September 1996

APPENDIX 3.4F

DIVERSION CULVERT CALCULATIONS

REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
16 Sep 1996
STATE OF UTAH

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Prep Plant Area – Culvert Capacity

Culvert ID	Size	Inlet Type	Available Headwater over Culvert Top	Inlet Control Capacity (a) (cfs)	Contributing Watersheds	Peak Flow (cfs) (b)	
CGC-1	18" cmp	Projecting	>1'	5.7	U1	0.95	OK
CGC-2	2-84" CMP	Mitered	>1'	2×295= 590	Pond 011, U2, U3a, U3b, U4	56.5	OK
CGC-3	24" CMP	48" drop inlet (Headwall)	2'	12.5	U4	0.96	OK
CGC-4	SEE APPENDIX 3.4						
CGC-5	60" CMP	48" × 64" Drop Inlet	8'	128	U5, Pond 013	33.58	OK
CGC-6	12" CMP	Projecting	>1'	2.1	D7	0.60	OK
CGC-7	18" CMP	Connects Pond 012A to Pond 012B (See Pond Calcs)					
CGC-8	60"×120" Box	Headwall	7'	280 (c)	U6, U7, U8	9.88	OK
CGC-9	24" CMP	Projecting	>1'	11.5	D3A + D3B	7.98	OK
CGC-10	24" CMP	Projecting	>1'	11.5	D4A + D4B	7.59	OK
CGC-11	24" CMP	Projecting	>1'	11.5	D4A + D4B	7.59	OK

Notes: (a) See nomograph #1 on next page. Capacity based on $h_w/D = 1.0$.
(b) See runoff + Sed. pond Calc's. Multiple watersheds added numerically. (ie, assumes all peak flows are temporarily concurrent)
(c) See nomograph #2 – attached.

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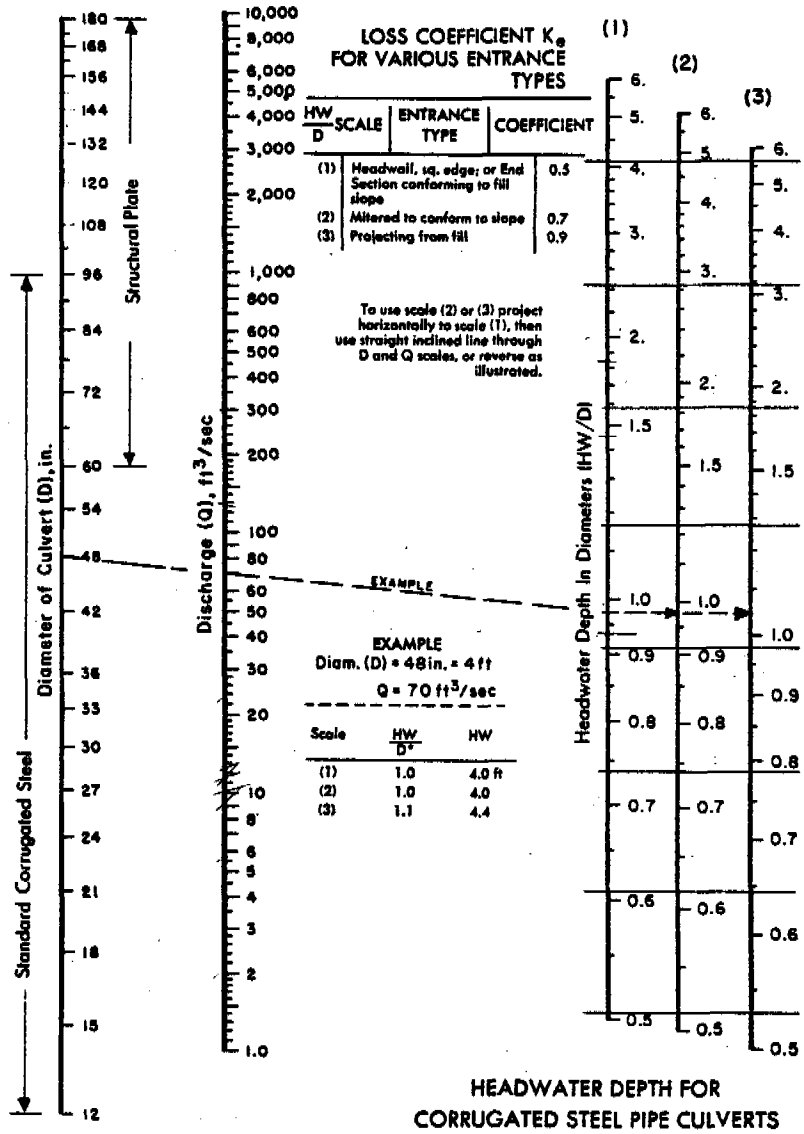

HEADWATER DEPTH FOR CORRUGATED STEEL PIPE CULVERTS WITH INLET CONTROL

FHWA HEC 5

Figure 4-28 *Inlet control* nomograph for corrugated steel *pipe* culverts. The manufacturers recommended keeping *HW/D* to a maximum of 1.5 and preferably to no more than 1.0.

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Nomograph #1 for corrugated steel pipe culverts.

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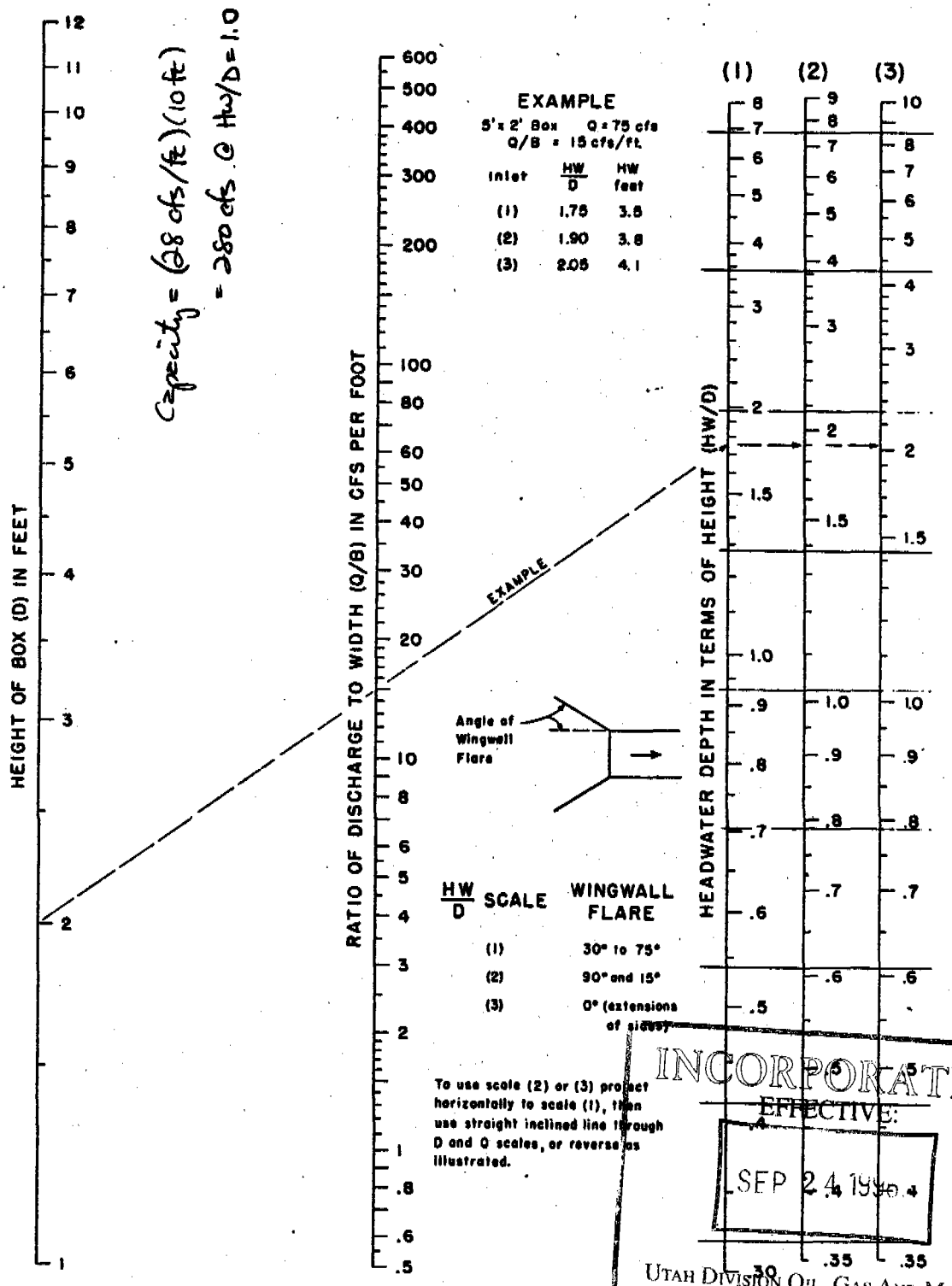
CHART I



