Panama Canal Authority
Engineering and Projects Department
Engineering Division
Geotechnical Branch

Study on the effect of deepening on Gaillard Cut slopes

Volume 3
Appendix B: Stability Analysis – East Bank

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April 2002

ACP
AUTORIDAD DEL CANAL DE PANAMA

Appendix B

Channel Deepening

Stability Analysis
Gaillard Cut – East Bank

April, 2002

Panama Canal Authority
Engineering Division - Geotechnical Branch

Summary of Stability Analises

Gaillard Cut - East Bank

Station	Representative Stations	Factor of Safety									
		Case 1	Case 2	Case 3	Case 4.1	Case 4.2	Case 5	Case 6	Case 7.1	Case 7.2	Case 8
		Existing	27 ft (blasted)	27 ft (removed)	27 ft (design-underwater slope)	27 ft (design-&dry excav.)	22 ft (blasted)	22 ft (removed)	22 ft (design-underwater slope)	22 ft (design-&dry excav.)	16 ft (blasted)
51k + 328 E (1684 + 00)	50k + 780 to 52k + 060	2.925	2.883	2.828	2.727	2.727	2.776	2.687	2.523	2.523	2.479
53k + 371 E (1751 + 00)	52k + 060 to 53k + 550	1.508	1.496	1.457	1.433	1.433	1.439	1.396	1.362	1.362	1.346
53k + 950 E (1770 + 04)	53k + 550 to 54k + 880	1.345	1.330	1.272	1.195	1.195	1.221	1.147	1.056	1.212	1.021
55k + 280 E (1813 + 65)	54k + 880 to 55k + 400	1.038	1.021	1.000	0.985	1.065	0.976	0.947	0.914	1.034	0.908
55k + 830 E (1831 + 70)	55k + 400 to 56k + 000	0.991	0.988	0.970	0.958	0.996	0.961	0.947	0.917	0.990	0.917
56k + 460 E (1852 + 36) (a)	56k + 000 to 56k + 560	0.921	0.919	0.892	0.861	0.912	0.875	0.843	0.789	0.913	0.784
56k + 460 E (1852 + 36) (b)	56k + 000 to 56k + 560	1.091	1.090	1.077	1.020	1.061	1.054	1.029	0.944	1.050	0.936
57k + 060 E (1872 + 00) (a)	56k + 560 to 57k + 160	1.343	1.343	1.322	1.304	1.304	1.311	1.276	1.228	1.228	1.227
57k + 060 E (1872 + 00) (b)	56k + 560 to 57k + 160	1.291	1.288	1.274	1.271	1.271	1.269	1.254	1.234	1.234	1.230
57k + 270 E (1878 + 93)	57k + 160 to 57k + 320	2.996	2.982	2.957	2.927	2.927	2.927	2.864	2.763	2.763	2.754
57k + 635 E (1890 + 91)	57k + 320 to 57k + 675	1.290	1.289	1.281	1.271	1.271	1.280	1.248	1.225	1.225	1.223
58k + 035 E (1904 + 00)	57k + 675 to 58k + 295	1.001	0.992	0.962	0.861	0.996	0.950	0.923	0.795	1.006	0.772
58k + 520 E (1920 + 00)	58k + 295 to 59k + 600	1.054	1.053	1.048	1.046	1.046	1.047	1.045	1.041	1.125	1.041
59k + 668 E (1957 + 61)	59k + 600 to 59k + 800	0.931	0.931	0.928	0.927	1.036	0.928	0.926	0.922	1.035	0.922
59k + 918 E (1966 + 00)	59k + 800 to 60k + 050	1.345	1.345	1.340	1.333	1.333	1.340	1.332	1.324	1.324	1.324
60k + 244 E (1976 + 50)	60k + 050 to 60k + 355	1.051	1.051	1.047	1.045	1.045	1.047	1.043	1.039	1.063	1.039
60k + 412 E (1982 + 00) (a)	60k + 355 to 60k + 500	1.199	1.199	1.186	1.176	N/A	1.186	1.173	1.161	N/A	1.160
60k + 412 E (1982 + 00) (b)	60k + 355 to 60k + 500	0.845	0.831	0.802	0.737	N/A	0.778	0.754	0.676	N/A	0.541
60k + 412 E (1982 + 00) (c)	60k + 355 to 60k + 500	0.794	0.794	0.793	0.634	N/A	0.753	0.717	0.588	N/A	0.588
60k + 594 E (1988 + 00) (a)	60k + 500 to 60k + 695	1.049	1.048	1.045	1.033	1.268	1.044	1.044	1.025	1.265	1.025
60k + 594 E (1988 + 00) (b)	60k + 500 to 60k + 695	1.023	1.014	0.965	0.896	1.022	0.956	0.891	0.812	0.954	0.785
60k + 747 E (1993 + 00) (a)	60k + 695 to 60k + 850	1.251	1.227	1.203	1.131	1.174	1.198	1.162	1.080	1.188	1.079
60k + 747 E (1993 + 00) (b)	60k + 695 to 60k + 850	0.996	0.987	0.981	0.960	1.015	0.981	0.936	0.950	1.059	0.938
60k + 747 E (1993 + 00) (c)	60k + 695 to 60k + 850	1.183	1.182	1.172	1.163	1.185	1.171	1.160	1.149	1.163	1.148
61k + 720 E (2025 + 00)	61k + 420 to 61k + 825	2.766	2.765	2.735	2.658	2.658	2.735	2.707	2.614	2.614	2.612

Index

51k + 328

53k + 371

53k + 950

55k + 280

55k + 830

56k + 460

57k + 060

57k + 270

57k + 635

58k + 035

58k + 520

59k + 668

59k + 918

60k + 244

60k + 412

60k + 594

60k + 747

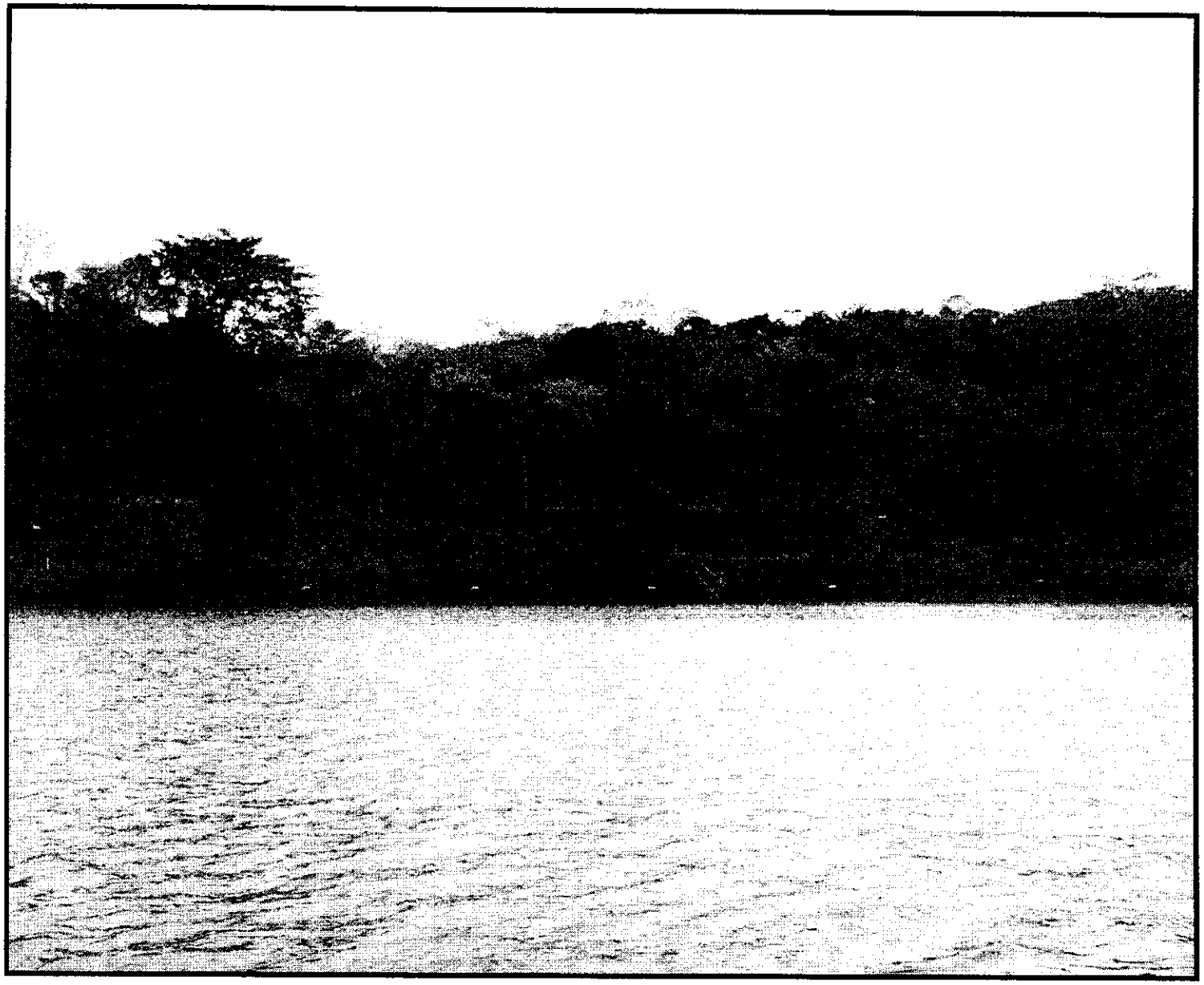
61k + 720

station 51k + 328 (1684 + 00)

East

Station: 51k + 328 (Chagres)

April 16, 2002



Case 1, Channel bottom = 32 ft

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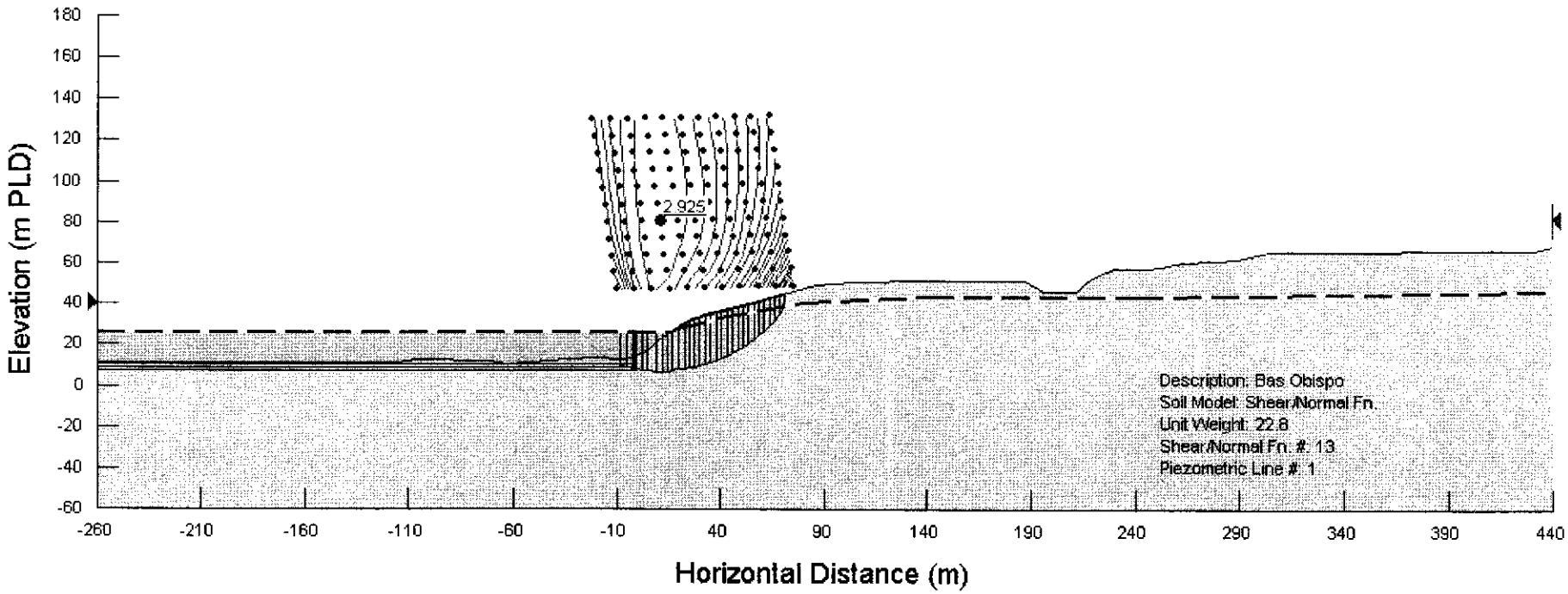
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 2, Channel bottom = 27 ft, Blasted material only

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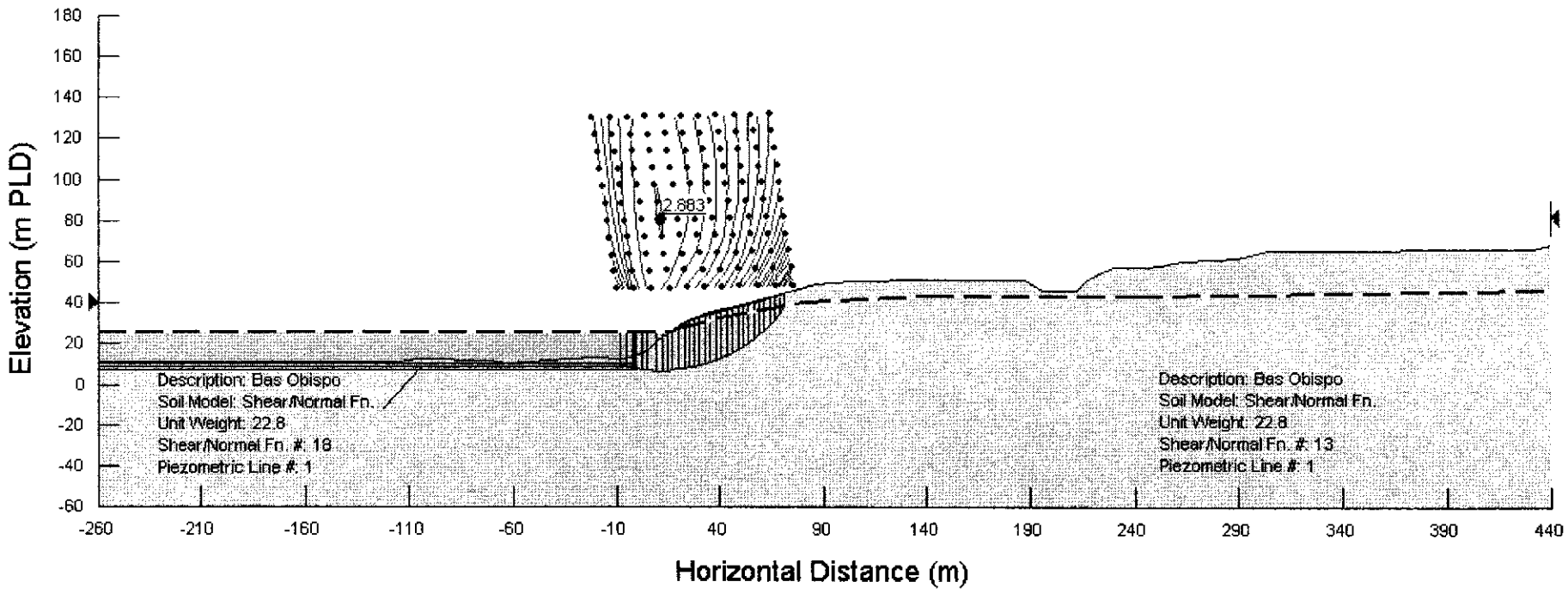
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 3, Channel bottom = 27 ft, Blasted & removed

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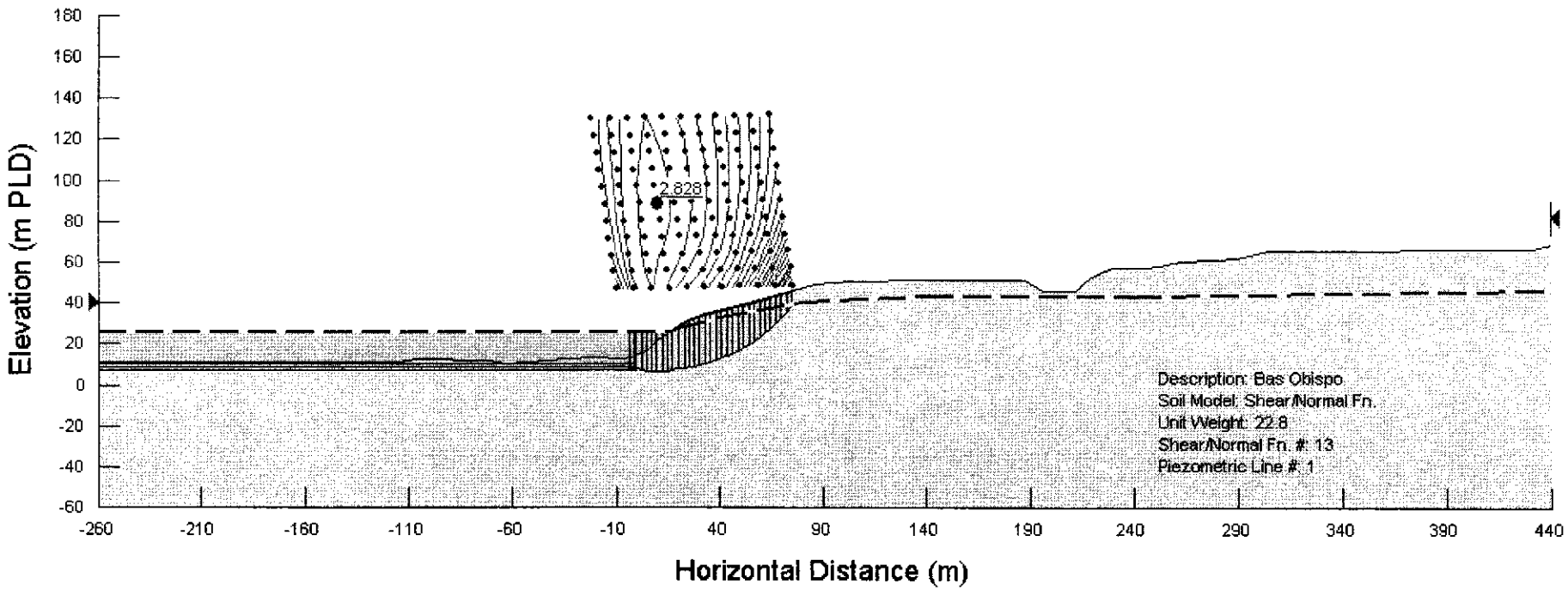
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 4.1, Channel bottom = 27 ft, Design (underwater slope)

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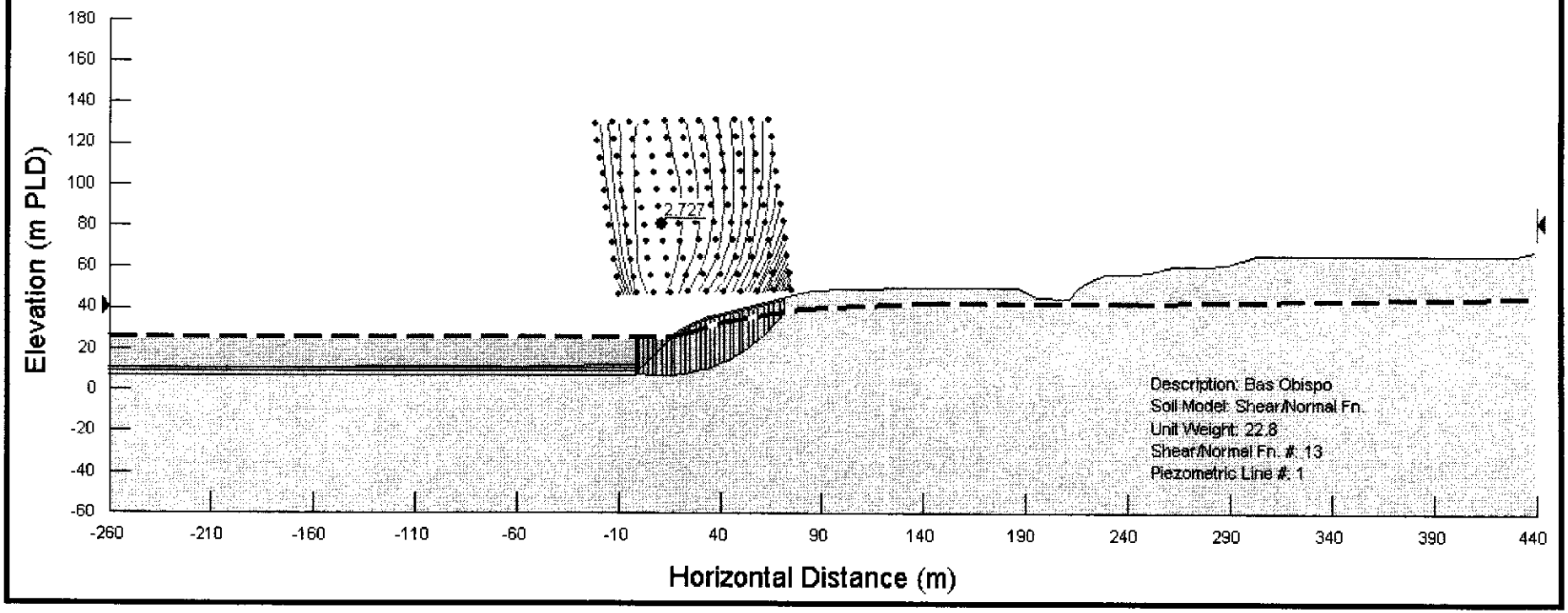
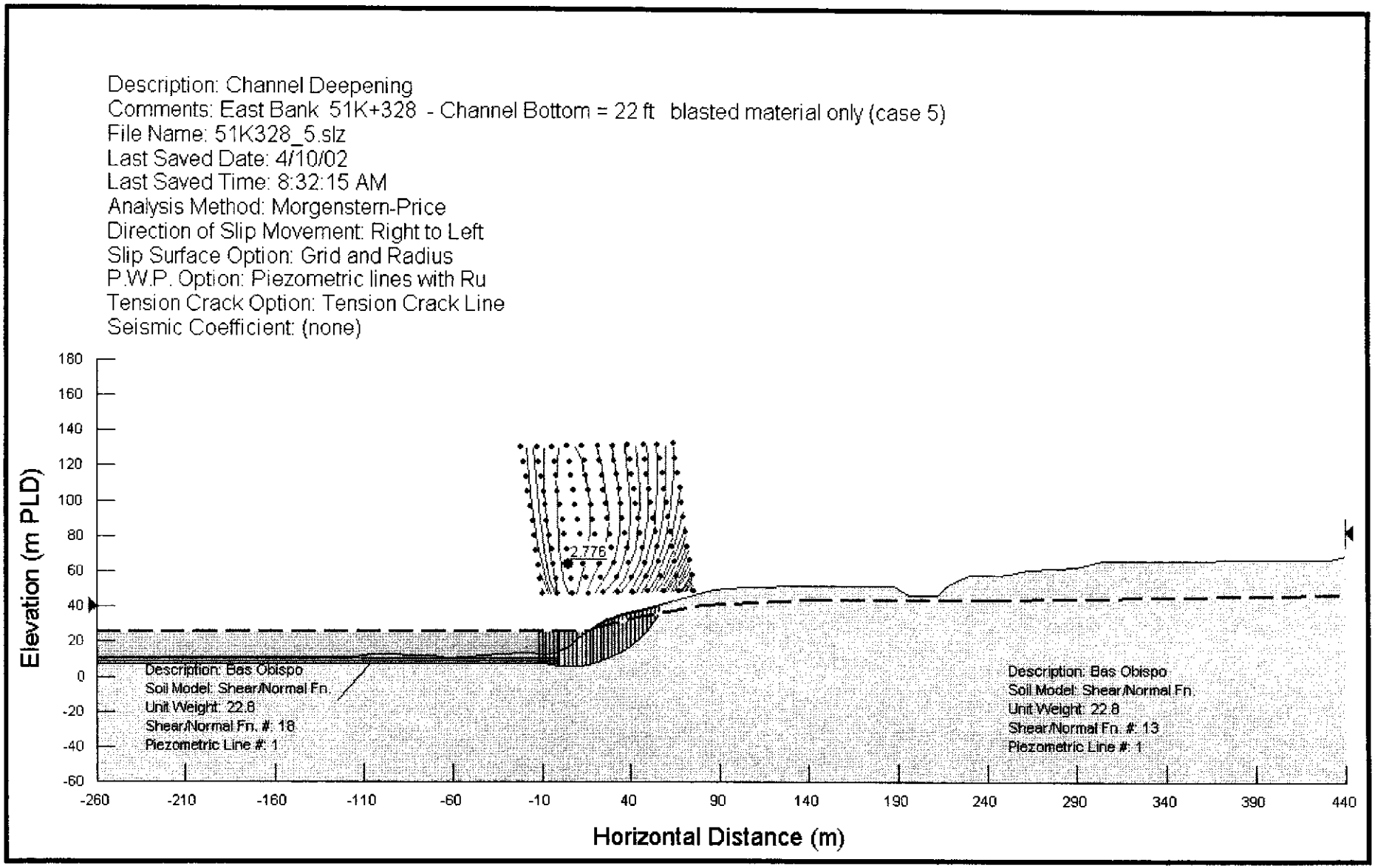
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 5, Channel bottom = 22 ft, Blasted material only



Case 6, Channel bottom = 22 ft, Blasted & removed

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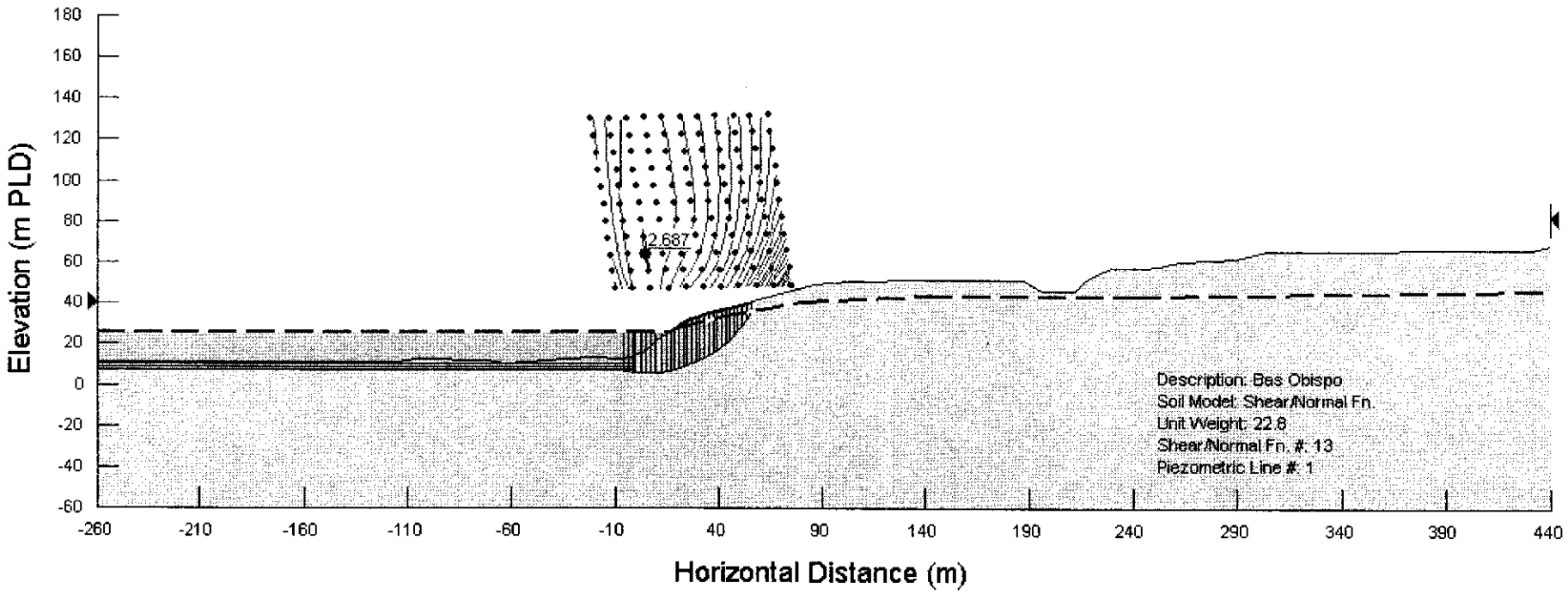
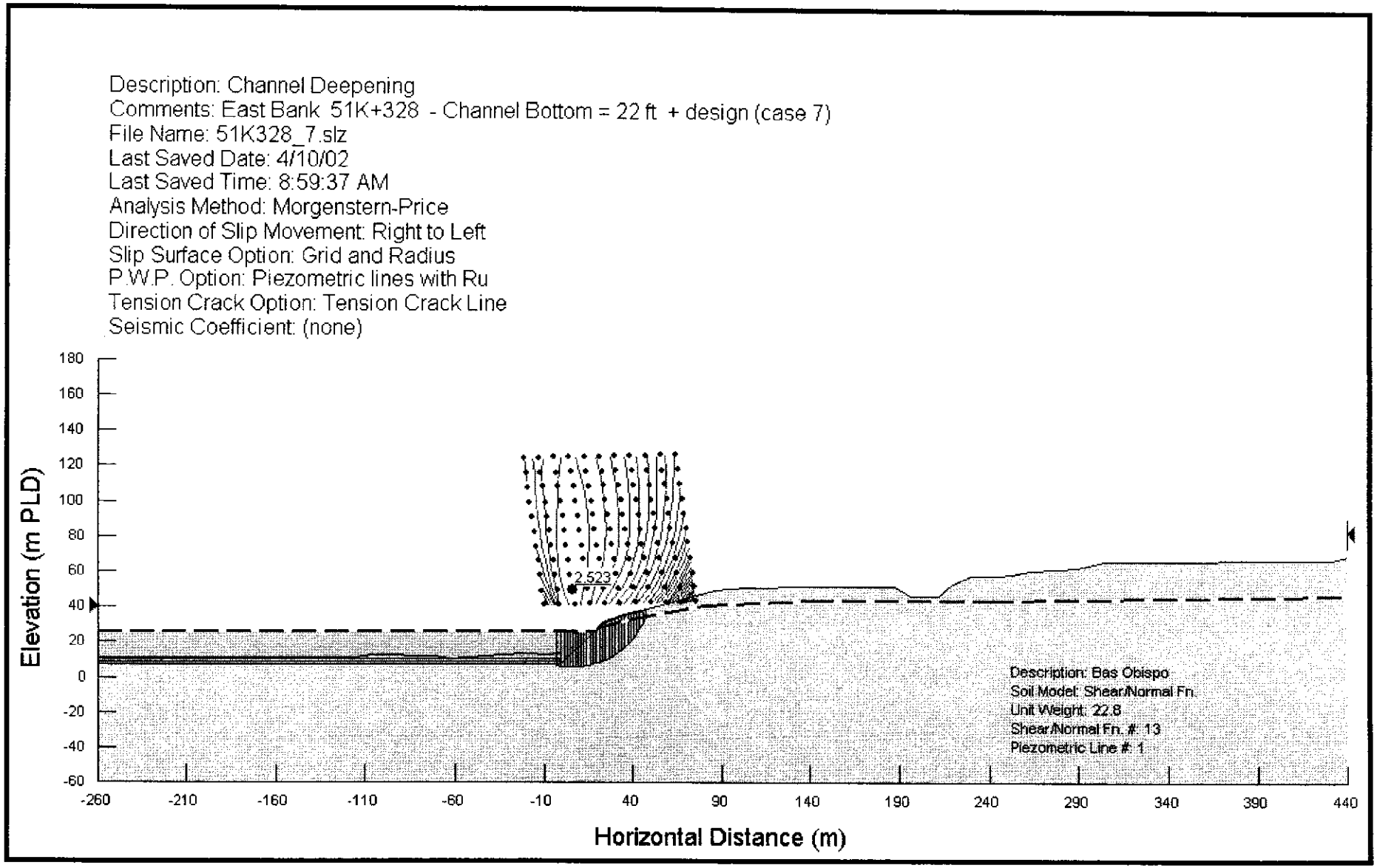
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 7.1, Channel bottom = 27 ft, Design (underwater slope)



Case 8, Channel bottom = 16 ft, Blasted

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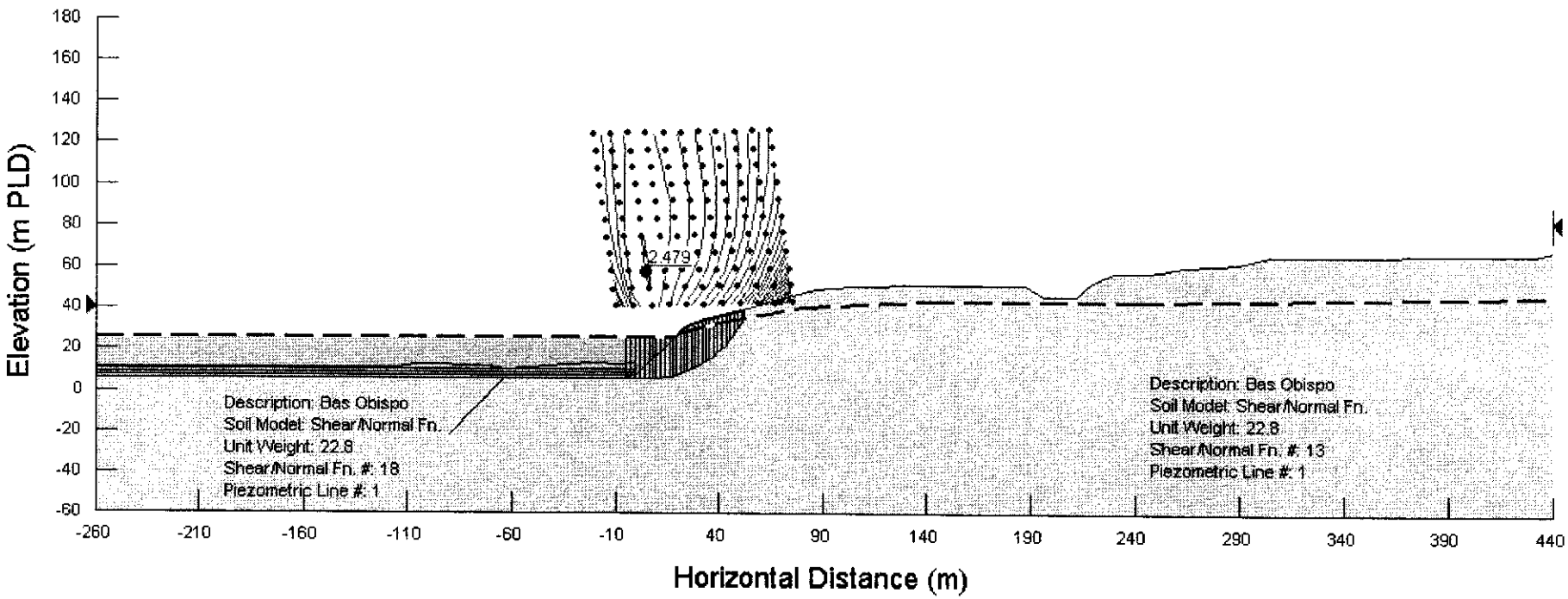
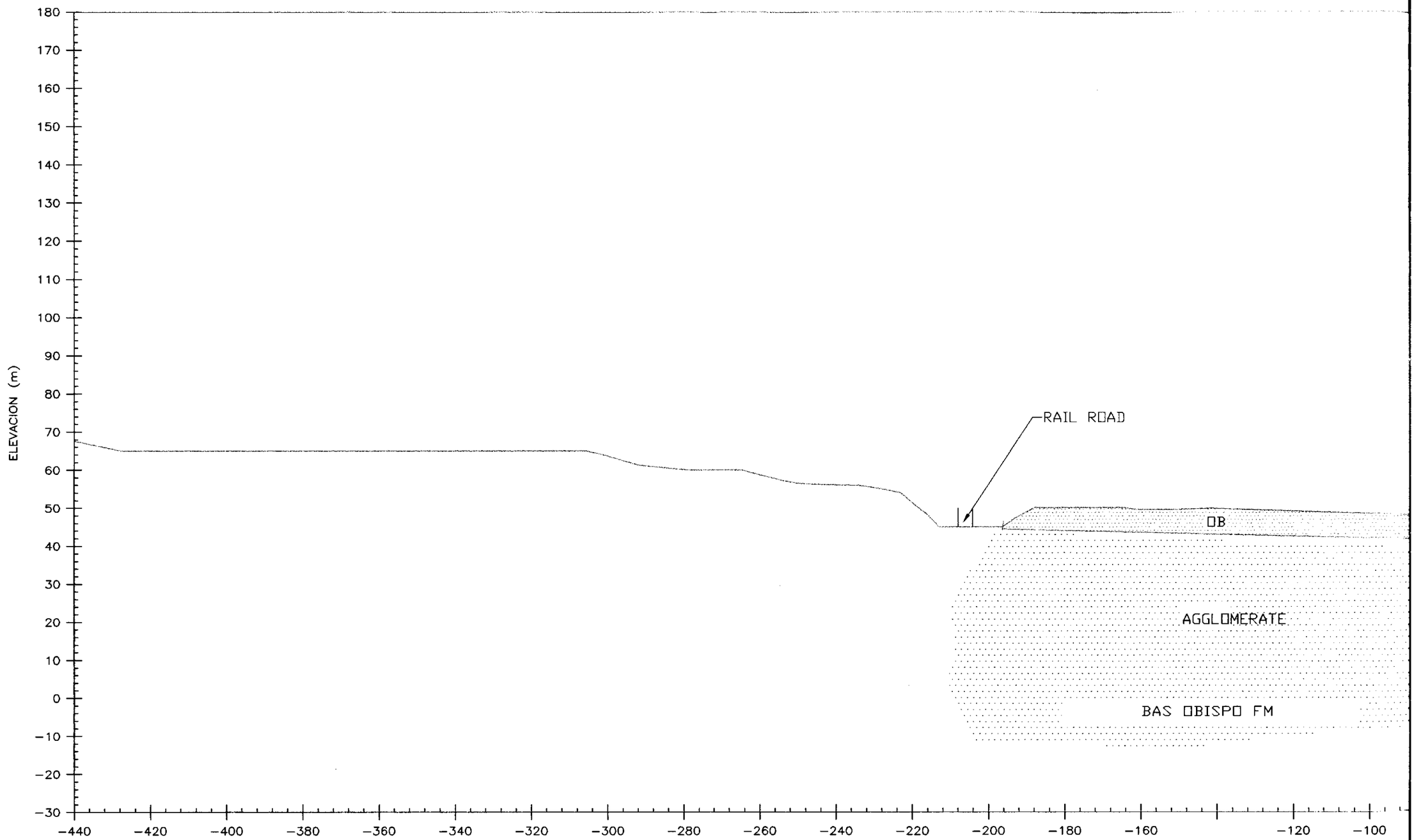
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

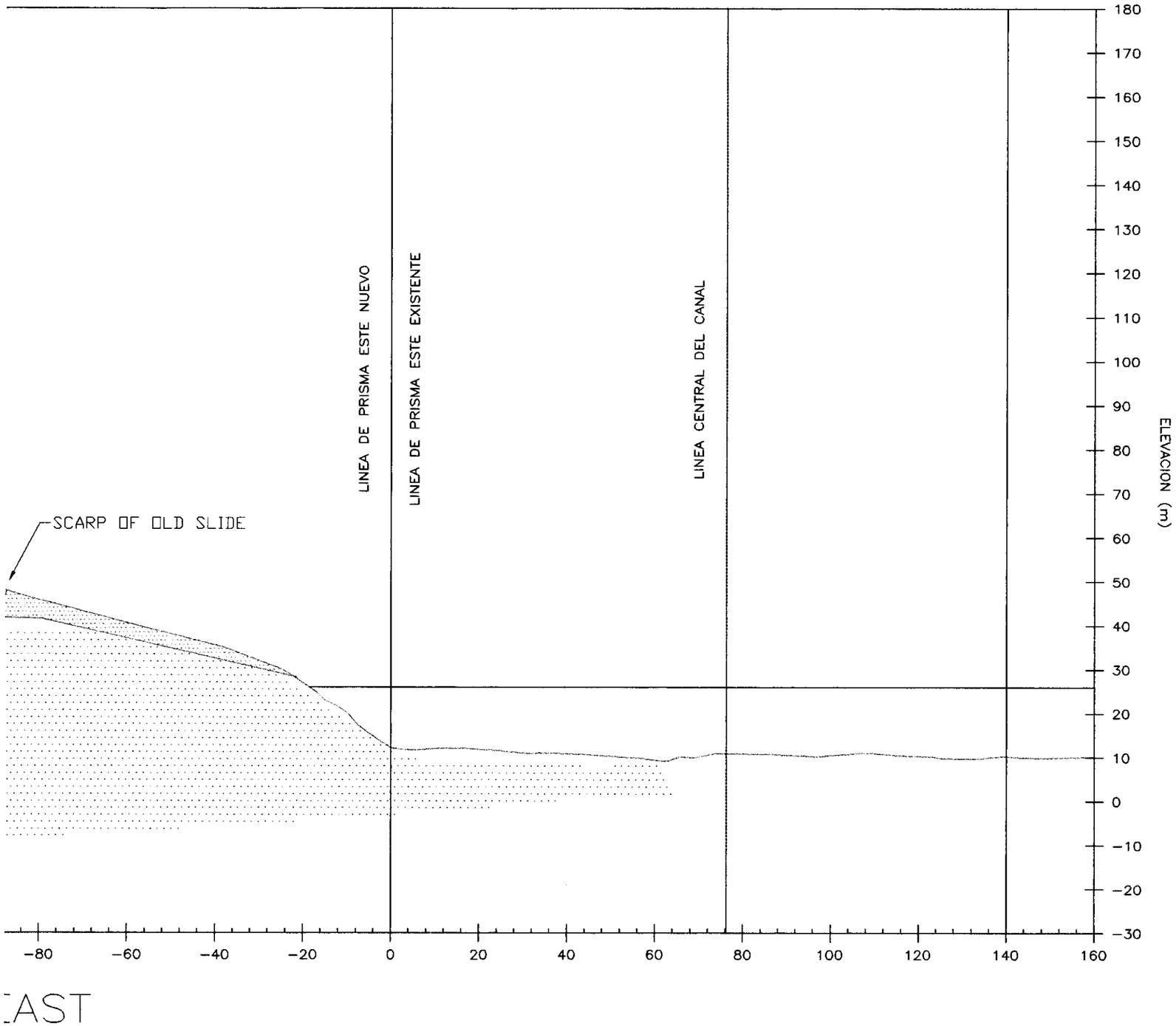


Summary, 51k + 328 (1684 + 00)

General Description	Range of stations:	50k + 780 to 52k + 060			
	Sector:	Chagres			
	Maximum height (m):	40			
	Cotangent of slope angle (cot. β):	2.5			
History	Last slide event:	October 5, 1910 (Bas Obispo Slide)			
Geology	Formation:	Bas Obispo			
	Lithology:	Aggomerate			
	Critical stratum at toe:	Agglomerate			
	Apparent dip of bedding:	Not defined			
Stability Analysis	Critical failure mechanism:	Rotational with tension crack in overburden			
	Shear strength model:	First time Bas Obispo			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.398	2.925	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		2.883	0.986	-1.44
	Case 3: Channel bottom = 27 ft, Blasted & removed		2.828	0.967	-3.32
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		2.727	0.932	-6.77
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.381	2.727	0.932	-6.77
	Case 5: Channel bottom = 22 ft, Blasted material only		2.776	0.949	-5.09
	Case 6: Channel bottom = 22 ft, Blasted & removed		2.687	0.919	-8.14
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		2.523	0.863	-13.74
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.406	2.523	0.863	-13.74
	Case 8: Channel bottom = 16 ft, Blasted		2.479	0.848	-15.25
Conclusions:	No stabilization is required				



51K+328 (1684+00)



AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 51K+328 (1684+00) ESTE

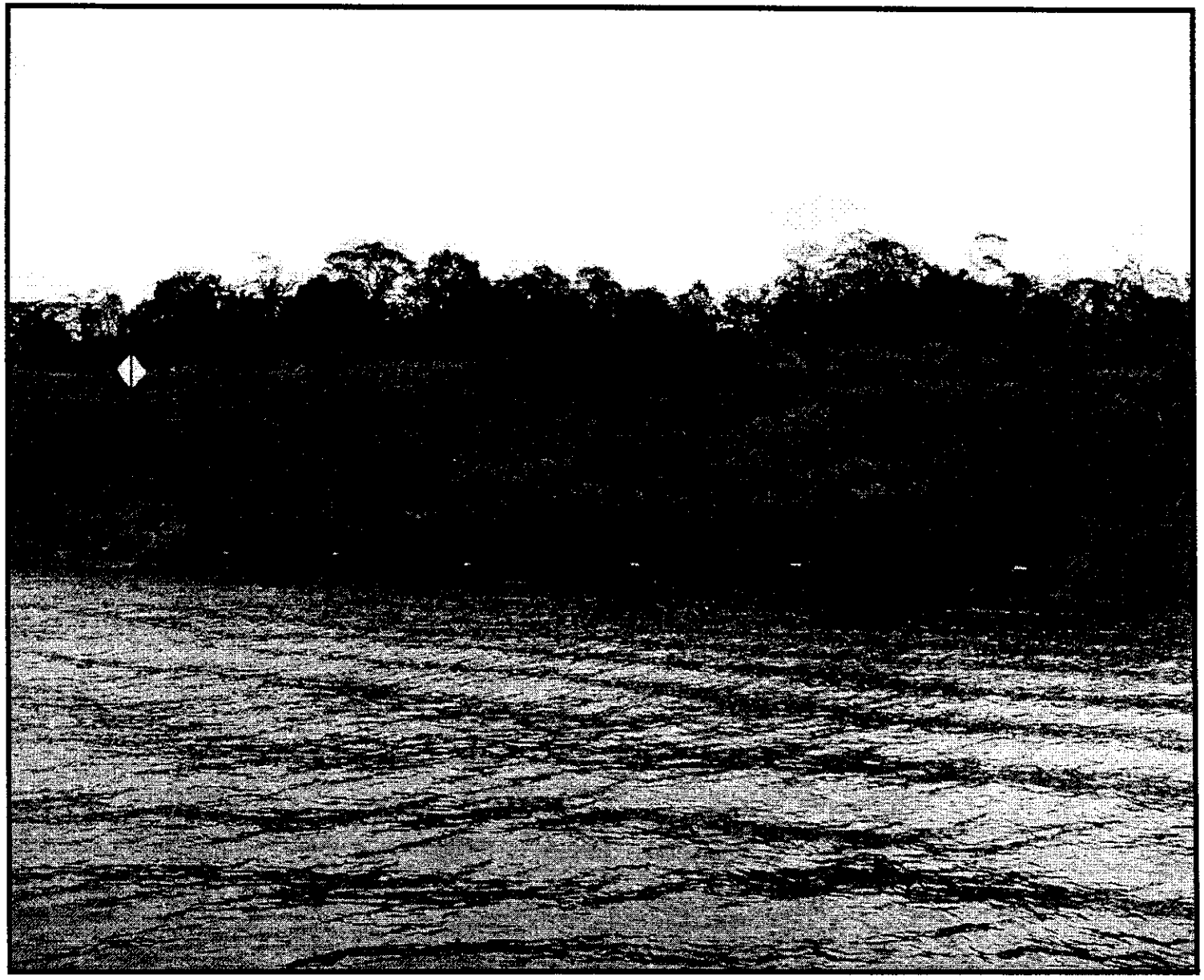
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: J. ARROCHA	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 53k + 371 (1751 + 00)

East

Station: 53k + 371 (Sardinilla)

April 16, 2002



Case 1, Channel bottom = 32 ft

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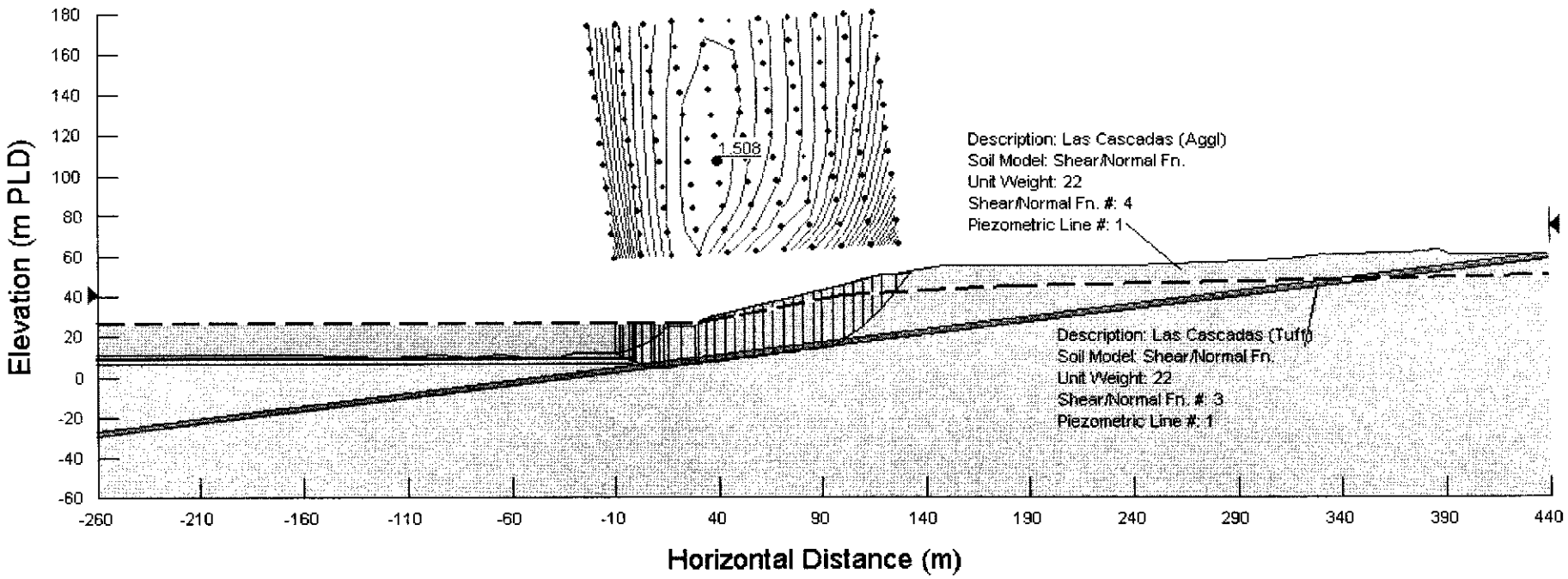
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 2, Channel bottom = 27 ft, Blasted material only

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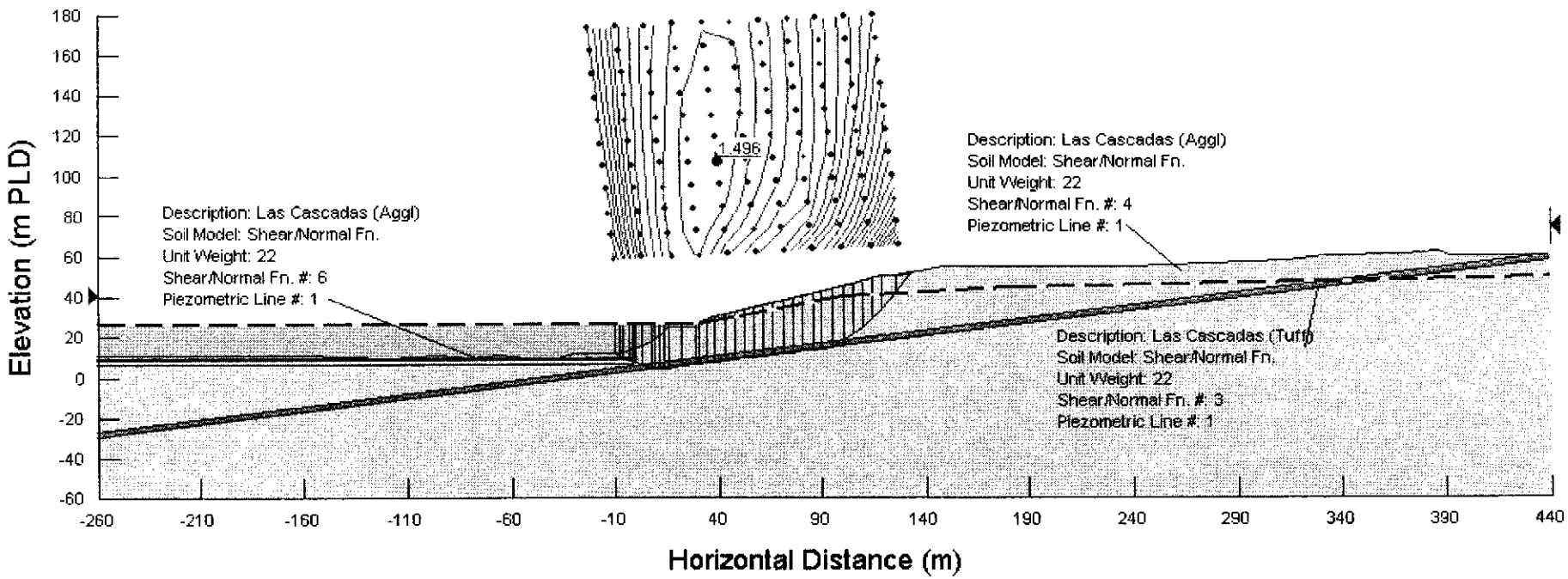

Case 3, Channel bottom = 27 ft, Blasted & removed

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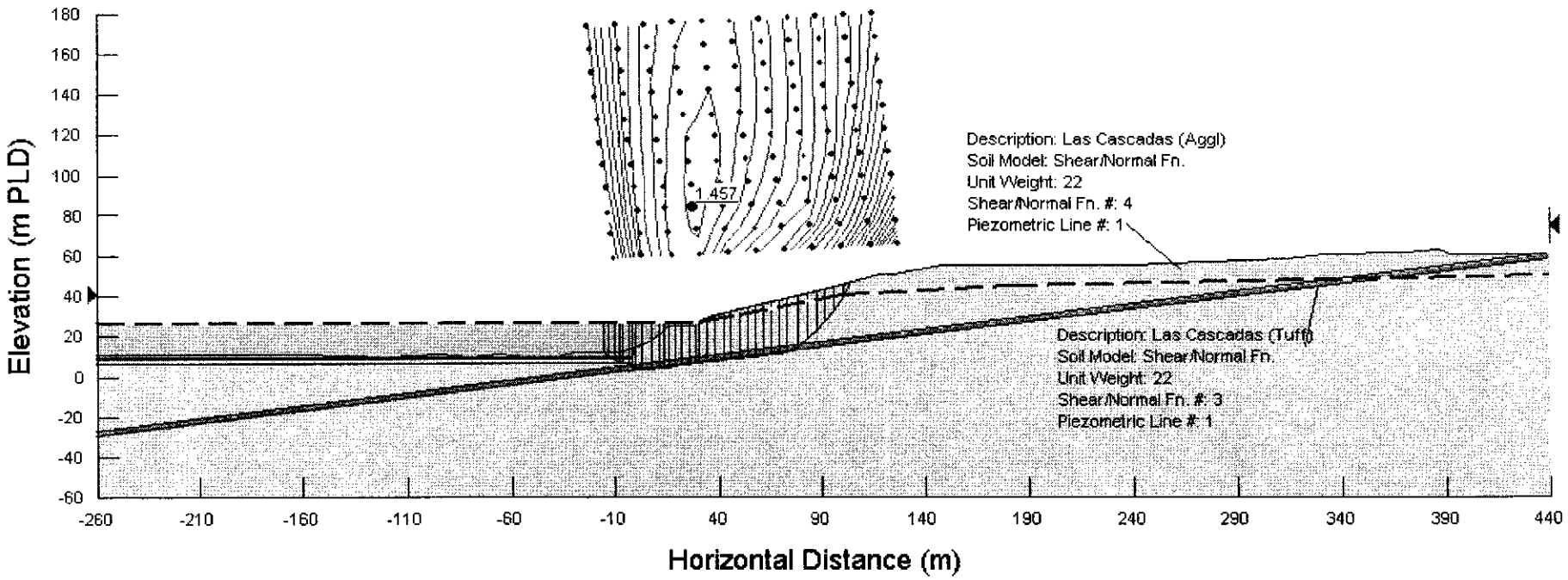
Seismic Coefficient: (none)



Case 4, Channel bottom = 27 ft, Design (underwater slope)

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Analysis Method: Morgenstern-Price
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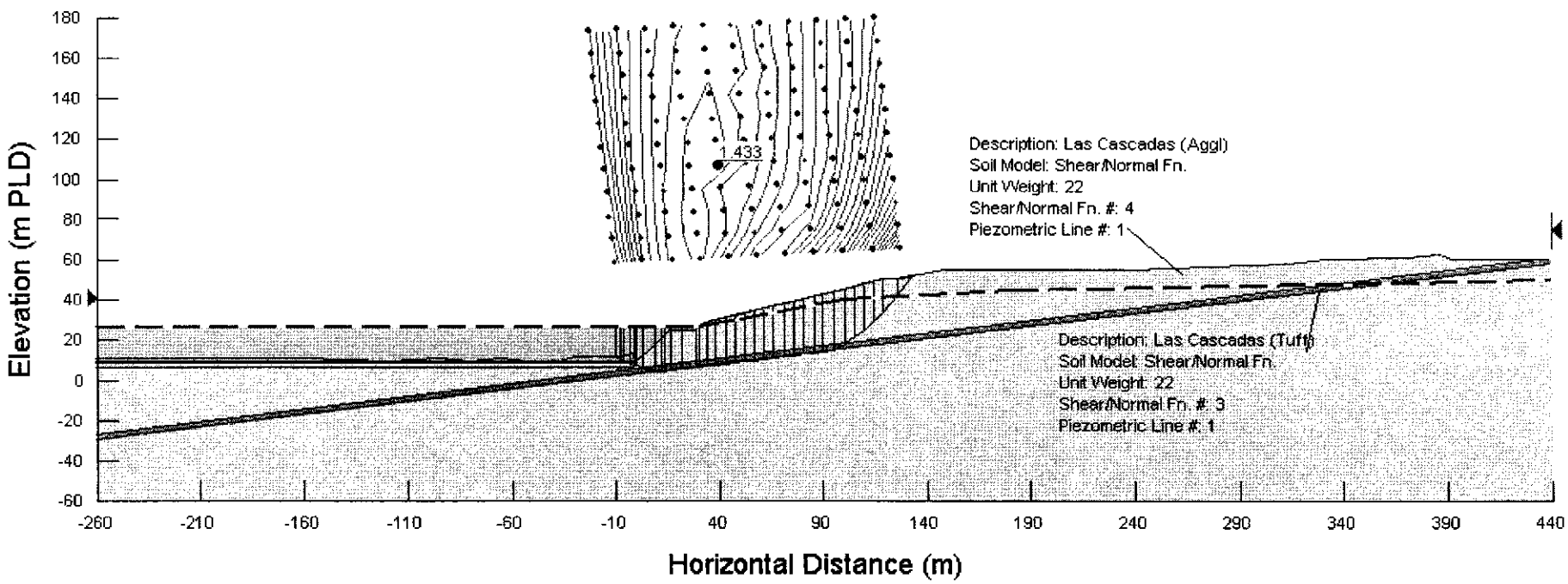
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 5, Channel bottom = 22 ft, Blasted material only

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Analysis Method: Morgenstern-Price
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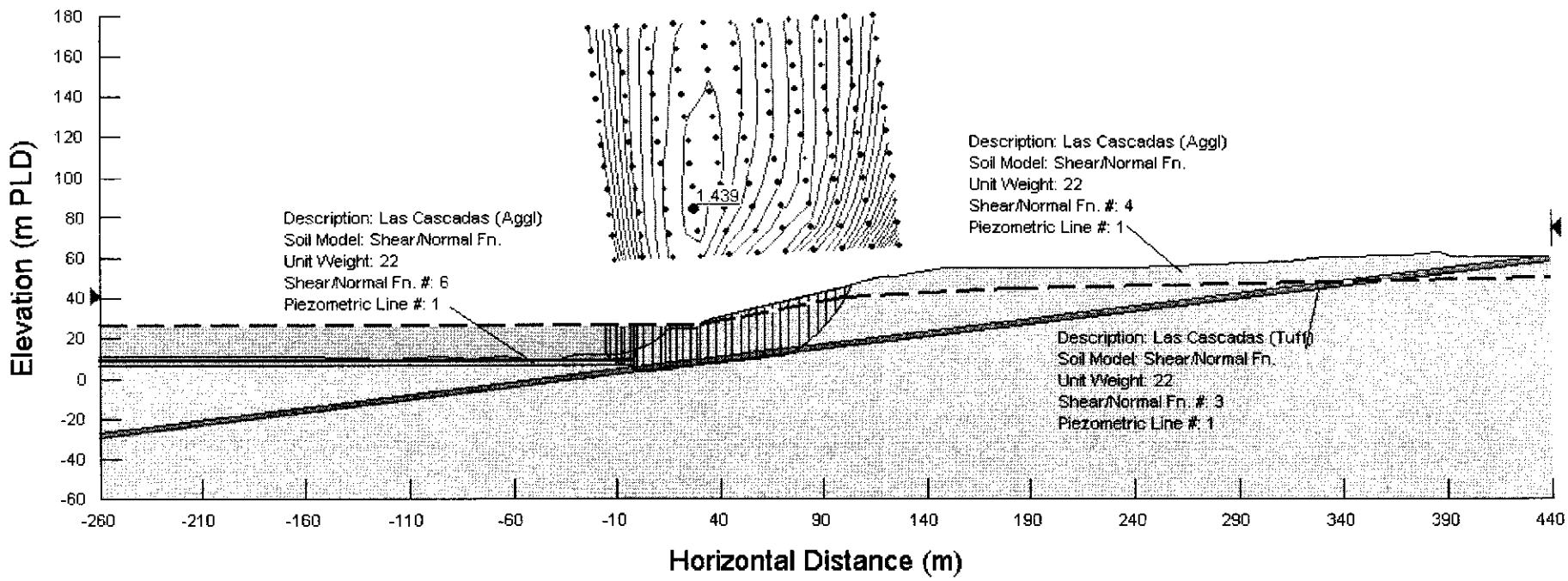
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 6, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
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Analysis Method: Morgenstern-Price
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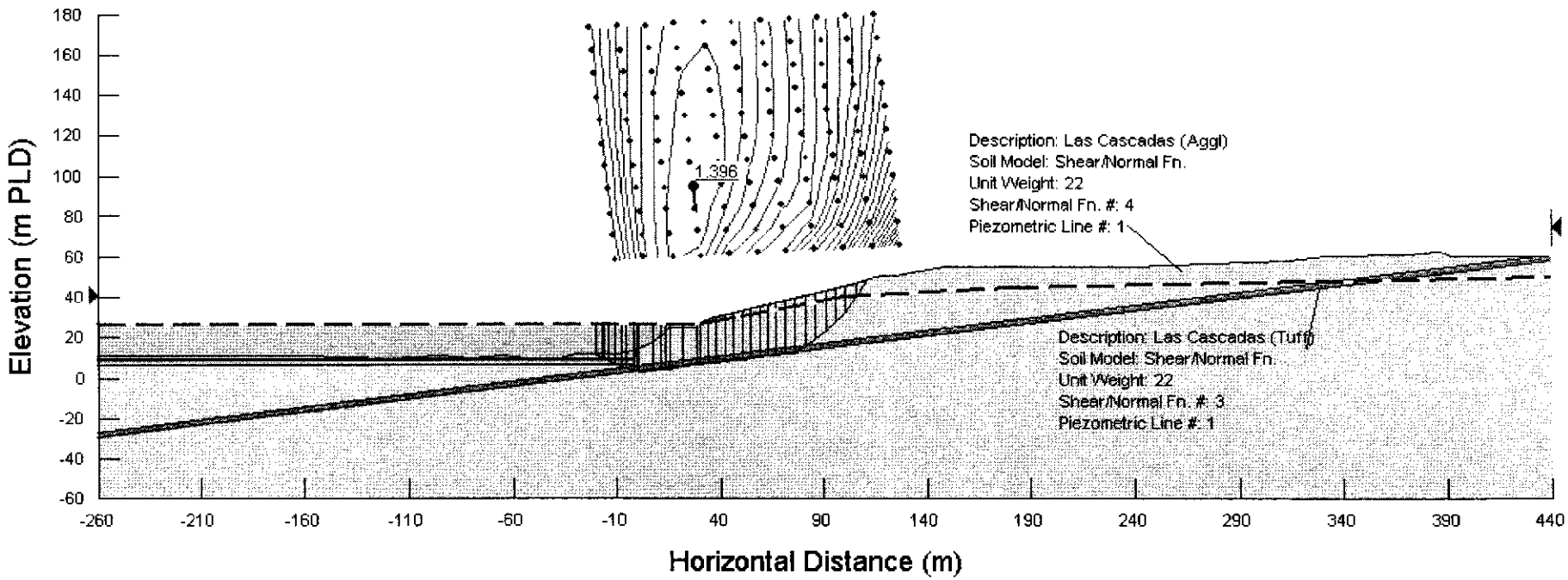
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 7, Channel bottom = 27 ft, Design (underwater slope)

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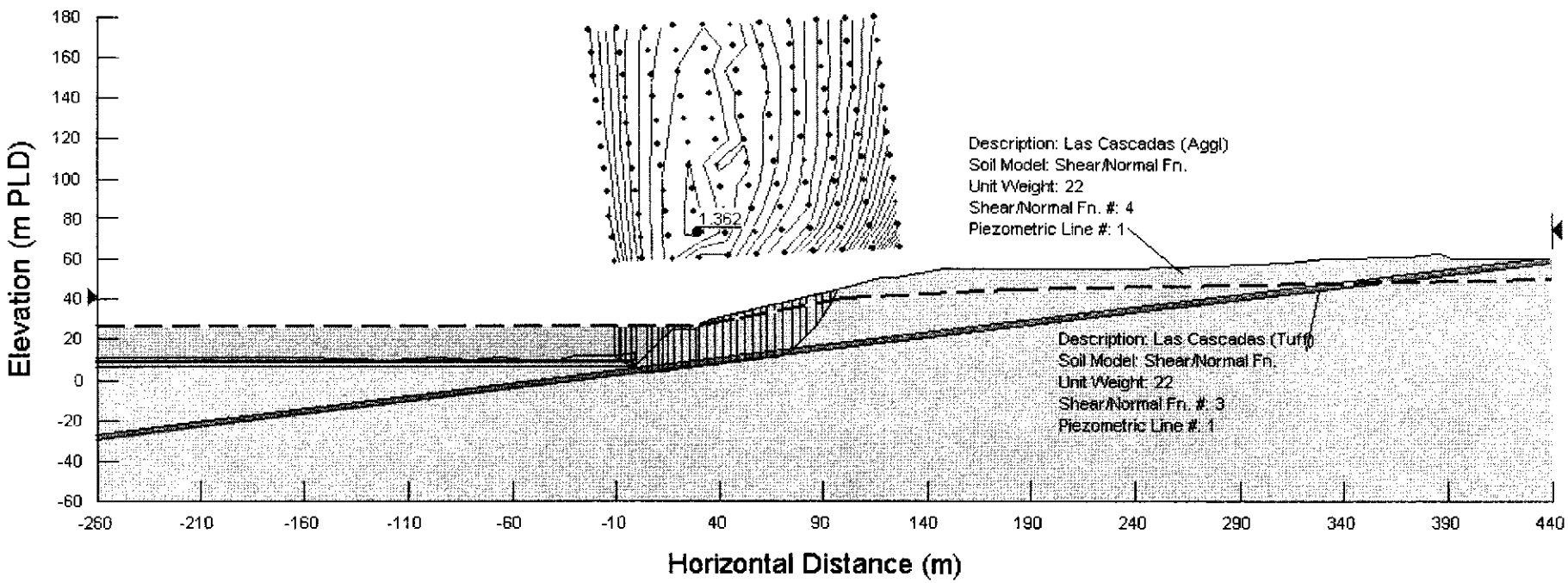

Case 8, Channel bottom = 16 ft, Blasted

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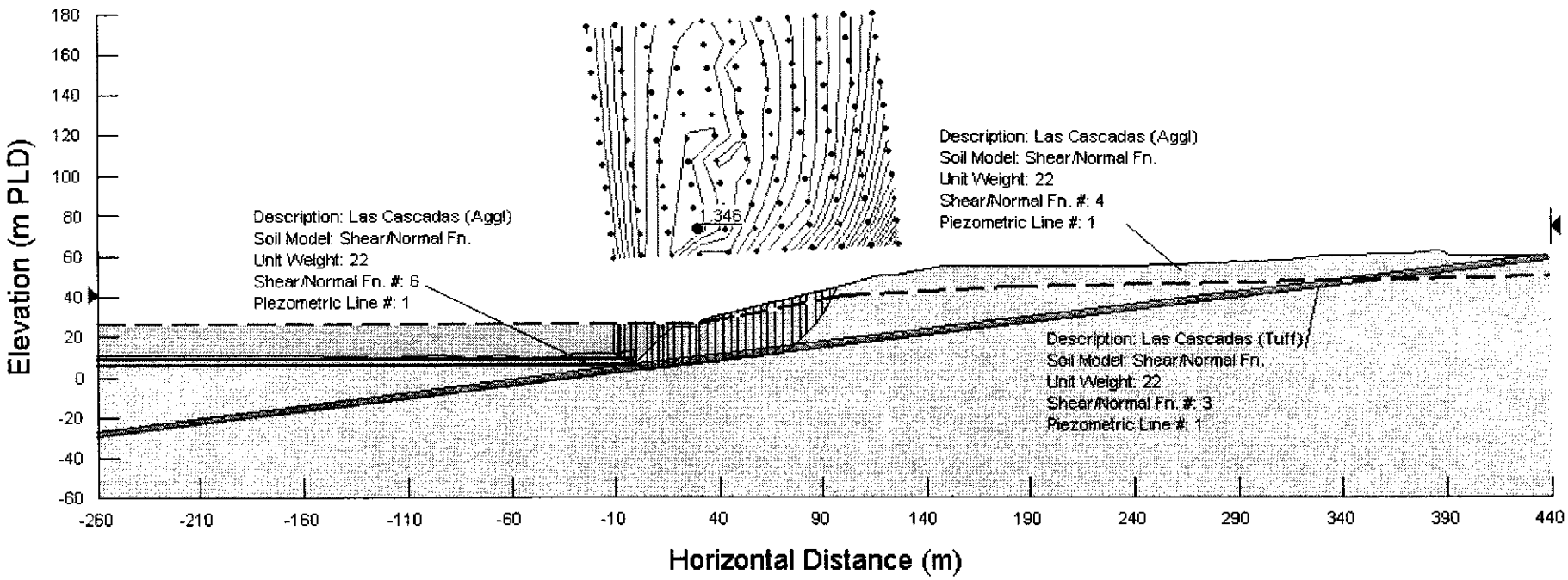
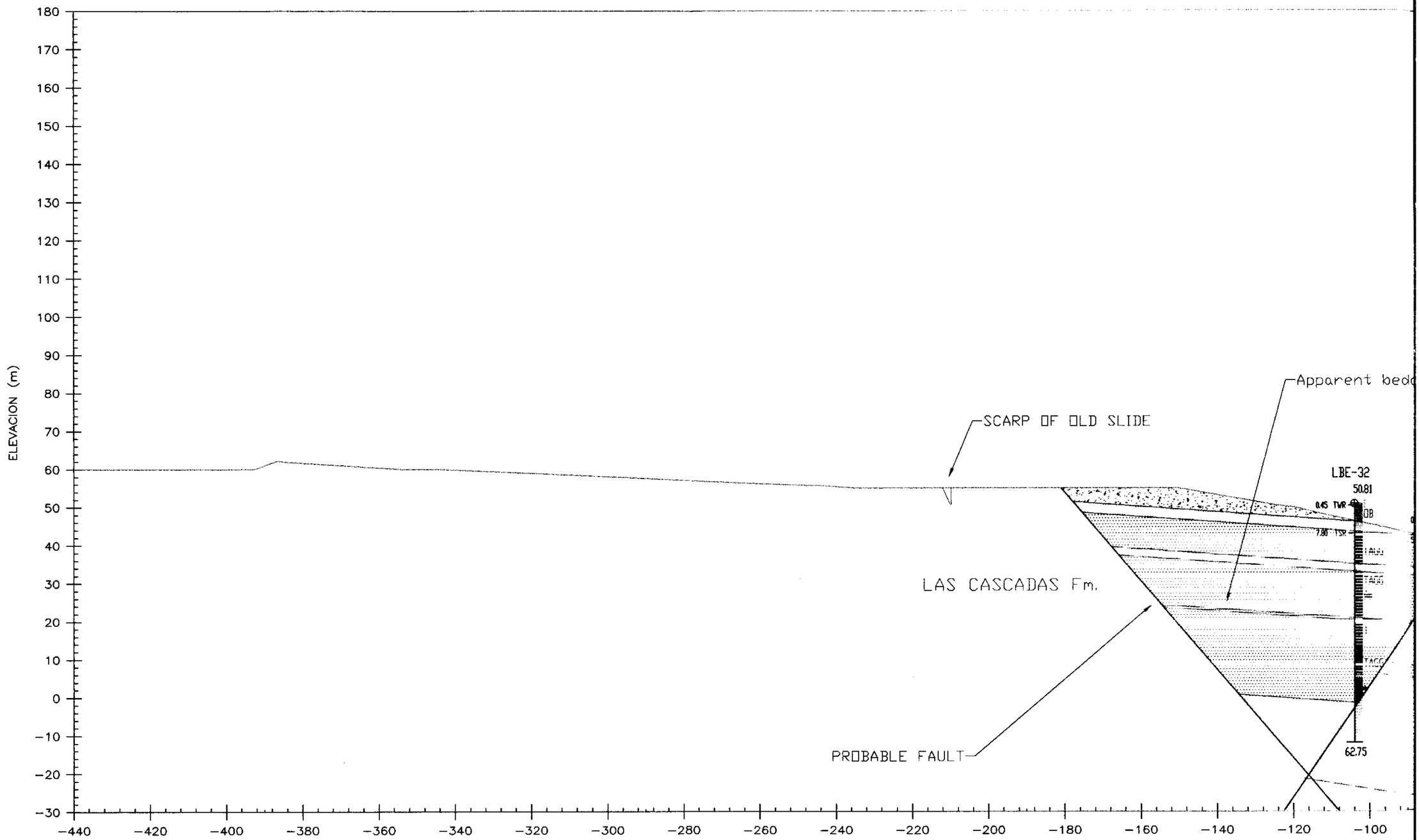
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

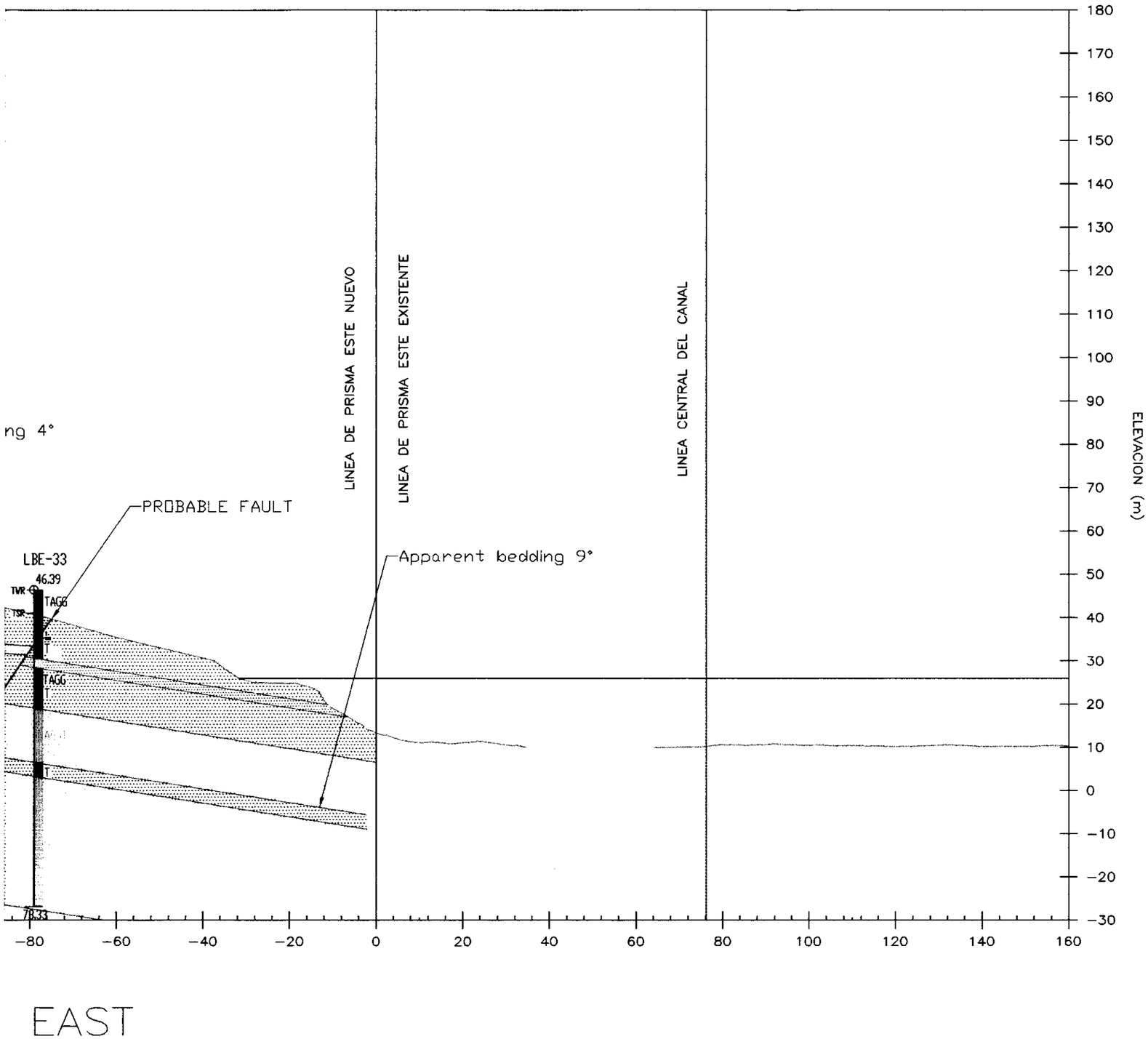


Summary, 53k + 371 (1751 + 00)

General Description	Range of stations:	52k + 060 to 53k + 550			
	Sector:	Sardinilla			
	Maximum height (m):	45			
	Cotangent of slope angle (cot. β):	3.3			
History	Last slide event:	December 5, 1965 (Las Cascadas Slide)			
Geology	Formation:	Las Cascadas			
	Lithology:	Agglomerate / Tuff			
	Critical stratum at toe:	Tuff			
	Apparent dip of bedding:	Toward the Canal			
Stability Analysis	Critical failure mechanism:	Translational along weak plane			
	Shear strength model:	Weak plane fully softened, tuff / First time agglomerate			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.369	1.508	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		1.496	0.992	-0.80
	Case 3: Channel bottom = 27 ft, Blasted & removed		1.457	0.966	-3.38
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.433	0.950	-4.97
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.456	1.433	0.950	-4.97
	Case 5: Channel bottom = 22 ft, Blasted material only		1.439	0.954	-4.58
	Case 6: Channel bottom = 22 ft, Blasted & removed		1.396	0.926	-7.43
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.362	0.903	-9.68
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.389	1.362	0.903	-9.68
	Case 8: Channel bottom = 16 ft, Blasted		1.346	0.893	-10.74
Conclusions:	No stabilization is required				



53K+371 (1751+00)



AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 53K+371 (1751+0) ESTE

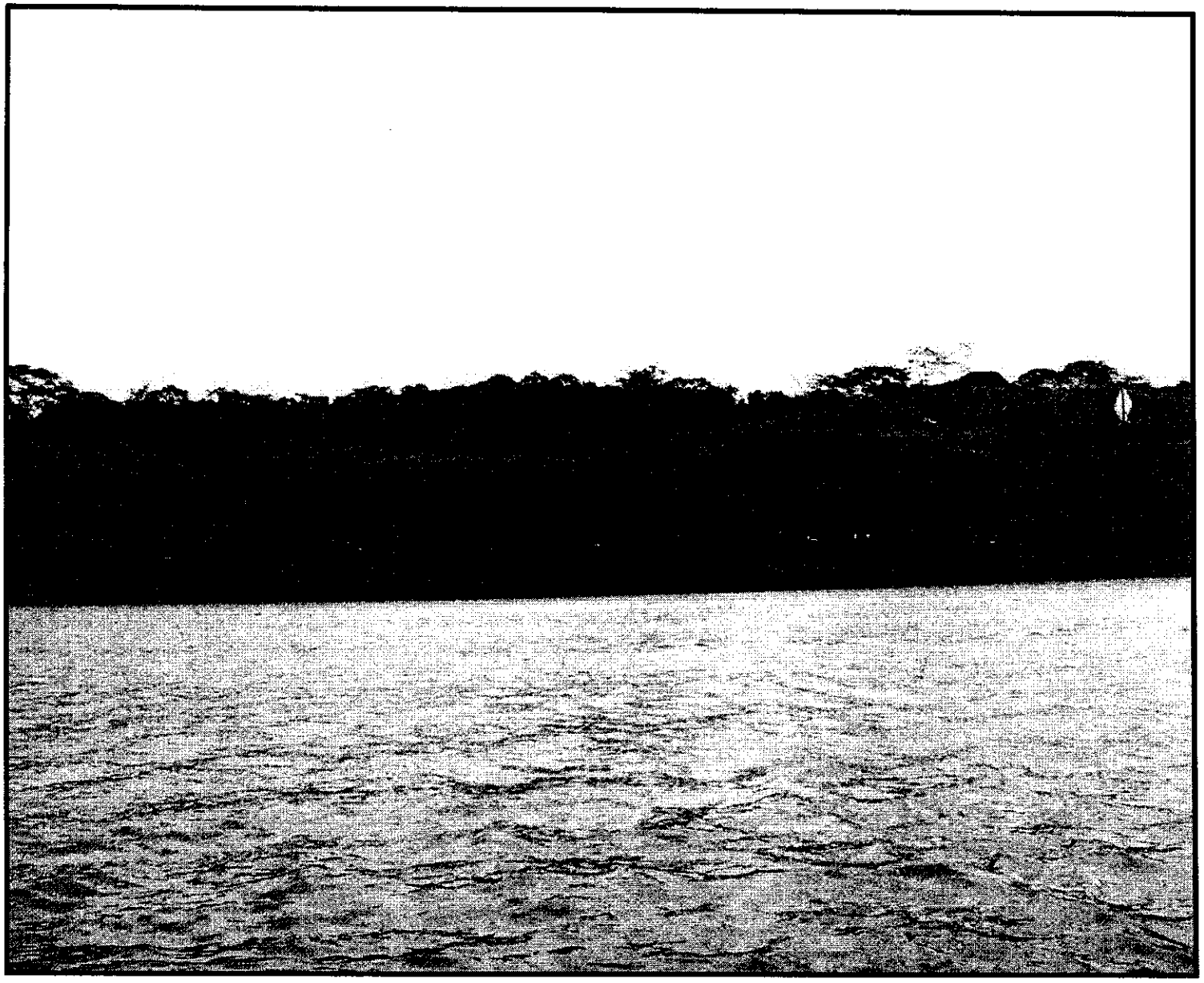
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: J. ARROCHA	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 53k + 950 (1770 + 04)

East

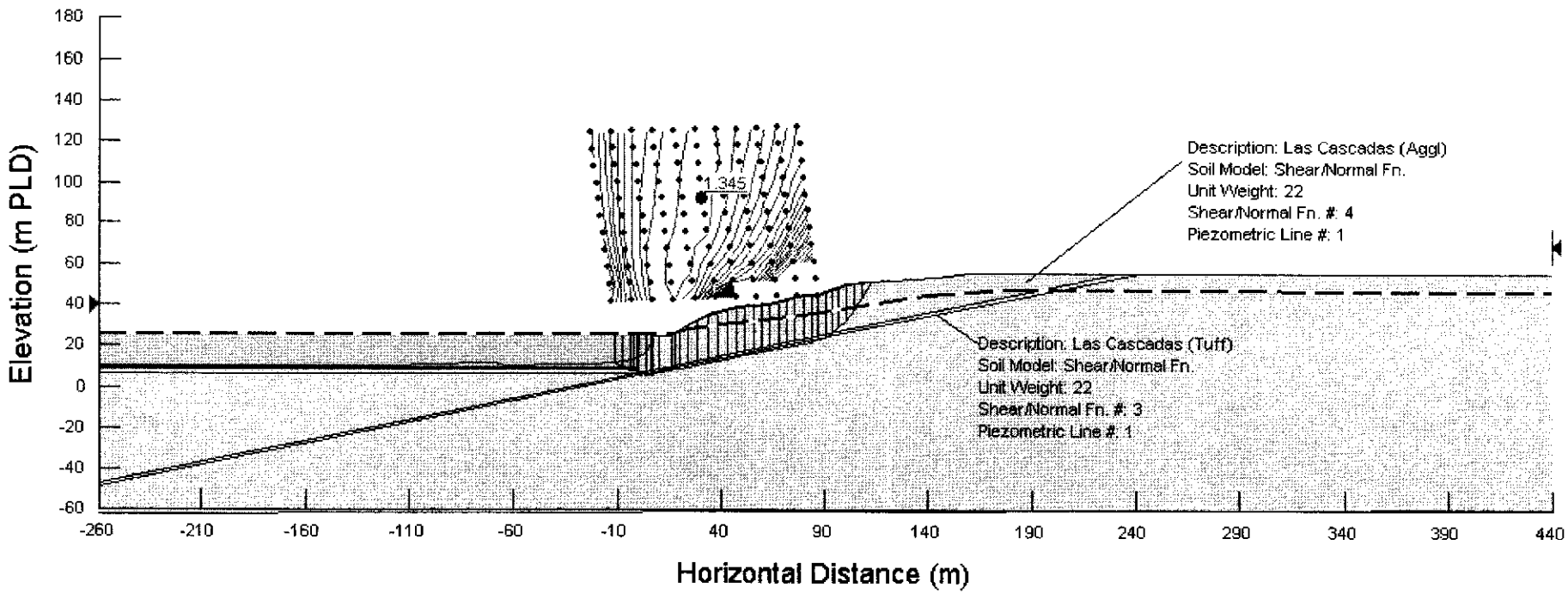
Station: 53k + 950 (Sardinilla)

April 16, 2002



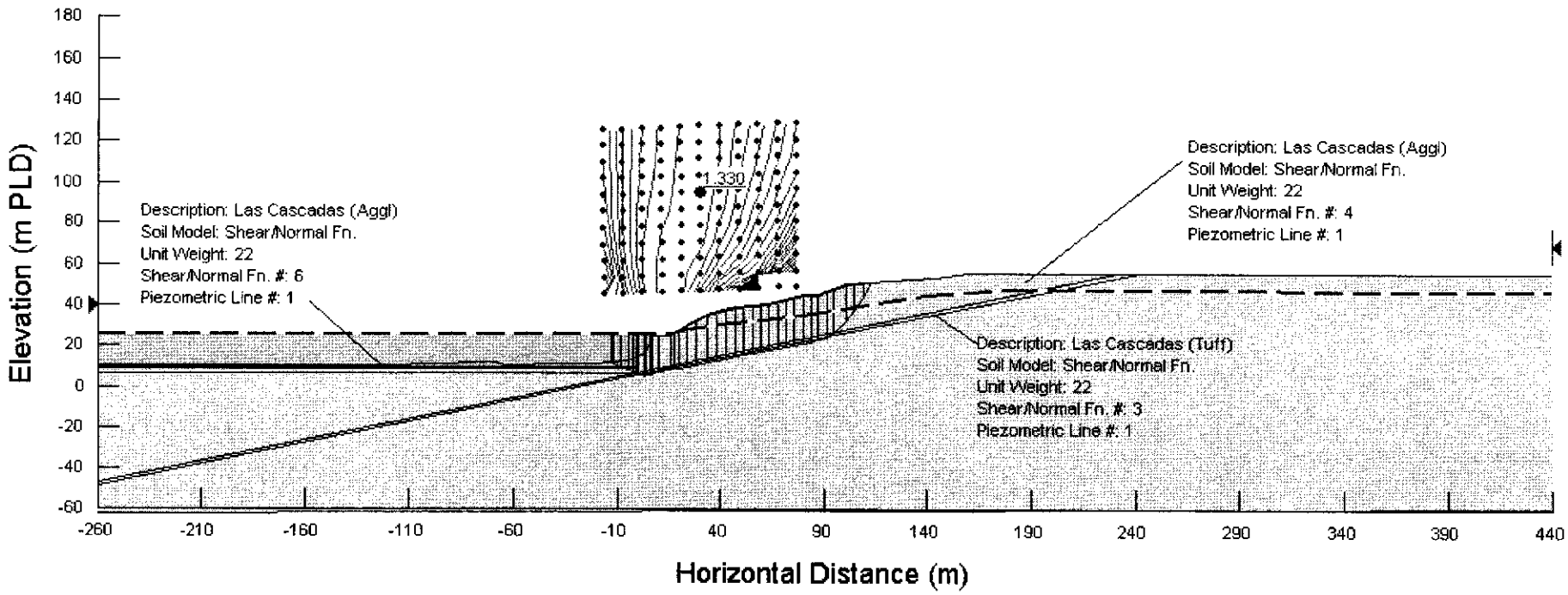
Case 1, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 32 ft (case 1)
File Name: 53K950_1.slz
Last Saved Date: 4/9/02
Last Saved Time: 9:32:06 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



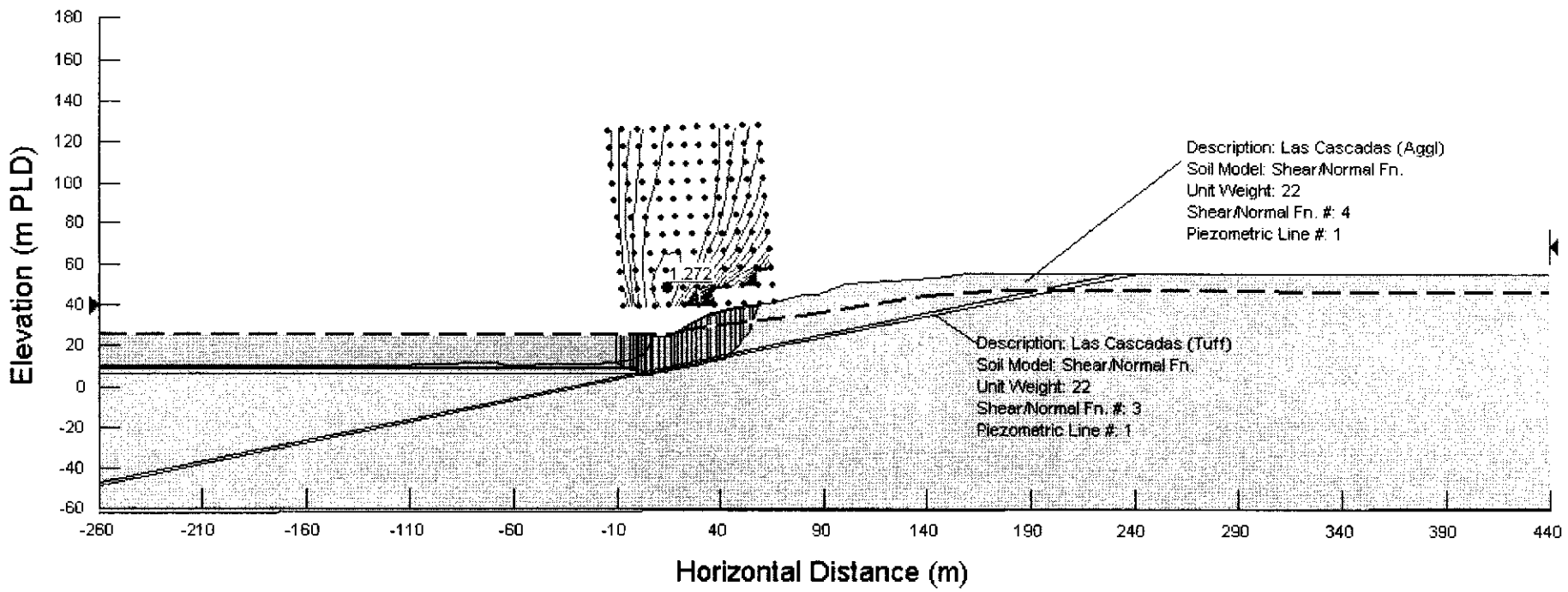
Case 2, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 53K950_2.slz
Last Saved Date: 4/9/02
Last Saved Time: 9:33:34 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



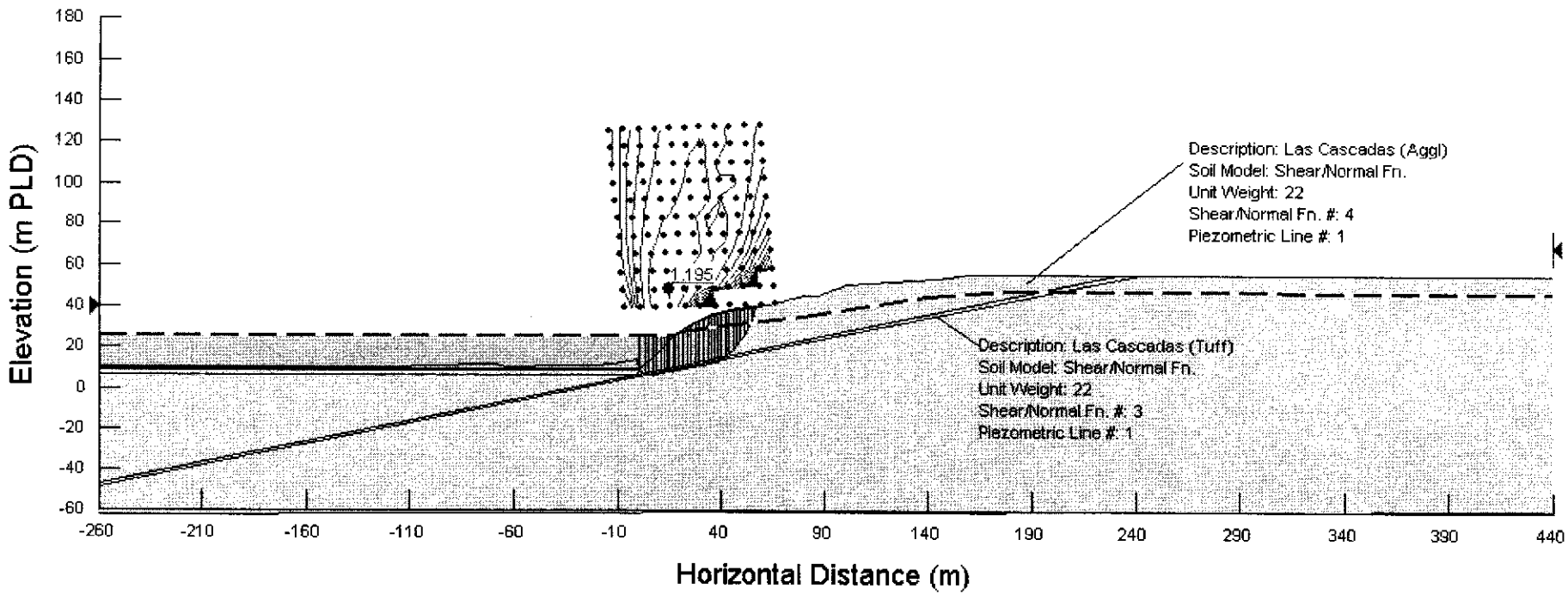
Case 3, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 53K950_3.slz
Last Saved Date: 4/9/02
Last Saved Time: 9:36:16 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



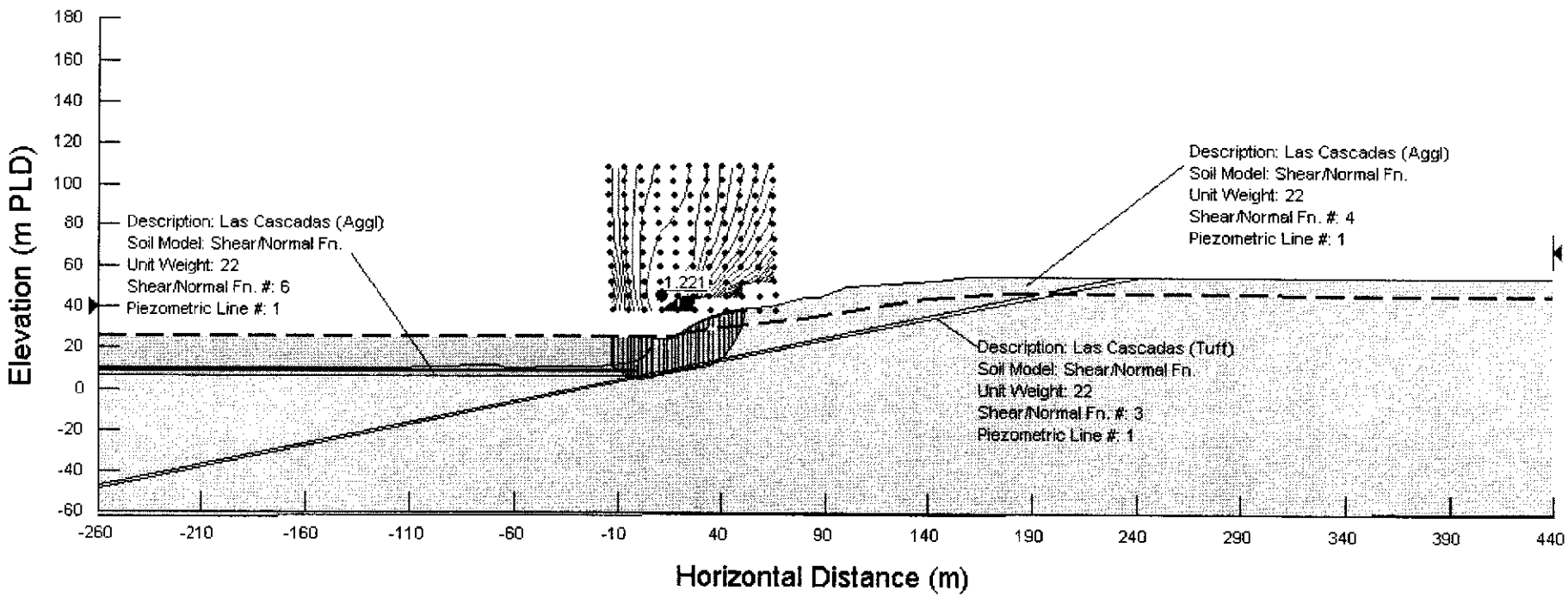
Case 4, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 27 ft + design (case 4)
File Name: 53K950_4.slz
Last Saved Date: 4/9/02
Last Saved Time: 9:58:30 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



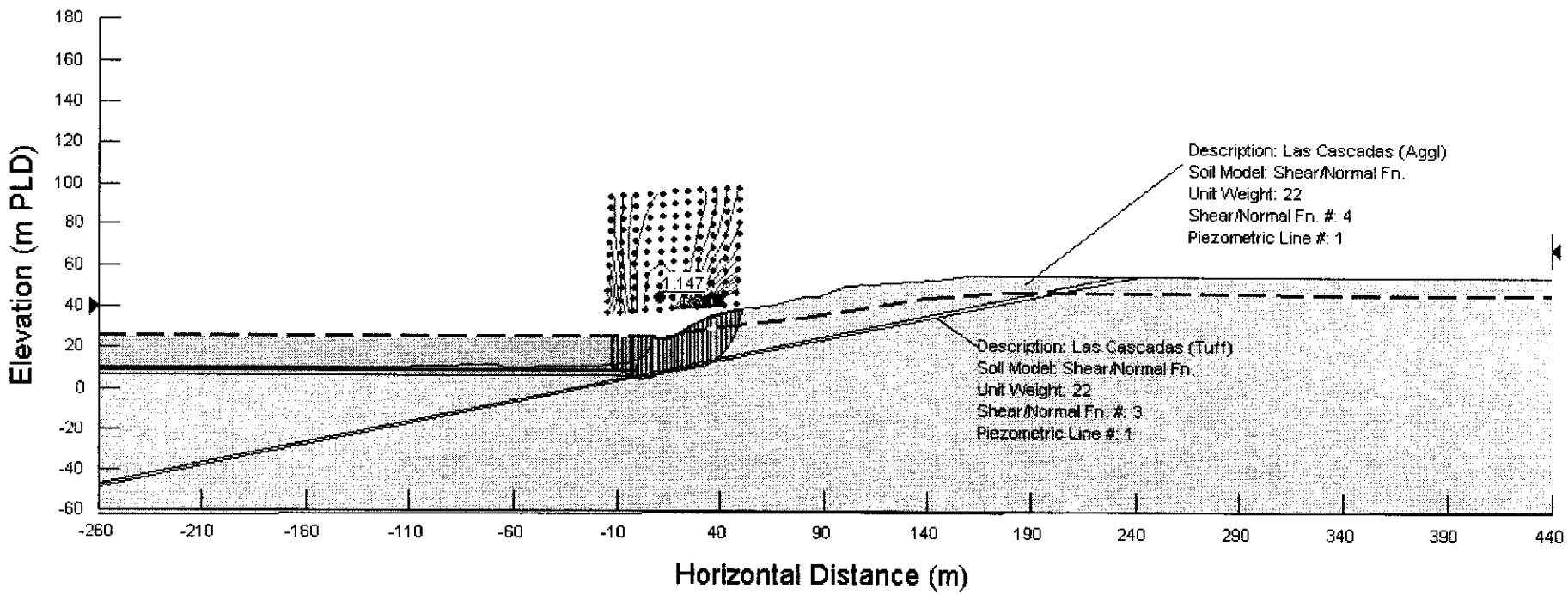
Case 5, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 53K950_5.slz
Last Saved Date: 4/9/02
Last Saved Time: 9:39:36 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

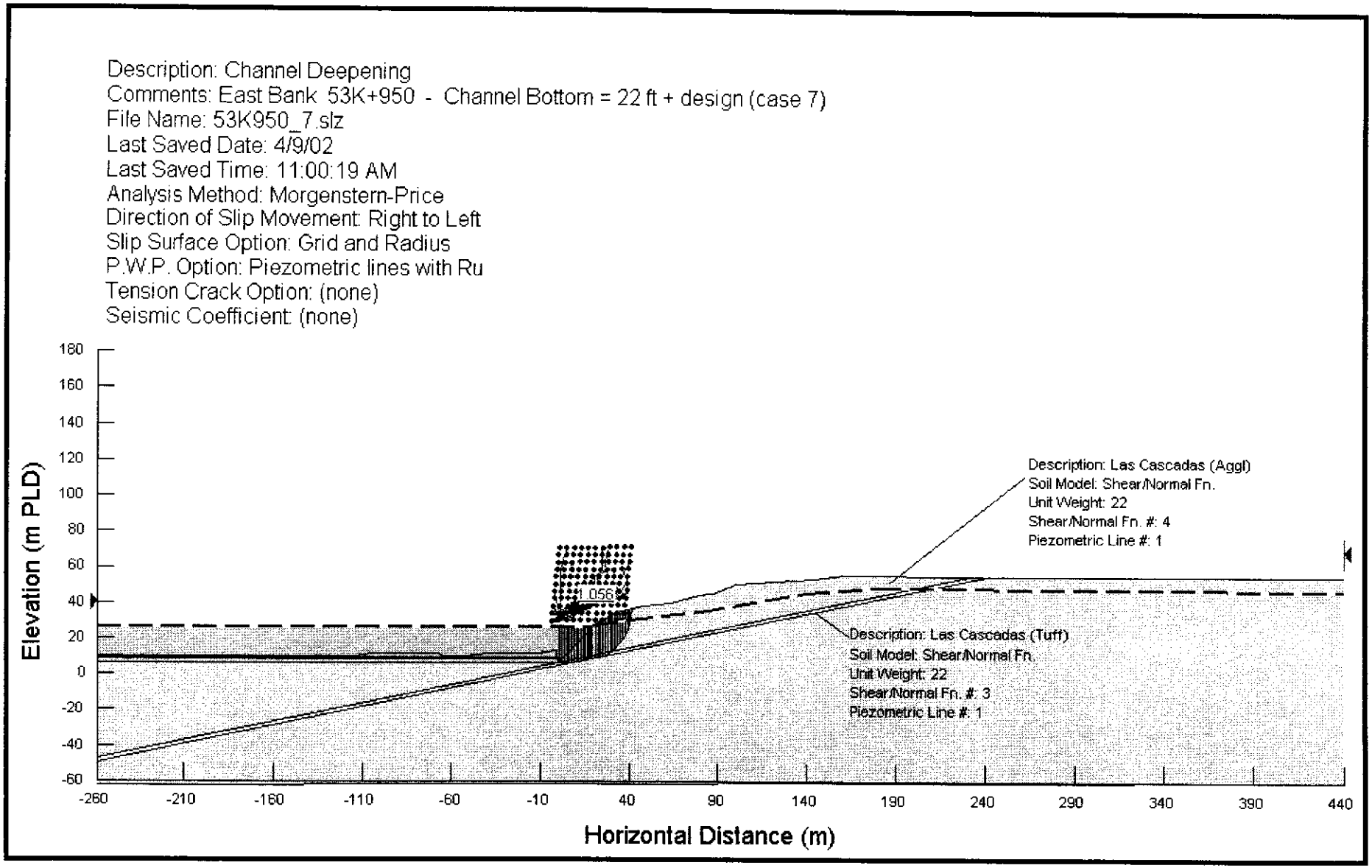


Case 6, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 53K950_6.slz
Last Saved Date: 4/9/02
Last Saved Time: 9:41:14 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

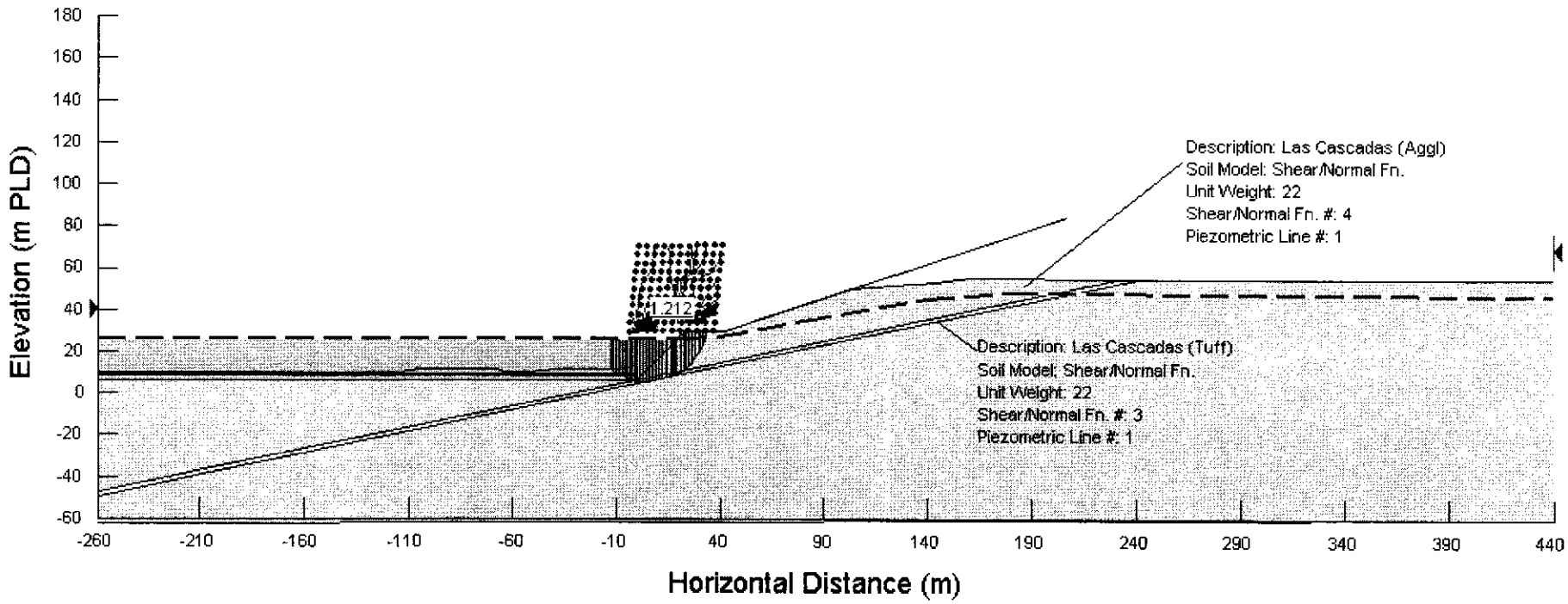


Case 7.1, Channel bottom = 27 ft, Design (underwater slope)



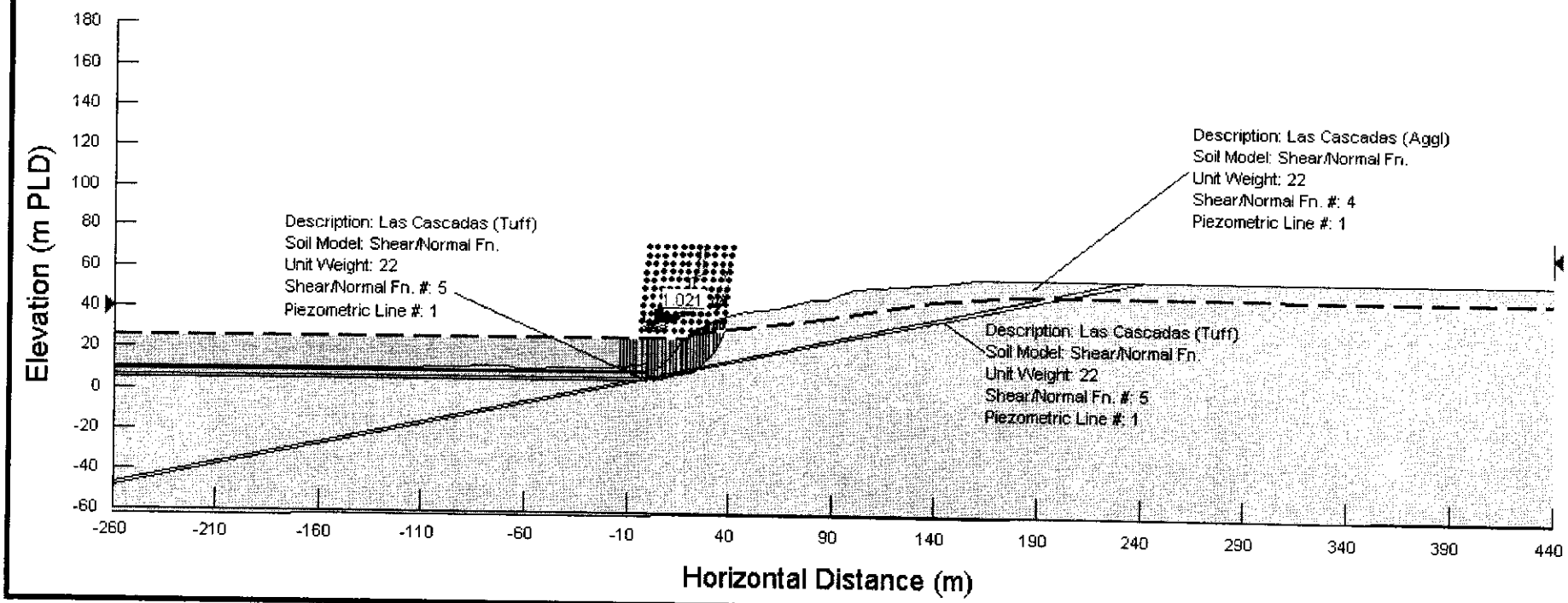
Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 22 ft + design (case 7)
File Name: 53K950_7e.slz
Last Saved Date: 4/9/02
Last Saved Time: 12:03:00 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 8, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 53K+950 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 53K950_8.slz
Last Saved Date: 4/9/02
Last Saved Time: 2:43:05 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

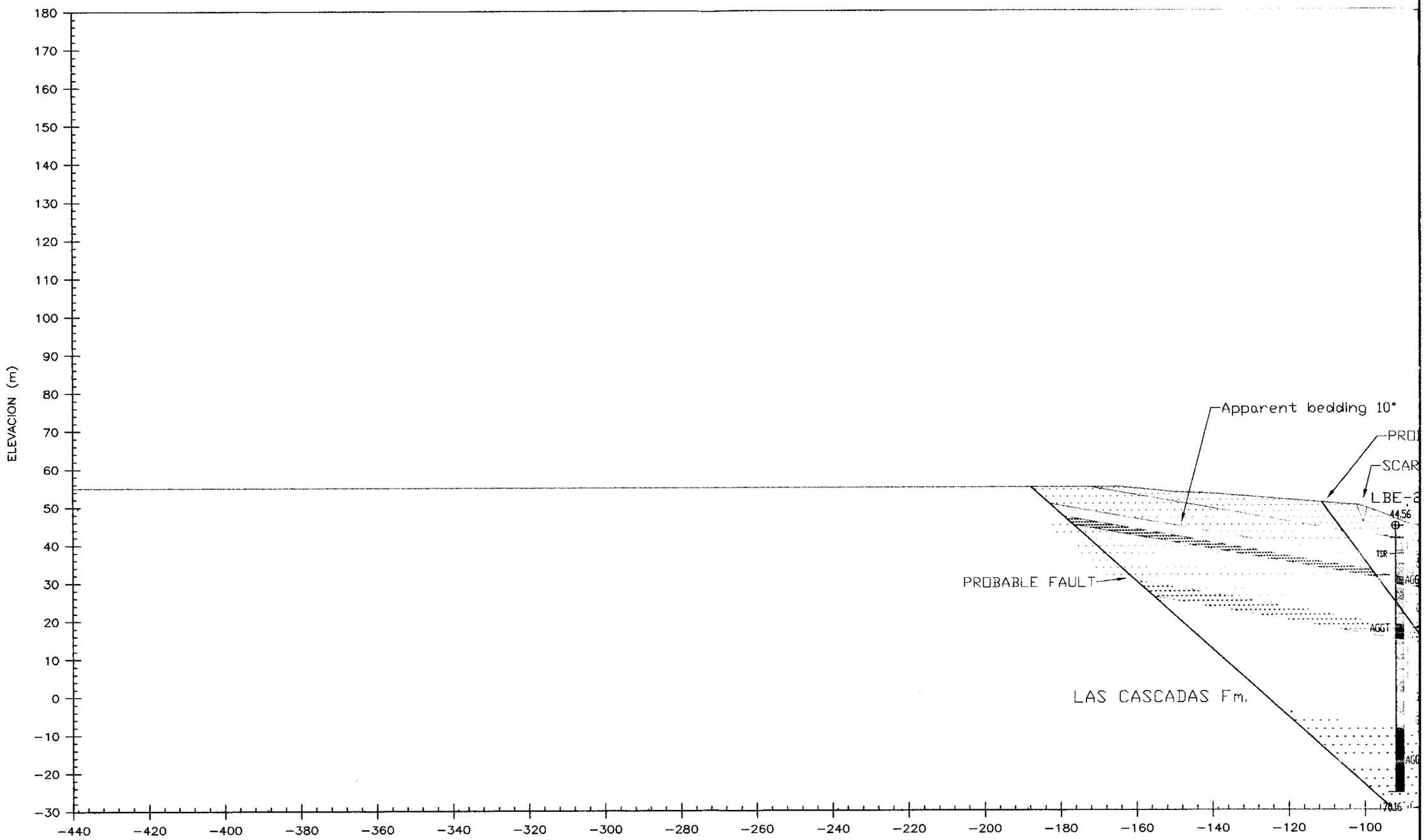


Summary, 53k + 950 (1770 + 04)

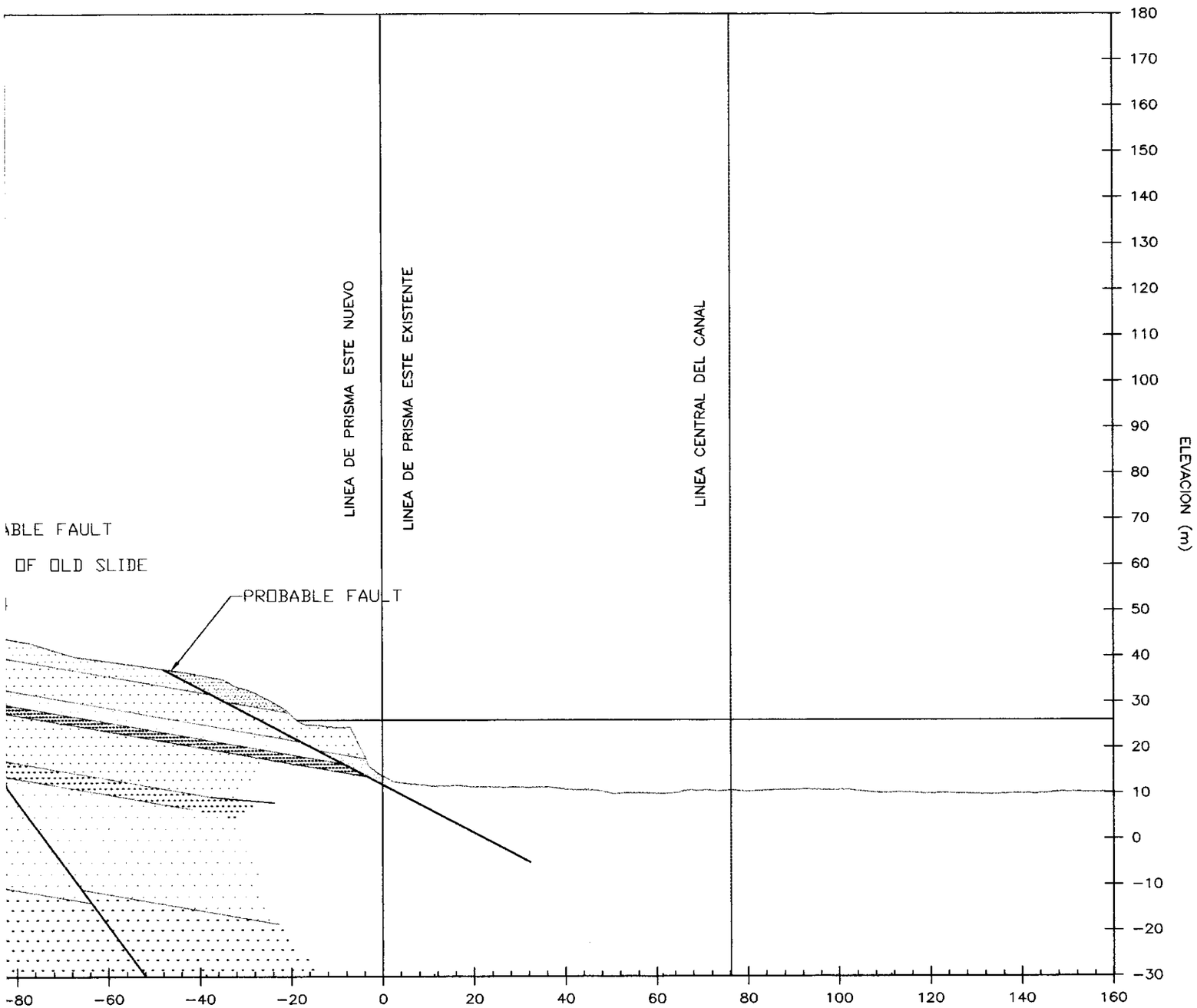
General Description	Range of stations:	53k + 550 to 54k + 880
	Sector:	Sardinilla
	Maximum height (m):	45
	Cotangent of slope angle (cot. β):	3.6
History	Last slide event:	1990 (Sta. 1603 E)
Geology	Formation:	Las Cascadas
	Lithology:	Agglomerate / Tuff
	Critical stratum at toe:	Tuff
	Apparent dip of bedding:	Toward the Canal
Stability Analysis	Critical failure mechanism:	Translational along weak plane
	Shear strength model:	Weak plane, fully softened tuff / First time agglomerate

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
Case 1: Channel bottom = 32 ft	0.314	1.345	1.000	0.00
Case 2: Channel bottom = 27 ft, Blasted material only		1.330	0.989	-1.12
Case 3: Channel bottom = 27 ft, Blasted & removed		1.272	0.946	-5.43
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.195	0.888	-11.15
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.359	1.195	0.888	-11.15
Case 5: Channel bottom = 22 ft, Blasted material only		1.221	0.908	-9.22
Case 6: Channel bottom = 22 ft, Blasted & removed		1.147	0.853	-14.72
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.056	0.785	-21.49
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.415	1.212	0.901	-9.89
Case 8: Channel bottom = 16 ft, Blasted		1.021	0.759	-24.09

Conclusions: Stabilization is required for Case 7


ELEVACION (m)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-440
-420
-400
-380
-360
-340
-320
-300
-280
-260
-240
-220
-200
-180
-160
-140
-120
-100
Apparent bedding 10°
PROBABLE FAULT
LAS CASCADAS Fm.
44.56
TSR
AGGT
17.16

53K+950 (1770



04) EAST

AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA
CORTE GAILLARD
ESTACION 53K+950 (1770+04) ESTE

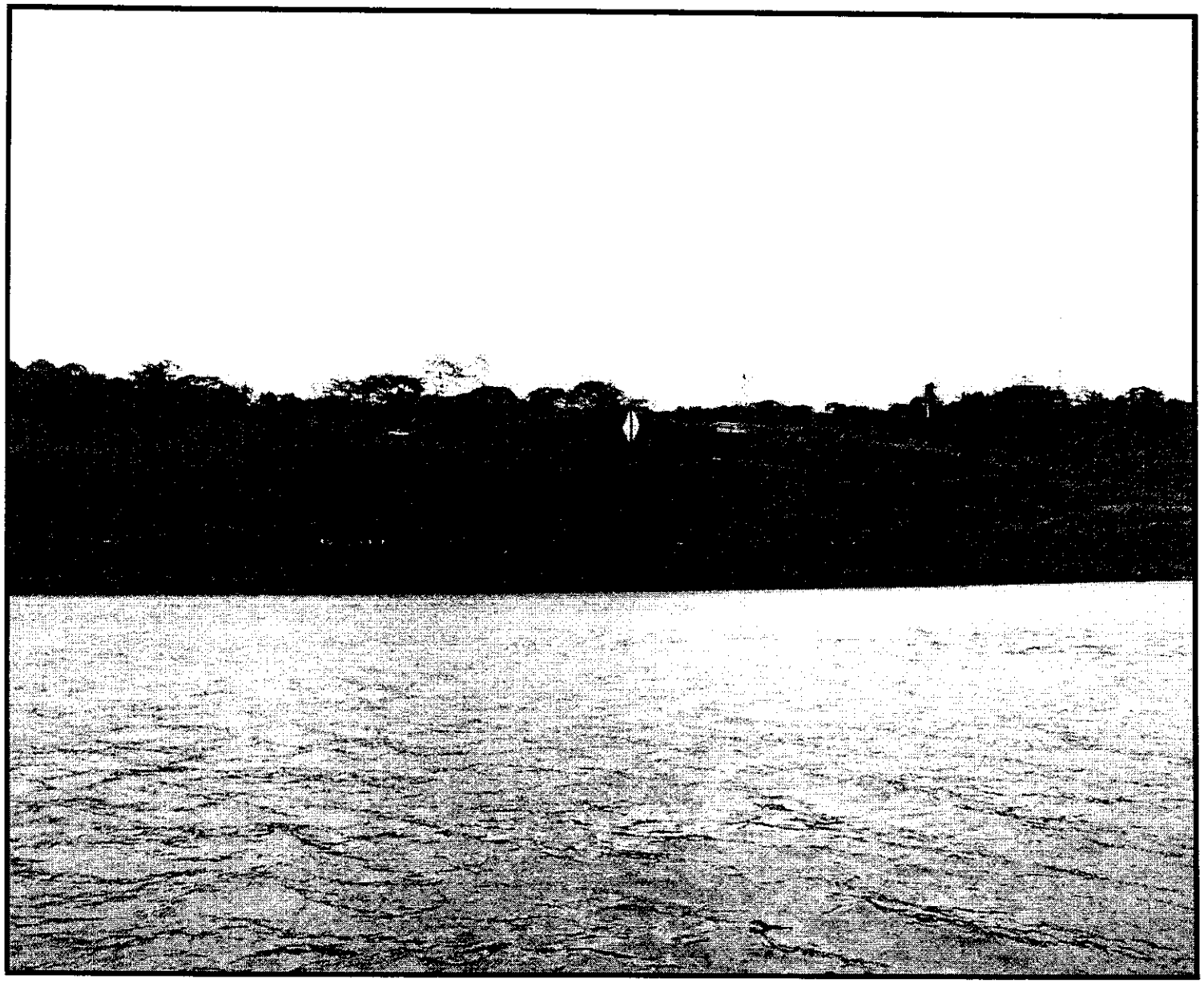
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: J. ARROCHA	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 55k + 280 (1813 + 65)

