LOWER CACHE CREEK, YOLO COUNTY, CA
CITY OF WOODLAND AND VICINITY

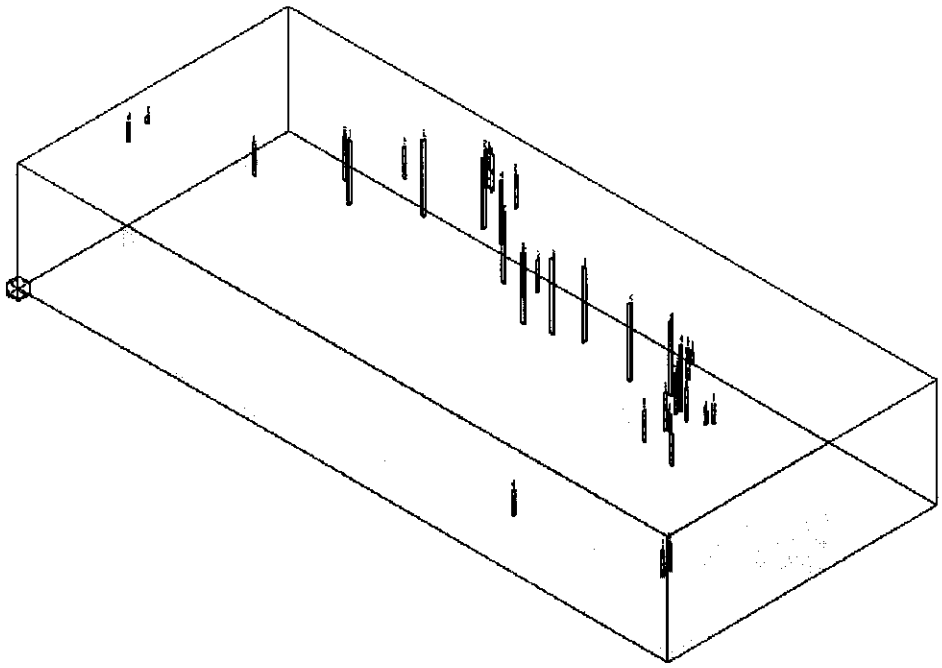
DRAFT FEASIBILITY REPORT
FOR POTENTIAL FLOOD DAMAGE
REDUCTION PROJECT

APPENDIX B

Geotechnical Risk-Based Analysis

LOWER CACHE CREEK
FEASIBILITY STUDY

GEOTECHNICAL RISK-BASED ANALYSIS



SEPTEMBER 2000

U. S. ARMY CORPS OF ENGINEERS
SOUTH PACIFIC DIVISION - SACRAMENTO DISTRICT
GEOTECHNICAL BRANCH - SOIL DESIGN SECTION

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Abbreviations

2H:1V - 2 Horizontal to 1 Vertical Slopes

BOD - Basis of Design

CPT - Cone Penetrometer Test

DS - Downstream

ΔH - change in hydraulic head

E[x] - Expected value of x

ETL - Engineering Technical Letter (COE)

FS - Factor of Safety

GW - groundwater

i - hydraulic gradient

i_{crit} - critical hydraulic gradient

i_e - hydraulic exit gradient

k_b - top blanket permeability

k_f - substratum permeability

k_h - horizontal permeability

k_v - vertical permeability

ln - natural logarithm

$N_{1(60)}$ - SPT blow counts corrected for overburden and energy

PFP - Probable Failure Point

PNP - Probable Nonfailure Point

Pr(f) - Probability of Failure

psf - pounds per square foot

q_T - normalized tip friction

R_f - Friction ratio

$\sigma[x]$ - standard deviation of x

SPT - Standard Penetration Test

t/ft^2 - tons per square foot

TOL - top of levee

USGS - United States Geological Survey

w/s - with some

US - Upstream

Var[x] - Variance of x

V(x) - coefficient of variation of x

z_b - top blanket thickness

z_f - substratum thickness

1.0 Introduction.

The purpose of this report is to present the results of the geotechnical risk based analysis. The risk-based analysis is conducted according to U. S. Army Corps of Engineers publication ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies," 28 May 1999. Reported PFP (probable failure point) and PNP (probable nonfailure point) values derived from probability of failure [Pr(f)] curves are given for the existing levees based on the results of field reconnaissance, engineering analysis, and judgement. This report is expected to be followed-up with a Geotechnical Basis of Design (BOD) report once the "selected plan" has been identified and further explorations are conducted.

2.0 Explorations.

CPT (cone penetrometer test) explorations were performed at the levee crowns with the approximate locations given in Table 2.1. A plan view of the CPT explorations are also shown in Figure 2.1 on a USGS quadrangle map.

Table 2.1
Location of CPT Explorations.

CPT #	Northing[1] (ft)	Easting[1] (ft)	Depth (ft)	Location
1	2,080,450	385,850	52.5	levee crown, right bank
2	2,078,500	386,950	59.7	levee crown, left bank
3	2,075,600	386,050	61.5	levee crown, right bank
4	2,071,300	386,100	59.7	levee crown, left bank
5	2,069,650	384,900	60.4	levee crown, right bank
6	2,067,900	383,950	56.9	levee crown, left bank
7	2,064,000	386,050	55.9	levee crown, right bank
8	2,061,650	388,150	50.0	levee crown, left bank
9	2,059,550	388,600	56.1	levee crown, right bank
10	2,055,450	387,150	60.5	levee crown, left bank
11	2,052,850	382,900	51.5	levee crown, left bank
12	2,041,750	375,300	5.2	levee crown, right bank
13	2,041,350	373,900	14.9	levee crown, right bank

[1] NAD 27, possible error (+-) 300 feet.

Classification of materials based on CPT explorations are shown in Figures 2.2 through 2.7. Where possible, CPT explorations were compared to the original field logs based on actual sampling of materials which were conducted for the original 1958 project. The original field logs (unaltered) are shown in Sheet B1.0. A comparison between the locations of the CPT explorations and the original field explorations are shown in Table 2.2.

Table 2.2
Location proximity between the CPT explorations
and the original 1958 explorations.

CPT # or Drill Hole (Left Bank)	Proximity	CPT # or Drill Hole (Right Bank)	Proximity
2F-8-10	>	CPT-1	>
CPT-2	2000' US of -10	CPT-3	>
CPT-4	>	CPT-5	1500' DS of –9
CPT-6	500' DS of –8	2F-8-9	>
2F-8-8	>	CPT-7	>
CPT-8	1000' DS of –7	CPT-9	>
2F-8-7	>	2F-8-3	>
2F-8-6,5,4	>	>	>
CPT-10	>	>	>
CPT-11	1500' DS of –2	>	>
2F-8-2	>	>	>

">" = greater than 2000' from nearest hole

When comparison is made between CPT-6 and 2F-8-8, it can be seen that the general pattern is the same but that the CPT generally characterizes the material slighter coarser than the 1958 explorations.

Plots of CPT tip resistance (q_T) and correlated blow counts ($N_{1(60)}$) versus depth are shown in Figures 2.8 through 2.13. Most holes were driven to specified depths except CPT-12 and -13 which were driven to 6 and 16 feet respectively, and were stopped due to the presence of large particles, estimated to be mostly gravels to cobbles. The cone penetrometer device could not penetrate these large particles without significant damage. Both CPT-12 and -13 were located at the Teichert Gravel Pit levees. The data from CPT-1 was found to be unreadable but should be similar to that of CPT-2 and -3.

Groundwater depths were determined by pore pressure dissipations for CPT's 2, 7, 8, and 11 and were found to be at 20, 35, 42, and 42 feet below the ground surface, respectively.

Levee geometry and cross-sections are shown in Table 2.3 and Figure 2.14. Surveys of the sections were performed by approximate methods and represent only relative geometries.

Table 2.3
Cross-Sectional Properties

Section	Waterside Height (feet)	Landside Height (feet)	Waterside Slope __H:1V	Landside Slope __H:1V
CPT-1	11	12	3.2	2.6
CPT-2	6	9	2.4	2.1
CPT-3	9	7	3.3	2.1
CPT-4	10	7	4.0	3.0
CPT-5	3.5	4	2.75	2.15
CPT-6	4	5	3.5	2.35
CPT-7	8	9	4	2.5
CPT-8	6	6	3	2.7

3.0 Engineering Properties of Explored Materials.

Major engineering properties include soil classification, shear strength, density, and permeability. Interpolation of CPT results was an extremely iterative and complex process that lead to the results shown in Table 3.1. Soil classification methods based on the R_f zone (Robertson and Campanella, 1983) were found to most closely match the 1958 field logs although the CPT correlations tend to be slightly coarser. Unit weights were determined by the correlations established by the CPTINT program developed by R. G. Campanella (Version 4.0, 12/20/91). Shear strengths were based on table correlations with tip resistance (q_T). Undrained shear strengths were interpolated from material types and blow count value correlations (Campanella), and correlated with the values listed in Terzaghi and Peck (1993), along with engineering judgement and experience with materials in the area.

Permeabilities were based on soil classification and correlations with standard engineering charts and tables, and engineering judgement. The estimated permeabilities based on soil classifications are listed in Table 3.2.

Table 3.1
Engineering Properties of Materials Based on CPT Explorations

CPT #	Depths (feet)	Soil Classification	In-situ Unit Weight (lb/ft^3)	Effective Friction Angle (degrees)	Undrained Shear Strength (psf)
2	00 - 22	silty sand to sand w/s silt	123	33	
	22 - 30	clayey silt	120	-	600
	30 - 42	clay to silty clay	125	-	2000
	42 - 60	clayey silt to silty sand	125	33	
3	00 -07	silty sand to fine sand	121	33	
	07 - 14	sand w/s silt to fine sand	123	37	
	14 - 24	silty sand to sand w/s silt	121	33	
	24 - 48	clay	124	-	1250
	48 - 56	clayey silt to silty sand	123	-	600
	56 - 60	clay	125	-	1250
4	00 - 10	clayey silt to silty sand	123	33	
	10 - 15	silty sand to sand w/s silt	122	33	
	15 - 25	clay to clayey silt	122	-	1250
	25 - 35	clay	122	-	1500
	35 - 55	silty clay to clayey silt	124	-	1500
	55 -60	sand w/s silt to sand	125	37	
5	00 - 06	silty sand to sand w/s silt	122	33	
	06 - 10	clayey silt to silty sand	122	33	
	10 - 20	sand w/s silt	121	33	
	20 - 24	sand	124	37	
	24 - 32	clay to silty clay	122	-	1250
	32 - 44	silty clay to clayey silt	121	-	600
	44 - 60	clay to clayey silt	125	-	1500
6	00 - 05	clayey silt to silty sand	124	33	
	05 - 10	clayey silt	122	-	800
	10 - 20	sand w/s silt to sand	124	37	
	20- 30	clay	122	-	1250
	30 - 56	clay to clayey silt	123	-	1000
7	00 - 12	silty sand to sand w/s silt	121	33	
	12 - 20	silty sand	121	30	
	20 - 35	clay	124	-	1500
	35 - 56	sand to gravelly sand	126	42	

Table 3.1 (cont.)
Engineering Properties of Materials Based on CPT Explorations

CPT #	Depths (feet)	Soil Classification	In-situ Unit Weight (lb/ft^3)	Effective Friction Angle (degrees)	Undrained Shear Strength (psf)
8	00 - 10	clayey silt to silty sand	124	33	
	10 - 30	silty sand to sand w/s silt	122	33	
	30 - 42	clay to silty clay	124	-	2000
	42 - 50	fine sand to gravelly sand	125	42	
9	00 - 22	sand w/s silt	121	33	
	22 - 30	clay to silty clay	121	-	1250
	30 - 38	clay	125	-	2000
	38 - 46	silty clay to clayey silt	122	-	800
	46 - 56	clay to silty clay	123	-	1250
10	00 - 05	clayey silt to sand w/s silt	123	33	
	05 - 10	clay	124	-	2000
	10 - 18	silty sand to sand w/s silt	121	33	
	18 - 32	silty clay to clayey silt	122	-	1250
	32 - 36	sand to gravelly sand	126	42	
	36 - 52	clay to silty clay	123	-	1250
	52 - 60	clayey silt	122	-	1000
11	00 - 03	clayey silt to silty sand	124	33	
	03 - 05	clay	124	-	2000
	05 - 11	silty sand	121	30	
	11 - 16	clayey silt	122	-	800
	16 - 40	sand w/s silt to fine sand	124	37	
	40 - 42	clayey silt	121	-	600
	42 - 52	sand to gravelly sand	129	42	
12	00 - 05	sand to gravelly sand	123	42	
13	00 - 06	fine sand	125	33	
	06 - 14	sand	125	37	
13A	00 - 07	fine sand	125	33	
13A was attempted adjacent to 13					

Table 3.2
Estimated Soil Permeabilities.

Soil Classification	Vertical Permeability k_v (ft/day)	Horizontal Permeability k_h (ft/day)	Ratio (k_h / k_v)
Clay	0.0003	0.0018	6
Silty clay	0.003	0.018	6
Clayey silt	0.03	0.18	6
Silty sand	0.3	1.2	4
Sand with some silt	1	4	4
Fine sand	10	40	4
Sand	100	200	2
Gravelly sand	1000	1000	1

4.0 Risk Based Analysis.

Risk-based analysis was performed according to the methods outlined in ETL 1110-2-556, "Risk-Based Analysis in Geotechnical Engineering for Support of Planning Studies," 28 May 1999. Cross-sections used for the analysis are shown in Figure 2.14. Due to the approximate nature of the surveyed sections, if the section for the 1954 template had steeper slopes and narrower crest widths, this section was used for the seepage and slope stability analyses.

Seepage analysis was completed using the computer program GMS/SEEP2D. Each section was analyzed to determine the results of through-seepage and underseepage using a steady-state seepage condition. Where a soil layer was classified as a range (clay to silty clay), the soil with the greatest permeability was used for the analysis (silty clay). It can be seen in Figures 4.1 through 4.4 that the sections that most likely present an underseepage problem are sections CPT-4, -6, and -8 where the exit gradient (i_e) with full hydraulic head is equal to 0.5. Sections CPT-2 and -6 were used for the probability of failure [Pr(f)] analysis and it can be seen in Figures 4.5 and 4.6 that with full hydraulic head, the Pr(f) for underseepage is equal to 3 and 26 percent respectively. The coefficients of variation for permeability ratio (k_f/k_b), top stratum thickness (z_f), and blanket thickness (z_b) were equal to 40, 50, and 30 percent respectively. An example of the Pr(f) calculation for CPT-6 is shown in Table 4.1.

Table 4.1
Underseepage Pr(f) Analysis for CPT-6 with full hydraulic head

Run	k_f/k_b	z_f (ft)	z_b (ft)	i	Variance	% of Total
1	6667	10.0	5.0	0.56		
2	10000	10.0	5.0	0.56		
3	4000	10.0	5.0	0.52	4.00E-04	1%
4	6667	15.0	5.0	0.56		
5	6667	5.0	5.0	0.52	4.00E-04	1%
6	6667	10.0	6.5	0.42		
7	6667	10.0	3.5	0.74	2.68E-02	97%
				Total:	0.0276	100%

E[i]	0.56	E[ln i]	-0.62201	
Var[i]	0.02761			
σ[i]	0.166161	σ[ln i]	0.29048	
V(i)	29.67%			
i_{crit}	0.65	$\ln(i_{crit})$	-0.43078	Pr(f)= 0.2552
				26%

f-substratum b-top blanket

Slope stability analysis was completed using the computer program WINUT3/UTEXAS3 (WES, Wright, 1992). The coefficients of variation used for the effective friction angle and the undrained shear strength were 10 and 40 percent respectively. Sections CPT-2 and -6 were analyzed and it can be seen in Figures 4.5 and 4.6 that with full hydraulic head (at the crown) the Pr(f) for slope stability is equal to 24 and 1 percent respectively. The computer program computes the expected values (E[FS]) and variance (Var[FS]) so that the number of manual calculations are slightly less than for the underseepage analysis, but nevertheless the calculations for CPT-2 are shown in Table 4.2.