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HEADWATER DEPTH FOR BOX CULVERTS WITH INLET CONTROL

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Nomograph #2 for Box Culverts.

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Prep Plant Area Culverts Min - Riprap Requirements

Culvert ID	Size	Slope (a) (%)	Peak (b) flow (cfs)	Velocity (c) (ft/s)	Minimum (d) Riprap D_{50} (in)
CGC-1	18" CMP	1	0.95	2.4	none
-2	2-84" CMP	5	56.5	9.5	7
-3	24" CMP	4	0.96	3.8	1
-4	SEE APPENDIX 3.4J				
-5	60" CMP	10	33.58	13.4	15
-6	12" CMP	4	0.60	3.6	1
-7	18" CMP	Connects Pond 012A to Pond 012B. See Pond Calcs			
-8	60"x120" Box	1	9.88	2.9	none
-9	24" CMP	1	7.98	4.2	NONE
-10	24" CMP	1	7.59	4.1	NONE
-11	24" CMP	1	7.59	4.1	NONE

Notes:
(a) Field measurement
(b) See runoff and sed. pond calcs.
(c) See attached calcs. Assume n = .024 for CMP + Concrete, and .010 for HDPE.
(d) See nomograph in this calc. Assume $K/d > 1 \therefore V_s = V$.

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Table 3.4 Permissible Velocities for Vegetated Channels.*

Cover	Permissible Velocity, fps: Erosion Resistant Soils (% Slope) 0-5	5-10	Over 10	Easily Eroded Soils (% Slope) 0-5	5-10	Over 10
Bermuda grass	8	7	6	6	5	4
Buffalo grass Kentucky bluegrass Smooth brome Blue grama Tall fescue	7	6	5	5	4	3
Lespedeza sericea Weeping lovegrass Kudzu Alfalfa Crabgrass	3.5	NR†	NR	2.5	NR	NR
Grass mixture	5	4	NR	4	3	NR
Annuals for temporary protection	3.5	NR	NR	2.5	NR	NR

* After Ree (1949).
† Not recommended.

Figure 3

Ref: Barfield, et. al. (1981)

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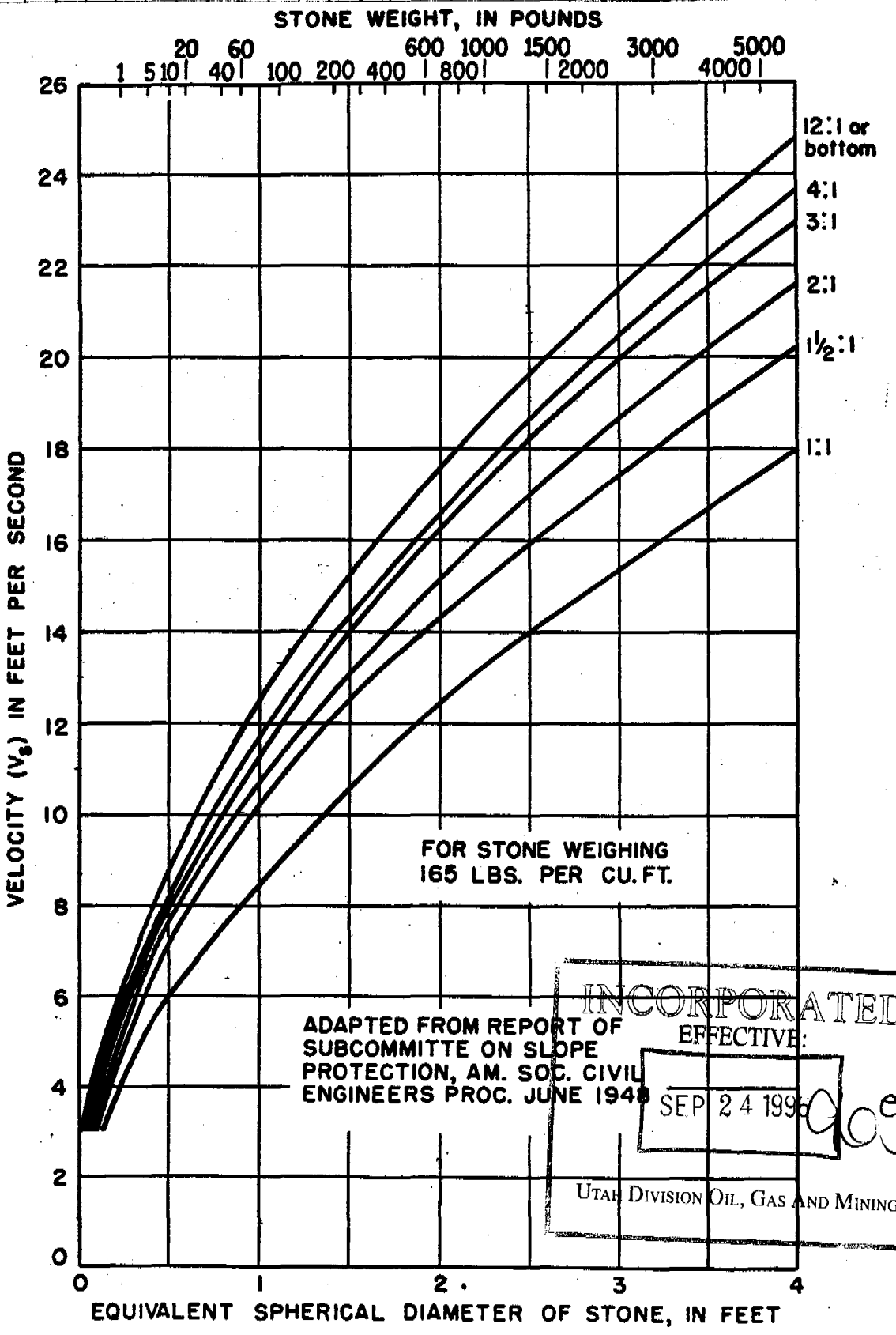

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FIG. 2-SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Prep Plant Culverts

Comment: CGC-1

Solve For Actual Depth

Given Input Data:

Diameter.....	1.50 ft
Slope.....	0.0100 ft/ft
Manning's n.....	0.024
Discharge.....	0.95 cfs

Computed Results:

Depth.....	0.41 ft
Velocity.....	2.39 fps
Flow Area.....	0.40 sf
Critical Depth....	0.36 ft
Critical Slope....	0.0168 ft/ft
Percent Full.....	27.64 %
Full Capacity.....	5.69 cfs
QMAX @.94D.....	6.12 cfs
Froude Number.....	0.77 (flow is Subcritical)

V = 2.39 ft/s No Riprap Required.