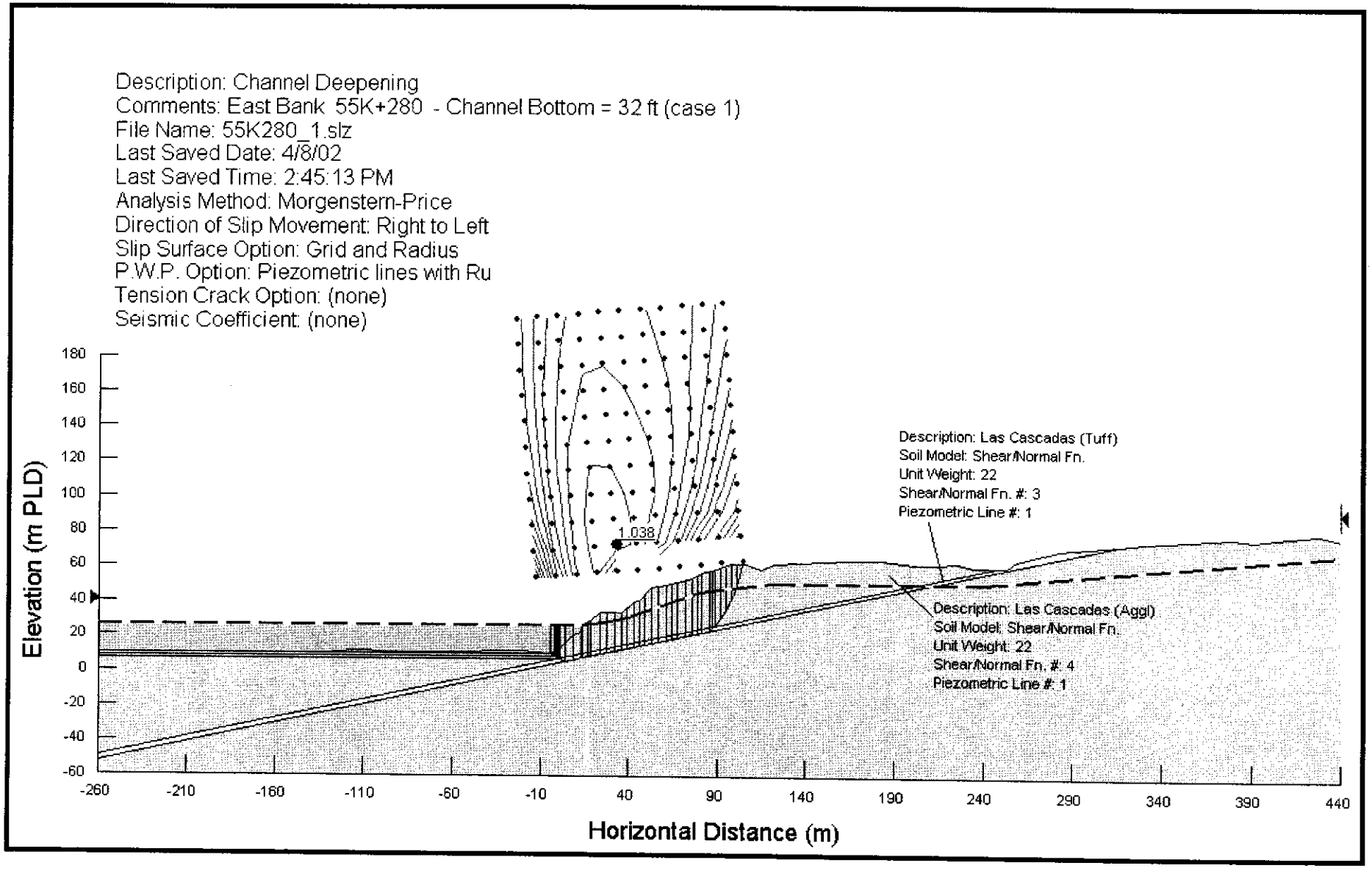
East

Station: 55k + 280 (Sardinilla)

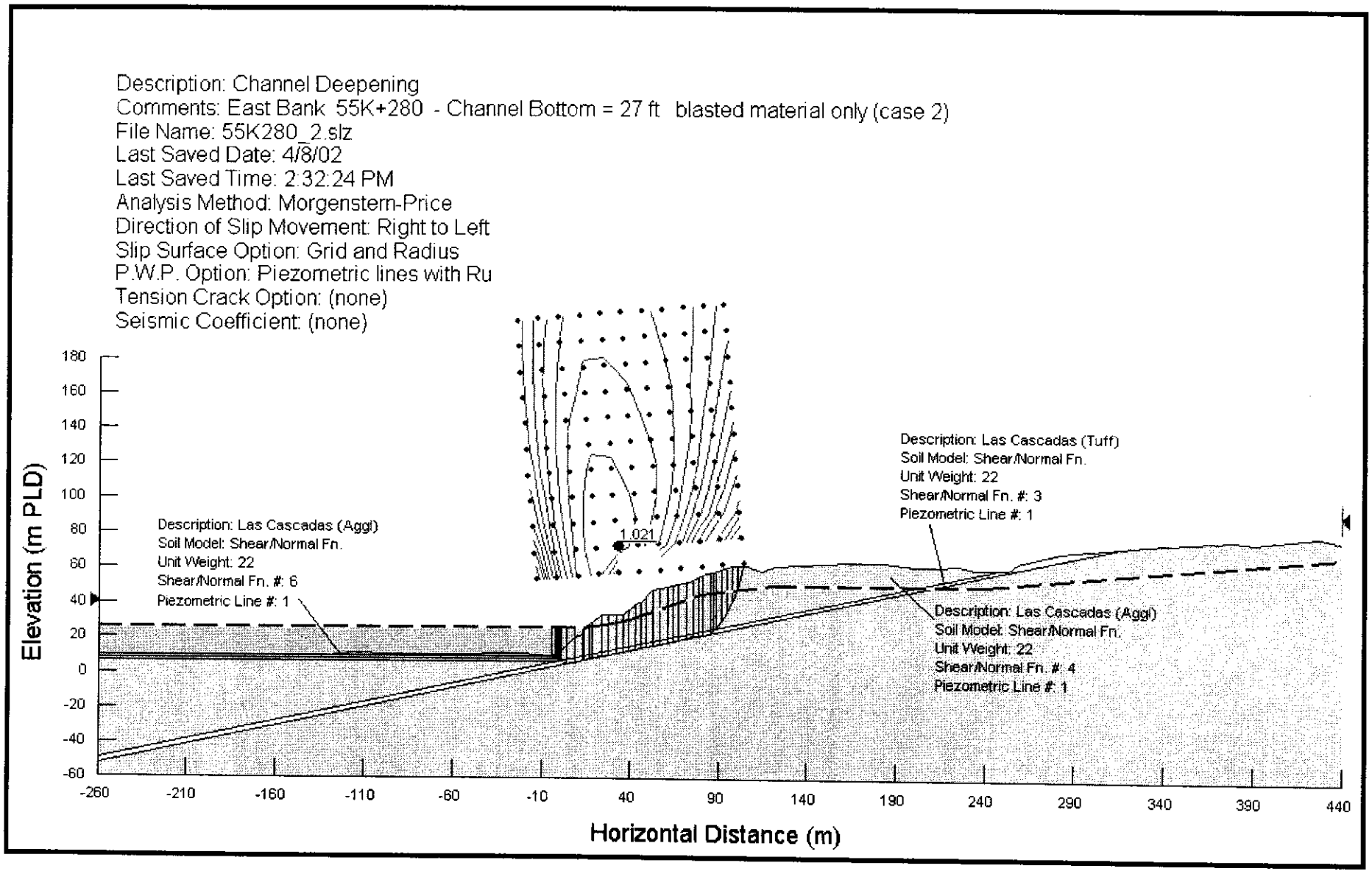
April 16, 2002



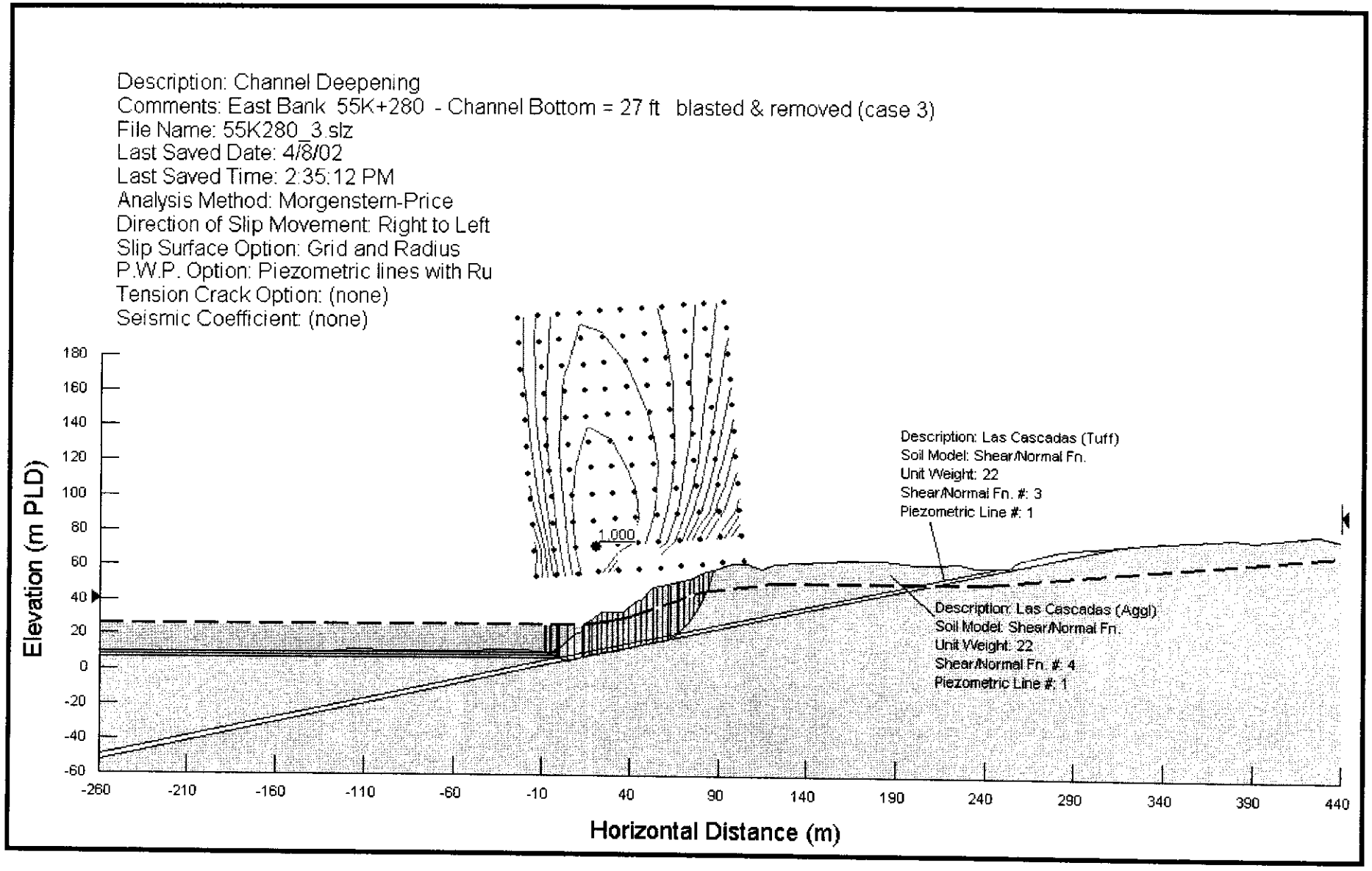
Case 1, Channel bottom = 32 ft



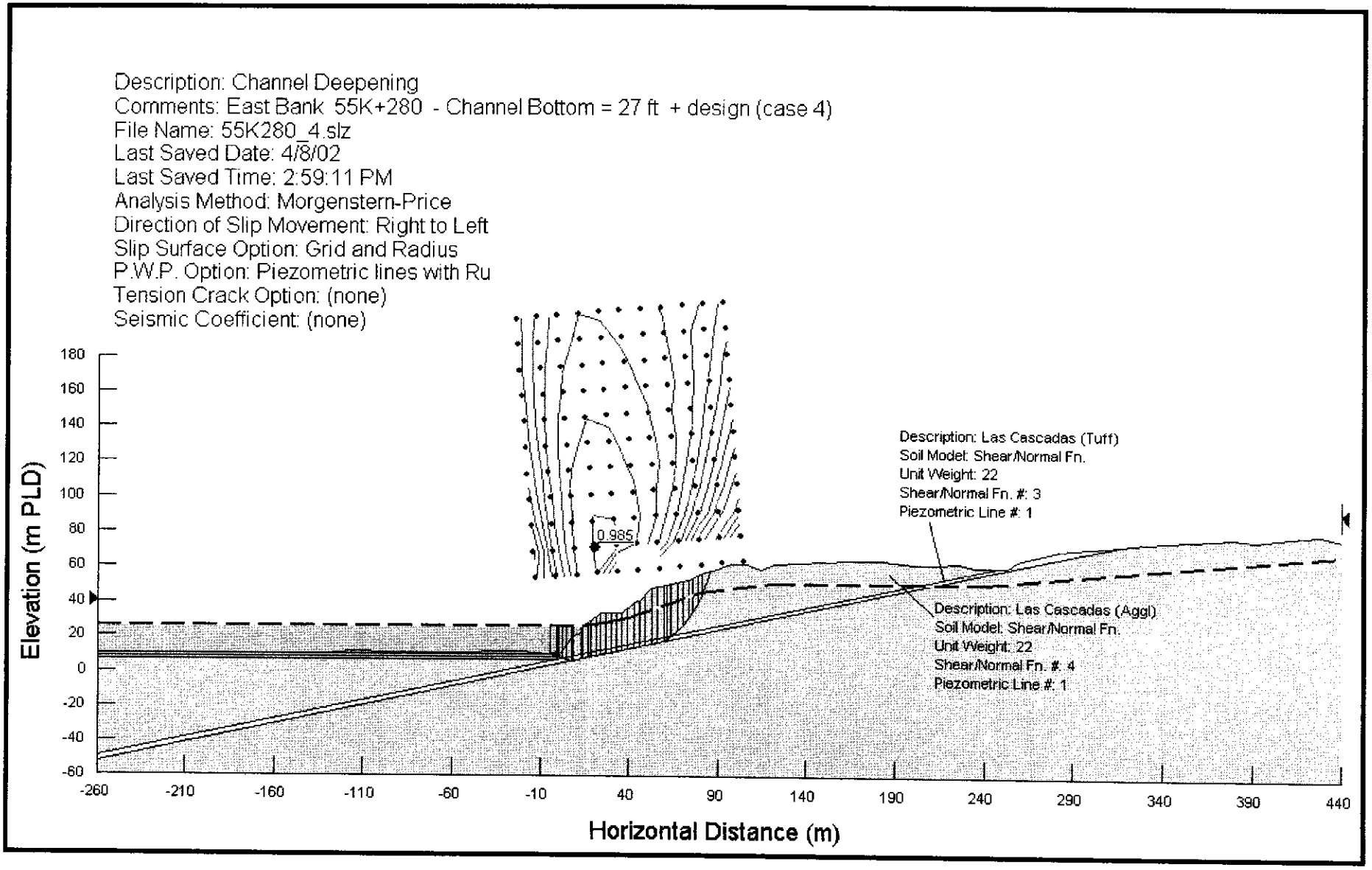
Case 2, Channel bottom = 27 ft, Blasted material only



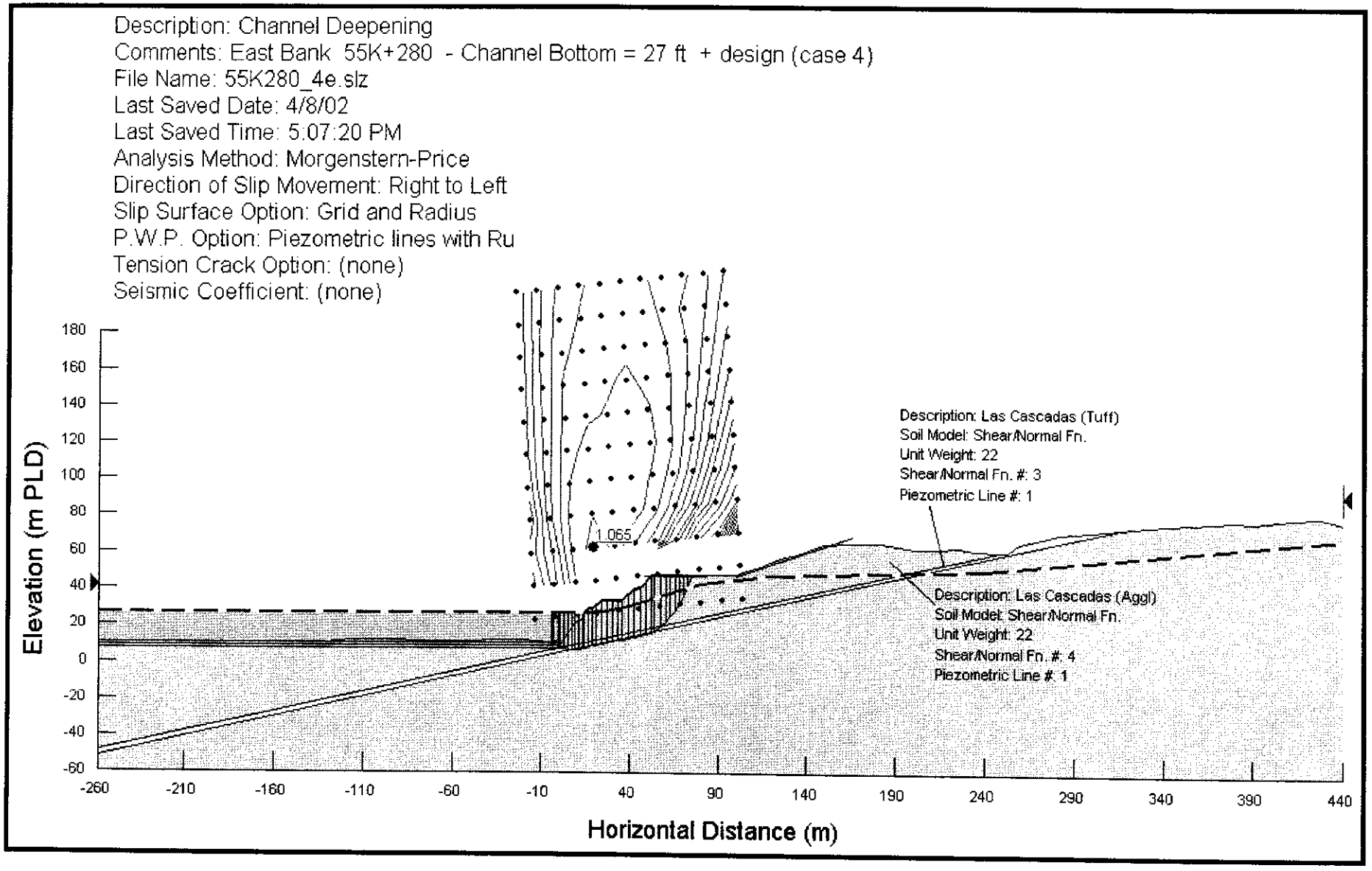
Case 3, Channel bottom = 27 ft, Blasted & removed



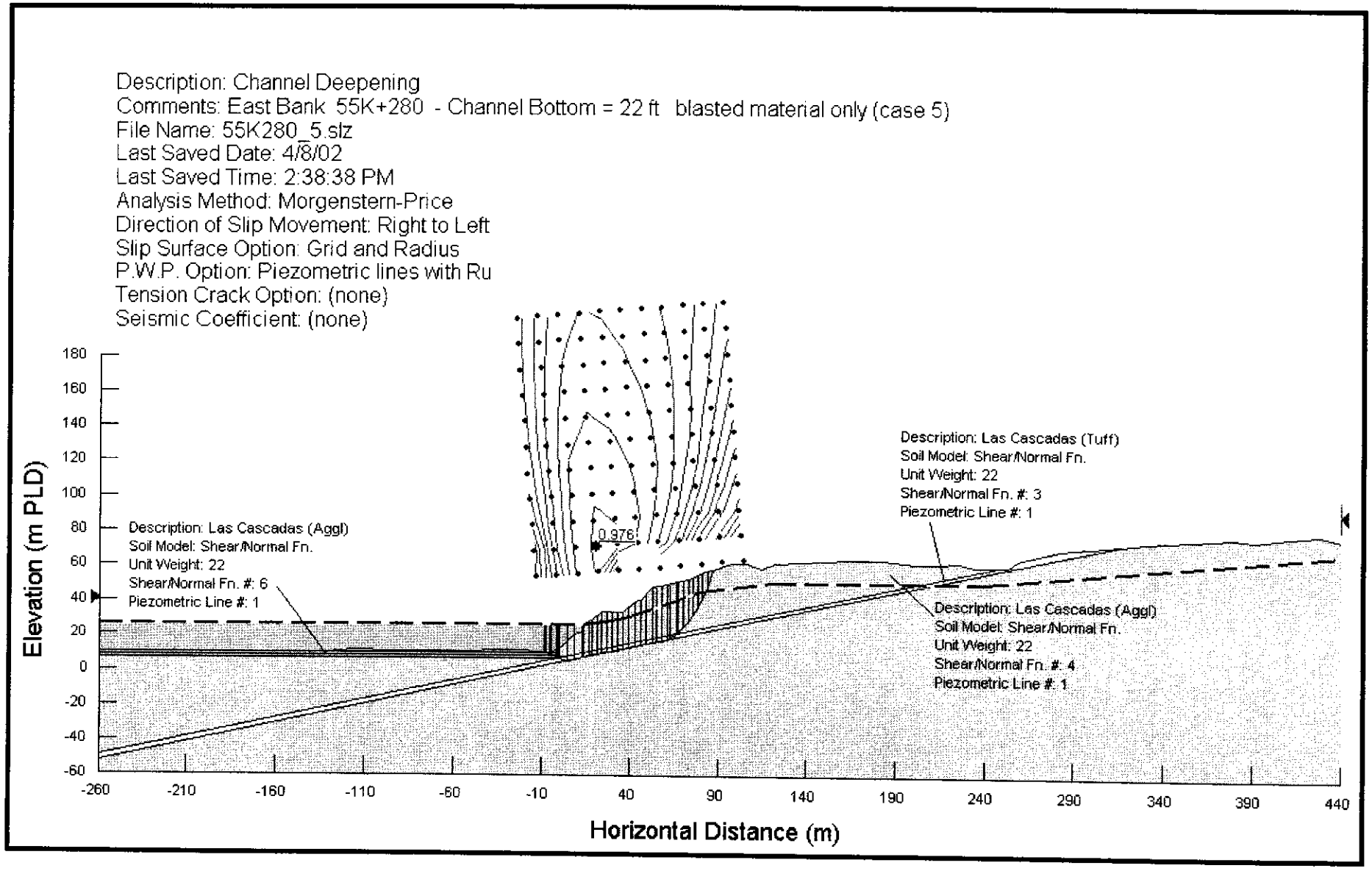
Case 4.1, Channel bottom = 27 ft, Design (underwater slope)



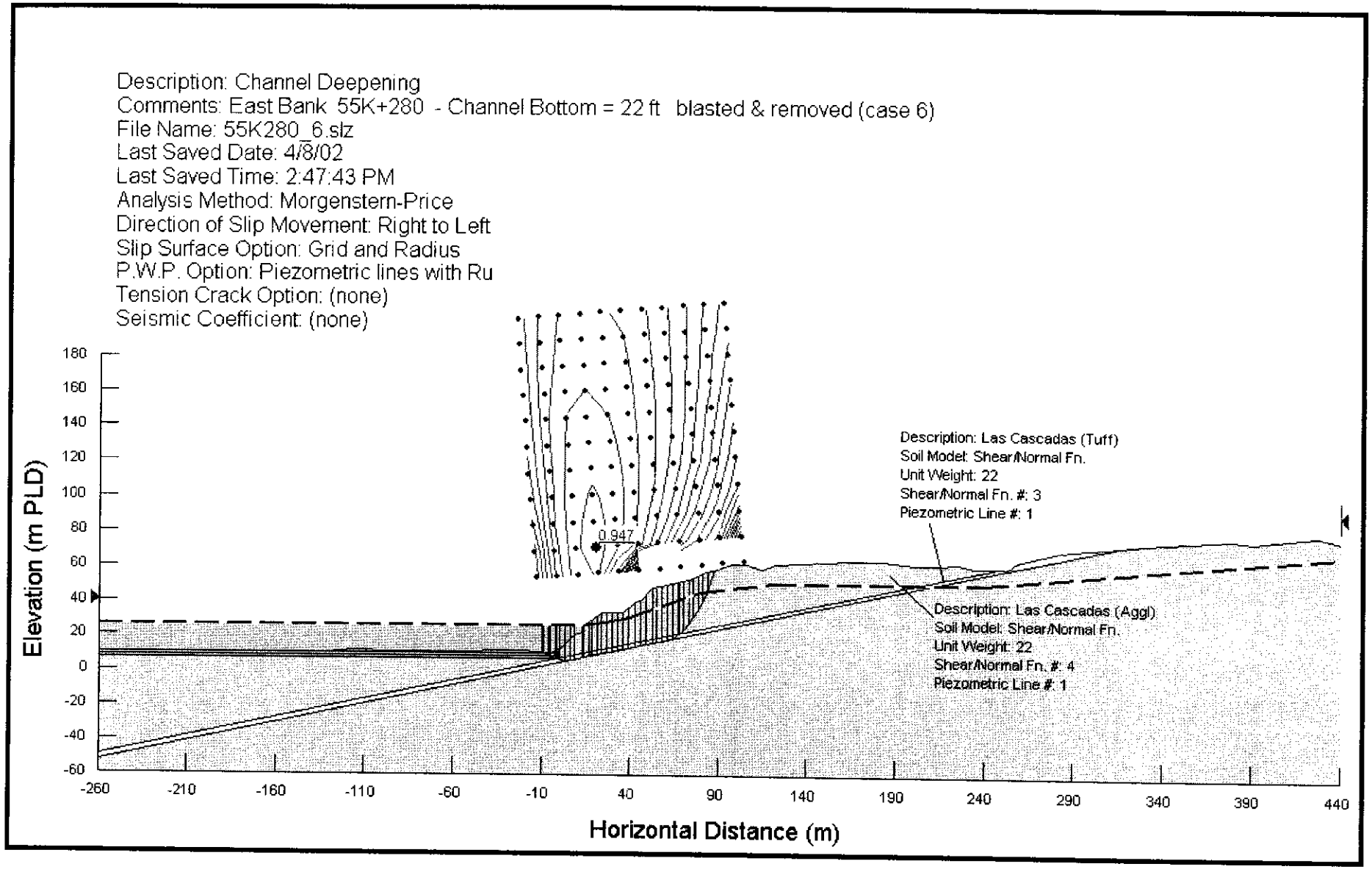
Case 4.2, Channel bottom = 27 ft, Design (& dry excavation)



Case 5, Channel bottom = 22 ft, Blasted material only

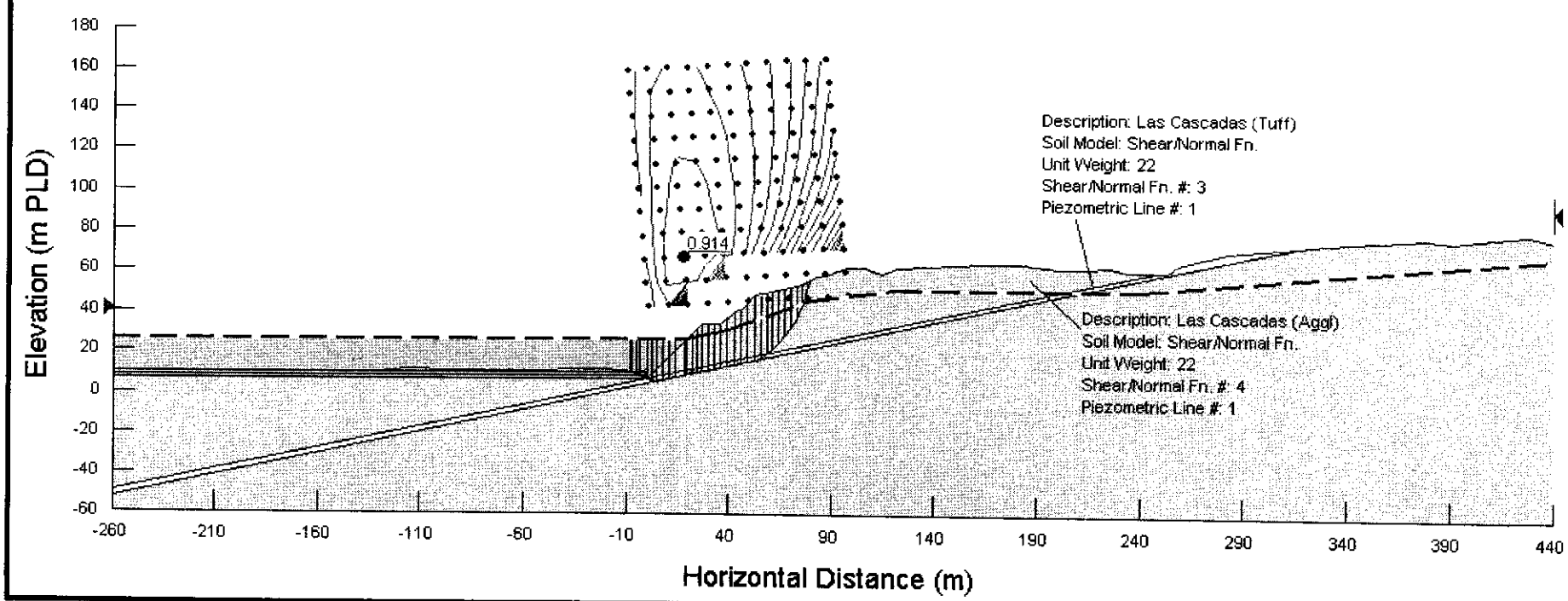


Case 6, Channel bottom = 22 ft, Blasted & removed



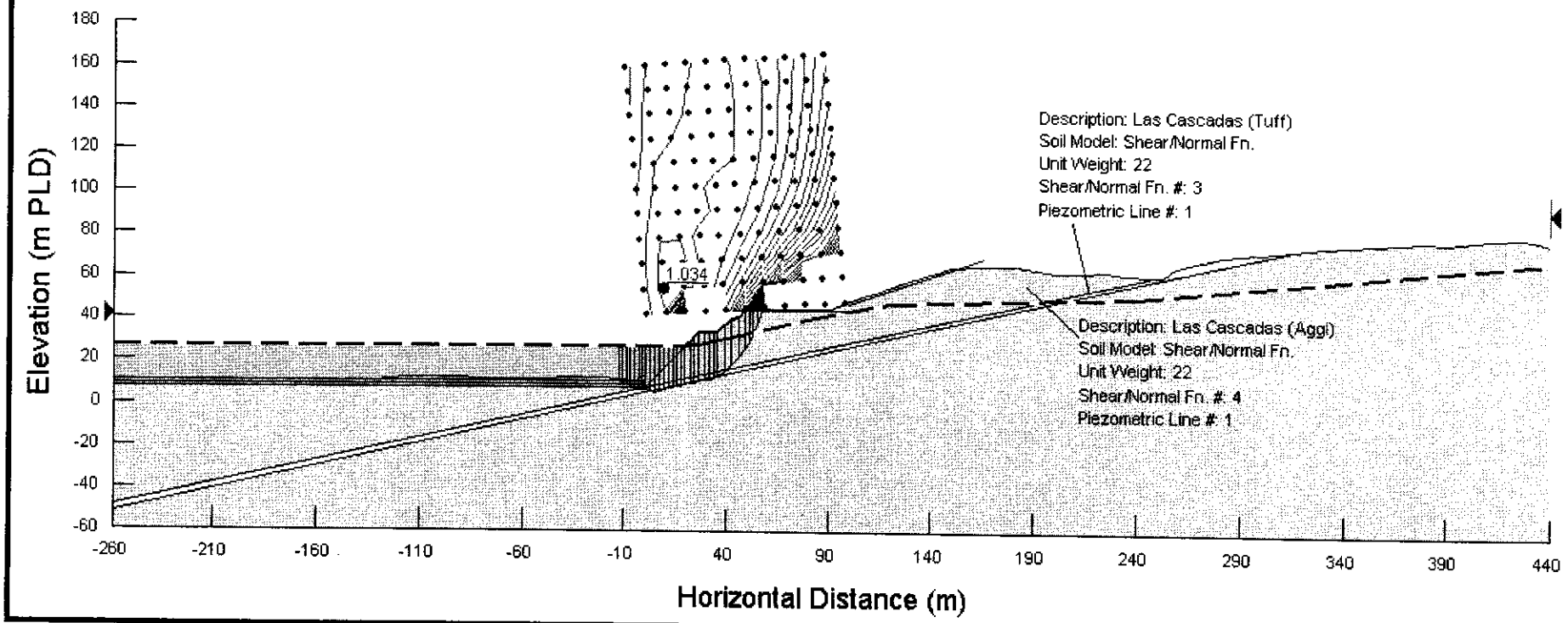
Case 7.1, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 55K+280 - Channel Bottom = 22 ft + design (case 7)
File Name: 55K280_7.slz
Last Saved Date: 4/8/02
Last Saved Time: 3:17:00 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



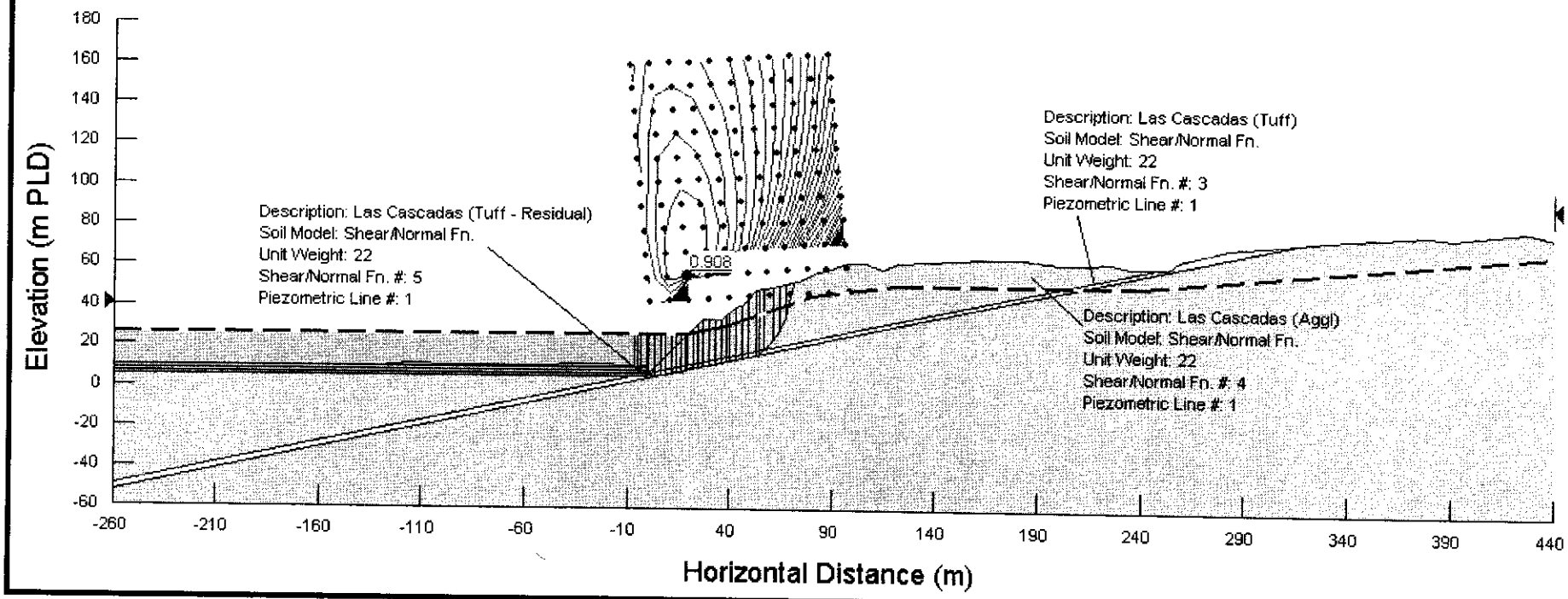
Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 55K+280 - Channel Bottom = 22 ft + design (case 7)
File Name: 55K280_7e.slz
Last Saved Date: 4/8/02
Last Saved Time: 5:14:18 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



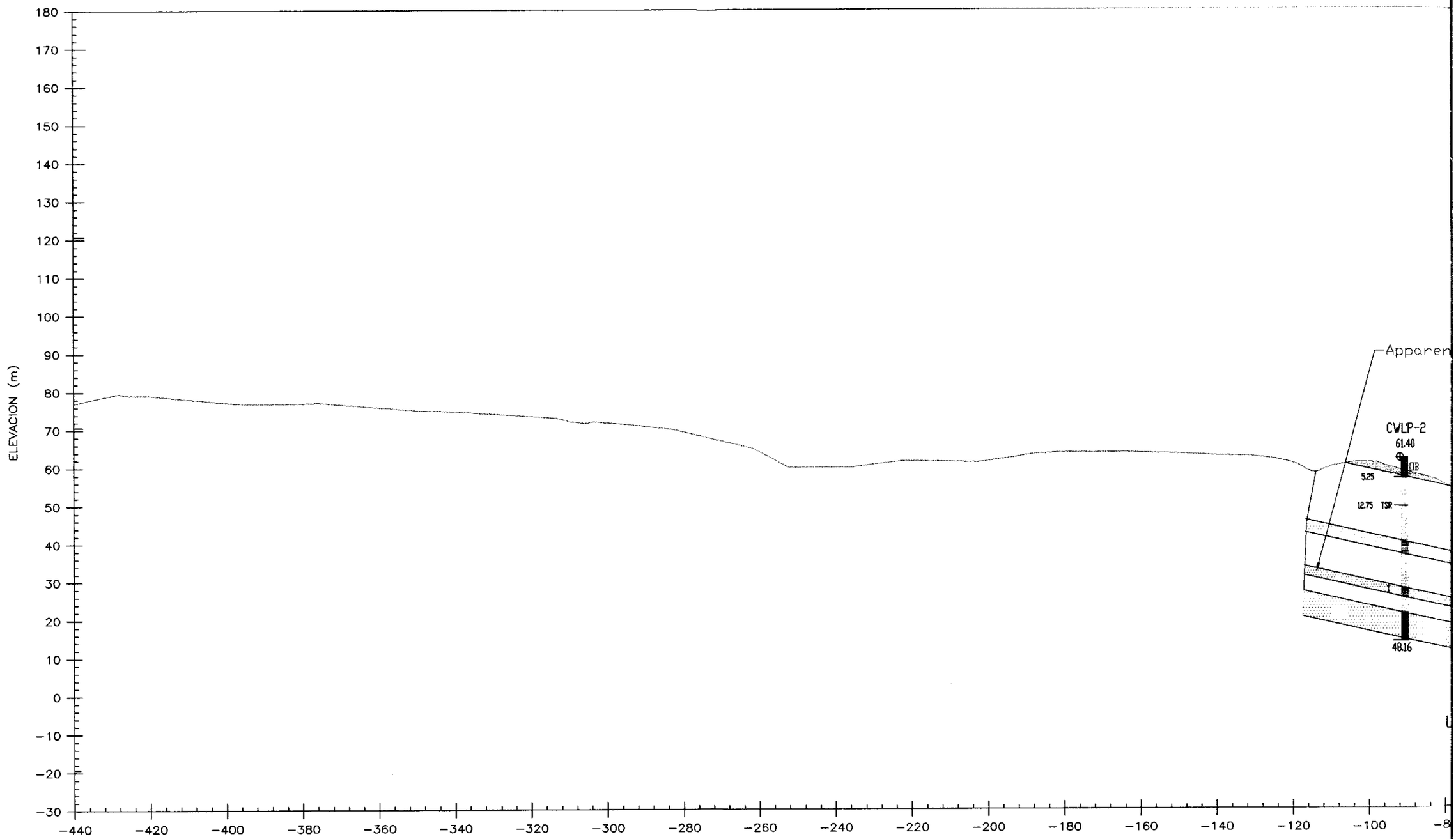
Case 8, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 55K+280 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 55K280_8.slz
Last Saved Date: 4/8/02
Last Saved Time: 3:30:34 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

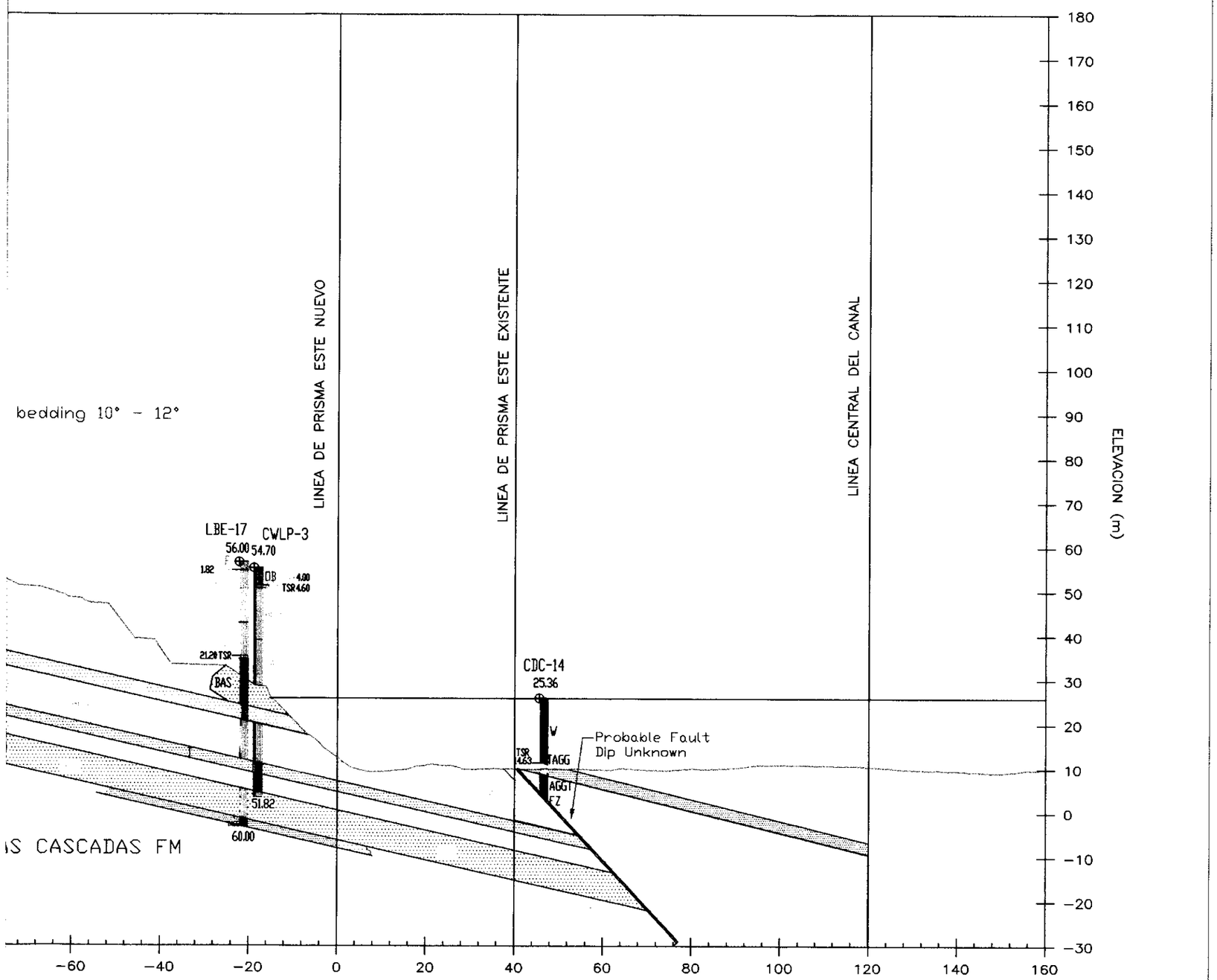


Summary, 55k + 280 (1813 + 65)

General Description	Range of stations:	54k + 880 to 55k + 400			
	Sector:	Sardinilla			
	Maximum height (m):	50			
	Cotangent of slope angle (cot. β):	2.0			
History	Last slide event:	1996 (North La Pita Slide, during widening)			
Geology	Formation:	Las Cascadas			
	Lithology:	Agglomerate - Tuff			
	Critical stratum at toe:	Weak plane tuff			
	Apparent dip of bedding:	Toward the Canal			
Stability Analysis	Critical failure mechanism:	Translational - along weak plane			
	Shear strength model:	Fully softened tuff weak plane / First time Cascadas			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.307	1.038	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		1.021	0.984	-1.64
	Case 3: Channel bottom = 27 ft, Blasted & removed		1.000	0.963	-3.66
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		0.985	0.949	-5.11
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.325	1.065	1.026	2.60
	Case 5: Channel bottom = 22 ft, Blasted material only		0.976	0.940	-5.97
	Case 6: Channel bottom = 22 ft, Blasted & removed		0.947	0.912	-8.77
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		0.914	0.881	-11.95
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.341	1.034	0.996	-0.39
	Case 8: Channel bottom = 16 ft, Blasted		0.908	0.875	-12.52
Conclusions:	Stabilization is required for Case 4 and Case 7				



55k+280 (1813+67) EAST



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DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 55K+280 (1813+67) ESTE

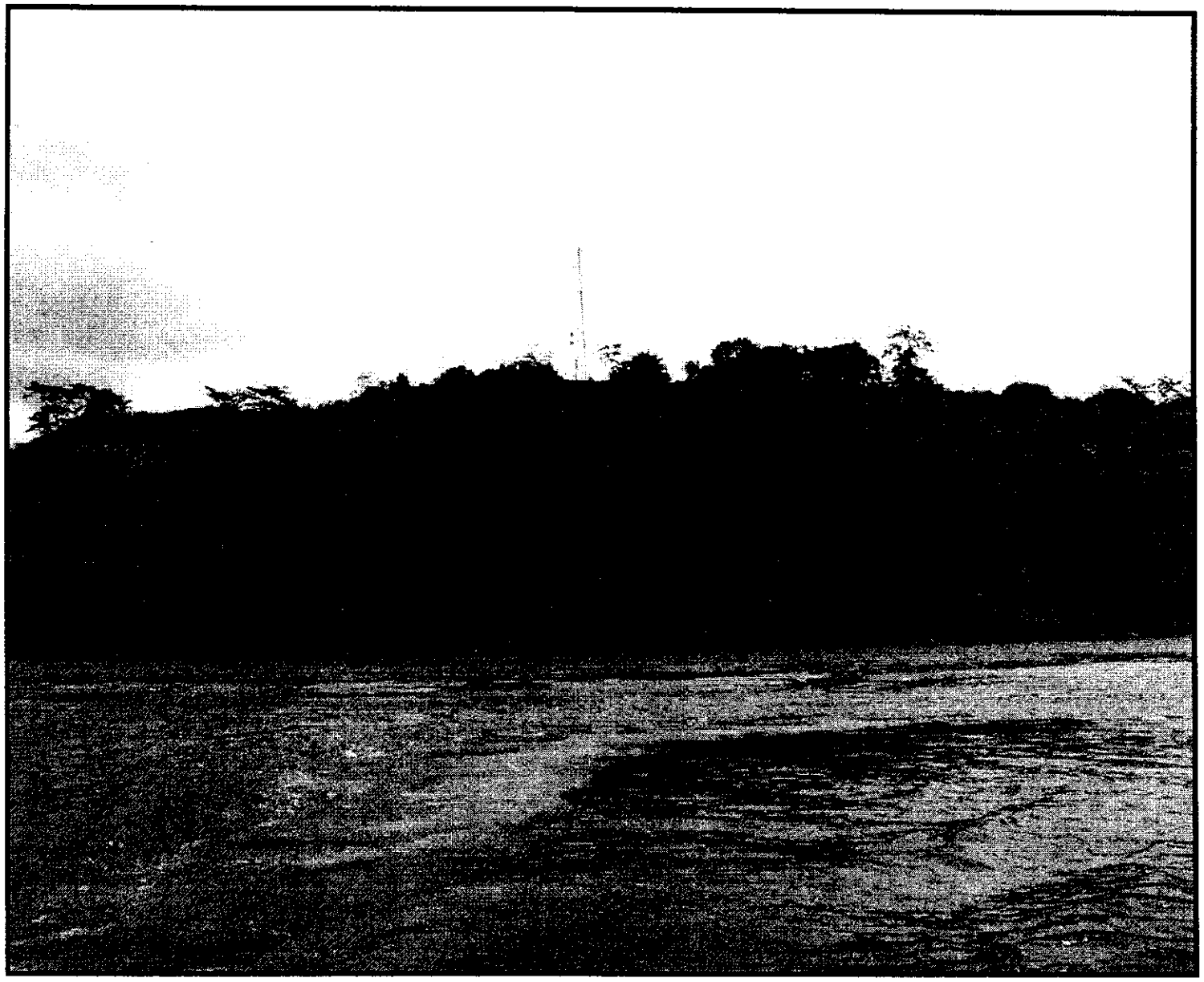
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: J. ARROCHA	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 55k + 830 (1830 + 70)

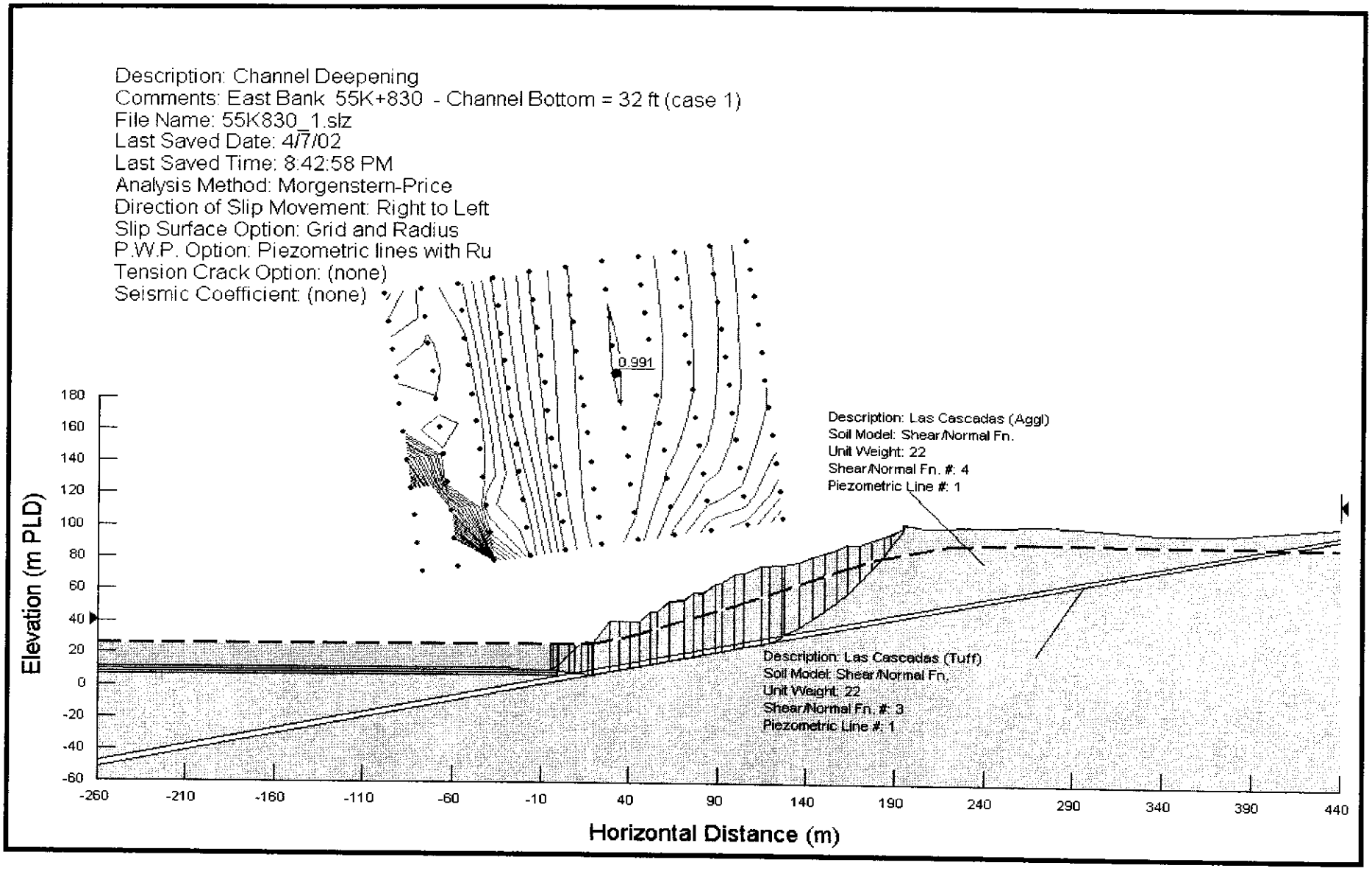
East

Station: 55k + 830 (La Pita)

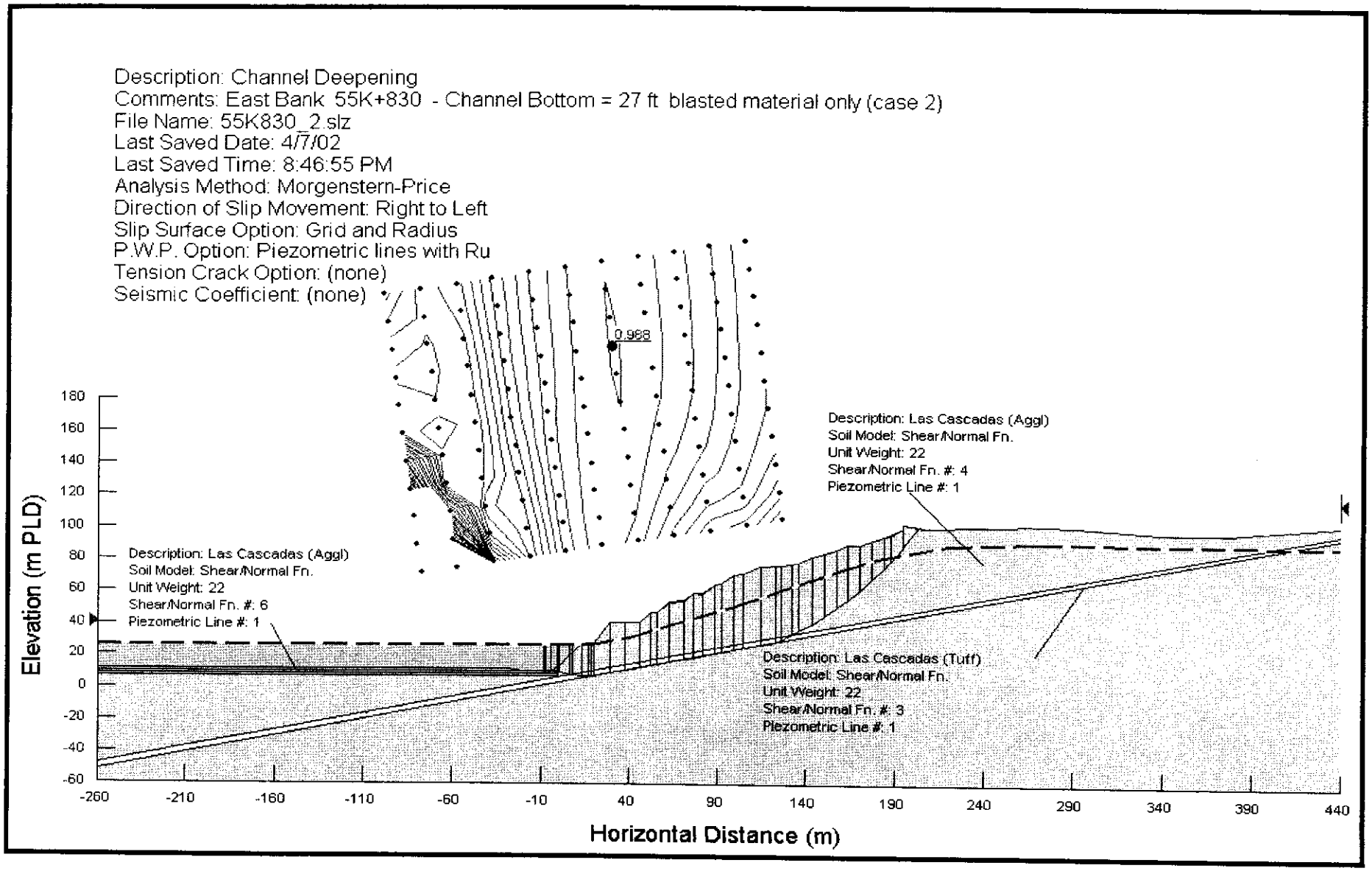
April 16, 2002



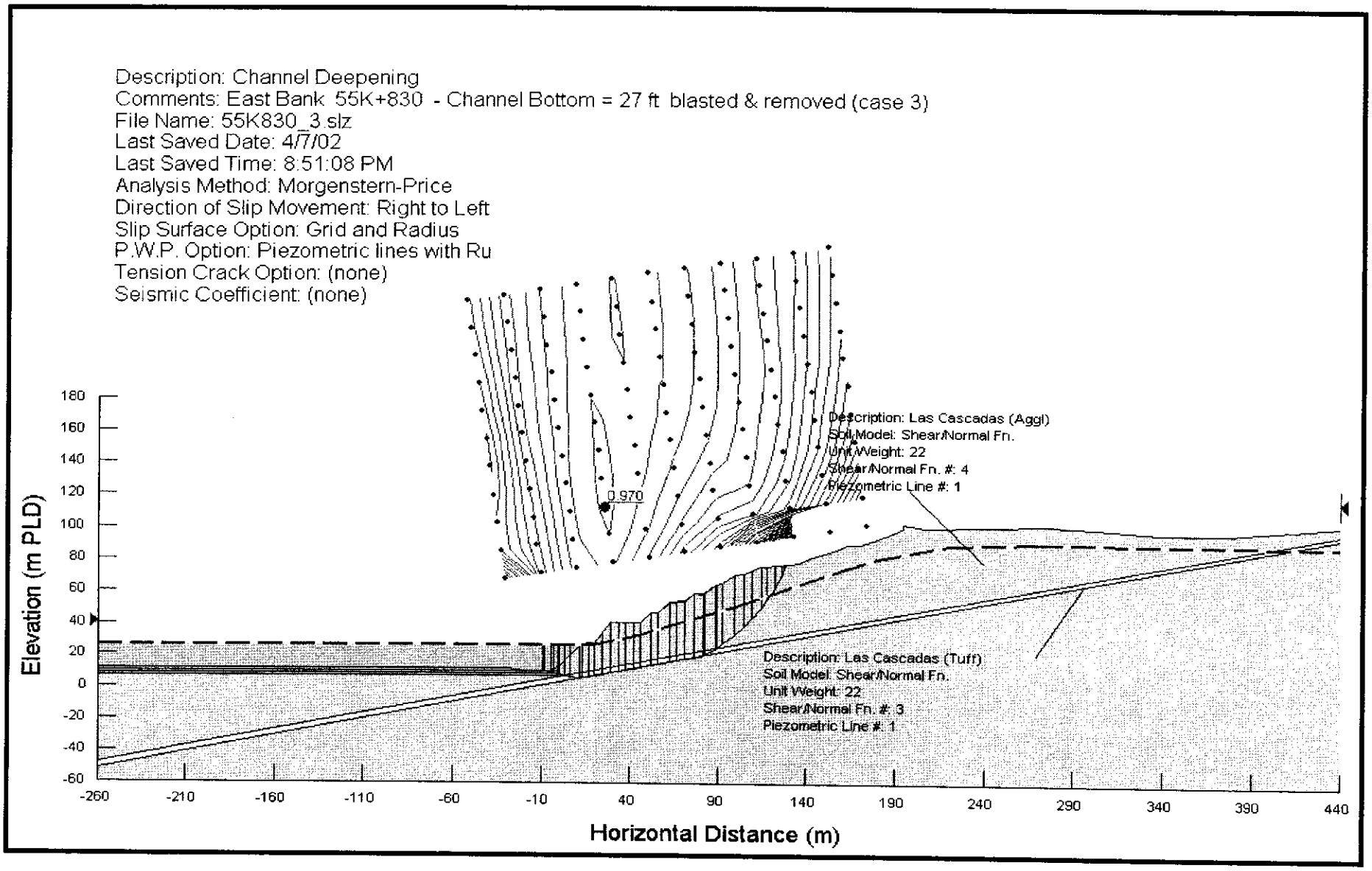
Case 1, Channel bottom = 32 ft



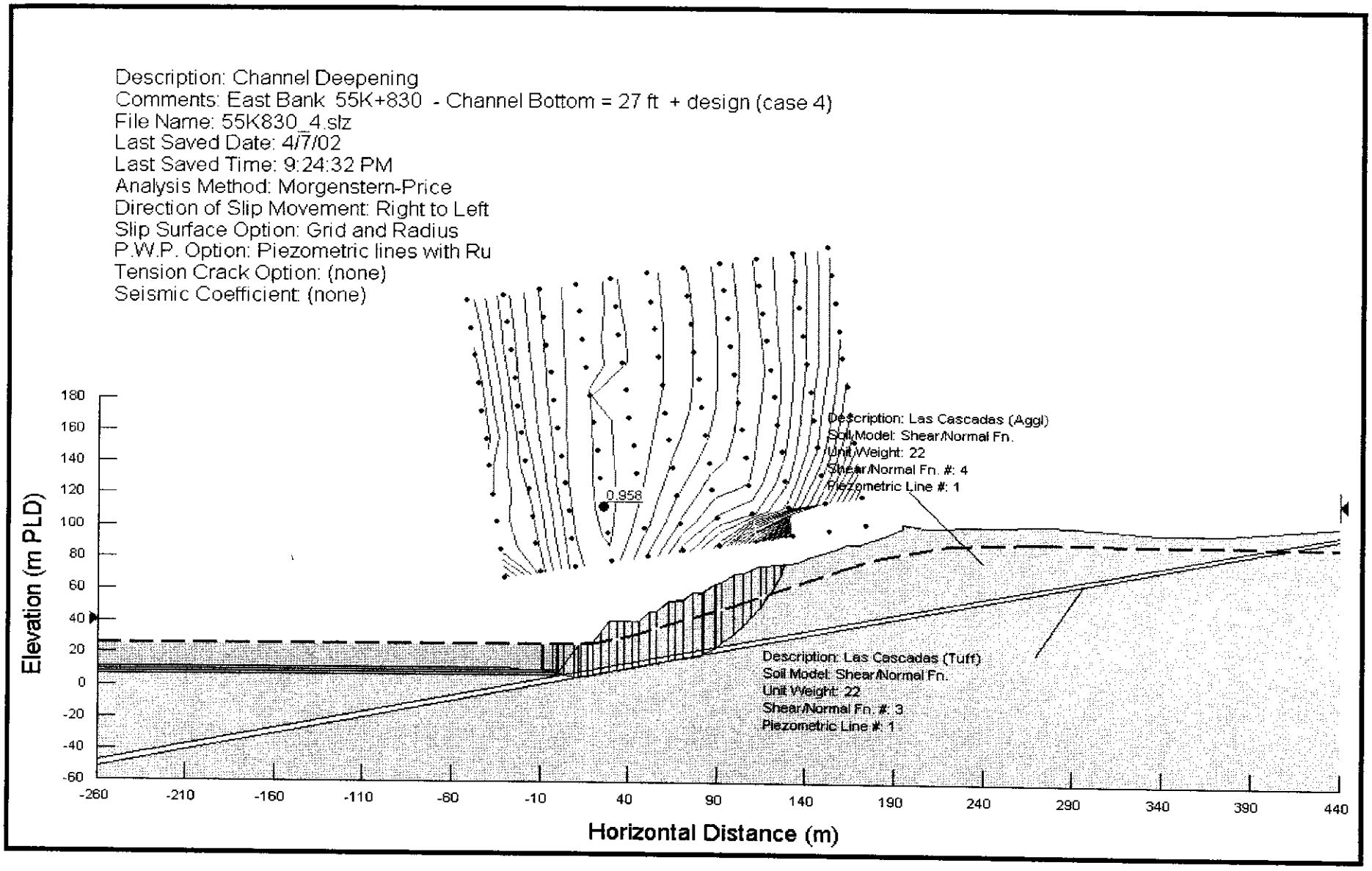
Case 2, Channel bottom = 27 ft, Blasted material only



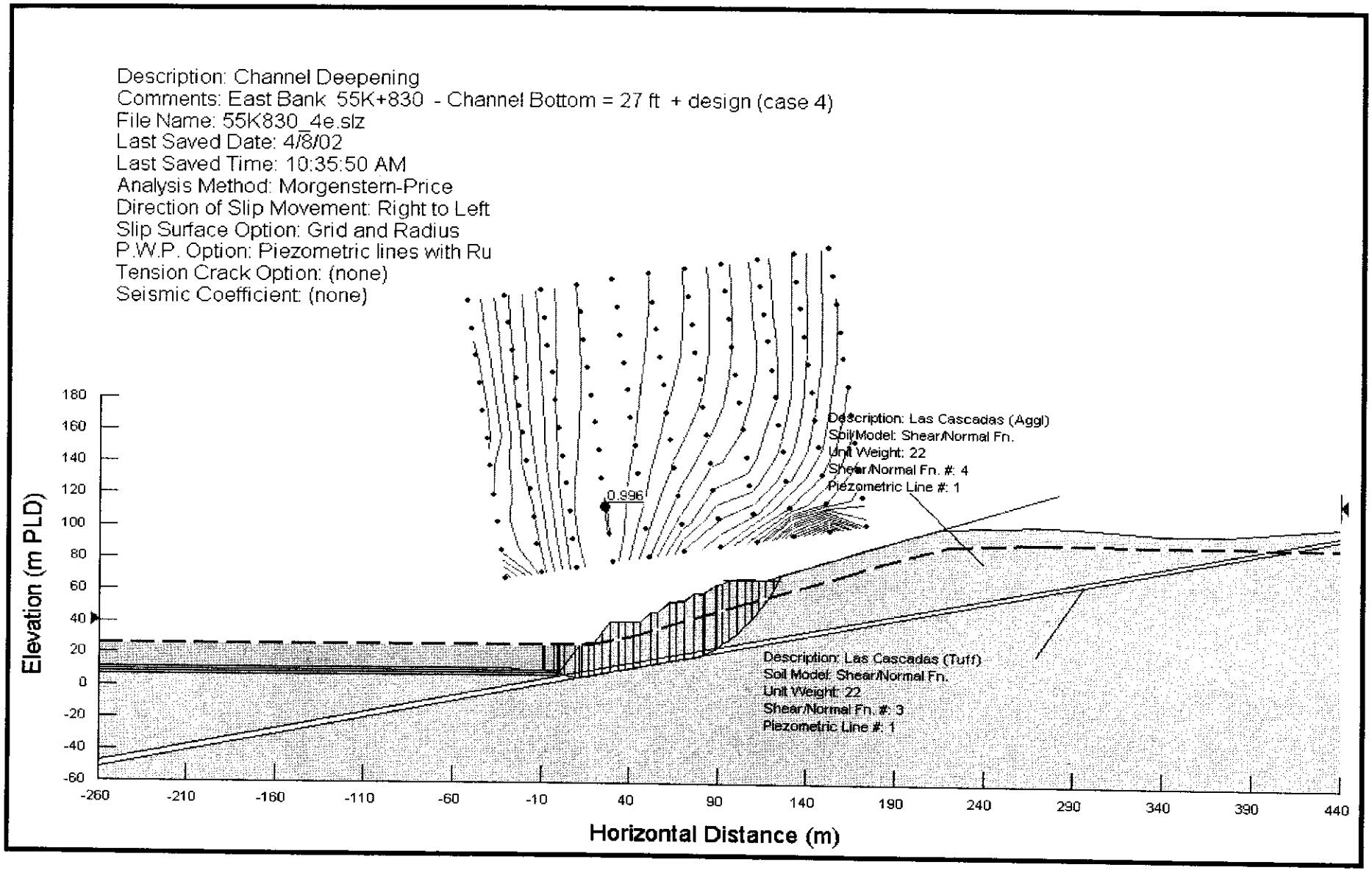
Case 3, Channel bottom = 27 ft, Blasted & removed



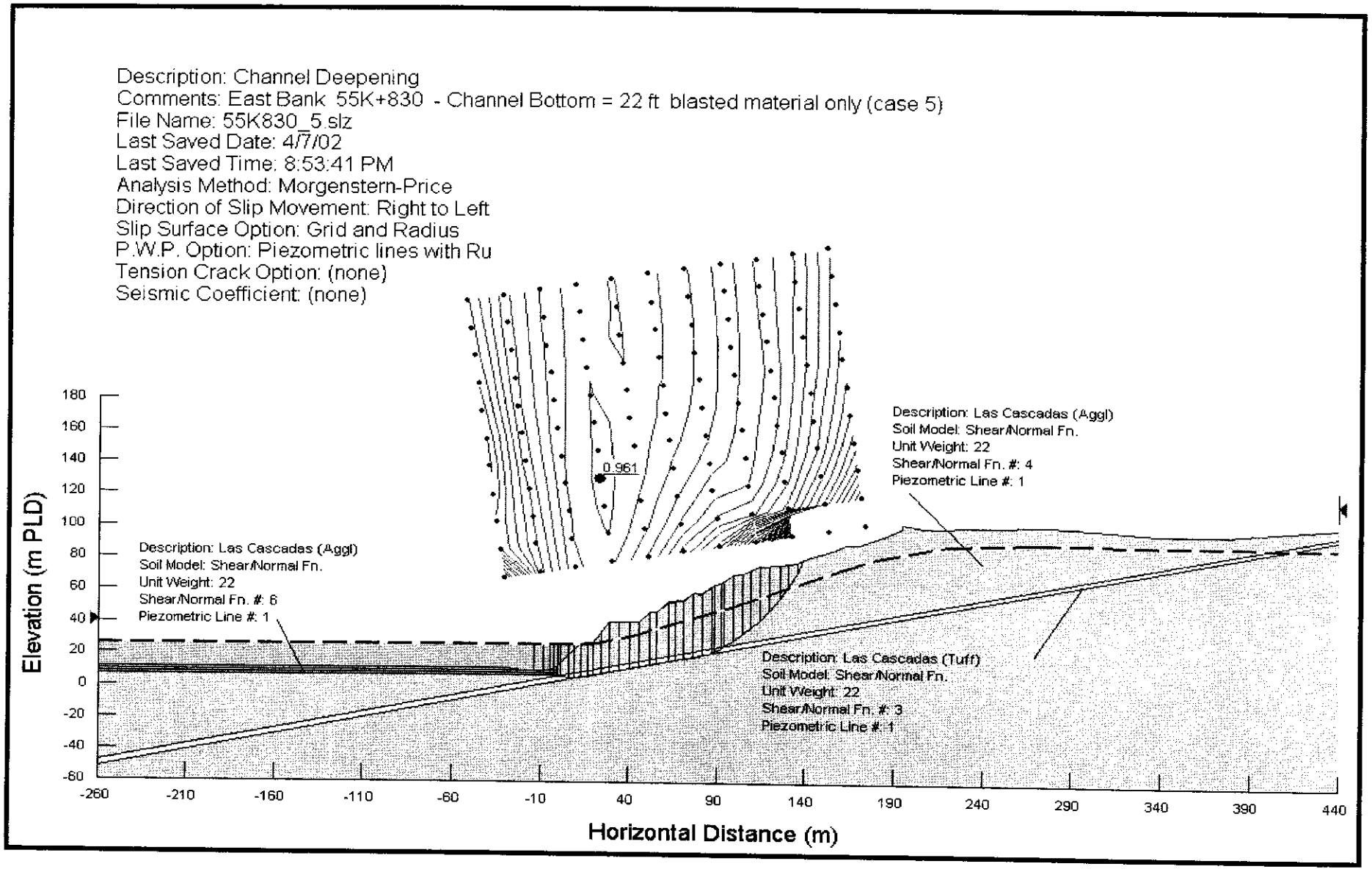
Case 4.1, Channel bottom = 27 ft, Design (underwater slope)



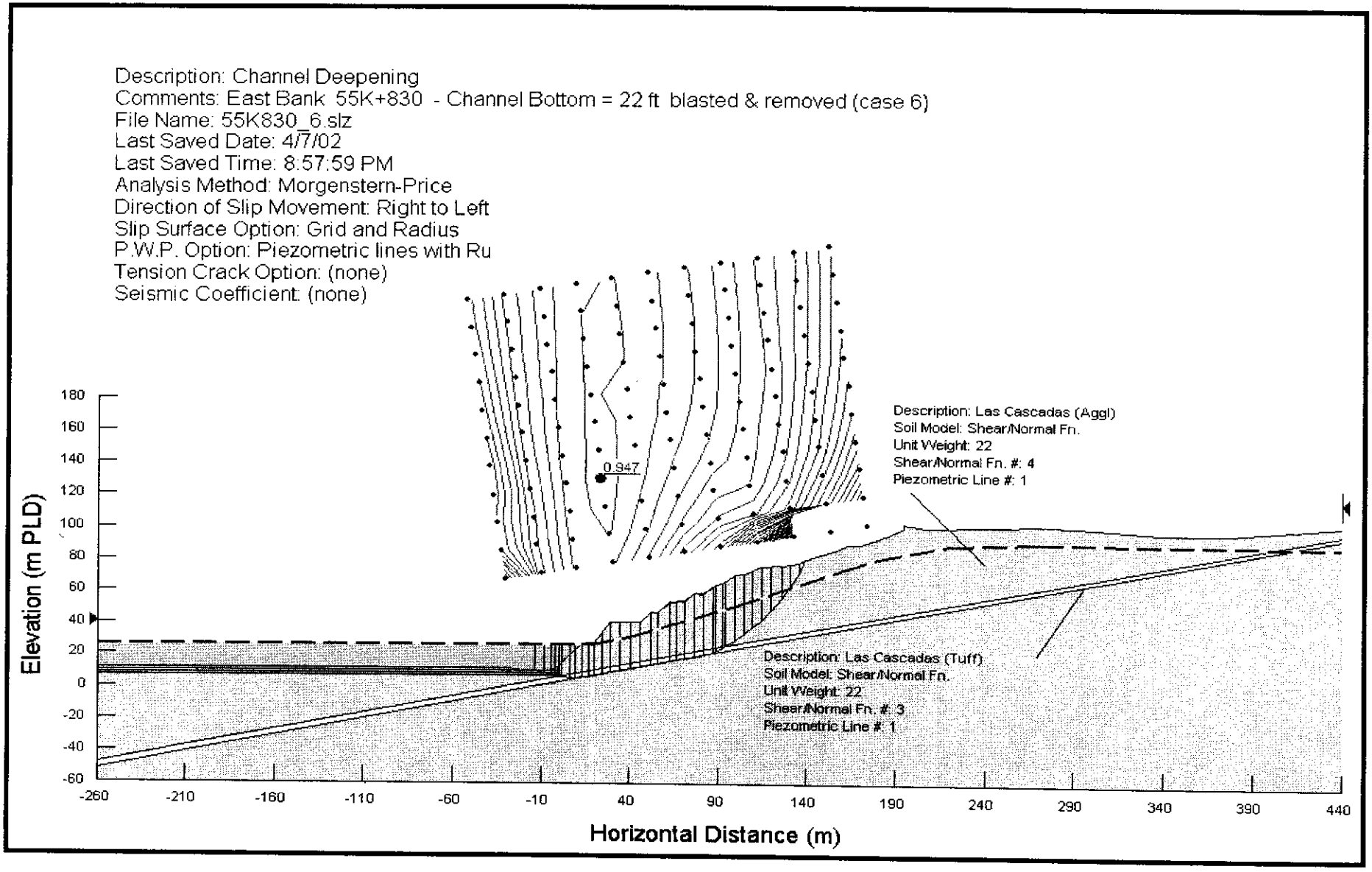
Case 4.2, Channel bottom = 27 ft, Design (& dry excavation)



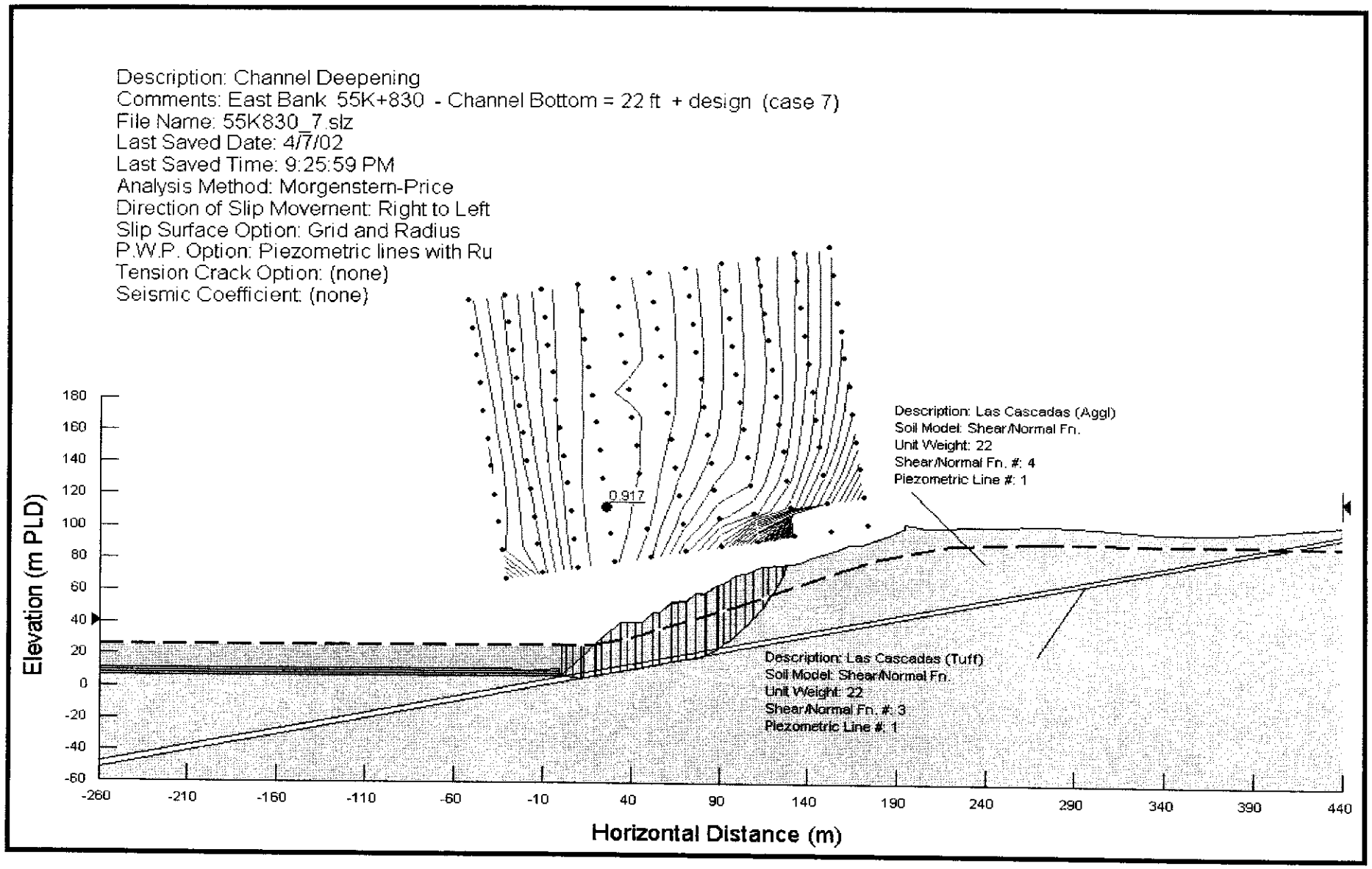
Case 5, Channel bottom = 22 ft, Blasted material only



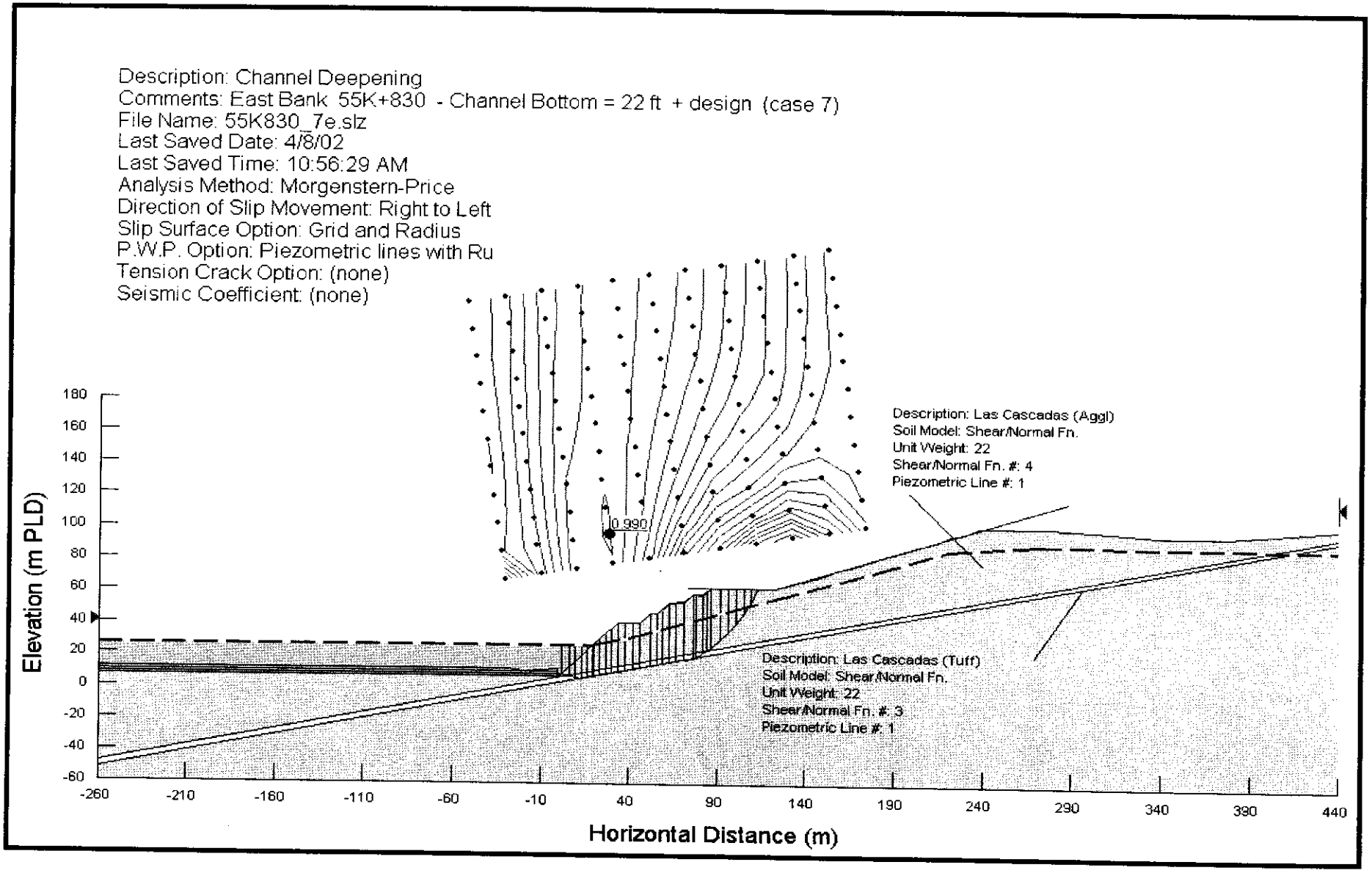
Case 6, Channel bottom = 22 ft, Blasted & removed



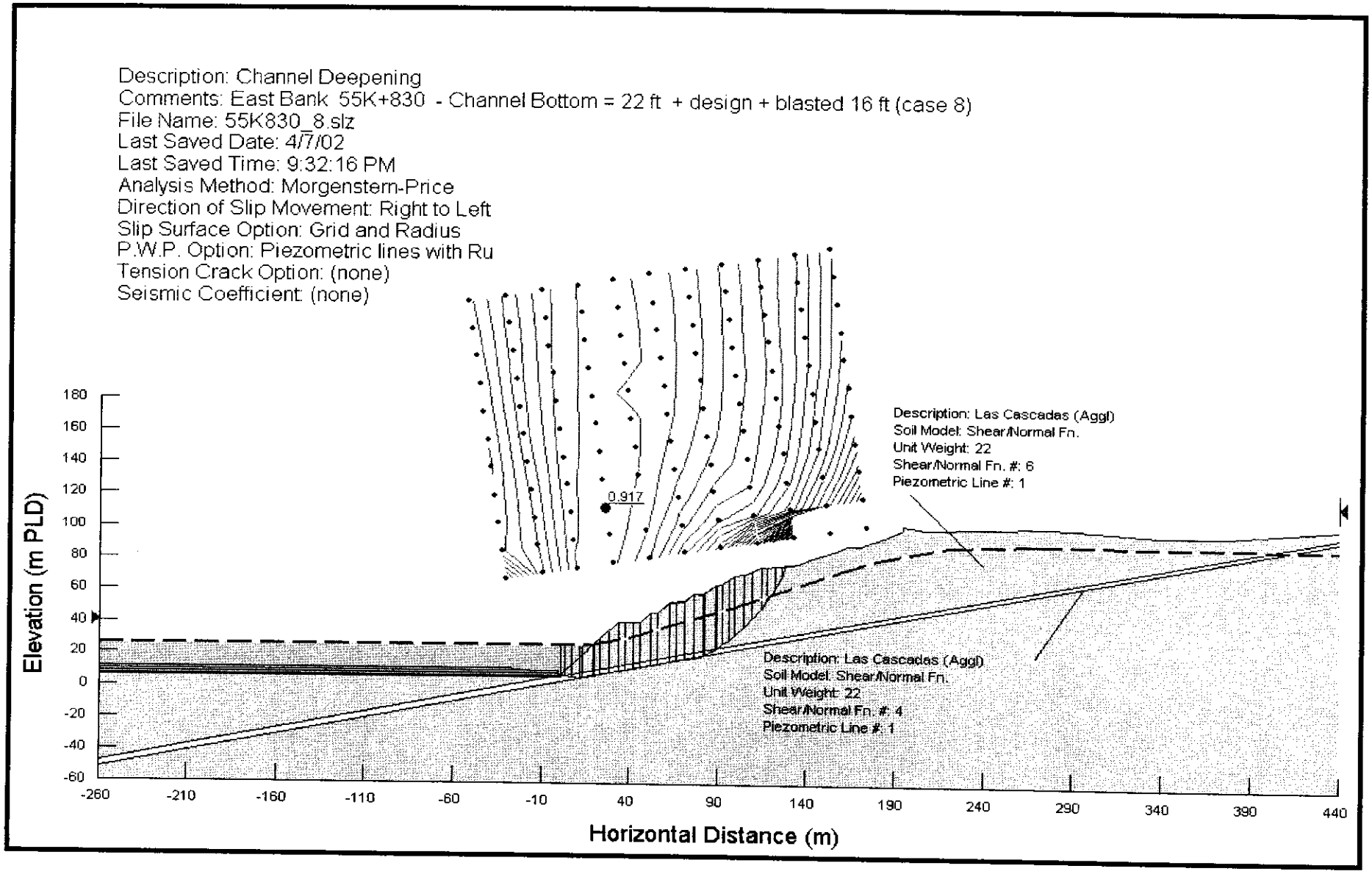
Case 7.1, Channel bottom = 27 ft, Design (underwater slope)



Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)

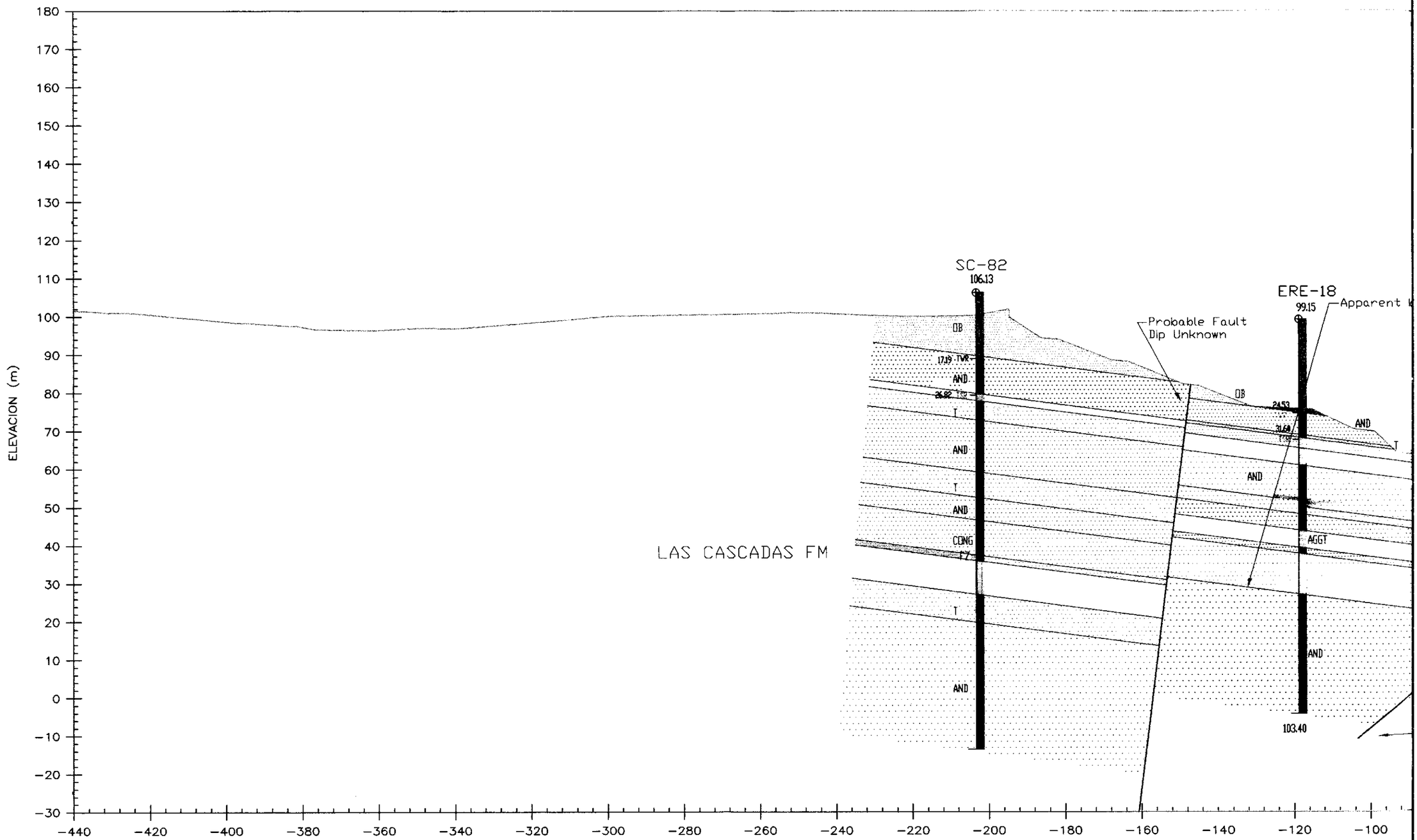


Case 8, Channel bottom = 16 ft, Blasted

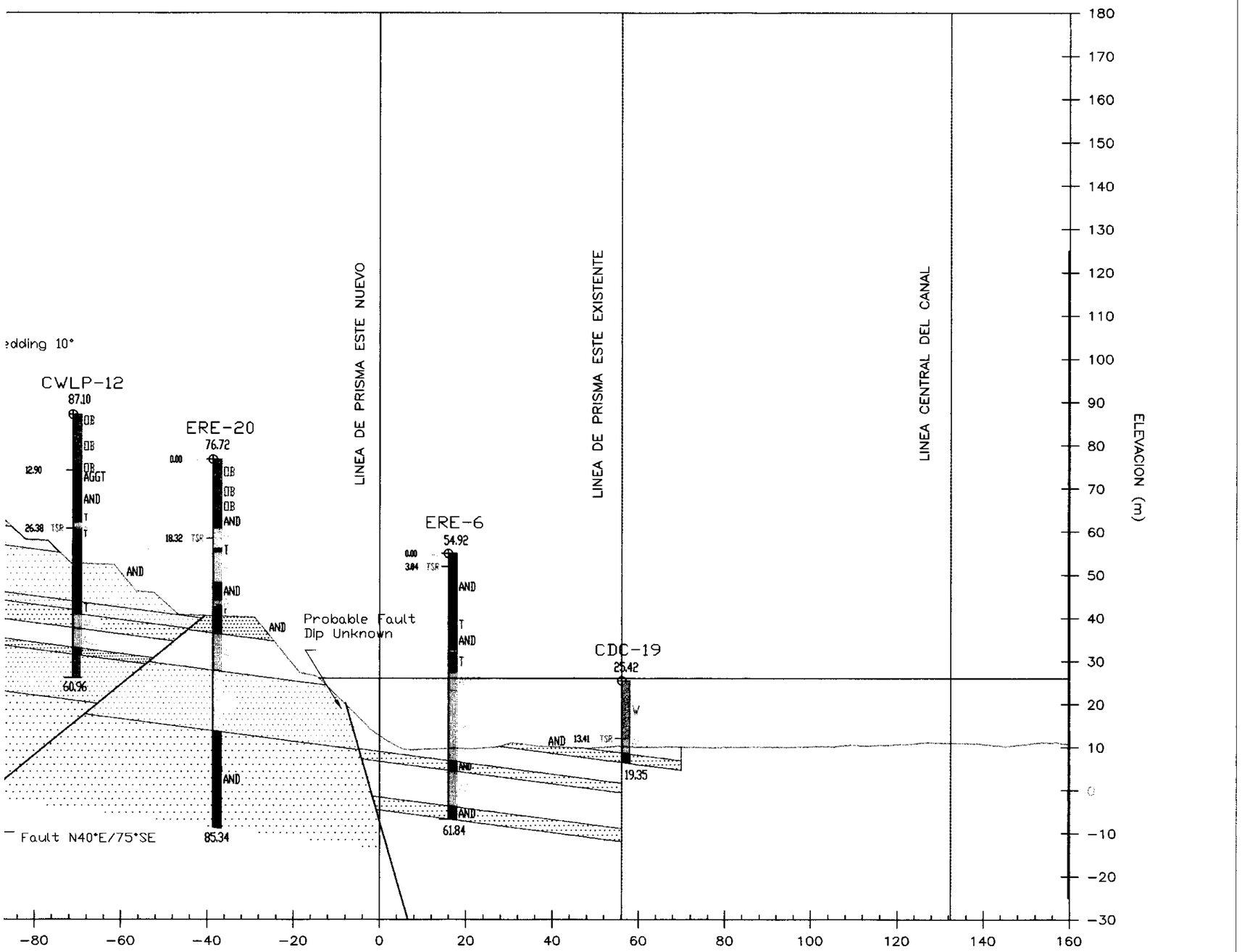


Summary, 55k + 830 (1831 + 70)

General Description	Range of stations:	55k + 400 to 56k + 000			
	Sector:	Central La Pita			
	Maximum height (m):	90			
	Cotangent of slope angle (cot. β):	2.3			
History	Last slide event:	1915 (Lower La Pita), 1909 (Upper La Pita), 1995 (Central La Pita)			
Geology	Formation:	Las Cascadas			
	Lithology:	Agglomerate / Andesite / Tuff			
	Critical stratum at toe:	Agglomerate / Andesite			
	Apparent dip of bedding:	Toward the Canal			
Stability Analysis	Critical failure mechanism:	Translational along weak plane			
	Shear strength model:	First time Cascadas agglomerate / Weak plane, Fully softened			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.277	0.991	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		0.988	0.997	-0.30
	Case 3: Channel bottom = 27 ft, Blasted & removed		0.970	0.979	-2.12
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		0.958	0.967	-3.33
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.286	0.996	1.005	0.50
	Case 5: Channel bottom = 22 ft, Blasted material only		0.961	0.970	-3.03
	Case 6: Channel bottom = 22 ft, Blasted & removed		0.947	0.956	-4.44
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		0.917	0.925	-7.47
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.278	0.990	0.999	-0.10
	Case 8: Channel bottom = 16 ft, Blasted		0.917	0.925	-7.47
Conclusions:	Stabilization is required for Case 4 and Case 7				



55K+830 (1831+70)



AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 55K+830 (1831+70) ESTE

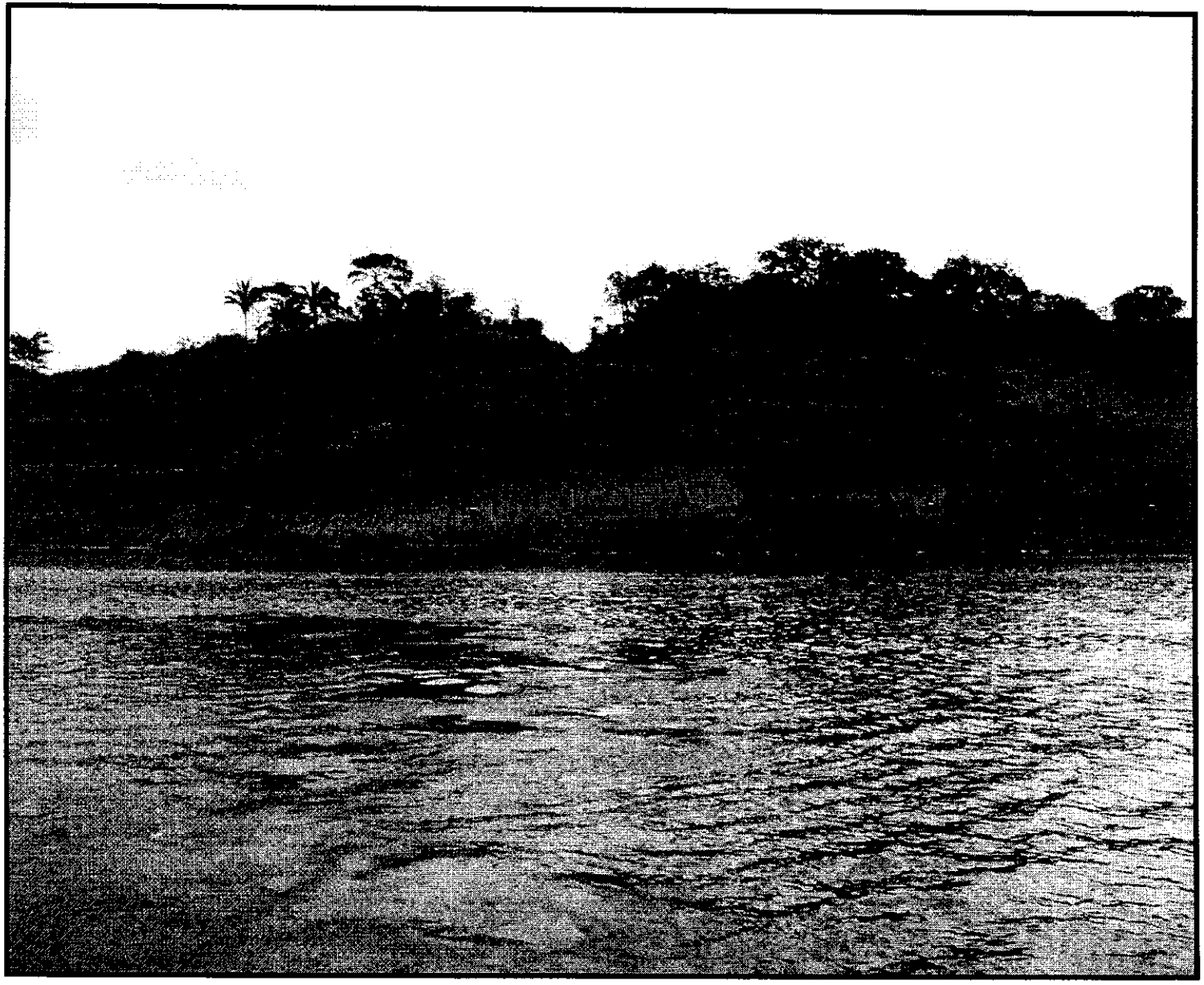
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: J. ARROCHA	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 56k + 460 (1852 + 36)

East

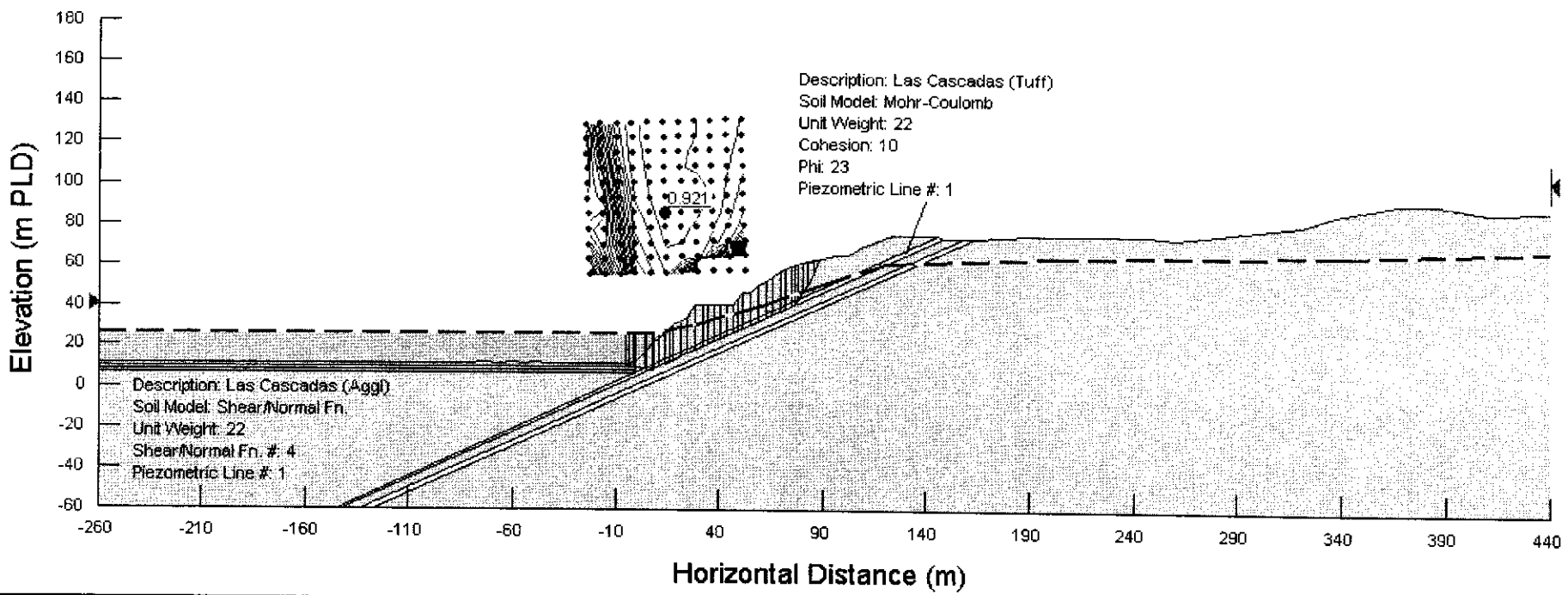
Station: 56k + 460 (Masambi)

April 16, 2002



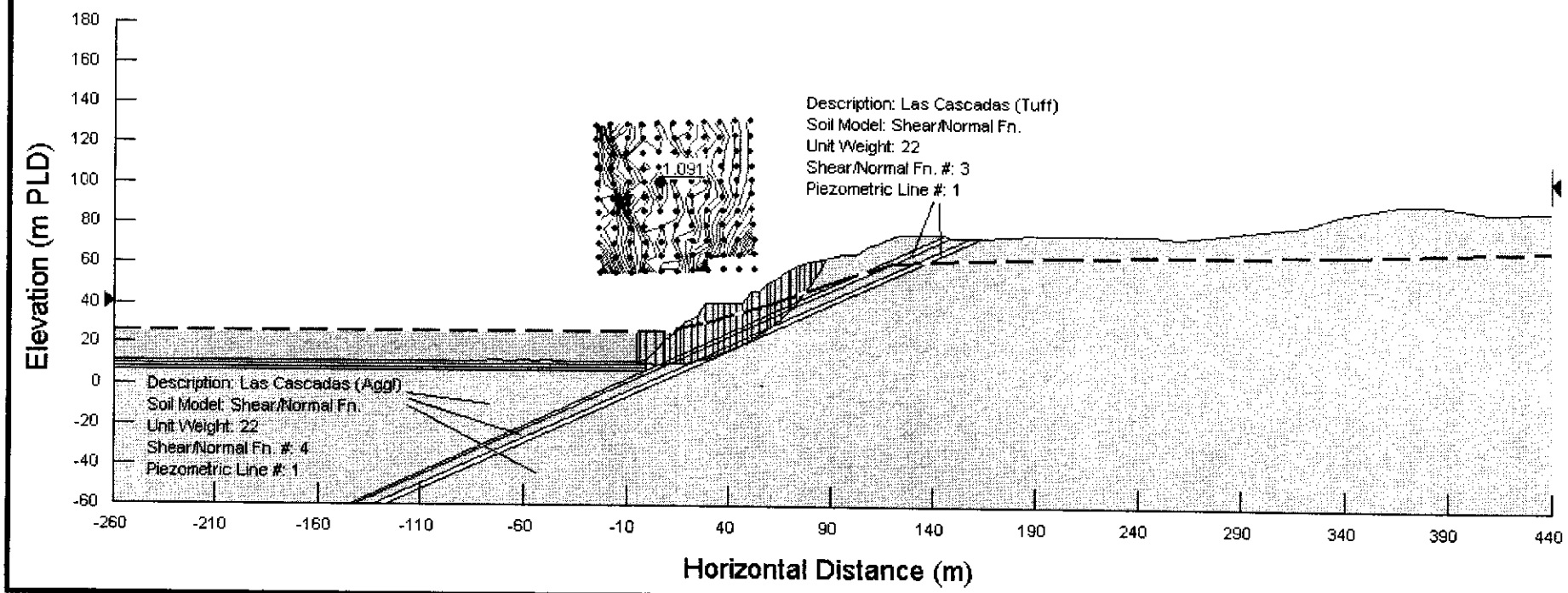
Case 1, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 32 ft (case 1)
File Name: 56K460_1.slz
Last Saved Date: 4/8/02
Last Saved Time: 10:02:36 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



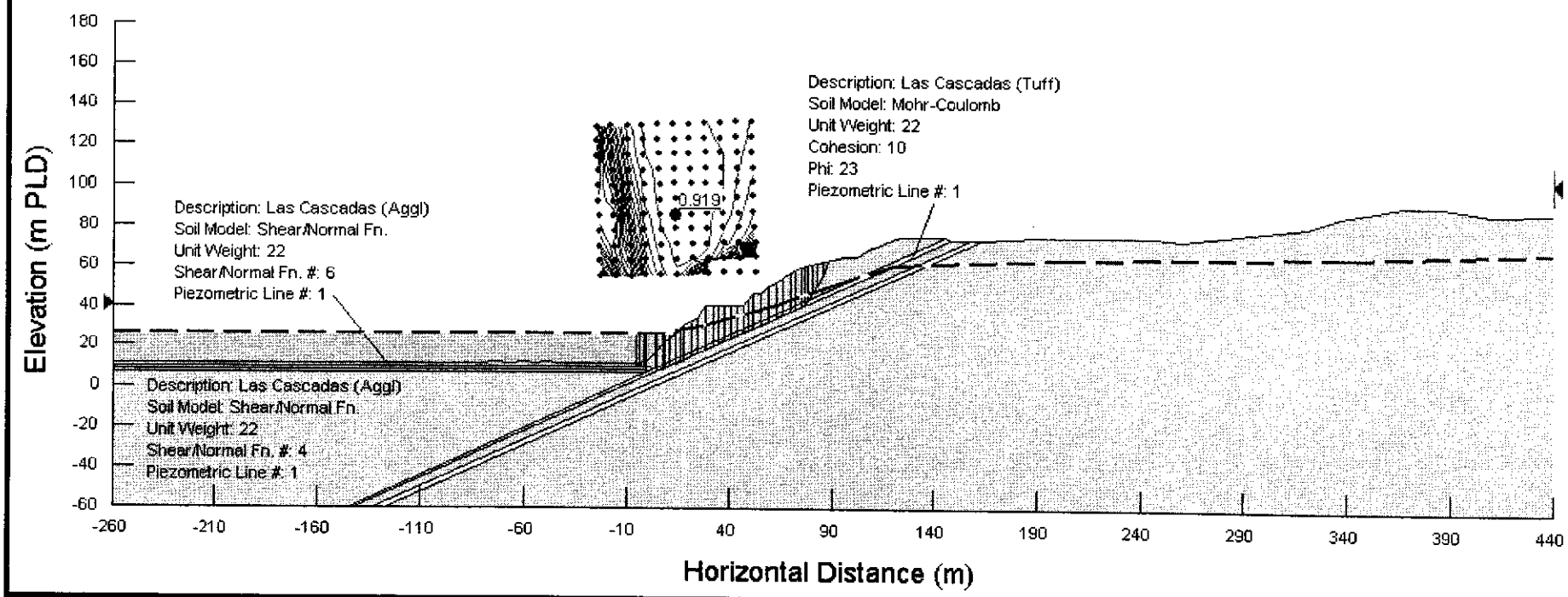
Case 1b, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 32 ft (case 1)
File Name: 56K460_1b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:20:32 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



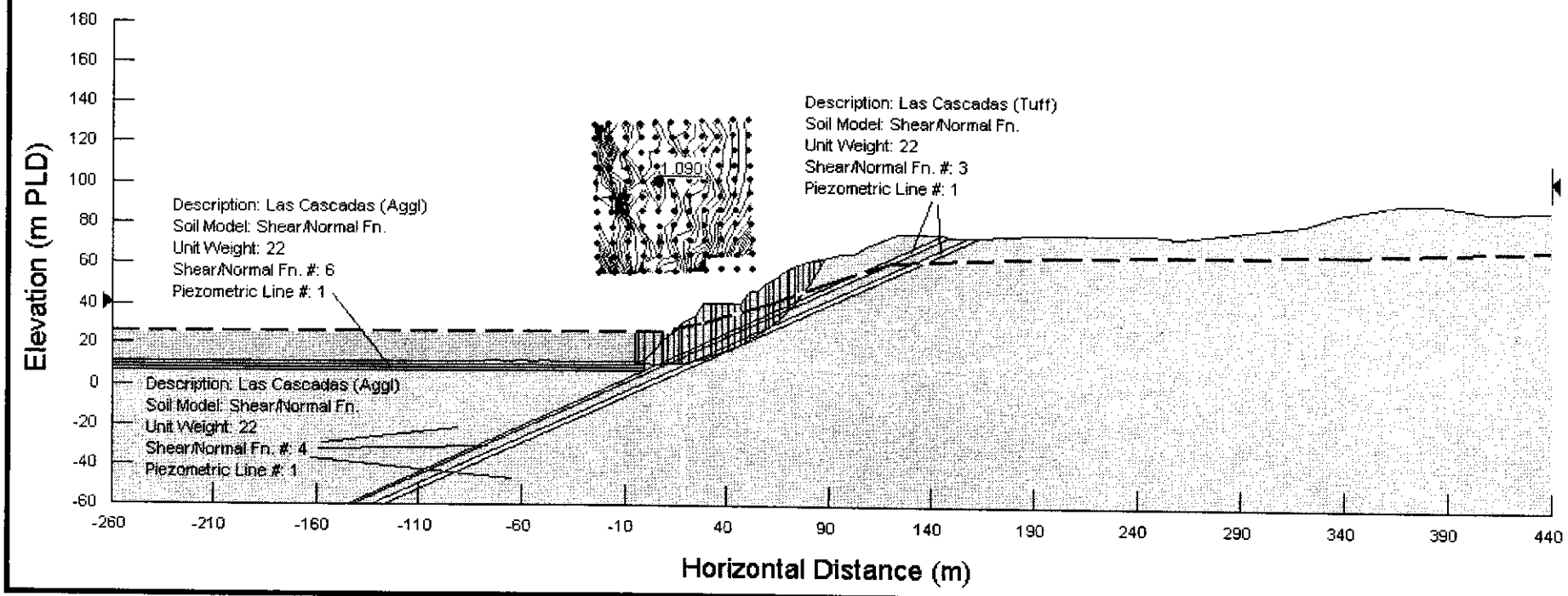
Case 2, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 56K460_2.slz
Last Saved Date: 4/8/02
Last Saved Time: 10:09:46 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



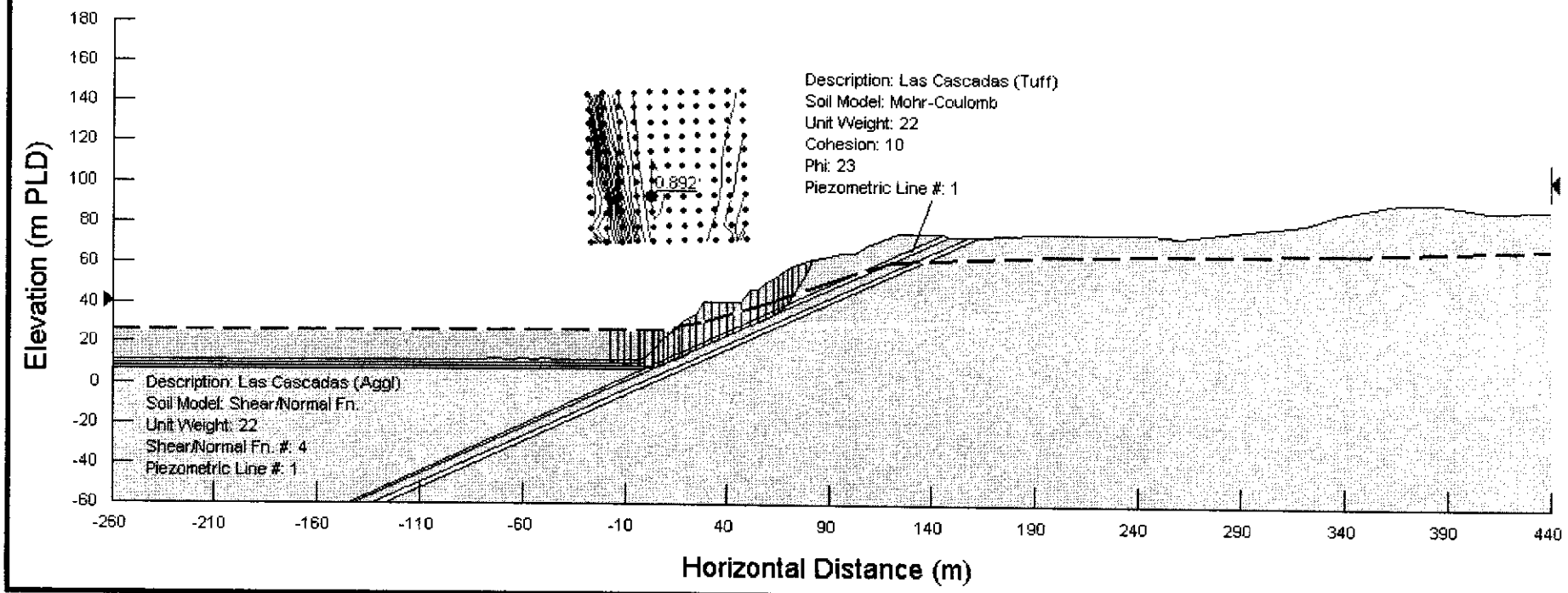
Case 2b, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 56K460_2b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:23:54 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



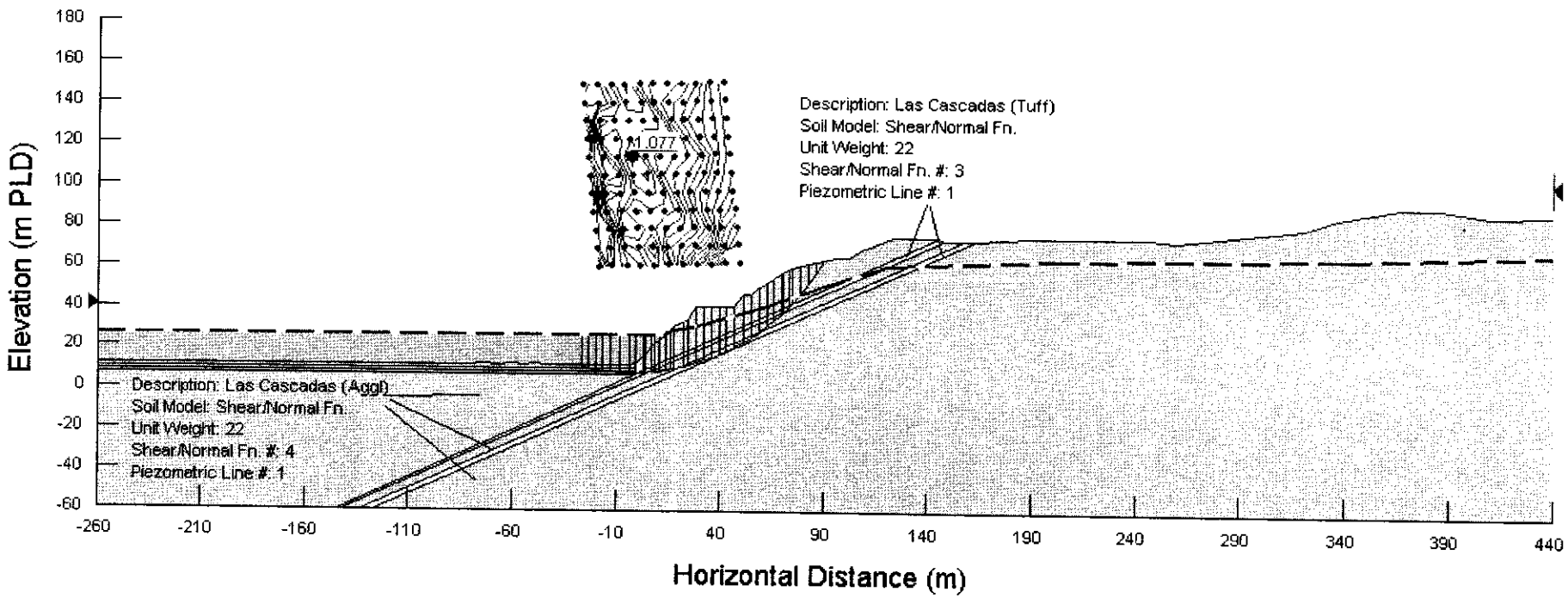
Case 3, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 56K460_3.slz
Last Saved Date: 4/8/02
Last Saved Time: 10:15:22 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



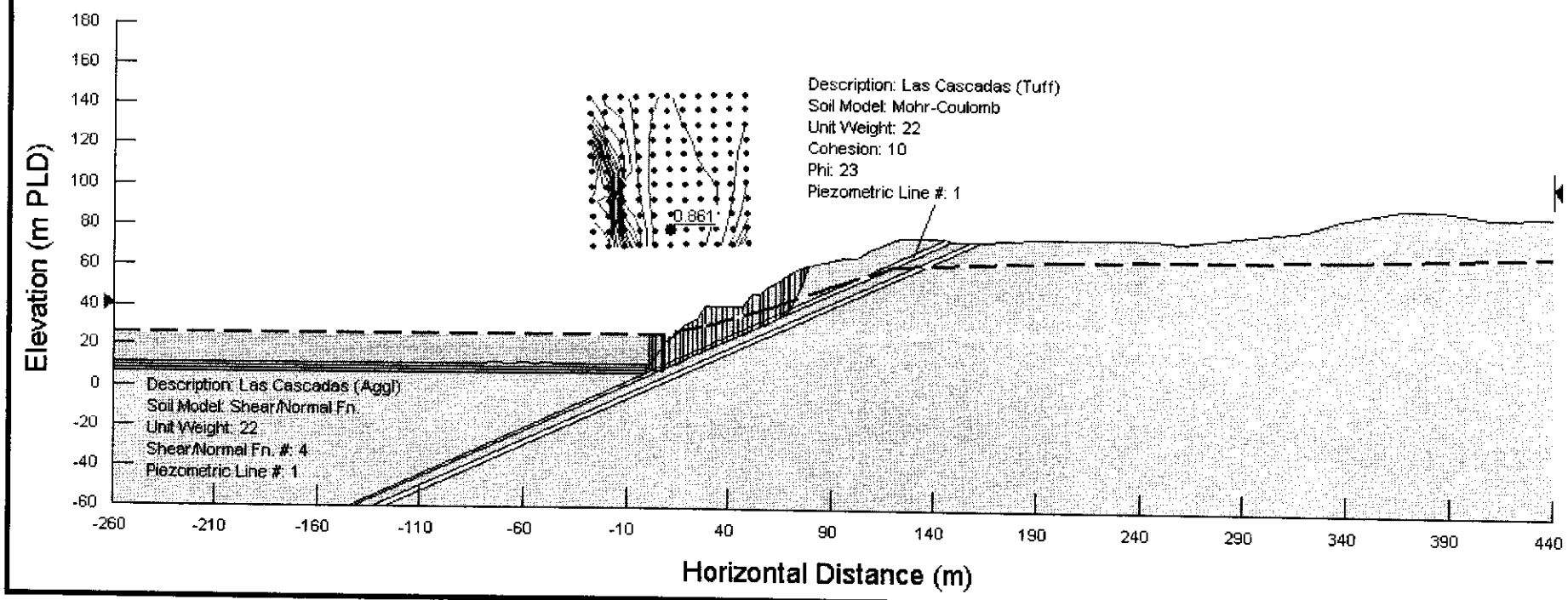
Case 3b, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 56K460_3b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:27:46 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



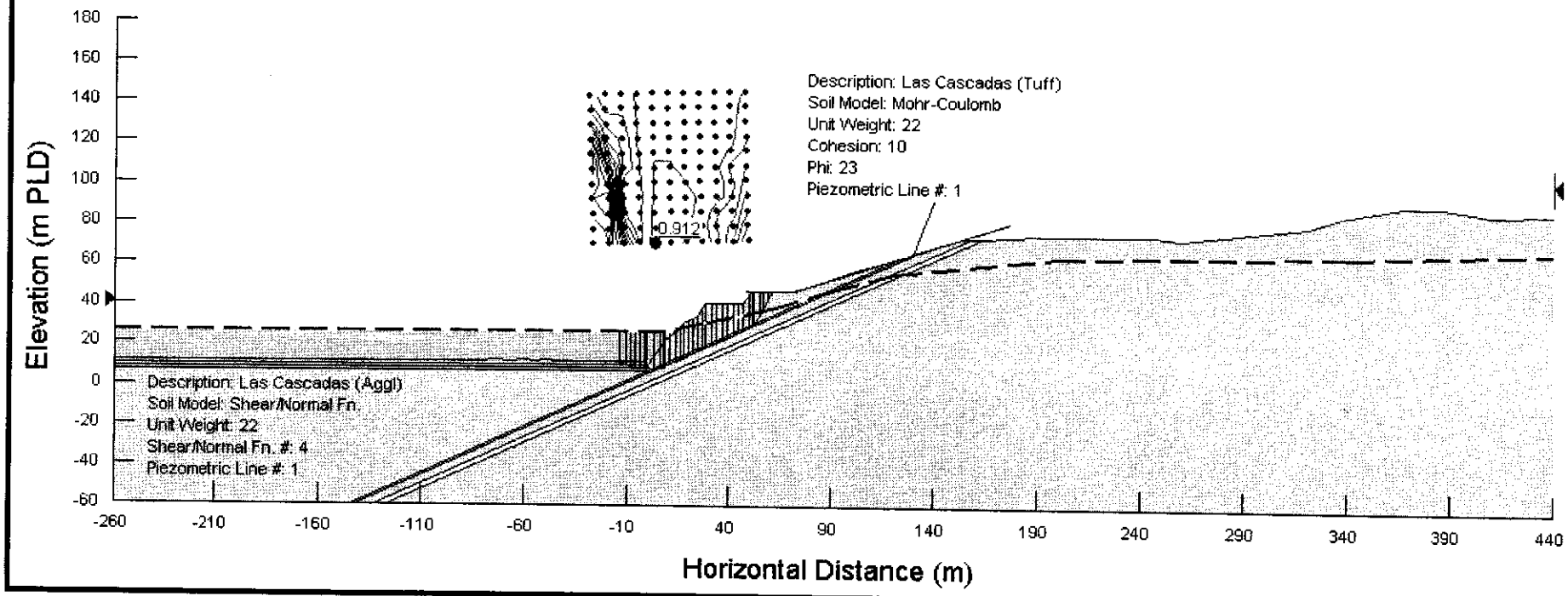
Case 4.1.a, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft + design (case 4)
File Name: 56K460_4.slz
Last Saved Date: 4/8/02
Last Saved Time: 10:45:14 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