Table 4.2
Slope Stability Pr(f) Analysis for CPT-2 with full hydraulic head

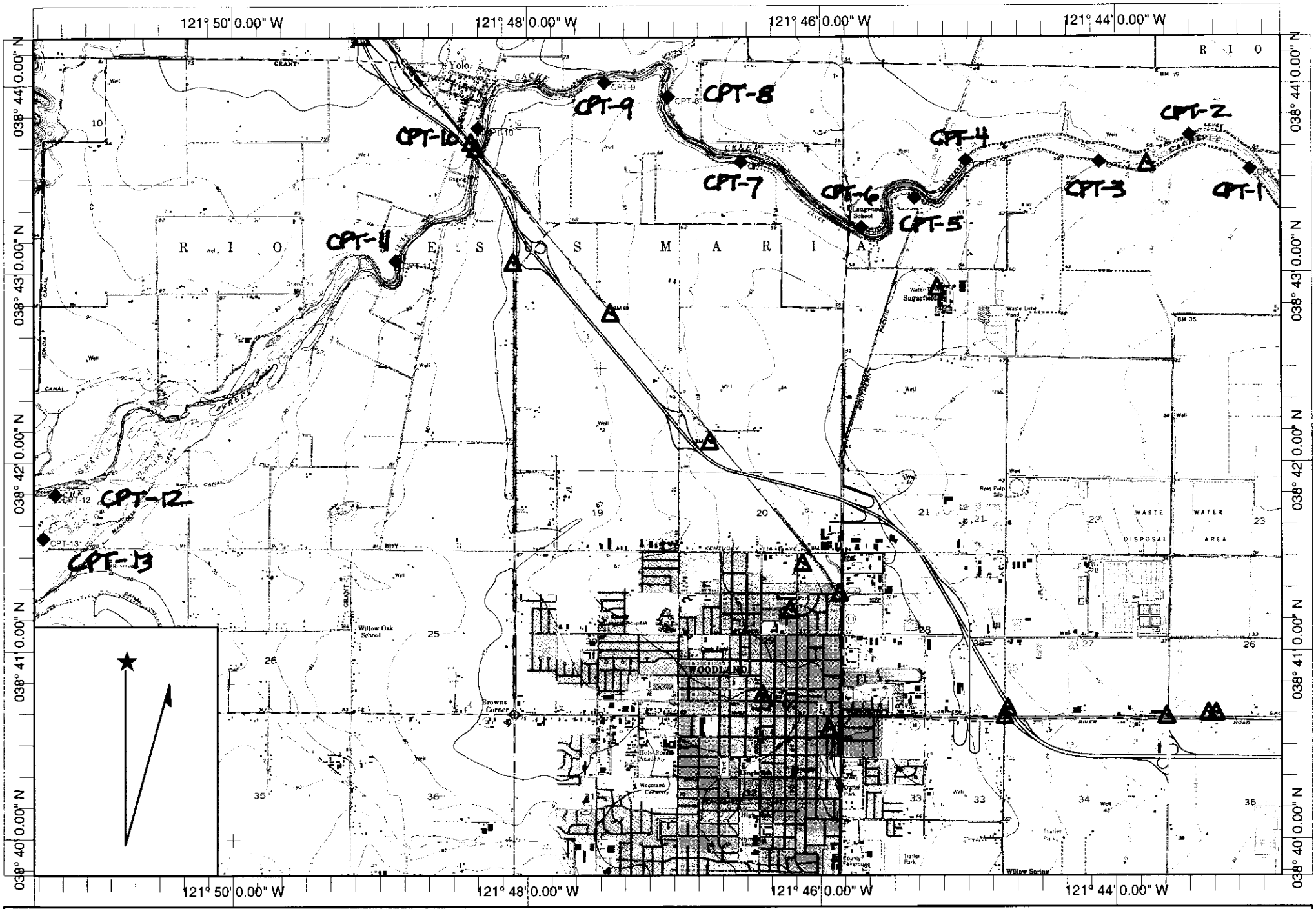
Water @ TOL		E[FS], Var[FS], Data from WINUT3	
E[FS] =	1.100	E[ln FS] =	0.087390
Var[FS] =	0.019320		
σ[FS] =	0.138996	σ[ln FS] =	0.125860
V_{FS} =	12.64%		
FS_{crit} =	1.0	Pr(f) =	0.243735
			24%

5.0 Conclusions.

Based on slope stability and underseepage analysis it was found that CPT-2 and -6 were the most critical or representative sections respectively. The probability of failure curves for CPT-2 and -6 are shown in Figures 4.5 and 4.6 respectively. Due to the possibility that not all cross-section (stratigraphy) types can be captured by a few explorations, the curves for CPT-2 and -6 representing the worst cases for slope stability and underseepage respectively, were developed into a composite graph, and using the same judgement values for each, the combined curve was calculated as shown in Figure 4.7. It can be seen from the combined curve of Figure 4.7 that the PNP (15% chance of failure) is located 2 feet below the top of levee, and that the probability of failure at the top of levee is approximately equal to 50 percent. The combined probability curve from Figure 4.7 should be used for any subsequent analysis.

The levees at the Teichert gravel pit were unable to be explored with CPT equipment, which was highly suspected. Further explorations using larger equipment or backhoes may be required depending on the selected design. Generally, in order for the relatively highly permeable levees to be safe when considering the effects of heavy seepage and seepage induced slope failures, the crest would have to have a minimum width of 30 feet with landside slopes no steeper than 2H:1V. The levees observed at the pit seemed to have these minimum dimensions but will be subject to further verification in the next phase of the analysis.

APPENDIX A
FIGURES



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Scale: 1 inch equals 4000 feet

Location: 038° 42' 01.7" N 121° 47' 07.2" W
Caption: Figure 2.1 Location of CPT Explorations [wt drk, lay lrg, lay info off, rulr on, nrth arro on, 1" tic off]

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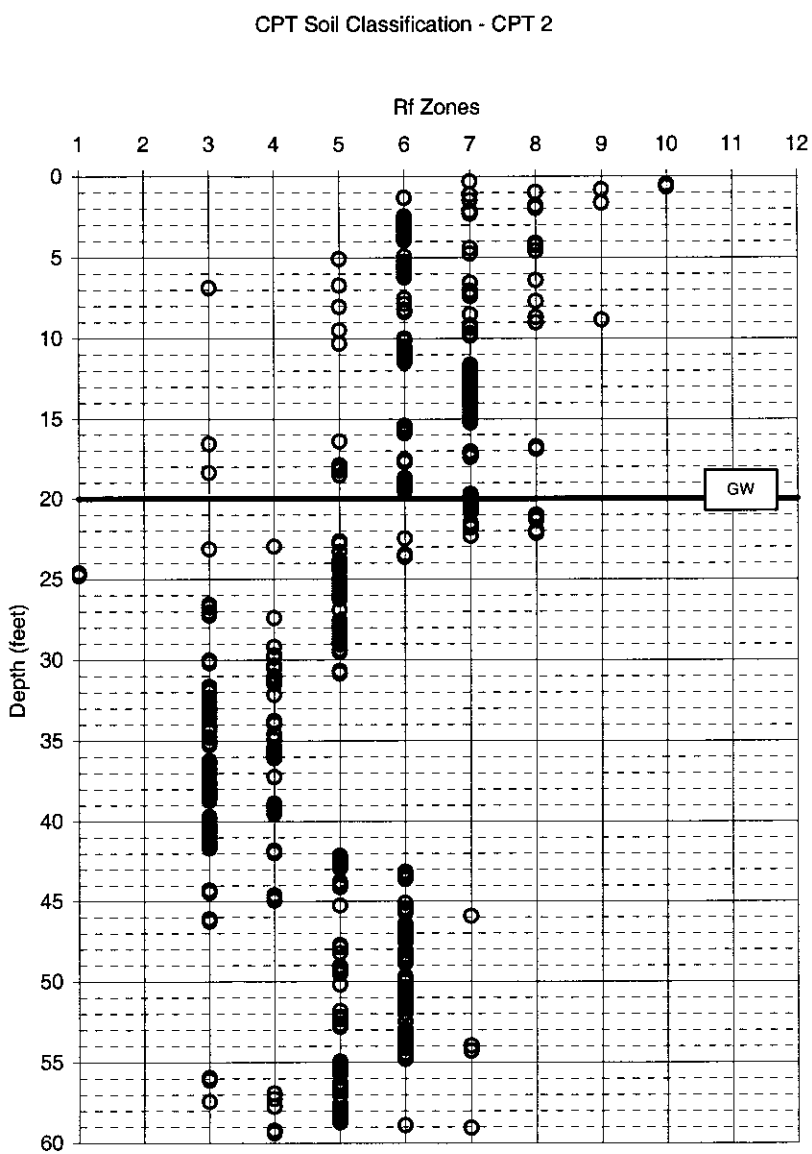

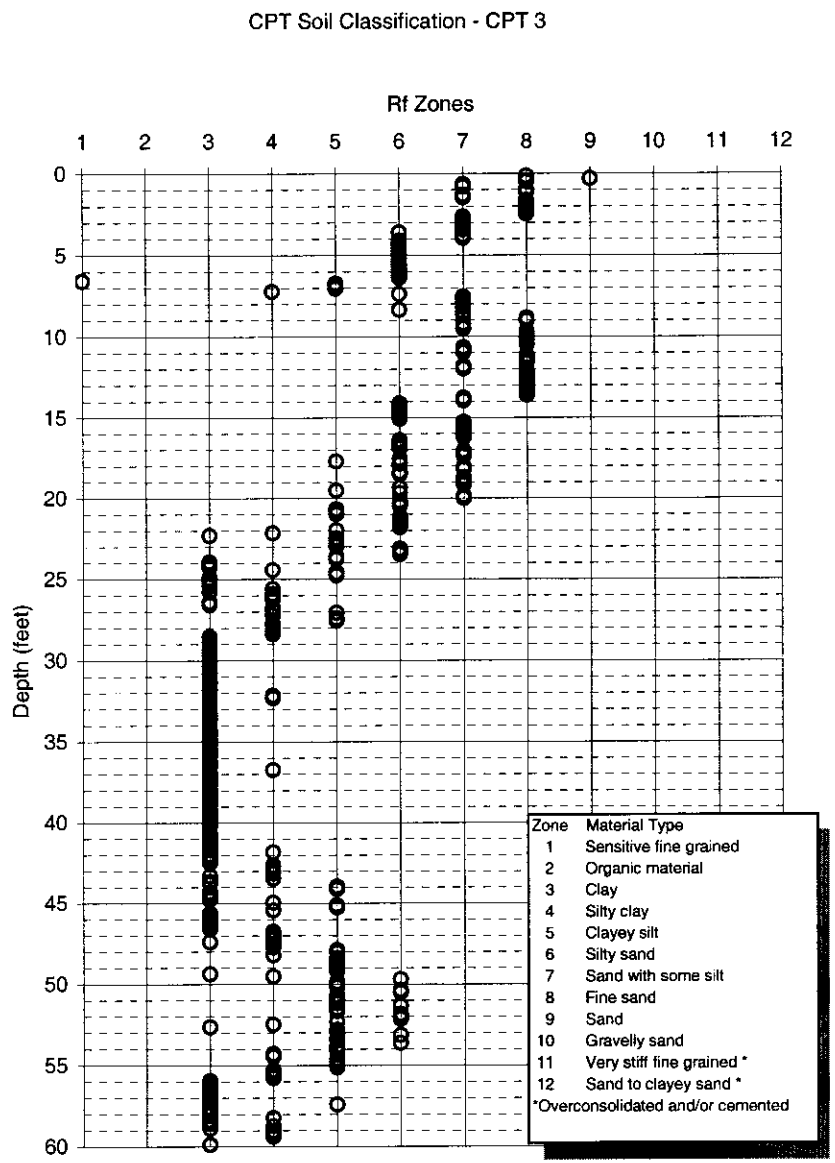

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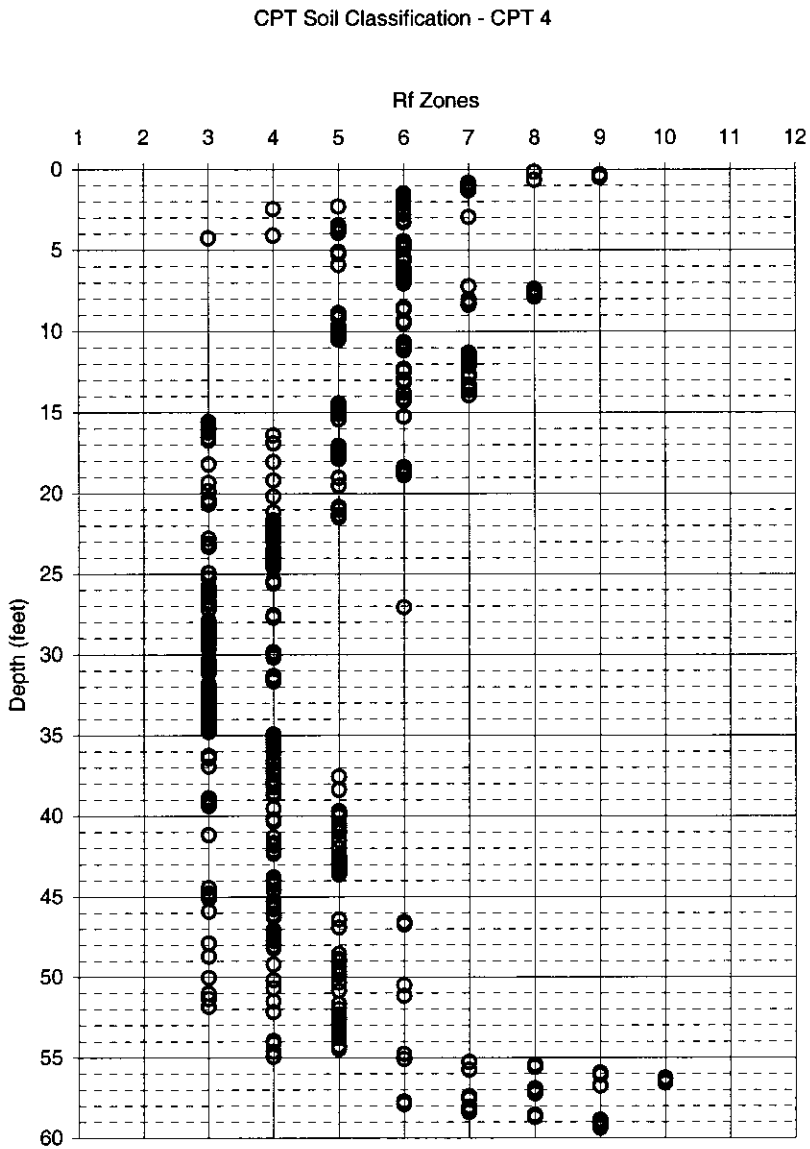
Figure 2.2



