. can be placed over the tailings surface when the depth to the static water table is 3.5 ft. (for an end slope of 1.5H:1V) and a minimum tailings strength of 117 psf. An initial lift thickness of 5 ft. can be placed when the static water level is at 6 ft. and a minimum tailings shear strength of 180 psf. However, a 10 ft. lift cannot be placed on the tailings surface without having significant deformation of the end slope. These recommendations are provided so that prior to fill placement the likelihood of successful placement can be assessed using probes that assess water depth or shear strength (i.e. tensiometers, penetrometers, torsional shear vanes). The results of these analyses are presented in Table I-2 and slope profiles are presented in Figure I-1.

TABLE I-2. MAXIMUM INITIAL LIFT THICKNESS, MINIMUM STRENGTH REQUIREMENTS, AND HAULAGE EQUIPMENT SETBACKS

Initial Lift Thickness (ft.)	End Profile Slope	Depth to Water Below Tailings Surface (ft.)	Minimum Tailings Shear Strength for Upper 5 ft. (psf)	Haulage Equipment Setback (ft.)
3	1.5H:1V	3.5	117	18.0
3	3H:1V	3.0	100	16.0
5	1.5H:1V	6.0	180	16.0
5	3H:1V	6.0	170	15.0
10	1.5H:1V	NA	NA	NA
10	3H:1V	NA	NA	NA

For a given initial lift thickness over tailings, the maximum secondary lift height is given in Table I-3 and shown in Figure I-2.

TABLE I-3. MAXIMUM LIFT THICKNESS FOR GIVEN INTIAL LIFT THICKNESS

Initial Lift Thickness (ft.)	Maximum Lift Thickness
3	5.0
5	13.0
10	23.0

It is expected that the largest piece of haulage equipment which will operate on the tailings surface is a CAT 631E scraper (or equivalent). Given this, the minimum lift thickness for this piece of equipment is estimated to be 3.2 ft. if a geogrid is used to reinforce the tailings surface. Other lift thickness' are presented in Table I-4.

TABLE I-4. MINIMUM LIFT THICKNESS TO PREVENT PUNCTURE

Equipment Type	Minimum Lift Thickness, Without Geogrid (ft.)	Minimum Lift Thickness, With Geogrid (ft.)
CAT 657E Scraper	7.1	5.5
CAT 631E Scraper	4.8	3.2
CAT D400E Articulated Truck	1.8	0.8
CAT D300E Articulated Truck	1.5	0.5

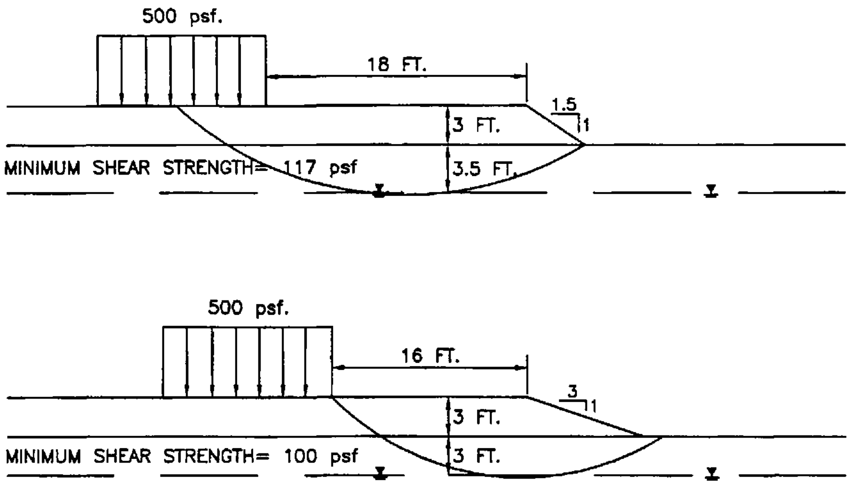
REFERENCES:

NAVFAC, 1971, DM-7 Design Manual; soil mechanics, foundations and earth structures," U.S. Government Printing Office.

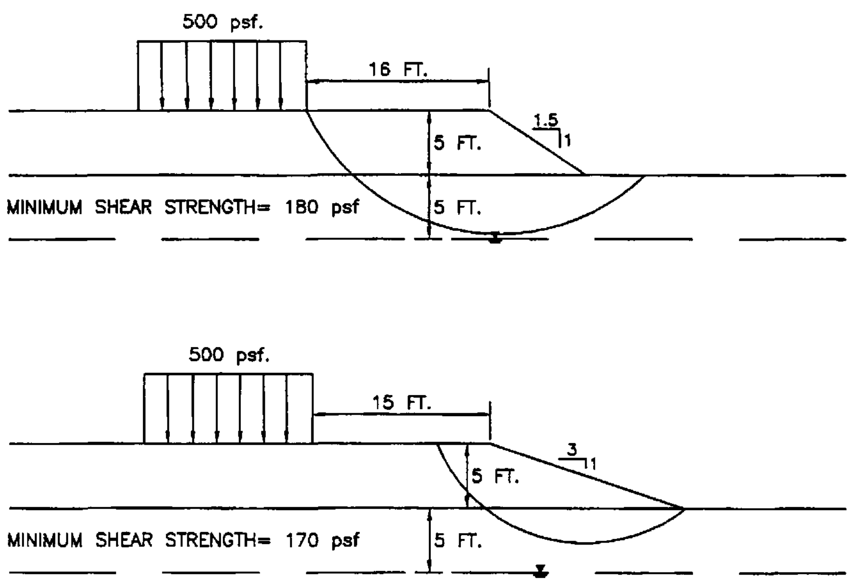
Sharma, S., 1995, XSTABL: An integrated slope stability analysis program. Version 5.105, Interactive Software Designs, Inc., p. 219.

TENSAR Environmental Systems Inc., 1987, TENSAR geogrid for subgrade improvement design guide and cost comparisons. The TENSAR Corporation, p. 6.

3 FT. MAXIMUM
LIFT THICKNESS



5 FT. MAXIMUM
LIFT THICKNESS

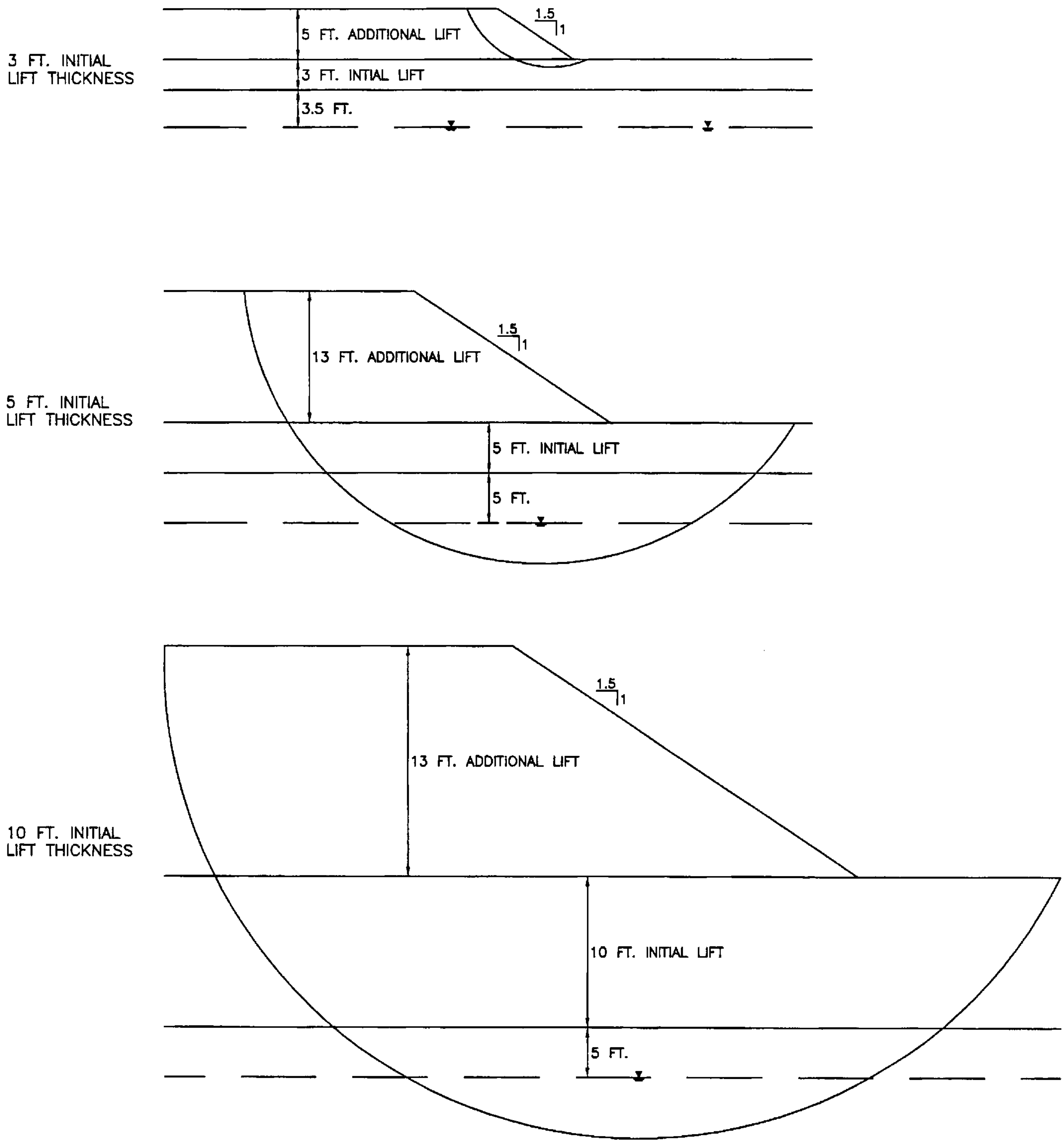


10 FT. MAXIMUM
LIFT THICKNESS

NA

Golder Associates Tucson, Arizona

CLIENT/PROJECT	TITLE		
BARRICK RESOURCES (USA) INC. RESERVATION CANYON TAILINGS	MAXIMUM LIFT THICKNESS AND EQUIPMENT SETBACKS		
	DRAWN MJG	DATE JULY 1999	JOB NO. 993–2037
	CHECKED MJG/CAN	SCALE N.T.S.	DWG NO./REV. NO.
	REVIEWED BRB	FILE NO. 2037T028	FIGURE NO. I–1



Golder Associates — Tucson, Arizona	TITLE	MAXIMUM LIFT THICKNESS FIR GIVEN INITIAL LIFT THICKNESS				
CLIENT/PROJECT: BARRICK RESOURCES (USA) INC. RESERVATION CANYON TAILINGS	DRAWN	MJG	DATE	JULY1999	JOB NO.	993-2037
	CHECKED	MJG/CAN	SCALE	N.T.S.	DWG NO./REV. NO.	
	REVIEWED	BRB	FILE NO.	2037T028	FIGURE NO.	I-2

XSTABL File: TS3_NCS1 7-15-99 9:11

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******************************************
*              X S T A B L               *
*                                        *
*        Slope Stability Analysis        *
*              using the                 *
*           Method of Slices             *
*                                        *
*         Copyright (C) 1992 Ä 95        *
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*        Moscow, ID 83843, U.S.A.        *
*                                        *
*          All Rights Reserved           *
*                                        *
*  Ver. 5.105                95 Ä 1318   *
******************************************
```

Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	400.0	7335.0	2
2	400.0	7335.0	404.3	7338.0	1
3	404.3	7338.0	500.0	7338.0	1

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	400.0	7335.0	500.0	7335.0	2
2	300.0	7331.5	500.0	7331.5	3
3	300.0	7330.0	500.0	7330.0	4
4	300.0	7325.0	500.0	7325.0	5
5	300.0	7320.0	500.0	7320.0	6

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit	Unit Weight Moist	Sat.	Cohesion Intercept	Friction Angle	Pore Pressure Parameter	Constant	Water Surface

No.	(pcf)	(pcf)	(psf)	(deg)	Ru	(psf)	No.
1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	117.2	.00	.000	.0	0
3	112.0	115.0	165.6	.00	.000	.0	0
4	112.0	115.0	216.1	.00	.000	.0	0
5	112.0	115.0	317.0	.00	.000	.0	0
6	112.0	115.0	418.0	.00	.000	.0	0

BOUNDARY LOADS

----

1 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	420.0	433.0	500.0	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 375.0 ft
and x = 399.0 ft

Each surface terminates between x = 404.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined

```
within the angular range defined by :

          Lower angular limit :=   -45.0 degrees
          Upper angular limit :=  (slope angle - 5.0) degrees


*************************************************************
**     Factor of safety calculation for surface #   169    **
**     failed to converge within FIFTY iterations          **
**                                                         **
**    The last calculated value of the FOS was  36.8819    **
**    This will be ignored for final summary of results    **
*************************************************************

Circular surface (FOS= 36.8819) is defined by: xcenter =    389.79
ycenter =   7352.44    Init. Pt. =    379.14   Seg. Length =   1.00
--------------------------------------------------------------------

************************************************************************
    --  WARNING  --  WARNING  --  WARNING  --  WARNING  --  (# 48)
************************************************************************
Negative effective stresses were calculated at the base of a slice.
This warning is usually reported for cases where slices have low self
weight and a relatively high "c" shear strength parameter.  In such
cases, this effect can only be eliminated by reducing the "c" value.
************************************************************************

    ------------------------------------------------------------
    USER SELECTED option to maintain strength greater than zero
    ------------------------------------------------------------


    Factors of safety have been calculated by the :

    * * * * *   SIMPLIFIED BISHOP METHOD   * * * * *


      The most critical circular failure surface
      is specified by 48 coordinate points
```

Point No.	x-surf (ft)	y-surf (ft)
1	391.55	7335.00
2	392.26	7334.29
3	392.99	7333.61
4	393.75	7332.96
5	394.53	7332.34
6	395.34	7331.74
7	396.16	7331.18
8	397.01	7330.65
9	397.88	7330.15

10	398.76	7329.68
11	399.66	7329.25
12	400.58	7328.85
13	401.51	7328.48
14	402.45	7328.15
15	403.41	7327.86
16	404.37	7327.60
17	405.35	7327.38
18	406.33	7327.19
19	407.32	7327.05
20	408.32	7326.93
21	409.31	7326.86
22	410.31	7326.82
23	411.31	7326.82
24	412.31	7326.86
25	413.31	7326.94
26	414.30	7327.05
27	415.29	7327.20
28	416.27	7327.39
29	417.25	7327.61
30	418.21	7327.87
31	419.17	7328.17
32	420.11	7328.50
33	421.04	7328.86
34	421.96	7329.26
35	422.86	7329.70
36	423.74	7330.17
37	424.61	7330.67
38	425.45	7331.20
39	426.28	7331.77
40	427.08	7332.36
41	427.87	7332.98
42	428.62	7333.64
43	429.35	7334.32
44	430.06	7335.03
45	430.74	7335.76
46	431.39	7336.52
47	432.01	7337.30
48	432.53	7338.00

**** Simplified BISHOP FOS = 1.508 ****

```
*********************************************************************
**                                                                 **
**  Out of the    900 surfaces generated and analyzed by XSTABL,   **
**         1 surfaces were found to have MISLEADING FOS values.    **
**                                                                 **
*********************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.508	410.87	7353.62	26.84	391.55	432.53	2.451E+05
2.	1.525	410.65	7354.93	27.60	391.55	432.69	2.492E+05
3.	1.533	408.32	7357.00	30.93	386.59	432.98	3.214E+05
4.	1.541	413.36	7351.99	24.51	395.69	433.22	2.011E+05
5.	1.548	410.62	7356.88	29.57	390.72	433.40	2.713E+05
6.	1.549	410.01	7357.25	29.99	389.90	433.29	2.813E+05
7.	1.561	410.66	7357.09	30.89	389.07	434.60	2.966E+05
8.	1.563	410.61	7350.98	23.02	394.03	429.76	1.801E+05
9.	1.566	413.02	7353.58	25.40	395.69	433.41	2.028E+05
10.	1.568	410.64	7357.00	31.40	388.24	435.38	3.078E+05

* * * END OF FILE * * *

XSTABL File: TS3_NCS2 7-15-99 9:16

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****************************************
*              X S T A B L             *
*                                      *
*       Slope Stability Analysis       *
*             using the                *
*          Method of Slices            *
*                                      *
*        Copyright (C) 1992 Ä 95       *
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*       Moscow, ID 83843, U.S.A.       *
*                                      *
*         All Rights Reserved          *
*                                      *
* Ver. 5.105                95 Ä 1318  *
****************************************
```

Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	400.0	7335.0	2
2	400.0	7335.0	409.0	7338.0	1
3	409.0	7338.0	500.0	7338.0	1

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	400.0	7335.0	500.0	7335.0	2
2	300.0	7331.0	500.0	7331.0	3
3	300.0	7330.0	500.0	7330.0	4
4	300.0	7325.0	500.0	7325.0	5
5	300.0	7320.0	500.0	7320.0	6

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit	Unit Weight Moist	Sat.	Cohesion Intercept	Friction Angle	Pore Pressure Parameter	Constant	Water Surface

No.	(pcf)	(pcf)	(psf)	(deg)	Ru	(psf)	No.
1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	100.4	.00	.000	.0	0
3	112.0	115.0	149.2	.00	.000	.0	0
4	112.0	115.0	199.6	.00	.000	.0	0
5	112.0	115.0	300.6	.00	.000	.0	0
6	112.0	115.0	401.6	.00	.000	.0	0

BOUNDARY LOADS
----

1 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	427.0	440.0	500.0	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 375.0 ft
and x = 399.0 ft

Each surface terminates between x = 404.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined

```
     within the angular range defined by :

             Lower angular limit :=   -45.0 degrees
             Upper angular limit :=  (slope angle - 5.0) degrees



   ************************************************************
   **      Factor of safety calculation for surface #    94    **
   **      failed to converge within FIFTY iterations          **
   **                                                          **
   **     The last calculated value of the FOS was  30.0057    **
   **     This will be ignored for final summary of results    **
   ************************************************************


Circular surface (FOS= 30.0057) is defined by: xcenter =    389.79
ycenter =   7360.33   Init. Pt. =    377.48   Seg. Length =   1.00
------------------------------------------------------------------


   ************************************************************
   **      Factor of safety calculation for surface #   287    **
   **      failed to converge within FIFTY iterations          **
   **                                                          **
   **     The last calculated value of the FOS was 109.4305    **
   **     This will be ignored for final summary of results    **
   ************************************************************


Circular surface (FOS=109.4305) is defined by: xcenter =    391.40
ycenter =   7367.39   Init. Pt. =    382.45   Seg. Length =   1.00
------------------------------------------------------------------


   ************************************************************
   **      Factor of safety calculation for surface #   546    **
   **      failed to converge within FIFTY iterations          **
   **                                                          **
   **     The last calculated value of the FOS was  32.7678    **
   **     This will be ignored for final summary of results    **
   ************************************************************


Circular surface (FOS= 32.7678) is defined by: xcenter =    395.42
ycenter =   7352.53   Init. Pt. =    389.90   Seg. Length =   1.00
------------------------------------------------------------------


   Factors of safety have been calculated by the :

   * * * * *   SIMPLIFIED BISHOP METHOD   * * * * *



     The most critical circular failure surface
```

is specified by 56 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	390.72	7335.00
2	391.43	7334.29
3	392.16	7333.61
4	392.91	7332.95
5	393.69	7332.32
6	394.48	7331.70
7	395.29	7331.12
8	396.12	7330.56
9	396.96	7330.02
10	397.82	7329.52
11	398.70	7329.04
12	399.59	7328.59
13	400.50	7328.16
14	401.42	7327.77
15	402.35	7327.41
16	403.29	7327.07
17	404.25	7326.76
18	405.21	7326.49
19	406.18	7326.24
20	407.15	7326.03
21	408.14	7325.85
22	409.12	7325.69
23	410.12	7325.57
24	411.11	7325.48
25	412.11	7325.43
26	413.11	7325.40
27	414.11	7325.40
28	415.11	7325.44
29	416.11	7325.51
30	417.10	7325.61
31	418.09	7325.74
32	419.08	7325.90
33	420.06	7326.09
34	421.04	7326.32
35	422.00	7326.57
36	422.96	7326.86
37	423.91	7327.17
38	424.85	7327.52
39	425.78	7327.89
40	426.69	7328.29
41	427.59	7328.73
42	428.48	7329.19
43	429.36	7329.67
44	430.21	7330.19
45	431.05	7330.73
46	431.88	7331.30
47	432.68	7331.89
48	433.47	7332.51
49	434.23	7333.16
50	434.98	7333.82
51	435.70	7334.51
52	436.40	7335.23
53	437.08	7335.96

54	437.73	7336.72
55	438.36	7337.49
56	438.75	7338.00

**** Simplified BISHOP FOS = 1.528 ****

```
*********************************************************************
**                                                                 **
**  Out of the    900 surfaces generated and analyzed by XSTABL,   **
**        3 surfaces were found to have MISLEADING FOS values.     **
**                                                                 **
*********************************************************************
```

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.528	413.43	7357.08	31.68	390.72	438.75	3.152E+05
2.	1.530	416.44	7355.39	29.09	395.69	439.69	2.620E+05
3.	1.548	413.57	7361.52	35.55	389.90	439.92	3.604E+05
4.	1.563	415.87	7356.67	29.61	395.69	439.12	2.582E+05
5.	1.568	417.74	7355.08	28.62	397.34	440.65	2.467E+05
6.	1.583	411.54	7364.84	39.43	385.76	440.20	4.340E+05
7.	1.591	413.58	7363.99	37.44	389.90	440.51	3.717E+05
8.	1.602	411.32	7364.36	38.39	386.59	439.42	4.095E+05
9.	1.602	412.11	7359.28	32.91	389.90	437.56	3.179E+05
10.	1.611	413.37	7362.54	35.14	391.55	439.05	3.285E+05

* * * END OF FILE * * *

XSTABL File: TS5_NCS1   7-15-99   9:31

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******************************************
*              X S T A B L               *
*                                        *
*        Slope Stability Analysis        *
*               using the                *
*           Method of Slices             *
*                                        *
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******************************************
```

Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	400.0	7335.0	2
2	400.0	7335.0	407.1	7340.0	1
3	407.1	7340.0	500.0	7340.0	1

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	400.0	7335.0	500.0	7335.0	2
2	300.0	7330.0	500.0	7330.0	3
3	300.0	7329.0	500.0	7329.0	4
4	300.0	7325.0	500.0	7325.0	5
5	300.0	7320.0	500.0	7320.0	6

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit	Unit Weight Moist	Sat.	Cohesion Intercept	Friction Angle	Pore Pressure Parameter	Constant	Water Surface

No.	(pcf)	(pcf)	(psf)	(deg)	Ru	(psf)	No.
1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	179.3	.00	.000	.0	0
3	112.0	115.0	248.4	.00	.000	.0	0
4	112.0	115.0	310.3	.00	.000	.0	0
5	112.0	115.0	409.4	.00	.000	.0	0
6	112.0	115.0	510.4	.00	.000	.0	0

BOUNDARY LOADS

----

1 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	423.0	436.0	500.0	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 375.0 ft
and x = 398.0 ft

Each surface terminates between x = 411.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined

within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 43 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	395.62	7335.00
2	396.42	7334.40
3	397.24	7333.83
4	398.09	7333.30
5	398.95	7332.79
6	399.83	7332.32
7	400.73	7331.88
8	401.65	7331.48
9	402.58	7331.12
10	403.52	7330.79
11	404.48	7330.49
12	405.44	7330.23
13	406.42	7330.01
14	407.40	7329.83
15	408.39	7329.68
16	409.39	7329.58
17	410.38	7329.51
18	411.38	7329.48
19	412.38	7329.48
20	413.38	7329.53
21	414.38	7329.61
22	415.37	7329.73
23	416.36	7329.89
24	417.34	7330.09
25	418.31	7330.32
26	419.27	7330.59
27	420.23	7330.90
28	421.17	7331.24
29	422.09	7331.62
30	423.00	7332.04
31	423.89	7332.49
32	424.77	7332.97
33	425.63	7333.48
34	426.46	7334.03
35	427.28	7334.61
36	428.07	7335.22
37	428.84	7335.86

38	429.58	7336.53
39	430.30	7337.23
40	430.99	7337.95
41	431.65	7338.70
42	432.28	7339.48
43	432.68	7340.00

**** Simplified BISHOP FOS = 1.530 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.530	411.55	7355.42	25.90	395.62	432.68	2.520E+05
2.	1.535	410.02	7358.04	28.98	392.45	432.57	3.084E+05
3.	1.544	410.56	7352.53	22.53	396.41	429.11	1.828E+05
4.	1.550	413.80	7353.10	24.03	398.00	433.89	2.317E+05
5.	1.564	410.39	7356.67	26.22	395.62	430.67	2.288E+05
6.	1.575	412.37	7359.37	28.70	397.21	433.55	2.607E+05
7.	1.576	403.58	7341.53	9.70	396.41	413.12	3.506E+04
8.	1.576	403.72	7342.61	11.11	395.62	414.55	4.482E+04
9.	1.577	403.54	7343.87	13.00	394.03	415.91	6.001E+04
10.	1.584	403.91	7343.78	12.64	394.83	415.88	5.604E+04

* * * END OF FILE * * *

XSTABL File: TS5_NCS2   7-15-99   9:34

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*****************************************
*              X S T A B L              *
*                                       *
*       Slope Stability Analysis        *
*              using the                *
*           Method of Slices            *
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*****************************************
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Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	400.0	7335.0	2
2	400.0	7335.0	415.0	7340.0	1
3	415.0	7340.0	500.0	7340.0	1

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	400.0	7335.0	500.0	7335.0	2
2	300.0	7330.0	500.0	7330.0	3
3	300.0	7329.0	500.0	7329.0	4
4	300.0	7325.0	500.0	7325.0	5
5	300.0	7320.0	500.0	7320.0	6

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit	Unit Weight Moist	Sat.	Cohesion Intercept	Friction Angle	Pore Pressure Parameter	Constant	Water Surface

No.	(pcf)	(pcf)	(psf)	(deg)	Ru	(psf)	No.
1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	167.4	.00	.000	.0	0
3	112.0	115.0	215.0	.00	.000	.0	0
4	112.0	115.0	265.4	.00	.000	.0	0
5	112.0	115.0	366.4	.00	.000	.0	0
6	112.0	115.0	467.4	.00	.000	.0	0

BOUNDARY LOADS

----

1 load(s) specified

Load No.	x-left (ft)	x-right (ft)	Intensity (psf)	Direction (deg)
1	430.0	443.0	500.0	.0

NOTE - Intensity is specified as a uniformly distributed force acting on a HORIZONTALLY projected surface.

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 375.0 ft
and x = 398.0 ft

Each surface terminates between x = 411.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined

within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface
is specified by 60 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	390.86	7335.00
2	391.59	7334.32
3	392.34	7333.65
4	393.11	7333.02
5	393.90	7332.40
6	394.70	7331.81
7	395.53	7331.24
8	396.37	7330.70
9	397.22	7330.18
10	398.09	7329.69
11	398.98	7329.22
12	399.88	7328.78
13	400.79	7328.37
14	401.71	7327.98
15	402.64	7327.62
16	403.59	7327.29
17	404.54	7326.99
18	405.50	7326.72
19	406.47	7326.47
20	407.45	7326.26
21	408.43	7326.07
22	409.42	7325.91
23	410.41	7325.78
24	411.40	7325.69
25	412.40	7325.62
26	413.40	7325.58
27	414.40	7325.57
28	415.40	7325.59
29	416.40	7325.64
30	417.40	7325.72
31	418.39	7325.83
32	419.38	7325.96
33	420.37	7326.13
34	421.35	7326.33
35	422.32	7326.56
36	423.29	7326.81
37	424.25	7327.09

38	425.20	7327.41
39	426.14	7327.75
40	427.07	7328.11
41	427.99	7328.51
42	428.89	7328.93
43	429.79	7329.38
44	430.67	7329.86
45	431.53	7330.36
46	432.38	7330.88
47	433.21	7331.44
48	434.03	7332.01
49	434.83	7332.61
50	435.61	7333.24
51	436.38	7333.88
52	437.12	7334.55
53	437.84	7335.25
54	438.54	7335.96
55	439.22	7336.69
56	439.88	7337.44
57	440.52	7338.22
58	441.13	7339.01
59	441.72	7339.81
60	441.85	7340.00

**** Simplified BISHOP FOS = 1.535 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.535	414.10	7359.07	33.46	390.86	441.85	4.796E+05
2.	1.542	415.69	7356.88	30.79	394.03	441.38	4.090E+05
3.	1.547	417.39	7355.49	29.32	396.41	441.98	3.761E+05
4.	1.547	413.71	7361.80	36.27	389.28	442.32	5.376E+05
5.	1.554	414.61	7363.44	38.09	389.28	443.90	5.685E+05
6.	1.559	417.81	7357.66	32.28	394.83	445.01	4.355E+05
7.	1.564	412.89	7359.23	33.84	389.28	440.50	4.890E+05
8.	1.565	413.17	7356.59	31.05	390.86	439.74	4.308E+05
9.	1.568	418.57	7356.71	31.02	396.41	444.45	4.049E+05
10.	1.568	415.27	7357.52	30.96	394.03	440.57	4.004E+05

* * * END OF FILE * * *

XSTABL File: TS3_NCS3   7-27-99   12:36

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****************************************
*               X S T A B L            *
*                                      *
*        Slope Stability Analysis      *
*               using the              *
*            Method of Slices          *
*                                      *
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****************************************
```

Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7338.0	400.0	7338.0	1
2	400.0	7338.0	404.5	7343.0	1
3	404.5	7343.0	500.0	7343.0	1

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	500.0	7335.0	2
2	300.0	7331.5	500.0	7331.5	3
3	300.0	7330.0	500.0	7330.0	4
4	300.0	7325.0	500.0	7325.0	5
5	300.0	7320.0	500.0	7320.0	6

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit	Unit Weight Moist	Sat.	Cohesion Intercept	Friction Angle	Pore Pressure Parameter	Constant	Water Surface

No.	(pcf)	(pcf)	(psf)	(deg)	Ru	(psf)	No.
1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	117.2	.00	.000	.0	0
3	112.0	115.0	165.6	.00	.000	.0	0
4	112.0	115.0	216.1	.00	.000	.0	0
5	112.0	115.0	317.0	.00	.000	.0	0
6	112.0	115.0	418.0	.00	.000	.0	0

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 375.0 ft
and x = 399.0 ft

Each surface terminates between x = 404.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

1.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 13 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	396.52	7338.00
2	397.50	7337.84
3	398.50	7337.80
4	399.50	7337.88
5	400.48	7338.08
6	401.43	7338.40
7	402.33	7338.84
8	403.17	7339.38
9	403.93	7340.02
10	404.62	7340.75
11	405.21	7341.56
12	405.69	7342.43
13	405.92	7343.00

**** Simplified BISHOP FOS = 1.038 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.038	398.34	7346.12	8.32	396.52	405.92	5.796E+03
2.	1.125	398.33	7343.52	5.81	396.52	404.03	1.938E+03
3.	1.127	400.13	7343.30	5.42	399.00	405.51	4.599E+03
4.	1.343	399.99	7344.03	6.58	397.34	406.46	9.106E+03
5.	1.355	397.09	7351.15	13.50	394.03	407.85	1.622E+04
6.	1.358	400.27	7345.21	7.52	398.17	407.41	1.116E+04
7.	1.516	400.75	7345.95	8.14	399.00	408.46	1.453E+04
8.	1.579	404.41	7352.99	21.45	389.07	423.26	1.454E+05
9.	1.581	400.70	7353.95	22.43	384.93	420.13	1.554E+05
10.	1.595	404.28	7353.17	21.48	389.07	423.39	1.465E+05

* * * END OF FILE * * *

XSTABL File: TS5_NCS3   7-27-99   12:40

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*  Ver. 5.105                  95 Ä 1318 *
******************************************
```

Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7340.0	400.0	7340.0	1
2	400.0	7340.0	419.5	7353.0	1
3	419.5	7353.0	500.0	7353.0	1

5 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	500.0	7335.0	2
2	300.0	7330.0	500.0	7330.0	3
3	300.0	7329.0	500.0	7329.0	4
4	300.0	7325.0	500.0	7325.0	5
5	300.0	7320.0	500.0	7320.0	6

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit	Unit Weight Moist	Unit Weight Sat.	Cohesion Intercept	Friction Angle	Pore Pressure Parameter	Pore Pressure Constant	Water Surface

No.	(pcf)	(pcf)	(psf)	(deg)	Ru	(psf)	No.
1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	179.3	.00	.000	.0	0
3	112.0	115.0	248.4	.00	.000	.0	0
4	112.0	115.0	310.3	.00	.000	.0	0
5	112.0	115.0	409.4	.00	.000	.0	0
6	112.0	115.0	510.4	.00	.000	.0	0

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 375.0 ft
and x = 398.0 ft

Each surface terminates between x = 420.0 ft
and x = 450.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

2.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 35 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	384.52	7340.00
2	385.95	7338.60
3	387.46	7337.29
4	389.05	7336.08
5	390.71	7334.97
6	392.44	7333.96
7	394.23	7333.07
8	396.07	7332.28
9	397.95	7331.61
10	399.87	7331.05
11	401.83	7330.62
12	403.80	7330.30
13	405.79	7330.11
14	407.79	7330.04
15	409.79	7330.10
16	411.78	7330.27
17	413.76	7330.57
18	415.71	7330.99
19	417.64	7331.54
20	419.53	7332.19
21	421.37	7332.97
22	423.17	7333.85
23	424.90	7334.85
24	426.57	7335.95
25	428.17	7337.15
26	429.70	7338.44
27	431.14	7339.83
28	432.49	7341.30
29	433.75	7342.86
30	434.91	7344.49
31	435.97	7346.18
32	436.92	7347.94
33	437.76	7349.76
34	438.49	7351.62
35	438.93	7353.00

**** Simplified BISHOP FOS = 1.180 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.180	407.93	7362.52	32.49	384.52	438.93	7.171E+05
2.	1.187	410.31	7361.48	31.19	387.69	440.30	6.769E+05
3.	1.194	411.91	7362.84	33.29	387.69	443.78	7.676E+05

4.	1.200	411.52	7364.30	34.59	386.90	444.12	8.086E+05
5.	1.201	412.87	7364.09	34.85	387.69	445.81	8.271E+05
6.	1.203	408.70	7365.22	35.50	383.72	442.16	8.442E+05
7.	1.205	409.82	7366.00	36.28	384.52	443.80	8.721E+05
8.	1.205	410.02	7365.26	36.47	383.72	444.29	9.108E+05
9.	1.206	406.46	7364.78	34.72	382.14	439.02	7.965E+05
10.	1.208	411.55	7361.38	30.88	389.28	441.19	6.689E+05

* * * END OF FILE * * *

XSTABL File: TS10_CS3   7-27-99   12:44

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****************************************
*              X S T A B L             *
*                                      *
*        Slope Stability Analysis      *
*               using the              *
*            Method of Slices          *
*                                      *
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*         Moscow, ID 83843, U.S.A.     *
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*                                      *
*  Ver. 5.105                95 Ä 1318 *
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Problem Description : Tailings Surface Construction

SEGMENT BOUNDARY COORDINATES

3 SURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7345.0	400.0	7345.0	1
2	400.0	7345.0	434.5	7368.0	1
3	434.5	7368.0	600.0	7368.0	1

4 SUBSURFACE boundary segments

Segment No.	x-left (ft)	y-left (ft)	x-right (ft)	y-right (ft)	Soil Unit Below Segment
1	300.0	7335.0	600.0	7335.0	2
2	300.0	7330.0	600.0	7330.0	3
3	300.0	7325.0	600.0	7325.0	4
4	300.0	7320.0	600.0	7320.0	5

ISOTROPIC Soil Parameters

6 Soil unit(s) specified

Soil Unit No.	Unit Weight Moist (pcf)	Sat. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Parameter Ru	Constant (psf)	Water Surface No.

1	125.0	125.0	.0	35.00	.000	.0	0
2	112.0	115.0	179.3	.00	.000	.0	0
3	112.0	115.0	248.4	.00	.000	.0	0
4	112.0	115.0	310.3	.00	.000	.0	0
5	112.0	115.0	409.4	.00	.000	.0	0
6	112.0	115.0	510.4	.00	.000	.0	0

A critical failure surface searching method, using a random technique for generating CIRCULAR surfaces has been specified.

900 trial surfaces will be generated and analyzed.

30 Surfaces initiate from each of 30 points equally spaced along the ground surface between x = 350.0 ft
and x = 398.0 ft

Each surface terminates between x = 435.0 ft
and x = 550.0 ft

Unless further limitations were imposed, the minimum elevation at which a surface extends is y = .0 ft

* * * * * DEFAULT SEGMENT LENGTH SELECTED BY XSTABL * * * * *

3.0 ft line segments define each trial failure surface.

ANGULAR RESTRICTIONS :

The first segment of each failure surface will be inclined within the angular range defined by :

Lower angular limit := -45.0 degrees
Upper angular limit := (slope angle - 5.0) degrees

Factors of safety have been calculated by the :

* * * * * SIMPLIFIED BISHOP METHOD * * * * *

The most critical circular failure surface is specified by 53 coordinate points

Point No.	x-surf (ft)	y-surf (ft)
1	356.62	7345.00
2	358.74	7342.88
3	360.95	7340.84
4	363.22	7338.89
5	365.57	7337.03
6	367.99	7335.25
7	370.47	7333.57
8	373.02	7331.98
9	375.62	7330.49
10	378.28	7329.09
11	380.99	7327.80
12	383.74	7326.61
13	386.54	7325.53
14	389.38	7324.55
15	392.25	7323.68
16	395.15	7322.92
17	398.08	7322.27
18	401.03	7321.73
19	404.00	7321.30
20	406.98	7320.98
21	409.97	7320.78
22	412.97	7320.69
23	415.97	7320.71
24	418.97	7320.84
25	421.96	7321.09
26	424.94	7321.45
27	427.90	7321.92
28	430.84	7322.51
29	433.76	7323.20
30	436.65	7324.01
31	439.51	7324.92
32	442.33	7325.94
33	445.11	7327.06
34	447.85	7328.29
35	450.54	7329.62
36	453.18	7331.05
37	455.76	7332.58
38	458.28	7334.21
39	460.74	7335.92
40	463.13	7337.74
41	465.45	7339.64
42	467.70	7341.62
43	469.87	7343.69
44	471.96	7345.84
45	473.97	7348.07
46	475.90	7350.37
47	477.74	7352.74
48	479.48	7355.18
49	481.13	7357.68
50	482.69	7360.25
51	484.15	7362.87
52	485.51	7365.54
53	486.65	7368.00

**** Simplified BISHOP FOS = 1.055 ****

The following is a summary of the TEN most critical surfaces

Problem Description : Tailings Surface Construction

	FOS (BISHOP)	Circle Center x-coord (ft)	Circle Center y-coord (ft)	Radius (ft)	Initial x-coord (ft)	Terminal x-coord (ft)	Resisting Moment (ft-lb)
1.	1.055	413.88	7400.27	79.58	356.62	486.65	6.462E+06
2.	1.055	418.11	7399.46	78.49	361.59	490.04	6.324E+06
3.	1.057	419.49	7402.00	81.25	361.59	493.27	6.656E+06
4.	1.058	421.76	7404.91	84.91	361.59	498.43	7.161E+06
5.	1.067	422.87	7412.49	96.92	353.31	509.30	9.341E+06
6.	1.067	423.69	7415.39	100.72	351.66	512.79	9.963E+06
7.	1.068	420.02	7410.37	93.40	353.31	503.70	8.720E+06
8.	1.068	415.14	7407.52	87.93	353.31	493.60	7.639E+06
9.	1.068	415.64	7409.64	92.12	350.00	497.85	8.470E+06
10.	1.068	427.23	7418.46	105.39	351.66	519.32	1.077E+07

* * * END OF FILE * * *

APPENDIX J

SURFACE HYDROLOGIC ANALYSIS

Golder Associates	Subject Barrick Mercur	Made by TJW	Job No 993-2037
	Reservation Canyon Tailings	Checked by MJG	Date 7/29/99
	Surface Water Hydrology	Approved by BRB	Sheet No 1 of 2

OBJECTIVE:
Determine design storm runoff rates for sizing of storm-water diversion channels, spillway, and auxillary spillway.
Design channel and spillway to contain peak design flows.

METHOD:
Storm runoff was computed using SCS curve number method.
Channel sizing was accomplished using FlowMaster, software program that solves surface water hydraulics using manning's equation.
Spillway sizing based on Bureau of Reclamation method for nappe shaped crest profile (Bureau of Reclamation, 1987)

ASSUMPTIONS:

Runoff curve numbers from JBR (1997) based on soil and vegetative baseline studies are:

81	for disturbed ground
60	for undisturbed ground

A Type II rainfall distribution was applied.

Design precipitation events from Miller, J.F., et.al. (1973) are:

2-yr, 24-hr event	1.8 inches
10-yr, 24-hr event	2.6 inches
50-yr, 24-hr event	3.4 inches
100-yr, 24-hr event	3.8 inches

Channel and Spillway sizing based on the 100-yr, 24-hr storm event.

Maximum spillway outflow assumes that reservoir is full at the time of the peak flow.

Subbasin areas are shown on Figure 11-1

CALCULATIONS:

Runoff calculations were performed using a hydrologic modeling program StormSHED (Boss International, 1995). StormSHED output is included with this Appendix.

Depth and velocity of channel flow was determined using a hydraulic modeling program FlowMaster (Haestad, 1997). FlowMaster output is included with this Appendix.

Auxiliary Spillway sizing is based on the equation:

$$Q = C \cdot L \cdot H^{3/2}$$

where:
C=coefficient=3.08
L=width of spillway
H=total head
(USBR, 1987)

CONCLUSIONS/RESULTS:

The peak runoff that must be conveyed by the Northern Channel resulting from the 100-yr, 24-hr storm event runoff from A&B basin is 179 cfs. A low flow channel, capable of conveying more frequent storm events (i.e. 2-yr, 24-hr of 12.4 cfs) will be provided. A channel alignment was developed that provides ease of construction and maximizes storm water interception. The Northern Channel consists of four channel reaches (A1 thru A4). Northern Channel reach A1 maintains a slope of 2.89 percent for approximately 250 feet. Channel section A1 has an trapezoidal cross-section with a minimum 10 foot bottom width and 2H:1V side slopes. Reach A2 also has a trapezoidal channel and is anticipated to be excavated in highly durable limestone with a minimum bottom width and 1H:1V side slopes at a grade of 2.89% for 300 feet. Channel reach A3 will have the same cross-sectional and grade characteristics as reach A1 for a distance of 750 feet. Reach A4 maintains a slope of 0.5 percent for approximately 1290 feet with an irregular cross-section consisting of a 1.5 foot deep triangular "low flow" ditch and a 10 foot wide, 3.8 foot deep "overflow channel" for extreme storm events.

Runoff from sub-basin C will flow into the reclaimed East Bay. Minor regrading may be necessary to promote drainage into the reclaimed East Bay. Where principle tributaries enter the east side of the East Bay, riprap erosion protection will be provided. The approximate limits of riprap are shown on Drawing No. 5. The riprapped channels should have a minimum cross-sectional area of 22 sq. ft. and will consist of schedule "B" riprap with a minimum depth of riprap equal to the maximum riprap size

i.e.:

Schedule B Riprap

PERCENT PASSING				
0%-5%	5%-15%	30%-50%	70%-85%	90%-100%
4"	8"	12"	18"	24"

The Main Spillway is sized to convey, at a minimum, the combined peak runoff from basin A&B and from the Tailings Pond Basin (see Figure 11-1) (179+84=263 cfs). The Main Spillway has been designed with 40 foot bottom width and 2.25H:1V interbench side slopes and a 1 percent slope. This results in a peak flow depth of 1.24 ft.

An Auxiliary Spillway will be provided for the unlikely potential situation of the main Spillway becoming blocked and a prolonged period of net stormwater accumulation occurs. The Auxiliary Spillway will be located in the berm that separates the tailings impoundment from the East Bay. The Auxiliary Spillway is sized to pass the combined peak runoff from basin A&B and the Tailings Pond Basin (263 cfs) without failure. The minimum crest elevation of the existing crest is 7344.5 ft amsl. The tailings surface elevation at the beach is 7339 ft amsl. To maintain a minimum 3 ft cover over tailings, the minimum spillway inlet invert elevation is 7342 ft amsl.. Therefore the maximum possible spillway depth is 2.5 feet. Providing 0.5 feet for freeboard or a maximum flow depth of 2 ft:

$$Q = C \cdot L \cdot H^{3/2}$$

$$263 = 3.08 \cdot L \cdot 2.0^{3/2}$$
$$L = 30.$$

Provide an Auxillary Spillway i.e. a low section in the embankment that is protected from erosion. Use a trapezoidal cross-section with 3H:1V sideslopes and 30 foot bottom width. A detail of the Auxillary Spillway is shown on Drawing No.10, detail 9. Riprap spillway and slope into the East Bay with Schedule B riprap.

REFERENCES:

Boss International, 1995, Boss StormSHED, Madison, WI.

Bureau of Reclamation, 1987, Design of Small Dams, U.S. Dept. Interior, U.S. Govt. Printing Office..

Haestad, 1996, FlowMaster for Windors, Haestad Methods International, Waterbury, CT.

JBR, 1997, JBR Environmental Consultants, Inc., Conceptual Plan for Regrading, Surface Water Hydrology and Storm-Water Routing, prepared for Barrick Mercur Mine.

Miller, J.F., et.al., 1973, Precipitation-Frequency Atlas of the United States, NOAA Atlas 2, National Oceanic and Atmospheric Administration, National Weather Service, Silver Spring, ND.

```
Mercur Mine
North Channel
======================================================================
                          BASIN SUMMARY

BASIN ID: 100yr         NAME: North Basin A+B
SCS METHODOLOGY
TOTAL AREA.......: 475.60 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:      TYPE2                      PERV          IMP
PRECIPITATION....:   3.80 inches    AREA..:  415.60 Acres   60.00 Acres
TIME INTERVAL....:      6.00 min    CN....:   60.00          81.00
                                    TC....:   49.63 min    65.72 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1300 p2yr: 1.50 s:0.5000
TcReach - Shallow L:1500.00 ks:11.00 s:0.5300
TcReach - Channel L:4500.00 kc:15.00 s:0.2780
PEAK RATE: 179.25 cfs  VOL:  32.19 Ac-ft  TIME:    756 min

BASIN ID: 10yr          NAME: North Basin A&B
SCS METHODOLOGY
TOTAL AREA.......: 475.60 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:      TYPE2                      PERV          IMP
PRECIPITATION....:   2.60 inches    AREA..:  415.60 Acres   60.00 Acres
TIME INTERVAL....:      6.00 min    CN....:   60.00          81.00
                                    TC....:   49.63 min    65.72 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1300 p2yr: 1.50 s:0.3670
TcReach - Shallow L: 450.00 ks:11.00 s:0.5560
TcReach - Channel L: 800.00 kc:15.00 s:0.3440
PEAK RATE:  48.51 cfs  VOL:  11.83 Ac-ft  TIME:    762 min

BASIN ID: 2yr           NAME: North Basin A+B
SCS METHODOLOGY
TOTAL AREA.......: 475.60 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:      TYPE2                      PERV          IMP
PRECIPITATION....:   1.80 inches    AREA..:  415.60 Acres   60.00 Acres
TIME INTERVAL....:      6.00 min    CN....:   60.00          81.00
                                    TC....:   49.63 min    65.72 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1300 p2yr: 1.50 s:0.5000
TcReach - Shallow L:1500.00 ks:11.00 s:0.5300
TcReach - Channel L:4500.00 kc:15.00 s:0.2780
PEAK RATE:  12.42 cfs  VOL:   3.39 Ac-ft  TIME:    762 min
```

Mercur Mine
North Channel

===

BASIN SUMMARY

```
BASIN ID: 50yr          NAME: North Basin A+B
SCS METHODOLOGY
TOTAL AREA.......: 475.60 Acres     BASEFLOWS:   0.00 cfs
RAINFALL TYPE....:     TYPE2                     PERV          IMP
PRECIPITATION....:   3.40 inches    AREA..:  415.60 Acres   60.00 Acres
TIME INTERVAL....:      6.00 min    CN....:   60.00          81.00
                                    TC....:   49.63 min    65.72 min
ABSTRACTION COEFF:   0.20
TcReach - Sheet   L: 300.00 ns:0.1300 p2yr: 1.50 s:0.5000
TcReach - Shallow L:1500.00 ks:11.00 s:0.5300
TcReach - Channel L:4500.00 kc:15.00 s:0.2780
PEAK RATE: 126.65 cfs  VOL:  24.57 Ac-ft  TIME:    756 min
```

Main Spillway
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	Main Spillway
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

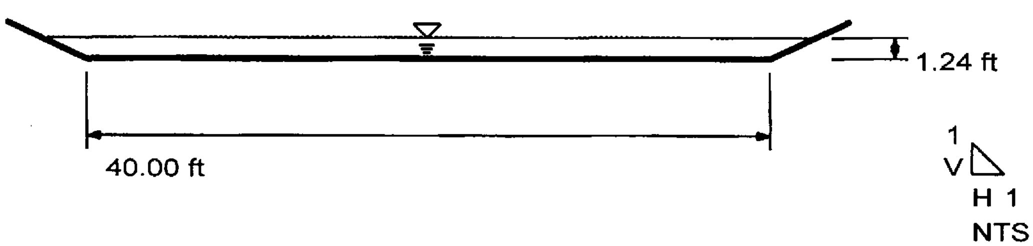
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.010000	ft/ft
Left Side Slope	2.250000	H : V
Right Side Slope	2.250000	H : V
Bottom Width	40.00	ft
Discharge	263.00	cfs

Results		
Depth	1.24	ft
Flow Area	53.14	ft^2
Wetted Perimeter	46.11	ft
Top Width	45.59	ft
Critical Depth	1.08	ft
Critical Slope	0.015968	ft/ft
Velocity	4.95	ft/s
Velocity Head	0.38	ft
Specific Energy	1.62	ft
Froude Number	0.81	
Flow is subcritical.		

Cross Section
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	Main Spillway
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.010000	ft/ft
Depth	1.24	ft
Left Side Slope	2.250000	H : V
Right Side Slope	2.250000	H : V
Bottom Width	40.00	ft
Discharge	263.00	cfs



Channel Reach A1
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

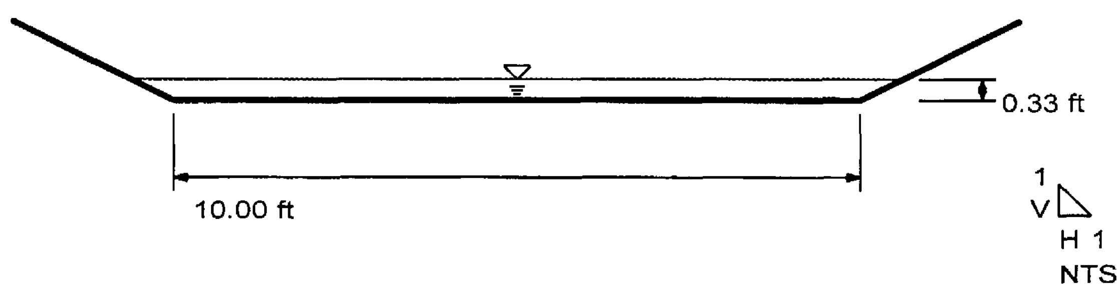
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	12.40	cfs

Results		
Depth	0.33	ft
Flow Area	3.55	ft²
Wetted Perimeter	11.49	ft
Top Width	11.33	ft
Critical Depth	0.35	ft
Critical Slope	0.023362	ft/ft
Velocity	3.50	ft/s
Velocity Head	0.19	ft
Specific Energy	0.52	ft
Froude Number	1.10	
Flow is supercritical.		

Channel Reach A1
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Depth	0.33	ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	12.40	cfs



Channel Reach A1
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

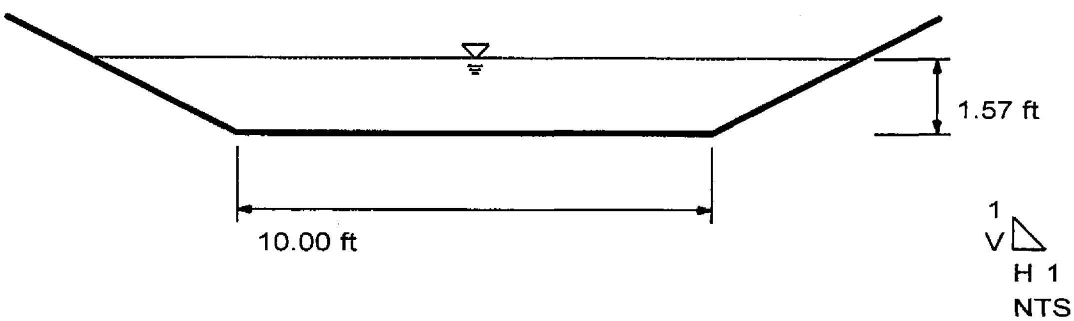
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	179.00	cfs

Results		
Depth	1.57	ft
Flow Area	20.59	ft^2
Wetted Perimeter	17.01	ft
Top Width	16.27	ft
Critical Depth	1.88	ft
Critical Slope	0.014877	ft/ft
Velocity	8.69	ft/s
Velocity Head	1.17	ft
Specific Energy	2.74	ft
Froude Number	1.36	
Flow is supercritical.		

Channel Reach A1
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A1
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Depth	1.57	ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	179.00	cfs



Channel Reach A2
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

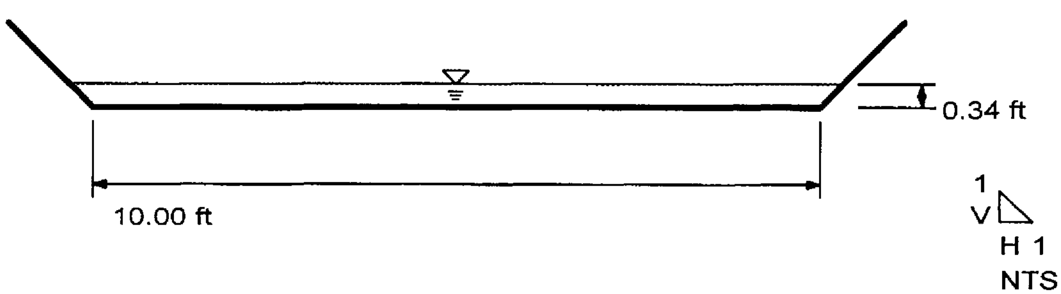
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	10.00	ft
Discharge	12.40	cfs

Results		
Depth	0.34	ft
Flow Area	3.48	ft²
Wetted Perimeter	10.95	ft
Top Width	10.67	ft
Critical Depth	0.36	ft
Critical Slope	0.023432	ft/ft
Velocity	3.56	ft/s
Velocity Head	0.20	ft
Specific Energy	0.53	ft
Froude Number	1.10	
Flow is supercritical.		

Channel Reach A2
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Depth	0.34	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	10.00	ft
Discharge	12.40	cfs



Channel Reach A2
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

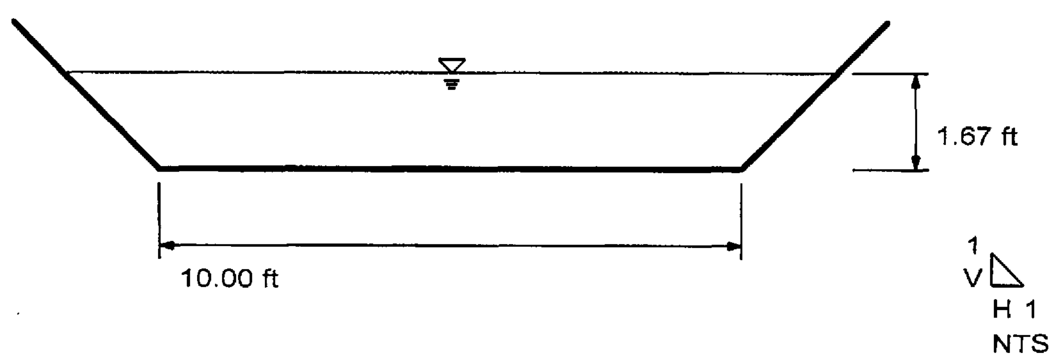
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	10.00	ft
Discharge	179.00	cfs

Results		
Depth	1.67	ft
Flow Area	19.43	ft²
Wetted Perimeter	14.71	ft
Top Width	13.33	ft
Critical Depth	2.01	ft
Critical Slope	0.015384	ft/ft
Velocity	9.21	ft/s
Velocity Head	1.32	ft
Specific Energy	2.98	ft
Froude Number	1.35	
Flow is supercritical.		

Channel Reach A2
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A2
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Depth	1.67	ft
Left Side Slope	1.000000	H : V
Right Side Slope	1.000000	H : V
Bottom Width	10.00	ft
Discharge	179.00	cfs



Channel Reach A3
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A3
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

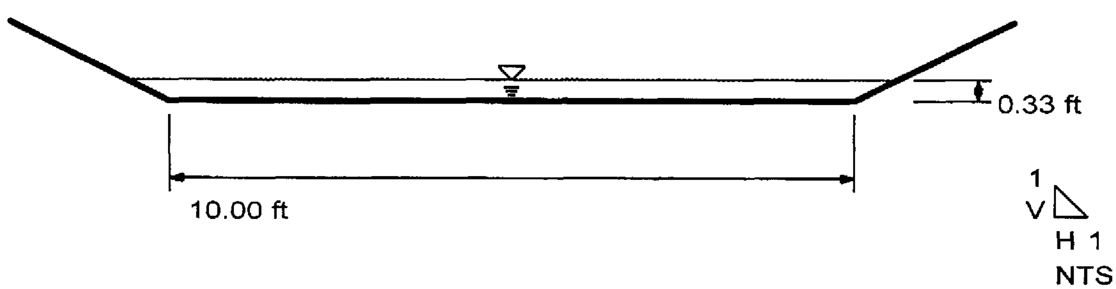
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	12.40	cfs

Results		
Depth	0.33	ft
Flow Area	3.55	ft^2
Wetted Perimeter	11.49	ft
Top Width	11.33	ft
Critical Depth	0.35	ft
Critical Slope	0.023362	ft/ft
Velocity	3.50	ft/s
Velocity Head	0.19	ft
Specific Energy	0.52	ft
Froude Number	1.10	
Flow is supercritical.		

Channel Reach A3
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A3
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Depth	0.33	ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	12.40	cfs



Channel Reach A3
Worksheet for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A3
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

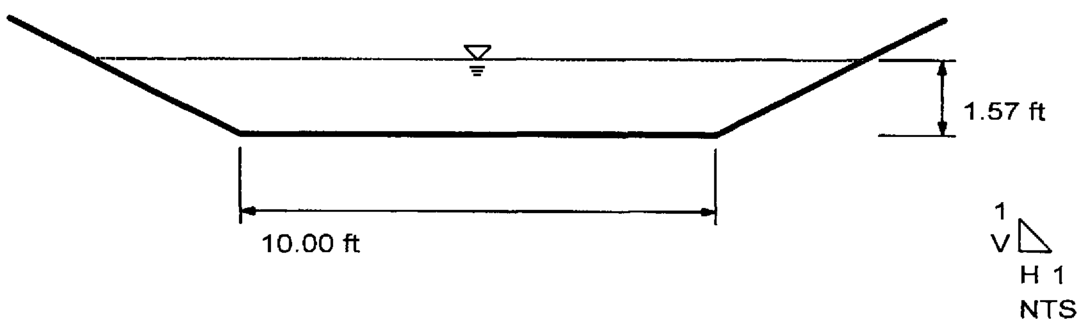
Input Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	179.00	cfs

Results		
Depth	1.57	ft
Flow Area	20.59	ft^2
Wetted Perimeter	17.01	ft
Top Width	16.27	ft
Critical Depth	1.88	ft
Critical Slope	0.014877	ft/ft
Velocity	8.69	ft/s
Velocity Head	1.17	ft
Specific Energy	2.74	ft
Froude Number	1.36	
Flow is supercritical.		

Channel Reach A3
Cross Section for Trapezoidal Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	2.89% slope channel reach A3
Flow Element	Trapezoidal Channel
Method	Manning's Formula
Solve For	Channel Depth

Section Data		
Mannings Coefficient	0.033	
Channel Slope	0.028900	ft/ft
Depth	1.57	ft
Left Side Slope	2.000000	H : V
Right Side Slope	2.000000	H : V
Bottom Width	10.00	ft
Discharge	179.00	cfs



Channel Reach A4
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	0.5% slope channel north of tailings
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Input Data

Channel Slope 0.005000 ft/ft

Elevation range: 0.00 ft to 5.30 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	5.30	0.00	14.00	0.045
6.00	2.30	14.00	29.10	0.033
14.00	1.50			
18.50	0.00			
29.10	5.30			

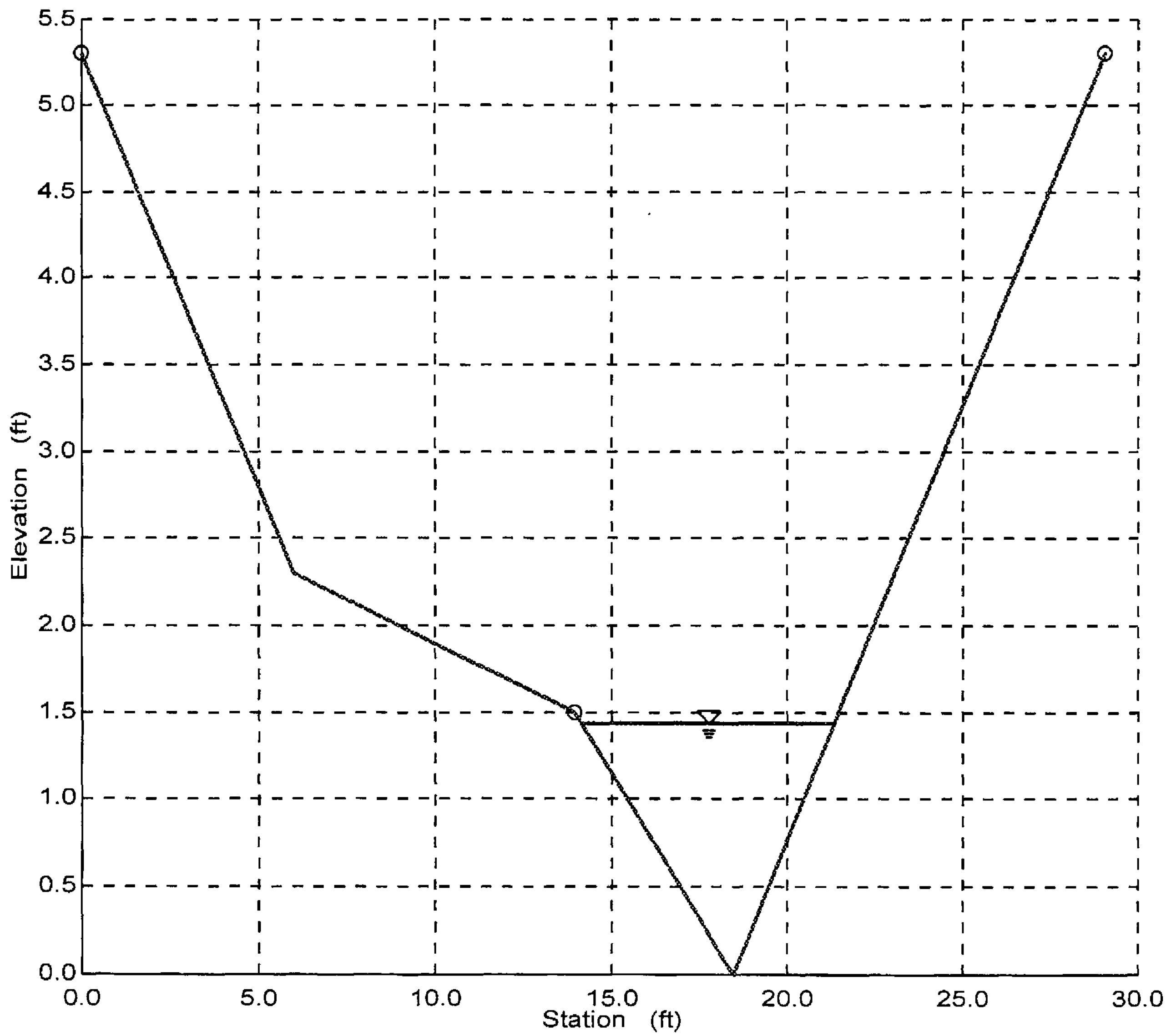
Discharge 12.40 cfs

Results		
Wtd. Mannings Coefficient	0.033	
Water Surface Elevation	1.43	ft
Flow Area	5.12	ft^2
Wetted Perimeter	7.73	ft
Top Width	7.16	ft
Height	1.43	ft
Critical Depth	1.09	ft
Critical Slope	0.021526	ft/ft
Velocity	2.42	ft/s
Velocity Head	0.09	ft
Specific Energy	1.52	ft
Froude Number	0.50	
Flow is subcritical.		

Channel Reach A4
Cross Section for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	0.5% slope channel north of tailings
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data		
Wtd. Mannings Coefficient	0.033	
Channel Slope	0.005000	ft/ft
Water Surface Elevation	1.43	ft
Discharge	12.40	cfs



Channel Reach A4
Worksheet for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	0.5% slope channel north of tailings
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Input Data

Channel Slope 0.005000 ft/ft

Elevation range: 0.00 ft to 5.30 ft.

Station (ft)	Elevation (ft)	Start Station	End Station	Roughness
0.00	5.30	0.00	14.00	0.045
6.00	2.30	14.00	29.10	0.033
14.00	1.50			
18.50	0.00			
29.10	5.30			

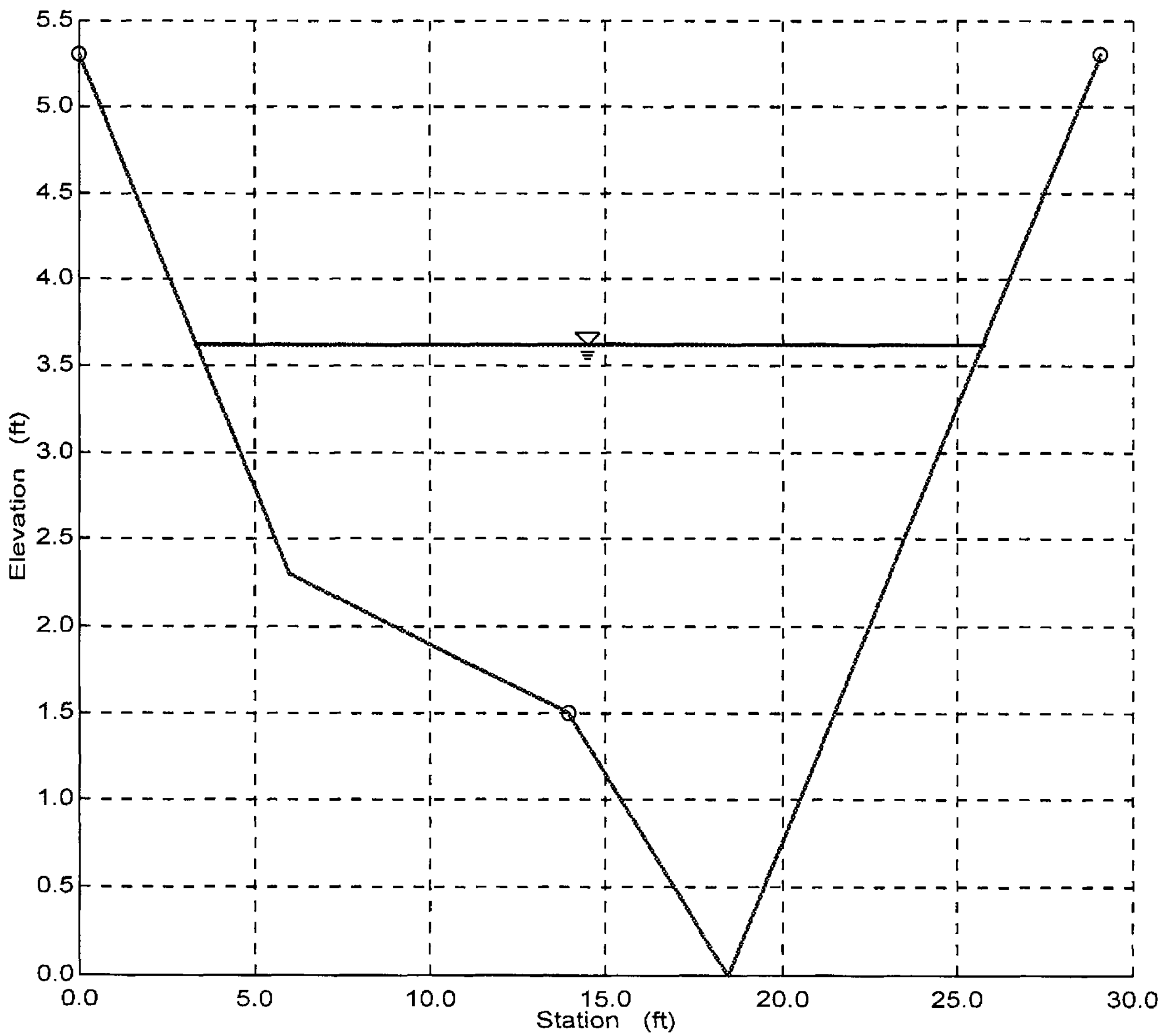
Discharge 179.00 cfs

Results		
Wtd. Mannings Coefficient	0.035	
Water Surface Elevation	3.63	ft
Flow Area	41.66	ft²
Wetted Perimeter	23.86	ft
Top Width	22.40	ft
Height	3.63	ft
Critical Depth	2.92	ft
Critical Slope	0.016170	ft/ft
Velocity	4.30	ft/s
Velocity Head	0.29	ft
Specific Energy	3.91	ft
Froude Number	0.56	
Flow is subcritical.		

Channel Reach A4
Cross Section for Irregular Channel

Project Description	
Project File	c:\haestad\fmw\mercur1.fm2
Worksheet	0.5% slope channel north of tailings
Flow Element	Irregular Channel
Method	Manning's Formula
Solve For	Water Elevation

Section Data		
Wtd. Mannings Coefficient	0.035	
Channel Slope	0.005000	ft/ft
Water Surface Elevation	3.63	ft
Discharge	179.00	cfs



APPENDIX K

BASELINE INSTRUMENTATION READINGS

APPENDIX K-1

PIEZOMETER READINGS

PIEZO #: 1
SERIAL #: 10915

RO: 9732.00
TO: 12.00 deg. C
C: 0.02204
K: -0.0309
BAROM. 31.57 " Hg
GE: 7233.1

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9304	6.58	8.28	22.03	0.00	7255.13	
1/7/98	9:00 AM	-4	23.26	9314	6.58	8.28	21.52	0.51	7254.62	
1/14/98	9:00 AM	-7	23.42	9317	6.58	8.28	21.37	0.15	7254.47	
1/22/98	9:30 AM	-4	23.28	9317	6.58	8.28	21.37	0.00	7254.47	
1/28/98	8:30 AM	-2	23.3	9314	6.58	8.28	21.52	-0.15	7254.62	
2/3/98	1:00 PM	4	23.06	9317	6.58	8.28	21.37	0.15	7254.47	
2/12/98	11:30 AM	1	23.35	9306	6.56	8.34	21.92	-0.55	7255.02	
2/20/98	9:00 AM	-1	23.13	9295	6.57	8.31	22.48	-0.56	7255.58	
3/25/98	9:00 AM	10	23.08	9278	6.57	8.31	23.35	-0.86	7256.45	
4/2/98	12:40 PM	6	23.3	9279	6.57	8.31	23.30	0.05	7256.40	
4/8/98	11:00 AM	4	23.32	9278	6.57	8.31	23.35	-0.05	7256.45	
4/15/98	10:30 AM	0	23.02	9262	6.57	8.31	24.16	-0.81	7257.26	
4/22/98	9:30 AM	11	23.46	9273	6.58	8.28	23.60	0.56	7256.70	
4/29/98	11:00 AM	15	23.42	9275	6.57	8.31	23.50	0.10	7256.60	
5/7/98	9:00 AM	6	23.26	9278	6.57	8.31	23.35	0.15	7256.45	
5/13/98	9:30 PM	10	23	9284	6.58	8.28	23.04	0.30	7256.14	
5/20/98	9:00 AM	15	23.28	9284	6.57	8.31	23.04	0.00	7256.14	
5/27/98	8:30 AM	5	23.25	9289	6.57	8.31	22.79	0.25	7255.89	
6/3/98	11:00 AM	16	23.19	9289	6.57	8.31	22.79	0.00	7255.89	
6/10/98	11:00 AM	10	23.29	9288	6.57	8.31	22.84	-0.05	7255.94	
6/17/98	1:00 PM	6	23.35	9279	6.57	8.31	23.30	-0.46	7256.40	
6/24/98	11:00 AM	18	23.28	9283	6.57	8.31	23.09	0.20	7256.19	
7/1/98	10:00 AM	24	23.4	9279	6.57	8.31	23.30	-0.20	7256.40	
7/8/98	8:00 AM	15	23.46	9280	6.57	8.31	23.25	0.05	7256.35	
7/15/98	8:00 AM	17	23.5	9279	6.57	8.31	23.30	-0.05	7256.40	
7/22/98	8:00AM	16	23.4	9280	6.58	8.28	23.25	0.05	7256.35	
7/29/98	8:00 AM	14	23.43	9279	6.57	8.31	23.30	-0.05	7256.40	
8/12/98	9:00 AM	16	23.58	9283	6.57	8.31	23.09	0.20	7256.19	
8/19/98	11:00 AM	20	23.45	9280	6.357	9.03	23.19	-0.10	7256.29	
8/31/98	9:00 AM	22	23.44	9291	6.57	8.31	22.69	0.51	7255.79	
9/11/98	10:00 AM	15	23.48	9297	6.57	8.31	22.38	0.31	7255.48	
9/16/98	11:00 AM	23	23.42	9290	6.57	8.31	22.74	-0.36	7255.84	
9/22/98	9:00 AM	17	23.38	9301	6.56	8.34	22.18	0.56	7255.28	
9/30/98	10:00 AM	16	23.32	9303	6.56	8.34	22.07	0.10	7255.17	
10/7/98	9:00 AM	6	23.46	9304	6.56	8.34	22.02	0.05	7255.12	
10/14/98	8:30 AM	5	23.32	9306	6.56	8.34	21.92	0.10	7255.02	
10/26/98	7:30 AM	6	23.7	9308	6.55	8.38	21.82	0.10	7254.92	
10/30/98	9:00 AM	3	23.8	9310	6.55	8.38	21.72	0.21	7254.82	
11/5/98	9:30 AM			9311	6.55	8.38	21.66	0.05	7254.76	
11/13/98	10:00 AM	4	23.4	9312	6.54	8.41	21.61	0.05	7254.71	
11/18/98	10:00 AM	0	23.4	9315	6.54	8.41	21.46	0.15	7254.56	
1/7/99	12:10PM	6.7		9318	6.52	8.48	21.30	0.16	7254.40	
2/6/99	9:30AM	5		9322	6.51	8.51	21.10	0.21	7254.20	
3/6/99	11:00AM	5		9322	6.5	8.54	21.09	0.00	7254.19	
5/6/99	2:30PM	15.6		9316	6.5	8.54	21.40	-0.31	7254.50	
7/26/99	1:00PM			9315	6.53	8.44	21.46	-0.06	7254.56	

PIEZO #: 3
SERIAL #: 10910

RO: 9624.00
TO: 9.00 deg. C
C: 0.02235
K: -0.0224
BAROM. 31.05 " Hg
GE: 7115

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9650	5.59	11.82	-1.49	-0.10	7113.51	
01/07/98	9:00 AM	-4	23.26	9655	5.59	11.82	-1.74	0.26	7113.26	
01/14/98	9:00 AM	-7	23.42	9656	5.59	11.82	-1.80	0.05	7113.20	
01/22/98	9:30 AM	-4	23.28	9656	5.59	11.82	-1.80	0.00	7113.20	
01/28/98	8:30 AM	-2	23.3	9654	5.59	11.82	-1.69	-0.10	7113.31	
02/03/98	1:00 PM	4	23.06	9658	5.6	11.78	-1.90	0.20	7113.10	
02/12/98	11:30 AM	1	23.35	9654	5.58	11.86	-1.69	-0.20	7113.31	
02/20/98	9:00 AM	-1	23.13	9658	5.59	11.82	-1.90	0.20	7113.10	
03/25/98	9:00 AM	10	23.08	9658	5.6	11.78	-1.90	0.00	7113.10	
04/02/98	12:40 PM	6	23.3	9659	5.6	11.78	-1.95	0.05	7113.05	
04/08/98	11:00 AM	4	23.32	9658	5.6	11.78	-1.90	-0.05	7113.10	
04/15/98	10:30 AM	0	23.02	9668	5.6	11.78	-2.41	0.52	7112.59	
04/22/98	9:30 AM	11	23.46	9650	5.6	11.78	-1.48	-0.93	7113.52	
04/29/98	11:00 AM	15	23.42	9652	5.6	11.78	-1.59	0.10	7113.41	
05/07/98	9:00 AM	6	23.26	9655	5.6	11.78	-1.74	0.15	7113.26	
05/13/98	9:30 PM	10	23	9660	5.6	11.78	-2.00	0.26	7113.00	
05/20/98	9:00 AM	15	23.28	9654	5.6	11.78	-1.69	-0.31	7113.31	
05/27/98	8:30 AM	5	23.25	9657	5.6	11.78	-1.85	0.15	7113.15	
06/03/98	11:00 AM	16	23.19	9656	5.6	11.78	-1.79	-0.05	7113.21	
06/10/98	11:00 AM	10	23.29	9655	5.6	11.78	-1.74	-0.05	7113.26	
06/17/98	1:00 PM	6	23.35	9659	5.6	11.78	-1.95	0.21	7113.05	
06/24/98	11:00 AM	18	23.28	9655	5.6	11.78	-1.74	-0.21	7113.26	
07/01/98	10:00 AM	24	23.4	9653	5.61	11.74	-1.64	-0.11	7113.36	
07/08/98	8:00 AM	15	23.46	9654	5.6	11.78	-1.69	0.05	7113.31	
07/15/98	8:00 AM	17	23.5	9650	5.61	11.74	-1.48	-0.21	7113.52	
07/22/98	8:00AM	16	23.4	9651	5.61	11.74	-1.53	0.05	7113.47	
07/29/98	8:00 AM	14	23.43	9651	5.61	11.74	-1.53	0.00	7113.47	
08/12/98	9:00 AM	16	23.58	9648	5.61	11.74	-1.38	-0.15	7113.62	
08/19/98	11:00 AM	20	23.45	9650	5.61	11.74	-1.48	0.10	7113.52	
08/31/98	9:00 AM	22	23.44	9651	5.61	11.74	-1.53	0.05	7113.47	
09/11/98	10:00 AM	15	23.48	9652	5.61	11.74	-1.59	0.05	7113.41	
09/16/98	11:00 AM	23	23.42	9651	5.61	11.74	-1.53	-0.05	7113.47	
09/22/98	9:00 AM	17	23.38	9653	5.61	11.74	-1.64	0.10	7113.36	
09/30/98	10:00 AM	16	23.32	9654	5.61	11.74	-1.69	0.05	7113.31	
10/07/98	9:00 AM	6	23.46	9652	5.61	11.74	-1.59	-0.10	7113.41	
10/14/98	8:30 AM	5	23.32	9654	5.62	11.70	-1.69	0.10	7113.31	
10/26/98	7:30 AM	6	23.7	9655	5.62	11.70	-1.74	0.05	7113.26	
10/30/98	9:00 AM	3	23.8	9657	5.62	11.70	-1.84	0.10	7113.16	
11/05/98	9:30 AM	0	0	9655	5.62	11.70	-1.74	-0.10	7113.26	
11/13/98	10:00 AM	4	23.4	9650	5.62	11.70	-1.48	-0.26	7113.52	
11/18/98	10:00 AM	0	23.4	9655	5.62	11.70	-1.74	0.26	7113.26	
1/7/99	12:10PM	6.7		9655	5.63	11.66	-1.74	0.00	7113.26	
2/6/99	9:30AM	5		9656	5.63	11.66	-1.79	0.05	7113.21	
3/6/99	11:00AM	5		9659	5.63	11.66	-1.94	0.15	7113.06	
5/6/99	2:30PM	15.6		9654	5.64	11.63	-1.68	-0.26	7113.32	
7/26/99	1:00PM			9651	5.65	11.59	-1.53	-0.16	7113.47	

PIEZO #: 4
SERIAL #: 10914

RO: 9906.00
TO: 10.00 deg. C
C: 0.02239
K: -0.0269
BAROM. 31.05 " Hg
GE: 7033.1

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9927	5.8	11.02	-1.15	-0.31	7031.95	
01/07/98	9:00 AM	-4	23.26	9932	5.8	11.02	-1.41	0.26	7031.69	
01/14/98	9:00 AM	-7	23.42	9931	5.8	11.02	-1.35	-0.05	7031.75	
01/22/98	9:30 AM	-4	23.28	9933	5.8	11.02	-1.46	0.10	7031.64	
01/28/98	8:30 AM	-2	23.3	9931	5.8	11.02	-1.35	-0.10	7031.75	
02/03/98	1:00 PM	4	23.06	9936	5.8	11.02	-1.61	0.26	7031.49	
02/12/98	11:30 AM	1	23.35	9931	5.77	11.13	-1.36	-0.25	7031.74	
02/20/98	9:00 AM	-1	23.13	9935	5.8	11.02	-1.56	0.20	7031.54	
03/25/98	9:00 AM	10	23.08	9936	5.8	11.02	-1.61	0.05	7031.49	
04/02/98	12:40 PM	6	23.3	9937	5.8	11.02	-1.66	0.05	7031.44	
04/08/98	11:00 AM	4	23.32	9936	5.8	11.02	-1.61	-0.05	7031.49	
04/15/98	10:30 AM	0	23.02	9938	5.8	11.02	-1.72	0.10	7031.38	
04/22/98	9:30 AM	11	23.46	9928	5.8	11.02	-1.20	-0.52	7031.90	
04/29/98	11:00 AM	15	23.42	9930	5.8	11.02	-1.30	0.10	7031.80	
05/07/98	9:00 AM	6	23.26	9933	5.81	10.98	-1.46	0.15	7031.64	
05/13/98	9:30 PM	10	23	9939	5.81	10.98	-1.77	0.31	7031.33	
05/20/98	9:00 AM	15	23.28	9932	5.8	11.02	-1.41	-0.36	7031.69	
05/27/98	8:30 AM	5	23.25	9935	5.81	10.98	-1.56	0.15	7031.54	
06/03/98	11:00 AM	16	23.19	9934	5.8	11.02	-1.51	-0.05	7031.59	
06/10/98	11:00 AM	10	23.29	9933	5.81	10.98	-1.46	-0.05	7031.64	
06/17/98	1:00 PM	6	23.35	9937	5.8	11.02	-1.66	0.21	7031.44	
06/24/98	11:00 AM	18	23.28	9933	5.81	10.98	-1.46	-0.21	7031.64	
07/01/98	10:00 AM	24	23.4	9931	5.81	10.98	-1.35	-0.10	7031.75	
07/08/98	8:00 AM	15	23.46	9932	5.81	10.98	-1.40	0.05	7031.70	
07/15/98	8:00 AM	17	23.5	9929	5.8	11.02	-1.25	-0.15	7031.85	
07/22/98	8:00AM	16	23.4	9929	5.81	10.98	-1.25	0.00	7031.85	
07/29/98	8:00 AM	14	23.43	9929	5.81	10.98	-1.25	0.00	7031.85	
08/12/98	9:00 AM	16	23.58	9926	5.81	10.98	-1.09	-0.15	7032.01	
08/19/98	11:00 AM	20	23.45	9927	5.81	10.98	-1.15	0.05	7031.95	
08/31/98	9:00 AM	22	23.44	9929	5.81	10.98	-1.25	0.10	7031.85	
09/11/98	10:00 AM	15	23.48	9931	5.81	10.98	-1.35	0.10	7031.75	
09/16/98	11:00 AM	23	23.42	9927	5.81	10.98	-1.15	-0.21	7031.95	
09/22/98	9:00 AM	17	23.38	9931	5.81	10.98	-1.35	0.21	7031.75	
09/30/98	10:00 AM	16	23.32	9933	5.81	10.98	-1.46	0.10	7031.64	
10/07/98	9:00 AM	6	23.46	9930	5.81	10.98	-1.30	-0.15	7031.80	
10/14/98	8:30 AM	5	23.32	9933	5.81	10.98	-1.46	0.15	7031.64	
10/26/98	7:30 AM	6	23.7	9934	5.81	10.98	-1.51	0.05	7031.59	
10/30/98	9:00 AM	3	23.8	9936	5.81	10.98	-1.61	0.10	7031.49	
11/05/98	9:30 AM	0	0	9934	5.81	10.98	-1.51	-0.10	7031.59	
11/13/98	10:00 AM	4	23.4	9929	5.81	10.98	-1.25	-0.26	7031.85	
11/18/98	10:00 AM	0	23.4	9934	5.82	10.94	-1.50	0.26	7031.60	
1/7/99	12:10PM	6.7		9933	5.82	10.94	-1.45	-0.05	7031.65	
2/6/99	9:30AM	5		9935	5.82	10.94	-1.56	0.10	7031.54	
3/6/99	11:00AM	5		9938	5.82	10.94	-1.71	0.15	7031.39	
5/6/99	2:30PM	15.6		9932	5.82	10.94	-1.40	-0.31	7031.70	
7/26/99	1:00PM			9931	5.83	10.91	-1.35	-0.05	7031.75	