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Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

8

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Prep Plant Culverts

Comment: CGC-2

Solve For Actual Depth

Given Input Data:

Diameter.....	7.00 ft
Slope.....	0.0500 ft/ft
Manning's n.....	0.024
Discharge.....	28.25 cfs

Since there are two 84" culverts, velocity was determined for one culvert at 1/2 the peak discharge.

Computed Results:

Depth.....	0.91 ft
Velocity.....	9.54 fps
Flow Area.....	2.96 sf
Critical Depth....	1.34 ft
Critical Slope....	0.0103 ft/ft
Percent Full.....	13.06 %
Full Capacity.....	773.76 cfs
QMAX @.94D.....	832.33 cfs
Froude Number.....	2.12 (flow is Supercritical)

assume 12:1 bottom slope.

$D_{50} = 0.6$ ft = 7 inches

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Prep Plant Culverts

Comment: CGC-3

Solve For Actual Depth

Given Input Data:

Diameter.....	2.00 ft
Slope.....	0.0400 ft/ft
Manning's n.....	0.024
Discharge.....	0.96 cfs

Computed Results:

Depth.....	0.27 ft
Velocity.....	3.78 fps
Flow Area.....	0.25 sf
Critical Depth....	0.34 ft
Critical Slope....	0.0160 ft/ft
Percent Full.....	13.51 %
Full Capacity.....	24.51 cfs
QMAX @.94D.....	26.36 cfs
Froude Number.....	1.55 (flow is Supercritical)

assume 12:1 bottom Slope.

$D_{50} = 0.1$ ft = 1 inch

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Prep Plant Culverts

Comment: CGC-5

Solve For Actual Depth

Given Input Data:

Diameter.....	5.00 ft
Slope.....	0.1000 ft/ft
Manning's n.....	0.024
Discharge.....	33.58 cfs

Computed Results:

Depth.....	0.93 ft
Velocity.....	13.37 fps
Flow Area.....	2.51 sf
Critical Depth....	1.61 ft
Critical Slope....	0.0112 ft/ft
Percent Full.....	18.56 %
Full Capacity.....	446.11 cfs
QMAX @.94D.....	479.89 cfs
Froude Number.....	2.93 (flow is Supercritical)

assume 4:1 slope for riprap sizing.

$D_{50} = 1.25' =$ 15 inches

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Prep Plant Culverts

Comment: CGC-6

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.0400 ft/ft
Manning's n.....	0.024
Discharge.....	0.60 cfs

Computed Results:

Depth.....	0.27 ft
Velocity.....	3.57 fps
Flow Area.....	0.17 sf
Critical Depth....	0.32 ft
Critical Slope....	0.0191 ft/ft
Percent Full.....	26.65 %
Full Capacity.....	3.86 cfs
QMAX @.94D.....	4.15 cfs
Froude Number.....	1.44 (flow is Supercritical)

Assume 12:1 bottom slope for calcs.

$D_{50} = 0.1' = \underline{\underline{1 \text{ inch}}}$

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Rectangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Prep Plant Culverts

Comment: CGC-8

Solve For Depth

Given Input Data:

Bottom Width.....	10.00 ft
Manning's n.....	0.024
Channel Slope....	0.0100 ft/ft
Discharge.....	9.88 cfs

Computed Results:

Depth.....	0.34 ft
Velocity.....	2.89 fps
Flow Area.....	3.41 sf
Flow Top Width...	10.00 ft
Wetted Perimeter.	10.68 ft
Critical Depth...	0.31 ft
Critical Slope...	0.0134 ft/ft
Froude Number....	0.87 (flow is Subcritical)

With the velocity low (< 3 fps) no riprap is required.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CGC-9

Comment: Culvert CGC-9

Solve For Actual Depth

Given Input Data:

Diameter.....	2.00 ft
Slope.....	0.0100 ft/ft
Manning's n.....	0.024
Discharge.....	7.98 cfs

Computed Results:

Depth.....	1.18 ft
Velocity.....	4.15 fps
Flow Area.....	1.92 sf
Critical Depth....	1.01 ft
Critical Slope....	0.0166 ft/ft
Percent Full.....	58.80 %
Full Capacity.....	12.25 cfs
QMAX @.94D.....	13.18 cfs
Froude Number.....	0.74 (flow is Subcritical)

AS THIS CULVERT IS TEMPORARY AND VELOCITY IS LOW, NO RIPRAP IS REQUIRED.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CGC-10

Comment: Culvert CGC-10

Solve For Actual Depth

Given Input Data:

Diameter.....	2.00 ft
Slope.....	0.0100 ft/ft
Manning's n.....	0.024
Discharge.....	7.59 cfs

Computed Results:

Depth.....	1.14 ft
Velocity.....	4.11 fps
Flow Area.....	1.85 sf
Critical Depth....	0.98 ft
Critical Slope....	0.0165 ft/ft
Percent Full.....	56.95 %
Full Capacity.....	12.25 cfs
QMAX @.94D.....	13.18 cfs
Froude Number.....	0.75 (flow is Subcritical)

AS THIS CULVERT IS TEMPORARY AND VELOCITY IS LOW, NO RIPRAP IS REQUIRED.

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Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CGC-11

Comment: Culvert CGC-11

Solve For Actual Depth

Given Input Data:

Diameter.....	2.00 ft
Slope.....	0.0100 ft/ft
Manning's n.....	0.024
Discharge.....	7.59 cfs

Computed Results:

Depth.....	1.14 ft
Velocity.....	4.11 fps
Flow Area.....	1.85 sf
Critical Depth....	0.98 ft
Critical Slope....	0.0165 ft/ft
Percent Full.....	56.95 %
Full Capacity.....	12.25 cfs
QMAX @.94D.....	13.18 cfs
Froude Number.....	0.75 (flow is Subcritical)

AS THIS CULVERT IS TEMPORARY AND VELOCITY IS LOW, NO RIPRAP IS REQUIRED.