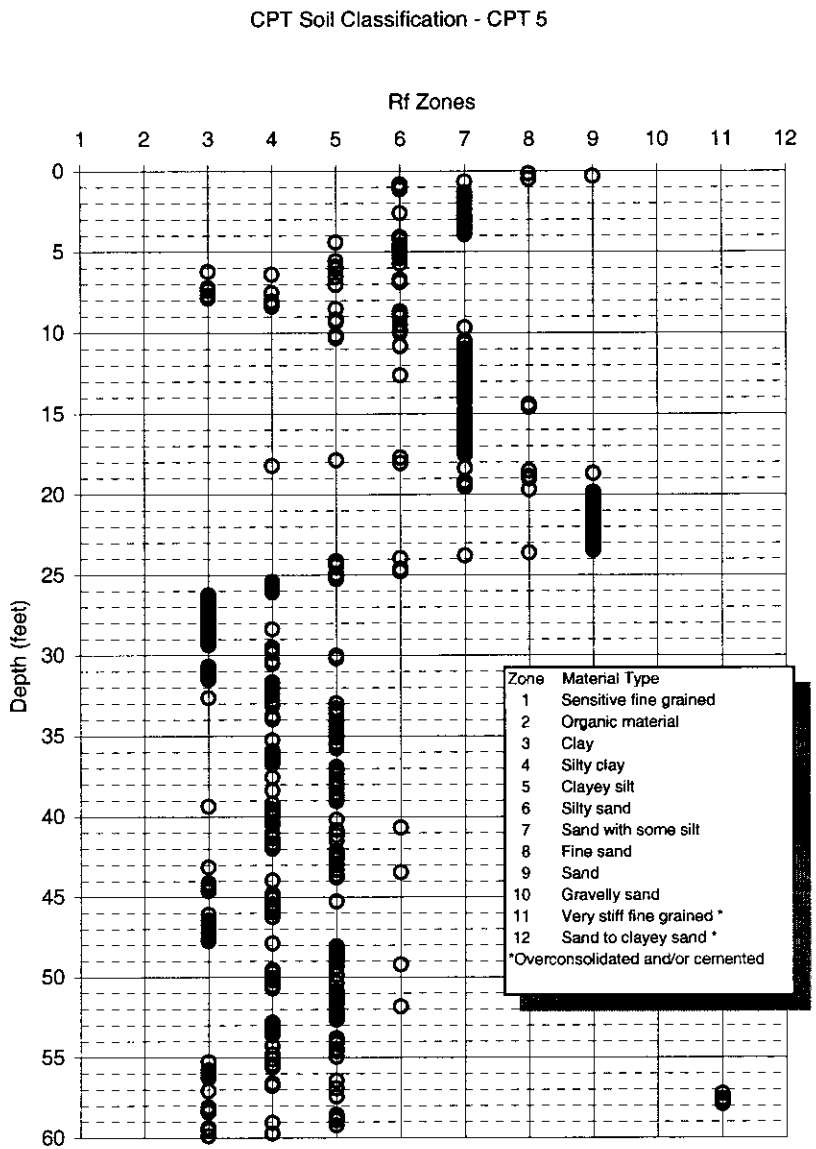


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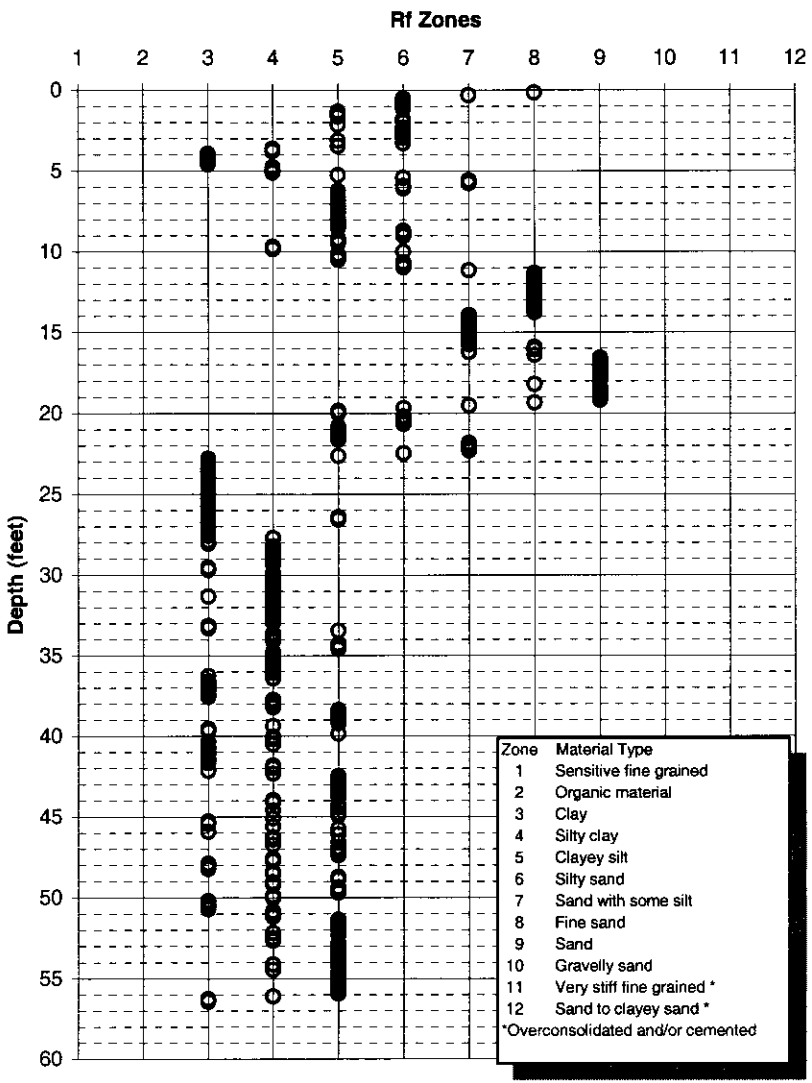
Figure 2.3

CPT Soil Classification - CPT 6



CPT Soil Classification - CPT 7

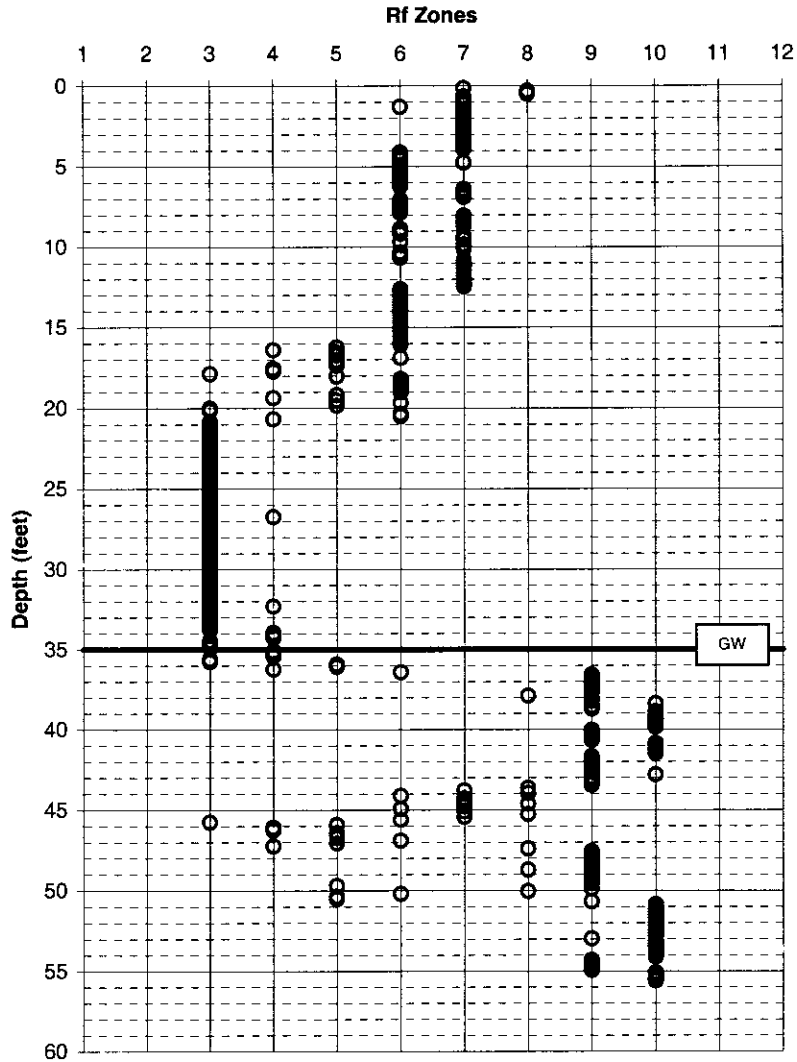


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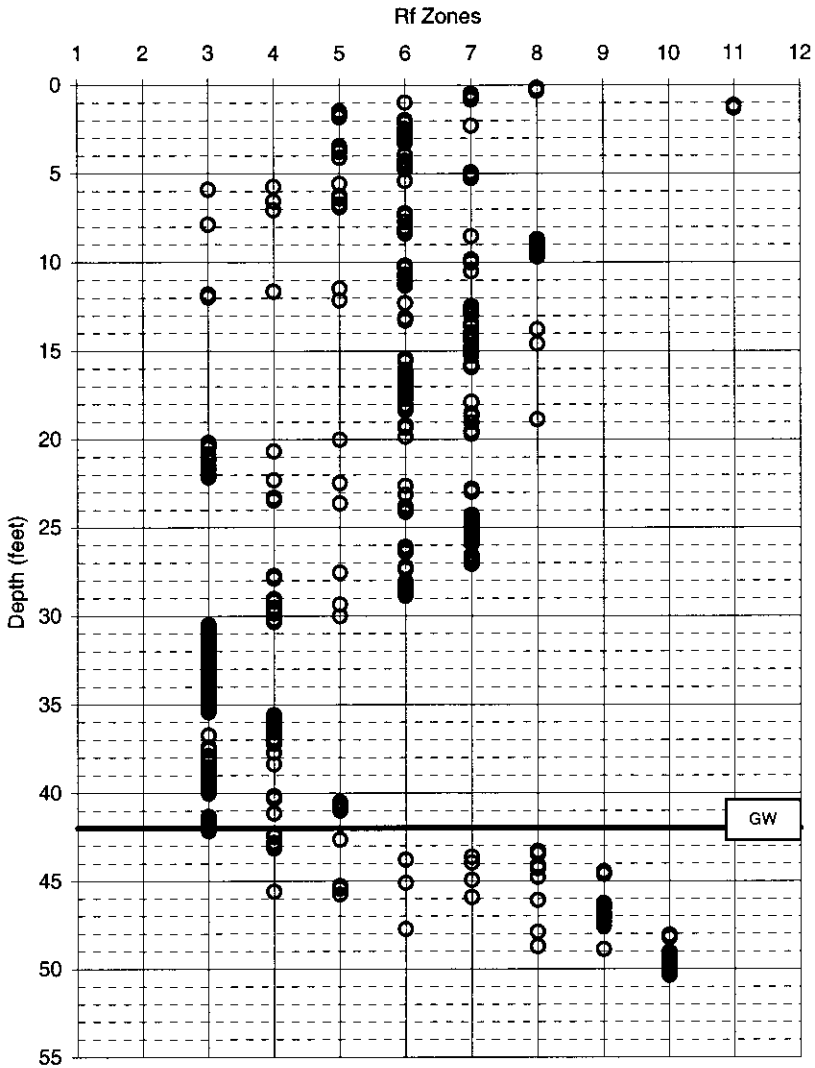
Figure 2.4

CPT Soil Classification - CPT 8



CPT Soil Classification - CPT 9

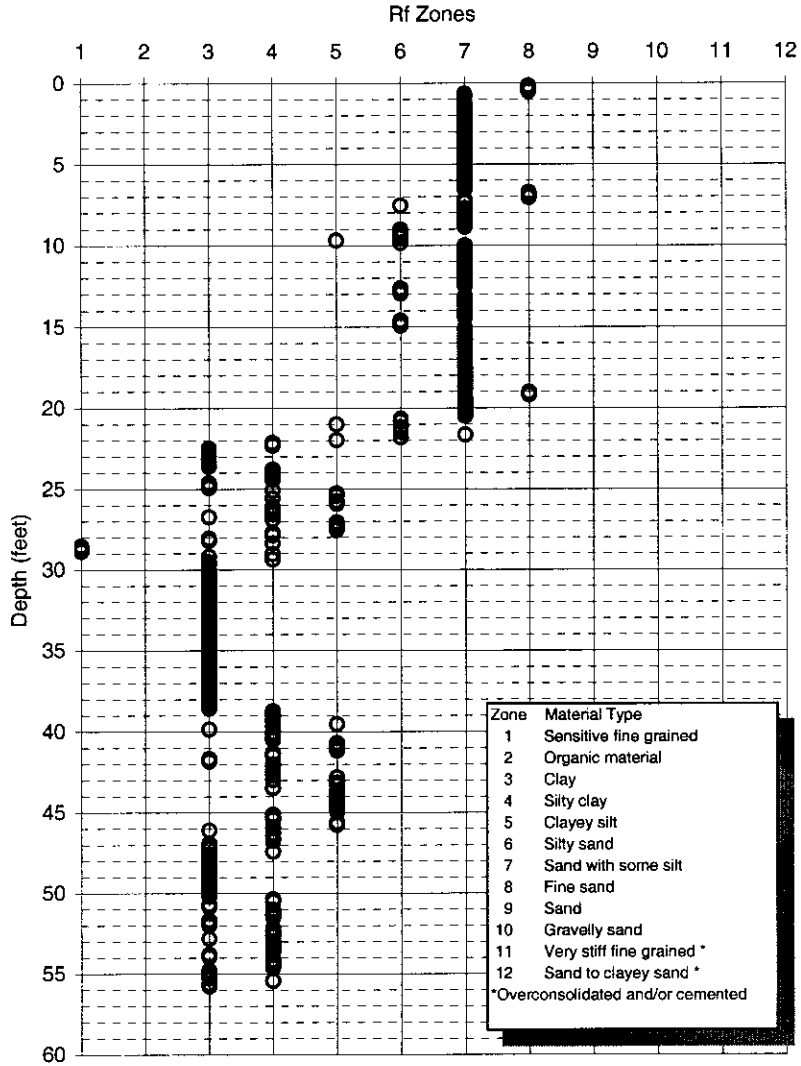


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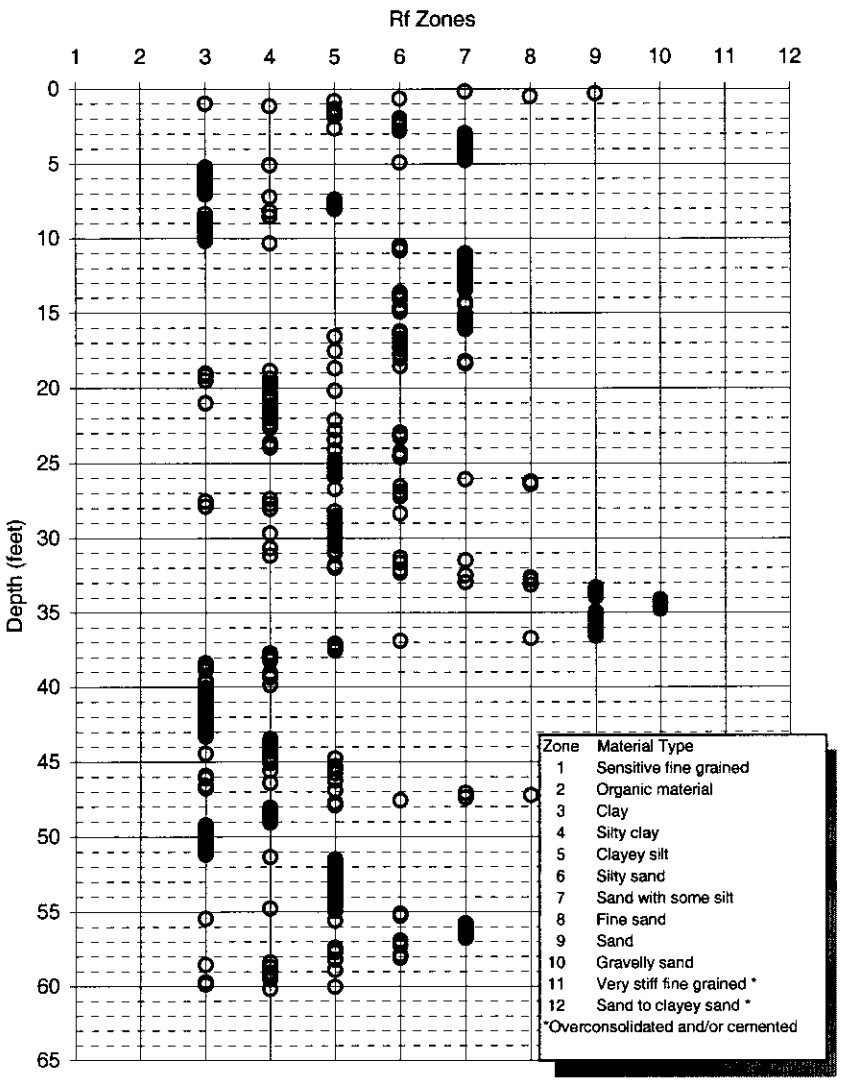
Figure 2.5