PIEZO #:	5	RO:	9636.00
SERIAL #:	10912	TO:	3.00 deg. C
		C:	0.02217
		K:	-0.0244
		BAROM.	31.98 " Hg

7096.1

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9651	5.81	10.98	-1.22	-0.31	7094.88	
01/07/98	9:00 AM	-4	23.26	9655	5.81	10.98	-1.42	0.20	7094.68	
01/14/98	9:00 AM	-7	23.42	9654	5.81	10.98	-1.37	-0.05	7094.73	
01/22/98	9:30 AM	-4	23.28	9656	5.81	10.98	-1.47	0.10	7094.63	
01/28/98	8:30 AM	-2	23.3	9655	5.81	10.98	-1.42	-0.05	7094.68	
02/03/98	1:00 PM	4	23.06	9659	5.81	10.98	-1.63	0.20	7094.47	
02/12/98	11:30 AM	1	23.35	9655	5.8	11.02	-1.42	-0.20	7094.68	
02/20/98	9:00 AM	-1	23.13	9659	5.81	10.98	-1.63	0.20	7094.47	
03/25/98	9:00 AM	10	23.08	9659	5.82	10.94	-1.62	0.00	7094.48	
04/02/98	12:40 PM	6	23.3	9661	5.82	10.94	-1.73	0.10	7094.37	
04/08/98	11:00 AM	4	23.32	9660	5.93	10.54	-1.65	-0.07	7094.45	
04/15/98	10:30 AM	0	23.02	9661	5.82	10.94	-1.73	0.07	7094.37	
04/22/98	9:30 AM	11	23.46	9651	5.82	10.94	-1.21	-0.51	7094.89	
04/29/98	11:00 AM	15	23.42	9653	5.82	10.94	-1.32	0.10	7094.78	
05/07/98	9:00 AM	6	23.26	9657	5.82	10.94	-1.52	0.20	7094.58	
05/13/98	9:30 PM	10	23	9662	5.83	10.91	-1.77	0.25	7094.33	
05/20/98	9:00 AM	15	23.28	9655	5.82	10.94	-1.42	-0.36	7094.68	
05/27/98	8:30 AM	5	23.25	9658	5.83	10.91	-1.57	0.15	7094.53	
06/03/98	11:00 AM	16	23.19	9657	5.83	10.91	-1.52	-0.05	7094.58	
06/10/98	11:00 AM	10	23.29	9656	5.83	10.91	-1.47	-0.05	7094.63	
06/17/98	1:00 PM	6	23.35	9661	5.82	10.94	-1.73	0.26	7094.37	
06/24/98	11:00 AM	18	23.28	9657	5.83	10.91	-1.52	-0.21	7094.58	
07/01/98	10:00 AM	24	23.4	9654	5.83	10.91	-1.37	-0.15	7094.73	
07/08/98	8:00 AM	15	23.46	9656	5.83	10.91	-1.47	0.10	7094.63	
07/15/98	8:00 AM	17	23.5	9651	5.83	10.91	-1.21	-0.26	7094.89	
07/22/98	8:00AM	16	23.4	9652	5.83	10.91	-1.26	0.05	7094.84	
07/29/98	8:00 AM	14	23.43	9653	5.83	10.91	-1.31	0.05	7094.79	
08/12/98	9:00 AM	16	23.58	9649	5.84	10.87	-1.11	-0.21	7094.99	
08/19/98	11:00 AM	20	23.45	9650	5.84	10.87	-1.16	0.05	7094.94	
08/31/98	9:00 AM	22	23.44	9652	5.84	10.87	-1.26	0.10	7094.84	
09/11/98	10:00 AM	15	23.48	9653	5.84	10.87	-1.31	0.05	7094.79	
09/16/98	11:00 AM	23	23.42	9650	5.84	10.87	-1.16	-0.15	7094.94	
09/22/98	9:00 AM	17	23.38	9655	5.84	10.87	-1.41	0.26	7094.69	
09/30/98	10:00 AM	16	23.32	9655	5.84	10.87	-1.41	0.00	7094.69	
10/07/98	9:00 AM	6	23.46	9653	5.84	10.87	-1.31	-0.10	7094.79	
10/14/98	8:30 AM	5	23.32	9657	5.84	10.87	-1.52	0.20	7094.58	
10/26/98	7:30 AM	6	23.7	9656	5.84	10.87	-1.47	-0.05	7094.63	
10/30/98	9:00 AM	3	23.8	9659	5.85	10.83	-1.62	0.15	7094.48	
11/05/98	9:30 AM	0	0	9658	5.85	10.83	-1.57	-0.05	7094.53	
11/13/98	10:00 AM	4	23.4	9651	5.85	10.83	-1.21	-0.36	7094.89	
11/18/98	10:00 AM	0	23.4	9656	5.85	10.83	-1.46	0.26	7094.64	
01/07/1999	12:10PM	6.7	23.26	9655	5.81	10.98	-1.42	-0.04	7094.68	
02/06/99	9:30AM	5		9657	5.86	10.80	-1.51	0.09	7094.59	
3/6/99	11:00AM	5		9661	5.86	10.80	-1.72	0.20	7094.38	
05/06/99	2:30PM	15.6		9656	5.86	10.80	-1.46	-0.26	7094.64	
07/26/99	1:00PM			9653	5.88	10.72	-1.30	-0.16	7094.80	

PIEZO #: 6
SERIAL #: 10911

RO: 9758.00
TO: 3.00 deg. C
C: 0.02302
K: -0.0322
BAROM. 31.98 " Hg
GE: 7041

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9776	5.91	10.61	-1.52	-0.32	7039.48	
01/07/98	9:00 AM	-4	23.26	9780	5.92	10.57	-1.73	0.21	7039.27	
01/14/98	9:00 AM	-7	23.42	9779	5.97	10.39	-1.66	-0.07	7039.34	
01/22/98	9:30 AM	-4	23.28	9781	5.92	10.57	-1.78	0.12	7039.22	
01/28/98	8:30 AM	-2	23.3	9779	5.92	10.57	-1.68	-0.11	7039.32	
02/03/98	1:00 PM	4	23.06	9784	5.92	10.57	-1.94	0.27	7039.06	
02/12/98	11:30 AM	1	23.35	9779	5.91	10.61	-1.68	-0.26	7039.32	
02/20/98	9:00 AM	-1	23.13	9782	5.92	10.57	-1.84	0.16	7039.16	
03/25/98	9:00 AM	10	23.08	9783	5.93	10.54	-1.89	0.05	7039.11	
04/02/98	12:40 PM	6	23.3	9785	5.93	10.54	-1.99	0.11	7039.01	
04/08/98	11:00 AM	4	23.32	9785	5.93	10.54	-1.99	0.00	7039.01	
04/15/98	10:30 AM	0	23.02	9786	5.93	10.54	-2.05	0.05	7038.95	
04/22/98	9:30 AM	11	23.46	9777	5.93	10.54	-1.57	-0.48	7039.43	
04/29/98	11:00 AM	15	23.42	9779	5.93	10.54	-1.68	0.11	7039.32	
05/07/98	9:00 AM	6	23.26	9781	5.92	10.57	-1.78	0.11	7039.22	
05/13/98	9:30 PM	10	23	9786	5.93	10.54	-2.05	0.26	7038.95	
05/20/98	9:00 AM	15	23.28	9780	5.93	10.54	-1.73	-0.32	7039.27	
05/27/98	8:30 AM	5	23.25	9783	5.93	10.54	-1.89	0.16	7039.11	
06/03/98	11:00 AM	16	23.19	9782	5.92	10.57	-1.84	-0.05	7039.16	
06/10/98	11:00 AM	10	23.29	9781	5.93	10.54	-1.78	-0.06	7039.22	
06/17/98	1:00 PM	6	23.35	9785	5.93	10.54	-1.99	0.21	7039.01	
06/24/98	11:00 AM	18	23.28	9781	5.93	10.54	-1.78	-0.21	7039.22	
07/01/98	10:00 AM	24	23.4	9778	5.93	10.54	-1.62	-0.16	7039.38	
07/08/98	8:00 AM	15	23.46	9781	5.93	10.54	-1.78	0.16	7039.22	
07/15/98	8:00 AM	17	23.5	9771	5.93	10.54	-1.25	-0.53	7039.75	
07/22/98	8:00AM	16	23.4	9777	5.92	10.57	-1.57	0.32	7039.43	
07/29/98	8:00 AM	14	23.43	9776	5.92	10.57	-1.52	-0.05	7039.48	
08/12/98	9:00 AM	16	23.58	9774	5.93	10.54	-1.41	-0.11	7039.59	
08/19/98	11:00 AM	20	23.45	9776	5.90	10.65	-1.52	0.11	7039.48	
08/31/98	9:00 AM	22	23.44	9777	5.94	10.50	-1.57	0.04	7039.43	
09/11/98	10:00 AM	15	23.48	9779	5.85	10.83	-1.70	0.13	7039.30	
09/16/98	11:00 AM	23	23.42	9777	5.85	10.83	-1.59	-0.11	7039.41	
09/22/98	9:00 AM	17	23.38	9779	5.93	10.54	-1.68	0.08	7039.32	
09/30/98	10:00 AM	16	23.32	9781	5.99	10.32	-1.77	0.09	7039.23	
10/07/98	9:00 AM	6	23.46	9778	5.94	10.50	-1.62	-0.15	7039.38	
10/14/98	8:30 AM	5	23.32	9782	5.94	10.50	-1.83	0.21	7039.17	
10/26/98	7:30 AM	6	23.7	9782	5.94	10.50	-1.83	0.00	7039.17	
10/30/98	9:00 AM	3	23.8	9784	5.95	10.46	-1.94	0.10	7039.06	
11/05/98	9:30 AM	0	0	9782	5.94	10.50	-1.83	-0.10	7039.17	
11/13/98	10:00 AM	4	23.4	9777	5.95	10.46	-1.56	-0.27	7039.44	
11/18/98	10:00 AM	0	23.4	9782	5.95	10.46	-1.83	0.27	7039.17	
1/7/99	12:10PM	6.7		9781	5.95	10.46	-1.78	-0.05	7039.22	
02/06/99	9:30AM	5		9783	5.95	10.46	-1.88	0.11	7039.12	
03/06/99	11:00AM	5		9786	5.95	10.46	-2.04	0.16	7038.96	
05/06/99	2:30PM	15.6		9781	5.96	10.43	-1.77	-0.27	7039.23	
07/26/99	1:00PM			9779	5.96	10.43	-1.67	-0.11	7039.33	

PIEZO #: 7
SERIAL #: 10900

RO: 9024.00
TO: 13.00 deg. C
C: 0.0208
K: -0.0208
BAROM. 31.57 " Hg
GE: 7232.9

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8639	6.6	8.21	18.70	0.29	7251.60	
01/07/98	9:00 AM	-4	23.26	8651	6.68	7.95	18.14	0.56	7251.04	
01/14/98	9:00 AM	-7	23.42	8660	6.6	8.21	17.70	0.44	7250.60	
01/22/98	9:30 AM	-4	23.28	8663	6.6	8.21	17.55	0.14	7250.45	
01/28/98	8:30 AM	-2	23.3	8663	6.6	8.21	17.55	0.00	7250.45	
02/03/98	1:00 PM	4	23.06	8666	6.6	8.21	17.41	0.14	7250.31	
02/12/98	11:30 AM	1	23.35	8638	6.58	8.28	18.75	-1.34	7251.65	
02/20/98	9:00 AM	-1	23.13	8607	6.59	8.25	20.24	-1.49	7253.14	
03/25/98	9:00 AM	10	23.08	8564	6.59	8.25	22.30	-2.06	7255.20	
04/02/98	12:40 PM	6	23.3	8564	6.59	8.25	22.30	0.00	7255.20	
04/08/98	11:00 AM	4	23.32	8564	6.59	8.25	22.30	0.00	7255.20	
04/15/98	10:30 AM	0	23.02	8566	6.6	8.21	22.21	0.09	7255.11	
04/22/98	9:30 AM	11	23.46	8558	6.6	8.21	22.59	-0.38	7255.49	
04/29/98	11:00 AM	15	23.42	8558	6.6	8.21	22.59	0.00	7255.49	
05/07/98	9:00 AM	6	23.26	8566	6.6	8.21	22.21	0.38	7255.11	
05/13/98	9:30 PM	10	23	8580	6.6	8.21	21.54	0.67	7254.44	
05/20/98	9:00 AM	15	23.28	8587	6.6	8.21	21.20	0.34	7254.10	
05/27/98	8:30 AM	5	23.25	8597	6.61	8.18	20.72	0.48	7253.62	
06/03/98	11:00 AM	16	23.19	8597	6.61	8.18	20.72	0.00	7253.62	
06/10/98	11:00 AM	10	23.29	8587	6.61	8.18	21.20	-0.48	7254.10	
06/17/98	1:00 PM	6	23.35	8564	6.59	8.25	22.30	-1.10	7255.20	
06/24/98	11:00 AM	18	23.28	8572	6.61	8.18	21.92	0.38	7254.82	
07/01/98	10:00 AM	24	23.4	8561	6.61	8.18	22.45	-0.53	7255.35	
07/08/98	8:00 AM	15	23.46	8572	6.61	8.18	21.92	0.53	7254.82	
07/15/98	8:00 AM	17	23.5	8559	6.61	8.18	22.54	-0.62	7255.44	
07/22/98	8:00AM	16	23.4	8560	6.61	8.18	22.50	0.05	7255.40	
07/29/98	8:00 AM	14	23.43	8560	6.61	8.18	22.50	0.00	7255.40	
08/12/98	9:00 AM	16	23.58	8583	6.61	8.18	21.39	1.10	7254.29	
08/19/98	11:00 AM	20	23.45	8583	6.61	8.18	21.39	0.00	7254.29	
08/31/98	9:00 AM	22	23.44	8607	6.61	8.18	20.24	1.15	7253.14	
09/11/98	10:00 AM	15	23.48	8623	6.61	8.18	19.47	0.77	7252.37	
09/16/98	11:00 AM	23	23.42	8593	6.61	8.18	20.91	-1.44	7253.81	
09/22/98	9:00 AM	17	23.38	8634	6.61	8.18	18.95	1.97	7251.85	
09/30/98	10:00 AM	16	23.32	8639	6.61	8.18	18.71	0.24	7251.61	
10/07/98	9:00 AM	6	23.46	8643	6.6	8.21	18.51	0.19	7251.41	
10/14/98	8:30 AM	5	23.32	8647	6.6	8.21	18.32	0.19	7251.22	
10/26/98	7:30 AM	6	23.7	8653	6.6	8.21	18.03	0.29	7250.93	
10/30/98	9:00 AM	3	23.8	8657	6.6	8.21	17.84	0.19	7250.74	
11/05/98	9:30 AM	0	0	8658	6.6	8.21	17.79	0.05	7250.69	
11/13/98	10:00 AM	4	23.4	8659	6.59	8.25	17.74	0.05	7250.64	
11/18/98	10:00 AM	0	23.4	8662	6.59	8.25	17.60	0.14	7250.50	
12/30/98	9:00AM	0	23.49	8639	6.6	8.21	18.70	-1.11	7251.60	
1/7/99	12:10PM	6.7		8674	6.57	8.31	17.02	1.68	7249.92	
02/06/99	9:30AM	5		8678	6.56	8.34	16.83	0.19	7249.73	
03/06/99	11:00AM	5		8672	6.57	8.31	17.12	-0.29	7250.02	
05/06/99	2:30PM	15.6		8649	6.16	9.71	18.15	-1.04	7251.05	
07/26/99	1:00PM			8650	6.66	8.02	18.19	-0.03	7251.09	

PIEZO #: 9
SERIAL #: 10902

RO: 9517.00
TO: 7.00 deg. C
C: 0.02452
K: -0.027
BAROM. 32.08 " Hg
GE 7230.3

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9035	6.32	9.15	27.13	0.17	7257.43	
01/07/98	9:00 AM	-4	23.26	9046	6.32	9.15	26.51	0.62	7256.81	
01/14/98	9:00 AM	-7	23.42	9051	6.32	9.15	26.23	0.28	7256.53	
01/22/98	9:30 AM	-4	23.28	9054	6.32	9.15	26.06	0.17	7256.36	
01/28/98	8:30 AM	-2	23.3	9054	6.32	9.15	26.06	0.00	7256.36	
02/03/98	1:00 PM	4	23.06	9057	6.32	9.15	25.89	0.17	7256.19	
02/12/98	11:30 AM	1	23.35	9042	6.31	9.19	26.73	-0.85	7257.03	
02/20/98	9:00 AM	-1	23.13	9020	6.32	9.15	27.98	-1.25	7258.28	
03/25/98	9:00 AM	10	23.08	8984	6.32	9.15	30.02	-2.04	7260.32	
04/02/98	12:40 PM	6	23.3	8978	6.32	9.15	30.36	-0.34	7260.66	
04/08/98	11:00 AM	4	23.32	8982	6.32	9.15	30.13	0.23	7260.43	
04/15/98	10:30 AM	0	23.02	8982	6.32	9.15	30.13	0.00	7260.43	
04/22/98	9:30 AM	11	23.46	8977	6.32	9.15	30.41	-0.28	7260.71	
04/29/98	11:00 AM	15	23.42	8978	6.32	9.15	30.36	0.06	7260.66	
05/07/98	9:00 AM	6	23.26	8983	6.32	9.15	30.07	0.28	7260.37	
05/13/98	9:30 PM	10	23	8994	6.32	9.15	29.45	0.62	7259.75	
05/20/98	9:00 AM	15	23.28	9001	6.32	9.15	29.05	0.40	7259.35	
05/27/98	8:30 AM	5	23.25	9008	6.32	9.15	28.66	0.40	7258.96	
06/03/98	11:00 AM	16	23.19	9012	6.32	9.15	28.43	0.23	7258.73	
06/10/98	11:00 AM	10	23.29	9005	6.31	9.19	28.83	-0.39	7259.13	
06/17/98	1:00 PM	6	23.35	8978	6.32	9.15	30.36	-1.53	7260.66	
06/24/98	11:00 AM	18	23.28	8992	6.31	9.19	29.56	0.79	7259.86	
07/01/98	10:00 AM	24	23.4	8986	6.31	9.19	29.90	-0.34	7260.20	
07/08/98	8:00 AM	15	23.46	8992	6.31	9.19	29.56	0.34	7259.86	
07/15/98	8:00 AM	17	23.5	8983	6.31	9.19	30.07	-0.51	7260.37	
07/22/98	8:00AM	16	23.4	8985	6.31	9.19	29.96	0.11	7260.26	
07/29/98	8:00 AM	14	23.43	8986	6.31	9.19	29.90	0.06	7260.20	
08/12/98	9:00 AM	16	23.58	9003	6.31	9.19	28.94	0.96	7259.24	
08/19/98	11:00 AM	20	23.45	9004	6.31	9.19	28.88	0.06	7259.18	
08/31/98	9:00 AM	22	23.44	9025	6.31	9.19	27.69	1.19	7257.99	
09/11/98	10:00 AM	15	23.48	9035	6.31	9.19	27.13	0.57	7257.43	
09/16/98	11:00 AM	23	23.42	9030	6.31	9.19	27.41	-0.28	7257.71	
09/22/98	9:00 AM	17	23.38	9046	6.31	9.19	26.51	0.91	7256.81	
09/30/98	10:00 AM	16	23.32	9049	6.31	9.19	26.34	0.17	7256.64	
10/07/98	9:00 AM	6	23.46	9053	6.31	9.19	26.11	0.23	7256.41	
10/14/98	8:30 AM	5	23.32	9058	6.31	9.19	25.83	0.28	7256.13	
10/26/98	7:30 AM	6	23.7	9063	6.31	9.19	25.55	0.28	7255.85	
10/30/98	9:00 AM	3	23.8	9065	6.31	9.19	25.43	0.11	7255.73	
11/05/98	9:30 AM	0	0	9068	6.31	9.19	25.26	0.17	7255.56	
11/13/98	10:00 AM	4	23.4	9069	6.31	9.19	25.21	0.06	7255.51	
11/18/98	10:00 AM	0	23.4	9072	6.31	9.19	25.04	0.17	7255.34	
1/7/99	12:10PM	6.7		9085	6.31		24.87	0.16	7255.17	
02/06/99	9:30AM	5		9088	6.31	9.19	24.13	0.74	7254.43	
3/6/99	11:00AM	5		9086	6.31	9.19	24.24	-0.11	7254.54	
05/06/99	2:30PM	15.6		9071	6.3	9.22	25.09	-0.85	7255.39	
07/26/99	1:00PM			9074	6.03	10.17	24.86	0.23	7255.16	

PIEZO #: 13
SERIAL #: 10892

RO: 9500.00
TO: 12.00 deg. C
C: 0.02315
K: -0.0301
BAROM. 31.57 " Hg
GE: 7232.7

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9249	6.71	7.85	13.69	1.07	7246.39	
01/07/98	9:00 AM	-4	23.26	9264	6.71	7.85	12.89	0.80	7245.59	
01/14/98	9:00 AM	-7	23.42	9275	6.70	7.89	12.30	1.39	7245.00	
01/22/98	9:30 AM	-4	23.28	9287	6.70	7.89	11.66	1.23	7244.36	
01/28/98	8:30 AM	-2	23.3	9290	6.70	7.89	11.50	0.80	7244.20	
02/03/98	1:00 PM	4	23.06	9293	6.70	7.89	11.34	0.32	7244.04	
02/12/98	11:30 AM	1	23.35	9289	6.68	7.95	11.55	-0.05	7244.25	
02/20/98	9:00 AM	-1	23.13	9261	6.69	7.92	13.05	-1.71	7245.75	
03/25/98	9:00 AM	10	23.08	9217	6.68	7.95	15.40	-3.85	7248.10	
04/02/98	12:40 PM	6	23.3	9214	6.68	7.95	15.56	-2.51	7248.26	
04/08/98	11:00 AM	4	23.32	9215	6.54	8.41	15.47	-0.07	7248.17	
04/15/98	10:30 AM	0	23.02	9215	6.68	7.95	15.50	0.05	7248.20	
04/22/98	9:30 AM	11	23.46	9111	6.69	7.92	21.06	-5.59	7253.76	
04/29/98	11:00 AM	15	23.42	9110	6.69	7.92	21.11	-5.61	7253.81	
05/07/98	9:00 AM	6	23.26	9125	6.69	7.92	20.31	0.75	7253.01	
05/13/98	9:30 PM	10	23	9170	6.70	7.89	17.91	3.20	7250.61	
05/20/98	9:00 AM	15	23.28	9193	6.70	7.89	16.68	3.63	7249.38	
05/27/98	8:30 AM	5	23.25	9208	6.70	7.89	15.88	2.03	7248.58	
06/03/98	11:00 AM	16	23.19	9210	6.70	7.89	15.77	0.91	7248.47	
06/10/98	11:00 AM	10	23.29	9185	6.70	7.89	17.11	-1.23	7249.81	
06/17/98	1:00 PM	6	23.35	9215	6.68	7.95	15.50	0.27	7248.20	
06/24/98	11:00 AM	18	23.28	9155	6.70	7.89	18.71	-1.60	7251.41	
07/01/98	10:00 AM	24	23.4	9134	6.71	7.85	19.83	-4.33	7252.53	
07/08/98	8:00 AM	15	23.46	9155	6.70	7.89	18.71	0.00	7251.41	
07/15/98	8:00 AM	17	23.5	9130	6.71	7.85	20.05	-0.21	7252.75	
07/22/98	8:00AM	16	23.4	9137	6.71	7.85	19.67	-0.96	7252.37	
07/29/98	8:00 AM	14	23.43	9132	6.72	7.82	19.94	0.10	7252.64	
08/12/98	9:00 AM	16	23.58	9188	6.72	7.82	16.95	2.72	7249.65	
08/19/98	11:00 AM	20	23.45	9170	6.72	7.82	17.91	-0.96	7250.61	
08/31/98	9:00 AM	22	23.44	9239	6.72	7.82	14.23	3.69	7246.93	
09/11/98	10:00 AM	15	23.48	9261	6.72	7.82	13.05	1.17	7245.75	
09/16/98	11:00 AM	23	23.42	9239	6.72	7.82	14.23	-1.17	7246.93	
09/22/98	9:00 AM	17	23.38	9278	6.72	7.82	12.15	2.08	7244.85	
09/30/98	10:00 AM	16	23.32	9288	6.72	7.82	11.61	2.62	7244.31	
10/07/98	9:00 AM	6	23.46	9294	6.72	7.82	11.29	0.85	7243.99	
10/14/98	8:30 AM	5	23.32	9303	6.72	7.82	10.81	0.80	7243.51	
10/26/98	7:30 AM	6	23.7	9316	6.72	7.82	10.12	1.17	7242.82	
10/30/98	9:00 AM	3	23.8	9318	6.72	7.82	10.01	0.80	7242.71	
11/05/98	9:30 AM	0	0	9319	6.72	7.82	9.96	0.16	7242.66	
11/13/98	10:00 AM	4	23.4	9324	6.72	7.82	9.69	0.32	7242.39	
11/18/98	10:00 AM	0	23.4	9329	6.72	7.82	9.42	0.53	7242.12	
01/07/99	12:10PM	6.7		9353	6.71	7.85	8.14	1.55	7240.84	
2/6/99	9:30AM	5		9358	6.7	7.89	7.87	1.55	7240.57	
03/06/99	11:00AM	5		9347	6.69	7.92	8.45	-0.32	7241.15	
05/06/99	2:30PM	15.6		9304	6.61	8.18	10.73	-2.86	7243.43	
07/26/99	1:00PM			9315	6.66	8.02	10.16	-1.70	7242.86	

PIEZO #: 15
SERIAL #: 10894

RO: 9772.00
TO: 10.00 deg. C
C: 0.02292
K: -0.0298
BAROM. 31.57 " Hg
GE: 7231.4

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9502	6.53	8.44	14.38	-0.05	7245.78	
01/07/98	9:00 AM	-4	23.26	9504	6.53	8.44	14.28	0.11	7245.68	
01/14/98	9:00 AM	-7	23.42	9508	6.53	8.44	14.07	0.21	7245.47	
01/22/98	9:30 AM	-4	23.28	9514	6.54	8.41	13.75	0.31	7245.15	
01/28/98	8:30 AM	-2	23.3	9513	6.54	8.41	13.80	-0.05	7245.20	
02/03/98	1:00 PM	4	23.06	9514	6.54	8.41	13.75	0.05	7245.15	
02/12/98	11:30 AM	1	23.35	9513	6.53	8.44	13.80	-0.05	7245.20	
02/20/98	9:00 AM	-1	23.13	9515	6.53	8.44	13.70	0.11	7245.10	
03/25/98	9:00 AM	10	23.08	9463	6.54	8.41	16.45	-2.75	7247.85	
04/02/98	12:40 PM	6	23.3	9493	6.54	8.41	14.86	1.59	7246.26	
04/08/98	11:00 AM	4	23.32	9470	6.54	8.41	16.08	-1.22	7247.48	
04/15/98	10:30 AM	0	23.02	9501	6.53	8.44	14.44	1.64	7245.84	
04/22/98	9:30 AM	11	23.46	9496	6.54	8.41	14.70	-0.27	7246.10	
04/29/98	11:00 AM	15	23.42	9496	6.54	8.41	14.70	0.00	7246.10	
05/07/98	9:00 AM	6	23.26	9506	6.54	8.41	14.17	0.53	7245.57	
05/13/98	9:30 PM	10	23	9513	6.54	8.41	13.80	0.37	7245.20	
05/20/98	9:00 AM	15	23.28	9510	6.54	8.41	13.96	-0.16	7245.36	
05/27/98	8:30 AM	5	23.25	9509	6.54	8.41	14.02	-0.05	7245.42	
06/03/98	11:00 AM	16	23.19	9508	6.54	8.41	14.07	-0.05	7245.47	
06/10/98	11:00 AM	10	23.29	9504	6.54	8.41	14.28	-0.21	7245.68	
06/17/98	1:00 PM	6	23.35	9493	6.54	8.41	14.86	-0.58	7246.26	
06/24/98	11:00 AM	18	23.28	9492	6.54	8.41	14.91	-0.05	7246.31	
07/01/98	10:00 AM	24	23.4	9479	6.54	8.41	15.60	-0.69	7247.00	
07/08/98	8:00 AM	15	23.46	9479	6.54	8.41	15.60	0.00	7247.00	
07/15/98	8:00 AM	17	23.5	9496	6.55	8.38	14.71	0.90	7246.11	
07/22/98	8:00AM	16	23.4	9501	6.55	8.38	14.44	0.26	7245.84	
07/29/98	8:00 AM	14	23.43	9504	6.55	8.38	14.28	0.16	7245.68	
08/12/98	9:00 AM	16	23.58	9510	6.55	8.38	13.97	0.32	7245.37	
08/19/98	11:00 AM	20	23.45	9505	6.55	8.38	14.23	-0.26	7245.63	
08/31/98	9:00 AM	22	23.44	9516	6.55	8.38	13.65	0.58	7245.05	
09/11/98	10:00 AM	15	23.48	9518	6.55	8.38	13.54	0.11	7244.94	
09/16/98	11:00 AM	23	23.42	9517	6.55	8.38	13.60	-0.05	7245.00	
09/22/98	9:00 AM	17	23.38	9521	6.56	8.34	13.39	0.21	7244.79	
09/30/98	10:00 AM	16	23.32	9523	6.56	8.34	13.28	0.11	7244.68	
10/07/98	9:00 AM	6	23.46	9522	6.56	8.34	13.33	-0.05	7244.73	
10/14/98	8:30 AM	5	23.32	9524	6.56	8.34	13.23	0.11	7244.63	
10/26/98	7:30 AM	6	23.7	9527	6.56	8.34	13.07	0.16	7244.47	
10/30/98	9:00 AM	3	23.8	9530	6.56	8.34	12.91	0.16	7244.31	
11/05/98	9:30 AM	0	0	9530	6.56	8.34	12.91	0.00	7244.31	
11/13/98	10:00 AM	4	23.4	9528	6.56	8.34	13.02	-0.11	7244.42	
11/18/98	10:00 AM	0	23.4	9532	6.56	8.34	12.80	0.21	7244.20	
1/7/99	12:10PM	6.7		9536	6.57	8.31	12.59	0.21	7243.99	
02/06/99	9:30AM	5		9540	6.57	8.31	12.38	0.21	7243.78	
03/06/99	11:00AM	5		9525	6.57	8.31	13.18	-0.79	7244.58	
5/6/99	2:30PM	15.6		9516	6.56		14.22	-1.05	7245.62	
07/26/99	1:00PM			9532	6.57	8.31	12.81	1.42	7244.21	

PIEZO #: 16
SERIAL #: 10896

RO: 9348.00
TO: 3.00 deg. C
C: 0.02874
K: -0.0431
BAROM. 31.98 " Hg
GE: 7216.7

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9250	6.51	8.51	5.95	0.00	7222.65	
01/07/98	9:00 AM	-4	23.26	9250	6.51	8.51	5.95	0.00	7222.65	
01/14/98	9:00 AM	-7	23.42	9257	6.51	8.51	5.49	0.46	7222.19	
01/22/98	9:30 AM	-4	23.28	9256	6.51	8.51	5.55	-0.07	7222.25	
01/28/98	8:30 AM	-2	23.3	9256	6.51	8.51	5.55	0.00	7222.25	
02/03/98	1:00 PM	4	23.06	9257	6.51	8.51	5.49	0.07	7222.19	
02/12/98	11:30 AM	1	23.35	9255	6.5	8.54	5.61	-0.13	7222.31	
02/20/98	9:00 AM	-1	23.13	9256	6.51	8.51	5.55	0.06	7222.25	
03/25/98	9:00 AM	10	23.08	9223	6.51	8.51	7.74	-2.19	7224.44	
04/02/98	12:40 PM	6	23.3	9243	6.51	8.51	6.41	1.33	7223.11	
04/08/98	11:00 AM	4	23.32	9230	6.51	8.51	7.28	-0.86	7223.98	
04/15/98	10:30 AM	0	23.02	9246	6.51	8.51	6.21	1.06	7222.91	
04/22/98	9:30 AM	11	23.46	9243	6.51	8.51	6.41	-0.20	7223.11	
04/29/98	11:00 AM	15	23.42	9316	6.51	8.51	1.57	4.84	7218.27	
05/07/98	9:00 AM	6	23.26	9252	6.51	8.51	5.82	-4.24	7222.52	
05/13/98	9:30 PM	10	23	9251	6.51	8.51	5.88	-0.07	7222.58	
05/20/98	9:00 AM	15	23.28	9255	6.51	8.51	5.62	0.27	7222.32	
05/27/98	8:30 AM	5	23.25	9255	6.51	8.51	5.62	0.00	7222.32	
06/03/98	11:00 AM	16	23.19	9253	6.51	8.51	5.75	-0.13	7222.45	
06/10/98	11:00 AM	10	23.29	9249	6.51	8.51	6.02	-0.27	7222.72	
06/17/98	1:00 PM	6	23.35	9242	6.51	8.51	6.48	-0.46	7223.18	
06/24/98	11:00 AM	18	23.28	9242	6.52	8.48	6.48	0.00	7223.18	
07/01/98	10:00 AM	24	23.4	9231	6.52	8.48	7.21	-0.73	7223.91	
07/08/98	8:00 AM	15	23.46	9231	6.52	8.48	7.21	0.00	7223.91	
07/15/98	8:00 AM	17	23.5	9243	6.52	8.48	6.42	0.80	7223.12	
07/22/98	8:00AM	16	23.4	9246	6.52	8.48	6.22	0.20	7222.92	
07/29/98	8:00 AM	14	23.43	9249	6.52	8.48	6.02	0.20	7222.72	
08/12/98	9:00 AM	16	23.58	9252	6.53	8.44	5.82	0.20	7222.52	
08/19/98	11:00 AM	20	23.45	9249	6.52	8.48	6.02	-0.20	7222.72	
08/31/98	9:00 AM	22	23.44	9256	6.53	8.44	5.56	0.46	7222.26	
09/11/98	10:00 AM	15	23.48	9258	6.53	8.44	5.43	0.13	7222.13	
09/16/98	11:00 AM	23	23.42	9256	6.53	8.44	5.56	-0.13	7222.26	
09/22/98	9:00 AM	17	23.38	9259	6.54	8.41	5.36	0.20	7222.06	
09/30/98	10:00 AM	16	23.32	9261	6.54	8.41	5.23	0.13	7221.93	
10/07/98	9:00 AM	6	23.46	9259	6.54	8.41	5.36	-0.13	7222.06	
10/14/98	8:30 AM	5	23.32	9261	6.54	8.41	5.23	0.13	7221.93	
10/26/98	7:30 AM	6	23.7	9264	6.54	8.41	5.03	0.20	7221.73	
10/30/98	9:00 AM	3	23.8	9266	6.54	8.41	4.90	0.13	7221.60	
11/05/98	9:30 AM	0	0	9265	6.54	8.41	4.97	-0.07	7221.67	
11/13/98	10:00 AM	4	23.4	9263	6.54	8.41	5.10	-0.13	7221.80	
11/18/98	10:00 AM	0	23.4	9267	6.55	8.38	4.84	0.26	7221.54	
1/7/99	12:10PM	6.7		9268	6.55	8.38	4.77	0.07	7221.47	
02/06/99	9:30AM	5		9271	6.55	8.38	4.57	0.20	7221.27	
03/06/99	11:00AM	5		9258	6.57	8.31	5.44	-0.87	7222.14	
5/6/1999	2:30PM	15.6		9250	6.54	8.41	5.96	-0.52	7222.66	
07/26/99	1:00PM			9267	6.53	8.44	4.83	1.13	7221.53	

PIEZO #: 17
SERIAL #: 10895

RO: 9176.00
TO: 12.00 deg. C
C: 0.02650
K: -0.0292
BAROM. 31.57 " Hg
GE: 7230.4

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8891	6.4	8.88	17.63	-0.06	7248.03	
01/07/98	9:00 AM	-4	23.26	8893	6.4	8.88	17.51	0.12	7247.91	
01/14/98	9:00 AM	-7	23.42	8896	6.4	8.88	17.33	0.18	7247.73	
01/22/98	9:30 AM	-4	23.28	8900	6.4	8.88	17.08	0.24	7247.48	
01/28/98	8:30 AM	-2	23.3	8900	6.4	8.88	17.08	0.00	7247.48	
02/03/98	1:00 PM	4	23.06	8902	6.4	8.88	16.96	0.12	7247.36	
02/12/98	11:30 AM	1	23.35	8900	6.37	8.98	17.08	-0.12	7247.48	
02/20/98	9:00 AM	-1	23.13	8902	6.4	8.88	16.96	0.12	7247.36	
03/25/98	9:00 AM	10	23.08	8864	6.4	8.88	19.28	-2.32	7249.68	
04/02/98	12:40 PM	6	23.3	8881	6.4	8.88	18.25	1.04	7248.65	
04/08/98	11:00 AM	4	23.32	8870	6.4	8.88	18.92	-0.67	7249.32	
04/15/98	10:30 AM	0	23.02	8887	6.4	8.88	17.88	1.04	7248.28	
04/22/98	9:30 AM	11	23.46	8884	6.4	8.88	18.06	-0.18	7248.46	
04/29/98	11:00 AM	15	23.42	8884	6.41	8.85	18.06	0.00	7248.46	
05/07/98	9:00 AM	6	23.26	8892	6.41	8.85	17.57	0.49	7247.97	
05/13/98	9:30 PM	10	23	8898	6.41	8.85	17.21	0.37	7247.61	
05/20/98	9:00 AM	15	23.28	8897	6.41	8.85	17.27	-0.06	7247.67	
05/27/98	8:30 AM	5	23.25	8897	6.41	8.85	17.27	0.00	7247.67	
06/03/98	11:00 AM	16	23.19	8896	6.41	8.85	17.33	-0.06	7247.73	
06/10/98	11:00 AM	10	23.29	8894	6.41	8.85	17.45	-0.12	7247.85	
06/17/98	1:00 PM	6	23.35	8881	6.4	8.88	18.25	-0.79	7248.65	
06/24/98	11:00 AM	18	23.28	8884	6.41	8.85	18.06	0.18	7248.46	
07/01/98	10:00 AM	24	23.4	8875	6.41	8.85	18.61	-0.55	7249.01	
07/08/98	8:00 AM	15	23.46	8875	6.41	8.85	18.61	0.00	7249.01	
07/15/98	8:00 AM	17	23.5	8887	6.41	8.85	17.88	0.73	7248.28	
07/22/98	8:00AM	16	23.4	8890	6.41	8.85	17.70	0.18	7248.10	
07/29/98	8:00 AM	14	23.43	8891	6.41	8.85	17.64	0.06	7248.04	
08/12/98	9:00 AM	16	23.58	8898	6.41	8.85	17.21	0.43	7247.61	
08/19/98	11:00 AM	20	23.45	8892	6.41	8.85	17.57	-0.37	7247.97	
08/31/98	9:00 AM	22	23.44	8905	6.41	8.85	16.78	0.79	7247.18	
09/11/98	10:00 AM	15	23.48	8907	6.41	8.85	16.66	0.12	7247.06	
09/16/98	11:00 AM	23	23.42	8905	6.41	8.85	16.78	-0.12	7247.18	
09/22/98	9:00 AM	17	23.38	8910	6.41	8.85	16.47	0.31	7246.87	
09/30/98	10:00 AM	16	23.32	8912	6.41	8.85	16.35	0.12	7246.75	
10/07/98	9:00 AM	6	23.46	8912	6.41	8.85	16.35	0.00	7246.75	
10/14/98	8:30 AM	5	23.32	8914	6.41	8.85	16.23	0.12	7246.63	
10/26/98	7:30 AM	6	23.7	8916	6.41	8.85	16.11	0.12	7246.51	
10/30/98	9:00 AM	3	23.8	8919	6.41	8.85	15.92	0.18	7246.32	
11/05/98	9:30 AM	0	0	8919	6.41	8.85	15.92	0.00	7246.32	
11/13/98	10:00 AM	4	23.4	8918	6.41	8.85	15.99	-0.06	7246.39	
11/18/98	10:00 AM	0	23.4	8921	6.41	8.85	15.80	0.18	7246.20	
1/7/99	12:10PM	6.7		8926	6.42	8.81	15.50	0.30	7245.90	
2/6/99	9:30AM	5		8930	6.42	8.81	15.25	0.24	7245.65	
03/06/99	11:00AM	5		8918	6.42	8.81	15.99	-0.73	7246.39	
05/06/99	2:30PM	15.6		8911	6.42	8.81	16.42	-0.43	7246.82	
07/26/99	1:00PM			8924	6.43	8.78	15.62	0.79	7246.02	

PIEZO #: 21
SERIAL #: 10903

RO: 9573.00
TO: 12.00 deg. C
C: 0.02306
K: -0.0208
BAROM. 31.57 " Hg 7216.9

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9343	60.70	-39.98	14.73	-0.37	7231.63	
01/07/98	9:00 AM	-4	23.26	9349	61.1	-40.12	14.42	0.31	7231.32	
01/14/98	9:00 AM	-7	23.42	9350	61.6	-40.30	14.37	0.04	7231.27	
01/22/98	9:30 AM	-4	23.28	9353	61.7	-40.33	14.22	0.16	7231.12	
01/28/98	8:30 AM	-2	23.3	9349	61.5	-40.26	14.42	-0.21	7231.32	
02/03/98	1:00 PM	4	23.06	9353	61.5	-40.26	14.21	0.21	7231.11	
02/12/98	11:30 AM	1	23.35	9352	61.7	-40.33	14.27	-0.06	7231.17	
02/20/98	9:00 AM	-1	23.13	9354	62.1	-40.47	14.17	0.10	7231.07	
03/25/98	9:00 AM	10	23.08	9331	63.9	-41.09	15.42	-1.25	7232.32	
04/02/98	12:40 PM	6	23.3	9345	63.9	-41.09	14.68	0.74	7231.58	
04/08/98	11:00 AM	4	23.32	9340	63.9	-41.09	14.94	-0.27	7231.84	
04/15/98	10:30 AM	0	23.02	9345	64.8	-41.40	14.69	0.25	7231.59	
04/22/98	9:30 AM	11	23.46	9339	64.9	-41.43	15.01	-0.32	7231.91	
04/29/98	11:00 AM	15	23.42	9338	64.7	-41.36	15.06	-0.05	7231.96	
05/07/98	9:00 AM	6	23.26	9349	64.8	-41.40	14.48	0.58	7231.38	
05/13/98	9:30 PM	10	23	9356	65.3	-41.56	14.11	0.36	7231.01	
05/20/98	9:00 AM	15	23.28	9351	66	-41.79	14.39	-0.28	7231.29	
05/27/98	8:30 AM	5	23.25	9353	66.2	-41.86	14.29	0.10	7231.19	
06/03/98	11:00 AM	16	23.19	9352	66.6	-41.99	14.35	-0.06	7231.25	
06/10/98	11:00 AM	10	23.29	9352	66.9	-42.09	14.35	0.00	7231.25	
06/17/98	1:00 PM	6	23.35	9346	63.8	-41.06	14.62	-0.27	7231.52	
06/24/98	11:00 AM	18	23.28	9347	66.8	-42.06	14.62	0.01	7231.52	
07/01/98	10:00 AM	24	23.4	9343	67.4	-42.25	14.84	-0.22	7231.74	
07/08/98	8:00 AM	15	23.46	9343	66.7	-42.02	14.83	0.01	7231.73	
07/15/98	8:00 AM	17	23.5	9348	68.6	-42.63	14.59	0.24	7231.49	
07/22/98	8:00AM	16	23.4	9349	68.70	-42.66		14.59	7216.90	
07/29/98	8:00 AM	14	23.43	9350	68.10	-42.47	14.48	-14.48	7231.38	
08/12/98	9:00 AM	16	23.58	9351	68.60	-42.63	14.43	0.05	7231.33	
08/19/98	11:00 AM	20	23.45	9350	68.10	-42.47	14.48	-0.05	7231.38	
08/31/98	9:00 AM	22	23.44	9350	69	-42.76	14.49	-0.01	7231.39	
09/11/98	10:00 AM	15	23.48	9353	69.8	-43.01	14.34	0.15	7231.24	
09/16/98	11:00 AM	23	23.42	9353	69.1	-42.79	14.33	0.01	7231.23	
09/22/98	9:00 AM	17	23.38	9357	70.2	-43.13	14.14	0.20	7231.04	
09/30/98	10:00 AM	16	23.32	9356	71.3	-43.47	14.21	-0.07	7231.11	
10/07/98	9:00 AM	6	23.46	9357	71.5	-43.53	14.16	0.05	7231.06	
10/14/98	8:30 AM	5	23.32	9356	71.6	-43.56	14.21	-0.05	7231.11	
10/26/98	7:30 AM	6	23.7	9361	71.6	-43.56	13.94	0.27	7230.84	
10/30/98	9:00 AM	3	23.8	9364	72	-43.68	13.79	0.15	7230.69	
11/05/98	9:30 AM	0	0	9363	72.3	-43.77	13.85	-0.06	7230.75	
11/13/98	10:00 AM	4	23.4	9362	73.4	-44.10	13.92	-0.07	7230.82	
11/18/98	10:00 AM	0	23.4	9365	73.4	-44.10	13.76	0.16	7230.66	
1/7/99	12:10PM	6.7		9367	75.5	-44.71	13.68	0.08	7230.58	
02/06/99	9:30AM	5		9372	75.9	-44.83	13.42	0.26	7230.32	
03/06/99	11:00AM	5		9370	77.1	-45.17	13.54	-0.12	7230.44	
05/06/99	2:30PM	15.6		9345	79.6	-45.86	14.91	-1.36	7231.81	
07/26/99	1:00PM			9367	82.9	-46.75	13.78	1.13	7230.68	

PIEZO #:	22	RO:	9725.00
SERIAL #:	10904	TO:	3.00 deg. C
		C:	0.02258
		K:	-0.0406
		BAROM.	31.98 " Hg
		GE:	7230.9

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9528	6.36	9.02	9.70	-0.36	7240.60	
01/07/98	9:00 AM	-4	23.26	9534	6.36	9.02	9.39	0.31	7240.29	
01/14/98	9:00 AM	-7	23.42	9534	6.36	9.02	9.39	0.00	7240.29	
01/22/98	9:30 AM	-4	23.28	9536	6.37	8.98	9.29	0.10	7240.19	
01/28/98	8:30 AM	-2	23.3	9534	6.37	8.98	9.39	-0.10	7240.29	
02/03/98	1:00 PM	4	23.06	9538	6.37	8.98	9.18	0.21	7240.08	
02/12/98	11:30 AM	1	23.35	9535	6.36	9.02	9.33	-0.15	7240.23	
02/20/98	9:00 AM	-1	23.13	9538	6.37	8.98	9.18	0.15	7240.08	
03/25/98	9:00 AM	10	23.08	9517	6.37	8.98	10.27	-1.09	7241.17	
04/02/98	12:40 PM	6	23.3	9531	6.29	9.26	9.52	0.75	7240.42	
04/08/98	11:00 AM	4	23.32	9525	6.37	8.98	9.86	-0.34	7240.76	
04/15/98	10:30 AM	0	23.02	9530	6.37	8.98	9.60	0.26	7240.50	
04/22/98	9:30 AM	11	23.46	9523	6.37	8.98	9.96	-0.36	7240.86	
04/29/98	11:00 AM	15	23.42	9523	6.37	8.98	9.96	0.00	7240.86	
05/07/98	9:00 AM	6	23.26	9531	6.37	8.98	9.55	0.42	7240.45	
05/13/98	9:30 PM	10	23	9538	6.38	8.95	9.18	0.36	7240.08	
05/20/98	9:00 AM	15	23.28	9533	6.37	8.98	9.44	-0.26	7240.34	
05/27/98	8:30 AM	5	23.25	9534	6.37	8.98	9.39	0.05	7240.29	
06/03/98	11:00 AM	16	23.19	9533	6.38	8.95	9.44	-0.06	7240.34	
06/10/98	11:00 AM	10	23.29	9532	6.38	8.95	9.50	-0.05	7240.40	
06/17/98	1:00 PM	6	23.35	9531	6.29	9.26	9.52	-0.02	7240.42	
06/24/98	11:00 AM	18	23.28	9529	6.38	8.95	9.65	-0.13	7240.55	
07/01/98	10:00 AM	24	23.4	9526	6.38	8.95	9.81	-0.16	7240.71	
07/08/98	8:00 AM	15	23.46	9529	6.37	8.98	9.65	0.16	7240.55	
07/15/98	8:00 AM	17	23.5	9526	6.38	8.95	9.81	-0.16	7240.71	
07/22/98	8:00AM	16	23.4	9529	6.38	8.95	9.65	0.16	7240.55	
07/29/98	8:00 AM	14	23.43	9530	6.38	8.95	9.60	0.05	7240.50	
08/12/98	9:00 AM	16	23.58	9530	6.39	8.91	9.60	0.00	7240.50	
08/19/98	11:00 AM	20	23.45	9532	6.38	8.95	9.50	0.11	7240.40	
08/31/98	9:00 AM	22	23.44	9529	6.39	8.91	9.66	-0.16	7240.56	
09/11/98	10:00 AM	15	23.48	9530	6.40	8.88	9.61	0.05	7240.51	
09/16/98	11:00 AM	23	23.42	9532	6.38	8.95	9.50	0.11	7240.40	
09/22/98	9:00 AM	17	23.38	9534	6.40	8.88	9.40	0.10	7240.30	
09/30/98	10:00 AM	16	23.32	9534	6.40	8.88	9.40	0.00	7240.30	
10/07/98	9:00 AM	6	23.46	9534	6.40	8.88	9.40	0.00	7240.30	
10/14/98	8:30 AM	5	23.32	9533	6.47	8.64	9.47	-0.07	7240.37	
10/26/98	7:30 AM	6	23.7	9539	6.41	8.85	9.14	0.33	7240.04	
10/30/98	9:00 AM	3	23.8	9541	6.41	8.85	9.04	0.10	7239.94	
11/05/98	9:30 AM	0	0	9541	6.41	8.85	9.04	0.00	7239.94	
11/13/98	10:00 AM	4	23.4	9535	6.41	8.85	9.35	-0.31	7240.25	
11/18/98	10:00 AM	0	23.4	9542	6.41	8.85	8.99	0.36	7239.89	
1/7/99	12:10PM	6.7		9542	6.42	8.81	8.99	0.00	7239.89	
02/06/99	9:30AM	5		9544	6.42	8.81	8.88	0.10	7239.78	
03/06/99	11:00AM	5		9542	6.43	8.78	8.99	-0.11	7239.89	
05/06/99	2:30PM	15.6		9516	6.42	8.81	10.34	-1.35	7241.24	
07/26/99	1:00PM			9535	6.42	8.81	9.35	0.99	7240.25	

PIEZO #: 23
Twinned with Piezometer # 24
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack

STANDPIPE ELEV: 7295.56
COLLAR ELEV: 7291.52
DEPTH TO TOP OF SCREEN: 69.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	49	7246.56	30.00	30.04	-0.42	
01/07/98	9:00 AM	49.28	7246.28	29.72	29.76	-0.28	
01/14/98	9:00 AM	49.68	7245.88	29.32	29.36	-0.40	
01/22/98	9:30 AM	49.75	7245.81	29.25	29.29	-0.07	
01/28/98	8:30 AM	49.6	7245.96	29.40	29.44	0.15	
02/03/98	1:00 PM	49.24	7246.32	29.76	29.80	0.36	
02/12/98	11:30 AM	48.8	7246.76	30.20	30.24	0.44	
02/20/98	9:00 AM	47.9	7247.66	31.10	31.14	0.90	
03/25/98	9:00 AM	46.98	7248.58	32.02	32.06	0.92	
04/02/98	12:40 PM	47.01	7248.55	31.99	32.03	-0.03	
04/08/98	11:00 AM	47.02	7248.54	31.98	32.02	-0.01	
04/15/98	10:30 AM	46.88	7248.68	32.12	32.16	0.14	
04/22/98	9:30 AM	47.1	7248.46	31.90	31.94	-0.22	
04/29/98	11:00 AM	47.12	7248.44	31.88	31.92	-0.02	
05/07/98	9:00 AM	47.22	7248.34	31.78	31.82	-0.10	
05/13/98	9:30 PM	47.21	7248.35	31.79	31.83	0.01	
05/20/98	9:00 AM	47.55	7248.01	31.45	31.49	-0.34	
05/27/98	8:30 AM	47.48	7248.08	31.52	31.56	0.07	
06/03/98	11:00 AM	47.65	7247.91	31.35	31.39	-0.17	
06/10/98	11:00 AM	47.6	7247.96	31.40	31.44	0.05	
06/17/98	1:00 PM	47.55	7248.01	31.45	31.49	0.05	
06/24/98	11:00 AM	47.52	7248.04	31.48	31.52	0.03	
07/01/98	10:00 AM	47.82	7247.74	31.18	31.22	-0.30	
07/08/98	8:00 AM	47.5	7248.06	31.50	31.54	0.32	
07/15/98	8:00 AM	47.5	7248.06	31.50	31.54	0.00	
07/22/98	8:00AM	47.55	7248.01	31.45	31.49	-0.05	
07/29/98	8:00 AM	47.4	7248.16	31.60	31.64	0.15	
08/12/98	9:00 AM	47.76	7247.80	31.24	31.28	-0.36	
08/19/98	11:00 AM	47.8	7247.76	31.20	31.24	-0.04	
08/31/98	9:00 AM	47.88	7247.68	31.12	31.16	-0.08	
09/11/98	10:00 AM	47.75	7247.81	31.25	31.29	0.13	
09/16/98	11:00 AM	48.34	7247.22	30.66	30.70	-0.59	
09/22/98	9:00 AM	48.3	7247.26	30.70	30.74	0.04	
09/30/98	10:00 AM	48.58	7246.98	30.42	30.46	-0.28	
10/07/98	9:00 AM	48.76	7246.80	30.24	30.28	-0.18	
10/14/98	8:30 AM	48.65	7246.91	30.35	30.39	0.11	
10/26/98	7:30 AM	48.89	7246.67	30.11	30.15	-0.24	
10/30/98	9:00 AM	56.47	7239.09	22.53	22.57	-7.58	
11/05/98	9:30 AM	48.94	7246.62	30.06	30.10	7.53	
11/18/98	10:00 AM	49.18	7246.38	29.82	29.86	-0.24	
12/30/98	9:00AM	49	20.00	30.00	-7196.52	0.18	
1/7/99	12:10PM	49.3	7335.50	29.70	118.98	-0.12	
02/06/99	9:30AM	49.54	7336.05	29.46	119.53	-0.54	
03/06/99	11:00AM	49.2	7335.82	29.80	119.30	0.10	
05/06/99	2:30PM	49.28	7336.21	29.72	119.69	0.26	
07/26/99	1:00PM	48.93		30.07	-7216.52	0.27	

PIEZO #:	24	RO:	8066.00
SERIAL #:	19974	TO:	21.00 deg. C
		C:	0.02678
		K:	0.0054
		BAROM.	31.05 " Hg
		GE:	7216.6

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	7763	6.45	8.71	18.57	0.19	7235.17	
01/07/98	9:00 AM	-4	23.26	7770	6.46	8.68	18.13	0.43	7234.73	
01/14/98	9:00 AM	-7	23.42	7774	6.46	8.68	17.89	0.25	7234.49	
01/22/98	9:30 AM	-4	23.28	7774	6.46	8.68	17.89	0.00	7234.49	
01/28/98	8:30 AM	-2	23.3	7772	6.46	8.68	18.01	-0.12	7234.61	
02/03/98	1:00 PM	4	23.06	7775	6.46	8.68	17.82	0.19	7234.42	
02/12/98	11:30 AM	1	23.35	7763	6.45	8.71	18.57	-0.74	7235.17	
02/20/98	9:00 AM	-1	23.13	7753	6.46	8.68	19.18	-0.62	7235.78	
03/25/98	9:00 AM	10	23.08	7738	6.46	8.68	20.11	-0.93	7236.71	
04/02/98	12:40 PM	6	23.3	7738	6.46	8.68	20.11	0.00	7236.71	
04/08/98	11:00 AM	4	23.32	7738	6.46	8.68	20.11	0.00	7236.71	
04/15/98	10:30 AM	0	23.02	7738	6.46	8.68	20.11	0.00	7236.71	
04/22/98	9:30 AM	11	23.46	7734	6.46	8.68	20.36	-0.25	7236.96	
04/29/98	11:00 AM	15	23.42	7735	6.46	8.68	20.30	0.06	7236.90	
05/07/98	9:00 AM	6	23.26	7738	6.46	8.68	20.11	0.19	7236.71	
05/13/98	9:30 PM	10	23	7747	6.46	8.68	19.55	0.56	7236.15	
05/20/98	9:00 AM	15	23.28	7744	6.37	8.98	19.74	-0.19	7236.34	
05/27/98	8:30 AM	5	23.25	7748	6.46	8.68	19.49	0.25	7236.09	
06/03/98	11:00 AM	16	23.19	7748	6.46	8.68	19.49	0.00	7236.09	
06/10/98	11:00 AM	10	23.29	7747	6.46	8.68	19.55	-0.06	7236.15	
06/17/98	1:00 PM	6	23.35	7743	6.47	8.64	19.80	-0.25	7236.40	
06/24/98	11:00 AM	18	23.28	7740	6.47	8.64	19.99	-0.19	7236.59	
07/01/98	10:00 AM	24	23.4	7740	6.47	8.64	19.99	0.00	7236.59	
07/08/98	8:00 AM	15	23.46	7743	6.47	8.64	19.80	0.19	7236.40	
07/15/98	8:00 AM	17	23.5	7739	6.47	8.64	20.05	-0.25	7236.65	
07/22/98	8:00AM	16	23.4	7740	6.47	8.64	19.99	0.06	7236.59	
07/29/98	8:00 AM	14	23.43	7739	6.47	8.64	20.05	-0.06	7236.65	
08/12/98	9:00 AM	16	23.58	7742	6.47	8.64	19.86	0.19	7236.46	
08/19/98	11:00 AM	20	23.45	7740	6.47	8.64	19.99	-0.12	7236.59	
08/31/98	9:00 AM	22	23.44	7751	6.47	8.64	19.31	0.68	7235.91	
09/11/98	10:00 AM	15	23.48	7756	6.47	8.64	19.00	0.31	7235.60	
09/16/98	11:00 AM	23	23.42	7750	6.47	8.64	19.37	-0.37	7235.97	
09/22/98	9:00 AM	17	23.38	7760	6.46	8.68	18.75	0.62	7235.35	
09/30/98	10:00 AM	16	23.32	7762	6.46	8.68	18.63	0.12	7235.23	
10/07/98	9:00 AM	6	23.46	7763	6.6	8.21	18.56	0.07	7235.16	
10/14/98	8:30 AM	5	23.32	7765	6.47	8.64	18.44	0.12	7235.04	
10/26/98	7:30 AM	6	23.7	7769	6.45	8.71	18.20	0.25	7234.80	
10/30/98	9:00 AM	3	23.8	7769	6.45	8.71	18.20	0.00	7234.80	
										Broken wire during tailings reclamation
01/07/99	12:10PM	6.7		7777	6.41	8.85	17.70	-17.70	7234.30	
02/06/99	9:30AM	5		7780	6.39	8.91	17.52	0.18	7234.12	
03/06/99	11:00AM	5		7779	6.39	8.91	17.58	-0.06	7234.18	
05/06/99	2:30PM	15.6		7773	6.4	8.88	17.95	-0.37	7234.55	
07/26/99	1:00PM			7768	6.45	8.71	18.26	-0.31	7234.86	

PIEZO #: 25
SERIAL #: 19972

RO: 9073.00
TO: 21.00 deg. C
C: 0.02144
K: -0.0214
BAROM. 31.57 " Hg
GE: 7201.3

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8304	6.48	8.61	38.65	0.15	7239.95	
01/07/98	9:00 AM	-4	23.26	8313	6.48	8.61	38.20	0.45	7239.50	
01/14/98	9:00 AM	-7	23.42	8318	6.48	8.61	37.96	0.25	7239.26	
01/22/98	9:30 AM	-4	23.28	8319	6.48	8.61	37.91	0.05	7239.21	
01/28/98	8:30 AM	-2	23.3	8317	6.48	8.61	38.00	-0.10	7239.30	
02/03/98	1:00 PM	4	23.06	8320	6.49	8.58	37.86	0.15	7239.16	
02/12/98	11:30 AM	1	23.35	8306	6.48	8.61	38.55	-0.69	7239.85	
02/20/98	9:00 AM	-1	23.13	8292	6.48	8.61	39.24	-0.69	7240.54	
03/25/98	9:00 AM	10	23.08	8270	6.48	8.61	40.33	-1.09	7241.63	
04/02/98	12:40 PM	6	23.3	8266	6.48	8.61	40.53	-0.20	7241.83	
04/08/98	11:00 AM	4	23.32	8265	6.48	8.61	40.58	-0.05	7241.88	
04/15/98	10:30 AM	0	23.02	8264	6.48	8.61	40.63	-0.05	7241.93	
04/22/98	9:30 AM	11	23.46	8262	6.49	8.58	40.73	-0.10	7242.03	
04/29/98	11:00 AM	15	23.42	8262	6.48	8.61	40.73	0.00	7242.03	
05/07/98	9:00 AM	6	23.26	8265	6.49	8.58	40.58	0.15	7241.88	
05/13/98	9:30 PM	10	23	8273	6.49	8.58	40.18	0.40	7241.48	
05/20/98	9:00 AM	15	23.28	8275	6.49	8.58	40.08	0.10	7241.38	
05/27/98	8:30 AM	5	23.25	8280	6.49	8.58	39.84	0.25	7241.14	
06/03/98	11:00 AM	16	23.19	8283	6.49	8.58	39.69	0.15	7240.99	
06/10/98	11:00 AM	10	23.29	8282	6.49	8.58	39.74	-0.05	7241.04	
06/17/98	1:00 PM	6	23.35	8266	6.48	8.61	40.53	-0.79	7241.83	
06/24/98	11:00 AM	18	23.28	8274	6.49	8.58	40.13	0.39	7241.43	
07/01/98	10:00 AM	24	23.4	8270	6.49	8.58	40.33	-0.20	7241.63	
07/08/98	8:00 AM	15	23.46	8274	6.49	8.58	40.13	0.20	7241.43	
07/15/98	8:00 AM	17	23.5	8266	6.48	8.61	40.53	-0.39	7241.83	
07/22/98	8:00AM	16	23.4	8267	6.49	8.58	40.48	0.05	7241.78	
07/29/98	8:00 AM	14	23.43	8266	6.49	8.58	40.53	-0.05	7241.83	
08/12/98	9:00 AM	16	23.58	8269	6.49	8.58	40.38	0.15	7241.68	
08/19/98	11:00 AM	20	23.45	8270	6.49	8.58	40.33	0.05	7241.63	
08/31/98	9:00 AM	22	23.44	8281	6.49	8.58	39.79	0.54	7241.09	
09/11/98	10:00 AM	15	23.48	8289	6.49	8.58	39.39	0.40	7240.69	
09/16/98	11:00 AM	23	23.42	8270	6.49	8.58	40.33	-0.94	7241.63	
09/22/98	9:00 AM	17	23.38	8295	6.49	8.58	39.09	1.24	7240.39	
09/30/98	10:00 AM	16	23.32	8296	6.49	8.58	39.05	0.05	7240.35	
10/07/98	9:00 AM	6	23.46	8302	6.49	8.58	38.75	0.30	7240.05	
10/14/98	8:30 AM	5	23.32	8306	6.49	8.58	38.55	0.20	7239.85	
10/26/98	7:30 AM	6	23.7	8309	6.49	8.58	38.40	0.15	7239.70	
10/30/98	9:00 AM	3	23.8	8313	6.49	8.58	38.20	0.20	7239.50	
										Broken wire during tailings reclamation
12/30/98	9:00AM	0	23.49	8304	6.48	8.61	38.65	-38.65	7239.95	
1/7/99	12:10PM	6.7		8336	6.49	8.58	37.07	1.58	7238.37	
02/06/99	9:30AM	5		8340	6.48	8.61	36.87	0.20	7238.17	
03/06/99	11:0AM	5		8334	6.47	8.64	37.16	-0.30	7238.46	
05/06/99	2:30PM	15.6		8320	6.44	8.75	37.85	-0.69	7239.15	
07/26/99	1:00PM			8308	6.43	8.78	38.44	-0.59	7239.74	

PIEZO #: 26
SERIAL #: 19977

RO: 8843.00
TO: 21.00 deg. C
C: 0.02084
K: -0.0167
BAROM. 31.57 " Hg
GE: 7146.5

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/31/96	1:00 PM	9	23.4	9059	6.38	8.95	-9.92	-0.01	7136.58	
1/7/98	9:00 AM	-4	23.26	9058	6.38	8.95	-9.87	0.05	7136.63	
1/23/97	1:00 PM	0	23.2	9058	6.38	8.95	-9.87	0.00	7136.63	
2/26/97	10:30 AM			9055	6.39	8.91	-9.73	0.15	7136.77	
3/4/97	1:10 PM	10	23.34	9056	6.39	8.91	-9.77	-0.05	7136.73	
3/11/97	12:55 AM	16	23.31	9055	6.39	8.91	-9.73	0.05	7136.77	
3/17/97	11:50 AM	6	23.49	9055	6.40	8.88	-9.73	0.00	7136.77	
3/26/97	2:05 PM	18	23.52	9054	6.39	8.91	-9.68	0.05	7136.82	
4/3/97	8:30 AM	-1	23.28	9056	6.40	8.88	-9.77	-0.09	7136.73	
4/9/97	9:15 AM	0	23.39	9054	6.40	8.88	-9.68	0.10	7136.82	
4/17/97	2:30 PM	20	23.36	9055	6.40	8.88	-9.73	-0.05	7136.77	
4/24/97	9:45 AM	-2	22.99	9055	6.40	8.88	-9.73	0.00	7136.77	
5/6/97	11:20 AM	19	23.7	9058	6.41	8.85	-9.87	-0.14	7136.63	
5/21/97	9:30 AM	13	23.39	9057	6.41	8.85	-9.82	0.05	7136.68	
										Broken wire noted - no longer reading.
07/26/99	1:00PM			9069	Wire Broken - Piezometer no longer functioning	#REF!	#REF!	#REF!	#REF!	

PIEZO #: 27
Twinned with Piezometer # 28
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 80 ft. (Comparative)

STANDPIPE ELEV: 7298.30
COLLAR ELEV: 7294.55
DEPTH TO TOP OF SCREEN: 75.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARITITVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	53.43	7244.87	31.57	30.32	-0.88	
01/07/98	9:00 AM	53.87	7244.43	31.13	29.88	-0.44	
01/14/98	9:00 AM	54.56	7243.74	30.44	29.19	-0.69	
01/22/98	9:30 AM	54.7	7243.60	30.30	29.05	-0.14	
01/28/98	8:30 AM	54.5	7243.80	30.50	29.25	0.20	
02/03/98	1:00 PM	54.47	7243.83	30.53	29.28	0.03	
02/12/98	11:30 AM	53.05	7245.25	31.95	30.70	1.42	
02/20/98	9:00 AM	51.4	7246.90	33.60	32.35	1.65	
03/25/98	9:00 AM	49.26	7249.04	35.74	34.49	2.14	
04/02/98	12:40 PM	49.39	7248.91	35.61	34.36	-0.13	
04/08/98	11:00 AM	49.3	7249.00	35.70	34.45	0.09	
04/15/98	10:30 AM	49.28	7249.02	35.72	34.47	0.02	
04/22/98	9:30 AM	49.38	7248.92	35.62	34.37	-0.10	
04/29/98	11:00 AM	49.25	7249.05	35.75	34.50	0.13	
05/07/98	9:00 AM	49.61	7248.69	35.39	34.14	-0.36	
05/13/98	9:30 PM	49.38	7248.92	35.62	34.37	0.23	
05/20/98	9:00 AM	50.46	7247.84	34.54	33.29	-1.08	
05/27/98	8:30 AM	50.94	7247.36	34.06	32.81	-0.48	
06/03/98	11:00 AM	50.86	7247.44	34.14	32.89	0.08	
06/10/98	11:00 AM	50.9	7247.40	34.10	32.85	-0.04	
06/17/98	1:00 PM	50.93	7247.37	34.07	32.82	-0.03	
06/24/98	11:00 AM	49.82	7248.48	35.18	33.93	1.11	
07/01/98	10:00 AM	49.48	7248.82	35.52	34.27	0.34	
07/08/98	8:00 AM	49.5	7248.80	35.50	34.25	-0.02	
07/15/98	8:00 AM	49.55	7248.75	35.45	34.20	-0.05	
07/22/98	8:00AM	49.48	7248.82	35.52	34.27	0.07	
07/29/98	8:00 AM	49.83	7248.47	35.17	33.92	-0.35	
08/12/98	9:00 AM	50.62	7247.68	34.38	33.13	-0.79	
08/19/98	11:00 AM	50.1	7248.20	34.90	33.65	0.52	
08/31/98	9:00 AM	51.65	7246.65	33.35	32.10	-1.55	
09/11/98	10:00 AM	51.02	7247.28	33.98	32.73	0.63	
09/16/98	11:00 AM	52.58	7245.72	32.42	31.17	-1.56	
09/22/98	9:00 AM	52.5	7245.80	32.50	31.25	0.08	
09/30/98	10:00 AM	52.92	7245.38	32.08	30.83	-0.42	
?	?	51.68	7246.62	33.32	32.07	1.24	
?	?	51.97	7246.33	33.03	31.78	-0.29	
10/07/98	9:00 AM	53.24	7245.06	31.76	30.51	-1.27	
10/14/98	8:30 AM	53.35	7244.95	31.65	30.40	-0.11	
10/26/98	7:30 AM	53.74	7244.56	31.26	30.01	-0.39	
10/30/98	9:00 AM	53.81	7244.49	31.19	29.94	-0.07	
11/05/98	9:30 AM	53.82	7244.48	31.18	29.93	-0.01	
11/13/98	10:00 AM						
11/18/98	10:00 AM	54.23	7244.07	30.77	29.52	-0.41	
12/30/98	9:00AM	53.43	21.57	31.57	-7192.98	31.57	
1/7/99	12:10PM	54.7	7335.50	30.30	120.95	-0.47	
02/06/99	9:30AM	54.8	7336.05	30.20	121.50	-1.37	
03/06/99	11:00AM	54	7335.82	31.00	121.27	0.70	
05/06/99	2:30PM	53.25	7336.21	31.75	121.66	1.55	
07/26/99	1:00PM	53.32		31.68	-7214.55	0.68	

PIEZO #: 28
SERIAL #: 19973

RO: 8742.00
TO: 21.00 deg. C
C: 0.02169
K: -0.0174
BAROM. 31.57 " Hg
GE: 7214.6

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8393	6.55	8.38	17.97	-0.45	7232.57	
01/07/98	9:00 AM	-4	23.26	8408	6.55	8.38	17.22	-0.75	7231.82	
01/14/98	9:00 AM	-7	23.42	8416	6.55	8.38	16.82	-0.40	7231.42	
01/22/98	9:30 AM	-4	23.28	8419	6.55	8.38	16.67	-0.15	7231.27	
01/28/98	8:30 AM	-2	23.3	8419	6.55	8.38	16.67	0.00	7231.27	
02/03/98	1:00 PM	4	23.06	8422	6.55	8.38	16.52	-0.15	7231.12	
02/12/98	11:30 AM	1	23.35	8391	6.54	8.41	18.07	1.55	7232.67	
02/20/98	9:00 AM	-1	23.13	8363	6.55	8.38	19.47	1.40	7234.07	
03/25/98	9:00 AM	10	23.08	8386	6.49	8.58	18.31	-1.16	7232.91	
04/02/98	12:40 PM	6	23.3	8321	6.54	8.41	21.57	3.26	7236.17	
04/08/98	11:00 AM	4	23.32	8350	6.55	8.38	20.12	-1.45	7234.72	
04/15/98	10:30 AM	0	23.02	8322	6.54	8.41	21.52	1.40	7236.12	
04/22/98	9:30 AM	11	23.46	8316	6.54	8.41	21.82	0.30	7236.42	
04/29/98	11:00 AM	15	23.42	8313	6.54	8.41	21.97	0.15	7236.57	
05/07/98	9:00 AM	6	23.26	8323	6.54	8.41	21.47	-0.50	7236.07	
05/13/98	9:30 PM	10	23	8335	6.54	8.41	20.87	-0.60	7235.47	
05/20/98	9:00 AM	15	23.28	8342	6.54	8.41	20.52	-0.35	7235.12	
05/27/98	8:30 AM	5	23.25	8349	6.54	8.41	20.17	-0.35	7234.77	
06/03/98	11:00 AM	16	23.19	8351	6.54	8.41	20.07	-0.10	7234.67	
06/10/98	11:00 AM	10	23.29	8341	6.54	8.41	20.57	0.50	7235.17	
06/17/98	1:00 PM	6	23.35	8321	6.54	8.41	21.57	1.00	7236.17	
06/24/98	11:00 AM	18	23.28	8329	6.54	8.41	21.17	-0.40	7235.77	
07/01/98	10:00 AM	24	23.4	8319	6.54	8.41	21.67	0.50	7236.27	
07/08/98	8:00 AM	15	23.46	8329	6.54	8.41	21.17	-0.50	7235.77	
07/15/98	8:00 AM	17	23.5	8318	6.54	8.41	21.72	0.55	7236.32	
07/22/98	8:00AM	16	23.4	8319	6.54	8.41	21.67	-0.05	7236.27	
07/29/98	8:00 AM	14	23.43	8318	6.54	8.41	21.72	0.05	7236.32	
08/12/98	9:00 AM	16	23.58	8337	6.54	8.41	20.77	-0.95	7235.37	
08/19/98	11:00 AM	20	23.45	8338	6.54	8.41	20.72	-0.05	7235.32	
08/31/98	9:00 AM	22	23.44	8360	6.54	8.41	19.62	-1.10	7234.22	
09/11/98	10:00 AM	15	23.48	8375	6.54	8.41	18.87	-0.75	7233.47	
09/16/98	11:00 AM	23	23.42	8360	6.54	8.41	19.62	0.75	7234.22	
09/22/98	9:00 AM	17	23.38	8386	6.54	8.41	18.32	-1.30	7232.92	
09/30/98	10:00 AM	16	23.32	8391	6.54	8.41	18.07	-0.25	7232.67	
10/07/98	9:00 AM	6	23.46	8395	6.54	8.41	17.87	-0.20	7232.47	
10/14/98	8:30 AM	5	23.32	8399	6.54	8.41	17.67	-0.20	7232.27	
10/26/98	7:30 AM	6	23.7	8400	6.54	8.41	17.62	-0.05	7232.22	
10/30/98	9:00 AM	3	23.8	8410	6.54	8.41	17.12	-0.50	7231.72	
										Broken wire during tailings reclamation
12/30/98	9:00AM	0	23.49	8393	6.55	8.38	17.97	17.97	7232.57	
1/7/99	12:10PM	6.7		8429	6.54	8.41	16.17	-1.80	7230.77	
02/06/99	9:30AM	5		8431	6.53	8.44	16.07	-0.10	7230.67	
03/06/99	11:00AM	5		8422	6.52	8.48	16.52	0.45	7231.12	
05/06/99	2:30PM	15.6		8398	6.15	9.75	17.67	1.15	7232.27	
07/26/99	1:00PM			8398	6.52	8.48	17.72	0.05	7232.32	

PIEZO #: 29
Twinned with Piezometer # 30
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 164 ft. (Comparative)

STANDPIPE ELEV: 7298.32
COLLAR ELEV: 7294.74
DEPTH TO TOP OF SCREEN: 159.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	92.37	7205.95	76.63	75.21	-0.42	
01/07/98	9:00 AM	92.82	7205.50	76.18	74.76	-0.45	
01/14/98	9:00 AM	93.61	7204.71	75.39	73.97	-0.79	
01/22/98	9:30 AM	93.80	7204.52	75.20	73.78	-0.19	
01/28/98	8:30 AM	92.82	7205.50	76.18	74.76	0.98	
02/03/98	1:00 PM	93.75	7204.57	75.25	73.83	-0.93	
02/12/98	11:30 AM	92.88	7205.44	76.12	74.70	0.87	
02/20/98	9:00 AM	91.94	7206.38	77.06	75.64	0.94	
03/25/98	9:00 AM	91.02	7207.30	77.98	76.56	0.92	
04/02/98	12:40 PM	91.48	7206.84	77.52	76.10	-0.46	
04/08/98	11:00 AM	91.50	7206.82	77.50	76.08	-0.02	
04/15/98	10:30 AM	91.87	7206.45	77.13	75.71	-0.37	
04/22/98	9:30 AM	92.16	7206.16	76.84	75.42	-0.29	
04/29/98	11:00 AM	91.92	7206.40	77.08	75.66	0.24	
05/07/98	9:00 AM	91.82	7206.50	77.18	75.76	0.10	
05/13/98	9:30 PM	91.87	7206.45	77.13	75.71	-0.05	
05/20/98	9:00 AM	92.82	7205.50	76.18	74.76	-0.95	
05/27/98	8:30 AM	92.98	7205.34	76.02	74.60	-0.16	
06/03/98	11:00 AM	92.86	7205.46	76.14	74.72	0.12	
06/10/98	11:00 AM	92.90	7205.42	76.10	74.68	-0.04	
06/17/98	1:00 PM	92.90	7205.42	76.10	74.68	0.00	
06/24/98	11:00 AM	92.95	7205.37	76.05	74.63	-0.05	
07/01/98	10:00 AM	93.35	7204.97	75.65	74.23	-0.40	
07/08/98	8:00 AM	93.40	7204.92	75.60	74.18	-0.05	
07/15/98	8:00 AM	93.97	7204.35	75.03	73.61	-0.57	
07/22/98	8:00AM	93.33	7204.99	75.67	74.25	0.64	
07/29/98	8:00 AM	93.40	7204.92	75.60	74.18	-0.07	
08/12/98	9:00 AM	95.20	7203.12	73.80	72.38	-1.80	
08/19/98	11:00 AM	93.98	7204.34	75.02	73.60	1.22	
08/31/98	9:00 AM	95.95	7202.37	73.05	71.63	-1.97	
09/11/98	10:00 AM	95.30	7203.02	73.70	72.28	0.65	
09/16/98	11:00 AM	97.18	7201.14	71.82	70.40	-1.88	
09/22/98	9:00 AM	97.20	7201.12	71.80	70.38	-0.02	
09/30/98	10:00 AM	97.98	7200.34	71.02	69.60	-0.78	
10/07/98	9:00 AM	98.25	7200.07	70.75	69.33	-0.27	
10/14/98	8:30 AM	98.36	7199.96	70.64	69.22	-0.11	
10/26/98	7:30 AM	98.60	7199.72	70.40	68.98	-0.24	
10/30/98	9:00 AM	98.85	7199.47	70.15	68.73	-0.25	
11/05/98	9:30 AM	98.81	7199.51	70.19	68.77	0.04	
11/18/98	10:00 AM	99.23	7199.09	69.77	68.35	-0.42	
12/30/98	9:00AM	92.37	66.63	76.63	-7064.11	6.86	
1/7/99	12:10PM	100	7335.50	69.00	204.76	-7.63	
02/06/99	9:30AM	103.40	7336.05	65.60	205.31	-3.40	
03/06/99	11:00AM	101.80	7335.82	67.20	205.08	1.60	
05/06/99	2:30PM	108.30	7336.21	60.70	205.47	-6.50	
07/26/99	1:00PM	113.22		55.78	-7130.74	-4.92	

PIEZO #:	30	RO:	8663.00
SERIAL #:	19975	TO:	21.00 deg. C
		C:	0.02226
		K:	-0.0111
		BAROM.	31.57 " Hg
		GE:	7130.7

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	7401	6.49	8.58	65.13	-0.05	7195.83	
01/07/98	9:00 AM	-4	23.26	7416	6.49	8.58	64.36	-0.77	7195.06	
01/14/98	9:00 AM	-7	23.42	7427	6.49	8.58	63.79	-0.56	7194.49	
01/22/98	9:30 AM	-4	23.28	7428	6.49	8.58	63.74	-0.05	7194.44	
01/28/98	8:30 AM	-2	23.3	7433	6.49	8.58	63.48	-0.26	7194.18	
02/03/98	1:00 PM	4	23.06	7437	6.49	8.58	63.28	-0.21	7193.98	
02/12/98	11:30 AM	1	23.35	7414	6.49	8.58	64.46	1.18	7195.16	
02/20/98	9:00 AM	-1	23.13	7401	6.49	8.58	65.13	0.67	7195.83	
03/25/98	9:00 AM	10	23.08	7346	6.59	8.25	67.96	2.83	7198.66	
04/02/98	12:40 PM	6	23.3	7391	6.49	8.58	65.64	-2.32	7196.34	
04/08/98	11:00 AM	4	23.32	7401	6.49	8.58	65.13	-0.51	7195.83	
04/15/98	10:30 AM	0	23.02	7403	6.49	8.58	65.02	-0.10	7195.72	
04/22/98	9:30 AM	11	23.46	7399	6.49	8.58	65.23	0.21	7195.93	
04/29/98	11:00 AM	15	23.42	7396	6.48	8.61	65.38	0.15	7196.08	
05/07/98	9:00 AM	6	23.26	7396	6.49	8.58	65.38	0.00	7196.08	
05/13/98	9:30 PM	10	23	7408	6.49	8.58	64.77	-0.62	7195.47	
05/20/98	9:00 AM	15	23.28	7417	6.49	8.58	64.30	-0.46	7195.00	
05/27/98	8:30 AM	5	23.25	7420	6.49	8.58	64.15	-0.15	7194.85	
06/03/98	11:00 AM	16	23.19	7419	6.49	8.58	64.20	0.05	7194.90	
06/10/98	11:00 AM	10	23.29	7422	6.49	8.58	64.05	-0.15	7194.75	
06/17/98	1:00 PM	6	23.35	7390	6.49	8.58	65.69	1.64	7196.39	
06/24/98	11:00 AM	18	23.28	7420	6.49	8.58	64.15	-1.54	7194.85	
07/01/98	10:00 AM	24	23.4	7424	6.49	8.58	63.95	-0.21	7194.65	
07/08/98	8:00 AM	15	23.46	7420	6.49	8.58	64.15	0.21	7194.85	
07/15/98	8:00 AM	17	23.5	7434	6.49	8.58	63.43	-0.72	7194.13	
07/22/98	8:00AM	16	23.4	7436	6.49	8.58	63.33	-0.10	7194.03	
07/29/98	8:00 AM	14	23.43	7442	6.49	8.58	63.02	-0.31	7193.72	
08/12/98	9:00 AM	16	23.58	7455	6.5	8.54	62.35	-0.67	7193.05	
08/19/98	11:00 AM	20	23.45	7450	6.5	8.54	62.61	0.26	7193.31	
08/31/98	9:00 AM	22	23.44	7450	6.5	8.54	62.61	0.00	7193.31	
09/11/98	10:00 AM	15	23.48	7473	6.5	8.54	61.43	-1.18	7192.13	
09/16/98	11:00 AM	23	23.42	7486	6.51	8.51	60.76	-0.67	7191.46	
09/22/98	9:00 AM	17	23.38	7485	6.5	8.54	60.81	0.05	7191.51	
09/30/98	10:00 AM	16	23.32	7507	6.51	8.51	59.68	-1.13	7190.38	
10/07/98	9:00 AM	6	23.46	7516	6.51	8.51	59.22	-0.46	7189.92	
10/14/98	8:30 AM	5	23.32	7527	6.51	8.51	58.66	-0.56	7189.36	
10/26/98	7:30 AM	6	23.7	7529	6.52	8.48	58.56	-0.10	7189.26	
10/30/98	9:00 AM	3	23.8	7536	6.51	8.51	58.20	-0.36	7188.90	
										Broken wire during tailings reclamation
1/7/99	12:10PM	6.7		7564	6.53	8.44	56.76	56.76	7187.46	
02/06/99	9:30AM	5		7623	6.53	8.44	53.73	-3.03	7184.43	
03/06/99	11:00AM	5		7670	6.53	8.44	51.32	-2.41	7182.02	
05/06/99	2:30PM	15.6		7713	6.51	8.51	49.11	-2.21	7179.81	
07/26/99	1:00PM			7807	6.5	8.54	44.28	-4.83	7174.98	