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APPENDIX 3.4G

AS-BUILT CALCULATIONS FOR POND 011

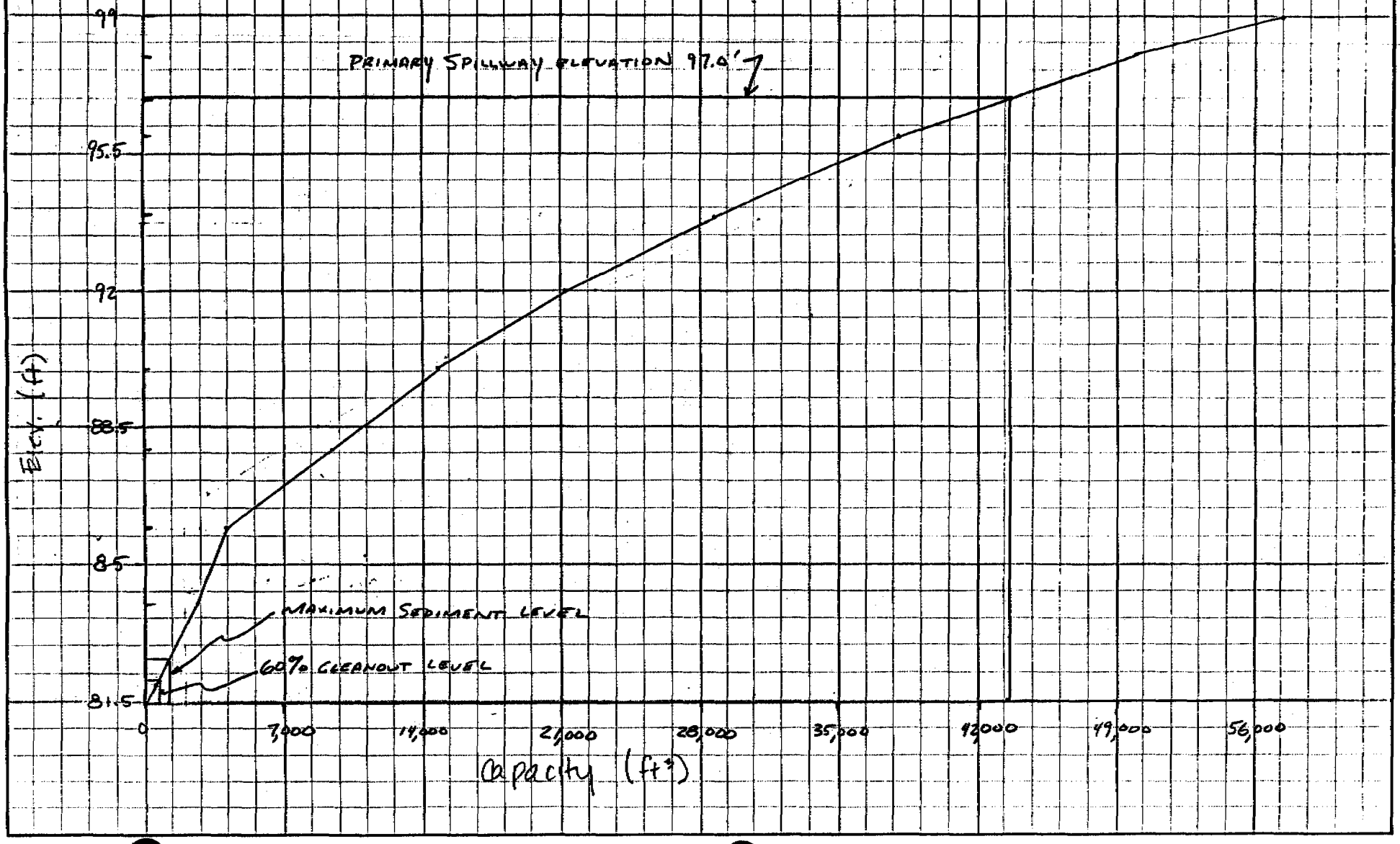
REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH
2/2/94

SEDIMENT POND 011

ELEV. (ft.)	AREA (ft^2)	ΔVOLUME (ft^3)	CUM. VOLUME (ft^3)
81.5	708		0
		413	
82.0	944		413
		2,244	
84.0	1,300		2,657
		2,900	
86.0	1,600		5,557
		3,904	
88.0	2,304		9,461
		5,228	
90.0	2,924		14,689
		6,504	
92.0	3,580		21,193
		7,552	
94.0	3,972		28,745
		9,216	
96.0	5,244		37,961
		5,602	
PRIMARY SPILLWAY → 97.0	5,960		43,563
		6,450	
98.0	6,940		50,013
		7,454	
TOP OF EMBANKMENT → 99.0	7,968		57,467

Pond 011

Stage-Capacity Curve



Soil erosion to Pond 011

Use Modified Universal Soil Loss Equation:

$A = R \cdot K \cdot LS \cdot VM$ (Israelson, et al., 1984)

A = soil loss per unit area
R = rainfall factor
K = Soil erodibility Factor
LS = topographic factor
VM = erosion control factor

R = 11 (Mean Annual R value from Figure 1, Israelson, et al., 1984)

K = 0.15 (Israelson, et al., 1984)

Sub Area CGWS-D1(a)

$$LS = \left(\frac{650 + 450s + 65s^2}{10{,}000 + s^2}\right)\left(\frac{l}{72.6}\right)^m$$ (Clyde, et al., 1978)

s = Slope $= \frac{40}{450} = 8.9\%$

l = Slope length = 450'

$m = .5$ (for slopes : $5\% < s < 10\%$)

$$LS = \left(\frac{650 + 450(8.9) + 65(8.9)^2}{10{,}000 + (8.9)^2}\right)\left(\frac{450}{72.6}\right)^{0.5} = 2.42$$

VM = 1.20 (Table 3, Israelson et al, 1984)
Representative of bare soil - compacted.

$A = (11)(.15)(2.42)(1.20) = 4.79$ tons/Ac/year

Area = 5.24 Acres

Unit Wt of Soil ~ 90 lb/ft³

A = 577.8 ft³/year

SubArea CGWS-D1(b)

R = 11
K = .15

LS: Slope = $\frac{6228 - 6150}{1100'}$ = 7.1%

l = 1100'

m = .5 (Clyde, et al., 1978)

$$LS = \left(\frac{650 + 450(7.1) + 65(7.1)^2}{10{,}000 + (7.1)^2}\right)\left(\frac{1100}{72.6}\right)^{0.5} = 2.76$$

VM = 1.20

$A = (11)(.15)(2.76)(1.20) = 5.46$ tons/Ac/year

Area = 7.36 Acres

Unit Wt of Soil ~ 90 lb/ft³

A = 893.0 ft³/year

TOTAL SEDIMENT TO POND 011 =

CGWS-D1(a) = 577.8 FT³/YR
CGWS-D1(b) = 893.0 FT³/YR
1,470.8 FT³/YR

Runoff Volume - Pond 011

10-year, 24-hour storm = 1.8 in

CN = 90 for disturbed Area

$$Q = \frac{(P - 0.2S)^2}{P + 0.8S} \qquad P > 0.2S$$ (Barfield et al, 1983)

$$S = \frac{1000}{CN} - 10 = 1.11$$

P = 1.8 in

$$Q = \frac{(1.8 - .2(1.11))^2}{1.8 + .8(1.11)} = 0.93 \text{ in} = .077 \text{ ft}$$

Disturbed area = 12.6 Acres

Runoff volume = (.077 ft)(12.6 Ac)(43,560 ft²/Ac)