CPT Soil Classification - CPT 10



CPT Soil Classification - CPT 11

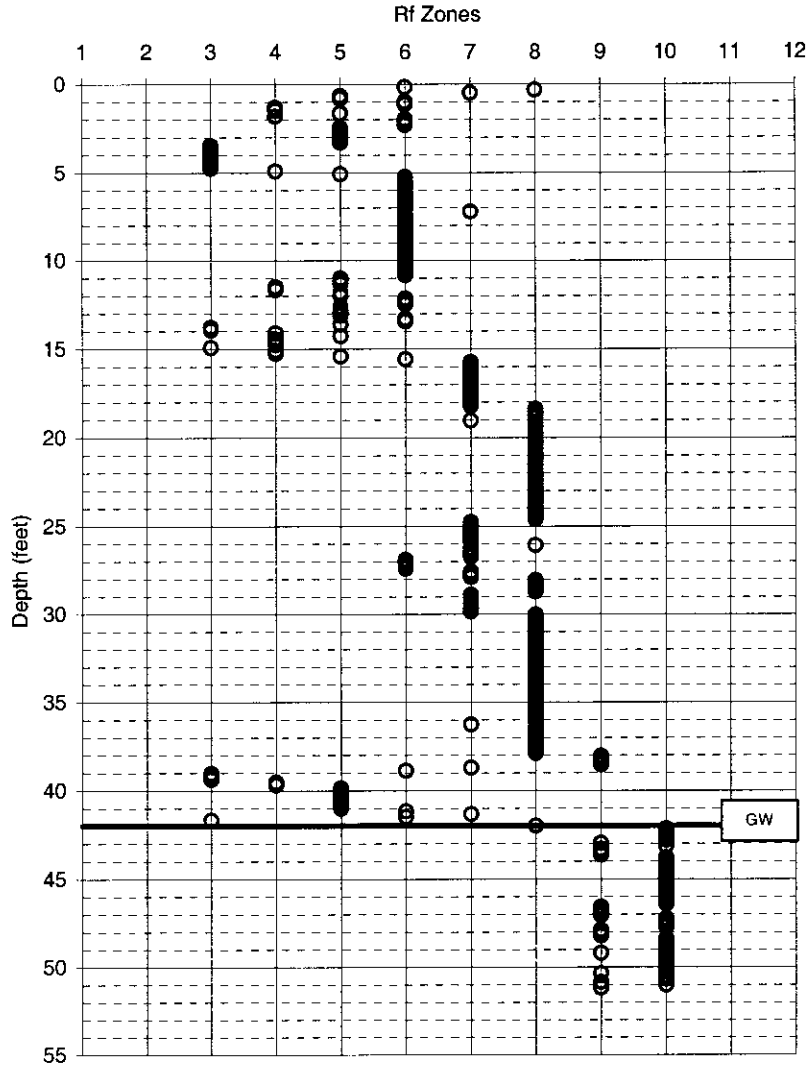


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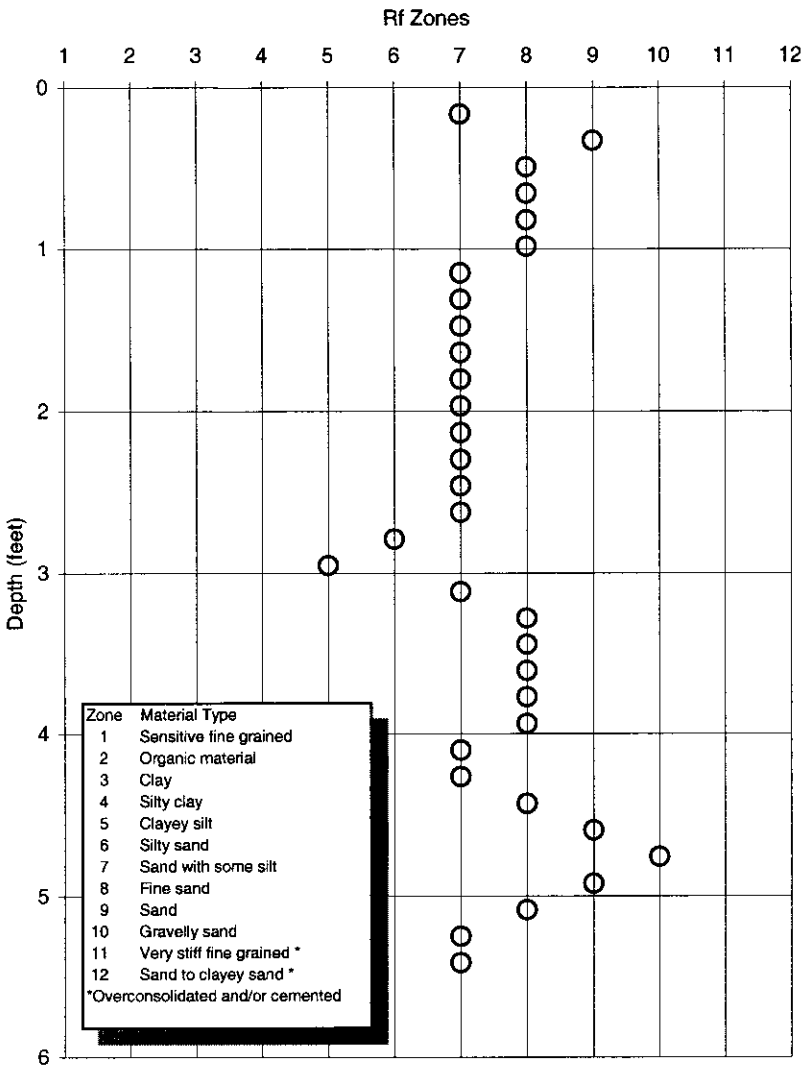
Figure 2.6

CPT Soil Classification - CPT -12



CPT Soil Classification - CPT -13

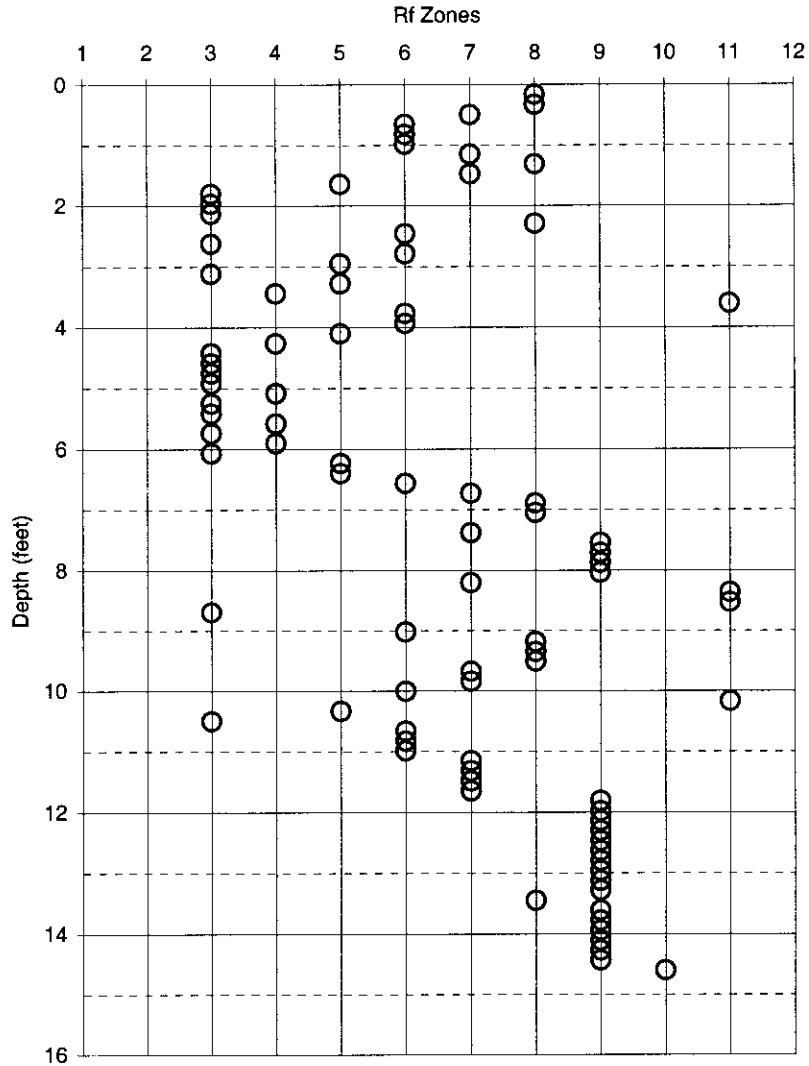


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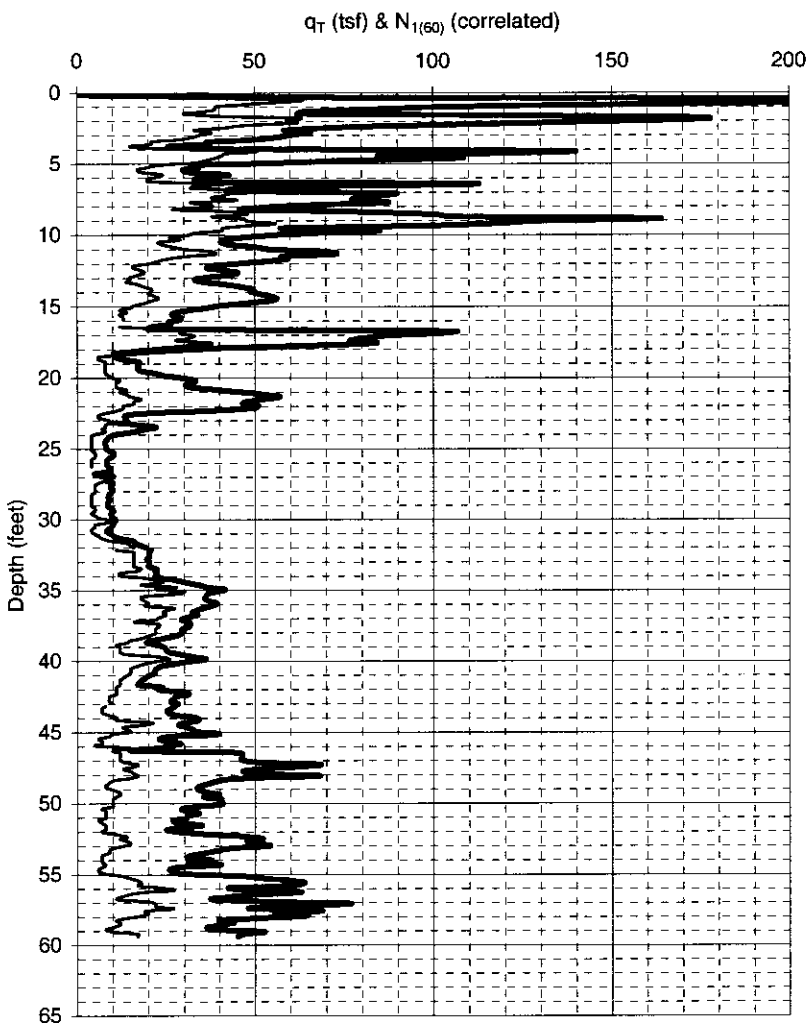
Figure 2.7