PIEZO #: 31
SERIAL #: 19976

RO: 8891.00
TO: 21.00 deg. C
C: 0.02393
K: -0.0168
BAROM. 31.57 " Hg
GE: 7200.1

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8416	6.60	8.21	26.72	-0.39	7226.82	
01/07/98	9:00 AM	-4	23.26	8428	6.6	8.21	26.06	-0.66	7226.16	
01/14/98	9:00 AM	-7	23.42	8437	6.59	8.25	25.56	-0.50	7225.66	
01/22/98	9:30 AM	-4	23.28	8442	6.60	8.21	25.28	-0.27	7225.38	
01/28/98	8:30 AM	-2	23.3	8443	6.60	8.21	25.23	-0.06	7225.33	
02/03/98	1:00 PM	4	23.06	8445	6.60	8.21	25.12	-0.11	7225.22	
02/12/98	11:30 AM	1	23.35	8421	6.59	8.25	26.44	1.32	7226.54	
02/20/98	9:00 AM	-1	23.13	8394	6.59	8.25	27.93	1.49	7228.03	
03/25/98	9:00 AM	10	23.08	8350	6.59	8.25	30.36	2.43	7230.46	
04/02/98	12:40 PM	6	23.3	8344	6.59	8.25	30.69	0.33	7230.79	
04/08/98	11:00 AM	4	23.32	8394	6.59	8.25	27.93	-2.76	7228.03	
04/15/98	10:30 AM	0	23.02	8344	6.59	8.25	30.69	2.76	7230.79	
04/22/98	9:30 AM	11	23.46	8339	6.59	8.25	30.97	0.28	7231.07	
04/29/98	11:00 AM	15	23.42	8337	6.59	8.25	31.08	0.11	7231.18	
05/07/98	9:00 AM	6	23.26	8345	6.59	8.25	30.64	-0.44	7230.74	
05/13/98	9:30 PM	10	23	8357	6.60	8.21	29.98	-0.66	7230.08	
05/20/98	9:00 AM	15	23.28	8364	6.60	8.21	29.59	-0.39	7229.69	
05/27/98	8:30 AM	5	23.25	8372	6.60	8.21	29.15	-0.44	7229.25	
06/03/98	11:00 AM	16	23.19	8373	6.60	8.21	29.09	-0.06	7229.19	
06/10/98	11:00 AM	10	23.29	8365	6.60	8.21	29.53	0.44	7229.63	
06/17/98	1:00 PM	6	23.35	8344	6.59	8.25	30.69	1.16	7230.79	
06/24/98	11:00 AM	18	23.28	8352	6.60	8.21	30.25	-0.44	7230.35	
07/01/98	10:00 AM	24	23.4	8343	6.60	8.21	30.75	0.50	7230.85	
07/08/98	8:00 AM	15	23.46	8352	6.60	8.21	30.25	-0.50	7230.35	
07/15/98	8:00 AM	17	23.5	8341	6.60	8.21	30.86	0.61	7230.96	
07/22/98	8:00AM	16	23.4	8342	6.60	8.21	30.80	-0.06	7230.90	
07/29/98	8:00 AM	14	23.43	8341	6.60	8.21	30.86	0.06	7230.96	
08/12/98	9:00 AM	16	23.58	8363	6.61	8.18	29.65	-1.21	7229.75	
08/19/98	11:00 AM	20	23.45	8363	6.61	8.18	29.65	0.00	7229.75	
08/31/98	9:00 AM	22	23.44	8385	6.61	8.18	28.43	-1.21	7228.53	
09/11/98	10:00 AM	15	23.48	8400	6.61	8.18	27.60	-0.83	7227.70	
09/16/98	11:00 AM	23	23.42	8364	6.61	8.18	29.59	1.99	7229.69	
09/22/98	9:00 AM	17	23.38	8411	6.61	8.18	27.00	-2.59	7227.10	
09/30/98	10:00 AM	16	23.32	8446	6.61	8.18	25.06	-1.93	7225.16	
10/07/98	9:00 AM	6	23.46	8422	6.61	8.18	26.39	1.32	7226.49	
10/14/98	8:30 AM	5	23.32	8427	6.61	8.18	26.11	-0.28	7226.21	
10/26/98	7:30 AM	6	23.7	8434	6.61	8.18	25.73	-0.39	7225.83	
10/30/98	9:00 AM	3	23.8	8437	6.61	8.18	25.56	-0.17	7225.66	
										Broken wire during tailings reclamation
12/30/98	9:00AM	0	23.49	8416	6.61	8.18	26.72	26.72	7226.82	
1/7/99	12:10PM	6.7		8454	6.61	8.18	24.62	-2.10	7224.72	
02/06/99	9:30AM	5		8453	6.60	8.21	24.68	0.05	7224.78	
03/06/99	11:00AM	5		8444	6.59	8.25	25.17	0.50	7225.27	
05/06/99	2:30PM	15.6		8419	6.57	8.31	26.55	1.38	7226.65	
07/26/99	1:00PM			8419	6.58	8.28	26.55	0.00	7226.65	

PIEZO #: 32
SERIAL #: 19979

RO: 8657.00
TO: 21.00 deg. C
C: 0.02118
K: -0.02118
BAROM. 31.57 " Hg
GE: 7030.8

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8816	5.8	11.02	-7.28	0.30	7023.52	
01/07/98	9:00 AM	-4	23.26	8821	5.8	11.02	-7.53	-0.24	7023.27	
01/14/98	9:00 AM	-7	23.42	8820	5.79	11.06	-7.48	0.05	7023.32	
01/22/98	9:30 AM	-4	23.28	8822	5.79	11.06	-7.58	-0.10	7023.22	
01/28/98	8:30 AM	-2	23.3	8820	5.79	11.06	-7.48	0.10	7023.32	
02/03/98	1:00 PM	4	23.06	8825	5.79	11.06	-7.72	-0.24	7023.08	
02/12/98	11:30 AM	1	23.35	8820	5.7	11.40	-7.50	0.23	7023.30	
02/20/98	9:00 AM	-1	23.13	8824	5.87	10.76	-7.66	-0.16	7023.14	
03/25/98	9:00 AM	10	23.08	8825	5.8	11.02	-7.72	-0.06	7023.08	
04/02/98	12:40 PM	6	23.3	8825	5.8	11.02	-7.72	0.00	7023.08	
04/08/98	11:00 AM	4	23.32	8884	5.8	11.02	-10.60	-2.88	7020.20	
04/15/98	10:30 AM	0	23.02	8827	5.8	11.02	-7.82	2.79	7022.98	
04/22/98	9:30 AM	11	23.46	8817	5.8	11.02	-7.33	0.49	7023.47	
04/29/98	11:00 AM	15	23.42	8818	5.8	11.02	-7.38	-0.05	7023.42	
05/07/98	9:00 AM	6	23.26	8821	5.8	11.02	-7.53	-0.15	7023.27	
05/13/98	9:30 PM	10	23	8827	5.8	11.02	-7.82	-0.29	7022.98	
05/20/98	9:00 AM	15	23.28	8820	5.8	11.02	-7.48	0.34	7023.32	
05/27/98	8:30 AM	5	23.25	8823	5.8	11.02	-7.62	-0.15	7023.18	
06/03/98	11:00 AM	16	23.19	8823	5.8	11.02	-7.62	0.00	7023.18	
06/10/98	11:00 AM	10	23.29	8822	5.8	11.02	-7.57	0.05	7023.23	
06/17/98	1:00 PM	6	23.35	8825	5.8	11.02	-7.72	-0.15	7023.08	
06/24/98	11:00 AM	18	23.28	8821	5.8	11.02	-7.53	0.20	7023.27	
07/01/98	10:00 AM	24	23.4	8819	5.8	11.02	-7.43	0.10	7023.37	
07/08/98	8:00 AM	15	23.46	8820	5.8	11.02	-7.48	-0.05	7023.32	
07/15/98	8:00 AM	17	23.5	8816	5.8	11.02	-7.28	0.20	7023.52	
07/22/98	8:00AM	16	23.4	8817	5.8	11.02	-7.33	-0.05	7023.47	
07/29/98	8:00 AM	14	23.43	8817	5.81	11.02	-7.33	0.00	7023.47	
08/12/98	9:00 AM	16	23.58	8814	5.81	5.81	-6.93	0.40	7023.87	
08/19/98	11:00 AM	20	23.45	8816	5.81	10.98	-7.28	-0.35	7023.52	
08/31/98	9:00 AM	22	23.44	8817	5.81	10.98	-7.33	-0.05	7023.47	
09/11/98	10:00 AM	15	23.48	8818	5.81	10.98	-7.38	-0.05	7023.42	
09/16/98	11:00 AM	23	23.42	8818	5.81	10.98	-7.38	0.00	7023.42	
09/22/98	9:00 AM	17	23.38	8819	5.81	10.98	-7.43	-0.05	7023.37	
09/30/98	10:00 AM	16	23.32	8821	5.81	10.98	-7.52	-0.10	7023.28	
10/07/98	9:00 AM	6	23.46	8817	5.81	10.98	-7.33	0.20	7023.47	
10/14/98	8:30 AM	5	23.32	8821	5.81	10.98	-7.52	-0.20	7023.28	
10/26/98	7:30 AM	6	23.7	8822	5.81	10.98	-7.57	-0.05	7023.23	
10/30/98	9:00 AM	3	23.8	8823	5.81	10.98	-7.62	-0.05	7023.18	
11/05/98	9:30 AM			8823	5.81	10.98	-7.62	0.00	7023.18	
11/13/98	10:00 AM	4	23.4	8816	5.81	10.98	-7.28	0.34	7023.52	
11/18/98	10:00 AM	0	23.4	8821	5.81	10.98	-7.52	-0.24	7023.28	
12/30/98	9:00AM	0	23.49	8816	5.8	11.02	-7.28	0.24	7023.52	
1/7/99	12:10PM	6.7		8822	5.81	10.98	-7.57	-0.29	7023.23	
02/06/99	9:30AM	5		8822	5.82	10.94	-7.57	0.00	7023.23	
03/06/99	11:00AM	5		8826	5.82	10.94	-7.77	-0.20	7023.03	
05/06/99	2:30PM	15.6		8819	5.82	10.94	-7.42	0.34	7023.38	
07/26/99	1:00PM			8817	5.83	10.91	-7.32	0.10	7023.48	

PIEZO #: 33
Twinned with Piezometer # 32
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 217 ft. (Comparative)

STANDPIPE ELEV: 7257.05
COLLAR ELEV: 7252.78
DEPTH TO TOP OF SCREEN: 212.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	222	7035.05	0.00	-0.73	0.00	
01/07/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
01/14/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
01/22/98	9:30 AM	222	7035.05	0.00	-0.73	0.00	
01/28/98	8:30 AM	222	7035.05	0.00	-0.73	0.00	
02/03/98	1:00 PM	222	7035.05	0.00	-0.73	0.00	
02/12/98	11:30 AM	222	7035.05	0.00	-0.73	0.00	
02/20/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
03/25/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
04/02/98	12:40 PM	222	7035.05	0.00	-0.73	0.00	
04/08/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
04/15/98	10:30 AM	222	7035.05	0.00	-0.73	0.00	
04/22/98	9:30 AM	222	7035.05	0.00	-0.73	0.00	
04/29/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
05/07/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
05/13/98	9:30 PM	222	7035.05	0.00	-0.73	0.00	
05/20/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
05/27/98	8:30 AM	222	7035.05	0.00	-0.73	0.00	
06/03/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
06/10/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
06/17/98	1:00 PM	222	7035.05	0.00	-0.73	0.00	
06/24/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
07/01/98	10:00 AM	222	7035.05	0.00	-0.73	0.00	
07/08/98	8:00 AM	222	7035.05	0.00	-0.73	0.00	
07/15/98	8:00 AM	222	7035.05	0.00	-0.73	0.00	
07/22/98	8:00AM	222	7035.05	0.00	-0.73	0.00	
07/29/98	8:00 AM	222	7035.05	0.00	-0.73	0.00	
08/12/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
08/19/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
08/31/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
09/11/98	10:00 AM	222	7035.05	0.00	-0.73	0.00	
09/16/98	11:00 AM	222	7035.05	0.00	-0.73	0.00	
09/22/98	9:00 AM	222	7035.05	0.00	-0.73	0.00	
09/30/98	10:00 AM	222	7035.05	0.00	-0.73	0.00	
12/30/98	9:00AM	222	-10.00	0.00	-7045.78	0.00	

PIEZO #: 34
SERIAL #: 10897

RO: 9757.00
TO: 19.00 deg. C
C: 0.02168
K: -0.0304
BAROM. 31.57 " Hg
GE: 7122.7

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9928	5.62	11.70	-8.04	0.35	7114.66	
01/07/98	9:00 AM	-4	23.26	9934	5.62	11.70	-8.34	-0.30	7114.36	
01/14/98	9:00 AM	-7	23.42	9932	5.62	11.70	-8.24	0.10	7114.46	
01/22/98	9:30 AM	-4	23.28	9945	5.62	11.70	-8.89	-0.65	7113.81	
01/28/98	8:30 AM	-2	23.3	9933	5.63	11.66	-8.29	0.60	7114.41	
02/03/98	1:00 PM	4	23.06	9938	5.63	11.66	-8.54	-0.25	7114.16	
02/12/98	11:30 AM	1	23.35	9933	5.63	11.66	-8.29	0.25	7114.41	
02/20/98	9:00 AM	-1	23.13	9938	5.64	11.63	-8.54	-0.25	7114.16	
03/25/98	9:00 AM	10	23.08	9939	5.63	11.66	-8.59	-0.05	7114.11	
04/02/98	12:40 PM	6	23.3	9938	5.64	11.63	-8.54	0.05	7114.16	
04/08/98	11:00 AM	4	23.32	9938	5.64	11.63	-8.54	0.00	7114.16	
04/15/98	10:30 AM	0	23.02	9941	5.63	11.66	-8.69	-0.15	7114.01	
04/22/98	9:30 AM	11	23.46	9931	5.64	11.63	-8.19	0.50	7114.51	
04/29/98	11:00 AM	15	23.42	9932	5.66	11.55	-8.23	-0.04	7114.47	
05/07/98	9:00 AM	6	23.26	9935	5.64	11.63	-8.39	-0.16	7114.31	
05/13/98	9:30 PM	10	23	9941	5.61	11.74	-8.69	-0.31	7114.01	
05/20/98	9:00 AM	15	23.28	9935	5.64	11.63	-8.39	0.31	7114.31	
05/27/98	8:30 AM	5	23.25	9935	5.64	11.63	-8.39	0.00	7114.31	
06/03/98	11:00 AM	16	23.19	9936	5.64	11.63	-8.44	-0.05	7114.26	
06/10/98	11:00 AM	10	23.29	9935	5.63	11.66	-8.39	0.05	7114.31	
06/17/98	1:00 PM	6	23.35	9937	5.63	11.66	-8.49	-0.10	7114.21	
06/24/98	11:00 AM	18	23.28	9935	5.64	11.63	-8.39	0.10	7114.31	
07/01/98	10:00 AM	24	23.4	9933	5.65	11.59	-8.28	0.10	7114.42	
07/08/98	8:00 AM	15	23.46	9936	5.64	11.63	-8.44	-0.15	7114.26	
07/15/98	8:00 AM	17	23.5	9929	5.65	11.59	-8.08	0.35	7114.62	
07/22/98	8:00AM	16	23.4	9931	5.65	11.59	-8.18	-0.10	7114.52	
07/29/98	8:00 AM	14	23.43	9931	5.65	11.59	-8.18	0.00	7114.52	
08/12/98	9:00 AM	16	23.58	9928	5.65	11.59	-8.03	0.15	7114.67	
08/19/98	11:00 AM	20	23.45	9930	5.65	11.59	-8.13	-0.10	7114.57	
08/31/98	9:00 AM	22	23.44	9931	5.65	11.59	-8.18	-0.05	7114.52	
09/11/98	10:00 AM	15	23.48	9933	5.65	11.59	-8.28	-0.10	7114.42	
09/16/98	11:00 AM	23	23.42	9930	5.65	11.59	-8.13	0.15	7114.57	
09/22/98	9:00 AM	17	23.38	9934	5.65	11.59	-8.33	-0.20	7114.37	
09/30/98	10:00 AM	16	23.32	9935	5.65	11.59	-8.38	-0.05	7114.32	
10/07/98	9:00 AM	6	23.46	9932	5.65	11.59	-8.23	0.15	7114.47	
10/14/98	8:30 AM	5	23.32	9936	5.65	11.59	-8.43	-0.20	7114.27	
10/26/98	7:30 AM	6	23.7	9936	5.66	11.55	-8.43	0.00	7114.27	
10/30/98	9:00 AM	3	23.8	9938	5.65	11.59	-8.53	-0.10	7114.17	
11/05/98	9:30 AM	0	0	9937	5.65	11.59	-8.48	0.05	7114.22	
11/13/98	10:00 AM	4	23.4	9931	5.66	11.55	-8.18	0.30	7114.52	
11/18/98	10:00 AM	0	23.4	9936	5.66	11.55	-8.43	-0.25	7114.27	
1/7/99	12:10PM	6.7		9937	5.66	11.55	-8.48	-0.05	7114.22	
02/06/99	9:30AM	5		9937	5.66	11.55	-8.48	0.00	7114.22	
03/06/99	11:00AM	5	•	9942	5.67	11.51	-8.73	-0.25	7113.97	
05/06/99	2:30PM	15.6		9935	5.68	11.47	-8.37	0.35	7114.33	
07/26/99	1:00PM			9935	5.69	11.43	-8.37	0.00	7114.33	

PIEZO #: 35
Twinned with Piezometer # 34
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 130 ft. (Comparative)

STANDPIPE ELEV: 7256.93
COLLAR ELEV: 7252.66
DEPTH TO TOP OF SCREEN: 125.50
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	135.50	7121.43	0.00	85.77	0.00	An Effective Pressure of 0.00 ft H2O is indicative of a dry standpipe
01/07/98	9:00 AM	135.50	7121.43	0.00	85.77	0.00	
01/14/98	9:00 AM	135.5	7121.43	0	85.77	0.00	
01/22/98	9:30 AM	135.5	7121.43	0	85.77	0.00	
01/28/98	8:30 AM	135.50	7121.43	0.00	85.77	0.00	
02/03/98	1:00 PM	135.5	7121.43	0.00	85.77	0.00	
02/12/98	11:30 AM	135.5	7121.43	0.00	85.77	0.00	
02/20/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
03/25/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
04/02/98	12:40 PM	135.5	7121.43	0.00	85.77	0.00	
04/08/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
04/15/98	10:30 AM	135.5	7121.43	0.00	85.77	0.00	
04/22/98	9:30 AM	135.5	7121.43	0.00	85.77	0.00	
04/29/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
05/07/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
05/13/98	9:30 PM	135.5	7121.43	0.00	85.77	0.00	
05/20/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
05/27/98	8:30 AM	135.5	7121.43	0.00	85.77	0.00	
06/03/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
06/10/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
06/17/98	1:00 PM	135.5	7121.43	0.00	85.77	0.00	
06/24/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
07/01/98	10:00 AM	135.5	7121.43	0.00	85.77	0.00	
07/08/98	8:00 AM	135.5	7121.43	0.00	85.77	0.00	
07/15/98	8:00 AM	135.5	7121.43	0.00	85.77	0.00	
07/22/98	8:00AM	135.5	7121.43	0.00	85.77	0.00	
07/29/98	8:00 AM	135.5	7121.43	0.00	85.77	0.00	
08/12/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
08/19/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
08/31/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
09/11/98	10:00 AM	135.5	7121.43	0.00	85.77	0.00	
09/16/98	11:00 AM	135.5	7121.43	0.00	85.77	0.00	
09/22/98	9:00 AM	135.5	7121.43	0.00	85.77	0.00	
09/30/98	10:00 AM	135.5	7121.43	0.00	85.77	0.00	
12/30/98	9:00AM	135.50	-10.00	0.00	197.00	0.00	An Effective Pressure of 0.00 ft H2O is indicative of a dry standpipe

PIEZO #: 36
SERIAL #: 19978

RO: 8582.00
TO: 21.00 deg. C
C: 0.02204
K: -0.00661
BAROM. 31.57 " Hg
GE: 6963.8

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8724	6.06	10.07	-7.05	0.31	6956.75	
01/07/98	9:00 AM	-4	23.26	8729	6.09	9.96	-7.31	-0.25	6956.49	
01/14/98	9:00 AM	-7	23.42	8726	6.06	10.07	-7.16	0.15	6956.64	
01/22/98	9:30 AM	-4	23.28	8729	6.06	10.07	-7.31	-0.15	6956.49	
01/28/98	8:30 AM	-2	23.3	8728	6.06	10.07	-7.26	0.05	6956.54	
02/03/98	1:00 PM	4	23.06	8733	6.06	10.07	-7.51	-0.25	6956.29	
02/12/98	11:30 AM	1	23.35	8728	6.05	10.10	-7.26	0.25	6956.54	
02/20/98	9:00 AM	-1	23.13	8732	6.06	10.07	-7.46	-0.20	6956.34	
03/25/98	9:00 AM	10	23.08	8733	6.06	10.07	-7.51	-0.05	6956.29	
04/02/98	12:40 PM	6	23.3	8732	6.06	10.07	-7.46	0.05	6956.34	
04/08/98	11:00 AM	4	23.32	8733	6.06	10.07	-7.51	-0.05	6956.29	
04/15/98	10:30 AM	0	23.02	8735	6.06	10.07	-7.61	-0.10	6956.19	
04/22/98	9:30 AM	11	23.46	8724	6.06	10.07	-7.05	0.56	6956.75	
04/29/98	11:00 AM	15	23.42	8726	6.06	10.07	-7.16	-0.10	6956.64	
05/07/98	9:00 AM	6	23.26	8729	6.06	10.07	-7.31	-0.15	6956.49	
05/13/98	9:30 PM	10	23	8734	6.06	10.07	-7.56	-0.25	6956.24	
05/20/98	9:00 AM	15	23.28	8728	6.06	10.07	-7.26	0.31	6956.54	
05/27/98	8:30 AM	5	23.25	8729	6.02	10.21	-7.31	-0.05	6956.49	
06/03/98	11:00 AM	16	23.19	8732	6.06	10.07	-7.46	-0.15	6956.34	
06/10/98	11:00 AM	10	23.29	8729	6.06	10.07	-7.31	0.15	6956.49	
06/17/98	1:00 PM	6	23.35	8733	6.06	10.07	-7.51	-0.20	6956.29	
06/24/98	11:00 AM	18	23.28	8729	6.06	10.07	-7.31	0.20	6956.49	
07/01/98	10:00 AM	24	23.4	8727	6.06	10.07	-7.21	0.10	6956.59	
07/08/98	8:00 AM	15	23.46	8730	6.06	10.07	-7.36	-0.15	6956.44	
07/15/98	8:00 AM	17	23.5	8723	6.06	10.07	-7.00	0.36	6956.80	
07/22/98	8:00AM	16	23.4	8725	6.06	10.07	-7.10	-0.10	6956.70	
07/29/98	8:00 AM	14	23.43	8725	6.06	10.07	-7.10	0.00	6956.70	
08/12/98	9:00 AM	16	23.58	8722	6.06	10.07	-6.95	0.15	6956.85	
08/19/98	11:00 AM	20	23.45	8725	6.06	10.07	-7.10	-0.15	6956.70	
08/31/98	9:00 AM	22	23.44	8724	6.06	10.07	-7.05	0.05	6956.75	
09/11/98	10:00 AM	15	23.48	8726	6.06	10.07	-7.16	-0.10	6956.64	
09/16/98	11:00 AM	23	23.42	8725	6.06	10.07	-7.10	0.05	6956.70	
09/22/98	9:00 AM	17	23.38	8727	6.06	10.07	-7.21	-0.10	6956.59	
09/30/98	10:00 AM	16	23.32	8728	6.06	10.07	-7.26	-0.05	6956.54	
10/07/98	9:00 AM	6	23.46	8725	6.06	10.07	-7.10	0.15	6956.70	
10/14/98	8:30 AM	5	23.32	8730	6.06	10.07	-7.36	-0.25	6956.44	
10/26/98	7:30 AM	6	23.7	8729	6.06	10.07	-7.31	0.05	6956.49	
10/30/98	9:00 AM	3	23.8	8731	6.06	10.07	-7.41	-0.10	6956.39	
11/05/98	9:30 AM			8731	6.06	10.07	-7.41	0.00	6956.39	
11/13/98	10:00 AM	4	23.4	8724	6.06	10.07	-7.05	0.36	6956.75	
11/18/98	10:00 AM	0	23.4	8729	6.06	10.07	-7.31	-0.25	6956.49	
1/7/99	12:10PM	6.7		8730	6.06	10.07	-7.36	-0.05	6956.44	
02/06/99	9:30AM	5		8729	6.06	10.07	-7.31	0.05	6956.49	
03/06/99	11:00AM	5		8734	6.06	10.07	-7.56	-0.25	6956.24	
05/06/99	2:30PM	15.6		8726	6.07	10.03	-7.15	0.41	6956.65	
07/26/99	1:00PM			8725	6.07	10.03	-7.10	0.05	6956.70	

PIEZO #: 37
Twinned with Piezometer # 36
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 289 ft. (Comparative)

STANDPIPE ELEV: 7256.93
COLLAR ELEV: 7252.83
DEPTH TO TOP OF SCREEN: 284.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	294	6962.93	0.00	-72.90	0.00	
01/07/98	9:00 AM	294.00	6962.93	0.00	-72.90	0.00	
01/14/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
01/22/98	9:30 AM	294	6962.93	0.00	-72.90	0.00	
01/28/98	8:30 AM	294	6962.93	0.00	-72.90	0.00	
02/03/98	1:00 PM	294	6962.93	0.00	-72.90	0.00	
02/12/98	11:30 AM	294	6962.93	0.00	-72.90	0.00	
02/20/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
03/25/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
04/02/98	12:40 PM	294	6962.93	0.00	-72.90	0.00	
04/08/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
04/15/98	10:30 AM	294	6962.93	0.00	-72.90	0.00	
04/22/98	9:30 AM	294	6962.93	0.00	-72.90	0.00	
04/29/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
05/07/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
05/13/98	9:30 PM	294	6962.93	0.00	-72.90	0.00	
05/20/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
05/27/98	8:30 AM	294	6962.93	0.00	-72.90	0.00	
06/03/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
06/10/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
06/17/98	1:00 PM	294	6962.93	0.00	-72.90	0.00	
06/24/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
07/01/98	10:00 AM	294	6962.93	0.00	-72.90	0.00	
07/08/98	8:00 AM	294	6962.93	0.00	-72.90	0.00	
07/15/98	8:00 AM	294	6962.93	0.00	-72.90	0.00	
07/22/98	8:00AM	294	6962.93	0.00	-72.90	0.00	
07/29/98	8:00 AM	294	6962.93	0.00	-72.90	0.00	
08/12/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
08/19/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
08/31/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
09/11/98	10:00 AM	294	6962.93	0.00	-72.90	0.00	
09/16/98	11:00 AM	294	6962.93	0.00	-72.90	0.00	
09/22/98	9:00 AM	294	6962.93	0.00	-72.90	0.00	
09/30/98	10:00 AM	294	6962.93	0.00	-72.90	0.00	

PIEZO #: 38
SERIAL #: 10899

RO: 9270.00
TO: 19.00 deg. C
C: 0.02389
K: -0.0334
BAROM. 31.57 " Hg
GE: 7191.3

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8580	6.41	8.85	38.81	-0.06	7230.11	
01/07/98	9:00 AM	-4	23.26	8588	6.42	8.81	38.37	-0.44	7229.67	
01/14/98	9:00 AM	-7	23.42	8580	6.41	8.85	38.81	0.44	7230.11	
01/22/98	9:30 AM	-4	23.28	8591	6.41	8.85	38.20	-0.61	7229.50	
01/28/98	8:30 AM	-2	23.3	8590	6.41	8.85	38.26	0.06	7229.56	
02/03/98	1:00 PM	4	23.06	8598	6.41	8.85	37.82	-0.44	7229.12	
02/12/98	11:30 AM	1	23.35	8584	6.42	8.81	38.59	0.77	7229.89	
02/20/98	9:00 AM	-1	23.13	8574	6.43	8.78	39.15	0.55	7230.45	
03/25/98	9:00 AM	10	23.08	8559	6.41	8.85	39.97	0.82	7231.27	
04/02/98	12:40 PM	6	23.3	8553	6.41	8.85	40.30	0.33	7231.60	
04/08/98	11:00 AM	4	23.32	8555	6.41	8.85	40.19	-0.11	7231.49	
04/15/98	10:30 AM	0	23.02	8556	6.41	8.85	40.13	-0.06	7231.43	
04/22/98	9:30 AM	11	23.46	8554	6.41	8.85	40.24	0.11	7231.54	
04/29/98	11:00 AM	15	23.42	8554	6.41	8.85	40.24	0.00	7231.54	
05/07/98	9:00 AM	6	23.26	8557	6.34	9.09	40.06	-0.18	7231.36	
05/13/98	9:30 PM	10	23	8555	6.34	9.09	40.17	0.11	7231.47	
05/20/98	9:00 AM	15	23.28	8554	6.41	8.85	40.24	0.07	7231.54	
05/27/98	8:30 AM	5	23.25	8568	6.42	8.81	39.48	-0.77	7230.78	
06/03/98	11:00 AM	16	23.19	8573	6.41	8.85	39.20	-0.28	7230.50	
06/10/98	11:00 AM	10	23.29	8570	6.42	8.81	39.36	0.17	7230.66	
06/17/98	1:00 PM	6	23.35	8552	6.41	8.85	40.35	0.99	7231.65	
06/24/98	11:00 AM	18	23.28	8567	6.41	8.85	39.53	-0.83	7230.83	
07/01/98	10:00 AM	24	23.4	8565	6.41	8.85	39.64	0.11	7230.94	
07/08/98	8:00 AM	15	23.46	8566	6.40	8.88	39.58	-0.06	7230.88	
07/15/98	8:00 AM	17	23.5	8564	6.41	8.85	39.69	0.11	7230.99	
07/22/98	8:00AM	16	23.4	8566	6.45	8.71	39.59	-0.10	7230.89	
07/29/98	8:00 AM	14	23.43	8567	6.31	9.19	39.50	-0.09	7230.80	
08/12/98	9:00 AM	16	23.58	8566	6.41	8.85	39.58	0.08	7230.88	
08/19/98	11:00 AM	20	23.45	8567	6.41	8.85	39.53	-0.06	7230.83	
08/31/98	9:00 AM	22	23.44	8580	6.41	8.85	38.81	-0.72	7230.11	
09/11/98	10:00 AM	15	23.48	8564	6.41	8.85	39.69	0.88	7230.99	
09/16/98	11:00 AM	23	23.42	8567	6.41	8.85	39.53	-0.17	7230.83	
09/22/98	9:00 AM	17	23.38	8590	6.41	8.85	38.26	-1.27	7229.56	
09/30/98	10:00 AM	16	23.32	8592	6.40	8.88	38.15	-0.11	7229.45	
10/07/98	9:00 AM	6	23.46	8595	6.40	8.88	37.98	-0.17	7229.28	
10/14/98	8:30 AM	5	23.32	8598	6.41	8.85	37.82	-0.16	7229.12	
10/26/98	7:30 AM	6	23.7	8599	6.35	9.05	37.75	-0.07	7229.05	
10/30/98	9:00 AM	3	23.8	8602	6.39	8.91	37.59	-0.15	7228.89	
11/05/98	9:30 AM			8605	6.41	8.85	37.43	-0.16	7228.73	
11/13/98	10:00 AM	4	23.4	8602	6.40	8.88	37.60	0.16	7228.90	
11/18/98	10:00 AM	0	23.4	8606	6.40	8.88	37.38	-0.22	7228.68	
12/30/98	9:00AM	0	23.49	8580	6.41	8.85	38.81	1.44	7230.11	
1/7/99	12:10PM	6.7		8615	6.4	8.88	36.88	-1.93	7228.18	
02/06/99	9:30AM	5		8617	6.37	8.98	36.76	-0.12	7228.06	
03/06/99	11:00AM	5		8618	6.38	8.95	36.71	-0.05	7228.01	
05/06/99	2:30PM	15.6		8612	6.40	8.88	37.04	0.34	7228.34	
07/26/99	1:00PM			8610	6.40	8.88	37.16	0.11	7228.46	

PIEZO #: 41
Twinned with Piezometer # 36
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 119 ft. (Comparative)

STANDPIPE ELEV: 7317.29
COLLAR ELEV: 7313.49
DEPTH TO TOP OF SCREEN: 114.00
SCREEN LENGTH 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	76	7241.29	48.00	144.80	0.21	
1/7/98	9:00 AM	75.82	7241.47	48.18	144.98	0.18	
1/14/98	9:00 AM	76.12	7241.17	47.88	144.68	-0.30	
01/22/98	9:30 AM	76	7241.29	48.00	144.80	0.12	
01/28/98	8:30 AM	76.12	7241.17	47.88	144.68	-0.12	
02/03/98	1:00 PM	76.22	7241.07	47.78	144.58	-0.10	
02/12/98	11:30 AM	76.1	7241.19	47.90	144.70	0.12	
02/20/94	9:00 AM	76.13	7241.16	47.87	144.67	-0.03	
03/25/98	9:00 AM	74.1	7243.19	49.90	146.70	2.03	
04/02/98	12:40 PM	74.61	7242.68	49.39	146.19	-0.51	
04/08/98	11:00 AM	74.4	7242.89	49.60	146.40	0.21	
04/15/98	10:30 AM	75.04	7242.25	48.96	145.76	-0.64	
04/22/98	9:30 AM	74.98	7242.31	49.02	145.82	0.06	
4/29/98	11:00 AM	75.3	7241.99	48.70	145.50	-0.32	
05/07/98	9:00 AM	75.67	7241.62	48.33	145.13	-0.37	
05/13/98	9:30 PM	75.4	7241.89	48.60	145.40	0.27	
05/20/98	9:00 AM	76.04	7241.25	47.96	144.76	-0.64	
05/27/98	8:30 AM	76.03	7241.26	47.97	144.77	0.01	
06/03/98	11:00 AM	76.08	7241.21	47.92	144.72	-0.05	
06/10/98	11:00 AM	76.07	7241.22	47.93	144.73	0.01	
06/17/98	1:00 PM	76.05	7241.24	47.95	144.75	0.02	
06/24/98	11:00 AM	75.36	7241.93	48.64	145.44	0.69	
07/01/98	10:00 AM	74.93	7242.36	49.07	145.87	0.43	
07/08/98	8:00 AM	75.2	7242.09	48.80	145.60	-0.27	
07/15/98	8:00 AM	75.65	7241.64	48.35	145.15	-0.45	
07/22/98	8:00AM	75.71	7241.58	48.29	145.09	-0.06	
07/29/98	8:00 AM	75.75	7241.54	48.25	145.05	-0.04	
08/12/98	9:00 AM	75.98	7241.31	48.02	144.82	-0.23	
08/19/98	11:00 AM	75.95	7241.34	48.05	144.85	0.03	
08/31/98	9:00 AM	76.8	7240.49	47.20	144.00	-0.85	
09/11/98	10:00 AM	76.3	7240.99	47.70	144.50	0.50	
09/16/98	11:00 AM	76.98	7240.31	47.02	143.82	-0.68	
09/22/98	9:00 AM	76.95	7240.34	47.05	143.85	0.03	
09/30/98	10:00 AM						
10/07/98	9:00 AM	77.15	7240.14	46.85	143.65	-0.20	
10/14/98	8:30 AM	78.58	7238.71	45.42	142.22	-1.43	
10/26/98	7:30 AM	77.42	7239.87	46.58	143.38	1.16	
10/30/98	9:00 AM	77.59	7239.70	46.41	143.21	-0.17	
11/05/98	9:30 AM	77.59	7239.70	46.41	143.21	0.00	
11/18/98	10:00 AM	77.57	7239.72	46.43	143.23	0.02	
12/30/98	9:00AM	76	38.00	48.00	-7058.49	1.57	
1/7/99	12:10PM	78.00	7335.50	46.00	239.01	-2.00	
2/6/99	9:30AM	78.25	7336.05	45.75	239.56	-0.25	
03/06/99	11:00AM	77.31	7335.82	46.69	239.33	0.94	
05/06/99	2:30PM	77.35	7336.21	46.65	239.72	-0.04	
07/26/99	1:00PM	78.2		45.80	-7096.49	-0.85	

PIEZO #: 42
SERIAL #: 10898

RO: 8904.00
TO: 19.00 deg. C
C: 0.02451
K: -0.147
BAROM. 31.57 " Hg
GE: 7280.5

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	8757	8.29	3.26	13.65	0.03	7294.1	
1/7/98	9:00 AM	-4	23.26	8757	8.29	3.26	13.65	0.00	7294.1	
1/14/98	9:00 AM	-7	23.42	8761	8.33	3.16	13.46	-0.19	7294.0	
1/22/98	9:30 AM	-4	23.28	8766	8.34	3.13	13.18	-0.27	7293.7	
1/28/98	8:30 AM	-2	23.3	8759	8.55	2.59	13.76	0.58	7294.3	
2/3/98	1:00 PM	4	23.06	8770	8.38	3.03	12.99	-0.77	7293.5	
2/12/98	11:30 AM	1	23.35	8768	8.4	2.98	13.12	0.13	7293.6	
2/20/98	9:00 AM	-1	23.13	8765	8.41	2.95	13.30	0.18	7293.8	
3/25/98	9:00 AM	10	23.08	8742	8.49	2.74	14.67	1.37	7295.2	
4/2/98	12:40 PM	6	23.3	8744	8.51	2.69	14.58	-0.10	7295.1	
4/8/98	11:00 AM	4	23.32	8750	8.41	2.95	14.15	-0.43	7294.7	
4/15/98	10:30 AM	0	23.02	8756	8.53	2.64	13.92	-0.23	7294.4	
4/22/98	9:30 AM	11	23.46	8759	8.52	2.67	13.74	-0.18	7294.2	
4/29/98	11:00 AM	15	23.42	8763	8.55	2.59	13.54	-0.20	7294.0	
5/7/98	9:00 AM	6	23.26	8765	8.56	2.57	13.43	-0.10	7293.9	
5/13/98	9:30 PM	10	23	8772	8.57	2.54	13.05	-0.39	7293.5	
5/20/98	9:00 AM	15	23.28	8775	8.58	2.51	12.88	-0.16	7293.4	
5/27/98	8:30 AM	5	23.25	8774	8.59	2.49	12.95	0.07	7293.5	
6/3/98	11:00 AM	16	23.19	8774	8.63	2.39	12.98	0.03	7293.5	
6/10/98	11:00 AM	10	23.29	8768	8.59	2.49	13.29	0.31	7293.8	
6/17/98	1:00 PM	6	23.35	8744	8.51	2.69	14.58	1.29	7295.1	
6/24/98	11:00 AM	18	23.28	8759	8.64	2.36	13.84	-0.74	7294.3	
7/1/98	10:00 AM	24	23.4	8754	8.65	2.34	14.13	0.29	7294.6	
7/8/98	8:00 AM	15	23.46	8760	8.64	2.36	13.78	-0.35	7294.3	
7/15/98	8:00 AM	17	23.5	8763	8.66	2.31	13.63	-0.15	7294.1	
7/22/98	8:00AM	16	23.4	8768	8.68	2.26	13.37	-0.27	7293.9	
7/29/98	8:00 AM	14	23.43	8775	8.69	2.24	12.98	-0.39	7293.5	
8/12/98	9:00 AM	16	23.58	8787	8.7	2.21	12.31	-0.67	7292.8	
8/19/98	11:00 AM	20	23.45	8780	8.69	2.24	12.70	0.39	7293.2	
8/31/98	9:00 AM	22	23.44	8797	8.73	2.14	11.77	-0.93	7292.3	
9/11/98	10:00 AM	15	23.48	8787	8.75	2.09	12.35	0.58	7292.9	
9/16/98	11:00 AM	23	23.42	8787	8.75	2.09	12.35	0.00	7292.9	
9/22/98	9:00 AM	17	23.38	8796	8.77	2.04	11.86	-0.49	7292.4	
9/30/98	10:00 AM	16	23.32	8799	8.77	2.04	11.69	-0.17	7292.2	
10/7/98	9:00 AM	6	23.46	8803	8.78	2.01	11.47	-0.22	7292.0	
10/14/98	8:30 AM	5	23.32	8806	8.79	1.99	11.31	-0.16	7291.8	
10/26/98	7:30 AM	6	23.7	8802	8.80	1.96	11.54	0.23	7292.0	
10/30/98	9:00 AM	3	23.8	8811	8.81	1.94	11.04	-0.50	7291.5	
11/5/98	9:30 AM	0	0	8814	8.82	1.92	10.88	-0.16	7291.4	
11/13/98	10:00 AM	4	23.4	8816	8.84	1.87	10.79	-0.10	7291.3	
11/18/98	10:00 AM	0	23.4	8817	8.92	1.67	10.80	0.01	7291.3	
1/7/99	12:10PM	6.7		8827	8.91	1.70	10.22	-0.57	7290.7	
02/06/99	9:30AM	5		8834	8.96	1.57	9.87	-0.35	7290.4	
03/06/99	11:00AM	5		8839	9.04	1.38	9.65	-0.22	7290.2	
05/06/99	2:30PM	15.6		8843	8.94	1.62	9.34	-0.31	7289.8	
07/26/99	1:00PM			8807	9.37	0.60	11.72	2.38	7292.2	

PIEZO #: 43
SERIAL #: 10909

RO: 9753.00
TO: 19.00 deg. C
C: 0.02466
K: -0.0296
BAROM. 31.57 " Hg
GE: 7189

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9286	6.25	9.40	27.22	0.51	7216.22	
01/07/98	9:00 AM	-4	23.26	9293	6.25	9.40	26.83	-0.40	7215.83	
01/14/98	9:00 AM	-7	23.42	9292	6.25	9.40	26.88	0.06	7215.88	
01/22/98	9:30 AM	-4	23.28	9295	6.25	9.40	26.71	-0.17	7215.71	
01/28/98	8:30 AM	-2	23.3	9293	6.25	9.40	26.83	0.11	7215.83	
02/03/98	1:00 PM	4	23.06	9298	6.25	9.40	26.54	-0.28	7215.54	
02/12/98	11:30 AM	1	23.35	9293	6.26	9.36	26.83	0.29	7215.83	
02/20/98	9:00 AM	-1	23.13	9297	6.26	9.36	26.60	-0.23	7215.60	
03/25/98	9:00 AM	10	23.08	9278	6.26	9.36	27.68	1.08	7216.68	
04/02/98	12:40 PM	6	23.3	9290	6.26	9.36	27.00	-0.68	7216.00	
04/08/98	11:00 AM	4	23.32	9297	6.26	9.36	26.60	-0.40	7215.60	
04/15/98	10:30 AM	0	23.02	9290	6.26	9.36	27.00	0.40	7216.00	
04/22/98	9:30 AM	11	23.46	9280	6.26	9.36	27.57	0.57	7216.57	
04/29/98	11:00 AM	15	23.42	9281	6.26	9.36	27.51	-0.06	7216.51	
05/07/98	9:00 AM	6	23.26	9291	6.26	9.36	26.94	-0.57	7215.94	
05/13/98	9:30 PM	10	23	9297	6.26	9.36	26.60	-0.34	7215.60	
05/20/98	9:00 AM	15	23.28	9291	6.26	9.36	26.94	0.34	7215.94	
05/27/98	8:30 AM	5	23.25	9292	6.27	9.33	26.89	-0.05	7215.89	
06/03/98	11:00 AM	16	23.19	9293	6.27	9.33	26.83	-0.06	7215.83	
06/10/98	11:00 AM	10	23.29	9291	6.27	9.33	26.94	0.11	7215.94	
06/17/98	1:00 PM	6	23.35	9290	6.26	9.36	27.00	0.05	7216.00	
06/24/98	11:00 AM	18	23.28	9288	6.27	9.33	27.11	0.12	7216.11	
07/01/98	10:00 AM	24	23.4	9284	6.27	9.33	27.34	0.23	7216.34	
07/08/98	8:00 AM	15	23.46	9288	6.27	9.33	27.11	-0.23	7216.11	
07/15/98	8:00 AM	17	23.5	9285	6.27	9.33	27.29	0.17	7216.29	
07/22/98	8:00AM	16	23.4	9288	6.27	9.33	27.11	-0.17	7216.11	
07/29/98	8:00 AM	14	23.43	9287	6.27	9.33	27.17	0.06	7216.17	
08/12/98	9:00 AM	16	23.58	9288	6.27	9.33	27.11	-0.06	7216.11	
08/19/98	11:00 AM	20	23.45	9288	6.27	9.33	27.11	0.00	7216.11	
08/31/98	9:00 AM	22	23.44	9286	6.28	9.29	27.23	0.12	7216.23	
09/11/98	10:00 AM	15	23.48	9288	6.27	9.33	27.11	-0.12	7216.11	
09/16/98	11:00 AM	23	23.42	9286	6.27	9.33	27.23	0.11	7216.23	
09/22/98	9:00 AM	17	23.38	9291	6.28	9.29	26.95	-0.28	7215.95	
09/30/98	10:00 AM	16	23.32	9290	6.28	9.29	27.00	0.06	7216.00	
10/07/98	9:00 AM	6	23.46	9290	6.28	9.29	27.00	0.00	7216.00	
10/14/98	8:30 AM	5	23.32	9289	6.28	9.29	27.06	0.06	7216.06	
10/26/98	7:30 AM	6	23.7	9295	6.28	9.29	26.72	-0.34	7215.72	
10/30/98	9:00 AM	3	23.8	6984	6.31	9.19	158.20	131.48	7347.20	possible misread of gauge
11/05/98	9:30 AM	0	0	9297	6.28	9.29	26.61	-131.60	7215.61	
11/13/98	10:00 AM	4	23.4	9293	6.28	9.29	26.83	0.23	7215.83	
11/18/98	10:00 AM	0	23.4	9298	6.28	9.29	26.55	-0.28	7215.55	
12/30/98	9:00AM	0	23.49	9286	6.25	9.40	27.22	0.68	7216.22	
1/7/99	12:10PM	6.7		9299	6.29	9.26	26.49	-0.73	7215.49	
02/06/99	9:30AM	5		9300	6.29	9.26	26.44	-0.06	7215.44	
03/06/99	11:00AM	5		9505	6.34	9.09	14.79	-11.65	7203.79	
05/06/99	2:30PM	15.6		9276	6.3	9.22	27.80	13.02	7216.80	
07/26/99	1:00PM			9289	6.31	9.19	27.07	-0.74	7216.07	

PIEZO #: 44
Twinned with Piezometer # 43
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 121 ft. (Comparative)

STANDPIPE ELEV: 7311.89
COLLAR ELEV: 7308.14
DEPTH TO TOP OF SCREEN: 116.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	79.52	7232.37	46.48	45.23	0.21	
01/07/98	9:00 AM	79.68	7232.21	46.32	45.07	-0.16	
01/14/98	9:00 AM	79.8	7232.09	46.20	44.95	-0.12	
01/22/98	9:30 AM	79.7	7232.19	46.30	45.05	0.10	
01/28/98	8:30 AM	79.80	7232.09	46.20	44.95	-0.10	
02/03/98	1:00 PM	79.55	7232.34	46.45	45.20	0.25	
02/12/98	11:30 AM	79.81	7232.08	46.19	44.94	-0.26	
02/20/98	9:00 AM	79.8	7232.09	46.20	44.95	0.01	
03/25/98	9:00 AM	78.65	7233.24	47.35	46.10	1.15	
04/02/98	12:40 PM	79.4	7232.49	46.60	45.35	-0.75	
04/08/98	11:00 AM	79.45	7232.44	46.55	45.30	-0.05	
04/15/98	10:30 AM	79.24	7232.65	46.76	45.51	0.21	
04/22/98	9:30 AM	79.22	7232.67	46.78	45.53	0.02	
04/29/98	11:00 AM	79.2	7232.69	46.80	45.55	0.02	
05/07/98	9:00 AM	79.56	7232.33	46.44	45.19	-0.36	
05/13/98	9:30 PM	79.56	7232.33	46.44	45.19	0.00	
05/20/98	9:00 AM	79.62	7232.27	46.38	45.13	-0.06	
05/27/98	8:30 AM	79.6	7232.29	46.40	45.15	0.02	
06/03/98	11:00 AM	79.5	7232.39	46.50	45.25	0.10	
06/10/98	11:00 AM	79.55	7232.34	46.45	45.20	-0.05	
06/17/98	1:00 PM	79.51	7232.38	46.49	45.24	0.04	
06/24/98	11:00 AM	79.35	7232.54	46.65	45.40	0.16	
07/01/98	10:00 AM	79.31	7232.58	46.69	45.44	0.04	
07/08/98	8:00 AM	79.3	7232.59	46.70	45.45	0.01	
07/15/98	8:00 AM	79.3	7232.59	46.70	45.45	0.00	
07/22/98	8:00AM	79.53	7232.36	46.47	45.22	-0.23	
07/29/98	8:00 AM	79.49	7232.40	46.51	45.26	0.04	
08/12/98	9:00 AM	79.7	7232.19	46.30	45.05	-0.21	
08/19/98	11:00 AM	79.65	7232.24	46.35	45.10	0.05	
08/31/98	9:00 AM	79.31	7232.58	46.69	45.44	0.34	
09/11/98	10:00 AM	79.3	7232.59	46.70	45.45	0.01	
09/16/98	11:00 AM	79.55	7232.34	46.45	45.20	-0.25	
09/22/98	9:00 AM	79.69	7232.20	46.31	45.06	-0.14	
09/30/98	10:00 AM	79.52	7232.37	46.48	45.23	0.17	
2/6/99	9:30AM	80.21	7336.05	45.79	148.91	-0.69	
03/06/99	11:00AM	79.82	7335.82	46.18	148.68	0.39	
05/06/99	2:30PM	80	7336.21	46.00	149.07	-0.18	
7/26/99	1:00PM	79.76		46.24	-7187.14	0.24	

PIEZO #: 45
SERIAL #: 10905

RO: 9651.00
TO: 19.00 deg. C
C: 0.02309
K: -0.0323
BAROM. 31.57 " Hg
GE: 7231.3

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (ft H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9475	6.34	9.09	10.11	0.32	7241.41	
01/07/98	9:00 AM	-4	23.26	9480	6.34	9.09	9.85	-0.27	7241.15	
01/14/98	9:00 AM	-7	23.42	9479	6.34	9.09	9.90	0.05	7241.20	
01/22/98	9:30 AM	-4	23.28	9484	6.34	9.09	9.63	-0.27	7240.93	
01/28/98	8:30 AM	-2	23.3	9481	6.35	9.05	9.80	0.16	7241.10	
02/03/98	1:00 PM	4	23.06	9484	6.34	9.09	9.63	-0.16	7240.93	
02/12/98	11:30 AM	1	23.35	9482	6.34	9.09	9.74	0.11	7241.04	
02/20/98	9:00 AM	-1	23.13	9487	6.34	9.09	9.47	-0.27	7240.77	
03/25/98	9:00 AM	10	23.08	9466	6.34	9.09	10.59	1.12	7241.89	
04/02/98	12:40 PM	6	23.3	9476	6.34	9.09	10.06	-0.53	7241.36	
04/08/98	11:00 AM	4	23.32	9487	6.34	9.09	9.47	-0.59	7240.77	
04/15/98	10:30 AM	0	23.02	9477	6.34	9.09	10.01	0.53	7241.31	
04/22/98	9:30 AM	11	23.46	9472	6.34	9.09	10.27	0.27	7241.57	
04/29/98	11:00 AM	15	23.42	9470	6.34	9.09	10.38	0.11	7241.68	
05/07/98	9:00 AM	6	23.26	9480	6.34	9.09	9.85	-0.53	7241.15	
05/13/98	9:30 PM	10	23	9486	6.34	9.09	9.53	-0.32	7240.83	
05/20/98	9:00 AM	15	23.28	9483	6.34	9.09	9.69	0.16	7240.99	
05/27/98	8:30 AM	5	23.25	9485	6.34	9.09	9.58	-0.11	7240.88	
06/03/98	11:00 AM	16	23.19	9484	6.34	9.09	9.63	0.05	7240.93	
06/10/98	11:00 AM	10	23.29	9484	6.33	9.12	9.63	0.00	7240.93	
06/17/98	1:00 PM	6	23.35	9477	6.33	9.12	10.00	0.37	7241.30	
06/24/98	11:00 AM	18	23.28	9480	6.34	9.09	9.85	-0.16	7241.15	
07/01/98	10:00 AM	24	23.4	9476	6.34	9.09	10.06	0.21	7241.36	
07/08/98	8:00 AM	15	23.46	9475	6.34	9.09	10.11	0.05	7241.41	
07/15/98	8:00 AM	17	23.5	9480	6.34	9.09	9.85	-0.27	7241.15	
07/22/98	8:00AM	16	23.4	9481	6.34	9.09	9.79	-0.05	7241.09	
07/29/98	8:00 AM	14	23.43	9482	6.33	9.12	9.74	-0.06	7241.04	
08/12/98	9:00 AM	16	23.58	9484	6.34	9.09	9.63	-0.10	7240.93	
08/19/98	11:00 AM	20	23.45	9484	6.34	9.09	9.63	0.00	7240.93	
08/31/98	9:00 AM	22	23.44	9483	6.33	9.12	9.69	0.05	7240.99	
09/11/98	10:00 AM	15	23.48	9487	6.33	9.12	9.47	-0.21	7240.77	
09/16/98	11:00 AM	23	23.42	9486	6.34	9.09	9.53	0.06	7240.83	
09/22/98	9:00 AM	17	23.38	9491	6.34	9.09	9.26	-0.27	7240.56	
09/30/98	10:00 AM	16	23.32	9491	6.33	9.12	9.26	0.00	7240.56	
10/07/98	9:00 AM	6	23.46	9492	6.33	9.12	9.21	-0.05	7240.51	
10/14/98	8:30 AM	5	23.32	9491	6.33	9.12	9.26	0.05	7240.56	
10/26/98	7:30 AM	6	23.7	9495	6.33	9.12	9.05	-0.21	7240.35	
10/30/98	9:00 AM	3	23.8	9497	6.34	9.09	8.94	-0.10	7240.24	
11/05/98	9:30 AM	0	0	9498	6.34	9.09	8.89	-0.05	7240.19	
11/13/98	10:00 AM	4	23.4	9497	6.34	9.09	8.94	0.05	7240.24	
11/18/98	10:00 AM	0	23.4	9499	6.34	9.09	8.84	-0.11	7240.14	
1/7/99	12:10PM	6.7		9501	6.34	9.09	8.73	-0.11	7240.03	
02/06/99	9:30AM	5		9506	6.33	9.12	8.46	-0.27	7239.76	
03/06/99	11:00AM	5		9404	6.29	9.26	13.88	5.42	7245.18	
05/06/99	2:30PM	15.6		9488	6.34	9.09	9.42	-4.46	7240.72	
07/26/99	1:00PM			9503	6.35	9.05	8.63	-0.80	7239.93	

PIEZO #: 46
Twinned with Piezometer # 45
SCREEN TYPE: Johnson 8 Slot, 40 X 60 pack
TRANSDUCER DEPTH: 79 ft. (Comparative)

STANDPIPE ELEV: 7312.01
COLLAR ELEV: 7308.26
DEPTH TO TOP OF SCREEN: 75.00
SCREEN LENGTH: 10.00
STANDPIPE DIAMETER: 1.5 INCHES

DATE	TIME	DEPTH TO WATER (FT)	WATER ELEVATION	EFFECTIVE PRESSURE (FT H2O)	COMPARATIVE PRESSURE (FT H2O)	CHANGE	REMARKS
12/30/97	9:00 AM	63.14	7248.87	21.86	19.61	-0.06	
01/07/98	9:00 AM	63.12	7248.89	21.88	19.63	0.02	
01/14/98	9:00 AM	63.18	7248.83	21.82	19.57	-0.06	
01/22/98	9:30 AM	63.15	7248.86	21.85	19.60	0.03	
01/28/98	8:30 AM	63.20	7248.81	21.80	19.55	-0.05	
02/03/98	1:00 PM	63.02	7248.99	21.98	19.73	0.18	
02/12/98	11:30 AM	63.45	7248.56	21.55	19.30	-0.43	
02/20/98	9:00 AM	63.25	7248.76	21.75	19.50	0.20	
03/25/98	9:00 AM	62.16	7249.85	22.84	20.59	1.09	
04/02/98	12:40 PM	62.82	7249.19	22.18	19.93	-0.66	
04/08/98	11:00 AM	62.50	7249.51	22.50	20.25	0.32	
04/15/98	10:30 AM	62.67	7249.34	22.33	20.08	-0.17	
04/22/98	9:30 AM	62.88	7249.13	22.12	19.87	-0.21	
04/29/98	11:00 AM	62.79	7249.22	22.21	19.96	0.09	
05/07/98	9:00 AM	63.17	7248.84	21.83	19.58	-0.38	
05/13/98	9:30 PM	63.17	7248.84	21.83	19.58	0.00	
05/20/98	9:00 AM	63.32	7248.69	21.68	19.43	-0.15	
05/27/98	8:30 AM	63.37	7248.64	21.63	19.38	-0.05	
06/03/98	11:00 AM	63.21	7248.80	21.79	19.54	0.16	
06/10/98	11:00 AM	63.25	7248.76	21.75	19.50	-0.04	
06/17/98	1:00 PM	63.20	7248.81	21.80	19.55	0.05	
06/24/98	11:00 AM	63.03	7248.98	21.97	19.72	0.17	
07/01/98	10:00 AM	62.98	7249.03	22.02	19.77	0.05	
07/08/98	8:00 AM	63.00	7249.01	22.00	19.75	-0.02	
07/15/98	8:00 AM	63.58	7248.43	21.42	19.17	-0.58	
07/22/98	8:00AM	63.39	7248.62	21.61	19.36	0.19	
07/29/98	8:00 AM	63.40	7248.61	21.60	19.35	-0.01	
08/12/98	9:00 AM	63.39	7248.62	21.61	19.36	0.01	
08/19/98	11:00 AM	63.41	7248.60	21.59	19.34	-0.02	
08/31/98	9:00 AM	63.27	7248.74	21.73	19.48	0.14	
09/11/98	10:00 AM	63.40	7248.61	21.60	19.35	-0.13	
09/16/98	11:00 AM	63.69	7248.32	21.31	19.06	-0.29	
09/22/98	9:00 AM	63.80	7248.21	21.20	18.95	-0.11	
09/30/98	10:00 AM	63.77	7248.24	21.23	18.98	0.03	
10/07/98	9:00 AM	63.64	7248.37	21.36	19.11	0.13	
10/14/98	8:30 AM	63.87	7248.14	21.13	18.88	-0.23	
10/26/98	7:30 AM	63.97	7248.04	21.03	18.78	-0.10	
11/18/98	10:00 AM	64.12	7247.89	20.88	18.63	-0.15	
12/30/98	9:00AM	63.14	11.86	21.86	-7217.40	0.98	
1/7/99	12:10PM	64.00	7335.50	21.00	106.24	-0.86	
02/06/99	9:30AM	64.52	7336.05	20.48	106.79	-0.52	
03/06/99	11:00AM	64.00	7335.82	21.00	106.56	0.52	
05/06/99	2:30PM	63.36	7336.21	21.64	106.95	0.64	
07/26/99	1:00PM	64.33		20.67	-7229.26	-0.97	

PIEZO #: 47
SERIAL #: 10908

RO: 9475.00
TO: 19.00 deg. C
C: 0.02673
K: -0.0294
BAROM. 31.57
GE: 7281.1

DATE	TIME	TEMP. C	BAROM.	R1 POS B	THERM.	T1	Pore Pressure (FT H2O)	CHANGE	Piezometric Surface	REMARKS
12/30/97	9:00 AM	0	23.49	9362	6.40	8.88	7.65	0.12	7288.75	
01/07/98	9:00 AM	-4	23.26	9363	6.4	8.88	7.59	-0.06	7288.69	
01/14/98	9:00 AM	-7	23.42	9363	6.40	8.88	7.59	0.00	7288.69	
01/22/98	9:30 AM	-4	23.28	9364	6.41	8.85	7.53	-0.06	7288.63	
01/28/98	8:30 AM	-2	23.3	9364	6.41	8.85	7.53	0.00	7288.63	
02/03/98	1:00 PM	4	23.06	9365	6.41	8.85	7.47	-0.06	7288.57	
02/12/98	11:30 AM	1	23.35	9365	6.41	8.85	7.47	0.00	7288.57	
02/20/98	9:00 AM	-1	23.13	9366	6.41	8.85	7.41	-0.06	7288.51	
03/25/98	9:00 AM	10	23.08	9355	6.41	8.85	8.09	0.68	7289.19	
04/02/98	12:40 PM	6	23.3	9356	6.41	8.85	8.03	-0.06	7289.13	
04/08/98	11:00 AM	4	23.32	9366	6.41	8.85	7.41	-0.62	7288.51	
04/15/98	10:30 AM	0	23.02	9359	6.41	8.85	7.84	0.43	7288.94	
04/22/98	9:30 AM	11	23.46	9358	6.41	8.85	7.90	0.06	7289.00	
04/29/98	11:00 AM	15	23.42	9359	6.41	8.85	7.84	-0.06	7288.94	
05/07/98	9:00 AM	6	23.26	9362	6.40	8.88	7.65	-0.19	7288.75	
05/13/98	9:30 PM	10	23	9365	6.40	8.88	7.47	-0.18	7288.57	
05/20/98	9:00 AM	15	23.28	9366	6.40	8.88	7.41	-0.06	7288.51	
05/27/98	8:30 AM	5	23.25	9365	6.40	8.88	7.47	0.06	7288.57	
06/03/98	11:00 AM	16	23.19	9364	6.40	8.88	7.53	0.06	7288.63	
06/10/98	11:00 AM	10	23.29	9364	6.40	8.88	7.53	0.00	7288.63	
06/17/98	1:00 PM	6	23.35	9356	6.41	8.85	8.03	0.50	7289.13	
06/24/98	11:00 AM	18	23.28	9363	6.40	8.88	7.59	-0.43	7288.69	
07/01/98	10:00 AM	24	23.4	9363	6.40	8.88	7.59	0.00	7288.69	
07/08/98	8:00 AM	15	23.46	9362	6.40	8.88	7.65	0.06	7288.75	
07/15/98	8:00 AM	17	23.5	9363	6.40	8.88	7.59	-0.06	7288.69	
07/22/98	8:00AM	16	23.4	9364	6.40	8.88	7.53	-0.06	7288.63	
07/29/98	8:00 AM	14	23.43	9367	6.40	8.88	7.35	-0.18	7288.45	
08/12/98	9:00 AM	16	23.58	9370	6.40	8.88	7.16	-0.18	7288.26	
08/19/98	11:00 AM	20	23.45	9368	6.40	8.88	7.28	0.12	7288.38	
08/31/98	9:00 AM	22	23.44	9375	6.40	8.88	6.85	-0.43	7287.95	
09/11/98	10:00 AM	15	23.48	9375	6.40	8.88	6.85	0.00	7287.95	
09/16/98	11:00 AM	23	23.42	9370	6.40	8.88	7.16	0.31	7288.26	
09/22/98	9:00 AM	17	23.38	9378	6.40	8.88	6.67	-0.49	7287.77	
09/30/98	10:00 AM	16	23.32	9380	6.40	8.88	6.54	-0.12	7287.64	
10/07/98	9:00 AM	6	23.46	9382	6.40	8.88	6.42	-0.12	7287.52	
10/14/98	8:30 AM	5	23.32	9383	6.40	8.88	6.36	-0.06	7287.46	
10/26/98	7:30 AM	6	23.7	9385	6.40	8.88	6.24	-0.12	7287.34	
10/30/98	9:00 AM	3	23.8	9386	6.40	8.88	6.17	-0.06	7287.27	
11/05/98	9:30 AM	0	0	9388	6.40	8.88	6.05	-0.12	7287.15	
11/13/98	10:00 AM	4	23.4	9389	6.40	8.88	5.99	-0.06	7287.09	
11/18/98	10:00 AM	0	23.4	9390	6.40	8.88	5.93	-0.06	7287.03	
01/07/99	12:10PM			9396	6.41	8.85	5.56	-0.37	7286.66	
02/06/99	9:30AM			9401	6.41	8.85	5.25	-0.31	7286.35	
03/06/99	11:00AM	5		9404	6.42	8.81	5.07	-0.18	7286.17	
05/06/99	2:30PM	15.6		9408	6.42	8.81	4.82	-0.25	7285.92	
07/26/99	1:00PM			9402	6.43	8.78	5.19	0.37	7286.29	

APPENDIX K-2

PRISM READINGS

LEVEE 1 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26022.43	25264.05	7259.38													
1/11/96	26022.49	25264.12	7259.33	0.092	0.092	-0.050	-0.050	0.105	0.105	0.013		1	40.60	1	40.60	
2/15/96	26022.44	25264.05	7259.37	0.086	0.010	0.040	-0.010	0.095	0.014	0.003		3	215.54	1	#DIV/0!	-45.00
3/22/96	26022.39	25264.05	7259.42	0.050	0.040	0.050	0.040	0.071	0.057	0.001		2	#DIV/0!	2	#DIV/0!	45.00
4/4/96	26022.40	25264.03	7259.39	0.022	0.036	-0.030	0.010	0.037	0.037	0.001	0.003	4	296.57	3	236.31	15.50
4/18/96	26022.39	25264.04	7259.39	0.014	0.041	0.000	0.010	0.014	0.042	0.000	0.002	2	135.00	3	255.96	13.63
4/25/96	26022.38	25264.01	7259.36	0.032	0.064	-0.030	-0.020	0.044	0.067	0.004	0.002	3	198.43	3	231.34	-17.35
5/2/96	26022.40	25264.01	7259.36	0.020	0.050	0.000	-0.020	0.020	0.054	0.002	0.002	1	#DIV/0!	3	216.87	-21.80
5/9/96	26022.41	25264.02	7259.39	0.014	0.036	0.030	0.010	0.033	0.037	0.002	0.002	1	45.00	3	213.69	15.50
5/31/96	26022.39	25264.01	7259.37	0.022	0.057	-0.020	-0.010	0.030	0.057	0.001	0.002	3	243.43	3	225.00	-10.02
6/5/96	26022.39	25264.01	7259.37	0.000	0.057	0.000	-0.010	0.000	0.057	0.000	0.001	1	#DIV/0!	3	225.00	-10.02
6/10/96	26022.38	25264.02	7259.41	0.014	0.058	0.040	0.030	0.042	0.066	0.002	0.001	2	135.00	3	239.04	27.23
6/13/96	26022.39	25264.00	7259.41	0.022	0.064	0.000	0.030	0.022	0.071	0.002	0.001	4	296.57	3	218.66	25.10
7/11/96	26022.38	25264.00	7259.40	0.010	0.071	-0.010	0.020	0.014	0.073	0.000	0.001	2	#DIV/0!	3	225.00	15.79
7/18/96	26022.41	25263.99	7259.36	0.032	0.063	-0.040	-0.020	0.051	0.066	0.001	0.001	4	341.57	3	198.43	-17.55
7/25/96	26022.39	25263.99	7259.39	0.020	0.072	0.030	0.010	0.036	0.073	0.001	0.001	2	#DIV/0!	3	213.69	7.90
8/16/96	26022.40	25264.01	7259.41	0.022	0.050	0.020	0.030	0.030	0.058	0.001	0.001	1	26.57	3	216.87	30.96
5/16/97	26022.38	25264.07	7260.16	0.063	0.054	0.750	0.780	0.753	0.782	0.003	0.001	2	108.43	2	158.20	86.05
5/22/97	26022.38	25264.06	7260.17	0.010	0.051	0.010	0.790	0.014	0.792	0.002	0.002	4	270.00	2	168.69	86.31
6/4/97	26022.41	25264.03	7260.19	0.042	0.028	0.020	0.810	0.047	0.810	0.001	0.002	4	315.00	3	225.00	88.00
6/11/97	26022.40	25264.03	7260.17	0.010	0.036	-0.020	0.790	0.022	0.791	0.003	0.002	2	#DIV/0!	3	236.31	87.39
6/18/97	26022.38	25264.04	7260.18	0.022	0.051	0.010	0.800	0.024	0.802	0.002	0.002	2	153.43	3	258.69	86.35
6/25/97	26022.39	25264.03	7260.16	0.014	0.045	-0.020	0.780	0.024	0.781	0.003	0.002	4	315.00	3	243.43	86.72
7/2/97	26022.40	25264.03	7260.15	0.010	0.036	-0.010	0.770	0.014	0.771	0.001	0.002	1	#DIV/0!	3	236.31	87.32
7/9/97	26022.40	25264.03	7260.17	0.000	0.036	0.020	0.790	0.020	0.791	0.003	0.002	1	#DIV/0!	3	236.31	87.39
7/16/97	26022.38	25264.03	7260.16	0.020	0.054	-0.010	0.780	0.022	0.782	0.001	0.002	2	#DIV/0!	3	248.20	86.05
7/25/97	26022.37	25264.04	7260.14	0.014	0.061	-0.020	0.760	0.024	0.762	0.002	0.002	2	135.00	3	260.54	85.42
7/30/97	26022.40	25264.01	7260.15	0.042	0.050	0.010	0.770	0.044	0.772	0.002	0.002	4	315.00	3	216.87	86.28
8/6/97	26022.39	25264.01	7260.14	0.010	0.057	-0.010	0.760	0.014	0.762	0.001	0.002	2	#DIV/0!	3	225.00	85.74
8/13/97	26022.39	25264.02	7260.13	0.010	0.050	-0.010	0.750	0.014	0.752	0.001	0.003	1	0.00	3	233.13	86.19
8/20/97	26022.39	25264.02	7260.16	0.000	0.050	0.030	0.780	0.030	0.782	0.004	0.003	1	#DIV/0!	3	233.13	86.33
8/27/97	26022.39	25264.02	7260.14	0.000	0.050	-0.020	0.760	0.020	0.762	0.003	0.003	1	#DIV/0!	3	233.13	86.24
9/2/97	26022.38	25264.04	7260.18	0.022	0.051	0.040	0.800	0.046	0.802	0.007	0.004	2	116.57	3	258.69	86.35
9/10/97	26022.39	25264.02	7260.15	0.022	0.050	-0.030	0.770	0.037	0.772	0.004	0.004	4	296.57	3	233.13	86.28
9/25/97	26022.38	25264.03	7260.16	0.014	0.054	0.010	0.780	0.017	0.782	0.001	0.004	2	135.00	3	248.20	86.05
10/1/97	26022.37	25264.03	7260.13	0.010	0.063	-0.030	0.750	0.032	0.753	0.005	0.004	2	#DIV/0!	3	251.57	85.18
10/8/97	26022.38	25264.03	7260.16	0.010	0.054	0.030	0.780	0.032	0.782	0.004	0.004	1	#DIV/0!	3	248.20	86.05
10/16/97	26022.40	25264.03	7260.13	0.020	0.036	-0.030	0.750	0.036	0.751	0.004	0.003	1	#DIV/0!	3	236.31	87.25
10/22/97	26022.37	25264.04	7260.10	0.032	0.061	-0.030	0.720	0.044	0.723	0.005	0.003	2	161.57	3	260.54	85.17
10/29/97	26022.40	25264.03	7260.12	0.032	0.036	0.020	0.740	0.037	0.741	0.003	0.003	4	341.57	3	236.31	87.21
11/5/97	26022.41	25264.02	7260.13	0.014	0.036	0.010	0.750	0.017	0.751	0.001	0.002	4	315.00	3	213.69	87.25
11/12/97	26022.41	25264.03	7260.13	0.010	0.028	0.000	0.750	0.010	0.751	0.000	0.001	1	0.00	3	225.00	87.84
11/19/97	26022.38	25264.05	7260.14	0.036	0.050	0.010	0.760	0.037	0.762	0.002	0.001	2	146.31	2	#DIV/0!	86.24
11/26/97	26022.38	25264.04	7260.14	0.010	0.051	0.000	0.760	0.010	0.762	0.000	0.001	4	270.00	3	258.69	86.16
12/3/97	26022.38	25264.04	7260.14	0.000	0.051	0.000	0.760	0.000	0.762	0.000	0.001	1	#DIV/0!	3	258.69	86.16
12/10/97	26022.40	25264.05	7260.12	0.022	0.030	-0.020	0.740	0.030	0.741	0.003	0.002	1	63.43	2	#DIV/0!	87.68
12/17/97	26022.39	25264.03	7260.13	0.022	0.045	0.010	0.750	0.024	0.751	0.002	0.001	3	206.57	3	243.43	86.59
12/23/97	26022.39	25264.04	7260.13	0.010	0.041	0.000	0.750	0.010	0.751	0.000	0.002	1	0.00	3	255.96	86.85
12/30/97	26022.38	25264.05	7260.16	0.014	0.050	0.030	0.780	0.033	0.782	0.004	0.003	2	135.00	2	#DIV/0!	86.33
1/7/98	26022.38	25264.06	7260.19	0.010	0.051	0.030	0.810	0.032	0.812	0.004	0.002	1	0.00	2	168.69	86.40
1/14/98	26022.39	25264.06	7260.19	0.010	0.041	0.000	0.810	0.010	0.811	0.000	0.003	1	#DIV/0!	2	165.96	87.09
1/27/98	26022.36	25264.05	7260.13	0.032	0.070	-0.060	0.750	0.068	0.753	0.004	0.003	3	251.57	2	#DIV/0!	84.67
2/3/98	26022.39	25264.03	7260.13	0.036	0.045	0.000	0.750	0.036	0.751	0.000	0.002	4	326.31	3	243.43	86.59
2/19/98	26022.36	25264.03	7260.14	0.030	0.073	0.010	0.760	0.032	0.763	0.001	0.001	2	#DIV/0!	3	254.05	84.53
3/25/98	26022.37	25264.04	7260.12	0.014	0.061	-0.020	0.740	0.024	0.742	0.001	0.002	1	45.00	3	260.54	85.30
4/3/98	26022.39	25264.03	7260.17	0.022	0.045	0.050	0.790	0.055	0.791	0.005	0.002	4	333.43	3	243.43	86.76
4/8/98	26022.40	25264.01	7260.15	0.022	0.050	-0.020	0.770	0.030	0.772	0.004	0.003	4	296.57	3	216.87	86.28
4/15/98	26022.36	25264.05	7260.13	0.057	0.070	-0.020	0.750	0.060	0.753	0.003	0.003	2	135.00	2	#DIV/0!	84.67
4/22/98	26022.39	25264.03	7260.14	0.036	0.045	0.010	0.760	0.037	0.761	0.001	0.003	4	326.31	3	243.43	86.63
4/29/98	26022.38	25264.04	7260.13	0.014	0.051	-0.010	0.750	0.017	0.752	0.001	0.003	2	135.00	3	258.69	86.11
5/7/98	26022.38	25264.04	7260.17	0.000	0.051	0.040	0.790	0.040	0.792	0.005	0.002	1	#DIV/0!	3	258.69	86.31
5/13/98	26022.40	25264.03	7260.17	0.022	0.036	0.000	0.790	0.022	0.791	0.000	0.003	4	333.43	3	236.31	87.39
5/21/98	26022.40	25264.01	7260.11	0.020	0.050	-0.060	0.730	0.063	0.732	0.007	0.004	4	270.00	3	216.87	86.08
5/28/98	26022.37	25264.04	7260.14	0.042	0.061	0.030	0.760	0.052	0.762	0.004	0.005	2	135.00	3	260.54	85.42
6/3/98	26022.35	25264.03	7260.09	0.022	0.082	-0.050	0.710	0.055	0.715	0.008	0.006	3	243.43	3	255.96	83.38
6/10/98	26022.38	25264.04	7260.17	0.032	0.051	0.080	0.790	0.086	0.792	0.011	0.008	1	71.57	3	258.69	86.31
6/17/98	26022.35	25264.03	7260.09	0.032	0.082	-0.080	0.710	0.086	0.715	0.011	0.008	3	251.57	3	255.96	83.38
6/24/98	26022.38	25264.03	7260.15	0.030	0.054	0.060	0.770	0.067	0.772	0.008	0.008	1	#DIV/0!	3	248.20	86.00

LEVEE 1 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
7/1/98	26022.35	25264.03	7260.12	0.030	0.082	-0.030	0.740	0.042	0.745	0.004	0.007	2	#DIV/0!	3	255.96	83.64
7/8/98	26022.35	25264.03	7260.12	0.000	0.082	0.000	0.740	0.000	0.745	0.000	0.006	1	#DIV/0!	3	255.96	83.64
7/15/98	26022.36	25264.05	7260.16	0.022	0.070	0.040	0.780	0.046	0.783	0.006	0.004	1	26.57	2	#DIV/0!	84.87
7/22/98	26022.37	25264.06	7260.14	0.014	0.061	-0.020	0.760	0.024	0.762	0.003	0.004	1	45.00	2	170.54	85.42
7/29/98	26022.36	25264.08	7260.10	0.010	0.071	-0.040	0.720	0.041	0.723	0.006	0.003	2	#DIV/0!	2	171.87	84.39
8/11/98	26022.36	25264.07	7260.10	0.010	0.073	0.000	0.720	0.010	0.724	0.000	0.003	1	0.00	2	164.05	84.23
8/19/98	26022.36	25264.06	7260.10	0.010	0.071	0.000	0.720	0.010	0.723	0.000	0.002	4	270.00	2	171.87	84.39
8/31/98	26022.36	25264.07	7260.06	0.010	0.073	-0.040	0.680	0.041	0.684	0.003	0.004	1	0.00	2	164.05	83.89
9/11/98	26022.38	25264.07	7260.16	0.020	0.054	0.100	0.780	0.102	0.782	0.009	0.004	1	#DIV/0!	2	158.20	86.05
9/16/98	26022.34	25264.11	7260.11	0.057	0.108	-0.050	0.730	0.075	0.738	0.009	0.006	2	135.00	2	146.31	81.57
9/22/98	26022.35	25264.06	7260.06	0.051	0.081	-0.050	0.680	0.071	0.685	0.009	0.007	4	281.31	2	172.87	83.24
9/30/98	26022.34	25264.08	7260.00	0.022	0.095	-0.060	0.620	0.064	0.627	0.007	0.009	2	116.57	2	161.57	81.30
10/7/98	26022.35	25264.07	7260.09	0.014	0.082	0.090	0.710	0.091	0.715	0.013	0.008	4	315.00	2	165.96	83.38
3/3/99	26022.31	25264.09	7260.05	0.045	0.126	-0.040	0.670	0.060	0.682	0.000	0.006	2	153.43	2	161.57	79.31
5/27/99	26022.34	25264.06	7260.07	0.042	0.091	0.020	0.690	0.047	0.696	0.000	0.004	4	315.00	2	173.66	82.52