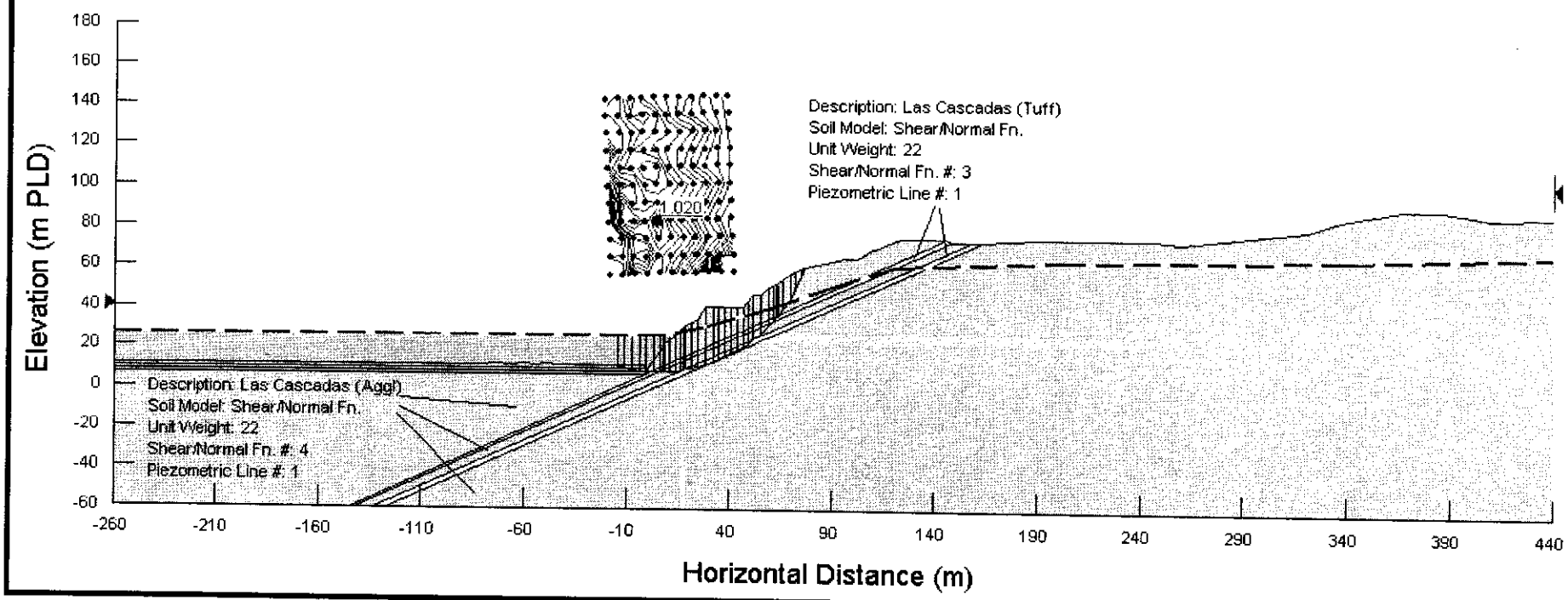
Case 4.2.a, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft + design (case 4)
File Name: 56K460_4e.slz
Last Saved Date: 4/8/02
Last Saved Time: 2:53:58 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



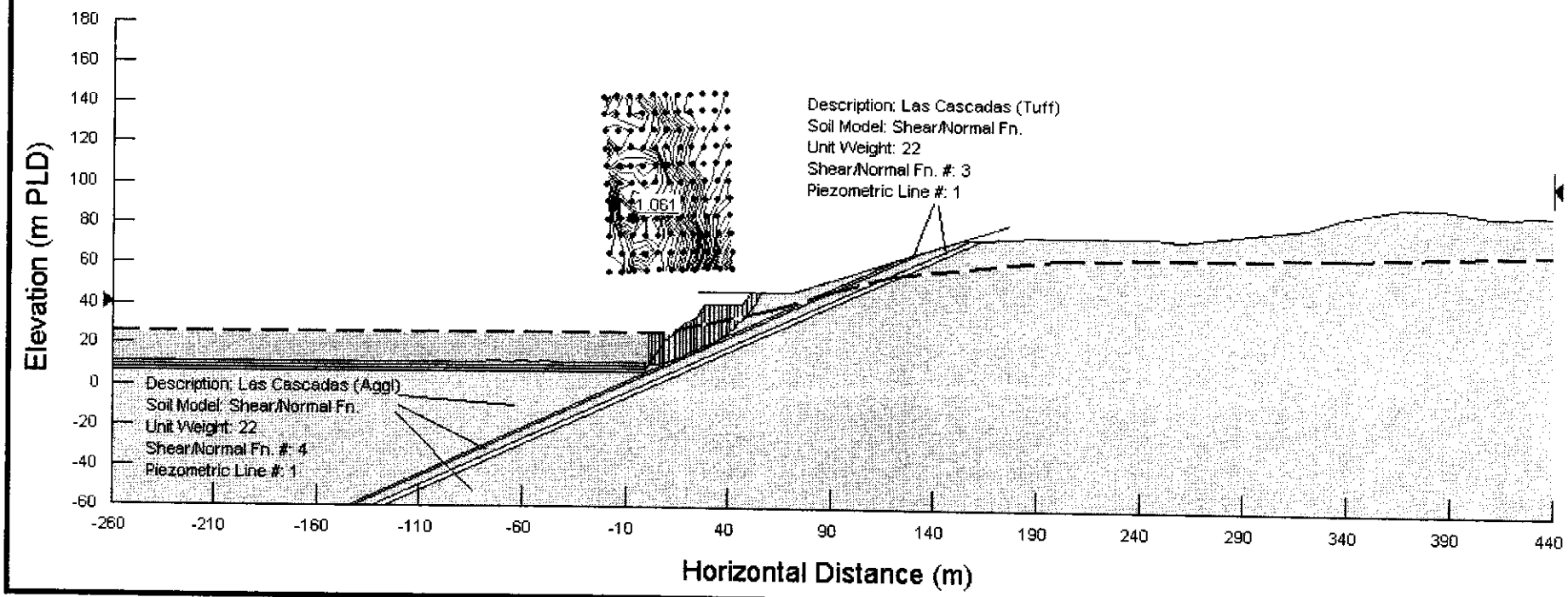
Case 4.1.b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft + design (case 4)
File Name: 56K460_4b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:30:51 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



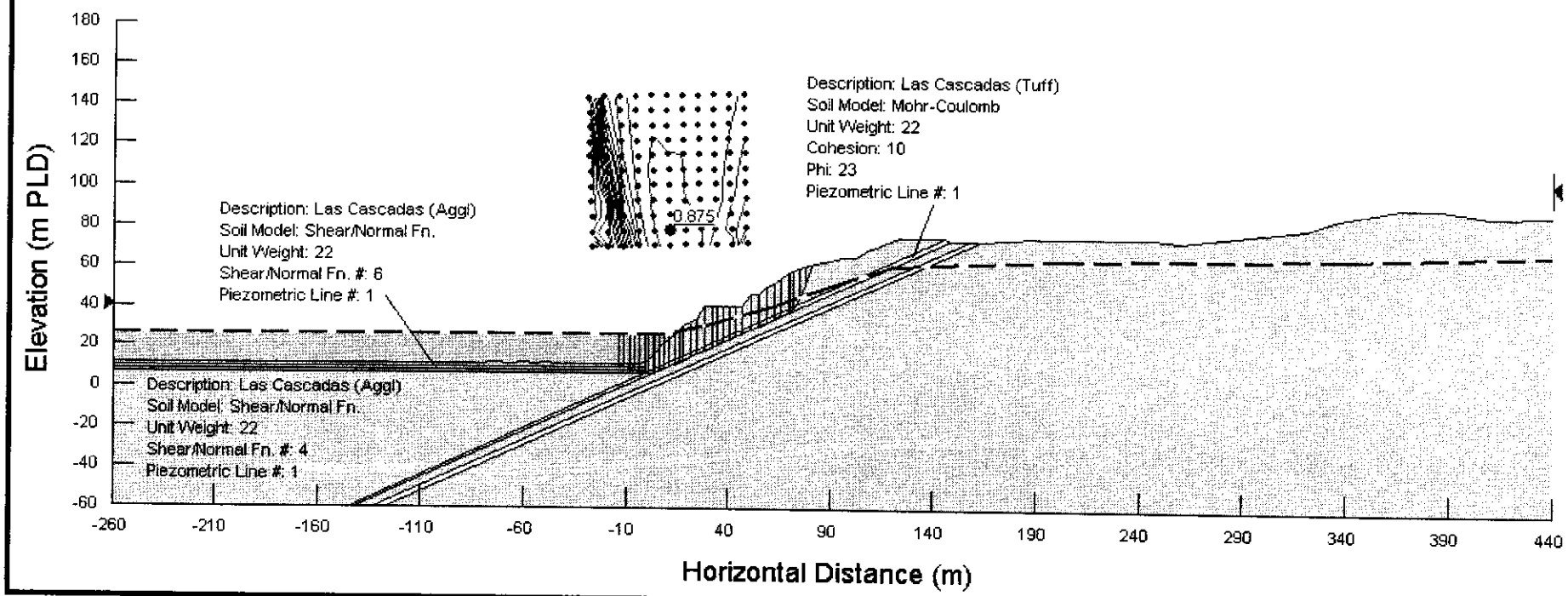
Case 4.2.b, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 27 ft + design (case 4)
File Name: 56K460_4be.slz
Last Saved Date: 4/8/02
Last Saved Time: 2:59:39 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



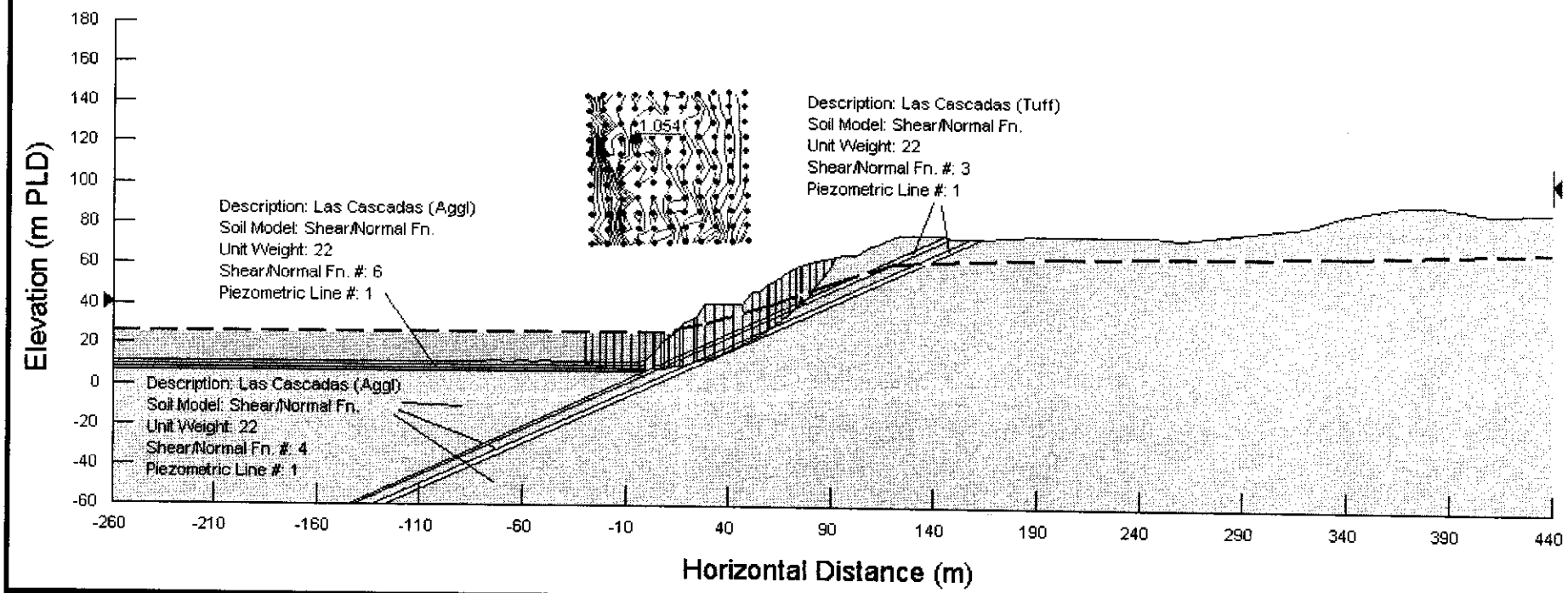
Case 5, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 56K460_5.slz
Last Saved Date: 4/8/02
Last Saved Time: 10:19:06 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



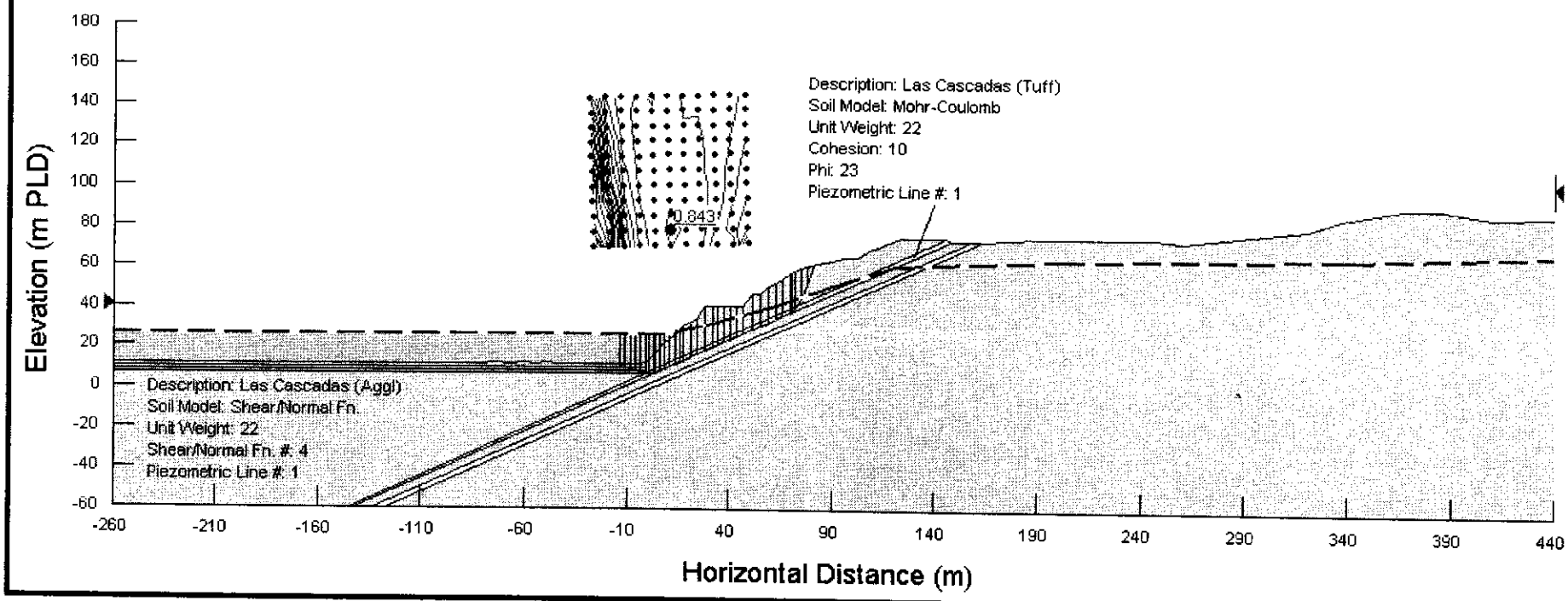
Case 5b, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 56K460_5b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:34:56 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



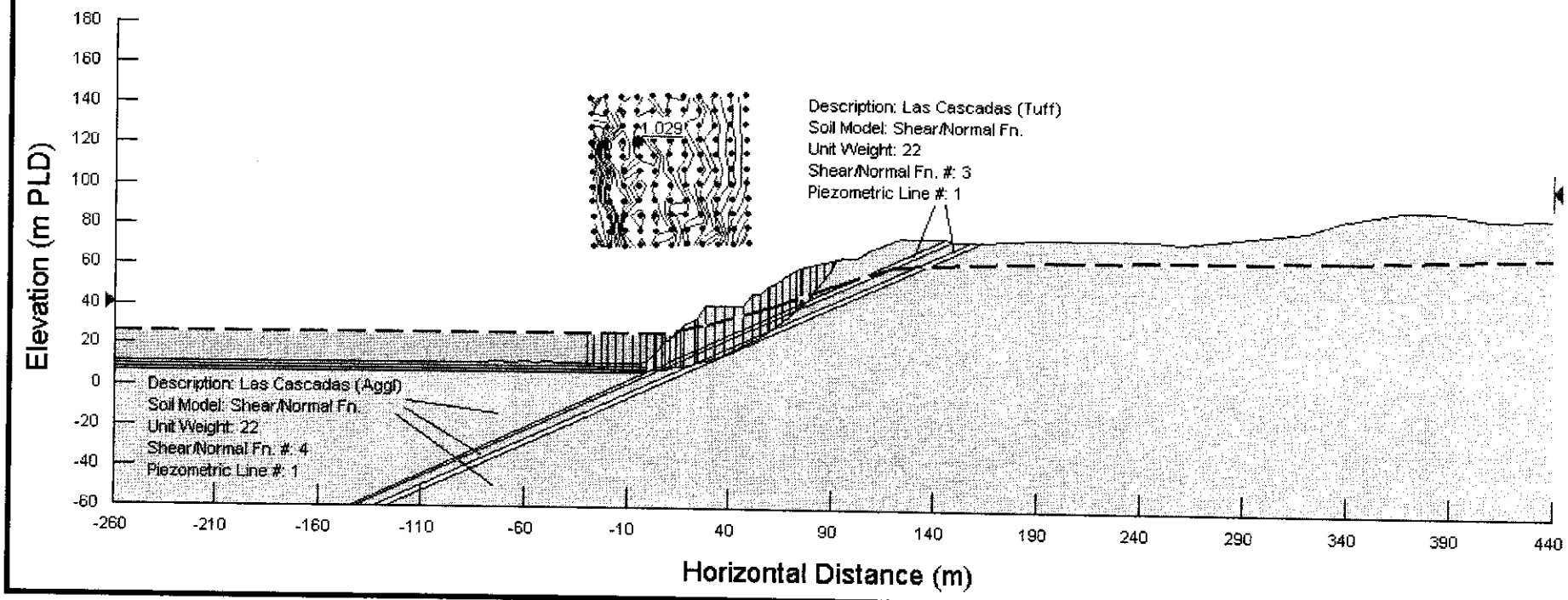
Case 6, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 56K460_6.slz
Last Saved Date: 4/8/02
Last Saved Time: 10:28:52 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



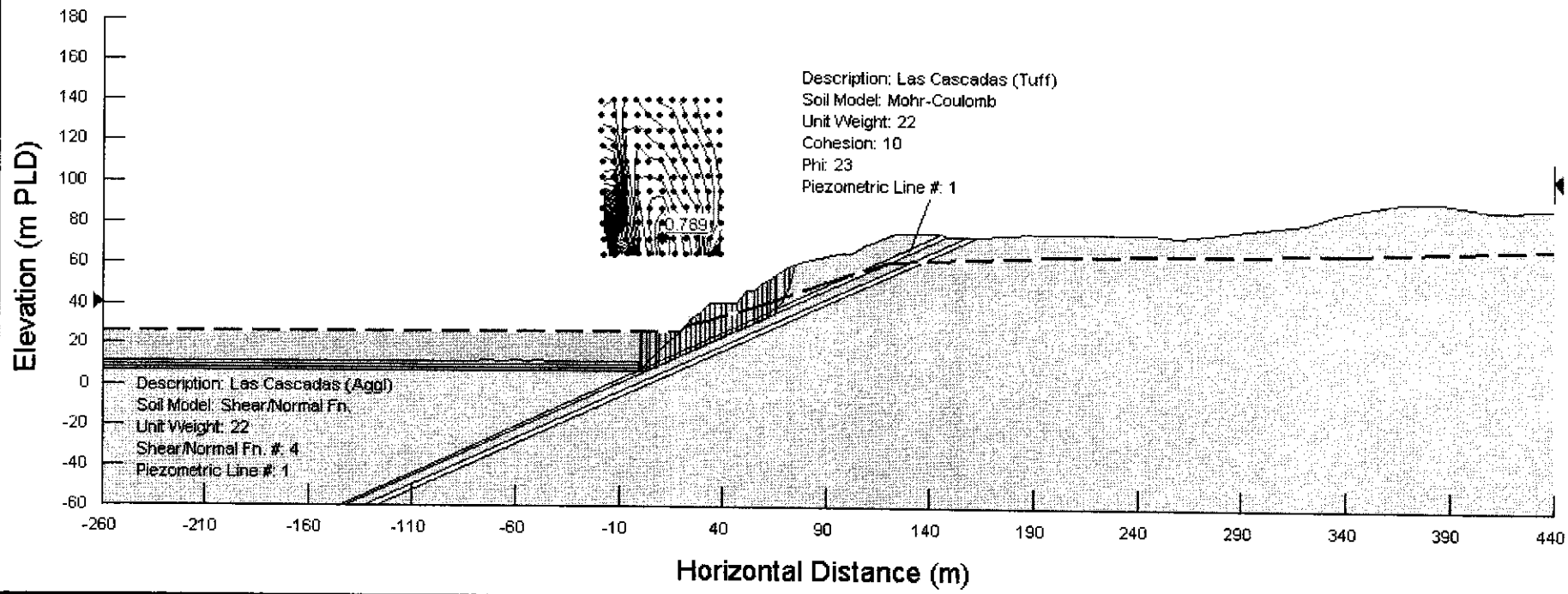
Case 6b, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 56K460_6b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:36:06 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



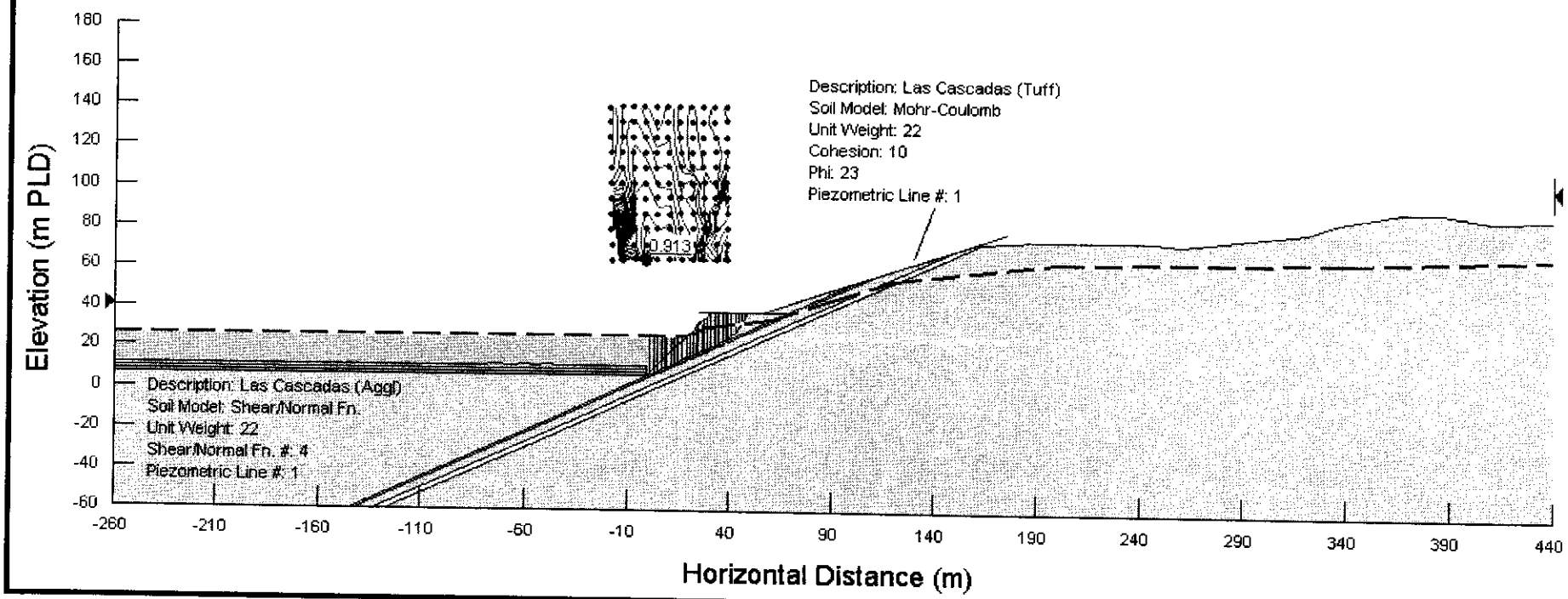
Case 7.1.a, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft + design (case 7)
File Name: 56K460_7.slz
Last Saved Date: 4/8/02
Last Saved Time: 1:35:44 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



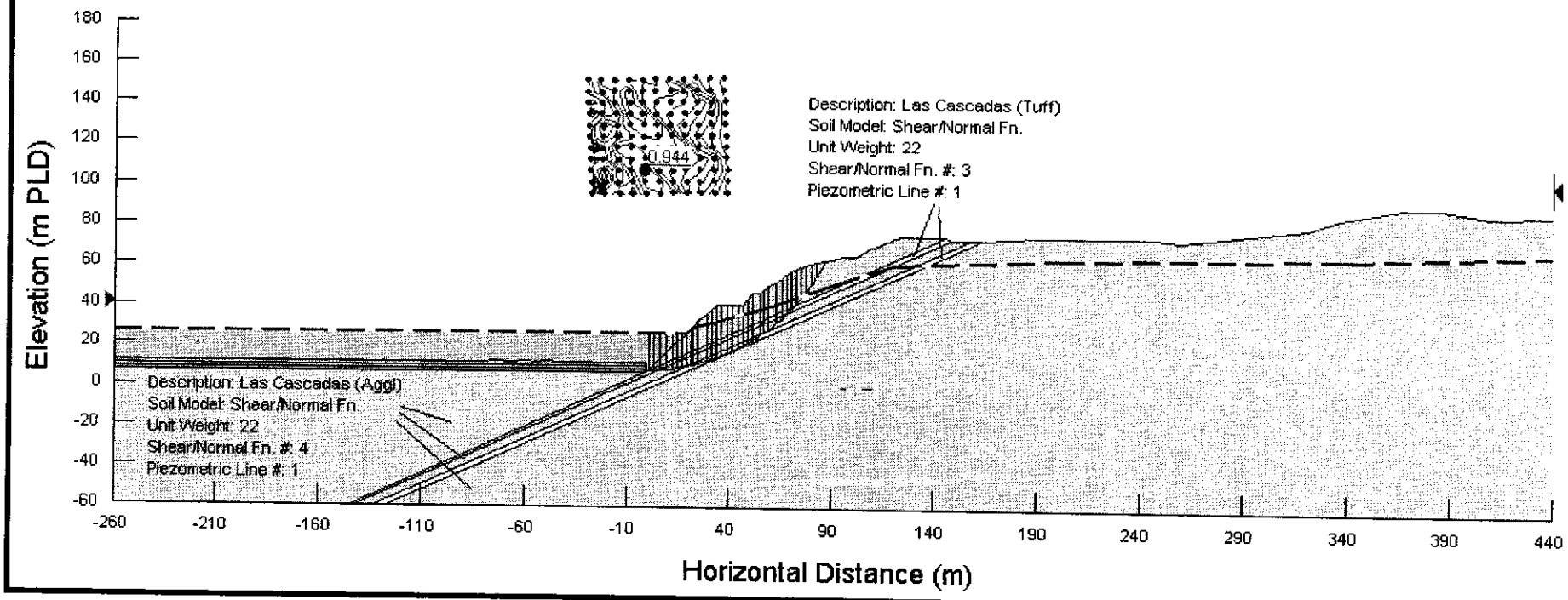
Case 7.2.a, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft + design (case 7)
File Name: 56K460_7e.slz
Last Saved Date: 4/8/02
Last Saved Time: 3:19:27 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



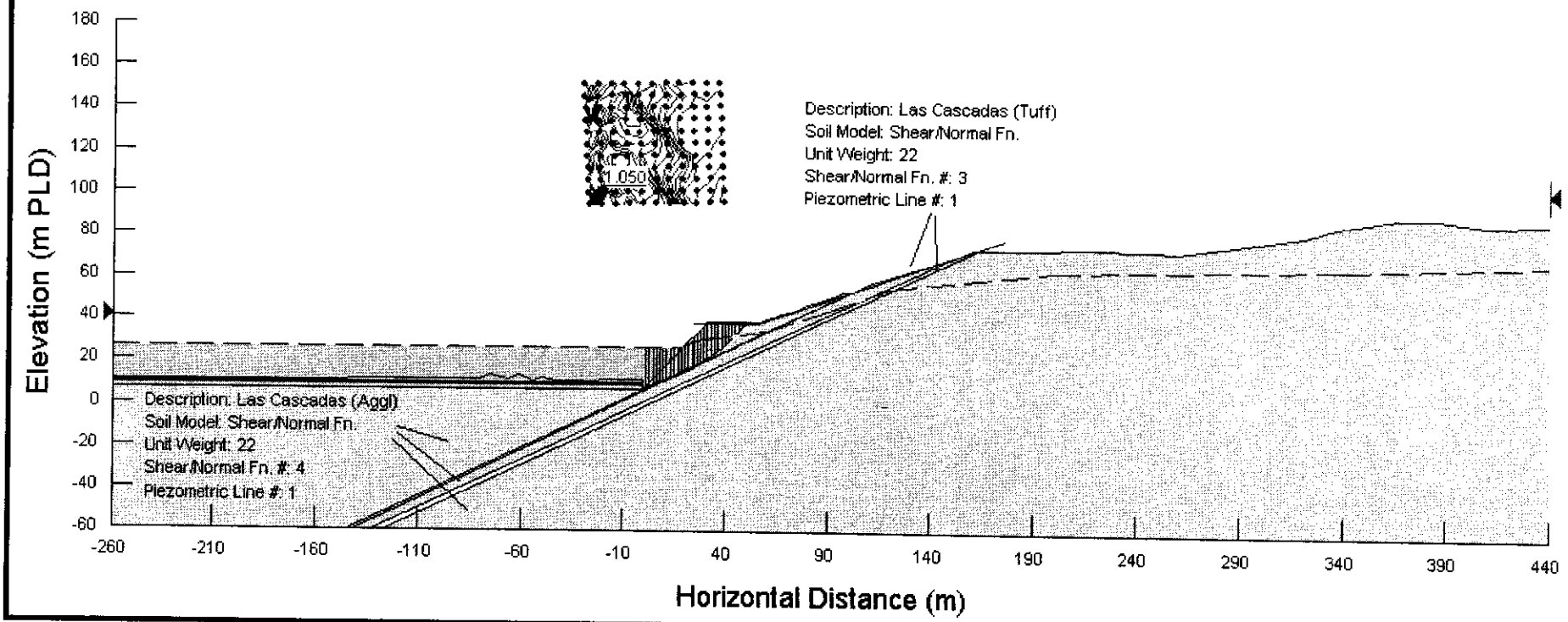
Case 7.1.b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft + design (case 7)
File Name: 56K460_7b.slz
Last Saved Date: 4/8/02
Last Saved Time: 1:36:53 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



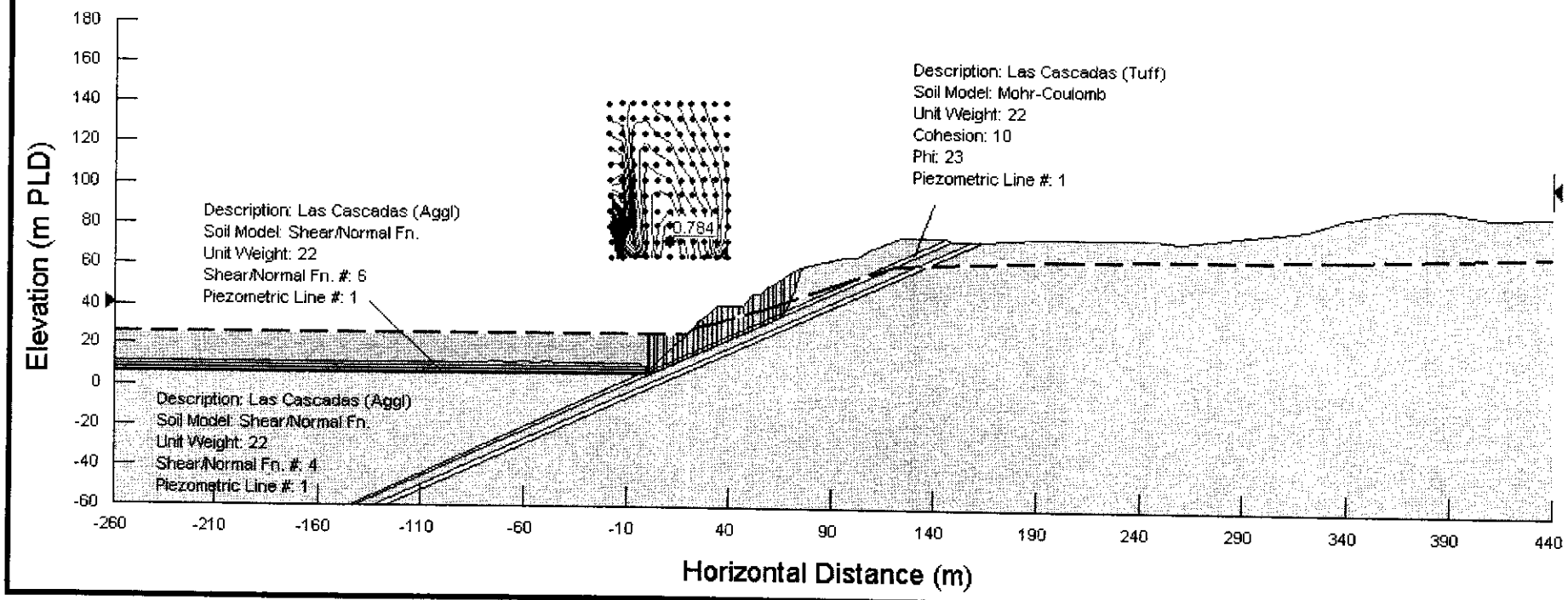
Case 7.2.b, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft + design (case 7)
File Name: 56K460_7be.slz
Last Saved Date: 4/8/02
Last Saved Time: 3:22:50 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



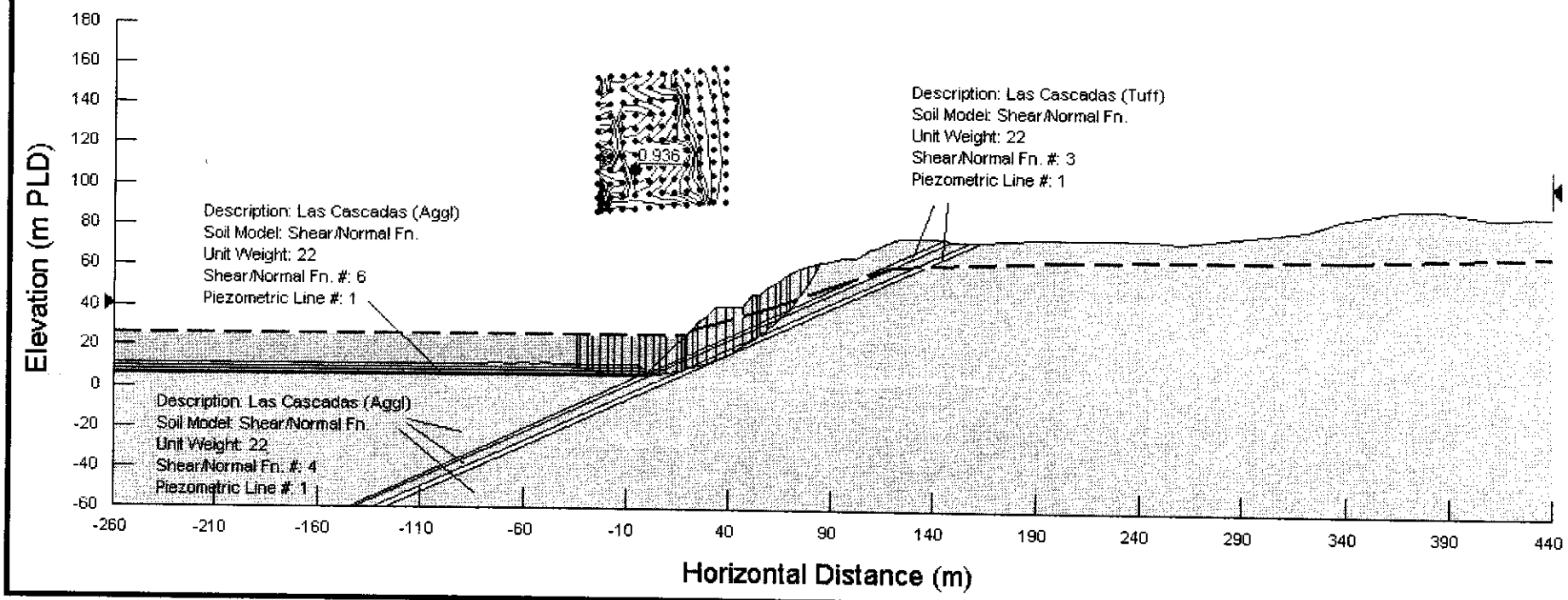
Case 8, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 56K460_8.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:13:38 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 8b, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 56K+460 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 56K460_8b.slz
Last Saved Date: 4/8/02
Last Saved Time: 11:58:23 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

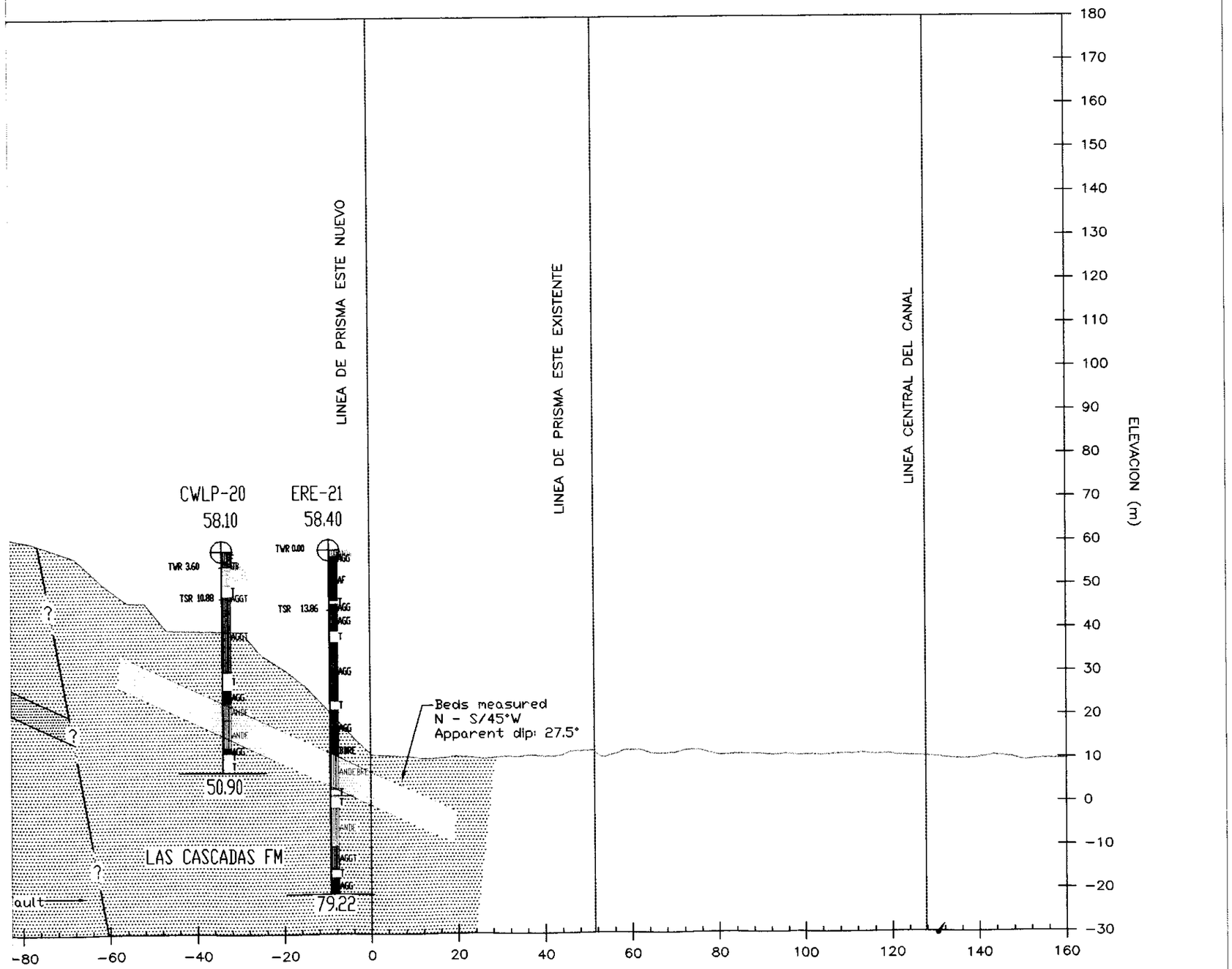


Summary, 56k + 460 (1852 + 36)

General Description	Range of stations:	56k + 000 to 56k + 560
	Sector:	South La Pita
	Maximum height (m):	65
	Cotangent of slope angle (cot. β):	2.0
History	Last slide event:	1913 (sta. 1685 E Slide) / 1996 (South La Pita Slide)
Geology	Formation:	Las Cascadas
	Lithology:	Agglomerate / Tuff / Andesite
	Critical stratum at toe:	Agglomerate / Tuff
	Apparent dip of bedding:	Toward the Canal
Stability Analysis	Critical failure mechanism:	Translational along weak plane / Rotational
	Shear strength model:	Fully softened Tuff, weak plane / First time Cascadas Agglomerate

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety		Relative Factor of Safety		Percentage of Change (%)	
		(a)	(b)	(a)	(b)	(a)	(b)
Case 1: Channel bottom = 32 ft	0.257	0.921	1.091	1.000	1.000	0.00	0.00
Case 2: Channel bottom = 27 ft, Blasted material only		0.919	1.090	0.998	0.999	-0.22	-0.09
Case 3: Channel bottom = 27 ft, Blasted & removed		0.892	1.077	0.969	0.987	-3.15	-1.28
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		0.861	1.020	0.935	0.935	-6.51	-6.51
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.302	0.912	1.061	0.990	0.973	-0.98	-2.75
Case 5: Channel bottom = 22 ft, Blasted material only		0.875	1.054	0.950	0.966	-4.99	-3.39
Case 6: Channel bottom = 22 ft, Blasted & removed		0.843	1.029	0.915	0.943	-8.47	-5.68
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		0.789	0.944	0.857	0.865	-14.33	-13.47
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.330	0.913	1.050	0.991	0.962	-0.87	-3.76
Case 8: Channel bottom = 16 ft, Blasted		0.784	0.936	0.851	0.858	-14.88	-14.21

Conclusions:	Stabilization is required for Case 4 and Case 7



AUTORIDAD DEL CANAL DE PANAMA

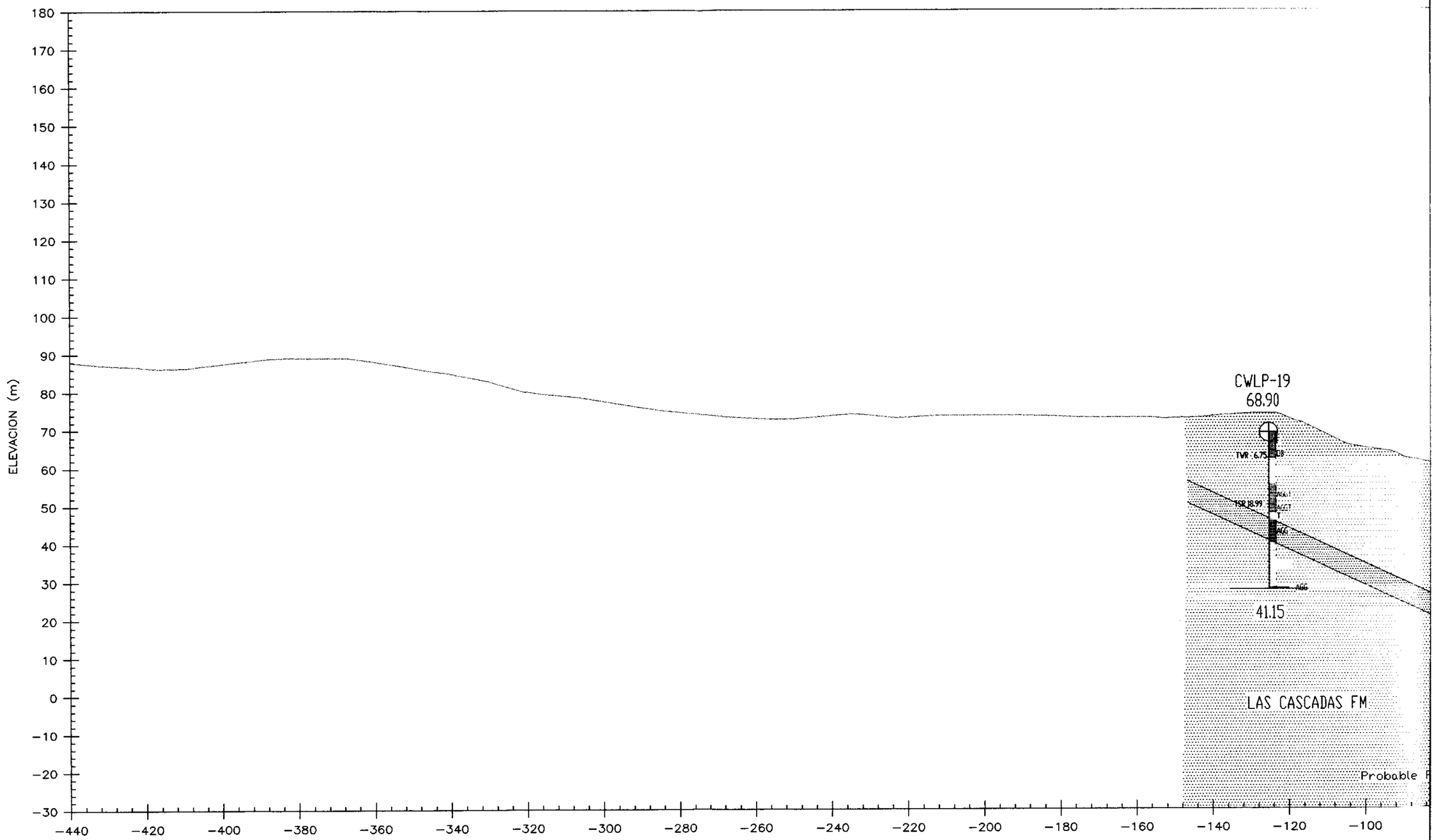
DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 56K+460 (1852+36) ESTE

ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: P. FRANCESCHI	DIBUJADO POR: J. RAMESCH



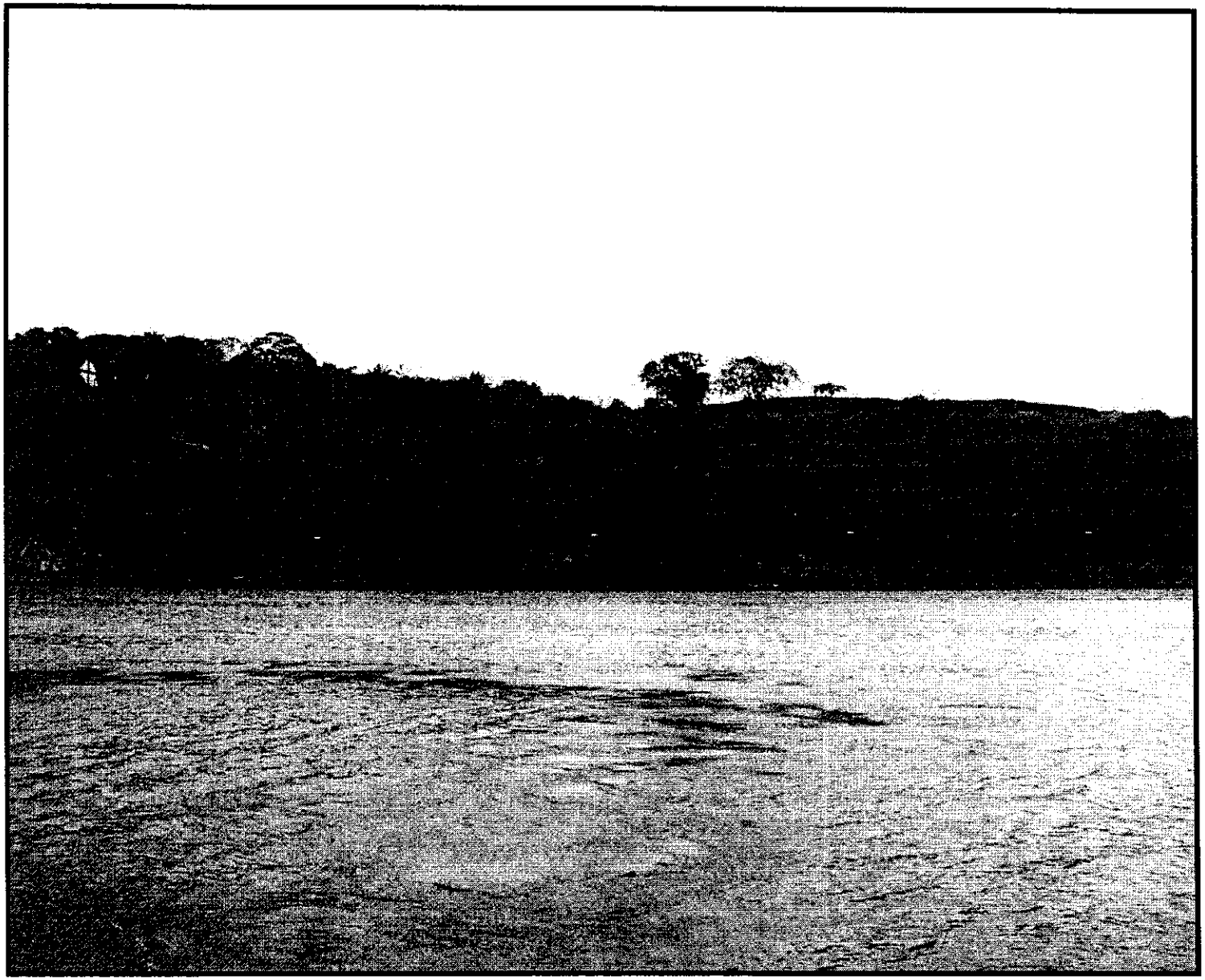
56K+460 (1852+36) E

station 57k + 060 (1872 + 00)

East

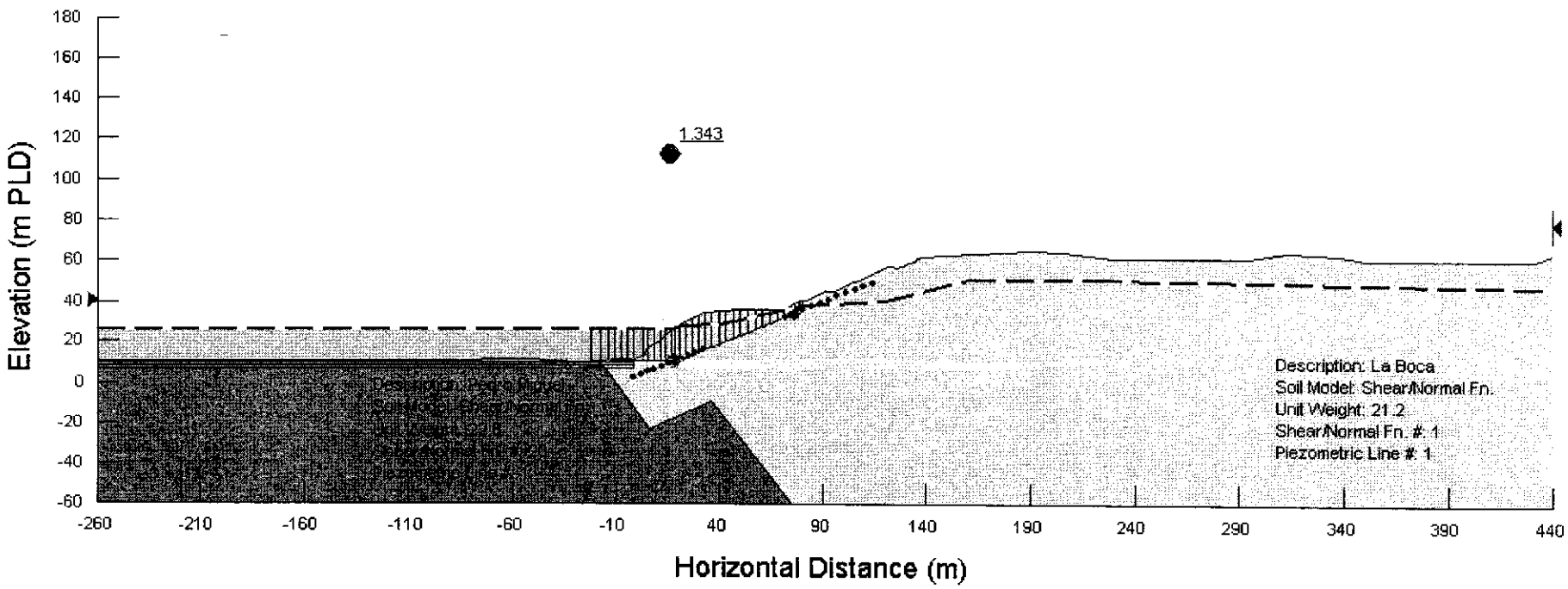
Station: 57k + 060 (Ceniza)

April 16, 2002

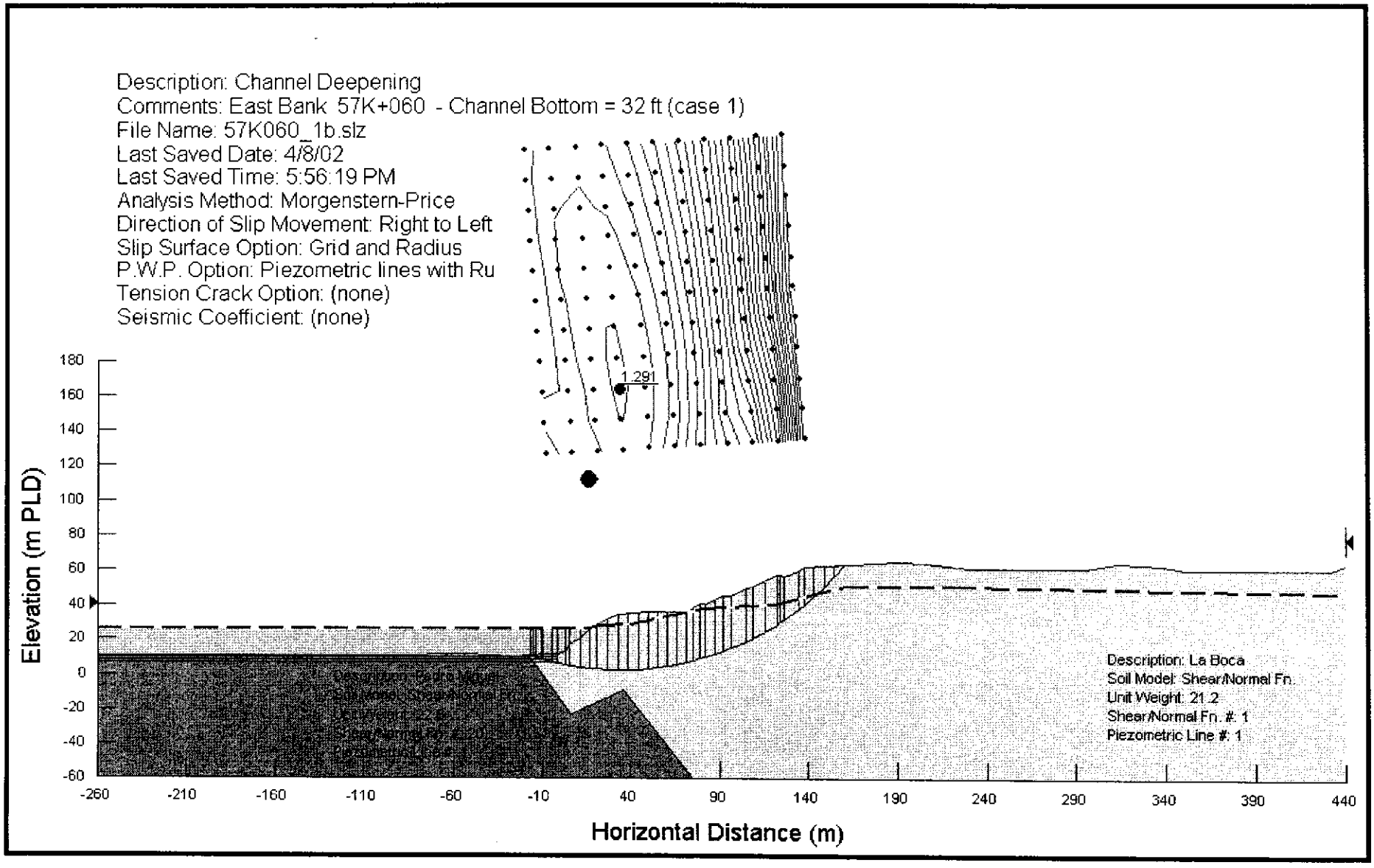


Case 1, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 32 ft (case 1)
File Name: 57K060_1.slz
Last Saved Date: 4/8/02
Last Saved Time: 5:32:52 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

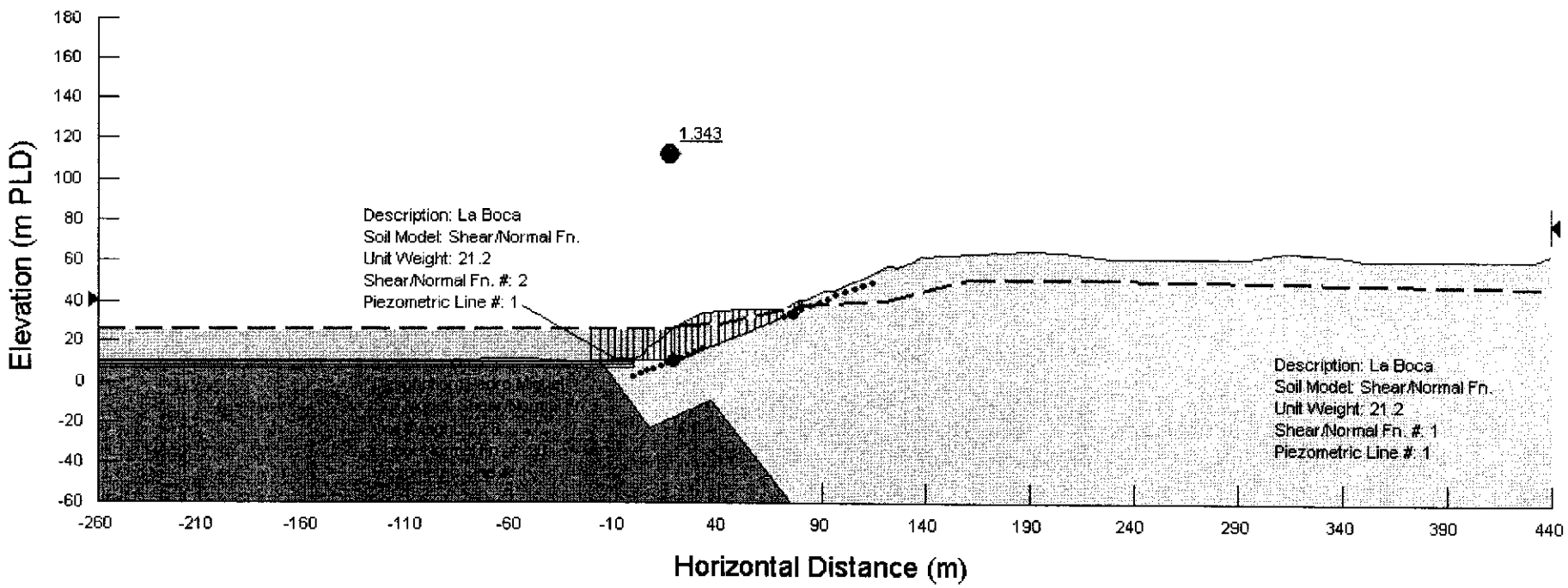


Case 1b, Channel bottom = 32 ft

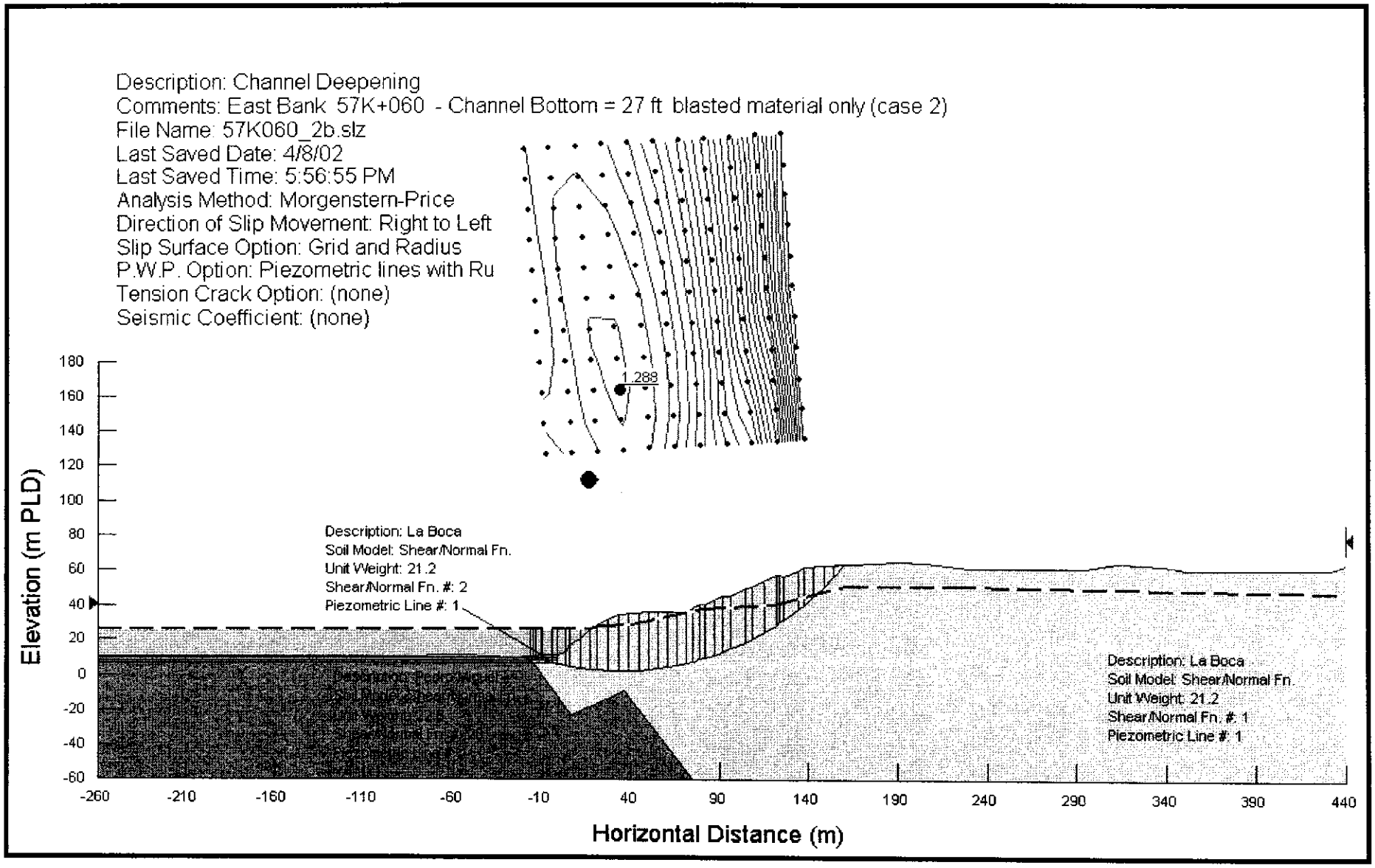


Case 2, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 57K060_2.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:46:20 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

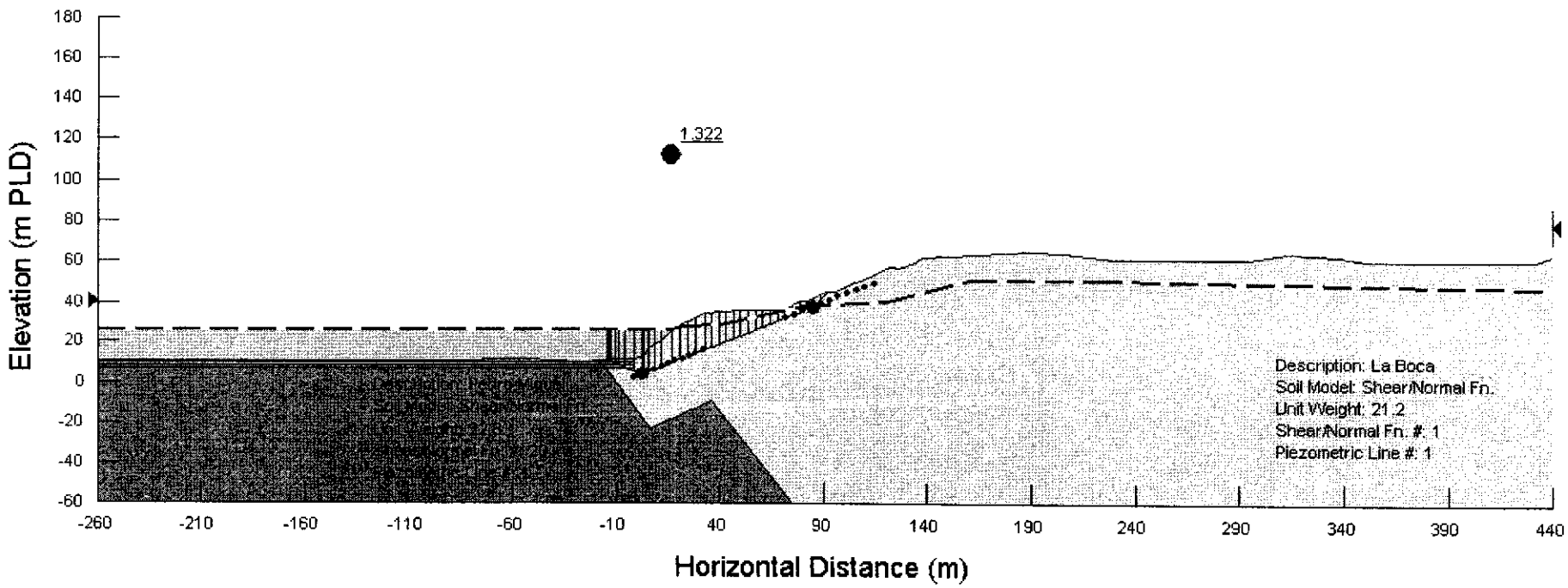


Case 2b, Channel bottom = 27 ft, Blasted material only

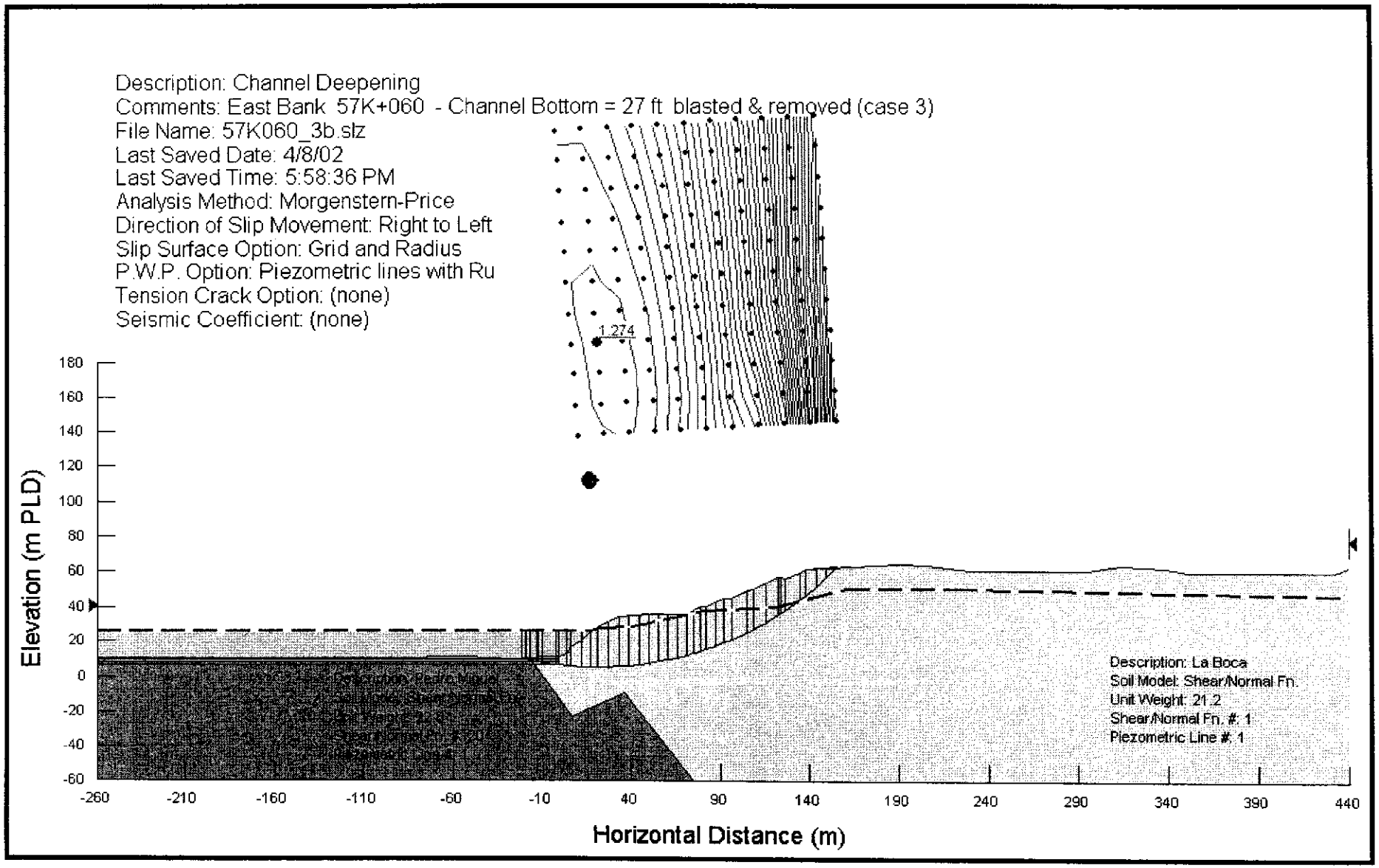


Case 3, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 57K060_3.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:48:14 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

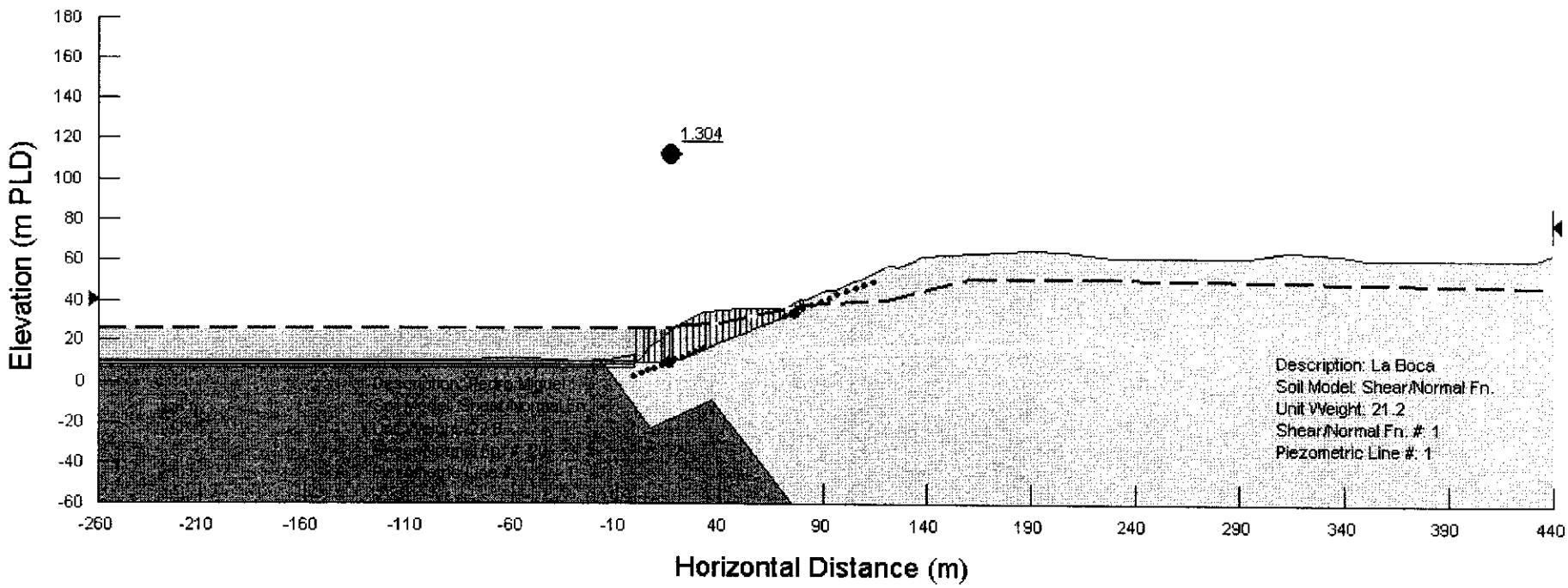


Case 3b, Channel bottom = 27 ft, Blasted & removed

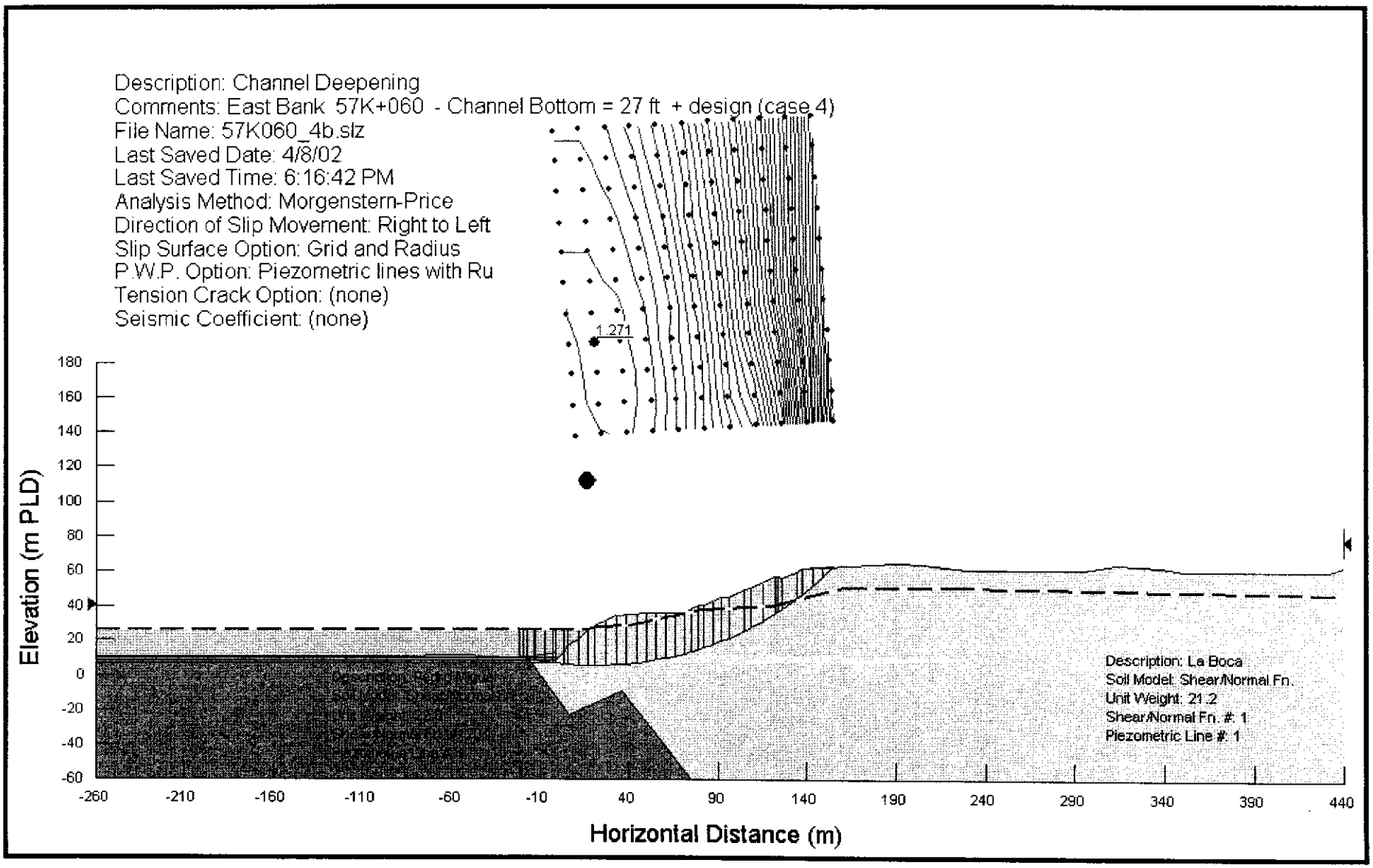


Case 4, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 27 ft + design (case 4)
File Name: 57K060_4.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:49:47 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

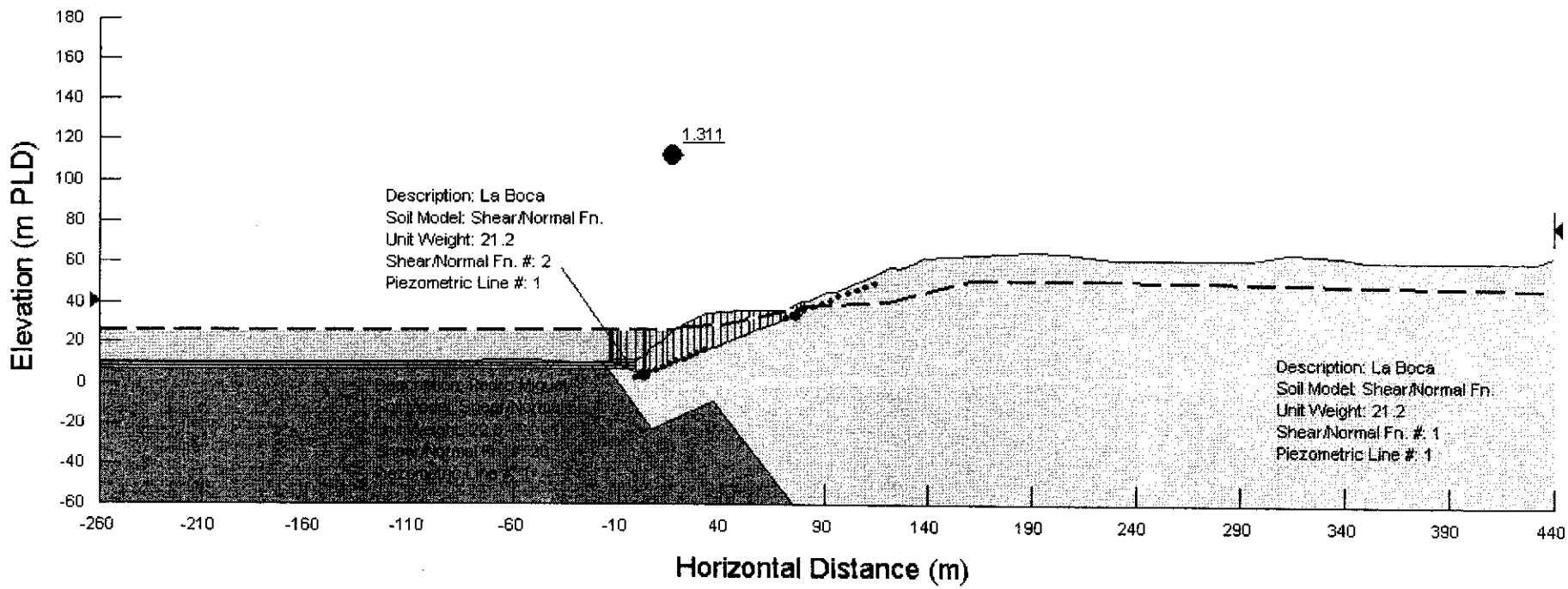


Case 4b, Channel bottom = 27 ft, Design (underwater slope)

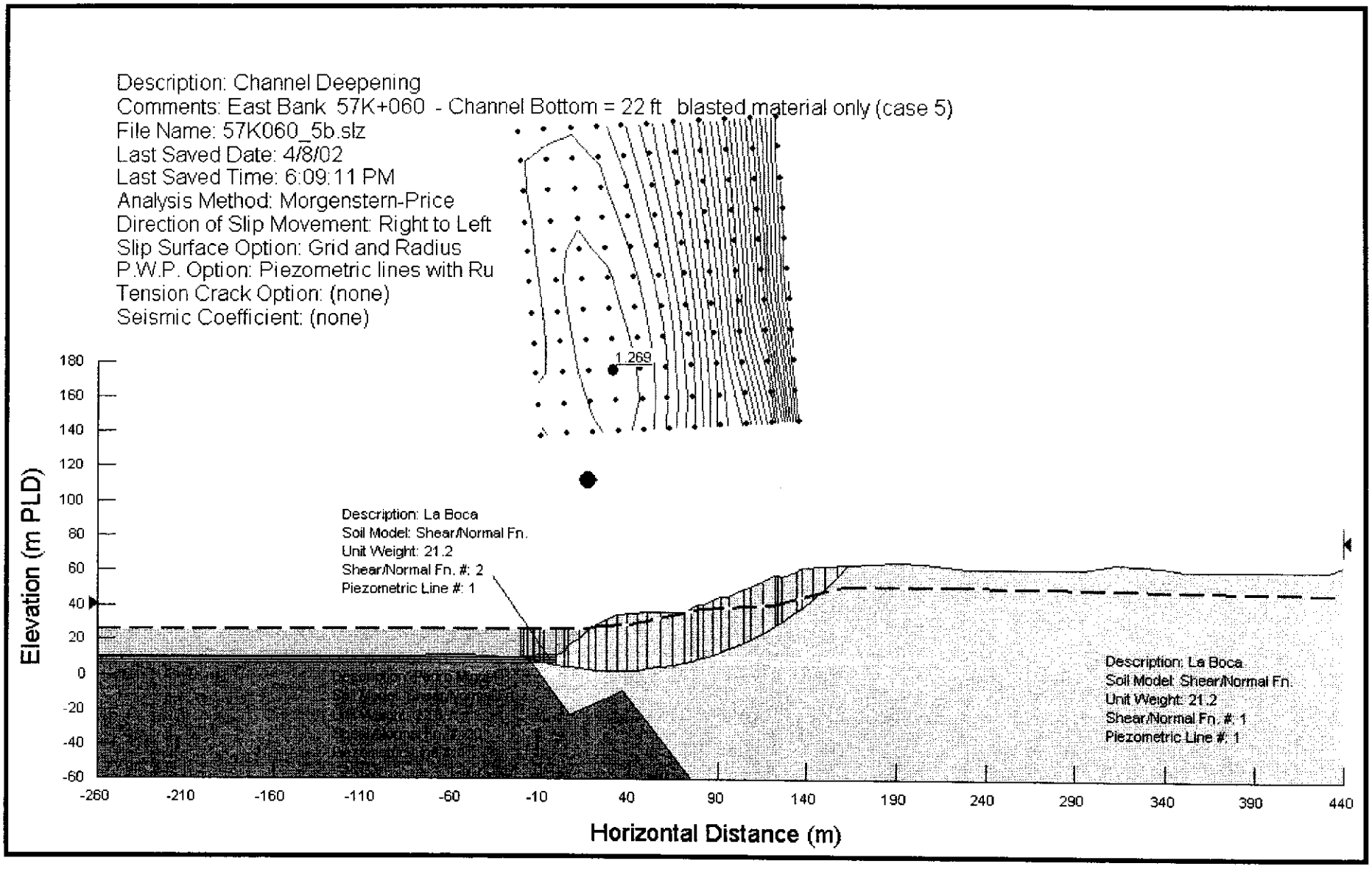


Case 5, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 57K060_5.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:51:08 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

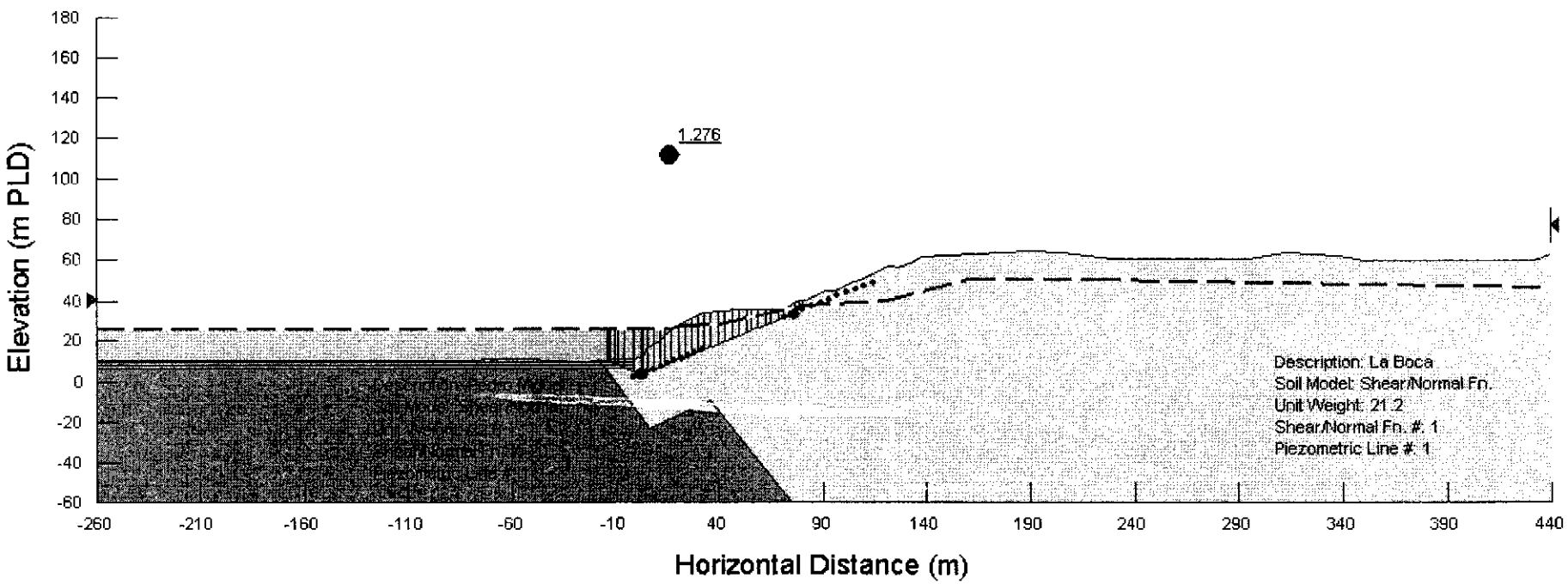


Case 5b, Channel bottom = 22 ft, Blasted material only

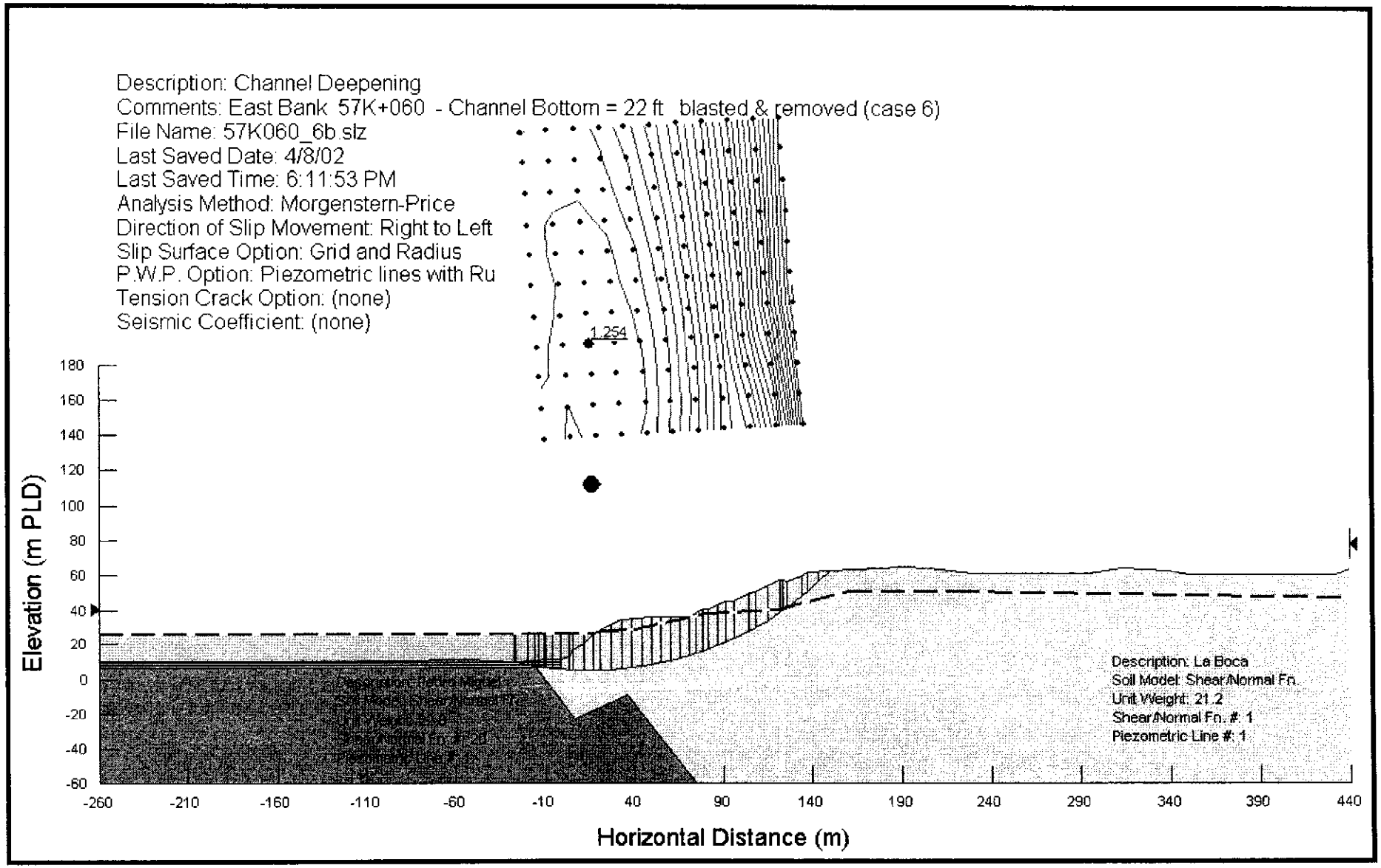


Case 6, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 57K060_6.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:52:35 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

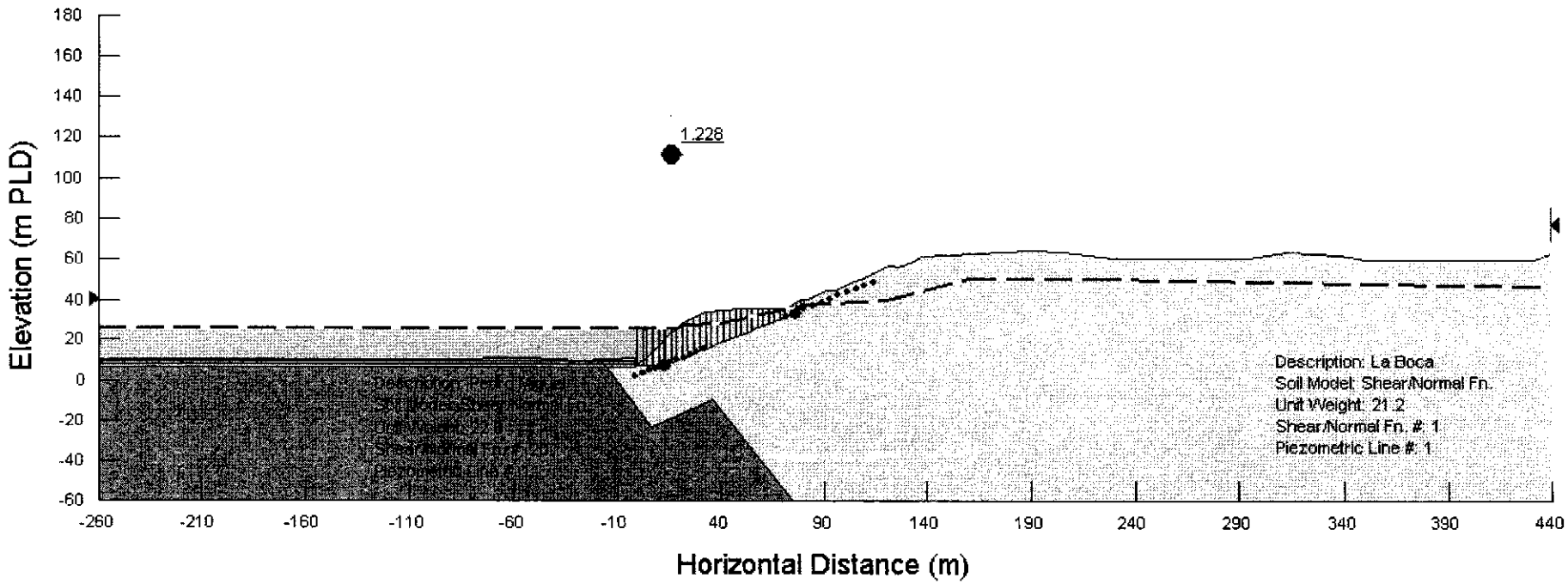


Case 6b, Channel bottom = 22 ft, Blasted & removed

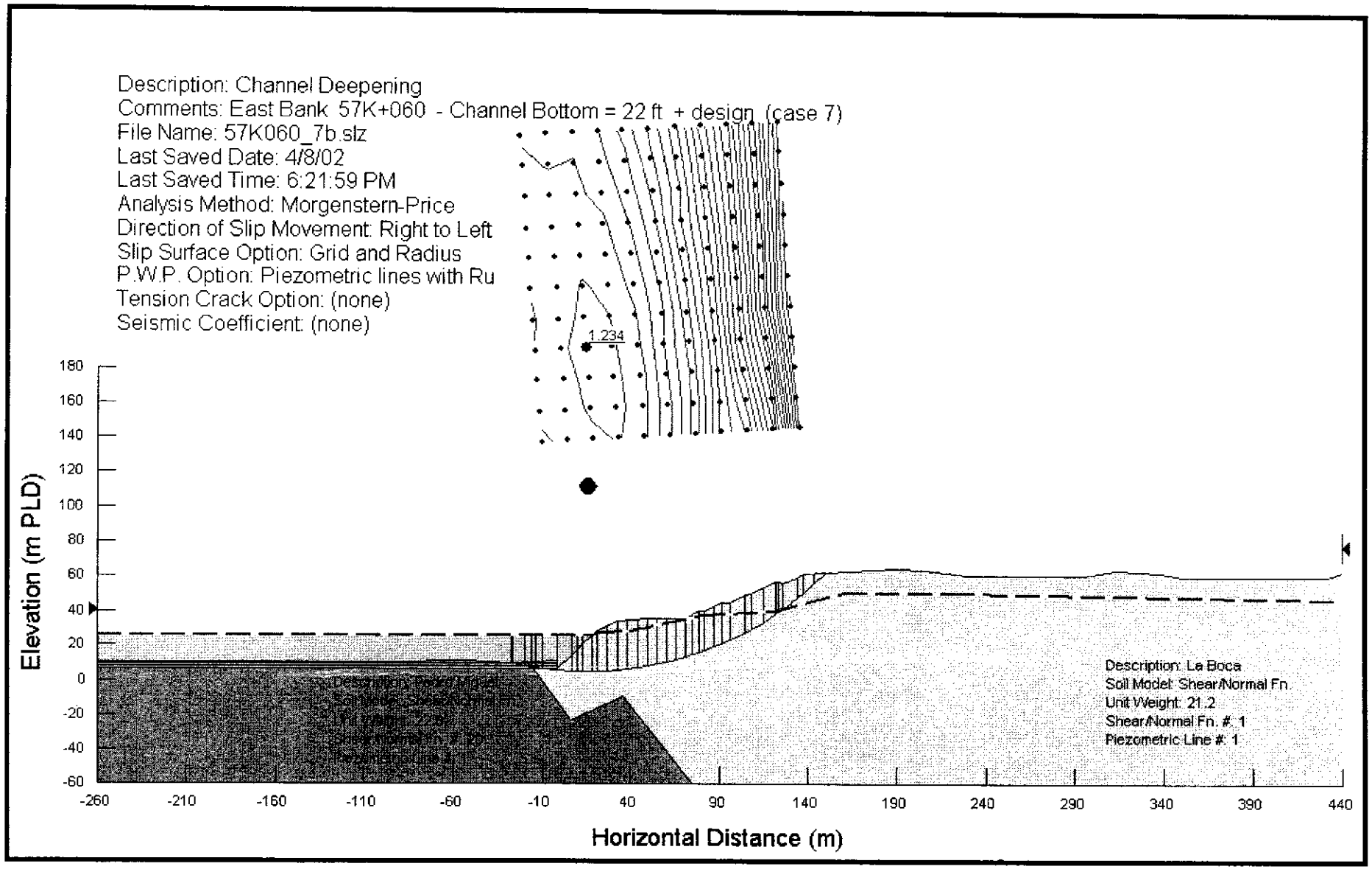


Case 7, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 22 ft + design (case 7)
File Name: 57K060_7.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:54:36 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

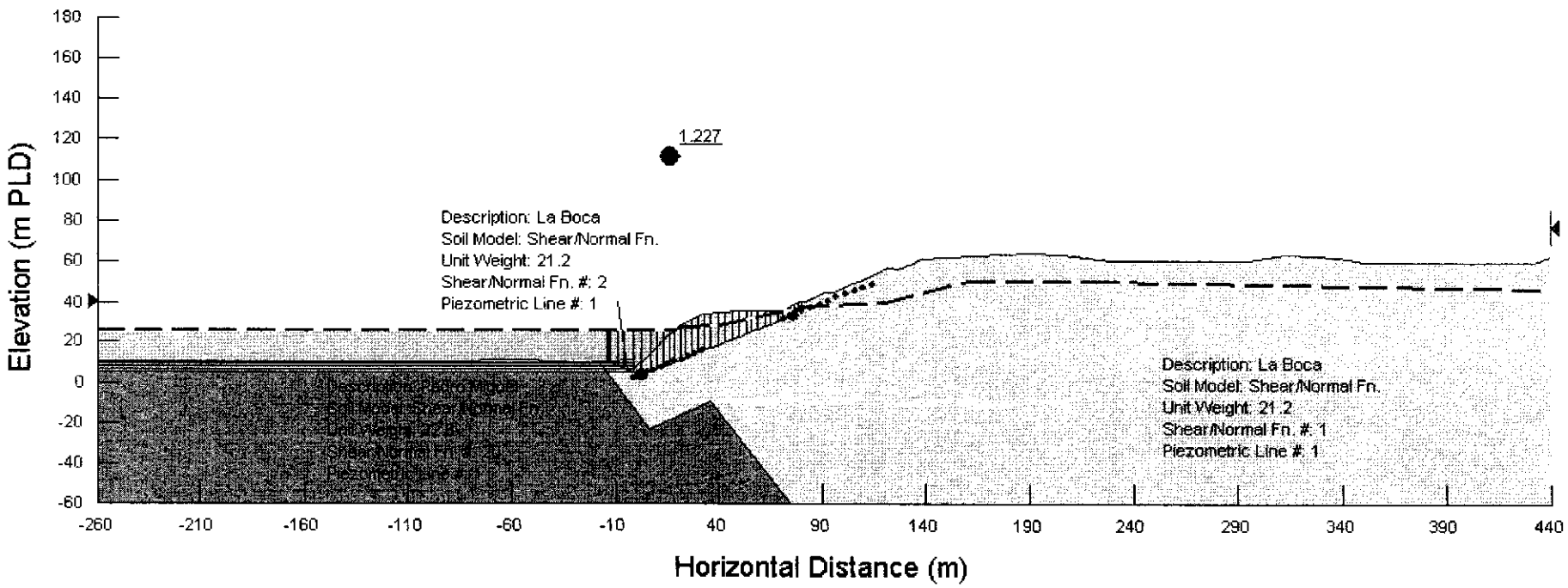


Case 7b, Channel bottom = 27 ft, Design (underwater slope)

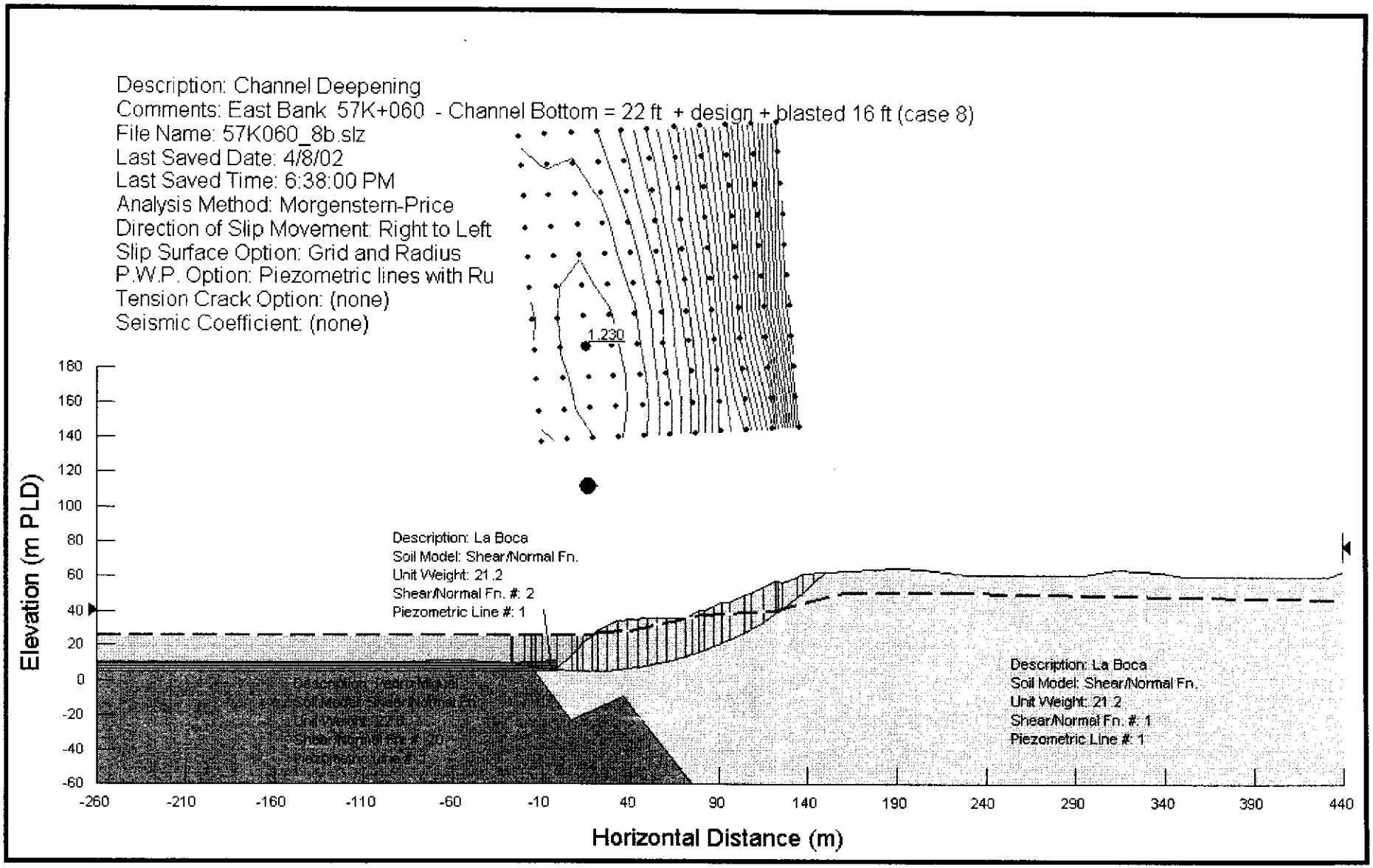


Case 8, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 57K+060 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 57K060_8.slz
Last Saved Date: 4/8/02
Last Saved Time: 6:55:56 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Block Specified
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 8b, Channel bottom = 16 ft, Blasted

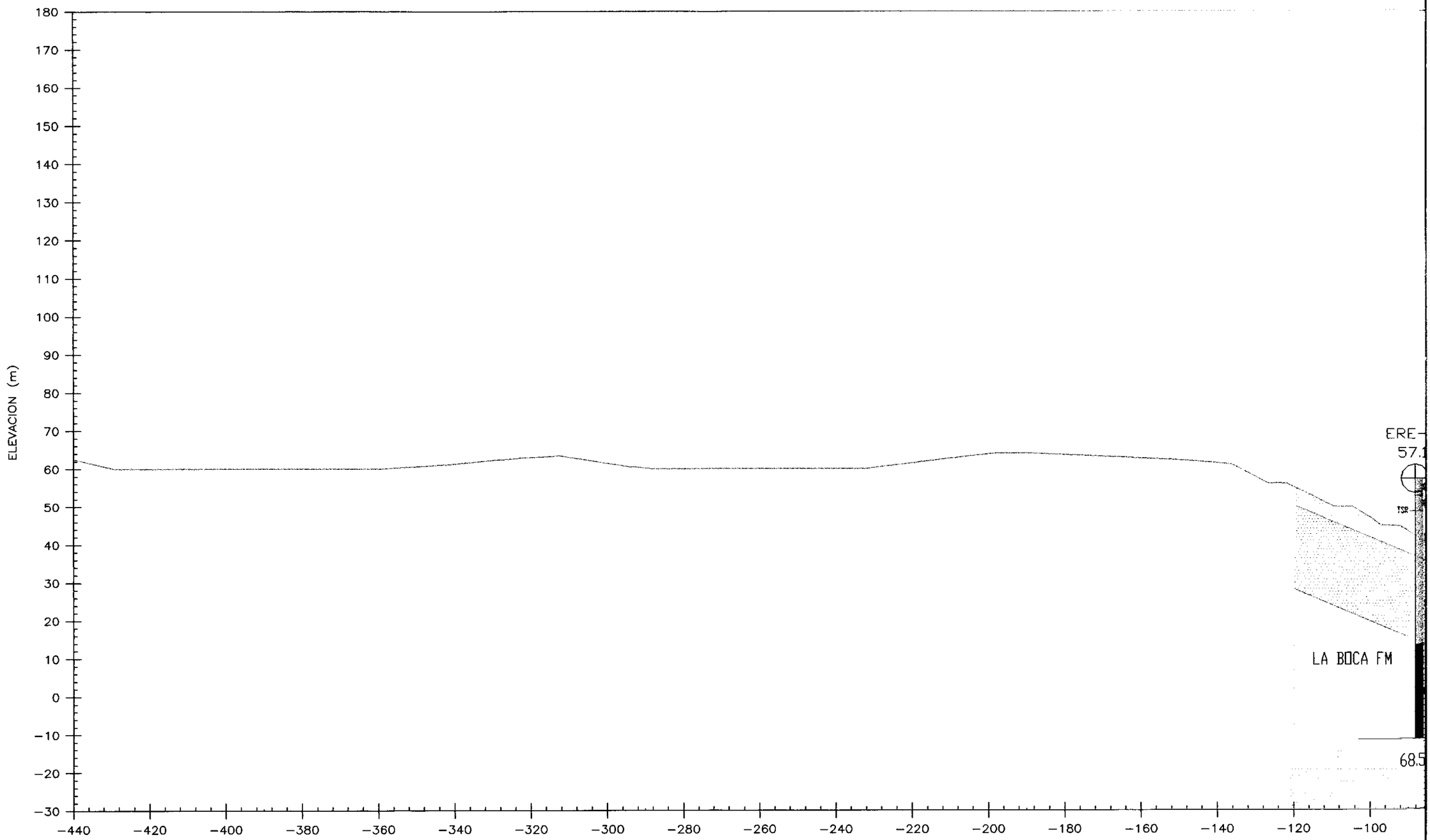


Summary, 57k + 060 (1872 + 00)

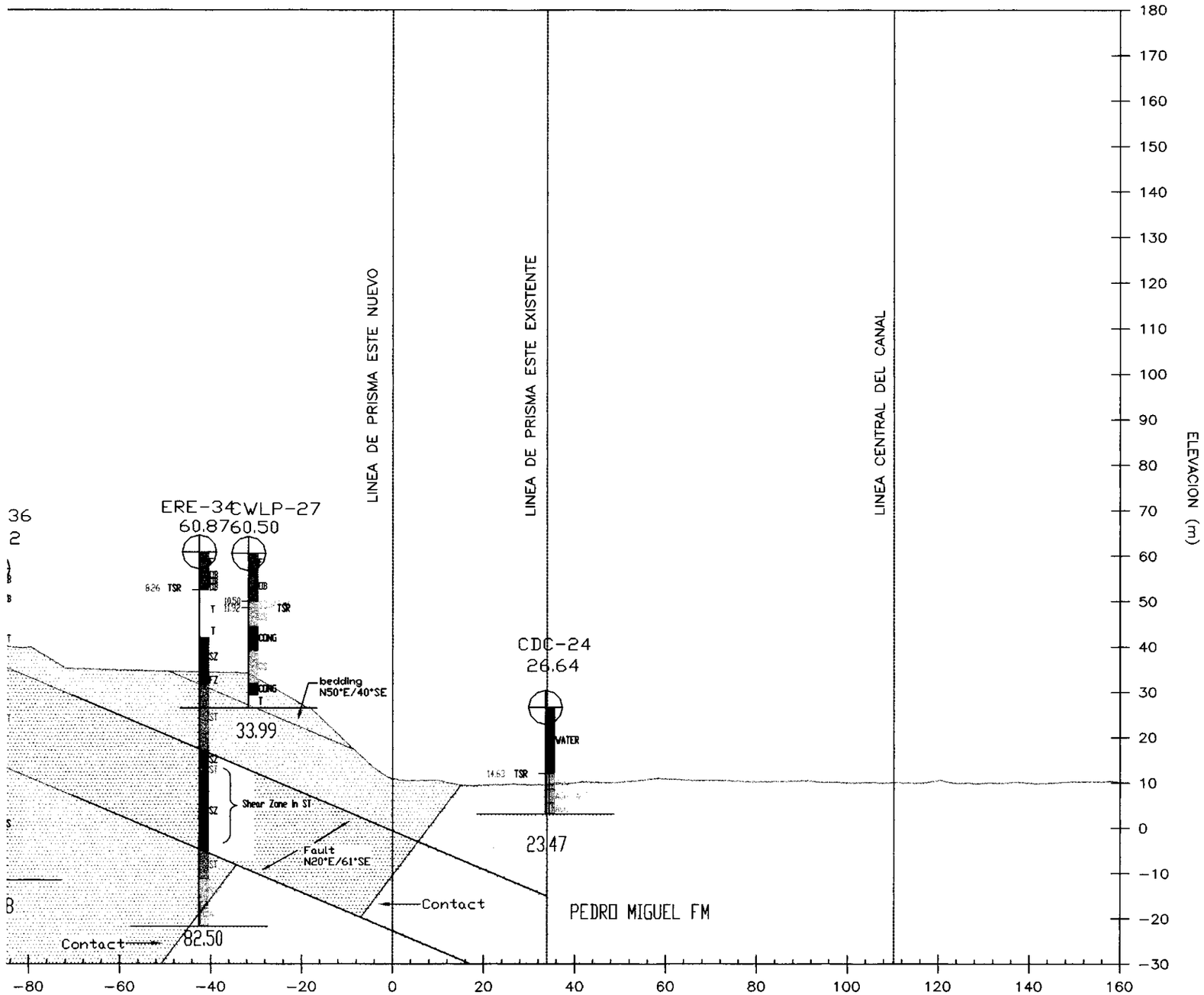
General Description	Range of stations:	56k + 560 to 57k + 160
	Sector:	Ceniza
	Maximum height (m):	50
	Cotangent of slope angle (cot. β):	2.72
History	Last slide event:	1912 (sta. 1702 Slide) / No slide during widening
Geology	Formation:	La Boca / Pedro Miguel Agglomerate
	Lithology:	Siltstone / Agglomerate
	Critical stratum at toe:	Siltstone
	Apparent dip of bedding:	Toward the Canal
Stability Analysis	Critical failure mechanism:	(a) Translational - Along bedding / (b) Rotational
	Shear strength model:	Fully softened, La Boca / First time, Pedro Miguel

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety		Relative Factor of Safety		Percentage of Change (%)	
		(a)	(b)	(a)	(b)	(a)	(b)
Case 1: Channel bottom = 32 ft	0.356	1.343	1.291	1.000	1.000	0.00	0.00
Case 2: Channel bottom = 27 ft, Blasted material only		1.343	1.288	1.000	0.998	0.00	-0.23
Case 3: Channel bottom = 27 ft, Blasted & removed		1.322	1.274	0.984	0.987	-1.56	-1.32
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.304	1.271	0.971	0.985	-2.90	-1.55
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.306	1.304	1.271	0.971	0.985	-2.90	-1.55
Case 5: Channel bottom = 22 ft, Blasted material only		1.311	1.269	0.976	0.983	-2.38	-1.70
Case 6: Channel bottom = 22 ft, Blasted & removed		1.276	1.254	0.950	0.971	-4.99	-2.87
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.228	1.234	0.914	0.956	-8.56	-4.42
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.344	1.228	1.234	0.914	0.956	-8.56	-4.42
Case 8: Channel bottom = 16 ft, Blasted		1.227	1.230	0.914	0.953	-8.64	-4.73

Conclusions:	No stabilization is required



57K+060 (1872+00)



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SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 57K+060 (1872+00) ESTE

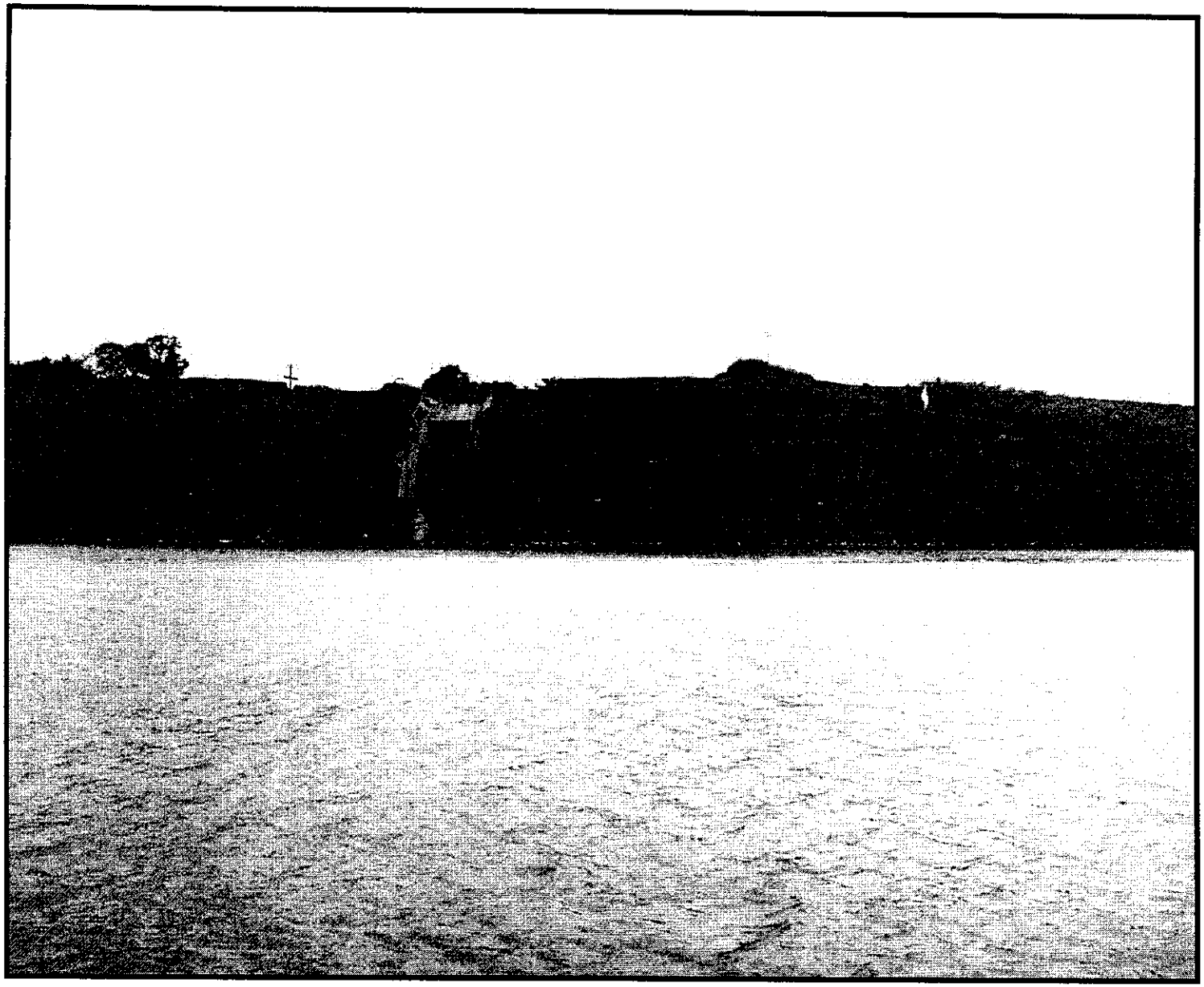
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: P. FRANCESCHI	DIBUJADO POR: J. RAMESCH

station 57k + 270 (1878 + 93)

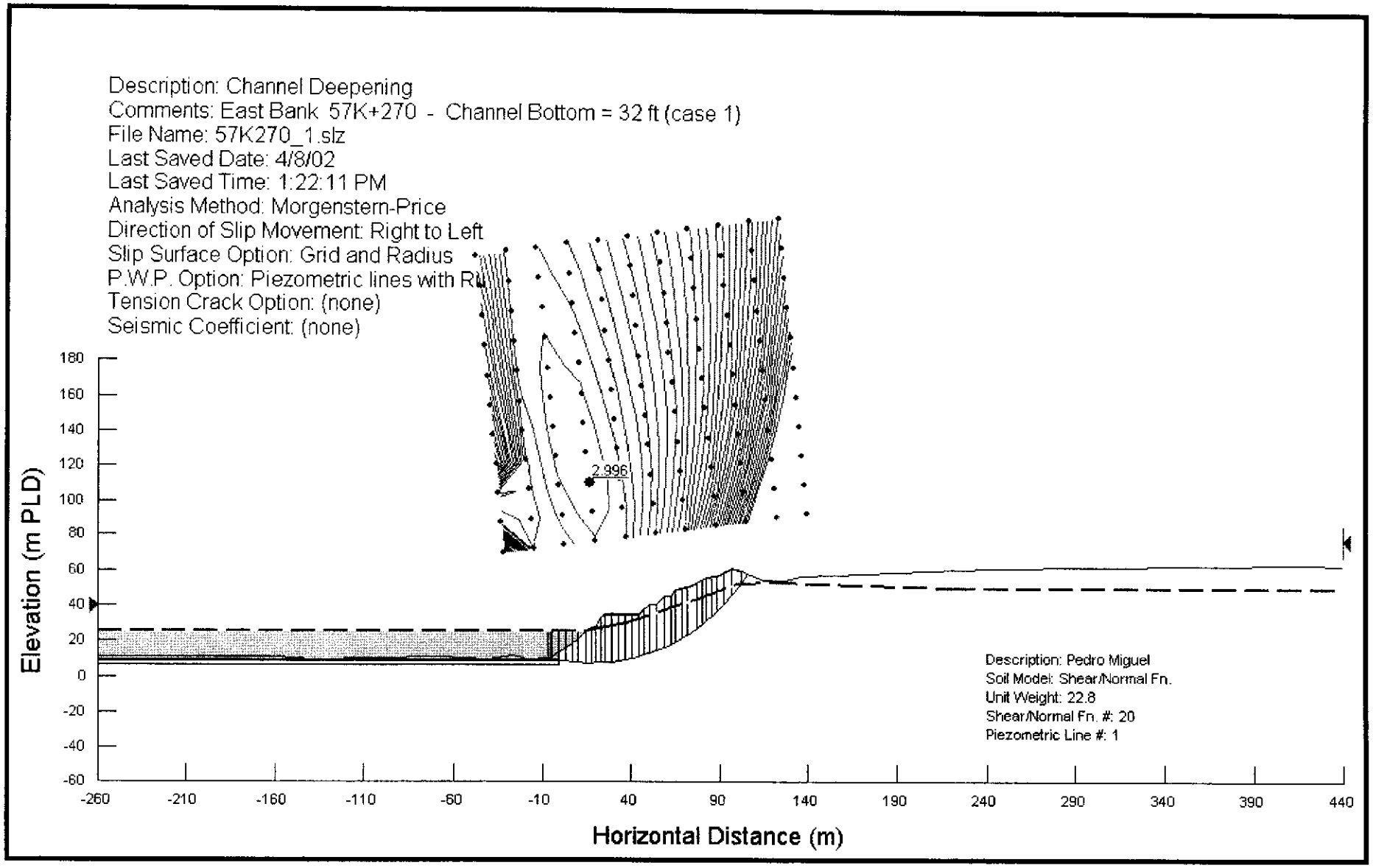
East

Station: 57k + 270 (Ceniza)