Cache Creek CPT -2



Cache Creek CPT -3

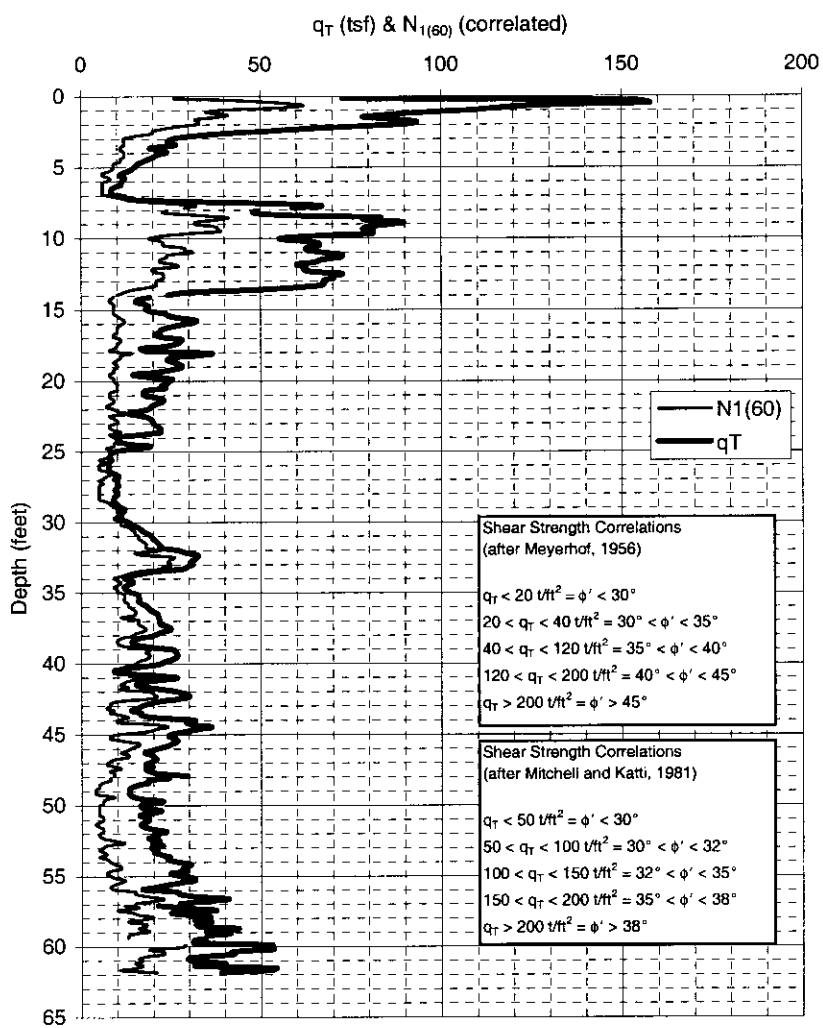


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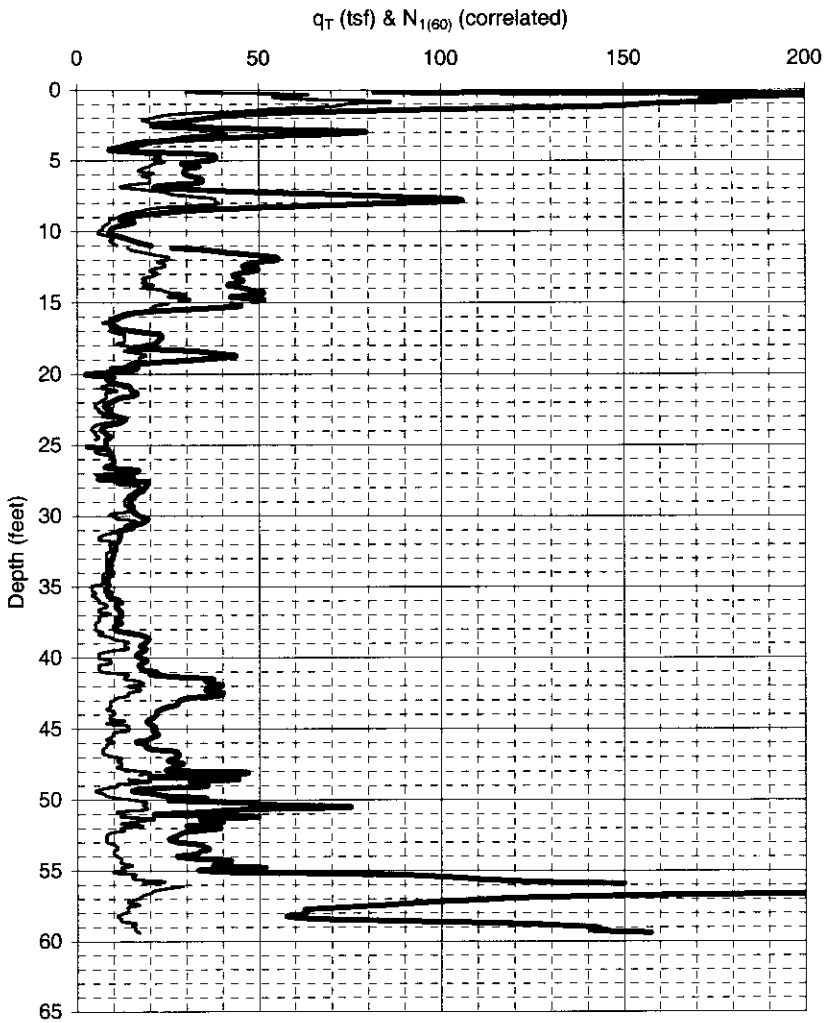
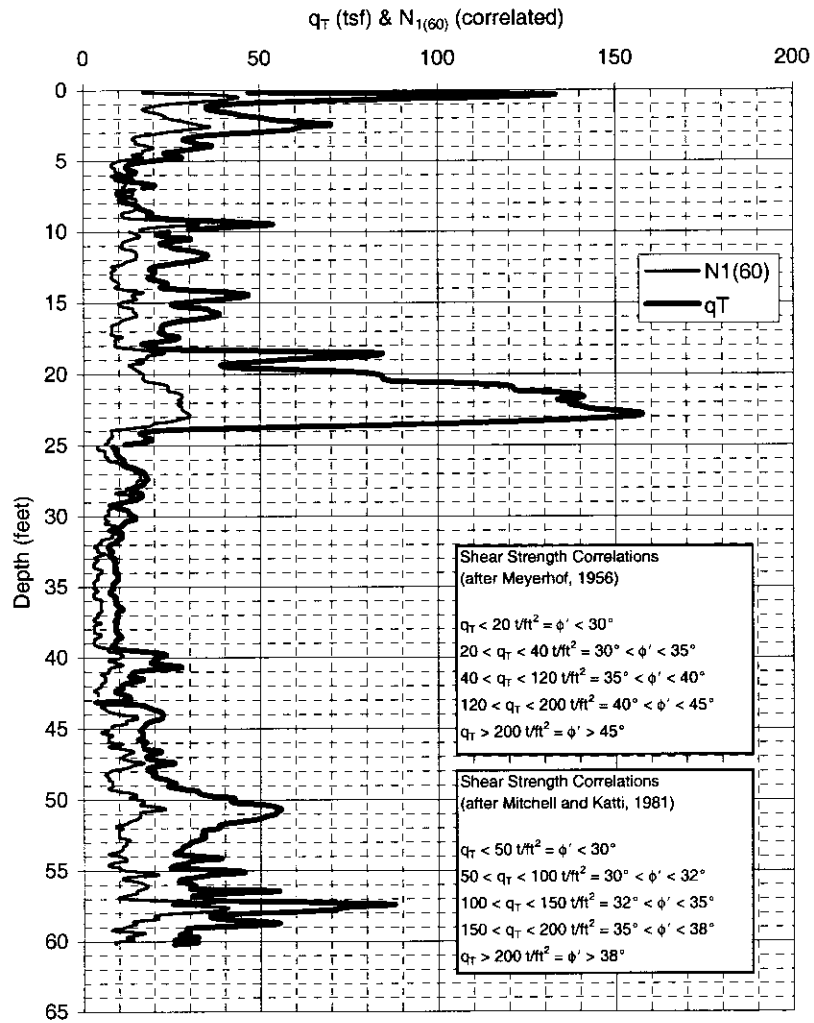
Figure 2.8

Cache Creek CPT -4

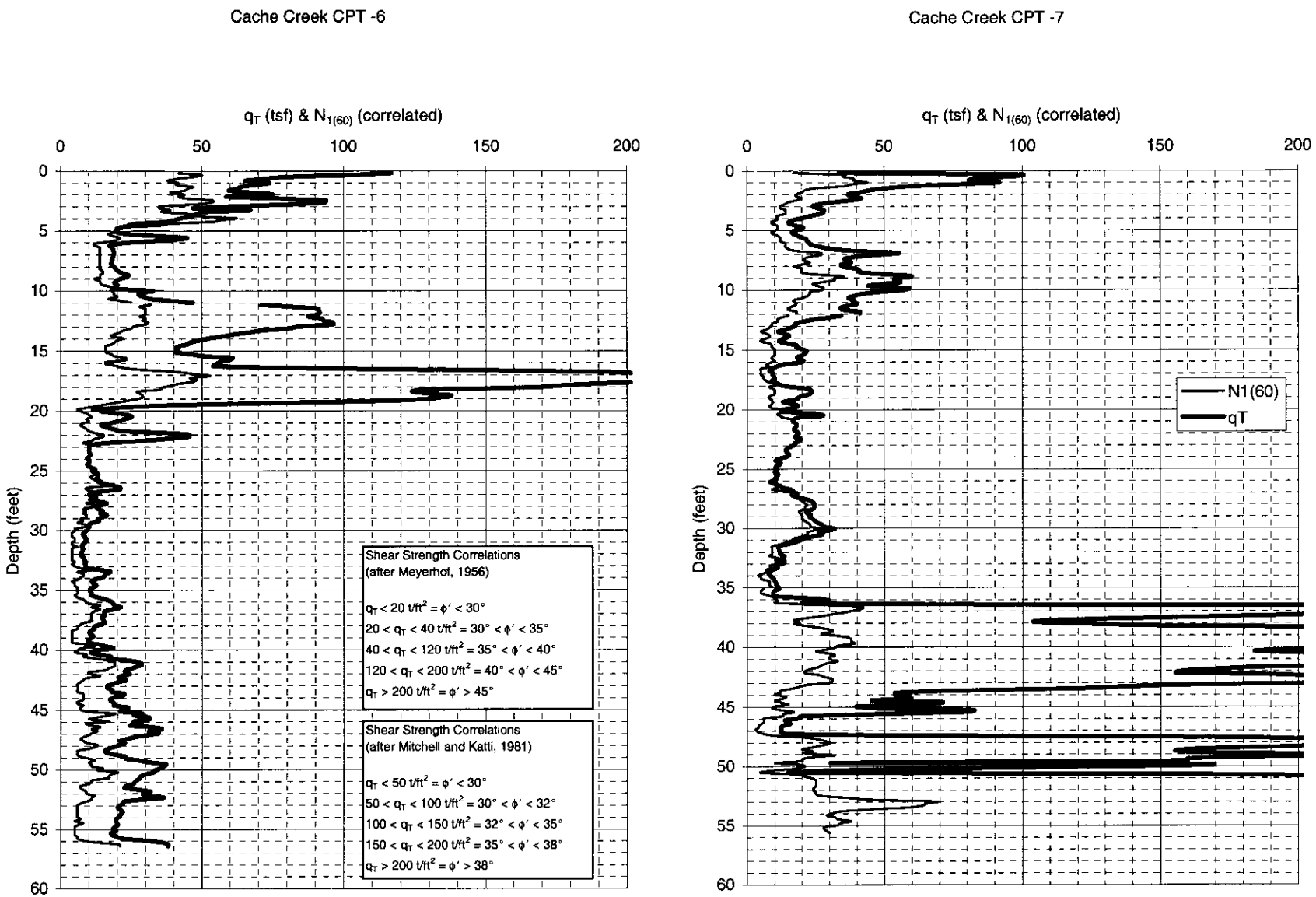


Cache Creek CPT -5



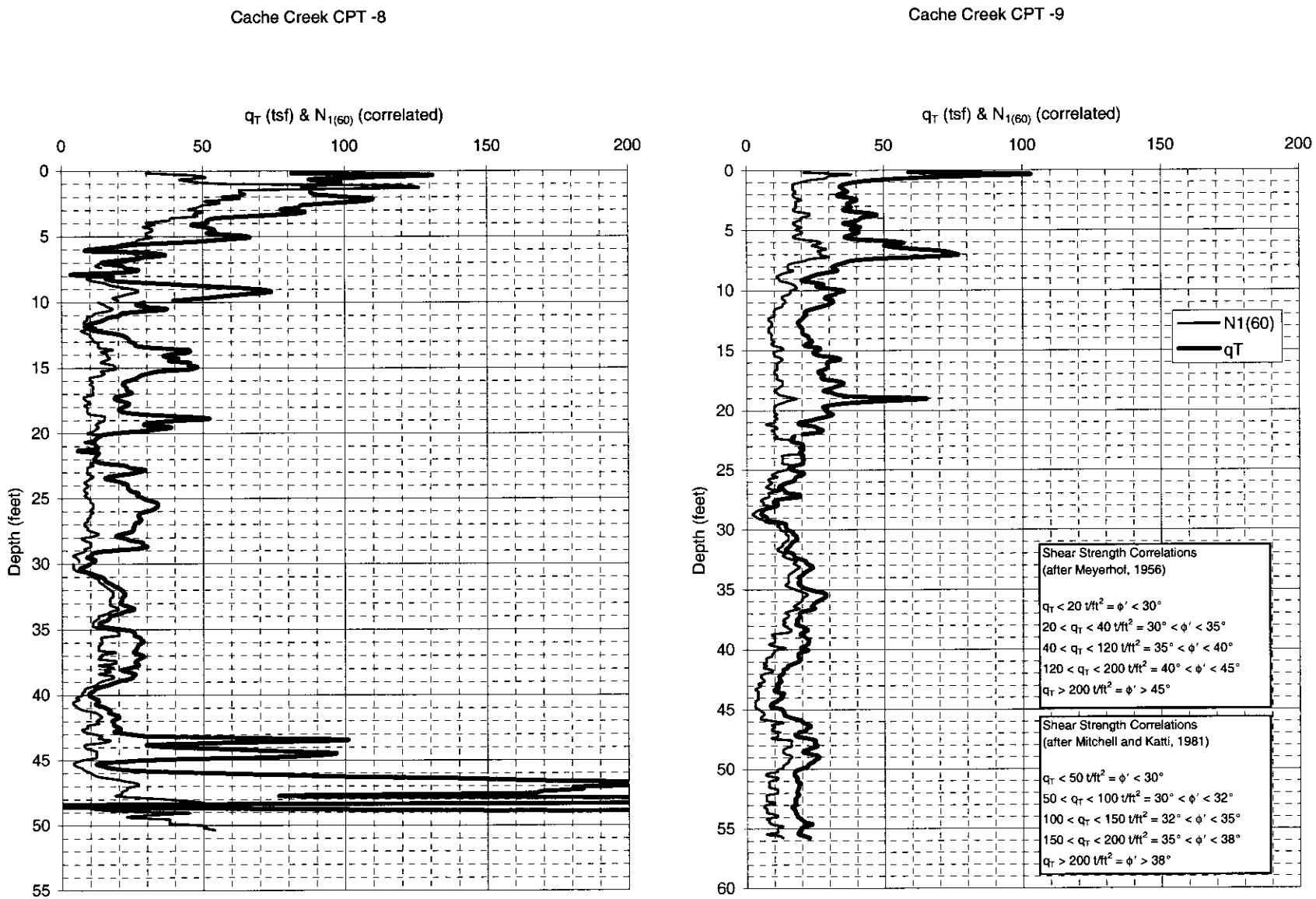
[08/28/2000 3:13 PM cptint1.xls]

Figure 2.9



[08/28/2000 3:18 PM cptint1.xls]

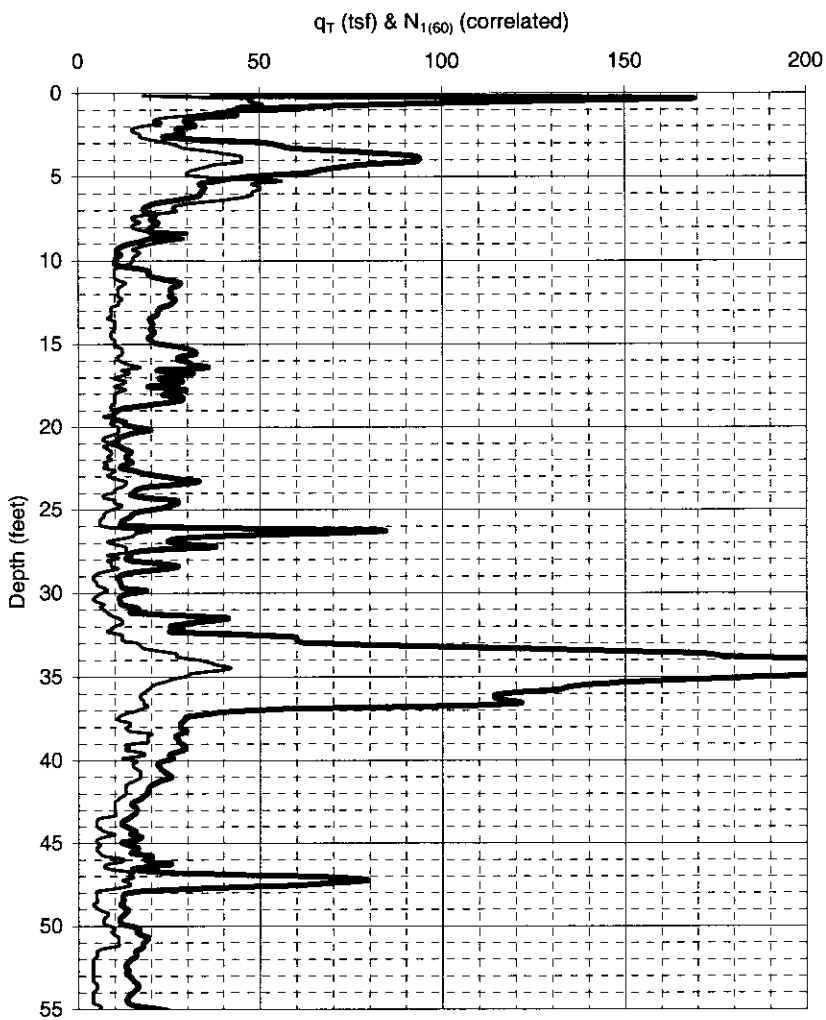
Figure 2.10



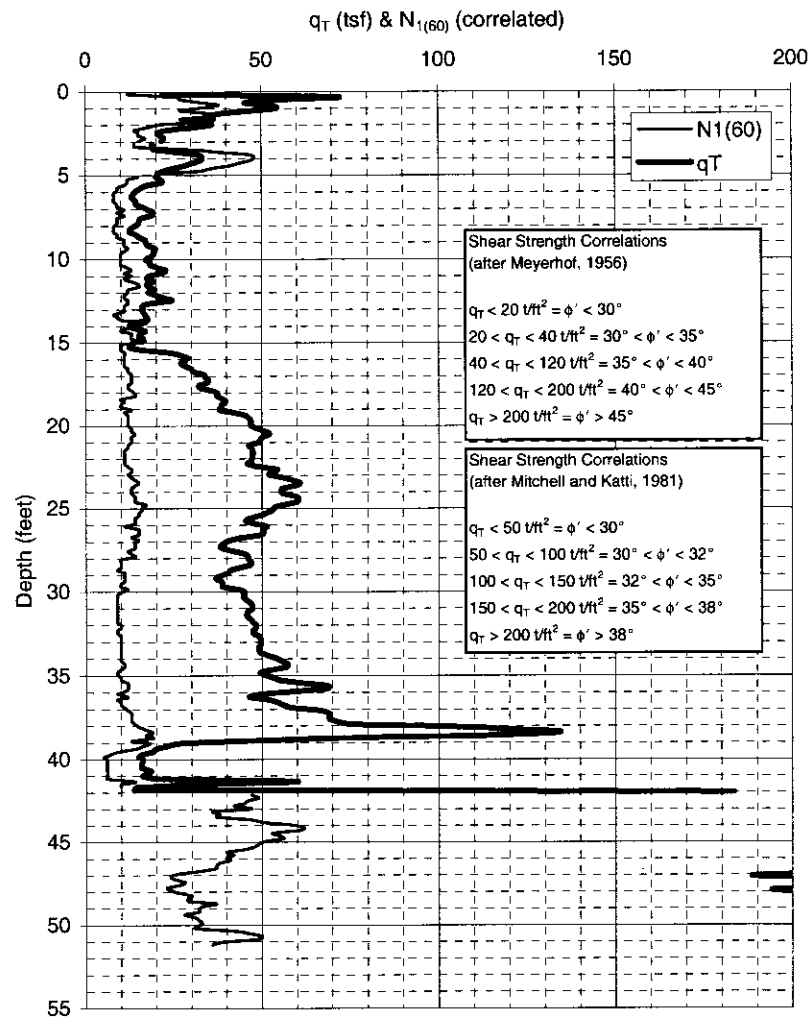
[08/28/2000 3:14 PM cptint2.xls]