LEVEE 2 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	25893.87	25111.94	7259.34													
1/11/96	25893.86	25111.95	7259.29	0.014	0.014	-0.050	-0.050	0.052	0.052	0.006		2	135.00	2	135.00	
2/8/96	25893.85	25111.96	7259.35	0.014	0.028	0.060	0.010	0.062	0.030	0.001		2	135.00	2	135.00	19.47
2/15/96	25893.85	25111.95	7259.29	0.010	0.022	-0.060	-0.050	0.061	0.055	0.004		4	270.00	2	153.43	-65.91
2/22/96	25893.86	25111.94	7259.32	0.014	0.010	0.030	-0.020	0.033	0.022	0.005		4	315.00	2	#DIV/0!	-63.43
2/29/96	25893.86	25111.96	7259.32	0.020	0.022	0.000	-0.020	0.020	0.030	0.001		1	0.00	2	116.57	-41.81
3/7/96	25893.89	25111.92	7259.31	0.050	0.028	-0.010	-0.030	0.051	0.041	0.002		4	306.87	4	315.00	-46.69
3/14/96	25893.83	25111.97	7259.32	0.078	0.050	0.010	-0.020	0.079	0.054	0.002		2	140.19	2	143.13	-21.80
3/22/96	25893.85	25111.95	7259.34	0.028	0.022	0.020	0.000	0.035	0.022	0.004		4	315.00	2	153.43	0.00
3/28/96	25893.85	25111.97	7259.32	0.020	0.036	-0.020	-0.020	0.028	0.041	0.003		1	0.00	2	123.69	-29.02
4/4/96	25893.87	25111.95	7259.32	0.028	0.010	0.000	-0.020	0.028	0.022	0.003		4	315.00	1	0.00	-63.43
4/18/96	25893.85	25111.95	7259.32	0.020	0.022	0.000	-0.020	0.020	0.030	0.001	0.003	2	#DIV/0!	2	153.43	-41.81
4/25/96	25893.85	25111.93	7259.28	0.020	0.022	-0.040	-0.060	0.045	0.064	0.005	0.003	4	270.00	3	243.43	-69.56
5/2/96	25893.86	25111.92	7259.29	0.014	0.022	0.010	-0.050	0.017	0.055	0.001	0.003	4	315.00	3	206.57	-65.91
5/9/96	25893.87	25111.94	7259.33	0.022	0.000	0.040	-0.010	0.046	0.010	0.006	0.003	1	26.57	1	#DIV/0!	#DIV/0!
5/31/96	25893.85	25111.94	7259.32	0.020	0.020	-0.010	-0.020	0.022	0.028	0.001	0.003	2	#DIV/0!	2	#DIV/0!	-45.00
6/5/96	25893.85	25111.94	7259.32	0.000	0.020	0.000	-0.020	0.000	0.028	0.000	0.002	1	#DIV/0!	2	#DIV/0!	-45.00
6/10/96	25893.83	25111.94	7259.30	0.020	0.040	-0.020	-0.040	0.028	0.057	0.006	0.003	2	#DIV/0!	2	#DIV/0!	-45.00
6/13/96	25893.86	25111.91	7259.32	0.042	0.032	0.020	-0.020	0.047	0.037	0.006	0.003	4	315.00	3	198.43	-32.31
7/11/96	25893.85	25111.91	7259.35	0.010	0.036	0.030	0.010	0.032	0.037	0.000	0.003	2	#DIV/0!	3	213.69	15.50
7/18/96	25893.83	25111.94	7259.29	0.036	0.040	-0.060	-0.050	0.070	0.064	0.004	0.003	2	123.69	2	#DIV/0!	-51.34
7/25/96	25893.84	25111.91	7259.28	0.032	0.042	-0.010	-0.060	0.033	0.073	0.001	0.002	4	288.43	3	225.00	-54.74
8/16/96	25893.86	25111.92	7259.32	0.022	0.022	0.040	-0.020	0.046	0.030	0.002	0.001	1	63.43	3	206.57	-41.81
5/16/97	25893.89	25111.96	7259.52	0.050	0.028	0.200	0.180	0.206	0.182	0.001	0.002	1	36.87	1	45.00	81.07
5/22/97	25893.89	25111.96	7259.53	0.000	0.028	0.010	0.190	0.010	0.192	0.002	0.001	1	#DIV/0!	1	45.00	81.53
6/4/97	25893.93	25111.91	7259.53	0.064	0.067	0.000	0.190	0.064	0.201	0.001	0.001	4	308.66	4	333.43	70.55
6/11/97	25893.89	25111.95	7259.52	0.057	0.022	-0.010	0.180	0.057	0.181	0.003	0.001	2	135.00	1	63.43	82.92
6/18/97	25893.88	25111.94	7259.52	0.014	0.010	0.000	0.180	0.014	0.180	0.000	0.002	3	225.00	1	#DIV/0!	86.82
6/25/97	25893.90	25111.94	7259.51	0.020	0.030	-0.010	0.170	0.022	0.173	0.001	0.002	1	#DIV/0!	1	#DIV/0!	79.99
7/2/97	25893.90	25111.93	7259.49	0.010	0.032	-0.020	0.150	0.022	0.153	0.003	0.002	4	270.00	4	341.57	78.10
7/9/97	25893.90	25111.94	7259.51	0.010	0.030	0.020	0.170	0.022	0.173	0.003	0.002	1	0.00	1	#DIV/0!	79.99
7/16/97	25893.89	25111.94	7259.52	0.010	0.020	0.010	0.180	0.014	0.181	0.001	0.002	2	#DIV/0!	1	#DIV/0!	83.66
7/25/97	25893.88	25111.96	7259.50	0.022	0.022	-0.020	0.160	0.030	0.162	0.002	#DIV/0!	2	116.57	1	26.57	82.04
7/30/97	25893.90	25111.93	7259.51	0.036	0.032	0.010	0.170	0.037	0.173	0.002	#DIV/0!	4	303.69	4	341.57	79.46
8/6/97	25893.90	25111.94	7259.49	0.010	0.030	-0.020	0.150	0.022	0.153	0.003	#DIV/0!	1	0.00	1	#DIV/0!	78.69
8/6/97	25893.90	25111.94	7259.49	0.000	0.030	0.000	0.150	0.000	0.153	#DIV/0!	#DIV/0!	1	#DIV/0!	1	#DIV/0!	78.69
8/20/97	25893.91	25111.93	7259.49	0.014	0.041	0.000	0.150	0.014	0.156	0.000	#DIV/0!	4	315.00	4	345.96	74.63
8/27/97	25893.91	25111.93	7259.49	0.000	0.041	0.000	0.150	0.000	0.156	0.000	#DIV/0!	1	#DIV/0!	4	345.96	74.63
9/2/97	25893.88	25111.94	7259.48	0.032	0.010	-0.010	0.140	0.033	0.140	0.003	#DIV/0!	2	161.57	1	#DIV/0!	85.91
9/10/97	25893.89	25111.92	7259.50	0.022	0.028	0.020	0.160	0.030	0.162	0.003	0.002	4	296.57	4	315.00	79.98
9/25/97	25893.89	25111.94	7259.50	0.020	0.020	0.000	0.160	0.020	0.161	0.000	0.002	1	0.00	1	#DIV/0!	82.87
10/1/97	25893.88	25111.93	7259.53	0.014	0.014	0.030	0.190	0.033	0.191	0.005	0.003	3	225.00	4	315.00	85.74
10/8/97	25893.89	25111.94	7259.50	0.014	0.020	-0.030	0.160	0.033	0.161	0.004	0.003	1	45.00	1	#DIV/0!	82.87
10/16/97	25893.90	25111.93	7259.49	0.014	0.032	-0.010	0.150	0.017	0.153	0.001	0.003	4	315.00	4	341.57	78.10
10/22/97	25893.89	25111.93	7259.46	0.010	0.022	-0.030	0.120	0.032	0.122	0.005	0.003	2	#DIV/0!	4	333.43	79.44
10/29/97	25893.90	25111.93	7259.49	0.010	0.032	0.030	0.150	0.032	0.153	0.004	0.002	1	#DIV/0!	4	341.57	78.10
11/5/97	25893.90	25111.93	7259.49	0.000	0.032	0.000	0.150	0.000	0.153	0.000	0.002	1	#DIV/0!	4	341.57	78.10
11/12/97	25893.90	25111.93	7259.49	0.000	0.032	0.000	0.150	0.000	0.153	0.000	0.002	1	#DIV/0!	4	341.57	78.10
11/19/97	25893.90	25111.93	7259.48	0.000	0.032	-0.010	0.140	0.010	0.144	0.001	0.001	1	#DIV/0!	4	341.57	77.27
11/26/97	25893.88	25111.94	7259.48	0.022	0.010	0.000	0.140	0.022	0.140	0.000	0.001	2	153.43	1	#DIV/0!	85.91
12/3/97	25893.89	25111.96	7259.51	0.022	0.028	0.030	0.170	0.037	0.172	0.005	0.002	1	26.57	1	45.00	80.55
12/10/97	25893.90	25111.95	7259.48	0.014	0.032	-0.030	0.140	0.033	0.144	0.004	0.003	4	315.00	1	71.57	77.27
12/17/97	25893.90	25111.94	7259.51	0.010	0.030	0.030	0.170	0.032	0.173	0.004	0.003	4	270.00	1	#DIV/0!	79.99
12/23/97	25893.90	25111.95	7259.50	0.010	0.032	-0.010	0.160	0.014	0.163	0.002	0.003	1	0.00	1	71.57	78.82
12/30/97	25893.90	25111.95	7259.51	0.000	0.032	0.010	0.170	0.010	0.173	0.001	0.002	1	#DIV/0!	1	71.57	79.46
1/7/98	25893.90	25111.94	7259.51	0.010	0.030	0.000	0.170	0.010	0.173	0.000	0.002	4	270.00	1	#DIV/0!	79.99
1/14/98	25893.89	25111.95	7259.50	0.014	0.022	-0.010	0.160	0.017	0.162	0.002	0.001	2	135.00	1	63.43	82.04
1/27/98	25893.88	25111.94	7259.50	0.014	0.010	0.000	0.160	0.014	0.160	0.000	0.001	3	225.00	1	#DIV/0!	86.42

LEVEE 2 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
2/3/98	25893.90	25111.94	7259.51	0.020	0.030	0.010	0.170	0.022	0.173	0.002	0.001	1	#DIV/0!	1	#DIV/0!	79.99
2/19/98	25893.89	25111.96	7259.51	0.022	0.028	0.000	0.170	0.022	0.172	0.000	0.001	2	116.57	1	45.00	80.55
3/25/98	25893.88	25111.94	7259.47	0.022	0.010	-0.040	0.130	0.046	0.130	0.001	0.002	3	206.57	1	#DIV/0!	85.60
4/3/98	25893.88	25111.95	7259.51	0.010	0.014	0.040	0.170	0.041	0.171	0.004	0.002	1	0.00	1	45.00	85.24
4/8/98	25893.90	25111.93	7259.51	0.028	0.032	0.000	0.170	0.028	0.173	0.000	0.002	4	315.00	4	341.57	79.46
4/15/98	25893.88	25111.94	7259.50	0.022	0.010	-0.010	0.160	0.024	0.160	0.002	0.002	2	153.43	1	#DIV/0!	86.42
4/22/98	25893.90	25111.92	7259.49	0.028	0.036	-0.010	0.150	0.030	0.154	0.001	0.002	4	315.00	4	326.31	76.48
4/29/98	25893.88	25111.94	7259.47	0.028	0.010	-0.020	0.130	0.035	0.130	0.003	0.003	2	135.00	1	#DIV/0!	85.60
5/7/98	25893.88	25111.95	7259.52	0.010	0.014	0.050	0.180	0.051	0.181	0.006	0.002	1	0.00	1	45.00	85.51
5/13/98	25893.89	25111.95	7259.52	0.010	0.022	0.000	0.180	0.010	0.181	0.000	0.003	1	#DIV/0!	1	63.43	82.92
5/21/98	25893.90	25111.91	7259.46	0.041	0.042	-0.060	0.120	0.073	0.127	0.007	0.005	4	284.04	4	315.00	70.53
5/28/98	25893.89	25111.93	7259.51	0.022	0.022	0.050	0.170	0.055	0.171	0.006	0.005	2	116.57	4	333.43	82.51
6/3/98	25893.88	25111.92	7259.47	0.014	0.022	-0.040	0.130	0.042	0.132	0.007	0.005	3	225.00	4	296.57	80.24
6/10/98	25893.88	25111.95	7259.52	0.030	0.014	0.050	0.180	0.058	0.181	0.007	0.007	1	0.00	1	45.00	85.51
6/17/98	25893.88	25111.92	7259.47	0.030	0.022	-0.050	0.130	0.058	0.132	0.007	0.006	4	270.00	4	296.57	80.24
6/24/98	25893.88	25111.94	7259.50	0.020	0.010	0.030	0.160	0.036	0.160	0.004	0.005	1	0.00	1	#DIV/0!	86.42
7/1/98	25893.87	25111.93	7259.48	0.014	0.010	-0.020	0.140	0.024	0.140	0.003	0.004	3	225.00	4	270.00	85.91
7/8/98	25893.87	25111.93	7259.48	0.000	0.010	0.000	0.140	0.000	0.140	0.000	0.003	1	#DIV/0!	4	270.00	85.91
7/15/98	25893.87	25111.95	7259.49	0.020	0.010	0.010	0.150	0.022	0.150	0.001	0.002	1	0.00	1	0.00	86.19
7/22/98	25893.88	25111.96	7259.49	0.014	0.022	0.000	0.150	0.014	0.152	0.000	0.001	1	45.00	1	26.57	81.52
7/29/98	25893.88	25111.96	7259.48	0.000	0.022	-0.010	0.140	0.010	0.142	0.001	0.002	1	#DIV/0!	1	26.57	80.93
8/11/98	25893.88	25111.95	7259.42	0.010	0.014	-0.060	0.080	0.061	0.081	0.005	0.002	4	270.00	1	45.00	79.98
8/19/98	25893.88	25111.95	7259.43	0.000	0.014	0.010	0.090	0.010	0.091	0.001	0.002	1	#DIV/0!	1	45.00	81.07
8/31/98	25893.87	25111.94	7259.49	0.014	0.000	0.060	0.150	0.062	0.150	0.005	0.003	3	225.00	1	#DIV/0!	#DIV/0!
9/11/98	25893.89	25111.96	7259.52	0.028	0.028	0.030	0.180	0.041	0.182	0.003	0.005	1	45.00	1	45.00	81.07
9/16/98	25893.85	25111.97	7259.46	0.041	0.036	-0.060	0.120	0.073	0.125	0.011	0.005	2	165.96	2	123.69	73.28
9/22/98	25893.88	25111.95	7259.44	0.036	0.014	-0.020	0.100	0.041	0.101	0.004	0.006	4	326.31	1	45.00	81.95
9/30/98	25893.87	25111.96	7259.49	0.014	0.020	0.050	0.150	0.052	0.151	0.006	0.006	2	135.00	1	0.00	82.41
10/7/98	25893.87	25111.95	7259.46	0.010	0.010	-0.030	0.120	0.032	0.120	0.004	0.005	4	270.00	1	0.00	85.24
3/3/99	25893.85	25111.96	7259.46	0.022	0.028	0.000	0.120	0.022	0.123	0.000	0.003	2	153.43	2	135.00	76.74
5/27/99	25893.85	25111.96	7259.44	0.000	0.028	-0.020	0.100	0.020	0.104	0.000	0.002	1	#DIV/0!	2	135.00	74.21
7/23/99	25893.85	25111.96	7259.47	0.000	0.030	0.030	0.130	0.030	0.133	0.001	0.001	772.09	1	0.00	3	182.51

LEVEE 3 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26100.77	25184.32	7309.13													
1/11/96	26100.78	25184.32	7309.10	0.010	0.010	-0.030	-0.030	0.032	0.032	0.004		1	#DIV/0!	1	#DIV/0!	
2/8/96	26100.78	25184.32	7309.10	0.000	0.010	0.000	-0.030	0.000	0.032	0.000		1	#DIV/0!	1	#DIV/0!	-71.57
2/15/96	26100.79	25184.31	7309.11	0.014	0.022	0.010	-0.020	0.017	0.030	0.000		4	315.00	4	333.43	-41.81
2/22/96	26100.80	25184.31	7309.12	0.010	0.032	0.010	-0.010	0.014	0.033	0.000	0.001	1	#DIV/0!	4	341.57	-17.55
2/29/96	26100.77	25184.34	7309.10	0.042	0.020	-0.020	-0.030	0.047	0.036	0.000	0.001	2	135.00	1	0.00	-56.31
3/7/96	26100.80	25184.29	7309.10	0.058	0.042	0.000	-0.030	0.058	0.052	0.002	0.002	4	300.96	4	315.00	-35.26
3/14/96	26100.75	25184.35	7309.11	0.078	0.036	0.010	-0.020	0.079	0.041	0.002	0.002	2	129.81	2	123.69	-29.02
3/22/96	26100.76	25184.33	7309.12	0.022	0.014	0.010	-0.010	0.024	0.017	0.003	0.002	4	296.57	2	135.00	-35.26
3/28/96	26100.78	25184.31	7309.09	0.028	0.014	-0.030	-0.040	0.041	0.042	0.004	0.002	4	315.00	4	315.00	-70.53
4/4/96	26100.79	25184.32	7309.10	0.014	0.020	0.010	-0.030	0.017	0.036	0.001	0.002	1	45.00	1	#DIV/0!	-56.31
4/18/96	26100.78	25184.33	7309.10	0.014	0.014	0.000	-0.030	0.014	0.033	0.000	0.002	2	135.00	1	45.00	-64.76
4/25/96	26100.78	25184.30	7309.10	0.030	0.022	0.000	-0.030	0.030	0.037	0.001	0.001	4	270.00	4	296.57	-53.30
5/2/96	26100.79	25184.29	7309.11	0.014	0.036	0.010	-0.020	0.017	0.041	0.001	0.001	4	315.00	4	303.69	-29.02
5/9/96	26100.79	25184.29	7309.08	0.000	0.036	-0.030	-0.050	0.030	0.062	0.003	0.001	1	#DIV/0!	4	303.69	-54.20
5/31/96	26100.78	25184.27	7309.08	0.022	0.051	0.000	-0.050	0.022	0.071	0.000	0.001	3	206.57	4	281.31	-44.44
6/5/96	26100.78	25184.27	7309.08	0.000	0.051	0.000	-0.050	0.000	0.071	0.000	0.001	1	#DIV/0!	4	281.31	-44.44
6/10/96	26100.77	25184.29	7309.11	0.022	0.030	0.030	-0.020	0.037	0.036	0.007	0.005	2	116.57	4	270.00	-33.69
6/13/96	26100.78	25184.26	7309.10	0.032	0.061	-0.010	-0.030	0.033	0.068	0.011	0.005	4	288.43	4	279.46	-26.25
7/11/96	26100.76	25184.26	7309.06	0.020	0.061	-0.040	-0.070	0.045	0.093	0.001	0.004	2	#DIV/0!	3	189.46	-49.01
7/18/96	26100.77	25184.27	7309.11	0.014	0.050	0.050	-0.020	0.052	0.054	0.006	0.004	1	45.00	4	270.00	-21.80
7/25/96	26100.76	25184.25	7309.10	0.022	0.071	-0.010	-0.030	0.024	0.077	0.003	0.004	3	206.57	3	188.13	-22.99
8/16/96	26100.78	25184.24	7309.09	0.022	0.081	-0.010	-0.040	0.024	0.090	0.001	0.002	4	333.43	4	277.13	-26.39
9/12/96	26100.77	25184.27	7309.09	0.032	0.050	0.000	-0.040	0.032	0.064	0.001	0.003	2	108.43	4	270.00	-38.66
9/19/96	26100.79	25184.26	7309.05	0.022	0.063	-0.040	-0.080	0.046	0.102	0.005	0.002	4	333.43	4	288.43	-51.67
9/26/96	26100.77	25184.25	7309.06	0.022	0.070	0.010	-0.070	0.024	0.099	0.000	0.002	3	243.43	4	270.00	-45.00
10/2/96	26100.76	25184.26	7309.08	0.014	0.061	0.020	-0.050	0.024	0.079	0.003	0.002	2	135.00	3	189.46	-39.42
10/10/96	26100.75	25184.24	7309.08	0.022	0.082	0.000	-0.050	0.022	0.096	0.002	0.002	3	206.57	3	194.04	-31.23
10/24/96	26100.76	25184.24	7309.06	0.010	0.081	-0.020	-0.070	0.022	0.107	0.001	0.001	1	#DIV/0!	3	187.13	-40.97
11/18/96	26100.76	25184.26	7309.03	0.020	0.061	-0.030	-0.100	0.036	0.117	0.000	0.002	1	0.00	3	189.46	-58.69
5/16/97	26100.76	25184.22	7309.01	0.040	0.100	-0.020	-0.120	0.045	0.157	0.000	0.002	4	270.00	3	185.71	-50.05
5/22/97	26100.76	25184.24	7309.01	0.020	0.081	0.000	-0.120	0.020	0.145	0.002	0.002	1	0.00	3	187.13	-56.10
6/4/97	26100.77	25184.21	7309.00	0.032	0.110	-0.010	-0.130	0.033	0.170	0.002	0.002	4	288.43	4	270.00	-49.76
6/11/97	26100.76	25184.25	7309.00	0.041	0.071	0.000	-0.130	0.041	0.148	0.003	0.003	2	104.04	3	188.13	-61.46
6/18/97	26100.79	25184.21	7309.01	0.050	0.112	0.010	-0.120	0.051	0.164	0.002	0.003	4	306.87	4	280.30	-47.03
6/25/97	26100.78	25184.20	7308.97	0.014	0.120	-0.040	-0.160	0.042	0.200	0.005	0.004	3	225.00	4	274.76	-53.03
7/2/97	26100.95	25184.30	7308.97	0.197	0.181	0.000	-0.160	0.197	0.242	0.006	0.005	1	59.53	4	353.66	-41.46
7/9/97	26100.95	25184.30	7308.99	0.000	0.181	0.020	-0.140	0.020	0.229	0.002	0.004	1	#DIV/0!	4	353.66	-37.70
7/16/97	26100.79	25184.22	7309.01	0.179	0.102	0.020	-0.120	0.180	0.157	0.010	0.004	3	243.43	4	281.31	-49.64
7/25/97	26100.78	25184.23	7308.97	0.014	0.091	-0.040	-0.160	0.042	0.184	0.003	0.004	2	135.00	4	276.34	-60.49
7/30/97	26100.80	25184.21	7308.98	0.028	0.114	0.010	-0.150	0.030	0.188	0.001	0.003	4	315.00	4	285.26	-52.76
8/6/97	26100.79	25184.21	7308.98	0.010	0.112	0.000	-0.150	0.010	0.187	0.000	0.003	2	#DIV/0!	4	280.30	-53.30
8/13/97	26100.79	25184.19	7308.97	0.020	0.132	-0.010	-0.160	0.022	0.207	0.003	0.002	4	270.00	4	278.75	-50.58
8/20/97	26100.79	25184.19	7308.99	0.000	0.132	0.020	-0.140	0.020	0.192	0.002	0.002	1	#DIV/0!	4	278.75	-46.79
8/27/97	26100.79	25184.19	7308.99	0.000	0.132	0.000	-0.140	0.000	0.192	0.000	0.002	1	#DIV/0!	4	278.75	-46.79
9/2/97	26100.79	25184.20	7309.00	0.010	0.122	0.010	-0.130	0.014	0.178	0.002	0.002	1	0.00	4	279.46	-46.90
9/10/97	26100.79	25184.18	7308.98	0.020	0.141	-0.020	-0.150	0.028	0.206	0.004	0.002	4	270.00	4	278.13	-46.69
9/25/97	26100.78	25184.20	7308.97	0.022	0.120	-0.010	-0.160	0.024	0.200	0.000	0.001	2	116.57	4	274.76	-53.03
10/1/97	26100.78	25184.18	7308.98	0.020	0.140	0.010	-0.150	0.022	0.205	0.001	0.002	4	270.00	4	274.09	-46.90
10/8/97	26100.78	25184.20	7308.92	0.020	0.120	-0.060	-0.210	0.063	0.242	0.005	0.002	1	0.00	4	274.76	-60.17
10/16/97	26100.79	25184.17	7308.94	0.032	0.151	0.020	-0.190	0.037	0.243	0.000	0.002	4	288.43	4	277.59	-51.46
10/22/97	26100.78	25184.20	7308.94	0.032	0.120	0.000	-0.190	0.032	0.225	0.003	0.002	2	108.43	4	274.76	-57.63
10/29/97	26100.80	25184.18	7308.95	0.028	0.143	0.010	-0.180	0.030	0.230	0.001	0.002	4	315.00	4	282.09	-51.50
11/5/97	26100.81	25184.17	7308.95	0.014	0.155	0.000	-0.180	0.014	0.238	0.001	0.001	4	315.00	4	284.93	-49.22
11/12/97	26100.81	25184.18	7308.95	0.010	0.146	0.000	-0.180	0.010	0.232	0.001	0.002	1	0.00	4	285.95	-51.03

LEVEE 3 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
11/19/97	26100.80	25184.18	7308.97	0.010	0.143	0.020	-0.160	0.022	0.215	0.002	0.001	2	#DIV/0!	4	282.09	-48.18
11/26/97	26100.79	25184.18	7308.98	0.010	0.141	0.010	-0.150	0.014	0.206	0.001	0.002	2	#DIV/0!	4	278.13	-46.69
12/3/97	26100.79	25184.21	7308.98	0.030	0.112	0.000	-0.150	0.030	0.187	0.003	0.003	1	0.00	4	280.30	-53.30
12/10/97	26100.82	25184.19	7308.92	0.036	0.139	-0.060	-0.210	0.070	0.252	0.009	0.004	4	326.31	4	291.04	-56.45
12/17/97	26100.81	25184.17	7308.95	0.022	0.155	0.030	-0.180	0.037	0.238	0.002	0.003	3	206.57	4	284.93	-49.22
12/23/97	26100.81	25184.18	7308.93	0.010	0.146	-0.020	-0.200	0.022	0.247	0.002	0.003	1	0.00	4	285.95	-53.94
12/30/97	26100.80	25184.19	7308.93	0.014	0.133	0.000	-0.200	0.014	0.240	0.001	0.004	2	135.00	4	282.99	-56.29
1/7/98	26100.80	25184.20	7308.96	0.010	0.124	0.030	-0.170	0.032	0.210	0.004	0.002	1	0.00	4	284.04	-53.96
1/14/98	26100.78	25184.21	7308.96	0.022	0.110	0.000	-0.170	0.022	0.203	0.001	0.002	2	153.43	4	275.19	-56.99
1/27/98	26100.77	25184.23	7308.96	0.022	0.090	0.000	-0.170	0.022	0.192	0.001	0.003	2	116.57	4	270.00	-62.10
2/3/98	26100.81	25184.17	7308.95	0.072	0.155	-0.010	-0.180	0.073	0.238	0.006	0.003	4	303.69	4	284.93	-49.22
2/19/98	26100.79	25184.21	7308.98	0.045	0.112	0.030	-0.150	0.054	0.187	0.003	0.003	2	116.57	4	280.30	-53.30
3/25/98	26100.79	25184.19	7308.94	0.020	0.132	-0.040	-0.190	0.045	0.231	0.001	0.003	4	270.00	4	278.75	-55.31
4/3/98	26100.80	25184.20	7308.98	0.014	0.124	0.040	-0.150	0.042	0.194	0.004	0.003	1	45.00	4	284.04	-50.49
4/8/98	26100.80	25184.21	7308.98	0.010	0.114	0.000	-0.150	0.010	0.188	0.001	0.002	1	0.00	4	285.26	-52.76
4/15/98	26100.77	25184.23	7308.96	0.036	0.090	-0.020	-0.170	0.041	0.192	0.001	0.002	2	146.31	4	270.00	-62.10
4/22/98	26100.81	25184.18	7308.96	0.064	0.146	0.000	-0.170	0.064	0.224	0.004	0.002	4	308.66	4	285.95	-49.42
4/29/98	26100.81	25184.17	7308.95	0.010	0.155	-0.010	-0.180	0.014	0.238	0.002	0.002	4	270.00	4	284.93	-49.22
5/7/98	26100.80	25184.20	7308.96	0.032	0.124	0.010	-0.170	0.033	0.210	0.003	0.004	2	108.43	4	284.04	-53.96
5/13/98	26100.76	25184.25	7309.00	0.064	0.071	0.040	-0.130	0.075	0.148	0.010	0.007	2	128.66	3	188.13	-61.46
5/21/98	26100.73	25184.15	7308.91	0.104	0.175	-0.090	-0.220	0.138	0.281	0.017	0.008	3	196.70	3	193.24	-51.56
5/28/98	26100.80	25184.19	7308.95	0.081	0.133	0.040	-0.180	0.090	0.224	0.008	0.008	1	60.26	4	282.99	-53.45
6/3/98	26100.78	25184.19	7308.92	0.020	0.130	-0.030	-0.210	0.036	0.247	0.004	0.009	2	#DIV/0!	4	274.40	-58.16
6/10/98	26100.80	25184.20	7308.96	0.022	0.124	0.040	-0.170	0.046	0.210	0.005	0.008	1	63.43	4	284.04	-53.96
6/17/98	26100.78	25184.19	7308.92	0.022	0.130	-0.040	-0.210	0.046	0.247	0.005	0.005	3	243.43	4	274.40	-58.16
6/24/98	26100.78	25184.17	7308.94	0.020	0.150	0.020	-0.190	0.028	0.242	0.001	0.004	4	270.00	4	273.81	-51.65
7/1/98	26100.76	25184.19	7308.95	0.028	0.130	0.010	-0.180	0.030	0.222	0.003	0.003	2	135.00	3	184.40	-54.08
7/8/98	26100.76	25184.19	7308.95	0.000	0.130	0.000	-0.180	0.000	0.222	0.000	0.002	1	#DIV/0!	3	184.40	-54.08
7/15/98	26100.73	25184.25	7308.95	0.067	0.081	0.000	-0.180	0.067	0.197	0.004	0.002	2	116.57	3	209.74	-65.87
7/22/98	26100.71	25184.23	7308.95	0.028	0.108	0.000	-0.180	0.028	0.210	0.002	0.002	3	225.00	3	213.69	-59.00
7/29/98	26100.71	25184.23	7308.92	0.000	0.108	-0.030	-0.210	0.030	0.236	0.004	0.002	1	#DIV/0!	3	213.69	-62.75
8/11/98	26100.75	25184.22	7308.92	0.041	0.102	0.000	-0.210	0.041	0.233	0.000	0.002	4	345.96	3	191.31	-64.10
8/19/98	26100.74	25184.21	7308.92	0.014	0.114	0.000	-0.210	0.014	0.239	0.001	0.001	3	225.00	3	195.26	-61.50
8/31/98	26100.75	25184.22	7308.92	0.014	0.102	0.000	-0.210	0.014	0.233	0.000	0.002	1	45.00	3	191.31	-64.10
9/11/98	26100.76	25184.22	7309.01	0.010	0.100	0.090	-0.120	0.091	0.157	0.007	0.005	1	#DIV/0!	3	185.71	-50.05
9/16/98	26100.73	25184.25	7308.90	0.042	0.081	-0.110	-0.230	0.118	0.244	0.017	0.005	2	135.00	3	209.74	-70.68
9/22/98	26100.73	25184.23	7308.91	0.020	0.098	0.010	-0.220	0.022	0.241	0.000	0.006	4	270.00	3	203.96	-65.88
9/30/98	26100.73	25184.24	7308.93	0.010	0.089	0.020	-0.200	0.022	0.219	0.003	0.006	1	0.00	3	206.57	-65.91
10/7/98	26100.74	25184.23	7308.91	0.014	0.095	-0.020	-0.220	0.024	0.240	0.003	0.005	4	315.00	3	198.43	-66.67
3/3/99	26100.73	25184.24	7308.93	0.014	0.089	0.020	-0.200	0.024	0.219	0.000	0.001	2	135.00	3	206.57	-65.91
5/27/99	26100.73	25184.17	7308.9	0.070	0.155	-0.030	-0.230	0.076	0.277	0.001	0.001	4	270.00	3	194.93	-55.98
7/23/99	26100.75	25184.18	7308.87	0.022	0.141	-0.030	-0.260	0.037	0.296	0.000	0.001	1	63.43	3	188.13	-61.46

LEVEE 4 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	25978.35	24934.30	7316.63													
1/11/96	25978.37	24934.30	7316.63	0.020	0.020	0.000	0.000	0.020	0.020	0.003		1	#DIV/0!	1	#DIV/0!	
2/8/96	25978.36	24934.30	7316.59	0.010	0.010	-0.040	-0.040	0.041	0.041	0.001		2	#DIV/0!	1	#DIV/0!	-75.96
2/15/96	25978.37	24934.30	7316.59	0.010	0.020	0.000	-0.040	0.010	0.045	0.000		1	#DIV/0!	1	#DIV/0!	-63.43
2/22/96	25978.38	24934.30	7316.62	0.010	0.030	0.030	-0.010	0.032	0.032	0.002	0.001	1	#DIV/0!	1	#DIV/0!	-18.43
2/29/96	25978.38	24934.30	7316.60	0.000	0.030	-0.020	-0.030	0.020	0.042	0.002	0.001	1	#DIV/0!	1	#DIV/0!	-45.00
3/7/96	25978.40	24934.28	7316.60	0.028	0.054	0.000	-0.030	0.028	0.062	0.003	0.002	4	315.00	4	338.20	-29.12
3/14/96	25978.36	24934.34	7316.59	0.072	0.041	-0.010	-0.040	0.073	0.057	0.001	0.002	2	123.69	1	14.04	-44.13
3/22/96	25978.39	24934.31	7316.61	0.042	0.041	0.020	-0.020	0.047	0.046	0.001	0.001	4	315.00	1	75.96	-25.88
3/28/96	25978.39	24934.29	7316.58	0.020	0.041	-0.030	-0.050	0.036	0.065	0.003	0.002	4	270.00	4	345.96	-50.49
4/4/96	25978.40	24934.29	7316.59	0.010	0.051	0.010	-0.040	0.014	0.065	0.000	0.002	1	#DIV/0!	4	348.69	-38.11
4/18/96	25978.39	24934.30	7316.57	0.014	0.040	-0.020	-0.060	0.024	0.072	0.001	0.002	2	135.00	1	#DIV/0!	-56.31
4/25/96	25978.39	24934.28	7316.53	0.020	0.045	-0.040	-0.100	0.045	0.110	0.005	0.002	4	270.00	4	333.43	-65.91
5/2/96	25978.41	24934.28	7316.55	0.020	0.063	0.020	-0.080	0.028	0.102	0.001	0.001	1	#DIV/0!	4	341.57	-51.67
5/9/96	25978.42	24934.27	7316.58	0.014	0.076	0.030	-0.050	0.033	0.091	0.002	0.002	4	315.00	4	336.80	-33.29
5/31/96	25978.41	24934.28	7316.56	0.014	0.063	-0.020	-0.070	0.024	0.094	0.000	0.002	2	135.00	4	341.57	-47.90
6/5/96	25978.41	24934.28	7316.56	0.000	0.063	0.000	-0.070	0.000	0.094	0.000	0.001	1	#DIV/0!	4	341.57	-47.90
6/10/96	25978.40	24934.26	7316.52	0.022	0.064	-0.040	-0.110	0.046	0.127	0.007	0.004	3	206.57	4	321.34	-59.80
6/13/96	25978.39	24934.26	7316.55	0.010	0.057	0.030	-0.080	0.032	0.098	0.010	0.004	2	#DIV/0!	4	315.00	-54.74
7/11/96	25978.43	24934.25	7316.53	0.041	0.094	-0.020	-0.100	0.046	0.137	0.001	0.004	4	345.96	4	327.99	-46.67
7/18/96	25978.45	24934.24	7316.51	0.022	0.117	-0.020	-0.120	0.030	0.167	0.004	0.004	4	333.43	4	329.04	-45.82
7/25/96	25978.44	24934.23	7316.47	0.014	0.114	-0.040	-0.160	0.042	0.196	0.004	0.003	3	225.00	4	322.13	-54.53
8/16/96	25978.48	24934.23	7316.48	0.040	0.148	0.010	-0.150	0.041	0.210	0.001	0.002	1	#DIV/0!	4	331.70	-45.45
9/12/96	25978.50	24934.23	7316.46	0.020	0.166	-0.020	-0.170	0.028	0.237	0.001	0.002	1	#DIV/0!	4	334.98	-45.76
9/19/96	25978.50	24934.24	7316.43	0.010	0.162	-0.030	-0.200	0.032	0.257	0.003	0.002	1	0.00	4	338.20	-51.07
9/26/96	25978.50	24934.25	7316.42	0.010	0.158	-0.010	-0.210	0.014	0.263	0.001	0.002	1	0.00	4	341.57	-53.02
10/2/96	25978.49	24934.24	7316.44	0.014	0.152	0.020	-0.190	0.024	0.244	0.003	0.002	3	225.00	4	336.80	-51.28
10/10/96	25978.50	24934.23	7316.43	0.014	0.166	-0.010	-0.200	0.017	0.260	0.002	0.002	4	315.00	4	334.98	-50.39
10/24/96	25978.50	24934.22	7316.39	0.010	0.170	-0.040	-0.240	0.041	0.294	0.002	0.002	4	270.00	4	331.93	-54.69
11/18/96	25978.52	24934.25	7316.37	0.036	0.177	-0.020	-0.260	0.041	0.315	0.001	0.002	1	33.69	4	343.61	-55.72
5/16/97	25978.59	24934.21	7316.30	0.081	0.256	-0.070	-0.330	0.107	0.418	0.001	0.001	4	330.26	4	339.44	-52.16
5/22/97	25978.58	24934.21	7316.28	0.010	0.247	-0.020	-0.350	0.022	0.428	0.002	0.001	2	#DIV/0!	4	338.63	-54.79
6/4/97	25978.60	24934.17	7316.28	0.045	0.282	0.000	-0.350	0.045	0.449	0.002	0.001	4	296.57	4	332.53	-51.16
6/11/97	25978.59	24934.21	7316.26	0.041	0.256	-0.020	-0.370	0.046	0.450	0.000	0.001	2	104.04	4	339.44	-55.29
6/18/97	25978.60	24934.17	7316.28	0.041	0.282	0.020	-0.350	0.046	0.449	0.000	0.001	4	284.04	4	332.53	-51.16
6/25/97	25978.61	24934.18	7316.26	0.014	0.286	-0.020	-0.370	0.024	0.468	0.003	0.002	1	45.00	4	335.22	-52.26
7/2/97	25978.63	24934.17	7316.25	0.022	0.309	-0.010	-0.380	0.024	0.490	0.003	0.002	4	333.43	4	335.10	-50.91
7/9/97	25978.63	24934.17	7316.26	0.000	0.309	0.010	-0.370	0.010	0.482	0.001	0.002	1	#DIV/0!	4	335.10	-50.16
7/16/97	25978.60	24934.18	7316.28	0.032	0.277	0.020	-0.350	0.037	0.447	0.005	0.002	2	161.57	4	334.36	-51.61
7/25/97	25978.61	24934.17	7316.24	0.014	0.291	-0.040	-0.390	0.042	0.486	0.004	0.002	4	315.00	4	333.43	-53.30
7/30/97	25978.61	24934.17	7316.24	0.000	0.291	0.000	-0.390	0.000	0.486	0.000	0.002	1	#DIV/0!	4	333.43	-53.30
8/6/97	25978.60	24934.17	7316.24	0.010	0.282	0.000	-0.390	0.010	0.481	0.001	0.002	2	#DIV/0!	4	332.53	-54.15
8/13/97	25978.61	24934.17	7316.24	0.010	0.291	0.000	-0.390	0.010	0.486	0.001	0.001	1	#DIV/0!	4	333.43	-53.30
8/20/97	25978.62	24934.17	7316.26	0.010	0.300	0.020	-0.370	0.022	0.476	0.001	0.001	1	#DIV/0!	4	334.29	-51.00
8/27/97	25978.61	24934.17	7316.25	0.010	0.291	-0.010	-0.380	0.014	0.478	0.000	0.001	2	#DIV/0!	4	333.43	-52.59
9/2/97	25978.61	24934.18	7316.24	0.010	0.286	-0.010	-0.390	0.014	0.484	0.001	0.001	1	0.00	4	335.22	-53.71
9/10/97	25978.62	24934.16	7316.25	0.022	0.304	0.010	-0.380	0.024	0.487	0.000	0.001	4	296.57	4	332.59	-51.33
9/25/97	25978.63	24934.16	7316.22	0.010	0.313	-0.030	-0.410	0.032	0.516	0.002	0.002	1	#DIV/0!	4	333.43	-52.64
10/1/97	25978.61	24934.17	7316.24	0.022	0.291	0.020	-0.390	0.030	0.486	0.005	0.002	2	153.43	4	333.43	-53.30
10/8/97	25978.62	24934.17	7316.22	0.010	0.300	-0.020	-0.410	0.022	0.508	0.003	0.002	1	#DIV/0!	4	334.29	-53.84
10/16/97	25978.64	24934.16	7316.24	0.022	0.322	0.020	-0.390	0.030	0.506	0.000	0.002	4	333.43	4	334.23	-50.45
10/22/97	25978.63	24934.18	7316.24	0.022	0.305	0.000	-0.390	0.022	0.495	0.002	0.003	2	116.57	4	336.80	-52.01
10/29/97	25978.65	24934.16	7316.20	0.028	0.331	-0.040	-0.430	0.049	0.543	0.007	0.003	4	315.00	4	334.98	-52.41
11/5/97	25978.65	24934.15	7316.19	0.010	0.335	-0.010	-0.440	0.014	0.553	0.002	0.002	4	270.00	4	333.43	-52.68
11/12/97	25978.65	24934.15	7316.20	0.000	0.335	0.010	-0.430	0.010	0.545	0.001	0.003	1	#DIV/0!	4	333.43	-52.04
11/19/97	25978.64	24934.18	7316.22	0.032	0.314	0.020	-0.410	0.037	0.516	0.004	0.003	2	108.43	4	337.52	-52.57
11/26/97	25978.63	24934.17	7316.21	0.014	0.309	-0.010	-0.420	0.017	0.521	0.001	0.002	3	225.00	4	335.10	-53.68
12/3/97	25978.65	24934.19	7316.20	0.028	0.320	-0.010	-0.430	0.030	0.536	0.002	0.002	1	45.00	4	339.86	-53.38
12/10/97	25978.67	24934.15	7316.20	0.045	0.353	0.000	-0.430	0.045	0.557	0.003	0.002	4	296.57	4	334.89	-50.56

LEVEE 4 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/17/97	25978.65	24934.15	7316.20	0.020	0.335	0.000	-0.430	0.020	0.545	0.002	0.002	2	#DIV/0!	4	333.43	-52.04
12/23/97	25978.65	24934.16	7316.20	0.010	0.331	0.000	-0.430	0.010	0.543	0.000	0.002	1	0.00	4	334.98	-52.41
12/30/97	25978.65	24934.18	7316.19	0.020	0.323	-0.010	-0.440	0.022	0.546	0.000	0.001	1	0.00	4	338.20	-53.71
1/7/98	25978.65	24934.17	7316.21	0.010	0.327	0.020	-0.420	0.022	0.532	0.002	0.001	4	270.00	4	336.57	-52.10
1/14/98	25978.65	24934.18	7316.19	0.010	0.323	-0.020	-0.440	0.022	0.546	0.002	0.001	1	0.00	4	338.20	-53.71
1/27/98	25978.65	24934.16	7316.19	0.020	0.331	0.000	-0.440	0.020	0.551	0.000	0.001	4	270.00	4	334.98	-53.04
2/3/98	25978.65	24934.15	7316.2	0.010	0.335	0.010	-0.430	0.014	0.545	0.001	0.001	4	270.00	4	333.43	-52.04
2/19/98	25978.65	24934.19	7316.2	0.040	0.320	0.000	-0.430	0.040	0.536	0.001	0.001	1	0.00	4	339.86	-53.38
3/25/98	25978.66	24934.18	7316.2	0.014	0.332	0.000	-0.430	0.014	0.544	0.000	0.001	4	315.00	4	338.84	-52.29
4/3/98	25978.67	24934.16	7316.18	0.022	0.349	-0.020	-0.450	0.030	0.570	0.003	0.004	4	296.57	4	336.37	-52.18
4/8/98	25978.61	24934.17	7316.24	0.061	0.291	0.060	-0.390	0.085	0.486	0.017	0.006	2	170.54	4	333.43	-53.30
4/15/98	25978.65	24934.16	7316.19	0.041	0.331	-0.050	-0.440	0.065	0.551	0.009	0.007	4	345.96	4	334.98	-53.04
4/22/98	25978.68	24934.14	7316.17	0.036	0.367	-0.020	-0.460	0.041	0.588	0.005	0.007	4	326.31	4	334.13	-51.44
4/29/98	25978.67	24934.16	7316.16	0.022	0.349	-0.010	-0.470	0.024	0.586	0.000	0.007	2	116.57	4	336.37	-53.38
5/7/98	25978.67	24934.17	7316.19	0.010	0.345	0.030	-0.440	0.032	0.559	0.003	0.007	1	0.00	4	337.89	-51.87
5/13/98	25978.59	24934.21	7316.26	0.089	0.256	0.070	-0.370	0.114	0.450	0.018	0.010	2	153.43	4	339.44	-55.29
5/21/98	25978.68	24934.14	7316.13	0.114	0.367	-0.130	-0.500	0.173	0.620	0.021	0.009	4	322.13	4	334.13	-53.74
5/28/98	25978.68	24934.16	7316.16	0.020	0.358	0.030	-0.470	0.036	0.591	0.004	0.010	1	0.00	4	337.01	-52.67
6/3/98	25978.67	24934.16	7316.14	0.010	0.349	-0.020	-0.490	0.022	0.602	0.002	0.010	2	#DIV/0!	4	336.37	-54.52
6/10/98	25978.67	24934.17	7316.19	0.010	0.345	0.050	-0.440	0.051	0.559	0.006	0.008	1	0.00	4	337.89	-51.87
6/17/98	25978.67	24934.16	7316.14	0.010	0.349	-0.050	-0.490	0.051	0.602	0.006	0.004	4	270.00	4	336.37	-54.52
6/24/98	25978.68	24934.16	7316.14	0.010	0.358	0.000	-0.490	0.010	0.607	0.001	0.004	1	#DIV/0!	4	337.01	-53.81
7/1/98	25978.67	24934.16	7316.16	0.010	0.349	0.020	-0.470	0.022	0.586	0.003	0.003	2	#DIV/0!	4	336.37	-53.38
7/8/98	25978.67	24934.16	7316.16	0.000	0.349	0.000	-0.470	0.000	0.586	0.000	0.002	1	#DIV/0!	4	336.37	-53.38
7/15/98	25978.67	24934.17	7316.17	0.010	0.345	0.010	-0.460	0.014	0.575	0.001	0.002	1	0.00	4	337.89	-53.10
7/22/98	25978.7	24934.13	7316.15	0.050	0.389	-0.020	-0.480	0.054	0.618	0.006	0.003	4	306.87	4	334.09	-50.97
7/29/98	25978.68	24934.17	7316.15	0.045	0.355	0.000	-0.480	0.045	0.597	0.003	0.002	2	116.57	4	338.50	-53.54
8/11/98	25978.67	24934.16	7316.15	0.014	0.349	0.000	-0.480	0.014	0.594	0.000	0.002	3	225.00	4	336.37	-53.96
8/19/98	25978.67	24934.17	7316.15	0.010	0.345	0.000	-0.480	0.010	0.591	0.000	0.002	1	0.00	4	337.89	-54.26
8/31/98	25978.67	24934.16	7316.14	0.010	0.349	-0.010	-0.490	0.014	0.602	0.001	0.004	4	270.00	4	336.37	-54.52
9/11/98	25978.59	24934.21	7316.3	0.094	0.256	0.160	-0.330	0.186	0.418	0.017	0.012	2	147.99	4	339.44	-52.16
9/16/98	25978.68	24934.16	7316.11	0.103	0.358	-0.190	-0.520	0.216	0.632	0.043	0.013	4	330.95	4	337.01	-55.42
9/22/98	25978.7	24934.15	7316.11	0.022	0.381	0.000	-0.520	0.022	0.645	0.002	0.013	4	333.43	4	336.80	-53.79
9/30/98	25978.69	24934.15	7316.13	0.010	0.372	0.020	-0.500	0.022	0.623	0.003	0.014	2	#DIV/0!	4	336.19	-53.38
10/7/98	25978.7	24934.16	7316.1	0.014	0.377	-0.030	-0.530	0.033	0.650	0.004	0.010	1	45.00	4	338.20	-54.58
3/3/99	25978.68	24934.11	7316.09	0.054	0.381	-0.010	-0.540	0.055	0.661	0.000	0.002	3	201.80	4	330.07	-54.81
5/27/99	25978.72	24934.11	7316.07	0.040	0.416	-0.020	-0.560	0.045	0.698	0.000	0.001	1	#DIV/0!	4	332.82	-53.40
7/23/99	25978.73	24934.1	7316.06	0.014	0.429	-0.010	-0.570	0.017	0.714	0.000	0.001	4	315.00	4	332.24	-53.01

MD1 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26379.64	23941.41	7254.20													
1/11/96	26379.65	23941.41	7254.17	0.010	0.010	-0.030	-0.030	0.032	0.032	0.004		1	#DIV/0!	1	#DIV/0!	
2/8/96	26379.65	23941.42	7254.17	0.010	0.014	0.000	-0.030	0.010	0.033	0.000		1	0.00	1	45.00	-64.76
2/15/96	26379.63	23941.39	7254.16	0.036	0.022	-0.010	-0.040	0.037	0.046	0.002		3	213.69	3	206.57	-60.79
2/22/96	26379.63	23941.40	7254.16	0.010	0.014	0.000	-0.040	0.010	0.042	0.000	0.002	1	0.00	3	225.00	-70.53
2/29/96	26379.67	23941.47	7254.17	0.081	0.067	0.010	-0.030	0.081	0.073	0.004	0.002	1	29.74	1	26.57	-24.09
3/7/96	26379.62	23941.38	7254.16	0.103	0.036	-0.010	-0.040	0.103	0.054	0.003	0.003	3	209.05	3	213.69	-47.97
3/14/96	26379.67	23941.47	7254.21	0.103	0.067	0.050	0.010	0.114	0.068	0.002	0.003	1	29.05	1	26.57	8.48
3/22/96	26379.65	23941.45	7254.20	0.028	0.041	-0.010	0.000	0.030	0.041	0.003	0.003	3	225.00	1	14.04	0.00
3/28/96	26379.64	23941.42	7254.19	0.032	0.010	-0.010	-0.010	0.033	0.014	0.005	0.002	3	198.43	1	0.00	-45.00
4/4/96	26379.65	23941.42	7254.20	0.010	0.014	0.010	0.000	0.014	0.014	0.000	0.003	1	#DIV/0!	1	45.00	0.00
4/18/96	26379.66	23941.46	7254.20	0.041	0.054	0.000	0.000	0.041	0.054	0.003	0.003	1	14.04	1	21.80	0.00
4/25/96	26379.62	23941.45	7254.15	0.041	0.045	-0.050	-0.050	0.065	0.067	0.002	0.002	3	255.96	2	116.57	-48.19
5/2/96	26379.62	23941.43	7254.17	0.020	0.028	0.020	-0.030	0.028	0.041	0.004	0.002	4	270.00	2	135.00	-46.69
5/9/96	26379.62	23941.40	7254.15	0.030	0.022	-0.020	-0.050	0.036	0.055	0.002	0.002	4	270.00	3	243.43	-65.91
5/31/96	26379.62	23941.41	7254.14	0.010	0.020	-0.010	-0.060	0.014	0.063	0.000	0.002	1	0.00	2	#DIV/0!	-71.57
6/10/96	26379.63	23941.46	7254.16	0.051	0.051	0.020	-0.040	0.055	0.065	0.000	0.002	1	11.31	2	101.31	-38.11
6/13/96	26379.60	23941.41	7254.12	0.058	0.040	-0.040	-0.080	0.071	0.089	0.008	0.002	3	210.96	2	#DIV/0!	-63.43
7/11/96	26379.59	23941.42	7254.16	0.014	0.051	0.040	-0.040	0.042	0.065	0.001	0.002	2	135.00	2	168.69	-38.11
7/18/96	26379.62	23941.41	7254.14	0.032	0.020	-0.020	-0.060	0.037	0.063	0.000	0.001	4	341.57	2	#DIV/0!	-71.57
7/25/96	26379.58	23941.41	7254.18	0.040	0.060	0.040	-0.020	0.057	0.063	0.000	0.002	2	#DIV/0!	2	#DIV/0!	-18.43
8/16/96	26379.60	23941.39	7254.16	0.028	0.045	-0.020	-0.040	0.035	0.060	0.000	0.001	4	315.00	3	243.43	-41.81
9/12/96	26379.62	23941.39	7254.17	0.020	0.028	0.010	-0.030	0.022	0.041	0.001	0.001	1	#DIV/0!	3	225.00	-46.69
9/26/96	26379.59	23941.39	7254.18	0.030	0.054	0.010	-0.020	0.032	0.057	0.001	0.001	2	#DIV/0!	3	248.20	-20.37
10/2/96	26379.59	23941.39	7254.14	0.000	0.054	-0.040	-0.060	0.040	0.081	0.004	0.002	1	#DIV/0!	3	248.20	-48.09
10/10/96	26379.56	23941.38	7254.18	0.032	0.085	0.040	-0.020	0.051	0.088	0.001	0.002	3	251.57	3	249.44	-13.17
10/24/96	26379.57	23941.41	7254.09	0.032	0.070	-0.090	-0.110	0.095	0.130	0.003	0.002	1	18.43	2	#DIV/0!	-57.53
11/18/96	26379.60	23941.41	7254.15	0.030	0.040	0.060	-0.050	0.067	0.064	0.003	0.003	1	#DIV/0!	2	#DIV/0!	-51.34
5/16/97	26379.56	23941.38	7254.11	0.050	0.085	-0.040	-0.090	0.064	0.124	0.000	0.003	3	233.13	3	249.44	-46.49
5/22/97	26379.59	23941.40	7254.12	0.036	0.051	0.010	-0.080	0.037	0.095	0.005	0.003	1	56.31	3	258.69	-57.49
6/4/97	26379.54	23941.37	7254.12	0.058	0.108	0.000	-0.080	0.058	0.134	0.003	0.003	3	239.04	3	248.20	-36.60
6/11/97	26379.57	23941.41	7254.12	0.050	0.070	0.000	-0.080	0.050	0.106	0.004	0.004	1	36.87	2	#DIV/0!	-48.81
6/18/97	26379.59	23941.41	7254.15	0.020	0.050	0.030	-0.050	0.036	0.071	0.005	0.004	1	#DIV/0!	2	#DIV/0!	-45.00
6/25/97	26379.59	23941.41	7254.12	0.000	0.050	-0.030	-0.080	0.030	0.094	0.003	0.004	1	#DIV/0!	2	#DIV/0!	-57.99
7/2/97	26379.56	23941.37	7254.11	0.050	0.089	-0.010	-0.090	0.051	0.127	0.005	0.003	3	216.87	3	243.43	-45.18
7/9/97	26379.55	23941.37	7254.12	0.010	0.098	0.010	-0.080	0.014	0.127	0.000	0.004	2	#DIV/0!	3	246.04	-39.09
7/16/97	26379.58	23941.42	7254.13	0.058	0.061	0.010	-0.070	0.059	0.093	0.005	0.003	1	30.96	2	170.54	-49.01
7/25/97	26379.58	23941.41	7254.12	0.010	0.060	-0.010	-0.080	0.014	0.100	0.001	0.003	4	270.00	2	#DIV/0!	-53.13
7/30/97	26379.55	23941.38	7254.11	0.042	0.095	-0.010	-0.090	0.044	0.131	0.006	0.002	3	225.00	3	251.57	-43.49
8/6/97	26379.55	23941.38	7254.11	0.000	0.095	0.000	-0.090	0.000	0.131	0.000	0.003	1	#DIV/0!	3	251.57	-43.49
8/13/97	26379.56	23941.39	7254.12	0.014	0.082	0.010	-0.080	0.017	0.115	0.002	0.003	1	45.00	3	255.96	-44.13
8/20/97	26379.55	23941.38	7254.11	0.014	0.095	-0.010	-0.090	0.017	0.131	0.002	0.004	3	225.00	3	251.57	-43.49
8/27/97	26379.56	23941.38	7254.12	0.010	0.085	0.010	-0.080	0.014	0.117	0.002	0.003	1	#DIV/0!	3	249.44	-43.12
9/2/97	26379.50	23941.45	7254.11	0.092	0.146	-0.010	-0.090	0.093	0.171	0.009	0.004	2	130.60	2	164.05	-31.72
9/10/97	26379.54	23941.38	7254.10	0.081	0.104	-0.010	-0.100	0.081	0.145	0.003	0.004	4	299.74	3	253.30	-43.77
9/25/97	26379.54	23941.39	7254.08	0.010	0.102	-0.020	-0.120	0.022	0.157	0.001	0.004	1	0.00	3	258.69	-49.64
10/1/97	26379.55	23941.39	7254.15	0.010	0.092	0.070	-0.050	0.071	0.105	0.009	0.005	1	#DIV/0!	3	257.47	-28.47
10/8/97	26379.55	23941.39	7254.12	0.000	0.092	-0.030	-0.080	0.030	0.122	0.002	0.003	1	#DIV/0!	3	257.47	-40.95
10/16/97	26379.55	23941.38	7254.10	0.010	0.095	-0.020	-0.100	0.022	0.138	0.002	0.003	4	270.00	3	251.57	-46.51
10/22/97	26379.56	23941.42	7254.10	0.041	0.081	0.000	-0.100	0.041	0.128	0.002	0.003	1	14.04	2	172.87	-51.12
10/29/97	26379.56	23941.40	7254.10	0.020	0.081	0.000	-0.100	0.020	0.128	0.000	0.002	4	270.00	3	262.87	-51.12
11/5/97	26379.54	23941.39	7254.08	0.022	0.102	-0.020	-0.120	0.030	0.157	0.004	0.002	3	243.43	3	258.69	-49.64
11/12/97	26379.54	23941.40	7254.09	0.010	0.100	0.010	-0.110	0.014	0.149	0.001	0.003	1	0.00	3	264.29	-47.58
11/19/97	26379.59	23941.43	7254.11	0.058	0.054	0.020	-0.090	0.062	0.105	0.006	0.003	1	59.04	2	158.20	-59.11
11/26/97	26379.55	23941.40	7254.11	0.050	0.091	0.000	-0.090	0.050	0.128	0.003	0.003	3	233.13	3	263.66	-44.82

MD1 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/3/97	26379.55	23941.38	7254.10	0.020	0.095	-0.010	-0.100	0.022	0.138	0.001	0.003	4	270.00	3	251.57	-46.51
12/10/97	26379.60	23941.41	7254.09	0.058	0.040	-0.010	-0.110	0.059	0.117	0.003	0.004	1	59.04	2	#DIV/0!	-70.02
12/17/97	26379.54	23941.37	7254.06	0.072	0.108	-0.030	-0.140	0.078	0.177	0.009	0.004	3	236.31	3	248.20	-52.43
12/23/97	26379.55	23941.37	7254.07	0.010	0.098	0.010	-0.130	0.014	0.163	0.002	0.003	1	#DIV/0!	3	246.04	-52.85
12/30/97	26379.54	23941.38	7254.06	0.014	0.104	-0.010	-0.140	0.017	0.175	0.002	0.005	2	135.00	3	253.30	-53.29
1/7/98	26379.57	23941.40	7254.15	0.036	0.071	0.090	-0.050	0.097	0.087	0.011	0.006	1	56.31	3	261.87	-35.26
1/14/98	26379.58	23941.42	7254.08	0.022	0.061	-0.070	-0.120	0.073	0.135	0.007	0.005	1	26.57	2	170.54	-63.12
1/27/98	26379.56	23941.41	7254.11	0.022	0.080	0.030	-0.090	0.037	0.120	0.001	0.006	3	243.43	2	#DIV/0!	-48.37
2/3/98	26379.54	23941.37	7254.06	0.045	0.108	-0.050	-0.140	0.067	0.177	0.008	0.006	3	206.57	3	248.20	-52.43
2/19/98	26379.55	23941.38	7254.1	0.014	0.095	0.040	-0.100	0.042	0.138	0.002	0.004	1	45.00	3	251.57	-46.51
3/25/98	26379.56	23941.42	7254.13	0.041	0.081	0.030	-0.070	0.051	0.107	0.001	0.003	1	14.04	2	172.87	-40.97
4/3/98	26379.56	23941.40	7254.16	0.020	0.081	0.030	-0.040	0.036	0.090	0.002	0.004	4	270.00	3	262.87	-26.39
4/8/98	26379.55	23941.38	7254.11	0.022	0.095	-0.050	-0.090	0.055	0.131	0.008	0.003	3	206.57	3	251.57	-43.49
4/15/98	26379.56	23941.41	7254.11	0.032	0.080	0.000	-0.090	0.032	0.120	0.001	0.004	1	18.43	2	#DIV/0!	-48.37
4/22/98	26379.53	23941.38	7254.09	0.042	0.114	-0.020	-0.110	0.047	0.158	0.005	0.004	3	225.00	3	254.74	-43.97
4/29/98	26379.52	23941.41	7254.12	0.032	0.120	0.030	-0.080	0.044	0.144	0.002	0.004	2	108.43	2	#DIV/0!	-33.69
5/7/98	26379.54	23941.41	7254.08	0.020	0.100	-0.040	-0.120	0.045	0.156	0.001	0.004	1	#DIV/0!	2	#DIV/0!	-50.19
5/13/98	26379.57	23941.41	7254.12	0.030	0.070	0.040	-0.080	0.050	0.106	0.008	0.005	1	#DIV/0!	2	#DIV/0!	-48.81
5/21/98	26379.51	23941.38	7254.08	0.067	0.133	-0.040	-0.120	0.078	0.179	0.009	0.005	3	243.43	3	257.01	-41.97
5/28/98	26379.54	23941.40	7254.11	0.036	0.100	0.030	-0.090	0.047	0.135	0.006	0.006	1	56.31	3	264.29	-41.85
6/3/98	26379.55	23941.43	7254.08	0.032	0.092	-0.030	-0.120	0.044	0.151	0.003	0.005	1	18.43	2	167.47	-52.47
6/10/98	26379.54	23941.41	7254.08	0.022	0.100	0.000	-0.120	0.022	0.156	0.001	0.004	3	206.57	2	#DIV/0!	-50.19
6/17/98	26379.55	23941.43	7254.08	0.022	0.092	0.000	-0.120	0.022	0.151	0.001	0.004	1	26.57	2	167.47	-52.47
6/24/98	26379.59	23941.41	7254.15	0.045	0.050	0.070	-0.050	0.083	0.071	0.012	0.006	4	333.43	2	#DIV/0!	-45.00
7/1/98	26379.52	23941.40	7254.08	0.071	0.120	-0.070	-0.120	0.099	0.170	0.014	0.006	3	261.87	3	265.24	-44.90
7/8/98	26379.51	23941.41	7254.08	0.014	0.130	0.000	-0.120	0.014	0.177	0.001	0.007	2	135.00	2	#DIV/0!	-42.71
7/15/98	26379.54	23941.42	7254.12	0.032	0.100	0.040	-0.080	0.051	0.128	0.007	0.007	1	71.57	2	174.29	-38.52
7/22/98	26379.55	23941.41	7254.11	0.014	0.090	-0.010	-0.090	0.017	0.127	0.000	0.005	4	315.00	2	#DIV/0!	-45.00
7/29/98	26379.56	23941.42	7254.07	0.014	0.081	-0.040	-0.130	0.042	0.153	0.004	0.002	1	45.00	2	172.87	-58.19
8/11/98	26379.55	23941.42	7254.08	0.010	0.091	0.010	-0.120	0.014	0.150	0.000	0.002	2	#DIV/0!	2	173.66	-52.96
8/19/98	26379.56	23941.42	7254.07	0.010	0.081	-0.010	-0.130	0.014	0.153	0.000	0.001	1	#DIV/0!	2	172.87	-58.19
8/31/98	26379.55	23941.43	7254.13	0.014	0.092	0.060	-0.070	0.062	0.116	0.003	0.002	2	135.00	2	167.47	-37.21
9/11/98	26379.56	23941.38	7254.11	0.051	0.085	-0.020	-0.090	0.055	0.124	0.001	0.002	4	281.31	3	249.44	-46.49
9/16/98	26379.59	23941.43	7254.11	0.058	0.054	0.000	-0.090	0.058	0.105	0.004	0.002	1	30.96	2	158.20	-59.11
9/22/98	26379.57	23941.39	7254.12	0.045	0.073	0.010	-0.080	0.046	0.108	0.001	0.002	3	206.57	3	254.05	-47.70
9/30/98	26379.57	23941.42	7254.1	0.030	0.071	-0.020	-0.100	0.036	0.122	0.002	0.002	1	0.00	2	171.87	-54.74
10/7/98	26379.56	23941.40	7254.07	0.022	0.081	-0.030	-0.130	0.037	0.153	0.004	0.003	3	206.57	3	262.87	-58.19
3/3/99	26379.53	23941.4	7254.09	0.030	0.110	0.020	-0.110	0.036	0.156	0.000	0.002	2	#DIV/0!	3	264.81	-44.88
5/27/99	26379.51	23941.35	7254.08	0.054	0.143	-0.010	-0.120	0.055	0.187	0.000	0.002	3	201.80	3	245.22	-39.97
7/23/99	26379.52	23941.38	7254.11	0.032	0.124	0.030	-0.090	0.044	0.153	0.001	0.001	1	18.43	3	255.96	-36.04

MD2 TIME	NORTHING	EASTING	ELEV.	INCREMENTA HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26150.67	24134.25	7253.34													
1/11/96	26150.66	24134.24	7253.32	0.014	0.014	-0.020	-0.020	0.024	0.024	0.003		3	225.00	3	225.00	
2/8/96	26150.66	24134.25	7253.34	0.010	0.010	0.020	0.000	0.022	0.010	0.001		1	0.00	2	#DIV/0!	0.00
2/15/96	26150.66	24134.24	7253.33	0.010	0.014	-0.010	-0.010	0.014	0.017	0.001		4	270.00	3	225.00	-35.26
2/22/96	26150.67	24134.23	7253.33	0.014	0.020	0.000	-0.010	0.014	0.022	0.001	0.001	4	315.00	4	270.00	-26.57
2/29/96	26150.69	24134.29	7253.33	0.063	0.045	0.000	-0.010	0.063	0.046	0.003	0.001	1	18.43	1	26.57	-12.60
3/7/96	26150.65	24134.21	7253.31	0.089	0.045	-0.020	-0.030	0.092	0.054	0.001	0.002	3	206.57	3	206.57	-33.85
3/14/96	26150.69	24134.29	7253.33	0.089	0.045	0.020	-0.010	0.092	0.046	0.001	0.002	1	26.57	1	26.57	-12.60
3/22/96	26150.65	24134.29	7253.34	0.040	0.045	0.010	0.000	0.041	0.045	0.000	0.002	2	#DIV/0!	2	116.57	0.00
3/28/96	26150.67	24134.27	7253.33	0.028	0.020	-0.010	-0.010	0.030	0.022	0.004	0.002	4	315.00	1	0.00	-26.57
4/4/96	26150.67	24134.25	7253.34	0.020	0.000	0.010	0.000	0.022	0.000	0.003	0.002	4	270.00	1	#DIV/0!	#DIV/0!
4/18/96	26150.67	24134.27	7253.35	0.020	0.020	0.010	0.010	0.022	0.022	0.002	0.002	1	0.00	1	0.00	26.57
4/25/96	26150.62	24134.25	7253.34	0.054	0.050	-0.010	0.000	0.055	0.050	0.004	0.002	3	248.20	2	#DIV/0!	0.00
5/2/96	26150.65	24134.26	7253.31	0.032	0.022	-0.030	-0.030	0.044	0.037	0.002	0.002	1	71.57	2	153.43	-53.30
5/9/96	26150.63	24134.23	7253.32	0.036	0.045	0.010	-0.020	0.037	0.049	0.002	0.002	3	213.69	3	243.43	-24.09
5/31/96	26150.64	24134.25	7253.30	0.022	0.030	-0.020	-0.040	0.030	0.050	0.000	0.002	1	26.57	2	#DIV/0!	-53.13
6/10/96	26150.64	24134.29	7253.30	0.040	0.050	0.000	-0.040	0.040	0.064	0.001	0.001	1	0.00	2	126.87	-38.66
6/13/96	26150.63	24134.24	7253.33	0.051	0.041	0.030	-0.010	0.059	0.042	0.007	0.002	3	191.31	3	255.96	-13.63
7/11/96	26150.60	24134.25	7253.30	0.032	0.070	-0.030	-0.040	0.044	0.081	0.001	0.002	2	161.57	2	#DIV/0!	-29.74
7/18/96	26150.62	24134.24	7253.28	0.022	0.051	-0.020	-0.060	0.030	0.079	0.000	0.002	4	333.43	3	258.69	-49.64
7/25/96	26150.60	24134.25	7253.33	0.022	0.070	0.050	-0.010	0.055	0.071	0.001	0.002	2	153.43	2	#DIV/0!	-8.13
8/16/96	26150.59	24134.20	7253.30	0.051	0.094	-0.030	-0.040	0.059	0.102	0.001	0.002	3	191.31	3	237.99	-22.98
9/12/96	26150.61	24134.21	7253.30	0.022	0.072	0.000	-0.040	0.022	0.082	0.001	0.002	1	63.43	3	236.31	-29.02
9/26/96	26150.60	24134.20	7253.32	0.014	0.086	0.020	-0.020	0.024	0.088	0.000	0.002	3	225.00	3	234.46	-13.09
10/2/96	26150.58	24134.21	7253.26	0.022	0.098	-0.060	-0.080	0.064	0.127	0.006	0.002	2	153.43	3	246.04	-39.09
10/10/96	26150.56	24134.20	7253.31	0.022	0.121	0.050	-0.030	0.055	0.124	0.000	0.002	3	243.43	3	245.56	-13.94
10/24/96	26150.57	24134.19	7253.26	0.014	0.117	-0.050	-0.080	0.052	0.141	0.001	0.002	4	315.00	3	239.04	-34.45
11/18/96	26150.61	24134.24	7253.27	0.064	0.061	0.010	-0.070	0.065	0.093	0.002	0.002	1	38.66	3	260.54	-49.01
5/16/97	26150.57	24134.20	7253.23	0.057	0.112	-0.040	-0.110	0.069	0.157	0.000	0.002	3	225.00	3	243.43	-44.53
5/22/97	26150.59	24134.22	7253.23	0.028	0.085	0.000	-0.110	0.028	0.139	0.003	0.002	1	45.00	3	249.44	-52.16
6/4/97	26150.55	24134.18	7253.24	0.057	0.139	0.010	-0.100	0.057	0.171	0.002	0.002	3	225.00	3	239.74	-35.75
6/11/97	26150.58	24134.22	7253.22	0.050	0.095	-0.020	-0.120	0.054	0.153	0.003	0.003	1	36.87	3	251.57	-51.67
6/18/97	26150.58	24134.25	7253.25	0.030	0.090	0.030	-0.090	0.042	0.127	0.004	0.003	1	0.00	2	#DIV/0!	-45.00
6/25/97	26150.58	24134.22	7253.25	0.030	0.095	0.000	-0.090	0.030	0.131	0.000	0.003	4	270.00	3	251.57	-43.49
7/2/97	26150.55	24134.19	7253.22	0.042	0.134	-0.030	-0.120	0.052	0.180	0.007	0.003	3	225.00	3	243.43	-41.81
7/9/97	26150.56	24134.19	7253.22	0.010	0.125	0.000	-0.120	0.010	0.173	0.001	0.003	1	#DIV/0!	3	241.39	-43.76
7/16/97	26150.56	24134.22	7253.23	0.030	0.114	0.010	-0.110	0.032	0.158	0.002	0.002	1	0.00	3	254.74	-43.97
7/25/97	26150.56	24134.21	7253.21	0.010	0.117	-0.020	-0.130	0.022	0.175	0.002	0.003	4	270.00	3	250.02	-48.00
7/30/97	26150.55	24134.19	7253.20	0.022	0.134	-0.010	-0.140	0.024	0.194	0.004	0.002	3	206.57	3	243.43	-46.22
8/6/97	26150.54	24134.20	7253.21	0.014	0.139	0.010	-0.130	0.017	0.191	0.000	0.002	2	135.00	3	248.96	-43.03
8/13/97	26150.55	24134.20	7253.22	0.010	0.130	0.010	-0.120	0.014	0.177	0.002	0.003	1	#DIV/0!	3	247.38	-42.71
8/20/97	26150.53	24134.18	7253.22	0.028	0.157	0.000	-0.120	0.028	0.197	0.003	0.004	3	225.00	3	243.43	-37.48
8/27/97	26150.53	24134.19	7253.21	0.010	0.152	-0.010	-0.130	0.014	0.200	0.000	0.003	1	0.00	3	246.80	-40.48
9/2/97	26150.58	24134.23	7253.24	0.064	0.092	0.030	-0.100	0.071	0.136	0.011	0.004	1	51.34	3	257.47	-47.33
9/10/97	26150.55	24134.21	7253.22	0.036	0.126	-0.020	-0.120	0.041	0.174	0.005	0.004	3	236.31	3	251.57	-43.49
9/25/97	26150.55	24134.20	7253.21	0.010	0.130	-0.010	-0.130	0.014	0.184	0.001	0.004	4	270.00	3	247.38	-45.00
10/1/97	26150.56	24134.23	7253.24	0.032	0.112	0.030	-0.100	0.044	0.150	0.006	0.005	1	18.43	3	259.70	-41.81
10/8/97	26150.56	24134.20	7253.24	0.030	0.121	0.000	-0.100	0.030	0.157	0.001	0.003	4	270.00	3	245.56	-39.61
10/16/97	26150.56	24134.20	7253.23	0.000	0.121	-0.010	-0.110	0.010	0.163	0.001	0.002	1	#DIV/0!	3	245.56	-42.31
10/22/97	26150.56	24134.21	7253.20	0.010	0.117	-0.030	-0.140	0.032	0.182	0.003	0.002	1	0.00	3	250.02	-50.10
10/29/97	26150.56	24134.19	7253.21	0.020	0.125	0.010	-0.130	0.022	0.181	0.000	0.001	4	270.00	3	241.39	-46.05
11/5/97	26150.56	24134.20	7253.20	0.010	0.121	-0.010	-0.140	0.014	0.185	0.001	0.001	1	0.00	3	245.56	-49.20
11/12/97	26150.56	24134.20	7253.21	0.000	0.121	0.010	-0.130	0.010	0.177	0.001	0.002	1	#DIV/0!	3	245.56	-47.09
11/19/97	26150.56	24134.19	7253.24	0.010	0.125	0.030	-0.100	0.032	0.160	0.002	0.001	4	270.00	3	241.39	-38.59
11/26/97	26150.56	24134.20	7253.22	0.010	0.121	-0.020	-0.120	0.022	0.170	0.001	0.002	1	0.00	3	245.56	-44.80
12/3/97	26150.59	24134.21	7253.22	0.032	0.089	0.000	-0.120	0.032	0.150	0.003	0.002	1	71.57	3	243.43	-53.30
12/10/97	26150.60	24134.21	7253.21	0.010	0.081	-0.010	-0.130	0.014	0.153	0.000	0.003	1	#DIV/0!	3	240.26	-58.19

MD2

MD2 TIME	NORTHING	EASTING	ELEV.	INCREMENTA HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/17/97	26150.56	24134.20	7253.18	0.041	0.121	-0.030	-0.160	0.051	0.200	0.007	0.003	3	255.96	3	245.56	-52.94
12/23/97	26150.57	24134.21	7253.18	0.014	0.108	0.000	-0.160	0.014	0.193	0.001	0.002	1	45.00	3	248.20	-56.05
12/30/97	26150.57	24134.20	7253.18	0.010	0.112	0.000	-0.160	0.010	0.195	0.000	0.003	4	270.00	3	243.43	-55.06
1/7/98	26150.59	24134.23	7253.24	0.036	0.082	0.060	-0.100	0.070	0.130	0.008	0.004	1	33.69	3	255.96	-50.49
1/14/98	26150.59	24134.22	7253.22	0.010	0.085	-0.020	-0.120	0.022	0.147	0.003	0.003	4	270.00	3	249.44	-54.55
1/27/98	26150.57	24134.22	7253.21	0.020	0.104	-0.010	-0.130	0.022	0.167	0.001	0.003	2	#DIV/0!	3	253.30	-51.23
2/3/98	26150.56	24134.20	7253.18	0.022	0.121	-0.030	-0.160	0.037	0.200	0.005	0.004	3	206.57	3	245.56	-52.94
2/19/98	26150.59	24134.21	7253.22	0.032	0.089	0.040	-0.120	0.051	0.150	0.003	0.003	1	71.57	3	243.43	-53.30
3/25/98	26150.57	24134.22	7253.19	0.022	0.104	-0.030	-0.150	0.037	0.183	0.001	0.003	2	153.43	3	253.30	-55.16
4/3/98	26150.56	24134.21	7253.23	0.014	0.117	0.040	-0.110	0.042	0.161	0.002	0.004	3	225.00	3	250.02	-43.22
4/8/98	26150.55	24134.19	7253.20	0.022	0.134	-0.030	-0.140	0.037	0.194	0.007	0.003	3	206.57	3	243.43	-46.22
4/15/98	26150.57	24134.22	7253.21	0.036	0.104	0.010	-0.130	0.037	0.167	0.004	0.005	1	33.69	3	253.30	-51.23
4/22/98	26150.52	24134.18	7253.16	0.064	0.166	-0.050	-0.180	0.081	0.245	0.011	0.006	3	231.34	3	244.98	-47.40
4/29/98	26150.53	24134.19	7253.19	0.014	0.152	0.030	-0.150	0.033	0.214	0.004	0.006	1	45.00	3	246.80	-44.56
5/7/98	26150.55	24134.21	7253.20	0.028	0.126	0.010	-0.140	0.030	0.189	0.003	0.006	1	45.00	3	251.57	-47.90
5/13/98	26150.58	24134.22	7253.22	0.032	0.095	0.020	-0.120	0.037	0.153	0.006	0.006	1	71.57	3	251.57	-51.67
5/21/98	26150.52	24134.18	7253.21	0.072	0.166	-0.010	-0.130	0.073	0.210	0.007	0.005	3	236.31	3	244.98	-38.14
5/28/98	26150.54	24134.21	7253.20	0.036	0.136	-0.010	-0.140	0.037	0.195	0.002	0.004	1	33.69	3	252.90	-45.83
6/3/98	26150.54	24134.22	7253.19	0.010	0.133	-0.010	-0.150	0.014	0.201	0.001	0.004	1	0.00	3	257.01	-48.35
6/10/98	26150.55	24134.21	7253.20	0.014	0.126	0.010	-0.140	0.017	0.189	0.002	0.003	4	315.00	3	251.57	-47.90
6/17/98	26150.54	24134.22	7253.19	0.014	0.133	-0.010	-0.150	0.017	0.201	0.002	0.003	2	135.00	3	257.01	-48.35
6/24/98	26150.58	24134.25	7253.25	0.050	0.090	0.060	-0.090	0.078	0.127	0.010	0.005	1	53.13	2	#DIV/0!	-45.00
7/1/98	26150.53	24134.22	7253.20	0.058	0.143	-0.050	-0.140	0.077	0.200	0.010	0.005	3	239.04	3	257.91	-44.36
7/8/98	26150.53	24134.22	7253.19	0.000	0.143	-0.010	-0.150	0.010	0.207	0.001	0.005	1	#DIV/0!	3	257.91	-46.33
7/15/98	26150.52	24134.21	7253.20	0.014	0.155	0.010	-0.140	0.017	0.209	0.000	0.005	3	225.00	3	255.07	-42.04
7/22/98	26150.53	24134.21	7253.20	0.010	0.146	0.000	-0.140	0.010	0.202	0.001	0.003	1	#DIV/0!	3	254.05	-43.88
7/29/98	26150.55	24134.22	7253.22	0.022	0.124	0.020	-0.120	0.030	0.172	0.004	0.002	1	63.43	3	255.96	-44.13
8/11/98	26150.53	24134.20	7253.17	0.028	0.149	-0.050	-0.170	0.057	0.226	0.004	0.002	3	225.00	3	250.35	-48.83
8/19/98	26150.54	24134.21	7253.18	0.014	0.136	0.010	-0.160	0.017	0.210	0.002	0.003	1	45.00	3	252.90	-49.63
8/31/98	26150.53	24134.20	7253.22	0.014	0.149	0.040	-0.120	0.042	0.191	0.002	0.003	3	225.00	3	250.35	-38.91
9/11/98	26150.57	24134.20	7253.23	0.040	0.112	0.010	-0.110	0.041	0.157	0.003	0.004	1	#DIV/0!	3	243.43	-44.53
9/16/98	26150.53	24134.24	7253.20	0.057	0.140	-0.030	-0.140	0.064	0.198	0.008	0.004	2	135.00	3	265.91	-44.93
9/22/98	26150.54	24134.19	7253.17	0.051	0.143	-0.030	-0.170	0.059	0.222	0.004	0.004	4	281.31	3	245.22	-49.90
9/30/98	26150.55	24134.23	7253.16	0.041	0.122	-0.010	-0.180	0.042	0.217	0.001	0.004	1	14.04	3	260.54	-55.95
10/7/98	26150.56	24134.23	7253.17	0.010	0.112	0.010	-0.170	0.014	0.203	0.002	0.003	1	#DIV/0!	3	259.70	-56.67
3/3/99	26150.54	24134.22	7253.16	0.022	0.133	-0.010	-0.180	0.024	0.224	0.000	0.001	3	243.43	3	257.01	-53.45
5/27/99	26150.53	24134.21	7253.17	0.014	0.146	0.010	-0.170	0.017	0.224	0.000	0.001	3	225.00	3	254.05	-49.42