= 42,370 ft³

POND CAPACITY @ PRIMARY SPILLWAY = 43,563 FT³
10 YEAR - 24 HR STORM RUNOFF = 42,370 FT³

1,193 FT³ = ROOM FOR SEDIMENT

TOTAL SEDIMENT YIELD = 1,471 FT³/YR
ROOM FOR SEDIMENT = 1,193 FT³ = 0.81 YEAR OF STORAGE

ELEVATION = 82.6 FT

60% CLEANOUT VOLUME = 716 FT³

ELEVATION = 82 FT

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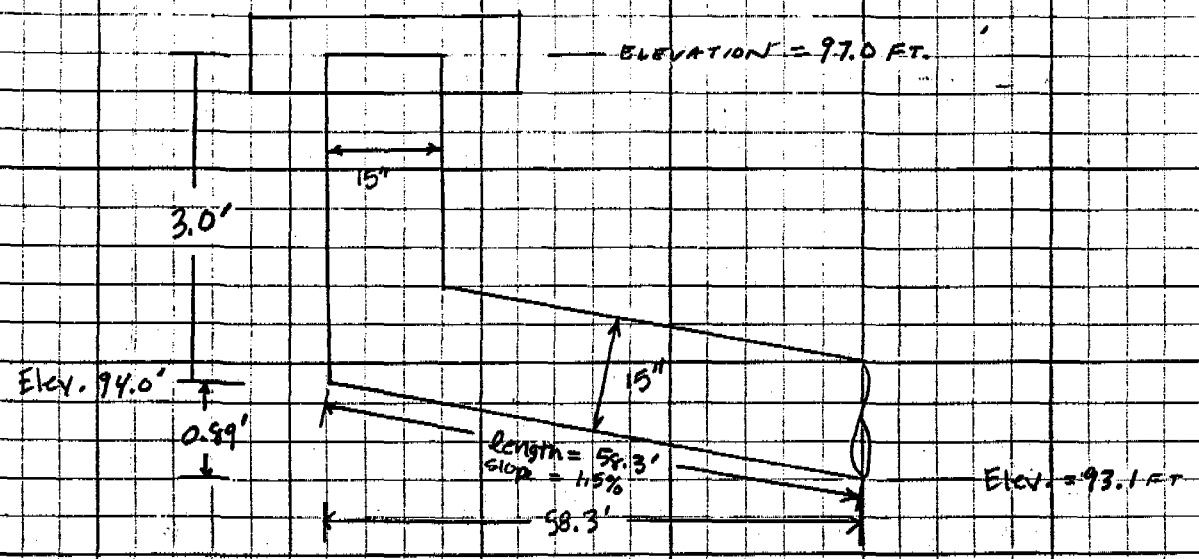
Pond 011

Spillway Data:



SEDCAD VERSION 3 DATA INPUT

DISTURBED WATERSHEDS: CGWS-D1(a) + D1(b)
25 YEAR - 6HR STORM = 1.6"

INPUT

TIME INCREMENT	= 0.1 HRS
STORM TYPE	= SCS 6 HR
DESIGN STORM	= 25 YR - 6HR
RAINFALL DEPTH	= 1.6 IN

No. OF JUNCTIONS	= 1
No. OF BRANCHES	= 1
No. OF STRUCTURES	= 1
No. OF SUBWATERSHEDS	= 2

SUBWATERSHEDS LOCATED @ STRUCTURE = 1 (CGWS-D1(a)) AND 2 (CGWS-D1(b))

CONTROL STRUCTURE TYPE = DETENTION BASIN
LABEL = POND 011

SUBWATERSHED (SWS)	AREA (AC)	Tc (HRS)	CN	H'GRAPH RESPONSE
1 (CGWS-D1(a))	5.24	0.066	90	F (FAST)
2 (CGWS-D1(b))	7.36	0.151	90	F

DEAD SLOPE - ASSUME 20%

CALCULATE Tc:

#1 (CGWS-D1(a))

SLOPE = 8.9% = Y
ℓ = 450'
$S = \frac{1000}{CN} - 10 = 1.11$

$$L = \frac{\ell^{0.8}(S+1)^{0.7}}{1900\, Y^{.5}}$$

$$= \frac{(450)^{.8}(2.11)^{.7}}{1900\sqrt{8.9}}$$

= 0.39 HR

$T_c = 1.67\,L = \underline{0.66}$ HR

#2 (CGWS-D1(b))

SLOPE = 7.1% = Y
ℓ = 1100
$S = \frac{1000}{CN} - 10 = 1.11$

$$L = \frac{(1100)^{.8}(2.11)^{.7}}{1900\,(7.1)^{.5}}$$

= 0.090 HR

$T_c = 1.67\,L = \underline{0.151}$ HR

8

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

POND 011 - CASTLE GATE MINE

by

Name: ANTHONY MAGLIOCCHINO

Company Name: EarthFax Engineering INC.
File Name: D:\UC150\011TRIAL

Date: 06-15-1992

Civil Software Design -- SEDCAD+ Version 3.1
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Company Name: EarthFax Engineering INC.
Filename: D:\UC150\011TRIAL User: ANTHONY MAGLIOCCHINO
Date: 06-15-1992 Time: 10:36:03
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	5.24	90	F	0.066	0.000	0.000	0.0	0.33	3.85
111	2	7.36	90	F	0.151	0.000	0.000	0.0	0.47	4.89
		Type: Pond Label: POND 011								
111	Structure	12.60							0.80	
111	Total IN	12.60							0.80	8.37
111	Total OUT								0.80	5.25

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Company Name: EarthFax Engineering INC.
Filename: D:\UC150\011TRIAL User: ANTHONY MAGLIOCCHINO
Date: 06-15-1992 Time: 10:36:03
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

POND INPUT/OUTPUT TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 12.6 acres
Total Contributing Drainage Area: 12.6 acres

DISCHARGE OPTIONS:

	Drop Inlet	Emergency Spillway
Riser Diameter (in)	15.0	----
Riser Height (ft)	3.00	----
Barrel Diameter (in)	15.0	----
Barrel Length (ft)	58.30	----
Barrel Slope (%)	1.50	----
Manning's n of Pipe	0.024	----
Spillway Elevation	97.0	----
Lowest Elevation of Holes	----	----
# of Holes/Elevation	----	----
Entrance Loss Coefficient	----	----
Tailwater Depth (ft)	----	----
Notch Angle (degrees)	----	----
Weir Width (ft)	----	----
Siphon Crest Elevation	----	----
Siphon Tube Diameter (in)	----	----
Siphon Tube Length (ft)	----	----
Manning's n of Siphon	----	----
Siphon Inlet Elevation	----	----
Siphon Outlet Elevation	----	----
Emergency Spillway Elevation	----	98.0
Crest Length (ft)	----	10.0
Z:1 (Left and Right)	-- --	2 2
Bottom Width (ft)	----	6.0

POND RESULTS:

Permanent Pool (ac-ft)
1.0

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	0.80	8.37
OUT	0.80	5.25

Peak Elevation	Hydrograph Detention Time (hrs)
97.8	0.00

****

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Company Name: EarthFax Engineering INC.
Filename: D:\UC150\011TRIAL User: ANTHONY MAGLIOCCHINO
Date: 06-15-1992 Time: 10:36:03
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-DISCHARGE TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 12.6 acres
Total Contributing Drainage Area: 12.6 acres

Elevation	Drop Inlet (cfs)	Emergency Spillway (cfs)	Total Discharge (cfs)
81.50	0.0	0.0	0.0
82.00	0.0	0.0	0.0
82.50	0.0	0.0	0.0
83.00	0.0	0.0	0.0
83.50	0.0	0.0	0.0
84.00	0.0	0.0	0.0
84.50	0.0	0.0	0.0
85.00	0.0	0.0	0.0
85.50	0.0	0.0	0.0
86.00	0.0	0.0	0.0
86.50	0.0	0.0	0.0
87.00	0.0	0.0	0.0
87.50	0.0	0.0	0.0
88.00	0.0	0.0	0.0
88.50	0.0	0.0	0.0
89.00	0.0	0.0	0.0
89.50	0.0	0.0	0.0
90.00	0.0	0.0	0.0
90.50	0.0	0.0	0.0
91.00	0.0	0.0	0.0
91.50	0.0	0.0	0.0
92.00	0.0	0.0	0.0
92.50	0.0	0.0	0.0
93.00	0.0	0.0	0.0
93.50	0.0	0.0	0.0
94.00	0.0	0.0	0.0
94.50	0.0	0.0	0.0
95.00	0.0	0.0	0.0
95.50	0.0	0.0	0.0
96.00	0.0	0.0	0.0
96.50	0.0	0.0	0.0
97.00	0.0	0.0	0.0
97.50	4.2	0.0	4.2
98.00	5.9	0.0	5.9
98.50	7.2	5.9	13.1