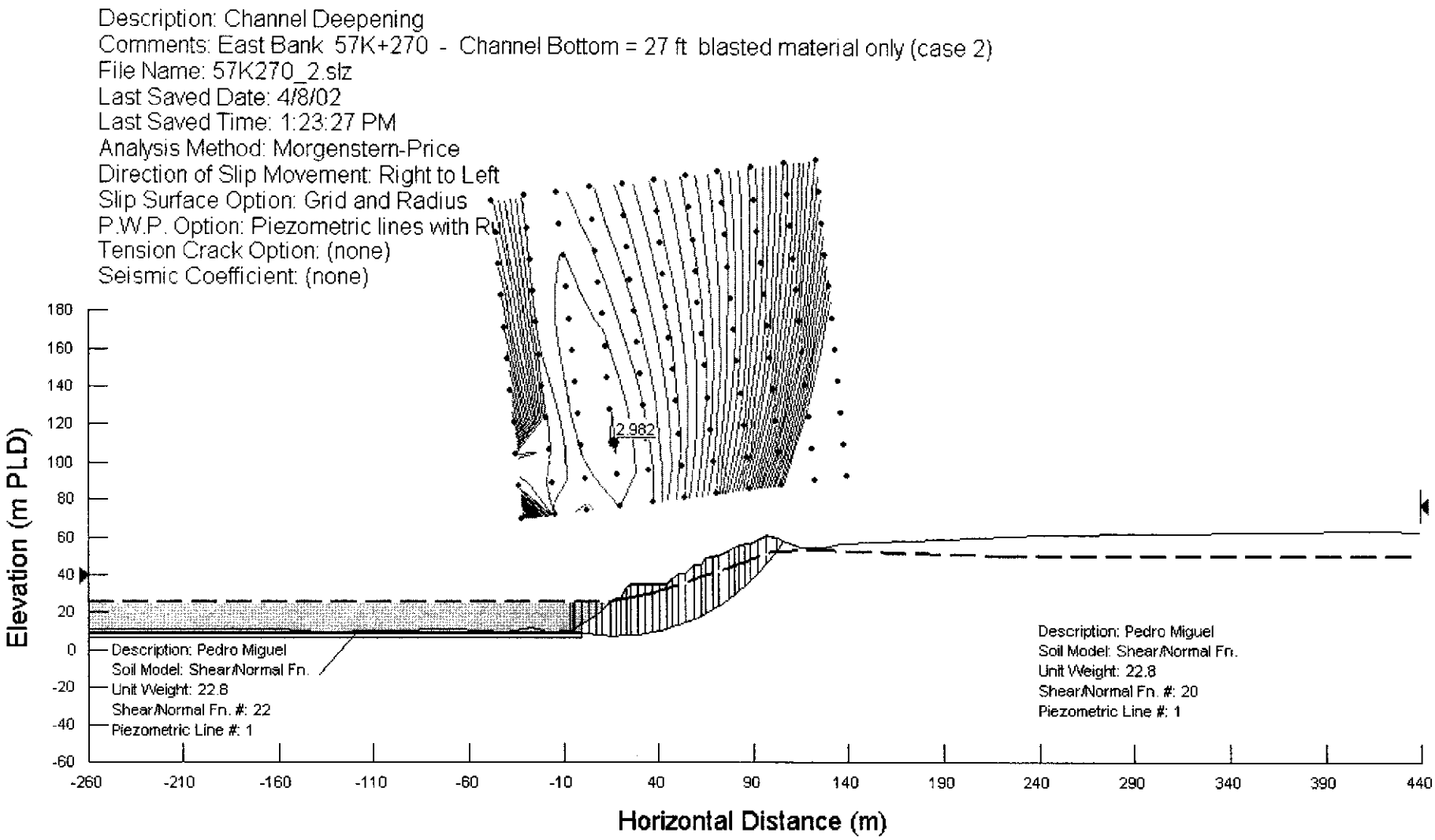
April 16, 2002



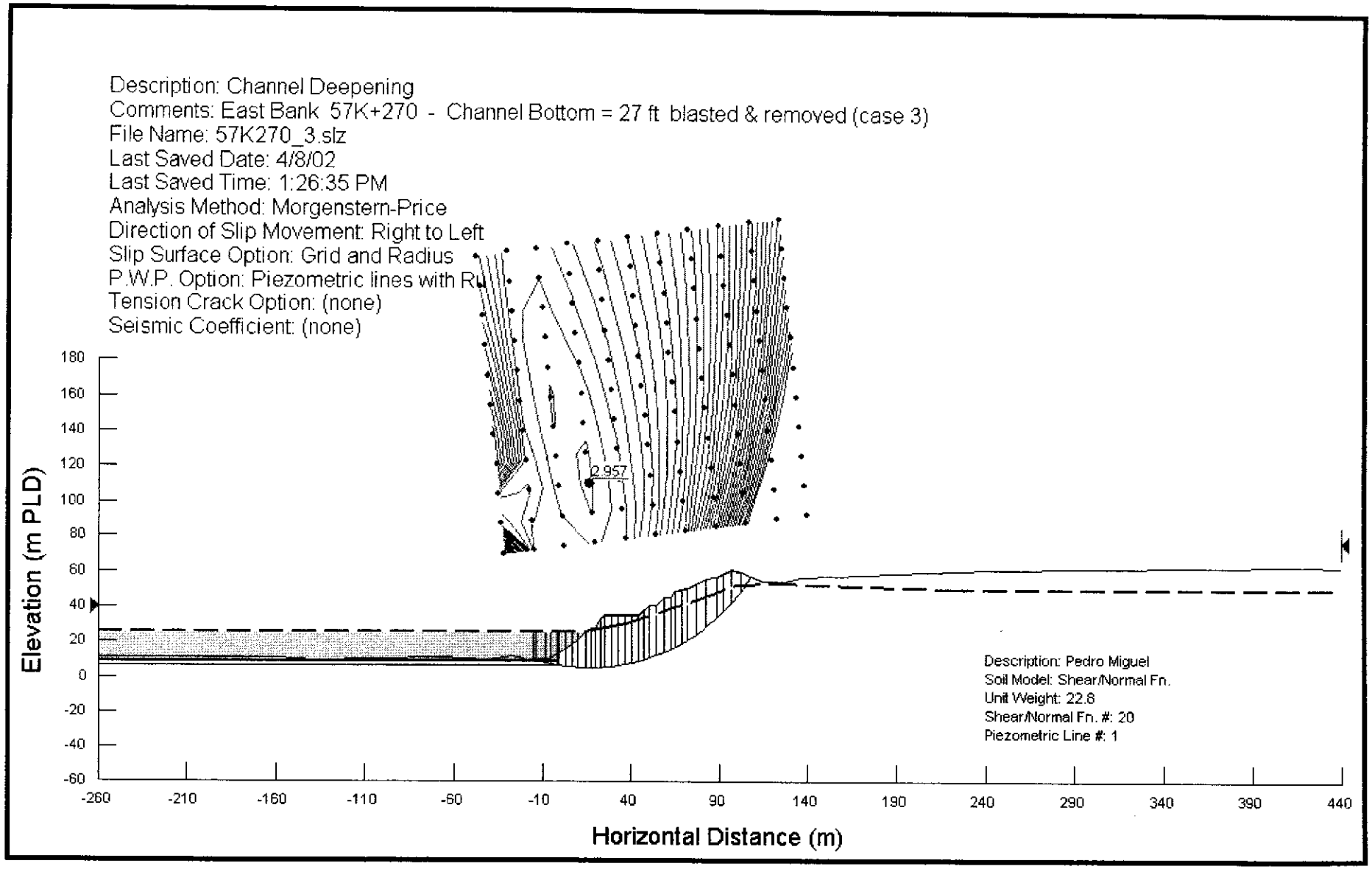
Case 1, Channel bottom = 32 ft



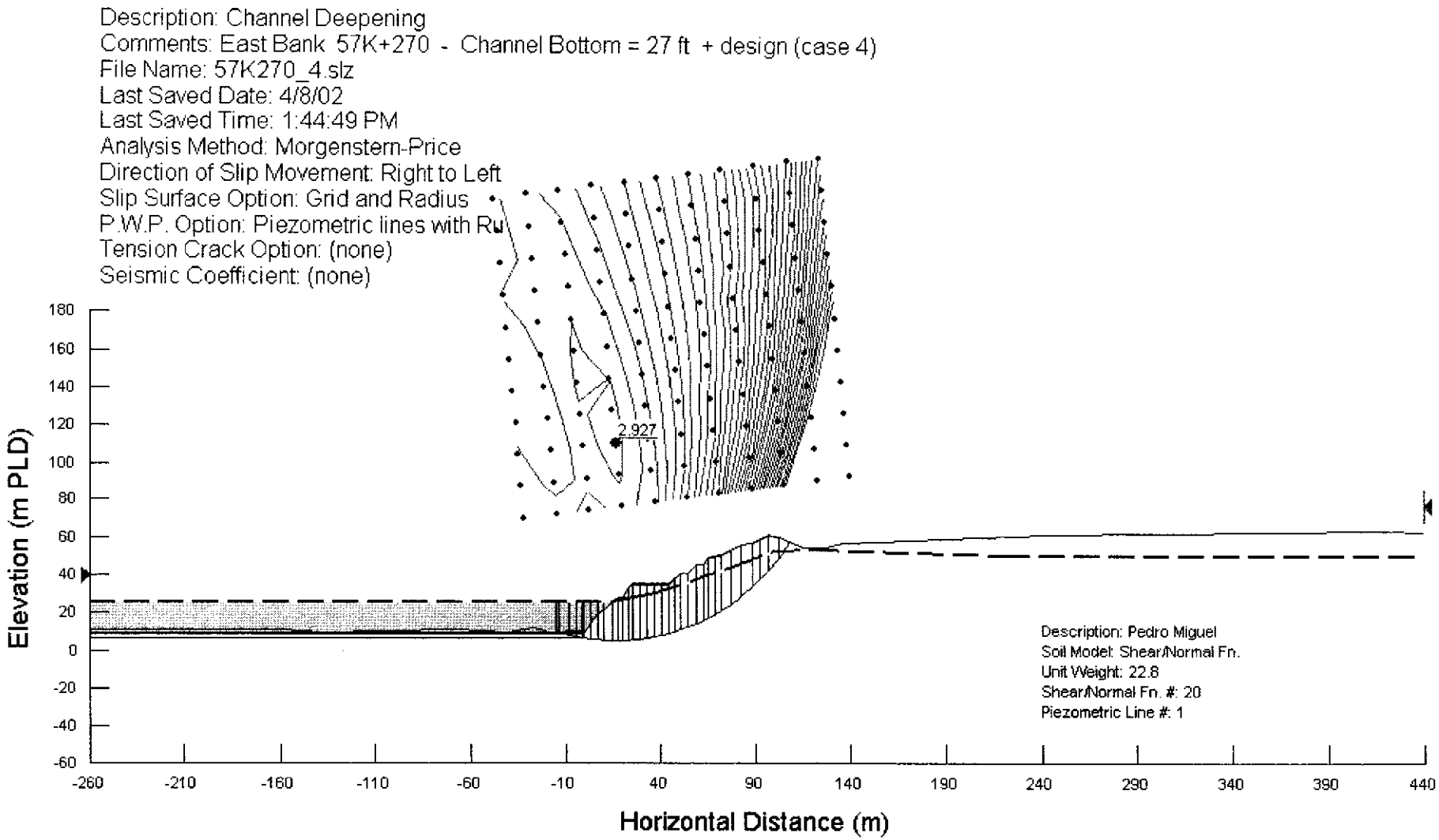
Case 2, Channel bottom = 27 ft, Blasted material only



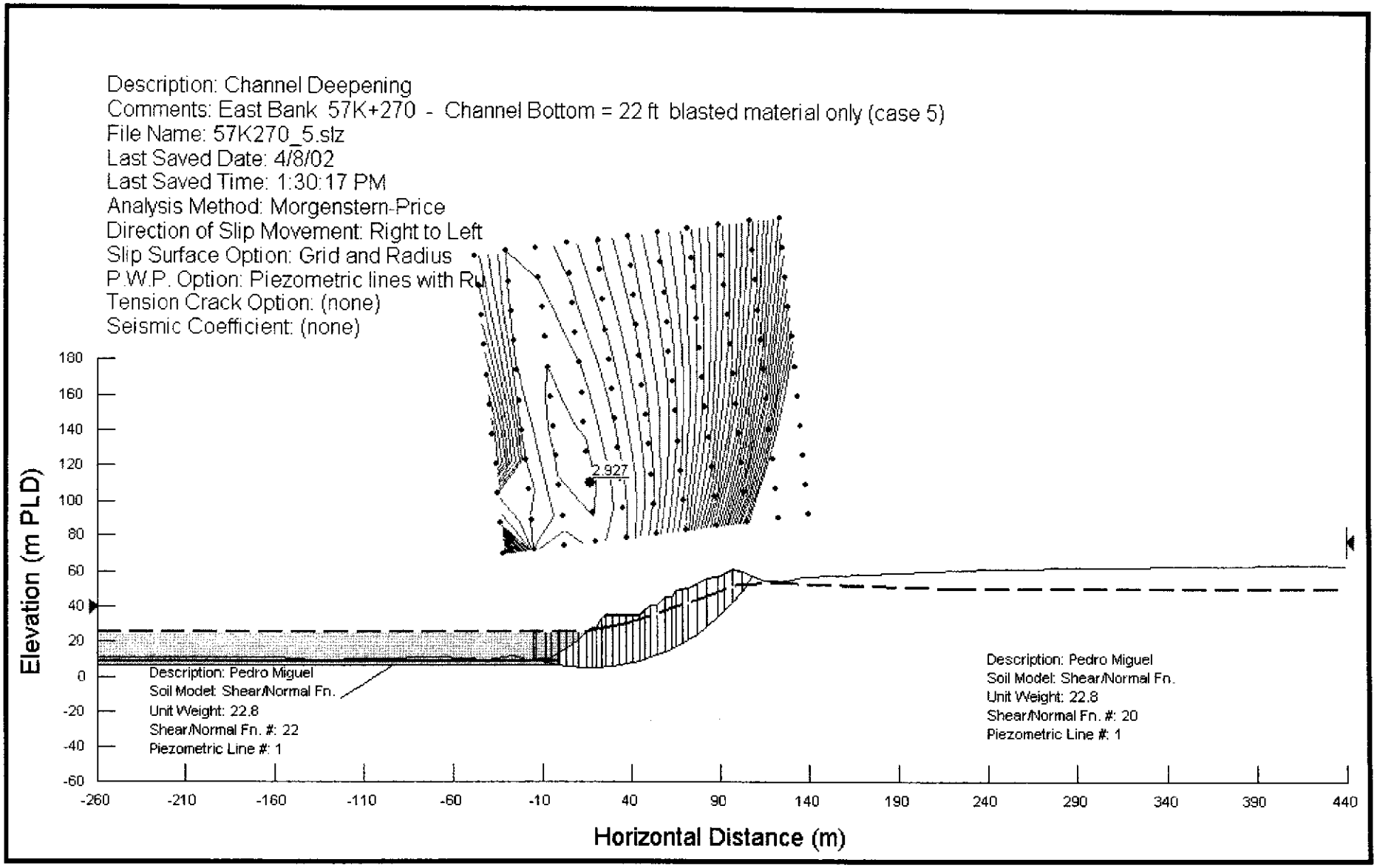
Case 3, Channel bottom = 27 ft, Blasted & removed



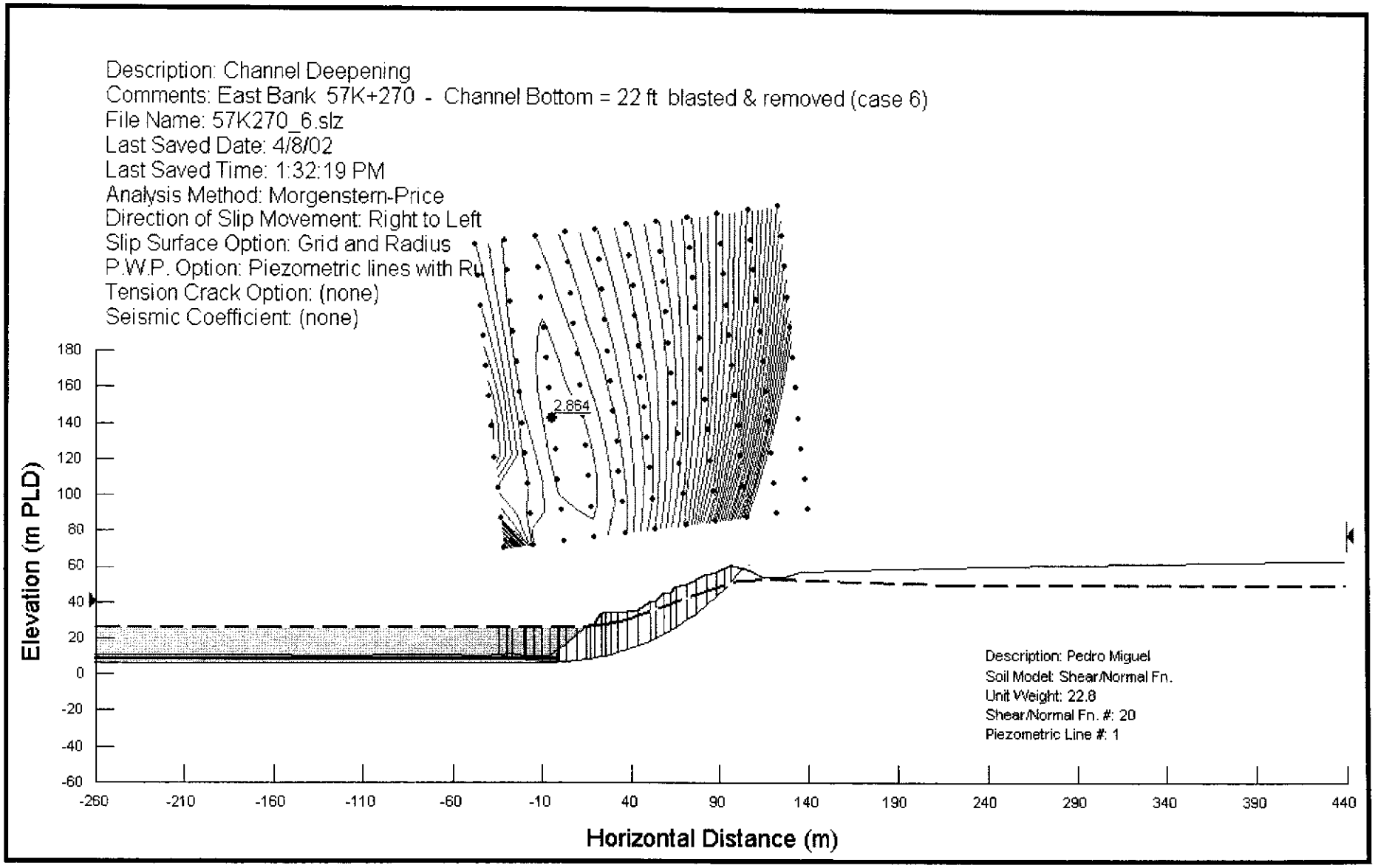
Case 4, Channel bottom = 27 ft, Design (underwater slope)



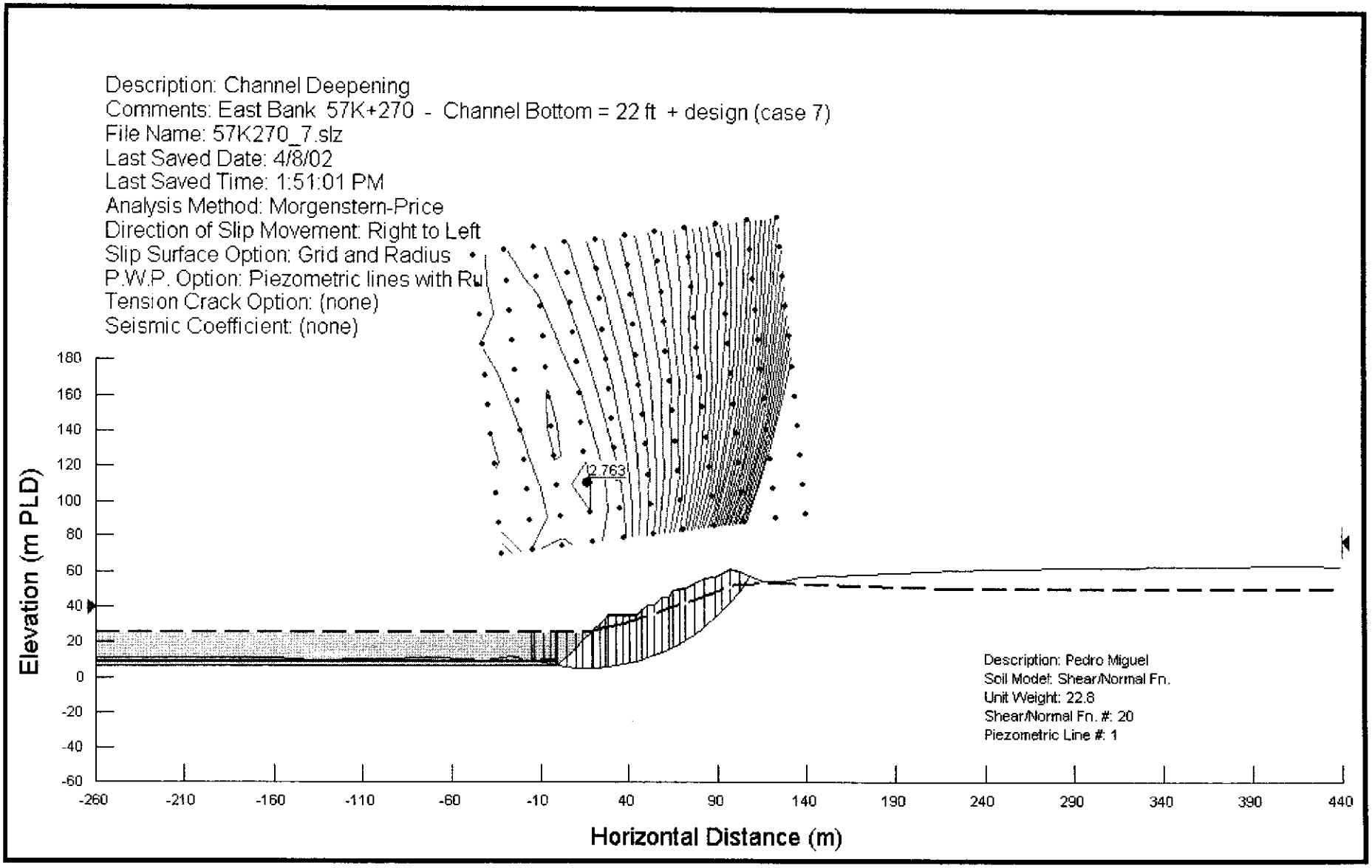
Case 5, Channel bottom = 22 ft, Blasted material only



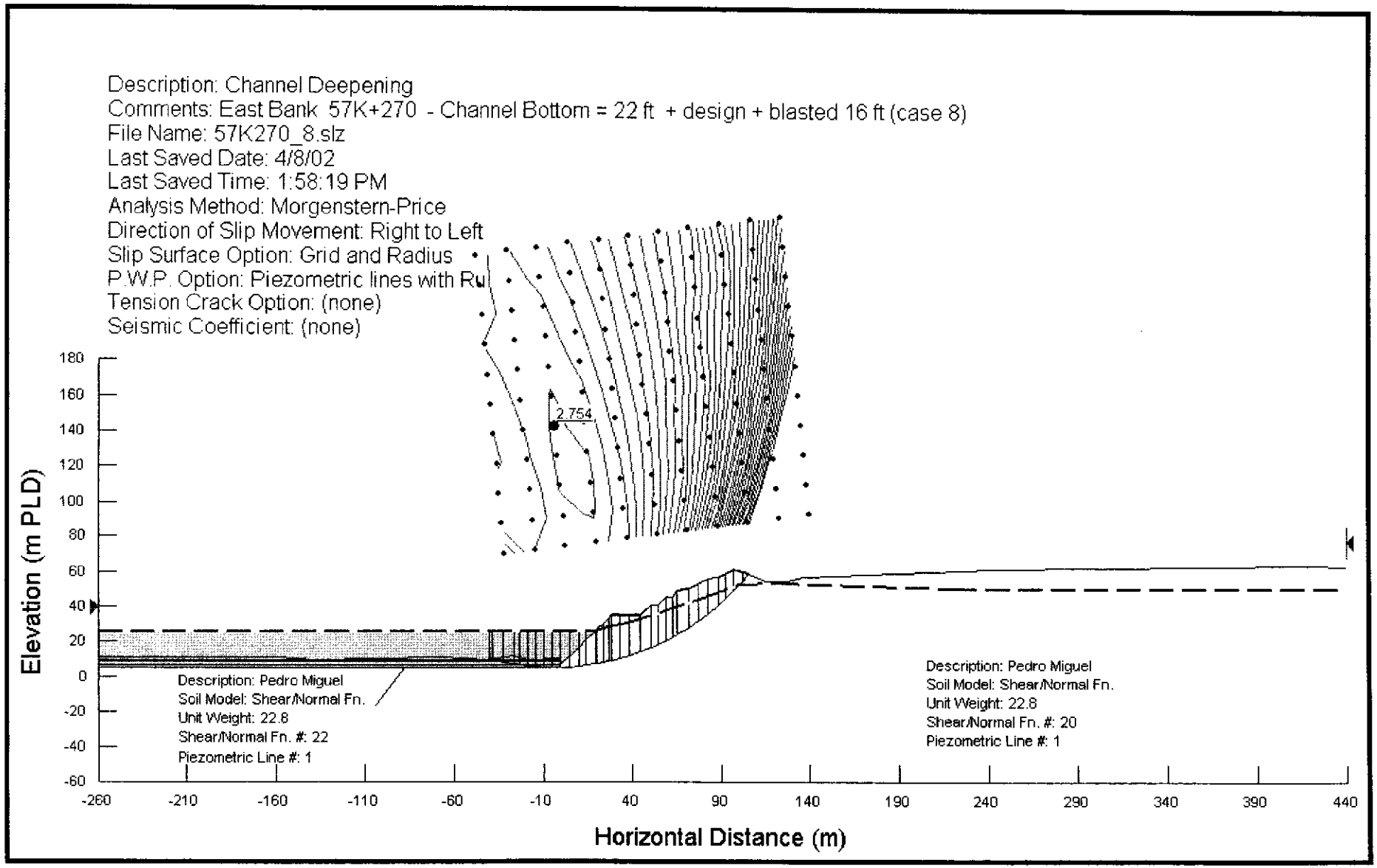
Case 6, Channel bottom = 22 ft, Blasted & removed



Case 7, Channel bottom = 27 ft, Design (underwater slope)

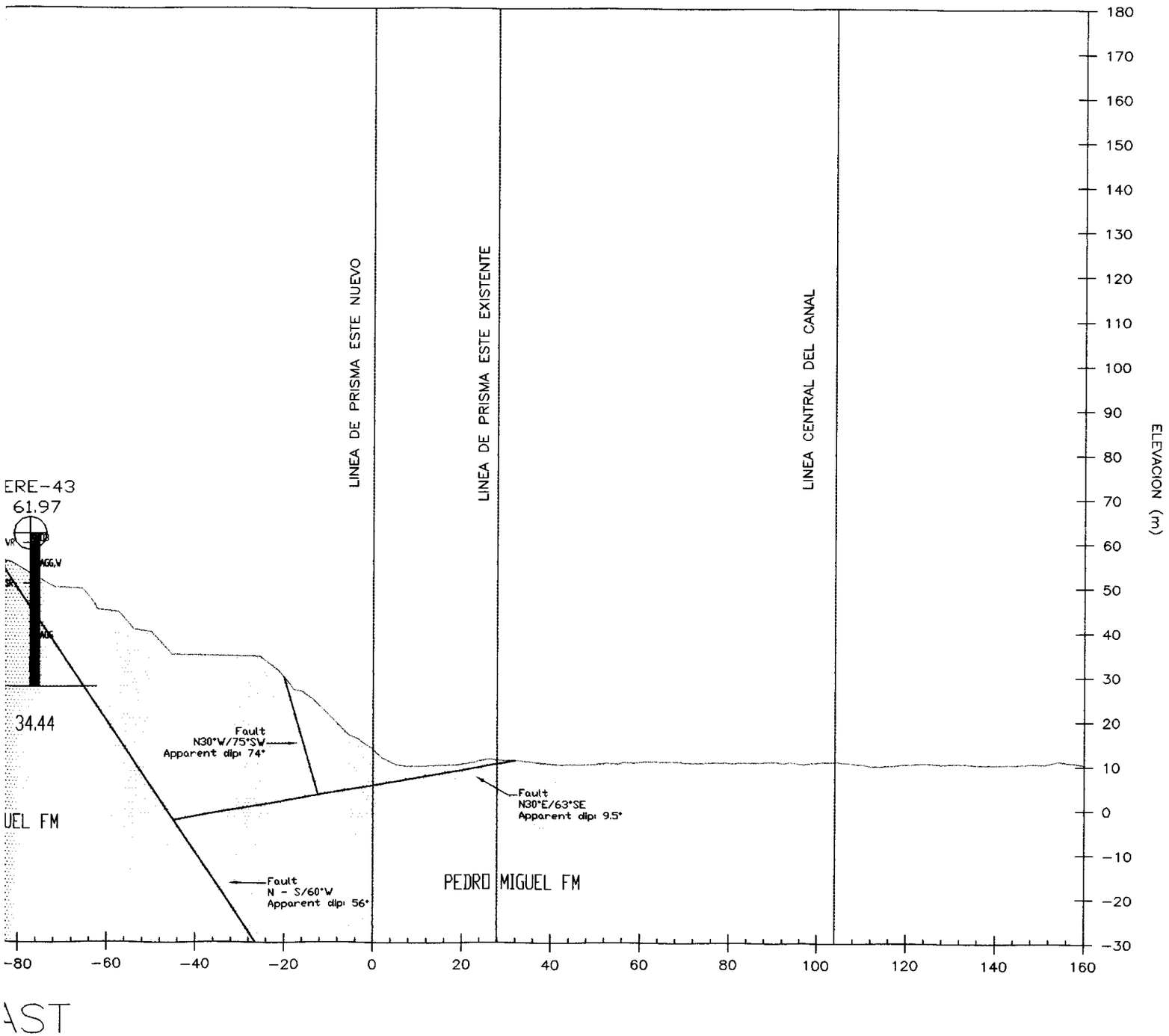


Case 8, Channel bottom = 16 ft, Blasted



Summary, 57k + 270 (1878 + 93)

General Description	Range of stations:	57k + 160 to 57k + 320			
	Sector:	Ceniza			
	Maximum height (m):	50			
	Cotangent of slope angle (cot. β):	2.0			
History	Last slide event:	1910 (sta. 1712 E Slide)			
Geology	Formation:	Pedro Miguel			
	Lithology:	Agglomerate			
	Critical stratum at toe:	Agglomerate			
	Apparent dip of bedding:	Not defined			
Stability Analysis	Critical failure mechanism:	Rotational			
	Shear strength model:	First time Pedro Miguel Agglomerate			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.348	2.996	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		2.982	0.995	-0.47
	Case 3: Channel bottom = 27 ft, Blasted & removed		2.957	0.987	-1.30
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		2.927	0.977	-2.30
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.348	2.927	0.977	-2.30
	Case 5: Channel bottom = 22 ft, Blasted material only		2.927	0.977	-2.30
	Case 6: Channel bottom = 22 ft, Blasted & removed		2.864	0.956	-4.41
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		2.763	0.922	-7.78
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.355	2.763	0.922	-7.78
	Case 8: Channel bottom = 16 ft, Blasted		2.754	0.919	-8.08
Conclusions:	No stabilization is required				



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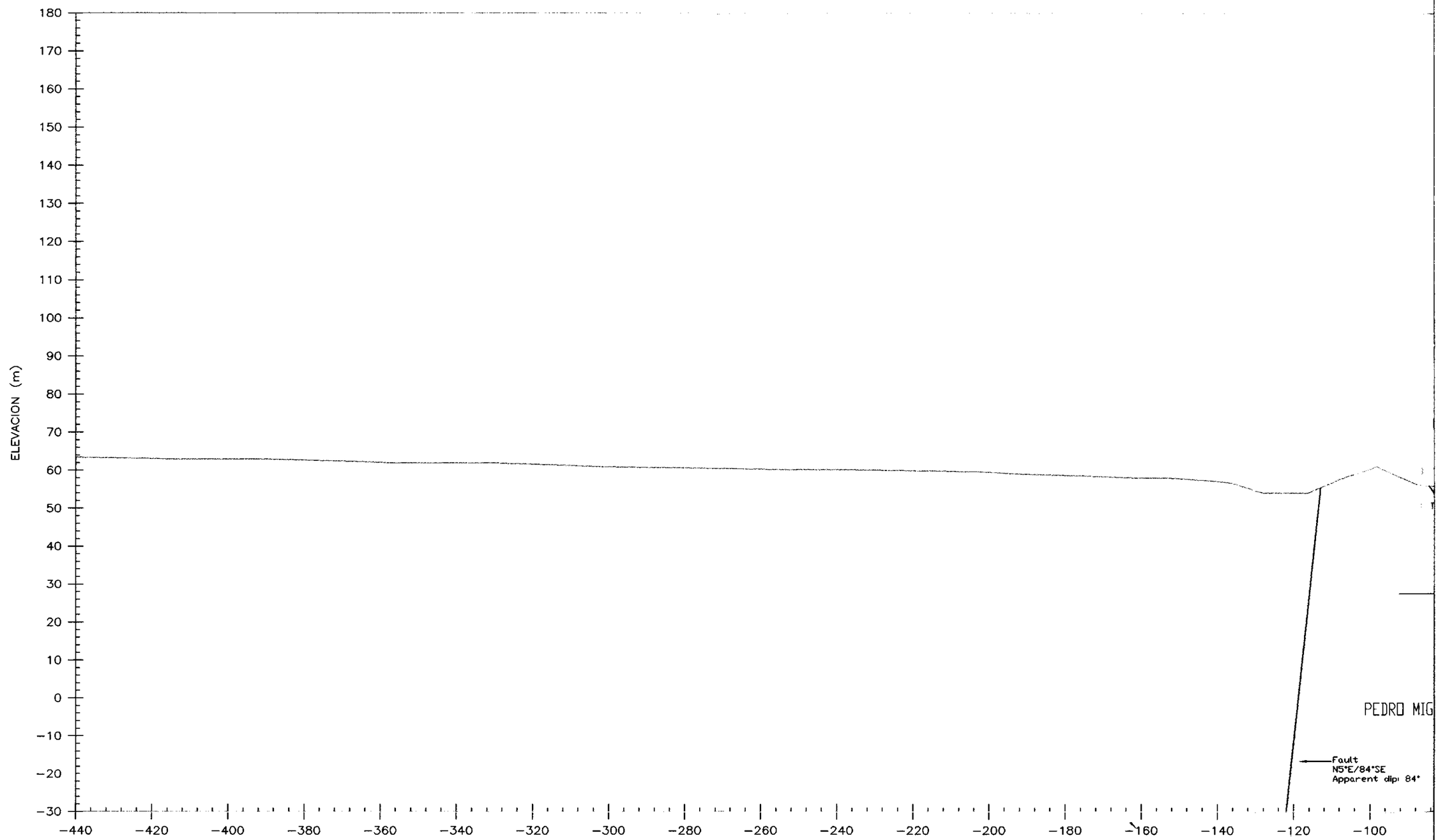
SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 57K+270 (1878+93) ESTE

ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: P. FRANCESCHI	DIBUJADO POR: J. RAMESCH

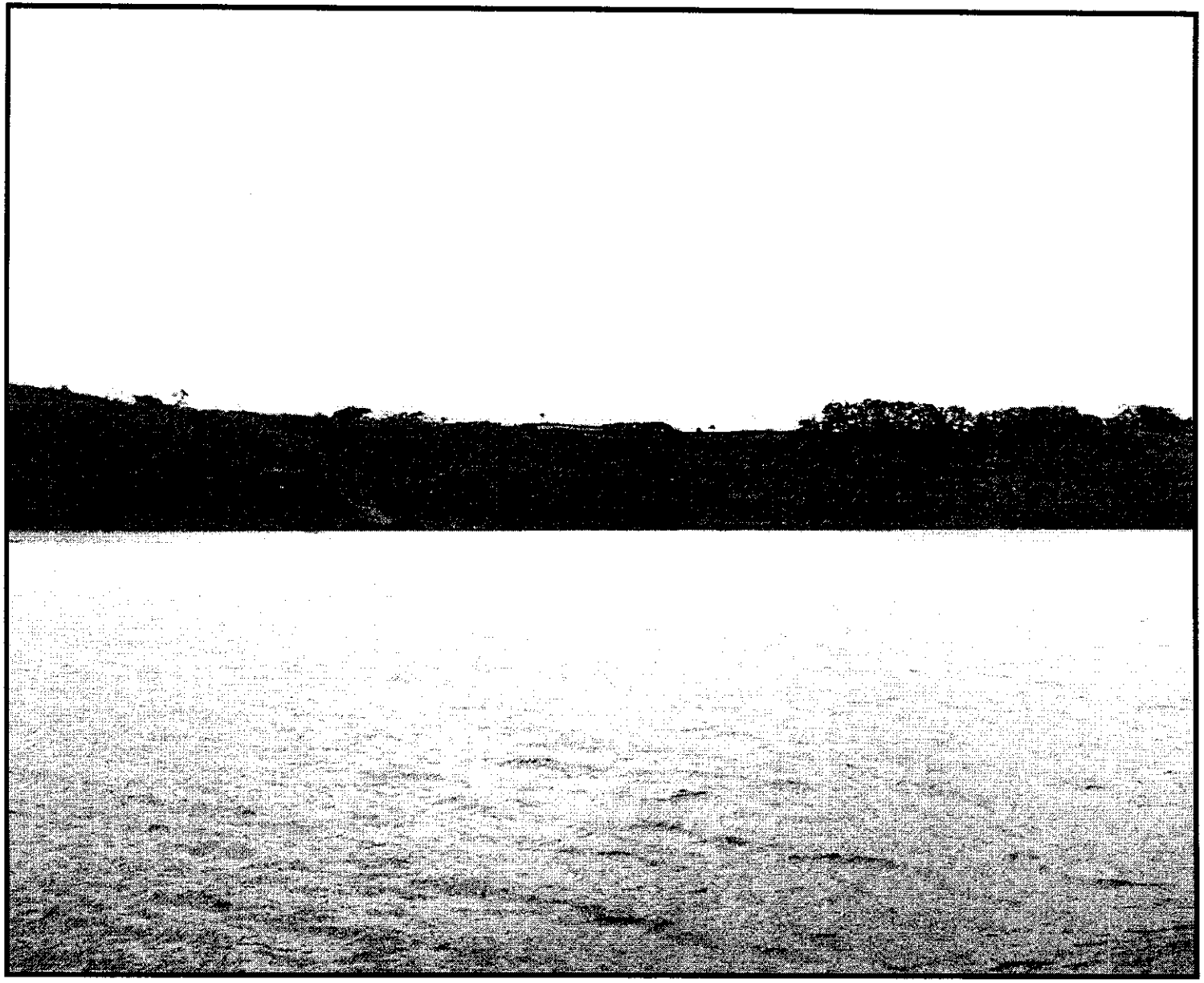

ELEVACION (m)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-440
-420
-400
-380
-360
-340
-320
-300
-280
-260
-240
-220
-200
-180
-160
-140
-120
-100
PEDRO MIG
Fault
N5°E/84°SE
Apparent dip: 84°
57K+270 (1878+93) E

station 57k + 635 (1890 + 91)

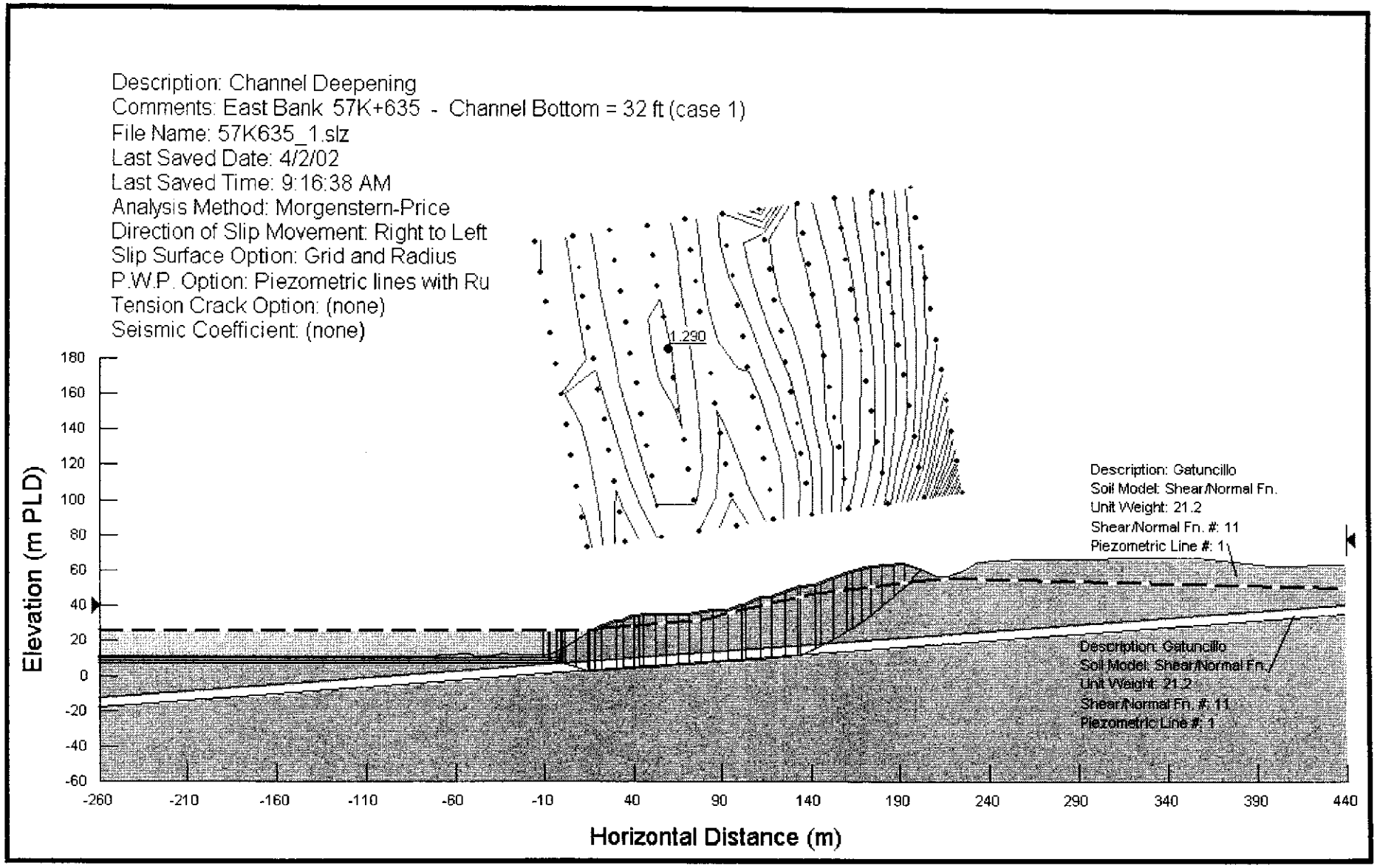
East

Station: 57k + 635 (Summit)

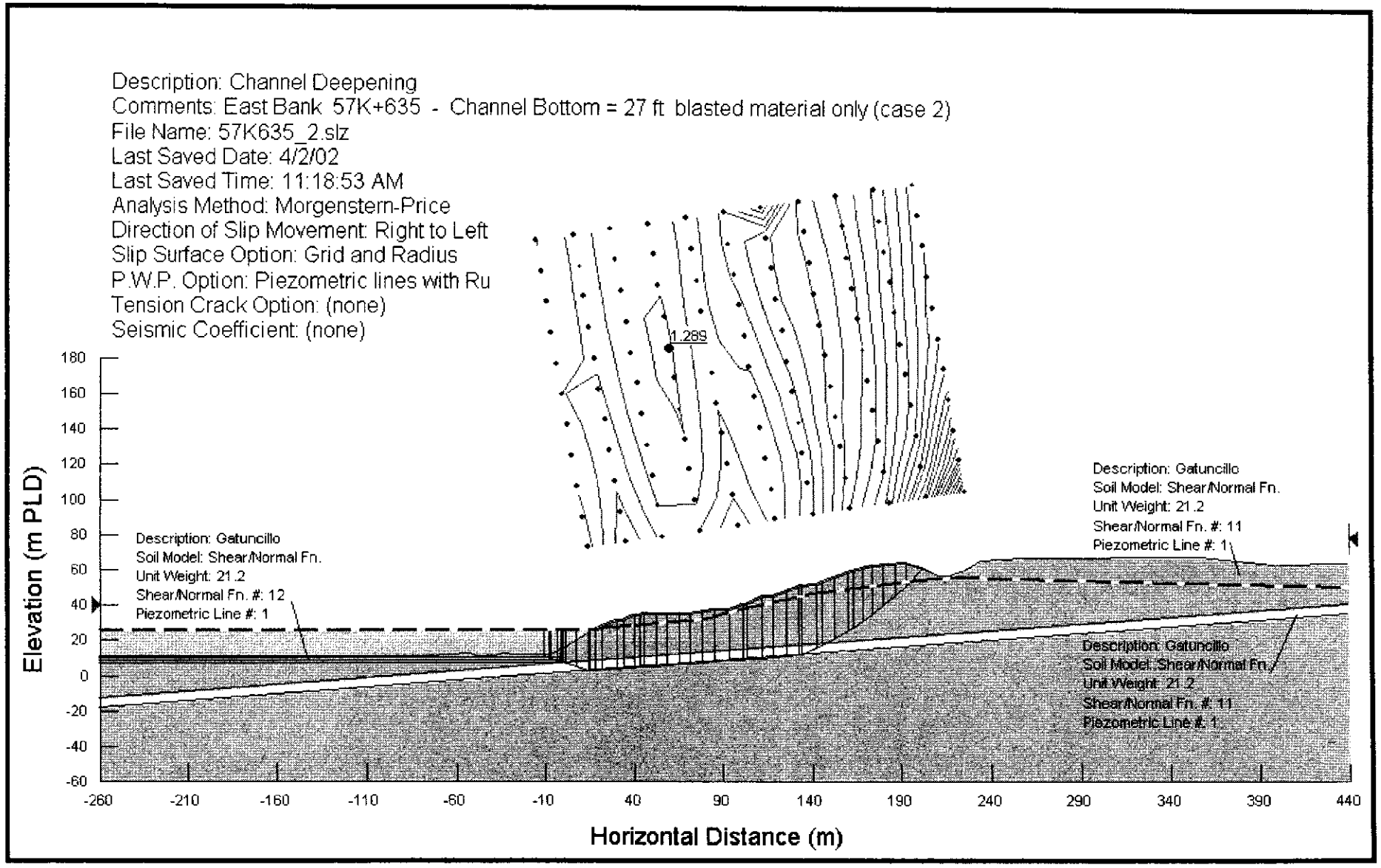
April 16, 2002



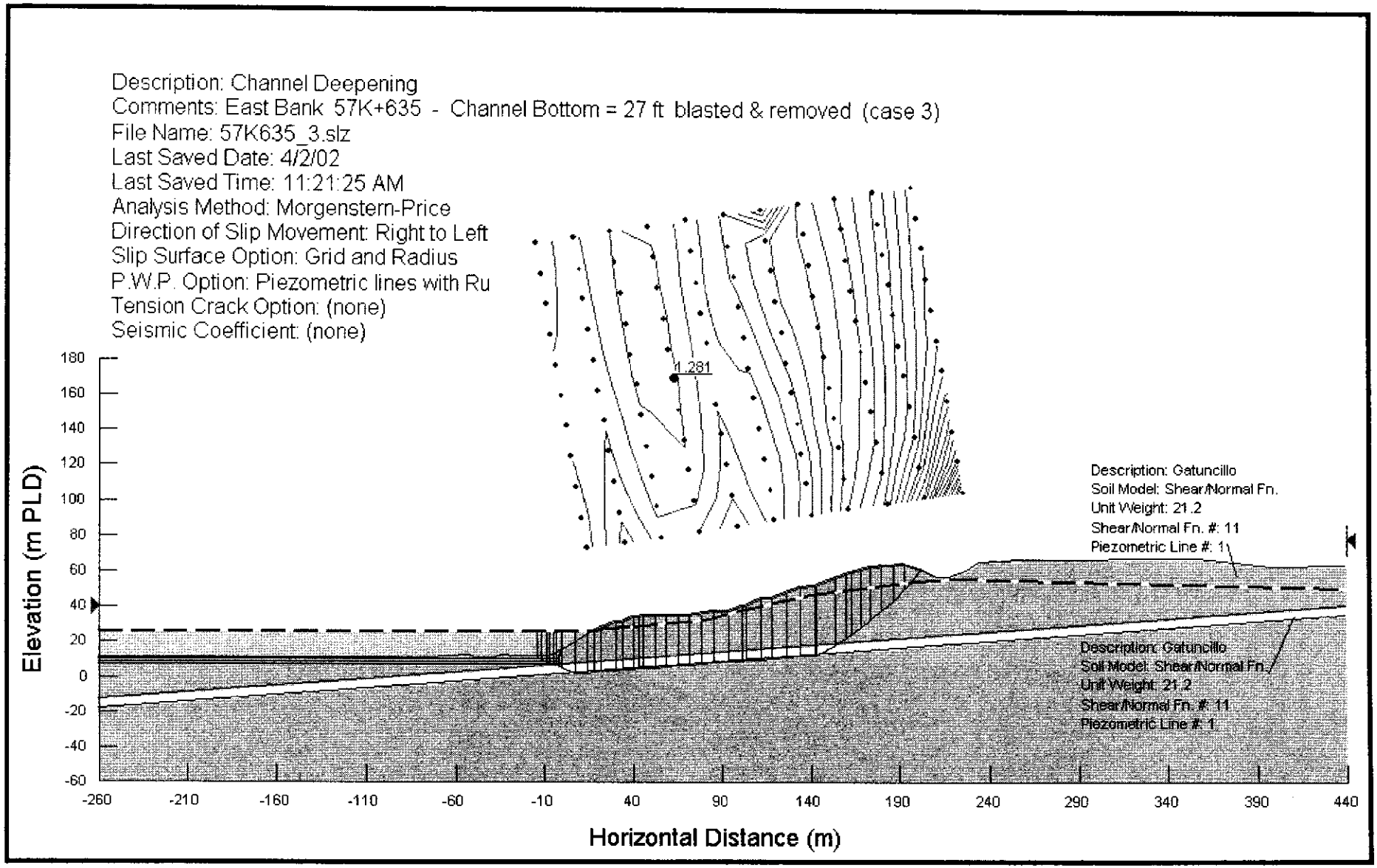
Case 1, Channel bottom = 32 ft



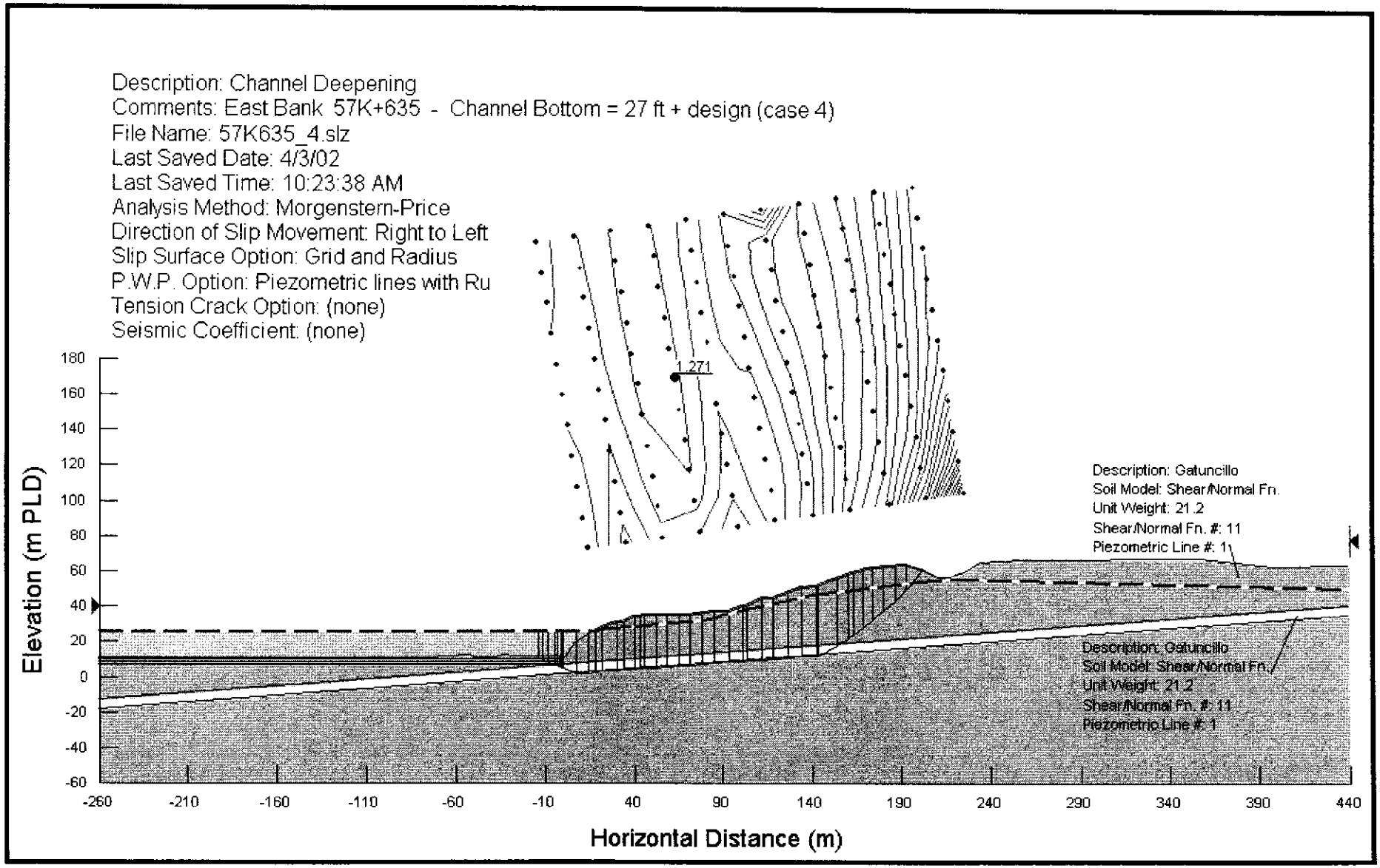
Case 2, Channel bottom = 27 ft, Blasted material only



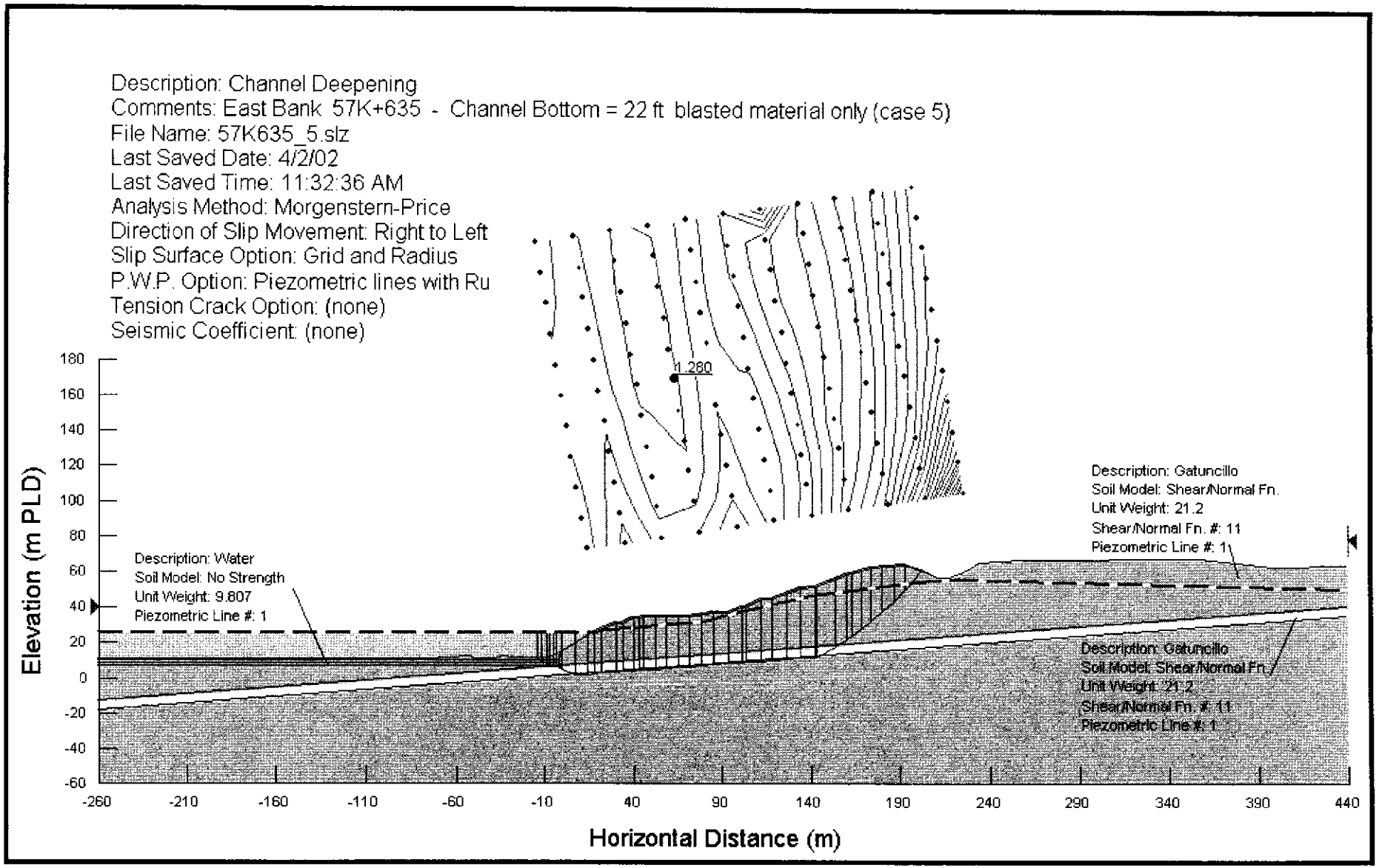
Case 3, Channel bottom = 27 ft, Blasted & removed



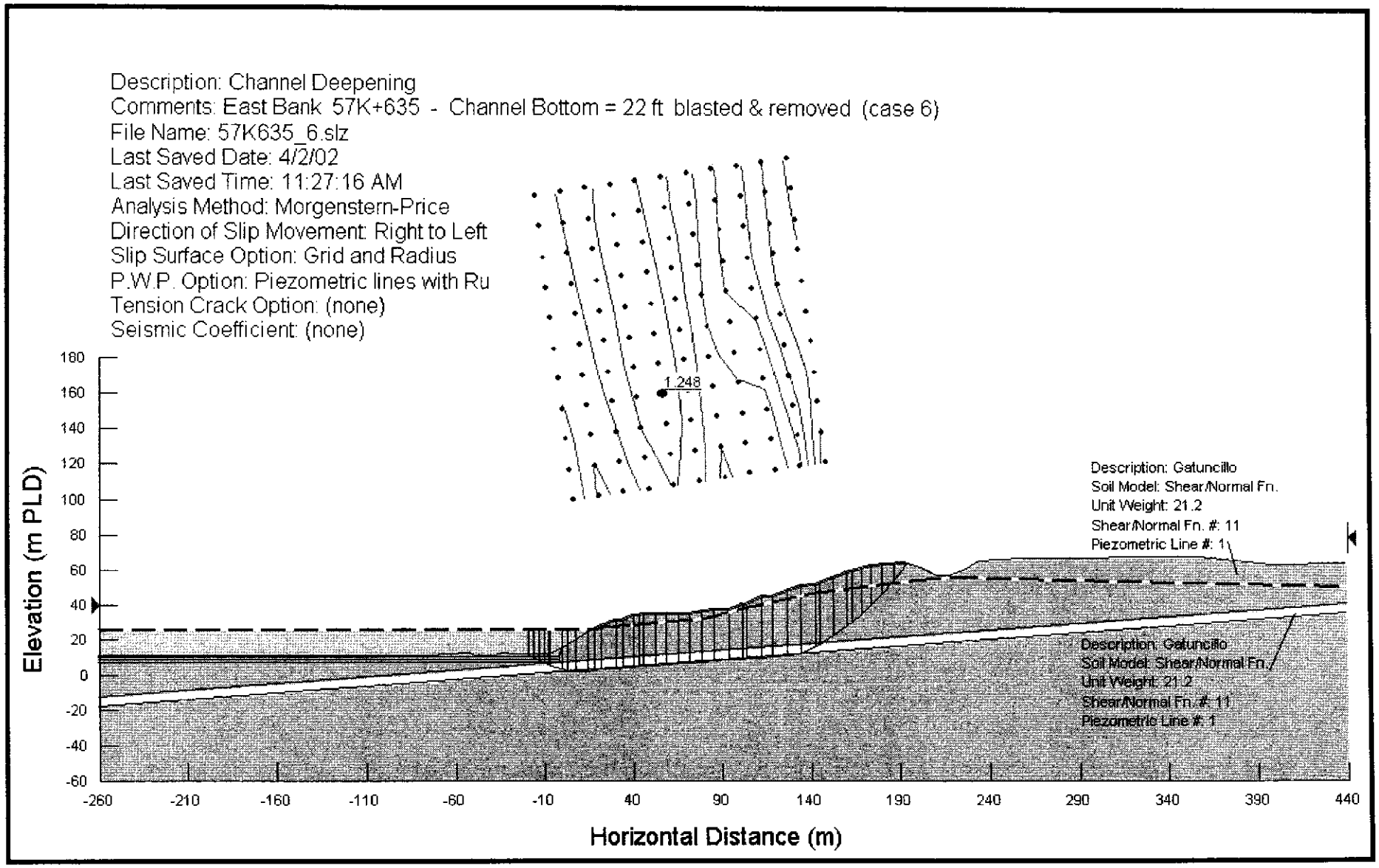
Case 4, Channel bottom = 27 ft, Design (underwater slope)



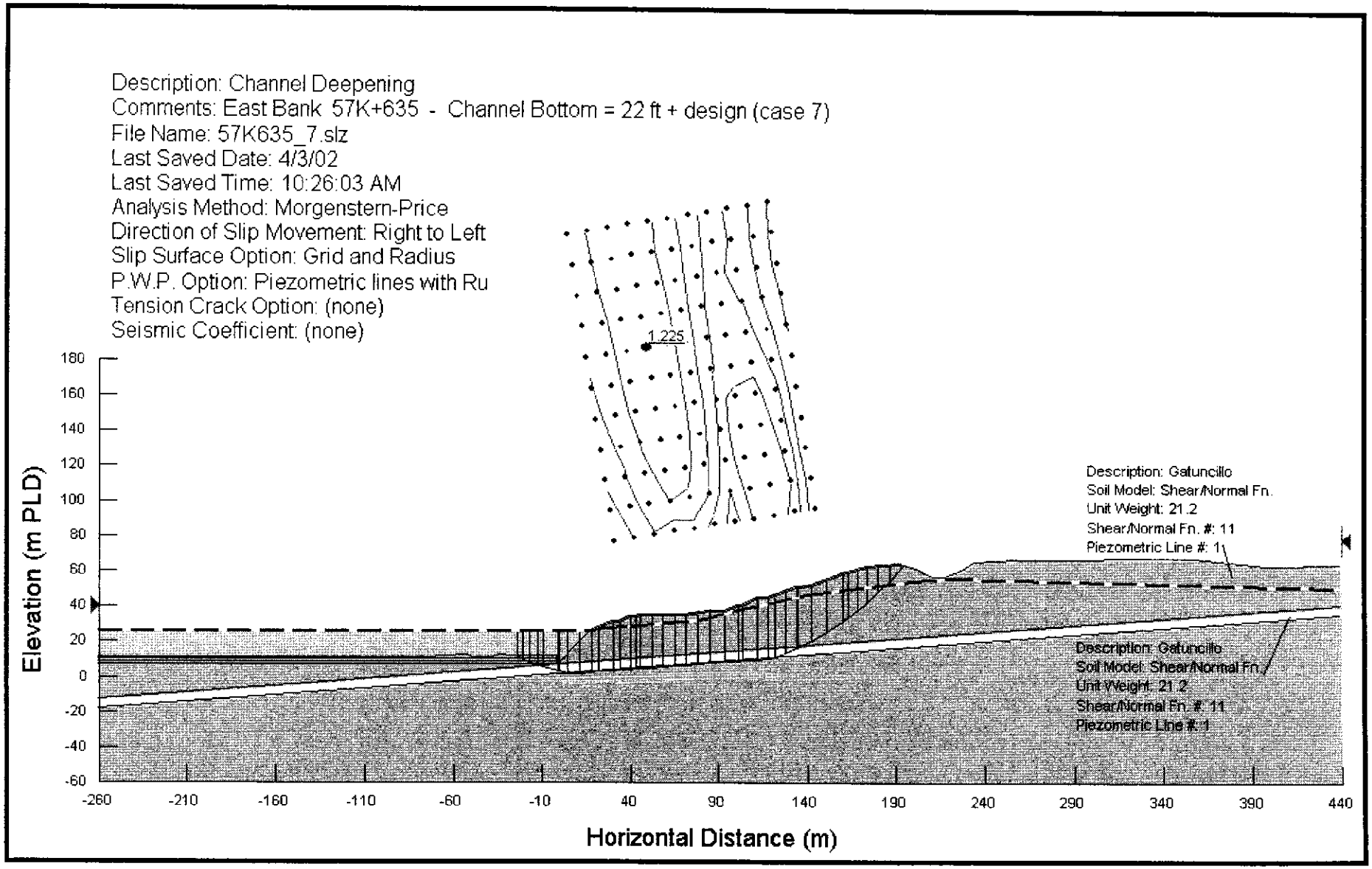
Case 5, Channel bottom = 22 ft, Blasted material only



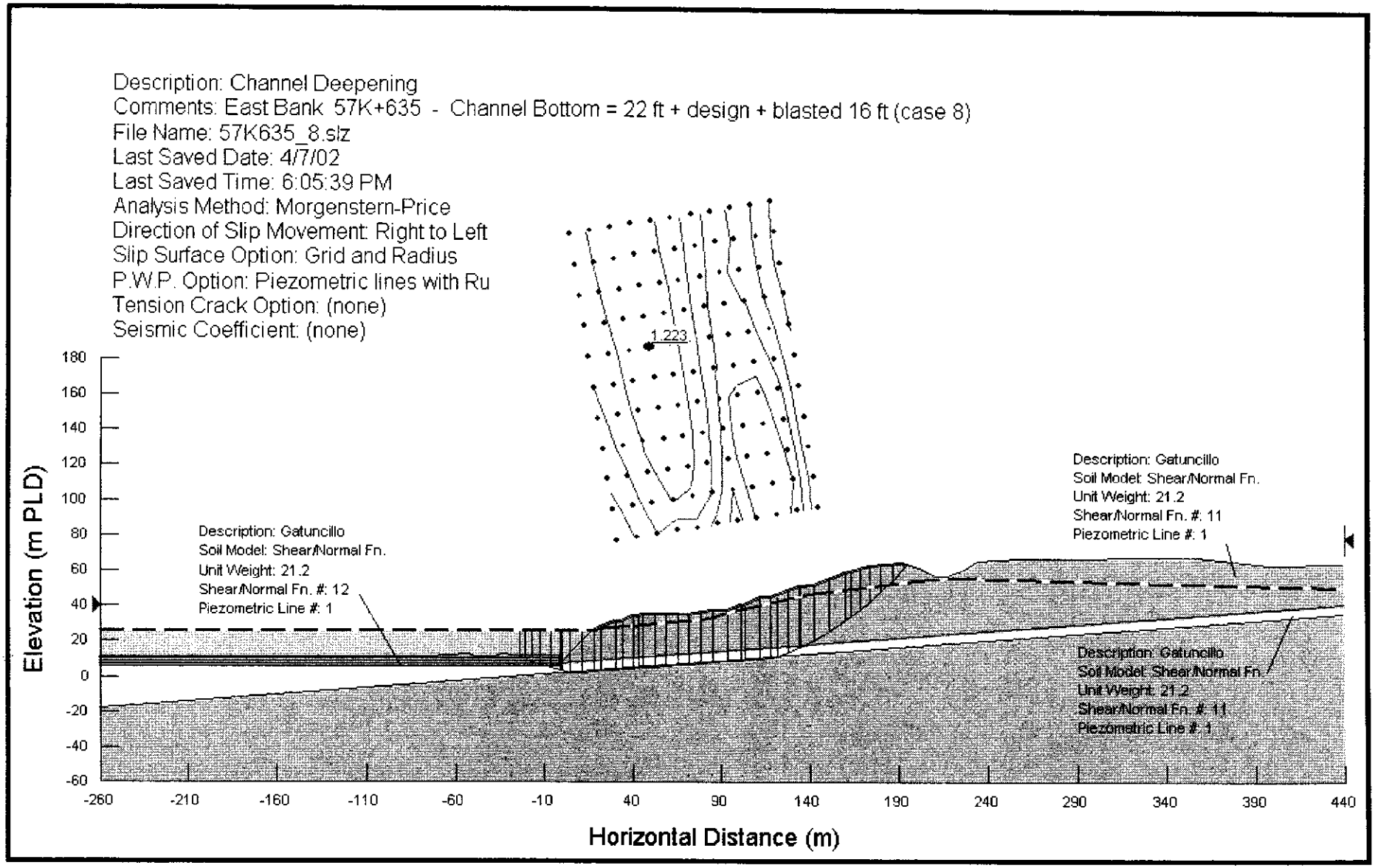
Case 6, Channel bottom = 22 ft, Blasted & removed



Case 7, Channel bottom = 27 ft, Design (underwater slope)

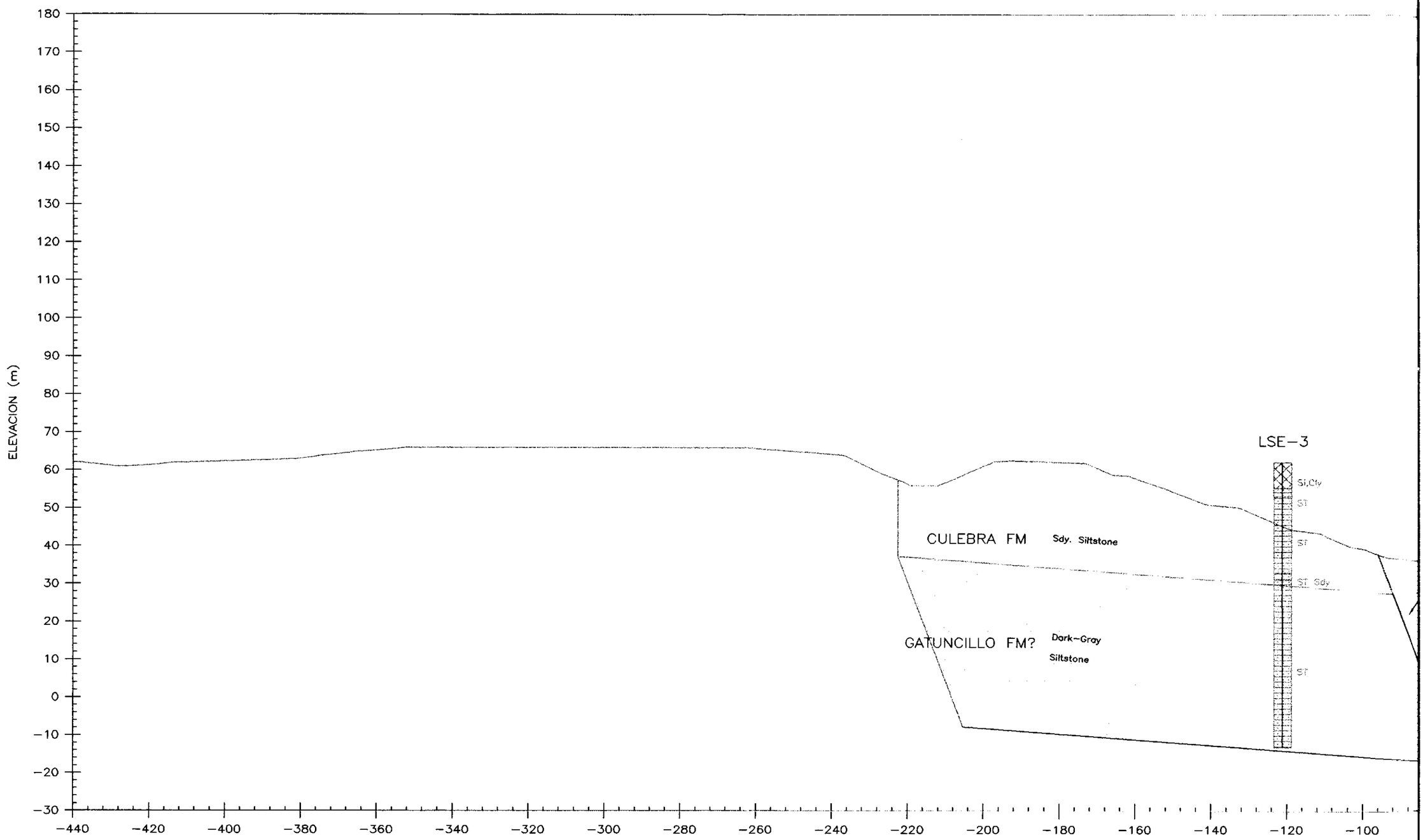


Case 8, Channel bottom = 16 ft, Blasted

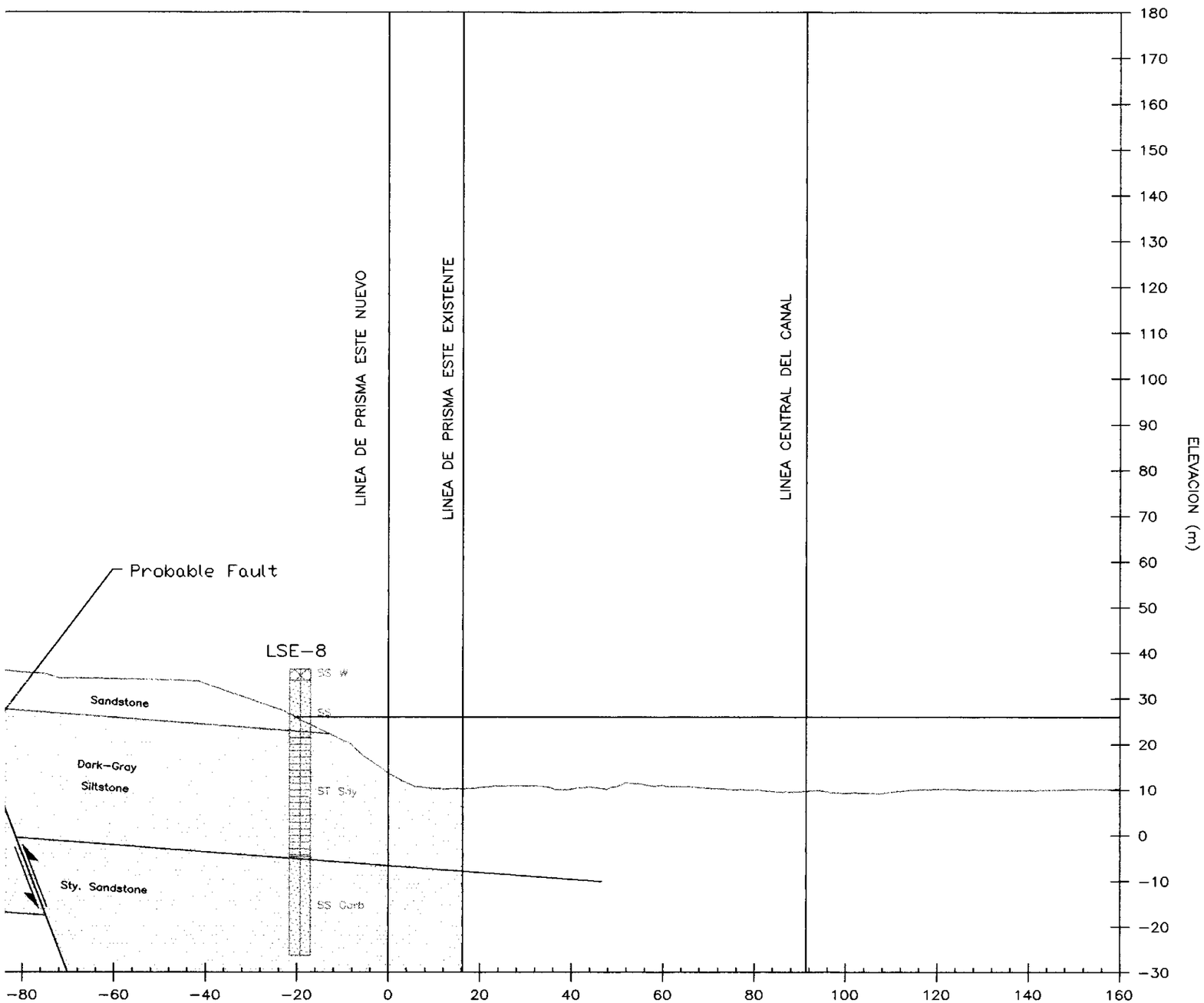


Summary, 57k + 635 (1890 + 91)

General Description	Range of stations:	57k + 320 to 57k + 675			
	Sector:	Summit			
	Maximum height (m):	54			
	Cotangent of slope angle (cot. β):	4.01			
July	Last slide event:	July, 1993 and 1986 (East Lirio Slide)			
Geology	Formation:	Culebra / Gatuncillo			
	Lithology:	Siltstone / Sandstone			
	Critical stratum at toe:	Siltstone			
	Apparent dip of bedding:	Toward the Canal			
Stability Analysis	Critical failure mechanism:	Translational			
	Shear strength model:	Fully softened, Gatuncillo			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.374	1.290	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		1.289	0.999	-0.08
	Case 3: Channel bottom = 27 ft, Blasted & removed		1.281	0.993	-0.70
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.271	0.985	-1.47
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.376	1.271	0.985	-1.47
	Case 5: Channel bottom = 22 ft, Blasted material only		1.280	0.992	-0.78
	Case 6: Channel bottom = 22 ft, Blasted & removed		1.248	0.967	-3.26
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.225	0.950	-5.04
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.378	1.225	0.950	-5.04
	Case 8: Channel bottom = 16 ft, Blasted		1.223	0.948	-5.19
Conclusions:	No stabilization is required				



57K+635 (1890+91)



AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 57K+635 (1890+90) ESTE

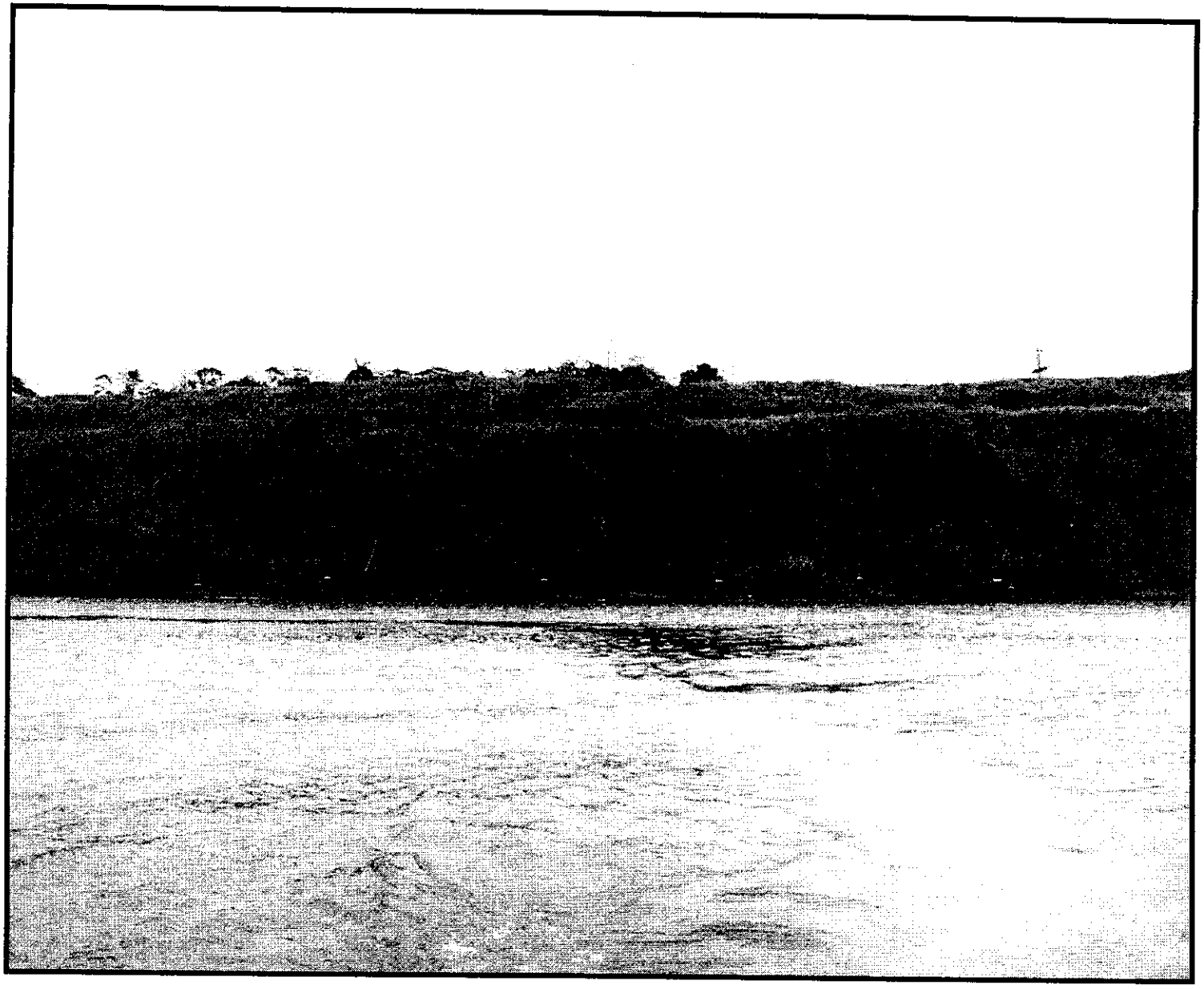
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: M. DE PUY	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 58k + 035 (1904 + 00)

East

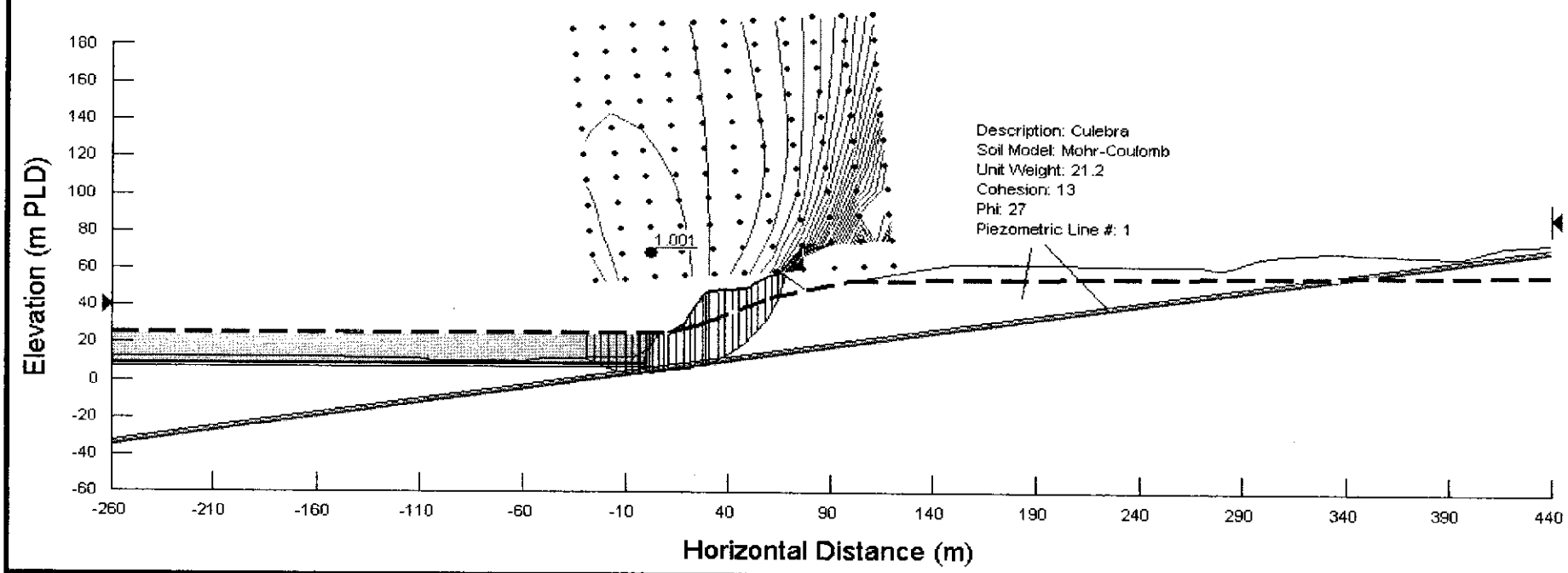
Station: 58k + 035 (Summit)

April 16, 2002



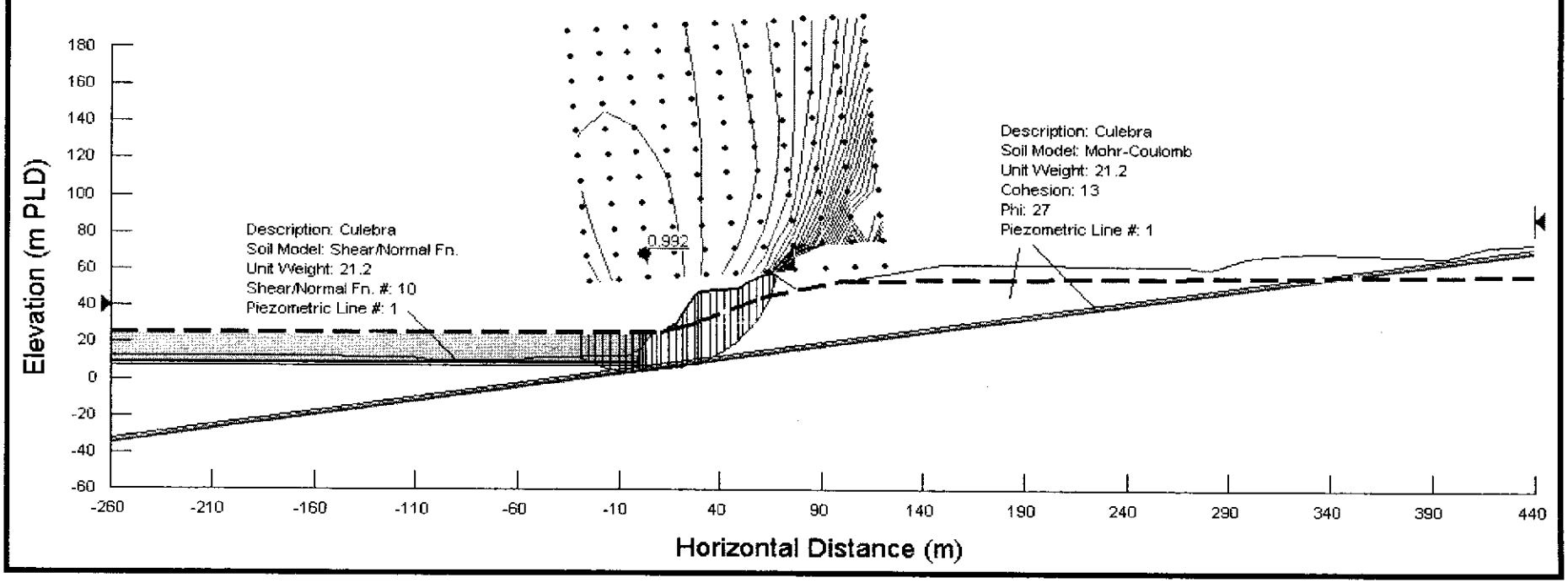
Case 1, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 32 ft (case 1)
File Name: 58K035_1.slz
Last Saved Date: 4/9/02
Last Saved Time: 1:53:48 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



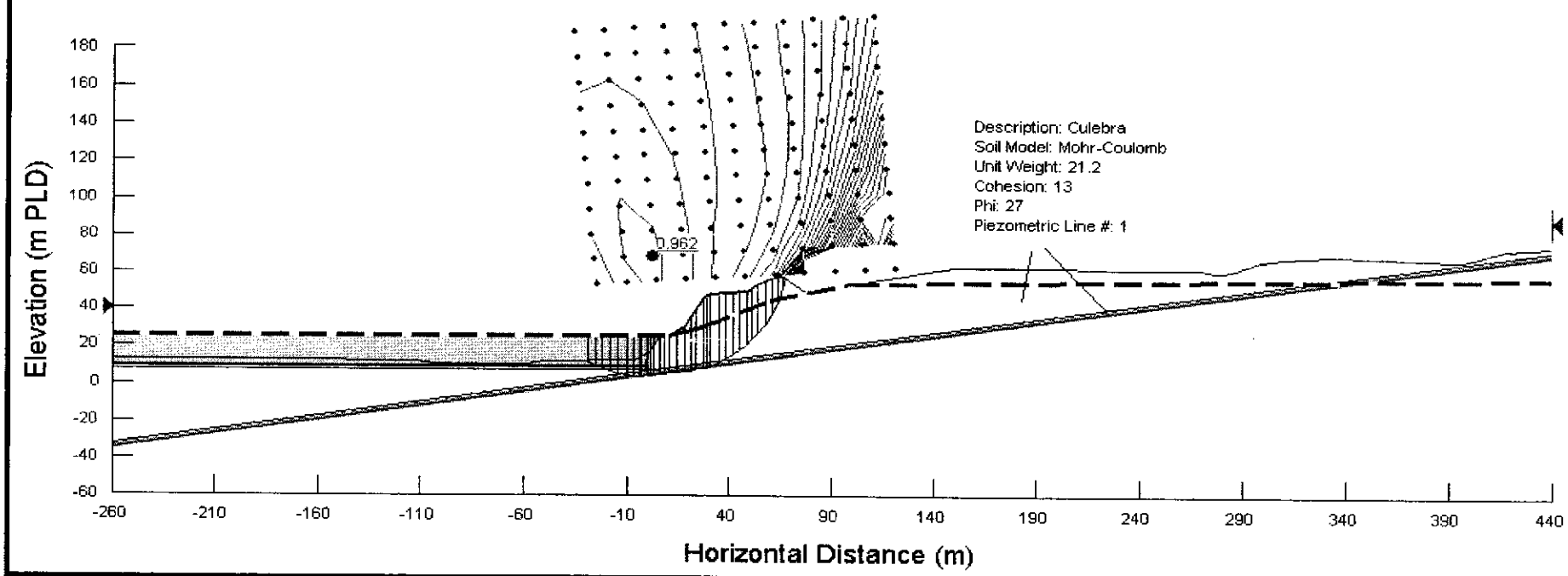
Case 2, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 58K035_2.slz
Last Saved Date: 4/9/02
Last Saved Time: 1:54:45 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



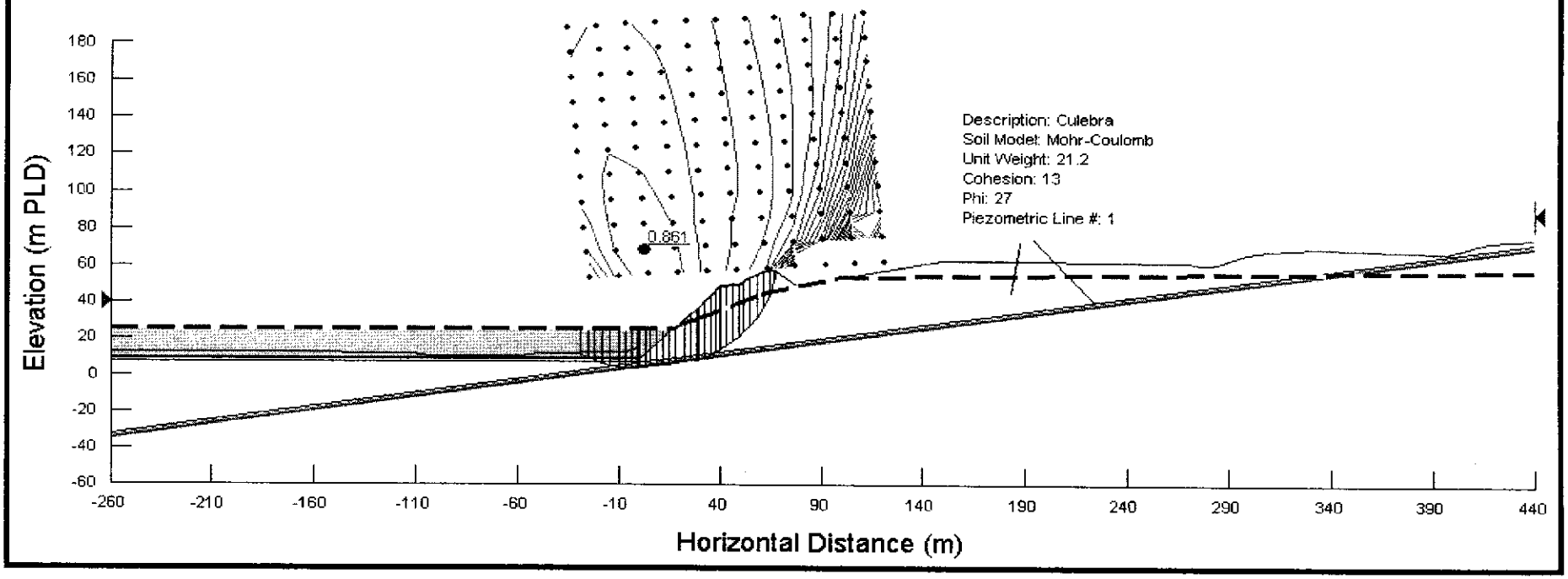
Case 3, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 58K035_3.slz
Last Saved Date: 4/9/02
Last Saved Time: 1:56:32 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



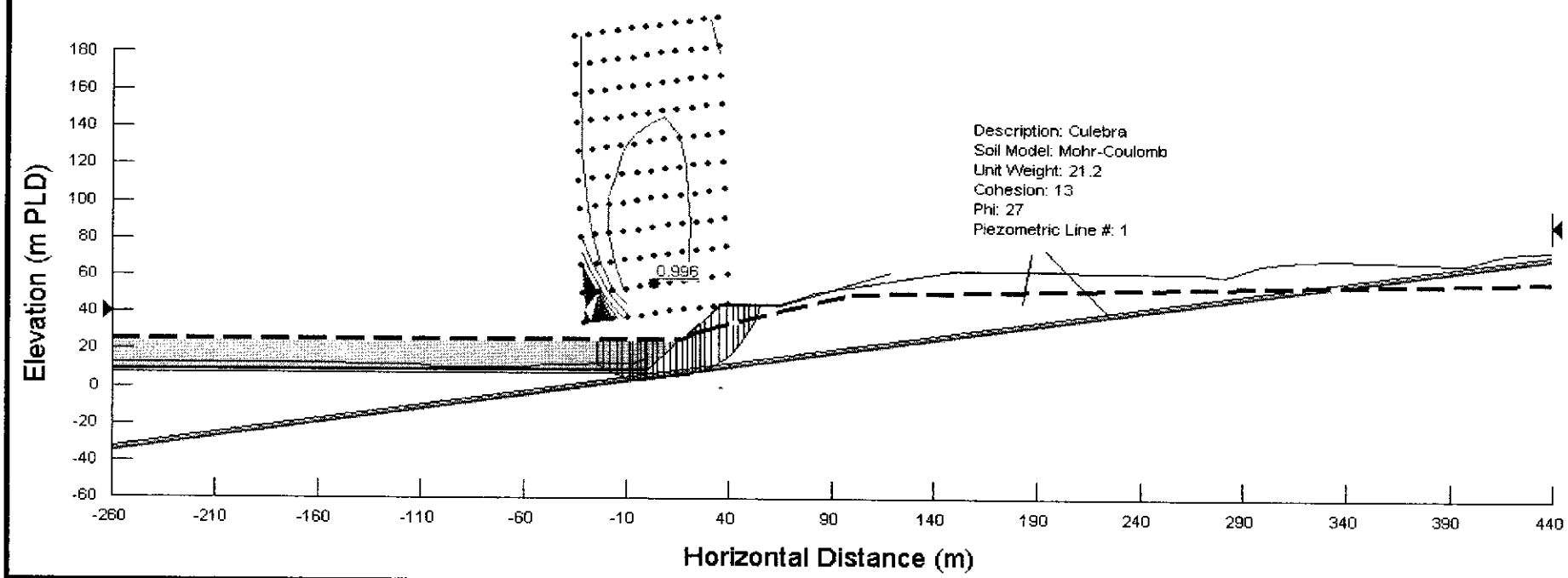
Case 4.1, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 27 ft + design (case 4)
File Name: 58K035_4.slz
Last Saved Date: 4/9/02
Last Saved Time: 2:10:58 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



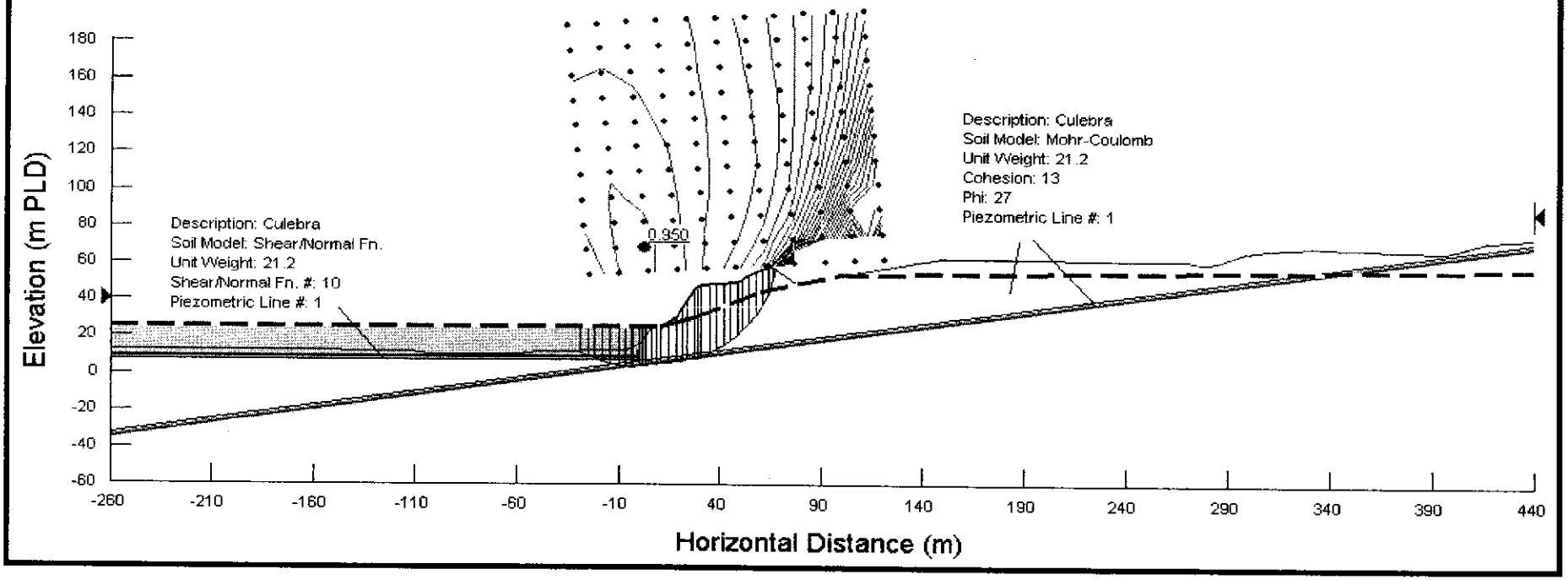
Case 4.2, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 27 ft + design (case 4)
File Name: 58K035_4e.slz
Last Saved Date: 4/9/02
Last Saved Time: 3:48:36 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



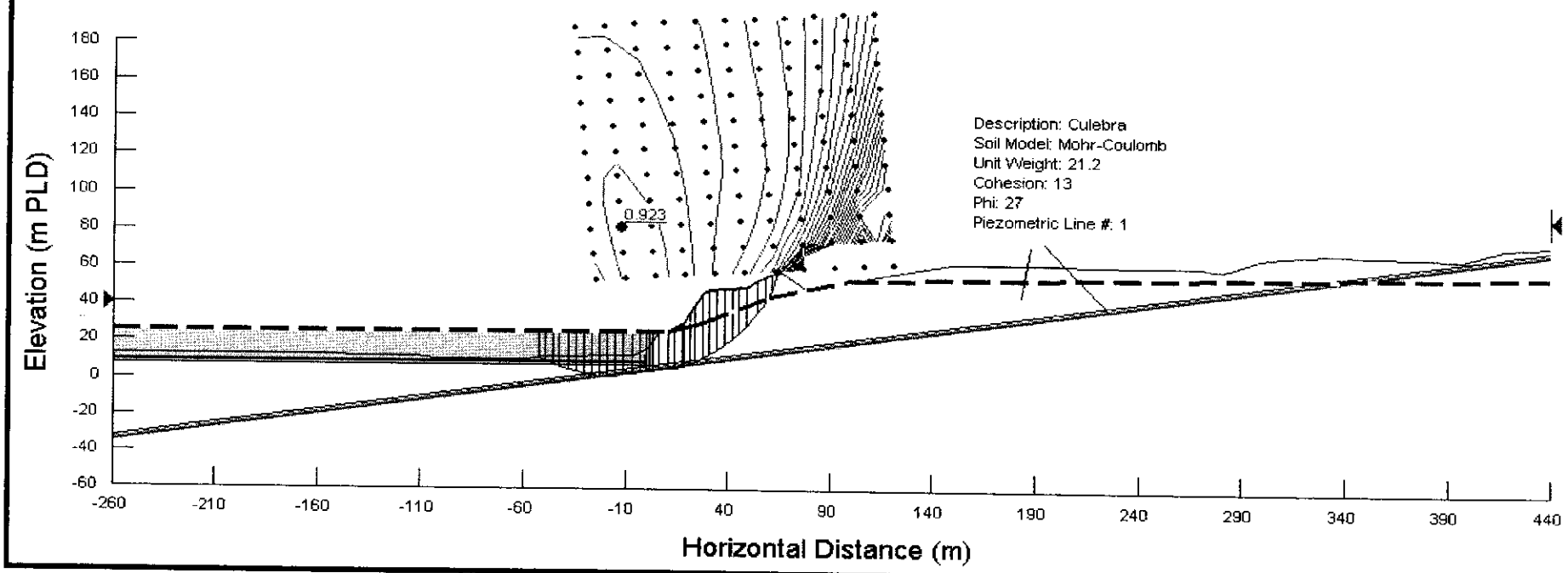
Case 5, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 58K035_5.slz
Last Saved Date: 4/9/02
Last Saved Time: 1:57:43 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



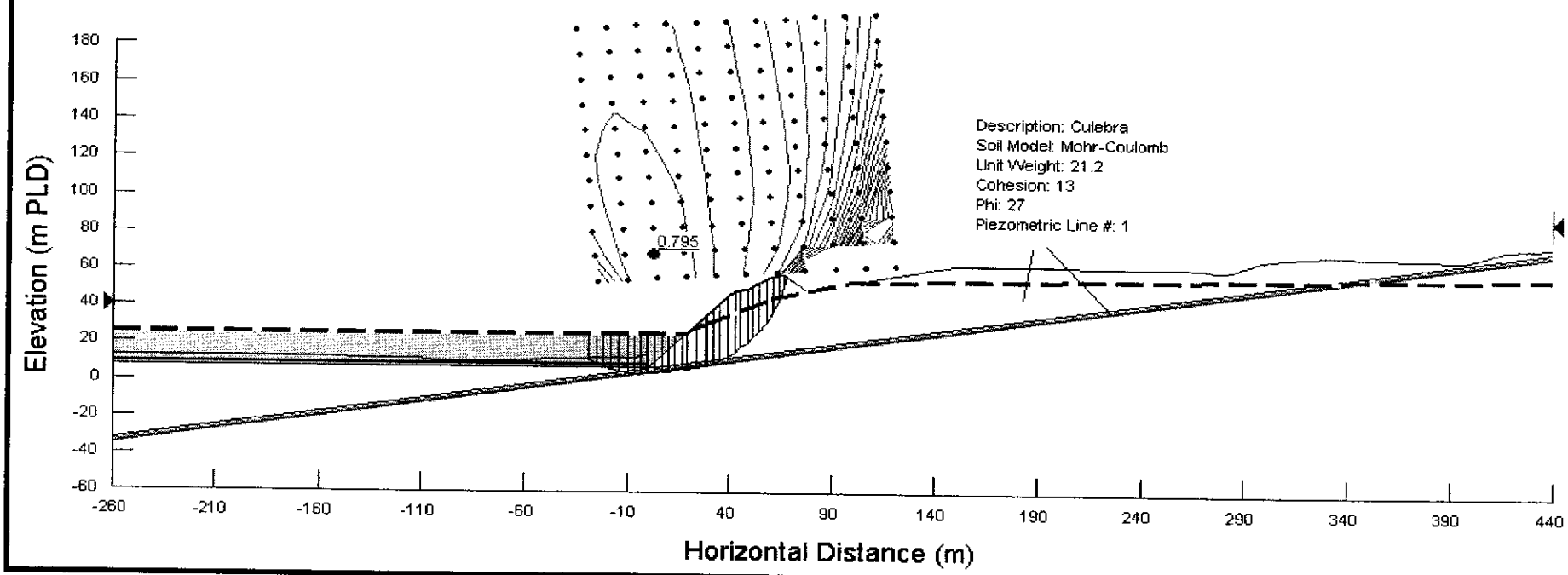
Case 6, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 58K035_6.slz
Last Saved Date: 4/9/02
Last Saved Time: 2:01:03 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



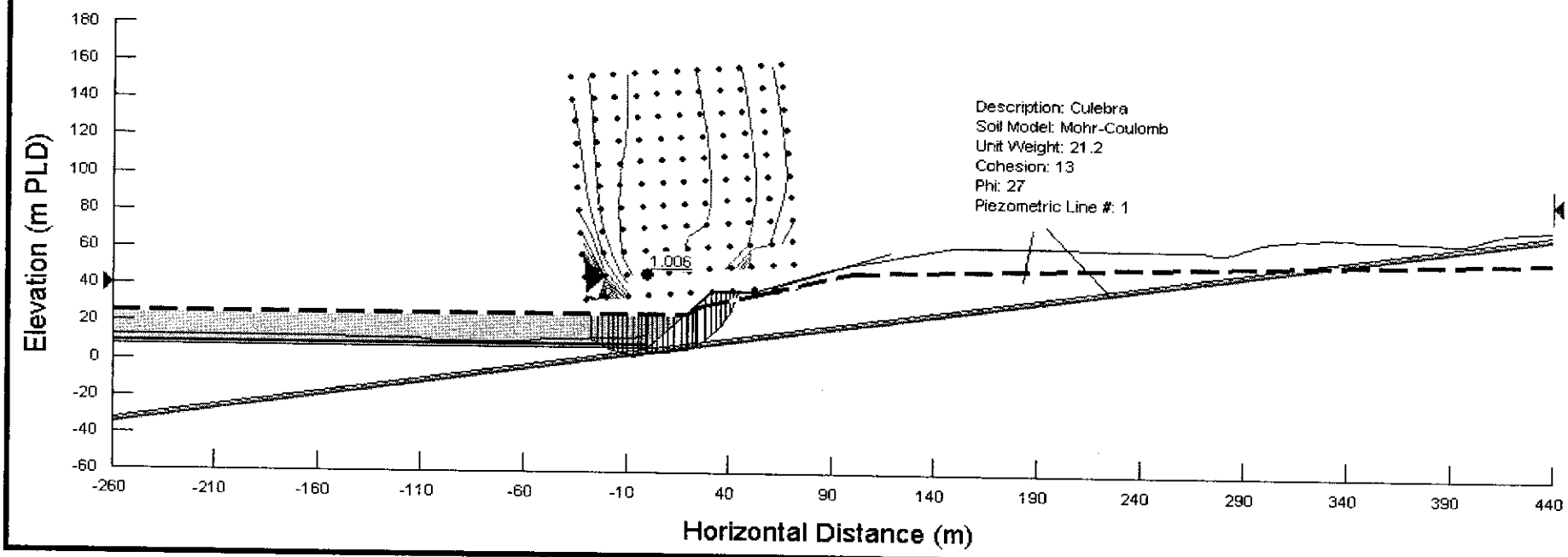
Case 7.1, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 22 ft + design (case 7)
File Name: 58K035_7.slz
Last Saved Date: 4/9/02
Last Saved Time: 2:19:22 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



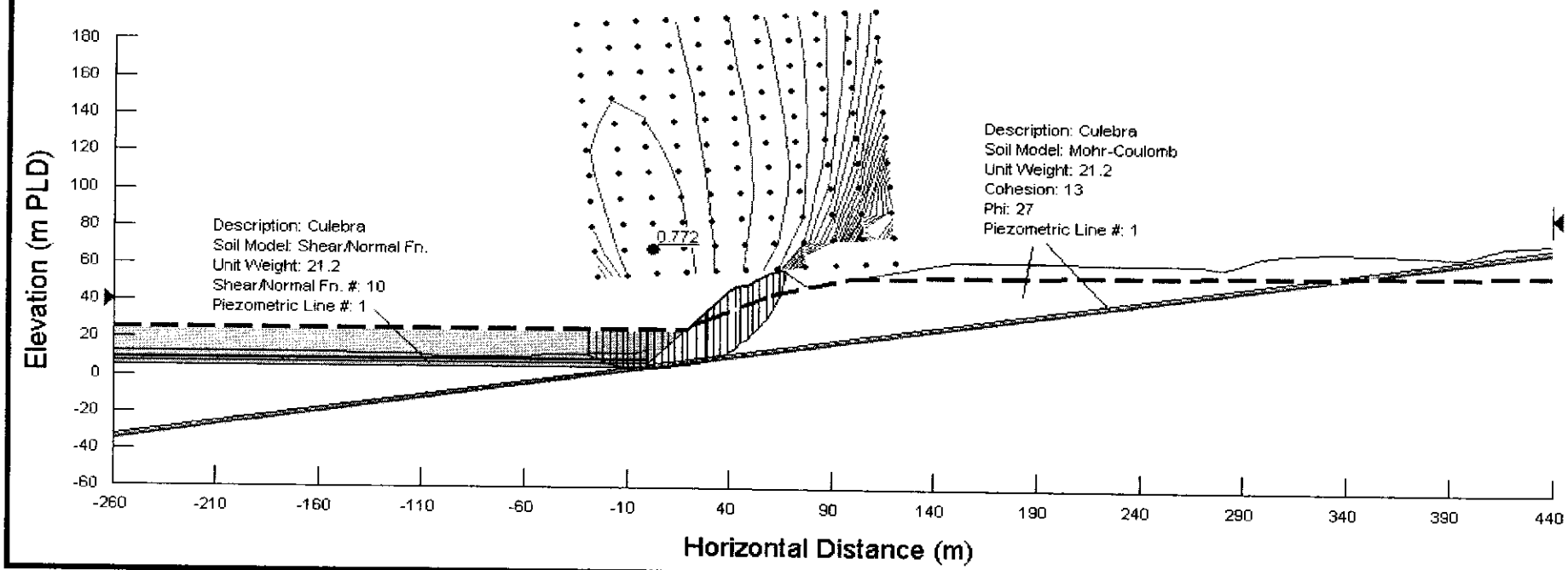
Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 22 ft + design (case 7)
File Name: 58K035_7e.slz
Last Saved Date: 4/9/02
Last Saved Time: 4:09:05 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 8, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 58K+035 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 58K035_8.slz
Last Saved Date: 4/9/02
Last Saved Time: 2:48:49 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

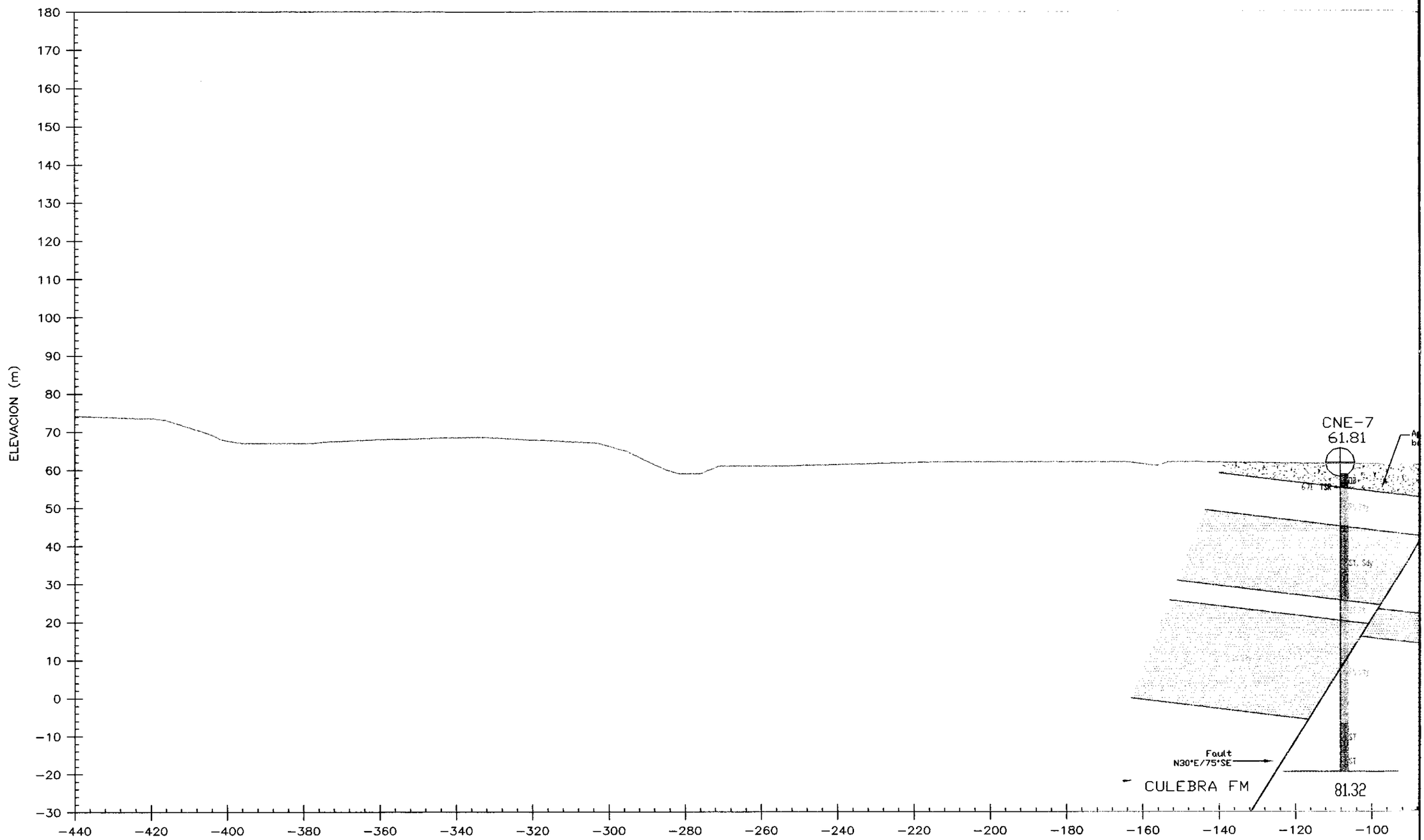


Summary, 58k + 035 (1904 + 00)

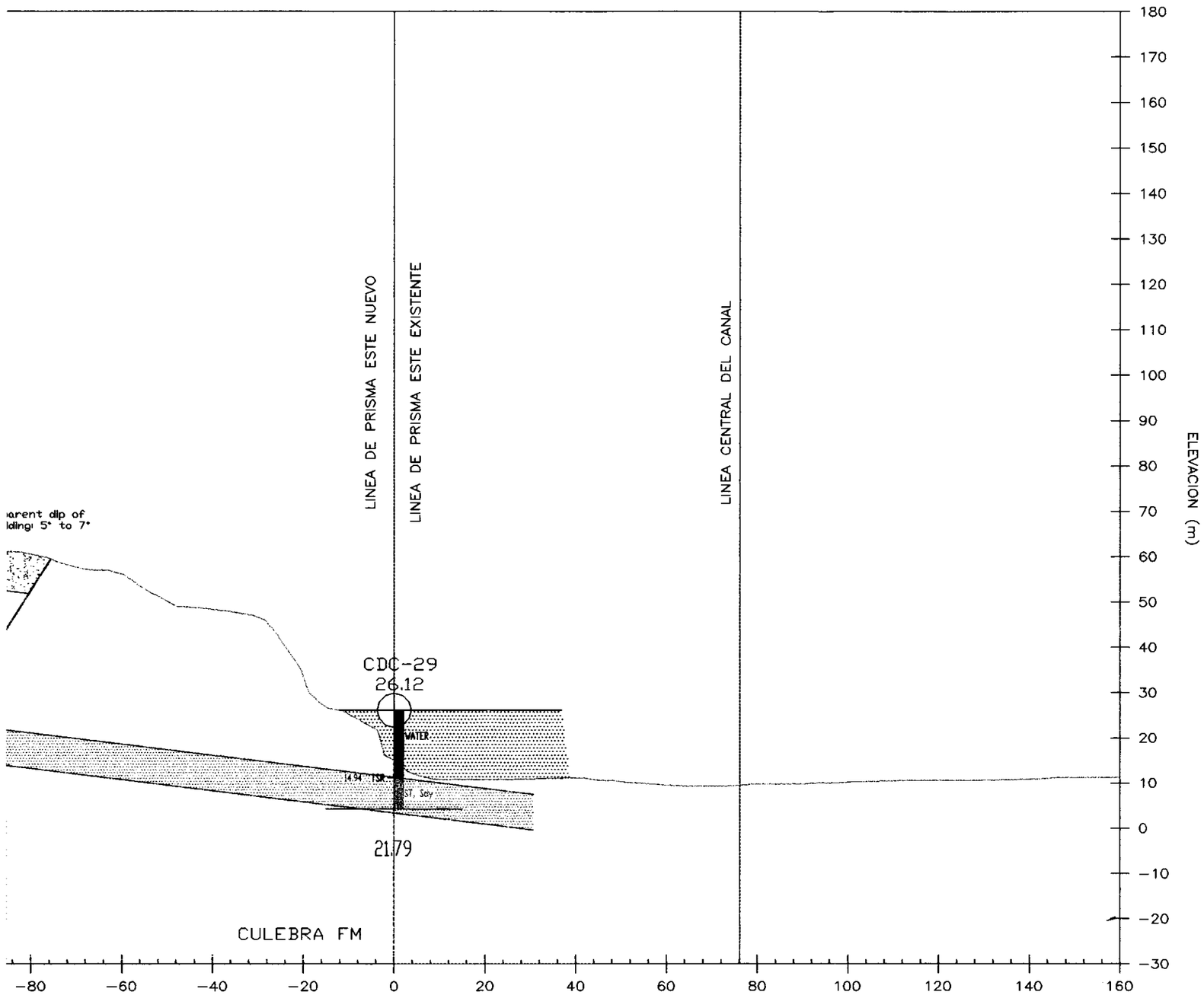
General Description	Range of stations:	57k + 675 to 58k + 295
	Sector:	Summit
	Maximum height (m):	50
	Cotangent of slope angle (cot. β):	2.16
History	Last slide event:	No know slide in this area
Geology	Formation:	Culebra
	Lithology:	Sandstone / Siltstone
	Critical stratum at toe:	Silty Sandstone
	Apparent dip of bedding:	Toward the slope
Stability Analysis	Critical failure mechanism:	Translational along bedding
	Shear strength model:	Derived from back analysis (∅ =27, c=13 kpa)

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
Case 1: Channel bottom = 32 ft	0.321	1.001	1.000	0.00
Case 2: Channel bottom = 27 ft, Blasted material only		0.992	0.991	-0.90
Case 3: Channel bottom = 27 ft, Blasted & removed		0.962	0.961	-3.90
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		0.861	0.860	-13.99
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.357	0.996	0.995	-0.50
Case 5: Channel bottom = 22 ft, Blasted material only		0.950	0.949	-5.09
Case 6: Channel bottom = 22 ft, Blasted & removed		0.923	0.922	-7.79
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		0.795	0.794	-20.58
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.394	1.006	1.005	0.50
Case 8: Channel bottom = 16 ft, Blasted		0.772	0.771	-22.88

Conclusions: Stabilization is required for Case 4 and Case 7



58K+035 (1904+00)



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SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 58K+035 (1904+00) ESTE

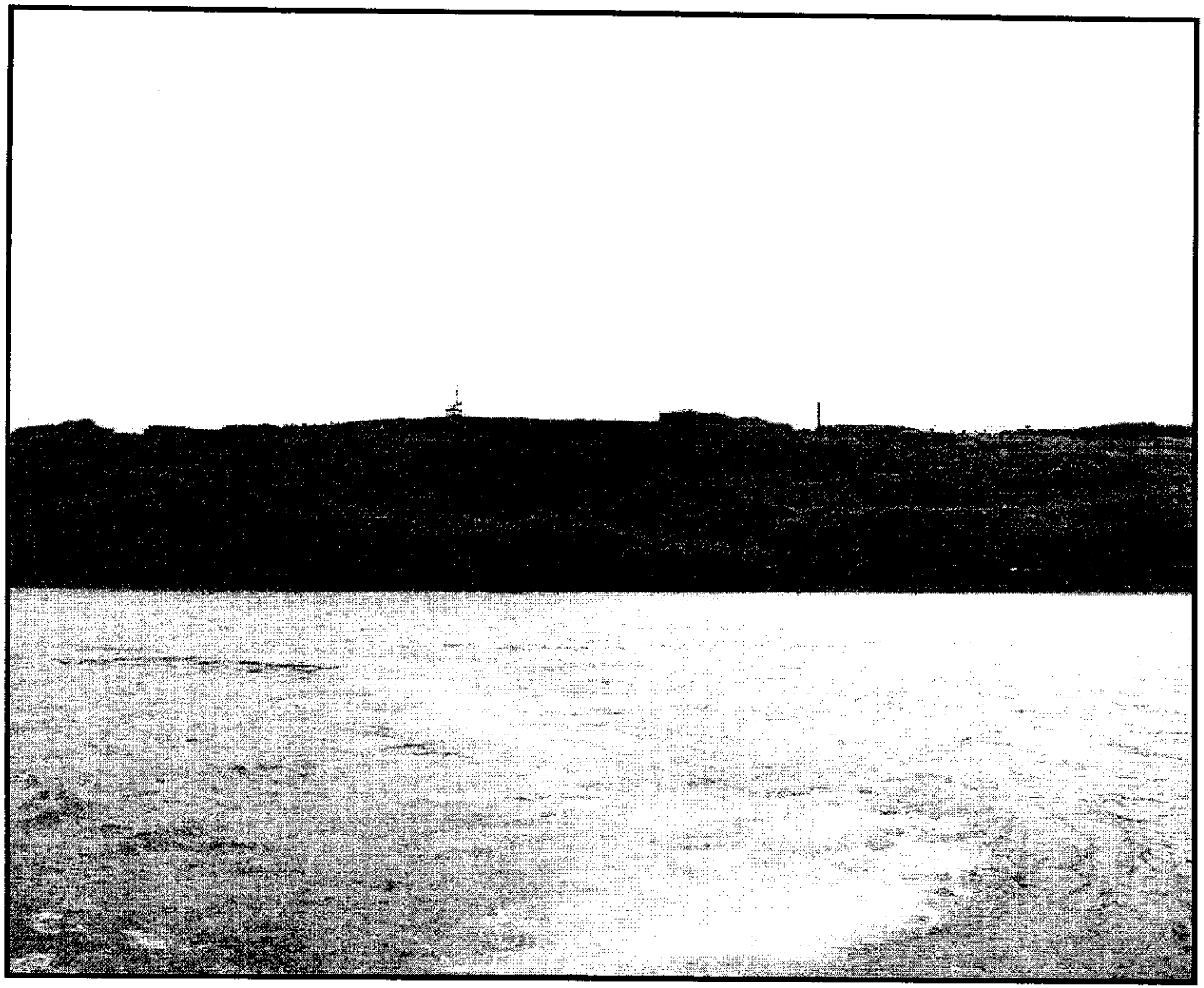
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: P. FRANCESCHI	DIBUJADO POR: J. RAMESCH

station 58k + 520 (1920 + 00)

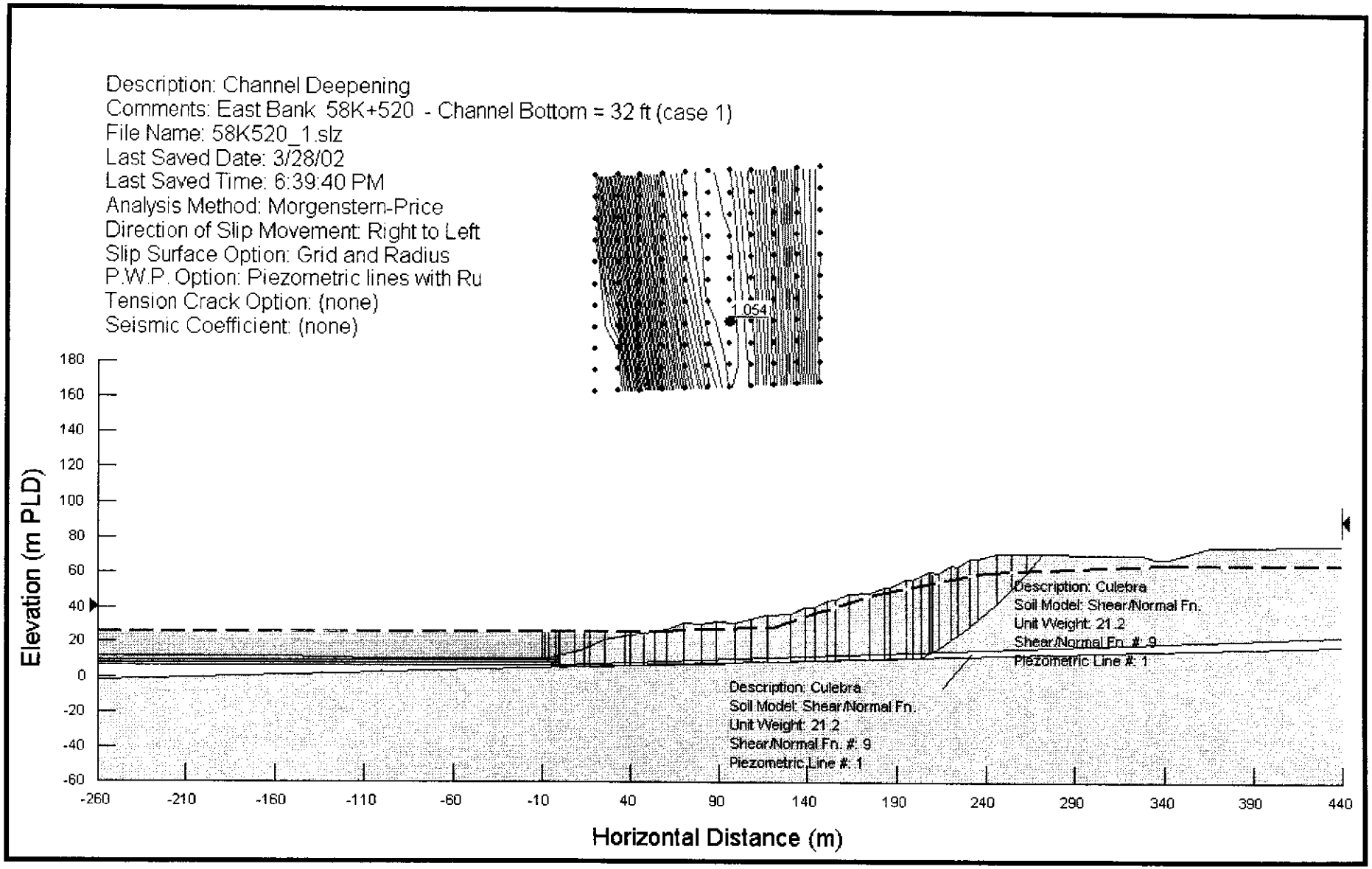
East

Station: 58k + 520 (Culebra)