MD3 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	NCREMENTA TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	25919.47	24328.54	7257.92													
1/11/96	25919.47	24328.54	7257.92	0.000	0.000	0.000	0.000	0.000	0.000	0.000		1	#DIV/0!	1	#DIV/0!	
2/8/96	25919.46	24328.53	7257.93	0.014	0.014	0.010	0.010	0.017	0.017	0.001		3	225.00	3	225.00	35.26
2/15/96	25919.46	24328.52	7257.93	0.010	0.022	0.000	0.010	0.010	0.024	0.001		4	270.00	3	206.57	24.09
2/22/96	25919.46	24328.53	7257.93	0.010	0.014	0.000	0.010	0.010	0.017	0.001	0.001	1	0.00	3	225.00	35.26
2/29/96	25919.48	24328.55	7257.91	0.028	0.014	-0.020	-0.010	0.035	0.017	0.000	0.001	1	45.00	1	45.00	-35.26
3/7/96	25919.48	24328.52	7257.92	0.030	0.022	0.010	0.000	0.032	0.022	0.001	0.001	4	270.00	4	296.57	0.00
3/14/96	25919.47	24328.57	7257.89	0.051	0.030	-0.030	-0.030	0.059	0.042	0.003	0.001	2	101.31	1	0.00	-45.00
3/22/96	25919.46	24328.55	7257.94	0.022	0.014	0.050	0.020	0.055	0.024	0.002	0.001	3	206.57	2	135.00	54.74
3/28/96	25919.47	24328.54	7257.90	0.014	0.000	-0.040	-0.020	0.042	0.020	0.001	0.001	4	315.00	1	#DIV/0!	#DIV/0!
4/4/96	25919.47	24328.54	7257.93	0.000	0.000	0.030	0.010	0.030	0.010	0.001	0.002	1	#DIV/0!	1	#DIV/0!	#DIV/0!
4/18/96	25919.48	24328.55	7257.90	0.014	0.014	-0.030	-0.020	0.033	0.024	0.001	0.001	1	45.00	1	45.00	-54.74
4/25/96	25919.44	24328.54	7257.93	0.041	0.030	0.030	0.010	0.051	0.032	0.001	0.001	3	255.96	2	#DIV/0!	18.43
5/2/96	25919.46	24328.54	7257.90	0.020	0.010	-0.030	-0.020	0.036	0.022	0.001	0.001	1	#DIV/0!	2	#DIV/0!	-63.43
5/9/96	25919.47	24328.53	7257.92	0.014	0.010	0.020	0.000	0.024	0.010	0.002	0.001	4	315.00	4	270.00	0.00
5/31/96	25919.46	24328.54	7257.91	0.014	0.010	-0.010	-0.010	0.017	0.014	0.000	0.001	2	135.00	2	#DIV/0!	-45.00
6/10/96	25919.45	24328.56	7257.83	0.022	0.028	-0.080	-0.090	0.083	0.094	0.008	0.003	2	116.57	2	135.00	-72.55
6/13/96	25919.44	24328.53	7257.89	0.032	0.032	0.060	-0.030	0.068	0.044	0.017	0.006	3	198.43	3	251.57	-43.49
7/18/96	25919.45	24328.53	7257.88	0.010	0.022	-0.010	-0.040	0.014	0.046	0.000	0.005	1	#DIV/0!	3	243.43	-60.79
7/25/96	25919.44	24328.54	7257.91	0.014	0.030	0.030	-0.010	0.033	0.032	0.002	0.004	2	135.00	2	#DIV/0!	-18.43
8/16/96	25919.43	24328.51	7257.92	0.032	0.050	0.010	0.000	0.033	0.050	0.001	0.003	3	198.43	3	233.13	0.00
9/12/96	25919.44	24328.51	7257.86	0.010	0.042	-0.060	-0.060	0.061	0.073	0.001	0.001	1	#DIV/0!	3	225.00	-54.74
9/26/96	25919.44	24328.50	7257.89	0.010	0.050	0.030	-0.030	0.032	0.058	0.001	0.001	4	270.00	3	216.87	-30.96
10/2/96	25919.44	24328.51	7257.88	0.010	0.042	-0.010	-0.040	0.014	0.058	0.000	0.001	1	0.00	3	225.00	-43.31
10/10/96	25919.42	24328.51	7257.92	0.020	0.058	0.040	0.000	0.045	0.058	0.000	0.001	2	#DIV/0!	3	239.04	0.00
10/24/96	25919.42	24328.50	7257.88	0.010	0.064	-0.040	-0.040	0.041	0.075	0.001	0.001	4	270.00	3	231.34	-31.99
11/18/96	25919.46	24328.54	7257.87	0.057	0.010	-0.010	-0.050	0.057	0.051	0.001	0.001	1	45.00	2	#DIV/0!	-78.69
5/16/97	25919.41	24328.52	7257.84	0.054	0.063	-0.030	-0.080	0.062	0.102	0.000	0.001	3	248.20	3	251.57	-51.67
5/22/97	25919.42	24328.54	7257.85	0.022	0.050	0.010	-0.070	0.024	0.086	0.003	0.001	1	26.57	2	#DIV/0!	-54.46
6/4/97	25919.40	24328.52	7257.85	0.028	0.073	0.000	-0.070	0.028	0.101	0.001	0.002	3	225.00	3	254.05	-43.88
6/11/97	25919.42	24328.53	7257.85	0.022	0.051	0.000	-0.070	0.022	0.087	0.002	0.002	1	63.43	3	258.69	-53.93
6/18/97	25919.41	24328.53	7257.84	0.010	0.061	-0.010	-0.080	0.014	0.100	0.002	0.002	2	#DIV/0!	3	260.54	-52.75
6/25/97	25919.42	24328.56	7257.85	0.032	0.054	0.010	-0.070	0.033	0.088	0.002	0.002	1	18.43	2	158.20	-52.43
7/2/97	25919.39	24328.51	7257.83	0.058	0.085	-0.020	-0.090	0.062	0.124	0.005	0.002	3	210.96	3	249.44	-46.49
7/9/97	25919.39	24328.51	7257.83	0.000	0.085	0.000	-0.090	0.000	0.124	0.000	0.003	1	#DIV/0!	3	249.44	-46.49
7/16/97	25919.42	24328.55	7257.84	0.050	0.051	0.010	-0.080	0.051	0.095	0.004	0.003	1	36.87	2	168.69	-57.49
7/25/97	25919.41	24328.54	7257.85	0.014	0.060	0.010	-0.070	0.017	0.092	0.000	0.003	3	225.00	2	#DIV/0!	-49.40
7/30/97	25919.40	24328.51	7257.82	0.032	0.076	-0.030	-0.100	0.044	0.126	0.007	0.002	3	198.43	3	246.80	-52.71
8/6/97	25919.40	24328.51	7257.82	0.000	0.076	0.000	-0.100	0.000	0.126	0.000	0.002	1	#DIV/0!	3	246.80	-52.71
8/13/97	25919.41	24328.53	7257.82	0.022	0.061	0.000	-0.100	0.022	0.117	0.001	0.002	1	26.57	3	260.54	-58.69
8/20/97	25919.40	24328.51	7257.85	0.022	0.076	0.030	-0.070	0.037	0.103	0.002	0.002	3	206.57	3	246.80	-42.59
8/27/97	25919.41	24328.52	7257.84	0.014	0.063	-0.010	-0.080	0.017	0.102	0.000	0.002	1	45.00	3	251.57	-51.67
9/2/97	25919.42	24328.53	7257.85	0.014	0.051	0.010	-0.070	0.017	0.087	0.003	0.002	1	45.00	3	258.69	-53.93
9/10/97	25919.40	24328.53	7257.83	0.020	0.071	-0.020	-0.090	0.028	0.114	0.003	0.002	2	#DIV/0!	3	261.87	-51.84
9/25/97	25919.42	24328.52	7257.85	0.022	0.054	0.020	-0.070	0.030	0.088	0.002	0.002	4	333.43	3	248.20	-52.43
10/1/97	25919.41	24328.54	7257.83	0.022	0.060	-0.020	-0.090	0.030	0.108	0.003	0.003	2	116.57	2	#DIV/0!	-56.31
10/8/97	25919.41	24328.52	7257.83	0.020	0.063	0.000	-0.090	0.020	0.110	0.000	0.003	4	270.00	3	251.57	-54.90
10/16/97	25919.40	24328.51	7257.80	0.014	0.076	-0.030	-0.120	0.033	0.142	0.004	0.003	3	225.00	3	246.80	-57.60
10/22/97	25919.42	24328.54	7257.81	0.036	0.050	0.010	-0.110	0.037	0.121	0.004	0.002	1	33.69	2	#DIV/0!	-65.56
10/29/97	25919.41	24328.51	7257.81	0.032	0.067	0.000	-0.110	0.032	0.129	0.001	0.002	3	198.43	3	243.43	-58.62
11/5/97	25919.41	24328.53	7257.80	0.020	0.061	-0.010	-0.120	0.022	0.135	0.001	0.002	1	0.00	3	260.54	-63.12
11/12/97	25919.41	24328.52	7257.80	0.010	0.063	0.000	-0.120	0.010	0.136	0.000	0.002	4	270.00	3	251.57	-62.21
11/19/97	25919.42	24328.51	7257.85	0.014	0.058	0.050	-0.070	0.052	0.091	0.006	0.003	4	315.00	3	239.04	-50.21
11/26/97	25919.40	24328.51	7257.82	0.020	0.076	-0.030	-0.100	0.036	0.126	0.005	0.003	2	#DIV/0!	3	246.80	-52.71
12/3/97	25919.43	24328.53	7257.84	0.036	0.041	0.020	-0.080	0.041	0.090	0.005	0.004	1	56.31	3	255.96	-62.73
12/10/97	25919.44	24328.52	7257.87	0.014	0.036	0.030	-0.050	0.033	0.062	0.004	0.006	4	315.00	3	236.31	-54.20

MD3 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	NCREMENTA TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/17/97	25919.40	24328.50	7257.83	0.045	0.081	-0.040	-0.090	0.060	0.121	0.008	0.005	3	243.43	3	240.26	-48.15
12/23/97	25919.49	24328.60	7257.85	0.135	0.063	0.020	-0.070	0.136	0.094	0.004	0.005	1	41.99	1	18.43	-47.90
12/30/97	25919.44	24328.53	7257.86	0.086	0.032	0.010	-0.060	0.087	0.068	0.004	0.004	3	215.54	3	251.57	-62.21
1/7/98	25919.43	24328.57	7257.86	0.041	0.050	0.000	-0.060	0.041	0.078	0.001	0.004	2	104.04	2	143.13	-50.19
1/14/98	25919.44	24328.54	7257.85	0.032	0.030	-0.010	-0.070	0.033	0.076	0.000	0.002	4	288.43	2	#DIV/0!	-66.80
1/27/98	25919.43	24328.53	7257.82	0.014	0.041	-0.030	-0.100	0.033	0.108	0.002	0.002	3	225.00	3	255.96	-67.59
2/3/98	25919.40	24328.50	7257.83	0.042	0.081	0.010	-0.090	0.044	0.121	0.002	0.002	3	225.00	3	240.26	-48.15
2/19/98	25919.43	24328.53	7257.84	0.042	0.041	0.010	-0.080	0.044	0.090	0.002	0.001	1	45.00	3	255.96	-62.73
3/25/98	25919.43	24328.52	7257.84	0.010	0.045	0.000	-0.080	0.010	0.092	0.000	0.002	4	270.00	3	243.43	-60.79
4/3/98	25919.41	24328.52	7257.83	0.020	0.063	-0.010	-0.090	0.022	0.110	0.002	0.002	2	#DIV/0!	3	251.57	-54.90
4/8/98	25919.40	24328.51	7257.82	0.014	0.076	-0.010	-0.100	0.017	0.126	0.003	0.002	3	225.00	3	246.80	-52.71
4/15/98	25919.43	24328.53	7257.82	0.036	0.041	0.000	-0.100	0.036	0.108	0.003	0.002	1	56.31	3	255.96	-67.59
4/28/98	25919.40	24328.49	7257.80	0.050	0.086	-0.020	-0.120	0.054	0.148	0.003	0.010	3	216.87	3	234.46	-54.36
4/29/98	25919.42	24328.51	7257.83	0.028	0.058	0.030	-0.090	0.041	0.107	0.040	0.011	1	45.00	3	239.04	-57.06
5/7/98	25919.42	24328.53	7257.86	0.020	0.051	0.030	-0.060	0.036	0.079	0.004	0.010	1	0.00	3	258.69	-49.64
5/13/98	25919.42	24328.53	7257.85	0.000	0.051	-0.010	-0.070	0.010	0.087	0.001	0.011	1	#DIV/0!	3	258.69	-53.93
5/21/98	25919.40	24328.50	7257.82	0.036	0.081	-0.030	-0.100	0.047	0.128	0.005	0.011	3	213.69	3	240.26	-51.12
5/28/98	25919.42	24328.42	7257.84	0.082	0.130	0.020	-0.080	0.085	0.153	0.003	0.003	4	284.04	3	202.62	-31.61
6/3/98	25919.40	24328.52	7257.80	0.102	0.073	-0.040	-0.120	0.110	0.140	0.002	0.004	2	101.31	3	254.05	-58.76
6/10/98	25919.42	24328.53	7257.86	0.022	0.051	0.060	-0.060	0.064	0.079	0.009	0.006	1	63.43	3	258.69	-49.64
6/17/98	25919.40	24328.52	7257.80	0.022	0.073	-0.060	-0.120	0.064	0.140	0.009	0.005	3	243.43	3	254.05	-58.76
6/24/98	25919.40	24328.51	7257.81	0.010	0.076	0.010	-0.110	0.014	0.134	0.001	0.004	4	270.00	3	246.80	-55.30
7/1/98	25919.40	24328.53	7257.81	0.020	0.071	0.000	-0.110	0.020	0.131	0.000	0.004	1	0.00	3	261.87	-57.27
7/8/98	25919.41	24328.52	7257.81	0.014	0.063	0.000	-0.110	0.014	0.127	0.001	0.003	4	315.00	3	251.57	-60.10
7/15/98	25919.40	24328.54	7257.85	0.022	0.070	0.040	-0.070	0.046	0.099	0.004	0.002	2	116.57	2	#DIV/0!	-45.00
7/22/98	25919.42	24328.50	7257.79	0.045	0.064	-0.060	-0.130	0.075	0.145	0.007	0.003	4	296.57	3	231.34	-63.78
7/29/98	25919.43	24328.52	7257.81	0.022	0.045	0.020	-0.110	0.030	0.119	0.004	0.003	1	26.57	3	243.43	-67.88
8/11/98	25919.42	24328.51	7257.81	0.014	0.058	0.000	-0.110	0.014	0.124	0.000	0.003	3	225.00	3	239.04	-62.07
8/19/98	25919.42	24328.52	7257.81	0.010	0.054	0.000	-0.110	0.010	0.122	0.000	0.003	1	0.00	3	248.20	-63.92
8/31/98	25919.43	24328.52	7257.83	0.010	0.045	0.020	-0.090	0.022	0.100	0.002	0.001	1	#DIV/0!	3	243.43	-63.58
9/11/98	25919.41	24328.52	7257.84	0.020	0.063	0.010	-0.080	0.022	0.102	0.000	0.002	2	#DIV/0!	3	251.57	-51.67
9/16/98	25919.42	24328.51	7257.79	0.014	0.058	-0.050	-0.130	0.052	0.142	0.008	0.002	4	315.00	3	239.04	-65.84
9/22/98	25919.42	24328.49	7257.79	0.020	0.071	0.000	-0.130	0.020	0.148	0.001	0.002	4	270.00	3	225.00	-61.46
9/30/98	25919.43	24328.52	7257.79	0.032	0.045	0.000	-0.130	0.032	0.137	0.001	0.002	1	18.43	3	243.43	-71.02
10/7/99	25919.43	24328.51	7257.8	0.010	0.050	0.010	-0.120	0.014	0.130	0.000	0.002	4	270.00	3	233.13	-67.38
3/3/99	25919.42	24328.52	7257.79	0.014	0.054	-0.010	-0.130	0.017	0.141	0.000	0.000	2	135.00	3	248.20	-67.50
5/27/99	25919.44	24328.51	7257.79	0.022	0.042	0.000	-0.130	0.022	0.137	0.000	0.000	4	333.43	3	225.00	-71.93
7/23/99	25919.42	24328.51	7257.77	0.020	0.058	-0.020	-0.150	0.028	0.161	0.000	-0.199	2	#DIV/0!	3	239.04	-68.76
				35548.456	35548.513	-7257.770	-7257.920	36281.785	36281.871	-0.998	-0.249	3	226.81	3	226.81	-11.54

MD4 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL ISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26398.49	23962.96	7261.03													
1/11/96	26398.51	23962.97	7261.00	0.022	0.022	-0.030	-0.030	0.037	0.037	0.005		1	63.43	1	63.43	
2/8/96	26398.51	23962.99	7261.04	0.020	0.036	0.040	0.010	0.045	0.037	0.000		1	0.00	1	33.69	15.50
2/15/96	26398.48	23962.95	7261.00	0.050	0.014	-0.040	-0.030	0.064	0.033	0.001		3	216.87	3	225.00	-64.76
2/22/96	26398.47	23962.94	7261.02	0.014	0.028	0.020	-0.010	0.024	0.030	0.000	0.002	3	225.00	3	225.00	-19.47
2/29/96	26398.54	23963.01	7261.01	0.099	0.071	-0.010	-0.020	0.099	0.073	0.006	0.003	1	45.00	1	45.00	-15.79
3/7/96	26398.49	23962.93	7261.01	0.094	0.030	0.000	-0.020	0.094	0.036	0.005	0.003	3	212.01	4	270.00	-33.69
3/22/96	26398.49	23963.01	7261.02	0.080	0.050	0.010	-0.010	0.081	0.051	0.001	0.003	1	0.00	1	0.00	-11.31
3/28/96	26398.50	23962.98	7261.02	0.032	0.022	0.000	-0.010	0.032	0.024	0.004	0.003	4	288.43	1	26.57	-24.09
4/4/96	26398.50	23962.97	7261.02	0.010	0.014	0.000	-0.010	0.010	0.017	0.001	0.003	4	270.00	1	45.00	-35.26
4/18/96	26398.53	23963.01	7261.02	0.050	0.064	0.000	-0.010	0.050	0.065	0.003	0.002	1	36.87	1	38.66	-8.88
4/25/96	26398.44	23962.99	7261.02	0.092	0.058	0.000	-0.010	0.092	0.059	0.001	0.002	3	257.47	2	149.04	-9.73
5/2/96	26398.47	23962.99	7261.02	0.030	0.036	0.000	-0.010	0.030	0.037	0.003	0.002	1	#DIV/0!	2	123.69	-15.50
5/9/96	26398.47	23962.94	7261.04	0.050	0.028	0.020	0.010	0.054	0.030	0.001	0.002	4	270.00	3	225.00	19.47
5/31/96	26398.48	23962.97	7261.01	0.032	0.014	-0.030	-0.020	0.044	0.024	0.000	0.002	1	18.43	2	135.00	-54.74
6/10/96	26398.47	23963.01	7261.00	0.041	0.054	-0.010	-0.030	0.042	0.062	0.004	0.002	2	104.04	2	111.80	-29.12
6/13/96	26398.45	23962.96	7261.00	0.054	0.040	0.000	-0.030	0.054	0.050	0.004	0.002	3	201.80	2	#DIV/0!	-36.87
7/11/96	26398.44	23962.97	7261.03	0.014	0.051	0.030	0.000	0.033	0.051	0.000	0.001	2	135.00	2	168.69	0.00
7/18/96	26398.45	23962.95	7261.01	0.022	0.041	-0.020	-0.020	0.030	0.046	0.001	0.001	4	296.57	3	255.96	-25.88
7/25/96	26398.43	23962.97	7261.03	0.028	0.061	0.020	0.000	0.035	0.061	0.002	0.001	2	135.00	2	170.54	0.00
8/16/96	26398.43	23962.94	7261.03	0.030	0.063	0.000	0.000	0.030	0.063	0.000	0.001	4	270.00	3	251.57	0.00
9/12/96	26398.45	23962.93	7261.00	0.022	0.050	-0.030	-0.030	0.037	0.058	0.000	0.002	4	333.43	3	233.13	-30.96
9/26/96	26398.44	23962.94	7261.01	0.014	0.054	0.010	-0.020	0.017	0.057	0.000	0.002	2	135.00	3	248.20	-20.37
10/2/96	26398.42	23962.98	7261.01	0.045	0.073	0.000	-0.020	0.045	0.075	0.003	0.001	2	116.57	2	164.05	-15.36
10/10/96	26398.38	23962.94	7261.01	0.057	0.112	0.000	-0.020	0.057	0.114	0.005	0.001	3	225.00	3	259.70	-10.14
10/24/96	26398.40	23962.95	7260.97	0.022	0.091	-0.040	-0.060	0.046	0.109	0.000	0.002	1	63.43	3	263.66	-33.53
11/18/96	26398.44	23962.98	7260.98	0.050	0.054	0.010	-0.050	0.051	0.073	0.001	0.002	1	53.13	2	158.20	-42.88
5/16/97	26398.40	23962.95	7260.92	0.050	0.091	-0.060	-0.110	0.078	0.142	0.000	0.002	3	233.13	3	263.66	-50.54
5/22/97	26398.42	23962.98	7260.92	0.036	0.073	0.000	-0.110	0.036	0.132	0.002	0.002	1	33.69	2	164.05	-56.50
6/4/97	26398.40	23962.96	7260.96	0.028	0.090	0.040	-0.070	0.049	0.114	0.001	0.002	3	225.00	2	#DIV/0!	-37.87
6/11/97	26398.40	23962.96	7260.93	0.000	0.090	-0.030	-0.100	0.030	0.135	0.003	0.003	1	#DIV/0!	2	#DIV/0!	-48.01
6/18/97	26398.41	23963.00	7260.98	0.041	0.089	0.050	-0.050	0.065	0.102	0.005	0.004	1	14.04	2	153.43	-29.21
6/25/97	26398.40	23962.97	7260.94	0.032	0.091	-0.040	-0.090	0.051	0.128	0.004	0.004	3	198.43	2	173.66	-44.82
7/2/97	26398.38	23962.93	7260.90	0.045	0.114	-0.040	-0.130	0.060	0.173	0.006	0.003	3	206.57	3	254.74	-48.75
7/9/97	26398.38	23962.94	7260.96	0.010	0.112	0.060	-0.070	0.061	0.132	0.006	0.004	1	0.00	3	259.70	-32.05
7/16/97	26398.39	23962.96	7260.94	0.022	0.100	-0.020	-0.090	0.030	0.135	0.000	0.003	1	26.57	2	#DIV/0!	-41.99
7/25/97	26398.40	23962.97	7260.93	0.014	0.091	-0.010	-0.100	0.017	0.135	0.000	0.003	1	45.00	2	173.66	-47.84
7/30/97	26398.37	23962.93	7260.93	0.050	0.124	0.000	-0.100	0.050	0.159	0.005	0.002	3	216.87	3	255.96	-38.95
8/6/97	26398.38	23962.94	7260.93	0.014	0.112	0.000	-0.100	0.014	0.150	0.001	0.001	1	45.00	3	259.70	-41.81
8/13/97	26398.38	23962.94	7260.92	0.000	0.112	-0.010	-0.110	0.010	0.157	0.001	0.002	1	#DIV/0!	3	259.70	-44.53
8/20/97	26398.36	23962.93	7260.96	0.022	0.133	0.040	-0.070	0.046	0.151	0.001	0.003	3	243.43	3	257.01	-27.68
8/27/97	26398.36	23962.94	7260.96	0.010	0.132	0.000	-0.070	0.010	0.149	0.000	0.003	1	0.00	3	261.25	-28.02
9/2/97	26398.40	23962.97	7260.97	0.050	0.091	0.010	-0.060	0.051	0.109	0.007	0.003	1	53.13	2	173.66	-33.53
9/10/97	26398.37	23962.96	7260.93	0.032	0.120	-0.040	-0.100	0.051	0.156	0.006	0.004	3	251.57	2	#DIV/0!	-39.81
9/25/97	26398.39	23962.96	7260.94	0.020	0.100	0.010	-0.090	0.022	0.135	0.001	0.003	1	#DIV/0!	2	#DIV/0!	-41.99
10/1/97	26398.35	23962.99	7260.94	0.050	0.143	0.000	-0.090	0.050	0.169	0.006	0.004	2	143.13	2	167.91	-32.15
10/8/97	26398.38	23962.95	7260.94	0.050	0.110	0.000	-0.090	0.050	0.142	0.004	0.003	4	306.87	3	264.81	-39.17
10/16/97	26398.39	23962.96	7260.93	0.014	0.100	-0.010	-0.100	0.017	0.141	0.000	0.004	1	45.00	2	#DIV/0!	-45.00
10/22/97	26398.39	23962.97	7260.88	0.010	0.100	-0.050	-0.150	0.051	0.181	0.007	0.004	1	0.00	2	174.29	-56.18
10/29/97	26398.38	23962.94	7260.95	0.032	0.112	0.070	-0.080	0.077	0.137	0.006	0.004	3	198.43	3	259.70	-35.59
11/5/97	26398.38	23962.93	7260.90	0.010	0.114	-0.050	-0.130	0.051	0.173	0.005	0.004	4	270.00	3	254.74	-48.75
11/12/97	26398.38	23962.93	7260.92	0.000	0.114	0.020	-0.110	0.020	0.158	0.002	0.005	1	#DIV/0!	3	254.74	-43.97

MD4 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL ISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
11/19/97	26398.40	23962.95	7260.95	0.028	0.091	0.030	-0.080	0.041	0.121	0.005	0.004	1	45.00	3	263.66	-41.46
11/26/97	26398.38	23962.96	7260.94	0.022	0.110	-0.010	-0.090	0.024	0.142	0.003	0.004	2	153.43	2	#DIV/0!	-39.29
12/3/97	26398.41	23962.97	7260.94	0.032	0.081	0.000	-0.090	0.032	0.121	0.003	0.003	1	71.57	2	172.87	-48.15
12/10/97	26398.41	23962.96	7260.96	0.010	0.080	0.020	-0.070	0.022	0.106	0.002	0.004	4	270.00	2	#DIV/0!	-41.19
12/17/97	26398.38	23962.95	7260.91	0.032	0.110	-0.050	-0.120	0.059	0.163	0.008	0.004	3	251.57	3	264.81	-47.37
12/23/97	26398.40	23962.94	7260.94	0.022	0.092	0.030	-0.090	0.037	0.129	0.006	0.004	4	333.43	3	257.47	-44.31
12/30/97	26398.41	23962.97	7260.95	0.032	0.081	0.010	-0.080	0.033	0.114	0.002	0.004	1	18.43	2	172.87	-44.78
1/7/98	26398.40	23962.98	7260.98	0.014	0.092	0.030	-0.050	0.033	0.105	0.001	0.003	2	135.00	2	167.47	-28.47
1/14/98	26398.41	23962.96	7260.96	0.022	0.080	-0.020	-0.070	0.030	0.106	0.000	0.002	4	296.57	2	#DIV/0!	-41.19
1/27/98	26398.38	23962.96	7260.93	0.030	0.110	-0.030	-0.100	0.042	0.149	0.003	0.002	2	#DIV/0!	2	#DIV/0!	-42.27
2/3/98	26398.38	23962.95	7260.91	0.010	0.110	-0.020	-0.120	0.022	0.163	0.002	0.002	4	270.00	3	264.81	-47.37
2/19/98	26398.41	23962.97	7260.94	0.036	0.081	0.030	-0.090	0.047	0.121	0.003	0.002	1	56.31	2	172.87	-48.15
3/25/98	26398.38	23962.99	7260.95	0.036	0.114	0.010	-0.080	0.037	0.139	0.001	0.002	2	146.31	2	164.74	-35.06
4/3/98	26398.39	23962.98	7260.95	0.014	0.102	0.000	-0.080	0.014	0.130	0.001	0.002	4	315.00	2	168.69	-38.11
4/8/98	26398.37	23962.93	7260.93	0.054	0.124	-0.020	-0.100	0.057	0.159	0.006	0.002	3	201.80	3	255.96	-38.95
4/15/98	26398.38	23962.96	7260.93	0.032	0.110	0.000	-0.100	0.032	0.149	0.001	0.003	1	18.43	2	#DIV/0!	-42.27
4/22/98	26398.35	23962.94	7260.90	0.036	0.141	-0.030	-0.130	0.047	0.192	0.006	0.003	3	236.31	3	261.87	-42.59
4/29/98	26398.35	23962.96	7260.90	0.020	0.140	0.000	-0.130	0.020	0.191	0.000	0.004	1	0.00	2	#DIV/0!	-42.88
5/7/98	26398.38	23962.98	7260.96	0.036	0.112	0.060	-0.070	0.070	0.132	0.007	0.003	1	56.31	2	169.70	-32.05
5/13/98	26398.40	23962.96	7260.93	0.028	0.090	-0.030	-0.100	0.041	0.135	0.000	0.005	4	315.00	2	#DIV/0!	-48.01
5/21/98	26398.32	23962.94	7260.91	0.082	0.171	-0.020	-0.120	0.085	0.209	0.009	0.004	3	255.96	3	263.29	-35.03
5/28/98	26398.35	23962.96	7260.91	0.036	0.140	0.000	-0.120	0.036	0.184	0.004	0.005	1	56.31	2	#DIV/0!	-40.60
6/3/98	26398.36	23962.97	7260.92	0.014	0.130	0.010	-0.110	0.017	0.171	0.002	0.004	1	45.00	2	175.60	-40.15
6/10/98	26398.38	23962.98	7260.96	0.022	0.112	0.040	-0.070	0.046	0.132	0.006	0.005	1	63.43	2	169.70	-32.05
6/17/98	26398.36	23962.97	7260.92	0.022	0.130	-0.040	-0.110	0.046	0.171	0.006	0.004	3	243.43	2	175.60	-40.15
6/24/98	26398.35	23962.97	7260.92	0.010	0.140	0.000	-0.110	0.010	0.178	0.001	0.003	2	#DIV/0!	2	175.91	-38.09
7/1/98	26398.36	23963.00	7260.92	0.032	0.136	0.000	-0.110	0.032	0.175	0.000	0.003	1	18.43	2	162.90	-38.96
7/8/98	26398.35	23963.00	7260.92	0.010	0.146	0.000	-0.110	0.010	0.182	0.001	0.003	2	#DIV/0!	2	164.05	-37.07
7/15/98	26398.37	23962.99	7260.97	0.022	0.124	0.050	-0.060	0.055	0.137	0.006	0.002	4	333.43	2	165.96	-25.88
7/22/98	26398.38	23962.97	7260.93	0.022	0.110	-0.040	-0.100	0.046	0.149	0.002	0.002	4	296.57	2	174.81	-42.16
7/29/98	26398.39	23962.99	7260.90	0.022	0.104	-0.030	-0.130	0.037	0.167	0.003	0.002	1	26.57	2	163.30	-51.23
8/11/98	26398.39	23962.99	7260.91	0.000	0.104	0.010	-0.120	0.010	0.159	0.001	0.002	1	#DIV/0!	2	163.30	-48.98
8/19/98	26398.40	23962.98	7260.90	0.014	0.092	-0.010	-0.130	0.017	0.159	0.000	0.026	4	315.00	2	167.47	-54.66
8/31/98	26397.61	23961.60	7260.66	1.590	1.620	-0.240	-0.370	1.608	1.662	0.125	0.026	3	209.79	3	212.91	-12.87
9/11/98	26397.61	23961.61	7260.67	0.010	1.611	0.010	-0.360	0.014	1.651	0.001	0.025	1	0.00	3	213.10	-12.59
9/16/98	26397.60	23961.63	7260.63	0.022	1.600	-0.040	-0.400	0.046	1.650	0.000	0.025	2	116.57	3	213.79	-14.03
9/22/98	26397.61	23961.62	7260.63	0.014	1.603	0.000	-0.400	0.014	1.652	0.000	0.025	4	315.00	3	213.29	-14.01
9/30/98	26397.60	23961.63	7260.63	0.014	1.600	0.000	-0.400	0.014	1.650	0.000	0.001	2	135.00	3	213.79	-14.03
10/7/98	26397.6	23961.62	7260.6	0.010	1.609	-0.030	-0.430	0.032	1.665	0.002	0.001	4	270.00	3	213.59	-14.97
3/3/99	26397.57	23961.62	7260.61	0.030	1.625	0.010	-0.420	0.032	1.679	0.000	0.001	2	#DIV/0!	3	214.47	-14.49
5/27/99	26397.56	23961.61	7260.59	0.014	1.639	-0.020	-0.440	0.024	1.697	0.000	0.001	3	225.00	3	214.56	-15.02
7/23/99	26397.56	23961.61	7260.61	0.000	1.639	0.020	-0.420	0.020	1.692	0.000	-0.200	1	#DIV/0!	3	214.56	-14.37
				35650.946	35652.542	-7260.610	-7261.030	36382.776	36384.424	-1.001	#DIV/0!	3	227.77	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51

MD4 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL ISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51
				0.000	35652.542	0.000	-7261.030	0.000	36384.424	#DIV/0!	#DIV/0!	1	#DIV/0!	3	227.77	-11.51

MD5 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE ISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	INVERSE VELOCITY (days/ft)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26167.11	24156.19	7260.40														
1/11/96	26167.11	24156.20	7260.37	0.010	0.010	-0.030	-0.030	0.032	0.032	0.004		252.98	1	0.00	1	0.00	
2/8/96	26167.11	24156.21	7260.40	0.010	0.020	0.030	0.000	0.032	0.020	0.000		2409.06	1	0.00	1	0.00	0.00
2/8/96	26167.11	24156.21	7260.40	0.000	0.020	0.000	0.000	0.000	0.020	#DIV/0!		#DIV/0!	1	#DIV/0!	1	0.00	0.00
2/22/96	26167.10	24156.18	7260.38	0.032	0.014	-0.020	-0.020	0.037	0.024	0.000		3114.64	3	198.43	3	225.00	-54.74
2/29/96	26167.13	24156.21	7260.36	0.042	0.028	-0.020	-0.040	0.047	0.049	0.003		285.77	1	45.00	1	45.00	-54.74
3/7/96	26167.10	24156.17	7260.35	0.050	0.022	-0.010	-0.050	0.051	0.055	0.001		1210.56	3	216.87	3	206.57	-65.91
3/14/96	26167.14	24156.25	7260.37	0.089	0.067	0.020	-0.030	0.092	0.073	0.003	0.003	374.08	1	26.57	1	26.57	-24.09
3/22/96	26167.10	24156.22	7260.39	0.050	0.032	0.020	-0.010	0.054	0.033	0.005	0.003	198.42	3	233.13	2	108.43	-17.55
3/28/96	26167.09	24156.19	7260.35	0.032	0.020	-0.040	-0.050	0.051	0.054	0.003	0.003	290.06	3	198.43	2	#DIV/0!	-68.20
4/4/96	26167.11	24156.19	7260.39	0.020	0.000	0.040	-0.010	0.045	0.010	0.006	0.004	159.63	1	#DIV/0!	1	#DIV/0!	#DIV/0!
4/18/96	26167.12	24156.20	7260.39	0.014	0.014	0.000	-0.010	0.014	0.017	0.001	0.004	1912.44	1	45.00	1	45.00	-35.26
4/25/96	26167.08	24156.21	7260.36	0.041	0.036	-0.030	-0.040	0.051	0.054	0.005	0.003	191.62	2	165.96	2	146.31	-47.97
5/2/96	26167.09	24156.20	7260.39	0.014	0.022	0.030	-0.010	0.033	0.024	0.004	0.003	238.45	4	315.00	2	153.43	-24.09
5/9/96	26167.08	24156.18	7260.36	0.022	0.032	-0.030	-0.040	0.037	0.051	0.004	0.003	264.20	3	206.57	3	251.57	-51.67
5/31/96	26167.08	24156.19	7260.35	0.010	0.030	-0.010	-0.050	0.014	0.058	0.000	0.003	3005.74	1	0.00	2	#DIV/0!	-59.04
6/10/96	26167.10	24156.25	7260.34	0.063	0.061	-0.010	-0.060	0.064	0.085	0.003	0.003	368.59	1	18.43	2	99.46	-44.61
6/13/96	26167.06	24156.17	7260.35	0.089	0.054	0.010	-0.050	0.090	0.073	0.004	0.002	250.93	3	206.57	3	248.20	-42.88
7/11/96	26167.05	24156.18	7260.38	0.014	0.061	0.030	-0.020	0.033	0.064	0.000	0.001	2961.88	2	135.00	3	260.54	-18.20
7/18/96	26167.07	24156.18	7260.35	0.020	0.041	-0.030	-0.050	0.036	0.065	0.000	0.001	9018.71	1	#DIV/0!	3	255.96	-50.49
7/25/96	26167.06	24156.20	7260.37	0.022	0.051	0.020	-0.030	0.030	0.059	0.001	0.001	1239.68	2	116.57	2	168.69	-30.47
8/16/96	26167.05	24156.15	7260.37	0.051	0.072	0.000	-0.030	0.051	0.078	0.001	0.001	1161.46	3	191.31	3	236.31	-22.59
9/12/96	26167.07	24156.16	7260.33	0.022	0.050	-0.040	-0.070	0.046	0.086	0.000	0.001	3408.77	1	63.43	3	233.13	-54.46
9/26/96	26167.05	24156.15	7260.35	0.022	0.072	0.020	-0.050	0.030	0.088	0.000	0.001	8109.40	3	243.43	3	236.31	-34.74
10/2/96	26167.06	24156.15	7260.36	0.010	0.064	0.010	-0.040	0.014	0.075	0.002	0.001	489.74	1	#DIV/0!	3	231.34	-31.99
10/10/96	26167.03	24156.15	7260.33	0.030	0.089	-0.030	-0.070	0.042	0.114	0.005	0.001	210.09	2	#DIV/0!	3	243.43	-38.05
10/24/96	26167.04	24156.15	7260.33	0.010	0.081	0.000	-0.070	0.010	0.107	0.000	0.002	2056.59	1	#DIV/0!	3	240.26	-40.97
11/18/96	26167.05	24156.17	7260.28	0.022	0.063	-0.050	-0.120	0.055	0.136	0.001	0.002	865.78	1	26.57	3	251.57	-62.21
5/16/97	26167.03	24156.14	7260.26	0.036	0.094	-0.020	-0.140	0.041	0.169	0.000	0.002	5395.98	3	213.69	3	237.99	-56.03
5/22/97	26167.04	24156.17	7260.27	0.032	0.073	0.010	-0.130	0.033	0.149	0.003	0.001	302.68	1	18.43	3	254.05	-60.75
6/4/97	26167.02	24156.13	7260.25	0.045	0.108	-0.020	-0.150	0.049	0.185	0.003	0.002	361.76	3	206.57	3	236.31	-54.20
6/11/97	26167.04	24156.16	7260.25	0.036	0.076	0.000	-0.150	0.036	0.168	0.002	0.002	419.00	1	33.69	3	246.80	-63.08
6/18/97	26167.02	24156.16	7260.26	0.020	0.095	0.010	-0.140	0.022	0.169	0.000	0.002	7871.30	2	#DIV/0!	3	251.57	-55.88
6/25/97	26167.02	24156.15	7260.22	0.010	0.098	-0.040	-0.180	0.041	0.205	0.005	0.002	194.08	4	270.00	3	246.04	-61.31
7/2/97	26167.01	24156.12	7260.24	0.032	0.122	0.020	-0.160	0.037	0.201	0.001	0.002	1778.13	3	198.43	3	235.01	-52.66
7/9/97	26167.02	24156.12	7260.23	0.010	0.114	-0.010	-0.170	0.014	0.205	0.000	0.002	2029.71	1	#DIV/0!	3	232.13	-56.15
7/16/97	26167.03	24156.17	7260.25	0.051	0.082	0.020	-0.150	0.055	0.171	0.005	0.003	208.82	1	11.31	3	255.96	-61.20
7/25/97	26167.04	24156.17	7260.22	0.010	0.073	-0.030	-0.180	0.032	0.194	0.003	0.002	391.43	1	#DIV/0!	3	254.05	-67.98
7/30/97	26167.02	24156.14	7260.22	0.036	0.103	0.000	-0.180	0.036	0.207	0.003	0.002	378.80	3	213.69	3	240.95	-60.23
8/6/97	26167.00	24156.14	7260.22	0.020	0.121	0.000	-0.180	0.020	0.217	0.001	0.003	742.28	2	#DIV/0!	3	245.56	-56.13
8/13/97	26167.01	24156.13	7260.21	0.014	0.117	-0.010	-0.190	0.017	0.223	0.001	0.003	1140.04	4	315.00	3	239.04	-58.46
8/20/97	26167.01	24156.12	7260.25	0.010	0.122	0.040	-0.150	0.041	0.193	0.004	0.002	236.93	4	270.00	3	235.01	-50.86
8/27/97	26167.00	24156.12	7260.23	0.010	0.130	-0.020	-0.170	0.022	0.214	0.003	0.002	335.70	2	#DIV/0!	3	237.53	-52.51
9/2/97	26167.03	24156.16	7260.23	0.050	0.085	0.000	-0.170	0.050	0.190	0.004	0.002	250.21	1	36.87	3	249.44	-63.32
9/10/97	26167.01	24156.15	7260.23	0.022	0.108	0.000	-0.170	0.022	0.201	0.001	0.002	728.39	3	243.43	3	248.20	-57.64
9/25/97	26167.03	24156.16	7260.24	0.022	0.085	0.010	-0.160	0.024	0.181	0.001	0.002	755.19	1	63.43	3	249.44	-61.90
10/1/97	26167.02	24156.17	7260.23	0.014	0.092	-0.010	-0.170	0.017	0.193	0.002	0.002	499.70	2	135.00	3	257.47	-61.53
10/8/97	26167.03	24156.15	7260.23	0.022	0.089	0.000	-0.170	0.022	0.192	0.000	0.001	5396.78	4	296.57	3	243.43	-62.25
10/16/97	26167.03	24156.13	7260.23	0.020	0.100	0.000	-0.170	0.020	0.197	0.001	0.001	1557.30	4	270.00	3	233.13	-59.53
10/22/97	26167.03	24156.16	7260.21	0.030	0.085	-0.020	-0.190	0.036	0.208	0.002	0.001	540.74	1	0.00	3	249.44	-65.79
10/29/97	26167.03	24156.13	7260.23	0.030	0.100	0.020	-0.170	0.036	0.197	0.002	0.001	630.87	4	270.00	3	233.13	-59.53
11/5/97	26167.03	24156.14	7260.24	0.010	0.094	0.010	-0.160	0.014	0.186	0.002	0.001	609.27	1	0.00	3	237.99	-59.48
11/12/97	26167.03	24156.13	7260.23	0.010	0.100	-0.010	-0.170	0.014	0.197	0.002	0.002	609.27	4	270.00	3	233.13	-59.53
11/19/97	26167.04	24156.15	7260.24	0.022	0.081	0.010	-0.160	0.024	0.179	0.003	0.002	387.47	1	26.57	3	240.26	-63.26
11/26/97	26167.03	24156.15	7260.23	0.010	0.089	-0.010	-0.170	0.014	0.192	0.002	0.002	541.42	2	#DIV/0!	3	243.43	-62.25
12/3/97	26167.04	24156.15	7260.22	0.010	0.081	-0.010	-0.180	0.014	0.197	0.001	0.002	1382.64	1	#DIV/0!	3	240.26	-65.87
12/10/97	26167.07	24156.18	7260.24	0.042	0.041	0.020	-0.160	0.047	0.165	0.005	0.003	218.72	1	45.00	3	255.96	-75.55
12/17/97	26167.02	24156.13	7260.21	0.071	0.108	-0.030	-0.190	0.077	0.219	0.008	0.004	131.07	3	225.00	3	236.31	-60.35

MD5 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE ISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	INVERSE VELOCITY (days/ft)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/23/97	26167.03	24156.16	7260.25	0.032	0.085	0.040	-0.150	0.051	0.173	0.008	0.004	130.42	1	18.43	3	249.44	-60.33
12/30/97	26167.05	24156.16	7260.23	0.020	0.067	-0.020	-0.170	0.028	0.183	0.001	0.005	691.02	1	#DIV/0!	3	243.43	-68.47
1/7/98	26167.05	24156.17	7260.25	0.010	0.063	0.020	-0.150	0.022	0.163	0.002	0.004	400.63	1	0.00	3	251.57	-67.14
1/14/98	26167.05	24156.17	7260.25	0.000	0.063	0.000	-0.150	0.000	0.163	0.000	0.003	#DIV/0!	1	#DIV/0!	3	251.57	-67.14
1/27/98	26167.04	24156.17	7260.23	0.010	0.073	-0.020	-0.170	0.022	0.185	0.002	0.002	587.06	2	#DIV/0!	3	254.05	-66.82
2/3/98	26167.02	24156.13	7260.21	0.045	0.108	-0.020	-0.190	0.049	0.219	0.005	0.002	207.72	3	206.57	3	236.31	-60.35
2/19/98	26167.04	24156.15	7260.22	0.028	0.081	0.010	-0.180	0.030	0.197	0.001	0.002	747.62	1	45.00	3	240.26	-65.87
3/25/98	26167.04	24156.17	7260.24	0.020	0.073	0.020	-0.160	0.028	0.176	0.001	0.002	1585.31	1	0.00	3	254.05	-65.53
4/3/98	26167.03	24156.17	7260.22	0.010	0.082	-0.020	-0.180	0.022	0.198	0.002	0.002	405.30	2	#DIV/0!	3	255.96	-65.39
4/8/98	26167.02	24156.14	7260.22	0.032	0.103	0.000	-0.180	0.032	0.207	0.002	0.002	533.36	3	198.43	3	240.95	-60.23
4/15/98	26167.04	24156.17	7260.23	0.036	0.073	0.010	-0.170	0.037	0.185	0.003	0.003	312.05	1	33.69	3	254.05	-66.82
4/22/98	26167.00	24156.14	7260.19	0.050	0.121	-0.040	-0.210	0.064	0.242	0.008	0.003	122.06	3	233.13	3	245.56	-60.08
4/29/98	26167.02	24156.15	7260.19	0.022	0.098	0.000	-0.210	0.022	0.232	0.001	0.004	677.47	1	63.43	3	246.04	-64.87
5/7/98	26167.03	24156.15	7260.24	0.010	0.089	0.050	-0.160	0.051	0.183	0.006	0.004	164.46	1	#DIV/0!	3	243.43	-60.79
5/13/98	26167.04	24156.16	7260.25	0.014	0.076	0.010	-0.150	0.017	0.168	0.003	0.006	397.96	1	45.00	3	246.80	-63.08
5/21/98	26166.99	24156.14	7260.19	0.054	0.130	-0.060	-0.210	0.081	0.247	0.010	0.005	101.58	3	248.20	3	247.38	-58.24
5/28/98	26167.02	24156.15	7260.21	0.032	0.098	0.020	-0.190	0.037	0.214	0.005	0.005	212.30	1	71.57	3	246.04	-62.60
6/3/98	26167.02	24156.17	7260.20	0.020	0.092	-0.010	-0.200	0.022	0.220	0.001	0.005	964.97	1	0.00	3	257.47	-65.25
6/10/98	26167.03	24156.15	7260.24	0.022	0.089	0.040	-0.160	0.046	0.183	0.005	0.005	189.58	4	296.57	3	243.43	-60.79
6/17/98	26167.02	24156.17	7260.20	0.022	0.092	-0.040	-0.200	0.046	0.220	0.005	0.004	189.58	2	116.57	3	257.47	-65.25
6/24/98	26167.01	24156.15	7260.19	0.022	0.108	-0.010	-0.210	0.024	0.236	0.002	0.003	443.56	3	206.57	3	248.20	-62.65
7/1/98	26167.01	24156.17	7260.20	0.020	0.102	0.010	-0.200	0.022	0.224	0.002	0.003	608.22	1	0.00	3	258.69	-62.98
7/8/98	26167.01	24156.17	7260.20	0.000	0.102	0.000	-0.200	0.000	0.224	0.000	0.002	#DIV/0!	1	#DIV/0!	3	258.69	-62.98
7/15/98	26167.02	24156.18	7260.22	0.014	0.091	0.020	-0.180	0.024	0.201	0.003	0.002	304.28	1	45.00	3	263.66	-63.29
7/22/98	26167.04	24156.15	7260.21	0.036	0.081	-0.010	-0.190	0.037	0.206	0.001	0.002	1427.62	4	303.69	3	240.26	-67.01
7/29/98	26167.04	24156.16	7260.19	0.010	0.076	-0.020	-0.210	0.022	0.223	0.002	0.002	412.12	1	0.00	3	246.80	-70.07
8/11/98	26167.01	24156.13	7260.19	0.042	0.117	0.000	-0.210	0.042	0.240	0.001	0.002	772.65	3	225.00	3	239.04	-60.96
8/19/98	26167.02	24156.14	7260.19	0.014	0.103	0.000	-0.210	0.014	0.234	0.001	0.001	1264.24	1	45.00	3	240.95	-63.88
8/31/98	26167.02	24156.13	7260.22	0.010	0.108	0.030	-0.180	0.032	0.210	0.002	0.002	502.51	4	270.00	3	236.31	-59.00
9/11/98	26167.03	24156.14	7260.26	0.014	0.094	0.040	-0.140	0.042	0.169	0.004	0.005	267.12	1	45.00	3	237.99	-56.03
9/16/98	26167.02	24156.13	7260.17	0.014	0.108	-0.090	-0.230	0.091	0.254	0.017	0.005	58.59	3	225.00	3	236.31	-64.81
9/22/98	26167.03	24156.13	7260.15	0.010	0.100	-0.020	-0.250	0.022	0.269	0.003	0.005	397.54	1	#DIV/0!	3	233.13	-68.20
9/30/98	26167.02	24156.15	7260.15	0.022	0.098	0.000	-0.250	0.022	0.269	0.000	0.005	14345.57	2	116.57	3	246.04	-68.50
10/7/99	26167.03	24156.15	7260.16	0.010	0.089	0.010	-0.240	0.014	0.256	0.000	0.004	29581.08	1	#DIV/0!	3	243.43	-69.56
3/3/99	26167.01	24156.14	7260.19	0.022	0.112	0.030	-0.210	0.037	0.238	0.000	0.001	-11966.57	3	243.43	3	243.43	-61.97
5/27/99	26167.01	24156.14	7260.13	0.000	0.112	-0.060	-0.270	0.060	0.292	0.001	0.000	1564.65	1	#DIV/0!	3	243.43	-67.51
7/23/99	26167.00	24156.12	7260.13	0.022	0.130	0.000	-0.270	0.022	0.300	0.000	-0.200	7499.50	3	206.57	3	237.53	

MD6 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	25934.36	24347.48	7260.46													
1/11/96	25934.37	24347.48	7260.42	0.010	0.010	-0.040	-0.040	0.041	0.041	0.005		1	#DIV/0!	1	#DIV/0!	
2/8/96	25934.36	24347.47	7260.45	0.014	0.010	0.030	-0.010	0.033	0.014	0.001		3	225.00	4	270.00	-45.00
2/15/96	25934.36	24347.45	7260.44	0.020	0.030	-0.010	-0.020	0.022	0.036	0.003		4	270.00	4	270.00	-33.69
2/22/96	25934.35	24347.45	7260.44	0.010	0.032	0.000	-0.020	0.010	0.037	0.000	0.002	2	#DIV/0!	3	198.43	-32.31
2/29/96	25934.36	24347.48	7260.44	0.032	0.000	0.000	-0.020	0.032	0.020	0.002	0.003	1	18.43	1	#DIV/0!	#DIV/0!
3/7/96	25934.37	24347.48	7260.42	0.010	0.010	-0.020	-0.040	0.022	0.041	0.003	0.003	1	#DIV/0!	1	#DIV/0!	-75.96
3/14/96	25934.37	24347.50	7260.40	0.020	0.022	-0.020	-0.060	0.028	0.064	0.003	0.003	1	0.00	1	26.57	-69.56
3/22/96	25934.36	24347.50	7260.44	0.010	0.020	0.040	-0.020	0.041	0.026	0.004	0.003	2	#DIV/0!	1	0.00	-45.00
3/28/96	25934.36	24347.48	7260.41	0.020	0.000	-0.030	-0.050	0.036	0.050	0.004	0.003	4	270.00	1	#DIV/0!	#DIV/0!
4/4/96	25934.37	24347.47	7260.46	0.014	0.014	0.050	0.000	0.052	0.014	0.005	0.003	4	315.00	4	315.00	0.00
4/18/96	25934.38	24347.50	7260.43	0.032	0.028	-0.030	-0.030	0.044	0.041	0.002	0.002	1	18.43	1	45.00	-46.69
4/25/96	25934.35	24347.47	7260.42	0.042	0.014	-0.010	-0.040	0.044	0.042	0.000	0.002	3	225.00	3	225.00	-70.53
5/2/96	25934.35	24347.46	7260.42	0.010	0.022	0.000	-0.040	0.010	0.046	0.000	0.001	4	270.00	3	206.57	-60.79
5/9/96	25934.36	24347.46	7260.42	0.010	0.020	0.000	-0.040	0.010	0.045	0.000	0.001	1	#DIV/0!	4	270.00	-63.43
5/31/96	25934.35	24347.47	7260.41	0.014	0.014	-0.010	-0.050	0.017	0.052	0.000	0.000	2	135.00	3	225.00	-74.21
6/10/96	25934.35	24347.50	7260.36	0.030	0.022	-0.050	-0.100	0.058	0.102	0.005	0.002	1	0.00	2	116.57	-77.40
6/13/96	25934.35	24347.46	7260.40	0.040	0.022	0.040	-0.060	0.057	0.064	0.013	0.004	4	270.00	3	206.57	-69.56
7/11/96	25934.34	24347.46	7260.43	0.010	0.028	0.030	-0.030	0.032	0.041	0.001	0.004	2	#DIV/0!	3	225.00	-46.69
7/25/96	25934.33	24347.46	7260.39	0.010	0.036	-0.040	-0.070	0.041	0.079	0.003	0.003	2	#DIV/0!	3	236.31	-62.75
8/16/96	25934.32	24347.43	7260.44	0.032	0.064	0.050	-0.020	0.059	0.067	0.001	0.003	3	198.43	3	218.66	-17.35
9/12/96	25934.35	24347.44	7260.42	0.032	0.041	-0.020	-0.040	0.037	0.057	0.000	0.001	1	71.57	3	194.04	-44.13
9/26/96	25934.33	24347.43	7260.41	0.022	0.058	-0.010	-0.050	0.024	0.077	0.001	0.001	3	243.43	3	210.96	-40.61
10/2/96	25934.34	24347.42	7260.41	0.014	0.063	0.000	-0.050	0.014	0.081	0.001	0.001	4	315.00	3	198.43	-38.33
10/10/96	25934.31	24347.41	7260.42	0.032	0.086	0.010	-0.040	0.033	0.095	0.002	0.001	3	251.57	3	215.54	-24.94
10/24/96	25934.31	24347.43	7260.39	0.020	0.071	-0.030	-0.070	0.036	0.099	0.000	0.002	1	0.00	3	225.00	-44.71
11/18/96	25934.35	24347.46	7260.38	0.050	0.022	-0.010	-0.080	0.051	0.083	0.001	0.002	1	53.13	3	206.57	-74.38
5/16/97	25934.33	24347.41	7260.33	0.054	0.076	-0.050	-0.130	0.073	0.151	0.000	0.003	3	201.80	3	203.20	-59.64
5/22/97	25934.35	24347.45	7260.37	0.045	0.032	0.040	-0.090	0.060	0.095	0.009	0.003	1	26.57	3	198.43	-70.64
6/4/97	25934.33	24347.40	7260.35	0.054	0.085	-0.020	-0.110	0.057	0.139	0.003	0.003	3	201.80	3	200.56	-52.16
6/11/97	25934.34	24347.43	7260.35	0.032	0.054	0.000	-0.110	0.032	0.122	0.002	0.003	1	18.43	3	201.80	-63.92
6/18/97	25934.32	24347.42	7260.34	0.022	0.072	-0.010	-0.120	0.024	0.140	0.003	0.003	3	243.43	3	213.69	-59.00
6/25/97	25934.33	24347.41	7260.32	0.014	0.076	-0.020	-0.140	0.024	0.159	0.003	0.002	4	315.00	3	203.20	-61.45
7/2/97	25934.32	24347.40	7260.33	0.014	0.089	0.010	-0.130	0.017	0.158	0.000	0.002	3	225.00	3	206.57	-55.47
7/9/97	25934.33	24347.40	7260.35	0.010	0.085	0.020	-0.110	0.022	0.139	0.003	0.002	1	#DIV/0!	3	200.56	-52.16
7/16/97	25934.34	24347.42	7260.35	0.022	0.063	0.000	-0.110	0.022	0.127	0.002	0.002	1	26.57	3	198.43	-60.10
7/25/97	25934.32	24347.44	7260.35	0.028	0.057	0.000	-0.110	0.028	0.124	0.000	0.002	2	135.00	3	225.00	-62.79
7/30/97	25934.33	24347.40	7260.34	0.041	0.085	-0.010	-0.120	0.042	0.147	0.005	0.002	4	284.04	3	200.56	-54.55
8/6/97	25934.33	24347.40	7260.33	0.000	0.085	-0.010	-0.130	0.010	0.156	0.001	0.002	1	#DIV/0!	3	200.56	-56.69
8/13/97	25934.33	24347.41	7260.32	0.010	0.076	-0.010	-0.140	0.014	0.159	0.001	0.002	1	0.00	3	203.20	-61.45
8/20/97	25934.32	24347.40	7260.35	0.014	0.089	0.030	-0.110	0.033	0.142	0.003	0.003	3	225.00	3	206.57	-50.88
8/27/97	25934.32	24347.41	7260.35	0.010	0.081	0.000	-0.110	0.010	0.136	0.001	0.002	1	0.00	3	209.74	-53.76
9/2/97	25934.34	24347.42	7260.36	0.022	0.063	0.010	-0.100	0.024	0.118	0.003	0.003	1	63.43	3	198.43	-57.69
9/10/97	25934.32	24347.40	7260.32	0.028	0.089	-0.040	-0.140	0.049	0.166	0.006	0.003	3	225.00	3	206.57	-57.43
9/25/97	25934.33	24347.41	7260.35	0.014	0.076	0.030	-0.110	0.033	0.134	0.002	0.003	1	45.00	3	203.20	-55.30
10/1/97	25934.32	24347.42	7260.32	0.014	0.072	-0.030	-0.140	0.033	0.157	0.004	0.003	2	135.00	3	213.69	-62.75
10/8/97	25934.33	24347.41	7260.33	0.014	0.076	0.010	-0.130	0.017	0.151	0.001	0.003	4	315.00	3	203.20	-59.64
10/16/97	25934.34	24347.41	7260.35	0.010	0.073	0.020	-0.110	0.022	0.132	0.002	0.002	1	#DIV/0!	3	195.95	-56.50
10/22/97	25934.35	24347.43	7260.34	0.022	0.051	-0.010	-0.120	0.024	0.130	0.000	0.002	1	26.57	3	191.31	-66.98
10/29/97	25934.33	24347.40	7260.32	0.036	0.085	-0.020	-0.140	0.041	0.164	0.005	0.002	3	213.69	3	200.56	-58.60
11/5/97	25934.33	24347.39	7260.34	0.010	0.095	0.020	-0.120	0.022	0.153	0.002	0.002	4	270.00	3	198.43	-51.87
11/12/97	25934.33	24347.40	7260.33	0.010	0.085	-0.010	-0.130	0.014	0.158	0.000	0.002	1	0.00	3	200.56	-56.69
11/19/97	25934.34	24347.41	7260.34	0.014	0.073	0.010	-0.120	0.017	0.140	0.002	0.002	1	45.00	3	195.95	-58.78
11/26/97	25934.34	24347.41	7260.34	0.000	0.073	0.000	-0.120	0.000	0.140	0.000	0.001	1	#DIV/0!	3	185.95	-58.76
12/3/97	25934.35	24347.42	7260.34	0.014	0.061	0.000	-0.120	0.014	0.135	0.001	0.001	1	45.00	3	189.46	-63.12
12/10/97	25934.37	24347.41	7260.36	0.022	0.071	0.020	-0.100	0.030	0.122	0.002	0.002	4	333.43	4	278.13	-54.74
12/17/97	25934.33	24347.41	7260.33	0.040	0.076	-0.030	-0.130	0.050	0.151	0.004	0.002	2	#DIV/0!	3	203.20	-59.64
12/23/97	25934.33	24347.41	7260.36	0.000	0.076	0.030	-0.100	0.030	0.126	0.004	0.002	1	#DIV/0!	3	203.20	-52.71
12/30/97	25934.35	24347.40	7260.36	0.022	0.081	0.000	-0.100	0.022	0.128	0.000	0.002	4	333.43	3	187.13	-51.12
1/7/98	25934.36	24347.42	7260.35	0.022	0.060	-0.010	-0.110	0.024	0.125	0.000	0.002	1	26.57	4	270.00	-61.39
1/14/98	25934.36	24347.43	7260.35	0.010	0.050	0.000	-0.110	0.010	0.121	0.001	0.001	1	0.00	4	270.00	-65.56
1/27/98	25934.35	24347.43	7260.34	0.010	0.051	-0.010	-0.120	0.014	0.130	0.001	0.001	2	#DIV/0!	3	191.31	-66.98
2/3/98	25934.33	24347.41	7260.33	0.028	0.076	-0.010	-0.130	0.030	0.151	0.003	0.001	3	225.00	3	203.20	-59.64
2/19/98	25934.35	24347.42	7260.34	0.022	0.061	0.010	-0.120	0.024	0.135	0.001	0.001	1	63.43	3	189.46	-63.12
3/25/98	25934.34	24347.40	7260.34	0.022	0.082	0.000	-0.120	0.022	0.148	0.000	0.001	3	206.57	3	194.04	-55.50

MD6 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
4/3/98	25934.34	24347.40	7260.34	0.000	0.082	0.000	-0.120	0.000	0.146	0.000	0.001	1	#DIV/0!	3	194.04	-55.50
4/8/98	25934.33	24347.40	7260.34	0.010	0.085	0.000	-0.120	0.010	0.147	0.000	0.000	2	#DIV/0!	3	200.56	-54.55
4/15/98	25934.33	24347.41	7260.33	0.010	0.076	-0.010	-0.130	0.014	0.151	0.000	0.000	1	0.00	3	203.20	-59.64
4/22/98	25934.33	24347.39	7260.34	0.020	0.095	0.010	-0.120	0.022	0.153	0.000	0.001	4	270.00	3	198.43	-51.67
4/29/98	25934.33	24347.40	7260.30	0.010	0.085	-0.040	-0.160	0.041	0.181	0.004	0.002	1	0.00	3	200.56	-61.90
5/7/98	25934.34	24347.41	7260.35	0.014	0.073	0.050	-0.110	0.052	0.132	0.006	0.003	1	45.00	3	195.95	-56.50
5/13/98	25934.34	24347.43	7260.35	0.020	0.054	0.000	-0.110	0.020	0.122	0.002	0.004	1	0.00	3	201.80	-63.92
5/21/98	25934.32	24347.38	7260.31	0.054	0.108	-0.040	-0.150	0.067	0.185	0.008	0.005	3	201.80	3	201.80	-54.32
5/28/98	25934.34	24347.41	7260.33	0.036	0.073	0.020	-0.130	0.041	0.149	0.005	0.004	1	33.69	3	195.95	-60.75
6/3/98	25934.33	24347.40	7260.33	0.014	0.085	0.000	-0.130	0.014	0.158	0.001	0.004	3	225.00	3	200.56	-56.69
6/10/98	25934.34	24347.41	7260.35	0.014	0.073	0.020	-0.110	0.024	0.132	0.003	0.004	1	45.00	3	195.95	-56.50
6/17/98	25934.33	24347.40	7260.33	0.014	0.085	-0.020	-0.130	0.024	0.156	0.003	0.003	3	225.00	3	200.56	-56.69
6/24/98	25934.33	24347.39	7260.32	0.010	0.095	-0.010	-0.140	0.014	0.169	0.002	0.003	4	270.00	3	198.43	-55.88
7/1/98	25934.33	24347.41	7260.34	0.020	0.078	0.020	-0.120	0.028	0.142	0.004	0.003	1	0.00	3	203.20	-57.60
7/8/98	25934.32	24347.41	7260.33	0.010	0.081	-0.010	-0.130	0.014	0.153	0.002	0.003	2	#DIV/0!	3	209.74	-58.19
7/15/98	25934.34	24347.41	7260.31	0.020	0.073	-0.020	-0.150	0.028	0.167	0.002	0.002	1	#DIV/0!	3	195.95	-64.11
7/22/98	25934.34	24347.40	7260.32	0.010	0.082	0.010	-0.140	0.014	0.162	0.001	0.002	4	270.00	3	194.04	-59.50
7/29/98	25934.34	24347.40	7260.35	0.000	0.082	0.030	-0.110	0.030	0.137	0.004	0.003	1	#DIV/0!	3	194.04	-53.14
8/11/98	25934.33	24347.38	7260.27	0.022	0.104	-0.080	-0.190	0.083	0.217	0.006	0.003	3	206.57	3	196.70	-61.21
8/19/98	25934.33	24347.39	7260.27	0.010	0.095	0.000	-0.190	0.010	0.212	0.001	0.002	1	0.00	3	198.43	-63.47
8/31/98	25934.34	24347.39	7260.27	0.010	0.092	0.000	-0.190	0.010	0.211	0.000	0.003	1	#DIV/0!	3	192.53	-64.12
9/11/98	25934.33	24347.41	7260.33	0.022	0.076	0.060	-0.130	0.064	0.151	0.008	0.004	2	116.57	3	203.20	-59.64
9/16/98	25934.34	24347.40	7260.29	0.014	0.082	-0.040	-0.170	0.042	0.189	0.008	0.003	4	315.00	3	194.04	-64.12
9/22/98	25934.36	24347.42	7260.30	0.028	0.060	0.010	-0.160	0.030	0.171	0.003	0.003	1	45.00	4	270.00	-69.44
9/30/98	25934.35	24347.42	7260.31	0.010	0.061	0.010	-0.150	0.014	0.162	0.001	0.004	2	#DIV/0!	3	169.46	-67.93
10/7/98	25934.34	24347.39	7260.3	0.032	0.092	-0.010	-0.160	0.033	0.185	0.003	0.003	3	198.43	3	192.53	-60.05
3/3/99	25934.36	24347.4	7260.28	0.014	0.081	-0.020	-0.180	0.024	0.187	0.000	0.002	1	45.00	3	187.13	-65.87
5/27/99	25934.33	24347.38	7260.26	0.028	0.104	-0.020	-0.200	0.035	0.226	0.000	0.001	3	225.00	3	196.70	-62.43
7/23/99	25934.34	24347.38	7260.29	0.010	0.102	0.030	-0.170	0.032	0.198	0.000	-0.199	1	#DIV/0!	3	191.31	-59.04

MD7 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26423.65	23993.37	7279.41													
1/11/96	26423.65	23993.36	7279.36	0.010	0.010	-0.050	-0.050	0.051	0.051	0.006		4	270.00	4	270.00	
2/8/96	26423.66	23993.38	7279.37	0.022	0.014	0.010	-0.040	0.024	0.042	0.000		1	26.57	1	45.00	-70.53
2/15/96	26423.63	23993.34	7279.37	0.050	0.036	0.000	-0.040	0.050	0.054	0.002		3	216.87	3	213.69	-47.97
2/22/96	26423.65	23993.36	7279.40	0.028	0.010	0.030	-0.010	0.041	0.014	0.006	0.003	1	45.00	4	270.00	-45.00
2/29/96	26423.69	23993.42	7279.39	0.072	0.064	-0.010	-0.020	0.073	0.067	0.008	0.003	1	33.69	1	38.66	-17.35
3/7/96	26423.63	23993.43	7279.39	0.061	0.063	0.000	-0.020	0.061	0.066	0.000	0.003	2	170.54	2	108.43	-17.55
3/14/96	26423.68	23993.44	7279.40	0.051	0.076	0.010	-0.010	0.052	0.077	0.001	0.003	1	78.69	1	23.20	-7.48
3/22/96	26423.65	23993.41	7279.39	0.042	0.040	-0.010	-0.020	0.044	0.045	0.004	0.003	3	225.00	1	0.00	-26.57
3/28/96	26423.64	23993.38	7279.38	0.032	0.014	-0.010	-0.030	0.033	0.033	0.002	0.002	3	198.43	2	135.00	-64.76
4/4/96	26423.65	23993.38	7279.37	0.010	0.010	-0.010	-0.040	0.014	0.041	0.001	0.002	1	#DIV/0!	1	0.00	-75.96
4/18/96	26423.68	23993.43	7279.39	0.058	0.067	0.020	-0.020	0.062	0.070	0.002	0.001	1	30.96	1	26.57	-16.60
4/25/96	26423.64	23993.40	7279.35	0.050	0.032	-0.040	-0.060	0.064	0.068	0.000	0.001	3	233.13	2	108.43	-62.21
5/2/96	26423.62	23993.39	7279.35	0.022	0.036	0.000	-0.060	0.022	0.070	0.000	0.001	3	243.43	2	146.31	-59.00
5/9/96	26423.62	23993.35	7279.35	0.040	0.036	0.000	-0.060	0.040	0.070	0.000	0.001	4	270.00	3	236.31	-59.00
5/31/96	26423.63	23993.39	7279.36	0.041	0.028	0.010	-0.050	0.042	0.057	0.001	0.000	1	14.04	2	135.00	-60.50
6/10/96	26423.62	23993.42	7279.33	0.032	0.058	-0.030	-0.080	0.044	0.099	0.004	0.001	2	108.43	2	120.96	-53.91
6/13/96	26423.62	23993.39	7279.38	0.030	0.036	0.050	-0.030	0.058	0.047	0.017	0.005	4	270.00	2	146.31	-39.76
7/11/96	26423.60	23993.38	7279.38	0.022	0.051	0.000	-0.030	0.022	0.059	0.000	0.004	3	243.43	2	168.69	-30.47
7/18/96	26423.63	23993.39	7279.36	0.032	0.028	-0.020	-0.050	0.037	0.057	0.000	0.003	1	71.57	2	135.00	-60.50
7/25/96	26423.61	23993.41	7279.39	0.028	0.057	0.030	-0.020	0.041	0.060	0.000	0.003	2	135.00	2	135.00	-19.47
8/16/96	26423.61	23993.37	7279.36	0.040	0.040	-0.030	-0.050	0.050	0.064	0.000	0.001	4	270.00	2	#DIV/0!	-51.34
9/12/96	26423.59	23993.36	7279.33	0.022	0.061	-0.030	-0.080	0.037	0.100	0.001	0.001	3	243.43	3	260.54	-52.75
9/26/96	26423.58	23993.37	7279.35	0.014	0.070	0.020	-0.060	0.024	0.092	0.001	0.001	2	135.00	2	#DIV/0!	-40.60
10/2/96	26423.58	23993.36	7279.32	0.010	0.071	-0.030	-0.090	0.032	0.114	0.004	0.002	4	270.00	3	261.87	-51.84
10/10/96	26423.56	23993.37	7279.30	0.022	0.090	-0.020	-0.110	0.030	0.142	0.003	0.002	2	153.43	2	#DIV/0!	-50.71
10/24/96	26423.57	23993.36	7279.30	0.014	0.081	0.000	-0.110	0.014	0.136	0.000	0.002	4	315.00	3	262.87	-53.76
11/18/96	26423.58	23993.39	7279.32	0.032	0.073	0.020	-0.090	0.037	0.116	0.001	0.002	1	18.43	2	164.05	-51.03
5/16/97	26423.53	23993.37	7279.25	0.054	0.120	-0.070	-0.160	0.088	0.200	0.000	0.002	3	248.20	2	#DIV/0!	-53.13
5/22/97	26423.56	23993.41	7279.25	0.050	0.098	0.000	-0.160	0.050	0.188	0.002	0.002	1	36.87	2	156.04	-58.39
6/4/97	26423.52	23993.35	7279.23	0.072	0.132	-0.020	-0.180	0.075	0.223	0.003	0.002	3	213.69	3	261.25	-53.84
6/11/97	26423.54	23993.39	7279.25	0.045	0.112	0.020	-0.160	0.049	0.195	0.004	0.003	1	26.57	2	169.70	-55.06
6/18/97	26423.55	23993.42	7279.27	0.032	0.112	0.020	-0.140	0.037	0.179	0.002	0.003	1	18.43	2	153.43	-51.39
6/25/97	26423.56	23993.41	7279.24	0.014	0.098	-0.030	-0.170	0.033	0.196	0.002	0.003	4	315.00	2	156.04	-59.91
7/2/97	26423.53	23993.37	7279.22	0.050	0.120	-0.020	-0.190	0.054	0.225	0.004	0.003	3	216.87	2	#DIV/0!	-57.72
7/9/97	26423.53	23993.36	7279.26	0.010	0.120	0.040	-0.150	0.041	0.192	0.005	0.003	4	270.00	3	265.24	-51.24
7/16/97	26423.54	23993.41	7279.28	0.051	0.117	0.020	-0.130	0.055	0.175	0.002	0.003	1	11.31	2	160.02	-48.00
7/25/97	26423.54	23993.40	7279.25	0.010	0.114	-0.030	-0.160	0.032	0.196	0.002	0.003	4	270.00	2	164.74	-54.53
7/30/97	26423.54	23993.40	7279.27	0.000	0.114	0.020	-0.140	0.020	0.181	0.003	0.003	1	#DIV/0!	2	164.74	-50.84
8/6/97	26423.54	23993.40	7279.26	0.000	0.114	-0.010	-0.150	0.010	0.188	0.001	0.002	1	#DIV/0!	2	164.74	-52.76
8/13/97	26423.54	23993.39	7279.25	0.010	0.112	-0.010	-0.160	0.014	0.195	0.001	0.003	4	270.00	2	169.70	-55.06
8/20/97	26423.54	23993.39	7279.30	0.000	0.112	0.050	-0.110	0.050	0.157	0.005	0.002	1	#DIV/0!	2	169.70	-44.53
8/27/97	26423.54	23993.40	7279.30	0.010	0.114	0.000	-0.110	0.010	0.158	0.000	0.002	1	0.00	2	164.74	-43.97
9/2/97	26423.57	23993.45	7279.25	0.058	0.113	-0.050	-0.160	0.077	0.196	0.006	0.003	1	30.96	2	135.00	-54.74
9/10/97	26423.53	23993.40	7279.26	0.064	0.124	0.010	-0.150	0.065	0.194	0.000	0.003	3	218.66	2	165.96	-50.49
9/25/97	26423.54	23993.42	7279.25	0.022	0.121	-0.010	-0.160	0.024	0.200	0.000	0.003	1	26.57	2	155.56	-52.94
10/1/97	26423.51	23993.41	7279.22	0.032	0.146	-0.030	-0.190	0.044	0.239	0.006	0.003	3	251.57	2	164.05	-52.54
10/8/97	26423.53	23993.40	7279.23	0.022	0.124	0.010	-0.180	0.024	0.218	0.003	0.002	4	333.43	2	165.96	-55.50
10/16/97	26423.53	23993.39	7279.23	0.010	0.122	0.000	-0.180	0.010	0.217	0.000	0.002	4	270.00	2	170.54	-55.95
10/22/97	26423.56	23993.44	7279.22	0.058	0.114	-0.010	-0.190	0.059	0.222	0.001	0.003	1	30.96	2	142.13	-59.03
10/29/97	26423.53	23993.38	7279.25	0.067	0.120	0.030	-0.160	0.073	0.200	0.003	0.001	3	206.57	2	175.24	-53.03
11/5/97	26423.53	23993.38	7279.25	0.000	0.120	0.000	-0.160	0.000	0.200	0.000	0.001	1	#DIV/0!	2	175.24	-53.03

MD7 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
11/12/97	26423.53	23993.38	7279.24	0.000	0.120	-0.010	-0.170	0.010	0.208	0.001	0.001	1	#DIV/0!	2	175.24	-54.69
11/19/97	26423.56	23993.43	7279.25	0.058	0.108	0.010	-0.160	0.059	0.193	0.002	0.001	1	30.96	2	146.31	-55.94
11/26/97	26423.53	23993.40	7279.27	0.042	0.124	0.020	-0.140	0.047	0.187	0.001	0.001	3	225.00	2	165.96	-48.54
12/3/97	26423.56	23993.42	7279.25	0.036	0.103	-0.020	-0.160	0.041	0.190	0.000	0.001	1	56.31	2	150.95	-57.24
12/10/97	26423.58	23993.43	7279.24	0.022	0.092	-0.010	-0.170	0.024	0.193	0.000	0.002	1	63.43	2	139.40	-61.53
12/17/97	26423.51	23993.39	7279.23	0.081	0.141	-0.010	-0.180	0.081	0.229	0.005	0.002	3	240.26	2	171.87	-51.84
12/23/97	26423.52	23993.40	7279.24	0.014	0.133	0.010	-0.170	0.017	0.216	0.002	0.002	1	45.00	2	167.01	-51.88
1/7/98	26423.55	23993.42	7279.27	0.036	0.112	0.030	-0.140	0.047	0.179	0.002	0.002	1	56.31	2	153.43	-51.39
1/14/98	26423.54	23993.41	7279.26	0.014	0.117	-0.010	-0.150	0.017	0.190	0.002	0.003	3	225.00	2	160.02	-52.03
1/27/98	26423.52	23993.41	7279.24	0.020	0.136	-0.020	-0.170	0.028	0.218	0.002	0.002	2	#DIV/0!	2	162.90	-51.34
2/3/98	26423.51	23993.39	7279.23	0.022	0.141	-0.010	-0.180	0.024	0.229	0.002	0.002	3	206.57	2	171.87	-51.84
2/19/98	26423.56	23993.32	7279.25	0.086	0.103	0.020	-0.160	0.088	0.190	0.002	0.002	4	305.54	3	240.95	-57.24
3/25/98	26423.55	23993.46	7279.26	0.140	0.135	0.010	-0.150	0.141	0.201	0.000	0.002	2	94.09	2	138.01	-48.11
4/3/98	26423.53	23993.44	7279.29	0.028	0.139	0.030	-0.120	0.041	0.184	0.002	0.002	3	225.00	2	149.74	-40.82
4/8/98	26423.54	23993.40	7279.24	0.041	0.114	-0.050	-0.170	0.065	0.205	0.004	0.002	4	284.04	2	164.74	-56.15
4/15/98	26423.52	23993.41	7279.24	0.022	0.136	0.000	-0.170	0.022	0.218	0.002	0.003	2	153.43	2	162.90	-51.34
4/22/98	26423.49	23993.40	7279.19	0.032	0.163	-0.050	-0.220	0.059	0.274	0.008	0.004	3	251.57	2	169.38	-53.50
4/29/98	26423.51	23993.41	7279.21	0.022	0.146	0.020	-0.200	0.030	0.247	0.004	0.005	1	63.43	2	164.05	-53.94
5/7/98	26423.53	23993.44	7279.26	0.036	0.139	0.050	-0.150	0.062	0.204	0.005	0.004	1	33.69	2	149.74	-47.20
5/13/98	26423.54	23993.39	7279.25	0.051	0.112	-0.010	-0.160	0.052	0.195	0.002	0.006	4	281.31	2	169.70	-55.06
5/21/98	26423.48	23993.42	7279.20	0.067	0.177	-0.050	-0.210	0.084	0.275	0.010	0.006	2	153.43	2	163.61	-49.84
5/28/98	26423.51	23993.42	7279.25	0.030	0.149	0.050	-0.160	0.058	0.218	0.008	0.006	1	#DIV/0!	2	160.35	-47.10
6/3/98	26423.52	23993.45	7279.22	0.032	0.153	-0.030	-0.190	0.044	0.244	0.004	0.006	1	18.43	2	148.39	-51.22
6/10/98	26423.53	23993.44	7279.26	0.014	0.139	0.040	-0.150	0.042	0.204	0.006	0.007	4	315.00	2	149.74	-47.20
6/17/98	26423.52	23993.45	7279.22	0.014	0.153	-0.040	-0.190	0.042	0.244	0.006	0.005	2	135.00	2	148.39	-51.22
6/24/98	26423.51	23993.43	7279.25	0.022	0.152	0.030	-0.160	0.037	0.221	0.003	0.005	3	206.57	2	156.80	-46.41
7/1/98	26423.52	23993.47	7279.22	0.041	0.164	-0.030	-0.190	0.051	0.251	0.004	0.004	1	14.04	2	142.43	-49.20
7/8/98	26423.52	23993.47	7279.22	0.000	0.164	0.000	-0.190	0.000	0.251	0.000	0.003	1	#DIV/0!	2	142.43	-49.20
7/15/98	26423.50	23993.44	7279.26	0.036	0.166	0.040	-0.150	0.054	0.223	0.004	0.002	3	213.69	2	154.98	-42.18
7/22/98	26423.52	23993.41	7279.23	0.036	0.136	-0.030	-0.180	0.047	0.226	0.000	0.002	4	303.69	2	162.90	-52.92
7/29/98	26423.54	23993.45	7279.22	0.045	0.136	-0.010	-0.190	0.046	0.234	0.001	0.002	1	26.57	2	143.97	-54.40
8/11/98	26423.48	23993.42	7279.20	0.067	0.177	-0.020	-0.210	0.070	0.275	0.003	0.002	3	243.43	2	163.61	-49.84
8/19/98	26423.48	23993.42	7279.21	0.000	0.177	0.010	-0.200	0.010	0.267	0.001	0.002	1	#DIV/0!	2	163.61	-48.46
8/31/98	26423.48	23993.42	7279.29	0.000	0.177	0.080	-0.120	0.080	0.214	0.004	0.002	1	#DIV/0!	2	163.61	-34.11
9/11/98	26423.53	23993.37	7279.25	0.071	0.120	-0.040	-0.160	0.081	0.200	0.001	0.004	4	315.00	2	#DIV/0!	-53.13
9/16/98	26423.47	23993.43	7279.23	0.085	0.190	-0.020	-0.180	0.087	0.262	0.012	0.004	2	135.00	2	161.57	-43.49
9/22/98	26423.47	23993.41	7279.20	0.020	0.184	-0.030	-0.210	0.036	0.279	0.003	0.005	4	270.00	2	167.47	-48.72
9/30/98	26423.52	23993.44	7279.23	0.058	0.148	0.030	-0.180	0.066	0.233	0.006	0.006	1	59.04	2	151.70	-50.64
10/7/98	26423.52	23993.42	7279.17	0.020	0.139	-0.060	-0.240	0.063	0.277	0.006	0.006	4	270.00	2	158.96	-59.87
3/3/99	26423.50	23993.43	7279.21	0.022	0.162	0.040	-0.200	0.046	0.257	0.000	0.003	2	153.43	2	158.20	-51.07
5/27/99	26423.47	23993.39	7279.19	0.050	0.181	-0.020	-0.220	0.054	0.285	0.000	0.003	3	216.87	2	173.66	-50.54
7/23/99	26423.48	23993.42	7279.19	0.032	0.177	0.000	-0.220	0.032	0.282	0.000	-0.199	1	18.43	2	163.61	-51.15

MD8 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	INVERSE VELOCITY (days/ft)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26199.26	24192.54	7282.56														
1/11/96	26199.26	24192.52	7282.54	0.020	0.020	-0.020	-0.020	0.028	0.028	0.004		282.84	4	270.00	4	270.00	
2/8/96	26199.27	24192.53	7282.53	0.014	0.014	-0.010	-0.030	0.017	0.033	0.000		5735.38	1	45.00	4	315.00	-64.76
2/15/96	26199.26	24192.53	7282.50	0.010	0.010	-0.030	-0.060	0.032	0.061	0.004		253.06	2	#DIV/0!	4	270.00	-80.54
2/22/96	26199.27	24192.52	7282.52	0.014	0.022	0.020	-0.040	0.024	0.046	0.002	0.002	466.61	4	315.00	4	296.57	-60.79
2/29/96	26199.28	24192.56	7282.50	0.041	0.028	-0.020	-0.060	0.046	0.066	0.003	0.003	341.35	1	14.04	1	45.00	-64.76
3/7/96	26199.26	24192.52	7282.52	0.045	0.020	0.020	-0.040	0.049	0.045	0.003	0.003	323.91	3	206.57	4	270.00	-63.43
3/14/96	26199.29	24192.57	7282.52	0.058	0.042	0.000	-0.040	0.058	0.058	0.002	0.003		1	30.96	1	45.00	-43.31
3/22/96	26199.27	24192.55	7282.54	0.028	0.014	0.020	-0.020	0.035	0.024	0.004	0.003	236.58	3	225.00	1	45.00	-54.74
3/28/96	26199.29	24192.56	7282.52	0.022	0.036	-0.020	-0.040	0.030	0.054	0.005	0.002	204.38	1	63.43	1	56.31	-47.97
4/4/96	26199.27	24192.52	7282.52	0.045	0.022	0.000	-0.040	0.045	0.046	0.001	0.002	872.18	3	206.57	4	296.57	-60.79
4/18/96	26199.30	24192.56	7282.53	0.050	0.045	0.010	-0.030	0.051	0.054	0.001	0.002	1744.35	1	36.87	1	63.43	-33.85
4/25/96	26199.25	24192.53	7282.51	0.058	0.014	-0.020	-0.050	0.062	0.052	0.000	0.002		3	239.04	3	225.00	-74.21
5/2/96	26199.26	24192.53	7282.50	0.010	0.010	-0.010	-0.060	0.014	0.061	0.001	0.001	789.52	1	#DIV/0!	4	270.00	-80.54
5/9/96	26199.26	24192.51	7282.48	0.020	0.030	-0.020	-0.080	0.028	0.085	0.004	0.001	284.41	4	270.00	4	270.00	-69.44
5/31/96	26199.27	24192.54	7282.49	0.032	0.010	0.010	-0.070	0.033	0.071	0.001	0.001	1493.62	1	18.43	1	#DIV/0!	-81.87
6/10/96	26199.28	24192.60	7282.47	0.061	0.063	-0.020	-0.090	0.064	0.110	0.004	0.002	254.52	1	9.46	1	18.43	-54.90
6/13/96	26199.24	24192.53	7282.49	0.081	0.022	0.020	-0.070	0.083	0.073	0.012	0.004	82.16	3	209.74	3	243.43	-72.28
7/11/96	26199.24	24192.53	7282.50	0.000	0.022	0.010	-0.060	0.010	0.064	0.000	0.003	2961.88	1	#DIV/0!	3	243.43	-69.56
7/18/96	26199.27	24192.54	7282.49	0.032	0.010	-0.010	-0.070	0.033	0.071	0.001	0.003	1047.99	1	71.57	1	#DIV/0!	-81.87
7/25/96	26199.24	24192.53	7282.50	0.032	0.022	0.010	-0.060	0.033	0.064	0.001	0.003	1047.99	3	251.57	3	243.43	-69.56
8/16/96	26199.23	24192.49	7282.47	0.041	0.058	-0.030	-0.090	0.051	0.107	0.002	0.001	509.18	3	194.04	3	210.96	-57.06
9/12/96	26199.24	24192.48	7282.44	0.014	0.063	-0.030	-0.120	0.033	0.136	0.001	0.001	950.42	4	315.00	3	198.43	-62.21
9/26/96	26199.24	24192.50	7282.43	0.020	0.045	-0.010	-0.130	0.022	0.137	0.000	0.001		1	0.00	3	206.57	-71.02
10/2/96	26199.23	24192.50	7282.44	0.010	0.050	0.010	-0.120	0.014	0.130	0.001	0.001	802.43	2	#DIV/0!	3	216.87	-67.38
10/10/96	26199.21	24192.51	7282.44	0.022	0.058	0.000	-0.120	0.022	0.133	0.000	0.001	2341.48	2	153.43	3	239.04	-64.08
10/24/96	26199.22	24192.50	7282.40	0.014	0.057	-0.040	-0.160	0.042	0.170	0.003	0.001	385.79	4	315.00	3	225.00	-70.53
11/18/96	26199.24	24192.53	7282.37	0.036	0.022	-0.030	-0.190	0.047	0.191	0.001	0.001	1157.11	1	33.69	3	243.43	-83.29
5/16/97	26199.24	24192.54	7282.32	0.010	0.020	-0.050	-0.240	0.051	0.241	0.000	0.001	3614.66	1	0.00	2	#DIV/0!	-85.24
5/22/97	26199.26	24192.55	7282.32	0.022	0.010	0.000	-0.240	0.022	0.240	0.000	0.001		1	63.43	1	0.00	-87.61
6/4/97	26199.23	24192.50	7282.34	0.058	0.050	0.020	-0.220	0.062	0.226	0.001	0.001		3	210.96	3	216.87	-77.20
6/11/97	26199.25	24192.54	7282.31	0.045	0.010	-0.030	-0.250	0.054	0.250	0.004	0.002	284.67	1	26.57	2	#DIV/0!	-87.71
6/18/97	26199.23	24192.53	7282.32	0.022	0.032	0.010	-0.240	0.024	0.242	0.001	0.002	861.48	3	243.43	3	251.57	-82.49
6/25/97	26199.24	24192.55	7282.32	0.022	0.022	0.000	-0.240	0.022	0.241	0.000	0.003	6763.59	1	26.57	2	153.43	-84.68
7/2/97	26199.24	24192.53	7282.27	0.020	0.022	-0.050	-0.290	0.054	0.291	0.007	0.003	140.50	4	270.00	3	243.43	-85.59
7/9/97	26199.24	24192.53	7282.30	0.000	0.022	0.030	-0.260	0.030	0.261	0.004	0.003	234.11	1	#DIV/0!	3	243.43	-85.08
7/16/97	26199.25	24192.54	7282.33	0.014	0.010	0.030	-0.230	0.033	0.230	0.004	0.003		1	45.00	2	#DIV/0!	-87.51
7/25/97	26199.25	24192.54	7282.30	0.000	0.010	-0.030	-0.260	0.030	0.260	0.003	0.003	300.25	1	#DIV/0!	2	#DIV/0!	-87.80
7/30/97	26199.25	24192.52	7282.29	0.020	0.022	-0.010	-0.270	0.022	0.271	0.002	0.003	465.89	4	270.00	3	206.57	-85.27
8/6/97	26199.24	24192.52	7282.28	0.010	0.028	-0.010	-0.280	0.014	0.281	0.002	0.003	666.63	2	#DIV/0!	3	225.00	-84.23
8/13/97	26199.24	24192.52	7282.27	0.000	0.028	-0.010	-0.290	0.010	0.291	0.001	0.003	703.44	1	#DIV/0!	3	225.00	-84.43
8/20/97	26199.23	24192.52	7282.32	0.010	0.036	0.050	-0.240	0.051	0.243	0.007	0.002	143.79	2	#DIV/0!	3	236.31	-81.46
8/27/97	26199.24	24192.52	7282.31	0.010	0.028	-0.010	-0.250	0.014	0.252	0.001	0.002	786.37	1	#DIV/0!	3	225.00	-83.55
9/2/97	26199.25	24192.54	7282.29	0.022	0.010	-0.020	-0.270	0.030	0.270	0.003	0.002		1	26.57	2	#DIV/0!	-87.88
9/10/97	26199.23	24192.53	7282.29	0.022	0.032	0.000	-0.270	0.022	0.272	0.000	0.002	4818.05	3	243.43	3	251.57	-83.32
9/25/97	26199.24	24192.53	7282.29	0.010	0.022	0.000	-0.270	0.010	0.271	0.000	0.001		1	#DIV/0!	3	243.43	-85.27
10/1/97	26199.24	24192.55	7282.28	0.020	0.022	-0.010	-0.280	0.022	0.281	0.002	0.001	601.98	1	0.00	2	153.43	-85.43
10/8/97	26199.25	24192.54	7282.27	0.014	0.010	-0.010	-0.290	0.017	0.290	0.001	0.001		4	315.00	2	#DIV/0!	-88.03
10/16/97	26199.24	24192.54	7282.25	0.010	0.020	-0.020	-0.310	0.022	0.311	0.003	0.002		2	#DIV/0!	2	#DIV/0!	-86.31
10/22/97	26199.25	24192.56	7282.27	0.022	0.022	0.020	-0.290	0.030	0.291	0.003	0.002		1	26.57	2	116.57	-85.59
10/29/97	26199.24	24192.54	7282.25	0.022	0.020	-0.020	-0.310	0.030	0.311	0.003	0.002		3	206.57	2	#DIV/0!	-86.31
11/5/97	26199.24	24192.53	7282.26	0.010	0.022	0.010	-0.300	0.014	0.301	0.001	0.002		4	270.00	3	243.43	-85.74
11/12/97	26199.24	24192.54	7282.25	0.010	0.020	-0.010	-0.310	0.014	0.311	0.001	0.003		1	0.00	2	#DIV/0!	-86.31