98.60	7.5	7.1	14.5
98.70	7.7	9.5	17.2
98.80	7.9	12.3	20.2
98.90	8.1	15.4	23.5
99.00	8.4	18.4	26.7

****

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Company Name: EarthFax Engineering INC.
Filename: D:\UC150\011TRIAL User: ANTHONY MAGLIOCCHINO
Date: 06-15-1992 Time: 10:36:03
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 12.6 acres
Total Contributing Drainage Area: 12.6 acres

SW#1: Drop Inlet
SW#2: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
81.50	0.00	0.02	0.00	0.00	
82.00	0.50	0.02	0.01	0.00	
82.50	1.00	0.02	0.02	0.00	
83.00	1.50	0.03	0.03	0.00	
83.50	2.00	0.03	0.05	0.00	
84.00	2.50	0.03	0.06	0.00	
84.50	3.00	0.03	0.08	0.00	
85.00	3.50	0.03	0.09	0.00	
85.50	4.00	0.04	0.11	0.00	
86.00	4.50	0.04	0.13	0.00	
86.50	5.00	0.04	0.15	0.00	
87.00	5.50	0.04	0.17	0.00	
87.50	6.00	0.05	0.19	0.00	
88.00	6.50	0.05	0.22	0.00	
88.50	7.00	0.06	0.24	0.00	
89.00	7.50	0.06	0.27	0.00	
89.50	8.00	0.06	0.30	0.00	
90.00	8.50	0.07	0.34	0.00	
90.50	9.00	0.07	0.37	0.00	
91.00	9.50	0.07	0.41	0.00	
91.50	10.00	0.08	0.45	0.00	
92.00	10.50	0.08	0.49	0.00	
92.50	11.00	0.08	0.53	0.00	
93.00	11.50	0.09	0.57	0.00	
93.50	12.00	0.09	0.61	0.00	
94.00	12.50	0.09	0.66	0.00	
94.50	13.00	0.10	0.71	0.00	
95.00	13.50	0.10	0.76	0.00	
95.50	14.00	0.11	0.81	0.00	
96.00	14.50	0.12	0.87	0.00	
96.50	15.00	0.13	0.93	0.00	
97.00	15.50	0.14	1.00	0.00	Stage of SW#1
97.50	16.00	0.15	1.07	4.18	
97.81	16.31	0.15	1.12	5.25	Peak Stage

98.00	16.50	0.16	1.15	5.91	Stage of SW#2
98.50	17.00	0.17	1.23	13.12	
98.60	17.10	0.17	1.25	14.52	
98.70	17.20	0.18	1.26	17.21	
[illegible].80	17.30	0.18	1.28	20.19	
98.90	17.40	0.18	1.30	23.48	
99.00	17.50	0.18	1.32	26.72	

****

CASTLE GATE PREP PLANT
OPERATION HYDROLOGY
PONDS - APP 3.4G

POND 011 - NORTH INLET RIPRAP / DEPTH

GEOMETRY: TRAPAZOIDAL
BW = 2.5 FT
DEPTH = 2.0 FT
MAX SLOPE = 44% ($\Delta V / \Delta H = 8/18'$)
MIN SLOPE = 7% ($\Delta V / \Delta H = 2/27$)
Q = 3.85 CFS (SEE SEDCAD RESULTS FOR 25-YR 6-HR EVENT, SWS = 1)
SS = 2:1

ASSUME D50 = K = 6" = 0.5'

$n = 0.0395\ D50^{1/6}$
$= 0.0395\ (0.5)^{1/6}$
$= 0.035$

USE FLOWMASTER (MAX SLOPE)

$V_{MAX} = 7.91$ FPS
DEPTH = 0.17 FT

USE USDOT FIGURES TO SIZE RIPRAP

$K/d = \frac{0.33}{0.17} > 1$ SO $\frac{V_s}{V} = 1$ (FIG 1)

$V_s = V = 7.91$ FPS

FROM FIG 2, WITH SS = 2:1

D50 = 6"

CHECK DEPTH:

USE FLOWMASTER (MIN SLOPE)

FLOW DEPTH = 0.29'
FREEBOARD = 0.50'
0.79 FT MIN < 2.0 FT OK

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 011 NORTH INLET

Solve For Depth

Given Input Data:

Bottom Width.....	2.50 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.4400 ft/ft ← MAX SLOPE
Discharge.....	3.85 cfs

Computed Results:

Depth.....	0.17 ft
Velocity.....	7.91 fps ← MAX VELOCITY
Flow Area.....	0.49 sf
Flow Top Width...	3.18 ft
Wetted Perimeter.	3.27 ft
Critical Depth...	0.38 ft
Critical Slope...	0.0281 ft/ft
Froude Number....	3.57 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 011 NORTH INLET

Solve For Depth

Given Input Data:

Bottom Width.....	2.50 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.0700 ft/ft ← MINIMUM SLOPE
Discharge.....	3.85 cfs

Computed Results:

Depth.....	0.29 ft
Velocity.....	4.29 fps
Flow Area.....	0.90 sf
Flow Top Width...	3.66 ft
Wetted Perimeter.	3.80 ft
Critical Depth...	0.38 ft
Critical Slope...	0.0281 ft/ft
Froude Number....	1.53 (flow is Supercritical)

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APP 3.4G CONT

POND 011 - SOUTH INLET RIPRAP / DEPTH

GEOMETRY: TRAPEZOIDAL
BW = 2 FT
DEPTH = 0.83 FT
SS = 1.5 : 1
MAX SLOPE = 44% ($\Delta V / \Delta H$ = 8'/18')
MIN SLOPE = 20% ($\Delta V / \Delta H$ = 2/10)
Q = 4.89 CFS (SEE SEDCAD RESULTS FOR 25-YEAR 6-HOUR PEAK OF SWS #2)

ASSUME D50 = K = 9" = 0.75

$$n = 0.0395\, D50^{1/6}$$
$$= 0.0395\,(0.75)^{1/6}$$
$$= 0.038$$

USE FLOWMASTER (MAX SLOPE)

V_{MAX} = 8.75 FPS
DEPTH = 0.24 FT

USE US DOT FIGURES

$$\frac{K}{d} = \frac{0.75}{0.24} >> 1 \quad \text{so} \quad \frac{V_s}{V} = 1 \quad \text{(FIG 1)}$$

FROM FIG 2, WITH V_s = 8.75 FPS, SS = 1.5 : 1

D50 = 9"

CHECK DEPTH:

USE FLOWMASTER (MIN. SLOPE)

FLOW DEPTH = 0.30 FT

0.30 FT FLOW
0.50 FT FREEBOARD
0.80 FT < 0.83 FT OK

20 A

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 011 SOUTH INLET

Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.038
Channel Slope....	0.4400 ft/ft ← MAX SLOPE
Discharge.....	4.89 cfs

Computed Results:

Depth.....	0.24 ft
Velocity.....	8.75 fps ← MAX VELOCITY
Flow Area.....	0.56 sf
Flow Top Width...	2.71 ft
Wetted Perimeter.	2.86 ft
Critical Depth...	0.50 ft
Critical Slope...	0.0321 ft/ft
Froude Number....	3.39 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