April 16, 2002

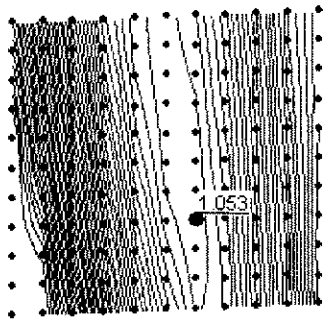


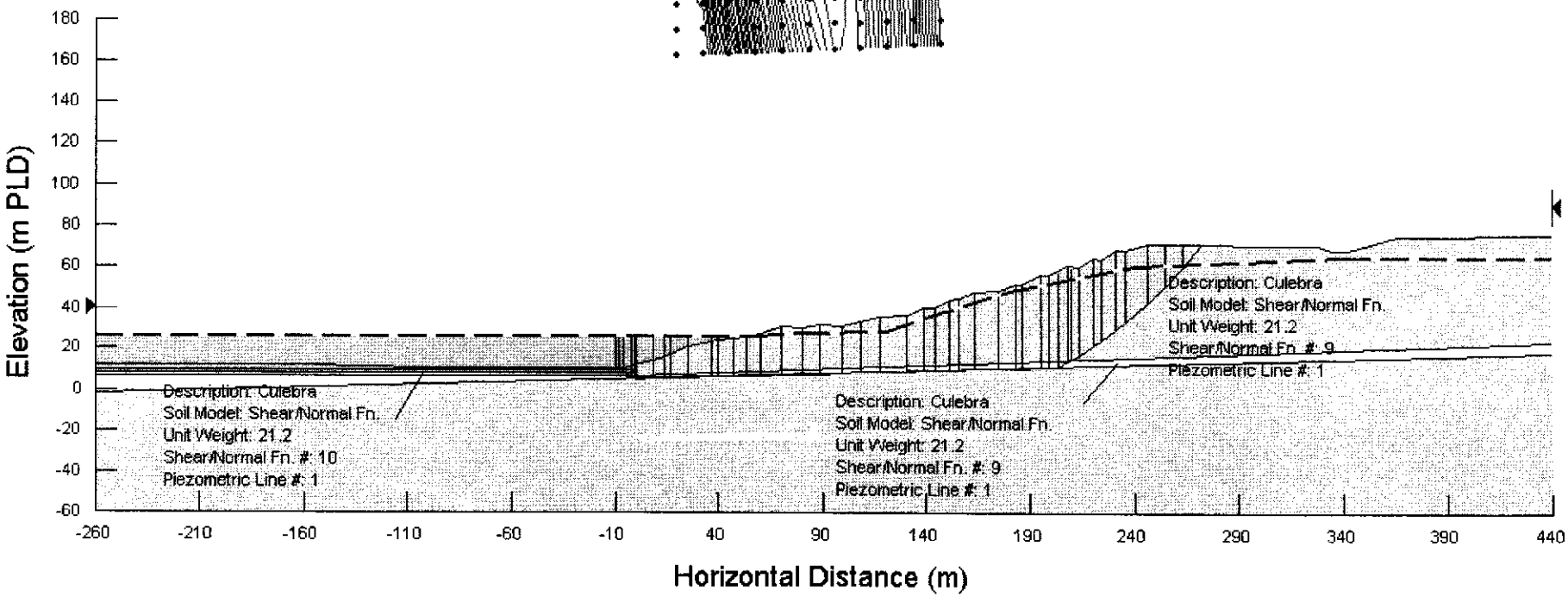
Case 1, Channel bottom = 32 ft



Case 2, Channel bottom = 27 ft, Blasted material only

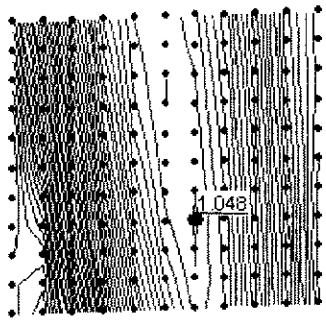
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 58K520_2.slz
Last Saved Date: 3/28/02
Last Saved Time: 6:53:12 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

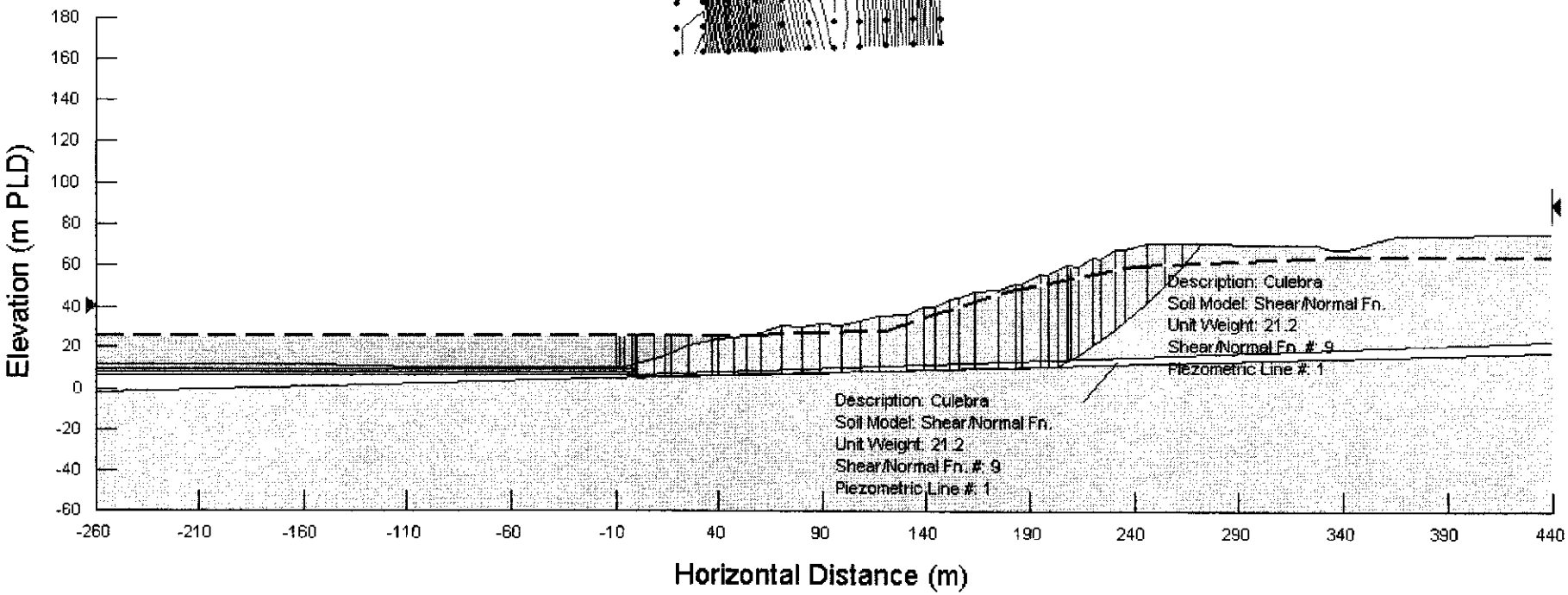




Case 3, Channel bottom = 27 ft, Blasted & removed

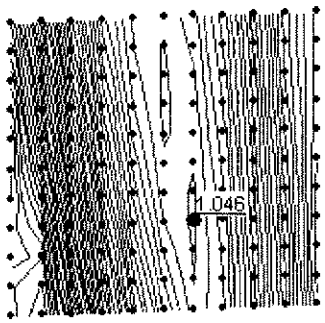
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 58K520_3.slz
Last Saved Date: 3/28/02
Last Saved Time: 6:57:53 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

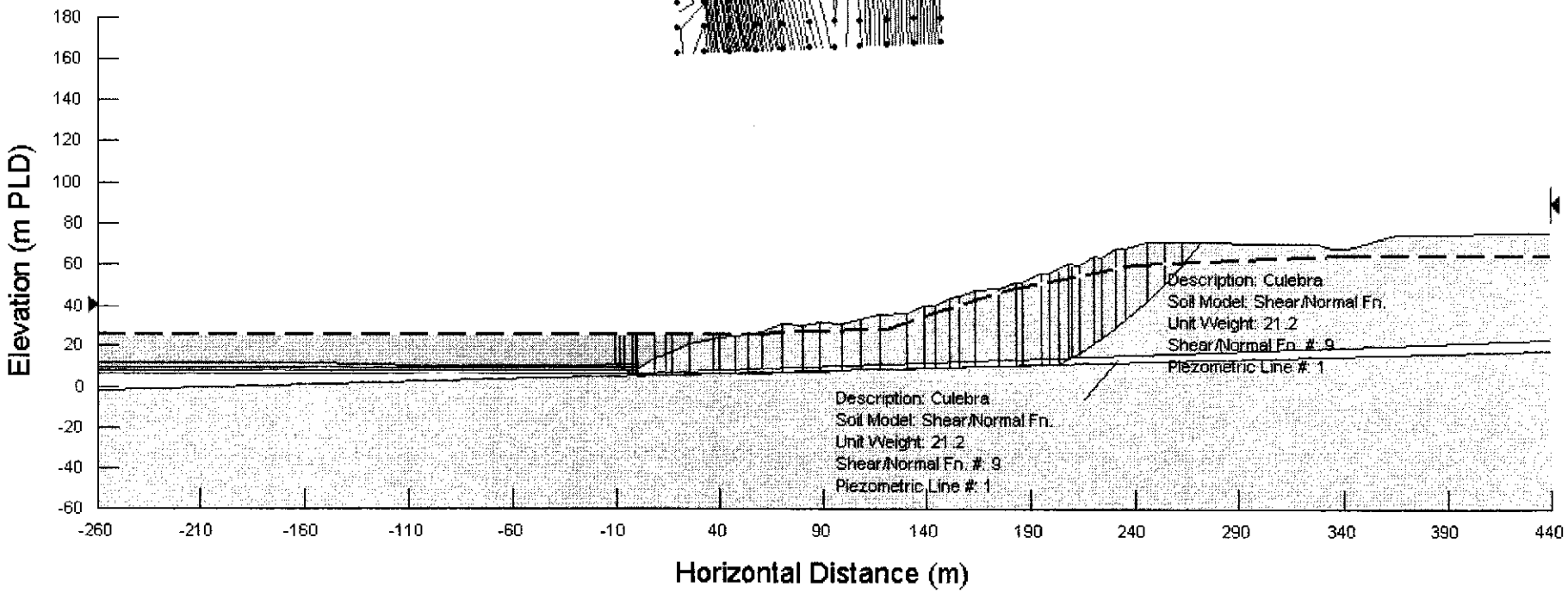




Case 4, Channel bottom = 27 ft, Design (underwater slope)

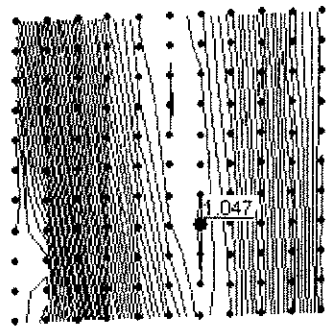
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 27 ft + design (case 4)
File Name: 58K520_4.slz
Last Saved Date: 4/3/02
Last Saved Time: 10:31:43 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

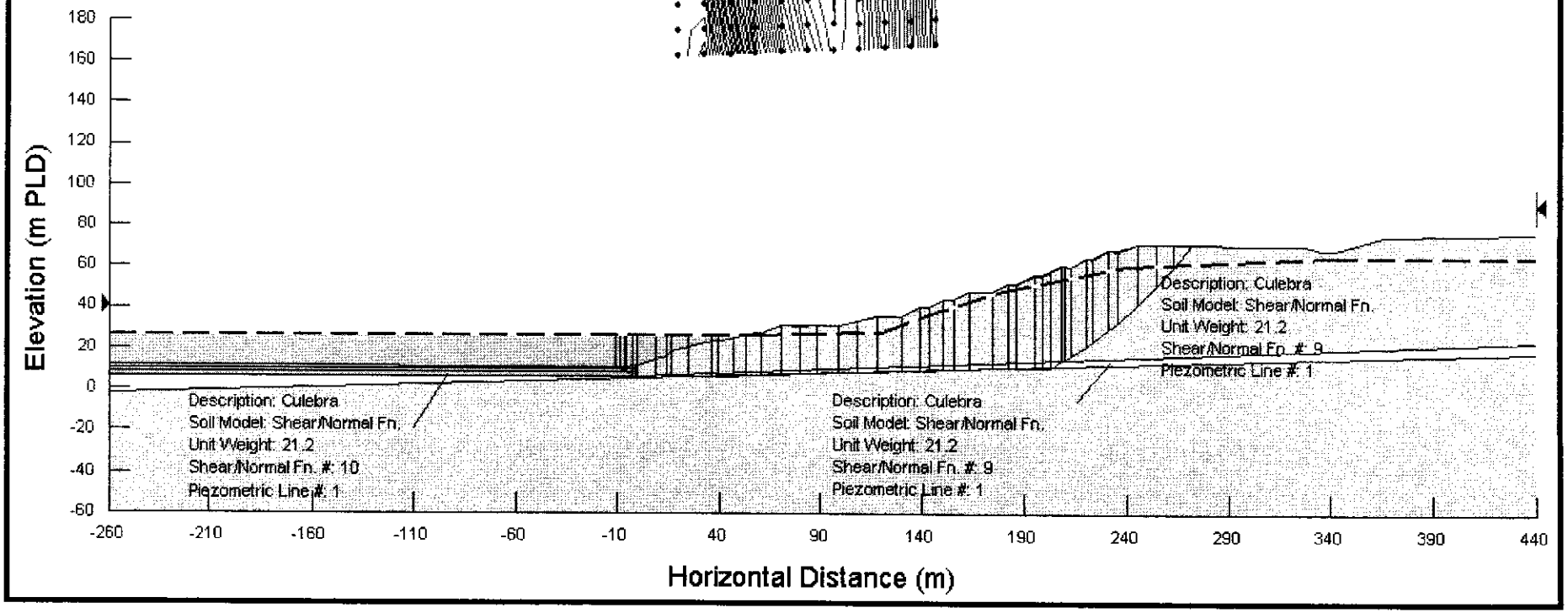




Case 5, Channel bottom = 22 ft, Blasted material only

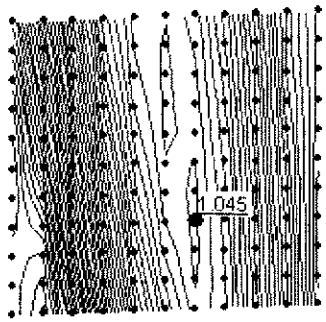
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 58K520_5.slz
Last Saved Date: 3/28/02
Last Saved Time: 7:07:49 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

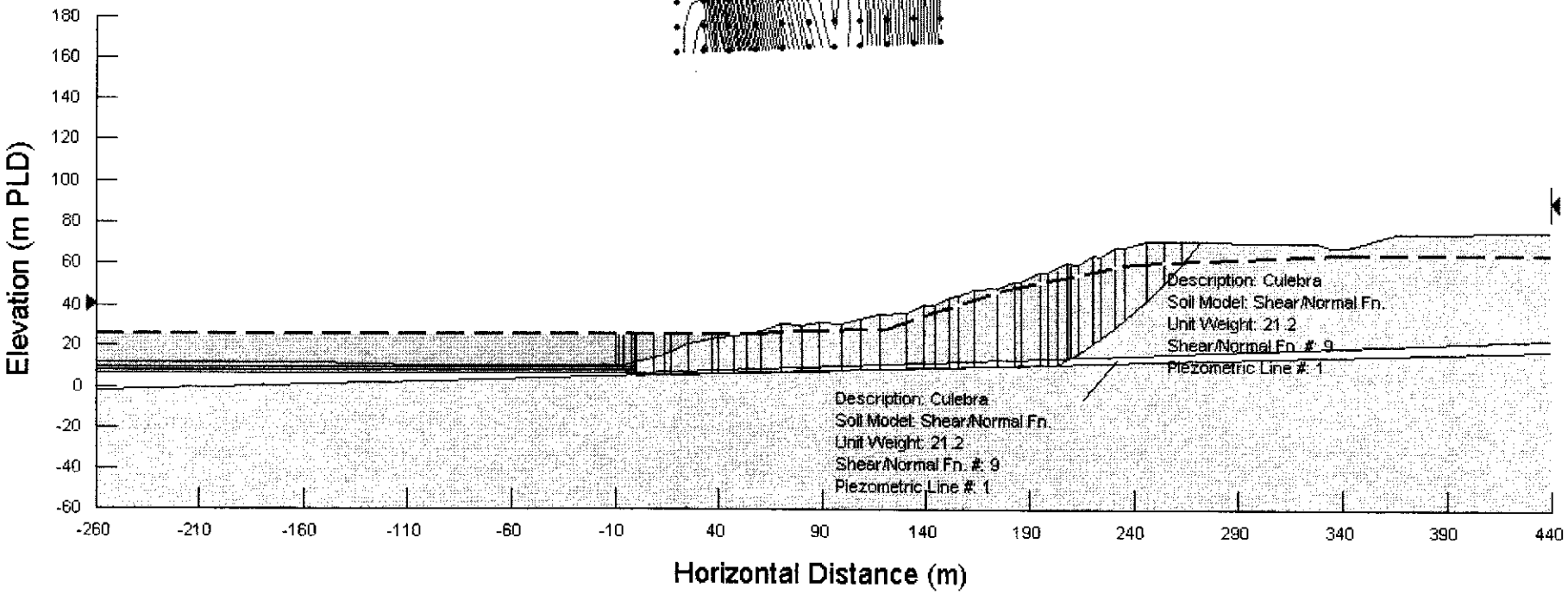




Case 6, Channel bottom = 22 ft, Blasted & removed

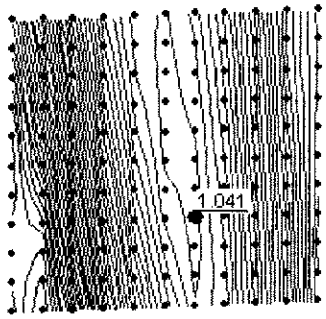
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 58K520_6.slz
Last Saved Date: 3/28/02
Last Saved Time: 7:10:15 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

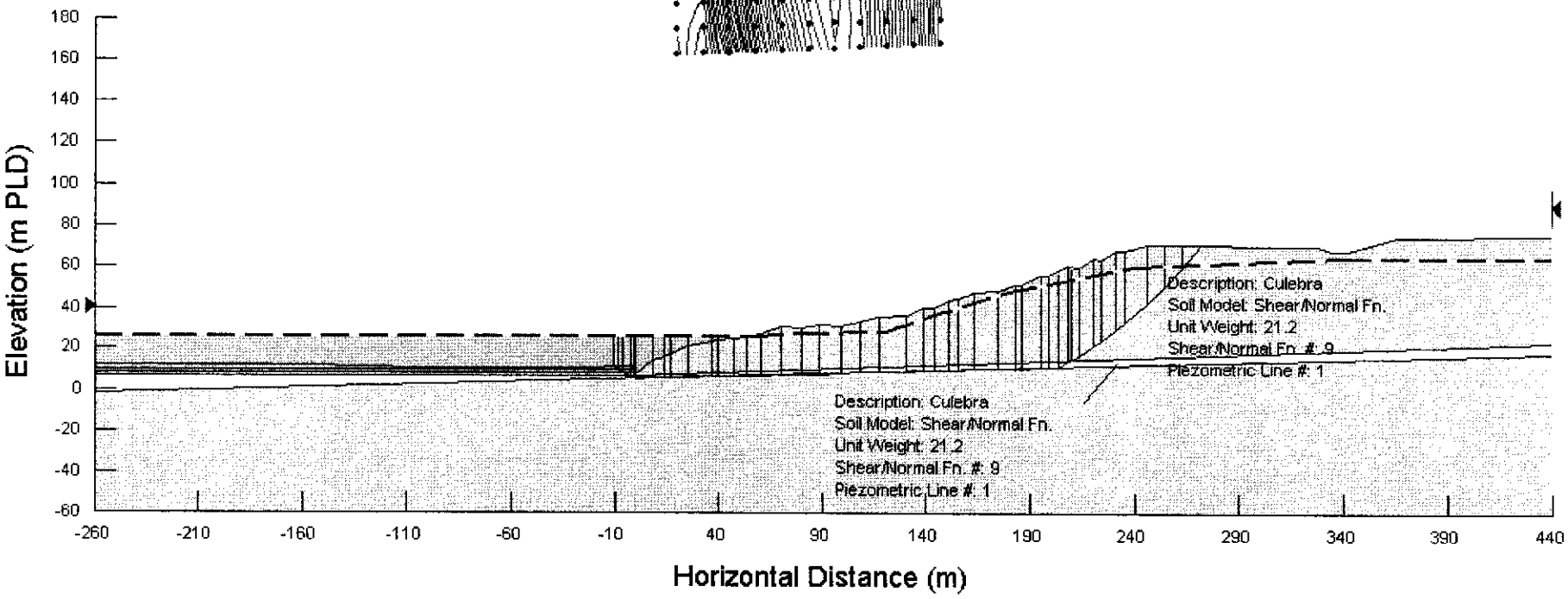




Case 7.1, Channel bottom = 27 ft, Design (underwater slope)

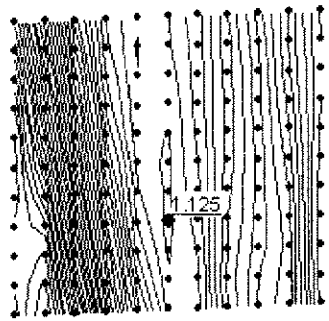
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 22 ft + design (case 7)
File Name: 58K520_7.slz
Last Saved Date: 4/3/02
Last Saved Time: 10:34:41 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

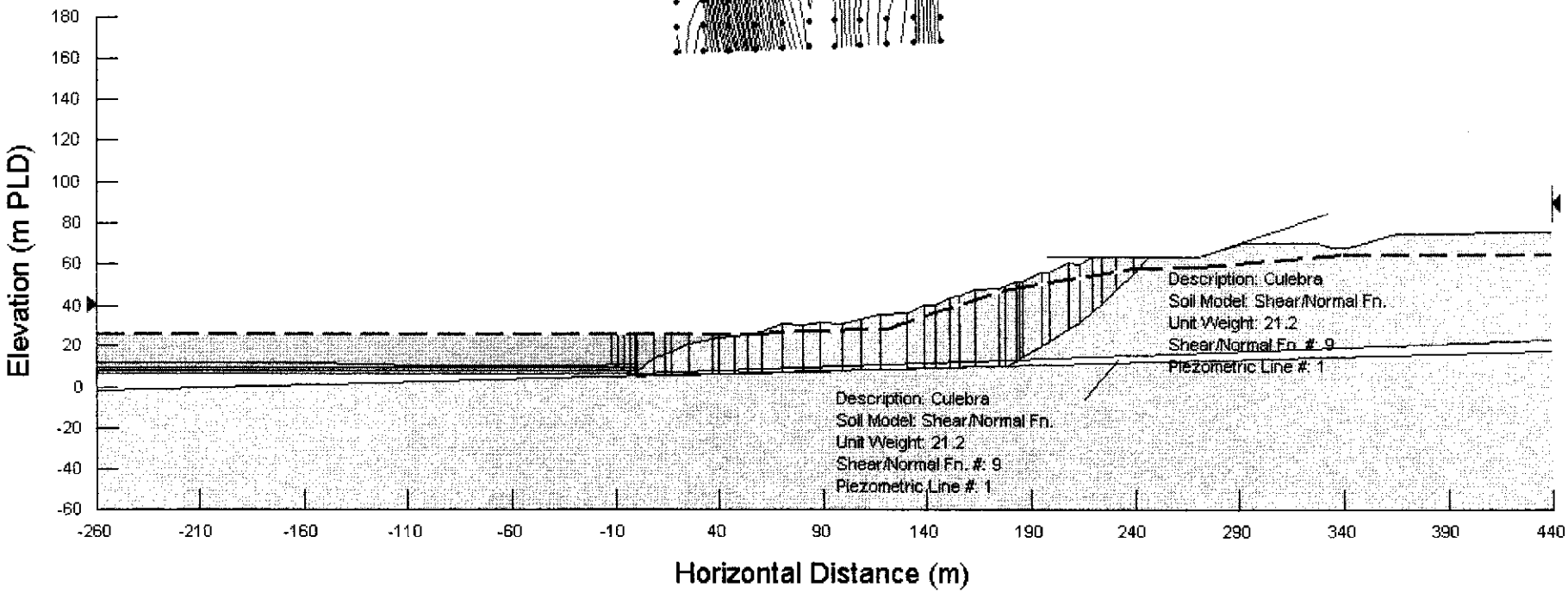




Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)

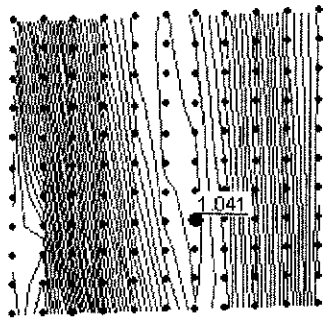
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 22 ft + design (case 7)
File Name: 58K520_7e.slz
Last Saved Date: 4/7/02
Last Saved Time: 4:01:17 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

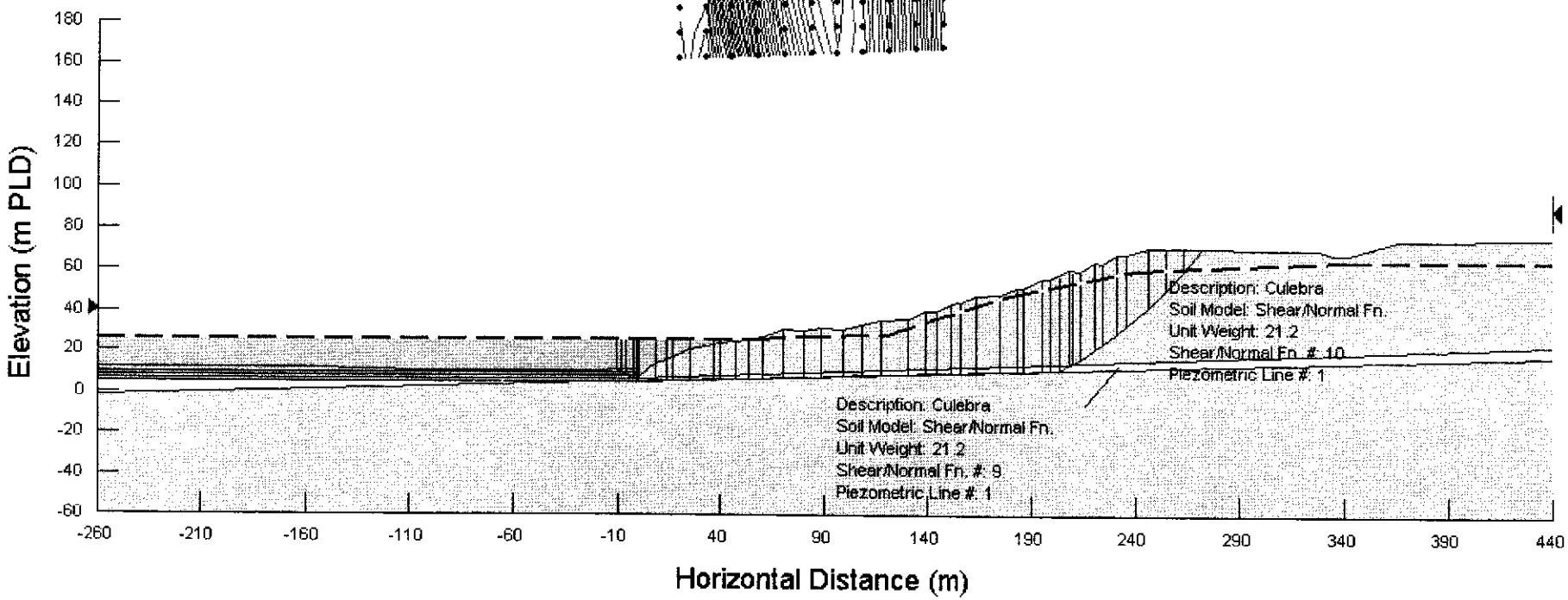




Case 8, Channel bottom = 16 ft, Blasted

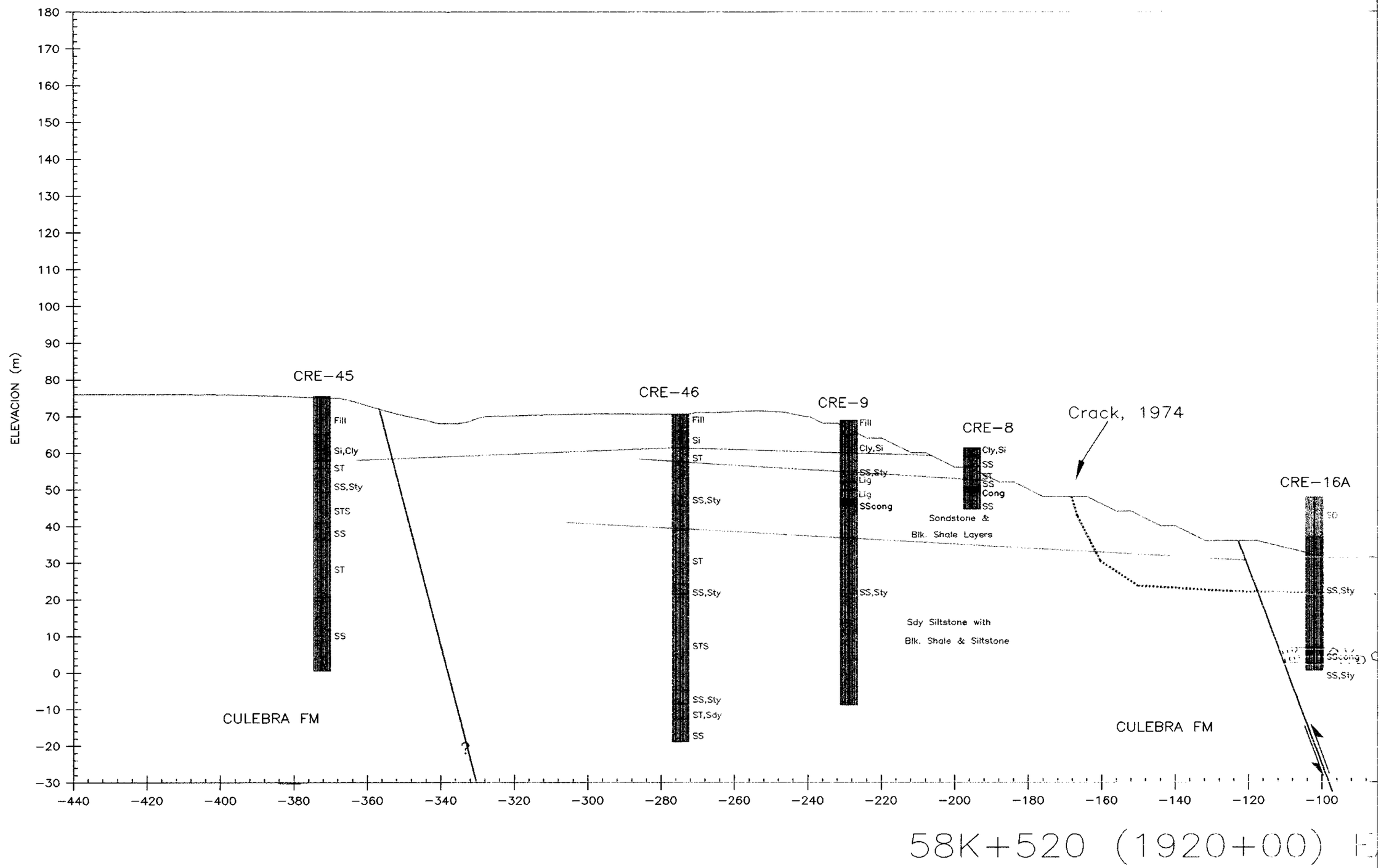
Description: Channel Deepening
Comments: East Bank 58K+520 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 58K520_8.slz
Last Saved Date: 4/7/02
Last Saved Time: 6:21:49 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

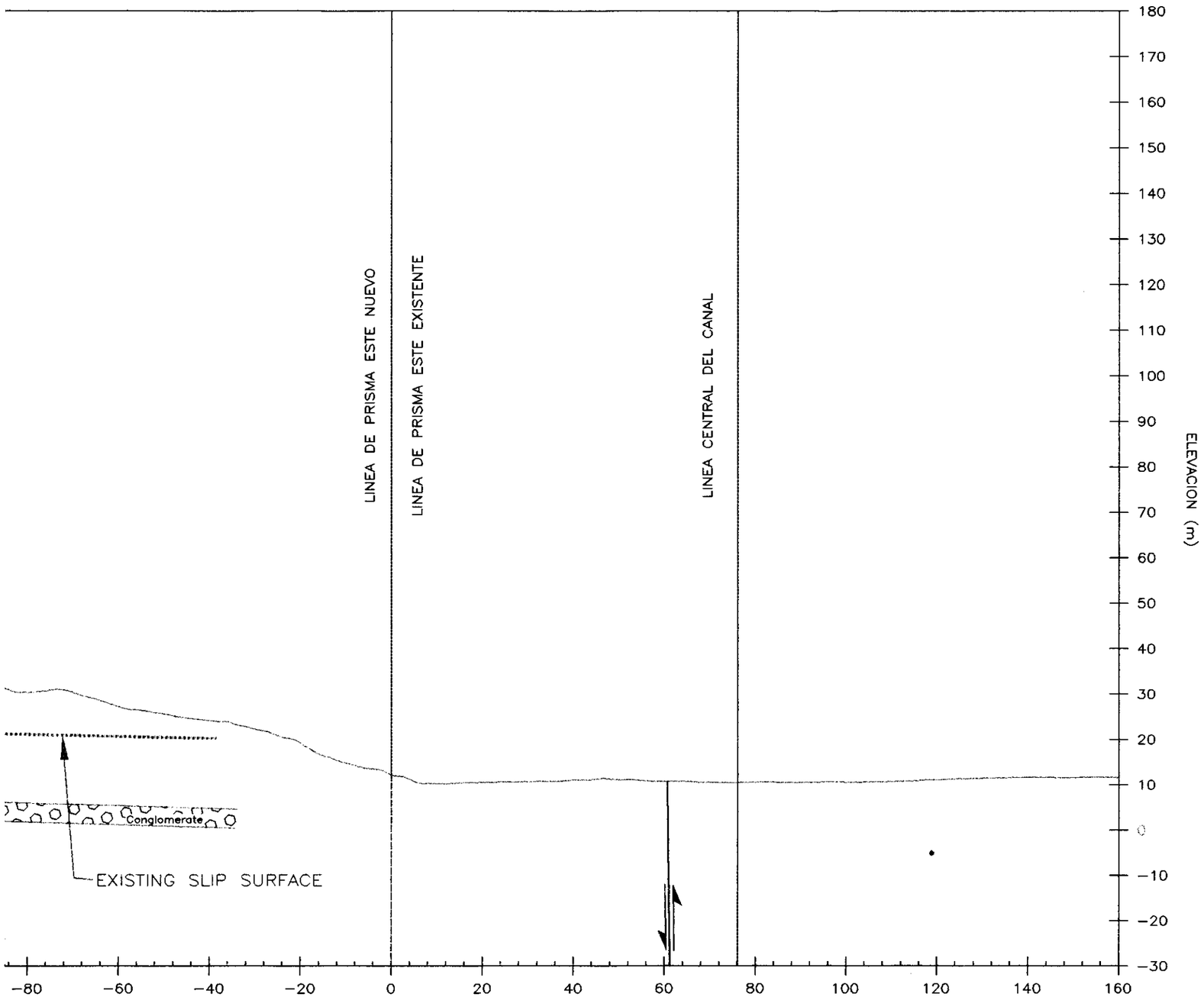




Summary, 58k + 520 (1920 + 00)

General Description	Range of stations:	58k + 295 to 59k + 600			
	Sector:	Culebra			
	Maximum height (m):	66			
	Cotangent of slope angle (cot. β):	7.11			
History	Last slide event:	December 9, 1998 (North East Culebra Slide)			
Geology	Formation:	Culebra			
	Lithology:	Shale / Sandstone / siltstone / Conglomerate			
	Critical stratum at toe:	Sandy siltstone with black shale			
	Apparent dip of bedding:	Toward the Canal			
Stability Analysis	Critical failure mechanism:	Translational			
	Shear strength model:	Fully softened, Culebra			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.371	1.054	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		1.053	0.999	-0.09
	Case 3: Channel bottom = 27 ft, Blasted & removed		1.048	0.994	-0.57
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.046	0.992	-0.76
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.383	1.046	0.992	-0.76
	Case 5: Channel bottom = 22 ft, Blasted material only		1.047	0.993	-0.66
	Case 6: Channel bottom = 22 ft, Blasted & removed		1.045	0.991	-0.85
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.041	0.988	-1.23
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.388	1.125	1.067	6.74
	Case 8: Channel bottom = 16 ft, Blasted		1.041	0.988	-1.23
Conclusions:	Stabilization is required for Case 7				


ELEVACION (m)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−440
−420
−400
−380
−360
−340
−320
−300
−280
−260
−240
−220
−200
−180
−160
−140
−120
−100
CRE−45
Fill
Si,Cly
ST
SS,Sty
STS
SS
ST
SS
CULEBRA FM
CRE−46
Fill
Si
ST
SS,Sty
ST
SS,Sty
STS
SS,Sty
ST,Sdy
SS
CRE−9
Fill
Cly,Si
SS,Sty
Lig
Lig
SScong
SS,Sty
Sdy Siltstone with
Blk. Shale & Siltstone
CRE−8
Cly,Si
SS
ST
SS
Cong
SS
Sandstone &
Blk. Shale Layers
Crack, 1974
CRE−16A
SD
SS,Sty
SScong
SS,Sty
CULEBRA FM
58K+520 (1920+00)



AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 58K+520 (1920+00) ESTE

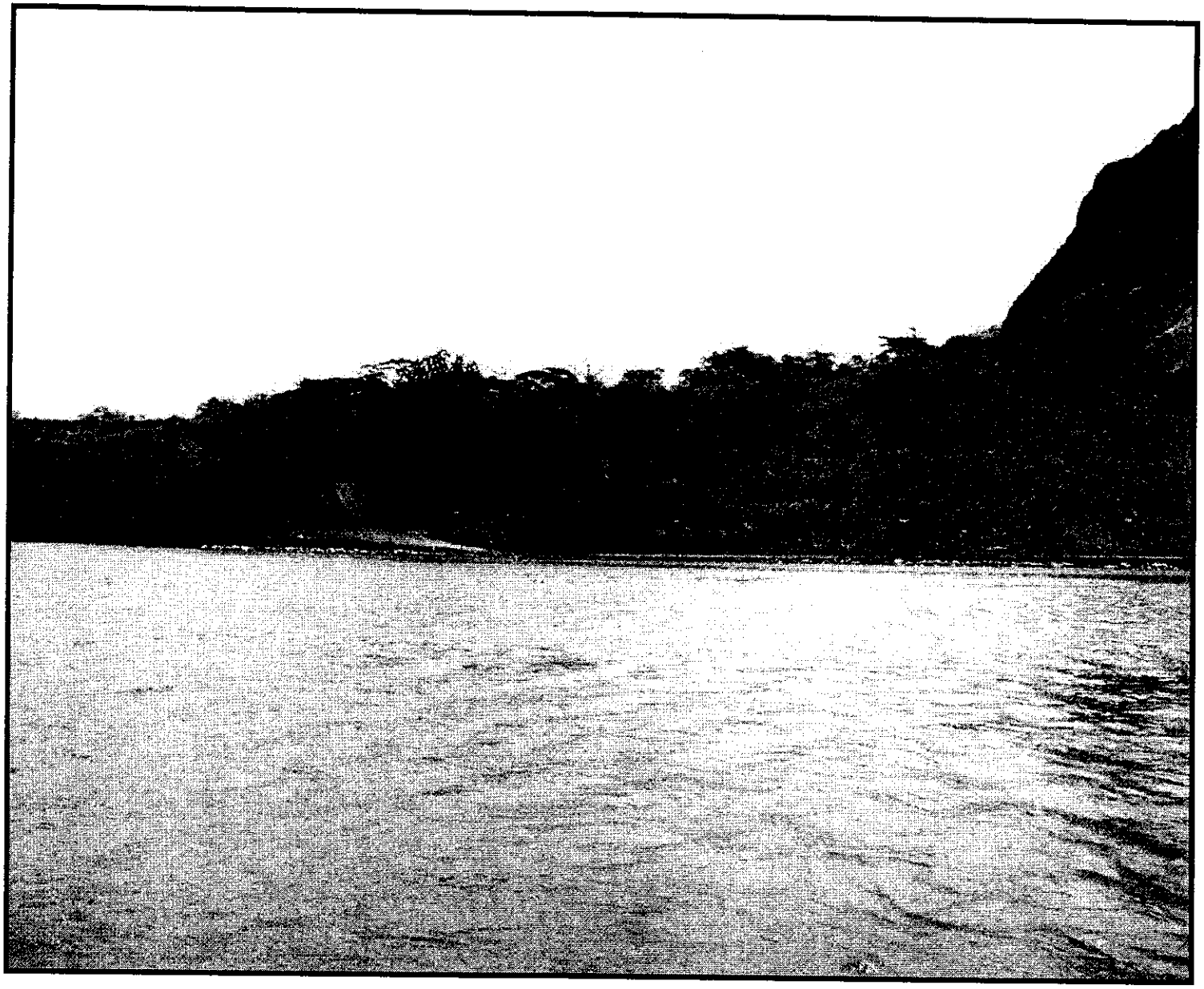
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: M. DE PUY	DIBUJADO POR: M. LACERDA & J. RAMESCH

station 59k + 668 (1957 + 61)

East

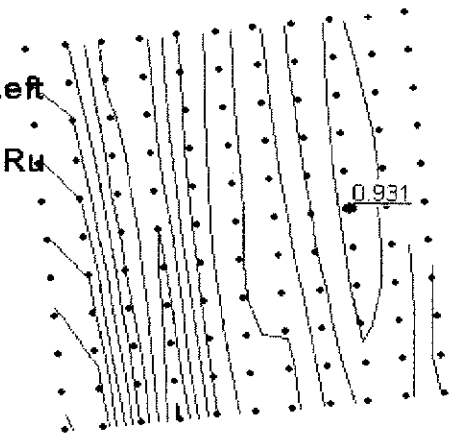
Station: 59k + 668 (Culebra)

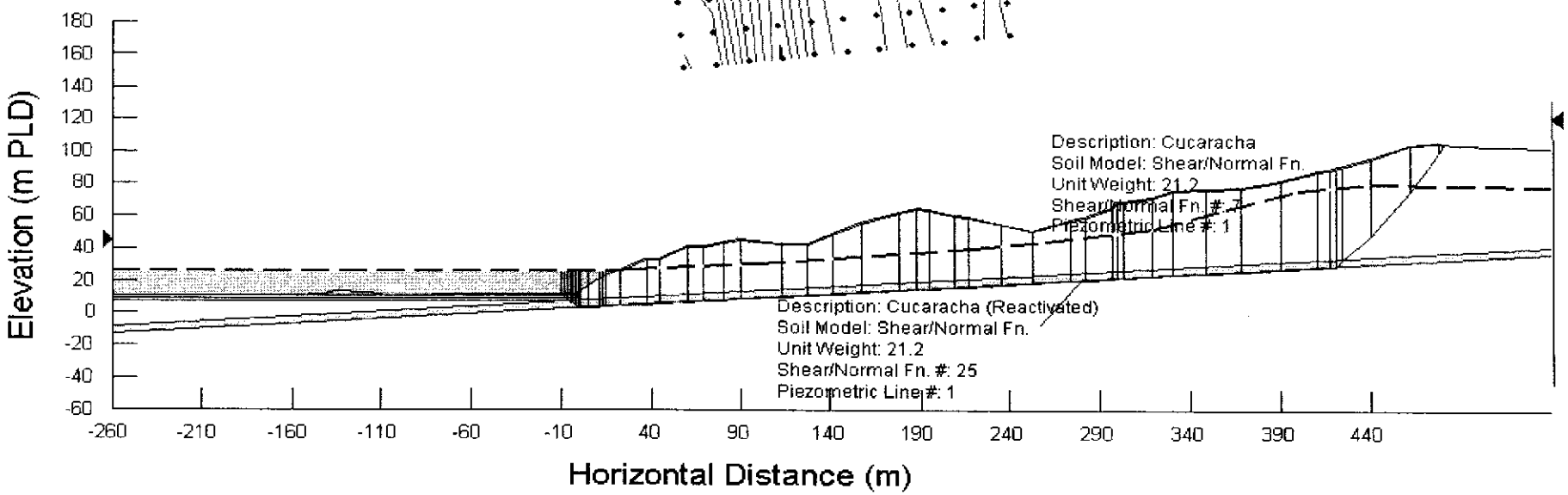
April 16, 2002



Case 1, Channel bottom = 32 ft

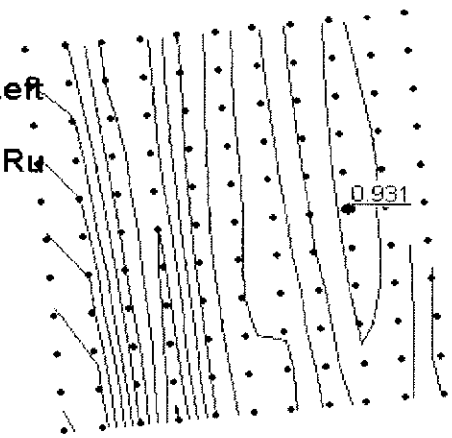
Description: Channel Deepening
Comments: East Bank 59K+668 - Channel Bottom = 32 ft (case 1)
File Name: 59K668_1.slz
Last Saved Date: 4/2/02
Last Saved Time: 4:38:31 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

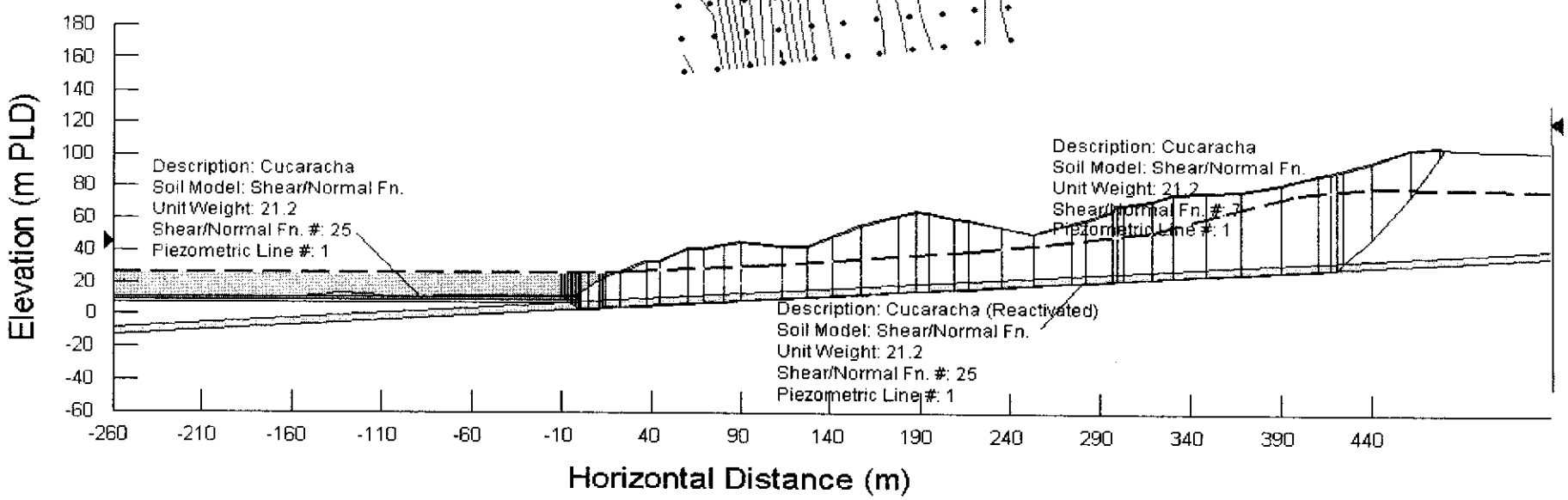




Case 2, Channel bottom = 27 ft, Blasted material only

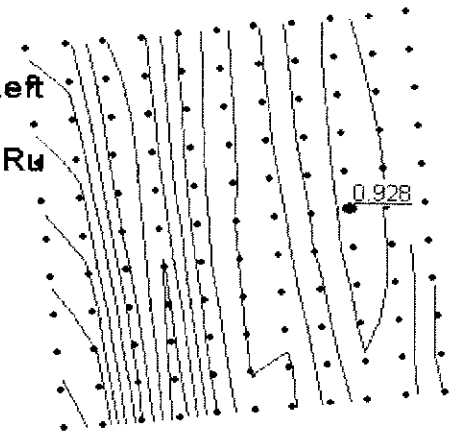
Description: Channel Deepening
Comments: East Bank 59K+668 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 59K668_2.slz
Last Saved Date: 4/2/02
Last Saved Time: 4:42:29 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

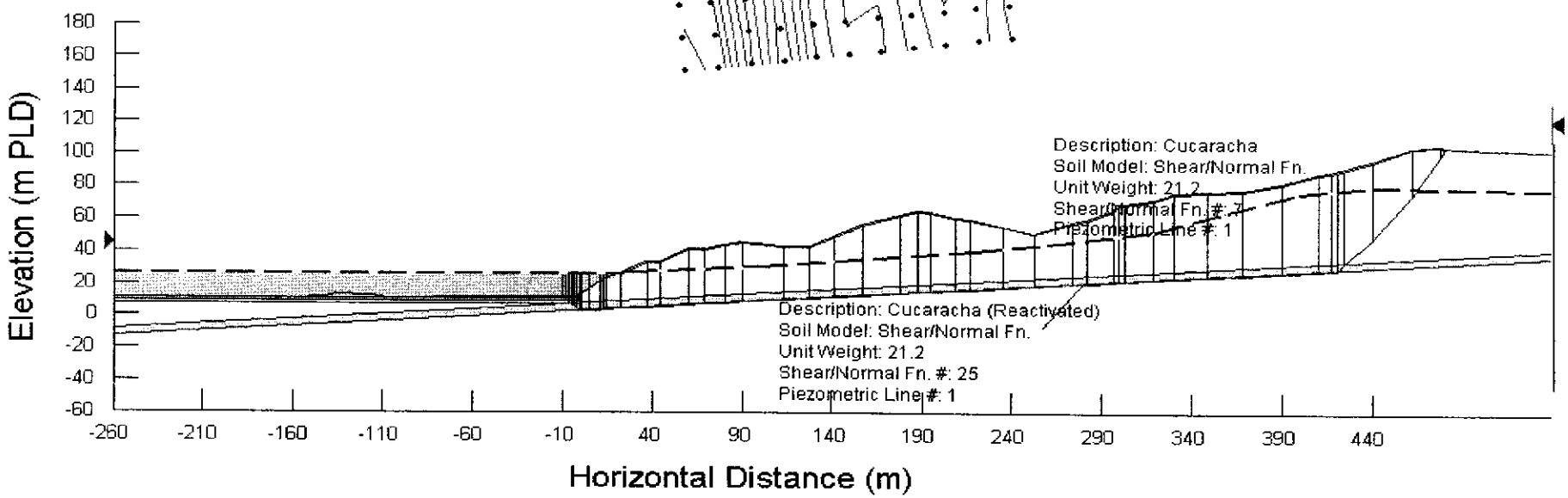




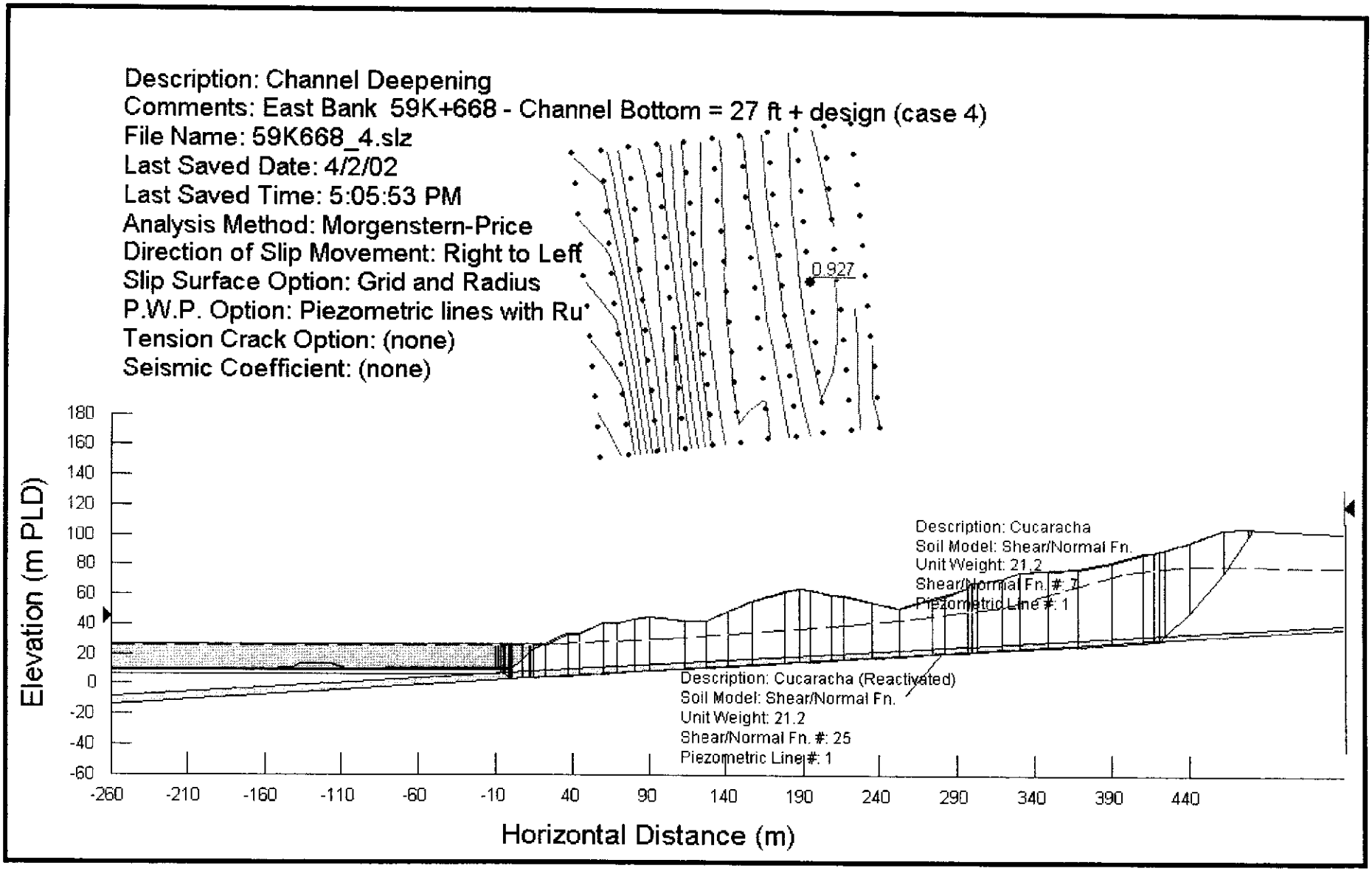
Case 3, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 59K+668 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 59K668_3.slz
Last Saved Date: 4/2/02
Last Saved Time: 4:46:52 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

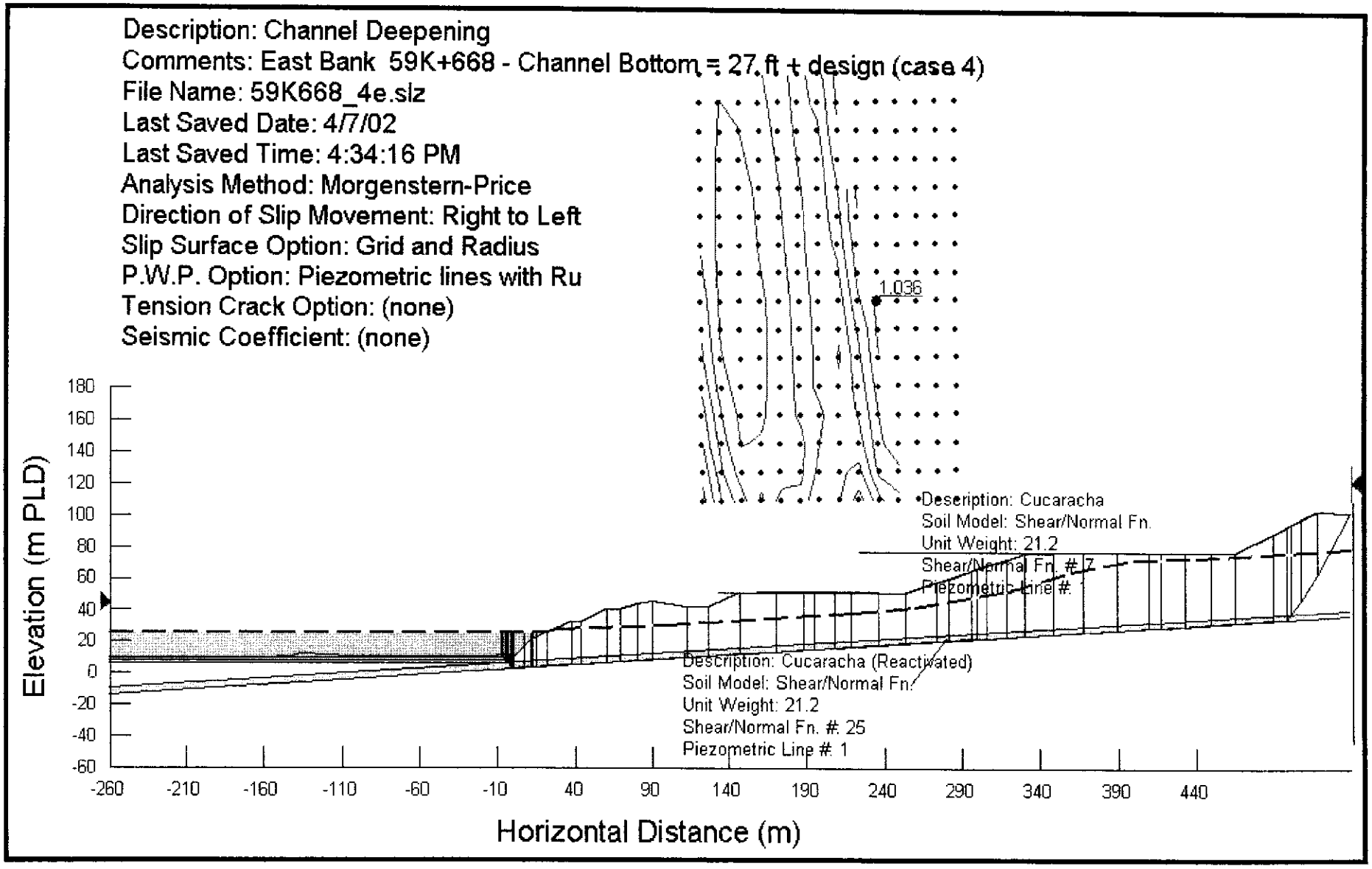




Case 4.1, Channel bottom = 27 ft, Design (underwater slope)

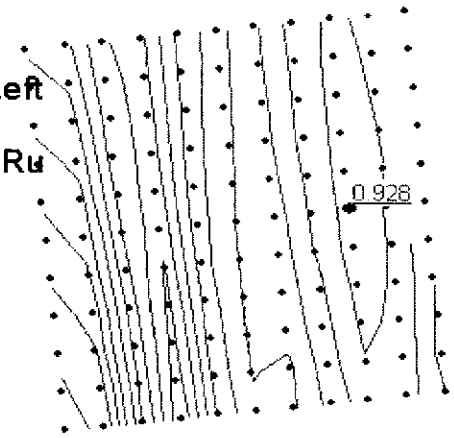


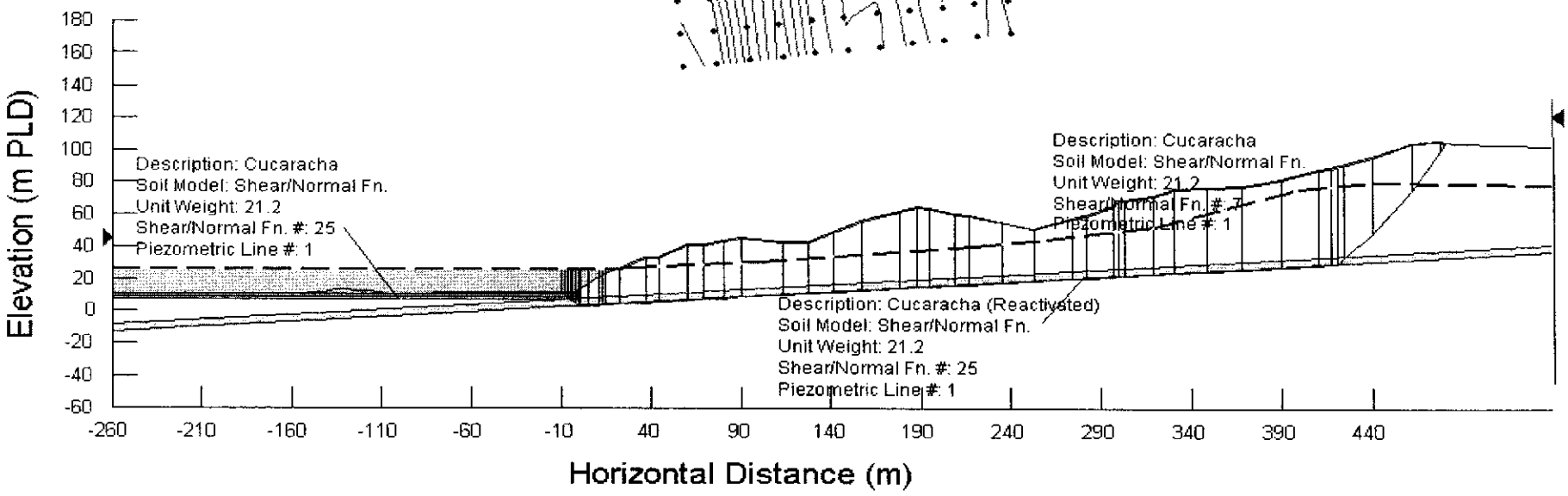
Case 4.2, Channel bottom = 27 ft, Design (& dry excavation)



Case 5, Channel bottom = 22 ft, Blasted material only

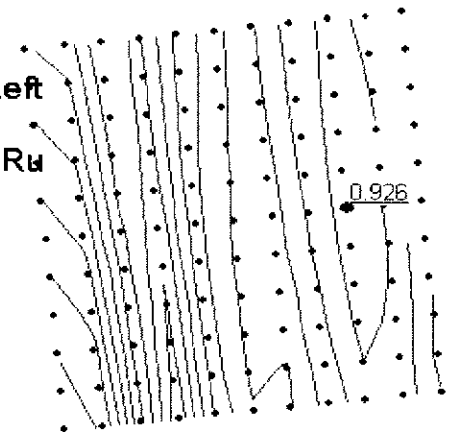
Description: Channel Deepening
Comments: East Bank 59K+668 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 59K668_5.slz
Last Saved Date: 4/2/02
Last Saved Time: 4:51:58 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

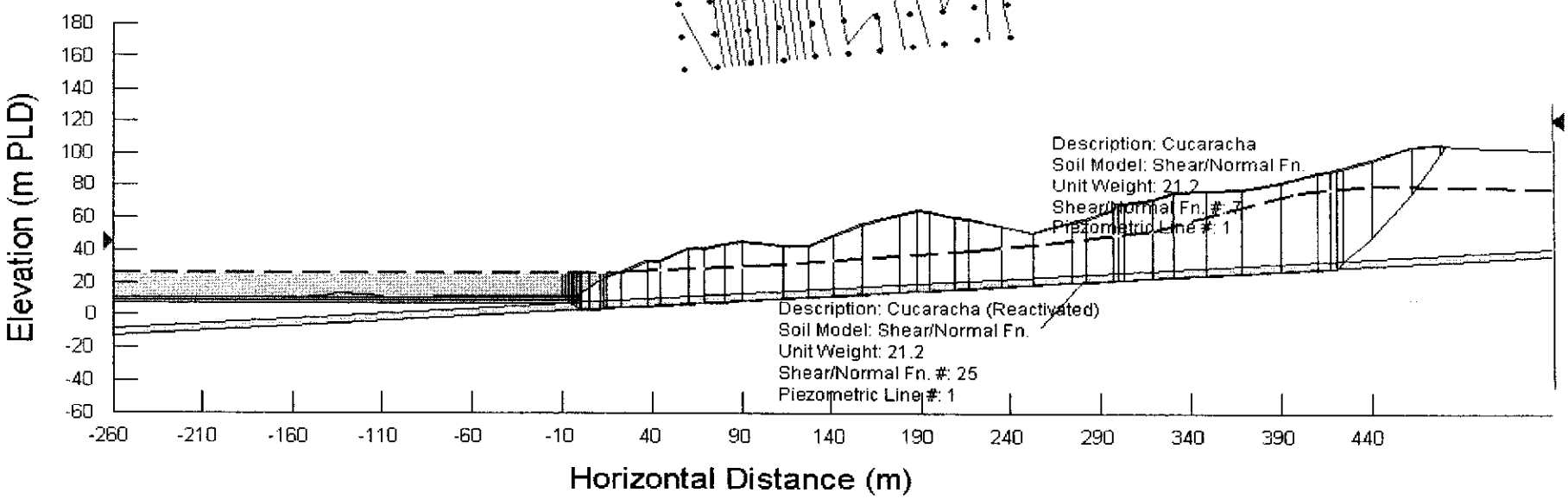




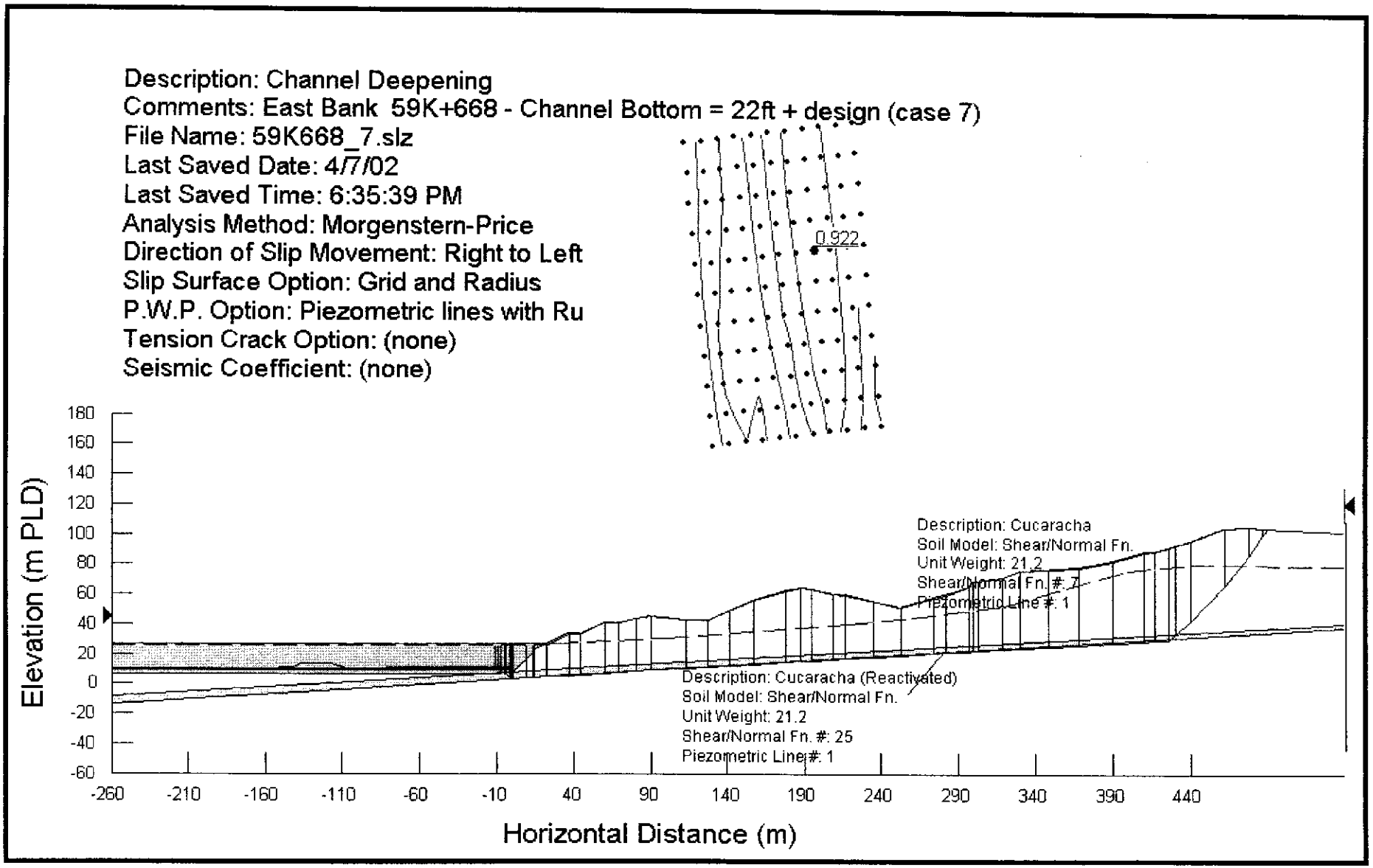
Case 6, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 59K+668 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 59K668_6.slz
Last Saved Date: 4/2/02
Last Saved Time: 4:54:41 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

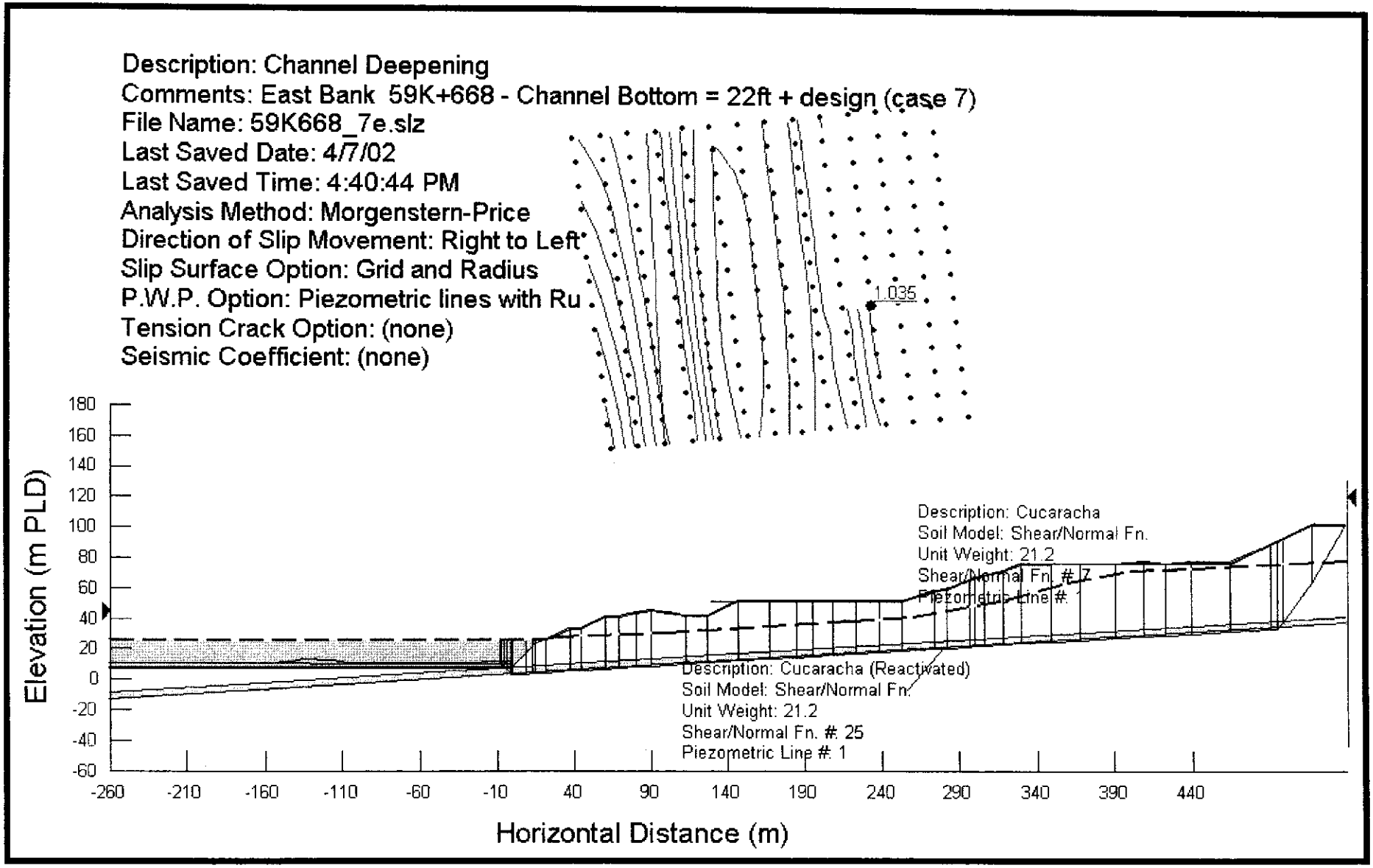




Case 7.1, Channel bottom = 27 ft, Design (underwater slope)

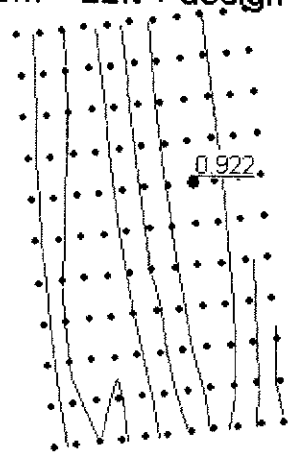


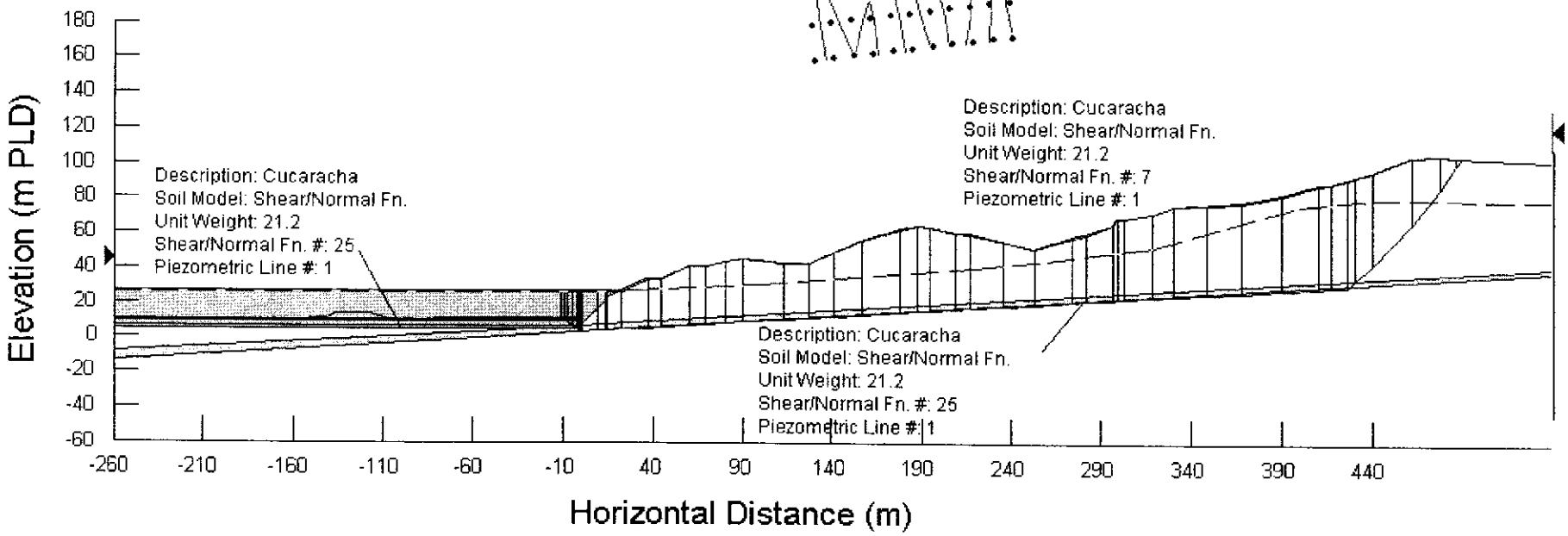
Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)



Case 8, Channel bottom = 16 ft, Blasted

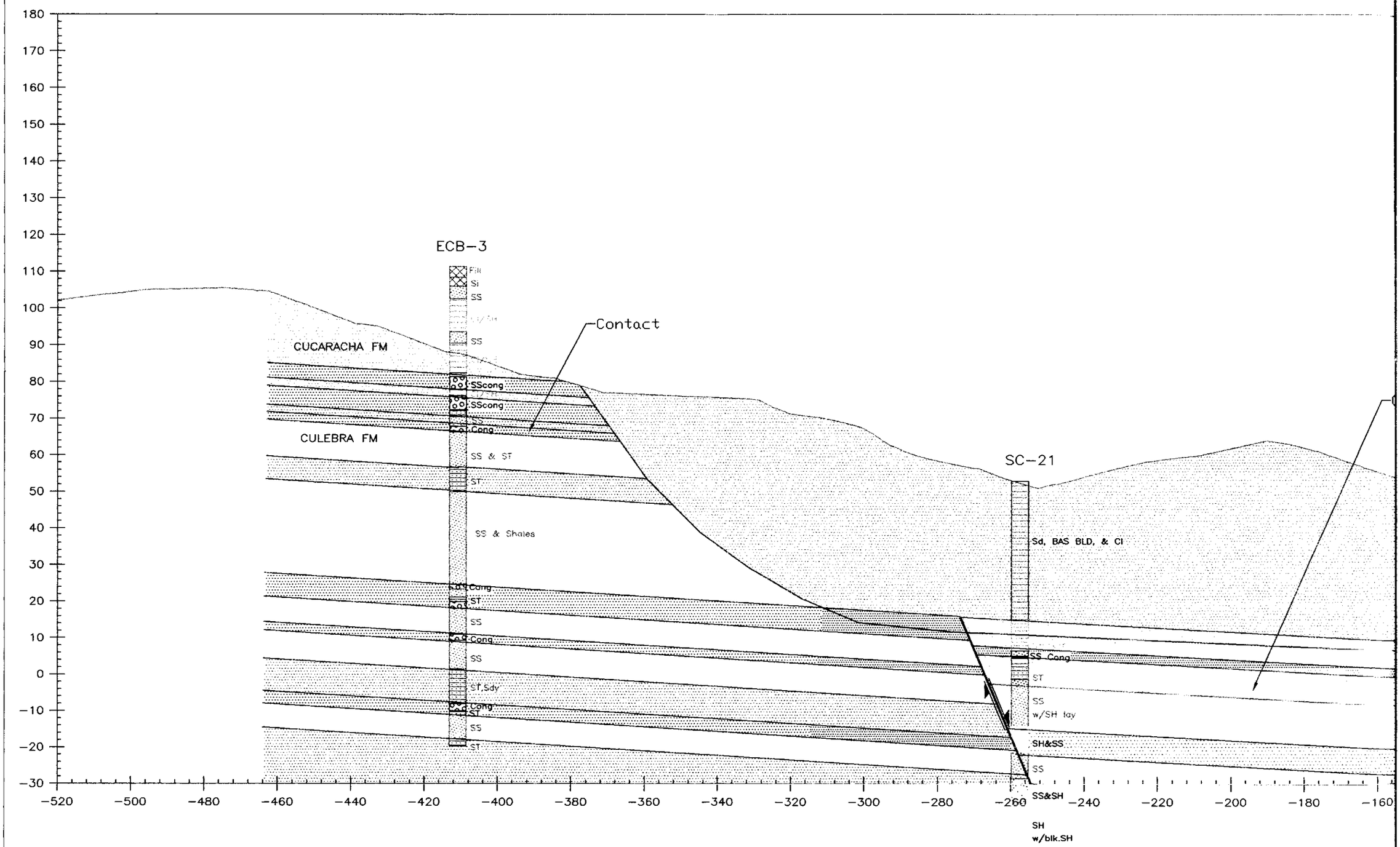
Description: Channel Deepening
Comments: East Bank 59K+668 - Channel Bottom = 22ft + design + blasted 16 ft (case 8)
File Name: 59K668_8.slz
Last Saved Date: 4/7/02
Last Saved Time: 6:49:48 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





Summary, 59k + 668 (957 + 61)

General Description	Range of stations:	59k + 600 to 59k + 800			
	Sector:	Culebra (East Culebra Slide)			
	Maximum height (m):	86			
	Cotangent of slope angle (cot. β):	5.14			
History	Last slide event:	1998 (Large deformations and cracks, currently very activate)			
Geology	Formation:	Cucaracha / Culebra			
	Lithology:	Shale / Clayshale / Sandstone / Siltstone / Conglomerate			
	Critical stratum at toe:	Shales / Clayshale			
	Apparent dip of bedding:	Toward the Canal			
Stability Analysis	Critical failure mechanism:	Translational			
	Shear strength model:	Residual, Cucaracha			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.303	0.931	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		0.931	1.000	0.00
	Case 3: Channel bottom = 27 ft, Blasted & removed		0.928	0.997	-0.32
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		0.927	0.996	-0.43
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.326	1.036	1.113	11.28
	Case 5: Channel bottom = 22 ft, Blasted material only		0.928	0.997	-0.32
	Case 6: Channel bottom = 22 ft, Blasted & removed		0.926	0.995	-0.54
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		0.922	0.990	-0.97
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.327	1.035	1.112	11.17
	Case 8: Channel bottom = 16 ft, Blasted		0.922	0.990	-0.97
Conclusions:	Stabilization is required for Case 4 and Case 7 (Drainage may be required)				


ECB-3
Contact
CUCARACHA FM
CULEBRA FM
SS
SScong
Cong
SS & ST
ST
SS & Shales
ST,Sdy
SC-21
Sd, BAS BLD, & Cl
SS Cong
w/SH lay
SH&SS
SS&SH
SH
w/blk.SH
180
170
160
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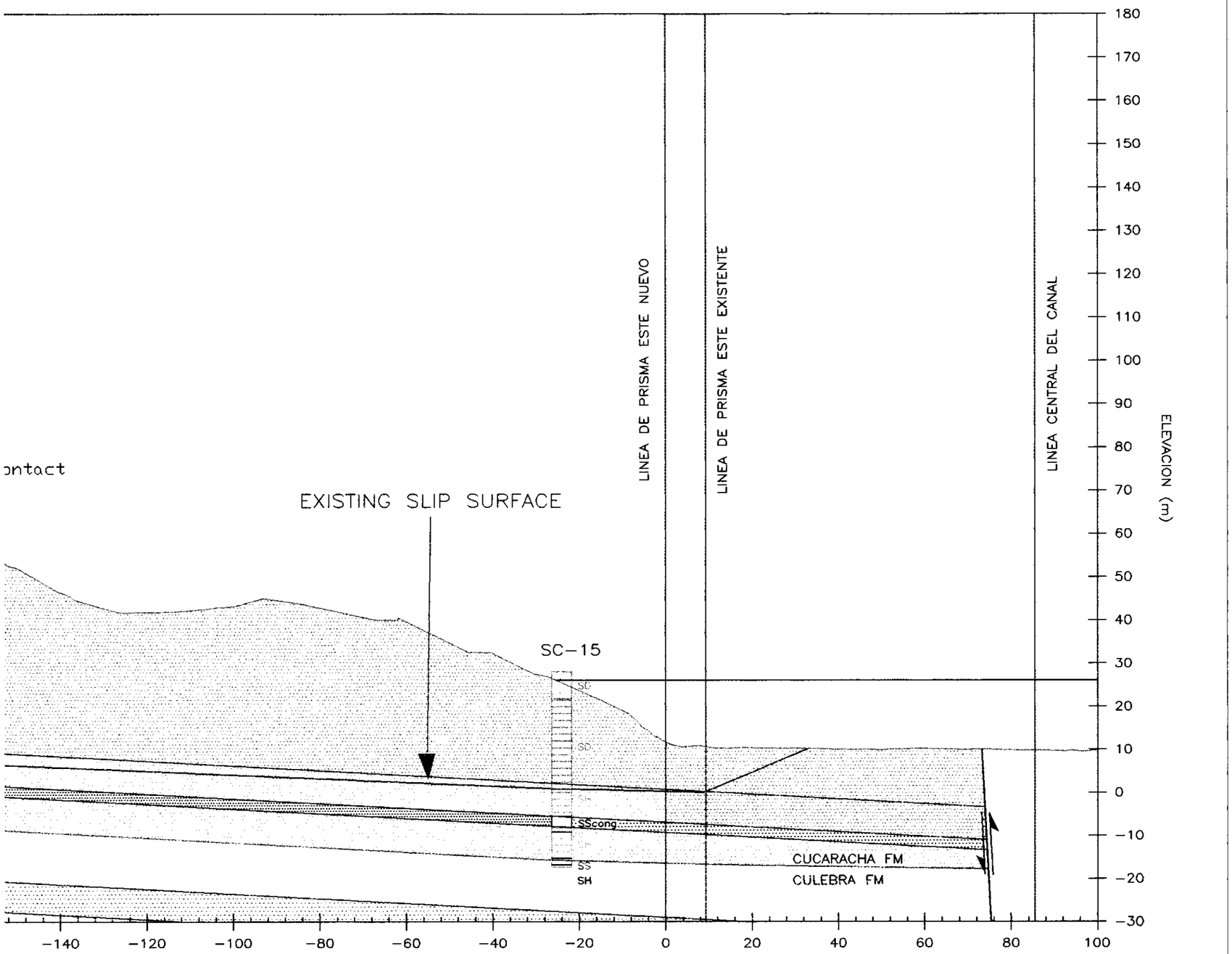
59K+668 (195



+61) EAST

AUTORIDAD DEL CANAL DE PANAMA

DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 59K+668 (1957+61) ESTE

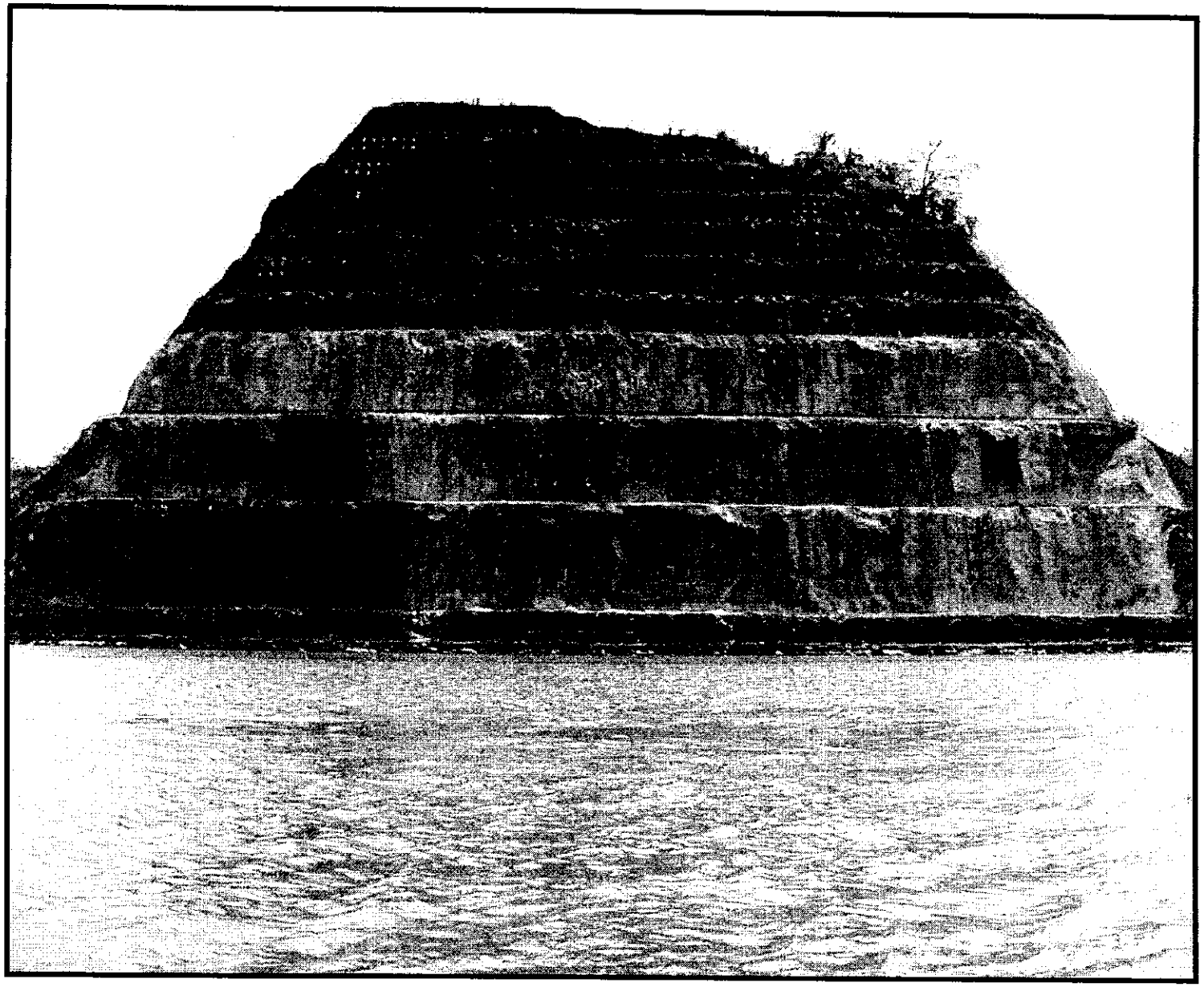
ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: M. DE PUY	DIBUJADO POR: J. ARROCHA & J. RAMESCH

station 59k + 918 (1966 + 00)

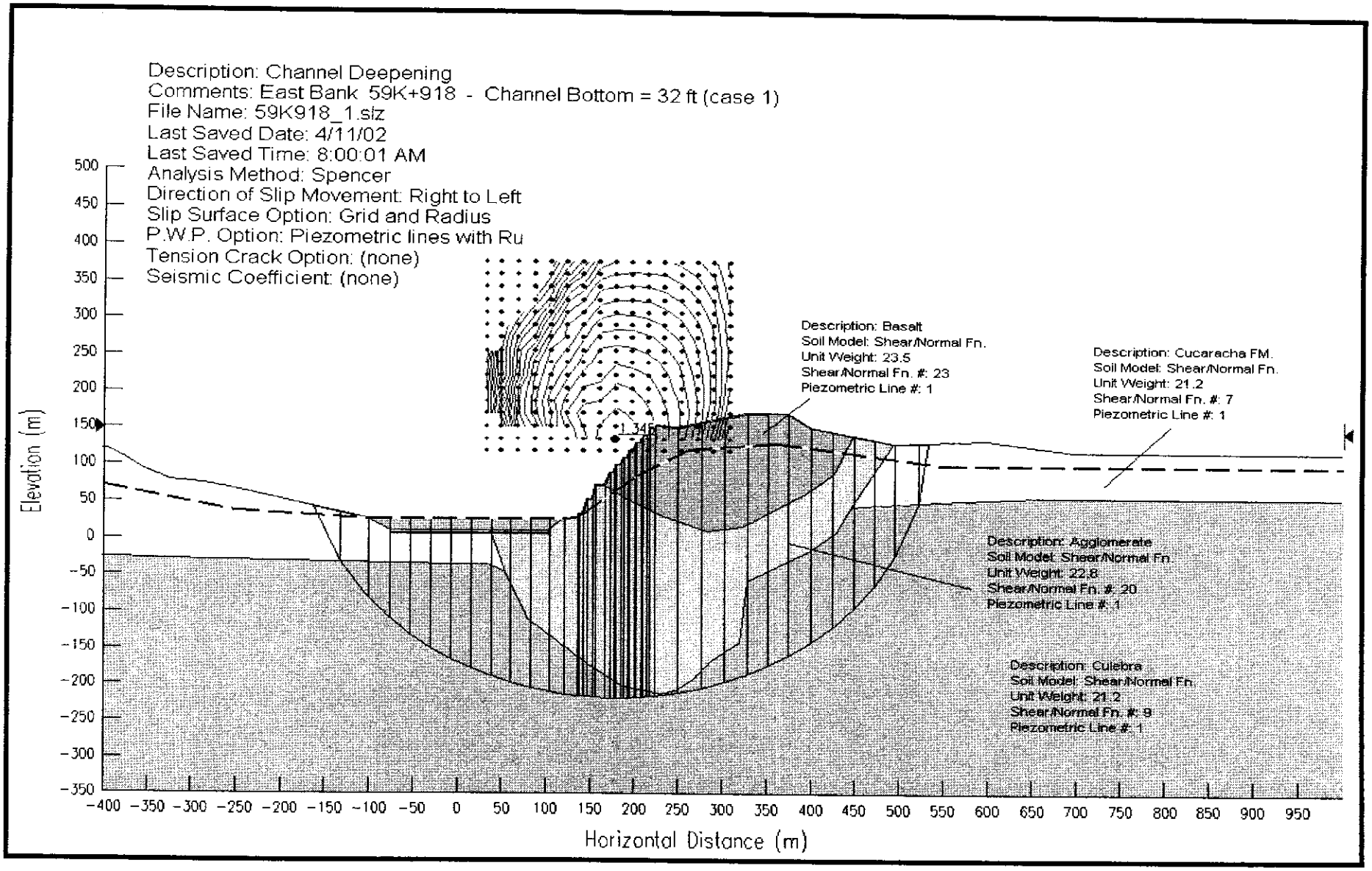
East

Station: 59k + 918 (Gold)

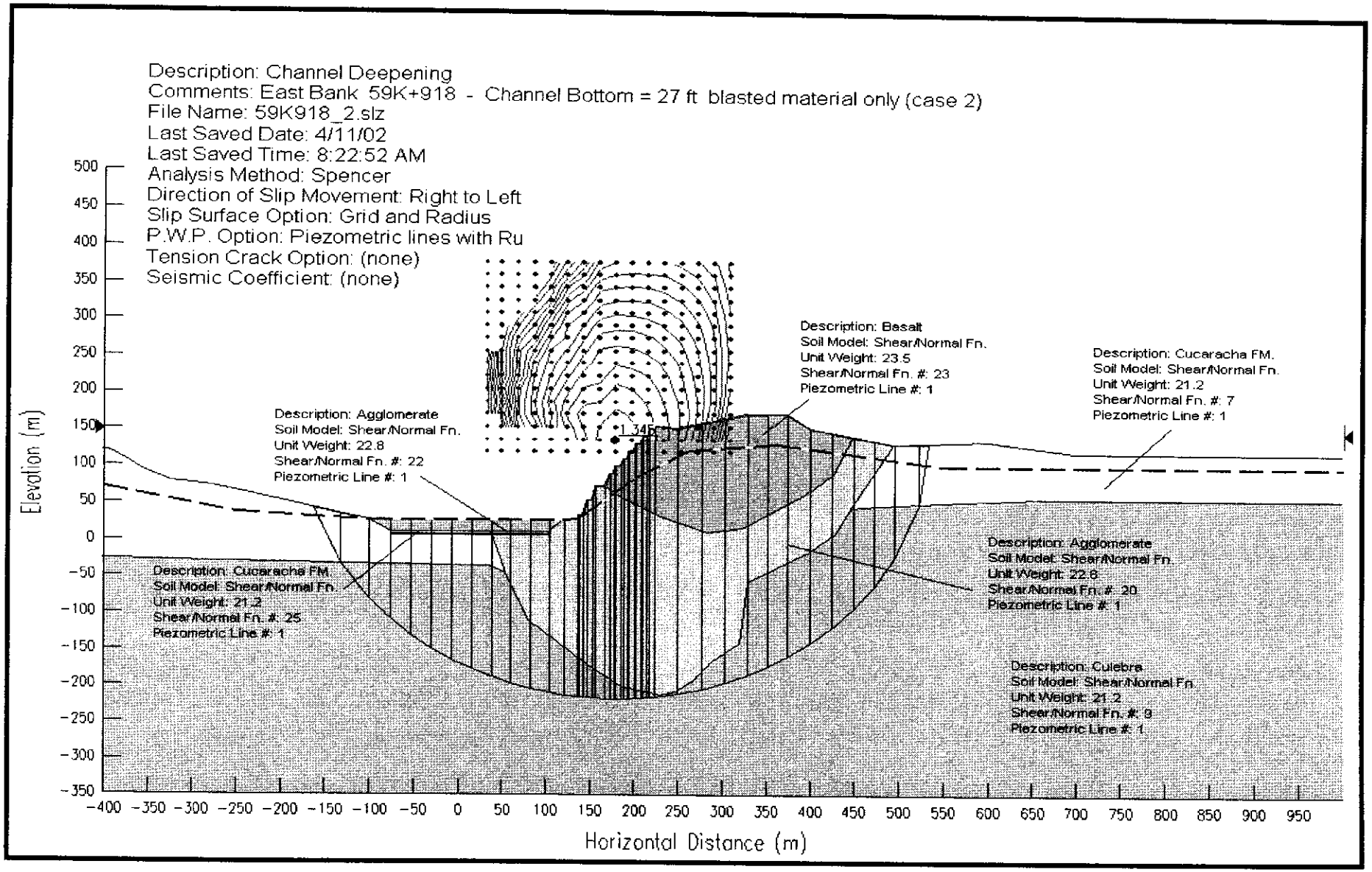
April 16, 2002



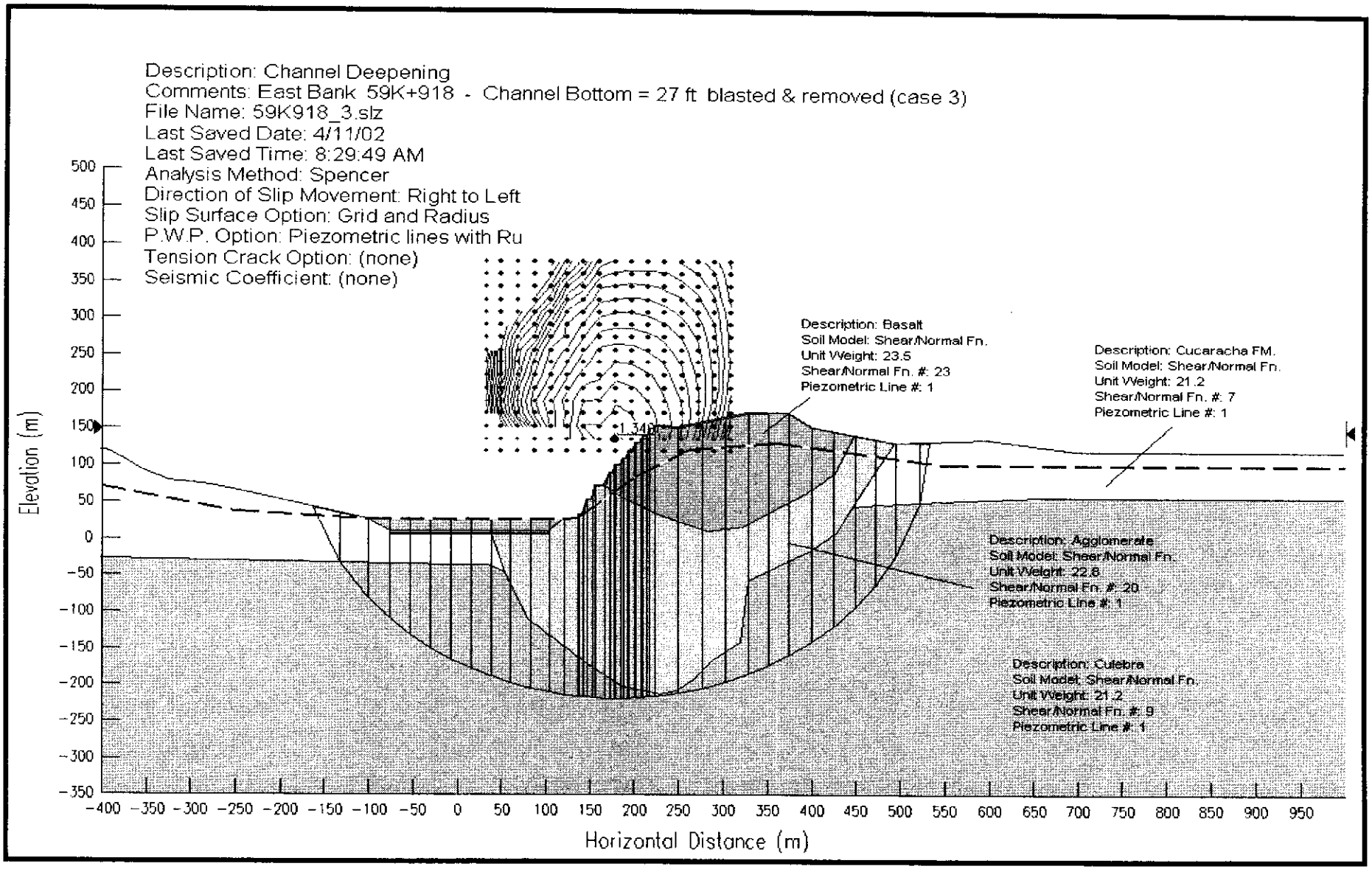
Case 1, Channel bottom = 32 ft



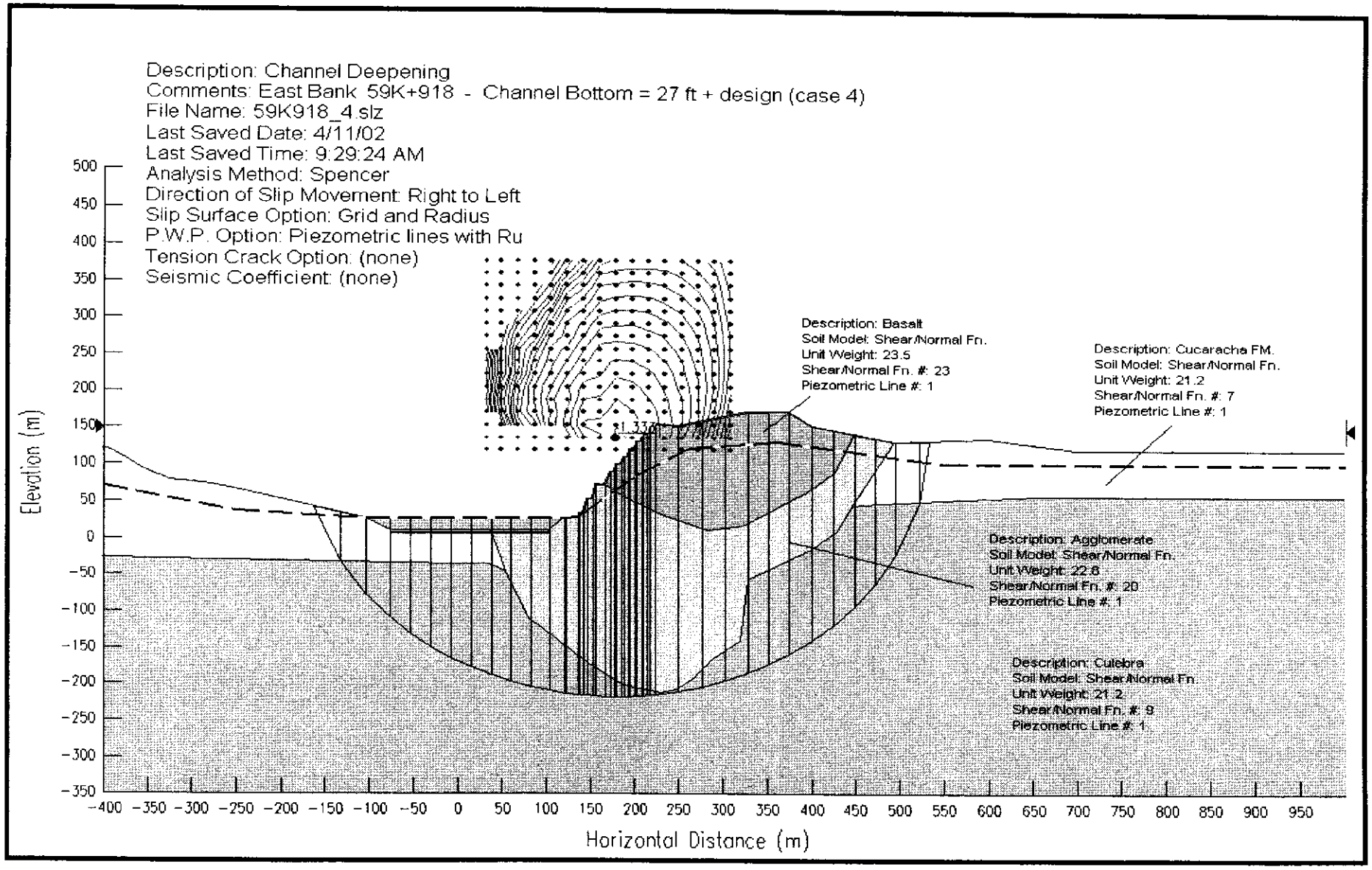
Case 2, Channel bottom = 27 ft, Blasted material only



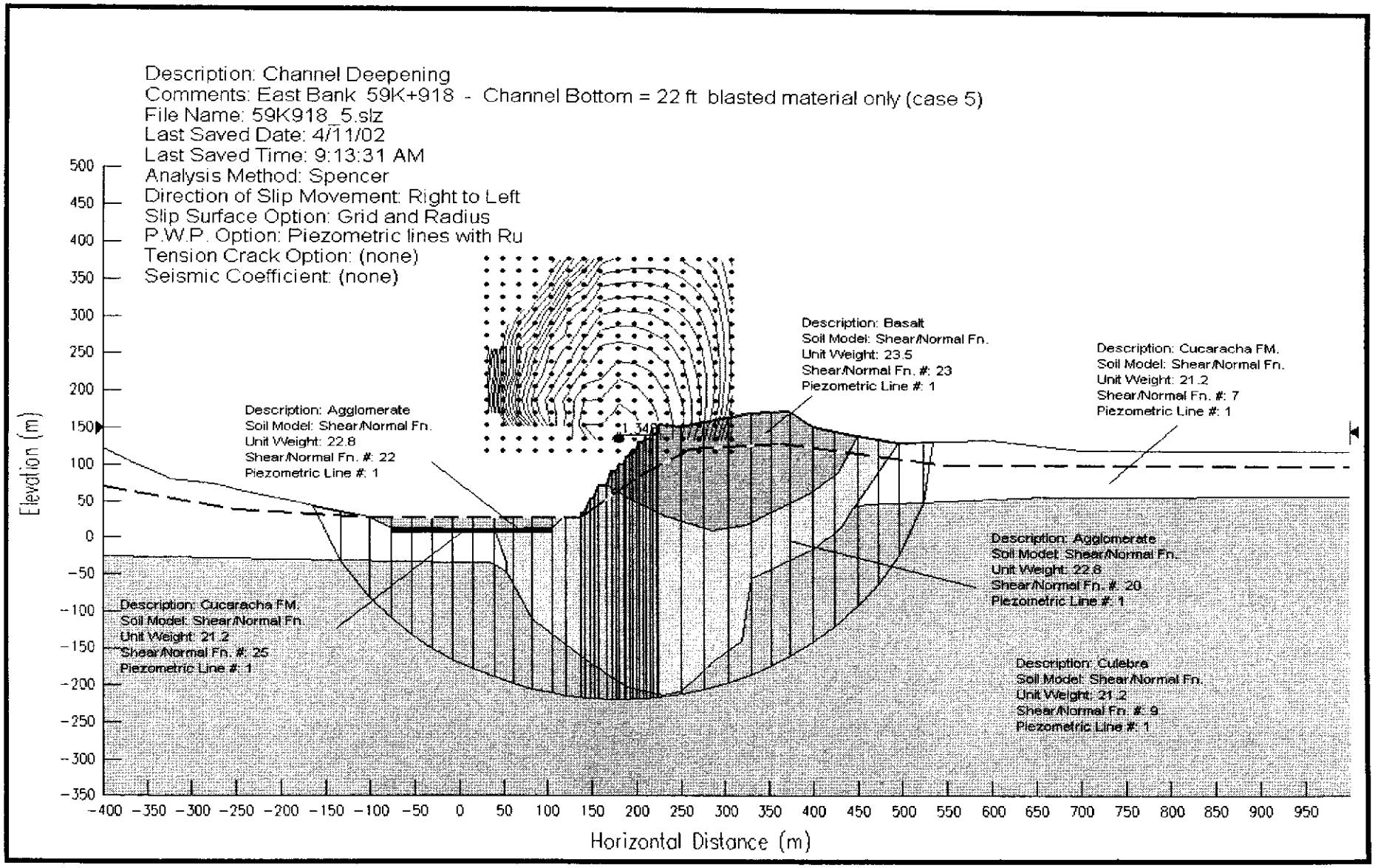
Case 3, Channel bottom = 27 ft, Blasted & removed



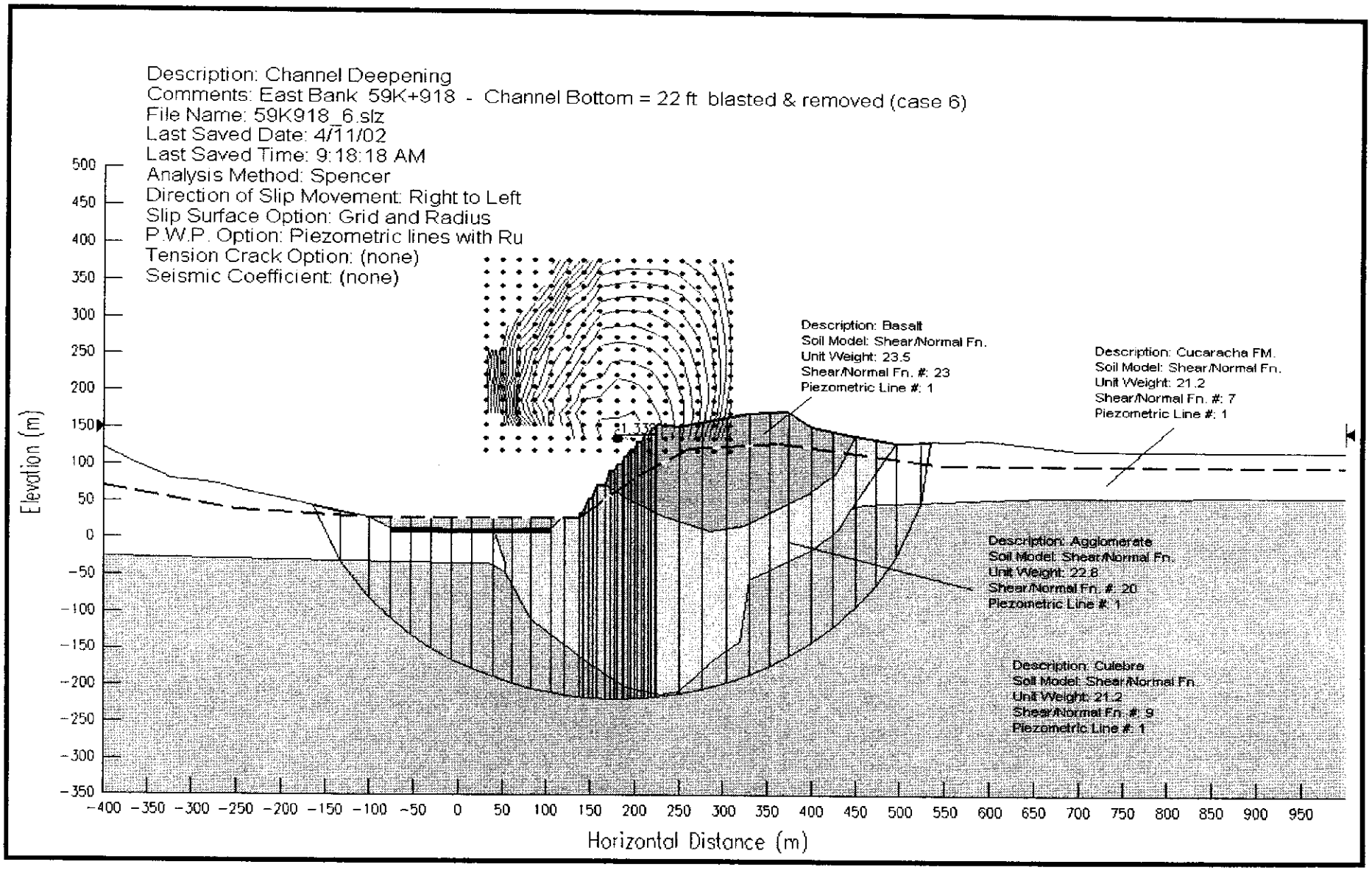
Case 4, Channel bottom = 27 ft, Design (underwater slope)



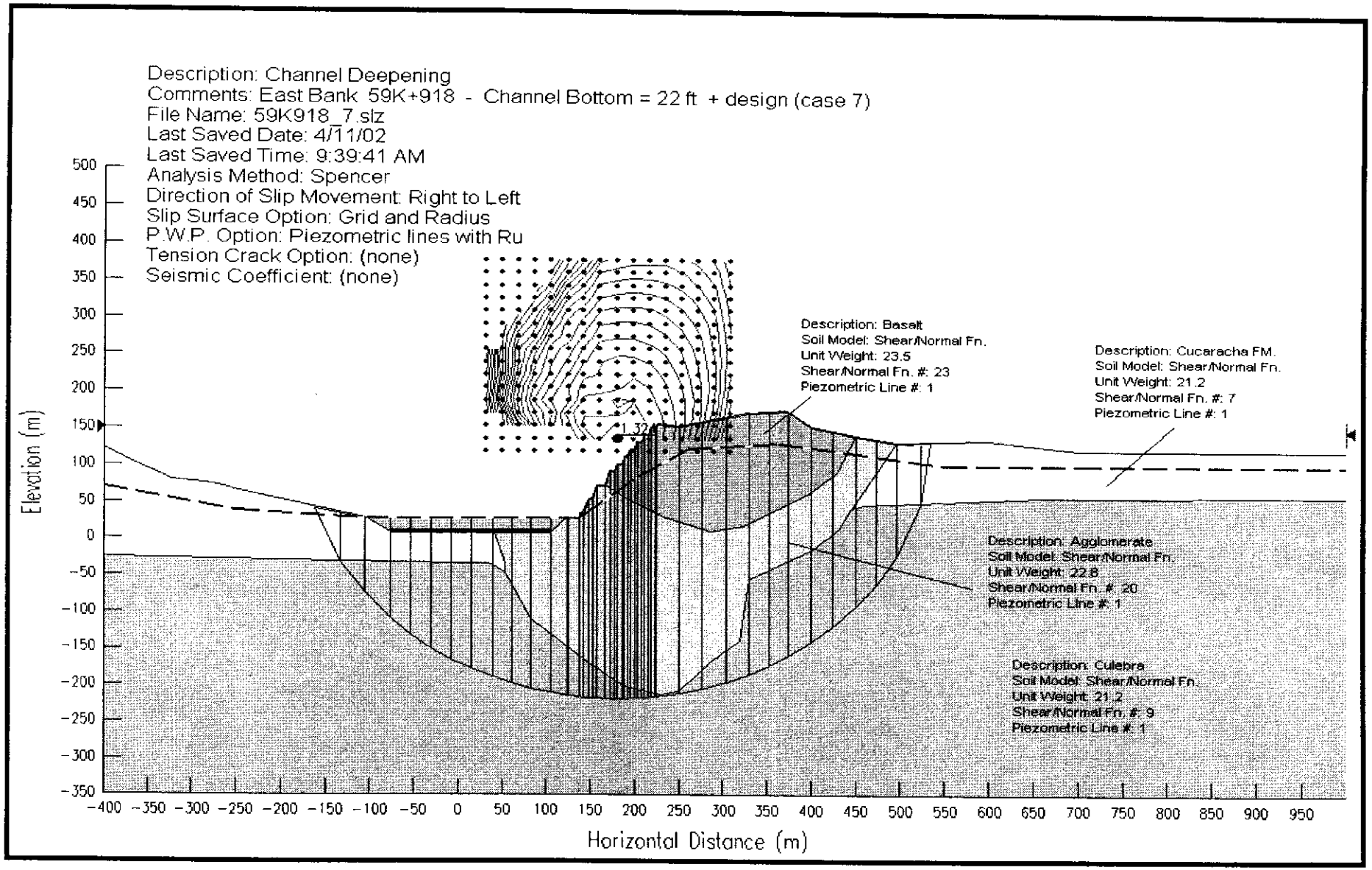
Case 5, Channel bottom = 22 ft, Blasted material only



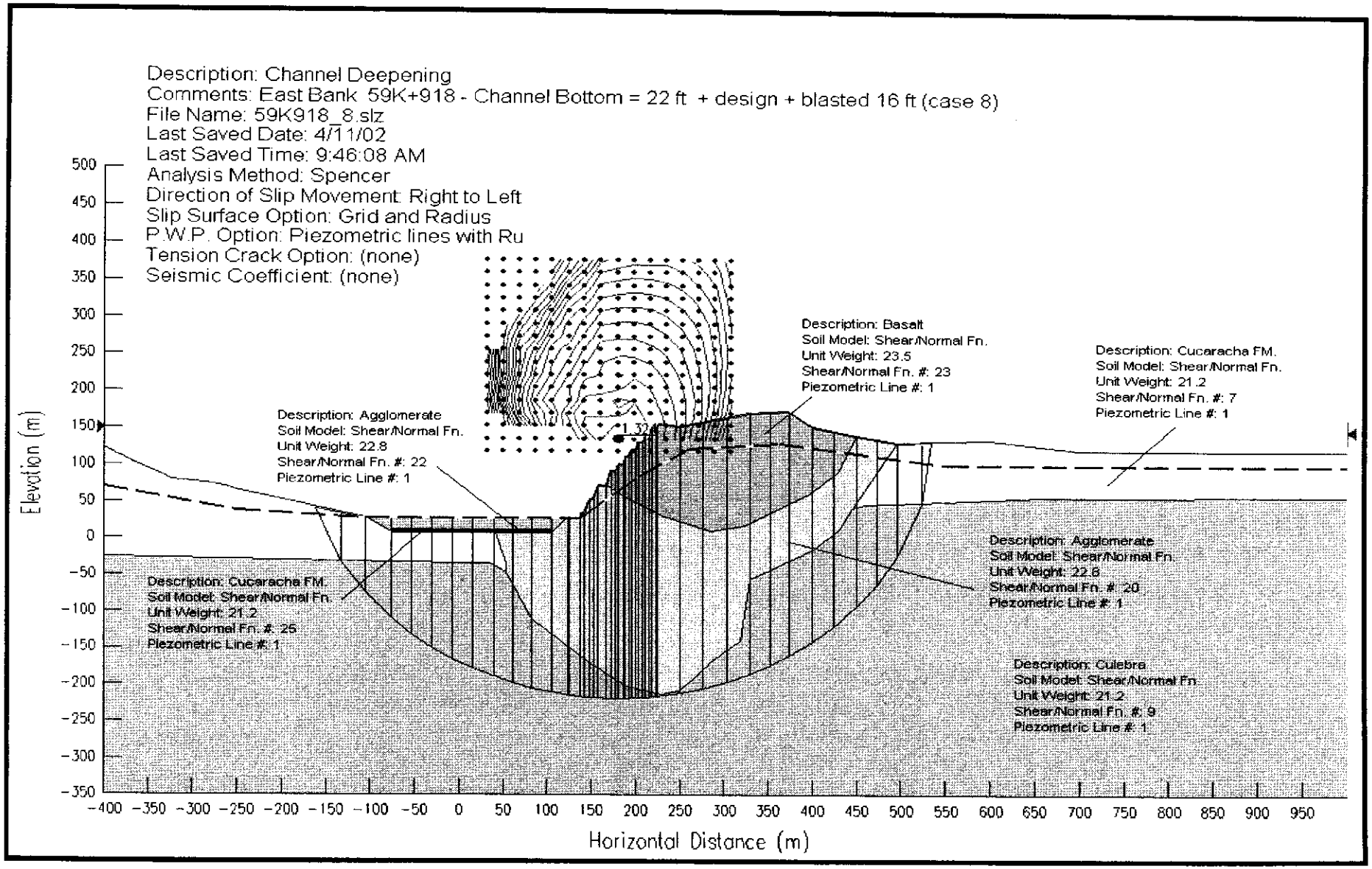
Case 6, Channel bottom = 22 ft, Blasted & removed



Case 7, Channel bottom = 27 ft, Design (underwater slope)

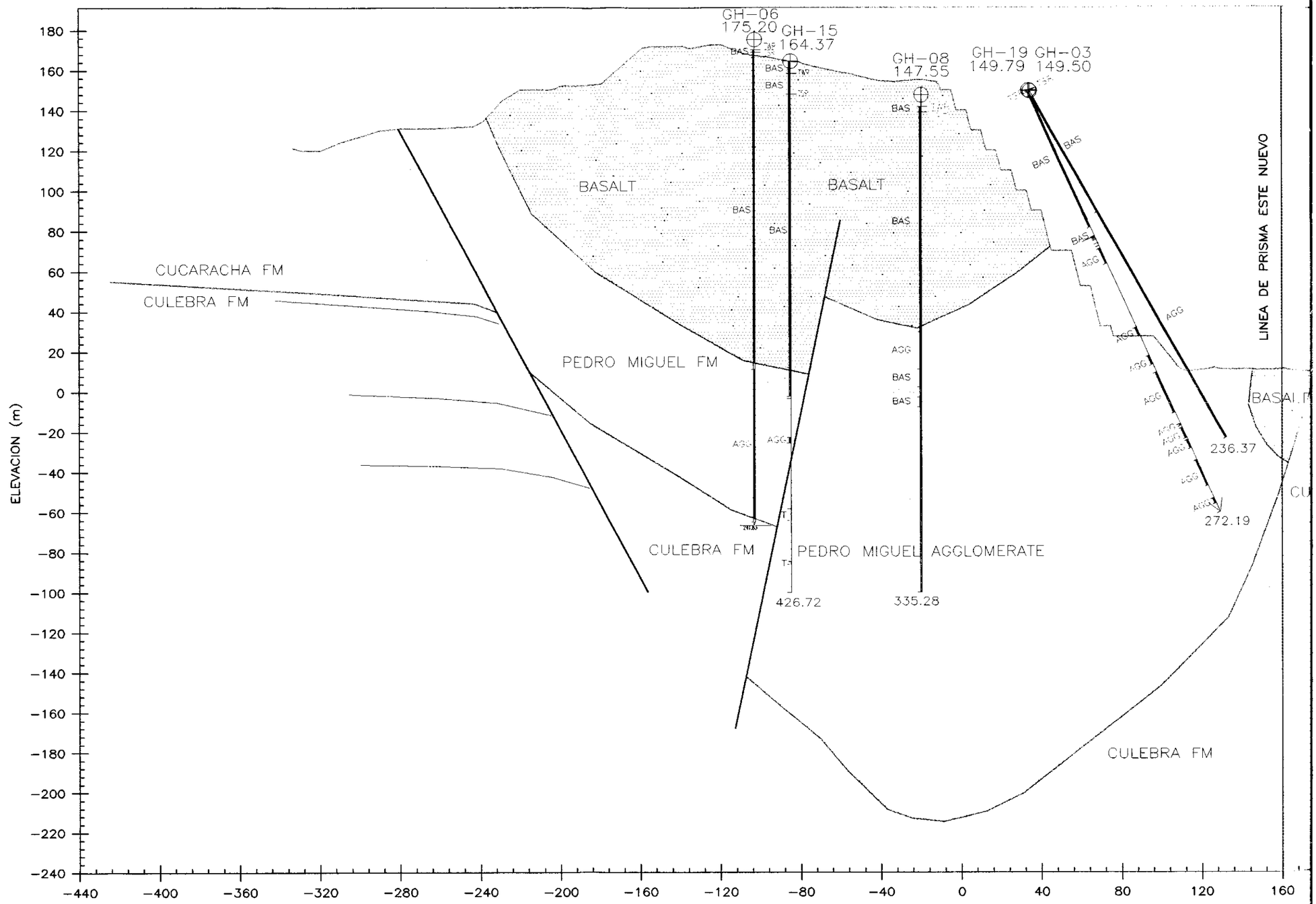


Case 8, Channel bottom = 16 ft, Blasted

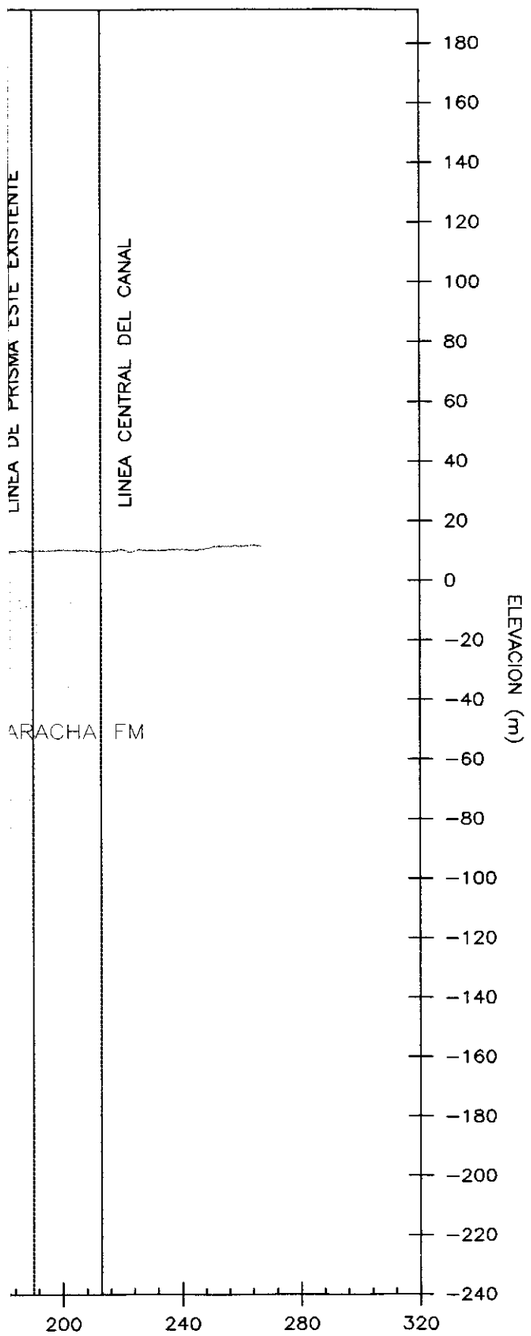


Summary, 59k + 918 (1966 + 00)