MD8 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	INVERSE VELOCITY (days/ft)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
11/19/97	26199.27	24192.55	7282.28	0.032	0.014	0.030	-0.280	0.044	0.280	0.004	0.002		1	71.57	1	45.00	-87.11
11/26/97	26199.25	24192.54	7282.28	0.022	0.010	0.000	-0.280	0.022	0.280	0.000	0.001		3	243.43	2	#DIV/0!	-87.95
12/3/97	26199.27	24192.54	7282.28	0.020	0.010	0.000	-0.280	0.020	0.280	0.000	0.001		1	#DIV/0!	1	#DIV/0!	-87.95
12/10/97	26199.29	24192.55	7282.29	0.022	0.032	0.010	-0.270	0.024	0.272	0.001	0.002		1	63.43	1	71.57	-83.32
12/17/97	26199.25	24192.52	7282.26	0.050	0.022	-0.030	-0.300	0.058	0.301	0.004	0.001		3	233.13	3	206.57	-85.74
12/23/97	26199.25	24192.53	7282.27	0.010	0.014	0.010	-0.290	0.014	0.290	0.002	0.002		1	0.00	3	225.00	-87.21
12/30/97	26199.25	24192.55	7282.25	0.020	0.014	-0.020	-0.310	0.028	0.310	0.003	0.002		1	0.00	2	135.00	-87.39
1/7/98	26199.26	24192.54	7282.27	0.014	0.000	0.020	-0.290	0.024	0.290	0.003	0.002		4	315.00	1	#DIV/0!	#DIV/0!
1/14/98	26199.27	24192.55	7282.27	0.014	0.014	0.000	-0.290	0.014	0.290	0.000	0.002		1	45.00	1	45.00	-87.21
1/27/98	26199.26	24192.57	7282.25	0.022	0.030	-0.020	-0.310	0.030	0.311	0.002	0.002		2	116.57	1	0.00	-84.47
2/3/98	26199.25	24192.52	7282.26	0.051	0.022	0.010	-0.300	0.052	0.301	0.002	0.001		3	191.31	3	206.57	-85.74
2/19/98	26199.27	24192.54	7282.28	0.028	0.010	0.020	-0.280	0.035	0.280	0.001	0.001		1	45.00	1	#DIV/0!	-87.95
3/25/98	26199.26	24192.57	7282.25	0.032	0.030	-0.030	-0.310	0.044	0.311	0.001	0.001		2	108.43	1	0.00	-84.47
4/3/98	26199.25	24192.56	7282.25	0.014	0.022	0.000	-0.310	0.014	0.311	0.000	0.002		3	225.00	2	116.57	-85.87
4/8/98	26199.25	24192.52	7282.29	0.040	0.022	0.040	-0.270	0.057	0.271	0.008	0.003		4	270.00	3	206.57	-85.27
4/15/98	26199.26	24192.57	7282.25	0.051	0.030	-0.040	-0.310	0.065	0.311	0.006	0.004		1	11.31	1	0.00	-84.47
4/22/98	26199.22	24192.54	7282.22	0.050	0.040	-0.030	-0.340	0.058	0.342	0.004	0.005		3	233.13	2	#DIV/0!	-83.29
4/29/98	26199.25	24192.55	7282.25	0.032	0.014	0.030	-0.310	0.044	0.310	0.005	0.005		1	71.57	2	135.00	-87.39
5/7/98	26199.25	24192.55	7282.25	0.000	0.014	0.000	-0.310	0.000	0.310	0.000	0.005		1	#DIV/0!	2	135.00	-87.39
5/13/98	26199.25	24192.54	7282.31	0.010	0.010	0.060	-0.250	0.061	0.250	0.010	0.006		4	270.00	2	#DIV/0!	-87.71
5/21/98	26199.23	24192.54	7282.22	0.020	0.030	-0.090	-0.340	0.092	0.341	0.011	0.006		2	#DIV/0!	2	#DIV/0!	-84.96
5/28/98	26199.24	24192.56	7282.20	0.022	0.028	-0.020	-0.360	0.030	0.361	0.003	0.005		1	26.57	2	135.00	-85.51
6/3/98	26199.25	24192.57	7282.21	0.014	0.032	0.010	-0.350	0.017	0.351	0.002	0.006		1	45.00	2	108.43	-84.84
6/10/98	26199.25	24192.50	7282.25	0.070	0.041	0.040	-0.310	0.081	0.313	0.006	0.005		4	270.00	3	194.04	-82.42
6/17/98	26199.25	24192.57	7282.21	0.070	0.032	-0.040	-0.350	0.081	0.351	0.006	0.005		1	0.00	2	108.43	-84.84
6/24/98	26199.24	24192.55	7282.27	0.022	0.022	0.060	-0.290	0.064	0.291	0.009	0.006		3	206.57	2	153.43	-85.59
7/1/98	26199.23	24192.57	7282.22	0.022	0.042	-0.050	-0.340	0.055	0.343	0.007	0.005		2	116.57	2	135.00	-82.89
7/8/98	26199.23	24192.56	7282.22	0.010	0.036	0.000	-0.340	0.010	0.342	0.000	0.005		4	270.00	2	146.31	-83.95
7/15/98	26199.25	24192.57	7282.26	0.022	0.032	0.040	-0.300	0.046	0.302	0.006	0.005		1	63.43	2	108.43	-83.98
7/22/98	26199.26	24192.55	7282.23	0.022	0.010	-0.030	-0.330	0.037	0.330	0.004	0.005		4	296.57	1	0.00	-88.26
7/29/98	26199.26	24192.55	7282.19	0.000	0.010	-0.040	-0.370	0.040	0.370	0.006	0.004		1	#DIV/0!	1	0.00	-88.45
8/11/98	26199.23	24192.54	7282.16	0.032	0.030	-0.030	-0.400	0.044	0.401	0.002	0.004		3	251.57	2	#DIV/0!	-85.71
8/19/98	26199.24	24192.54	7282.17	0.010	0.020	0.010	-0.390	0.014	0.391	0.001	0.004		1	#DIV/0!	2	#DIV/0!	-87.06
8/31/98	26199.24	24192.55	7282.24	0.010	0.022	0.070	-0.320	0.071	0.321	0.006	0.005		1	0.00	2	153.43	-86.00
9/11/98	26199.24	24192.54	7282.32	0.010	0.020	0.080	-0.240	0.081	0.241	0.007	0.009		4	270.00	2	#DIV/0!	-85.24
9/16/98	26199.24	24192.54	7282.18	0.000	0.020	-0.140	-0.380	0.140	0.381	0.028	0.009		1	#DIV/0!	2	#DIV/0!	-86.99
9/22/98	26199.27	24192.56	7282.21	0.036	0.022	0.030	-0.350	0.047	0.351	0.005	0.009		1	56.31	1	26.57	-86.34
9/30/98	26199.25	24192.55	7282.21	0.022	0.014	0.000	-0.350	0.022	0.350	0.000	0.008		3	243.43	2	135.00	-87.69
10/7/98	26199.26	24192.56	7282.21	0.014	0.020	0.000	-0.350	0.014	0.351	0.000	0.007		1	45.00	1	0.00	-86.73
3/3/99	26199.25	24192.56	7282.19	0.010	0.022	-0.020	-0.370	0.022	0.371	0.000	0.001		2	#DIV/0!	2	116.57	-86.54
5/27/99	26199.23	24192.54	7282.15	0.028	0.030	-0.040	-0.410	0.049	0.411	0.000	0.000		3	225.00	2	#DIV/0!	-85.82
7/23/99	26199.24	24192.55	7282.14	0.014	0.022	-0.010	-0.420	0.017	0.421	0.000	-0.200		1	45.00	2	153.43	-86.95

MD9 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	25970.20	24394.18	7285.60													
1/11/96	25970.21	24394.18	7285.59	0.010	0.010	-0.010	-0.010	0.014	0.014	0.002		1	#DIV/0!	1	#DIV/0!	
2/8/96	25970.22	24394.18	7285.57	0.010	0.020	-0.020	-0.030	0.022	0.036	0.001		1	#DIV/0!	1	#DIV/0!	-56.31
2/15/96	25970.21	24394.19	7285.58	0.014	0.014	0.010	-0.020	0.017	0.024	0.002		2	135.00	1	45.00	-54.74
2/22/96	25970.21	24394.17	7285.59	0.020	0.014	0.010	-0.010	0.022	0.017	0.001	0.003	4	270.00	4	315.00	-35.26
2/29/96	25970.22	24394.19	7285.57	0.022	0.022	-0.020	-0.030	0.030	0.037	0.003	0.003	1	26.57	1	63.43	-53.30
3/7/96	25970.21	24394.17	7285.59	0.022	0.014	0.020	-0.010	0.030	0.017	0.003	0.003	3	206.57	4	315.00	-35.26
3/14/96	25970.23	24394.22	7285.57	0.054	0.050	-0.020	-0.030	0.057	0.058	0.006	0.004	1	21.80	1	36.87	-30.96
3/22/96	25970.21	24394.21	7285.60	0.022	0.032	0.030	0.000	0.037	0.032	0.003	0.004	3	243.43	1	18.43	0.00
3/28/96	25970.22	24394.21	7285.55	0.010	0.036	-0.050	-0.050	0.051	0.062	0.005	0.004	1	#DIV/0!	1	33.69	-54.20
4/4/96	25970.22	24394.19	7285.59	0.020	0.022	0.040	-0.010	0.045	0.024	0.005	0.004	4	270.00	1	63.43	-24.09
4/18/96	25970.22	24394.20	7285.57	0.010	0.028	-0.020	-0.030	0.022	0.041	0.001	0.004	1	0.00	1	45.00	-46.69
4/25/96	25970.21	24394.20	7285.54	0.010	0.022	-0.030	-0.060	0.032	0.064	0.003	0.004	2	#DIV/0!	1	26.57	-69.56
5/2/96	25970.21	24394.18	7285.58	0.020	0.010	0.040	-0.020	0.045	0.022	0.006	0.003	4	270.00	1	#DIV/0!	-63.43
5/9/96	25970.21	24394.17	7285.55	0.010	0.014	-0.030	-0.050	0.032	0.052	0.004	0.003	4	270.00	4	315.00	-74.21
5/31/96	25970.21	24394.18	7285.56	0.010	0.010	0.010	-0.040	0.014	0.041	0.000	0.003	1	0.00	1	#DIV/0!	-75.96
6/10/96	25970.21	24394.21	7285.57	0.030	0.032	0.010	-0.030	0.032	0.044	0.000	0.003	1	0.00	1	18.43	-43.49
6/13/96	25970.21	24394.19	7285.55	0.020	0.014	-0.020	-0.050	0.028	0.052	0.003	0.001	4	270.00	1	45.00	-74.21
7/11/96	25970.19	24394.19	7285.53	0.020	0.014	-0.020	-0.070	0.028	0.071	0.001	0.001	2	#DIV/0!	2	135.00	-78.58
7/18/96	25970.22	24394.20	7285.54	0.032	0.028	0.010	-0.060	0.033	0.066	0.001	0.001	1	71.57	1	45.00	-64.76
7/25/96	25970.19	24394.18	7285.54	0.036	0.010	0.000	-0.060	0.036	0.061	0.001	0.001	3	236.31	2	#DIV/0!	-80.54
8/16/96	25970.19	24394.16	7285.54	0.020	0.022	0.000	-0.060	0.020	0.064	0.000	0.001	4	270.00	3	206.57	-69.56
9/12/96	25970.19	24394.14	7285.53	0.020	0.041	-0.010	-0.070	0.022	0.081	0.001	0.000	4	270.00	3	194.04	-59.50
9/26/96	25970.21	24394.16	7285.53	0.028	0.022	0.000	-0.070	0.028	0.073	0.001	0.001	1	45.00	4	296.57	-72.28
10/2/96	25970.21	24394.16	7285.53	0.000	0.022	0.000	-0.070	0.000	0.073	0.000	0.001	1	#DIV/0!	4	296.57	-72.28
10/10/96	25970.20	24394.17	7285.53	0.014	0.010	0.000	-0.070	0.014	0.071	0.000	0.001	2	135.00	4	270.00	-81.87
10/24/96	25970.20	24394.17	7285.50	0.000	0.010	-0.030	-0.100	0.030	0.100	0.002	0.001	1	#DIV/0!	4	270.00	-84.29
11/18/96	25970.22	24394.16	7285.50	0.022	0.028	0.000	-0.100	0.022	0.104	0.000	0.001	4	333.43	4	315.00	-74.21
5/16/97	25970.23	24394.15	7285.43	0.014	0.042	-0.070	-0.170	0.071	0.175	0.000	0.001	4	315.00	4	315.00	-75.99
5/22/97	25970.24	24394.19	7285.43	0.041	0.041	0.000	-0.170	0.041	0.175	0.000	0.001	1	14.04	1	75.96	-76.37
6/4/97	25970.22	24394.14	7285.44	0.054	0.045	0.010	-0.160	0.055	0.166	0.001	0.001	3	201.80	4	296.57	-74.38
6/11/97	25970.23	24394.16	7285.43	0.022	0.036	-0.010	-0.170	0.024	0.174	0.001	0.001	1	26.57	4	326.31	-78.03
6/18/97	25970.24	24394.17	7285.42	0.014	0.041	-0.010	-0.180	0.017	0.185	0.002	0.001	1	45.00	4	345.96	-77.10
6/25/97	25970.23	24394.16	7285.43	0.014	0.036	0.010	-0.170	0.017	0.174	0.002	0.001	3	225.00	4	326.31	-78.03
7/2/97	25970.24	24394.15	7285.43	0.014	0.050	0.000	-0.170	0.014	0.177	0.000	0.001	4	315.00	4	323.13	-73.61
7/9/97	25970.23	24394.16	7285.44	0.014	0.036	0.010	-0.160	0.017	0.164	0.002	0.001	2	135.00	4	326.31	-77.30
7/16/97	25970.24	24394.16	7285.45	0.010	0.045	0.010	-0.150	0.014	0.157	0.001	0.001	1	#DIV/0!	4	333.43	-73.40
7/25/97	25970.23	24394.16	7285.43	0.010	0.036	-0.020	-0.170	0.022	0.174	0.002	0.001	2	#DIV/0!	4	326.31	-78.03
7/30/97	25970.23	24394.16	7285.42	0.000	0.036	-0.010	-0.180	0.010	0.184	0.002	0.002	1	#DIV/0!	4	326.31	-78.67
8/6/97	25970.23	24394.16	7285.42	0.000	0.036	0.000	-0.180	0.000	0.184	0.000	0.002	1	#DIV/0!	4	326.31	-78.67
8/13/97	25970.24	24394.16	7285.41	0.010	0.045	-0.010	-0.190	0.014	0.195	0.002	0.002	1	#DIV/0!	4	333.43	-76.76
8/20/97	25970.24	24394.15	7285.43	0.010	0.050	0.020	-0.170	0.022	0.177	0.003	0.001	4	270.00	4	323.13	-73.61
8/27/97	25970.24	24394.15	7285.42	0.000	0.050	-0.010	-0.180	0.010	0.187	0.001	0.001	1	#DIV/0!	4	323.13	-74.48
9/2/97	25970.24	24394.16	7285.43	0.010	0.045	0.010	-0.170	0.014	0.176	0.002	0.002	1	0.00	4	333.43	-75.26
9/10/97	25970.24	24394.14	7285.43	0.020	0.057	0.000	-0.170	0.020	0.179	0.000	0.001	4	270.00	4	315.00	-71.59
9/25/97	25970.25	24394.15	7285.44	0.014	0.058	0.010	-0.160	0.017	0.170	0.001	0.001	1	45.00	4	329.04	-69.98
10/1/97	25970.24	24394.18	7285.42	0.032	0.040	-0.020	-0.180	0.037	0.184	0.002	0.001	2	108.43	1	#DIV/0!	-77.47
10/8/97	25970.25	24394.17	7285.42	0.014	0.051	0.000	-0.180	0.014	0.187	0.000	0.001	4	315.00	4	348.69	-74.18
10/16/97	25970.25	24394.15	7285.40	0.020	0.058	-0.020	-0.200	0.028	0.208	0.003	0.002	4	270.00	4	329.04	-73.75
10/22/97	25970.25	24394.16	7285.37	0.010	0.054	-0.030	-0.230	0.032	0.236	0.005	0.002	1	0.00	4	338.20	-76.82
10/29/97	25970.24	24394.15	7285.38	0.014	0.050	0.010	-0.220	0.017	0.226	0.002	0.002	3	225.00	4	323.13	-77.20

MD9 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
11/5/97	25970.25	24394.15	7285.39	0.010	0.058	0.010	-0.210	0.014	0.218	0.001	0.002	1	#DIV/0!	4	329.04	-74.48
11/12/97	25970.24	24394.15	7285.38	0.010	0.050	-0.010	-0.220	0.014	0.226	0.001	0.003	2	#DIV/0!	4	323.13	-77.20
11/19/97	25970.26	24394.16	7285.42	0.022	0.063	0.040	-0.180	0.046	0.191	0.005	0.002	1	63.43	4	341.57	-70.64
11/26/97	25970.25	24394.16	7285.41	0.010	0.054	-0.010	-0.190	0.014	0.197	0.001	0.002	2	#DIV/0!	4	338.20	-74.18
12/3/97	25970.28	24394.18	7285.42	0.036	0.080	0.010	-0.180	0.037	0.197	0.000	0.002	1	56.31	1	#DIV/0!	-66.04
12/10/97	25970.29	24394.18	7285.44	0.010	0.090	0.020	-0.160	0.022	0.184	0.002	0.002	1	#DIV/0!	1	#DIV/0!	-60.64
12/17/97	25970.26	24394.16	7285.42	0.036	0.063	-0.020	-0.180	0.041	0.191	0.001	0.001	3	236.31	4	341.57	-70.64
12/23/97	25970.27	24394.16	7285.42	0.010	0.073	0.000	-0.180	0.010	0.194	0.001	0.001	1	#DIV/0!	4	344.05	-67.98
12/30/97	25970.28	24394.16	7285.43	0.010	0.082	0.010	-0.170	0.014	0.189	0.001	0.001	1	#DIV/0!	4	345.96	-64.12
1/7/98	25970.26	24394.16	7285.41	0.020	0.063	-0.020	-0.190	0.028	0.200	0.001	0.001	2	#DIV/0!	4	341.57	-71.59
1/14/98	25970.27	24394.15	7285.41	0.014	0.076	0.000	-0.190	0.014	0.205	0.001	0.001	4	315.00	4	336.80	-68.16
1/27/98	25970.26	24394.17	7285.39	0.022	0.061	-0.020	-0.210	0.030	0.219	0.001	0.002	2	116.57	4	350.54	-73.85
2/3/98	25970.26	24394.16	7285.42	0.010	0.063	0.030	-0.180	0.032	0.191	0.004	0.001	4	270.00	4	341.57	-70.64
2/19/98	25970.28	24394.18	7285.42	0.028	0.080	0.000	-0.180	0.028	0.197	0.000	0.001	1	45.00	1	#DIV/0!	-66.04
3/25/98	25970.26	24394.16	7285.38	0.028	0.063	-0.040	-0.220	0.049	0.229	0.001	0.002	3	225.00	4	341.57	-73.96
4/3/98	25970.27	24394.15	7285.42	0.014	0.076	0.040	-0.180	0.042	0.195	0.004	0.002	4	315.00	4	336.80	-67.07
4/8/98	25970.23	24394.16	7285.42	0.041	0.036	0.000	-0.180	0.041	0.184	0.002	0.002	2	165.96	4	326.31	-78.67
4/15/98	25970.26	24394.17	7285.39	0.032	0.061	-0.030	-0.210	0.044	0.219	0.005	0.003	1	71.57	4	350.54	-73.85
4/22/98	25970.25	24394.14	7285.40	0.032	0.064	0.010	-0.200	0.033	0.210	0.001	0.003	3	198.43	4	321.34	-72.25
4/29/98	25970.27	24394.17	7285.37	0.036	0.071	-0.030	-0.230	0.047	0.241	0.004	0.004	1	33.69	4	351.87	-72.91
5/7/98	25970.26	24394.16	7285.42	0.014	0.063	0.050	-0.180	0.052	0.191	0.006	0.004	3	225.00	4	341.57	-70.64
5/13/98	25970.23	24394.16	7285.43	0.030	0.036	0.010	-0.170	0.032	0.174	0.003	0.004	2	#DIV/0!	4	326.31	-78.03
5/21/98	25970.25	24394.14	7285.38	0.028	0.064	-0.050	-0.220	0.057	0.229	0.007	0.005	4	315.00	4	321.34	-73.77
5/26/98	25970.26	24394.16	7285.40	0.022	0.063	0.020	-0.200	0.030	0.210	0.003	0.004	1	26.57	4	341.57	-72.45
6/3/98	25970.26	24394.16	7285.38	0.000	0.063	-0.020	-0.220	0.020	0.229	0.003	0.004	1	#DIV/0!	4	341.57	-73.96
6/10/98	25970.26	24394.16	7285.42	0.000	0.063	0.040	-0.180	0.040	0.191	0.005	0.005	1	#DIV/0!	4	341.57	-70.64
6/17/98	25970.26	24394.17	7285.38	0.010	0.061	-0.040	-0.220	0.041	0.228	0.005	0.004	1	0.00	4	350.54	-74.54
6/24/98	25970.27	24394.15	7285.41	0.022	0.076	0.030	-0.190	0.037	0.205	0.003	0.004	4	296.57	4	336.80	-68.16
7/1/98	25970.35	24394.18	7285.47	0.085	0.150	0.060	-0.130	0.104	0.198	0.001	0.003	1	69.44	1	#DIV/0!	-40.91
7/8/98	25970.35	24394.18	7285.47	0.000	0.150	0.000	-0.130	0.000	0.198	0.000	0.002	1	#DIV/0!	1	#DIV/0!	-40.91
7/15/98	25970.27	24394.17	7285.41	0.081	0.071	-0.060	-0.190	0.100	0.203	0.001	0.001	3	262.87	4	351.87	-69.59
7/22/98	25970.28	24394.16	7285.40	0.014	0.082	-0.010	-0.200	0.017	0.216	0.002	0.001	4	315.00	4	345.96	-67.59
7/29/98	25970.30	24394.17	7285.39	0.022	0.100	-0.010	-0.210	0.024	0.233	0.002	0.001	1	63.43	4	354.29	-64.43
8/11/98	25970.27	24394.17	7285.35	0.030	0.071	-0.040	-0.250	0.050	0.260	0.002	0.001	2	#DIV/0!	4	351.87	-74.21
8/19/98	25970.28	24394.17	7285.35	0.010	0.081	0.000	-0.250	0.010	0.263	0.000	0.002	1	#DIV/0!	4	352.87	-72.13
8/31/98	25970.28	24394.17	7285.39	0.000	0.081	0.040	-0.210	0.040	0.225	0.003	0.002	1	#DIV/0!	4	352.87	-69.00
9/11/98	25970.23	24394.15	7285.43	0.054	0.042	0.040	-0.170	0.067	0.175	0.005	0.005	3	248.20	4	315.00	-75.99
9/16/98	25970.26	24394.14	7285.36	0.032	0.072	-0.070	-0.240	0.077	0.251	0.015	0.005	4	341.57	4	326.31	-73.28
9/22/98	25970.27	24394.15	7285.35	0.014	0.076	-0.010	-0.250	0.017	0.261	0.002	0.005	1	45.00	4	336.80	-73.06
9/30/98	25970.27	24394.16	7285.35	0.010	0.073	0.000	-0.250	0.010	0.260	0.000	0.004	1	0.00	4	344.05	-73.76
10/7/98	25970.28	24394.15	7285.36	0.014	0.085	0.010	-0.240	0.017	0.255	0.001	0.004	4	315.00	4	339.44	-70.40
3/3/99	25970.27	24394.15	7285.36	0.010	0.076	0.000	-0.240	0.010	0.252	0.000	0.001	2	#DIV/0!	4	336.80	-72.39
5/27/99	25970.27	24394.13	7285.34	0.020	0.086	-0.020	-0.260	0.028	0.274	0.000	0.000	4	270.00	4	324.46	-71.69
7/23/99	25970.27	24394.14	7285.34	0.010	0.081	0.000	-0.260	0.010	0.272	0.000	-0.200	1	0.00	4	330.26	-72.77

MD10 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT RATE (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26462.17	24038.11	7309.37													
1/11/96	26462.18	24038.12	7309.37	0.014	0.014	0.000	0.000	0.014	0.014	0.002		1	45.00	1	45.00	
2/8/96	26462.19	24038.14	7309.34	0.022	0.036	-0.030	-0.030	0.037	0.047	0.001		1	26.57	1	33.69	-39.76
2/15/96	26462.18	24038.14	7309.30	0.010	0.032	-0.040	-0.070	0.041	0.077	0.004		2	#DIV/0!	1	18.43	-65.69
2/22/96	26462.19	24038.13	7309.34	0.014	0.028	0.040	-0.030	0.042	0.041	0.005	0.003	4	315.00	1	45.00	-46.69
2/29/96	26462.19	24038.15	7309.34	0.020	0.045	0.000	-0.030	0.020	0.054	0.002	0.004	1	0.00	1	26.57	-33.85
3/7/96	26462.17	24038.19	7309.32	0.045	0.080	-0.020	-0.050	0.049	0.094	0.006	0.004	2	116.57	1	0.00	-32.01
3/14/96	26462.22	24038.20	7309.32	0.051	0.103	0.000	-0.050	0.051	0.114	0.003	0.003	1	78.69	1	29.05	-25.90
3/22/96	26462.19	24038.20	7309.33	0.030	0.092	0.010	-0.040	0.032	0.100	0.002	0.003	2	#DIV/0!	1	12.53	-23.45
3/28/96	26462.19	24038.18	7309.34	0.020	0.073	0.010	-0.030	0.022	0.079	0.004	0.003	4	270.00	1	15.95	-22.40
4/4/96	26462.21	24038.18	7309.31	0.020	0.081	-0.030	-0.060	0.036	0.100	0.003	0.003	1	#DIV/0!	1	29.74	-36.66
4/18/96	26462.20	24038.20	7309.30	0.022	0.095	-0.010	-0.070	0.024	0.118	0.001	0.003	2	116.57	1	18.43	-36.42
4/25/96	26462.18	24038.19	7309.29	0.022	0.081	-0.010	-0.080	0.024	0.114	0.001	0.003	3	243.43	1	7.13	-44.78
5/2/96	26462.18	24038.17	7309.33	0.020	0.061	0.040	-0.040	0.045	0.073	0.006	0.003	4	270.00	1	9.46	-33.33
5/9/96	26462.20	24038.18	7309.28	0.022	0.076	-0.050	-0.090	0.055	0.118	0.006	0.003	1	63.43	1	23.20	-49.76
5/31/96	26462.20	24038.20	7309.28	0.020	0.095	0.000	-0.090	0.020	0.131	0.001	0.003	1	0.00	1	18.43	-43.49
6/13/96	26462.17	24038.19	7309.31	0.032	0.080	0.030	-0.060	0.044	0.100	0.002	0.004	3	251.57	1	0.00	-36.87
7/11/96	26462.16	24038.20	7309.25	0.014	0.091	-0.060	-0.120	0.062	0.150	0.002	0.002	2	135.00	2	96.34	-52.96
7/18/96	26462.18	24038.21	7309.24	0.022	0.100	-0.010	-0.130	0.024	0.164	0.002	0.002	1	63.43	1	5.71	-52.29
7/25/96	26462.16	24038.21	7309.28	0.020	0.100	0.040	-0.090	0.045	0.135	0.004	0.003	2	#DIV/0!	2	95.71	-41.85
8/16/96	26462.13	24038.17	7309.23	0.050	0.072	-0.050	-0.140	0.071	0.157	0.001	0.003	3	216.87	2	123.69	-62.75
9/12/96	26462.18	24038.22	7309.16	0.071	0.110	-0.070	-0.210	0.099	0.237	0.003	0.003	1	45.00	1	5.19	-62.26
9/26/96	26462.18	24038.26	7309.09	0.040	0.150	-0.070	-0.280	0.081	0.318	0.006	0.003	1	0.00	1	3.81	-61.77
10/2/96	26462.19	24038.29	7309.13	0.032	0.181	0.040	-0.240	0.051	0.301	0.003	0.003	1	18.43	1	6.34	-52.96
10/10/96	26462.17	24038.29	7309.10	0.020	0.180	-0.030	-0.270	0.036	0.324	0.003	0.003	2	#DIV/0!	1	0.00	-56.31
10/24/96	26462.17	24038.28	7309.06	0.010	0.170	-0.040	-0.310	0.041	0.354	0.002	0.003	4	270.00	1	0.00	-61.26
11/18/96	26462.18	24038.31	7309.04	0.032	0.200	-0.020	-0.330	0.037	0.386	0.001	0.002	1	18.43	1	2.86	-58.75
5/16/97	26462.21	24038.39	7308.93	0.085	0.283	-0.110	-0.440	0.139	0.523	0.001	0.002	1	20.56	1	8.13	-57.27
5/22/97	26462.19	24038.42	7308.92	0.036	0.311	-0.010	-0.450	0.037	0.547	0.004	0.002	2	123.69	1	3.69	-55.38
6/4/97	26462.19	24038.39	7308.92	0.030	0.281	0.000	-0.450	0.030	0.530	0.001	0.002	4	270.00	1	4.09	-58.04
6/11/97	26462.21	24038.40	7308.91	0.022	0.293	-0.010	-0.460	0.024	0.545	0.002	0.002	1	63.43	1	7.85	-57.53
6/18/97	26462.21	24038.43	7308.90	0.030	0.322	-0.010	-0.470	0.032	0.570	0.004	0.002	1	0.00	1	7.13	-55.54
6/25/97	26462.20	24038.42	7308.89	0.014	0.311	-0.010	-0.480	0.017	0.572	0.000	0.002	3	225.00	1	5.53	-57.02
7/2/97	26462.18	24038.39	7308.88	0.036	0.280	-0.010	-0.490	0.037	0.564	0.001	0.002	3	213.69	1	2.05	-60.24
7/9/97	26462.19	24038.40	7308.89	0.014	0.291	0.010	-0.480	0.017	0.561	0.000	0.002	1	45.00	1	3.95	-58.80
7/16/97	26462.20	24038.43	7308.88	0.032	0.321	-0.010	-0.490	0.033	0.586	0.004	0.002	1	18.43	1	5.36	-56.74
7/25/97	26462.22	24038.44	7308.86	0.022	0.334	-0.020	-0.510	0.030	0.610	0.003	0.002	1	63.43	1	8.62	-56.80
7/30/97	26462.19	24038.42	7308.87	0.036	0.311	0.010	-0.500	0.037	0.589	0.004	0.003	3	236.31	1	3.69	-58.15
8/6/97	26462.19	24038.42	7308.85	0.000	0.311	-0.020	-0.520	0.020	0.606	0.002	0.003	1	#DIV/0!	1	3.69	-59.15
8/13/97	26462.19	24038.42	7308.84	0.000	0.311	-0.010	-0.530	0.010	0.614	0.001	0.003	1	#DIV/0!	1	3.69	-59.62
8/20/97	26462.19	24038.41	7308.88	0.010	0.301	0.040	-0.490	0.041	0.575	0.006	0.003	4	270.00	1	3.81	-58.47
8/27/97	26462.19	24038.42	7308.88	0.010	0.311	0.000	-0.490	0.010	0.580	0.001	0.002	1	0.00	1	3.69	-57.63
9/2/97	26462.21	24038.47	7308.89	0.054	0.362	0.010	-0.480	0.055	0.601	0.004	0.002	1	21.80	1	6.34	-52.96
9/10/97	26462.19	24038.43	7308.85	0.045	0.321	-0.040	-0.520	0.060	0.611	0.001	0.003	3	206.57	1	3.58	-58.34
9/25/97	26462.19	24038.44	7308.85	0.010	0.331	0.000	-0.520	0.010	0.616	0.000	0.002	1	0.00	1	3.47	-57.55
10/1/97	26462.19	24038.47	7308.84	0.030	0.361	-0.010	-0.530	0.032	0.641	0.004	0.002	1	0.00	1	3.18	-55.77
10/8/97	26462.17	24038.48	7308.82	0.022	0.370	-0.020	-0.550	0.030	0.663	0.003	0.002	2	153.43	1	0.00	-56.07
10/16/97	26462.15	24038.47	7308.83	0.022	0.361	0.010	-0.540	0.024	0.649	0.002	0.003	3	243.43	2	93.18	-56.27
10/22/97	26462.20	24038.48	7308.80	0.051	0.371	-0.030	-0.570	0.059	0.680	0.005	#DIV/0!	1	78.69	1	4.64	-56.93
10/22/97	26462.20	24038.44	7308.83	0.040	0.331	0.030	-0.540	0.050	0.634	#DIV/0!	#DIV/0!	4	270.00	1	5.19	-58.47
11/5/97	26462.18	24038.44	7308.79	0.010	0.331	-0.040	-0.580	0.041	0.668	0.002	#DIV/0!	2	#DIV/0!	1	3.47	-60.32
11/12/97	26462.19	24038.44	7308.80	0.000	0.331	0.010	-0.570	0.010	0.659	0.001	#DIV/0!	1	#DIV/0!	1	3.47	-59.89
11/19/97	26462.19	24038.44	7308.79	0.000	0.331	-0.010	-0.580	0.010	0.668	0.001	#DIV/0!	1	#DIV/0!	1	3.47	-60.32
11/26/97	26462.19	24038.44	7308.80	0.000	0.331	0.010	-0.570	0.010	0.659	0.001	0.001	1	#DIV/0!	1	3.47	-59.89
12/3/97	26462.22	24038.47	7308.82	0.042	0.363	0.020	-0.550	0.047	0.659	0.000	0.002	1	45.00	1	7.91	-56.54
12/10/97	26462.25	24038.48	7308.79	0.032	0.379	-0.030	-0.580	0.044	0.693	0.005	0.003	1	71.57	1	12.20	-56.87
12/17/97	26462.20	24038.42	7308.80	0.078	0.311	0.010	-0.570	0.079	0.650	0.006	0.003	3	219.81	1	5.53	-61.35
12/23/97	26462.21	24038.46	7308.79	0.041	0.352	-0.010	-0.580	0.042	0.679	0.005	0.004	1	14.04	1	6.52	-58.73

MD10 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMENT RATE (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/30/97	26462.23	24038.48	7308.79	0.028	0.375	0.000	-0.580	0.028	0.691	0.002	0.004	1	45.00	1	9.21	-57.13
1/7/98	26462.24	24038.50	7308.85	0.022	0.396	0.060	-0.520	0.064	0.654	0.005	0.005	1	26.57	1	10.18	-52.69
1/14/98	26462.24	24038.50	7308.80	0.000	0.396	-0.050	-0.570	0.050	0.694	0.006	0.003	1	#DIV/0!	1	10.18	-55.20
1/27/98	26462.24	24038.54	7308.83	0.040	0.436	0.030	-0.540	0.050	0.694	0.000	0.004	1	0.00	1	9.25	-51.10
2/3/98	26462.20	24038.42	7308.80	0.126	0.311	-0.030	-0.570	0.130	0.650	0.006	0.003	3	198.43	1	5.53	-61.35
2/19/98	26462.22	24038.47	7308.82	0.054	0.363	0.020	-0.550	0.057	0.658	0.001	0.003	1	21.80	1	7.91	-58.54
3/25/98	26462.21	24038.52	7308.78	0.051	0.412	-0.040	-0.590	0.065	0.720	0.002	0.002	2	101.31	1	5.57	-55.08
4/3/98	26462.22	24038.52	7308.80	0.010	0.413	0.020	-0.570	0.022	0.704	0.002	0.007	1	#DIV/0!	1	6.95	-54.07
4/8/98	26462.19	24038.42	7308.87	0.104	0.311	0.070	-0.500	0.126	0.589	0.023	0.008	3	196.70	1	3.69	-58.15
4/15/98	26462.24	24038.54	7308.83	0.130	0.436	-0.040	-0.540	0.136	0.694	0.015	0.009	1	22.62	1	9.25	-51.10
4/22/98	26462.20	24038.47	7308.73	0.081	0.361	-0.100	-0.640	0.128	0.735	0.006	0.009	3	209.74	1	4.76	-60.56
4/29/98	26462.21	24038.52	7308.76	0.051	0.412	0.030	-0.610	0.059	0.736	0.000	0.009	1	11.31	1	5.57	-55.97
5/7/98	26462.19	24038.51	7308.75	0.022	0.400	-0.010	-0.620	0.024	0.738	0.000	0.011	3	243.43	1	2.86	-57.14
5/13/98	26462.21	24038.40	7308.91	0.112	0.293	0.160	-0.460	0.195	0.545	0.032	0.013	4	280.30	1	7.85	-57.53
5/21/98	26462.18	24038.49	7308.73	0.095	0.380	-0.180	-0.640	0.203	0.744	0.025	0.012	2	108.43	1	1.51	-59.29
5/28/98	26462.21	24038.53	7308.75	0.050	0.422	0.020	-0.620	0.054	0.750	0.001	0.013	1	36.87	1	5.44	-55.77
6/3/98	26462.22	24038.56	7308.71	0.032	0.453	-0.040	-0.660	0.051	0.800	0.008	0.015	1	18.43	1	6.34	-55.55
6/10/98	26462.19	24038.51	7308.75	0.058	0.400	0.040	-0.620	0.071	0.738	0.009	0.010	3	210.96	1	2.86	-57.14
6/17/98	26462.22	24038.56	7308.71	0.058	0.453	-0.040	-0.660	0.071	0.800	0.009	0.008	1	30.96	1	6.34	-55.55
6/24/98	26462.20	24038.51	7308.77	0.054	0.401	0.060	-0.600	0.081	0.722	0.011	0.008	3	201.80	1	4.29	-56.24
7/1/98	26462.21	24038.54	7308.75	0.032	0.432	-0.020	-0.620	0.037	0.756	0.005	0.007	1	18.43	1	5.31	-55.14
7/8/98	26462.21	24038.53	7308.75	0.010	0.422	0.000	-0.620	0.010	0.750	0.001	0.006	4	270.00	1	5.44	-55.77
7/15/98	26462.21	24038.53	7308.77	0.000	0.422	0.020	-0.600	0.020	0.733	0.002	0.004	1	#DIV/0!	1	5.44	-54.89
7/22/98	26462.22	24038.49	7308.75	0.041	0.383	-0.020	-0.620	0.046	0.729	0.001	0.002	4	284.04	1	7.50	-58.28
7/29/98	26462.23	24038.50	7308.73	0.014	0.395	-0.020	-0.640	0.024	0.752	0.003	0.002	1	45.00	1	8.75	-58.34
8/11/98	26462.21	24038.53	7308.74	0.036	0.422	0.010	-0.630	0.037	0.758	0.000	0.001	2	123.69	1	5.44	-56.19
8/19/98	26462.22	24038.52	7308.74	0.014	0.413	0.000	-0.630	0.014	0.753	0.001	0.001	4	315.00	1	6.95	-56.75
8/31/98	26462.21	24038.52	7308.75	0.010	0.412	0.010	-0.620	0.014	0.744	0.001	0.005	2	#DIV/0!	1	5.57	-56.40
9/11/98	26462.21	24038.39	7308.93	0.130	0.283	0.180	-0.440	0.222	0.523	0.020	0.016	4	270.00	1	8.13	-57.27
9/16/98	26462.21	24038.55	7308.69	0.160	0.442	-0.240	-0.680	0.288	0.811	0.058	0.017	1	0.00	1	5.19	-56.99
9/22/98	26462.21	24038.53	7308.71	0.020	0.422	0.020	-0.660	0.028	0.783	0.005	0.017	4	270.00	1	5.44	-57.41
9/30/98	26462.22	24038.55	7308.75	0.022	0.443	0.040	-0.620	0.046	0.762	0.003	0.021	1	26.57	1	6.48	-54.46
10/7/98	26462.22	24038.56	7308.7	0.010	0.453	-0.050	-0.670	0.051	0.809	0.007	0.018	1	0.00	1	6.34	-55.95
3/3/99	26462.23	24038.59	7308.7	0.032	0.484	0.000	-0.670	0.032	0.826	0.000	0.004	1	18.43	1	7.13	-54.17
5/27/99	26462.18	24038.56	7308.64	0.058	0.450	-0.060	-0.730	0.084	0.858	0.000	0.002	3	239.04	1	1.27	-58.34
7/23/99	26462.21	24038.58	7308.67	0.036	0.472	0.030	-0.700	0.047	0.844	0.000	0.002	1	56.31	1	4.86	-56.03

MD11 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	INVERSE VELOCITY (days/ft)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26235.66	24240.02	7312.09														
1/11/96	26235.68	24240.01	7312.07	0.022	0.022	-0.020	-0.020	0.030	0.030	0.004		266.67	4	333.43	4	333.43	
2/8/96	26235.69	24240.06	7312.06	0.051	0.050	-0.010	-0.030	0.052	0.058	0.001		989.07	1	11.31	1	36.87	-30.96
2/15/96	26235.69	24240.02	7312.03	0.040	0.030	-0.030	-0.060	0.050	0.067	0.001		797.95	4	270.00	1	#DIV/0!	-63.43
2/22/96	26235.69	24240.02	7312.03	0.000	0.030	0.000	-0.060	0.000	0.067	0.000	0.003	#DIV/0!	1	#DIV/0!	1	#DIV/0!	-63.43
2/29/96	26235.71	24240.05	7312.00	0.036	0.058	-0.030	-0.090	0.047	0.107	0.006	0.003	174.32	1	33.69	1	59.04	-57.06
3/7/96	26235.69	24240.02	7312.03	0.036	0.030	0.030	-0.060	0.047	0.067	0.006	0.003	174.32	3	213.69	1	#DIV/0!	-63.43
3/14/96	26235.71	24240.09	7312.03	0.073	0.086	0.000	-0.060	0.073	0.105	0.005	0.003		1	15.95	1	35.54	-34.90
3/22/96	26235.69	24240.09	7312.02	0.020	0.076	-0.010	-0.070	0.022	0.103	0.000	0.003	5555.25	2	#DIV/0!	1	23.20	-42.59
3/28/96	26235.71	24240.08	7312.02	0.022	0.078	0.000	-0.070	0.022	0.105	0.000	0.002	4166.43	4	333.43	1	39.81	-41.87
4/4/96	26235.71	24240.05	7312.01	0.030	0.058	-0.010	-0.080	0.032	0.099	0.001	0.002	1189.28	4	270.00	1	59.04	-53.91
4/18/96	26235.73	24240.11	7312.02	0.063	0.114	0.010	-0.070	0.064	0.134	0.002	0.001	402.35	1	18.43	1	37.87	-31.55
4/25/96	26235.69	24240.07	7311.98	0.057	0.058	-0.040	-0.110	0.069	0.124	0.001	0.002		3	225.00	1	30.96	-62.07
5/2/96	26235.70	24240.07	7311.97	0.010	0.064	-0.010	-0.120	0.014	0.136	0.002	0.002	607.87	1	#DIV/0!	1	38.66	-61.92
5/9/96	26235.70	24240.07	7311.99	0.000	0.064	0.020	-0.100	0.020	0.119	0.002	0.002	405.30	1	#DIV/0!	1	38.66	-57.37
5/31/96	26235.70	24240.08	7311.94	0.010	0.072	-0.050	-0.150	0.051	0.166	0.002	0.002	461.32	1	0.00	1	33.69	-64.32
6/5/96	26235.70	24240.11	7311.93	0.030	0.098	-0.010	-0.160	0.032	0.188	0.004	0.003	233.10	1	0.00	1	23.96	-58.39
6/10/96	26235.70	24240.11	7311.93	0.000	0.098	0.000	-0.160	0.000	0.188	0.000	0.004	#DIV/0!	1	#DIV/0!	1	23.96	-58.39
6/13/96	26235.72	24240.09	7311.95	0.028	0.092	0.020	-0.140	0.035	0.168	0.007	0.004	148.13	4	315.00	1	40.60	-56.63
7/11/96	26235.69	24240.08	7311.95	0.032	0.067	0.000	-0.140	0.032	0.155	0.000	0.004	2260.11	3	251.57	1	26.57	-64.40
7/18/96	26235.71	24240.10	7311.90	0.028	0.094	-0.050	-0.190	0.057	0.212	0.008	0.003	123.04	1	45.00	1	32.01	-63.59
7/25/96	26235.70	24240.10	7311.93	0.010	0.089	0.030	-0.160	0.032	0.183	0.004	0.004	242.81	2	#DIV/0!	1	26.57	-60.79
8/16/96	26235.68	24240.05	7311.87	0.054	0.036	-0.060	-0.220	0.081	0.223	0.002	0.003	555.11	3	201.80	1	33.69	-80.69
9/12/96	26235.74	24240.09	7311.80	0.072	0.106	-0.070	-0.290	0.100	0.309	0.003	0.003		1	56.31	1	46.81	-69.87
9/26/96	26235.75	24240.11	7311.80	0.022	0.127	0.000	-0.290	0.022	0.317	0.001	0.003	1787.34	1	26.57	1	45.00	-66.30
10/2/96	26235.74	24240.12	7311.79	0.014	0.128	-0.010	-0.300	0.017	0.326	0.002	0.002	632.35	2	135.00	1	38.66	-66.88
10/10/96	26235.72	24240.13	7311.75	0.022	0.125	-0.040	-0.340	0.046	0.362	0.005	0.002	221.22	2	153.43	1	28.61	-69.77
10/24/96	26235.73	24240.11	7311.71	0.022	0.114	-0.040	-0.380	0.046	0.397	0.002	0.002	407.17	4	296.57	1	37.87	-73.30
11/18/96	26235.78	24240.16	7311.70	0.071	0.184	-0.010	-0.390	0.071	0.431	0.001	0.002	721.37	1	45.00	1	40.60	-64.70
5/16/97	26235.81	24240.22	7311.51	0.067	0.250	-0.190	-0.580	0.201	0.632	0.001	0.002		1	26.57	1	36.87	-66.68
5/22/97	26235.84	24240.26	7311.54	0.050	0.300	0.030	-0.550	0.058	0.626	0.001	0.002		1	36.87	1	36.87	-61.39
6/4/97	26235.82	24240.22	7311.49	0.045	0.256	-0.050	-0.600	0.067	0.652	0.002	0.002	502.28	3	206.57	1	38.66	-66.88
6/11/97	26235.84	24240.26	7311.52	0.045	0.300	0.030	-0.570	0.054	0.644	0.001	0.002	848.18	1	26.57	1	36.87	-62.24
6/18/97	26235.82	24240.25	7311.48	0.022	0.280	-0.040	-0.610	0.046	0.671	0.004	0.002	257.92	3	243.43	1	34.82	-65.33
6/25/97	26235.83	24240.24	7311.47	0.014	0.278	-0.010	-0.620	0.017	0.679	0.001	0.002	851.83	4	315.00	1	37.69	-65.85
7/2/97	26235.83	24240.23	7311.46	0.010	0.270	-0.010	-0.630	0.014	0.685	0.001	0.002	1165.22	4	270.00	1	38.99	-66.79
7/9/97	26235.83	24240.23	7311.47	0.000	0.270	0.010	-0.620	0.010	0.676	0.001	0.002		1	#DIV/0!	1	38.99	-66.45
7/16/97	26235.84	24240.27	7311.48	0.041	0.308	0.010	-0.610	0.042	0.683	0.001	0.001	991.44	1	14.04	1	35.75	-63.21
7/25/97	26235.85	24240.28	7311.45	0.014	0.322	-0.030	-0.640	0.033	0.716	0.004	0.001	272.10	1	45.00	1	36.16	-63.29
7/30/97	26235.84	24240.25	7311.44	0.032	0.292	-0.010	-0.650	0.033	0.713	0.001	0.001	1299.14	3	198.43	1	38.05	-65.80
8/6/97	26235.84	24240.25	7311.44	0.000	0.292	0.000	-0.650	0.000	0.713	0.000	0.001	#DIV/0!	1	#DIV/0!	1	38.05	-65.80
8/20/97	26235.83	24240.26	7311.44	0.010	0.286	0.000	-0.650	0.010	0.710	0.000	0.001	5690.97	2	#DIV/0!	1	36.47	-66.25
8/27/97	26235.83	24240.25	7311.44	0.000	0.286	0.000	-0.650	0.000	0.710	0.000	0.001	#DIV/0!	1	#DIV/0!	1	36.47	-66.25
9/2/97	26235.86	24240.29	7311.44	0.050	0.336	0.000	-0.650	0.050	0.732	0.004	0.002		1	36.87	1	36.53	-62.66
9/10/97	26235.83	24240.25	7311.42	0.050	0.286	-0.020	-0.670	0.054	0.728	0.000	0.003	2485.45	3	216.87	1	36.47	-66.88
9/25/97	26235.84	24240.26	7311.41	0.014	0.300	-0.010	-0.680	0.017	0.743	0.001	0.003		1	45.00	1	36.87	-66.19
10/1/97	26235.83	24240.29	7311.36	0.032	0.319	-0.050	-0.730	0.059	0.797	0.009	0.004	112.27	2	108.43	1	32.20	-66.39
10/8/97	26235.85	24240.27	7311.39	0.028	0.314	0.030	-0.700	0.041	0.767	0.004	0.003		4	315.00	1	37.23	-65.84
10/16/97	26235.85	24240.28	7311.39	0.010	0.322	0.000	-0.700	0.010	0.771	0.000	0.003		1	0.00	1	36.16	-65.30
10/22/97	26235.86	24240.29	7311.38	0.014	0.336	-0.010	-0.710	0.017	0.785	0.002	0.004		1	45.00	1	36.53	-64.67
10/29/97	26235.84	24240.26	7311.39	0.036	0.300	0.010	-0.700	0.037	0.762	0.003	0.003		3	213.69	1	36.87	-66.80
11/5/97	26235.85	24240.26	7311.37	0.010	0.306	-0.020	-0.720	0.022	0.782	0.003	0.002		1	#DIV/0!	1	38.37	-66.97
11/12/97	26235.84	24240.26	7311.38	0.010	0.300	0.010	-0.710	0.014	0.771	0.002	0.003		2	#DIV/0!	1	36.87	-67.09
11/19/97	26235.86	24240.30	7311.37	0.045	0.344	-0.010	-0.720	0.046	0.798	0.004	0.003		1	26.57	1	35.54	-64.46
11/26/97	26235.86	24240.29	7311.39	0.010	0.336	0.020	-0.700	0.022	0.776	0.003	0.003		4	270.00	1	36.53	-64.36
12/3/97	26235.88	24240.30	7311.41	0.022	0.356	0.020	-0.680	0.030	0.768	0.001	0.003		1	63.43	1	38.16	-62.36

MD11 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	INVERSE VELOCITY (days/ft)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/10/97	26235.89	24240.31	7311.37	0.014	0.370	-0.040	-0.720	0.042	0.810	0.006	0.003		1	45.00	1	38.42	-62.79
12/17/97	26235.85	24240.27	7311.36	0.057	0.314	-0.010	-0.730	0.057	0.795	0.002	0.003		3	225.00	1	37.23	-66.73
12/23/97	26235.86	24240.28	7311.35	0.014	0.328	-0.010	-0.740	0.017	0.809	0.002	0.002		1	45.00	1	37.57	-66.09
12/30/97	26235.87	24240.30	7311.36	0.022	0.350	0.010	-0.730	0.024	0.810	0.000	0.002		1	26.57	1	36.87	-64.38
1/7/98	26235.88	24240.31	7311.37	0.014	0.364	0.010	-0.720	0.017	0.807	0.000	0.001		1	45.00	1	37.18	-63.18
1/14/98	26235.88	24240.31	7311.37	0.000	0.364	0.000	-0.720	0.000	0.807	0.000	0.001		1	#DIV/0!	1	37.18	-63.18
1/27/98	26235.87	24240.33	7311.34	0.022	0.374	-0.030	-0.750	0.037	0.838	0.002	0.002		2	116.57	1	34.11	-63.47
2/3/98	26235.85	24240.27	7311.36	0.063	0.314	0.020	-0.730	0.066	0.795	0.006	0.002		3	198.43	1	37.23	-66.73
2/19/98	26235.88	24240.30	7311.41	0.042	0.356	0.050	-0.680	0.066	0.768	0.002	0.003		1	45.00	1	38.16	-62.36
3/25/98	26235.88	24240.33	7311.32	0.030	0.380	-0.090	-0.770	0.095	0.859	0.003	0.003		1	0.00	1	35.36	-63.73
4/3/98	26235.88	24240.32	7311.33	0.010	0.372	0.010	-0.760	0.014	0.846	0.001	0.008		4	270.00	1	36.25	-63.92
4/8/98	26235.84	24240.25	7311.44	0.081	0.292	0.110	-0.650	0.136	0.713	0.027	0.010		3	209.74	1	38.05	-65.80
4/15/98	26235.87	24240.33	7311.34	0.085	0.374	-0.100	-0.750	0.132	0.838	0.018	0.011		1	20.56	1	34.11	-63.47
4/22/98	26235.86	24240.31	7311.30	0.022	0.352	-0.040	-0.790	0.046	0.865	0.004	0.011		3	206.57	1	34.59	-65.97
4/29/98	26235.88	24240.32	7311.26	0.022	0.372	-0.040	-0.830	0.046	0.910	0.006	0.012		1	63.43	1	36.25	-65.86
5/7/98	26235.88	24240.32	7311.32	0.000	0.372	0.060	-0.770	0.060	0.855	0.007	0.014		1	#DIV/0!	1	36.25	-64.21
5/13/98	26235.84	24240.26	7311.52	0.072	0.300	0.200	-0.570	0.213	0.644	0.035	0.017		3	213.69	1	36.87	-62.24
5/21/98	26235.85	24240.29	7311.26	0.032	0.330	-0.260	-0.830	0.262	0.893	0.031	0.016		1	18.43	1	35.13	-68.31
5/28/98	26235.88	24240.32	7311.29	0.042	0.372	0.030	-0.800	0.052	0.882	0.002	0.016		1	45.00	1	36.25	-65.06
6/3/98	26235.88	24240.35	7311.26	0.036	0.386	-0.030	-0.830	0.047	0.915	0.006	0.016		2	123.69	1	31.22	-65.07
6/10/98	26235.88	24240.32	7311.32	0.036	0.372	0.060	-0.770	0.070	0.855	0.009	0.011		4	303.69	1	36.25	-64.21
6/17/98	26235.86	24240.35	7311.26	0.036	0.386	-0.060	-0.830	0.070	0.915	0.009	0.005		2	123.69	1	31.22	-65.07
6/24/98	26235.87	24240.32	7311.27	0.032	0.366	0.010	-0.820	0.033	0.898	0.002	0.005		4	288.43	1	34.99	-65.94
7/1/98	26235.89	24240.35	7311.28	0.036	0.402	0.010	-0.810	0.037	0.904	0.001	0.004		1	33.69	1	34.88	-63.59
7/8/98	26235.89	24240.35	7311.28	0.000	0.402	0.000	-0.810	0.000	0.904	0.000	0.003		1	#DIV/0!	1	34.88	-63.59
7/15/98	26235.89	24240.34	7311.30	0.010	0.394	0.020	-0.790	0.022	0.883	0.003	0.001		4	270.00	1	35.71	-63.49
7/22/98	26235.92	24240.33	7311.30	0.032	0.405	0.000	-0.790	0.032	0.888	0.001	0.002		4	341.57	1	39.99	-62.88
7/29/98	26235.91	24240.33	7311.27	0.010	0.398	-0.030	-0.820	0.032	0.912	0.003	0.002		2	#DIV/0!	1	38.88	-64.10
8/11/98	26235.88	24240.34	7311.25	0.032	0.388	-0.020	-0.840	0.037	0.925	0.001	0.002		2	161.57	1	34.51	-65.19
8/19/98	26235.88	24240.34	7311.26	0.000	0.388	0.010	-0.830	0.010	0.916	0.001	0.001		1	#DIV/0!	1	34.51	-64.93
8/31/98	26235.88	24240.33	7311.25	0.010	0.380	-0.010	-0.840	0.014	0.922	0.000	0.007		4	270.00	1	35.36	-65.65
9/11/98	26235.81	24240.22	7311.51	0.130	0.250	0.260	-0.580	0.291	0.632	0.026	0.018		3	212.47	1	36.87	-66.68
9/16/98	26235.90	24240.35	7311.25	0.158	0.408	-0.260	-0.840	0.304	0.934	0.060	0.019		1	34.70	1	36.03	-64.09
9/22/98	26235.90	24240.34	7311.21	0.010	0.400	-0.040	-0.880	0.041	0.967	0.005	0.019		4	270.00	1	36.87	-65.56
9/30/98	26235.91	24240.37	7311.24	0.032	0.430	0.030	-0.850	0.044	0.953	0.002	0.019		1	18.43	1	35.54	-63.16
10/7/98	26235.90	24240.35	7311.21	0.022	0.408	-0.030	-0.880	0.037	0.970	0.002	0.014		3	206.57	1	36.03	-65.12
3/3/99	26235.92	24240.39	7311.17	0.045	0.452	-0.040	-0.920	0.060	1.025	0.000	0.002		1	26.57	1	35.10	-63.82
5/27/99	26235.93	24240.37	7311.14	0.022	0.442	-0.030	-0.950	0.037	1.048	0.000	0.001		4	296.57	1	37.65	-65.05
7/23/99	26235.93	24240.39	7311.15	0.020	0.458	0.010	-0.940	0.022	1.046	0.000	-0.200		1	0.00	1	36.12	-64.02

MD12 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
1/3/96	26007.87	24441.70	7316.05													
1/11/96	26007.88	24441.70	7316.04	0.010	0.010	-0.010	-0.010	0.014	0.014	0.002		1	#DIV/0!	1	#DIV/0!	
2/8/96	26007.89	24441.71	7315.99	0.014	0.022	-0.050	-0.060	0.052	0.064	0.002		1	45.00	1	63.43	-69.56
2/15/96	26007.89	24441.71	7315.99	0.000	0.022	0.000	-0.060	0.000	0.064	0.000		1	#DIV/0!	1	63.43	-69.56
2/22/96	26007.90	24441.70	7315.99	0.014	0.030	0.000	-0.060	0.014	0.067	0.000	0.002	4	315.00	1	#DIV/0!	-63.43
2/29/96	26007.95	24441.71	7315.99	0.051	0.081	0.000	-0.060	0.051	0.100	0.005	0.002	1	78.69	1	82.87	-36.66
3/7/96	26007.93	24441.79	7315.98	0.082	0.108	-0.010	-0.070	0.083	0.129	0.004	0.003	2	104.04	1	33.69	-32.91
3/14/96	26007.93	24441.75	7315.97	0.040	0.078	-0.010	-0.080	0.041	0.112	0.002	0.003	4	270.00	1	50.19	-45.69
3/22/96	26007.91	24441.73	7315.98	0.028	0.050	0.010	-0.070	0.030	0.086	0.003	0.003	3	225.00	1	53.13	-54.46
3/28/96	26007.93	24441.73	7315.96	0.020	0.067	-0.020	-0.090	0.028	0.112	0.004	0.003	1	#DIV/0!	1	63.43	-53.30
4/4/96	26007.93	24441.72	7315.98	0.010	0.063	0.020	-0.070	0.022	0.094	0.003	0.003	4	270.00	1	71.57	-47.90
4/18/96	26007.97	24441.73	7315.97	0.041	0.104	-0.010	-0.080	0.042	0.132	0.003	0.002	1	75.96	1	73.30	-37.46
4/25/96	26007.91	24441.75	7315.94	0.063	0.064	-0.030	-0.110	0.070	0.127	0.001	0.002	2	161.57	1	38.66	-59.80
5/2/96	26007.93	24441.72	7315.96	0.036	0.063	0.020	-0.090	0.041	0.110	0.002	0.002	4	303.69	1	71.57	-54.90
5/9/96	26007.92	24441.71	7315.94	0.014	0.051	-0.020	-0.110	0.024	0.121	0.002	0.002	3	225.00	1	78.69	-65.13
5/31/96	26007.94	24441.75	7315.92	0.045	0.086	-0.020	-0.130	0.049	0.156	0.002	0.002	1	26.57	1	54.46	-56.51
6/10/96	26007.93	24441.72	7315.93	0.032	0.063	0.010	-0.120	0.033	0.136	0.002	0.002	3	198.43	1	71.57	-62.21
7/11/96	26007.94	24441.73	7315.93	0.014	0.076	0.000	-0.120	0.014	0.142	0.000	0.003	1	45.00	1	66.80	-57.60
7/18/96	26007.96	24441.77	7315.88	0.045	0.114	-0.050	-0.170	0.067	0.205	0.009	0.003	1	26.57	1	52.13	-56.15
7/25/96	26007.96	24441.77	7315.90	0.000	0.114	0.020	-0.150	0.020	0.188	0.002	0.003	1	#DIV/0!	1	52.13	-52.76
9/12/96	26008.02	24441.77	7315.79	0.060	0.166	-0.110	-0.260	0.125	0.308	0.002	0.004	1	#DIV/0!	1	64.98	-57.52
9/26/96	26008.04	24441.77	7315.76	0.020	0.184	-0.030	-0.290	0.036	0.343	0.003	0.004	1	#DIV/0!	1	67.62	-57.63
10/2/96	26008.03	24441.78	7315.79	0.014	0.179	0.030	-0.260	0.033	0.316	0.005	0.003	2	135.00	1	63.43	-55.47
10/10/96	26008.03	24441.79	7315.76	0.010	0.184	-0.030	-0.290	0.032	0.343	0.003	0.003	1	0.00	1	60.64	-57.67
10/24/96	26008.04	24441.79	7315.72	0.010	0.192	-0.040	-0.330	0.041	0.382	0.003	0.003	1	#DIV/0!	1	62.10	-59.76
11/18/96	26008.07	24441.80	7315.71	0.032	0.224	-0.010	-0.340	0.033	0.407	0.001	0.003	1	71.57	1	63.43	-56.67
5/16/97	26008.14	24441.83	7315.54	0.076	0.300	-0.170	-0.510	0.186	0.592	0.001	0.002	1	66.80	1	64.29	-59.56
5/22/97	26008.16	24441.83	7315.58	0.020	0.318	0.040	-0.470	0.045	0.567	0.004	0.002	1	#DIV/0!	1	65.85	-55.93
6/4/97	26008.15	24441.82	7315.54	0.014	0.305	-0.040	-0.510	0.042	0.594	0.002	0.002	3	225.00	1	66.80	-59.15
6/11/97	26008.15	24441.84	7315.56	0.020	0.313	0.020	-0.490	0.028	0.581	0.002	0.002	1	0.00	1	63.43	-57.43
6/18/97	26008.17	24441.85	7315.55	0.022	0.335	-0.010	-0.500	0.024	0.602	0.003	0.002	1	63.43	1	63.43	-56.15
6/25/97	26008.15	24441.84	7315.55	0.022	0.313	0.000	-0.500	0.022	0.590	0.002	0.002	3	243.43	1	63.43	-57.95
7/2/97	26008.14	24441.80	7315.52	0.041	0.288	-0.030	-0.530	0.051	0.603	0.002	0.002	3	194.04	1	69.68	-61.49
7/9/97	26008.14	24441.80	7315.53	0.000	0.288	0.010	-0.520	0.010	0.594	0.001	0.002	1	#DIV/0!	1	69.68	-61.03
7/16/97	26008.14	24441.83	7315.52	0.030	0.300	-0.010	-0.530	0.032	0.609	0.002	0.002	1	0.00	1	64.29	-60.52
7/25/97	26008.19	24441.81	7315.51	0.054	0.338	-0.010	-0.540	0.055	0.637	0.003	#DIV/0!	4	338.20	1	71.03	-57.93
7/30/97	26008.18	24441.81	7315.52	0.010	0.329	0.010	-0.530	0.014	0.624	0.003	#DIV/0!	2	#DIV/0!	1	70.46	-58.17
8/6/97	26008.18	24441.80	7315.51	0.010	0.326	-0.010	-0.540	0.014	0.631	0.001	#DIV/0!	4	270.00	1	72.12	-58.90
8/6/97	26008.18	24441.81	7315.50	0.010	0.329	-0.010	-0.550	0.014	0.641	#DIV/0!	#DIV/0!	1	0.00	1	70.46	-59.12
8/20/97	26008.17	24441.82	7315.52	0.014	0.323	0.020	-0.530	0.024	0.621	0.001	#DIV/0!	2	135.00	1	68.20	-58.63
8/27/97	26008.17	24441.81	7315.52	0.010	0.320	0.000	-0.530	0.010	0.619	0.000	#DIV/0!	4	270.00	1	69.86	-58.91
9/2/97	26008.17	24441.83	7315.51	0.020	0.327	-0.010	-0.540	0.022	0.631	0.002	#DIV/0!	1	0.00	1	66.57	-58.81
9/10/97	26008.16	24441.84	7315.49	0.014	0.322	-0.020	-0.560	0.024	0.646	0.002	0.002	2	135.00	1	64.23	-60.10
9/25/97	26008.16	24441.83	7315.49	0.010	0.318	0.000	-0.560	0.010	0.644	0.000	0.002	4	270.00	1	65.85	-60.42
10/1/97	26008.17	24441.83	7315.47	0.010	0.327	-0.020	-0.580	0.022	0.666	0.004	0.002	1	#DIV/0!	1	66.57	-60.59
10/8/97	26008.19	24441.85	7315.47	0.028	0.353	0.000	-0.580	0.028	0.679	0.002	0.002	1	45.00	1	64.89	-58.64
10/16/97	26008.18	24441.83	7315.47	0.022	0.336	0.000	-0.580	0.022	0.670	0.001	0.002	3	206.57	1	67.25	-59.90
10/22/97	26008.19	24441.84	7315.47	0.014	0.349	0.000	-0.580	0.014	0.677	0.001	0.002	1	45.00	1	66.37	-58.94
10/29/97	26008.19	24441.82	7315.48	0.020	0.342	0.010	-0.570	0.022	0.665	0.002	0.001	4	270.00	1	69.44	-59.05
11/5/97	26008.19	24441.82	7315.47	0.000	0.342	-0.010	-0.580	0.010	0.673	0.001	0.001	1	#DIV/0!	1	69.44	-59.49
11/12/97	26008.18	24441.82	7315.47	0.010	0.332	0.000	-0.580	0.010	0.669	0.001	0.001	2	#DIV/0!	1	68.84	-60.18
11/19/97	26008.20	24441.84	7315.48	0.028	0.358	0.010	-0.570	0.030	0.673	0.001	0.001	1	45.00	1	67.01	-57.83
11/26/97	26008.19	24441.84	7315.48	0.010	0.349	0.000	-0.570	0.010	0.669	0.001	0.001	2	#DIV/0!	1	66.37	-58.50
12/3/97	26008.20	24441.84	7315.48	0.010	0.358	0.000	-0.570	0.010	0.673	0.001	0.001	1	#DIV/0!	1	67.01	-57.83
12/10/97	26008.21	24441.85	7315.46	0.014	0.372	-0.020	-0.590	0.024	0.697	0.003	0.001	1	45.00	1	66.19	-57.79

MD12 TIME	NORTHING	EASTING	ELEV.	INCREMENTAL HORIZONTAL DISTANCE (ft)	CUMULATIVE HORIZONTAL DISTANCE (ft)	INCREMENTAL VERTICAL DISTANCE (ft)	CUMULATIVE VERTICAL DISTANCE (ft)	INCREMENTAL TOTAL DISTANCE (ft)	CUMULATIVE TOTAL DISTANCE (ft)	SLOPE DISPLACEMEN PER DAY (ft/day)	SLOPE DISPLACEMENT RATE MOVING AVG (ft/day)	SECTOR (INCREM)	INCREMENTAL DISPLACEMENT AZIMUTH	SECTOR (CUMULATIVE)	CUMULATIVE DISPLACEMENT AZIMUTH	CUMULATIVE DIP ANGLE
12/17/97	26008.20	24441.83	7315.44	0.022	0.355	-0.020	-0.610	0.030	0.706	0.001	0.001	3	206.57	1	68.50	-59.82
12/23/97	26008.20	24441.82	7315.44	0.010	0.351	0.000	-0.610	0.010	0.704	0.000	0.001	4	270.00	1	70.02	-60.07
12/30/97	26008.21	24441.85	7315.45	0.032	0.372	0.010	-0.600	0.033	0.706	0.000	0.001	1	18.43	1	66.19	-58.23
1/7/98	26008.21	24441.85	7315.46	0.000	0.372	0.010	-0.590	0.010	0.697	0.001	0.001	1	#DIV/0!	1	66.19	-57.79
1/14/98	26008.22	24441.86	7315.45	0.014	0.385	-0.010	-0.600	0.017	0.713	0.002	0.001	1	45.00	1	65.43	-57.32
1/27/98	26008.22	24441.86	7315.45	0.000	0.385	0.000	-0.600	0.000	0.713	0.000	0.001	1	#DIV/0!	1	65.43	-57.32
2/3/98	26008.20	24441.83	7315.44	0.036	0.355	-0.010	-0.610	0.037	0.706	0.001	0.001	3	213.69	1	68.50	-59.82
2/19/98	26008.20	24441.84	7315.48	0.010	0.358	0.040	-0.570	0.041	0.673	0.002	0.001	1	0.00	1	67.01	-57.83
3/25/98	26008.23	24441.86	7315.44	0.036	0.394	-0.040	-0.610	0.054	0.726	0.002	0.003	1	56.31	1	66.04	-57.14
4/3/98	26008.42	24441.81	7315.43	0.196	0.561	-0.010	-0.620	0.197	0.836	0.012	0.012	4	345.26	1	78.69	-47.87
4/8/98	26008.18	24441.81	7315.52	0.240	0.329	0.090	-0.530	0.256	0.624	0.042	0.014	2	#DIV/0!	1	70.46	-58.17
4/15/98	26008.22	24441.86	7315.45	0.064	0.385	-0.070	-0.600	0.095	0.713	0.013	0.014	1	38.66	1	65.43	-57.32
4/22/98	26008.22	24441.83	7315.42	0.030	0.373	-0.030	-0.630	0.042	0.732	0.003	0.015	4	270.00	1	69.62	-59.35
4/29/98	26008.24	24441.84	7315.41	0.022	0.396	-0.010	-0.640	0.024	0.752	0.003	0.013	1	63.43	1	69.27	-58.28
5/7/98	26008.23	24441.84	7315.43	0.010	0.386	0.020	-0.620	0.022	0.730	0.003	0.009	2	#DIV/0!	1	68.75	-58.08
5/13/98	26008.15	24441.84	7315.56	0.080	0.313	0.130	-0.490	0.153	0.581	0.025	0.011	2	#DIV/0!	1	63.43	-57.43
5/21/98	26008.22	24441.84	7315.39	0.070	0.377	-0.170	-0.660	0.184	0.760	0.022	0.011	1	#DIV/0!	1	68.20	-60.27
5/26/98	26008.23	24441.84	7315.39	0.010	0.386	0.000	-0.660	0.010	0.765	0.001	0.010	1	#DIV/0!	1	68.75	-59.66
6/3/98	26008.22	24441.86	7315.38	0.022	0.385	-0.010	-0.670	0.024	0.773	0.001	0.011	2	116.57	1	65.43	-60.13
6/10/98	26008.23	24441.84	7315.43	0.022	0.386	0.050	-0.620	0.055	0.730	0.006	0.007	4	296.57	1	68.75	-58.08
6/17/98	26008.22	24441.86	7315.38	0.022	0.385	-0.050	-0.670	0.055	0.773	0.006	0.003	2	116.57	1	65.43	-60.13
6/24/98	26008.23	24441.85	7315.39	0.014	0.390	0.010	-0.660	0.017	0.767	0.001	0.004	4	315.00	1	67.38	-59.42
7/1/98	26008.34	24441.87	7315.40	0.112	0.500	0.010	-0.650	0.112	0.820	0.008	0.006	1	79.70	1	70.11	-52.44
7/8/98	26008.24	24441.87	7315.40	0.100	0.407	0.000	-0.650	0.100	0.767	0.008	0.005	2	#DIV/0!	1	65.32	-57.94
7/15/98	26008.23	24441.88	7315.44	0.014	0.402	0.040	-0.610	0.042	0.731	0.005	0.005	2	135.00	1	63.43	-56.58
7/22/98	26008.25	24441.86	7315.41	0.028	0.412	-0.030	-0.640	0.041	0.761	0.004	0.006	4	315.00	1	67.17	-57.21
7/29/98	26008.29	24441.86	7315.39	0.040	0.449	-0.020	-0.660	0.045	0.798	0.005	0.005	1	#DIV/0!	1	69.15	-55.75
8/11/98	26008.25	24441.84	7315.36	0.045	0.405	-0.030	-0.690	0.054	0.800	0.000	0.003	3	243.43	1	69.78	-59.59
8/19/98	26008.25	24441.85	7315.37	0.010	0.409	0.010	-0.680	0.014	0.793	0.001	0.003	1	0.00	1	68.46	-59.00
8/31/98	26008.25	24441.84	7315.40	0.010	0.405	0.030	-0.650	0.032	0.766	0.002	0.005	4	270.00	1	69.78	-58.08
9/11/98	26008.14	24441.83	7315.54	0.110	0.300	0.140	-0.510	0.178	0.592	0.016	0.012	3	264.81	1	64.29	-59.56
9/16/98	26008.25	24441.85	7315.36	0.112	0.409	-0.180	-0.690	0.212	0.802	0.042	0.013	1	79.70	1	68.46	-59.37
9/22/98	26008.26	24441.85	7315.35	0.010	0.418	-0.010	-0.700	0.014	0.815	0.002	0.013	1	#DIV/0!	1	68.96	-59.17
9/30/98	26008.26	24441.87	7315.38	0.020	0.425	0.030	-0.670	0.036	0.794	0.003	0.016	1	0.00	1	66.45	-57.59
10/7/98	26008.26	24441.85	7315.35	0.020	0.418	-0.030	-0.700	0.036	0.815	0.003	0.013	4	270.00	1	68.96	-59.17
3/3/99	26008.28	24441.85	7315.32	0.020	0.437	-0.030	-0.730	0.036	0.851	0.000	0.002	1	#DIV/0!	1	69.90	-59.12
5/27/99	26008.29	24441.85	7315.3	0.010	0.446	-0.020	-0.750	0.022	0.873	0.000	0.002	1	#DIV/0!	1	70.35	-59.26
7/23/99	26008.3	24441.85	7315.29	0.010	0.455	-0.010	-0.760	0.014	0.886	0.000	0.001	1	#DIV/0!	1	70.77	-59.07

APPENDIX L

METHOD OF CONSTRUCTION BY OBSERVATION TECHNICAL DISCUSSIONS

THE OBSERVATIONAL METHOD IN ENVIRONMENTAL GEOTECHNICS

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Abstract

The observational method is an important aspect of risk management in geotechnical engineering. Recent considerations in its evolution are reviewed. It is noted that there are some circumstances in environmental geotechnics that are ideal for the application of the observational method. However there are others in which it is seriously constrained. Constraints arise from: 1) the regulatory environment, 2) the nature of decision-making related to environmental matters and, 3) the issue of longevity. These matters are amplified by discussions on the role of the observational method in mine waste management, in ground remediation, in landfill design, and in nuclear waste management.

Introduction

The overriding requirement in engineering is for the constructed (manufactured) entity or process to fulfill its intended function. That it should do so safely, economically and in an environmentally acceptable manner are also usually desirable, but not always essential, objectives. That is, the dam must store water in a safe, economical and environmentally approved manner; the foundation must support the load in a safe and economic manner; and the landfill must function in a contained manner while still being economical and in compliance with environmental regulations.

The geotechnical engineer has a long tradition of success in meeting these requirements under conditions that differ from many other types of technological endeavour. The natural materials that the geotechnical engineer must deal with are complex and do not afford the luxury of replication. Construction processes, either in-situ or associated with the construction operation itself, are performed under circumstances very different from the controlled environment of a manufacturing plant. As a result, uncertainty is a perpetual component of geotechnical design and construction. In view of the successes in the past of geotechnical design practice, there is considerable value in understanding how the geotechnical engineer deals with this uncertainty and in evaluating how this methodology might be applied to environmental design problems.

It is rare for the geotechnical engineer to rely on prediction to meet his objectives. In practice, prediction is considered to be a chimera, only worth contemplating under the most idealized circumstances. The practice of the geotechnical engineer is more modest. Risk is managed to overcome the limitations of site characterization, knowledge of material properties, other unknowns and the vagaries of construction practice. Performance is assured through design that is not driven by prediction in any direct manner and this is executed by means of the observational method.

The evolution of the observational method has had a profound influence on the practice of geotechnical engineering. It is not without its pitfalls, as will be noted below, but the observational method is widely recognized as providing a conceptual framework for geotechnical design that differs from other types of engineering design.

Some problems of environmental geotechnics are similar in kind to traditional geotechnical engineering, but many raise new issues. In some instances the observational method provides an excellent framework from which to address these problems. In others, it provides restraints on the practice of the geotechnical engineer in dealing with certain environmental problems.

It is the intent of this paper to summarize the evolution of the observational method, to assess the differences between design issues in environmental geotechnics and more traditional aspects of geotechnical engineering and to underline circumstances not only where the observational method can be applied effectively but also where there are limitations to its application.

Evolution Of The Observational Method

Peck's [22] classical paper summarizes the evolution of the observational method in its restricted geotechnical sense and it is essential to quote his summary of the method.

"In brief, the complete application of the method embodies the following ingredients:

a) Exploration sufficient to establish at least the general nature, pattern and properties of the deposits, but not necessarily in detail.

b) Assessment of the most probable conditions and the most unfavourable conceivable deviations from these conditions. In this assessment geology often plays a major role.

c) Establishment of the design based on a working hypothesis of behaviour anticipated under the most probable conditions.

d) Selection of quantities to be observed as construction proceeds and calculation of their anticipated values on the basis of the working hypothesis.

e) Calculation of values of the same quantities under the most unfavourable conditions compatible with available data concerning the subsurface conditions.

f) Selection in advance of a course of action or modification of design for every foreseeable significant deviation of the observational findings from those predicted on the basis of the working hypothesis.

g) Measurement of quantities to be observed and evaluation of actual conditions.

h) Modification of design to suit actual conditions.

The degree to which all these steps can be followed depends on the nature and complexity of the work. We can readily distinguish between projects, on the one hand, in which events have already set the stage for the observational method as being almost the only hope of success, and those, on the other hand, in which use of the method has been envisioned from the inception of the project. Applications of the first type are much the more familiar."

Peck [22] went on to provide examples of successful application but then drew attention to significant pitfalls such as:

i) Failure to anticipate unfavourable conditions: Potentially the most serious blunder in applying the observational method is the failure to select in advance appropriate courses of action for all foreseeable deviations of the real conditions, as disclosed by the observations, from those assumed in the design.

ii) The dominance on the project exercised by the concern whether or not a single potential problem can be solved.

iii) Choice of significant observations: The selection of proper quantities to observe and measure requires a feel for the significant physical phenomena governing the behaviour of the project during construction and after completion.

iv) Influence of progressive failure: The presence of brittle elements in a resisting mass may, if not appreciated, lead to failure in spite of the use of the observational method.

v) Complications in contractual relations.

One might also note that the observational method is limited when dealing with dynamic loading.

Others have added to our understanding of the concept and its application. In particular D'Appolonia [5] extended it to the operational phase of facilities and processes through his concept of "monitored decisions", see Figure 1. This extension is particularly useful when considering various problems in environmental geotechnics that arise during operational phases and require contingency planning. Muir Wood [20] characterized the observational method as a flexible design philosophy, capable of achieving very substantial benefits, provided that flexible adaptation can be accommodated in both procedural and contractual arrangements. Muir Wood [20] also notes some conflict between the implementation of certain Quality Assurance and Quality Control programs and the need to foster iterations between geotechnical design and construction.