20B

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 011 SOUTH INLET

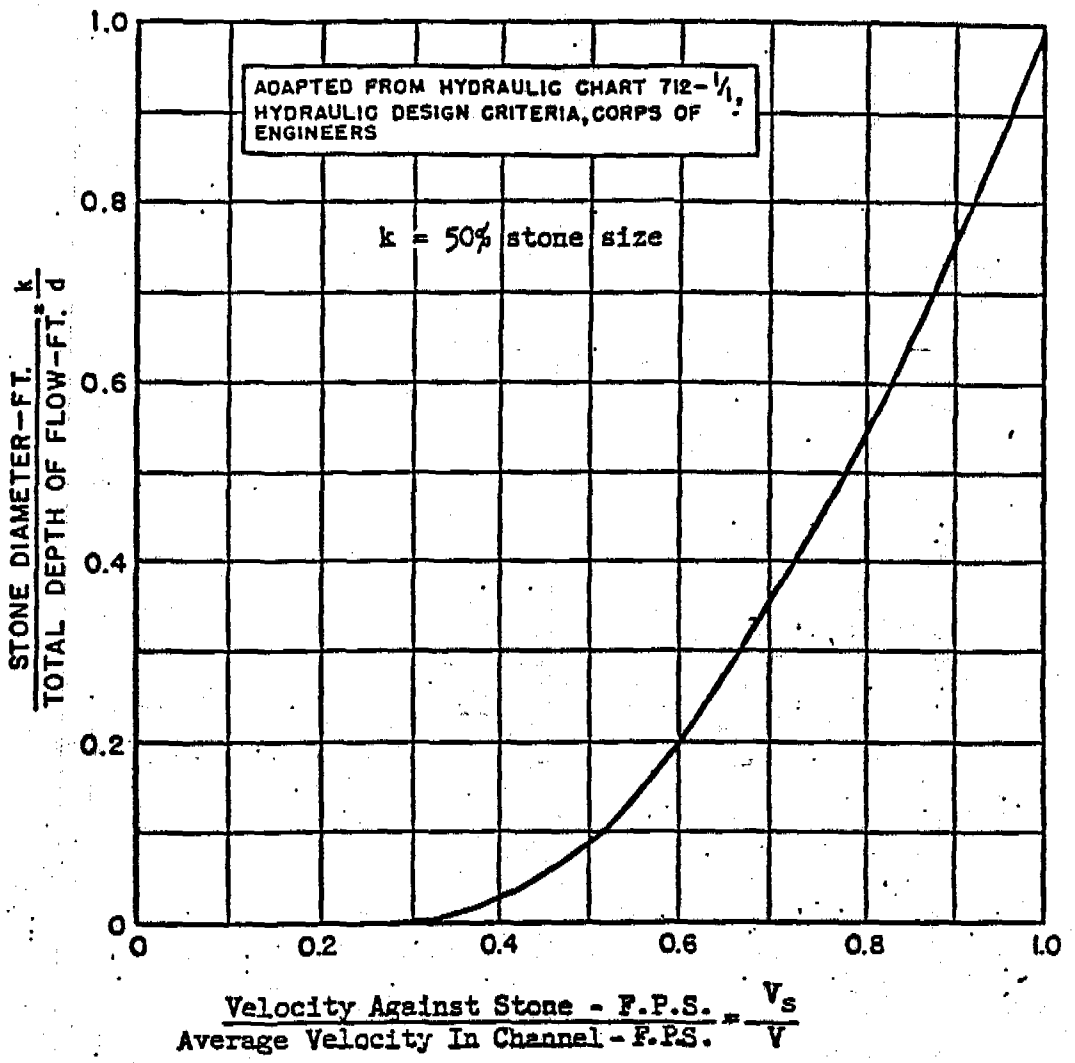
Solve For Depth

Given Input Data:

Bottom Width.....	2.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.038
Channel Slope....	0.2000 ft/ft
Discharge.....	4.89 cfs

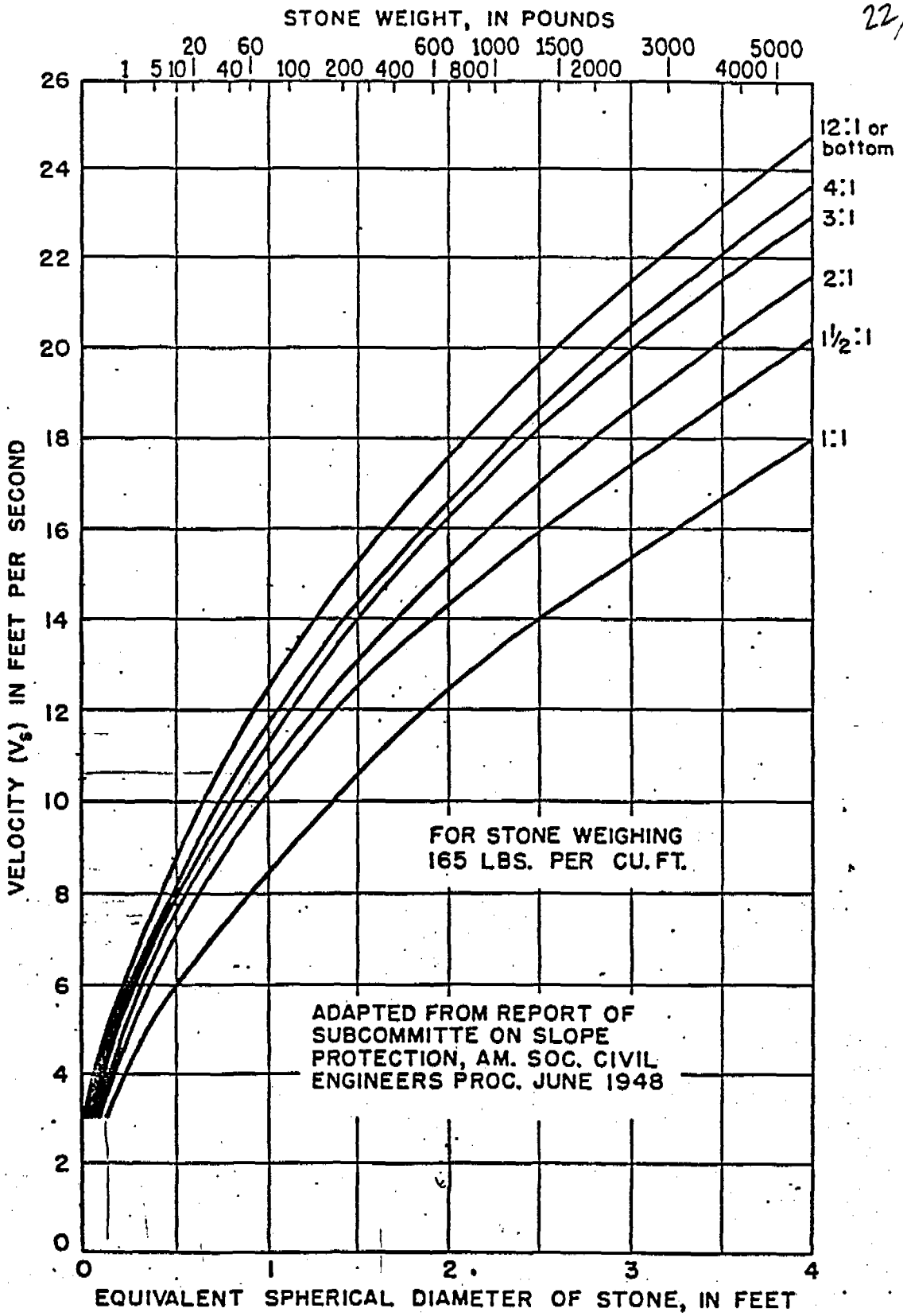
Computed Results:

Depth.....	0.30 ft
Velocity.....	6.70 fps
Flow Area.....	0.73 sf
Flow Top Width...	2.89 ft
Wetted Perimeter.	3.07 ft
Critical Depth...	0.50 ft
Critical Slope...	0.0321 ft/ft
Froude Number....	2.35 (flow is Supercritical)