General Description	Range of stations:	59k + 800 to 60k + 050			
	Sector:	Gold			
	Maximum height (m):	160			
	Cotangent of slope angle (cot. β):	0.81			
History	Last slide event:	May 1998 (Local rock slide during widening)			
Geology.	Formation:	Pedro Miguel / Basalt / Cucaracha			
	Lithology:	Agglomerate / Basalt / Clayshale / Sandstone			
	Critical stratum at toe:	Agglomerate / Clayshale			
	Apparent dip of bedding:	Not defined			
Stability Analysis	Critical failure mechanism:	Rotational - global failure			
	Shear strength model:	First time agglomerate, basalt / Fully softened, cucaracha culebra			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.423	1.345	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		1.345	1.000	0.00
	Case 3: Channel bottom = 27 ft, Blasted & removed		1.340	0.996	-0.37
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.333	0.991	-0.89
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.422	1.333	0.991	-0.89
	Case 5: Channel bottom = 22 ft, Blasted material only		1.340	0.996	-0.37
	Case 6: Channel bottom = 22 ft, Blasted & removed		1.332	0.990	-0.97
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.324	0.984	-1.56
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.423	1.324	0.984	-1.56
	Case 8: Channel bottom = 16 ft, Blasted		1.324	0.984	-1.56
Conclusions:	No stabilization is required				



59K+918 (1965+81) EAST



AUTORIDAD DEL CANAL DE PANAMA

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SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 59K+916 (1965+81) ESTE

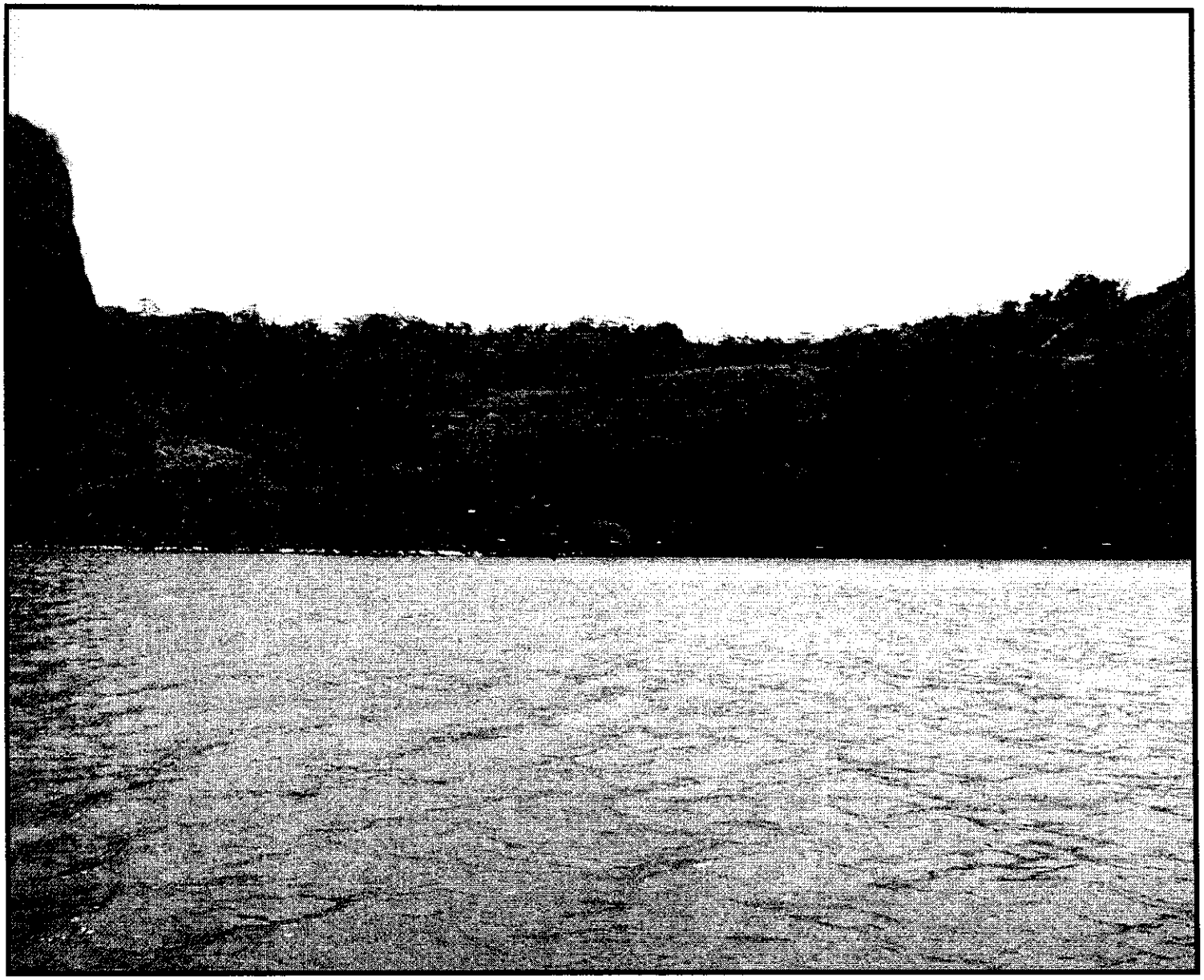
ESCALA: 1:2000	FECHA: ABRIL 2002
GEOLOGIA POR: M. DE PUY	DIBUJADO POR: J. RAMESCH

station 60k + 244 (1976 + 50)

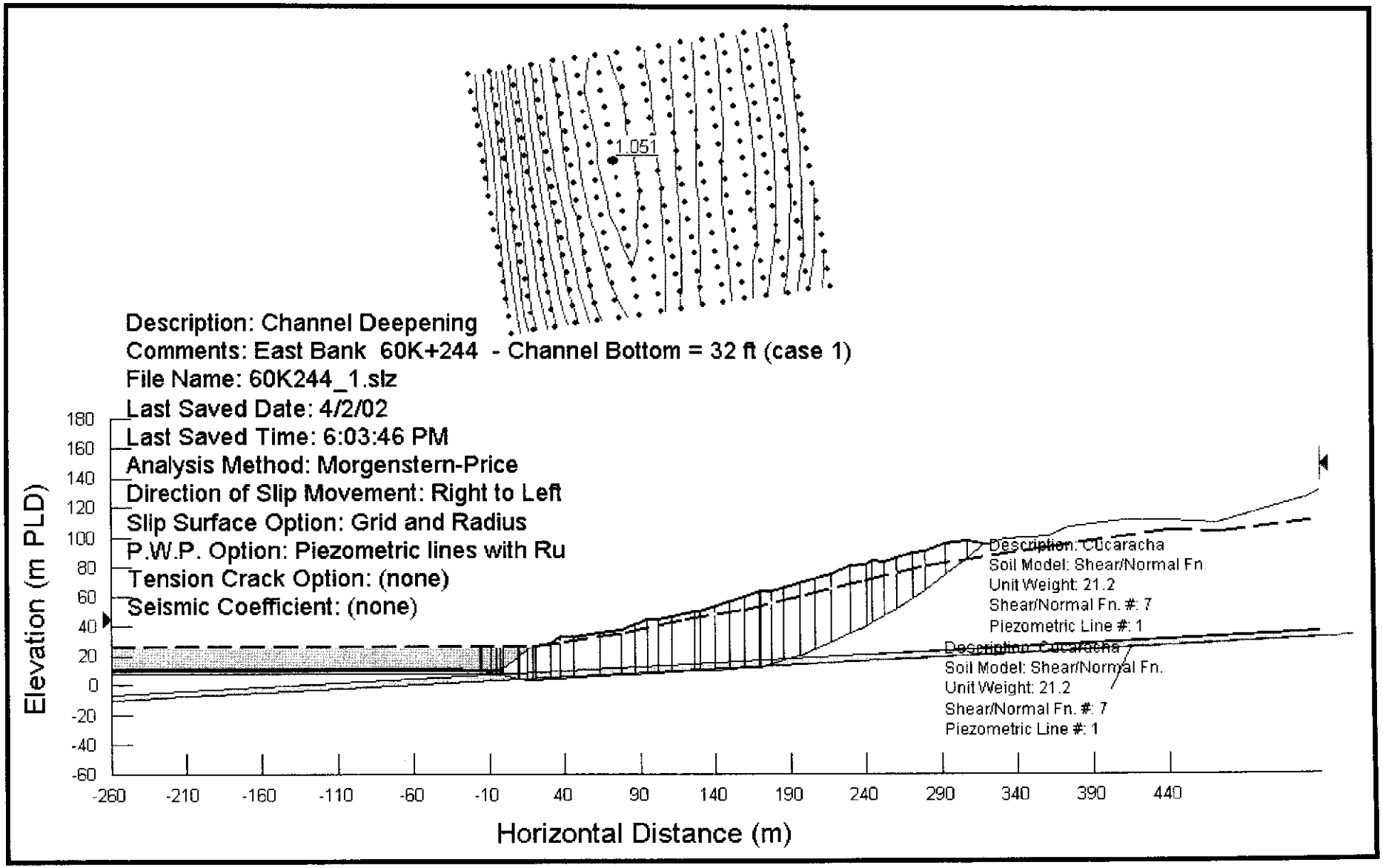
East

Station: 60k + 244 (Cucaracha)

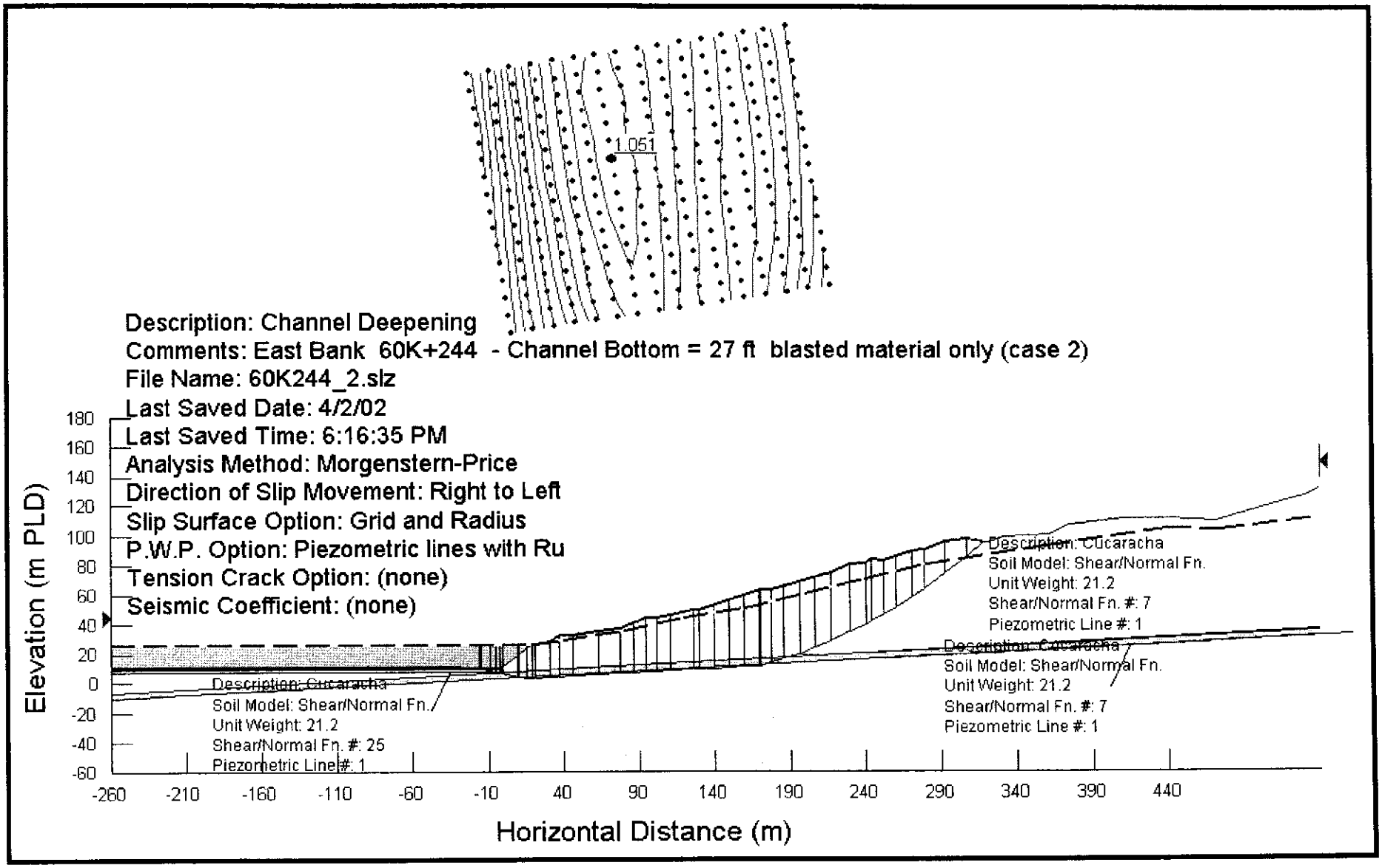
April 16, 2002



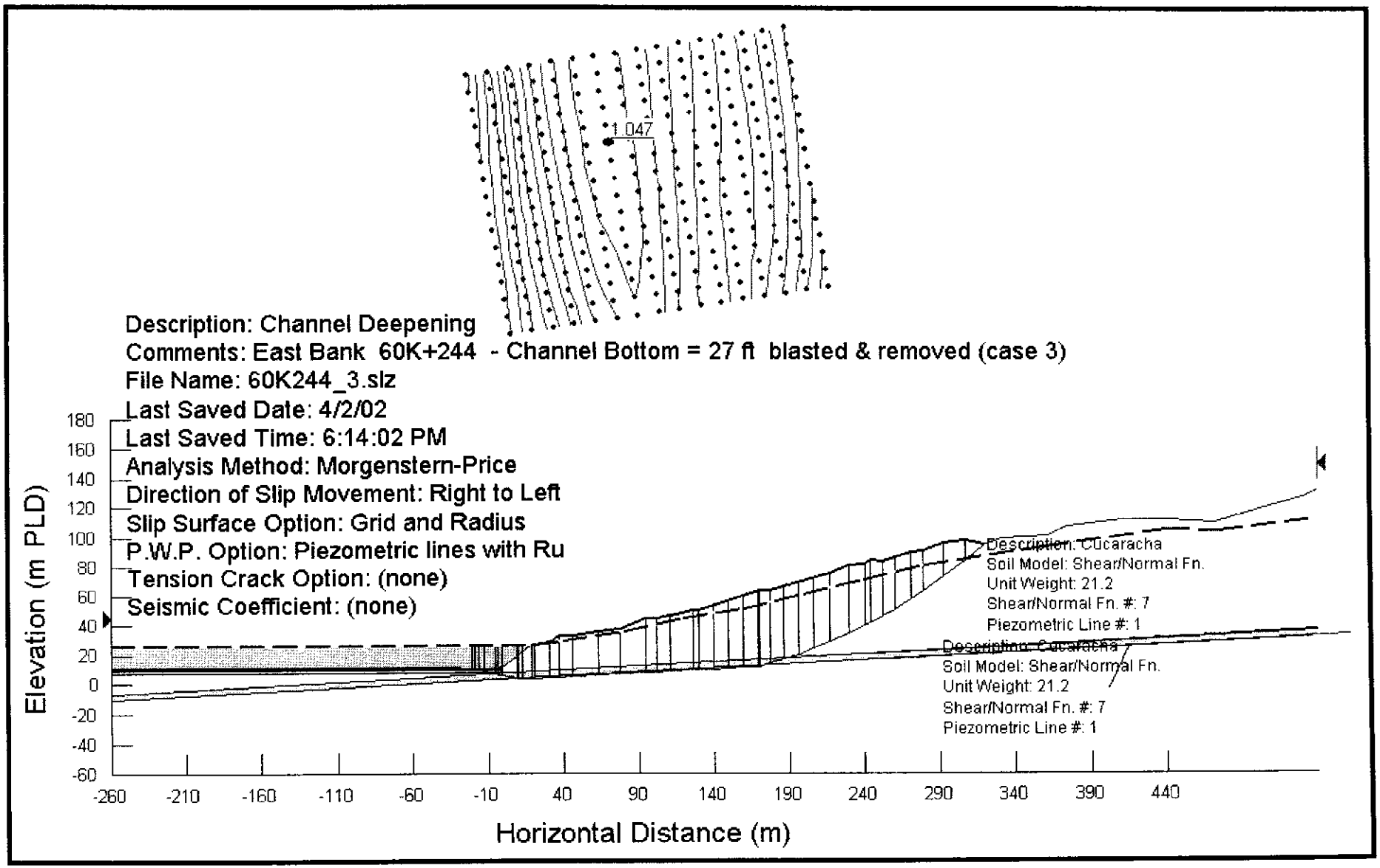
Case 1, Channel bottom = 32 ft



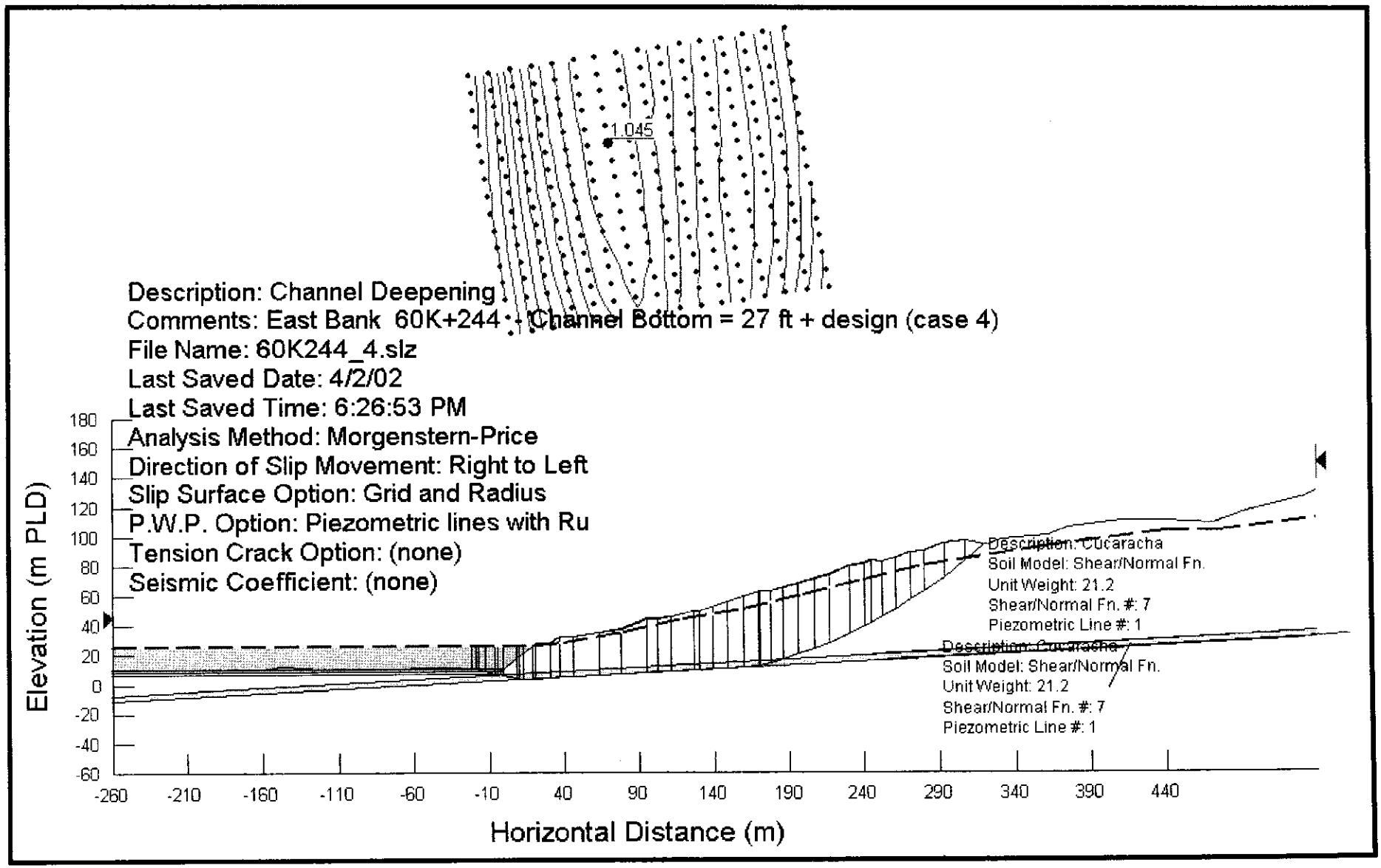
Case 2, Channel bottom = 27 ft, Blasted material only



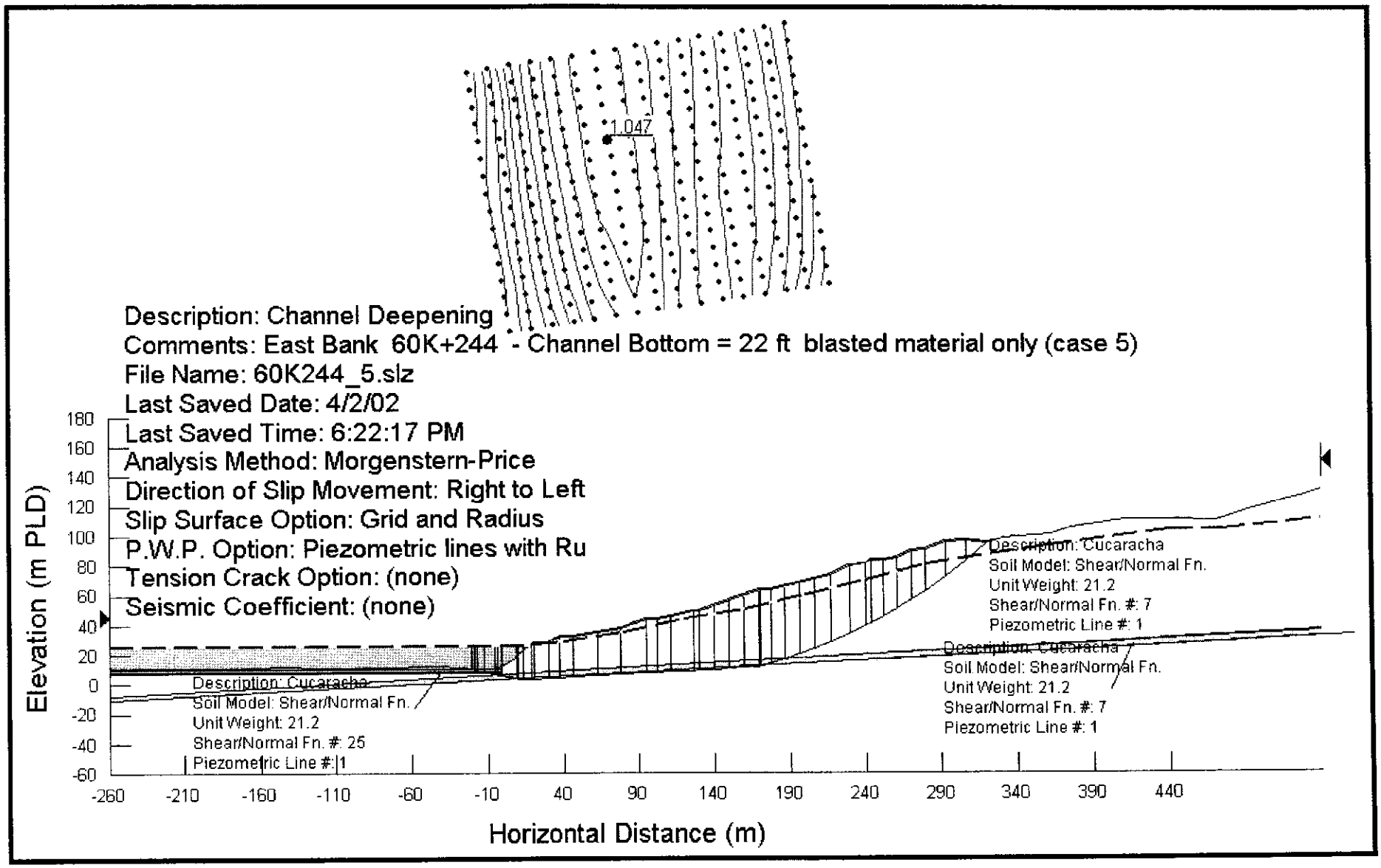
Case 3, Channel bottom = 27 ft, Blasted & removed



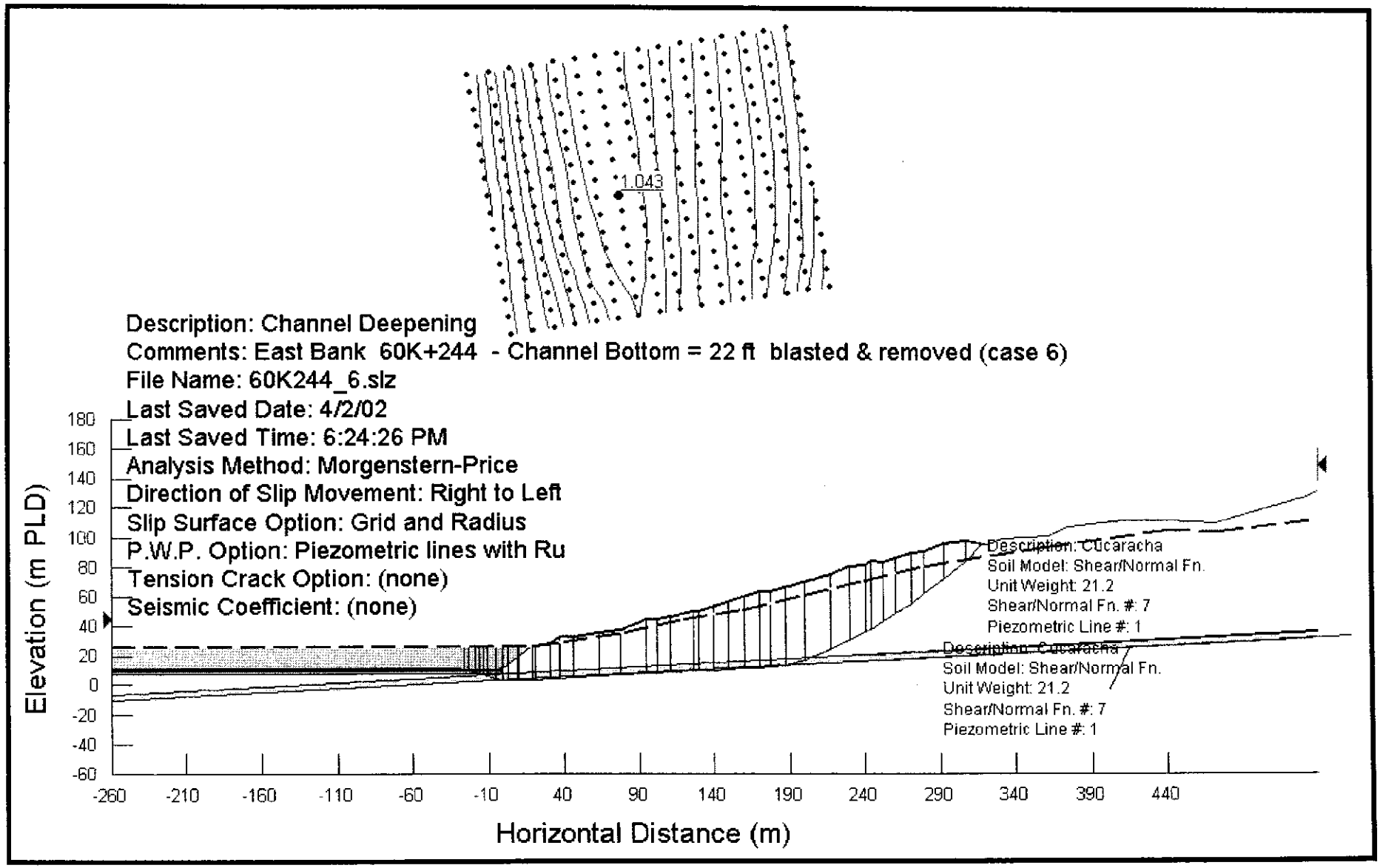
Case 4, Channel bottom = 27 ft, Design (underwater slope)



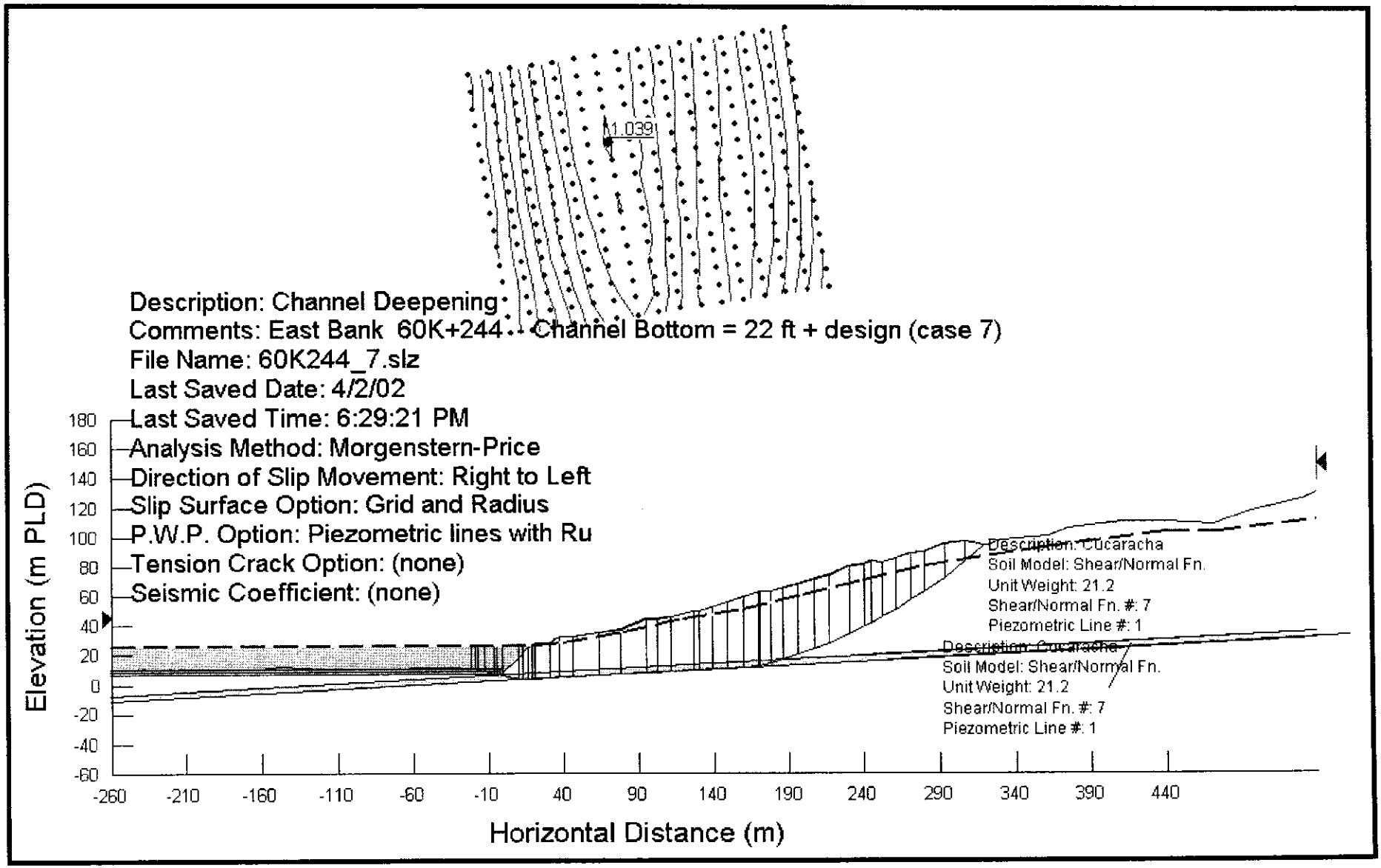
Case 5, Channel bottom = 22 ft, Blasted material only



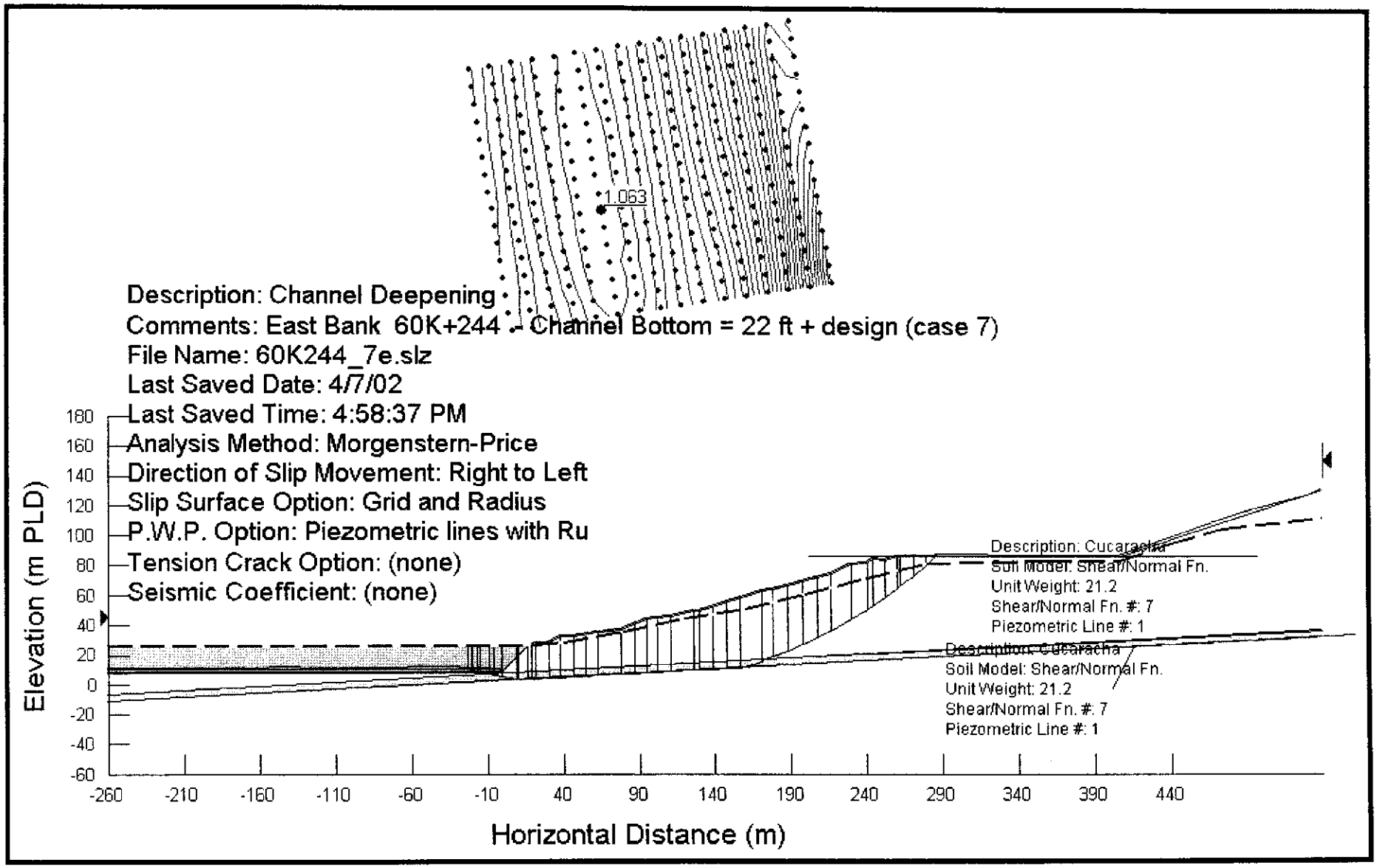
Case 6, Channel bottom = 22 ft, Blasted & removed



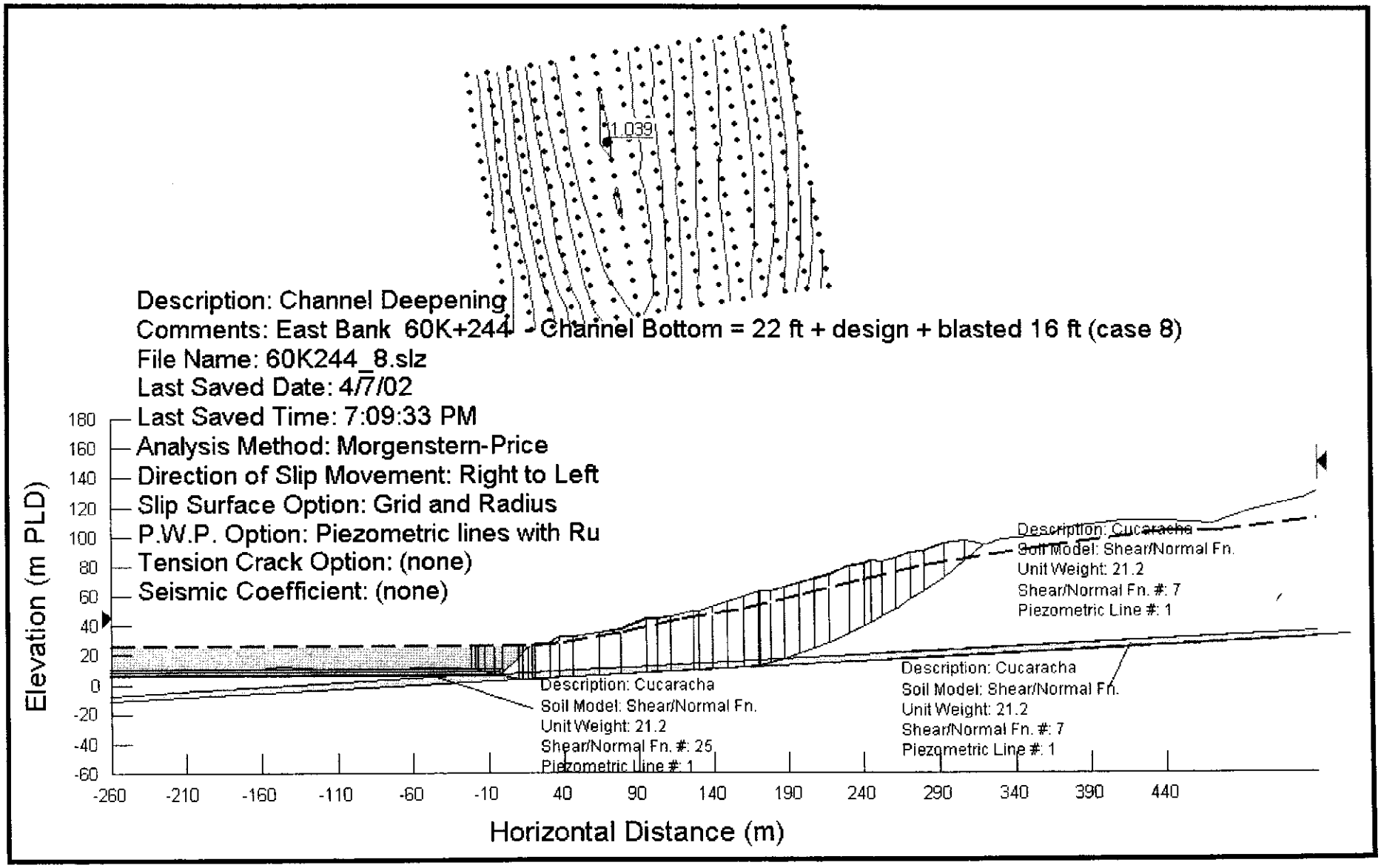
Case 7.1, Channel bottom = 27 ft, Design (underwater slope)



Case 7.2, Channel bottom = 27 ft, Design (& dry excavation)

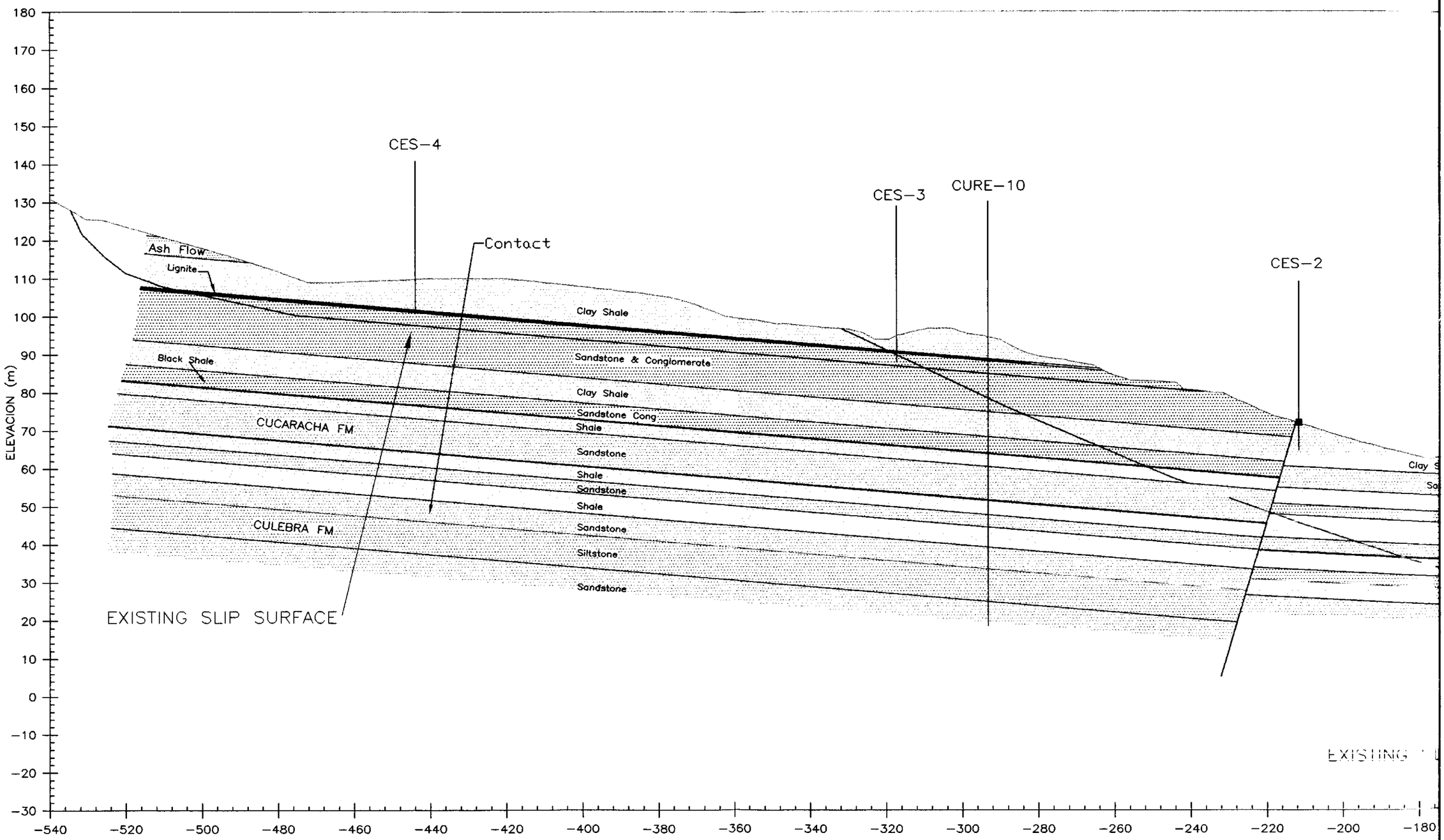


Case 8, Channel bottom = 16 ft, Blasted



Summary, 60k + 244 (1976 + 50)

General Description	Range of stations:	60k + 050 to 60k + 355			
	Sector:	Cucaracha			
	Maximum height (m):	100			
	Cotangent of slope angle (cot. β):	4.7			
History	Last slide event:	October 13, 1986 (East Cucaracha Slide)			
Geology	Formation:	Cucaracha			
	Lithology:	Clayshale / Sandstone / Conglomerate / Ash flow			
	Critical stratum at toe:	Chayshale / Shale			
	Apparent dip of bedding:	Toward the Canal, 7°			
Stability Analysis	Critical failure mechanism:	Translational			
	Shear strength model:	Fully softened, Cucaracha			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.367	1.051	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		1.051	1.000	0.00
	Case 3: Channel bottom = 27 ft, Blasted & removed		1.047	0.996	-0.38
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.045	0.994	-0.57
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.374	1.045	0.994	-0.57
	Case 5: Channel bottom = 22 ft, Blasted material only		1.047	0.996	-0.38
	Case 6: Channel bottom = 22 ft, Blasted & removed		1.043	0.992	-0.76
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.039	0.989	-1.14
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.380	1.063	1.011	1.14
	Case 8: Channel bottom = 16 ft, Blasted		1.039	0.989	-1.14
Conclusions:	Stabilization is required for Case 7				


CES-4
CES-3
CURE-10
CES-2
Contact
Ash Flow
Lignite
Clay Shale
Sandstone & Conglomerate
Black Shale
Clay Shale
Sandstone Cong
Shale
CUCARACHA FM
Sandstone
Shale
Sandstone
Shale
Sandstone
CULEBRA FM
Siltstone
Sandstone
EXISTING SLIP SURFACE
ELEVACION (m)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-540
-520
-500
-480
-460
-440
-420
-400
-380
-360
-340
-320
-300
-280
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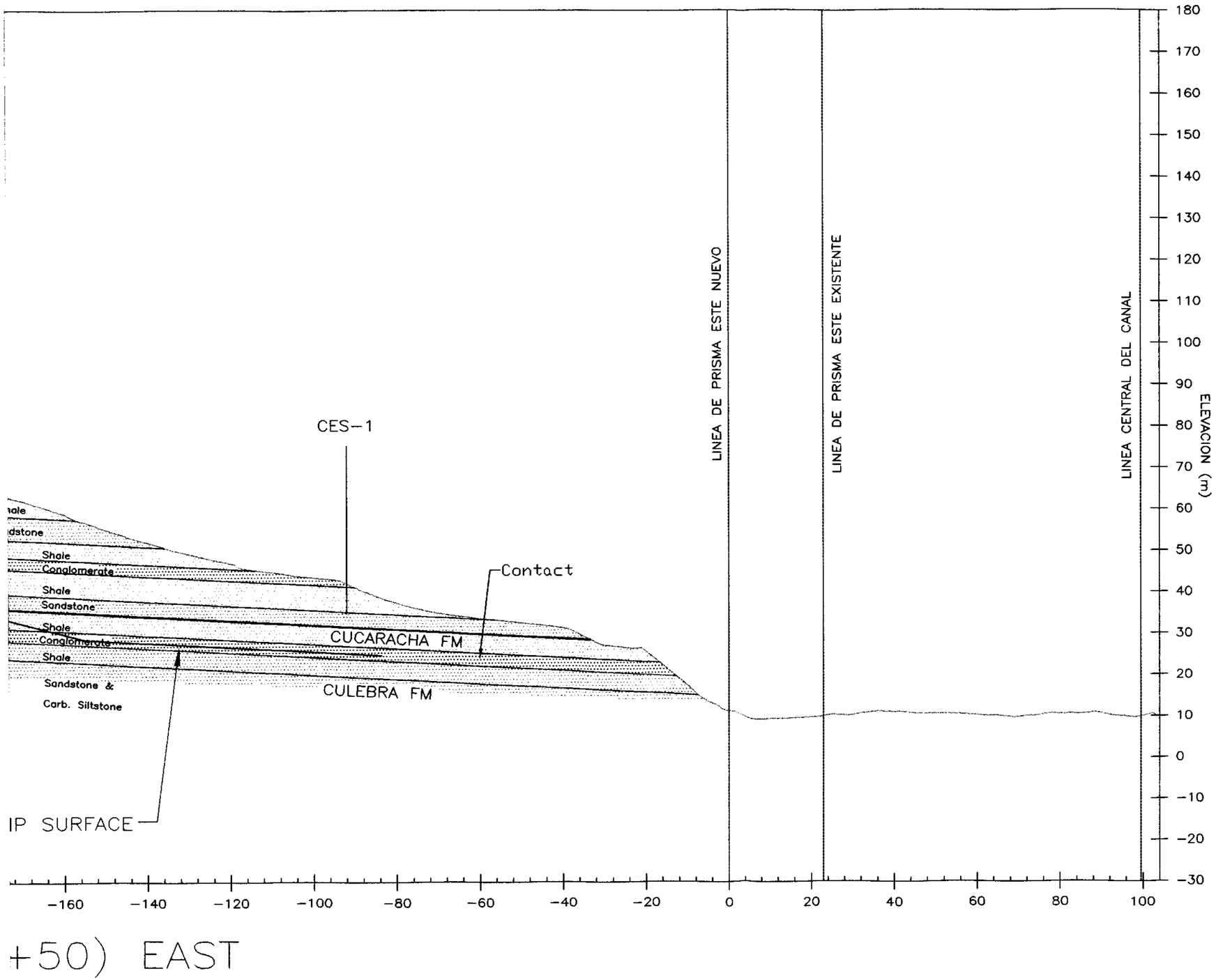
-240
-220
-200
-180
60K+244 (1976



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SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 60K+244 (1976+50) ESTE

ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: M. DE PUY	DIBUJADO POR: P. FRANCESCHI & J. RAMESCH

station 60k + 412 (1982 + 00)

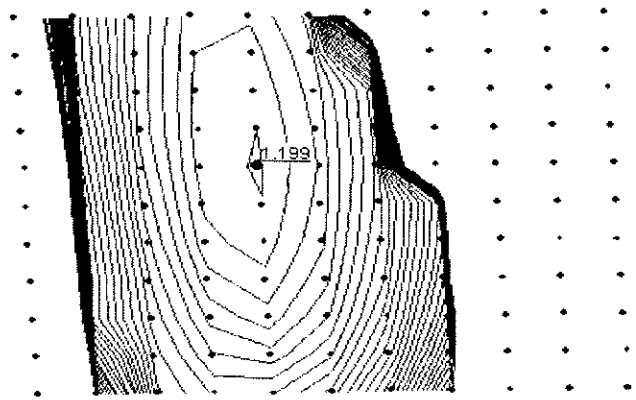
East

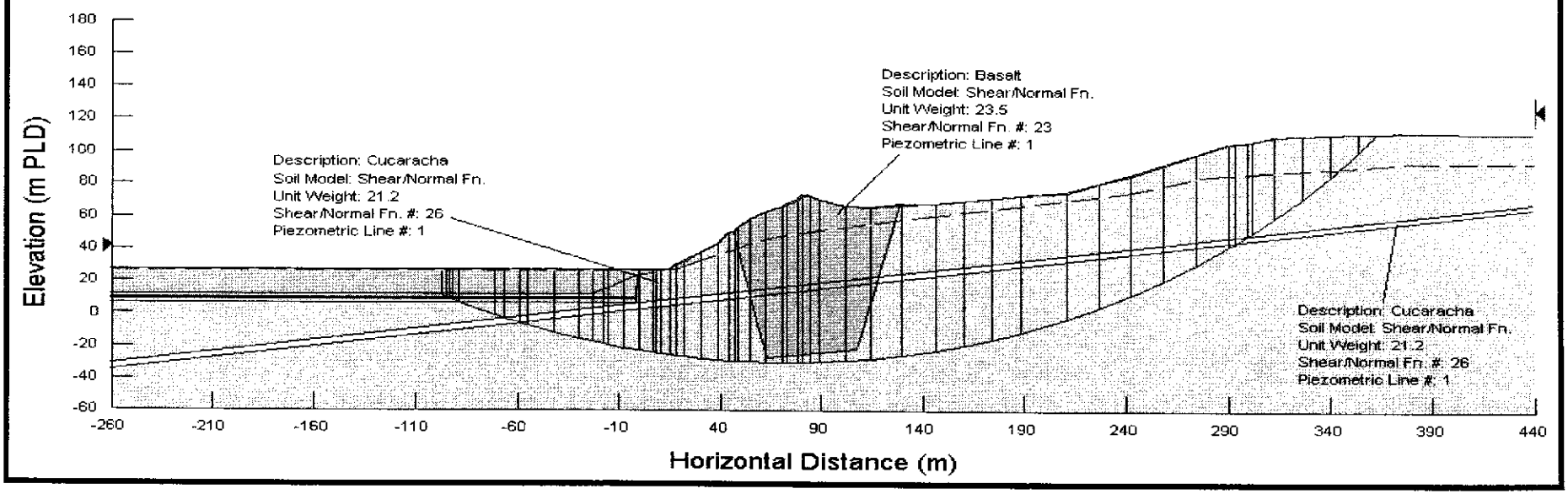
Station: 60k + 412 (Cucarcha)

April 16, 2002

Case 1a, Channel bottom = 32 ft

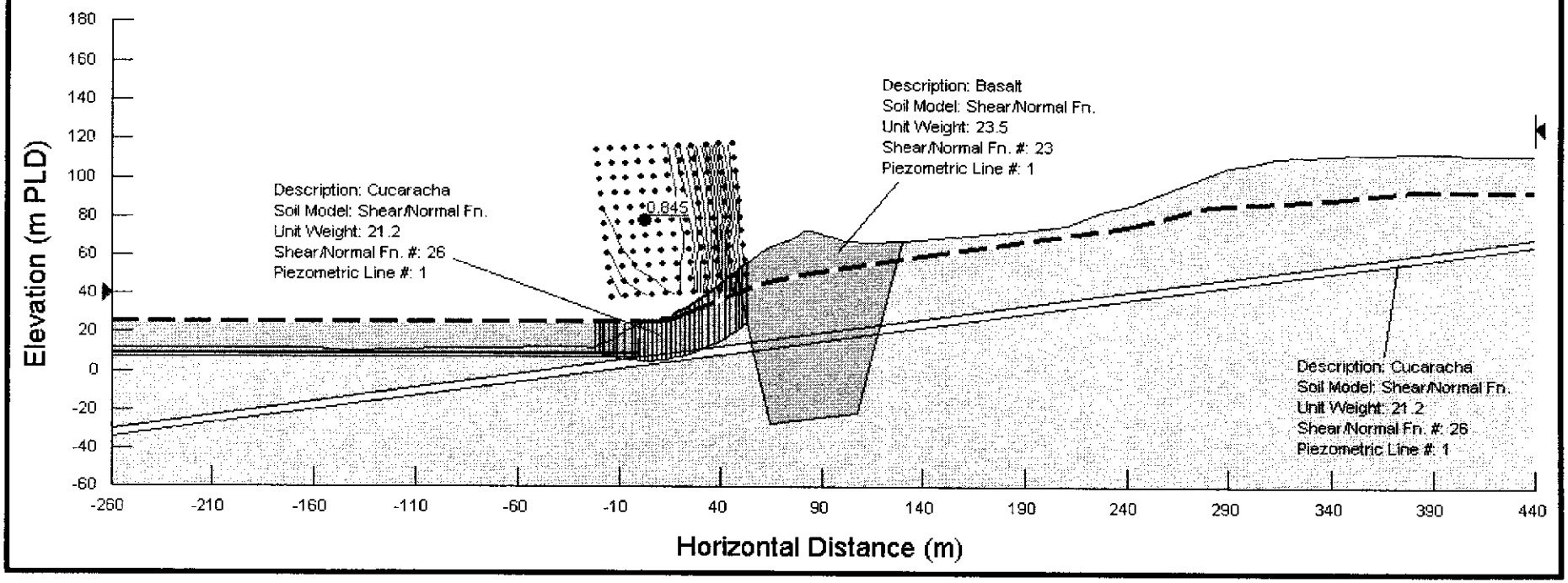
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 32 ft (case 1)
File Name: 60K412_1.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:00:35 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





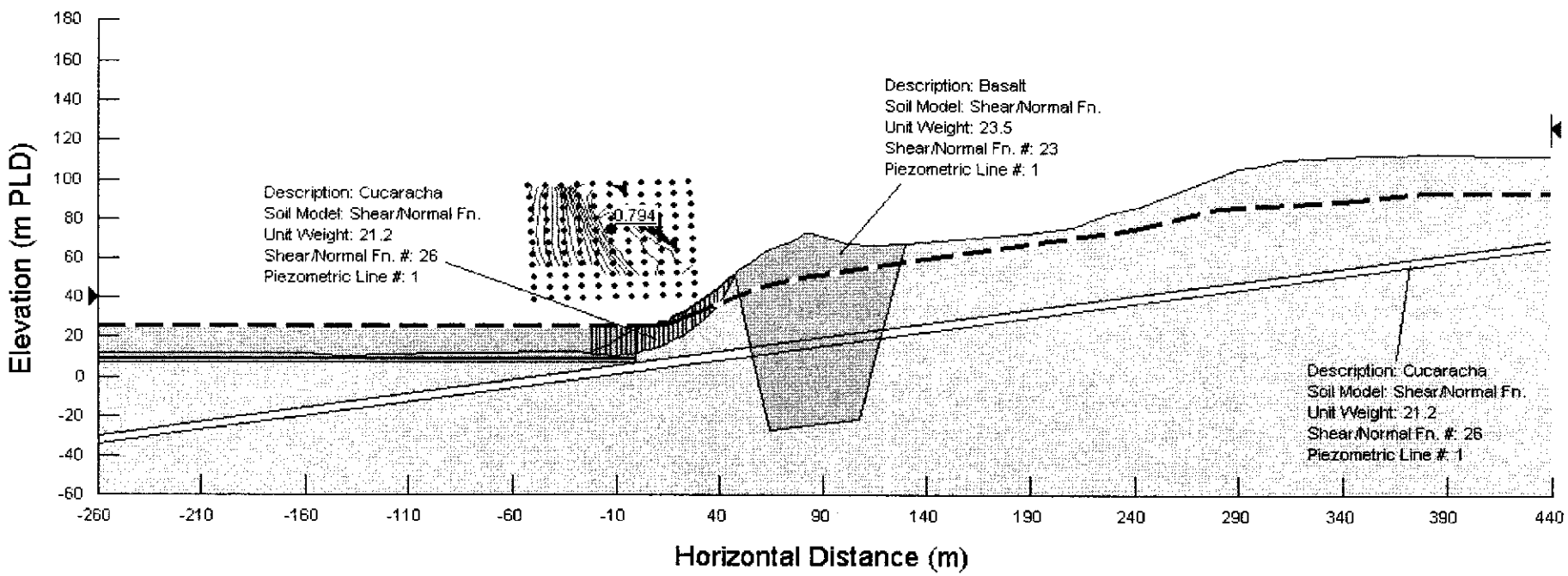
Case 1b, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 32 ft (case 1)
File Name: 60K412_1b.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:04:01 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



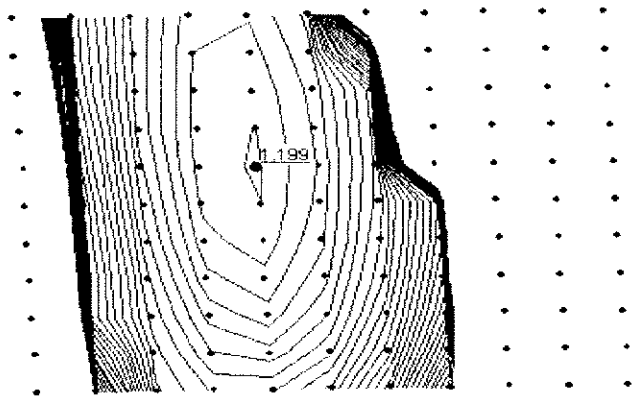
Case 1c, Channel bottom = 32 ft

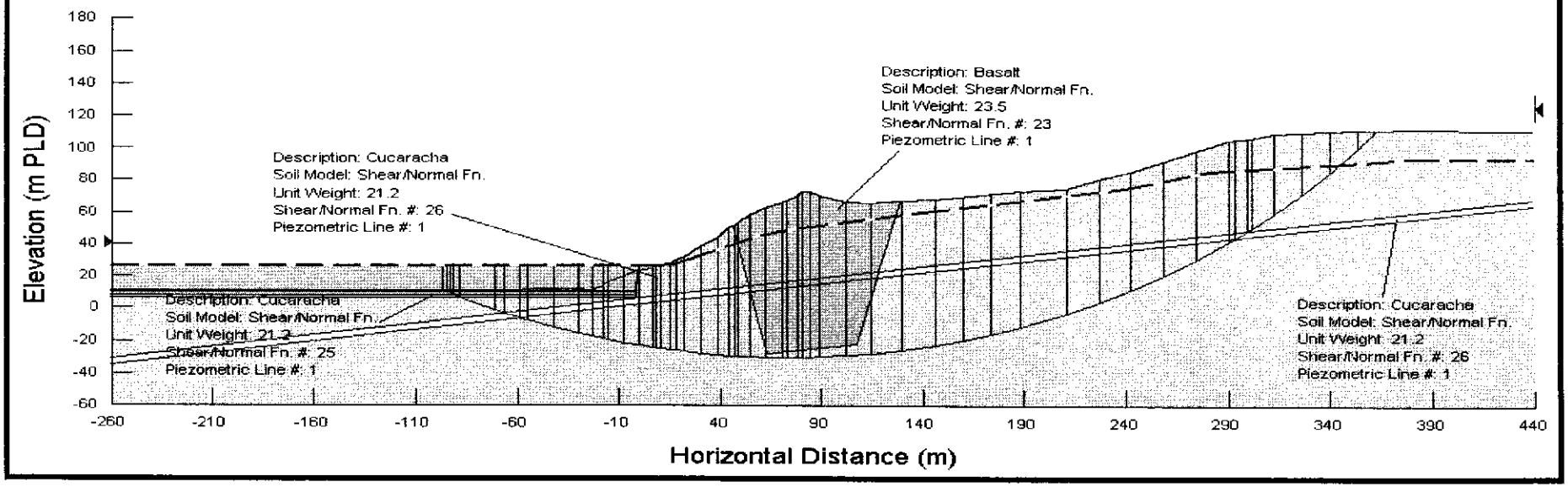
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 32 ft (case 1)
File Name: 60K412_1c.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:33:18 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 2a, Channel bottom = 27 ft, Blasted material only

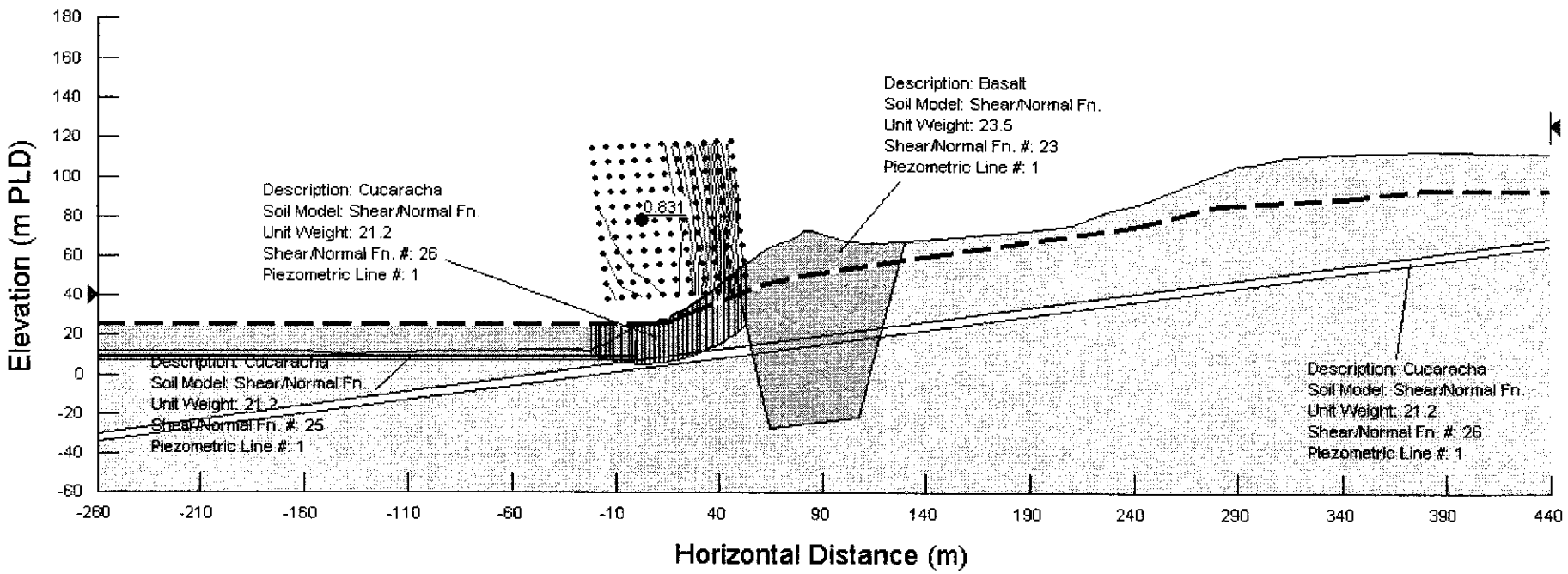
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 60K412_2.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:04:10 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





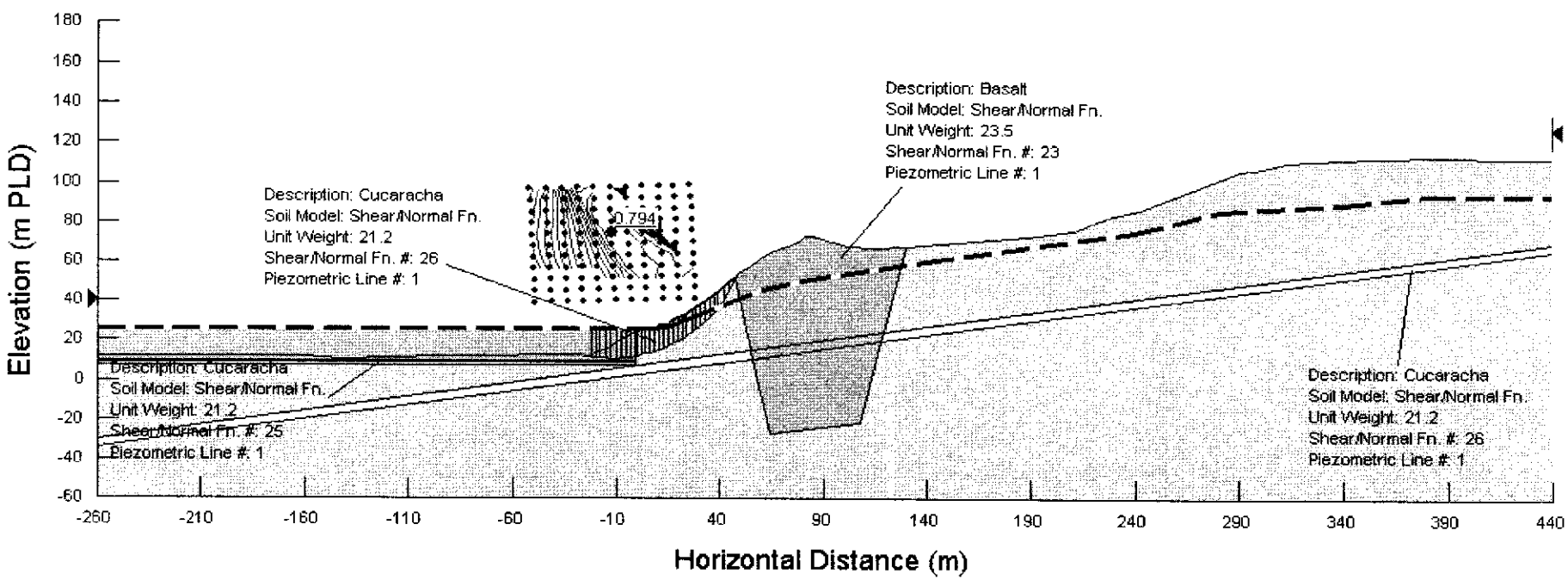
Case 2b, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 60K412_2b.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:07:41 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



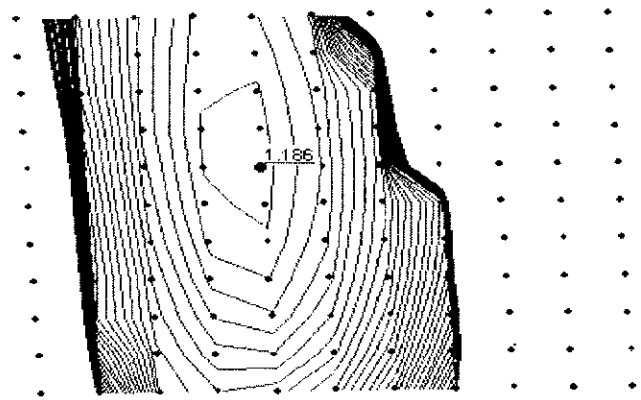
Case 2c, Channel bottom = 27 ft, Blasted material only

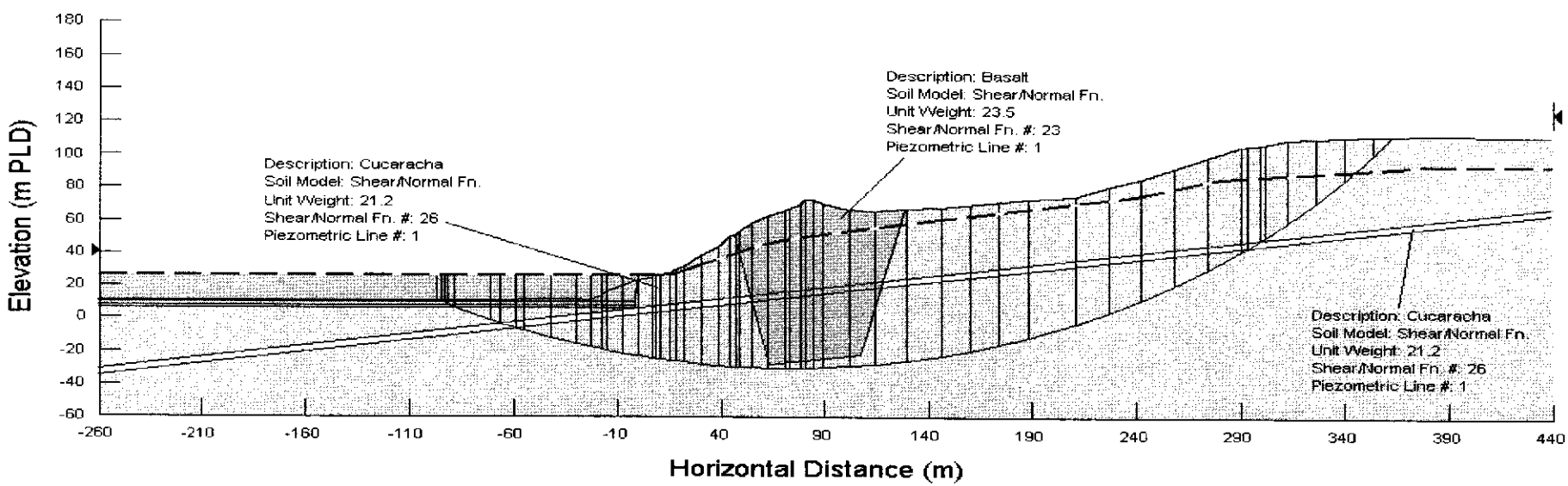
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 60K412_2c.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:35:59 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 3a, Channel bottom = 27 ft, Blasted & removed

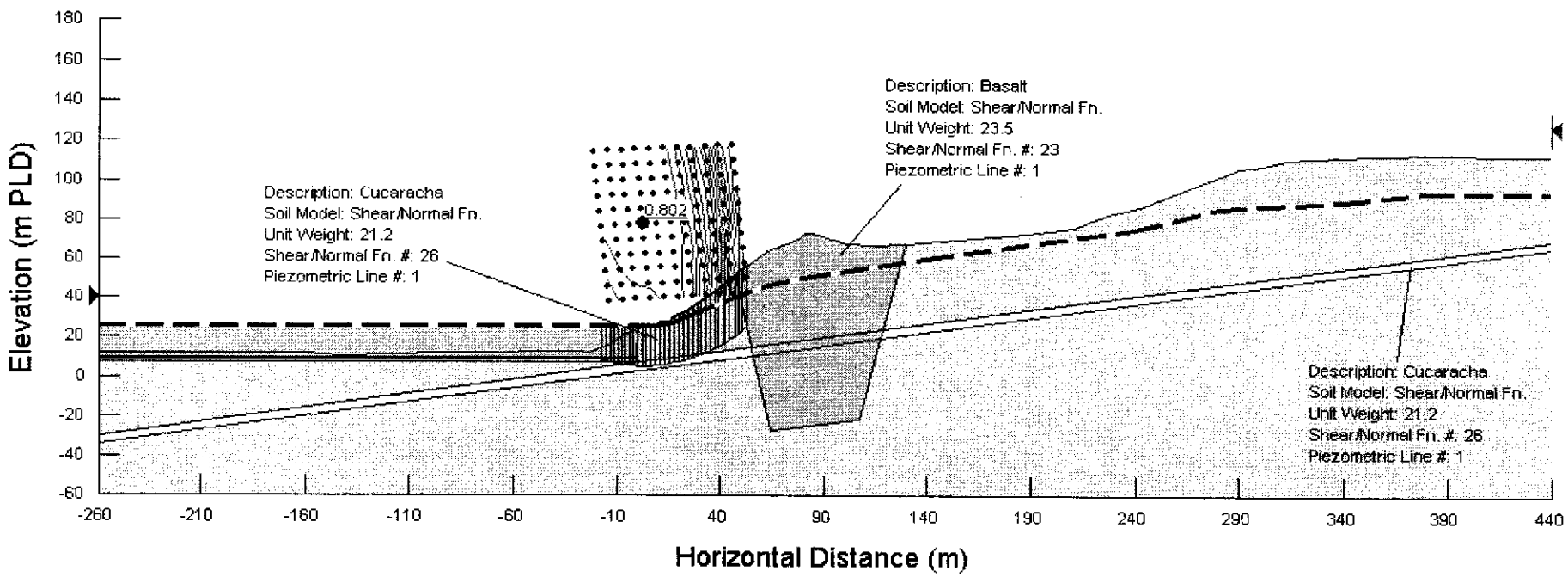
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 60K412_3.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:06:33 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





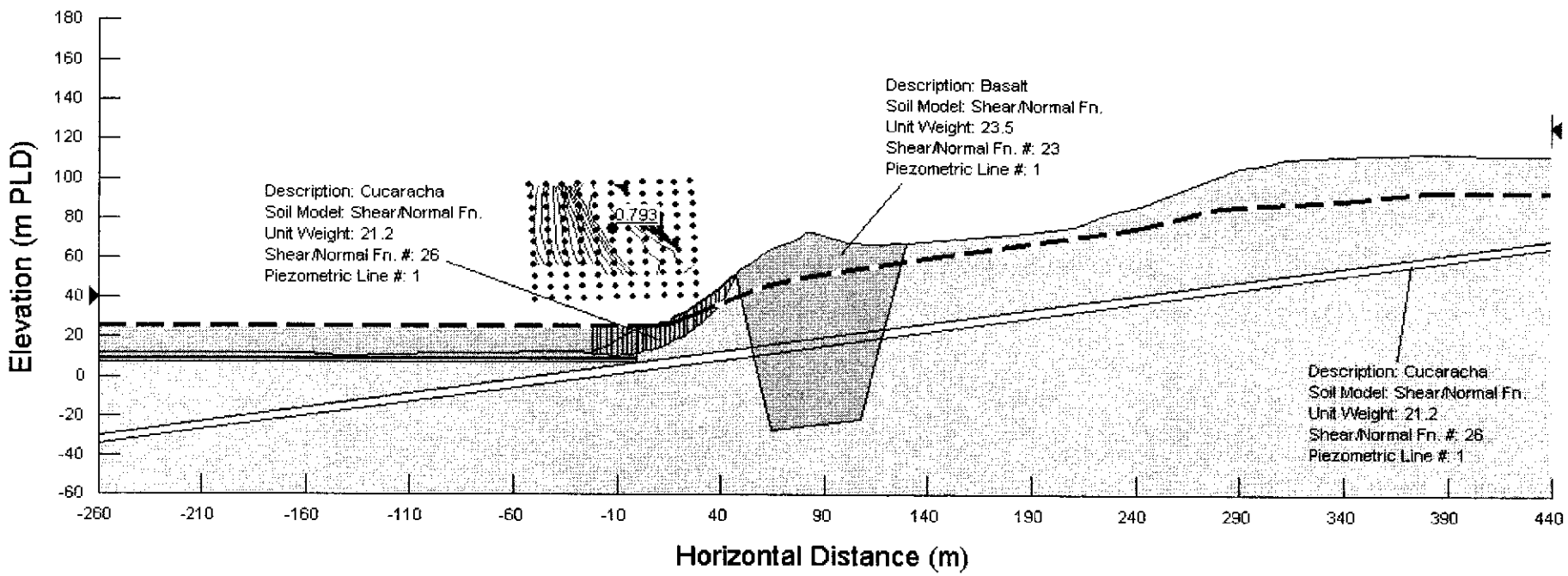
Case 3b, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 60K412_3b.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:11:39 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



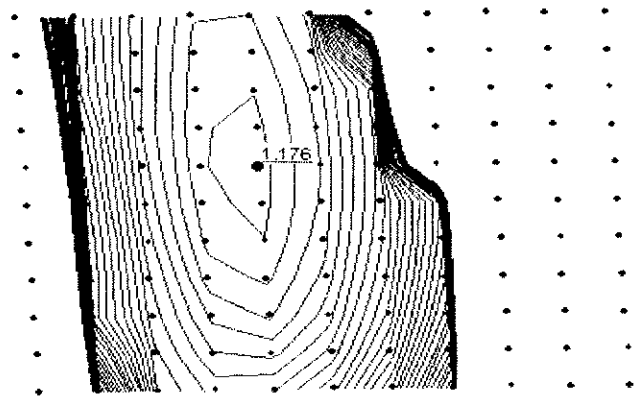
Case 3c, Channel bottom = 27 ft, Blasted & removed

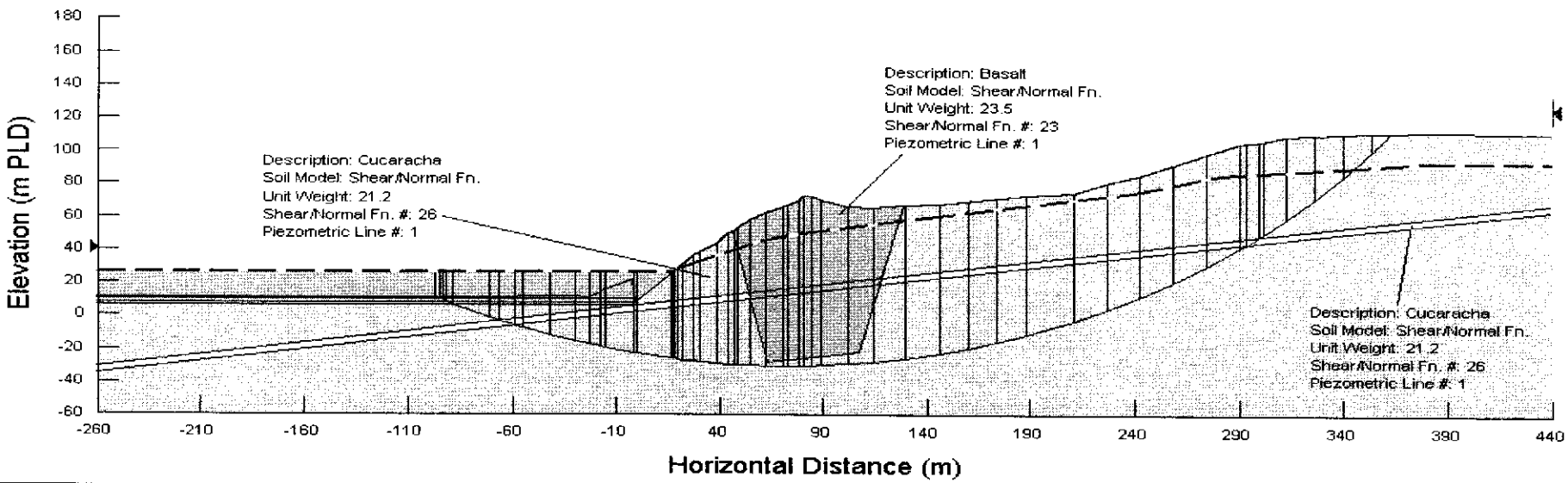
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 60K412_3c.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:38:29 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 4a, Channel bottom = 27 ft, Design (underwater slope)

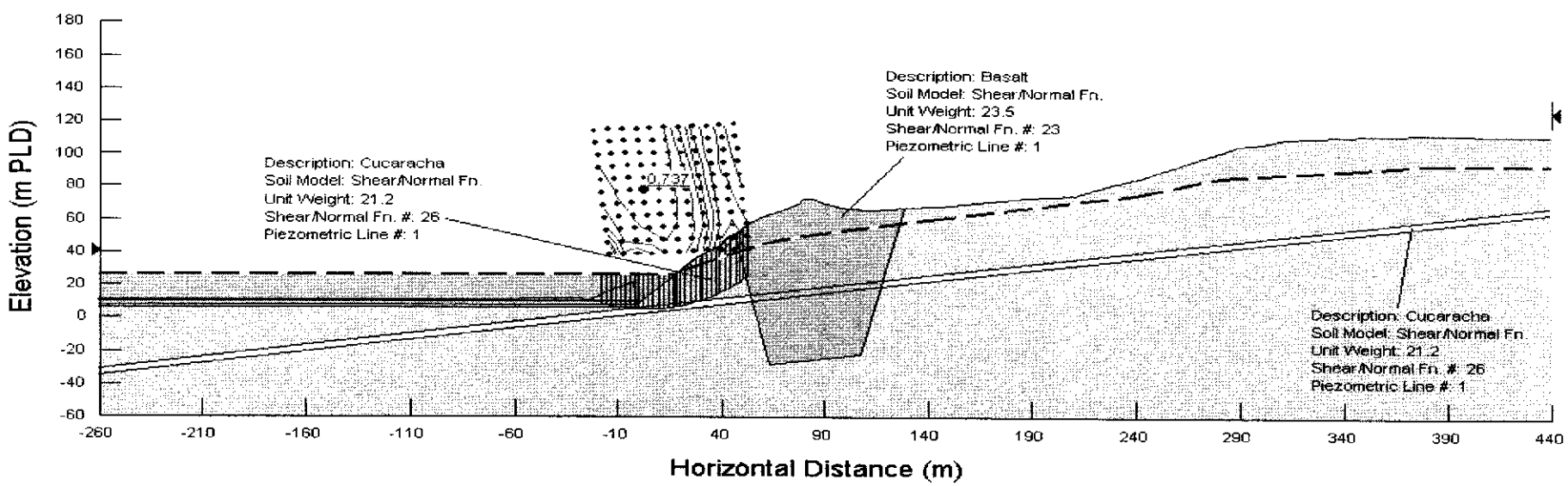
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K412_4.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:27:51 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





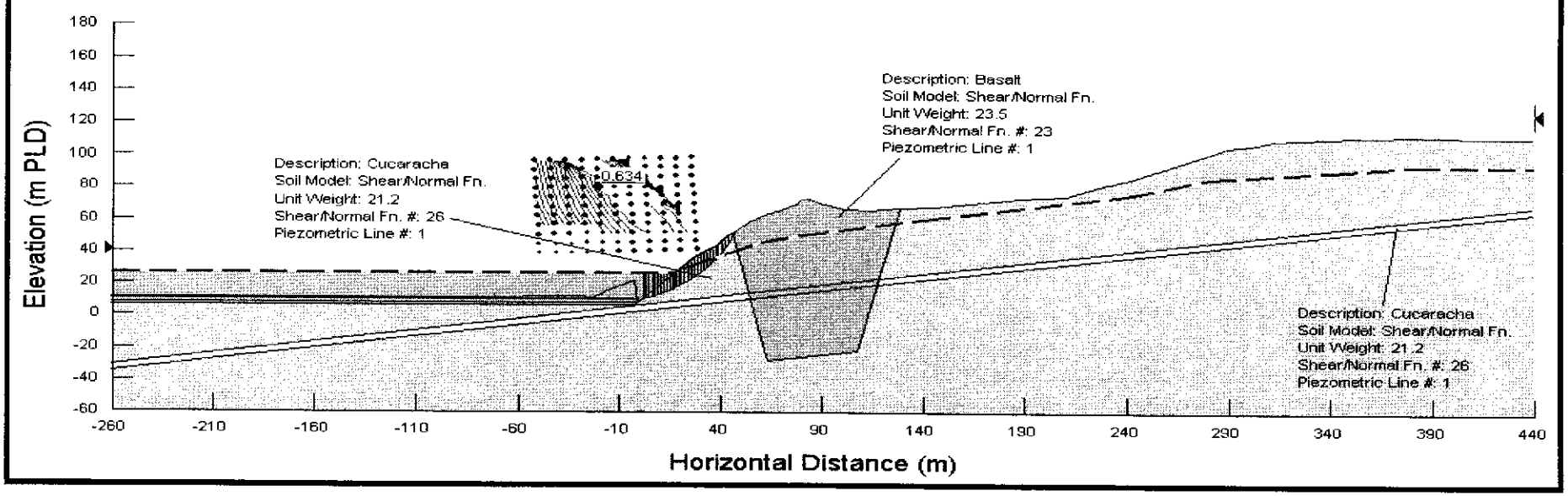
Case 4b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K412_4b.slz
Last Saved Date: 4/10/02
Last Saved Time: 6:03:13 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



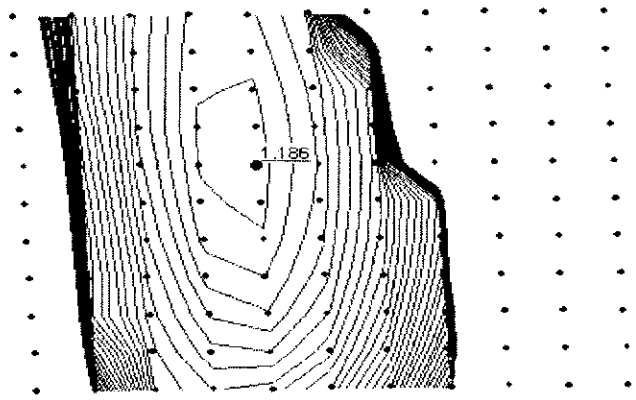
Case 4c, Channel bottom = 27 ft, Design (underwater slope)

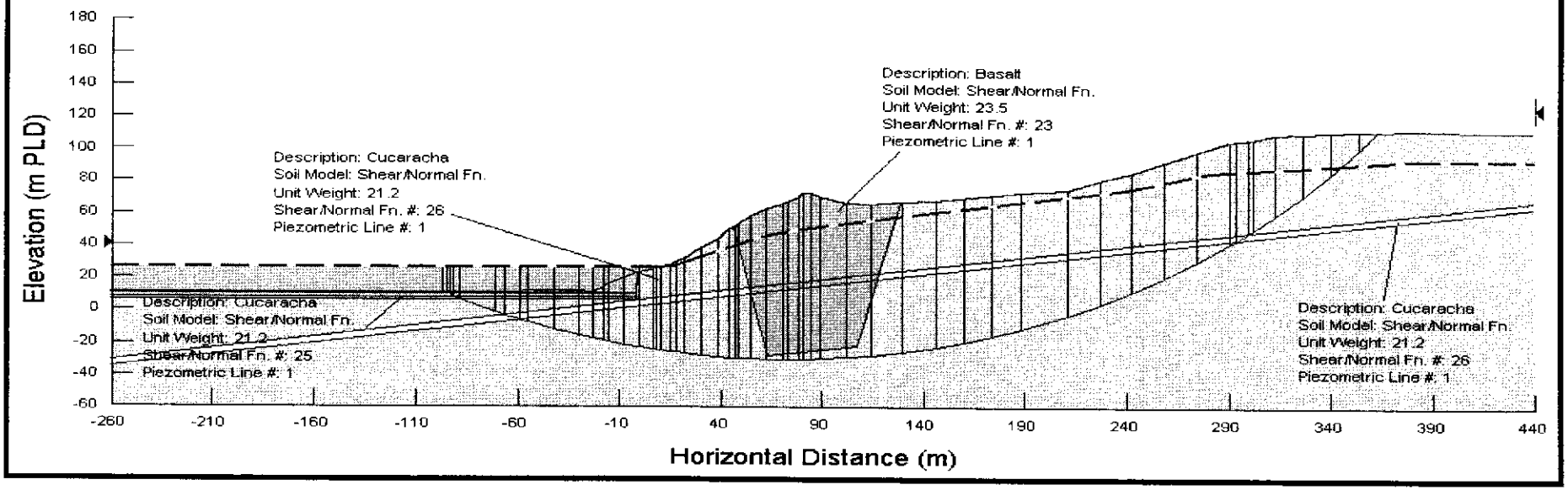
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K412_4c.slz
Last Saved Date: 4/10/02
Last Saved Time: 7:08:50 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 5a, Channel bottom = 22 ft, Blasted material only

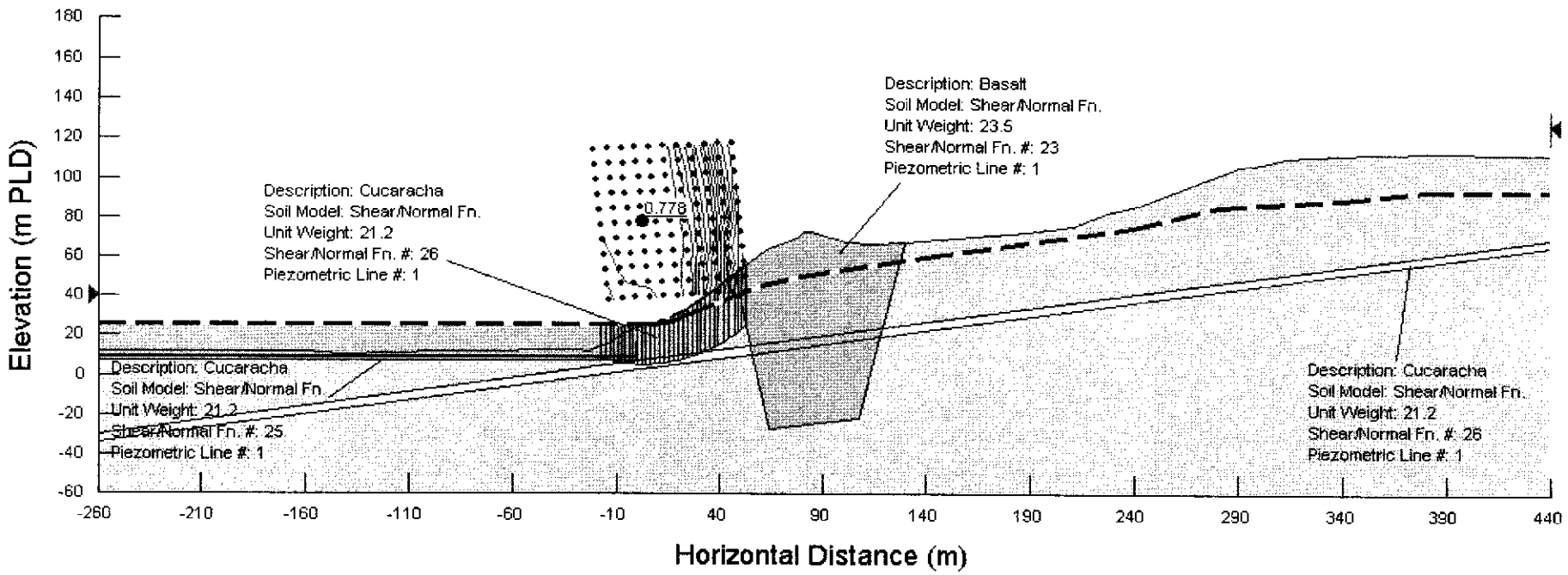
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 60K412_5.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:13:13 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





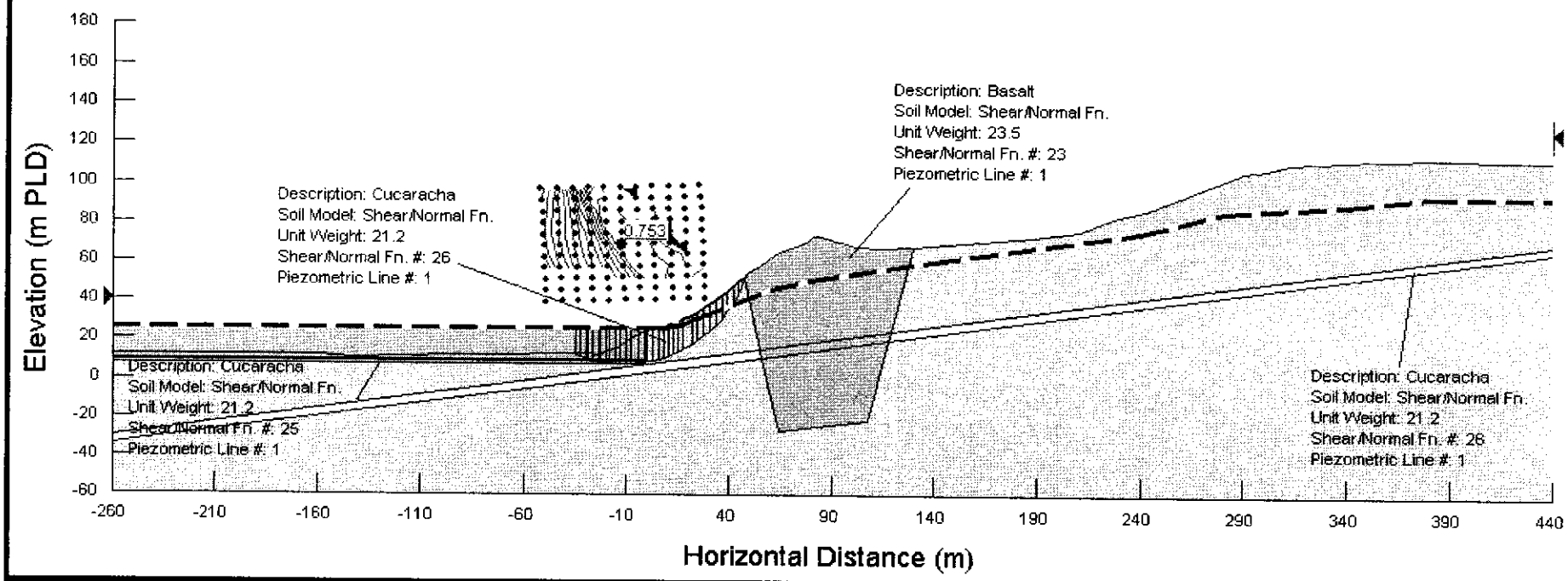
Case 5b, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 60K412_5b.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:15:26 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



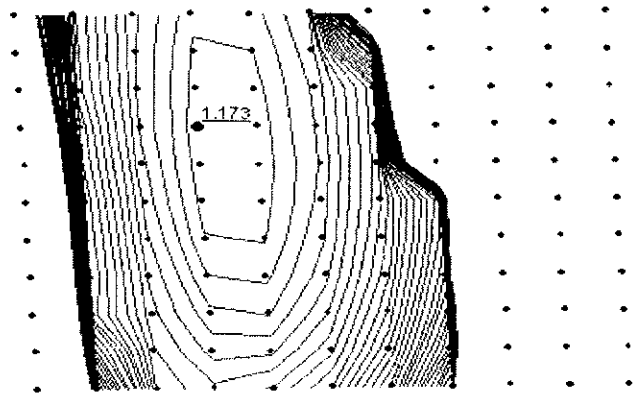
Case 5c, Channel bottom = 22 ft, Blasted material only

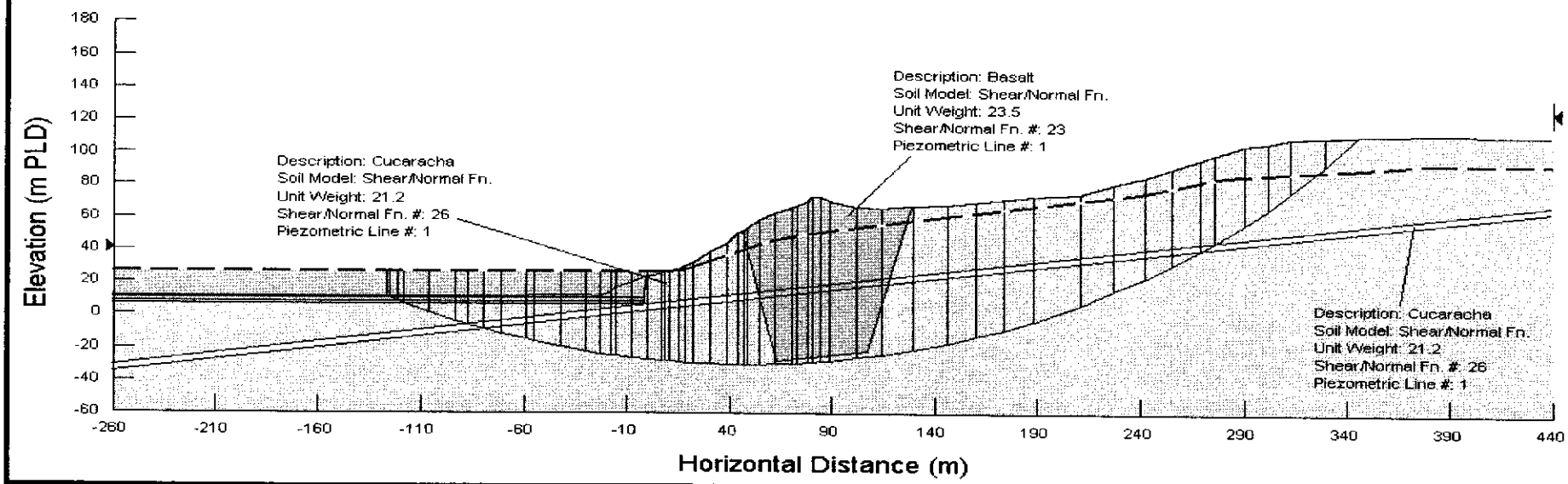
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 60K412_5c.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:41:00 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 6a, Channel bottom = 22 ft, Blasted & removed

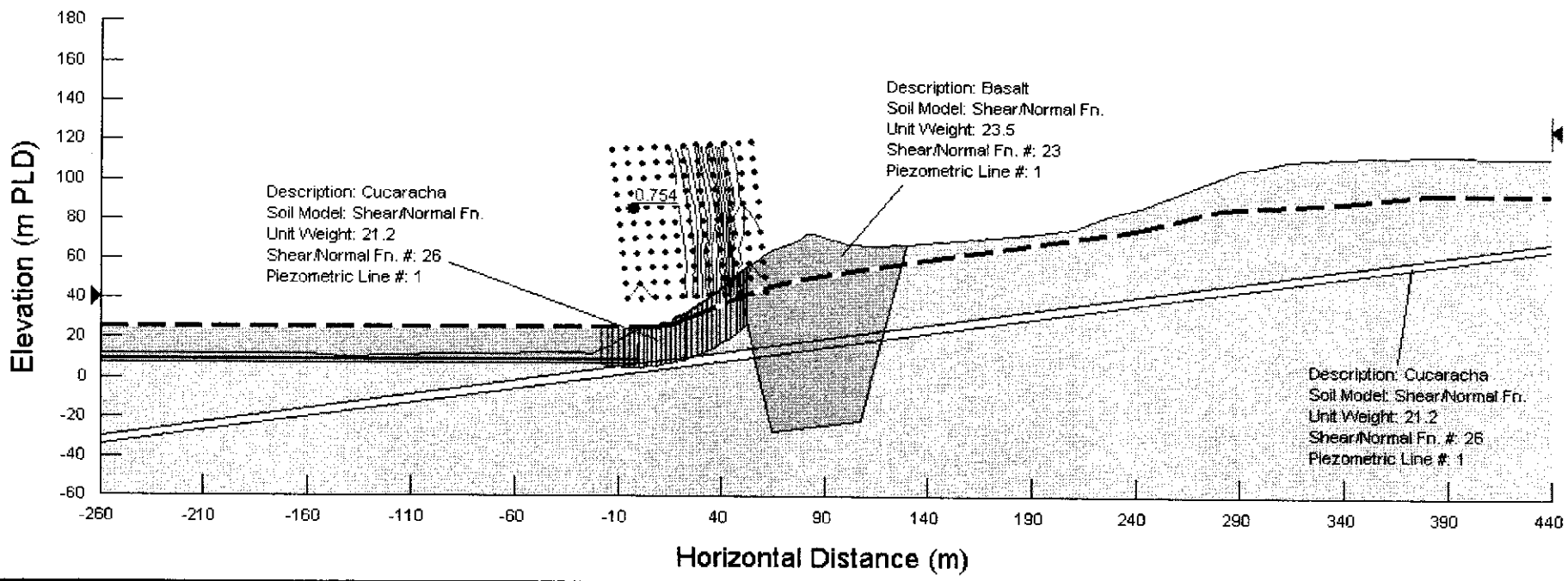
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 60K412_6.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:16:04 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





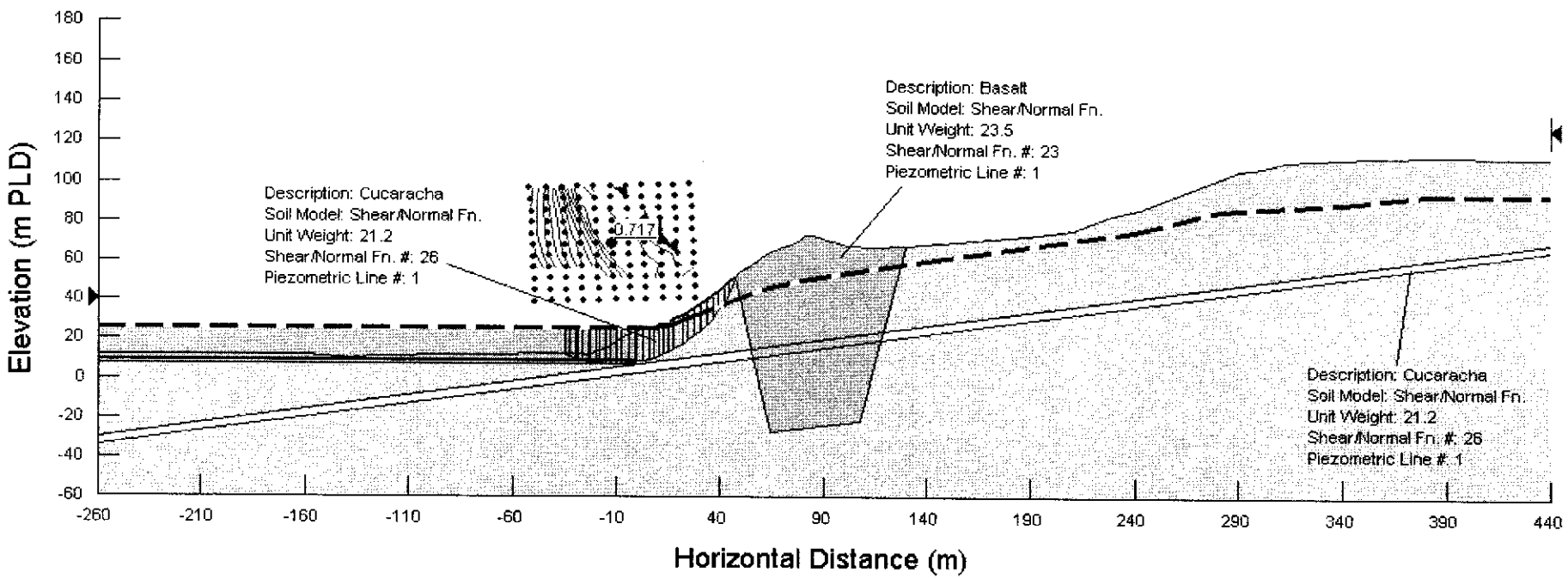
Case 6b, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 60K412_6b.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:26:18 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



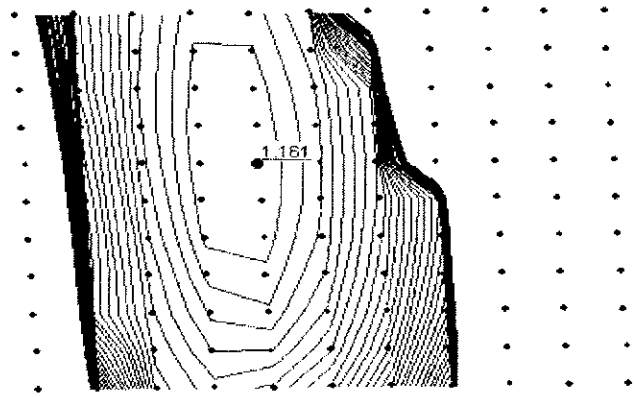
Case 6c, Channel bottom = 22 ft, Blasted & removed

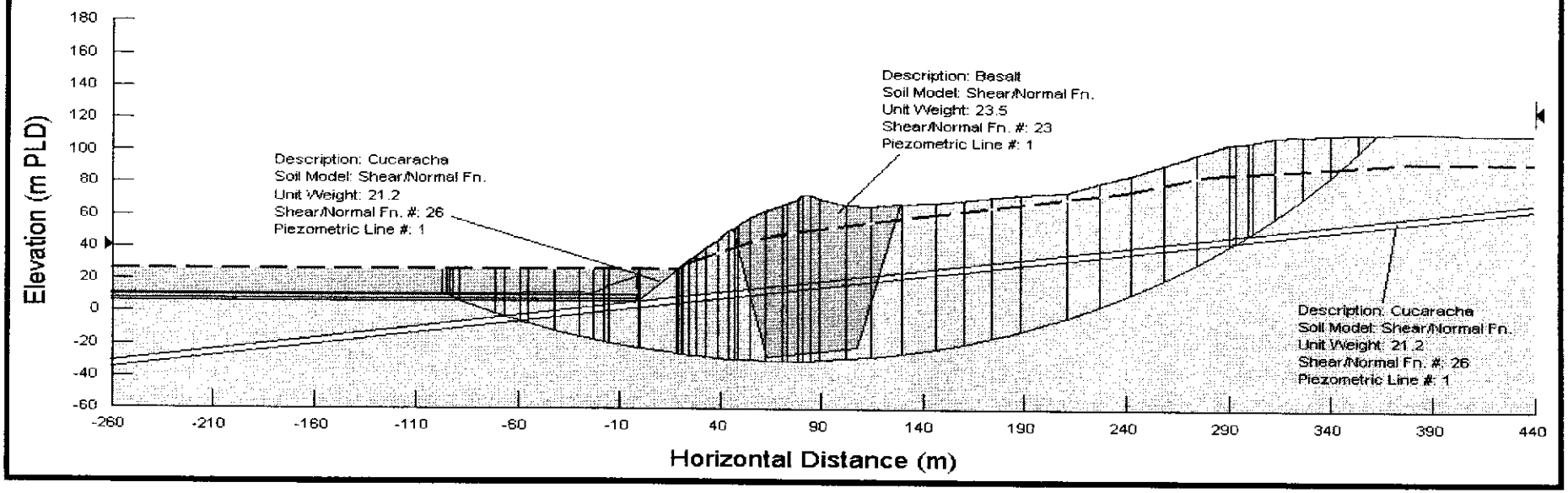
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 60K412_6c.slz
Last Saved Date: 4/10/02
Last Saved Time: 5:43:05 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 7a, Channel bottom = 27 ft, Design (underwater slope)

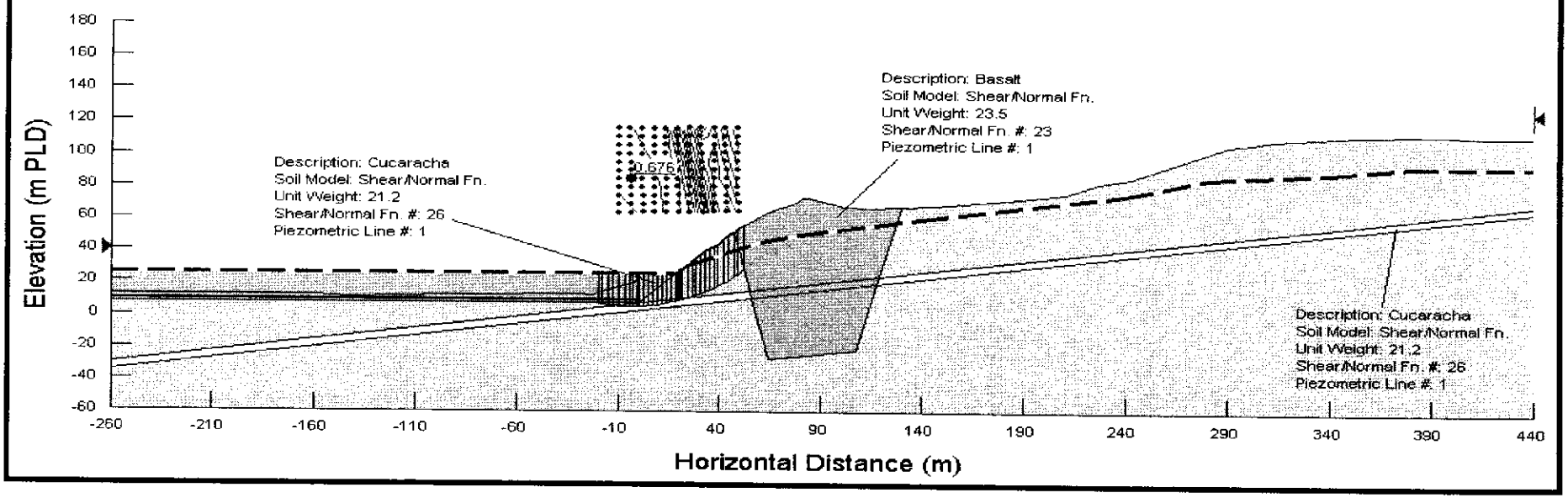
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K412_7.slz
Last Saved Date: 4/10/02
Last Saved Time: 1:56:35 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





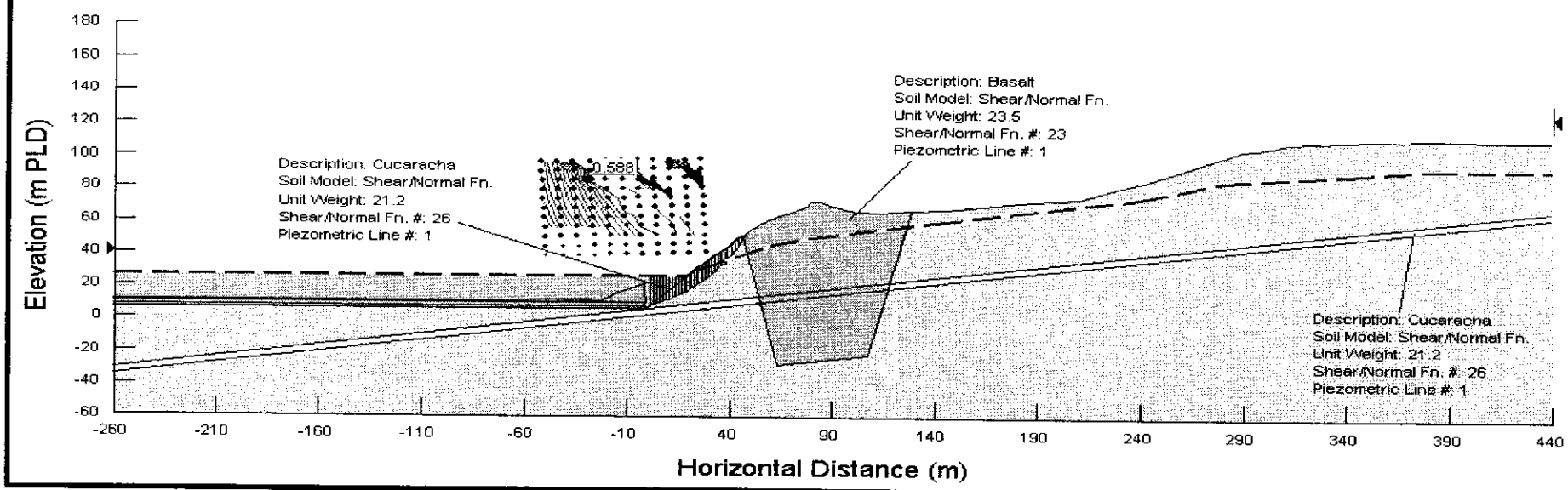
Case 7b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K412_7b.slz
Last Saved Date: 4/10/02
Last Saved Time: 6:32:27 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



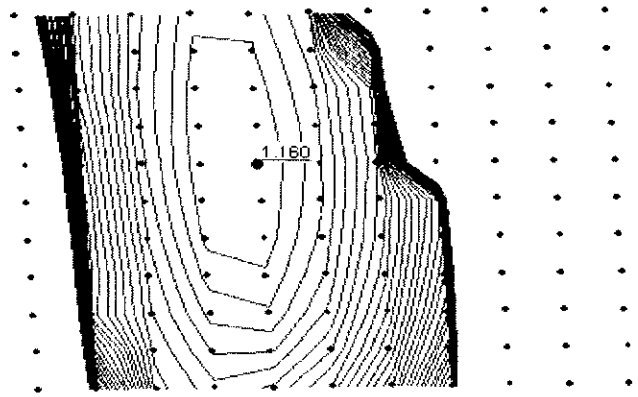
Case 7c, Channel bottom = 27 ft, Design (underwater slope)

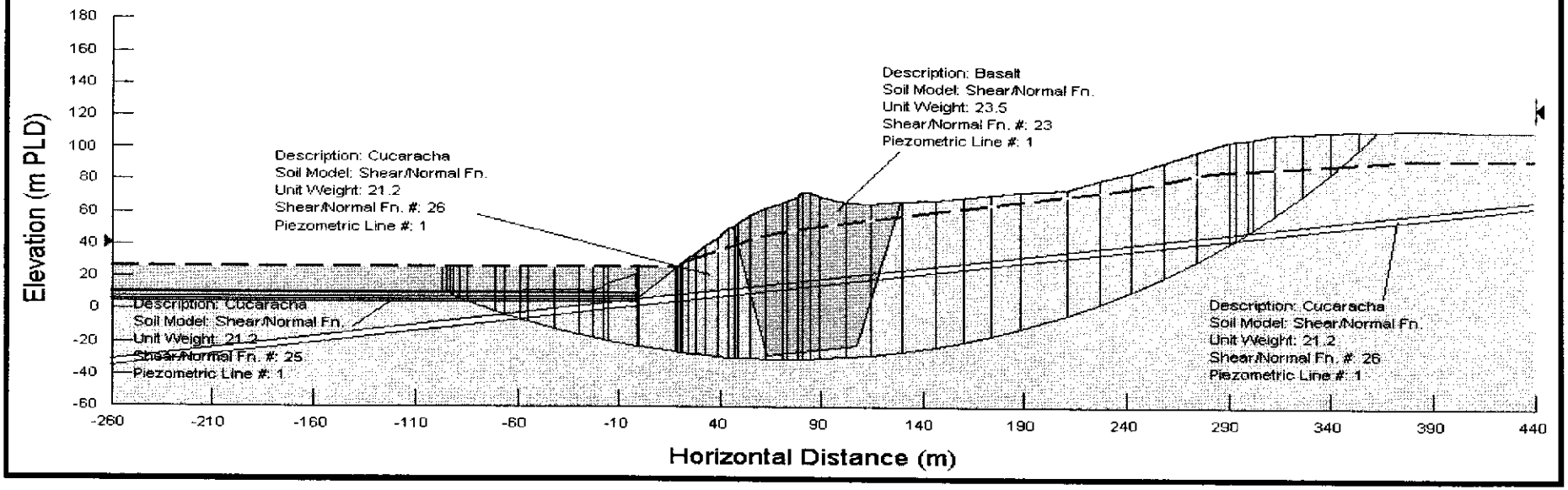
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K412_7c.slz
Last Saved Date: 4/10/02
Last Saved Time: 7:12:43 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



Case 8a, Channel bottom = 16 ft, Blasted

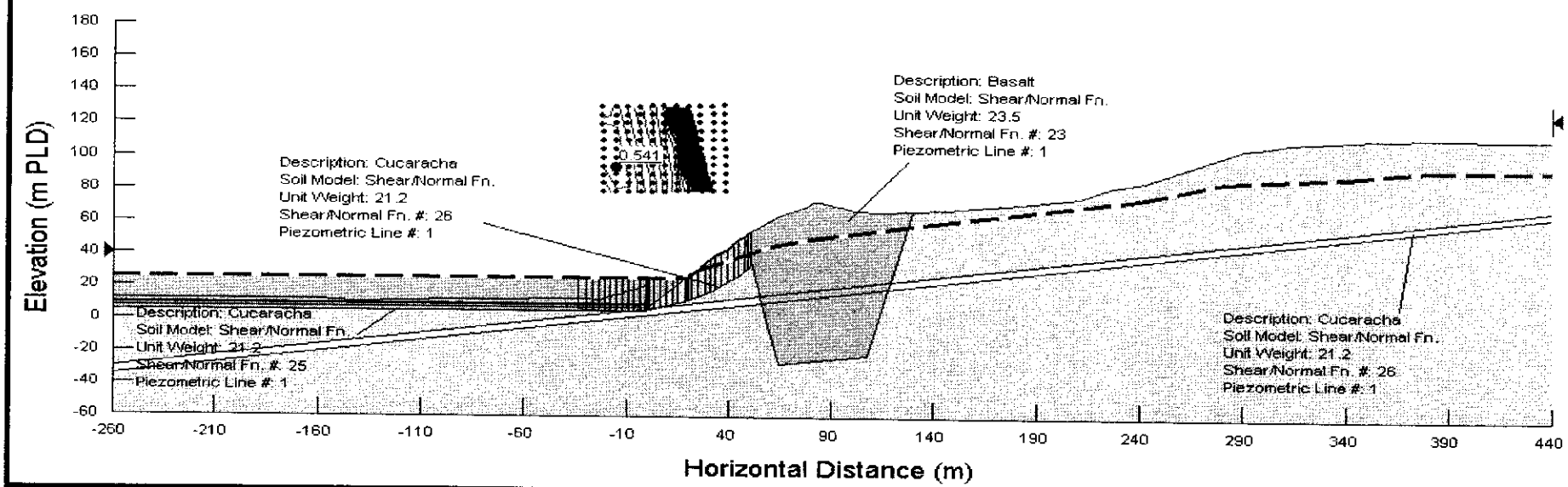
Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 60K412_8.slz
Last Saved Date: 4/10/02
Last Saved Time: 2:20:46 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)





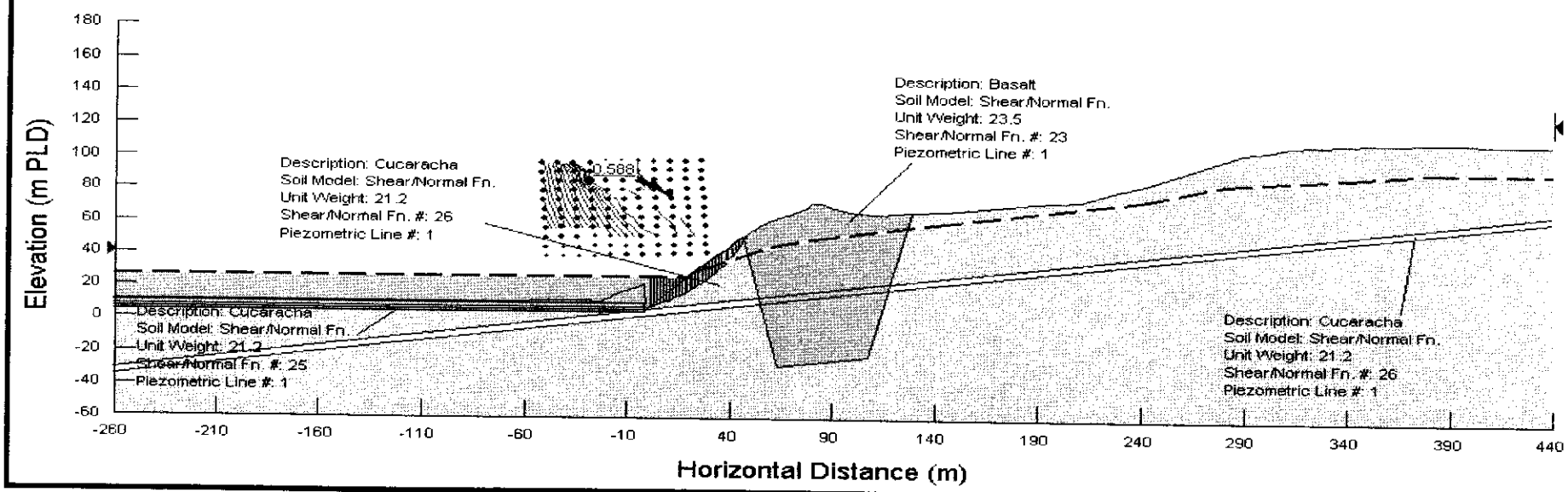
Case 8b, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 60K412_8b.slz
Last Saved Date: 4/10/02
Last Saved Time: 6:49:03 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 8c, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 60K+412 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 60K412_8c.slz
Last Saved Date: 4/10/02
Last Saved Time: 7:15:41 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

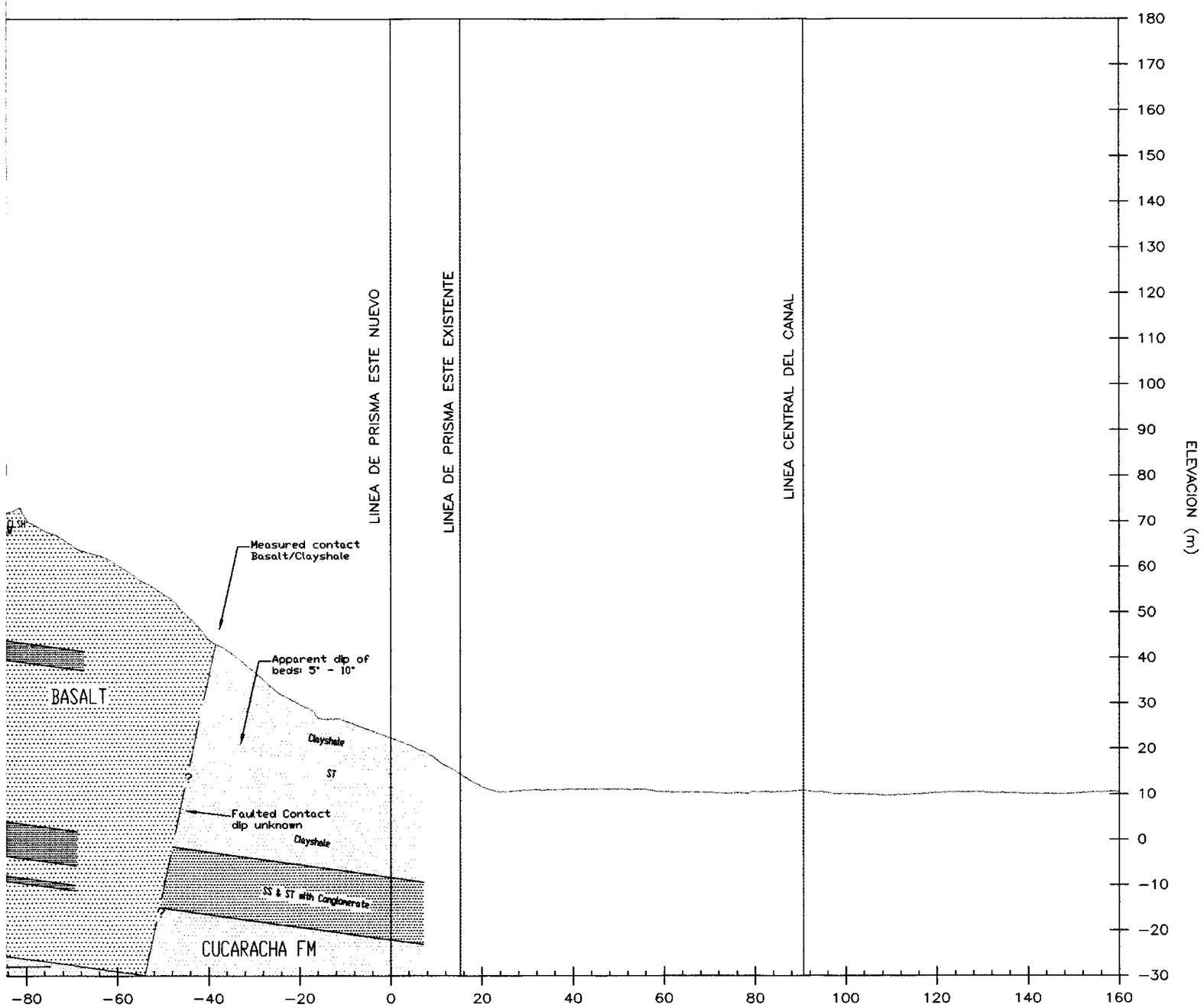


Summary, 60k + 412 (1982 + 00)

General Description	Range of stations:	60k + 355 to 60k + 500
	Sector:	Cucaracha
	Maximum height (m):	100
	Cotangent of slope angle (cot. β):	1.5
History	Last slide event:	January, 1999 (Purple Rock)
Geology	Formation:	Basalt / Cucaracha
	Lithology:	Basalt / Clayshale / Sandstone / Siltstone / Shale
	Critical stratum at toe:	Clayshale
	Apparent dip of bedding:	Toward the Canal
Stability Analysis	Critical failure mechanism:	Rotational
	Shear strength model:	Fully softened - upper - Cucaracha / First time Basalt

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety			Relative Factor of Safety			Percentage of Change (%)		
		(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Case 1: Channel bottom = 32 ft	0.394	1.199	0.845	0.794	1.000	1.000	1.000	0.00	0.00	0.00
Case 2: Channel bottom = 27 ft, Blasted material only		1.199	0.831	0.794	1.000	0.983	1.000	0.00	-1.66	0.00
Case 3: Channel bottom = 27 ft, Blasted & removed		1.186	0.802	0.793	0.989	0.949	0.999	-1.08	-5.09	-0.13
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.176	0.737	0.634	0.981	0.872	0.798	-1.92	-12.78	-20.15
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.370	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Case 5: Channel bottom = 22 ft, Blasted material only		1.186	0.778	0.753	0.989	0.921	0.948	-1.08	-7.93	-5.16
Case 6: Channel bottom = 22 ft, Blasted & removed		1.173	0.754	0.717	0.978	0.892	0.903	-2.17	-10.77	-9.70
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.161	0.676	0.588	0.968	0.800	0.741	-3.17	-20.00	-25.94
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.374	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
Case 8: Channel bottom = 16 ft, Blasted		1.160	0.541	0.588	0.967	0.640	0.741	-3.25	-35.98	-25.94

Conclusions: Stabilization is required for Case 4 and Case 7. The stabilization scheme will use rock anchors. Excavation is not recommended for this area.