The application of the observational method is enhanced by new developments in instrumentation and data-processing. It is also enhanced by new developments in computer modelling and simulation. Chen, Morgenstern, and Chan [2] have emphasized that the most effective use of finite element modelling and related techniques is in history matching of performance as an adjunct to the

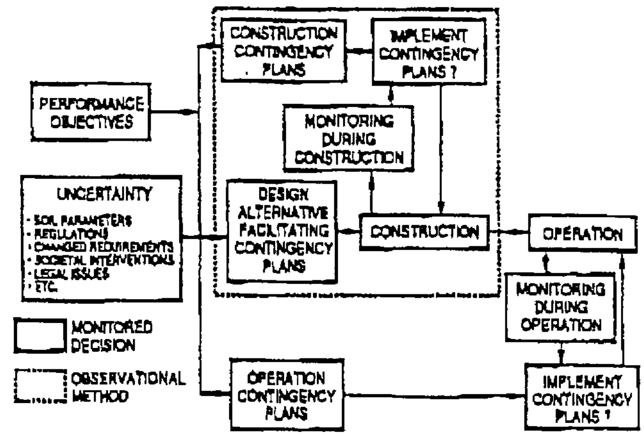

Figure 1. Flow Diagram of the Monitored-Decision Process (D'Appolonia, 1990)

observational method, as opposed to forecasting behaviour during the design phase.

There has been a considerable effort expended in recent years to develop a reliability based design approach that can accommodate different kinds of uncertainty such as uncertainty in the geological model, parameter uncertainty, cost uncertainty and other important considerations. The work of Freeze and his students [7] [13] may be the most ambitious to date. Quantitative case histories based on these methods tend to reaffirm principles of the observational method such as " . . . it was more important to know whether the field value is above or below some threshold value than it is to know its actual numerical value . . ., and . . . indicating the importance of a conceptual understanding of the site geology in estimating prior probabilities . . . ."

There is no fundamental conflict between reliability based design and the observational method, provided that Bayesian statistical updating is used. However there may be a conflict if the decision criteria controlling the design are overly simplistic. As Freeze et al., [7] state, the common risk-cost-benefit approach to design is based on the calculation of the probability of failure, P_f, or the reliability, $(1 - P_f)$. Hashimoto et al. [9] [10] have suggested that reliability does not provide a complete measure of technical performance. They introduce the concept of robustness in engineering design. A design is robust if it has the flexibility to permit adaptation to a wide range of potential conditions at little cost. When there is large uncertainty in future loads (or capacities) robustness is very desirable. There may be economic tradeoffs available between reliability and robustness.

In this terminology, it would appear that the observational method is a method that emphasizes robustness. It will be of interest in the future to see robustness incorporated into engineering design decision analysis.

Issues In Environmental Geotechnics

Morgenstern [18] reviewed the emergence of the field of environmental geotechnics and concluded that it should be primarily identified with the geotechnical aspects of waste management. It is possible to characterize the geotechnically sensitive problems according to the waste stream encountered and for geotechnical purposes it is useful to distinguish the following: 1) municipal waste, 2) industrial waste, 3) agricultural waste, 4) mining waste, and 5) nuclear waste:

1) Municipal waste: Municipal waste may be contained in landfills which are not generally regarded as hazardous. In industrialized countries, landfill siting, design, construction, operation and closure are becoming increasingly complex and costly. Geotechnical engineering has input to many aspects of landfill development and operation.

2) Industrial waste: Many industrial activities result in hazardous waste that has entered the ground. Non-hazardous waste materials, such as coal fly-ash, are also produced by industrial processes. There are geotechnical challenges associated with the increased utilization of such waste. Otherwise storage issues do not differ greatly from those encountered in the disposal of municipal waste.

   Generators of hazardous waste are increasingly under pressure to reduce or eliminate their waste stream. Legislation is aggressive, particularly in the USA, requiring "cradle-to-grave" management and cleanup of past contaminated site. Complex management systems have evolved. The geotechnical engineer makes contributions to many aspects of contaminant control and site remediation.

3) Agricultural waste: Geotechnical aspects of farm waste management have not received as much attention as other waste management issues. Intensive farming can readily result in ground water contamination.

4) Mine waste: Geotechnical engineering has long made contributions to mine waste management. A distinction can be made between dry waste streams and wet waste streams [17]. The design of dry waste dumps and of tailings dams are illustrative of different geotechnical issues arising from these two streams. In some mineral processes, large amounts of water are utilized in separation and large volumes of waste result. Many other geotechnically sensitive issues arise in the mining industry such as mitigation of acid generation, environmentally safe operation of heap leaching and design for reclamation and abandonment.

5) Nuclear waste: Nuclear waste generates different public perceptions than other industrial wastes. In many countries dealing with this issue low and intermediate level reactor wastes are stored in either above ground or in-ground engineered structures. Some of the most costly research and development programs in geotechnical engineering have been mounted to address the issue of long term storage of high level waste. No nation has

yet fully resolved this issue and a variety of repository and containment strategies are under investigation.

Important differences arise in the practice of geotechnical waste management when compared with other areas of geotechnical engineering. For example, undertakings are often highly interdisciplinary and the geotechnical engineer is obliged to extend his scientific and technological range in order to function effectively in the design team. The appropriate technology is also very regional dependent. This is more so than, say, the design of a dam. These and other related factors warrant analysis, but they have little bearing on the application of the observational method. Other issues arise that do and they are the focus of this presentation.

While there are some circumstances in environmental geotechnics such as within the mining industry that are ideal for the application of the observational method, there are others in which it is seriously constrained. Constraints arise from i) the regulatory environment, ii) the nature of decision-making related to environmental matters and iii) the issue of longevity.

Environmental issues are highly regulated. The geotechnical engineer is no stranger to regulations but he has usually had little to no input into the framing of the regulations that circumscribe his environmental design practice. The regulatory structure is most highly developed in the USA and it has emphasized the use of quantitative risk analysis in the decision-making process. For example Wallace and Lincoln [26] summarize this process as implemented by the U.S. Environmental Protection Agency (EPA) in their evaluation of Superfund site remediation. They note that quantitative risk assessments are conducted for each potential remedial alternative to determine whether the remedy can reduce the health and environmental risks to acceptable levels and the subsequent decision with regard to remedial design and actions is driven by this process. This tendency of enforced quantification of what might be unknowable is in conflict with the effective application of the observational method. It promotes the false view that more study will necessarily reduce uncertainty and it encourages a separation between design and construction or implementation. Jasanoff [14] has analyzed the broad implications of this trend in the United States with fascinating conclusions:

"I have suggested that risk assessment in the United States is the product of a political process that combines large policy expectations with little trust in those called upon to formulate specific policy outcomes. Such a system threatens the credibility both of regulators and science as an institution. Pressing the evidence to produce levels of precision that it cannot support augments controversy and may feed the disenchantment with science and the scientific community already endemic in the U.S. political environment".

The observational method with its emphasis on reasonable assurance has much to commend it as an alternate basis for decision making.

The resolution of environmental issues almost always involves decision-making in the public domain. The specific process will vary from jurisdiction to jurisdiction. It may involve formalized quasi-judicial hearings to review an environmental impact statement or it may require more local informal hearings. Increasingly, the geotechnical engineer, together with other technical specialists, will find that he is not trusted. There is a disaffection with specialists on the part of the public. The geotechnical engineer must learn to earn trust on these occasions through his objectivity, the reasonableness of his claims and the ability to translate his engineering into terms and concepts appropriate for decision-making in the public domain. Under these circumstances it is important that the observational method not be construed as trial and error.

There is an understandable desire on the part of the public for waste management and related containment to have negligible impact in perpetuity. This is manifest at its most extreme in public policy related to high level nuclear waste storage. The issue of longevity creates problems for the geotechnical engineer.

It becomes increasingly necessary to understand the physical phenomenon involved in the long term to a high degree and it is necessary to have confidence in the long term behaviour of materials, whether natural or manufactured. However, this may not be enough. The use of the observational method relies on systematic performance monitoring and effecting changes in the light of this monitoring. It should be noted that the consistent application of such measures is limited to about 50-75 years of experience. There is difficulty in claiming that one can rely on such methods for a contaminating life span of hundreds of years, let alone the thousands of years that might be required in the design of nuclear waste repertories. The existence of a stable society is a necessary condition for reliance on the observational method. History suggests that even the required social stability cannot be assumed to exist too far into the future. This creates both an ethical and a technical dilemma for the geotechnical engineer. These issues will be discussed in more detail in the context of the examples of the use of the observational method in environmental applications that follow.

The Observational Method In Mine Waste Management

The mining industry often provides near ideal conditions for the application of the observational method. Excavations or construction of waste management structures proceed in an incremental manner over many years. As a result there is often ample opportunity to observe and modify design or procedures. This concept is entirely consistent with the philosophy of continuous improvement that is characteristic of, at least, the larger mining operations. Moreover the artificial contractual barriers that arise between owners, consultants and contractors and which inhibit making changes can be reduced to a minimum in the mining industry. The successful completion of the Mildred Lake Settling Basin (tailings dam) at the Syncrude Canada Ltd. oil sand mine site, Ft. McMurray, Alberta, Canada provides a vivid example. Details on the geotechnical aspects of oil sand recovery are given by Morgenstern et al. [19].

Approximately 475×10^6 m^3 of sand, 400×10^6 m^3 of sludge and 50×10^6 m^3 of free water will require storage for several decades within this basin. To accommodate these volumes approximately 18 km of dyke ranging from 32 to 90 m in final height have been constructed. At completion, the basin will have a surface area of 17 km^2. It is currently (1994) nearing completion.

The general layout is illustrated in Figure 2. For planning purposes the dyke perimeter has been divided into 700 m long segments which are referred to as cells. The cell locations are also shown in Figure 2.

Figure 3 illustrates a typical design section for the tailings dyke. The compacted shell is constructed by utilizing hydraulic construction techniques employing dozer compaction. During the winter months when this is not feasible, the tailings stream is discharged upstream of the compacted shell to form a beach. The downstream slope angles are largely dictated by the underlying geology and associated shear strength parameters together with pore pressure response. Beneath much of the dyke is found the Cretaceous Clearwater Formation, a highly plastic clay-shale that has been weakened to its residual strength by glacial drag porcesses.

Given the complexity of the foundation and the scale of the project, it was considered at the outset that design and subsequent construction should utilize the observational method. Initial design was based on approximately average properties and instrumentation was installed in different cells. The intensity of instrumentation depended stability. Construction proceeded cautiously. Advanced stress analysis was initiated to study the movement mechanism and this revealed that strain in the toe zone was a key issue. Advances were made in instrumentation for strain in the toe region and the dyke was completed on the basis of strain monitoring. In this way in excess of 40 cm of slip were accommodated in the foundation of the dyke in a safe manner. There was always the additional option of more slope flattening but at substantial cost.

The observational method provided an economical resolution of a difficult geotechnical problem that standard analytical procedures could not encompass. The application of the observation method employed not only flexible planning but also advances in geological understanding, instrumentation and theoretical analysis. The relatively slow rate of construction of the dyke facilitated its application.

The Observational Method In Ground Remediation

One of the most widely used methods for remediation of contaminated groundwater is the pump-and-treat method. Contaminated groundwater is pumped to the surface and contaminants are then removed in an appropriate treatment system so that the water can be discharged or re-injected. There are many problems associated with estimating the cleanup time and hence the cost and efficiency of this technology. Kent and Mann [15] note that there have been very few documented case histories of complete cleanup of a contaminated aquifer. Many recovery operations have been terminated, but most have not recovered all of the contaminant mass. A review of several case histories indicates that removing 10-25 plume volumes may be necessary to reduce contaminants to acceptable levels. Many professionals are beginning to believe that recovery well systems may never reduce concentrations of organic contaminants to background levels.

Many of the technical problems associated with this and other remediation techniques are reasonably well understood and undoubtedly advances in scientific understanding will increase the range of problems that can be addressed adequately. However, it is important to recognize McCarty's [16] caution:

" .... there needs to be a recognition that there are many sites of contamination that, if not entirely beyond our ability for rectification in an environmentally satisfactory way, may at least require many years to remediate, may involve enormous sums of money, and may create other environmental and social problems that may be equal to or greater than that posed by the contamination itself. Because of the great diversity of the problem sites, setting criteria and priorities for cleanup is not a simple task. An easy solution is not likely to be found."

The frustration expressed by all parties involved in the remediation of contaminated soils and ground water is understandable.

This frustration is compounded by the management process in which site remediation studies, design and execution unfold. In a series of penetrating studies Wallace and Lincoln [26], Brown, Lincoln and Wallace [1], and Holm [12] have analyzed the U.S. Environmental Protection Agency (EPA) procedures and find them wanting in their handling of uncertainty. They propose instead a process that by explicitly recognizing uncertainty in a proper application of the observational method offers the opportunity to reduce project time and costs as well as risks.

The current management process for Superfund site remediation is illustrated in Figure 5. It follows a traditional study-design-build approach. A remedial investigation (RI) is initiated which results in a feasibility study (FS) that compares the alternatives for remediation. The client proposes and the EPA selects an alternative (the record of decision, ROD). A consultant designs the remediation (remedial design - RD) and contractors bid on implementation

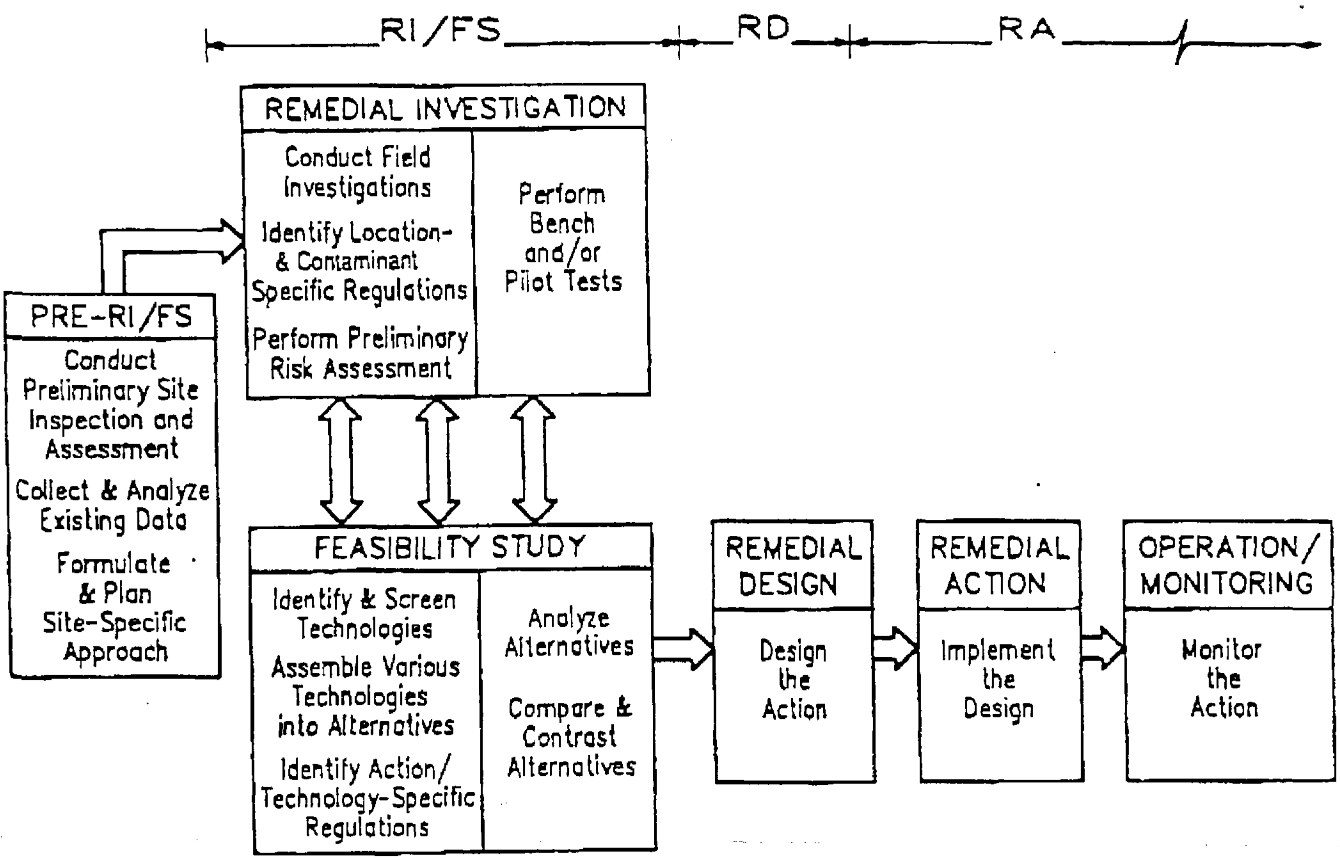

Figure 5. Schematic of the remedial process (Holm, 1993)

(remedial action - RA). Both RD and RA may involve supplemental site investigation. This procedure, common in many types of engineering, emphasizes the reduction of uncertainty early in the life of a project. However, as stressed in the preceding references, this is not an appropriate strategy for coping with the inherent uncertainty of ground remediation.

Often difficulties result in failure to advance in the process due to this uncertainty. There is an implied separation of the decision - making process into specific steps and there may be an inference that the remediation goal is to be reached at completion of implementation. Holm [12] observes that the combined effect may manifest itself as a hesitancy to establish objectives for remediation and an insistence that additional data be gathered often with the mistaken impression that uncertainty will be eliminated.

These authors advocate the incorporation of the observational method into the methodology of waste remediation by requiring the total process to be a continuum. That is, the interpretation of conditions, criteria and performance that are made in the process are working hypotheses. Reassessment continues from pre - RI/FS through implementation. Additional data needs are assessed based on their potential to disprove the working hypotheses. Decisions are finalized only after the remedy is in place and sufficient monitoring has been conducted to confirm performance. This distinction is illustrated in Figure 6.

As summarized by Brown, Lincoln and Wallace [1] the key contributions of the observational method to ground remediation

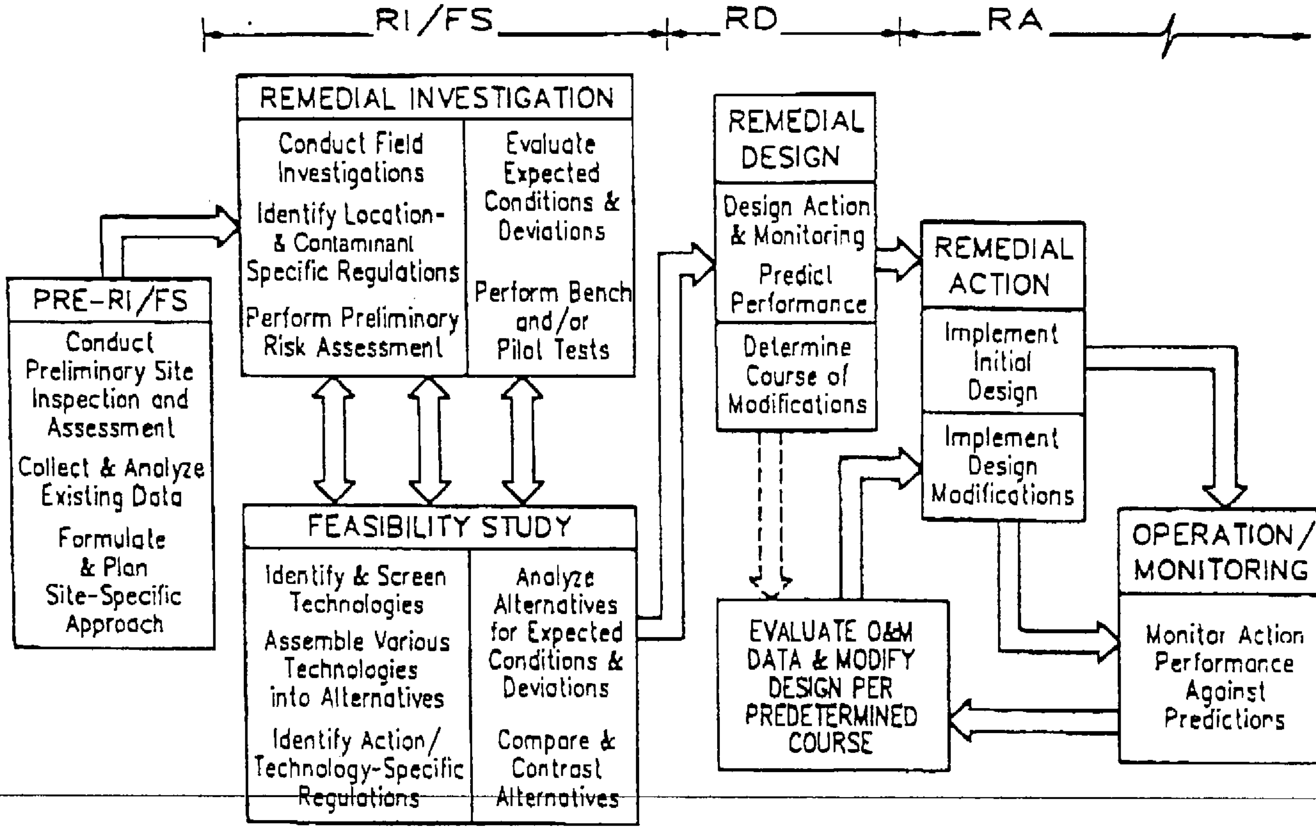

Figure 6. Schematic of the observational method (Holm, 1993)

are:

1. Remedial design based on the most probable site conditions,

2. Identification of reasonable deviations from those conditions,

3. Identification of parameters to observe so as to detect deviations during remediations,

4. Preparation of contingency plans for each deviation.

The observational method offers the potential to reduce time and cost, as well as to decrease the risks associated with remediation. This is becoming recognized with advances in pump-and-treat technology that employ dynamic adaptive well field management techniques [11].

The Observational Method in Landfill Design

The design of landfills has become increasingly complex. In the case of non-hazardous waste landfills, it is common to require a leachate collection and removal system overlying a composite liner composed of a geomembrane and compacted clay liner. For hazardous waste landfills much practice is influenced by EPA requirements of a double liner system with a leachate collection layer located above a primary geomembrane liner and a leak detection and removal system located below the primary liner and above the secondary composite liner. Even more complex systems have been proposed and constructed.

Final covers are also increasingly multi-layer systems designed to control erosion, support vegetation, inhibit infiltration and facilitate gas drainage.

The observational method is often embedded in the monitoring measures and implementation of remedial measures should they become necessary. Say that the operational life of the landfill is 20 years, it would not be difficult for the geotechnical engineer to promise acceptable performance for a 30 year post closure period. There is experience with monitoring engineered structures over this period and concern over fundamental durability of the geosynthetics utilized in landfills is minimal for this duration. However, social fairness in dealing with environmental problems increasingly requires negligible impact over a much longer period; even perpetuity! This taxes reliance on the observational method.

The issue of longevity arises in many ways. In some instances, leachate production and accumulation may be deferred for many decades. In other instances the long term reliability of landfill components may be questioned. This concern might arise from intrinsic degradation of geosynthetic materials themselves or, as is more likely, from practical considerations of clogging of leachate control measures. As emphasized by Rowe [23], there is a moral responsibility to consider the longer term consequences. In some areas there is also a regulatory responsibility to consider environmental protection in perpetuity.

An interesting example of the latter is the Ontario Ministry of the Environment guidelines associated with its Reasonable Use Policy which provides a means of quantifying long term negligible effects in a rational manner. This policy places no time constraint on the period during which the landfill is to have a negligible effect on local reasonable use of groundwater. An unacceptable impact could be expressed in terms of a limiting contamination concentration at the site boundary. As a result it becomes necessary to assess the service life of the facility and compare it with the "contaminating lifespan", which is the period of time during which the landfill will produce contaminants at levels that could have unacceptable impacts if they were discharged to the environment.

The contaminating lifespan will depend on the contaminant transport pathway, the leachate strength, the mass of waste and infiltration through the cover. It is conceivable that the contaminating lifespan, driven by diffusion processes, could be measured in hundreds of years and under these circumstances the geotechnical designer cannot in good conscience rely on the observation method. Rowe [24] has indicated methods for estimating the contaminating lifespan of landfills and he notes the need to monitor leachate levels and concentrations for the entire contaminating lifespan of the landfill. If these levels exceed trigger levels, appropriate leachate control measures would be initiated. In essence, he is advocating allowable contaminating lifespans that can be managed by the observational method, say 50-75 years.

This would be consistent with good geotechnical practice, but would introduce more active landfill control measures than are common today. For example, it would make sense to maximize leachate generation during the active phase of landfill development. While simple in concept, this is not so readily achieved. Crutcher and Mosher [4] have described the moisture addition and leachate recycle program at a large landfill and note problems that arise from interference with the gas collection system, moisture short-circuiting during recycle in the refuse, enhanced gas and odour problems and leachate treatment issues. Other measures that can affect the contaminating lifespan include inward gradient systems during the active operating phase and improving the sorption characteristics of clay barriers [8].

It is important that the geotechnical engineer involved in landfill design recognize the constraints that long contaminating lifespans impose upon the application of the observational method in practice.

The Observational Method In Nuclear Waste Management

The development of a nuclear waste management policy has been both difficult and contentious in many countries. There are a variety of issues involved but the comments here will be restricted to scientific and technological issues. The debates over scientific evidence are most extensive in the USA and this experience will be used to highlight the role of the observational method in developing a nuclear waste management policy.

Controversies over evidence have been particularly important because of the many scientific uncertainties and problems inherent in trying to ensure that nuclear waste in a geological repository will harm neither people nor the environment for the thousands of years that the waste will remain hazardous. Colglazier [3] notes that this requirement of guaranteeing adequate safety over millennia is an unprecedented undertaking for our regulatory and scientific institutions.

There is widespread international agreement that deep geological disposal is the best option for disposing of high-level radioactive waste. While there is no reason to doubt that such a repository could be built, and not withstanding very substantial expenditures to date, a study conducted by the Board on Radioactive Waste Management, U.S. National Research Council [21] concluded that the U.S. Program, as conceived and implemented over the past decade, was unlikely to succeed. They attributed a high degree of inflexibility to the U.S. approach which was not well matched to the technical task. In particular the approach assumed that the properties and future behaviour of a geological repository can be determined and specified with a very high degree of certainty. In reality, they observed, the inherent variability of the geological environment will necessitate frequent changes in the specifications, with resultant delays, frustration and loss of public confidence.

The Board was also concerned that geological models, and indeed scientific knowledge generally, had been inappropriately applied. They noted that computer modelling techniques and geophysical analysis can and should have a key role in the assessment of long-term repository isolation. In the face of public concerns about safety, however, models were being asked to predict the detailed structure and behaviour of sites over thousands of years. The Board believes that this was scientifically unsound and would lead to bad engineering practice.

Following a study, the Board ultimately advocated a strategy based on the following premises:

i) Surprises are inevitable in the course of investigating any proposed site, and things are bound to go wrong on a minor scale in the development of a repository.

ii) If the repository design can be changed in response to new information, minor problems can be fixed without affecting safety, and major problems, if any appear, can be remedied before damage is done to the environment or the public health.

Three principles are embodied in the advocated flexible approach:

i) Start with the simplest description of what is known, so that the largest and most significant uncertainties can be identified early in the program and given priority attention.

ii) Meet problems as they emerge, instead of trying to anticipate in advance all the complexities of a natural geological environment.

iii) Define the goal broadly in ultimate performance terms, rather than immediate requirements, so that increased knowledge can be incorporated in the design at a specific site.

This approach is, for all practical purposes, the observational method and it is a recognition of the realities of geotechnical practice.

Nuclear repository design requires consideration of safety for periods well in excess of those that can be relied upon by monitoring alone. One means of extending the time scale to offer a reasonable assurance in the design is to rely on natural analogues. Fortunately, several exist that are meaningful for underground repository design.

Conclusions

The geotechnical engineer, artful in the application of the observational method, has no difficulty in accepting the dictum cited by Southwood [25]: "The things we would like to know may be unknowable".

The observational method is an effective method for coping with uncertainty in the implementation of engineering works, particularly uncertainty arising from ground conditions. As such it is a means of risk management and it is sometimes in conflict with other procedures for risk management.

The value of the observational method in conventional geotechnical engineering has been proven beyond a doubt. It has also been shown to be effective in various aspects of environmental geotechnics such as mine waste management and in-situ remediation. However restraints arise in its application from a limited understanding of the observational method, from a dominance of regulations that pre-empt its use, and from issues associated with longevity that limit its practical application.

Neither the public at large nor many regulatory agencies have a full appreciation of and a trust in the application of the observational method for waste management engineering. This is an issue that challenges the geotechnical engineer and requires on-going attention so that the observational method is not perceived as design by trial and error. Risk communication is an integral part of risk management.

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Seven Guidelines for Managing Uncertainty in Geoenvironmental Design

Robert B. Gilbert[1] and Travis C. McGrath[2]

ABSTRACT: Seven, practical guidelines for managing uncertainty in geoenvironmental design are presented. They range in scope from evaluating uncertainty to reducing it and limiting its impact on design performance. The guidelines are derived from theoretical considerations, but do not require an expertise of (or even a background in) the theory to be employed. Simple tools are provided and a design case history is analyzed to facilitate the implementation of these guidelines in practice.

INTRODUCTION

Uncertainty is significant in geoenvironmental design: site conditions vary spatially and with time; field-scale, long-term performance is not known for many engineered systems; and costs and schedules cannot be predicted with accuracy. There have been numerous attempts at applying decision theory and probability theory to account for uncertainty in geoenvironmental design. Specific applications include groundwater remediation (e.g., Sitar et al. 1987; Freeze et al. 1990; Massmann et al. 1991; Woldt et al. 1991), waste containment (e.g., Tang et al. 1994; Benson and Daniel 1994; Gilbert and Tang 1995b) and nuclear waste management (e.g., Roberds et al. 1991; Keeney and von Winterfeldt 1993). However, most of the theoretical work is confined to the world of research, and a large gap currently exists between uncertainty management in theory and practice. It is unreasonable to expect all practitioners to become experts in the theory so that they can apply it in practice. It is also unreasonable to expect that an expert will be involved in every geoenvironmental design project.

The goal of this paper is to present practical guidelines for uncertainty management that are derived from theory. Seven guidelines will be presented: three of the guidelines deal with evaluating uncertainty and its impact on geoenvironmental design, while the remaining four guidelines deal with

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managing the uncertainty. Simple tools will be provided to facilitate the implementation of these guidelines in practice. A design case history will be used to demonstrate the guidelines and to illustrate key points. Appendix I provides background information for the case history; this information will be referenced in discussions throughout the remainder of the paper.

GUIDELINE 1

Judgment is essential in evaluating and representing uncertainty.

Uncertainty means that the outcome of a design (i.e., how it will perform) is not known at the outset. Although all uncertainty is ultimately due to a lack of knowledge, it is convenient in practice to consider two types of uncertainty: random uncertainty and systematic (or model) uncertainty.

Random Uncertainty

Random uncertainty results from variability with time and/or location. Examples include the daily precipitation at a site (varying from day to day), the hydraulic conductivity of a soil layer (varying with location), or the ratio between an actual construction cost and the estimated cost (varying from project to project). Because of this variability, there will be uncertainty in predicting new values (e.g., at future times or different locations).

A random variable model provides a practical tool to quantify variability. This model describes the frequencies with which different values of the variable will occur. For example, a random variable model for the ratio of actual cost to estimated cost in site remediation is shown as a probability distribution on Fig. 1a. This model was developed from data supplied by the U. S. Environmental Protection Agency for 102 Superfund sites (Davis 1996). A random variable model can be continuous (the variable can take on any value) or discrete as in Fig. 1a (the variable can only take on discrete values). In many instances, a discrete model is sufficient for practical purposes even though it may not be entirely realistic. There are several useful properties of a random variable model, as shown on Fig. 1a: the expected or mean value, μ (a measure of the central value for the variable), and the standard deviation, σ (a measure of the variability about the mean value). Since random uncertainty is due to variability, the standard deviation indicates the magnitude of random uncertainty.

Systematic (or Model) Uncertainty

Systematic (or model) uncertainty results from uncertainty in the random variable models used to represent random uncertainty. Rarely ever in geoenvironmental design will sufficient information exist to formulate the complete probability distribution for a random variable model. For example, the mean ratio between actual cost and estimated cost (Fig. 1a) is uncertain because it is based on data from only 102 sites.

Uncertainty in a random variable model is systematic in the sense that it does not vary (e.g., there is only one mean even though its exact value is not known).

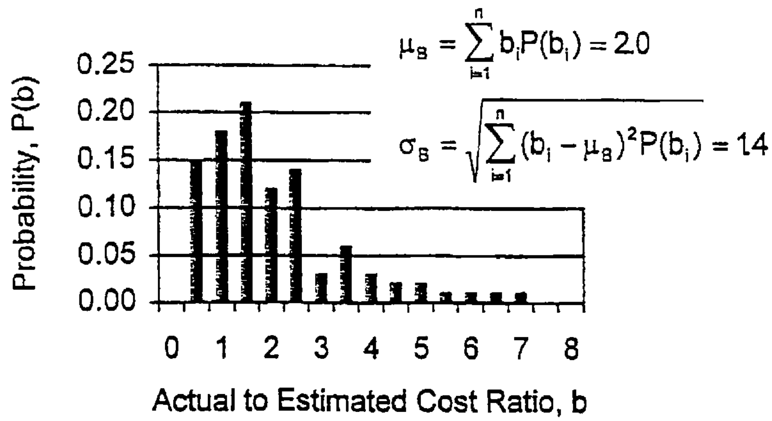
Systematic uncertainty is typically the dominant source of uncertainty in geoenvironmental design due to the scarcity of data. For example, remedial actions have been implemented at only a small percentage of the listed Superfund sites (Russell and Davis 1995). Also, design performance data from five years ago may not be relevant today due to improvements in technology or regulatory changes. Therefore, judgment is essential in evaluating systematic uncertainty.

Theory provides some guidance in the application of judgment. First, model uncertainty, like random uncertainty, can be represented using a probability distribution. For example, a probability distribution representing systematic uncertainty in the mean cost ratio is shown on Fig. 1b. Note that each possible mean cost ratio has an associated distribution accounting for random uncertainty. The probabilities in Fig. 1b do not represent the frequency of occurrence, but rather the likelihood that the mean is equal to different values.

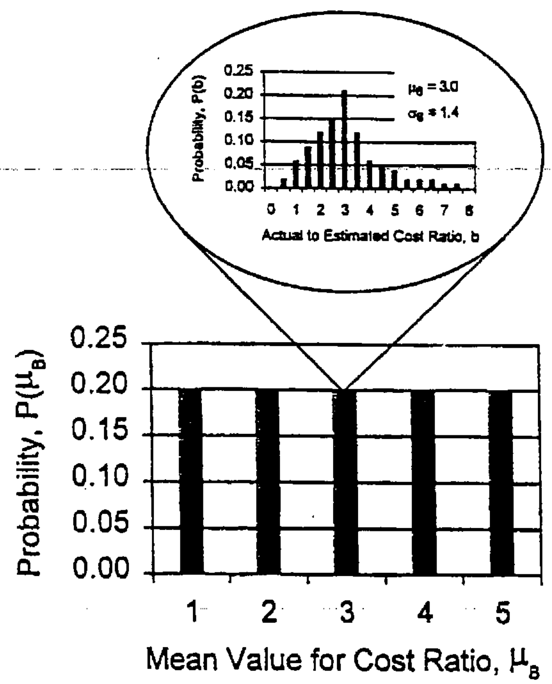
Second, the most important role of judgment is to identify all possible outcomes. The probabilities in Fig. 1b represent the likelihoods relative to all possible outcomes (i.e., a mean of 1, 2, 3, 4 or 5). Failure to consider a possible outcome (e.g., a mean cost ratio of 10) can lead to ineffective design decisions. For example, many pump-and-treat systems were implemented in the 1980s without recognizing their ineffectiveness at removing non-aqueous phase liquids (NRC 1994).

Third, another role of judgment is to impose realistic constraints on the probability distribution. Some outcomes, such as a negative construction cost, may not be possible. Information theory provides guidance on appropriate probability distributions to represent systematic uncertainty within constraints imposed by judgment; an appropriate distribution is one that minimizes unintended biases (e.g., Tribus 1969). Suggested probability distributions for typical constraints are summarized in Table 1. As an example, a discretized version of a uniform distribution (Table 1) is used to model systematic uncertainty in the mean cost ratio (Fig. 1b) because upper and lower bounds can be assigned based on judgment.

Finally, judgment must be applied with care. Cognitive theory suggests potential problems in quantifying judgment into a probability distribution. The most common problems are underestimating the magnitude of uncertainty and imposing artificial biases (e.g., Capen 1976). Formal techniques for subjective assessments are available to minimize these effects (e.g., Roberds 1990). However, most of the problems can be controlled simply by being aware that they exist and clearly defining the parameters to be estimated.



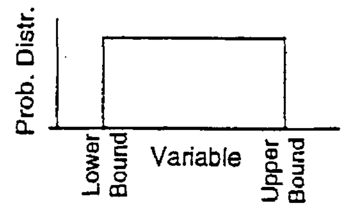
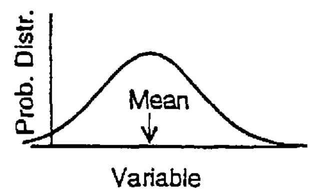
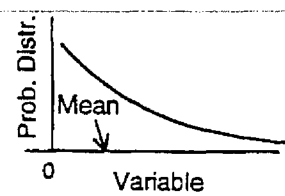
(a) Random Uncertainty in Cost Ratio



(b) Systematic Uncertainty in Mean Cost Ratio

Fig. 1. Random Variable Model for Ratio of Actual to Estimated Cost in Site Remediation

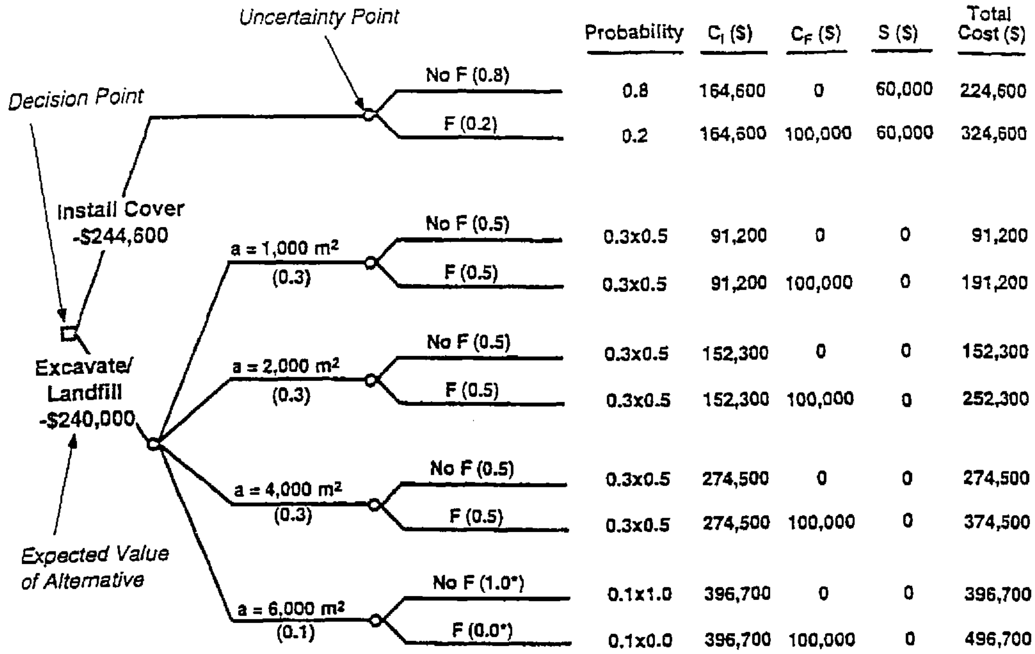
Table 1. Suggested Probability Distributions Given Constraints Imposed by Judgment

Constraints Imposed by Judgment	Suggested Probability Distribution	Significant Features
Upper and Lower Bounds	**Uniform** 	All possible values are equally likely Mean value at mid-point of lower and upper bounds Symmetrical distribution about mean value
Mean Value and Standard Deviation	**Normal** 	68 % of values are within ±1 standard deviation from mean 95 % of values are within ±2 standard deviations from mean Symmetrical distribution about mean value
Positive Values and Mean Value	**Exponential** 	63 % of values are less than mean Asymmetrical distribution

GUIDELINE 2

The outcome of a design (e.g., satisfactory or unsatisfactory performance) will be uncertain. The value of a design is related to the consequences of different outcomes weighted by the likelihoods that those outcomes occur.

Design constitutes a series of decisions that are made under uncertainty and, therefore, risk. A decision tree, as shown on Fig. 2 for the case history site at the completion of Phase I soil sampling (Appendix I), provides a useful tool for analyzing and discussing the design process. For each design alternative, different outcomes can occur. An outcome may be described by a single event (e.g., the cover performs satisfactorily and no future corrective action is required) or a series of events (e.g., 1,000 m^2 of contaminated soil is excavated to a depth of 0.5 m and there is no residual contamination or need for future corrective action).



F = Future corrective action required
a = Area of contaminated soil requiring remediation (to a depth of 0.5 m) based on sampling during excavation
C_I = Cost of implementation (construction, maintenance and monitoring)
C_F = Cost of future corrective action
S = Cost of restricting future land use at the site
* Entire work area is excavated - chance for residual contamination assumed negligible

Fig. 2. Decision Tree for Case History Site

Each design outcome has a likelihood of occurrence and an associated consequence. The likelihood of occurrence for an individual event is indicated by the values in parentheses on Fig. 2. As an example, the likelihood that 1,000 m^2 of contaminated soil will have to be excavated is equal to 0.3 based on existing data. The likelihood of occurrence for an outcome is obtained by multiplying the likelihoods together for all events leading to that outcome. The likelihood that 1,000 m^2 of soil will have to be excavated and that no residual contamination exists is 0.3x0.5 = 0.15 (Fig. 2). The consequence for each possible design outcome is expressed as a total cost on Fig. 2. Estimation of the likelihoods and consequences that are used in the decision tree is discussed in the next section.

The expected (or representative) value of a decision is obtained by weighting each possible consequence by its likelihood

$$\text{Expected Value} = E(\text{Value}) = \sum_{i=1}^{n} (\text{Consequence})_i \times p_i \tag{1}$$

where p_i is the probability that outcome i occurs, $(\text{Consequence})_i$ is the consequence associated with outcome i, and n is the number of possible outcomes. The expected value of a design alternative provides a convenient measure to compare the value of different designs. If benefits are positive and costs are negative, then the design with the maximum expected value will have the maximum value. In the decision tree shown on Fig. 2, the excavate alternative has the maximum (least negative) expected value. The expected value concept is also helpful in simplifying design decisions. Design outcomes that do not have large consequences or that are not likely are less important, and can possibly be neglected.

GUIDELINE 3

Design decisions should be based only on outcomes that are tangible and consequences that can be measured. Sensitivity analyses should always be conducted to evaluate how estimated quantities affect the value of different design alternatives.

A major difficulty in design is quantifying the likelihoods and consequences of different design outcomes. The key to this process is defining outcomes that are tangible. If an outcome is not tangible, then it is impossible to assess its likelihood of occurrence (one would never know if the outcome had or had not occurred) and it is impossible to evaluate its consequences (consequences could never be linked directly to the outcome). While this guideline is seemingly obvious, it is frequently ignored in practice. For example, an increased risk of cancer in humans due to a site with groundwater contamination is <u>not</u> a tangible outcome, although it is commonly used as a design guideline (e.g., USEPA 1989). Even at the infamous Love Canal site, which is probably the most studied case of site contamination, direct links have never been drawn between environmental contamination and human health effects (e.g., Danzo 1988; Hoffman 1995). An alternative outcome that is tangible would be the contaminant concentration at an exposure point. The case history site (Appendix I) also provides an example of decision outcomes that are not tangible. An example set of tangible outcomes for this site is provided in Table 2.

Table 2. Example Set of Tangible Outcomes for Case-History Site

Original Outcomes Considered	Alternative Outcomes that are Tangible
Overall protection of human health and the environment Long-term effectiveness and permanence Reduction of toxicity, mobility or volume of contaminant Short-term effectiveness	No future corrective action required if mercury concentrations are kept below: 1) 20 mg/kg in the upper 0.5 m of on-site soils and sediments from drainage ditches; and 2) 2 μg/l in groundwater samples taken from wells completed in the shallow aquifer
Implementability	Minimize time to complete remediation
Cost	Minimize total expected cost

Once tangible outcomes are defined, there may still be considerable uncertainty in the likelihoods and the consequences associated with those outcomes. The most rigorous approach to account for this uncertainty is to develop full probability distributions representing both random and systematic uncertainties in these parameters. However, in general, uncertain likelihoods and consequences can be represented simply with estimates for their mean values in design decisions. The value for a design alternative is then approximated from (1) as follows

$$E(\text{Value}) \cong \sum_{i=1}^{n} \overline{(\text{Consequence})}_i \times \overline{p}_i \quad (2)$$

where $\overline{p}_i$ is an estimate for the mean likelihood and $\overline{(\text{Consequence})}_i$ is an estimate for the mean consequence associated with outcome i. Estimation of these mean values is addressed in the following subsections.

Estimation of Mean Likelihoods

Uncertainty in the frequency of occurrence for an outcome arises from a lack of performance data. Consider a case in which a given outcome has been observed to occur x times in n designs. An estimate for the mean likelihood of occurrence, $\overline{p}_i$, is given by $\overline{p}_i \cong (x+1)/(n+2)$ (Ang and Tang 1975). For example, if a design is implemented 5 times and performs successfully each time, then the mean likelihood of unsatisfactory performance, $\overline{p}_i$, would be estimated as 0.14 (i.e., x = 0 failures). Note that the actual frequency of poor performance may be much smaller, but the limited data set does not support a smaller estimate for the mean likelihood. Also note that if no data are available (i.e., n = 0), then the estimate for the mean likelihood is 0.5, which is consistent with a uniform distribution bounded by 0 and 1 (Table 1). For the design decision on Fig. 2, it is difficult to estimate the likelihood that future corrective action will be required if the soil is excavated (i.e., the likelihood that contaminated soil is left on-site, leading to future problems). Since the data needed to make this assessment do not exist, the likelihood is estimated to be 0.5.

Performance data will be rare in most instances. While a 0.5 value can serve as a starting point for the mean likelihood, performance modeling can also provide information on the likelihood. The performance model, which can be physical, empirical, analytical or numerical, predicts performance of the design under different conditions. For example, a numerical model of unsaturated flow is used commonly to predict infiltration rates through covers as a function of environmental conditions and cover properties. If probability distributions for the model input parameters are known, then the frequency of different outcomes can be estimated with this model (e.g., the frequency of different infiltration rates). There will be uncertainty in these calculated frequencies because of systematic uncertainties in the input parameters and in the performance model itself (i.e., how well the model represents reality).

A simple chart to account for model uncertainty in estimating $\overline{p}_i$ is provided on Fig. 3. Z is a measure of performance, defined such that Z<0 indicates unacceptable performance (e.g., Z = a maximum allowable, annual infiltration rate minus the actual infiltration rate through a cover). The mean value of Z, μ_Z, is assumed to be greater than zero (e.g., the cover will typically be designed so that the average, annual infiltration rate is less than a maximum allowable rate). The standard deviation of Z, σ_Z, represents the random uncertainty in Z (e.g., due to variability in precipitation between years). Model uncertainty (e.g., uncertainty in the model used to estimate the infiltration rate) is represented by σ_M. The curves on Fig. 3, which are developed assuming that Z is normally distributed (Gilbert and Tang 1995a), can be used to estimate the mean likelihood of unacceptable performance as a function of σ_Z / μ_Z and σ_M / σ_Z. For example, if the annual infiltration rate has a mean of 50 mm/yr and a standard deviation of 20 mm/yr while the allowable infiltration rate is 80 mm/yr, then $\mu_Z = 80 - 50 = 30$ mm/yr and $\sigma_Z / \mu_Z = 20/30 = 0.67$. If there is no model uncertainty ($\sigma_M = 0$), then the mean likelihood of unsatisfactory performance in a given year is 0.07 (Fig. 3). If $\sigma_M / \sigma_Z = 1.0$, then the mean likelihood increases to 0.14 (Fig. 3). The ratio σ_M / σ_Z will typically be greater than one, and may approach values as large as five.

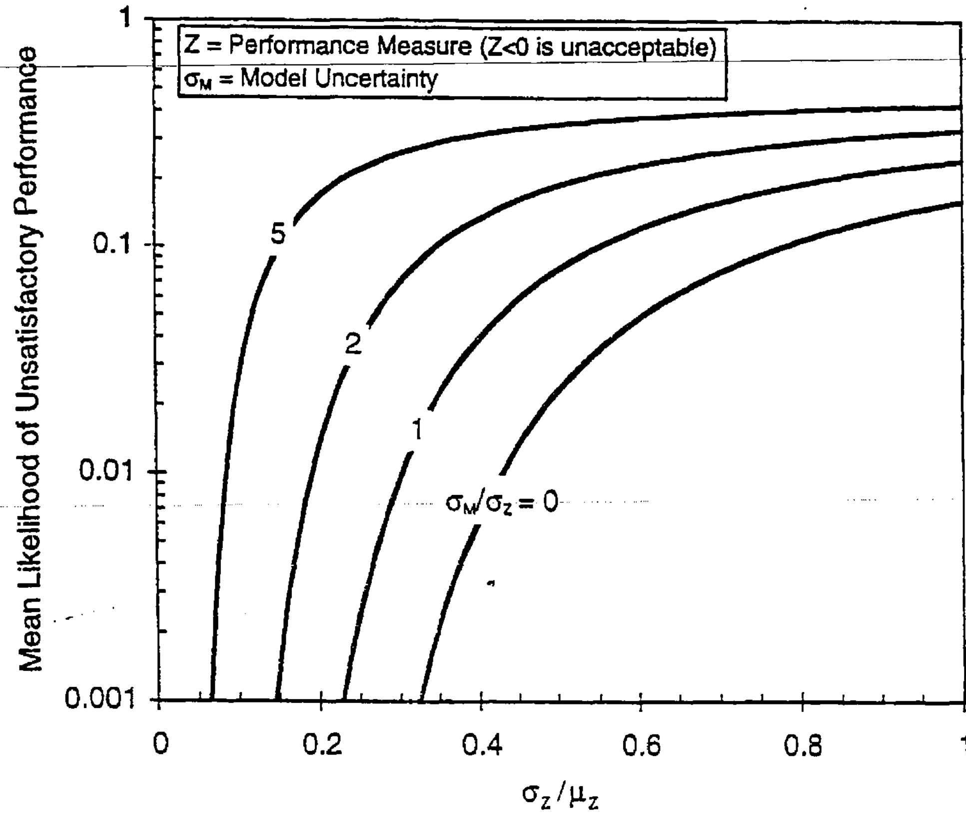


Fig. 3. Effect of Model Uncertainty on the Mean Likelihood of an Outcome

Estimation of Mean Consequences

The potential consequences of unsuccessful or successful designs include: design costs, construction costs, operation and maintenance costs, corrective action costs, legal costs, regulatory fines, environmental effects, human-health effects, worker safety, publicity, land re-use and good-will. There is uncertainty in estimating the consequences associated with a given design outcome (e.g., unsuccessful performance). The outcome may occur many years in the future or be drawn out over long periods of time. Also, an outcome may lead to multiple, incongruous costs and benefits that are difficult to quantify and combine into a single value.

Utility theory has been developed to manage the difficulties in quantifying consequences (e.g., Raiffa 1968). The premise of utility theory is to express all consequences, whether monetary or not, on a normalized utility scale so that they can be combined and compared. The advantage of the utility approach is its generality: different types of consequences can be handled (e.g., construction cost and aesthetic value) and different decision-maker preferences can be accommodated (e.g., a $10,000,000 loss may be much more significant to a small versus large company). The main limitation of utility theory is also related to its generality. Evaluation of utility values is subjective, which can affect the usefulness of this approach in practice. Many previous authors have discussed the problems in assigning utility values (e.g., Raiffa 1968; Clemen 1991) and in combining utility values from different decision makers (e.g., Merkhofer and Keeney 1987).

An alternative approach to utility that minimizes problems with subjectiveness is to express all consequences in measurable terms, such as economic terms as in Fig. 2. There are several advantages to this approach. It is easier to estimate consequences if they are expressed in concrete terms as opposed to abstract terms. Although tough issues such as aversion to large monetary losses and the intrinsic value of the environment still must be addressed, at least there is some basis for assigning an economic value in a capitalistic society. Also, it is easier to communicate consequences to decision makers and to the public if they are expressed in economic terms. Finally, if consequences can be measured, then the actual consequences of different outcomes can be determined over time after a design is implemented. In this way, actual consequences can be compared with estimated values to provide information for future designs. Therefore, it is recommended that design decisions be based not only on tangible outcomes, but also on consequences that can be measured.

Sensitivity Analyses

Even with tangible outcomes and measurable consequences, it can be difficult in practice to quantify likelihoods and consequences. Sensitivity analyses should always be performed to evaluate how uncertain quantities affect the value of different design options. For example, the following quantities are difficult to estimate in the decision tree shown on Fig. 2: the reliability of the cover system (i.e., the likelihood that it performs successfully in the long term); the cost of restricted land-use for the cover alternative, S; and the present-worth cost of future corrective action for either alternative, C_F (this cost is assumed to be equal for the two alternatives). The value of each design alternative has been evaluated as a function of these variables, and the results are shown on Fig. 4. Each curve for a given cover reliability represents combinations of S and C_F for which the two alternatives have equal expected costs. If the cover reliability is 0.8 and C_F is \$100,000, for example, then the two designs have equal value for S equal to \$55,400. For pairs of cost values above a particular cover-reliability curve, the excavation alternative minimizes the expected cost. For pairs below the curve, the cover alternative has the lower expected cost.

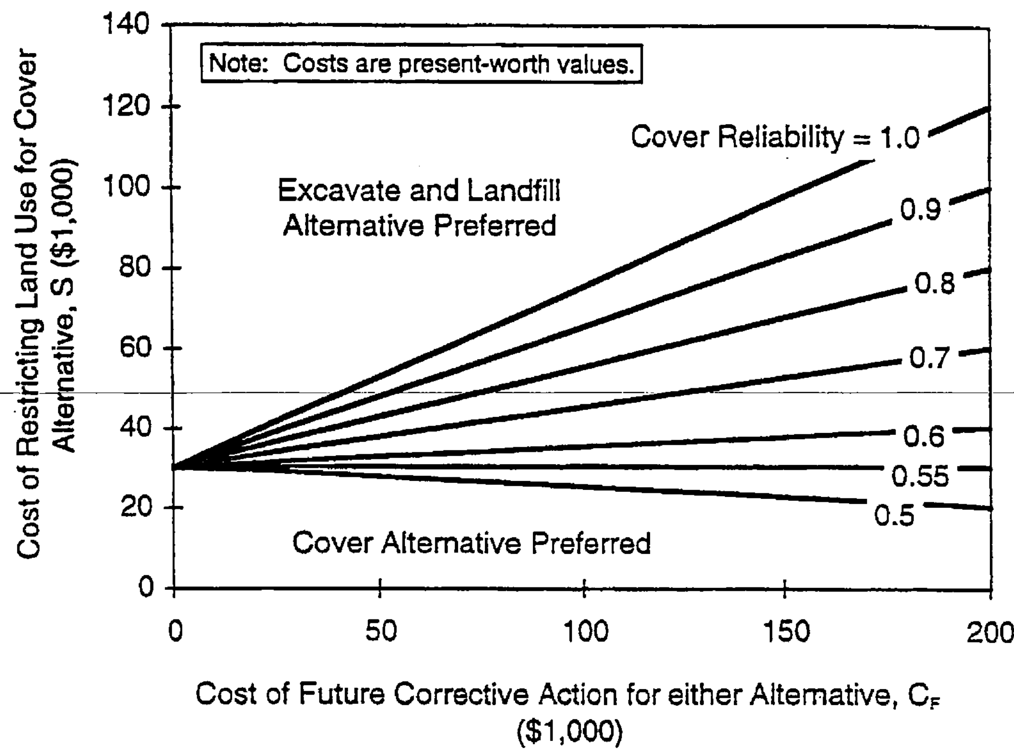


Fig. 4. Sensitivity of Decision to Uncertain Costs and Cover Reliability

There are several interesting conclusions that can be drawn from Fig. 4. The relative design values are insensitive to C_F if the cover reliability is equal to 0.55. At this reliability level, the excavate alternative will have the maximum value for all S values greater than \$30,400. The sensitivity of the decision to the cost of future corrective action increases as the reliability level increases. The reliability of the cover is expected to be greater than 0.55. The primary mode of failure, gully erosion and subsequent contaminant outwash caused by a single, major storm event, is not very likely. An upper-bound value for the reliability is 1.0. At this reliability level, the critical value for S is not much greater than \$30,400 for small C_F values. However, as C_F approaches \$200,000, the critical value of S approaches \$120,000. Since a reasonable upper bound for C_F is \$200,000, the excavate alternative will be preferred over the cover alternative if the cost of restricted land use is greater than \$120,000, regardless of the cover reliability.

GUIDELINE 4

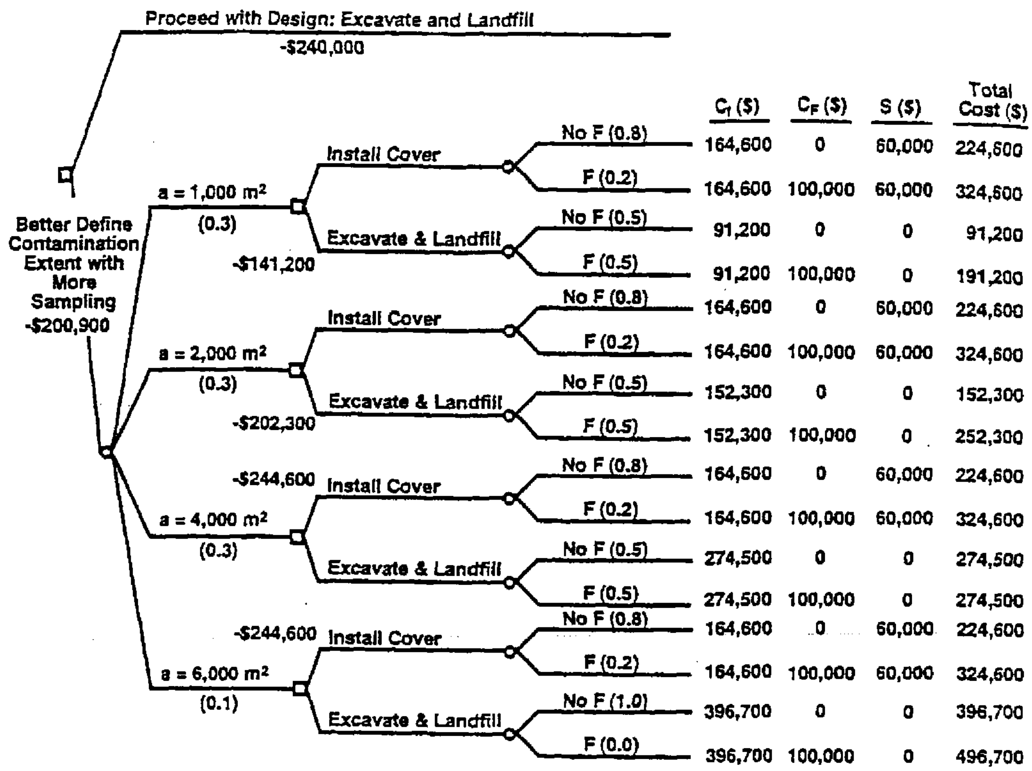
There are two approaches for managing uncertainty in design: (1) try to reduce the uncertainty by obtaining more information and (2) try to limit the impact of uncertainty on performance of the design.

Thus far, this paper has addressed the evaluation of uncertainty and the analysis of its effects on design. The remainder of the paper will deal with the management of uncertainty in design. There are two basic approaches for managing uncertainty: (1) reduce the uncertainty and (2) limit its impact on design performance.

An example of uncertainty management through uncertainty reduction is shown on Fig. 5 for the case history site. A reduction of uncertainty in the area of contaminated soil (and therefore the volume assuming an average excavation depth of 0.5 m) through additional sampling may prove valuable. The benefit of knowing the area before deciding to excavate the soil is that the area may be larger than expected, in which case the cover option may be preferable. For example, if the entire 6,000 m^2 work area is contaminated, then the cover alternative has greater value than the excavate alternative (Fig. 5). The maximum possible value from this approach is obtained if the area is determined with certainty by the additional sampling (i.e., uncertainty is eliminated). The design value if uncertainty in the volume is eliminated is -\$200,900, compared to a value of -\$240,000 if no further sampling is performed (Fig. 5); therefore, the maximum possible value of additional sampling is \$39,100.

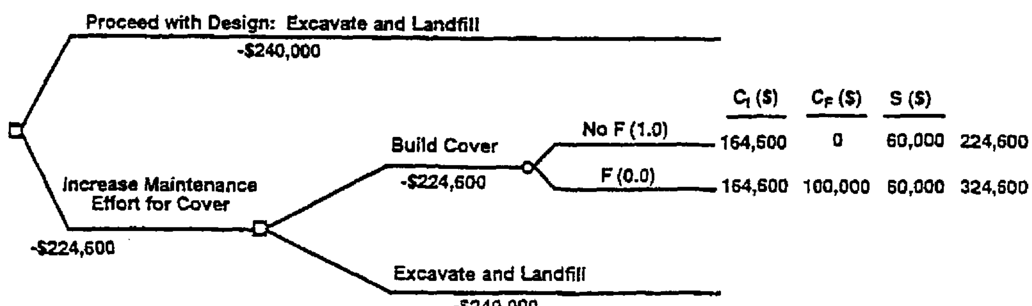
An example of uncertainty management through limiting its impact on design performance is shown on Fig. 6. The impact of uncertainty in long-term performance of the cover can be reduced by increasing the level of maintenance. In this case, the maximum possible value is obtained if the cover reliability is increased to 1.0. The design value for this approach is -\$224,600, compared to the base case value of –\$240,000 (Fig. 6); therefore, the maximum possible value of improved reliability is \$15,400.

The value gained through uncertainty management depends on the increased benefits or reduced costs associated with the design, but also on the cost associated with the management. For example, the maximum \$39,200 value associated with eliminating the uncertainty in the contaminated soil volume corresponds to approximately 200 soil samples analyzed for mercury content. It may not be possible to eliminate uncertainty in the contaminated area with 200 additional samples. As another example, it may not be possible to ensure successful cover performance by spending an additional present-worth amount of $15,400 on maintenance. Optimization of the value gained through uncertainty management is discussed in the following sections.



Note: See Fig. 2 for notation

Fig. 5. Value of Additional Sampling to Reduce Uncertainty



Note: See Fig. 2 for notation

Fig. 6. The Value of Limiting the Impact of Uncertainty

GUIDELINE 5

Uncertainty in an average (e.g., the average fraction of surficial soils contaminated with mercury) can generally be reduced with additional data. Uncertainty in a detail (e.g., the specific boundary of soil contaminated with mercury) is usually more difficult to reduce.

Reduction of Uncertainty in Averages

Average values are commonly of interest in design decisions. Examples include the average contaminant concentrations in groundwater upgradient and downgradient from a site, the average volume of contaminated soils, the average hydraulic conductivity of a clay liner, the average shear strength along an interface in a containment system, and the average annual infiltration through a cover. Uncertainty in the estimated average for a variable is related to the amount of random variability in the variable (with time or location) and to the number of measured values (at different times or locations) as follows

$$\sigma_{\overline{X}} = \frac{\sigma_X}{\sqrt{n}} \qquad (3)$$

where X is the variable, $\overline{X}$ is the average, $\sigma_{\overline{X}}$ is the standard deviation of the average (systematic uncertainty), σ_X is the standard deviation representing random variability in X and n is the number of independent measurements of X.

The simple relationship in (3) provides useful insight into optimizing the value of information for average values. First, variables with the largest variability (large σ_X) will have the greatest uncertainty in the average for a given number of measurements. The magnitude of σ_X is related both to real variations in X and artificial variations due to random errors in the measurement process. In general, investigation programs should focus more attention on variables with large σ_X values, although the focus also depends on the importance of $\overline{X}$ in the design decision and the cost of measurements. Second, there is a diminishing return in uncertainty reduction with additional measurements. The reduction in uncertainty can be measured by $\sigma_{\overline{X}}/\sigma_X$, which is equal to $1/\sqrt{n}$ from (3). Hence, the marginal reduction in the uncertainty with increasing n decreases as n increases, as shown on Fig. 7 (the curve labeled independent sampling).

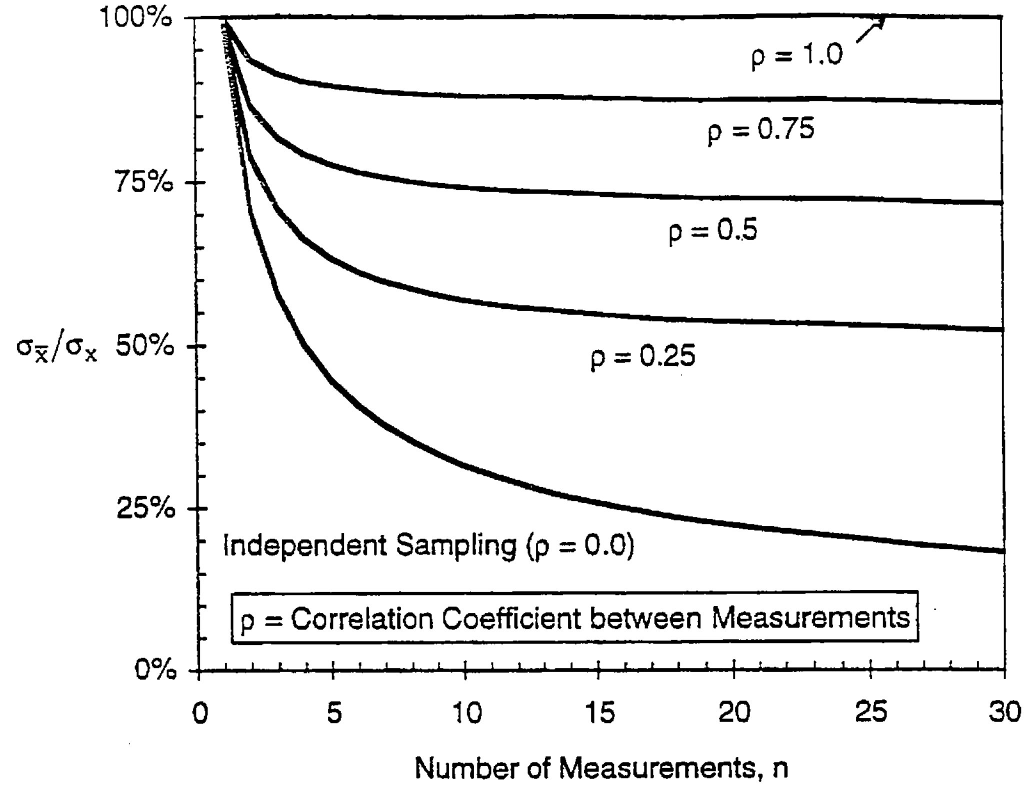


Fig. 7. Uncertainty Reduction versus Sampling Effort

The ability to reduce uncertainty in an average with measurements is affected by correlations between measurements. Measurements will be positively correlated if samples are spaced closely or if there is a systematic error in the measurement process (e.g., sample disturbance). For positively correlated measurements, (3) is modified as follows (e.g., Cochran 1963)

$$\sigma_{\bar{x}} = \frac{\sigma_x}{\sqrt{n}}\sqrt{1+(n-1)\rho} \tag{4}$$

where ρ is the correlation coefficient between measurements (ρ ranges in magnitude from 0.0 for no correlation to 1.0 for perfect correlation). Each measurement is assumed to be correlated with every other measurement in (4), typical of a systematic error in the measurement process. As the correlation increases, the sampling efficiency decreases, as shown on Fig. 7. This reduction in efficiency occurs because positively correlated samples provide redundant information; the amount of redundancy increases with increasing ρ. It is impossible to achieve a $\sigma_{\bar{X}}/\sigma_X$ ratio that is less than $\sqrt{\rho}$, regardless of the number of measurements (Fig. 7).

In many cases, only samples that are located close together will be correlated. As an example in the case history (Appendix I), mercury measurements in surficial soils were highly correlated within a radius of several meters. In these cases, the effective correlation coefficient for the group of n samples will be smaller than the correlation coefficient between closely spaced samples. When there is a correlation of ρ between n_ρ pairs of samples and no correlation between the remainder of the samples, the effective correlation coefficient for the entire sample group, ρ_{eff}, can be approximated by the following (e.g., Gilbert 1987)

$$\rho_{eff} = \left(\frac{2n_\rho}{n(n-1)}\right)\rho \tag{5}$$

For example, if twenty measurements are made (n = 20) and pairs of adjacent measurements are correlated ($n_\rho = 19$) with $\rho = 0.8$, then ρ_{eff} is equal to 0.08. Journel and Huijbregts (1978) and Vanmarcke (1983) provide more detailed treatments for spatially correlated data.

Additional unknowns will also limit the effectiveness in reducing $\sigma_{\bar{X}}$ with measurements. The effect of additional unknowns can be accounted for approximately by replacing σ_X in (3) with an effective value, σ_{eff}, that is larger to reflect the additional uncertainty. As an example, if the standard deviation of X is not known (rarely ever will σ_X be known if the mean of X is not known), then σ_{eff} is approximated by $\sigma_{eff} \cong s\sqrt{(n-1)/(n-3)}$ where s is an estimate for σ_X based on the measured data (Ang and Tang 1975). Consider the case where $s \approx \sigma_X$ and $n = 5$; σ_{eff} is approximately 1.4 times greater than the estimate for σ_X due to the additional uncertainty. The difference between σ_{eff} and σ_X decreases with increasing n.

An application of these concepts to the case history site demonstrates their usefulness. Mercury-contaminated soil is distributed across the site in concentrated areas (or hot spots) that correspond to areas where mercury was temporarily stored. It is not possible to determine the location, size or frequency of these hot spots based on the limited site history information and Phase I sampling. The average fraction of contaminated area (relative to the 6,000-m^2 work area) will provide information about the expected volume of contaminated soil. Reduction in the uncertainty about this average fraction is shown on Fig. 8 as a function of the number of additional samples. These curves were generated by numerically simulating a random pattern of contamination across the site, and then sampling from the simulated site according to a fixed grid. Curves are shown for two different average hot-spot diameters. Note that the curves follow the same general trend as that shown on Fig. 7 for the simple model. Also, note that the sampling efficiency decreases for smaller sample spacings because adjacent samples are correlated (i.e., they may come from the same hot spot).

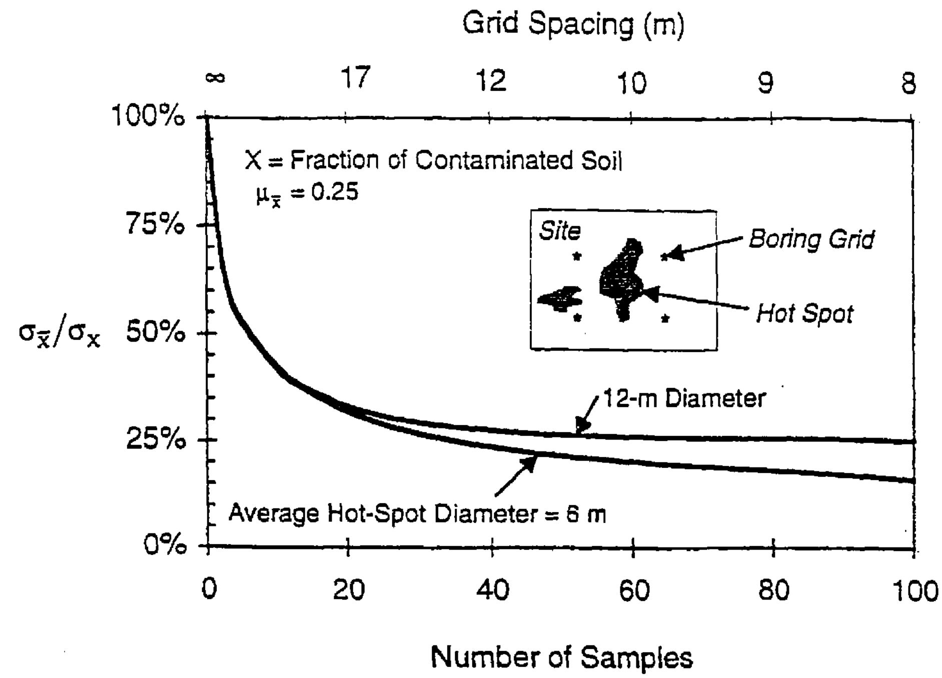


Fig. 8. Numerical Simulation Results for Estimating the Fraction of Contaminated Soil

Reduction of Uncertainty in Details

Details are more useful pieces of information than averages in many design decisions. For example, information about specific hot spots (i.e., their location and size), not the average fraction of contaminated soils, is necessary to develop an excavation plan and accurately estimate the cost of clean-up. While averages can generally be inferred from measured data, details are more difficult to infer. An example is the average mercury concentration (an average) versus the concentration at a specific location in the soil (a detail). Uncertainty in the average can be reduced by taking measurements from anywhere on the site as long as they provide representative samples. However, the only way to reduce uncertainty in the concentration at a specific location is to take a measurement from at (or near if concentrations are correlated) the location. If the location is not known, as is the case in trying to define the boundaries of mercury contamination, then significant effort may be required to reduce uncertainty in the detail.

The case history site provides valuable lessons in the difficulties associated with reducing uncertainty in details. First, a common approach is to try to reduce the number of required samples by identifying the locations of hot-spots based on site history, visual markings, or other information. The Phase I sampling program was designed around these identified hot spots. However, based on subsequent results from the Phase II sampling effort, only 15 percent of the hot spots were identified and 85 percent were undetected in Phase I because of its biased design. Therefore, care should be exercised in applying judgment (as discussed in the first section of this paper). In general, a regular grid of sample locations will be the most effective. Second, the 181 additional samples obtained in Phase II were largely ineffective at reducing uncertainty in the boundaries of contamination because the average sample spacing was greater than the typical hot-spot sizes. Therefore, this additional sampling effort had limited value because it was not designed to extract the information needed for design.

GUIDELINE 6

Redundant designs (i.e., systems that are not highly dependent on the performance of an individual component) can reduce the impact of uncertainty on performance. The value added through redundancy depends on the degree of dependence between the performance of individual components and that of the system.

One approach to reduce the impact that uncertainty has on design performance is to include redundancy in the design. Redundant designs incorporate systems that do not depend heavily on any single aspect or component. For example, a composite liner (i.e., a compacted clay layer overlain by a geomembrane) forms a redundant containment system. Leakage across the compacted clay is primarily controlled by its hydraulic conductivity, while leakage across the geomembrane is generally governed by defects in the geomembrane (e.g., Giroud and Bonaparte 1989). Since the hydraulic conductivity of the clay is essentially independent of the size and frequency of holes in the geomembrane, the reliability of the composite liner is expected to be greater than that for either a single clay liner or a single geomembrane liner (i.e., the likelihood of excessive leakage should be less for the system than for either component alone).

The following redundancy factor provides a useful measure to quantify system redundancy

$$\mathrm{RF} = \frac{\text{Likelihood that a Component Performs Unsatisfactorily}}{\text{Likelihood that the System Performs Unsatisfactorily}} \tag{6}$$

where RF is the redundancy factor. The magnitude of RF indicates the gain in reliability due to redundancy: RF = 1.0 indicates a non-redundant system, while RF >> 1.0 indicates a highly redundant system. For example, consider a liner that is designed with a maximum allowable leakage rate of 1,000 lphd. For a single geomembrane liner, the likelihood of exceeding this rate is high due to the potential for holes in the geomembrane: $P(Q_{FML} > 1{,}000 \text{ lphd}) = 0.9$. For a compacted clay liner with a hydraulic conductivity less than 1.0×10^{-9} m/s, the likelihood is smaller: $P(Q_{CCL} > 1{,}000 \text{ lphd}) = 0.2$. Finally, the likelihood for the composite liner is very small: $P(Q_{COMP} > 1{,}000 \text{ lphd}) = 0.001$. These likelihoods are estimated based on an analysis of laboratory and field data (Gilbert 1993). If performance of the clay liner is assumed to be independent of the geomembrane liner, then the redundancy factor is estimated as follows

$$RF = \frac{P(Q_{FML} > 1{,}000 \text{ lphd} \cup Q_{CCL} > 1{,}000 \text{ lphd})}{P(Q_{COMP} > 1{,}000 \text{ lphd})} = \frac{0.9 + 0.2 - (0.9)(0.2)}{0.001} = 920 \quad (7)$$

where $\cup$ indicates that either or both of the outcomes occur. Hence, this composite liner system exhibits substantial redundancy. The value of this redundancy depends on how the increased reliability, say from 0.8 for a single compacted clay liner to 0.999 for a composite liner, affects the value of the design (e.g., Fig. 6). If this value is greater than the cost of a geomembrane liner, then the composite liner provides a useful alternative to manage uncertainty in the performance of the clay liner.

The magnitude of RF depends on the degree of dependence between the performance of individual components and that of the system. In this composite liner, the frequency and size of defects in the geomembrane are unrelated to the hydraulic conductivity of the clay liner. Further, the performance of the composite liner system is not very sensitive to either the defects or the hydraulic conductivity. An example of a less redundant system is a composite liner consisting of a geosynthetic clay liner (GCL) overlain by a geomembrane. Since both the GCL and the geomembrane are susceptible to damage during construction and operation, RF is estimated to be about an order of magnitude smaller.

GUIDELINE 7

Flexible designs (i.e., systems that can be modified during and after construction in response to unexpected conditions), if implemented properly, are very effective at adding value.

Flexible designs are those that can be modified in response to unexpected conditions during and after construction. This approach, which has been referred to as the Observational Method in geotechnical engineering (Peck 1969) and proposed for geoenvironmental engineering (e.g., Holm 1993), is very effective at improving the value of a design. Its only potential drawback, besides the cost required to implement a flexible design, is the possibility that the design will not be flexible enough to accommodate unanticipated conditions (note that unanticipated conditions are those considered impossible at the design stage, while unexpected conditions are those considered possible but not typical). However, this drawback applies to all design alternatives and is not peculiar to flexible designs.

The case history site provides examples of both inflexible and flexible design alternatives. The excavate-and-dispose option is inflexible because there is no flexibility available if the contaminated volume of soil is unexpectedly large. An example of a similar design that was unsuccessful because of inflexibility is the PPI Superfund site (Acar et al. 1995). An excavate-and-dispose option was selected but had to be abandoned, at considerable expense and time delay, because of the release of volatile organics during excavation. Conversely, the cover alternative is more flexible in that it can be inspected and maintained continually over its lifetime.

The keys to successful implementation of a flexible design are to (1) design a monitoring program that will reduce the important uncertainties over time and (2) have contingency plans available to manage unexpected outcomes. These concepts have already been addressed in this paper in the context of new designs, and the same principles apply to flexible, evolving designs.

CONCLUSIONS

Seven, practical guidelines for managing uncertainty in geoenvironmental design are presented and discussed in this paper. While these guidelines are derived from theoretical considerations, all of the guidelines could be classified as common sense (a result that lends some credibility to the theory). There are two major conclusions that we have drawn from applying the theory of uncertainty management to practice. First, there is a tremendous need for more, higher quality performance data (both technical and economic) for geoenvironmental systems. Much of what has been compiled is never analyzed (e.g., it is only compiled to satisfy regulatory requirements) or does not provide useful information as feedback to the design process. An integrated, national effort should be initiated to compile and analyze performance data to improve the value of future designs. Second, the most important aspect of uncertainty management is communication. All parties involved in a design need to be aware of the uncertainties, the potential design outcomes (favorable and unfavorable), and the potential consequences associated with those outcomes. This communication is essential, whether or not a formal approach is adopted to manage uncertainty.

APPENDIX I. CASE HISTORY SITE DESCRIPTION

The case history site is a 14,000-m^2 residential plot (Fig. 9) located in southeast Texas. Soil within a 6,000-m^2 work area has been contaminated with mercury from a processing operation. The owner has not divulged the details of the operation to investigators, so the number, locations and sizes of the former storage piles must be inferred from physical evidence (e.g., disturbed soil).

The site is generally flat and level. The site stratigraphy, from on-site well logs, is 1.5 to 2.0 m of silty clay overlying 1.5 to 7.5 m of clayey, fine sand, which grades into clay at a depth of about 9 m. This clay layer extends to a depth of approximately 40 m, below which lies the primary-use aquifer for the local population. Laboratory tests indicate that the surficial clay is overconsolidated and that its hydraulic conductivity in laboratory samples is approximately 2.5×10^{-6} cm/s. No secondary features have been observed in the surficial clays, and no mercury has been detected in the groundwater within the upper layer of fine sand.

A two-phase sampling program was conducted to determine the extent of soil contamination at the site. In Phase I, 16 boreholes were drilled down to a maximum depth of 9 m and mercury-test samples were taken intermittently to a maximum depth of 3.5 m (no mercury was detected below a depth of 1.5 m). The boreholes were placed where contamination was believed to be most likely based on visual evidence of waste transport and storage and soil disturbance. However, the results from the first phase did not sufficiently delineate the extent of contamination, so a second sampling phase was conducted. In Phase II, 181 soil samples were collected from across the entire site to a maximum depth of 0.3 m. Mercury concentrations in the samples ranged from non-detect (<0.12 mg/kg) to 1,760 mg/kg. A health-risk assessment for the site indicated that the soil should be remediated to a mercury concentration below 20 mg/kg.

Three remedial alternatives were originally considered at the site. The first, a monitoring-only alternative, was removed from consideration because it did not satisfy applicable or relevant and appropriate requirements. The second, containment of the work area with a cover, and the third, excavating the contaminated soil for disposal in an existing off-site landfill, were compared in a qualitative discussion of pros and cons. The following criteria were applied to compare the alternatives: overall protection of human health and the environment; long-term effectiveness and permanence; reduction of toxicity, mobility or volume of contaminant; short-term effectiveness; implementability; and cost. The excavation alternative was selected.

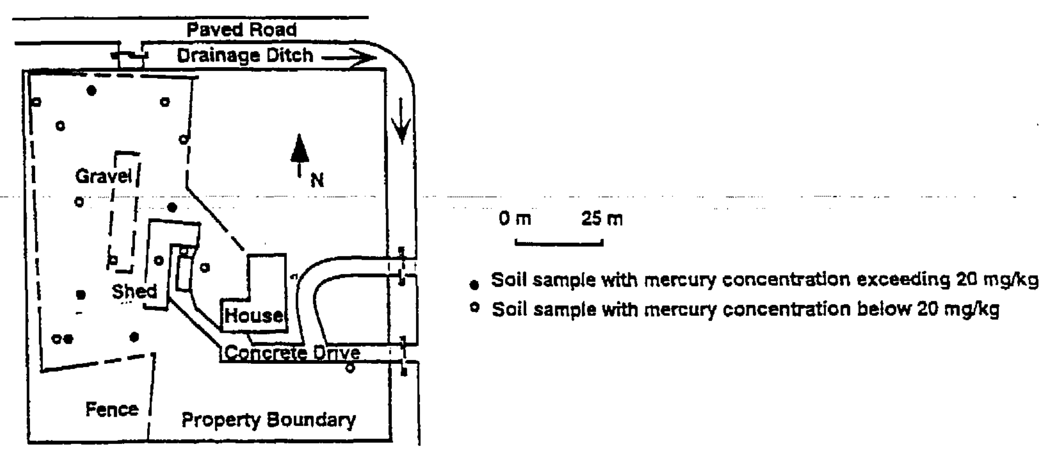


Fig. 9. Site Plan for Case History Site

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APPENDIX M

CLOSURE AND POST-CLOSURE MONITORING PLAN

Golder Associates Inc.

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April 9, 1999

Our Ref: 983-2344-1.3

Barrick Resources (USA) Inc.
Mercur Gold Mine
P.O. Box 834
Tooele, UT 84074-0838

Attention: Mr. Lennie Boteilho

RE: CLOSURE AND POST-CLOSURE TAILINGS MONITORING PROGRAM DOCUMENTATION.