Figure 2.11

Cache Creek CPT -10



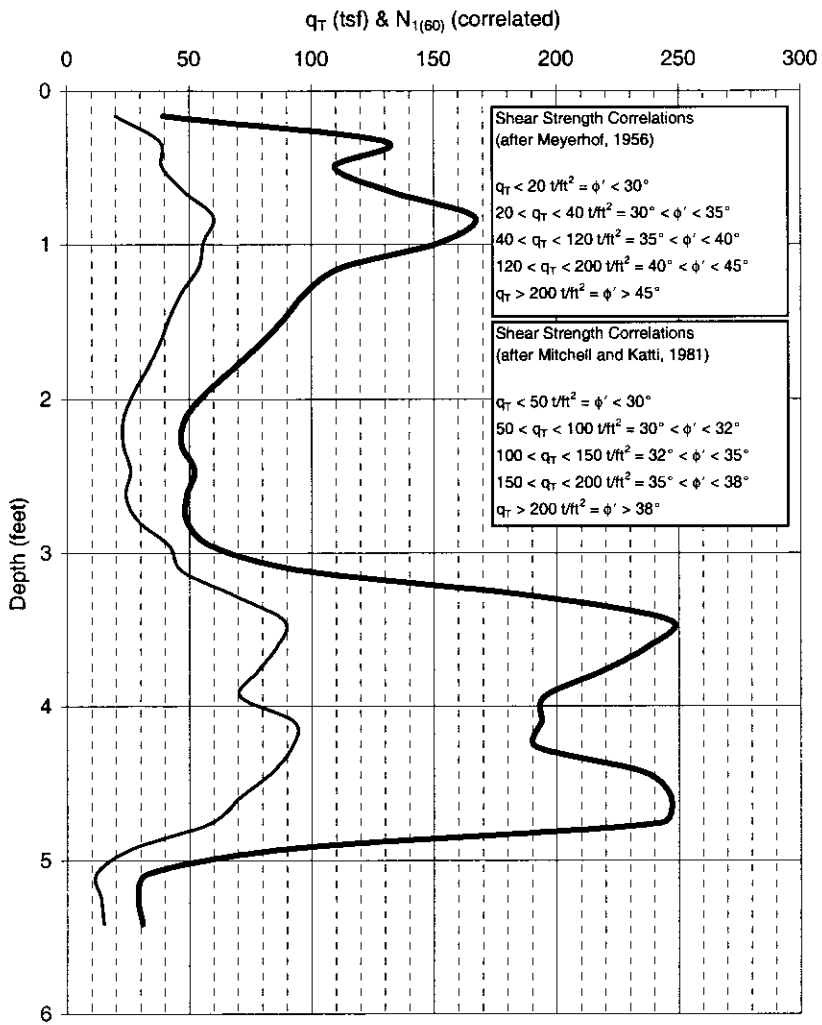
Cache Creek CPT -11



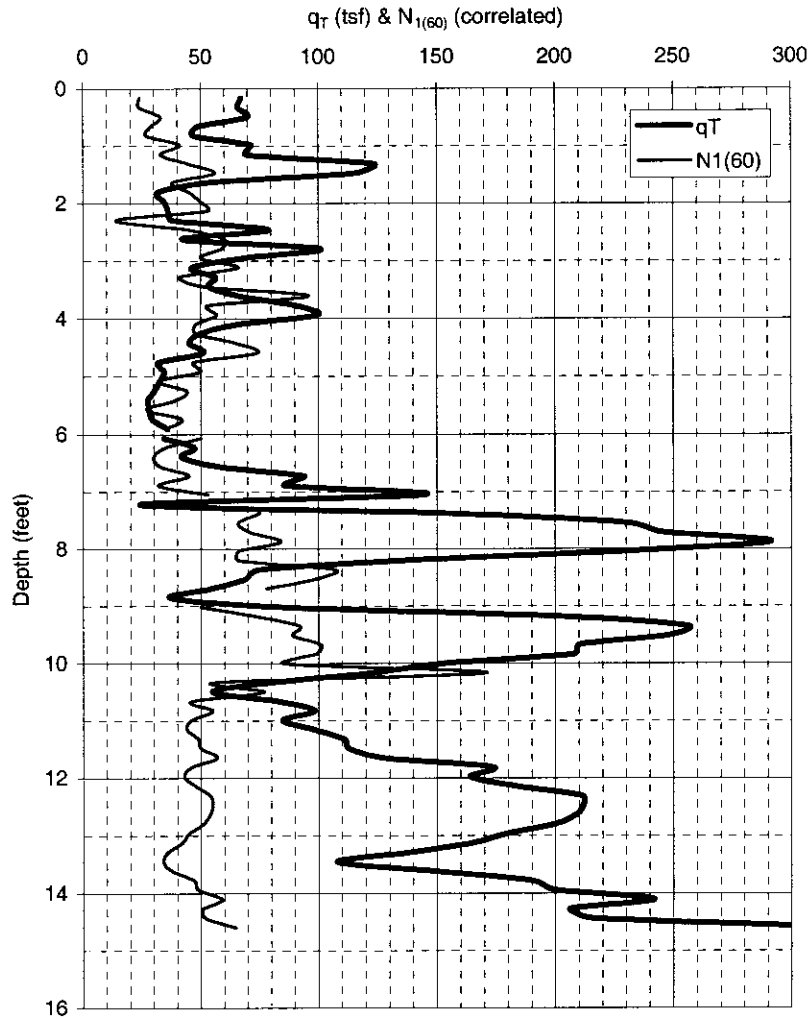
[08/28/2000 3:15 PM cptint2.xls]

Figure 2.12

Cache Creek CPT -12

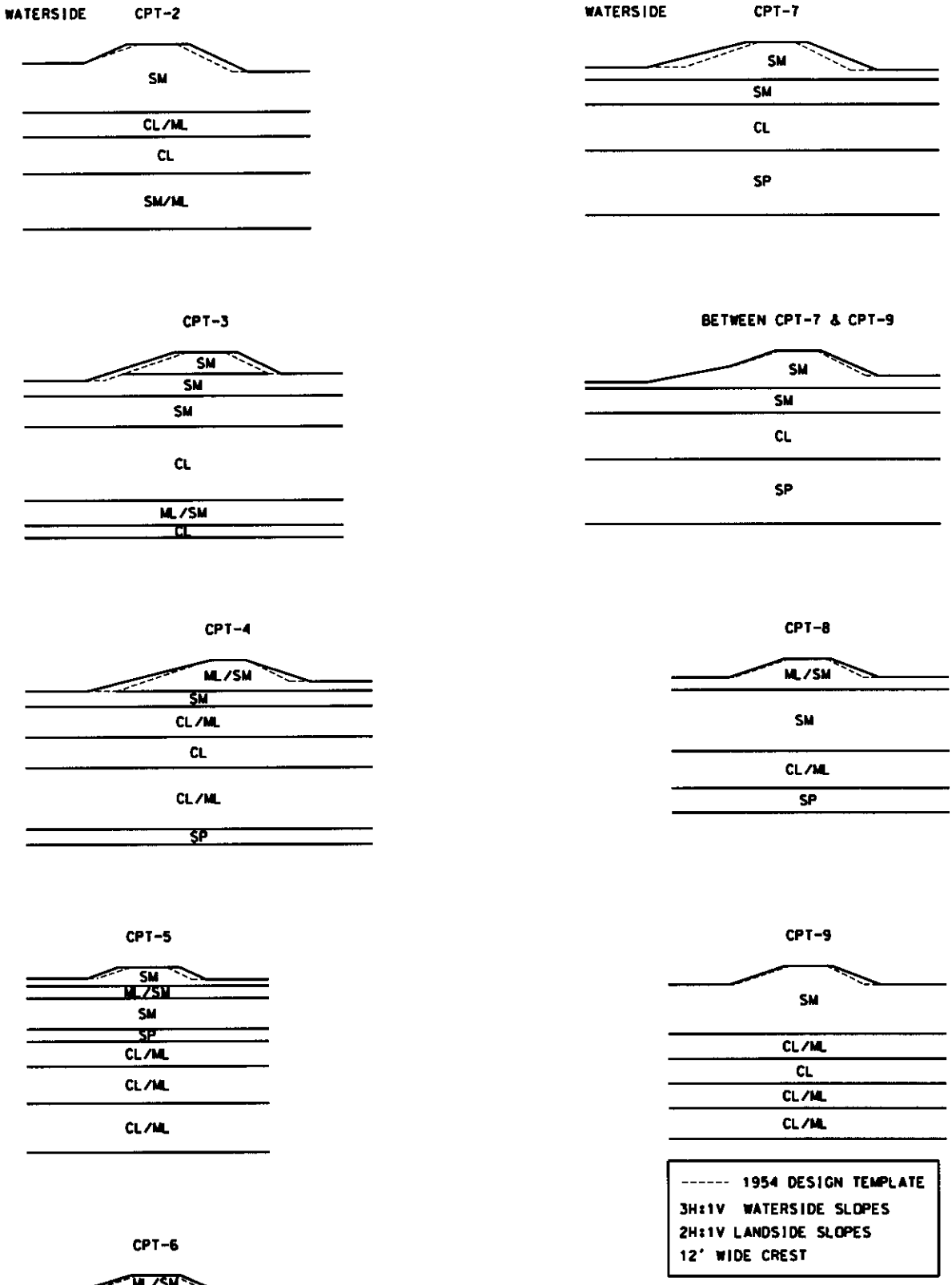


Cache Creek CPT -13



[08/28/2000 3:16 PM cptint2.xls]