AUTORIDAD DEL CANAL DE PANAMA

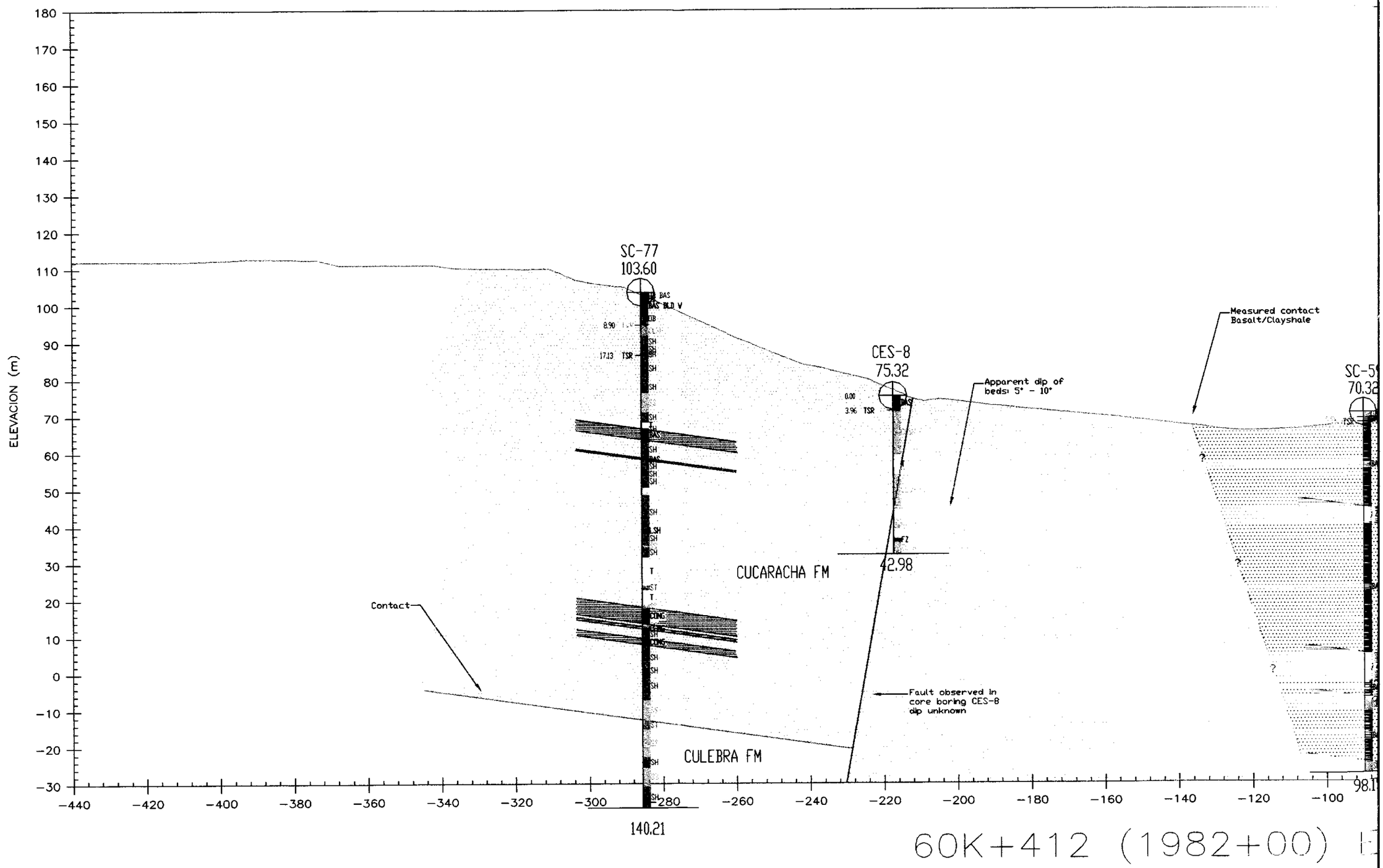
DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 60K+412 (1982+00) ESTE

ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: P. FRANCESCHI	DIBUJADO POR: J. RAMESCH


ELEVACION (m)
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
-20
-30
-440
-420
-400
-380
-360
-340
-320
-300
-280
-260
-240
-220
-200
-180
-160
-140
-120
-100
SC-77
103.60
CES-8
75.32
SC-5
70.32
98.1
140.21
42.98
CUCARACHA FM
CULEBRA FM
Contact
Apparent dip of beds: 5° - 10°
Measured contact Basalt/Clayshale
Fault observed in core boring CES-8 dip unknown
60K+412 (1982+00)

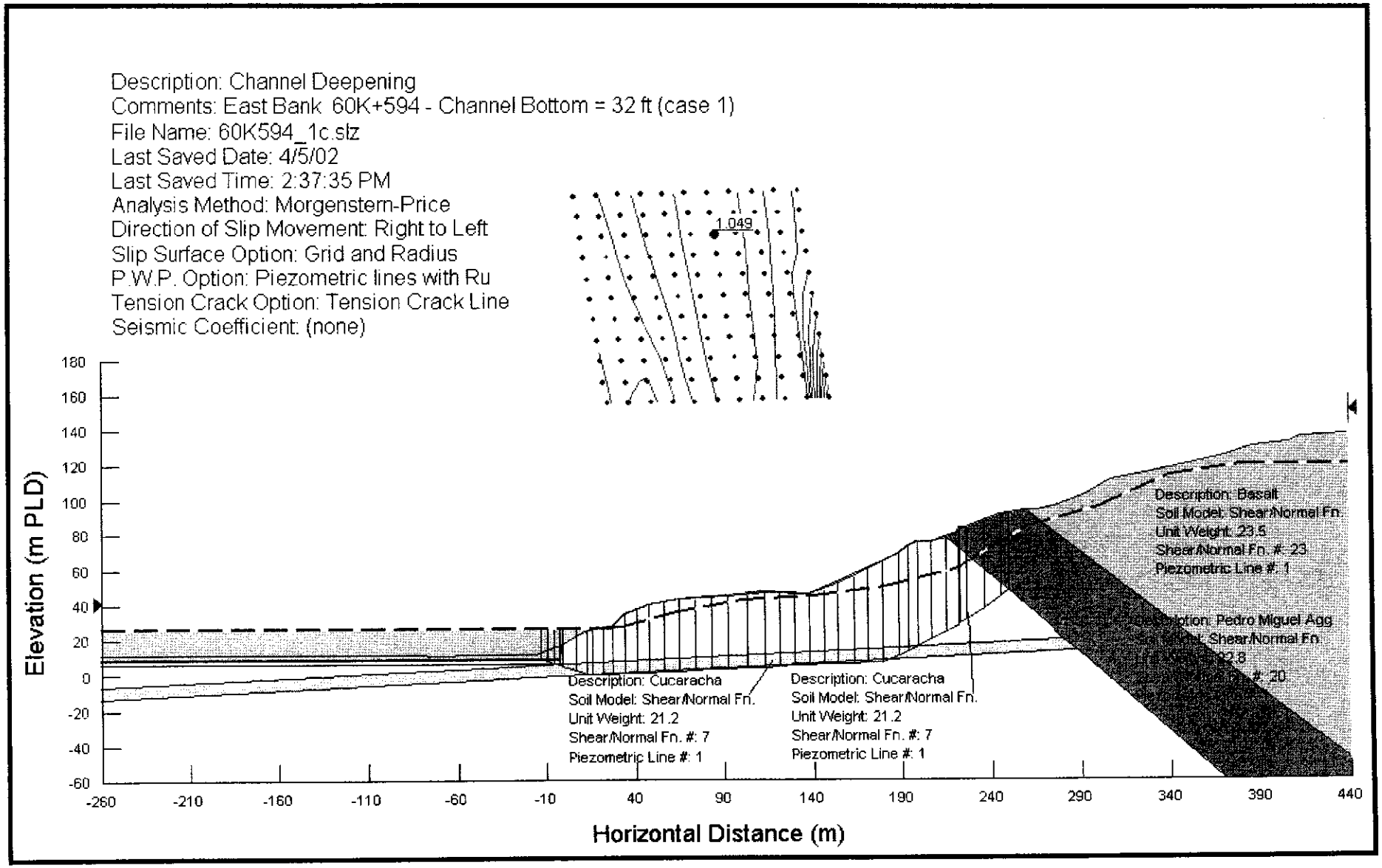
station 60k + 594 (1988 + 00)

East

Station: 60k + 594 (Cucaracha)

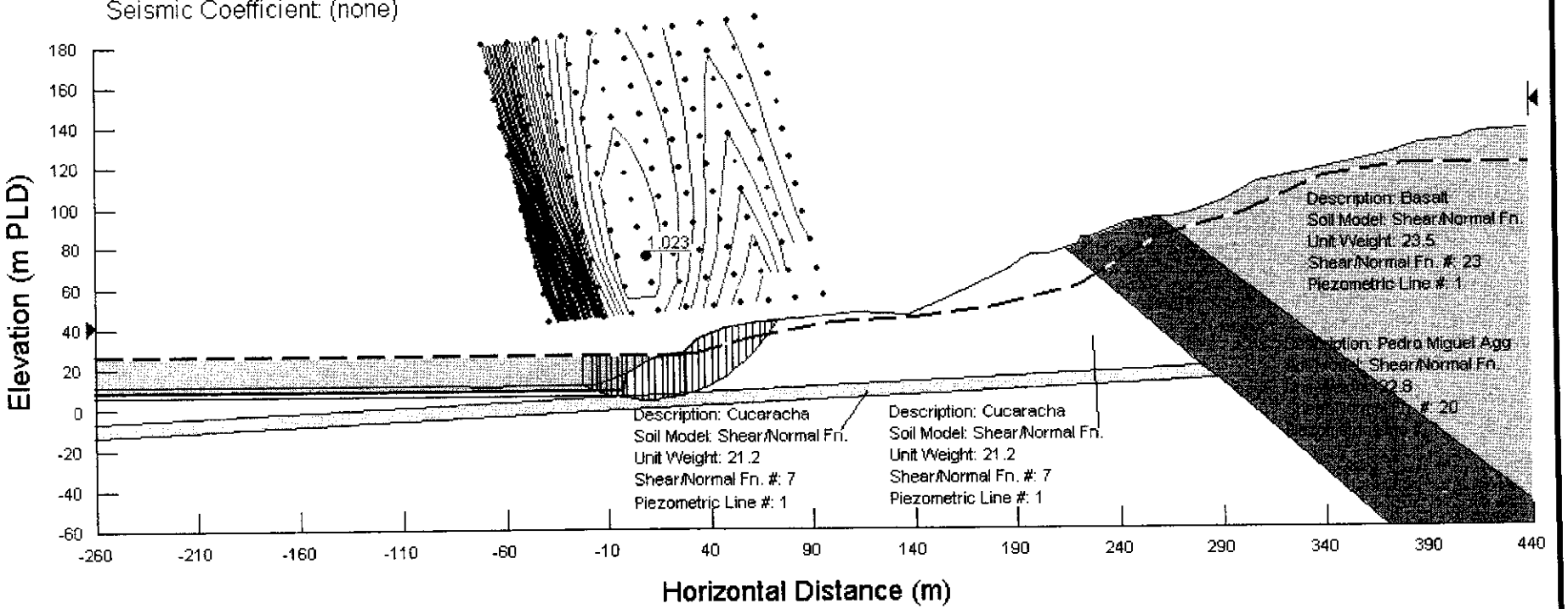
April 16, 2002

Case 1a, Channel bottom = 32 ft

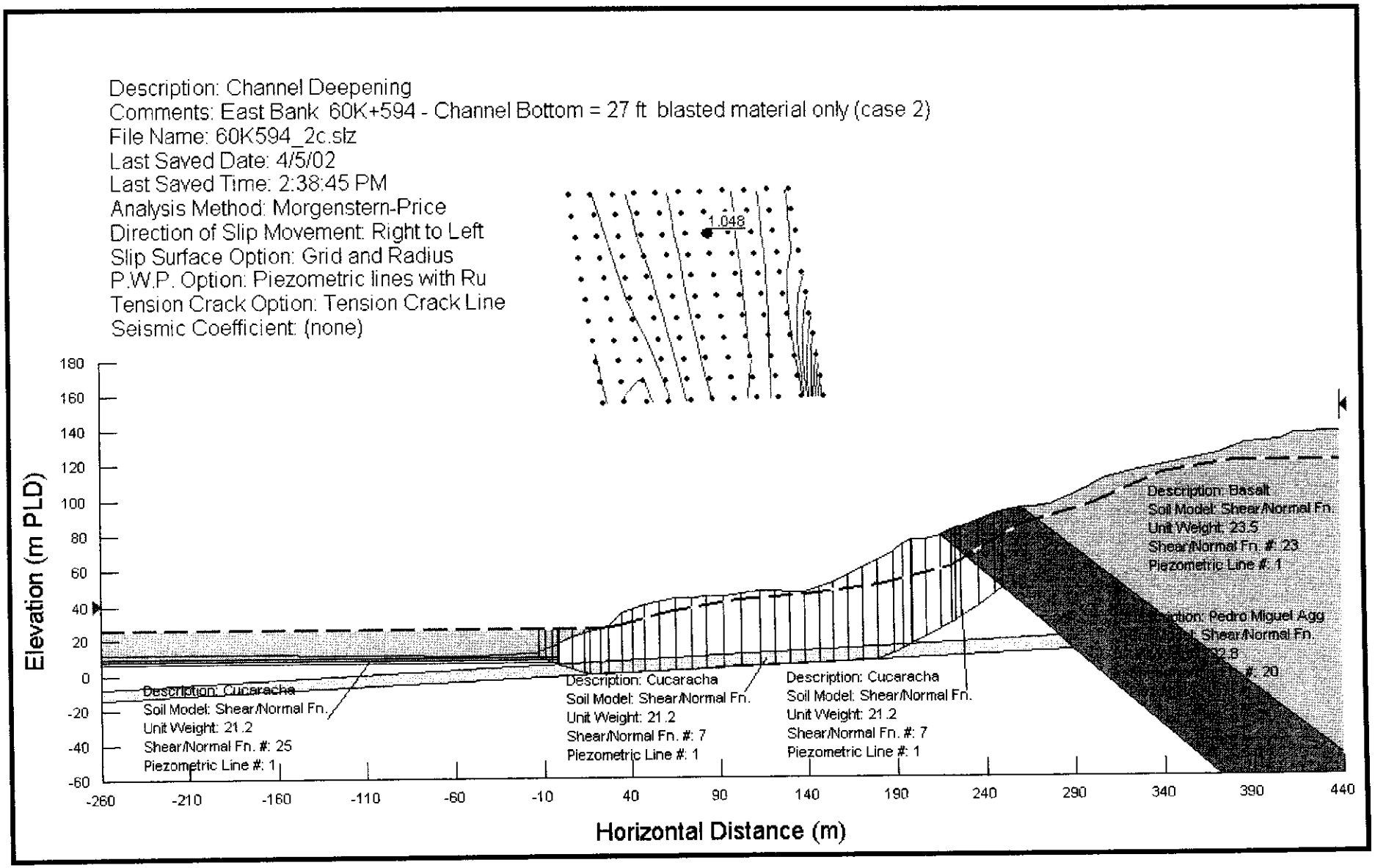


Case 1b, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 60K+594 - Channel Bottom = 32 ft (case 1)
File Name: 60K594_1b.slz
Last Saved Date: 3/30/02
Last Saved Time: 4:17:27 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

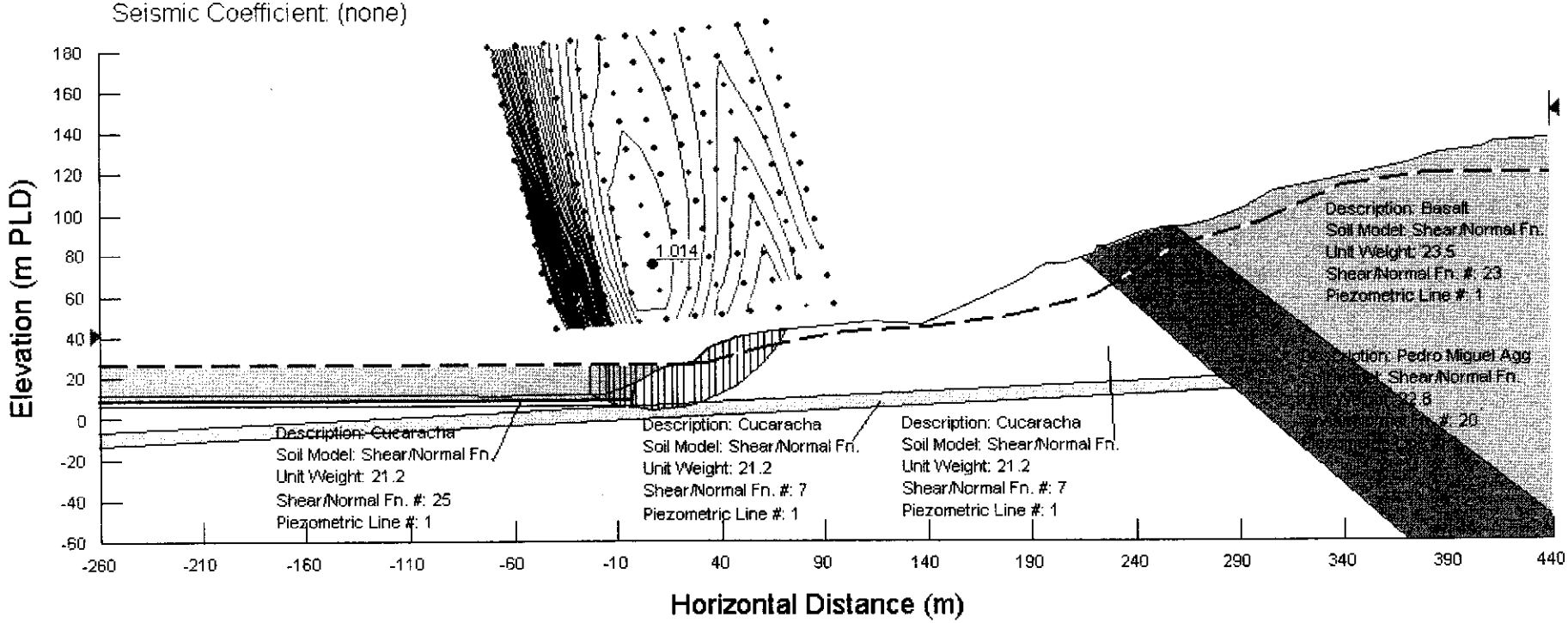


Case 2a, Channel bottom = 27 ft, Blasted material only

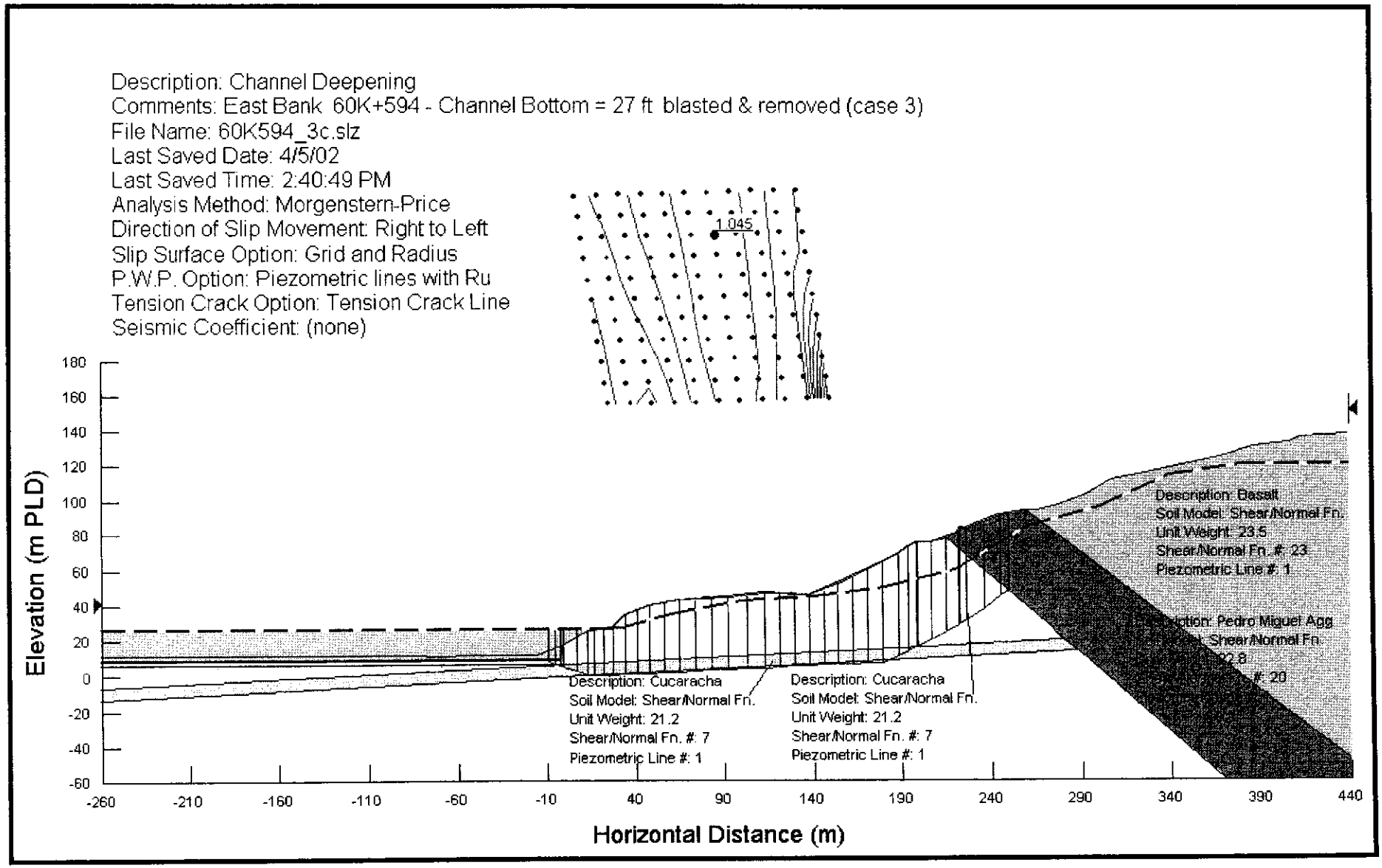


Case 2b, Channel bottom = 27 ft, Blasted material only

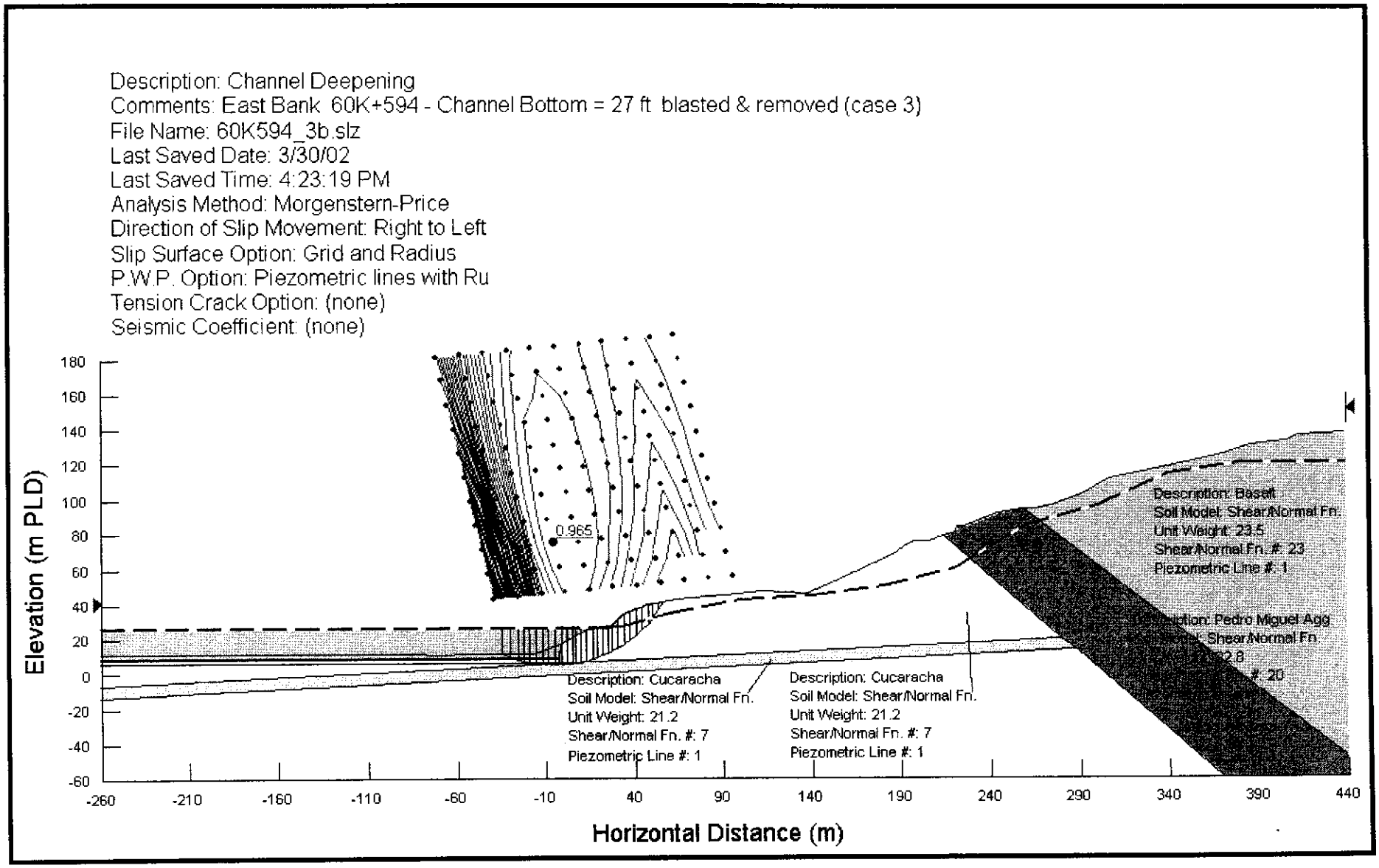
Description: Channel Deepening
Comments: East Bank 60K+594 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 60K594_2b.slz
Last Saved Date: 4/1/02
Last Saved Time: 8:42:46 AM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



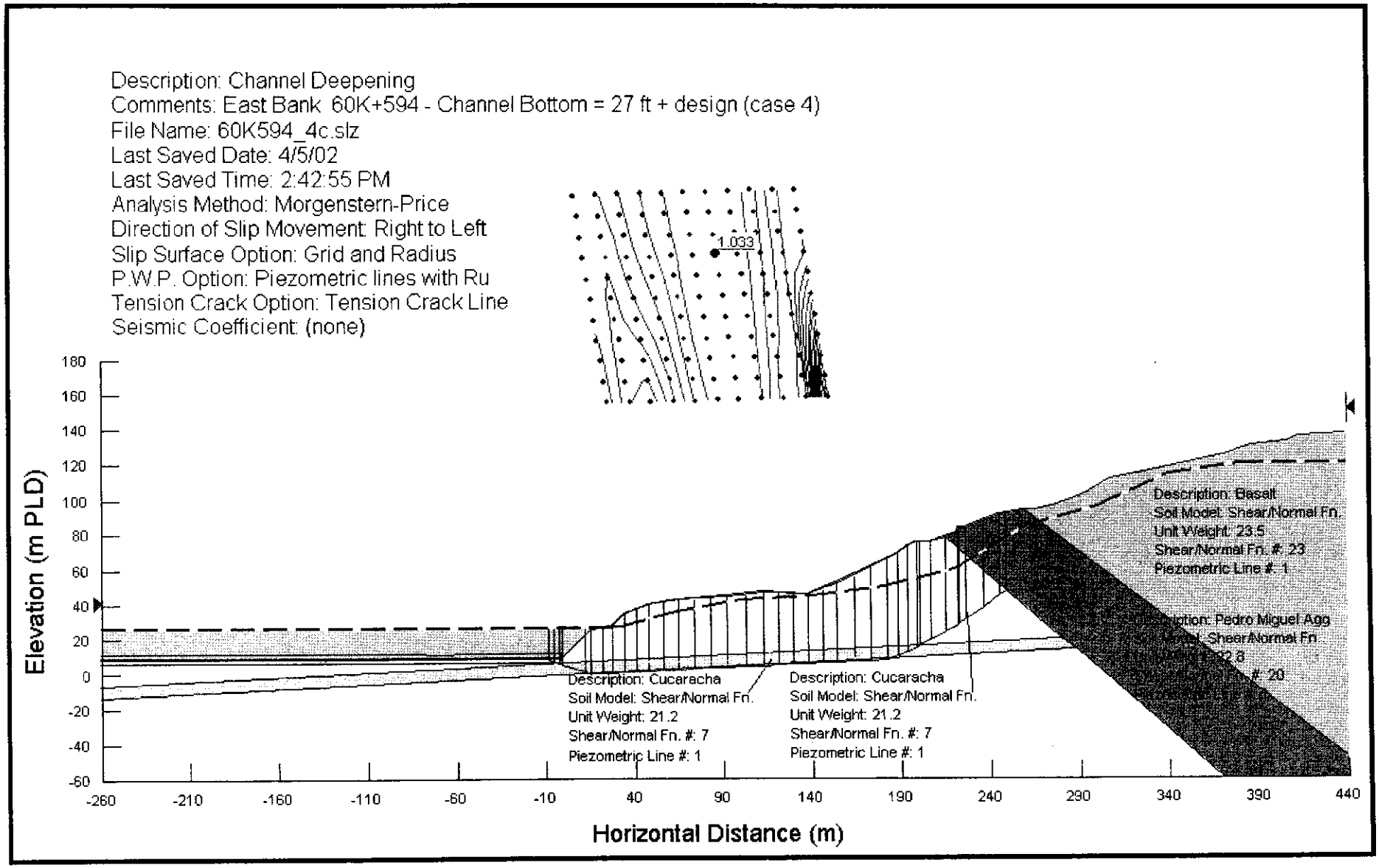
Case 3a, Channel bottom = 27 ft, Blasted & removed



Case 3b, Channel bottom = 27 ft, Blasted & removed

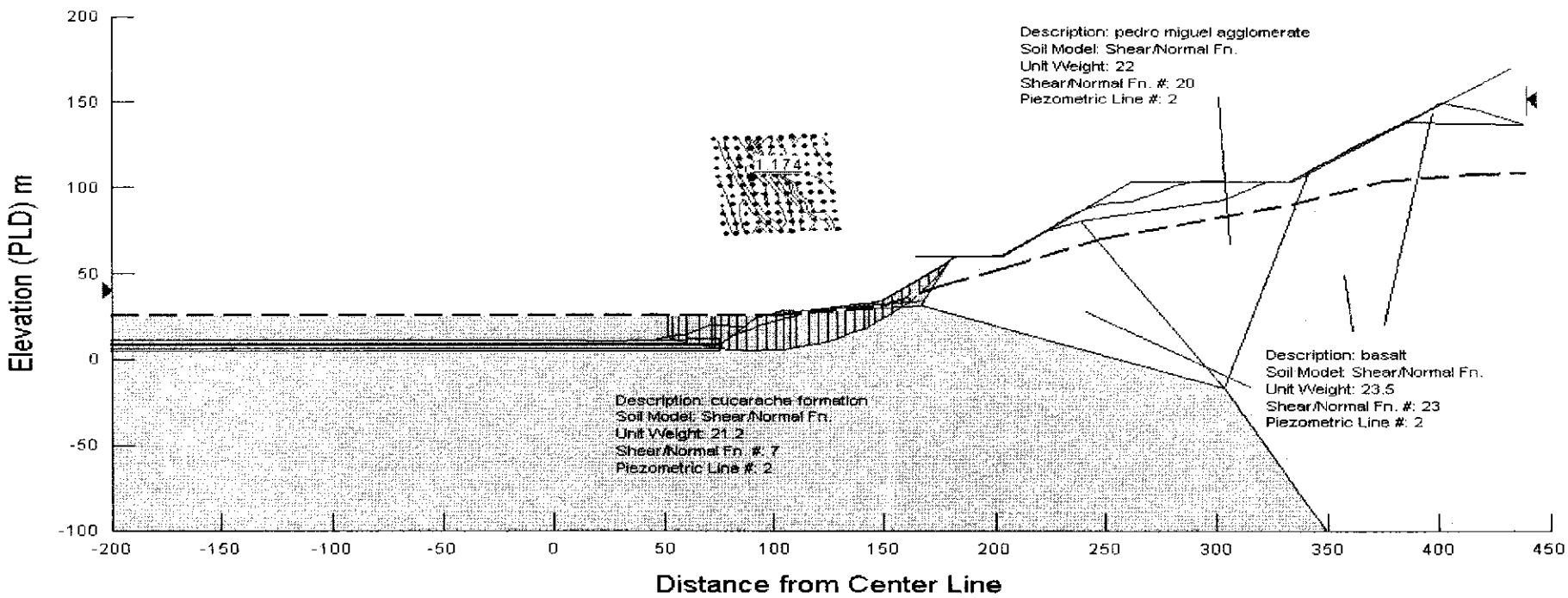


Case 4.1.a, Channel bottom = 27 ft, Design (underwater slope)



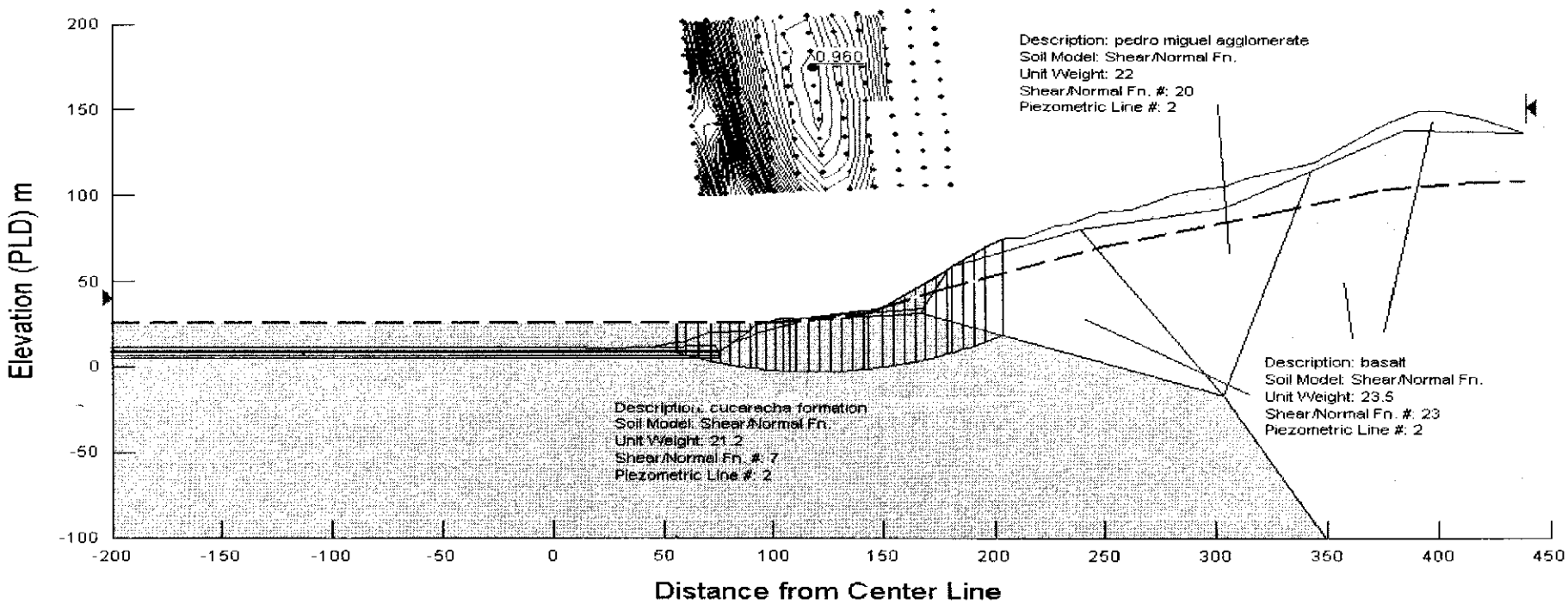
Case 4.2.a, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4e.slz
Last Saved Date: 4/14/02
Last Saved Time: 1:42:43 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



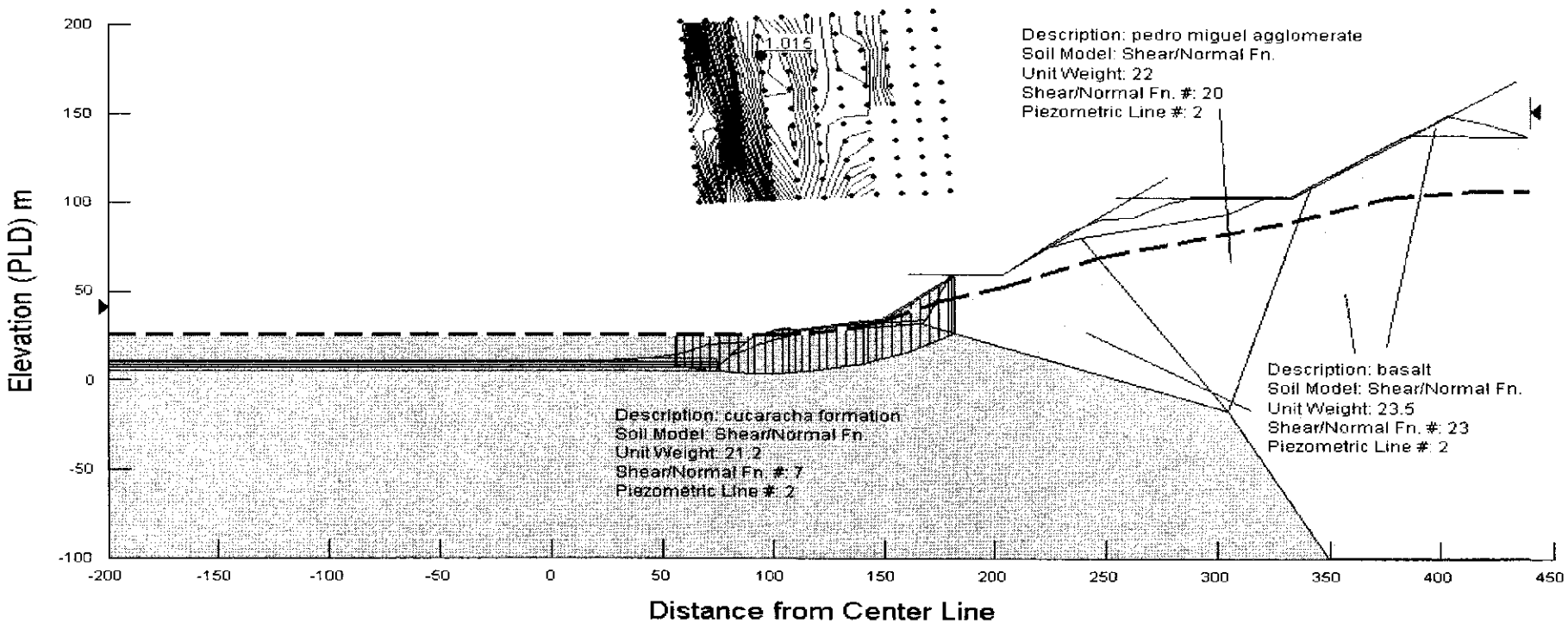
Case 4.1.b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4b.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:53:18 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

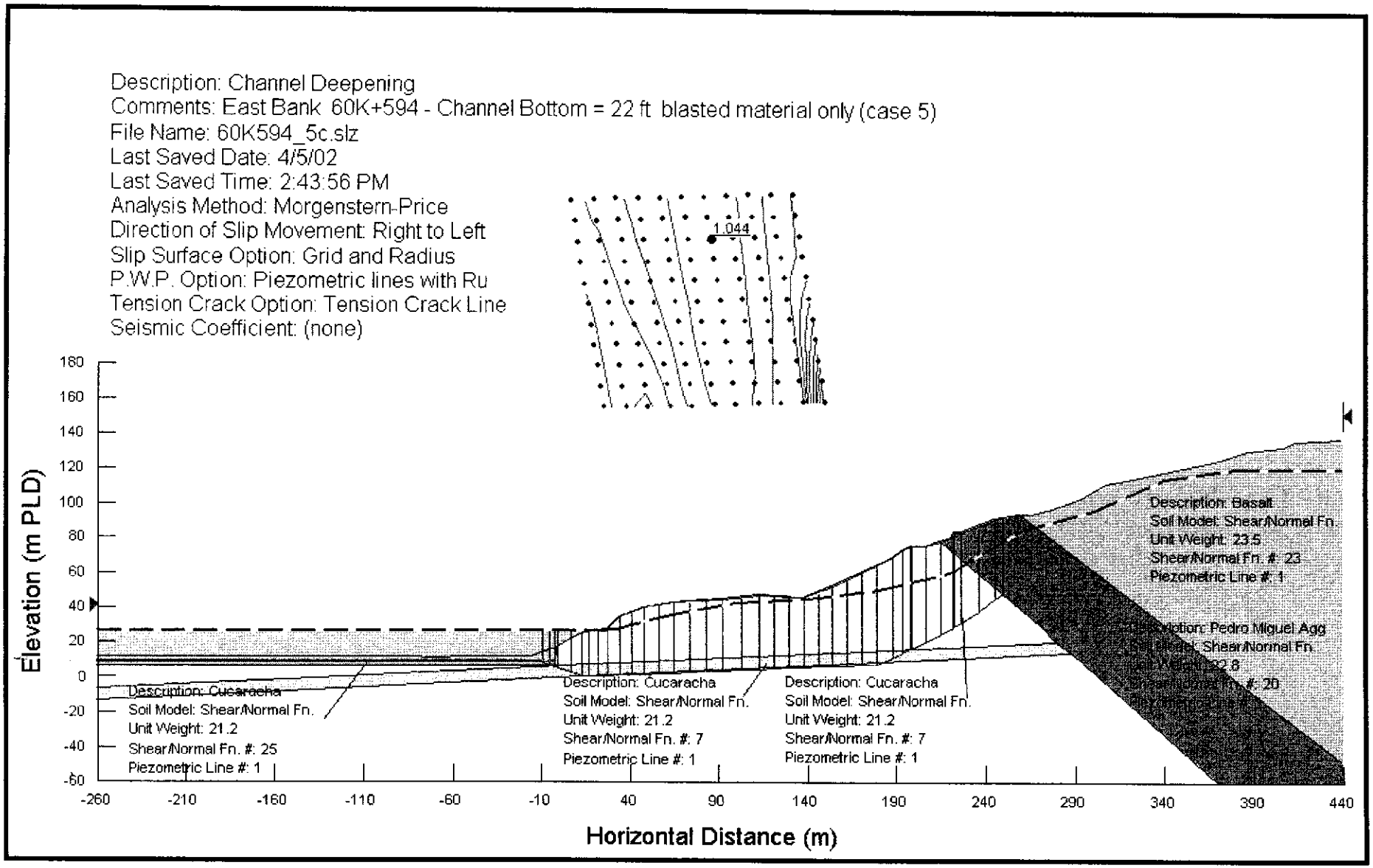


Case 4.2.b, Channel bottom = 27 ft, Design (& dry excavation)

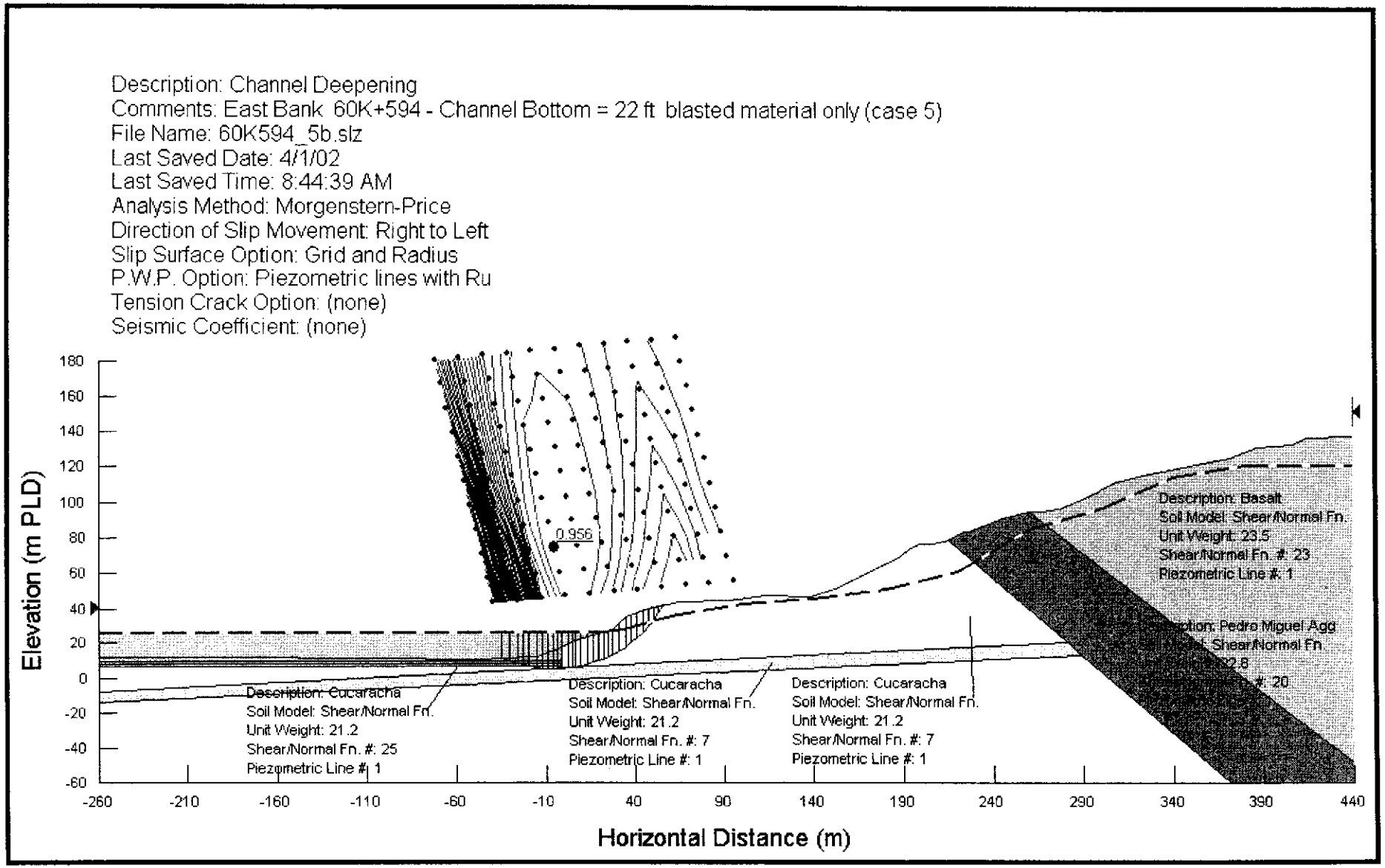
Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4be.slz
Last Saved Date: 4/14/02
Last Saved Time: 12:14:30 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



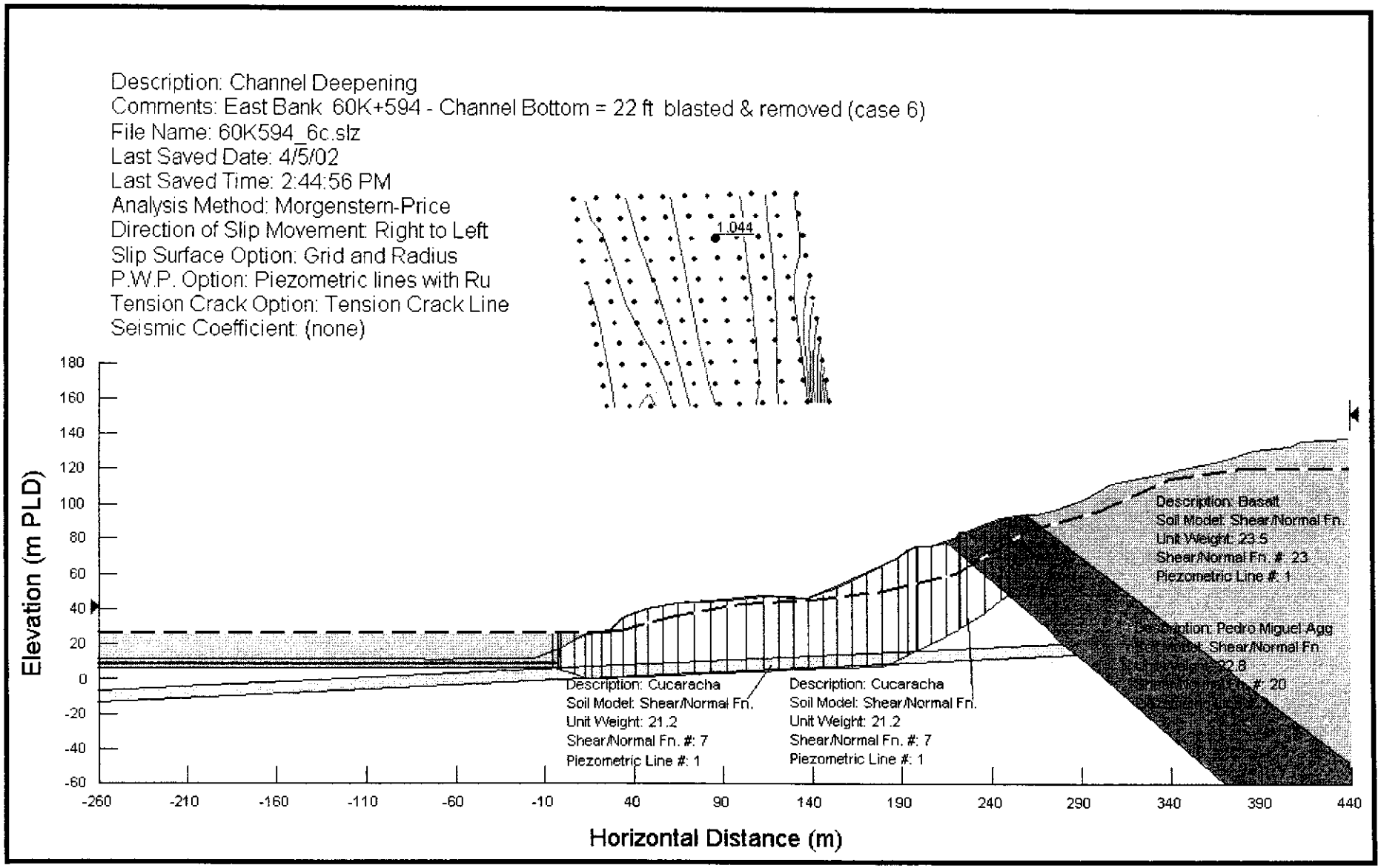
Case 5a, Channel bottom = 22 ft, Blasted material only



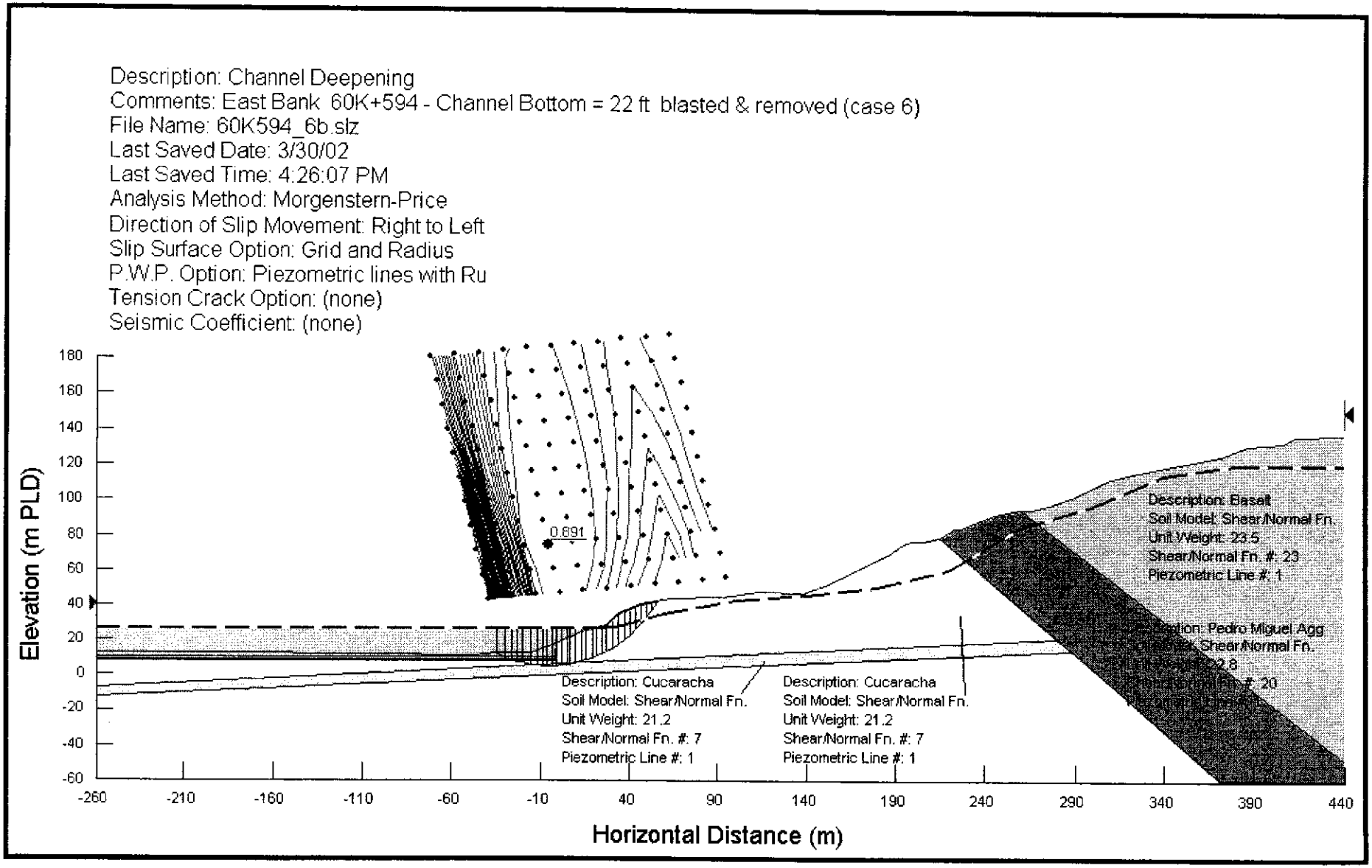
Case 5b, Channel bottom = 22 ft, Blasted material only



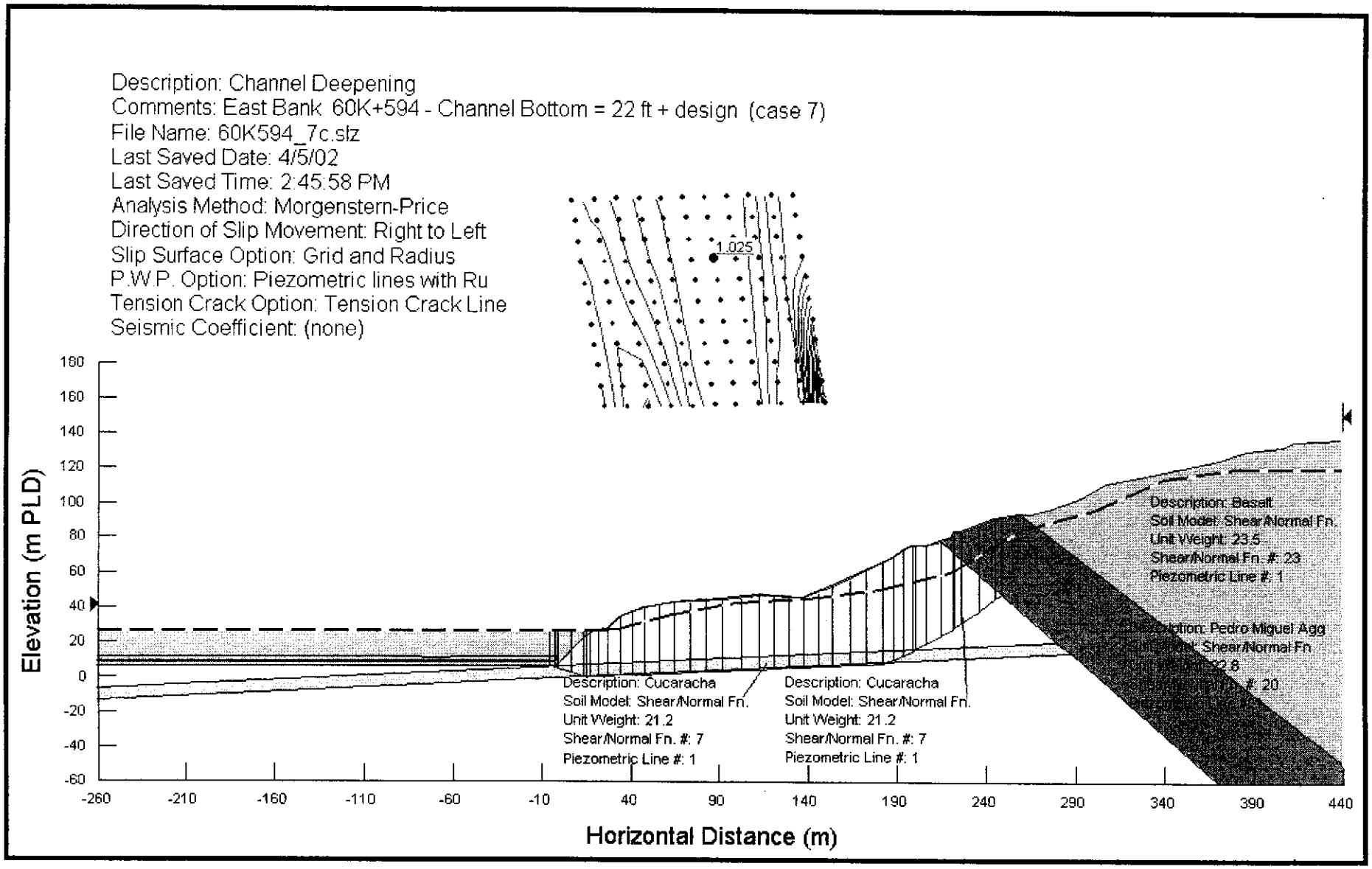
Case 6a, Channel bottom = 22 ft, Blasted & removed



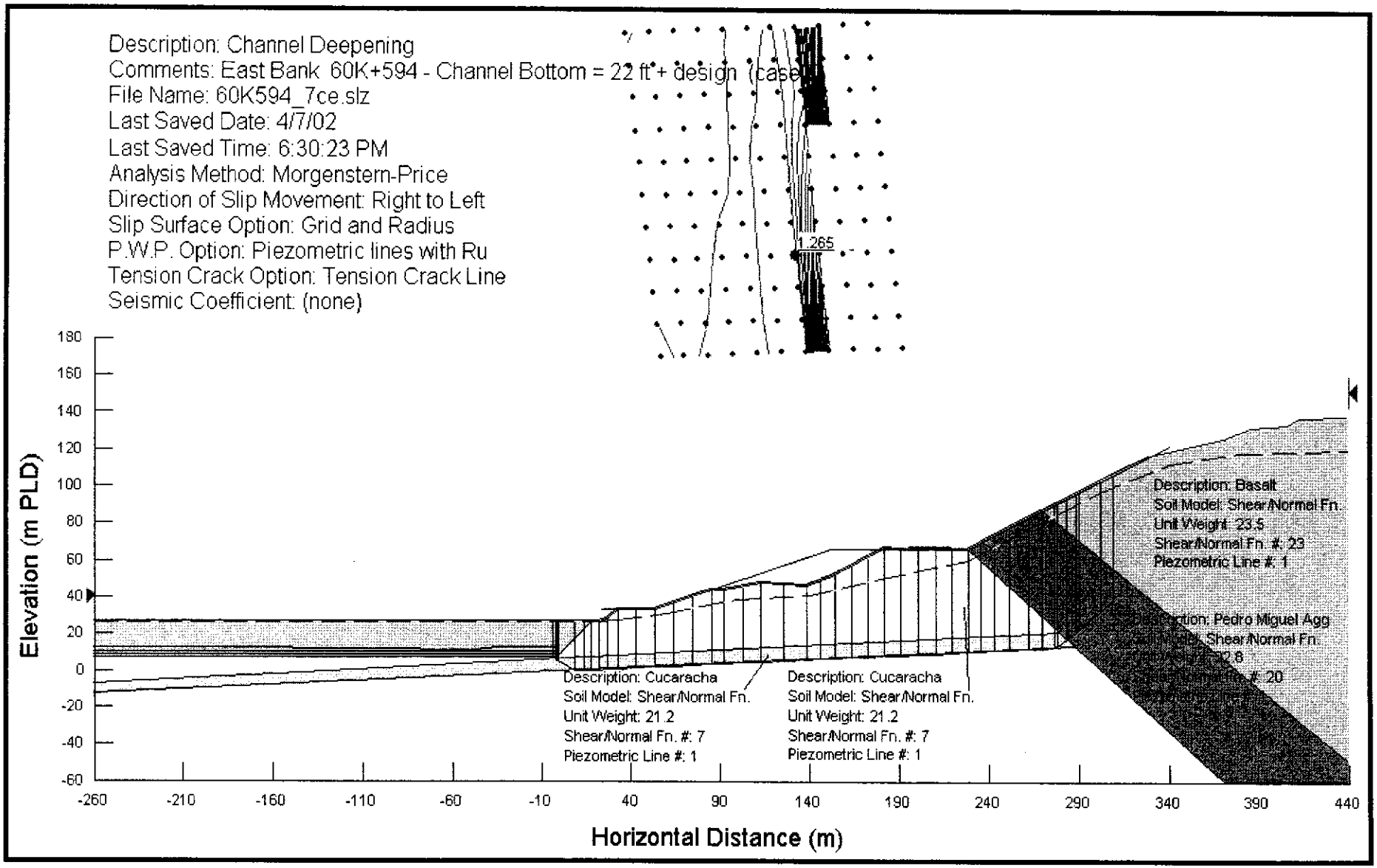
Case 6b, Channel bottom = 22 ft, Blasted & removed



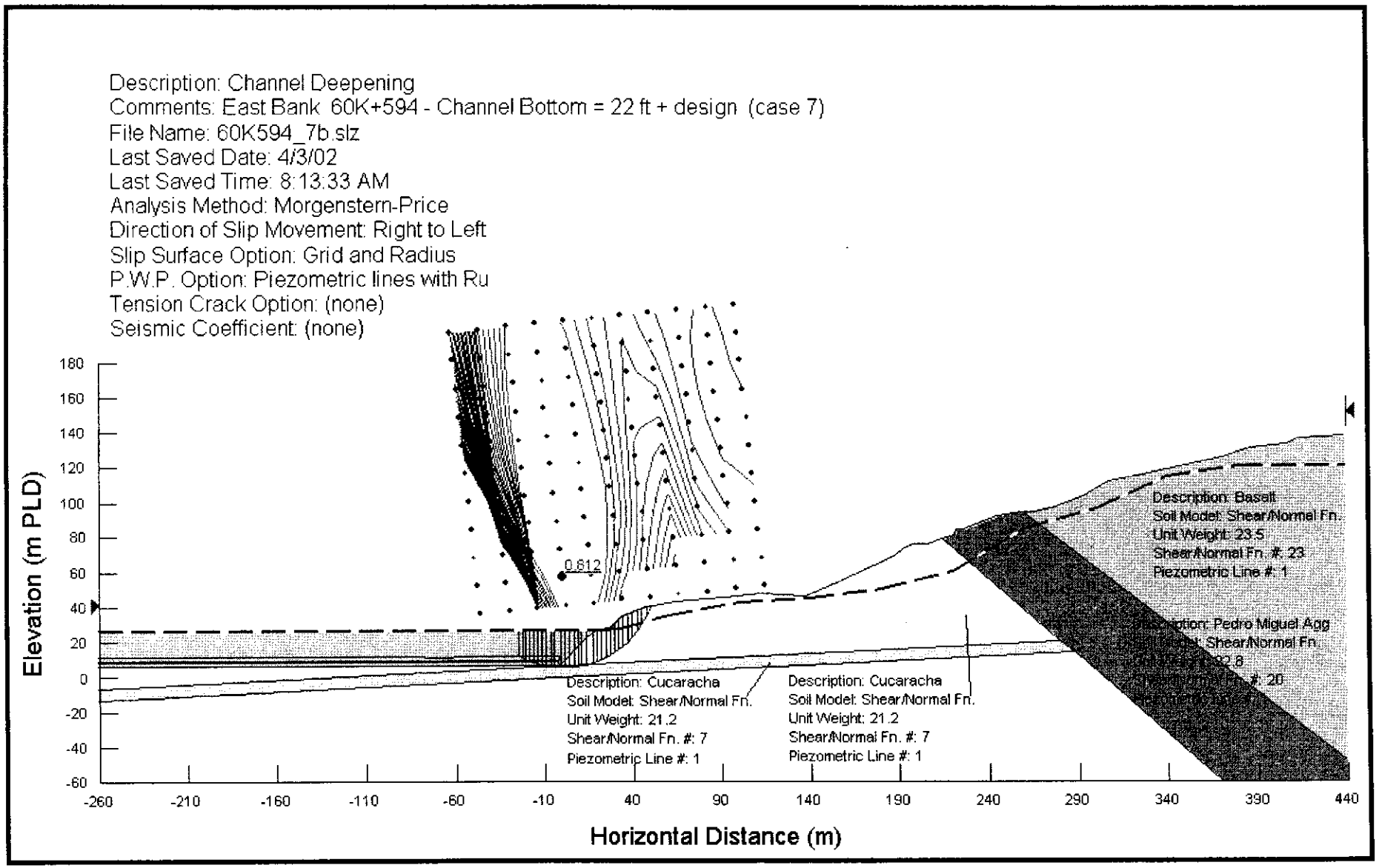
Case 7.1.a, Channel bottom = 27 ft, Design (underwater slope)



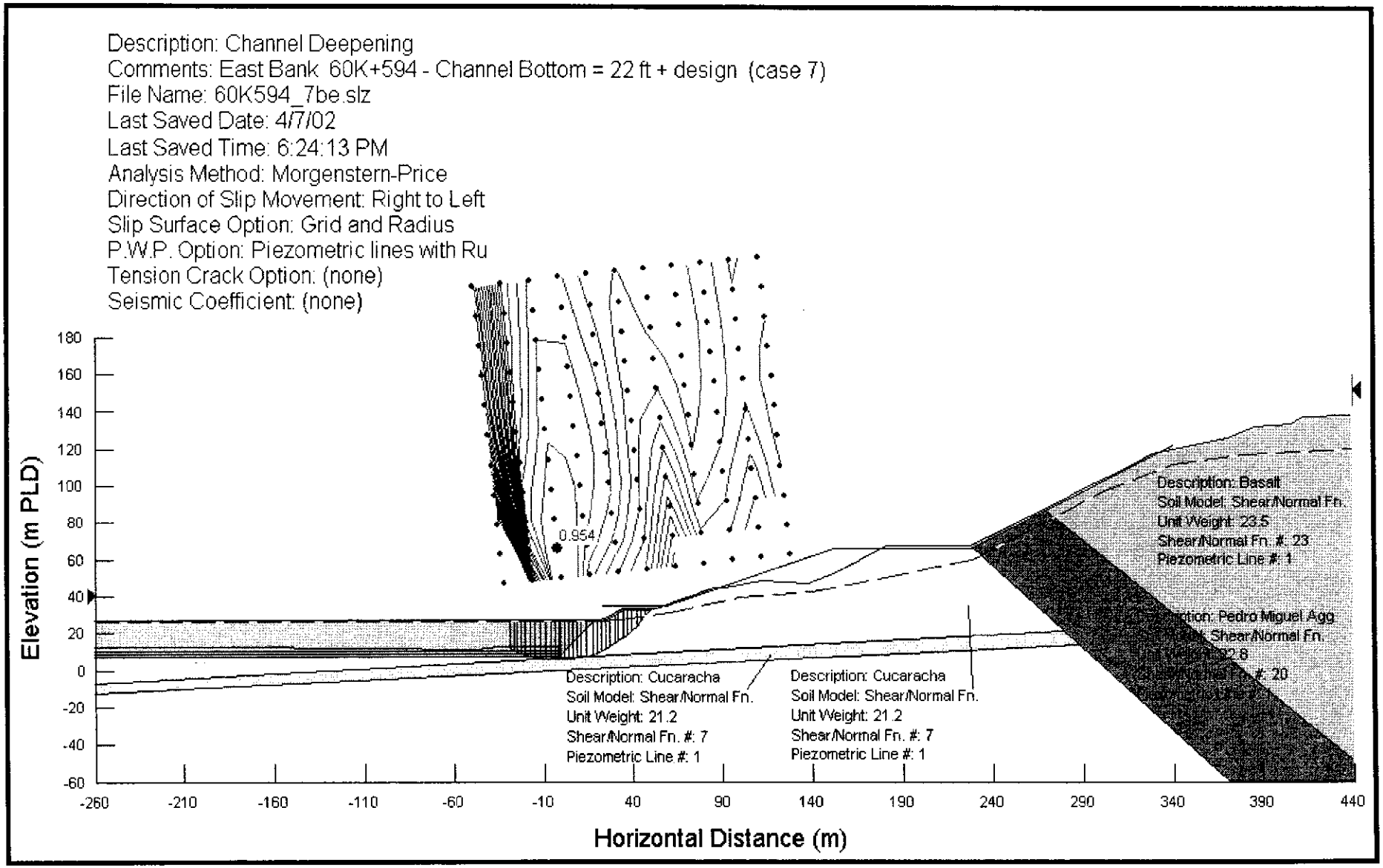
Case 7.2.a, Channel bottom = 27 ft, Design (& dry excavation)



Case 7.1.b, Channel bottom = 27 ft, Design (underwater slope)

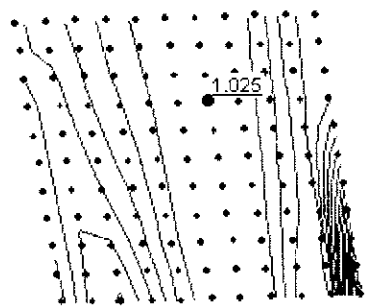


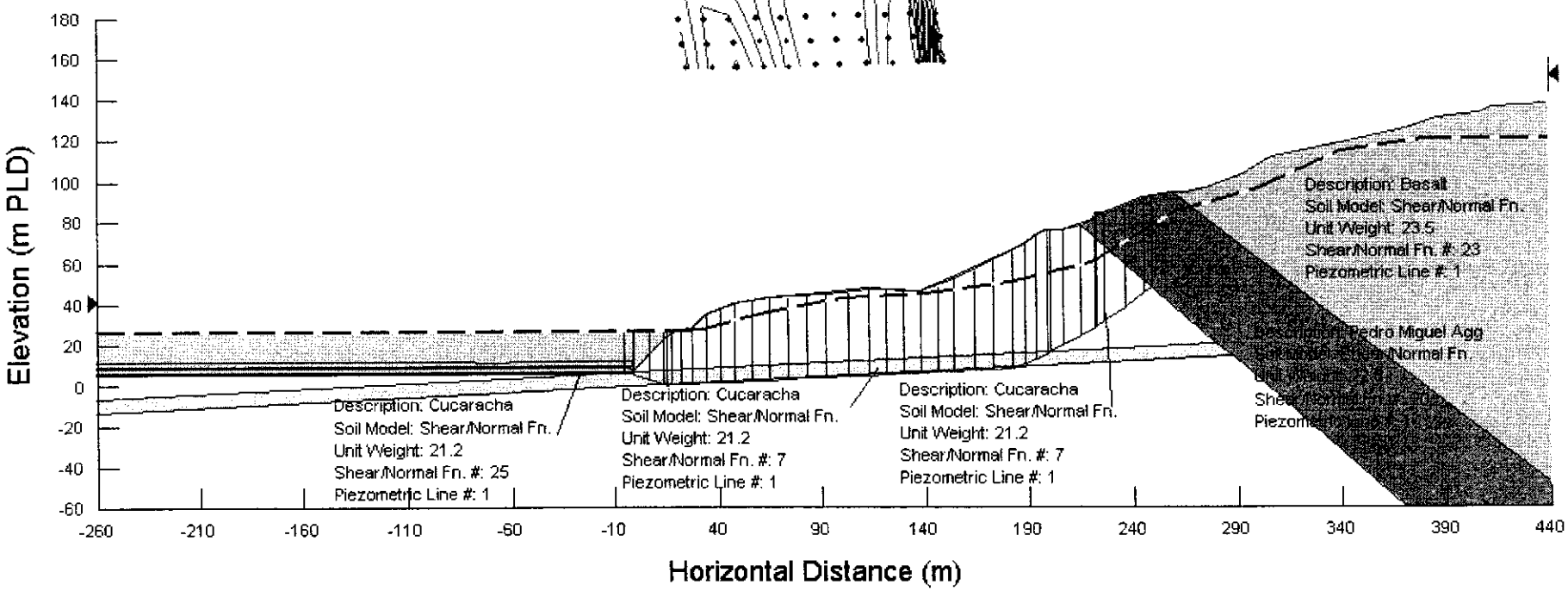
Case 7.2.b, Channel bottom = 27 ft, Design (& dry excavation)



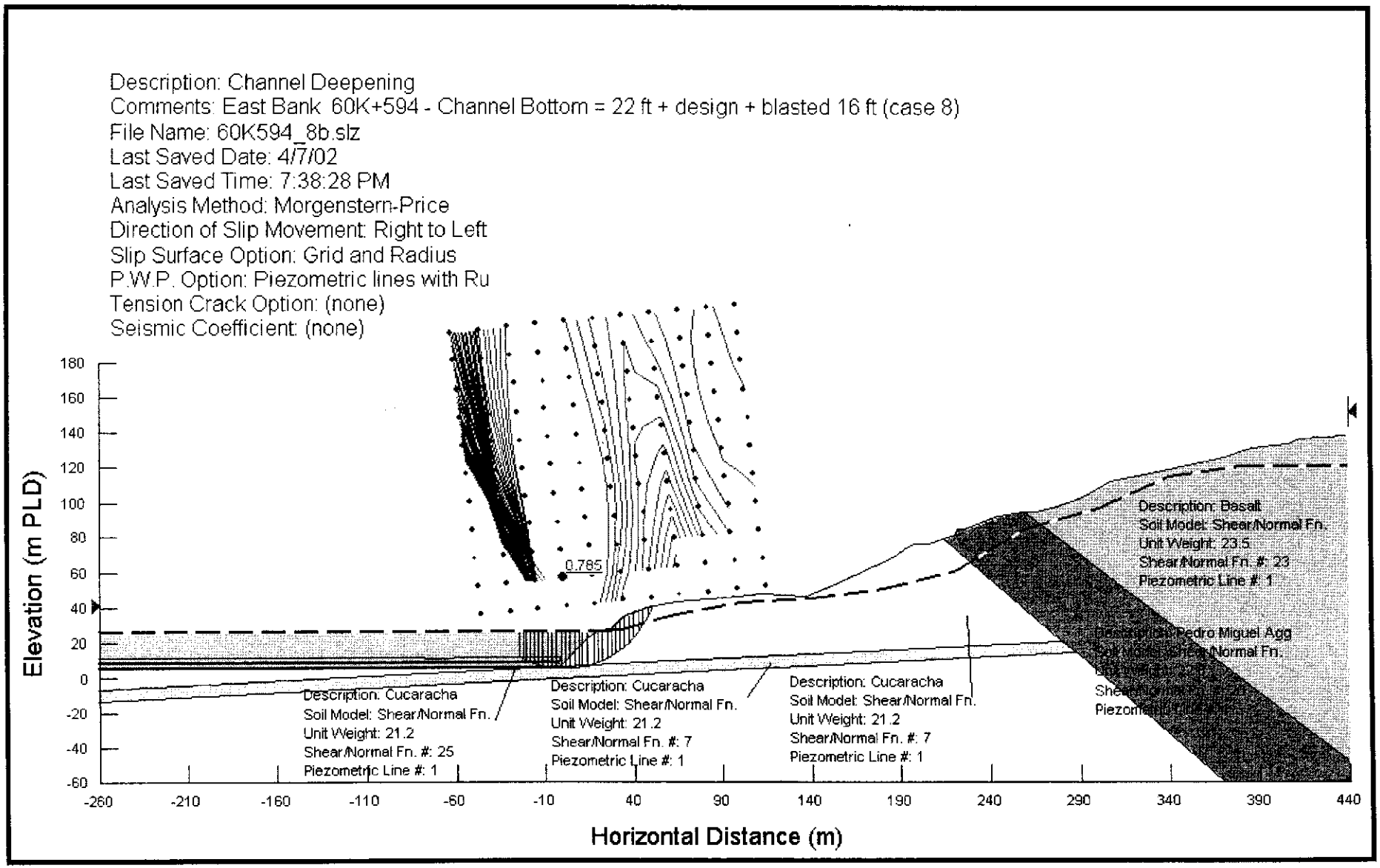
Case 8a, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 60K+594 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 60K594_8c.slz
Last Saved Date: 4/7/02
Last Saved Time: 7:31:37 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)





Case 8b, Channel bottom = 16 ft, Blasted

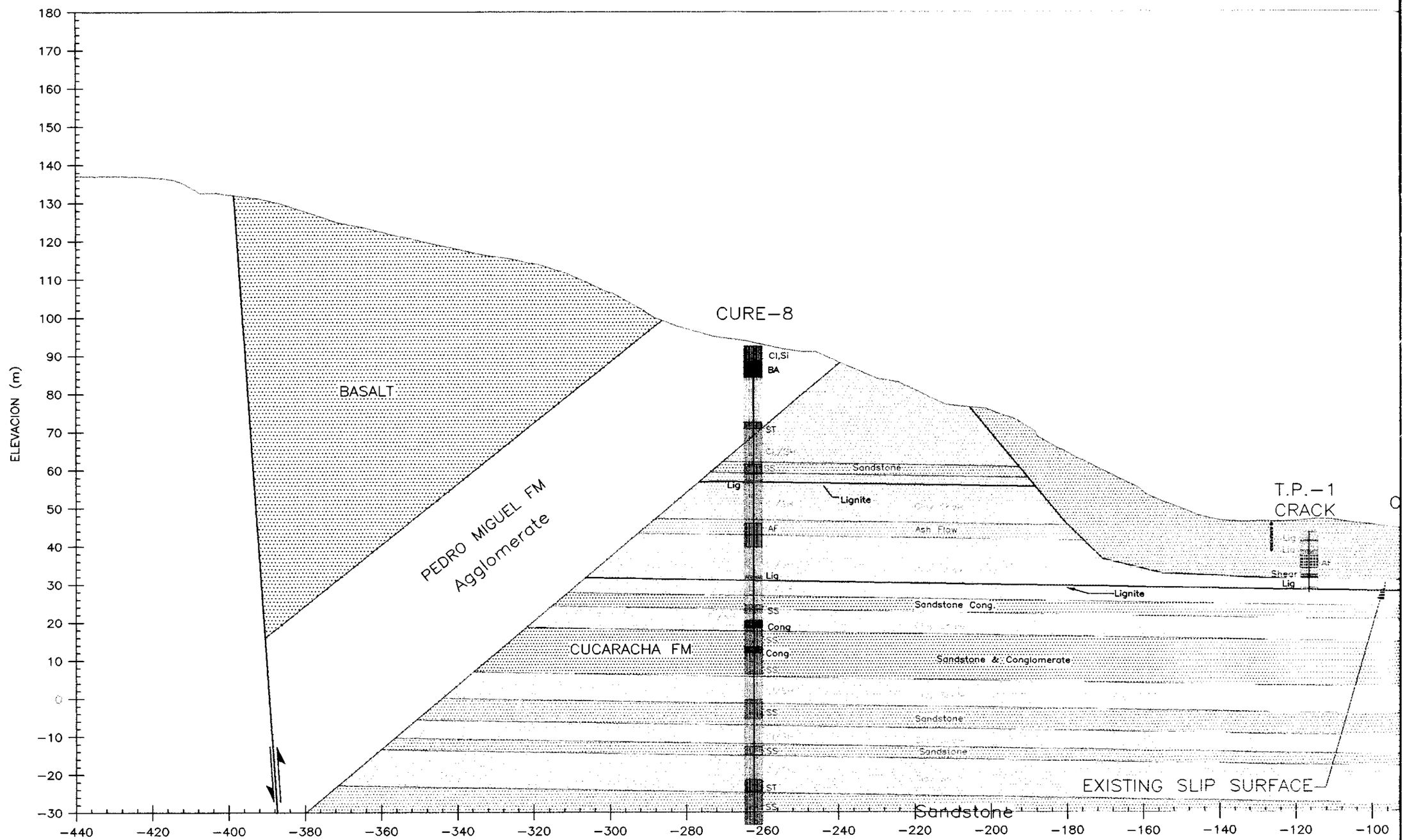


Summary, 60k + 594 (1988 + 00)

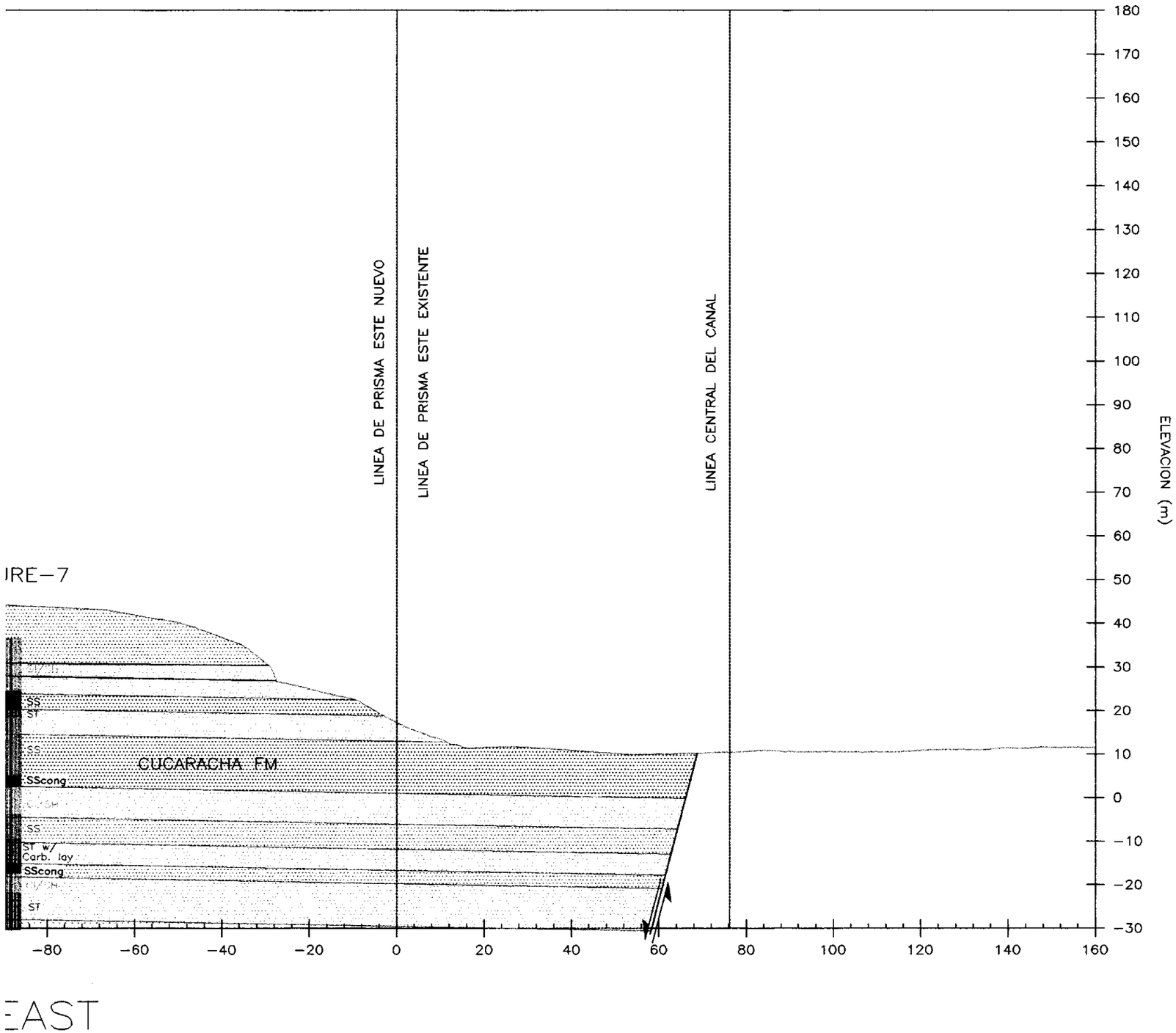
General Description	Range of stations:	60k + 500 to 60k + 695
	Sector:	Cucaracha
	Maximum height (m):	127
	Cotangent of slope angle (cot. β):	3.6
History	Last slide event:	October 13, 1986 (South East Cucaracha Slide)
Geology	Formation:	Cucaracha / Pedro Miguel Agglomerate / Basalt
	Lithology:	Clayshale / Sanstone / siltstone / Ash flow / Cong. / Agg / Basalt
	Critical stratum at toe:	Clayshale / Sansdstone
	Apparent dip of bedding:	Toward the Canal, 10°
Stability Analysis	Critical failure mechanism:	Translational
	Shear strength model:	Fully softened, Cucaracha

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety		Relative Factor of Safety		Percentage of Change (%)	
		(a)	(b)	(a)	(b)	(a)	(b)
Case 1: Channel bottom = 32 ft	0.367	1.049	1.023	1.000	1.000	0.00	0.00
Case 2: Channel bottom = 27 ft, Blasted material only		1.048	1.014	0.999	0.991	-0.10	-0.88
Case 3: Channel bottom = 27 ft, Blasted & removed		1.045	0.965	0.996	0.943	-0.38	-5.67
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.033	0.896	0.985	0.876	-1.53	-12.41
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.400	1.268	1.022	1.209	0.999	20.88	-0.10
Case 5: Channel bottom = 22 ft, Blasted material only		1.044	0.956	0.995	0.935	-0.48	-6.55
Case 6: Channel bottom = 22 ft, Blasted & removed		1.044	0.891	0.995	0.871	-0.48	-12.90
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.025	0.812	0.977	0.794	-2.29	-20.63
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.394	1.265	0.954	1.206	0.933	20.59	-6.74
Case 8: Channel bottom = 16 ft, Blasted		1.025	0.785	0.977	0.767	-2.29	-23.26

Conclusions:	Stabilization is required for Case 4 and Case 7



60K+594 (1988+00)



AUTORIDAD DEL CANAL DE PANAMA

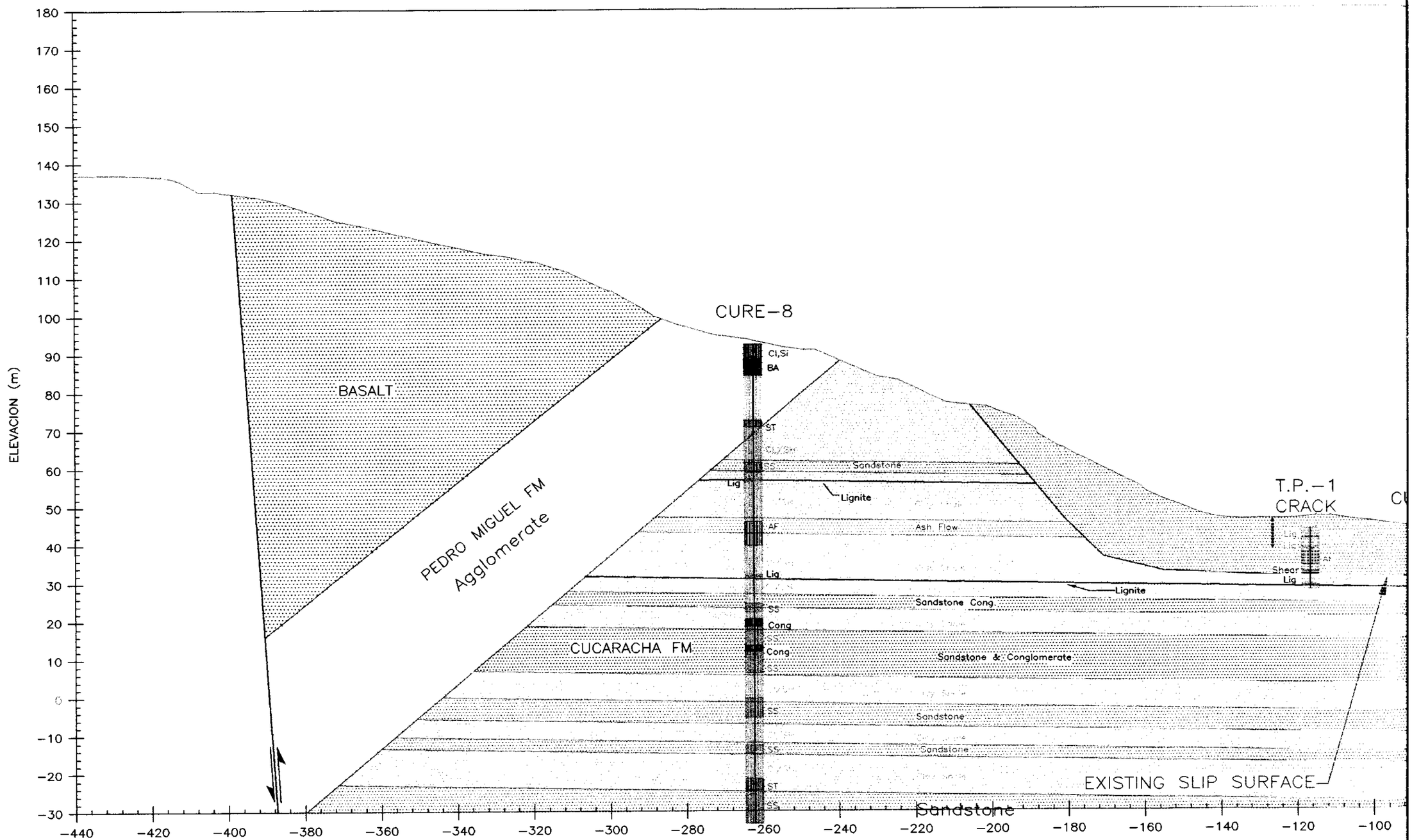
DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 60K+594 (1988+00) ESTE

ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: M. DE PUY	DIBUJADO POR: M. LACERDA & J. RAMESCH



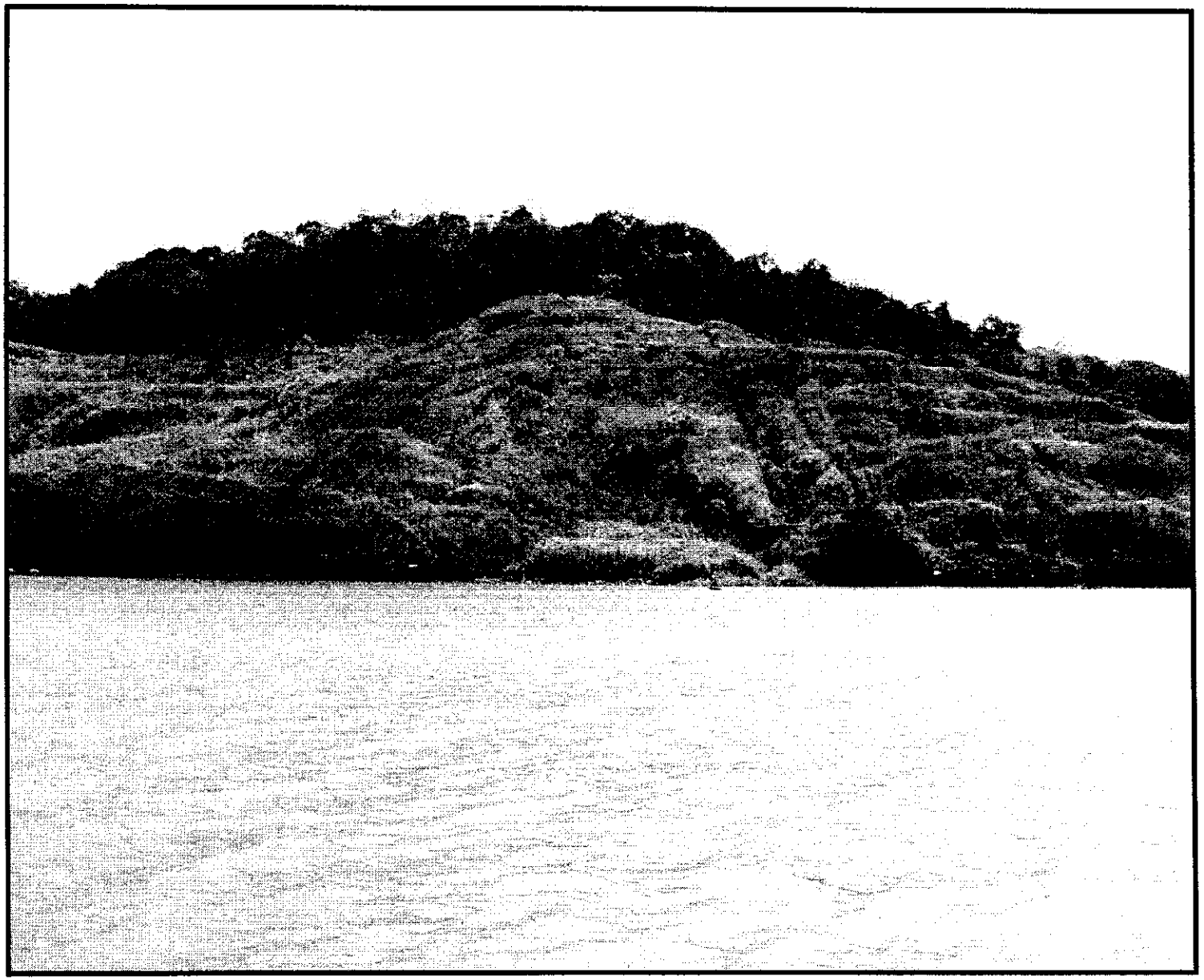
60K+594 (1988+00)

station 60k + 747 (1993 + 00)

East

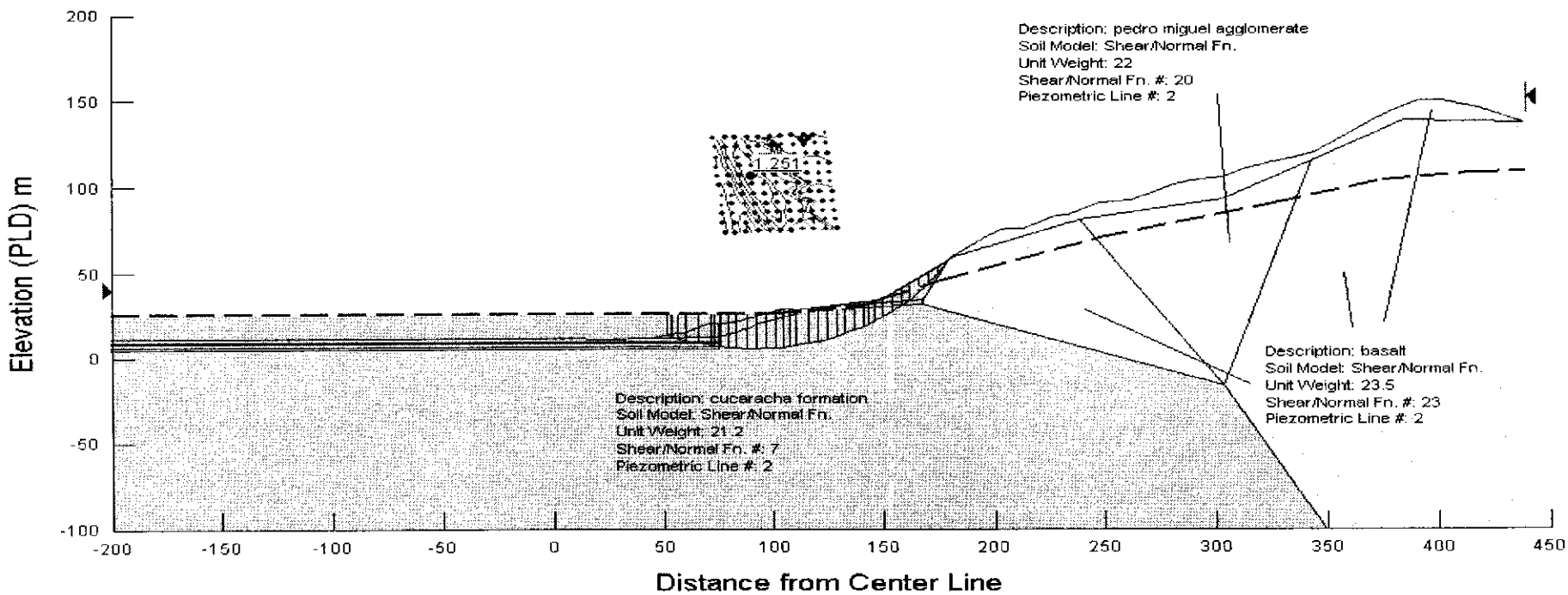
Station: 60k + 747 (Cucaracha)

April 16, 2002



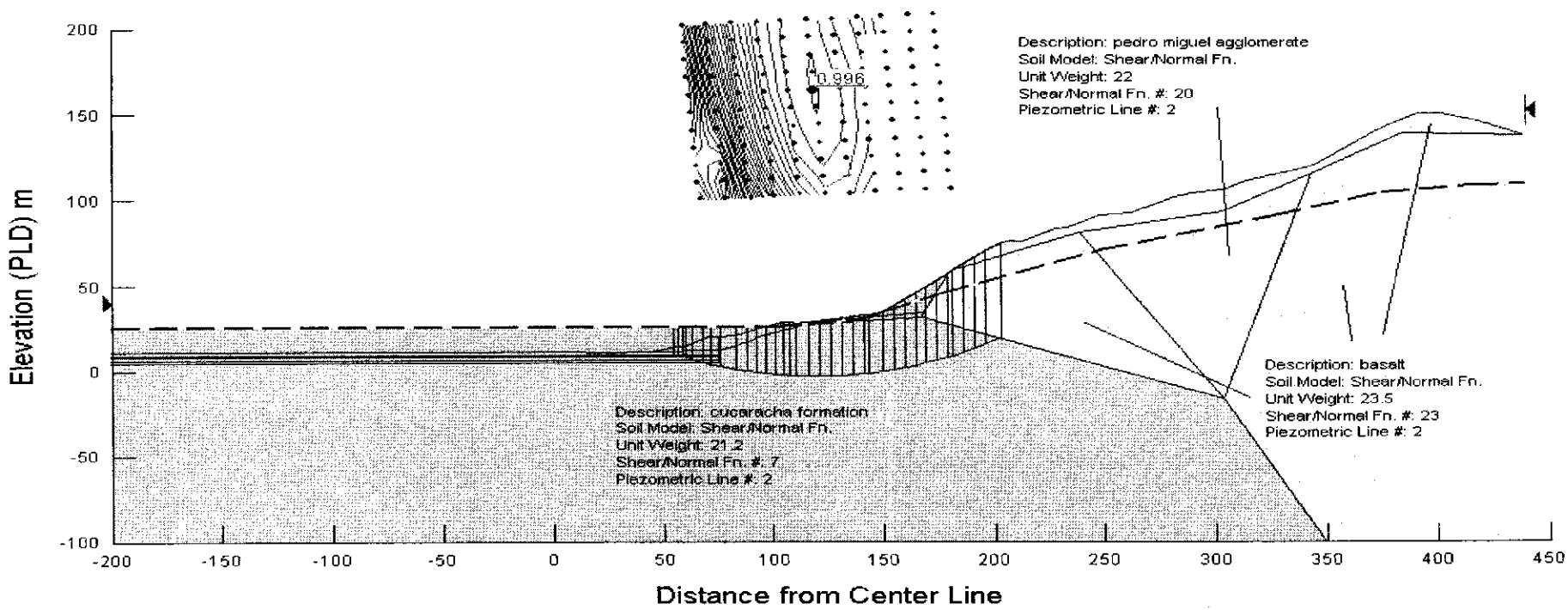
Case 1a, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 32 ft (case 1)
File Name: 60K747_1.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:07:01 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

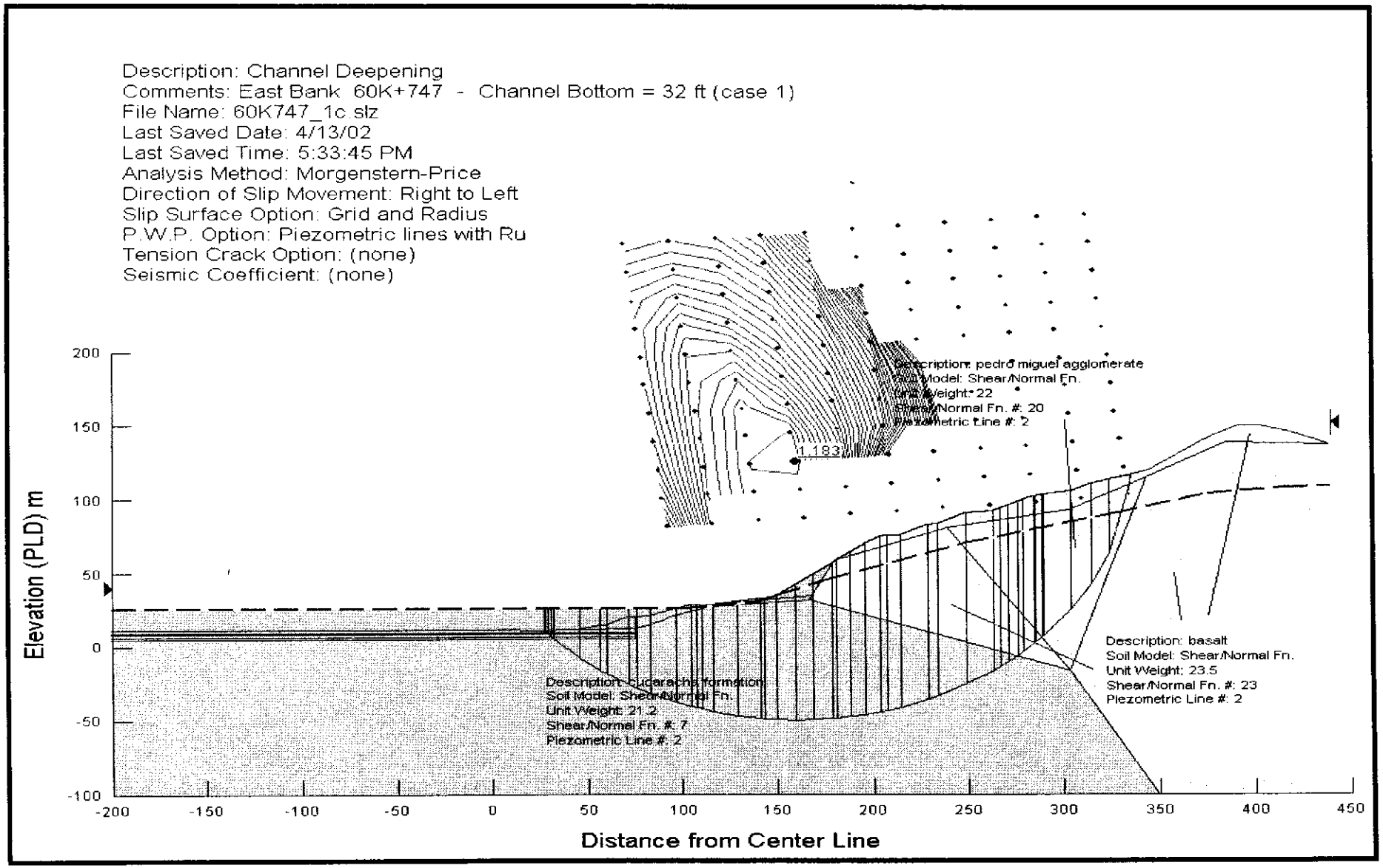


Case 1b, Channel bottom = 32 ft

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 32 ft (case 1)
File Name: 60K747_1b.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:43:33 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

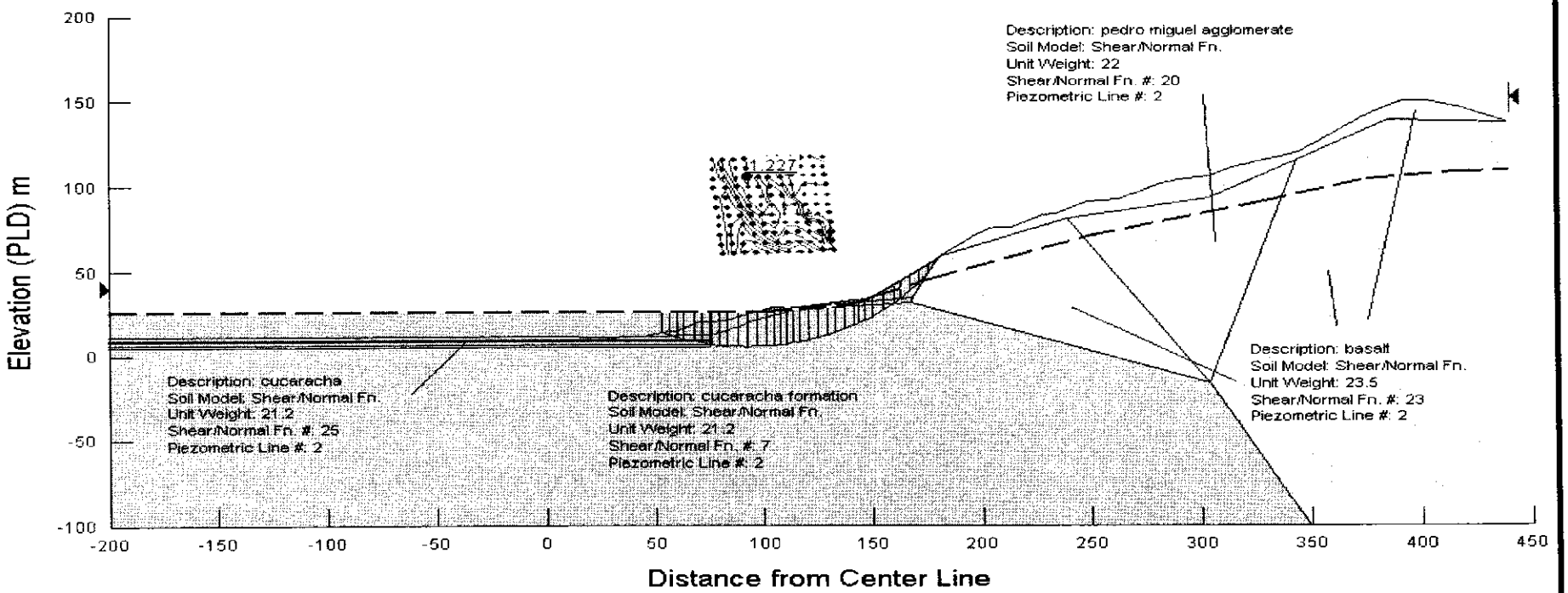


Case 1c, Channel bottom = 32 ft



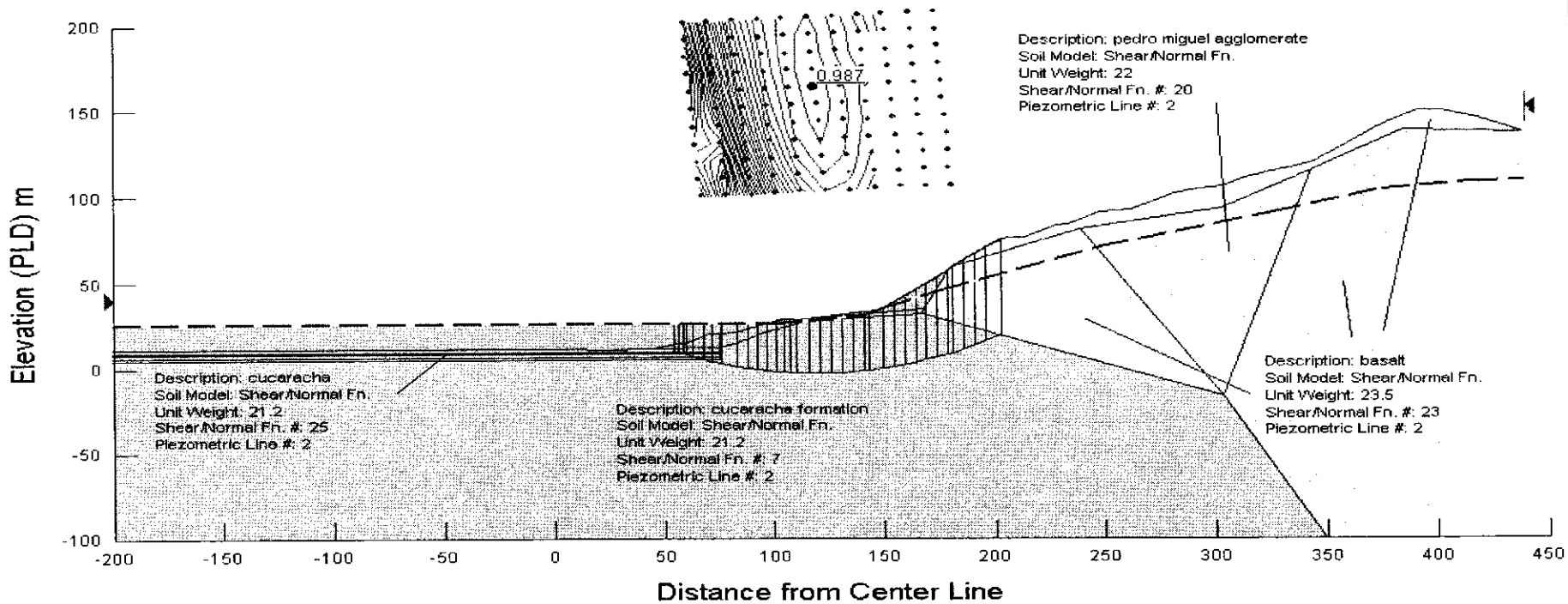
Case 2a, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 60K747_2.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:16:26 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

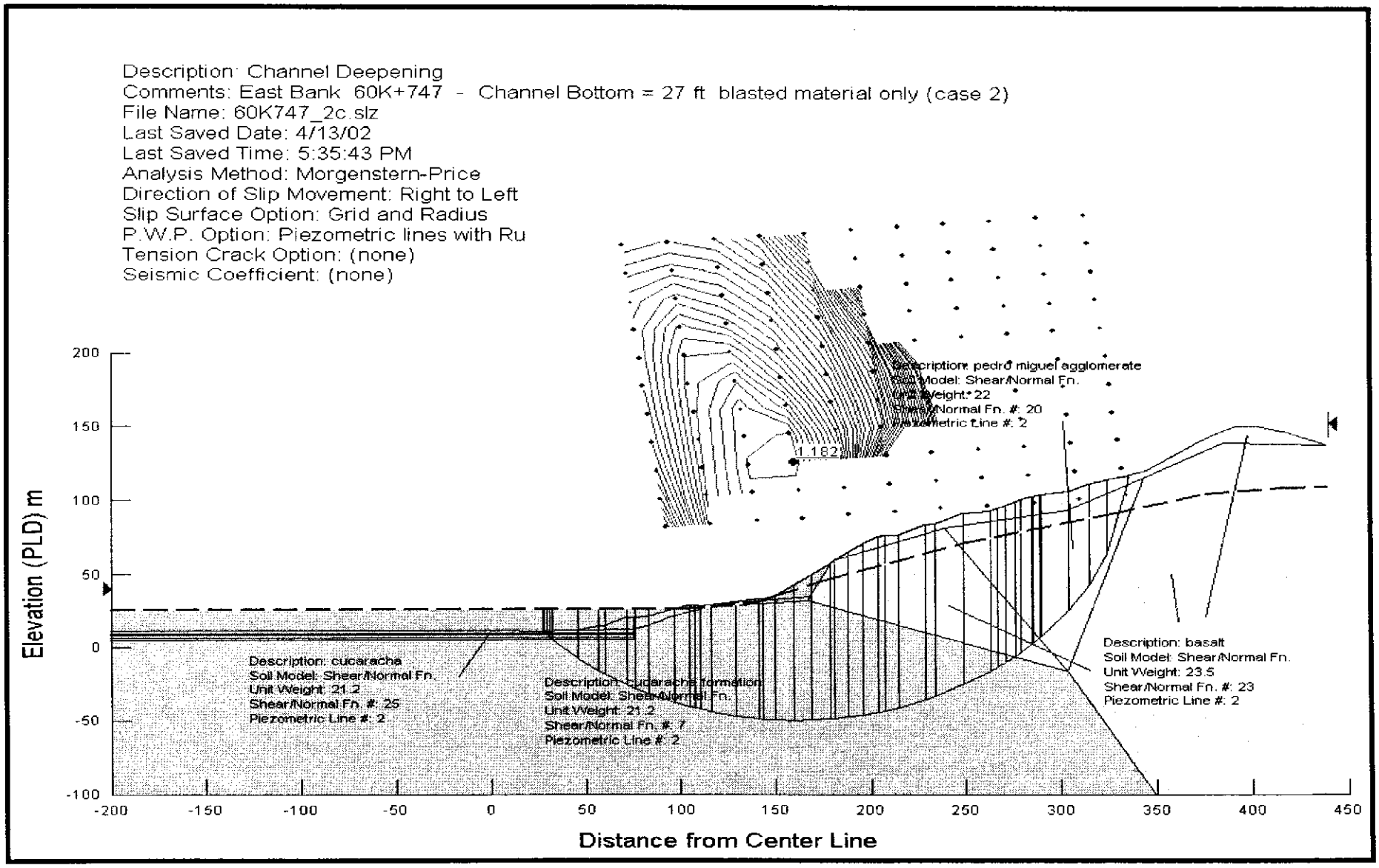


Case 2b, Channel bottom = 27 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft blasted material only (case 2)
File Name: 60K747_2b.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:45:58 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

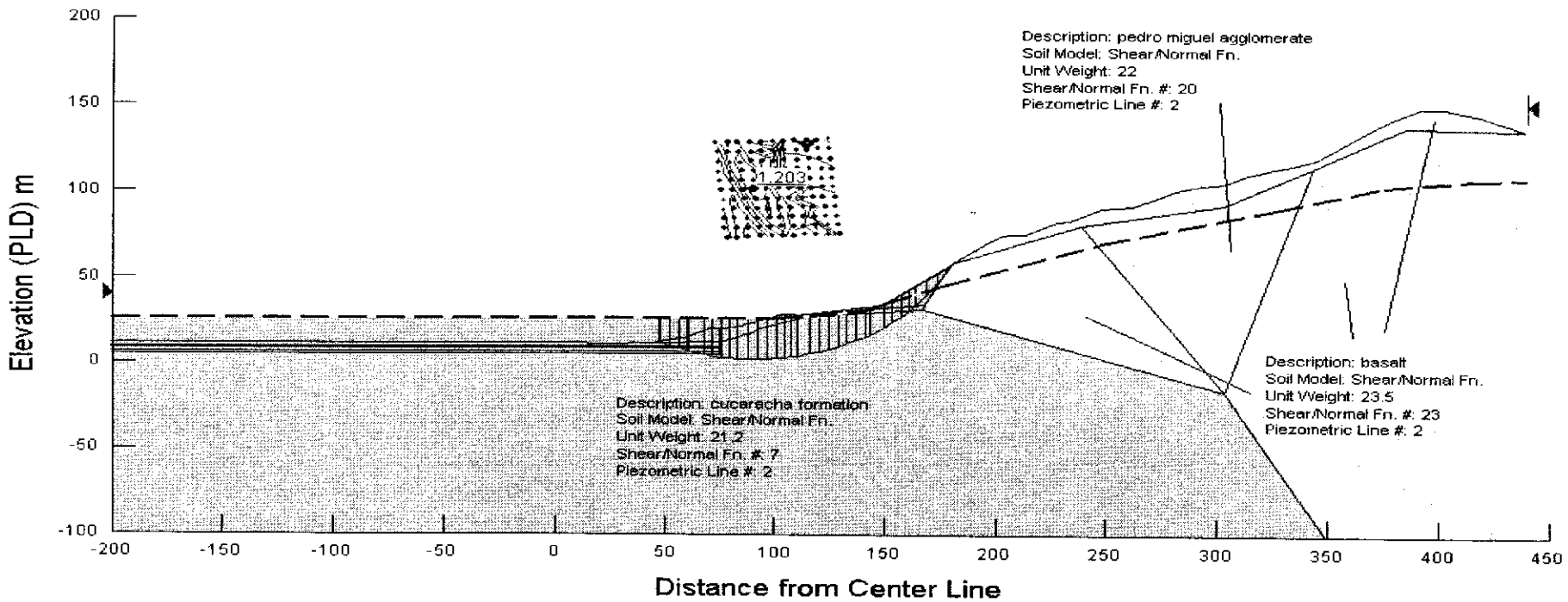


Case 2c, Channel bottom = 27 ft, Blasted material only



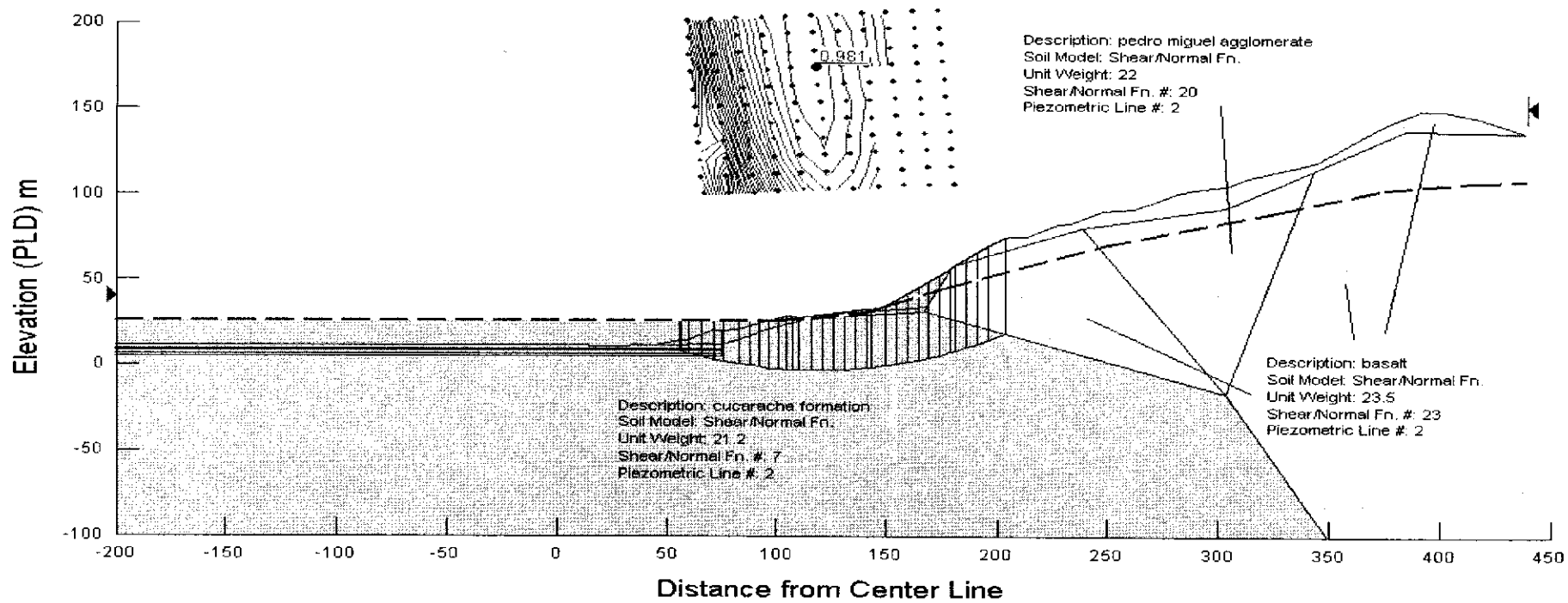
Case 3a, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 60K747_3.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:19:11 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