Dear Lennie:

This letter has been prepared to document the logic and technical approach to the Closure and Post-Closure monitoring program that has been developed by Golder Associates Inc. (Golder) for implementation at the Reservation Canyon Tailing Facility (tailing facility). This monitoring plan has been developed based upon the results of recent site investigations and analyses conducted to support closure of the facility.

Introduction

The tailing facility ceased deposition operations in March, 1998, after which the final Phase I Reclamation activities were completed. The monitoring program described below has been developed to accommodate both the Closure and Post-Closure periods. The Closure period, as defined herein, is that time period during which construction and reclamation activities associated with the tailing facility are ongoing. The Post-Closure period is that period of time following completion of the final Closure construction activities until the time that the facility is no longer designated a regulated impounding structure.

Previous Operations Monitoring Plan

The existing piezometer and survey prism installations were installed during operations to permit the monitoring of pore pressures and slope movements in the Main Dam, the Main Dam Buttress, and the Levee Buttress. There are 30 piezometers located on the Main Dam and the Levee Buttress. Of these, 7 are standpipe piezometers and 23 are vibrating wire piezometers. Piezometer and prism locations are respectively provided in Figures 1 and 2, with a summary of the piezometer installations provided in Table 1.

TABLE 1
SUMMARY OF PIEZOMETER INSTALLATIONS

Piezometer #	Type	Northing	Easting	Collar Elev.	Screen/Gauge Elev.	Material at Screen/Gauge	Notes
1	Vib. Wire	26454.21	24026.08	7237.57	7233.1	Tailing	
3	Vib. Wire	26125.13	24105.42	7252.59	7115	Downstream Shell	Dry
4	Vib. Wire	26125.13	24105.42	7252.59	7033.1	Downstream Shell	Dry
5	Vib. Wire	26134.79	24110.32	7252.22	7096.1	Downstream Shell	Dry. Angle hole at 65 degrees.
6	Vib. Wire	26134.79	24110.32	7252.22	7041	Downstream Shell	Dry. Angle hole at 65 degrees.
7	Vib. Wire	26218.3	24214.86	7237.23	7232.9	Tailings	
9	Vib. Wire	26296.53	24308.12	7235.62	7230.3	Tailings	
13	Vib. Wire	25987.82	24410.69	7237.68	7232.7	Tailings	
15	Vib. Wire	25991.37	25029.36	7236.66	7231.4	Tailings	
16	Vib. Wire	25959.21	25056.59	7251.33	7216.7	Levee Rockfill	
17	Vib. Wire	26044.89	24985.18	7235.66	7230.4	Tailings	
21	Vib. Wire	26087.56	25209.57	7250.97	7216.9	Levee Rockfill	
22	Vib. Wire	26120.22	25182	7236.17	7230.9	Tailings	
23	Standpipe	26488.83	23980.52	7291.52	7212.6	Tailings	Johnson 8 slot screen, 40x60 pack, 10 ft. screened
24	Vib. Wire	26488.83	23980.52	7291.52	7216.6	Tailings	
25	Vib. Wire	26465	2399.71	7292.27	7201.3	Clay Core	
26	Vib. Wire	26447.13	23991.56	7291.48	7146.5	Clay Core	
27	Standpipe	26258.87	24187.4	7294.55	7210.6	Tailings	Johnson 8 slot screen, 40x60 pack, 10 ft. screened
28	Vib. Wire	26258.87	24187.4	7294.55	7214.6	Tailings	
29	Standpipe	26248.23	24187.79	7294.74	7125.7	Clay Core	Clay Core
30	Vib. Wire	26248.23	24187.79	7294.74	7130.7	Clay Core	
31	Vib. Wire	26236.23	24196.53	7295.08	7200.1	Upstream Shell	
32	Vib. Wire	26176.36	24060.16	7257.05	7030.8	Downstream Shell	Dry
33	Standpipe	26176.36	24060.16	7257.05	7030.8	Downstream Shell	Dry. Johnson 8 slot screen, 40x60 pack, 10 ft. screened.
34	Vib. Wire	26161.23	24073.49	7256.93	7122.7	Downstream Shell	Dry
35	Standpipe	26161.23	24073.49	7256.93	7117.2	Downstream Shell	
36	Vib. Wire	26146.47	24086.41	7256.93	6963.8	Dam Bedrock	Upper limestone member of the Mississippian Great Blue Formation.
37	Standpipe	26146.47	24086.41	7256.93	6958.8	Dam Bedrock	Upper limestone member of the Mississippian Great Blue Formation. Johnson 8 slot screen, 40x60 pack. Not functioning.
38	Vib. Wire	26530.75	24054.77	7306.34	7191.3	Tailings	
41	Standpipe	26015.32	24971.63	7313.49	7189.5	Tailings	Johnson 8 slot screen, 40x60 pack, 10 ft. screened.
42	Vib. Wire	26198.07	24830.47	7282.5	7280.5	Tailings	
43	Vib. Wire	26138.75	25219.09	7308.98	7189	Tailings	
44	Standpipe	26138.75	25219.09	7308.98	7183	Tailings	Johnson 8 slot screen, 40x60 pack, 10 ft. screened
45	Vib. Wire	26159.58	25164.6	7308.26	7231.3	Tailings	
46	Standpipe	26159.58	25164.6	7308.26	7223.3	Tailings	Johnson 8 slot screen, 40x60 pack, 10 ft. screened
47	Vib. Wire	26328.53	25043.54	7283.12	7281.1	Tailings	

A total of 12 survey prisms are located on the Main Dam, with 4 on the Levee Buttress. Prism locations are shown on Figure 2. During active operations of the tailing impoundment, these prisms were monitored twice a month to track movements associated with the impounding structures. Golder has recently input the prism readings from 1996 through the present into an excel spreadsheet that calculates the incremental horizontal, vertical and total displacement, displacement direction, and the rate of displacement. The database shows that normal movements have occurred due to settlement of the upstream constructed buttresses into the tailing beach. These movements have slowed considerably since upstream construction activities have ceased, as would be expected.

Barrick personnel have historically conducted the facility piezometer and survey prism monitoring and it is anticipated that Barrick personnel will continue to perform the monitoring requirements throughout the Closure and Post-Closure periods.

Technical Basis of Closure and Post-Closure Monitoring Plan

Golder performed a detailed site investigation of the tailing facility from August 1998 through February 1999 to support the closure design. The investigation included 11 cone penetration test soundings and four twinned boreholes that were sampled at nominal 20-foot intervals. The soundings and boreholes were advanced both from the beach and from a floating barge. A thorough characterization of the distribution of pore pressures and tailing material properties was obtained, which provided the technical basis for the closure design.

As a part of the closure design, a monitoring program was developed for implementation through the Closure and Post-Closure periods. The monitoring program described herein reflects the results of analyzing the detailed data gained during the site investigation and considers that active tailing deposition operations have ceased. Threshold limits associated with the Closure and Post-Closure piezometer monitoring program developed by Golder differ from the "Critical Pore Pressure Readings" that were previously developed and applied during operations. It is important to emphasize that since cessation of active operations, the tailing impoundment is undergoing active draindown of the pore water fluids. The continuing decrease in pore water pressures associated with this draindown will theoretically result in a continuing increase of the stability of the tailing embankments. This continuing increase in stability and the associated reduction in risk of a potential dam failure were considered in the development of the proposed monitoring frequencies for the Closure and Post-Closure periods.

The piezometers installed in the Main Dam and Levee Buttress embankments were installed to allow the pore pressures to be monitored within the embankments and the embankment foundations. Excess pore pressures can have a destabilizing effect on embankment stability and it is necessary to determine what pore pressure values are indicative of unacceptable stability conditions within the tailing embankments. To quantify these values, stability sensitivity analyses were performed over a range of simulated pore pressures. This analyses was conducted with the computer package XSTABL to determine the minimum piezometer readings that would indicate Factors of Safety (FOS) below recommended levels. Pore pressures were modeled using a pore pressure grid, with the pore pressure distributions estimated by assuming hydrostatic pore pressure conditions. Since the actual measured pore pressure gradients are less than hydrostatic, the assumption of hydrostatic conditions is considered conservative.

The stability modeling analyses were conducted to support final closure of the tailing facility. The results of this modeling provide defensible and conservative criteria for developing the Closure and Post-Closure monitoring program for the tailing facility. Contractive behavior of loose tailings can result in a progressive reduction of the available shear strength, a phenomena referred to as strain softening. In order to account for potential strain softening, the stability analyses conservatively incorporated total stress shear strength parameters for all loose and slow draining soil materials, which included all of the tailing materials. The FOS were determined as a function of the corresponding pore pressures, to provide guidance as to various levels of potential instability within the tailing embankments. These levels of potential instability are referred to herein as Alert Levels, which are documented on Table 2. Alert Levels are provided in terms of piezometric head reported in feet of water (head) above mean sea level (amsl). An appropriate and widely accepted minimum steady state design FOS for dams is 1.5. A piezometer reading indicative of a FOS below 1.5 would trigger the first alert level response. Piezometer readings indicative of lower FOS values of 1.3 and 1.1 trigger second and third alert level responses, respectively. The corresponding actions associated with each alert level are provided on Table 6.

The stability analyses conducted to develop a suitable monitoring program for the tailing facility conservatively assumed a phreatic level in the toe areas of the embankments at the top of the screen elevation (for the standpipe piezometers) or at the gauge elevation (for the vibrating wire piezometers). This assumption is considered conservative based on historical monitoring data, which indicates these monitoring locations are typically dry. For those monitoring points located in the toe areas of the embankments, as indicated by notes on Table 2, exceedance of the screen/gauge elevations would deviate from the assumed phreatic conditions in the embankment toe areas. This would constitute a 2nd alert level and trigger the responses indicated on Table 6, until evaluated by a qualified geotechnical engineer. For comparative purposes, Table 2 also includes the "Operations Critical Pore Pressure Readings" and the "Operations Phreatic Head" levels which were previously used as alert levels during operations.

A comparison of the alert levels previously used during operations with the Closure and Post-Closure alert levels developed herein indicates that, in general, the Closure and Post-Closure alert levels are more conservative than those previously used during operations. This is likely the result of the approach to use conservative undrained shear strength parameters in the stability analyses, rather than less conservative effective stress parameters, for determining the Closure and Post-Closure alert levels.

TABLE 2
PIEZOMETER MONITORING ALERT LEVELS REPORTED IN TOTAL HEAD (FT AMSL)

Piezo-meter	Location	Screen/ Gauge Elev. (ft. amsl)	Piezometric Head on Dec, 31, 1998[1]	Operations Critical Pore Pressure Reading[3]	Operations Piezometric Head (ft. amsl)[3]	1st Alert Level (ft. amsl)	2nd Alert Level (ft. amsl)	3rd Alert Level (ft. amsl)
1	Main Dam	7233.1	7254.6	75	7308	7280	7293	7298
3	Main Dam	7115.0	7113.3	115	7230	7115.0[1]	7115.0[1]	7115.0[1]
4	Main Dam	7033.1	7031.6	184	7217	7033.1[1]	7033.1[1]	7033.1[1]
5	Main Dam	7096.1	7091.6	152	7193	7096.1[1]	7096.1[1]	7096.1[1]
6	Main Dam	7041.0	7039.2	208	7249	7041.0[1]	7041.0[1]	7041.0[1]
7	Main Dam	7232.9	7250.5	101	7334	7280	7293	7298
9	Main Dam	7230.3	7255.3	162	7392	7320	7333	7338
13	Main Dam	7232.7	7242.1	68	7301	7280	7293	7298
15	Levee Buttress	7231.4	7244.2	122	7353	7297	7301	7304
16	Levee Buttress	7216.7	7221.5	138	7355	7282	7286	7289
17	Levee Buttress	7230.4	7246.2	185	7415	7322	7326	7329
21	Levee Buttress	7216.9	7230.7	156	7373	7282	7286	7289
22	Levee Buttress	7230.9	7239.9	133	7364	7297	7301	7304
23[2]	Main Dam	7212.6	7246.4	111	7323	7280	7293	7298
24	Main Dam	7216.52	7234.4	106	7323	7280	7293	7298
25	Main Dam	7216.6	7184.1	202	7348	7280	7293	7298
27[2]	Main Dam	7210.6	7244.1	120	7330	7280	7293	7298
28	Main Dam	7294.6	7231.0	113	7328	7280	7293	7298
29[2]	Main Dam	7125.8	7199.1	236	7362	7280	7293	7298
30	Main Dam	7130.7	7187.8	229	7360	7280	7293	7298
31	Main Dam	7200.08	7224.9	133	7333	7280	7293	7298
32	Main Dam	7030.8	7023.1	186	7217	7030.8[1]	7030.8[1]	7030.8[1]
33[2]	Main Dam	7030.8	Dry standpipe	186	7217	7030.8[1]	7030.8[1]	7030.8[1]
34	Main Dam	7122.7	7114.1	109	7232	7122.7[1]	7122.7[1]	7122.7[1]
35[2]	Main Dam	7117.2	Dry standpipe	114	7231	7117.2[1]	7117.2[1]	7117.2[1]
36	Main Dam	6963.8	6956.5	245	7209	7250	7250	7250
37[2]	Main Dam	6958.8	Dry standpipe	250	7209	7250	7250	7250
38	Main Dam	7191.3	7228.7	157	7348	7300	7313	7318
41[2]	Levee Buttress	7189.5	7239.7	225	7414	7322	7326	7329
42	Levee Buttress	7280.5	7291.3	111	7393	7360	7364	7367
43	Levee Buttress	7189.0	7215.6	224	7413	7297	7301	7304
44[2]	Levee Buttress	7183.0	7232.4	234	7417	7322	7326	7329
45	Levee Buttress	7231.3	7240.1	158	7389	7322	7326	7329
46[2]	Levee Buttress	7223.3	7247.9	172	7395	7322	7326	7329
47	Levee Buttress	7281.1	7287.0	250	7395	7360	7364	7367

Notes:

1) Any measured water level above the screen/gauge elevation within the downstream shell would constitute a condition that deviates from the assumed phreatic levels in the downstream toe used in the stability analyses, and as such require evaluation by a qualified geotechnical engineer.
2) Indicates a standpipe piezometer monitoring location.
3) The "Operations Critical Pore Pressure Readings" and the "Operations Phreatic Head" levels are the critical monitoring readings which were previously used throughout operations.

Closure and Post-Closure Monitoring Program

The tailing facility monitoring program for Closure and the Post-Closure conditions will consist of the following three components:

- Piezometer monitoring;
- Prism monitoring; and,
- Visual inspections.

The three Closure and Post-Closure monitoring components include criterion for normal activities, critical responses, and a commitment to notify and mobilize (if necessary) a qualified geotechnical engineer for events indicating a critical condition.

Piezometer Monitoring

Monitoring of the previously installed piezometers will be continued throughout the Closure and Post-Closure period, until draindown of the impoundment has reached a level that ensures safe pore pressure conditions will be maintained over the long-term.

Both the Post-Closure and Closure monitoring schedules include a "Steady State" and "Critical" condition schedule. The Closure monitoring schedule also includes a "Construction" condition. As used herein, these conditions are defined as:

- The Steady State condition refers to those time periods when construction activities are not ongoing and the measured pore pressures are less than Alert Level 1 conditions, i.e., the FOS's are greater than 1.5;

- Critical conditions apply during certain unusual events which may impact the stability of the embankments, as defined below on Table 3, and in response to the exceedance of the 2nd Alert Level conditions; and,

- Construction conditions apply during those periods when placement of the soil cover on the tailing facility is occurring and for 30-days following these activities.

TABLE 3
UNUSUAL EVENTS THAT TRIGGER
"CRITICAL MONITORING CONDITIONS"

A tailing pond elevation in excess of 7339-ft elevation.
For 30-days following a seismic event with a magnitude greater than 4.0, with an epicenter within 60-miles from the site.
If a reading showed a significant rise relative to the previous reading, i.e., greater than 10-ft.
Rapid rise of water level in standpipe piezometer(s), i.e., greater than 10-ft.
Piezometer readings that exceeds the 2nd Alert Level Conditions.
Water level readings in currently dry standpipe piezometer(s) and positive pore pressure readings in piezometer(s) located in the downstream shell or in bedrock.

The Closure and Post-Closure monitoring schedule developed to monitor the embankment piezometer readings is provided on Table 4.

Prism Monitoring

The prism surveys will be continued throughout the Closure period, but monitoring during Steady State Conditions in the Post-Closure period is not considered necessary unless an event that triggers Critical conditions occurs (as defined by Table 3). The logic of discontinuing prism monitoring during steady state Post-Closure conditions is that the phreatic conditions within the impoundment are predicted to be significantly lower following the Closure period. As a result, the embankments FOS's will be well in excess of 1.5.

The Closure and Post-Closure prism-monitoring schedule is provided on Table 5. Provided conditions are not Critical or that active construction of the soil cover is not ongoing, prism surveys should be conducted on a quarterly basis during the Closure period. Monitoring during "Construction Conditions" should occur on a monthly basis. The monitoring frequency during Critical conditions is increased to monthly and weekly intervals for the Post-Closure and Closure periods, respectively. In the event that anomalous readings occur, a qualified geotechnical engineer will be notified immediately to evaluate the data and impacts on potential embankment stability.

TABLE 4
PIEZOMETER MONITORING SCHEDULE

Piezometer	Post-Closure Period		Closure Period		
	Steady State	Critical	Steady State	Construction	Critical
1	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
3	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
4	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
5	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
6	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
7	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
9	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
13	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
15	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
16	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
17	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
21	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
22	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
23	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
27	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
29	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
32	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
33	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
34	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
36	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
38	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
41	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
42	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
43	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
44	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
45	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
46	Quarterly	Monthly	Monthly	Weekly	Twice Weekly
47	Quarterly	Monthly	Monthly	Weekly	Twice Weekly

TABLE 5
PRISM MONITORING SCHEDULE

Piezometer	Post-Closure Period		Closure Period		
	Steady State Conditions	Critical Conditions	Steady State Conditions	Construction Conditions	Critical Conditions
1	Not Applicable	Monthly	Quarterly	Monthly	Weekly
3	Not Applicable	Monthly	Quarterly	Monthly	Weekly
4	Not Applicable	Monthly	Quarterly	Monthly	Weekly
5	Not Applicable	Monthly	Quarterly	Monthly	Weekly
6	Not Applicable	Monthly	Quarterly	Monthly	Weekly
7	Not Applicable	Monthly	Quarterly	Monthly	Weekly
9	Not Applicable	Monthly	Quarterly	Monthly	Weekly
13	Not Applicable	Monthly	Quarterly	Monthly	Weekly
15	Not Applicable	Monthly	Quarterly	Monthly	Weekly
16	Not Applicable	Monthly	Quarterly	Monthly	Weekly
17	Not Applicable	Monthly	Quarterly	Monthly	Weekly
21	Not Applicable	Monthly	Quarterly	Monthly	Weekly
22	Not Applicable	Monthly	Quarterly	Monthly	Weekly
23	Not Applicable	Monthly	Quarterly	Monthly	Weekly
27	Not Applicable	Monthly	Quarterly	Monthly	Weekly
29	Not Applicable	Monthly	Quarterly	Monthly	Weekly
32	Not Applicable	Monthly	Quarterly	Monthly	Weekly
33	Not Applicable	Monthly	Quarterly	Monthly	Weekly
34	Not Applicable	Monthly	Quarterly	Monthly	Weekly
36	Not Applicable	Monthly	Quarterly	Monthly	Weekly
38	Not Applicable	Monthly	Quarterly	Monthly	Weekly
41	Not Applicable	Monthly	Quarterly	Monthly	Weekly
42	Not Applicable	Monthly	Quarterly	Monthly	Weekly
43	Not Applicable	Monthly	Quarterly	Monthly	Weekly
44	Not Applicable	Monthly	Quarterly	Monthly	Weekly
45	Not Applicable	Monthly	Quarterly	Monthly	Weekly
46	Not Applicable	Monthly	Quarterly	Monthly	Weekly
47	Not Applicable	Monthly	Quarterly	Monthly	Weekly

Visual Monitoring

Visual inspections of the embankments will be completed during routine monitoring activities. In addition, the engineer-of-record will make annual inspections during the late spring of each year throughout the closure period. The purpose and objective of visual inspections are to identify potential indicators of instability so that proactive steps can be taken to ensure that the embankments remain stable. The embankments will be inspected for evidence of seeps, sloughs, subsidence, unusual settlements, excessive erosion, and tension cracks, which are all potential indicators of instability. Should any of these features be observed, Barrick's site manager and a qualified geotechnical engineer will be notified. Evidence of seepage includes localized moist soil, puddles without precipitation, or localized lush vegetation. Excessive erosional gullies that could potentially lead to a local slope failure, which could then progress into a more significant failure, will be noted and recorded and then scheduled for maintenance and repair. Tension cracks will be noted and recorded. The formation of small to moderate tension cracks are expected to occur in response to settlement. However, since the formation of tension cracks is also an indicator of slope movements, the location and size of tension cracks within 50-ft of the embankments will be recorded to aid in the determination of their cause. A qualified geotechnical engineer will be notified in the event of occurrence of any tension cracks that are not generally parallel to the crest of the embankments, that could potentially transect the core; any tension cracks which are visually increasing in size; a significant increase in the frequency of tension cracks; or, any unusually large tension cracks. Visual monitoring information will be recorded on the attached "Tailings Embankment Visual Monitoring Form", or other similar form.

TABLE 6
ALERT LEVEL RESPONSE

Alert Level	Response
1st Monitoring Alert Level, per Table 2 (1.3 < FOS < 1.5)	Increase the piezometer and prism monitoring schedule during the Closure Period to "Construction Conditions", per Tables 4 and 5. Notify Richard Hall, P.E. at the State of Utah Dam Safety Section (801-538-7373). Increase the piezometer and prism monitoring schedule during the Post-Closure Period to "Critical Conditions", per Tables 4 and 5. Notify Richard Hall, P.E. at the State of Utah Dam Safety Section (801-538-7373).
2nd Monitoring Alert Level, per Table 2 (1.1 < FOS < 1.3), or Triggering Event (Table 3) or Anomalous Prism Reading	Commence "Critical Condition" monitoring schedule. Cease loading or other ongoing construction activities. Retain a qualified geotechnical engineer to review the data and provide recommendations. Notify Richard Hall, P.E. at the State of Utah Dam Safety Section (801-538-7373).
3rd Alert Level, per Table 2	Maintain "Critical Condition" monitoring schedule. Cease all construction activities. The qualified geotechnical engineer will be directed to develop a mitigation plan. The State Engineer (Richard Hall, P.E. at 801-538-7373) will be notified and advised of the response actions being implemented.

Summary

Golder has developed this Closure and Post-Closure monitoring plan for implementation at the Mercur tailing impoundment, based upon the results of recent site investigations and analyses conducted to support closure of the facility. This monitoring plan generally provides for more conservative alert level criteria than that used during operations, but with a decreased monitoring schedule. The decreased monitoring schedule has been developed in recognition that the tailing impoundment has been undergoing active draindown since operations ceased in the spring of 1998. The result of this draindown is a continuing decrease in pore pressures and a corresponding increase in the factor of safety against failure. Should you need any additional information or clarification please do not hesitate to contact the undersigned.

Sincerely,

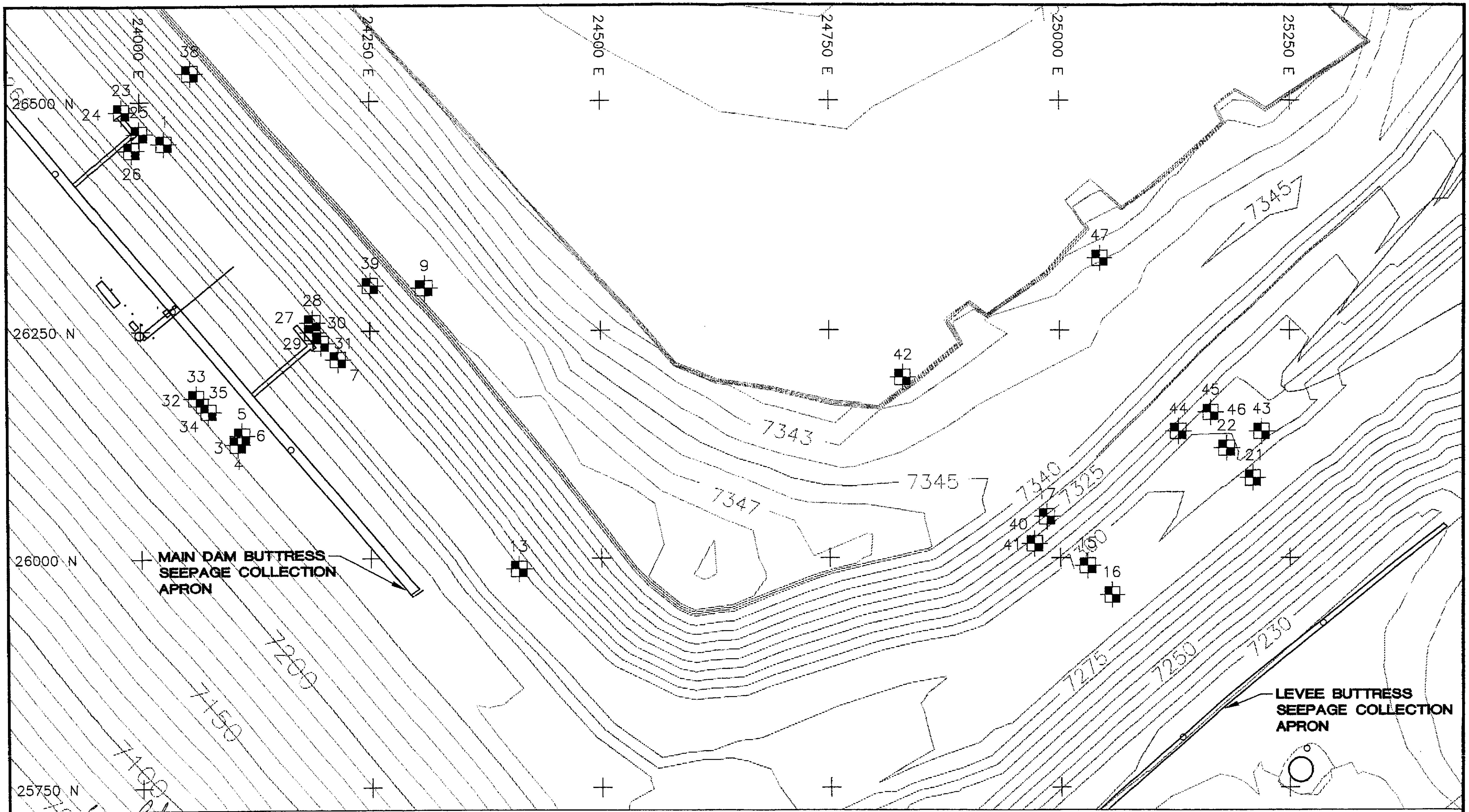
GOLDER ASSOCIATES INC.

Brent Bronson, P.E.
Director U.S. Mining Sector
Associate

PROFESSIONAL ENGINEER
REGISTERED
98-356129-2202
4-9-99
STATE OF UTAH
BRENT R. BRONSON

BB/san

FIGURES



PROFESSIONAL ENGINEER
REGISTERED
98-356129-2202
4-7-99
STATE OF UTAH
BRENT B. BRONSON

Golder Associates

Tucson, Arizona

CLIENT/PROJECT

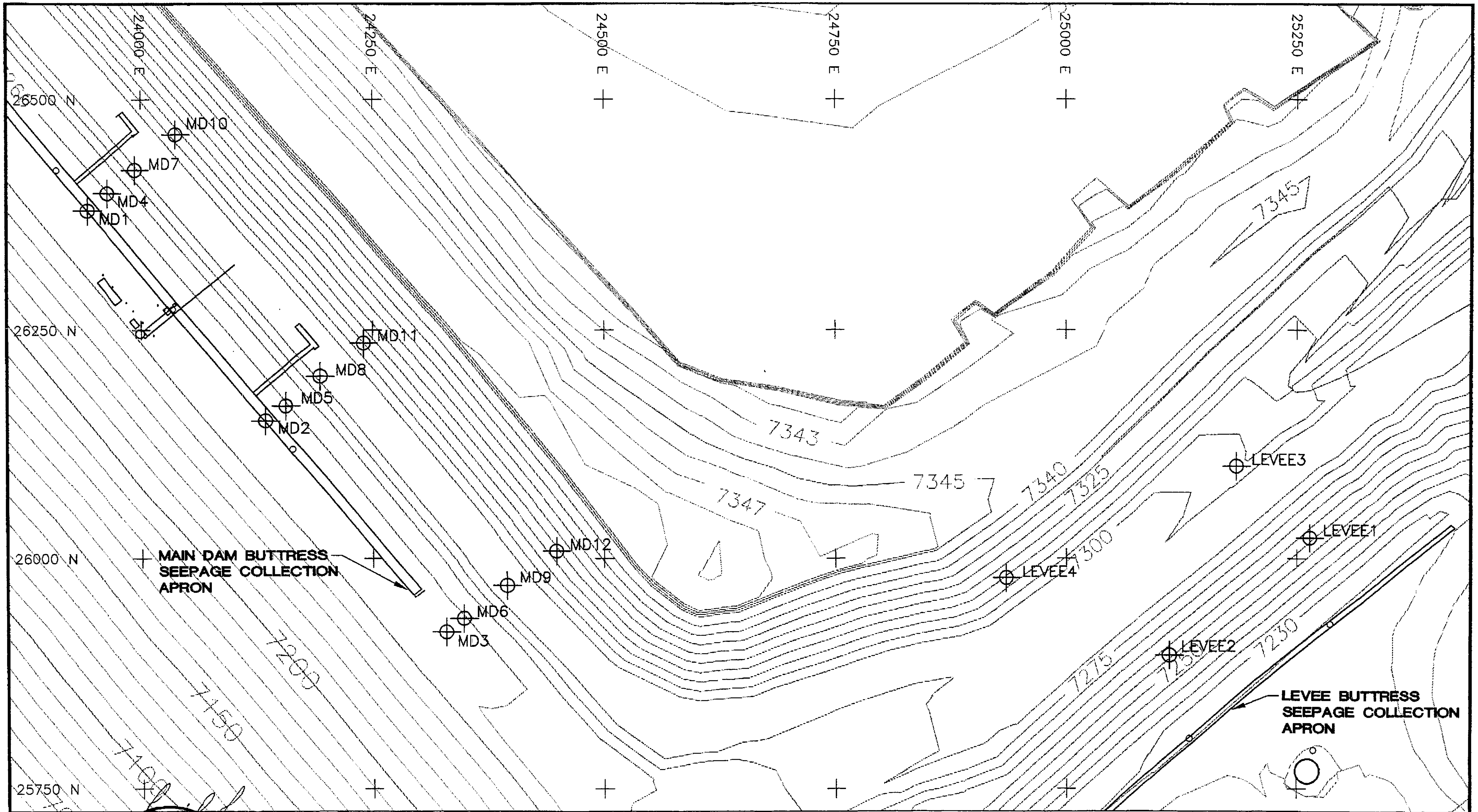
BARRICK

BARRICK RESOURCES (USA) - MERCUR MINE
RESERVATION CANYON TAILINGS
PRELIMINARY CLOSURE DESIGN

TITLE

MAIN DAM AND LEVEE BUTTRESS PIEZOMETER LOCATIONS

DRAWN	MJG, CAN	DATE	FEB 1999	JOB NO.	983-2344
CHECKED	TJW	SCALE	1"=100'	DWG. NO./REV. NO.	
REVIEWED	BRB	FILE NO.	2344PRISM	FIGURE NO.	1



PROFESSIONAL ENGINEER REGISTERED 98-358129-2202 6-9-99 STATE OF UTAH BRENT R. BRONSON

Golder Associates Tucson, Arizona

TITLE	MAIN DAM AND LEVEE BUTTRESS PRISM LOCATIONS				
DRAWN	MJG, CAN	DATE	FEB 1999	JOB NO.	983-2344
CHECKED	TJW	SCALE	1"=100'	DWG. NO./REV. NO.	
REVIEWED	BRB	FILE NO.	2344PRISM	FIGURE NO.	2

CLIENT/PROJECT
BARRICK RESOURCES (USA) - MERCURE MINE
RESERVATION CANYON TAILINGS
PRELIMINARY CLOSURE DESIGN
BARRICK

MONITORING FORM

TAILINGS EMBANKMENT VISUAL MONITORING FORM

MONITOR (NAME) ______________ POND ELEVATION ______________ DATE ______________

RECENT WEATHER CONDITIONS ____

____

EVIDENCE OF SEEPAGE (INDICATE LOCATION ON SKETCH BELOW) ______________

____

____

EROSIONAL FEATURES (INDICATE LOCATION ON SKETCH BELOW) ______________

____

____

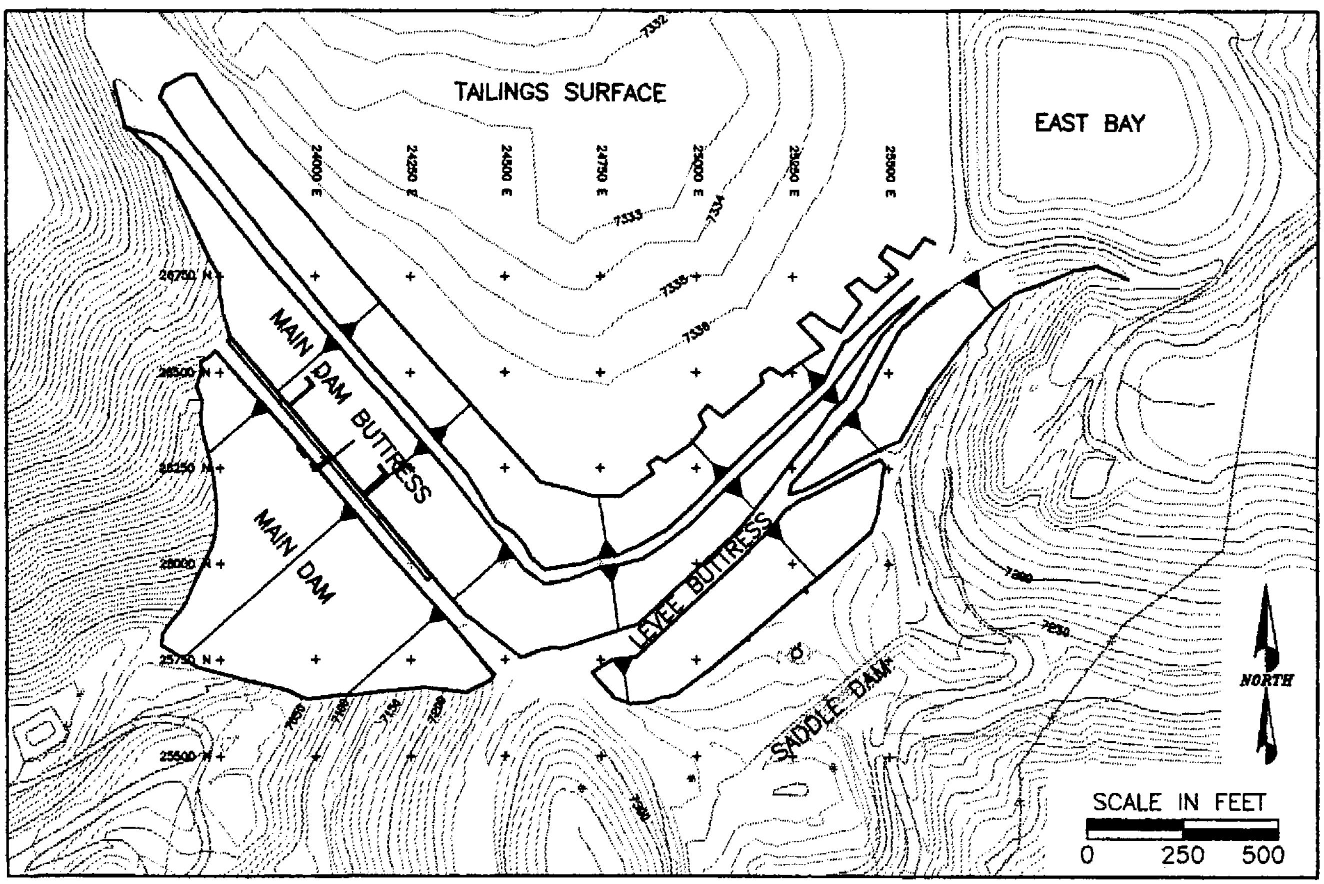
TENSION/SETTLEMENT CRACK OBSERVATIONS (INDICATE LOCATION ON SKETCH BELOW) ______________

____

____

RECOMMENDATIONS/ACTIONS TAKEN: ____

PERSONS NOTIFIED: ____



APPENDIX N

CONSTRUCTION SPECIFICATIONS

BARRICK RESOURCES (USA) INC. - MERCUR MINE
MERCUR CANYON
TOOELE COUNTY, UTAH

IV. CONSTRUCTION SPECIFICATION

FOR

RECLAMATION OF
RESERVATION CANYON TAILINGS IMPOUNDMENT

PROFESSIONAL ENGINEER
REGISTERED
98-356129-2202
7-30-99
STATE OF UTAH
BRENT R. BRONSON

CONSTRUCTION SPECIFICATIONS FOR BARRICK RESOURCES (USA) INC. - MERCUR MINE RECLAMATION OF RESERVATION CANYON TAILINGS IMPOUNDMENT

SECTION	TITLE	REVISION NO.	DATE
DIVISION 1	GENERAL REQUIREMENTS		
SECTION 01090	DEFINITIONS	1	JULY 30, 1999
SECTION 01300	QUALITY ASSURANCE AND CONSTRUCTION DOCUMENTATION	1	JULY 30, 1999
SECTION 01500	MOBILIZATION	1	JULY 30, 1999
SECTION 01600	CONTRACT CLOSEOUT	1	JULY 30, 1999
DIVISION 2	MERCUR MINE SITE RECLAMATION		
SECTION 02100	SITE PREPARATION	1	JULY 30, 1999
SECTION 02200	EARTHWORKS	1	JULY 30, 1999
SECTION 02278	GEOGRID	1	JULY 30, 1999

DIVISION 1
GENERAL REQUIREMENTS

SECTION 01090 DEFINITIONS

PART 1: GENERAL

1.01 SUMMARY:

A. This Section contains definitions and references applicable to the Specifications.

B. Definitions

- "Bidder" The party (or parties) submitting a Proposal to perform the Work.
- "Bonds" Include Bid, performance and payment bonds and other instruments of security.
- "Completion" Means that all Work has been fully completed, (except correction during the Period of Warranty).
- "Contract" The contract entered into by the **OWNER** through the **PROJECT MANAGER** (**OWNER's** Representative) and the **CONTRACTOR** including, without limitation, all of the documents listed under Article 2.0 hereof, and others, if any, listed in the Contract Agreement or in a subsequent Change Agreements signed by the **OWNER** through the **PROJECT MANAGER** (**OWNER's** Representative) and the **CONTRACTOR**.
- "Contract Agreement" The principal document of the Contract, signed by the **OWNER** through the **PROJECT MANAGER** (**OWNER**'s Representative) and the **CONTRACTOR**, that specifies the total Contract Price.
- "Contract Amendment" (Change Order) The document signed by the CONTRACTOR and the OWNER through the **PROJECT MANAGER** (**OWNER**'s Representative) to amend the Contract to provide for changed or extra work and, accordingly, an increase or decrease in the Contract Price.
- "Contract Documents" are defined as the Agreement, Addenda (which pertain to the Contract Documents), Form of Proposal which constitutes **CONTRACTOR**'s Bid (including documentation accompanying the Bid and any post-Bid documentation submitted prior to the Notice of Award) when attached as an exhibit to the Agreement, the Bonds, the General Conditions, the Contract Specifications the Construction Specifications, and the Drawings, together with all Modifications issued after the execution of the Agreement.
- "Contract Price" The total amount of the charges for the Work ("estimated" or "fixed lump sum") stipulated in the Contract Agreement subject to such additions or deductions as may be made under the terms and conditions of the Contract.
- "Contract Unit Prices" The fixed unit prices or rates established by the Proposal which, initially, are applied to estimated measurements of volume, time, or other units of performance to establish an <u>estimated</u> Contract Price, and, which ultimately, are applied to actual measurements to establish a <u>final</u> Contract Price.

- "**CONTRACTOR**" is defined as the party which has executed a Contract Agreement for the specified Work with **OWNER.**

- "Drawings" is defined as the drawings in conjunction with these Specifications titled, Barrick Resources (USA) Inc. – Mercur Mine, Reservation Canyon Tailings Impoundment, Final Closure Design.

- "**ENGINEER**" is defined as the "Engineer of Record" and is a representative appointed and authorized by the **OWNER.** The **ENGINEER** shall be a registered Professional Engineer in the State of Utah, or a designated site representative under his supervision during construction.

- "Equal To, or Equal" Means equal in all respects to the specified product and accepted or reviewed for use in the Work by the Manager, in writing.

- "Final Acceptance" The written Final Acceptance of the Work issued by the **OWNER** through the **PROJECT MANAGER (OWNER**'s Representative) following final inspection, Mechanical Acceptance, and 100 percent completion of the Work.

- "Mechanical Acceptance" The written declaration by the **OWNER** through **the PROJECT MANAGER (OWNER**'s Representative) that any operable unit of equipment or separable portion of the Work is mechanically operative to the extent that all of the deficiencies which can be determined prior to the initiation of use have been corrected by the **CONTRACTOR.**

- "Mercur" Barrick Mercur Mine, Mercur, Utah.

- "Notice" Notices are to be defined as <u>written</u> notice.

- "Off-site Material" is defined as material obtained from sources other than on-site excavations or borrow areas.

- "On-site Material" is defined as borrow soils obtained from within required facility excavations and designated borrow areas;

- "**OWNER**" Barrick Resources (USA) Inc., a Delaware corporation with offices in Salt Lake City, Utah.

- "Products" are defined as new material, machines, components, equipment, fixtures, and systems forming the Work. This does not include machinery and equipment used for preparation, fabrication, conveying and erection of the Work. Products may also include existing material or components required for reuse.

- "Project" is defined as Reclamation of Reservation Canyon Tailings Impoundment.

- "**PROJECT MANAGER**" is defined as the designee(s) or an authorized representative of Barrick Resources (USA) Inc. ("**OWNER**") responsible for the project management. The individual designated by **OWNER** is the only person who may execute the Contract and subsequent Contract Amendments.

- "Proposal" (or "Bid") The written offer setting forth the price(s) to perform the Work, as submitted by the Bidder to the **OWNER** through the **PROJECT MANAGER (OWNER**'s Representative).

- "Quality Assurance Team" is defined as the individuals working under the direction of the **ENGINEER** to perform on site quality assurance tasks for **OWNER.**

- "Record Documents" are defined as the documents prepared and certified by a Registered Land Surveyor in Utah documenting the progress, location, type and quantity of materials placed to complete the Work.

- "Revisions" are defined as changes made to the Specifications or the Drawings that are approved by the **PROJECT MANAGER** and the **ENGINEER** in writing after the Specifications on the Drawings have been finalized.

- "Site" The lands of the **OWNER** under, in, or through which the Work is to be executed.

- "Specifications" is defined as this document of technical specifications prepared for **OWNER.**

- "Subcontractor" The party which, with approval of the **OWNER** through **the PROJECT MANAGER** (**OWNER**'s Representative), has executed a subcontract with the **CONTRACTOR** for the performance of a part of the Work.

- "Substantial Completion" Means the same as and adopts the definition of "Substantial Completion" or "Substantial Performance" contained in the lien legislation in effect in the State in which the Work is to be performed, and in the event no legislative definition exists for the expression "Substantial Completion" or "Substantial Performance" in the said State, Substantial Completion means that the Work has been essentially completed, sufficient to permit beneficial use by the **OWNER** for its intended purpose, and that only items of Work which cannot be completed due to conditions outside the **CONTRACTOR**'s control remain to be done.

- "Supplier" Any party, which with approval of the **PROJECT MANAGER** and **OWNER**, has executed a contract with the **CONTRACTOR** or any Subcontractor to supply materials or equipment in performance of a part of the Work and includes, but is not limited to, a material man.

- "Work" The work to be performed as specified in the Contract Agreement and referred to in the Contract Documents all inclusively as "the Work."

- All slopes are described in terms of horizontal distance to vertical distance.

C. References

References to known standard specifications, including American Society of Testing Materials (ASTM), American National Standards Institute (ANSI), and Federal Test Method Standards (FTMS), shall mean and intend latest edition of such standards/specifications adopted and published at date of receipt of bids. All materials, fabrication, erection and related work required for this project shall comply with these standards/specifications which form part of this Specification as applicable, the same as if fully set forth herein.

** END OF SECTION **

SECTION 01300 QUALITY ASSURANCE AND CONSTRUCTION DOCUMENTATION

PART 1: GENERAL

1.01 SUMMARY:

The intent of this Section is to define the requirements of the Project Construction Quality Assurance (CQA) Program and the Construction Quality Control (CQC) documentation required by the **CONTRACTOR**. The **ENGINEER** will be responsible for all CQA and testing as documented in these Specifications, and will compile a construction certification report at the completion of the Work. **CONTRACTOR** is required to complete all Work and CQC in accordance with the Project requirements. Prior to approval of Work, the **PROJECT MANAGER** will coordinate with **ENGINEER** to ensure that the Work has been completed in accordance with the Work requirements.

1.02 ASSURANCE TESTING AND FREQUENCY:

Quality Assurance tests and frequency are discussed throughout the Specifications. The frequencies indicated are minimums only, and do not include retests of failed materials. Those quality assurance tests and testing frequencies to be conducted in the field by the **PROJECT MANAGER, ENGINEER** or the CQA Team are included in Table 01300-1 at the end of this Section.

1.03 CONSTRUCTION CERTIFICATION DOCUMENTATION:

A. The **CONTRACTOR** shall be responsible for ensuring that accurate surveys are obtained for the as-built locations and elevations, and where applicable, the type, thickness, and geometry of any and all pipes, shape of grading areas prior to material placement, thickness and elevation of subsoil and topsoil layers, ditches, geosynthetic materials, limits of revegetation, and any other aspect of the work required by the contract. The **ENGINEER** may require surveys to document critical construction components. These survey requirements will be coordinated by the **PROJECT MANAGER**, in accordance with the Contract Documents.

B. Submittals By **OWNER** Upon Completion of Work

Within fourteen (14) calendar days after completion of the WORK, **CONTRACTOR** shall furnish **OWNER** and **ENGINEER** with "Record Drawings" (also referred to as "As-Built Drawings") of the Work. All surveying Record Drawings shall be signed and sealed by the Utah licensed surveyor who directed the work. The required surveying for surface topography generation shall be carried out on a 100-foot by 100-foot grid with additional survey points required to define the topographic features (i.e., toe of slope, crest of slope, breaks in grade), unless otherwise directed by **PROJECT MANAGER.** Surveying for pipe layout Record Drawings shall be at fifty (50) foot spacing, breaks in grade and tie-ins from supplementary pipes

CONTRACTOR will submit completed Record Drawings within fourteen (14) calendar days upon completion of the work in the following manner:

1. Submit one (1) reproducible copy to the **OWNER**.

2. Submit one (1) non-reproducible copy to the **OWNER**.

3. Submit one (1) electronic copy to the **ENGINEER** on a 3.5 inch IBM compatible diskette, in AutoCad Version 13.0 or 14.0 format.

4. Submit one (1) reproducible copy to the **ENGINEER**.

5. Submit one (1) non-reproducible copy to the **ENGINEER**.

C. MEASUREMENT AND PAYMENT.

CQC documentation required by **CONTRACTOR** shall be considered incidental and no separate payment will be made for CQC documentation requirements.

TABLE 01300-1
MERCUR MINE CLOSURE
GENERAL QUALITY ASSURANCE TABLE

Item	Test Method	Minimum Testing Frequency[1]	Survey[2]
1.0 Geogrid	Observation	All Shifts	
	Conformance Testing (per Section 2278)	1/250,000 square ft	
2.0 Earthworks			
2.1 Excavation	Observation of excavation conditions and grade stakes	Per excavation	May require surveying depending on the purpose of the excavation.
2.2 Regrading or Reshaping	Observation	Observation	Grade staking required As Built when complete or prior to cover-up with subsequent layer of fill.
2.3 Structural Fill	Observation	As-Needed	Grade staking during filling As Built when complete
	Compaction – Approved Method Specification	All Shifts	
	Moisture Content ASTM D-2216	1/10,000 cubic yards	
23 Grading Fill	Observation	All shifts	Thickness of layer; lift thickness; rate of advancement (ft/day); depth to water; presence and height of mudwave; and, unusual or unsafe conditions.
	Thickness- Excavations or Settlement Plates	One per Acre (minimum)	
2.4 Subsoil	Observation	All shifts	Thickness of layer; lift thickness; rate of advancement (ft/day); presence and height of mudwave; depth to water; and, unusual or unsafe conditions.
	Thickness- Excavations or Settlement Plates	One per Acre	
2.5 Topsoil	Observation	All shifts	Thickness of layer
	Thickness - Excavations	1/10,000 ft^2	

Notes:
1 The results of all CQA observations and testing (field and laboratory) will be presented in a certification report.
2 Record ("As-built") drawings will be prepared and submitted in a certification report.
3 Fill materials with a high percentage of particles in excess of three quarters (3/4) inch nominal size, which in the opinion of the **ENGINEER** are not practical to be tested for moisture density control with ASTM D698 procedures, shall be placed and compacted according to a method specification to be determined and approved by the **ENGINEER**.

** END OF SECTION **

SECTION 01500 MOBILIZATION

PART 1: GENERAL

1.01 SUMMARY:

A. Mobilization shall consist of the complete preparatory work and operations, including but not limited to, those necessary for the movement of personnel, equipment, supplies and incidentals to the project site; for the establishment of offices, buildings and other facilities necessary to complete the Work; and for other work and operations **CONTRACTOR** must perform or costs **CONTRACTOR** must incur before beginning work on the project, which is not covered in other bid items. Demobilization of personnel, equipment, supplies and incidentals from the site at the conclusion of construction activities are considered incidental to Mobilization and no separate payment will be made for demobilization.

B. Measurement and Payment

1. Payment for the performance of the mobilization work as above specified will be made at the contract lump sum price for the item "Mobilization"

2. The partial payment amounts to be allowed for "Mobilization" under the contract will be as follows:

   a. Ten (10) percent of the amount bid for mobilization, less normal retainage, will be paid for each one (1) percent of total original contract amount earned from other bid items.

3. The above schedule of partial payments for mobilization shall not be construed to limit or preclude partial payments otherwise provided by the agreement.

** END OF SECTION **

SECTION 01600 CONTRACT CLOSEOUT

PART 1: GENERAL

1.01 DESCRIPTION:

PROJECT MANAGER shall prepare punch list when notified by **CONTRACTOR** that work is completed. **PROJECT MANAGER** and **ENGINEER** will conduct one final inspection only. (Note: Failure of **PROJECT MANAGER** to include any items on punch list does not alter responsibility of **CONTRACTOR** to complete THE Work in accord with Contract Documents.) Deliver all items called for herein and under various SPECIFICATION sections, and other Contract Documents requirements, to **OWNER** at completion of work.

** END OF SECTION **

DIVISION 2
RECLAMATION OF
RESERVATION CANYON TAILING IMPOUNDMENT

SECTION 02100 SITE PREPARATION

PART 1: GENERAL

1.01 SUMMARY:

A. This Work includes all the site preparation activities within the spillway limits, borrow areas, or other construction areas that require: clearing and grubbing, Topsoil stockpiling, and installation of temporary surface water and erosion controls. This Work is to be performed for the purpose of preparing the site for all earthwork related activities associated with the Reclamation of the Reservation Canyon Tailings Impoundment Project specifically regrading, soil placement, erosion control, and surface water channel construction activities.

B. Refer to the following Sections for related work:

Section 01300 - Quality Assurance and Construction Documentation
Section 02200 - Earthworks
Section 02278 - Geogrid

1.02 QUALITY ASSURANCE:

A. **ENGINEER** shall at all times have access to the work during its construction and shall be furnished with every reasonable facility for ascertaining that the materials and workmanship are in accordance with the Drawings and these Specifications.

B. All site preparation operations shall be carried out under the observation of **ENGINEER** or **PROJECT MANAGER.** Testing shall be performed by **ENGINEER** in accordance with Section 01300 - Quality Assurance and Construction Documentation.

C. Any work found unsatisfactory or any work disturbed by subsequent operations before acceptance is granted shall be corrected by **CONTRACTOR** as directed by **PROJECT MANAGER.**

1.03 MEASUREMENT AND PAYMENT

A. Measurement and payment shall be:

1. Clearing and Grubbing shall be considered incidental for all in-scope Work;

2. Per net volume (yd^3) of Topsoil stripped and acceptably stockpiled.

PART 2: EXECUTION

2.01 CLEARING AND GRUBBING:

A. Clearing and grubbing shall be done in designated areas within the footprint of the spillway, or other components of the Work where virgin ground will be impacted as delineated on the Drawings. Clearing and grubbing shall extend a maximum of fifteen (15) feet and a minimum of five (5) feet outside of the construction limits. Areas for clearing and grubbing shall be released to the **CONTRACTOR** by the **PROJECT MANAGER**. No pioneering of roads across undisturbed areas shall be allowed without prior written approval of the **PROJECT MANAGER.**

No clearing and grubbing shall be performed until written permission is given by the **PROJECT MANAGER.** Clearing and grubbing shall consist of cutting trees and brush to the ground level, removing such material, along with wood, rubbish, and any other vegetation, and disposing of all such material in the accepted manner described below.

B. The **CONTRACTOR** shall clear all vegetative matter, rubbish, roots in excess of one (1) inch diameter, and other deleterious materials from the delineated areas.

Cleared and grubbed vegetation shall be removed and disposed of in stockpiles, by controlled burning, or wasted by way of other approved methods in an area designated by the **PROJECT MANAGER** in accordance with permits obtained from the appropriate local, State, and Federal regulatory agencies.

2.02 TOPSOIL:

A. Stripping of the salvageable Topsoil shall be done where Topsoil is present within the entire area of the stripping limits as designated on the Drawings, as determined by **PROJECT MANAGER.**

Topsoil shall be excavated and removed in a manner which will minimize contamination with other soil horizons.

Such measures as are necessary shall be taken to insure that the removal of Topsoil does not result in erosion or excessive sedimentation.

B. In areas designated to be stripped of unsuitable or objectionable material, said materials shall be stripped to the full depth of organic soil as determined by **ENGINEER** and **PROJECT MANAGER.**

C. Removed Topsoil shall be stockpiled at locations designated by the **PROJECT MANAGER** or placed directly on components of the Work requiring replacement of Topsoil as directed by the **PROJECT MANAGER.** Stored Topsoil shall not be disturbed by construction activities, and shall be protected from wind and water erosion, unnecessary compaction, and contamination which would lessen the capability of the material to support vegetation when redistributed. Topsoil stockpiles will be graded to minimize erosion and prevent ponding of precipitation in the stockpile areas. Stockpiled Topsoil shall be protected by an effective cover of non-noxious, quick-growing, annual and perennial plants, seeded or planted during the first appropriate growing season after removal.

2.03 TEMPORARY EROSION AND SURFACE WATER CONTROLS:

A. The **CONTRACTOR** shall be responsible for providing temporary erosion and surface water controls during construction and shall be responsible for, and shall repair at his own expense, any damage to the foundation, structures or other parts of the WORK caused by stormwater runoff, or failure of any temporary erosion or surface water controls.

B. The **CONTRACTOR** shall be responsible for providing temporary surface water controls during construction. All temporary surface water controls not part of the permanent facility shall be removed, leveled and graded. Disturbance of areas beyond the clearing limits shall not be undertaken without prior written approval by **PROJECT MANAGER.**

C. The **CONTRACTOR** shall have full responsibility for the adequacy of the temporary erosion and surface water controls. The sizing for temporary erosion and surface water controls should consider the duration of the construction activities, the time of the year of construction, characteristics of the storms during the construction seasons, cost of possible damage, cost of delay to the construction completion of the Work, and the safety of workmen. Historic rainfall data for the Barrick Mercur site and synthetic storm hydrographs for various return periods will be made available to **CONTRACTOR** by **PROJECT MANAGER**, upon request. **ENGINEER, OWNER** and **PROJECT MANAGER** assumes no responsibility for any interpretations or conclusions made by the **CONTRACTOR** from the supplied data.

** END OF SECTION **

SECTION 02200 EARTHWORKS

PART 1: GENERAL

1.01 SUMMARY:

A. This Work includes all the earthwork activities required to reclaim the tailings impoundment. This work includes, but is not limited to; excavation, haulage, and placement of Grading Fill, Subsoil, and Topsoil ,materials for the soil cover; construction of the final spillways and drainage channels; and, procurement, haulage and deployment of geogrid as required for construction of the soil cover.

B. Refer to the following Sections for related work:

Section 01300 - Quality Assurance and Construction Documentation
Section 02100 - Site Preparation
Section 02278 - Geogrid

1.02 QUALITY ASSURANCE AND QUALITY CONTROL:

A. **ENGINEER** shall at all times have access to the work during its construction and shall be furnished with every reasonable facility for ascertaining that the materials and workmanship are in accordance with the Drawings and these Specifications.

B. All excavation, backfill, and grading operations shall be carried out under the observation of **PROJECT MANAGER**. Testing shall be performed by **ENGINEER** in accordance with Section 01300 - Quality Assurance and Construction Documentation.

B. Any work found unsatisfactory or any work disturbed by subsequent operations before acceptance is granted, shall be corrected by **CONTRACTOR** as directed by **PROJECT MANAGER.**

C. Contractor to record the total thickness of layer; lift thickness; rate of advancement of the lift (ft/day); depth to water; presence and height of mudwave; and, unusual or unsafe conditions while placing the Grading Fill materials, or Subsoil Fill where Grading Fill materials are not required.

1.03 MEASUREMENT AND PAYMENT

A. Measurement and payment shall be made for:

1. Per unit (placed cubic yard) of grading fill loaded, hauled and placed to the minimum thickness indicated on the Drawings. Measurement will be made by pre and post-excavation surveys of settlement plates, installed on nominal 200-ft centers. Billable quantities will be based on neat line in-place fill.

2. Per unit (placed square yard) of Subsoil (loaded, hauled, and placed) to a nominal thickness of two (2) feet, per the tolerances defined in these

specifications and thicknesses as shown on the Drawings. Measurement will be based upon a neat line post-construction surface survey of the placed subsoillimits. Subsoil excavated from the spillway excavations will be conducted to the lines and grades as shown on the Drawings.

3. Per unit (square yard) of Topsoil (loaded, hauled, and placed) to a nominal true thickness of one (1) foot, per the tolerances defined in these specifications and thickness as shown on the Drawings. Measurement will be based upon a neat line post-construction survey of the placed topsoil limits.

4. Per unit (square yard) of geogrid deployed from **OWNER'S** stockpile.

5. Per unit (linear foot) of diversion channel type, constructed to the lines and grades shown on the Drawings, unless designated otherwise by the Contract Documents.

6. Per unit (cubic yard) of Riprap loaded, hauled and placed.

7. Per cubic yard of Structural Fill (load, haul, and place) to the lines and grades shown on the drawings, except for Structural Fill required as part of the construction of the Diversion channels which are incidental to diversion channel unit payment.

B. No separate measurement or payment shall be made for stockpiles, unless otherwise approved by the **PROJECT MANAGER.**

PART 2: PRODUCTS

2.01 FILL MATERIALS:

A. Fill materials will be soils, gravels or rock fills approved by **PROJECT MANAGER and ENGINEER**. The materials shall be free of organic matter, debris, frozen material, and other deleterious materials, and shall consist as follows:

1. Subsoil: Subsoil shall be Common Excavation consisting of clean soil and waste rock materials excavated from the Alluvial Subsoil Stockpile or the Spillway Cut area as approved by the **PROJECT MANAGER** and **ENGINEER**. The subsoil in the Spillway Cut Stockpile shall not be excavated beyond the lines and grades illustrated on the Drawings. The maximum particle size allowed for fill shall be sixteen (16) inches, unless approved otherwise by **ENGINEER**, as measured in two adjacent and perpendicular dimensions.

2. Topsoil: Topsoil shall consist of organic soil materials excavated from undisturbed ground in the Spillway Cut or designated stockpiles, as approved by the **PROJECT MANAGER.**

3. Grading Fill: Grading Fill shall consist of limestone rockfill from the Suggar Shack Quarry, from excess rockfill materials which comprise the crest berm, subsoil materials or other material as pre-approved by the **PROJECT MANAGER** and **ENGINEER.**

4. Structural Fill: Structural Fill shall consist of soil and rock materials used for diversions, and other areas as designated on the Drawings. The suitability of Structural Fill material will require evaluation by **ENGINEER** and approval by **PROJECT MANAGER** and **ENGINEER**. Structural Fill will have a maximum particle size of sixty-seven (67) percent of the Lift Height and will compaction by an approved method specification. Any materials greater than the allowable size will be broken down or removed.

5. Riprap: shall consist of hard, dense, durable stone, angular to subrounded in shape and resistant to weathering, e.g., limestone. Riprap shall have a particle size gradation that generally conforms to the Riprap schedule shown on the Drawings. Riprap is to be developed from the rock excavations and/or from the Sugar Shack quarry as visually approved by the **PROJECT MANAGER** and **ENGINEER.**

2.02 EXCAVATED MATERIALS:

A. Common Excavation: This classification includes all material other than rock excavation.

B. Rock Excavation: This classification includes all solid rock which cannot be removed until loosened by blasting, boring, or wedging. It is further defined as rock of such hardness and texture that it cannot be loosened or broken down by a single shank ripper mounted on a D-9 Caterpillar Bulldozer (or equivalent) in good operating condition handled by an experienced operator. In areas where it is impractical to classify material by use of the ripper described, rock excavation is defined as sound material of such hardness and texture that it cannot be excavated with a Caterpillar 235 Backhoe (or equivalent) in good operating condition handled by an experienced operator. It also includes boulders and detached pieces of solid rock greater than three quarters of a cubic yard in volume.

C. Excavated bedrock materials shall be classified in accordance with Article 2.01 of this Section.

PART 3: EXECUTION

3.01 BORROW AREAS:

A. Excavation of materials from the various borrow areas shall be performed in such a way as to minimize the disturbance to surrounding areas. Material removed from the borrow areas shall be taken directly to the fill areas or, if required, stockpiled. Any stockpiles, if required, shall be located at sites pre-approved by the **PROJECT MANAGER.**

B. Borrow area excavations shall be graded and properly maintained to provide adequate drainage at all times. Work shall be suspended by the **CONTRACTOR** when, in the opinion of the **PROJECT MANAGER**, the site is overly wet, muddy, or otherwise unsuitable for proper maintenance, until directed otherwise by the **PROJECT MANAGER.**

C. At the conclusion of the Work, all borrow area excavations shall be left with smooth neat lines and grades suitable for reclamation, with grades that are in general conformance with the Drawings.

3.02 SUBGRADE:

A. The Structural Fill materials shall be placed on bedrock or suitable subgrade which has been prepared by the **CONTRACTOR** and approved by the **ENGINEER**. Alluvial soils located within the limits of placement of Structural Fill will be scarified to a depth of one (1) foot. The subgrade will be moisture conditioned and compacted to a minimum of ninety-five (95) percent of the maximum dry density, as determined by the standard Proctor test (ASTM D698), or by an equivlalent method specification approved by **ENGINEER**. The **ENGINEER** will inspect and approve the exposed subgrade prior to any fill being placed. In rock areas, the **CONTRACTOR** shall prepare the subgrade by removing loose rock fragments until competent foundation material is encountered, as approved by **ENGINEER**.

B. The subgrade shall not contain saturated or other deleterious materials as determined by the **PROJECT MANAGER** or **ENGINEER**.

C. The **CONTRACTOR** shall protect prepared subgrades from disturbance due to weather, construction equipment, or other factors. Subgrade surfaces, including previously approved subgrade, which become softened or otherwise unsuitable, shall be repaired to the satisfaction of the **PROJECT MANAGER** and **ENGINEER**. Subgrades found to exhibit swelling, heaving or other similar conditions shall be replaced or reworked by the **CONTRACTOR** to remove such defects.

3.03 FILL PLACEMENT:

A. General Requirements

Fill placement activities shall be performed to achieve the lines and grades as shown on the Drawings, to tolerance of plus or minus two tenths (± 0.2) feet, unless approved otherwise. The following general guidelines shall be followed except as noted elsewhere in this Section.

1. No Structural Fill materials shall be placed until the site preparation activities have been completed as specified in Section 02100, and subgrade preparation activities have been completed as specified herein Article 3.02 of this Section. The procedures for fill placement shall be reviewed by **ENGINEER** and approved by **PROJECT MANAGER** prior to start of fill placement.

2. No brush, roots, sod, or other deleterious or unsuitable materials shall be incorporated in the fills. The suitability of all materials intended for use in the fill shall be subject to approval by **PROJECT MANAGER** and **ENGINEER**. **CONTRACTOR** shall temporarily stop fill placement due to weather conditions, if materials and installation do not meet these Specifications.

3. At all times during construction, the surface of the fill shall be graded and maintained by the **CONTRACTOR** to prevent ponding of water and for storm water drainage.

4. Except as otherwise specified or approved by **ENGINEER** and **PROJECT**

MANAGER, the **CONTRACTOR** shall dump and spread fill in such a manner so that no excessive gaps are left between successively-dumped loads of materials. The fill shall be leveled prior to compaction by means of a dozer or grader, or other suitable approved equipment, to obtain a surface free from depressions.

B. Structural Fill

1. **CONTRACTOR** shall apply water required for moisture conditioning on the fill or in the borrow areas, for Structural fill materials with moisture conditioning requirements. Structural Fill will be placed to the lines and grades as shown on the Drawings, to a tolerance of plus or minus two-tenths (± 0.2) foot, unless approved otherwise by the **PROJECT MANAGER** and **ENGINEER**. Unless noted otherwise, Structural Fill will be compacted with a method specification approved by ENGINEER, at a moisture content of minus four (4) to plus three (3) percent of the optimum moisture content.

   Prior to mixing of wet and dry material on the fill to obtain the proper moisture content, approval shall be obtained from **ENGINEER**. Placing mixed material on the fill can only be done after the material has been mixed so that a uniform distribution of the moisture content has been achieved.

2. Structural Fill used to construct safety berms and diversion channel sections will be compacted with a method specification by wheel rolling the surface of the berm, or other methods approved by the **PROJECT MANAGER** and **ENGINEER**.

C. Grading Fill

1. The limits of Grading Fill placement will be determined based upon foundation conditions encountered in the field. It is the intent of this scope of work to terminate the limits of placement of Grading Fill materials when foundation conditions prohibit the efficient placement of these materials, e.g., when placement of fill materials on the tailing surface results in mud-wave displacement of the tailings in excess of one and five tenths (1.5) vertical foot.

2. Geogrid has been approved for use by **CONTRACTOR** to stabilize the surface of the tailings where required for safety or where its use is cost efficient due to higher equipment productivities. **CONTRACTOR** will haul geogrid from **OWNER's** stockpile and will complete deployment in accordance with Section 2278 of these Specifications. It will be the **PROJECT MANAGER**'s decision whether to deploy geogrid or altenatively to allow the tailings subgrade to dry further to increase its shear strength. Whenever the average shear strength of the upper two (2) feet of the tailings subgrade is less than 200 psf, geogrid is required prior to material placement. The average shear strength of the tailings can be assessed using tensiometerrs, penetrometers, and torsional shear vanes.

   Biaxial geogrid is to be deployed directly on the tailings surface, after which the Grading Fill (or Subsoil Fill) is pushed out over the geogrid. In general, only low ground pressure dozers, e.g., a Catapillar D4C LGP dozer with wide tracks (gross weight of approximately 17,400 lbs) should be used to place the fill over the geogrid layers. From the point of truck dump, the fill may typically be advanced to within 15-ft of the leading edge of the placed fill with larger dozers, if the area covered is deemed stable. The low ground pressure dozer (LGP) should then be used to move the grading fill or subsoil material forward over the geogrid.

The technique of placing the fill over very soft soils with the dozer is important. When the LGP dozer approaches the leading edge of the fill, the height of the fill being pushed should not exceed one-half of the dozer blade height. The operator should lift the blade at the leading edge of the fill in order for the fill to spill down onto the exposed geogrid, rather than being pushed downward by the blade. The leading edge of the fill is leveled to the specific lift thickness. The mounding of material at the leading edge on soft soils is strictly prohibited. This placement procedure prevents excessive pressure from being exerted on the subgrade before the geogrid is fully anchored and minimizes mudwaving of the underlying soft soil.

3. No Grading Filll materials shall be placed until the areas have been approved for fill placement by the **PROJECT MANAGER** and **ENGINEER.** The procedures for fill placement shall be evaluated and approved by the **PROJECT MANAGER** and **ENGINEER** prior to start of fill placement.

4. Placement of Grading Filll activities shall be performed to achieve the design requirements as defined in these specifications and shown on the Drawings. Grading Fill shall be placed to neat lines to the minimum thicknesses shown on the Drawings, confirmed by settlement plates constructed on 200-ft centers (unless approved otherwise by **OWNER**). Tolerances for Grading Fill thickness are minus two (2) tenths to plus five (5) tenths of the Grading Filll thickness requirements shown on the Drawings. Any filling beyond these limits shall be at the expense of the **CONTRACTOR**, unless approved otherwise by the **PROJECT MANAGER.**

5. **ENGINEER** has provided guidance calculations to **CONTRACTOR** of the estimated maximum initial and subsequent lift heights, minimum lift heights, setback distances, etc. for various depth of subsurface water, tailings shear strength, slope of leading edge, presence of geogrid etc. conditions. These guidance have been provided so that prior to fill placement, the likelehood of successful placement can be assessed using probes that assess water depth and tailings shear strength (i.e., tensiometers, penetrometers, torsional shear vanes). However, it is expected that the **CONTRACTOR** will constantly refine placement techniques based upon experience and observations gained during the construction period.

D. Subsoil

1. Placement of Subsoil activities shall be performed to achieve the lines, grades, and design requirements as shown on the Drawings. Tolerances for Subsoil are a minimum thickness of one (1) foot and a maximum thickness of one and twenty-five one hundreds (1.25) feet on the buttresses and above the existing Capillary Break rockfill surface constructed on the Reservation Canyon Tailings Impoundment. For those sectors of the impoundment beyond the limits of the existing Capillary Break rockfill, the tolerances for subsoil shall be a minimum thickness of one and seventy-five hundredths (1.75) feet to two and three tenths (2.3) feet. Any filling beyond these limits shall be at the expense of the **CONTRACTOR**, unless approved otherwise by the **PROJECT MANAGER.**

2. No Subsoil materials shall be placed until the areas have been approved for fill

placement by the **PROJECT MANAGER** and **ENGINEER**. The procedures for fill placement shall be evaluated and approved by the **PROJECT MANAGER** and **ENGINEER** prior to start of fill placement.

3. Subsoil fill placement directly on tailings shall be conducted in accordance to the geogrid and fill placement requirements discussed above in Article 3.03C of this section and Section 2278 of these specifications.

E. Topsoil

1. Topsoil placement activities shall be performed to achieve the lines, grades, and design requirements as shown on the Drawings. Tolerances are as follows:

   a. Topsoil shall be placed to a nominal true thickness of twelve (12) inches, a maximum thickness of fourteen (14) inches, and a minimum thickness of ten (10) inches above the Regraded surface or the Subsoil surface as specified on the Drawings.

   b. Topsoil thickness not within acceptable tolerance as determined by the **ENGINEER** and **PROJECT MANAGER** will be corrected by and at the expense of the **CONTRACTOR**, unless approved otherwise by the **PROJECT MANAGER.**

2. No Topsoil materials shall be placed until the areas have been approved for fill placement by the **PROJECT MANAGER.**

3. Topsoil shall be placed in one lift in such a manner to minimize compaction. The procedures for fill placement shall be evaluated and approved by the **ENGINEER** and **PROJECT MANAGER** prior to start of fill placement.

3.04 EXCAVATIONS:

A. Unless specifically noted otherwise, all excavations shall be performed to the lines and grades shown on the Drawings, or to approved field fit modifications made thereto, as approved by the **ENGINEER** and **PROJECT MANAGER**. Any excavation beyond these limits shall be at the expense of the **CONTRACTOR**, unless approved otherwise by the **PROJECT MANAGER.** No excavation or stripping shall begin until the Surveyor has provided construction staking for the proposed work. The exposed subgrade shall be inspected and approved by the **ENGINEER** and **PROJECT MANAGER** prior to any fill placed. Final surface shall be free of loose materials, clods, and other debris including grade stakes and hubs.

B. Excavations shall be graded and properly maintained to provide adequate drainage at all times. Work shall be suspended by **CONTRACTOR** when, in the opinion of **PROJECT MANAGER**, the site is overly wet, muddy, or otherwise unsuitable for proper maintenance.

C. Blasting if required for Rock Excavation shall be conducted only by trained and experienced personnel who hold blasting certificates for the Work.

D. All necessary precautions shall be taken to preserve the material below and beyond the lines of excavation in the soundest possible condition. Where required to complete the Work, all excess excavation or overexcavation shall be refilled with approved materials, placed and compacted to the satisfaction of the **PROJECT MANAGER**.

E. Safe temporary construction slopes are the responsibility of the **CONTRACTOR**.

F. The **CONTRACTOR** shall inspect all temporary and permanent open-cut excavations on a regular basis for signs of instability. Should signs of instability be noted, the **CONTRACTOR** shall undertake remedial measures immediately and shall notify the **PROJECT MANAGER** as soon as possible.

G. It will be the **CONTRACTOR's** responsibility to remove all loose materials from the excavated slopes and to maintain the slopes in a safe and stable condition at all times during the progress of the Work.

H. Before undertaking Rock Excavation, the **CONTRACTOR** will submit the proposed method of excavation to the **ENGINEER** and **PROJECT MANAGER** for review and approval. The **CONTRACTOR** will have the responsibility to ensure the method conforms to all applicable laws and regulations and conforms to proven safe practices for the type of rock, proximity to structures and other installations, prevents the opening of seams and otherwise provides for minimal disturbance or the breaking the rock beyond the required lines, levels and grades, and keeps the danger and danger area to the minimum practical. Use line drilling and pre-splitting, or pre-shearing in conjunction with cushion blasting or other approved method for final rock slopes. Use approved blasting mats as necessary to restrain the movement of material. Provide all flagman, signs, sirens, and other means necessary for safe use of explosives. Before each blast, clear all personnel, vehicles etc. from the blast area to safe limits and then ensure no personnel, vehicles etc. enter the area until after completion of the blast. Scale the sides of rock cuts as soon as possible, preferably as the sides become exposed.

I. Construct Diversion Channels with uniform gradients between approved control points for the approved channel alignment, without excessive sags and without humps, unless specifically approved otherwise by the **ENGINEER**. Cross sectional flow areas for the Diversion Channels shown on the Drawings are the minimum allowable sections. Channel cross sections are not to be achieved through the construction of levees unless shown as such on the Drawings or approved by the **ENGINEER**. The diversion channel alignments may require field adjustment to maintain the channel tolerances as defined in this section and on the Drawings. Tolerances of approved diversion alignments, unless approved otherwise by the **ENGINEER**, will be as follows:

1. For channel sections which will be excavated in fill materials, the tolerance of the constructed alignments shall be within minus one-half (1/2) to plus one-half (1/2) percent of the design grades as shown on the Drawings, with a minimum allowable gradient of one-quarter (0.25) percent between fifty (50) foot stations.

2. For channel sections which will be excavated in native material the tolerance of the constructed alignments shall be within minus one-half (1/2) to plus one (1) percent of the design grades as shown on the Drawings, with a minimum allowable gradient of one-quarter (0.25) percent between fifty (50) foot stations.

** END OF SECTION **

SECTION 02278 GEOGRID

PART 1: GENERAL

1.01 DESCRIPTION:

A. The **CONTRACTOR** shall furnish all labor, materials, tools, equipment, supervision, transportation, and installation services necessary, for the deployment and installation of the geogrid that will be used to stabilize the surface of the tailings. **CONTRACTOR** will use geogrid for all haulage routes within the tailings impoundment and to stabilize the surface of the tailings in those areas where required to safely and efficiently complete the work. The Work shall be carried out in accordance with this Specification and the Construction Drawings.

1.02 RELATED WORK:

A. Section 02200 - Earthworks

1.03 REFERENCES:

A. American Society for Testing and Materials (ASTM) most current version:

1. ASTM D1388 - Method for Measuring Flexural Rigidity
2. ASTM D1777 - Method for Measuring Thickness of Textile Materials.
3. ASTM D4101 – Method for the Determination of Polypropylene Content
4. GRI1 - Test Method GG1 - Geogrid Tensile Strength.
5. GRI - Test Method GG2 - Geogrid Junction Strength.
6. GRI - Test Method GG3 - Creep Behavior and Long Term Design Loads of Geogrid.

1.04 MEASUREMENT AND PAYMENT

Per unit (square yard) of geogrid deployed and installed from **OWNERS** stockpile.

1.05 SUBMITTALS:

A. The **CONTRACTOR** shall abide by all qualification and submittal requirements of Sections 01300.

1.06 QUALITY ASSURANCE:

A. The geogrid is to be delivered to the site at least 14 calendar days prior to installation to allow sufficient time for conformance testing.

B. Any geogrid rolls that do not meet the requirements of this Specification will be rejected. The OWNER will be required to replace the rejected material with new material that conforms to the specification.

1.07 DELIVERY, STORAGE, AND HANDLING:

A. Packing and Shipping

1. Geogrids shall be supplied in rolls wrapped in relatively opaque protective covers.

2. Geogrid or geocomposite rolls shall be marked or tagged with the following information:

a. Manufacturer's name
b. Product identification
c. Roll number
d. Roll dimensions
e. Batch or lot number

B. Storage and Protection

1. OWNER will provide on-site storage area for geogrid rolls from time of delivery until installation.

2. After Geosynthetics Installation **CONTRACTOR** has removed material from storage area, protect geogrid, ultraviolet light exposure, and other sources of damage.

3. Preserve integrity and readability of geogrid roll labels.

PART 2: PRODUCTS

2.01 MATERIALS

A. Geogrid shall be Tensar BX1100 or pre-approved equivalent by **ENGINEER**.

B. Geogrid Requirements

1. Furnish materials whose "minimum average roll values", as defined by Federal Highway Administration (FHWA), meet or exceed geogrid property values specified in Table 2278-1. Obtain written approval for these materials from the **ENGINEER**.

TABLE 2278-1
GEOGRID PROPERTIES AND TEST METHODS

Property	Test Method	Units	Value
Interlock			
• Aperture Size	I.D. Calipered		
- D		in	1.0 (nom)
- MD		in	1.3 (nom)
• Open Area	COE Method	%	70 (min)
• Thickness	ASTM D1777-64		
• Ribs		in	0.03 (nom)
• Junctions		in	0.11 (nom)
• Secant Aperture Stability Modulus @ 20 cm-kg	Grid Aperture Test (Univ. Alaska Fairbanks)	cm-kg/deg	3.2
Reinforcement			
Flexural Rigidity - MD	ASTM D1388-64	mg-cm	250,000 (min)
Tensile Modulus- MD	GRI GG1-87	lb/ft	14,000 (min) 1
Junctions			
• Strength	GRI GG2-87	lb/ft	765 (min)
• Efficiency	GRI GG2-87	%	90 (min)
Material			
Polypropylene	ASTM D4101 Group 1 /Class 1 /Grade 2	%	98 (min)
Carbon Black	ASTM 4218	%	0.5 (min)

Notes:
1) MD = Machine direction
CMD = Cross machine direction
2) Tensar BX-1100 or approved equivalent

2.02 SOURCE QUALITY CONTROL:

Ensure that geogrid manufacturer meets the conditions in this section.

A. Geogrid Tests and Inspection

1. Geogrid shall be tested by geogrid manufacturer for quality control to evaluate the minimum geogrid requirements as specified in Table 2278-1. Samples not satisfying specifications shall result in the rejection of applicable rolls.

2. At geogrid manufacturer's discretion and expense, additional testing of individual rolls may be performed to more closely identify noncomplying rolls and to qualify individual rolls.

3. Geogrid manufacturer shall perform quality control tests for at least one per lot, or one per every 100,000 ft^2 of geogrid produced, whichever is greater.

PART 3: EXECUTION

3.01 EXAMINATIONS:

A. Conformance Testing

1. Geogrid manufacturer shall supply samples of geogrid to **ENGINEER** for conformance testing. Unless otherwise specified, samples shall be taken at a rate of one per lot, not to exceed one conformance test per 250, 000 square feet of geogrid.

2. At a minimum, the following tests shall be performed for quality assurance conformance testing in accordance with test methods specified in Table 2278-1:

   a. Mass per unit area
   b. Aperture size
   c. Wide strip tensile strength
   d. Node strength
   e. Density
   f. Thickness
   g. Carbon black content

3. Geogrid shall be rejected if conformance test results do not meet or exceed the values presented in Table 2278-1.

3.02 INSTALLATION:

A. Geogrid Deployment

1. No equipment or tools shall damage the geogrid by handling, trafficking, or other means.

2. No personnel working on the geogrid shall smoke, wear damaging shoes or engage in other activities that could damage the geogrid.

3. On slopes, the geogrid shall be securely anchored and then rolled down the slope in such a manner as to continually keep the sheet in tension.

4. In the presence of wind, all geogrids shall be weighted with sandbags or the equivalent. Such sandbags shall be installed during deployment and shall remain until replaced with cover material.

5. Geogrid panels shall be deployed directly on the tailings surface in such a manner as to preclude wrinkles and folds.

6. Once the biaxial geogrid layers have been placed, the grading or subsoil fill is pushed out over the geogrid. In general, only low ground pressure dozers, e.g., a Catapillar D4C LGP dozer with wide tracks (gross weight of approximately 17,400 lbs) should be used to place the fill over the geogrid layers. From the point of truck dump, the fill may typically be advanced to

within 15-ft of the leading edge of the placed fill with larger dozers, if the area covered is deemed stable. The low ground pressure dozer (LGP) should then be used to move the grading fill or subsoil material forward over the geogrid.

7. The technique of placing the fill over very soft soils with the dozer is important. When the LGP dozer approaches the leading edge of the fill, the height of the fill being pushed should not exceed one-half of the dozer blade height. The operator should lift the blade at the leading edge of the fill in order for the fill to spill down onto the exposed geogrid, rather than being pushed downward by the blade. The leading edge of the fill is leveled to the specific lift thickness. The mounding of material at the leading edge on soft soils is strictly prohibited. This placement procedure prevents excessive pressure from being exerted on the subgrade before the geogrid is fully anchored and minimizes mudwaving of the underlying soft soil.

8. Care must be taken to ensure that the leading edge of the fill is at least 20-ft from a geogrid end-lap position at the end of the daily operation. This is to guard against localized shear failure which may occur through the lap.

B. Seaming

1. Adjacent geogrid shall be placed edge to edge according to Construction Drawings and manufacturer Specifications. In extremely soft material, some shifting of the lap may occur during installation. In these cases UV-stabilized plastic ties must be installed at 2-ft intervals to maintain proper lap.

2. Where the geogrid is to be joined, a splice approved by the manufacturer shall be used. The splice shall not have any metallic components.

C. Defects and Repairs:

1. The **ENGINEER** and **OWNER** will identify any areas requiring repair. The **CONTRACTOR** shall immediately make all repairs and replacements necessary, to the approval of the **PROJECT MANAGER** and at no additional cost to the **OWNER**.

2. In the event that a failure of the biaxial geogrid occurs during construction, the failed area is patched by back-blading the area to remove approximately one-foot of fill. A patch of biaxial geogrid is placed over the failed area and extends at least 6-ft in all directions beyond the failed area to achieve anchorage. The one-foot of fill is then placed over the top of the geogrid to complete the patch.

** END OF SECTION **