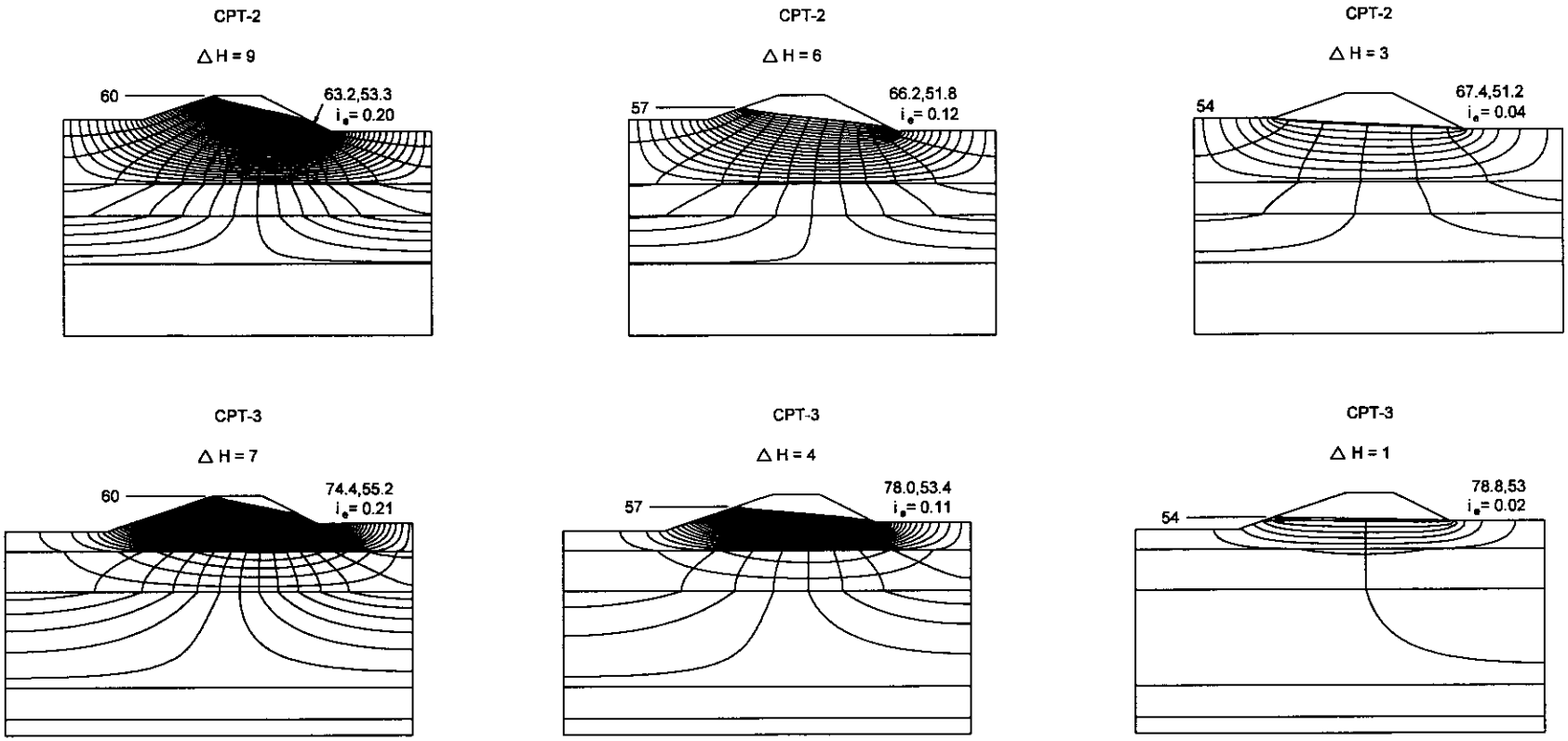
Figure 2.13



CACHE CREEK SIMPLIFIED
STRATIGRAPHY MODELS

FIGURE 2.14

...\data\westside tribs\ccsec.dan Aug. 28, 2000 15:27:11

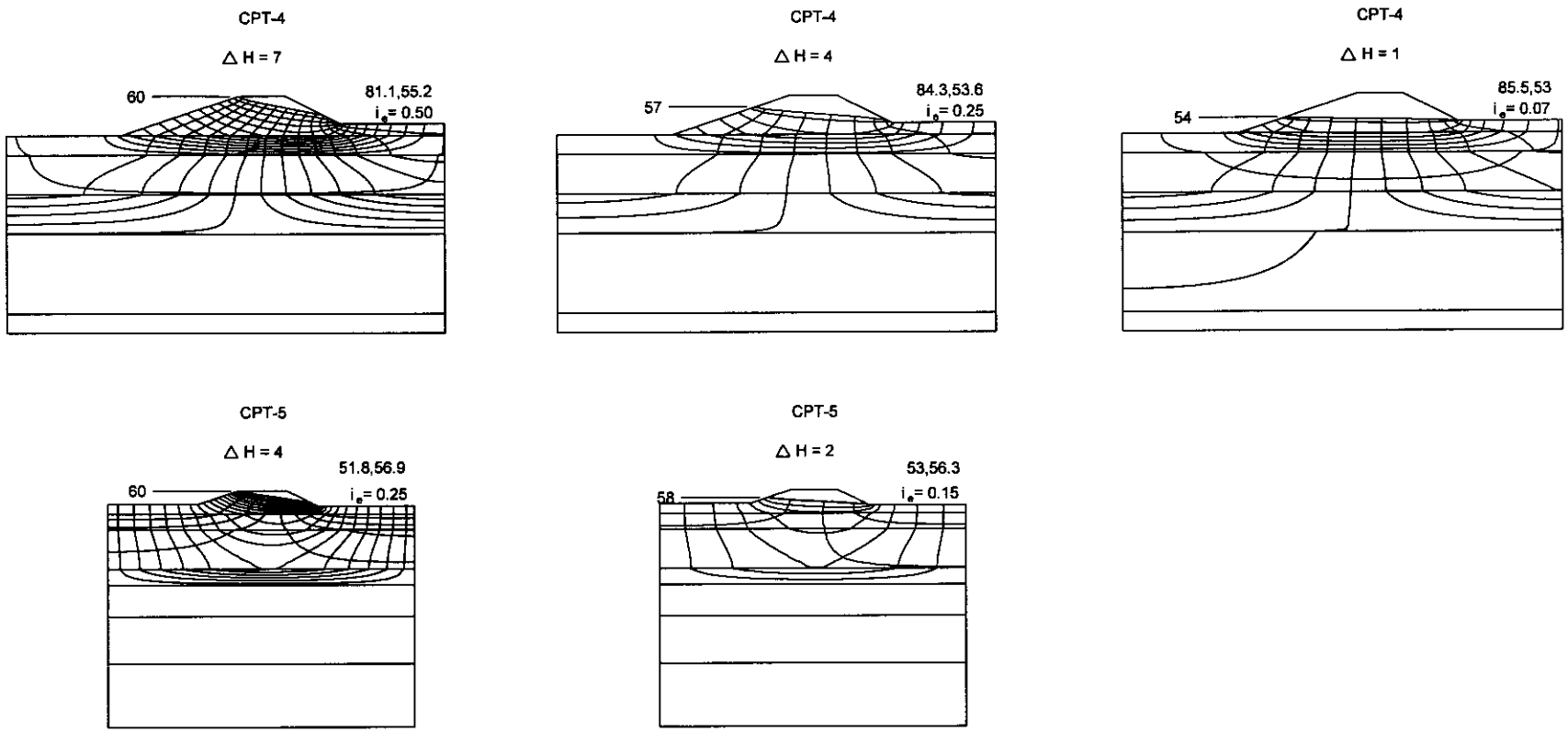


CACHE CREEK CPT'S 2 AND 3
RISK-BASED SEEPAGE ANALYSES

NOTES:
1) COORDINATES SHOWN ARE NOT ELEVATIONS

FIGURE 4.1

...\westside tribs\flownets2.dgn Aug. 28, 2000 15:28:47

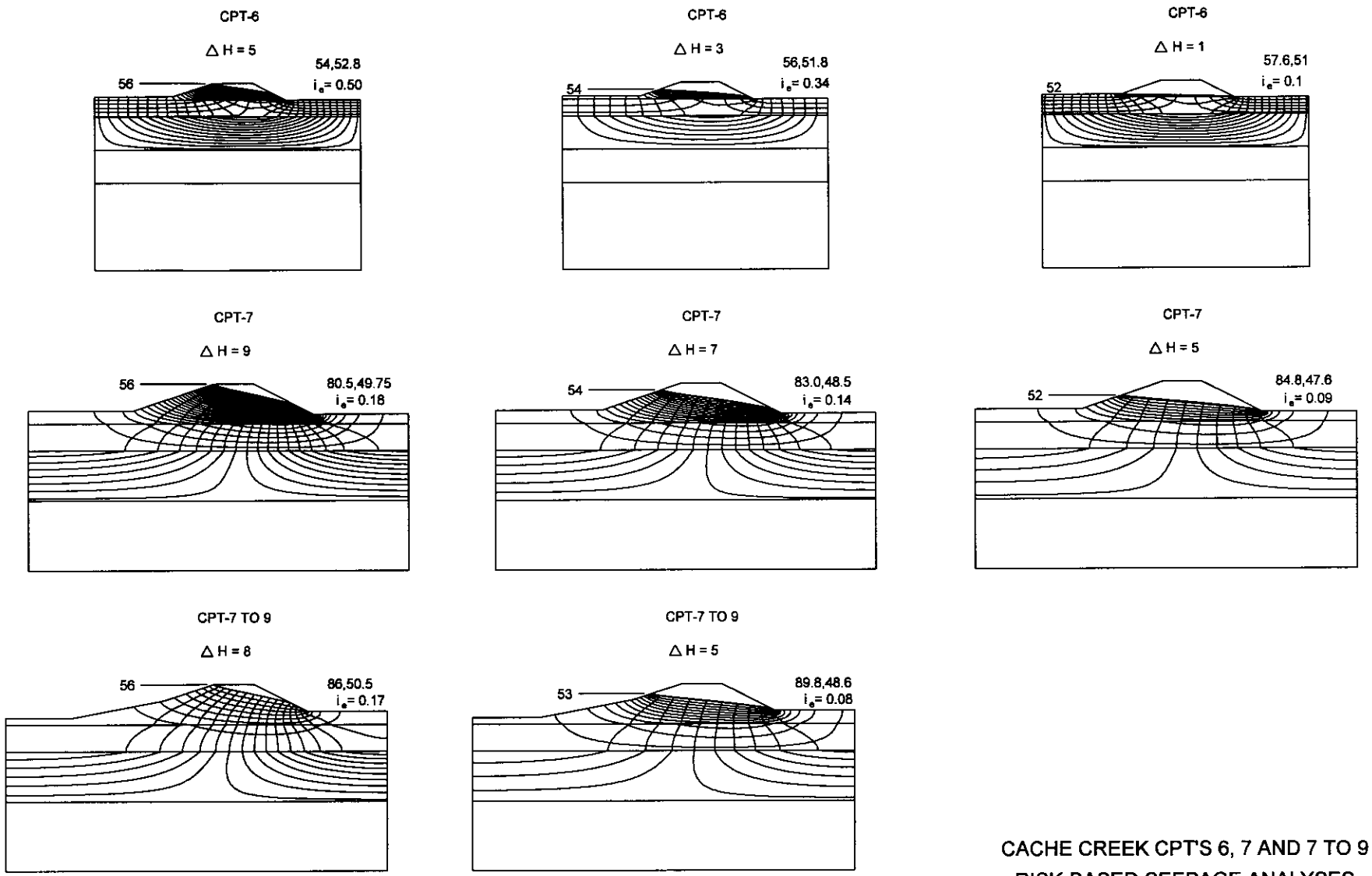


CACHE CREEK CPT'S 4 AND 5
RISK-BASED SEEPAGE ANALYSES

NOTES:
1) COORDINATES SHOWN ARE NOT ELEVATIONS

FIGURE 4.2

...\westside tribs\flownets2.dgn Aug. 28, 2000 15:28:55

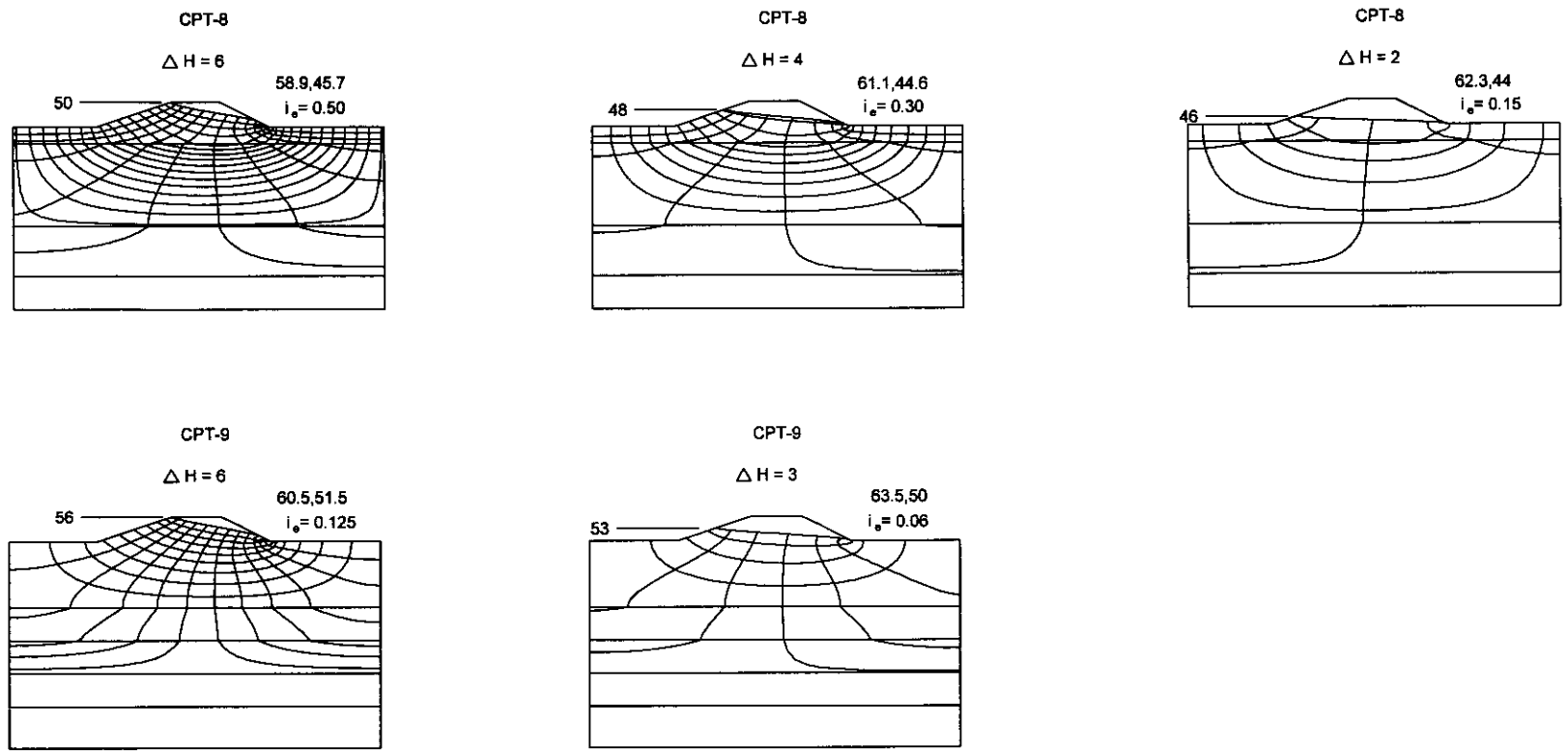


CACHE CREEK CPT'S 6, 7 AND 7 TO 9
RISK-BASED SEEPAGE ANALYSES

NOTES:
1) COORDINATES SHOWN ARE NOT ELEVATIONS

FIGURE 4.3

...\westside tribs\flownets2.dgn Aug. 28, 2000 15:29:01



CACHE CREEK CPT'S 8 AND 9
RISK-BASED SEEPAGE ANALYSES

NOTES:
1) COORDINATES SHOWN ARE NOT ELEVATIONS

FIGURE 4.4

...\westside tribs\flownets2.dgn Aug. 28, 2000 15:29:08

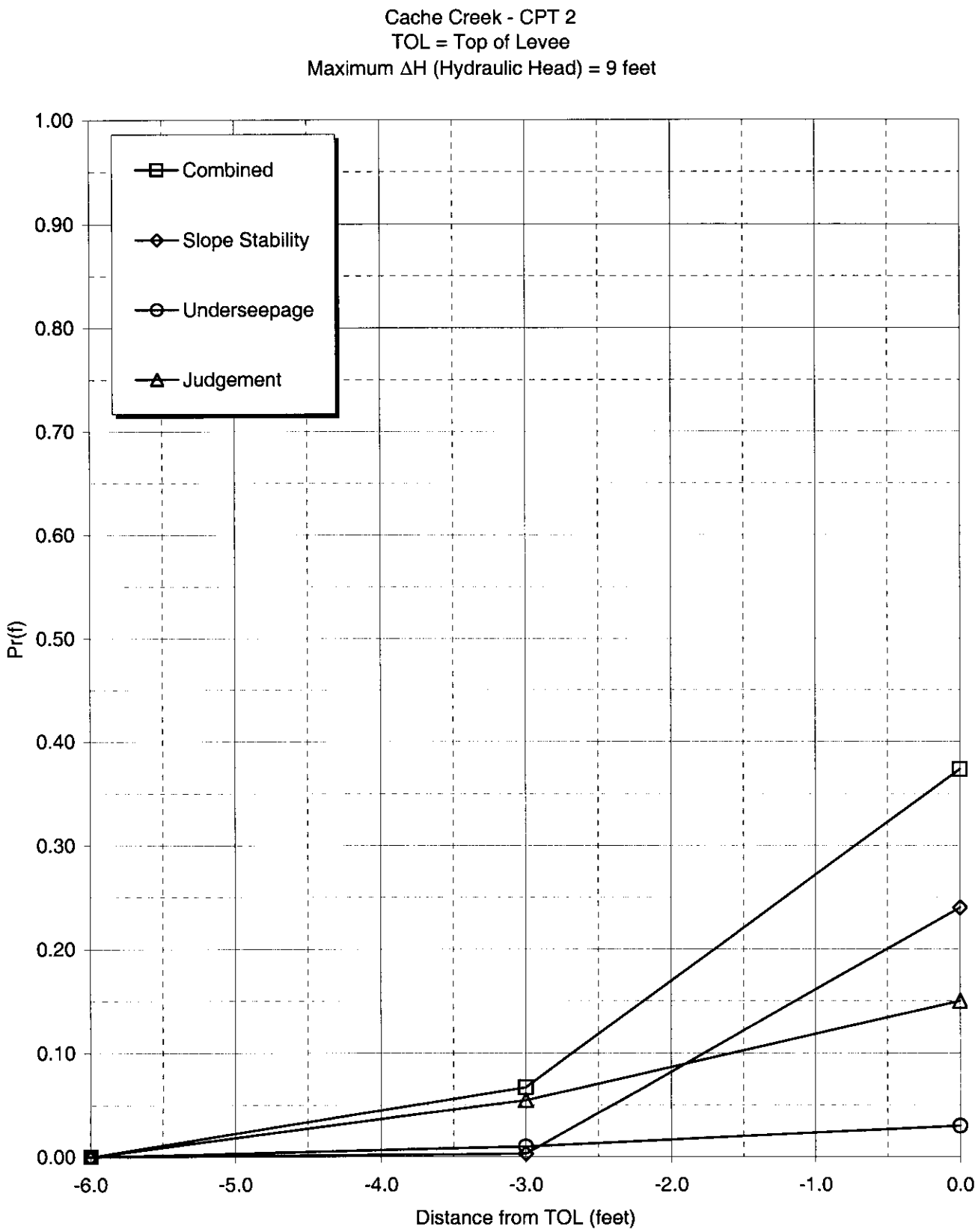

Cache Creek - CPT 2
TOL = Top of Levee
Maximum ΔH (Hydraulic Head) = 9 feet
Combined
Slope Stability
Underseepage
Judgement
Pr(f)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-6.0
-5.0
-4.0
-3.0
-2.0
-1.0
0.0
Distance from TOL (feet)