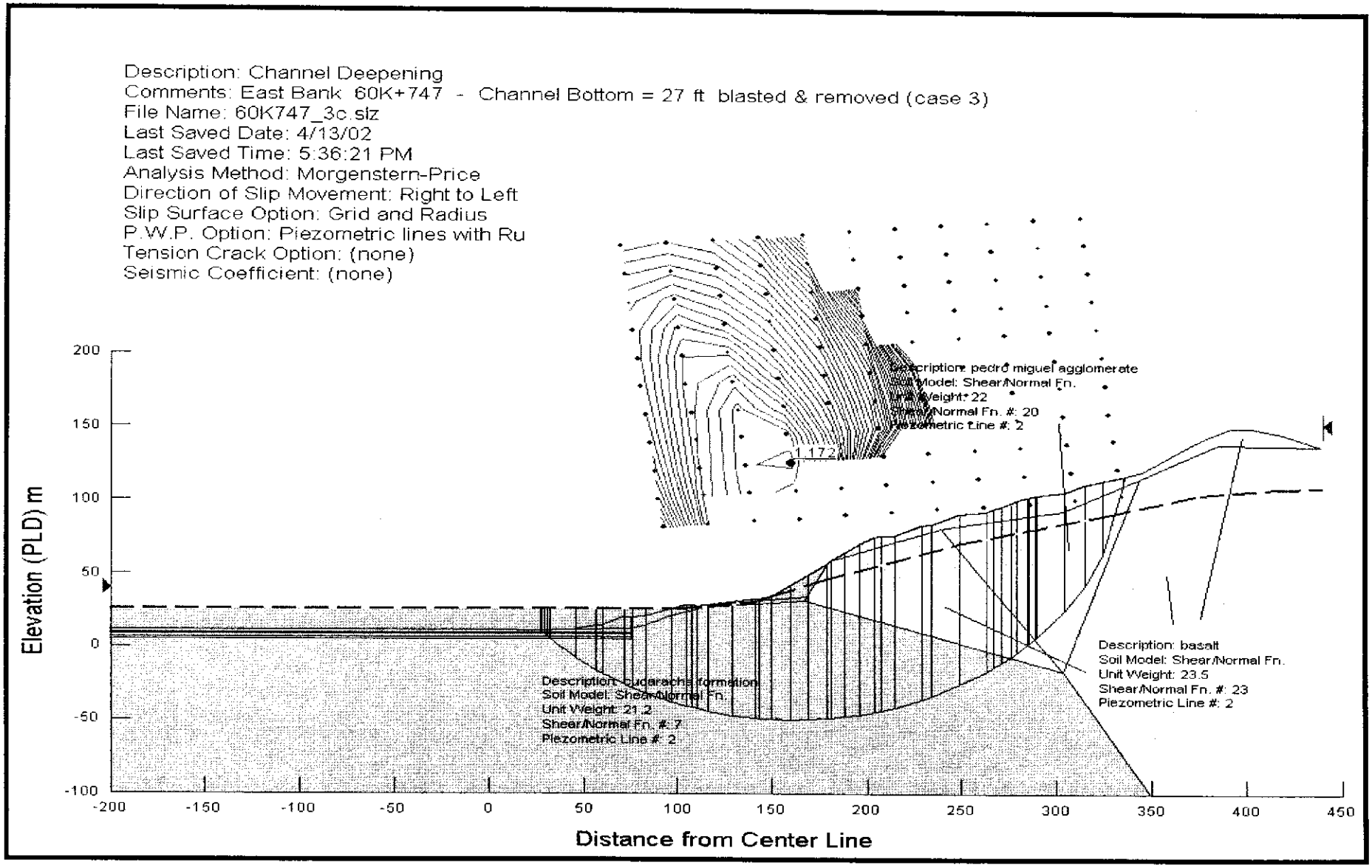


Case 3b, Channel bottom = 27 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft blasted & removed (case 3)
File Name: 60K747_3b.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:50:03 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

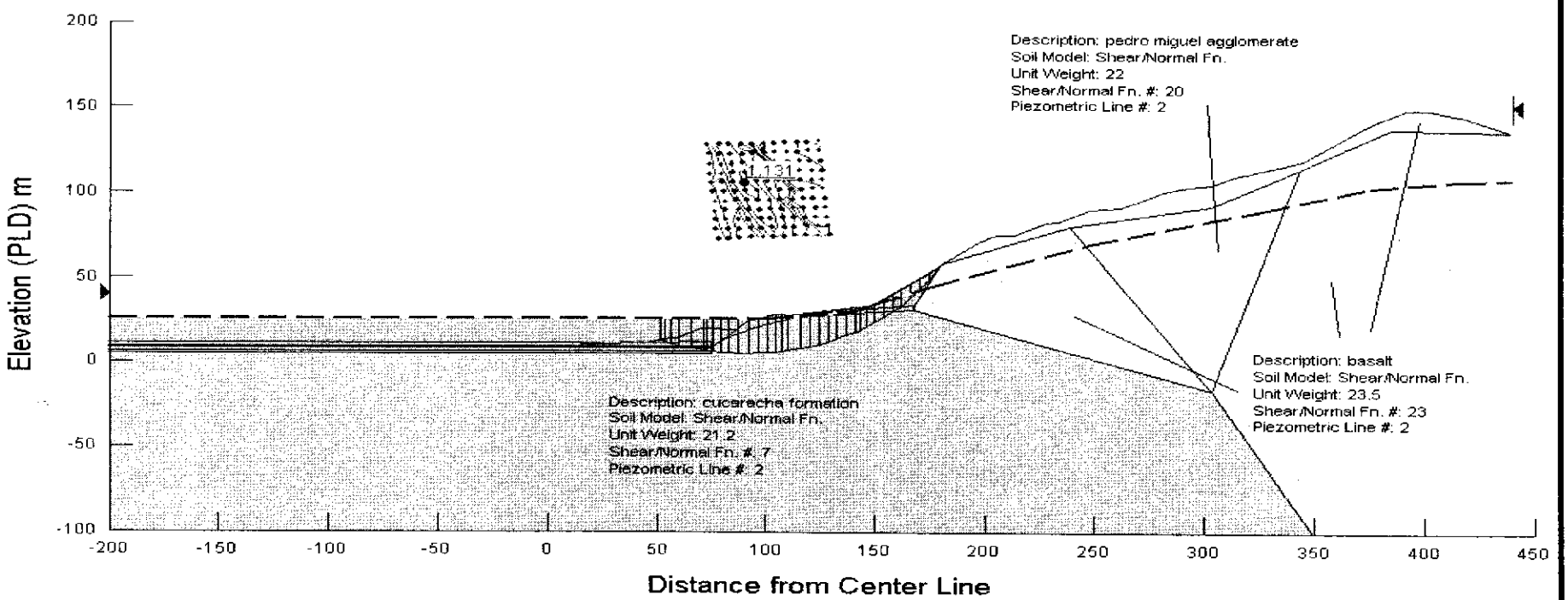


Case 3c, Channel bottom = 27 ft, Blasted & removed



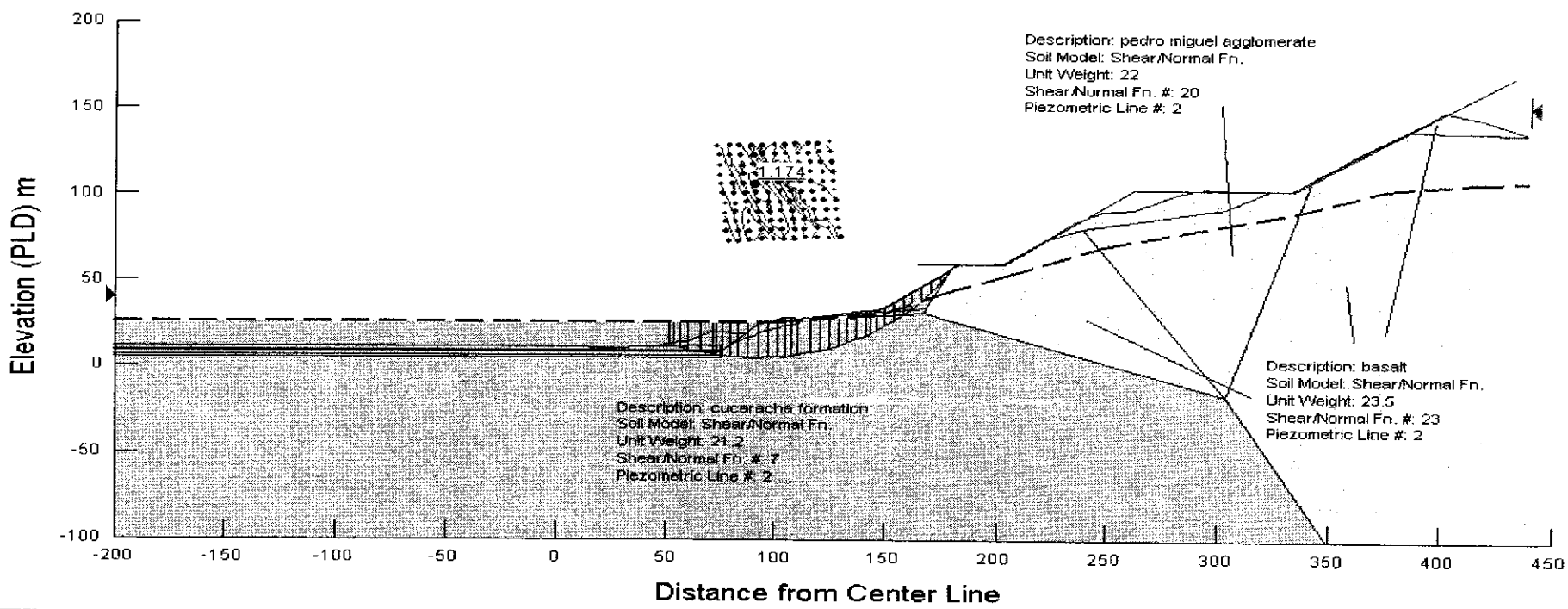
Case 4.1.a, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:22:29 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



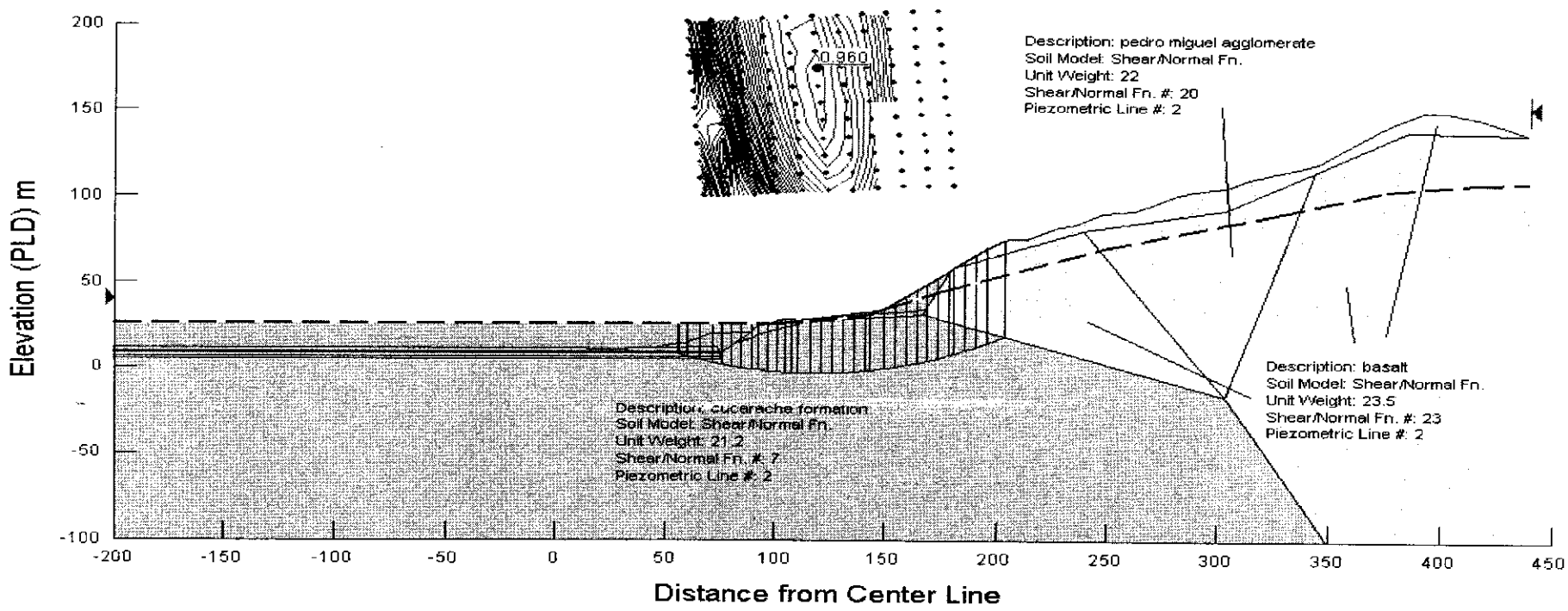
Case 4.2.a, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4e.slz
Last Saved Date: 4/14/02
Last Saved Time: 1:42:43 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



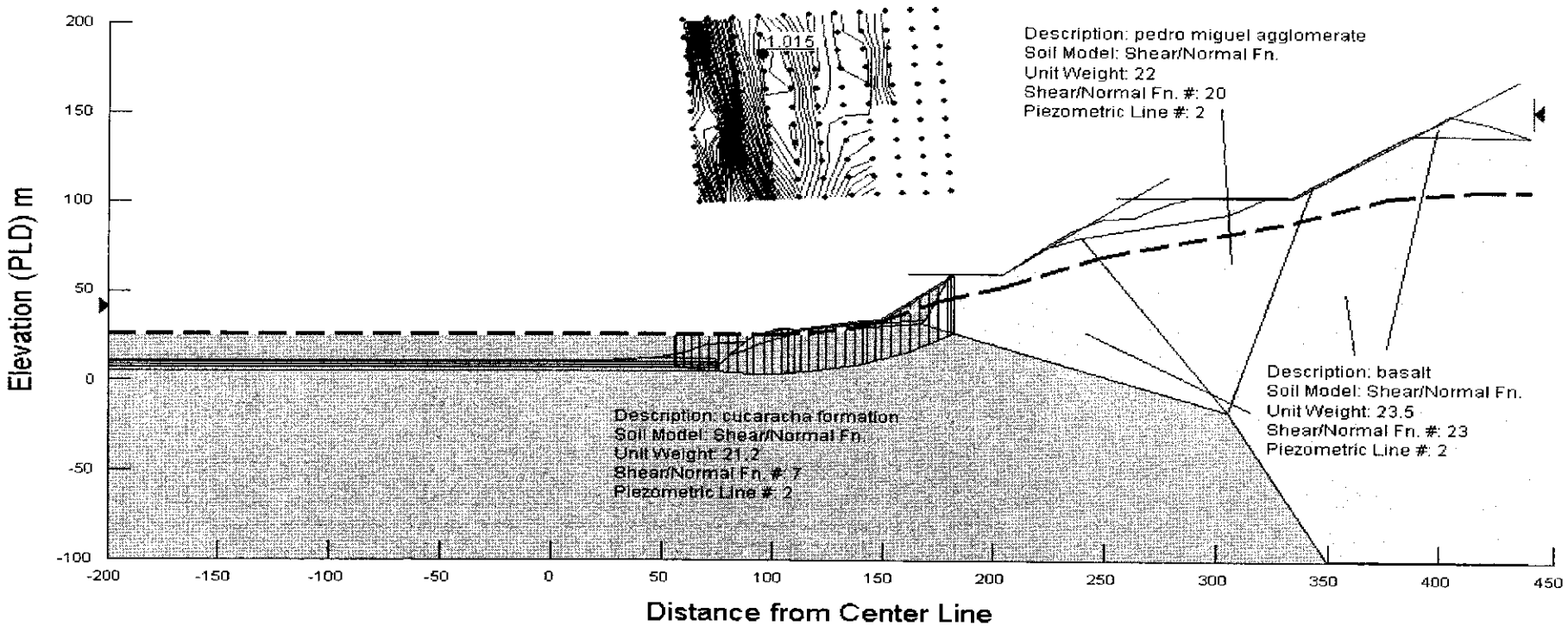
Case 4.1.b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4b.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:53:18 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

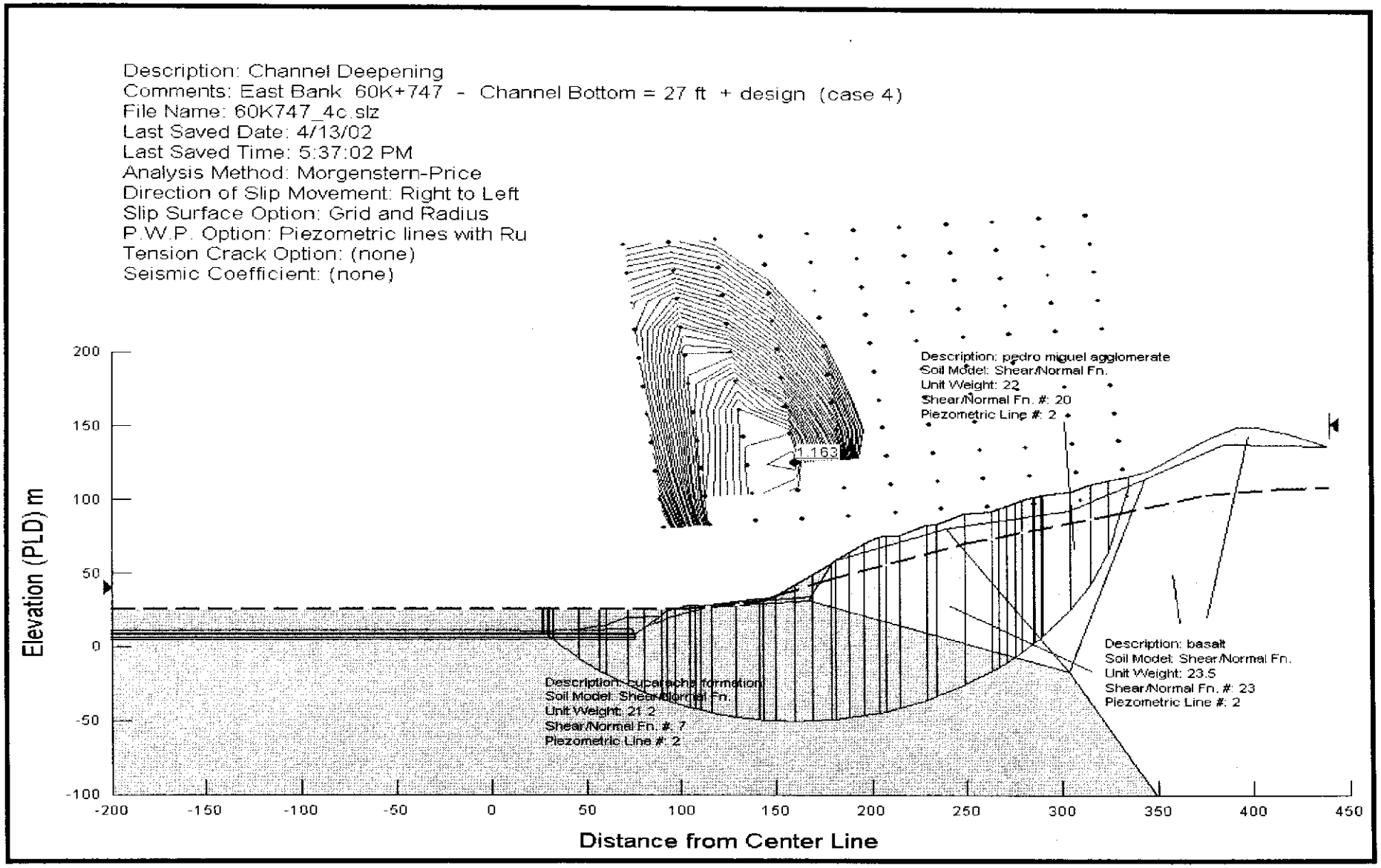


Case 4.2.b, Channel bottom = 27 ft, Design (& dry excavation)

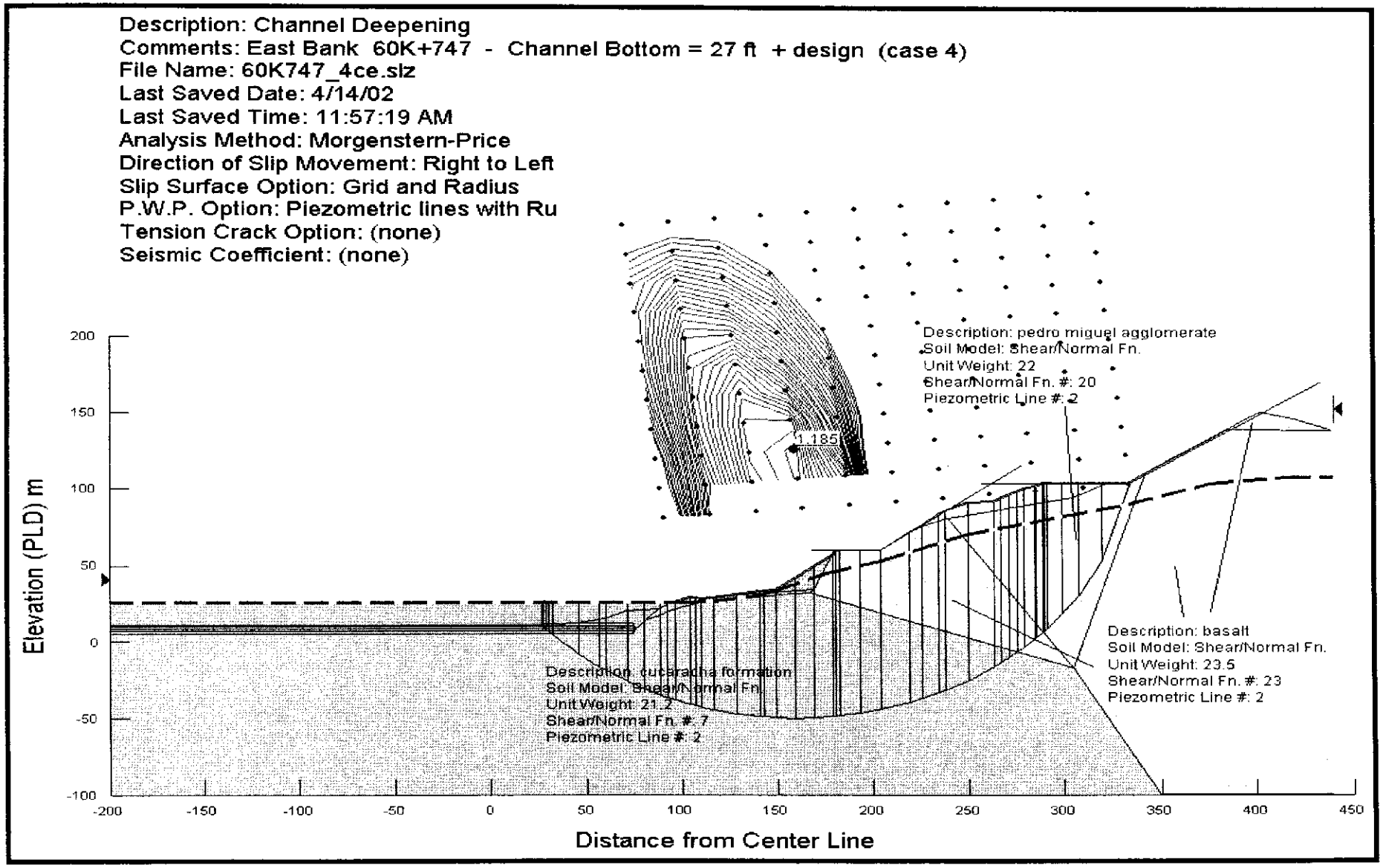
Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 27 ft + design (case 4)
File Name: 60K747_4be.slz
Last Saved Date: 4/14/02
Last Saved Time: 12:14:30 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 4.1.c, Channel bottom = 27 ft, Design (underwater slope)

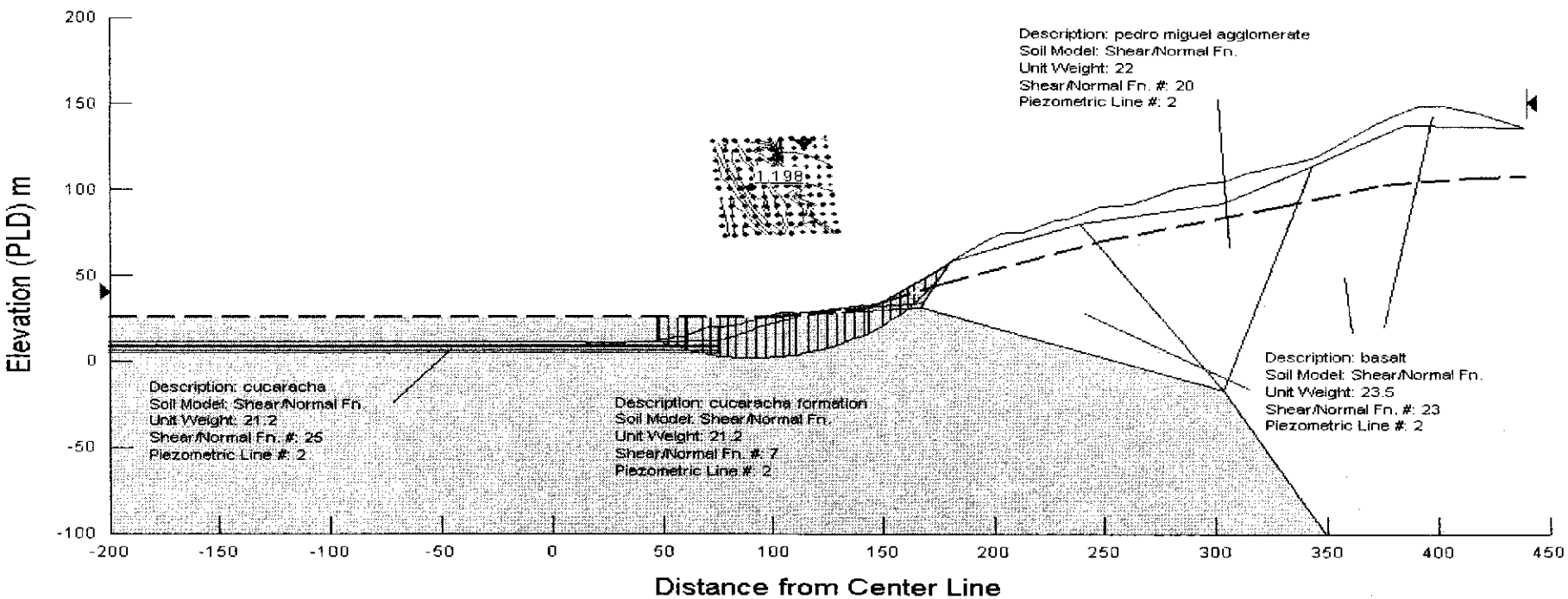


Case 4.2.c, Channel bottom = 27 ft, Design (& dry excavation)



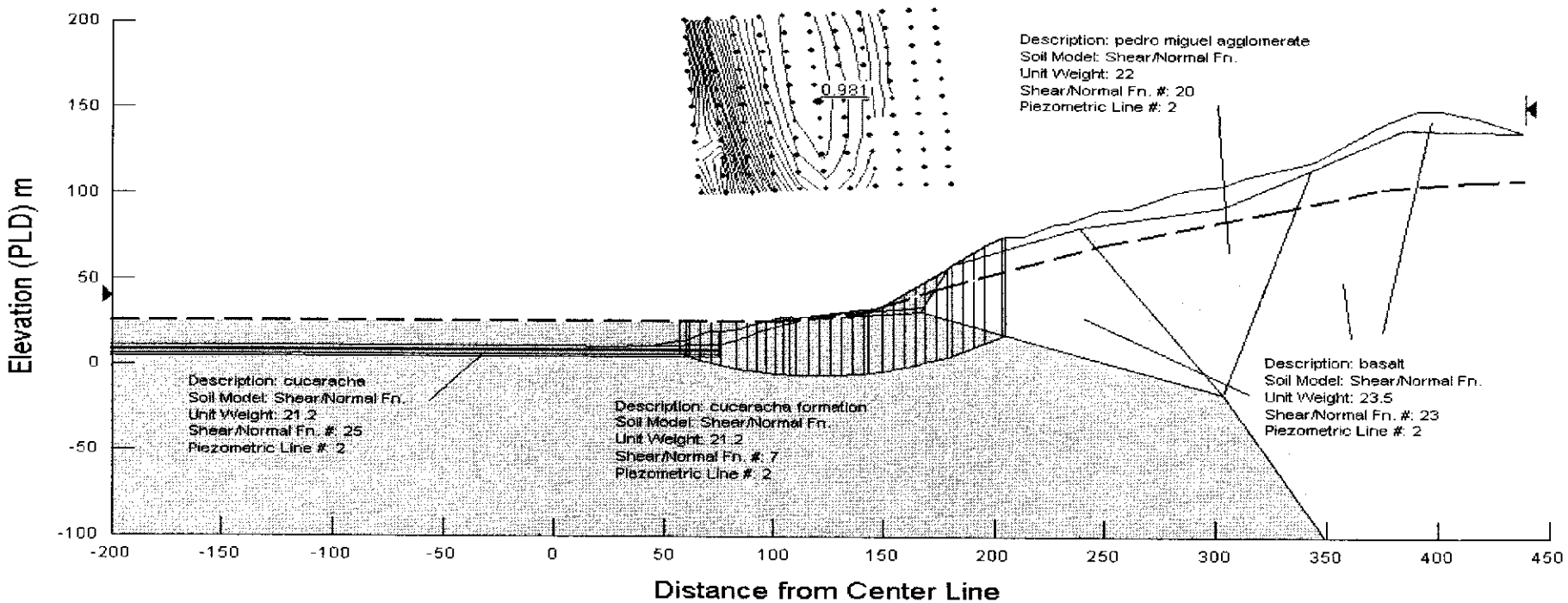
Case 5a, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft blasted material only (case 5)
File Name: 60K747_5.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:26:01 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

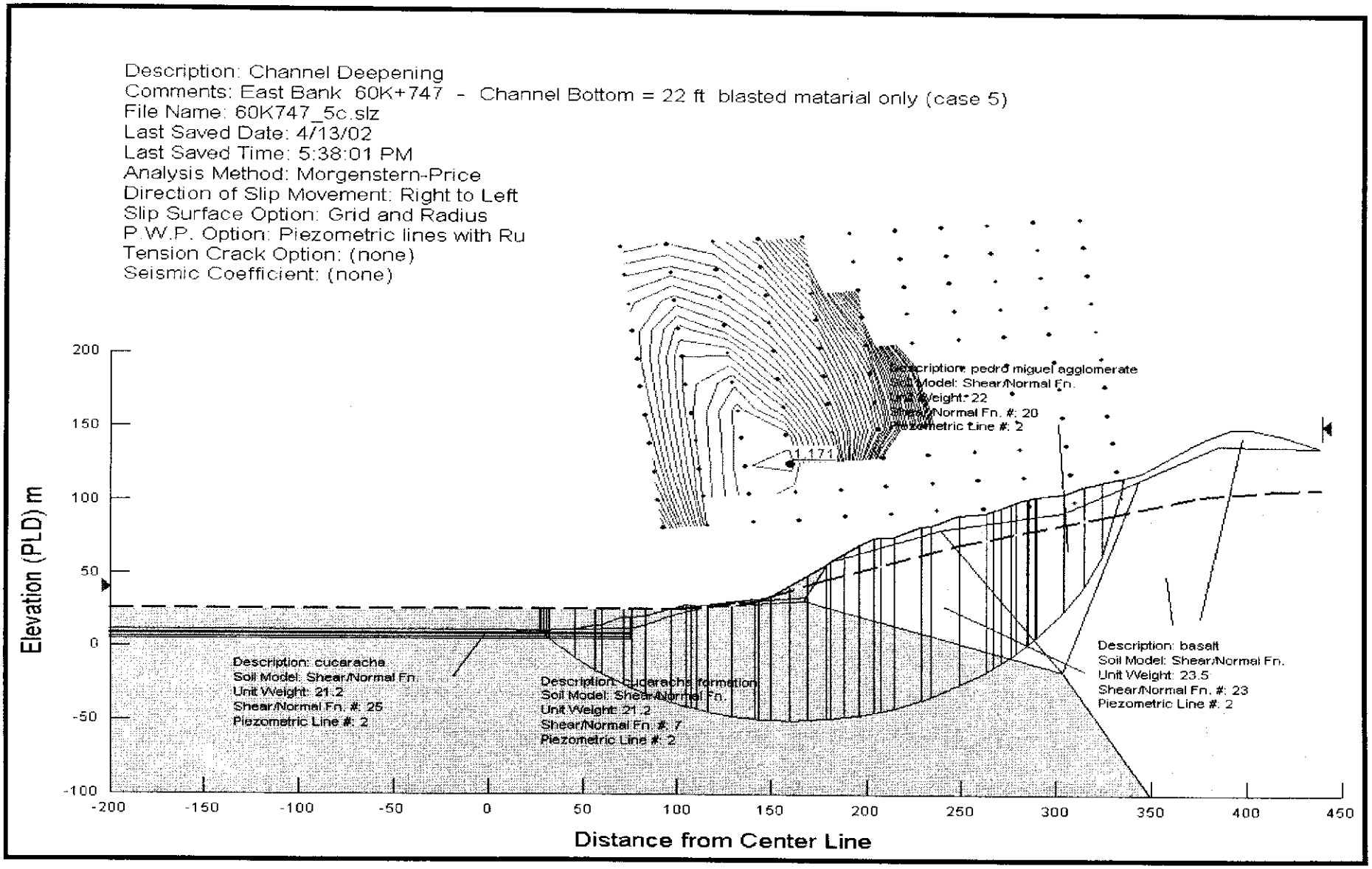


Case 5b, Channel bottom = 22 ft, Blasted material only

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft blasted matarial only (case 5)
File Name: 60K747_5b.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:55:36 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

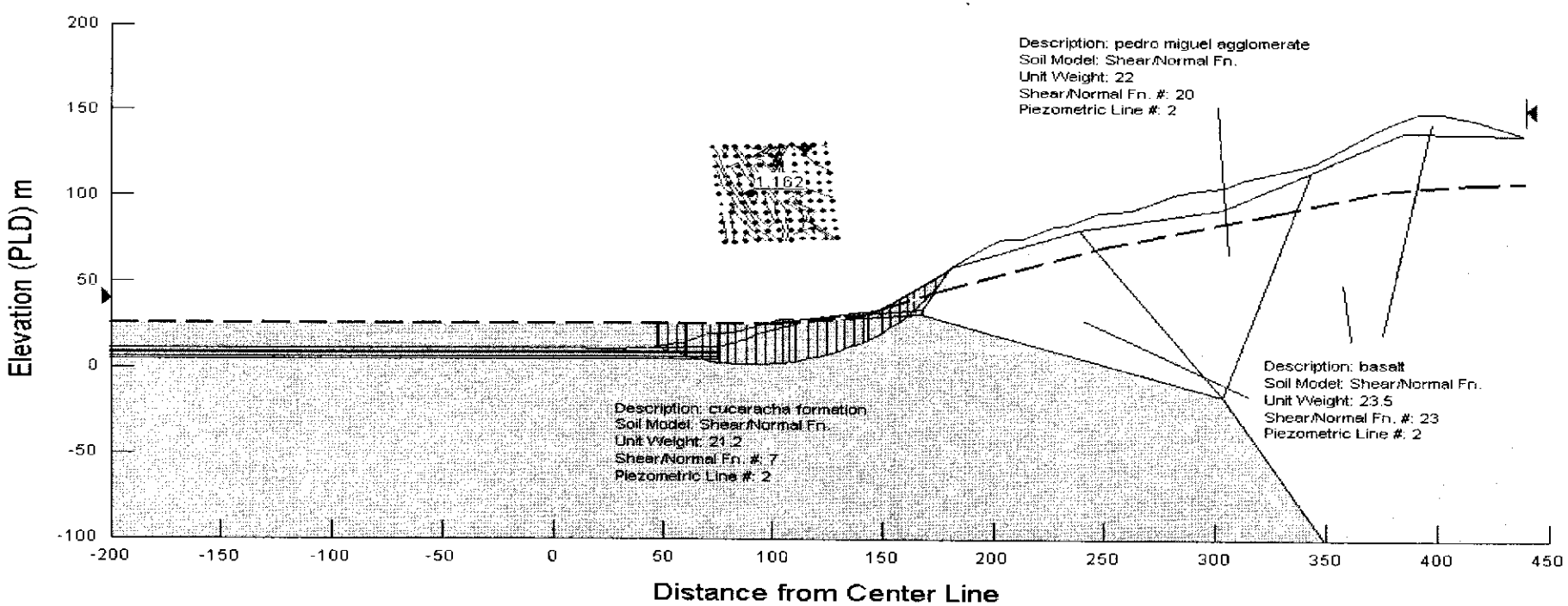


Case 5c, Channel bottom = 22 ft, Blasted material only



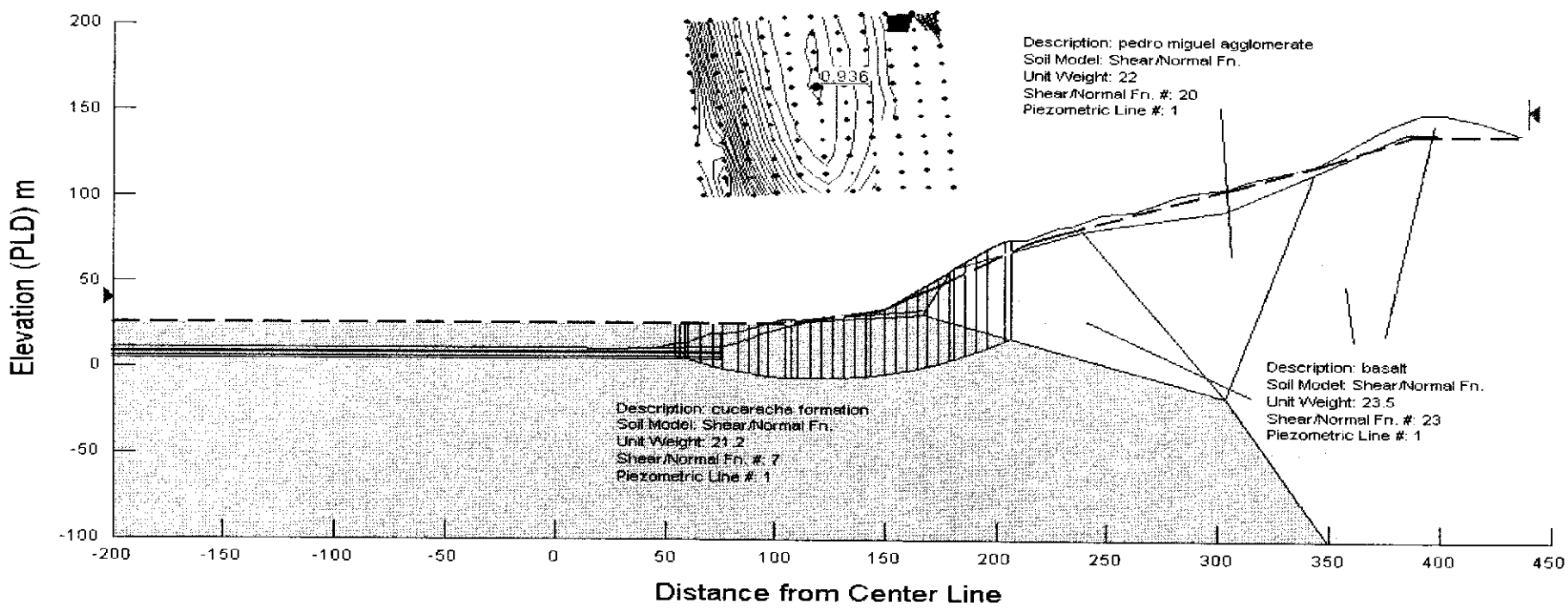
Case 6a, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 60K747_6.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:28:35 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

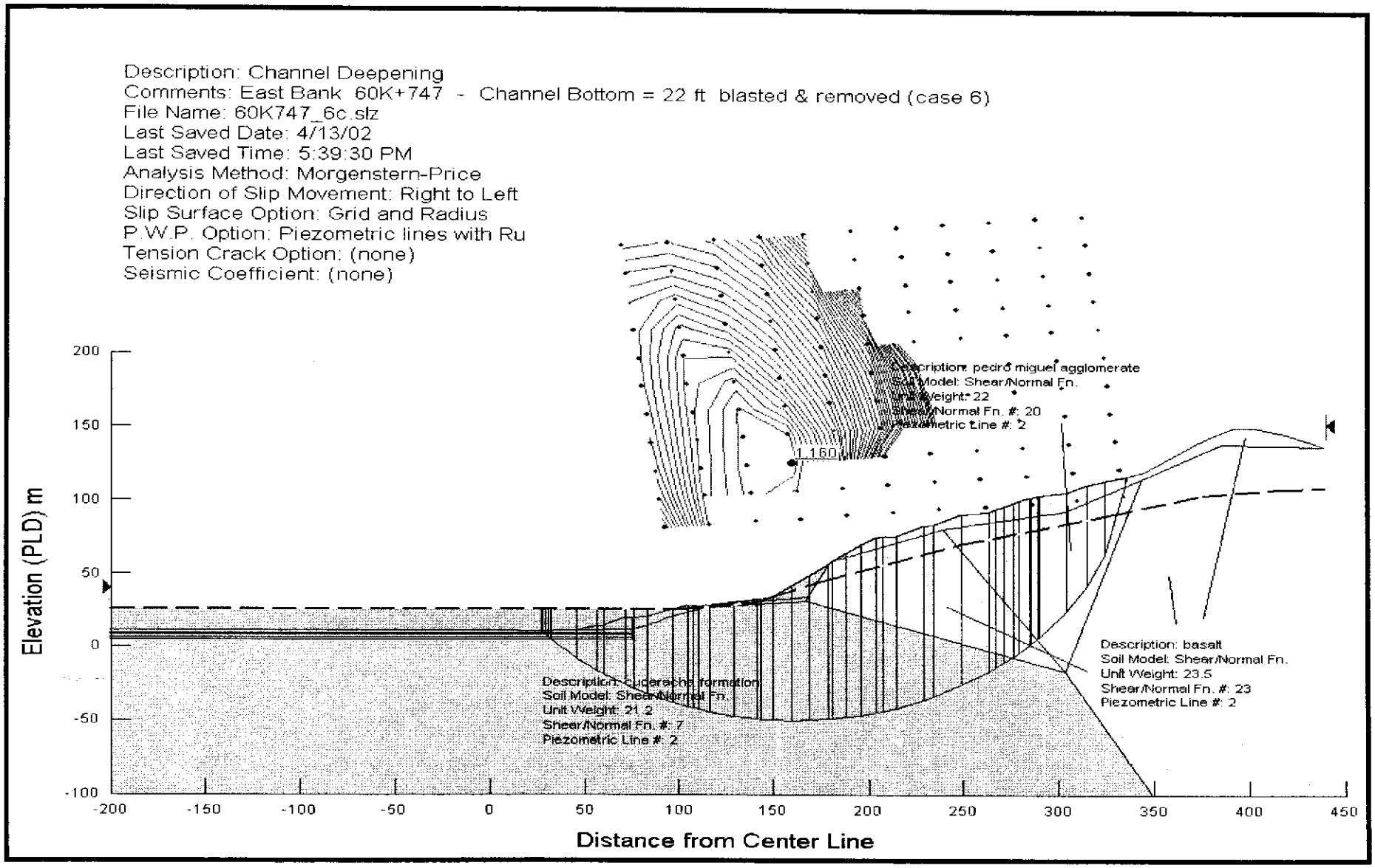


Case 6b, Channel bottom = 22 ft, Blasted & removed

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft blasted & removed (case 6)
File Name: 60K747_6b.slz
Last Saved Date: 4/13/02
Last Saved Time: 4:00:19 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

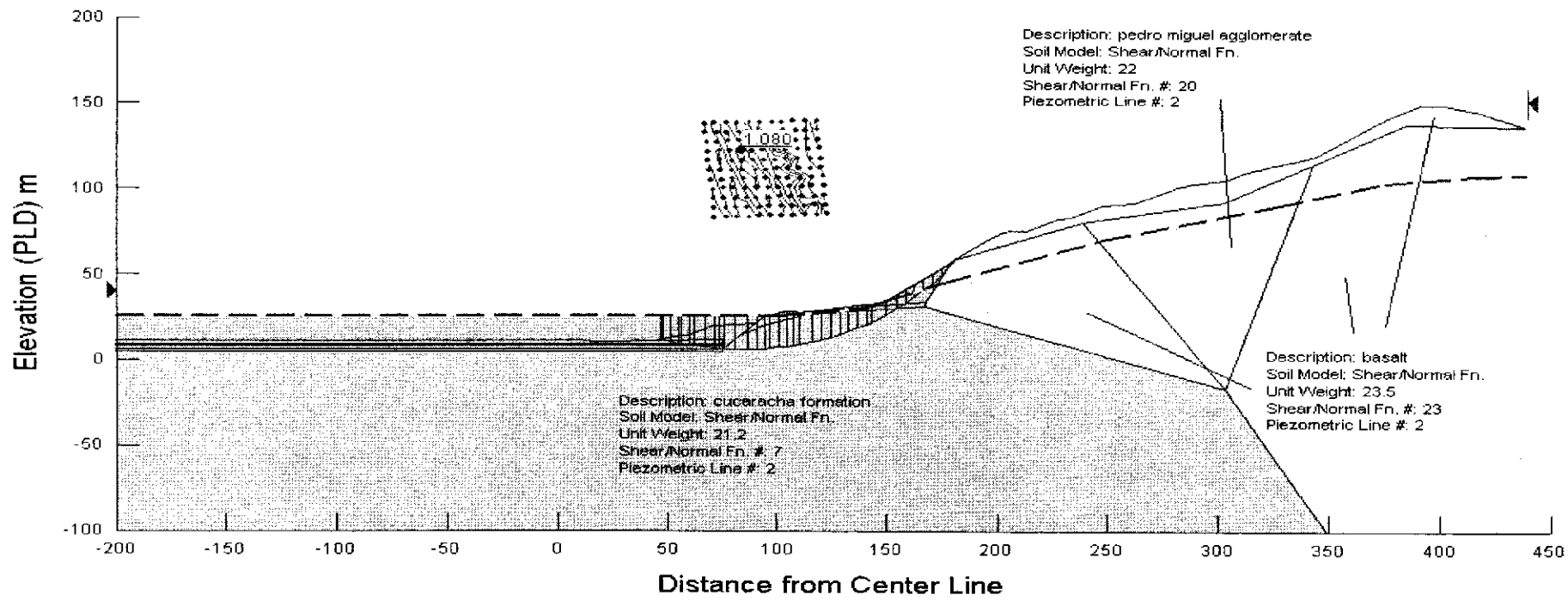


Case 6c, Channel bottom = 22 ft, Blasted & removed



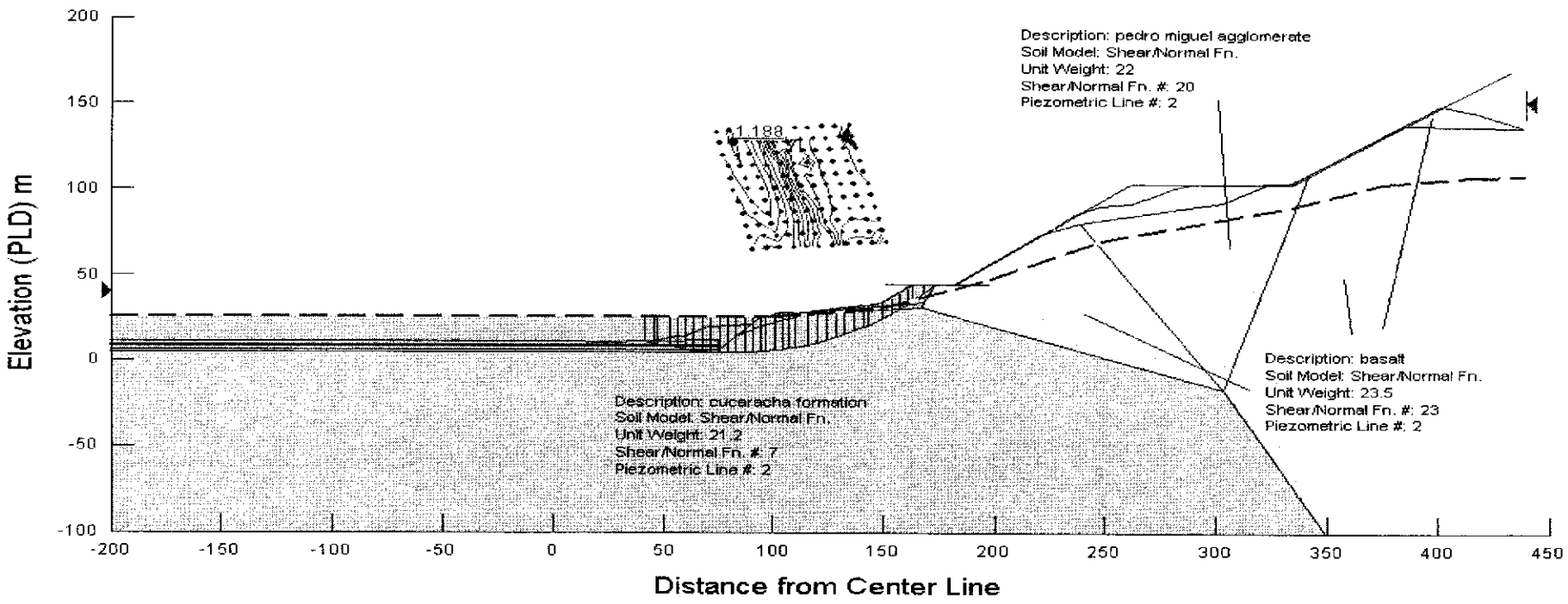
Case 7.1.a, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K747_7.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:32:06 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



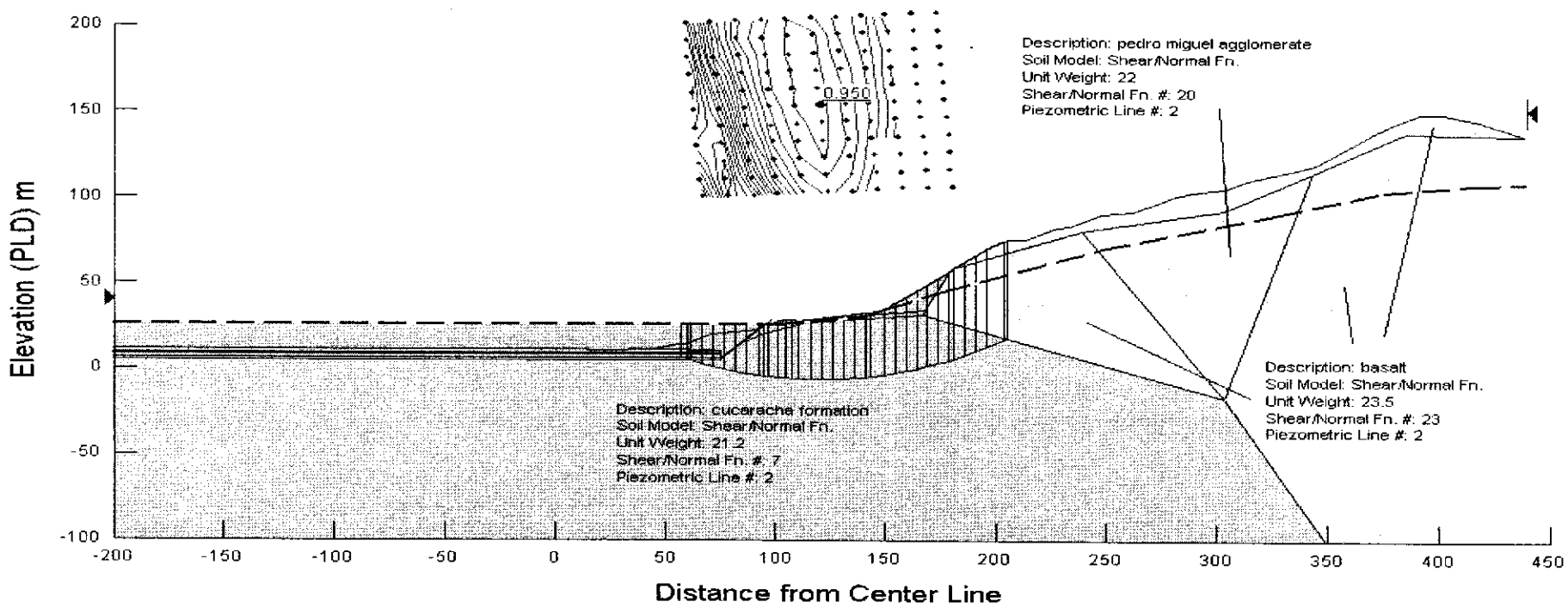
Case 7.2.a, Channel bottom = 27 ft, Design (& dry excavation)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K747_7e.slz
Last Saved Date: 4/14/02
Last Saved Time: 1:16:30 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)



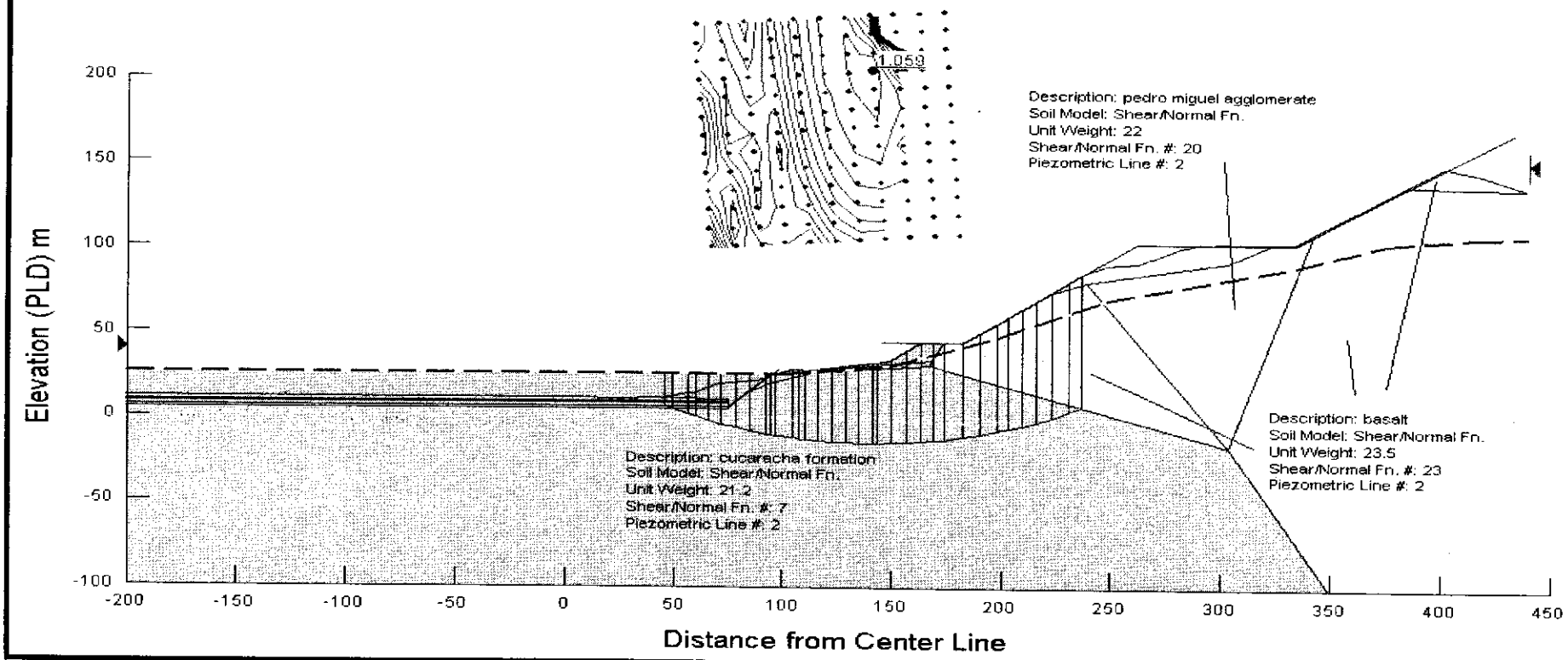
Case 7.1.b, Channel bottom = 27 ft, Design (underwater slope)

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K747_7b.slz
Last Saved Date: 4/13/02
Last Saved Time: 4:04:29 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)

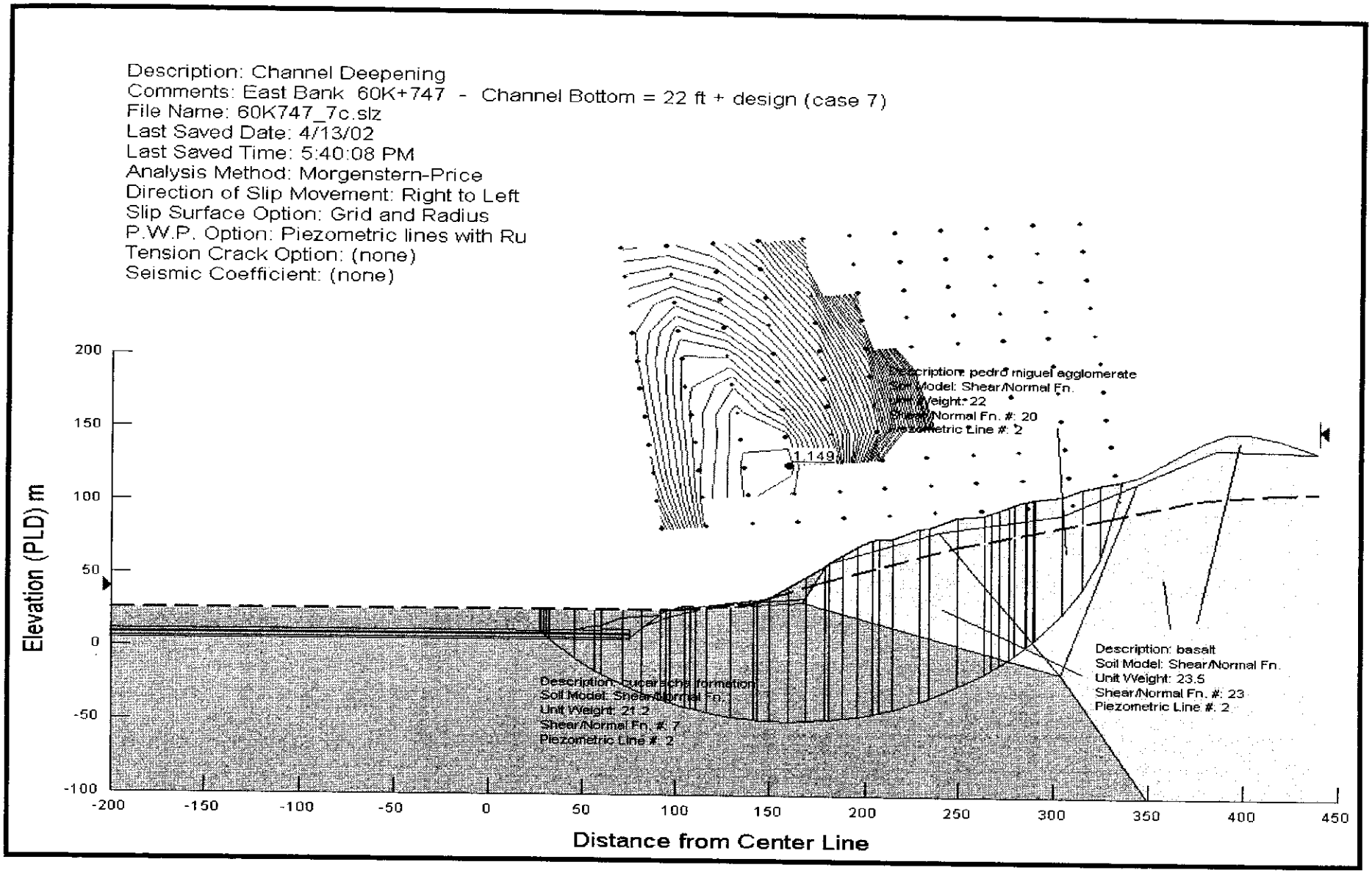


Case 7.2.b, Channel bottom = 27 ft, Design (& dry excavation)

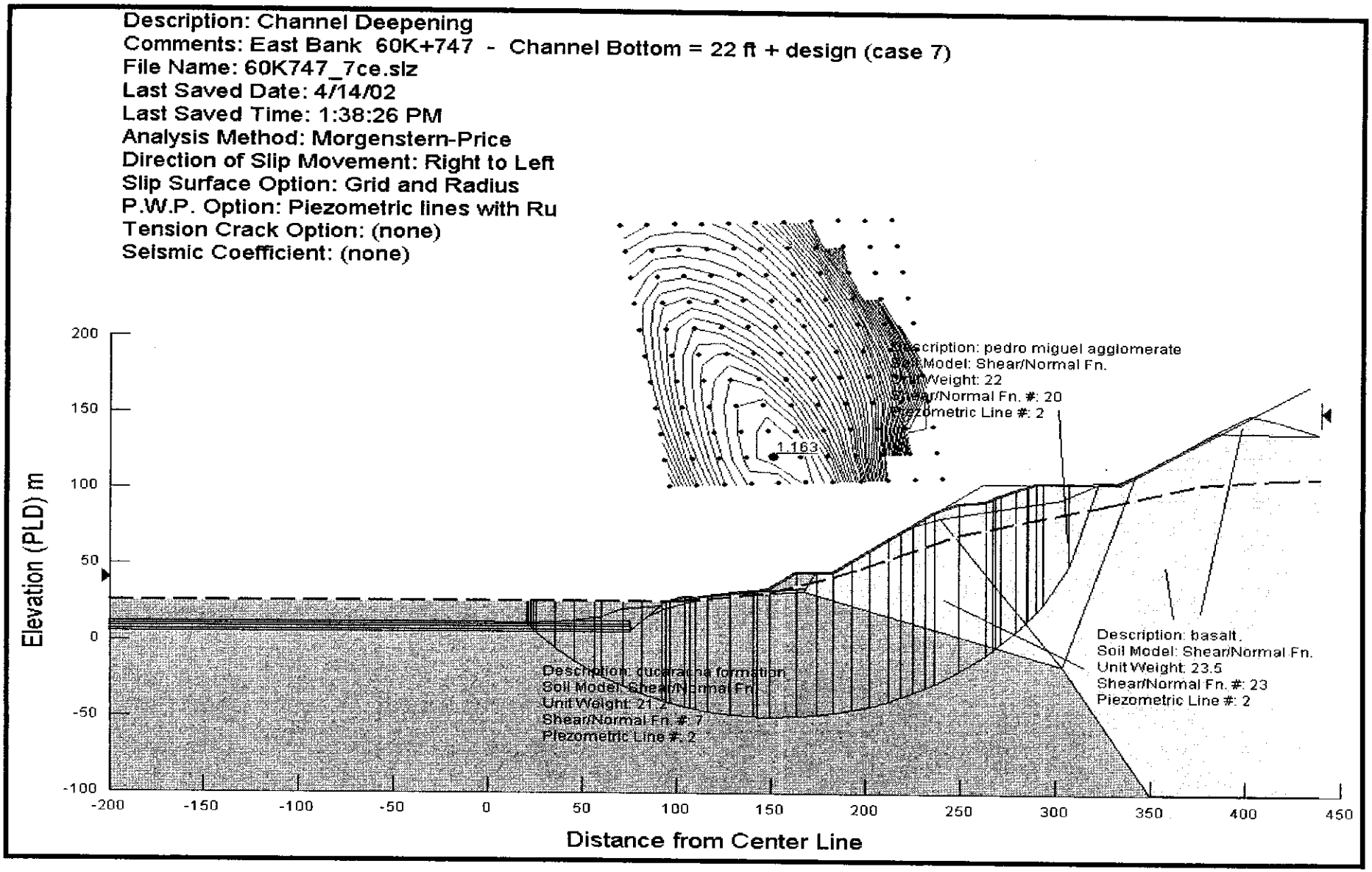
Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft + design (case 7)
File Name: 60K747_7be.slz
Last Saved Date: 4/14/02
Last Saved Time: 1:22:30 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 7.1.c, Channel bottom = 27 ft, Design (underwater slope)

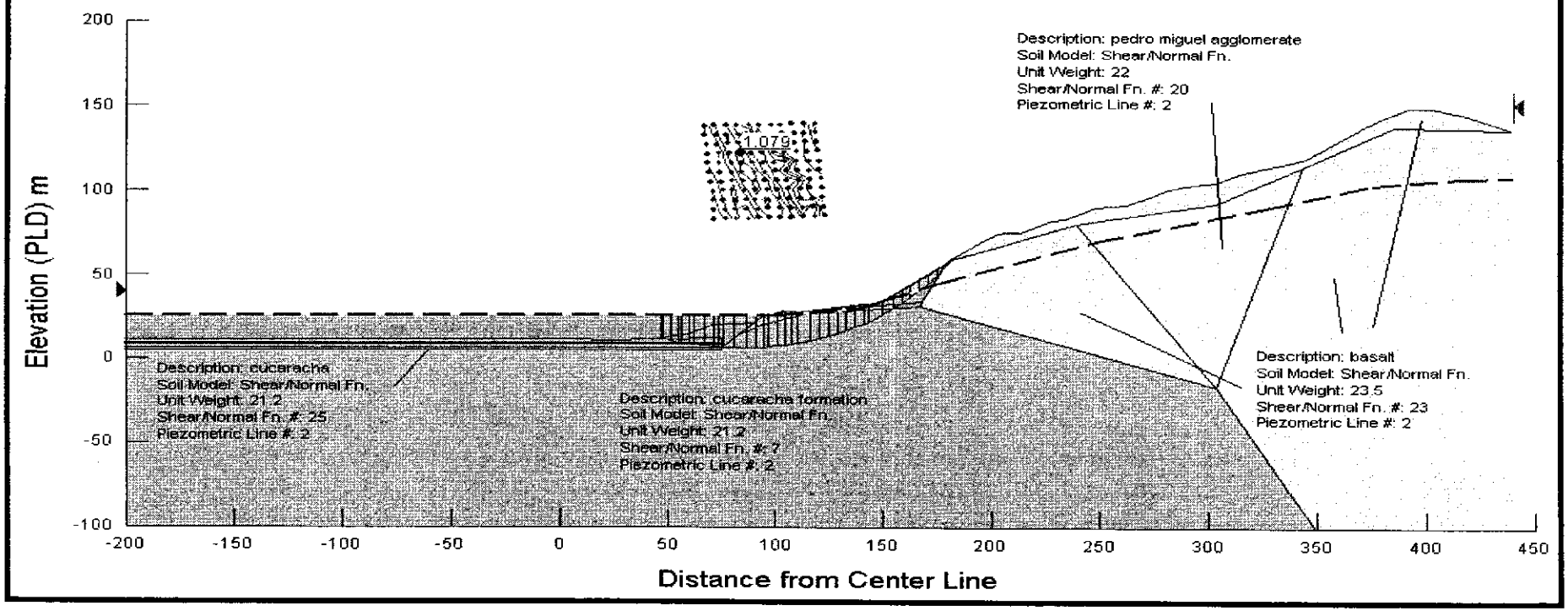


Case 7.2.c, Channel bottom = 27 ft, Design (& dry excavation)



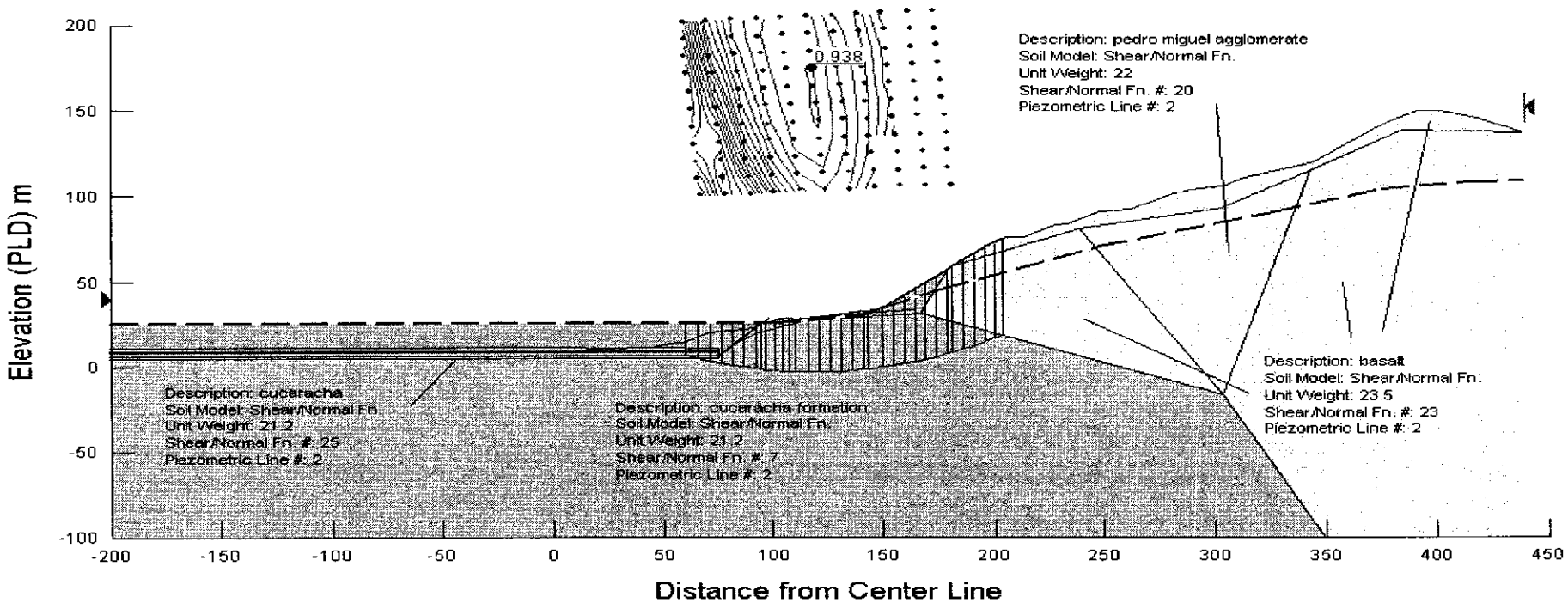
Case 8a, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 60K747_8.slz
Last Saved Date: 4/13/02
Last Saved Time: 3:34:43 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: (none)
Seismic Coefficient: (none)

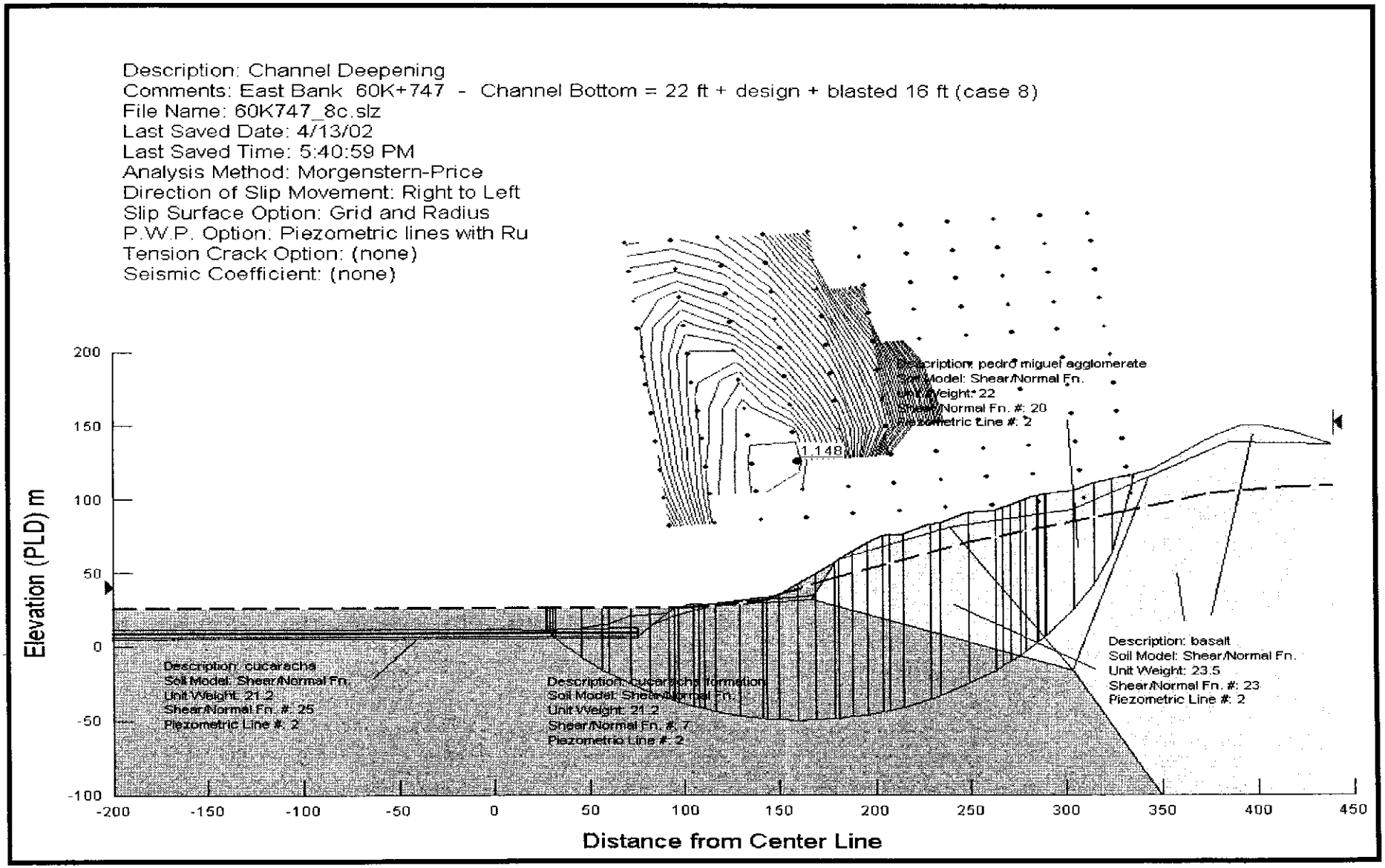


Case 8b, Channel bottom = 16 ft, Blasted

Description: Channel Deepening
Comments: East Bank 60K+747 - Channel Bottom = 22 ft + design + blasted 16 ft (case 8)
File Name: 60K747_8b.slz
Last Saved Date: 4/13/02
Last Saved Time: 4:10:05 PM
Analysis Method: Morgenstern-Price
Direction of Slip Movement: Right to Left
Slip Surface Option: Grid and Radius
P.W.P. Option: Piezometric lines with Ru
Tension Crack Option: Tension Crack Line
Seismic Coefficient: (none)



Case 8c, Channel bottom = 16 ft, Blasted

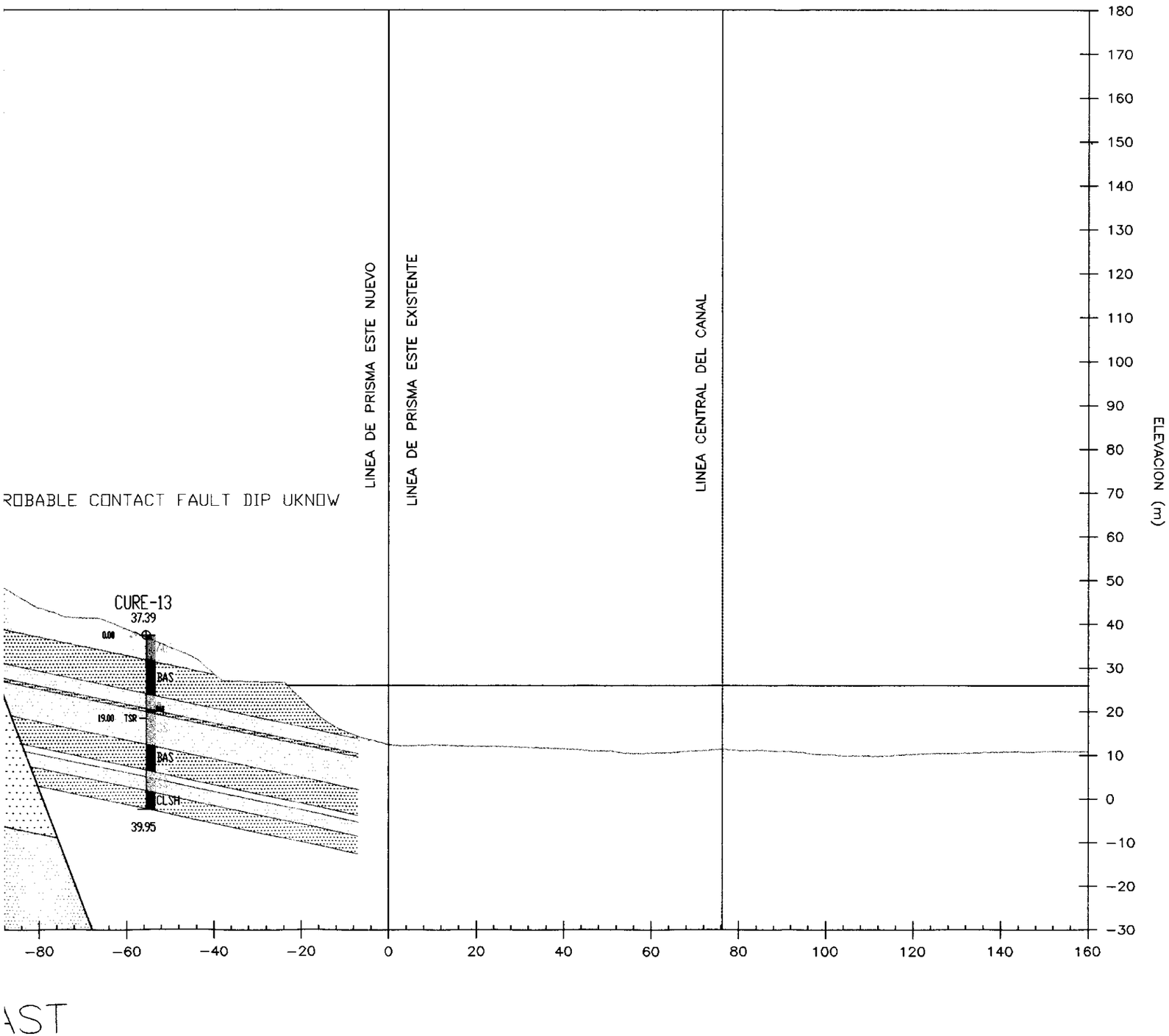


Summary, 60k + 747 (1993 + 00)

General Description	Range of stations:	60k + 695 to 60k + 850
	Sector:	Cucaracha
	Maximum height (m):	140
	Cotangent of slope angle (cot. β):	1.6
History	Last slide event:	November 27, 2001 (South Cucaracha Slide)
Geology	Formation:	Cucaracha / Pedro Miguel
	Lithology:	Clayshale / Agglomerate
	Critical stratum at toe:	Clayshale
	Apparent dip of bedding:	Toward the Canal, 10°
Stability Analysis	Critical failure mechanism:	(a), (c) - Rotational / (b) Rotational - Tension crack
	Shear strength model:	Fully softened - Cucaracha / First time BAsalt

	Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety			Relative Factor of Safety			Percentage of Change (%)		
		(a)	(b)	(c)	(a)	(b)	(c)	(a)	(b)	(c)
Case 1: Channel bottom = 32 ft	0.396	1.251	0.996	1.183	1.000	1.000	1.000	0.000	0.000	0.000
Case 2: Channel bottom = 27 ft, Blasted material only		1.227	0.987	1.182	0.981	0.991	0.999	-1.918	-0.904	-0.085
Case 3: Channel bottom = 27 ft, Blasted & removed		1.203	0.981	1.172	0.962	0.985	0.991	-3.837	-1.506	-0.930
Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		1.131	0.960	1.163	0.904	0.964	0.983	-9.592	-3.614	-1.691
Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.400	1.174	1.015	1.185	0.938	1.019	1.002	-6.155	1.908	0.169
Case 5: Channel bottom = 22 ft, Blasted material only		1.198	0.981	1.171	0.958	0.985	0.990	-4.237	-1.506	-1.014
Case 6: Channel bottom = 22 ft, Blasted & removed		1.162	0.936	1.160	0.929	0.940	0.981	-7.114	-6.024	-1.944
Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		1.080	0.950	1.149	0.863	0.954	0.971	-13.669	-4.618	-2.874
Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.435	1.188	1.059	1.163	0.950	1.063	0.983	-5.036	6.325	-1.691
Case 8: Channel bottom = 16 ft, Blasted		1.079	0.938	1.148	0.863	0.942	0.970	-13.749	-5.823	-2.959

Conclusions: Stabilization is required for Case 4 and Case 7. Currently, a remedial excavation is bring designed for South Cucaracha. Therefore, factors of safety have been computed using the ground surface after implementing this stabilization work.



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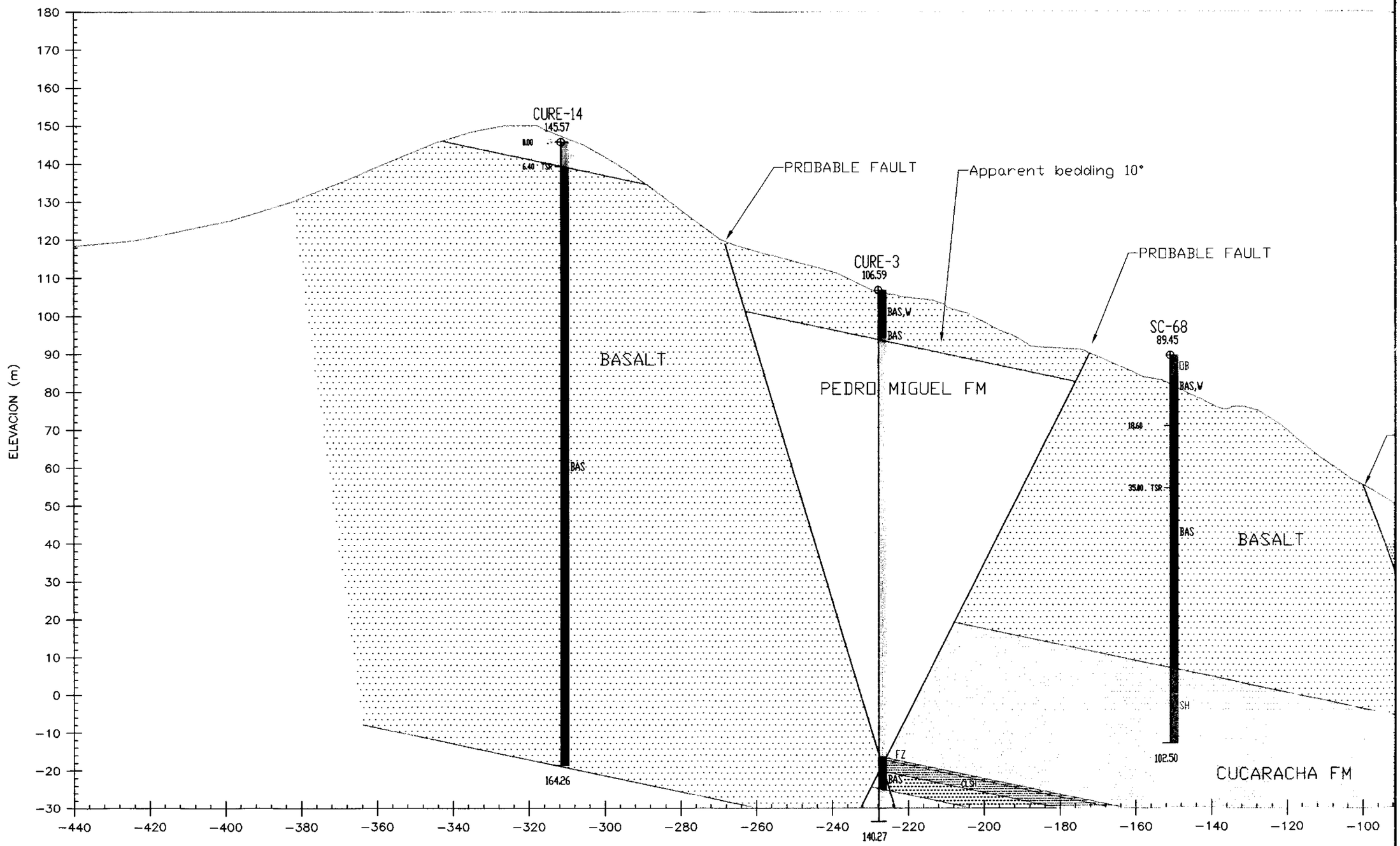
DEPARTAMENTO DE INGENIERIA Y PROYECTOS
DIVISION DE INGENIERIA
ALTOS DE BALBOA, REPUBLICA DE PANAMA

SECCION GEOLOGICA

CORTE GAILLARD

ESTACION 60K+747 (1993+00) ESTE

ESCALA: 1:1000	FECHA: ABRIL 2002
GEOLOGIA POR: J. ARROCHA & P. FRANCESCHI	DIBUJADO POR: J. ARROCHA & J. RAMESCH


ELEVACION (m)
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150
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120
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-10
-20
-30
-440
-420
-400
-380
-360
-340
-320
-300
-280
-260
-240
-220
-200
-180
-160
-140
-120
-100
CURE-14
145.57
0.00
6.40 TSR
BAS
164.26
CURE-3
106.59
BAS,V
BAS
SC-68
89.45
OB
BAS,V
18.60
35.00 TSR
BAS
SH
102.50
PROBABLE FAULT
Apparent bedding 10°
PROBABLE FAULT
BASALT
PEDRO MIGUEL FM
BASALT
CUCARACHA FM
FZ
BAS
CLST
140.27
60K+747 (1993+00)

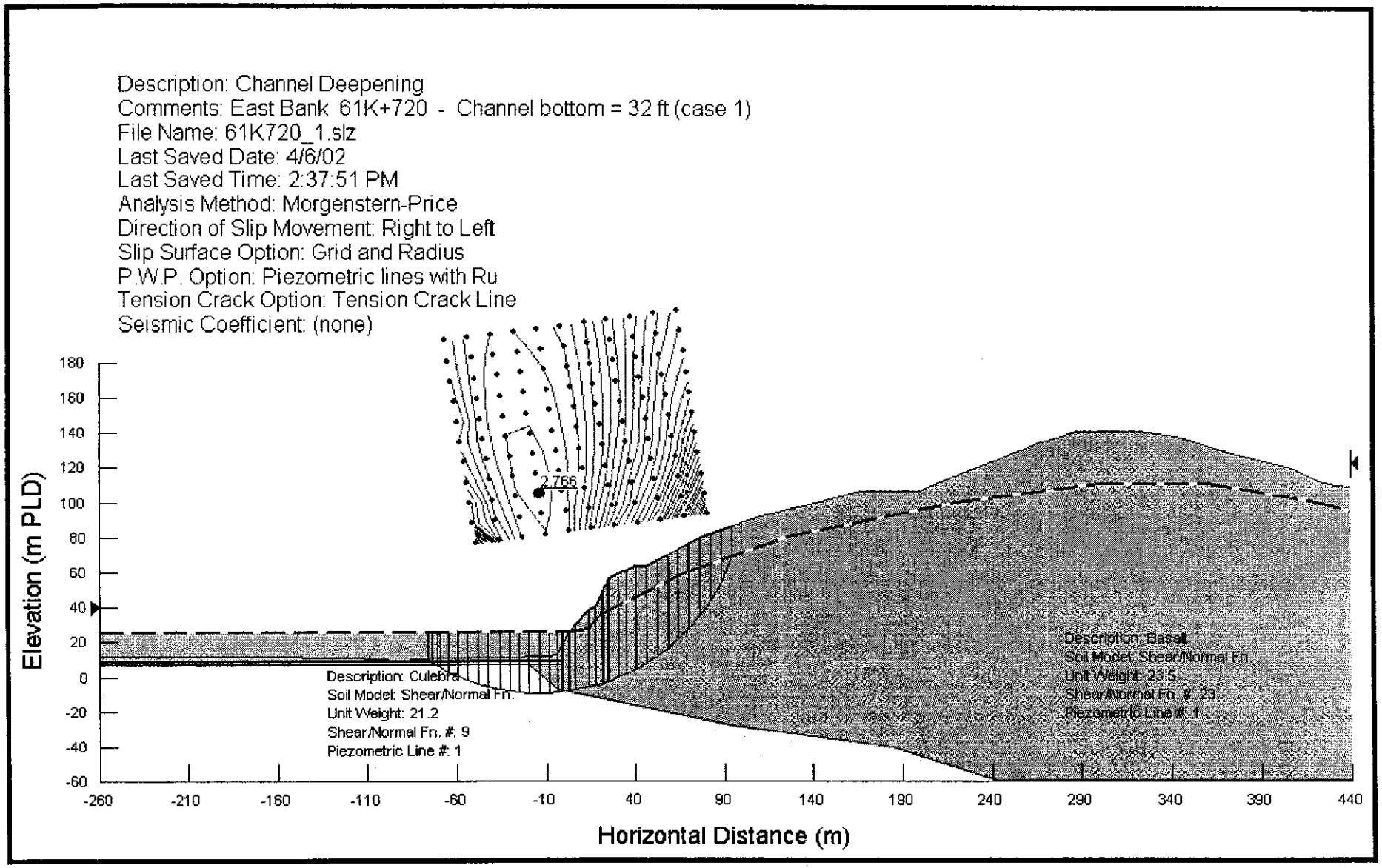
station 61k + 720 (2025 + 00)

East

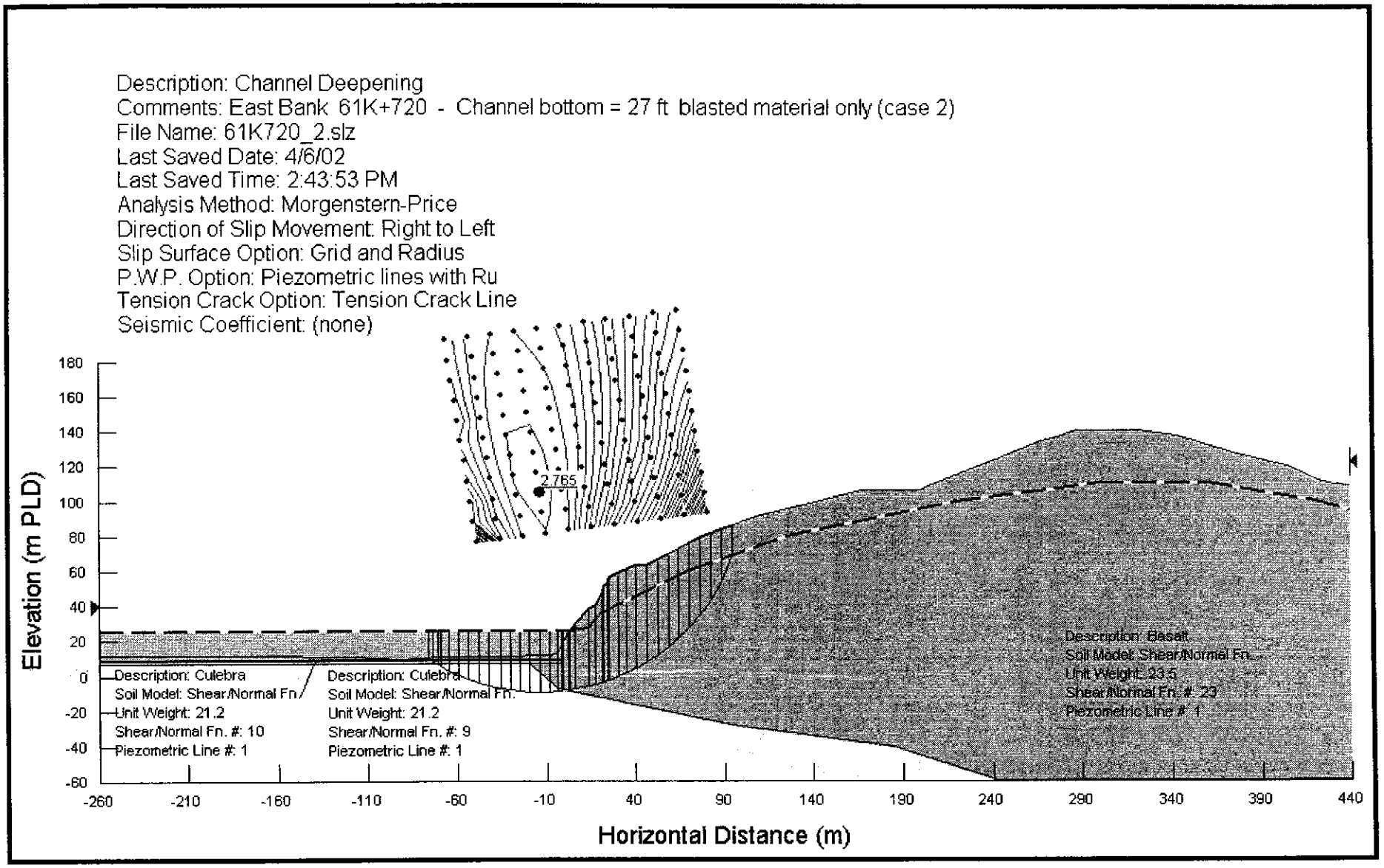
Station: 61k + 720 (Nitro)

April 16, 2002

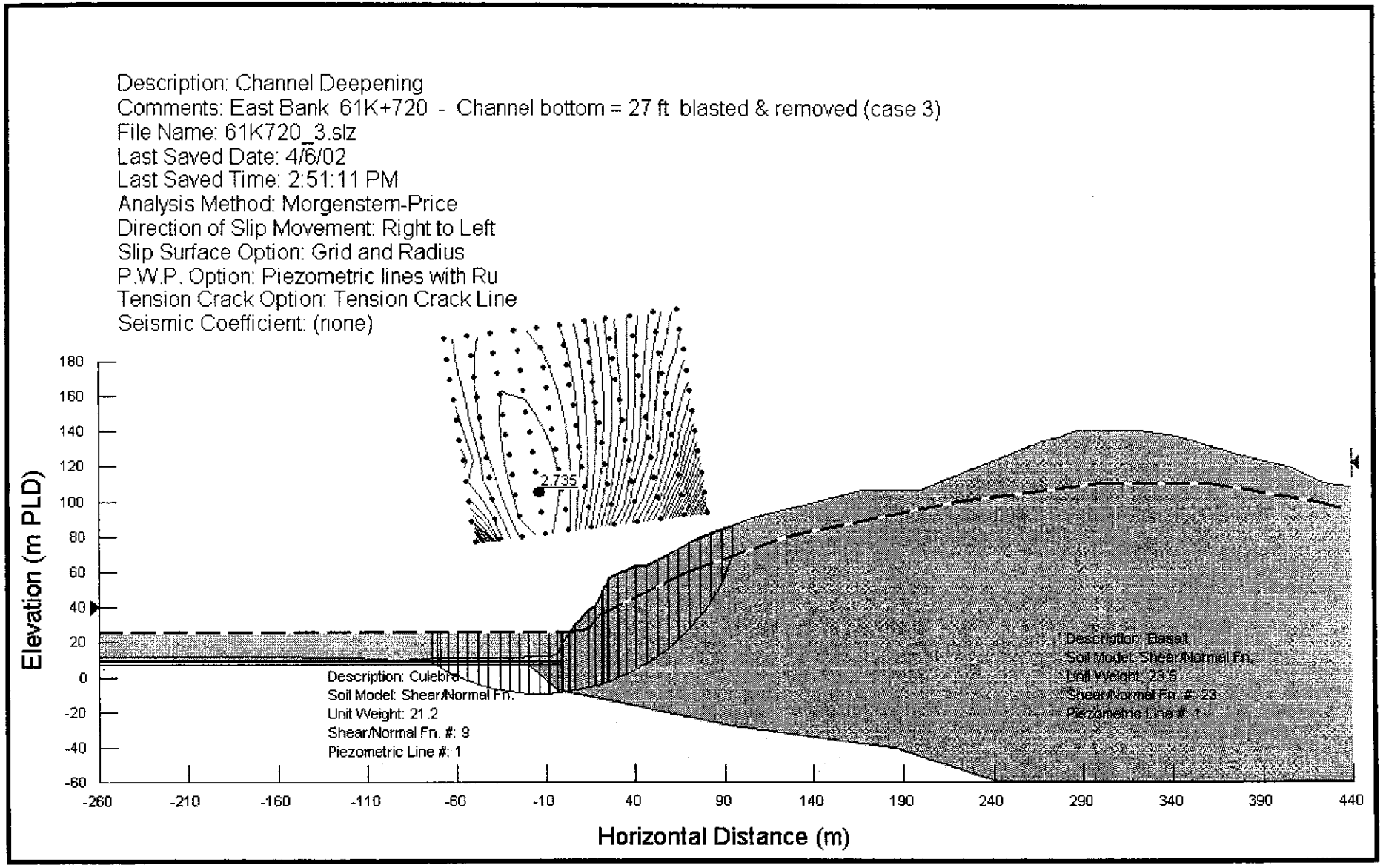
Case 1, Channel bottom = 32 ft



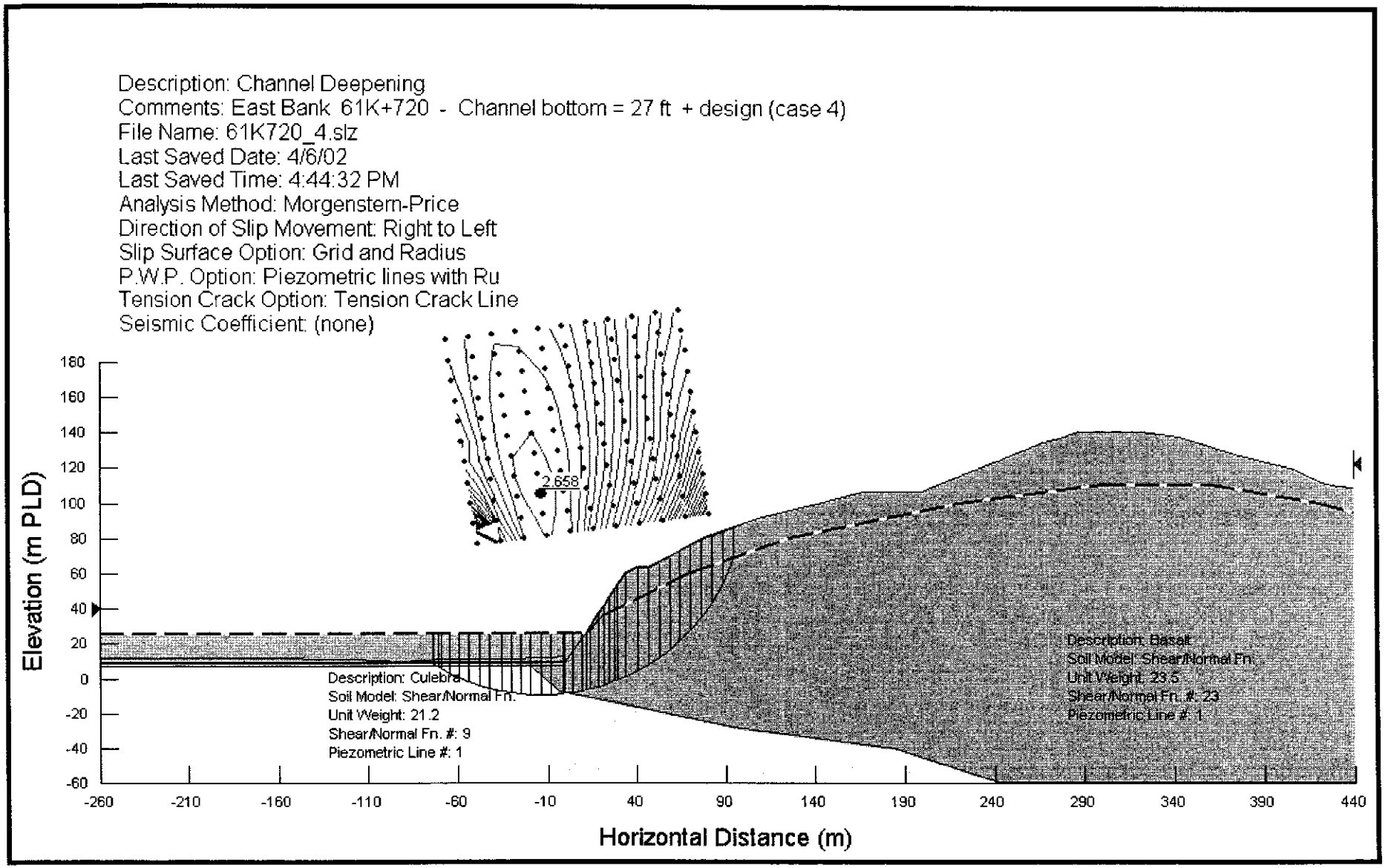
Case 2, Channel bottom = 27 ft, Blasted material only



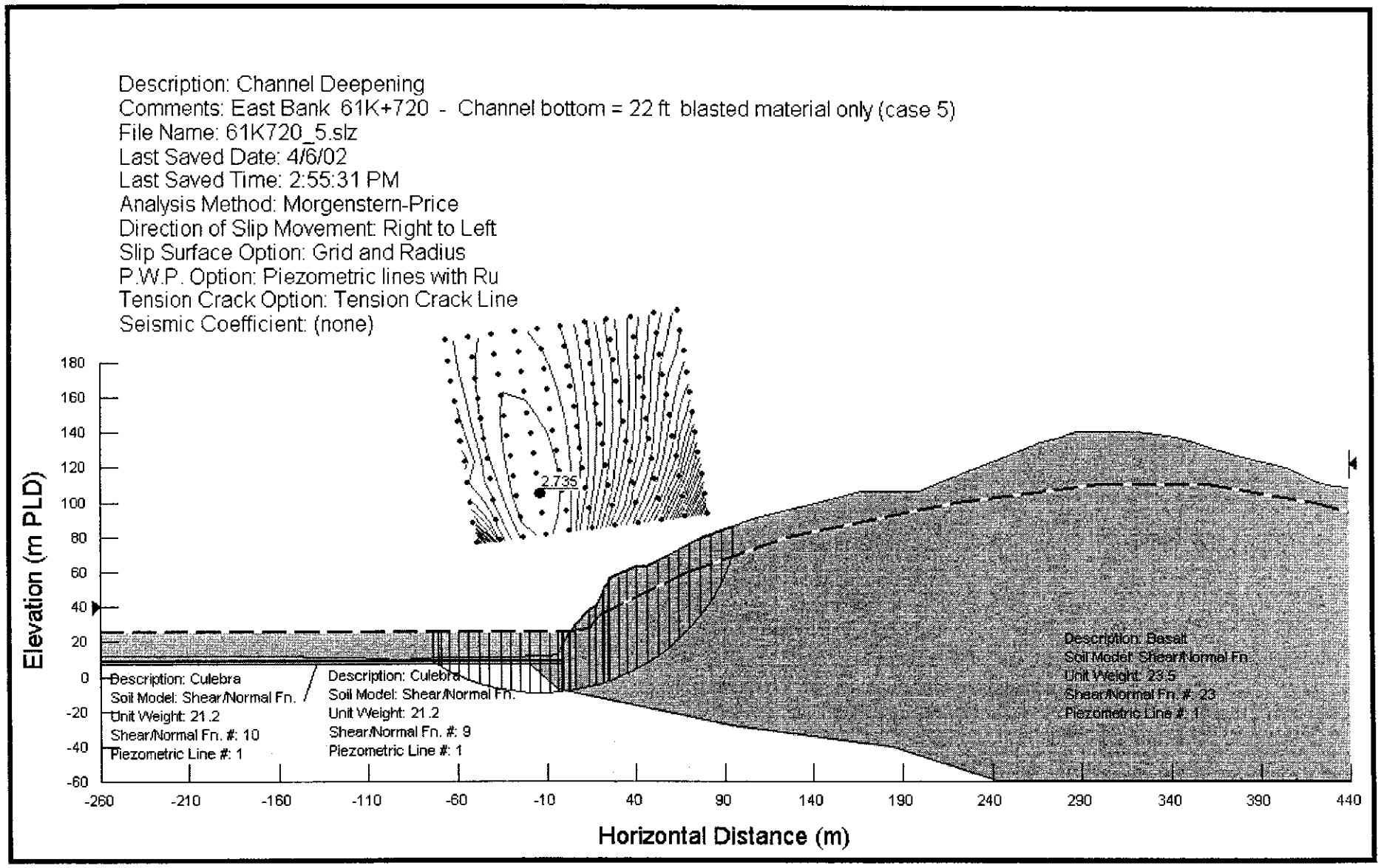
Case 3, Channel bottom = 27 ft, Blasted & removed



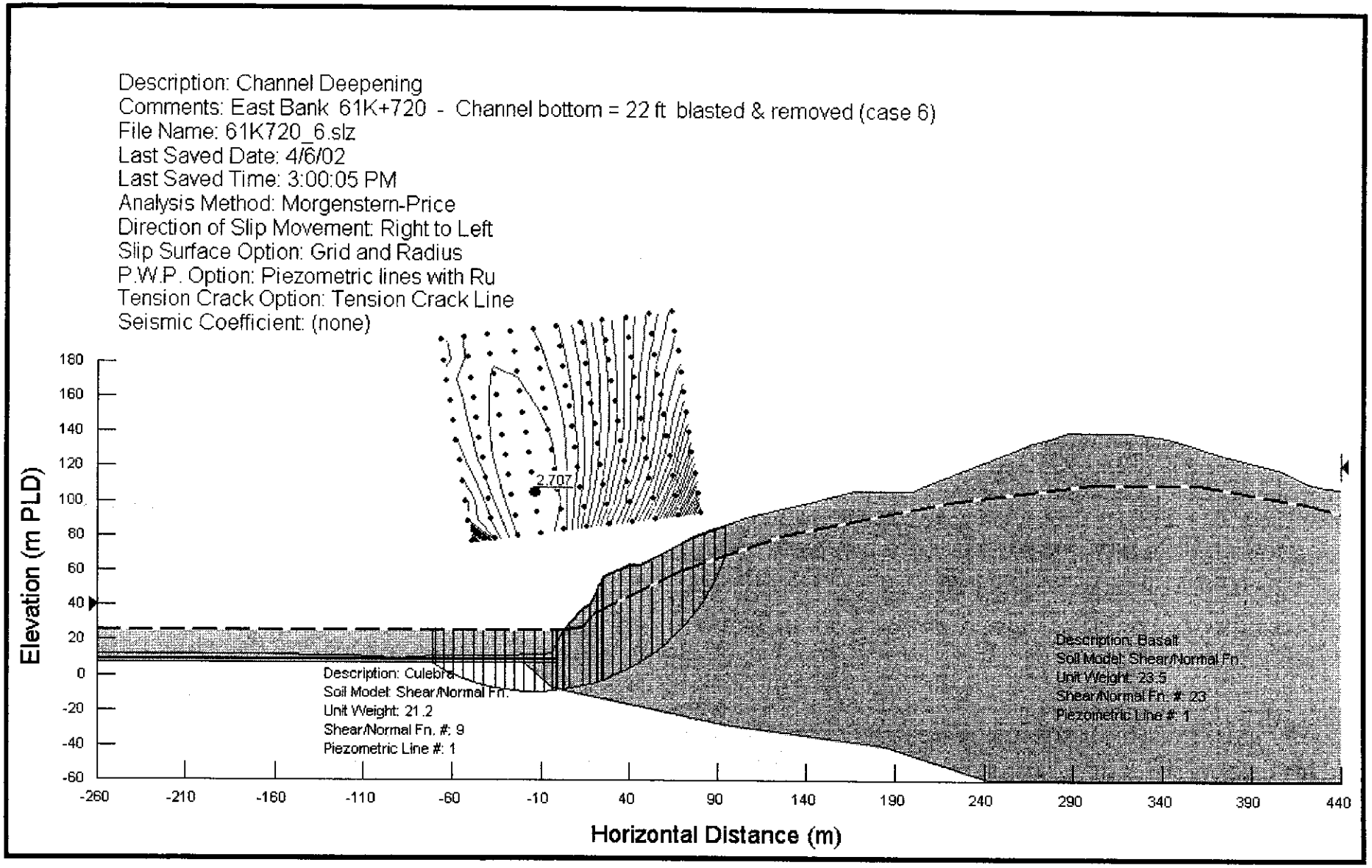
Case 4, Channel bottom = 27 ft, Design (underwater slope)



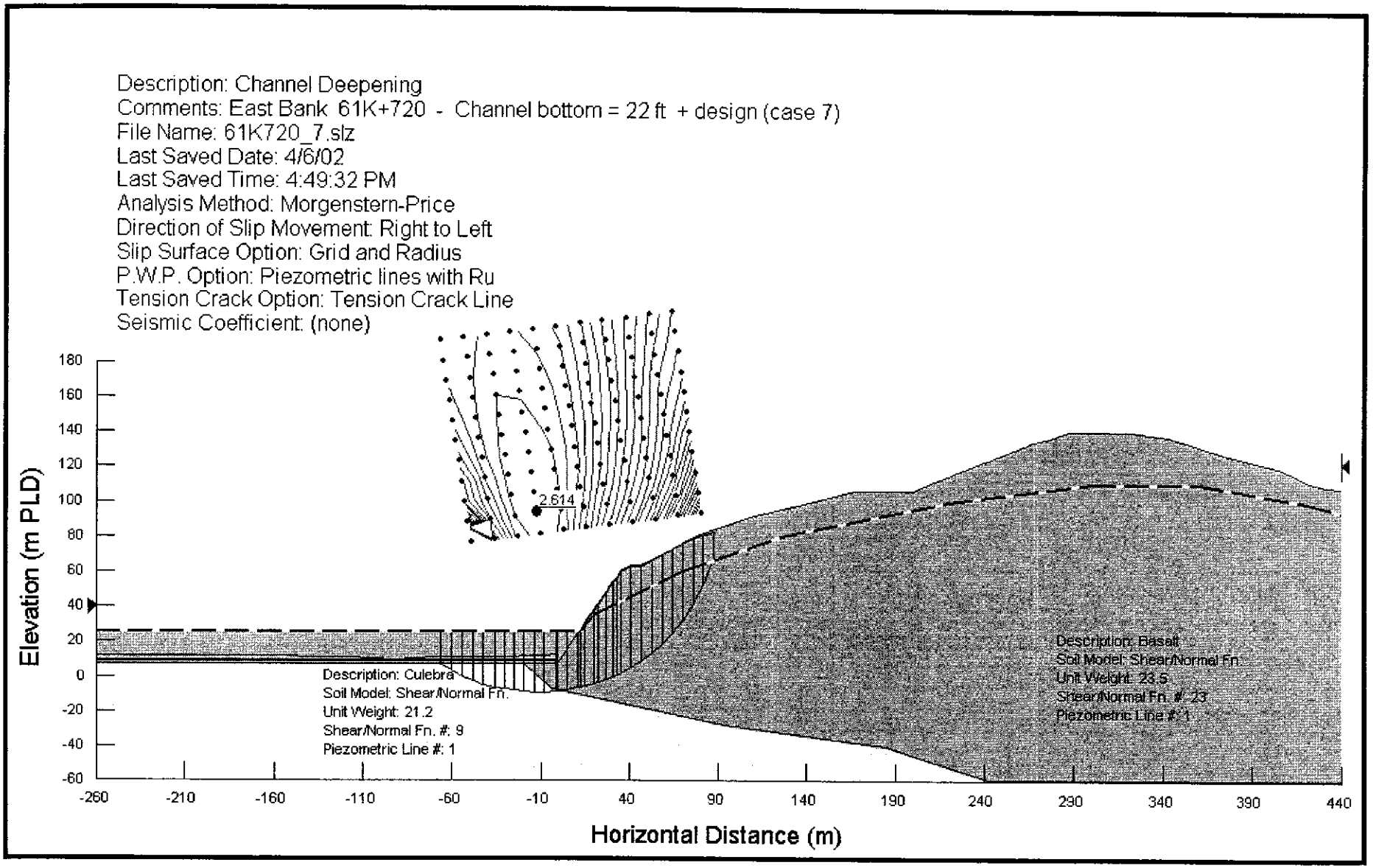
Case 5, Channel bottom = 22 ft, Blasted material only



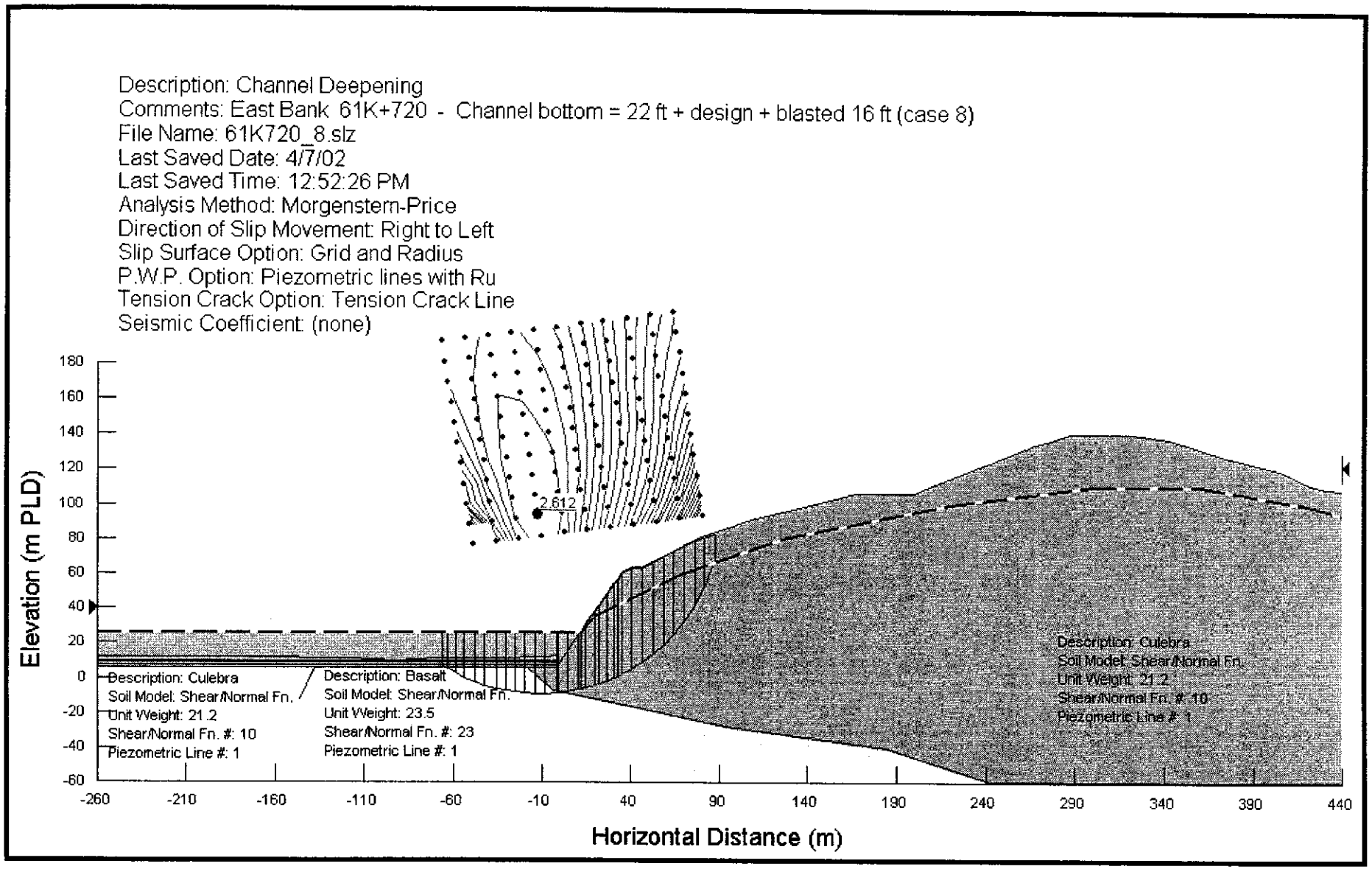
Case 6, Channel bottom = 22 ft, Blasted & removed



Case 7, Channel bottom = 27 ft, Design (underwater slope)

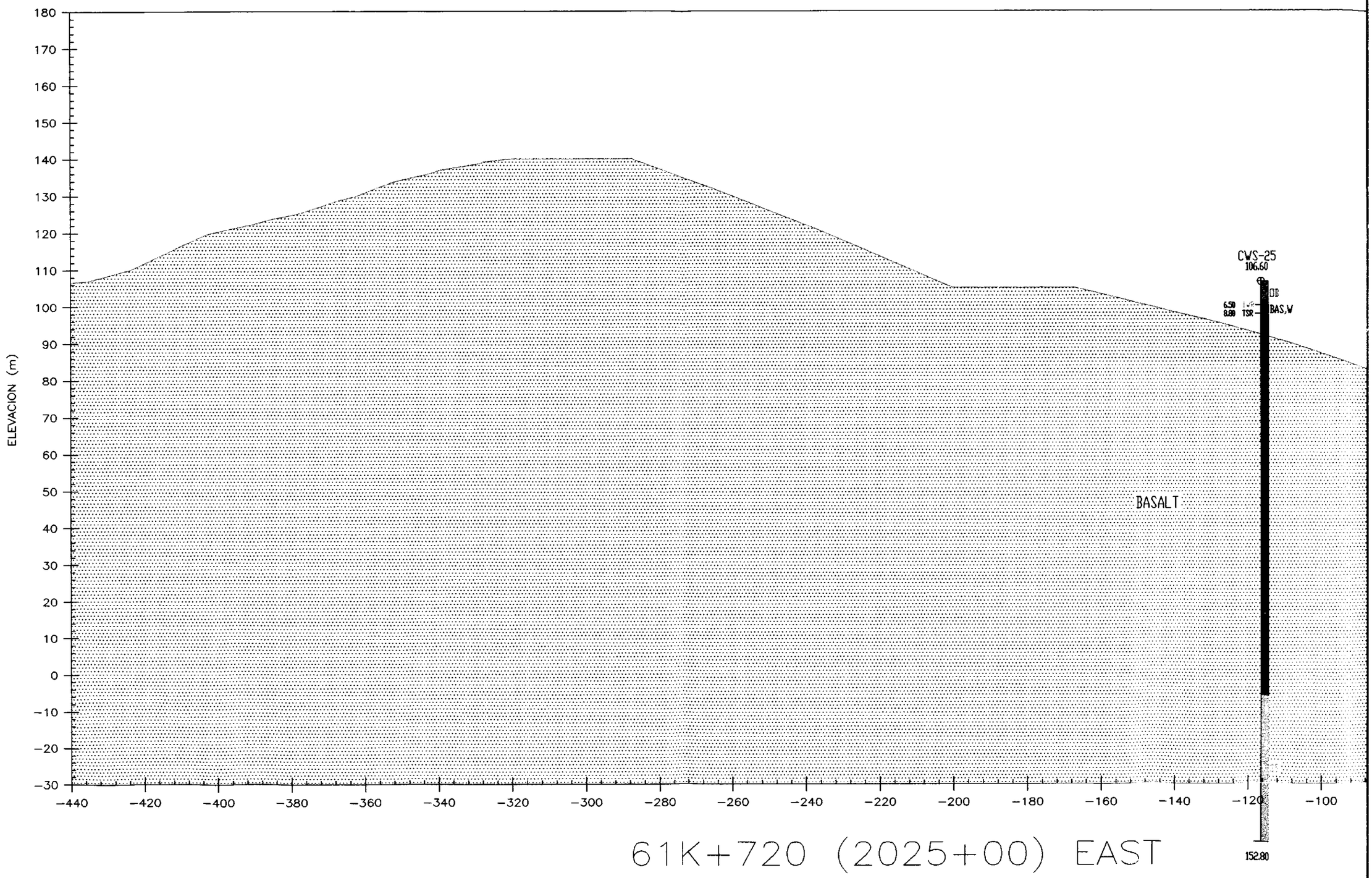


Case 8, Channel bottom = 16 ft, Blasted



Summary, 61k + 720 (2025 + 00)

General Description	Range of stations:	61k + 420 to 61k + 825			
	Sector:	Nitro			
	Maximum height (m):	130			
	Cotangent of slope angle (cot. β):	2.25			
History	Last slide event:	No known event (Paraiso Slide to the south)			
Geology	Formation:	Basalt / Culebra			
	Lithology:	Basalt / Sandstone / Siltstone			
	Critical stratum at toe:	Basalt			
	Apparent dip of bedding:	Not defined			
Stability Analysis	Critical failure mechanism:	Rotational and tension crack			
	Shear strength model:	First time Basalt / Fully softened Culebra			
		Operative average pore pressure ratio (aproximate), Ru:	Factor of Safety	Relative Factor of Safety	Percentage of Change (%)
	Case 1: Channel bottom = 32 ft	0.355	2.766	1.000	0.00
	Case 2: Channel bottom = 27 ft, Blasted material only		2.765	1.000	-0.04
	Case 3: Channel bottom = 27 ft, Blasted & removed		2.735	0.989	-1.12
	Case 4.1: Channel bottom = 27 ft, Design (underwater slope)		2.658	0.961	-3.90
	Case 4.2: Channel bottom = 27 ft, Design (& dry excavation)	0.364	2.658	0.961	-3.90
	Case 5: Channel bottom = 22 ft, Blasted material only		2.735	0.989	-1.12
	Case 6: Channel bottom = 22 ft, Blasted & removed		2.707	0.979	-2.13
	Case 7.1: Channel bottom = 22 ft, Design (underwater slope)		2.614	0.945	-5.50
	Case 7.2: Channel bottom = 22 ft, Design (& dry excavation)	0.354	2.614	0.945	-5.50
	Case 8: Channel bottom = 16 ft, Blasted		2.612	0.944	-5.57
Conclusions:	No stabilization is required				


ELEVACION (m)
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CWS-25
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OB
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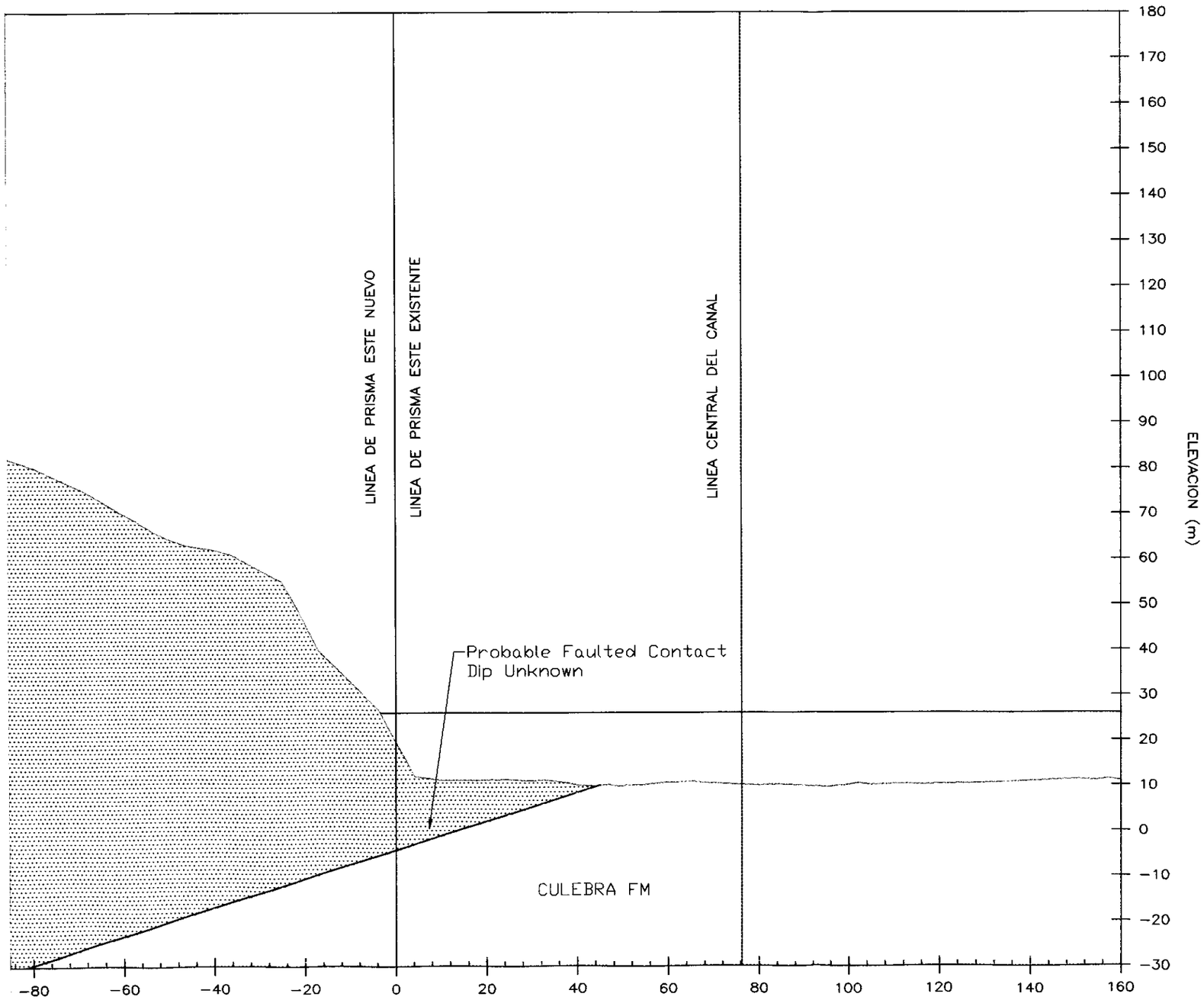
8.80 TSR
BAS,W
BASALT
152.80
61K+720 (2025+00) EAST



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ESTACION 61K+720 (2025+00) ESTE

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GEOLOGIA POR: J. ARROCHA	DIBUJADO POR: J. ARROCHA & J. RAMESCH