Figure 4.5

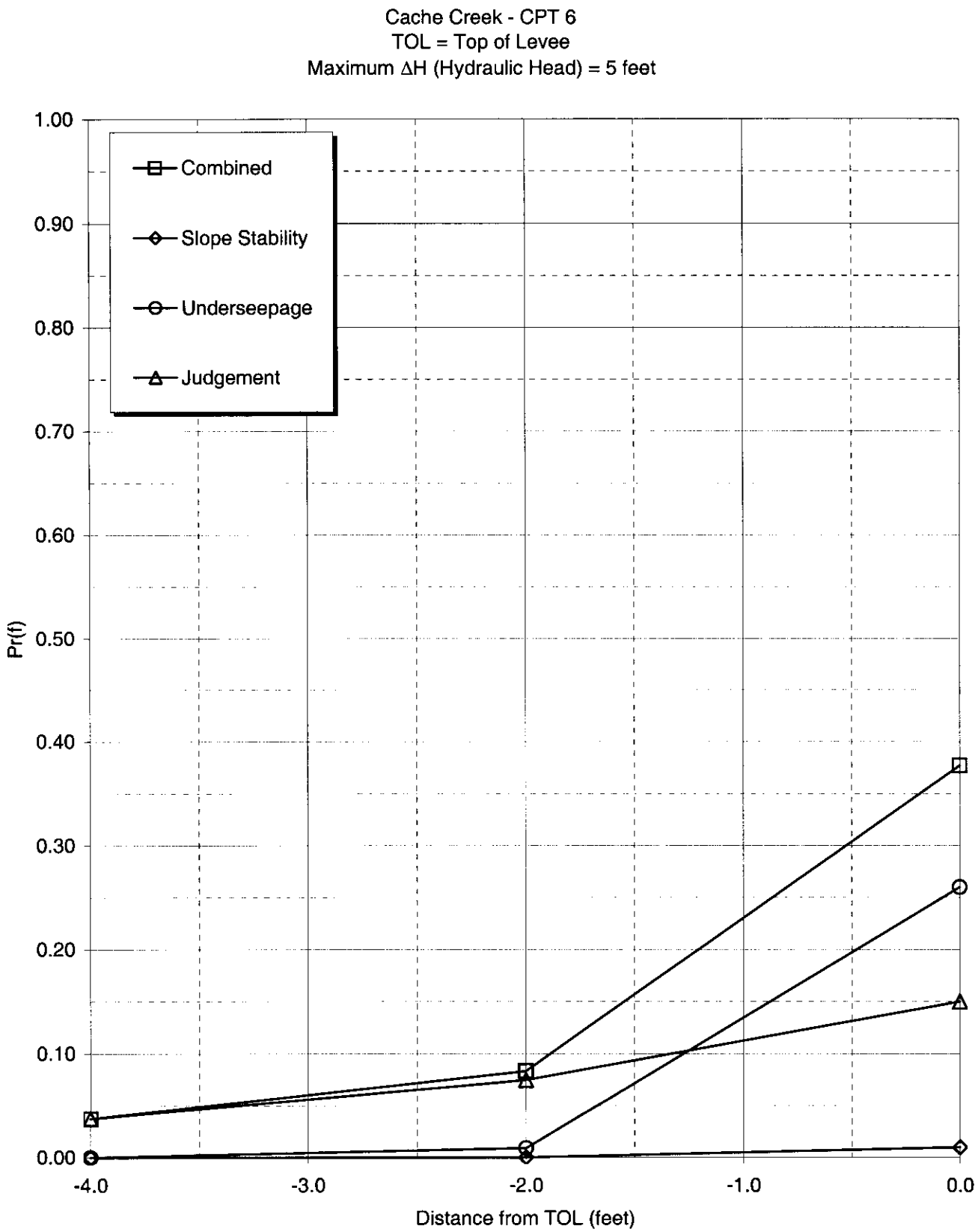

Cache Creek - CPT 6
TOL = Top of Levee
Maximum ΔH (Hydraulic Head) = 5 feet
Combined
Slope Stability
Underseepage
Judgement
Pr(f)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-4.0
-3.0
-2.0
-1.0
0.0
Distance from TOL (feet)

Figure 4.6

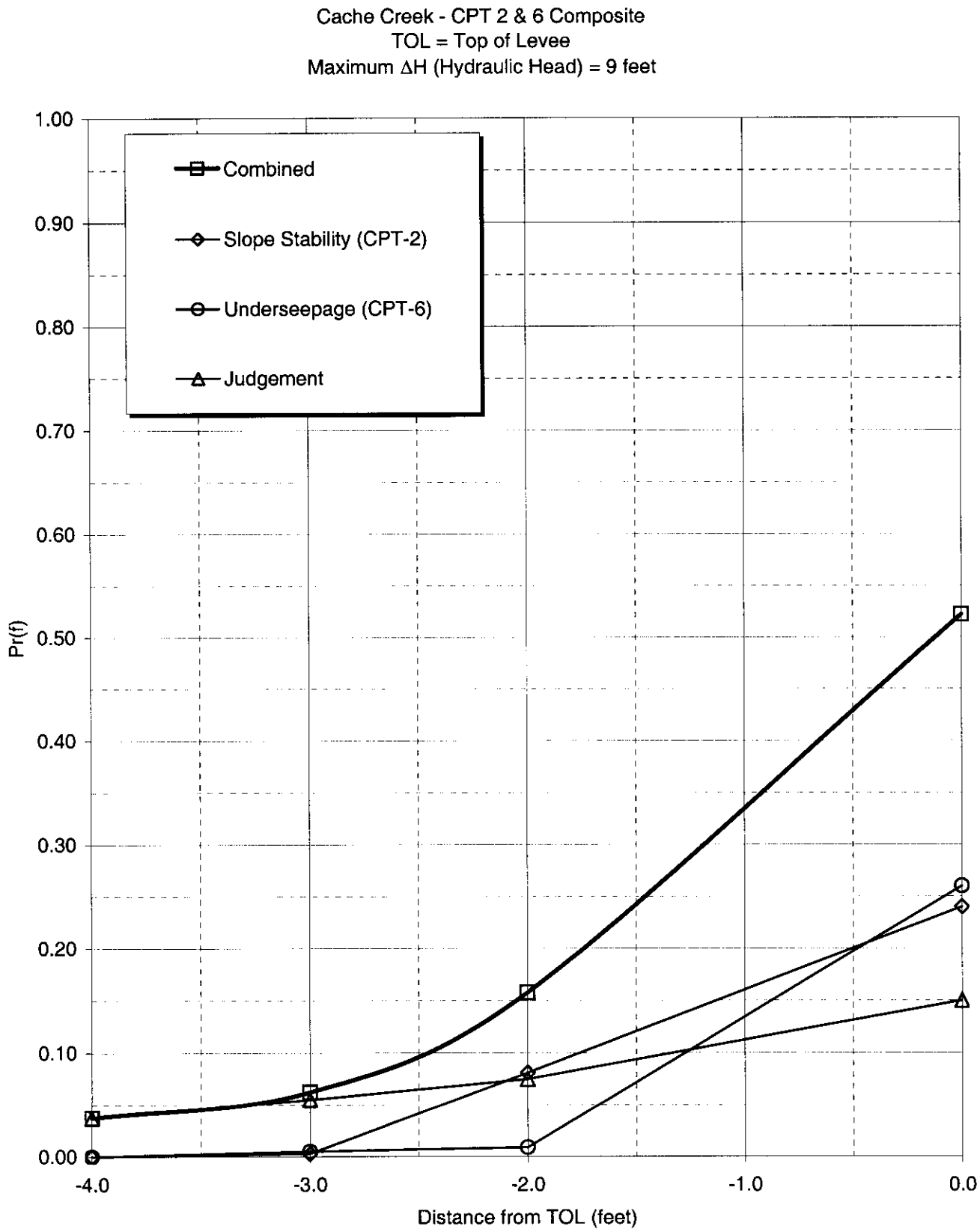

Cache Creek - CPT 2 & 6 Composite
TOL = Top of Levee
Maximum ΔH (Hydraulic Head) = 9 feet
Combined
Slope Stability (CPT-2)
Underseepage (CPT-6)
Judgement
Pr(f)
1.00
0.90
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0.00
-4.0
-3.0
-2.0
-1.0
0.0
Distance from TOL (feet)

Figure 4.7

2F-8-1
Elev. 90.0

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				2	98		NP	21	SILT
5.0'	ML				13	87		NP	32	SANDY SILT
	ML				43	57		NP	26	SANDY SILT
10.0'	SM	37	49	14				NP	4	SILTY GRAVELLY SAND
15.0'	SP	46	47	7				NP	4	GRAVELLY SAND
	GP	57	39	4				NP	3	SANDY GRAVEL
20.0'	SP	44	51	5				NP	5	GRAVELLY SAND
	SP		94	6				NP	8	SAND
										WATER JUNE 58
25.0'	SP	33	61	6				NP	11	GRAVELLY SAND

2F-8-2
Elev. 92.0

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				17	83		NP	14	SANDY SILT
5.0'	CL				8	92	37	16	28	CLAY
	CL				11	89	35	13	24	CLAY
10.0'	SM				68	32		NP	10	SILTY SAND
	SM				81	19		NP	9	SILTY SAND
15.0'	CL				22	78	31	12	22	SANDY CLAY
20.0'	CL				6	94	42	21	19	CLAY
	CL				5	95	39	20	18	CLAY
25.0'	CL				10	90	41	20	23	CLAY
30.0'	CL				8	92	42	21	26	CLAY
35.0'	CL				11	89	39	17	28	CLAY

2F-8-3
Elev. 87.1

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				17	83		NP	12	SANDY SILT
5.0'	ML				9	91		NP	13	SILT
10.0'	ML				16	84		NP	11	SANDY SILT
	ML				6	94		NP	18	SILT
15.0'	SM				51	49		NP	12	SILTY SAND
	SM				67	33		NP	12	SILTY SAND
20.0'	CL				30	70	30	11	25	SANDY CLAY
	CL				8	92	44	21	27	CLAY
25.0'	CL				14	86	42	20	24	SANDY CLAY

2F-8-4
Elev. 83.8

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				28	72		NP	8	SANDY SILT
5.0'	SM				50	50		NP	12	SILTY SAND
10.0'	ML				37	63		NP	17	SANDY SILT
15.0'	ML				47	53		NP	12	
	ML				4	96		NP	35	SILT
20.0'	ML				21	79		NP	29	SANDY SILT
25.0'	CL				20	80	41	18	28	SANDY CLAY
	ML				35	65		NP	19	SANDY SILT
30.0'	CL				15	85	34	12	26	C SANDY CLAY
	CL				15	85	36	15	27	C SANDY CLAY

2F-8-5
Elev. 83.5

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				37	63		NP	10	SANDY SILT
5.0'	ML				39	61		NP	18	SANDY SILT
10.0'	SM				59	41		NP	11	SILTY SAND
15.0'	CL				24	76	31	11	23	SANDY CLAY
20.0'	CL				4	96	35	11	33	CLAY
25.0'	CL				19	81	40	19	26	SANDY CLAY
	CL				29	71	30	12	20	SANDY CLAY
30.0'	CL				10	90	37	13	28	C CLAY
	CL				10	90	44	20	26	C CLAY

2F-8-6
Elev. 83.4

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				42	58		NP	7	
5.0'	ML				35	65		NP	18	
10.0'	ML				17	83		NP	21	SANDY SILT
15.0'	ML				30	70		NP	20	
20.0'	ML				5	95		NP	32	SILT
25.0'	ML				10	90		NP	35	
	ML				32	68		NP	18	SANDY SILT
30.0'	CL				10	90	36	15	28	CLAY

2F-8-7
Elev. 75.9

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	SP				96	4		NP	4	SAND
5.0'	SP				95	5		NP	3	
	SM				82	18		NP	8	SILTY SAND
10.0'	SP				95	5		NP	3	SAND
15.0'	SM				65	35		NP	9	
	SM				56	44		NP	10	SILTY SAND
20.0'	SM			24	58	18		NP	12	SILTY GRAVELLY SAND
25.0'	SP		34	62	4	26	10	4		GRAVELLY SAND
27.5'	CL			23	77	37	19	11		SANDY CLAY

2F-8-8
Elev. 67.0

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	CL				25	75	30	12	12	SANDY CLAY
5.0'	CL				16	84	32	12	15	
10.0'	SM				58	42		NP	10	SILTY SAND
	ML				48	52		NP	18	SANDY SILT
15.0'	SP	9			86	5		NP	3	SAND
	SM	39			48	13		NP	6	SILTY GRAVELLY SAND
20.0'	ML				3	97	35	10	36	SILT
25.0'	CH				8	92	53	28	30	FAT CLAY
	CL				16	84	39	21	20	
30.0'	CL				26	74	33	16	24	SANDY CLAY
35.0'	CL				25	75	29	10	27	

2F-8-9
Elev. 70.3

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				25	75		NP	13	
5.0'	ML				36	64		NP	15	SANDY SILT
	ML				47	53		NP	13	
10.0'	ML				5	95		NP	29	SILT
15.0'	ML				33	67		NP	20	SANDY SILT
20.0'	SP	17			76	7		NP	10	GRAVELLY SAND
	SP	5			74	11		NP	10	GRAVELLY SAND
25.0'	SM				51	49		NP	22	SILTY SAND
	CH				19	81	53	26	38	SANDY FAT CLAY

2F-8-10
Elev. 50.4

Depth	Unified	G	R	S	A	Fi	LL	PI	MC	Description
0.0	ML				16	84		NP	23	SANDY SILT
5.0'	ML				17	83		NP	24	SANDY SILT
	CL				29	71	28	10	19	SANDY CLAY
	SP	15			80	5		NP	6	
10.0'	ML				36	64		NP	30	GRAVELLY SAND
	SM	17			71	12		NP	6	SANDY SILT SILTY GRAVELLY SAND
15.0'	SM									WATER MAY 58
	SM				86	14		NP	18	SILTY SAND
20.0'	CH				4	96	54	28	37	FAT CLAY
24.0'										

LEGEND

GP Poorly-graded Gravels, Gravel-Sand mixtures, little or no fines.
SP Poorly-graded Sand, Gravelly Sand, little or no fines.
SM Silty Sand, Sand-Silt mixtures.
SC Clayey Sand, Sand-Clay mixtures.
ML Inorganic Silt and very fine Sand, Rock flour, Silty or Clayey fine Sand or Clayey Silt with low plasticity.
CL Inorganic Clay of low to medium plasticity, Gravelly Clay, Sandy Clay, Silty Clay, Lean Clay.
CH Inorganic Clay of high plasticity, Fat Clay.
GR Gravel.
SA Sand.
FI Fines.
LL Liquid Limit.
PI Plasticity Index.
MC Moisture Content.
C Cemented material.
N.P. Nonplastic.

NOTES

1. All classifications are laboratory classifications in accordance with the C. of E. "Unified Soil Classification System".
2. All holes were drilled to specified depth except holes 2F-8-7, 2F-8-10, 2F-8-11 and 2F-8-13 wwhere refusal was met due to caving sand and gravels.
3. Elevations are referred to C. of E. datum 3.0 feet below mean sea level.

GRAPHIC SCALE
1"=5' 0 1' 2.5' 5' 10' 15' 20' 25'

REDRAWN FROM 1958 ORIGINAL

US Army Corps of Engineers
Sacramento District

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS
SACRAMENTO, CALIFORNIA

SACRAMENTO DISTRICT
IN-HOUSE DESIGN
1325 "J" STREET
SACRAMENTO, CA 95814-2922

CACHE CREEK
CALIFORNIA
FLOOD CONTROL PROJECT
LEVEE CONSTRUCTION
YOLO BYPASS TO HIGH GROUND
LOGS OF EXPLORATIONS
2F-8-1 THROUGH 2F-8-10

Sheet reference number:
B1.0
Sheet

Reference - Exploration Log file no.: XXX-01-XXX
Soil Design Section Sheet No.: 1 of X