VELOCITY AGAINST STONE ON CHANNEL BOTTOM

FIGURE 1



SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

FIGURE 2

Pond 011 — Outlet structure (velocity check)

Peak outflow = 5.25 cfs (see SEDCAD output)
Diameter = 15"
Slope = 0.015

Full flow capacity (from hyd. elements graph):

$$Q_f = \frac{1.486}{n} R^{2/3} S^{1/2} A$$

$$= \left(\frac{1.486}{0.024}\right)(0.3125)^{2/3}(0.015)^{1/2}(1.227)$$

$$= 4.28 \text{ cfs}$$

Max. flow capacity

$$Q_{max} = (1.07) Q_f$$

$$= (1.07)(4.28) = 4.58 \text{ cfs} \Rightarrow \text{culvert flowing under pressure}$$

Determine outflow velocity using pipe total head loss equation (see Barfield et al., 1981):

$$H' = \frac{V^2}{2g}(1 + K_e + K_b + K_c L)$$

$$V^2 = \frac{(H')(2g)}{1 + K_e + K_b + K_c L}$$

$K_e = 1.0$
$K_b = 0.5$
$K_c = \frac{(5087)(0.024)^2}{(15)^{4/3}} = 0.08$

} see Barfield et al. (1981)

$L = 58.3$ ft

$$H' = [97.8 - 93.1 - (1.25)(0.6)]$$

$$= 3.95 \text{ ft}$$

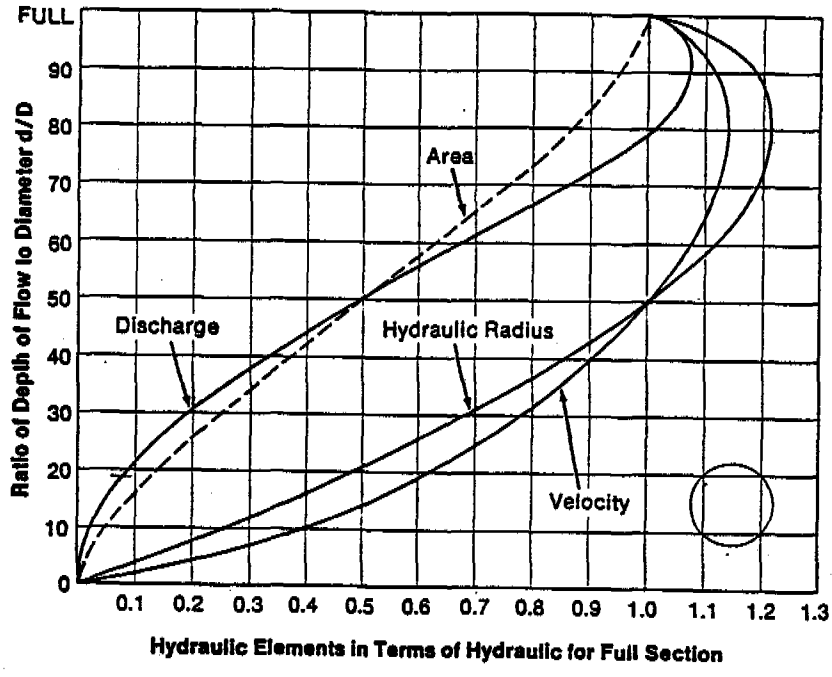


Figure 4-37 Hydraulic elements graph for circular corrugated steel pipe.

Table 4-14 Full Flow Data for Round Pipe

Diameter, in.	Area, ft²	Hydraulic Radius, ft	Diameter, in.	Area, ft²	Hydraulic Radius, ft
12	0.785	0.250	156	132.7	3.25
15	1.227	0.3125	162	143.1	3.375
18	1.767	0.375	168	153.9	3.5
21	2.405	0.437	174	165.1	3.625
24	3.142	0.50	180	176.7	3.75
30	4.909	0.625	186	188.7	3.875
36	7.069	0.75	192	201.1	4.0
42	9.621	0.875	198	213.8	4.125
48	12.566	1.0	204	227.0	4.25
54	15.904	1.125	210	240.5	4.375
60	19.635	1.25	216	254.5	4.5
66	23.758	1.375	222	268.8	4.625
72	28.27	1.5	228	283.5	4.75
78	33.18	1.625	234	298.6	4.875
84	38.49	1.75	240	314.2	5.0
90	44.18	1.875	246	330.1	5.125
96	50.27	2.0	252	346.4	5.25
108	63.62	2.25	258	363.1	5.375
114	70.88	2.375	264	380.1	5.5
120	78.54	2.5	270	397.6	5.625
126	86.59	2.625	276	415.5	5.75
132	95.03	2.75	282	433.7	5.875
138	103.87	2.875	288	452.4	6.0
144	113.10	3.00	294	471.4	6.125
150	122.7	3.125	300	490.9	6.25

$$V^2 = \frac{(3.95)(2)(32.2)}{1 + 1.0 + 0.5 + (0.08)(58.3)}$$

$$= 35.5$$

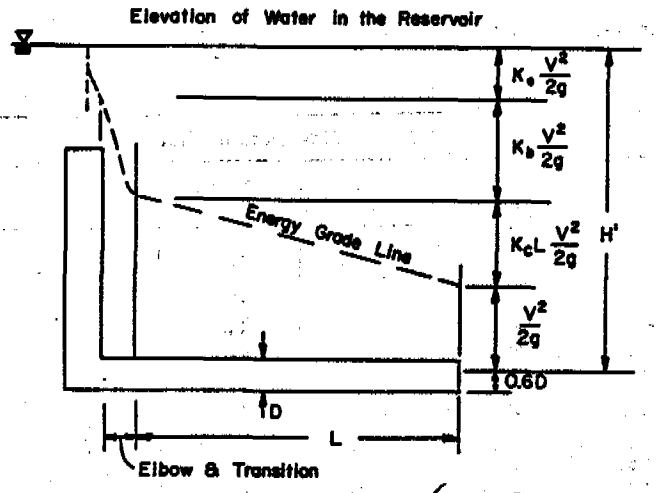
$$V = 5.96 \text{ ft/sec}$$

Discharges onto channel bottom w/ $d_{50} = 18''$

Assume $\frac{k}{d} > 1.0$. Hence, $V_s = V$

Req'd $d_{50} < 6''$ (see previous charts).

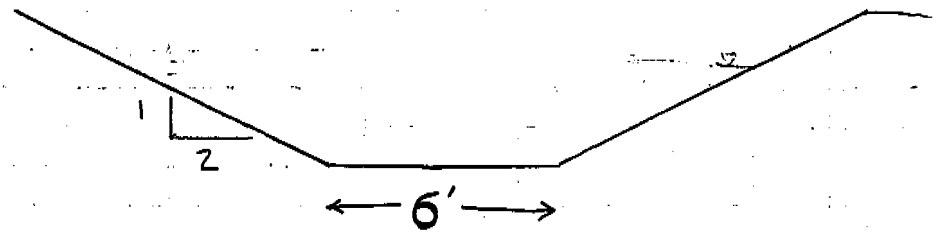
Thus, RIPRAP IS OK. Velocity adequate.



(FROM BARFIELD ET AL, 1981)

Figure 4.5. Energy losses for flow in a drop inlet spillway considering bend losses and entrance losses separately.

Pond 011 – Emergency Spillway
(Riprap Sizing)



Q = 6.59 cfs Manning's n = .035
(Q FROM EMERGENCY SPILLWAY ONLY SEDCAD RUN)
→ max. slope on pond outslope = 4/12 = .33

Results: (SEE FOLLOWING PAGE)
Max Flow velocity = 6.76 ft/sec

SIZE RIPRAP FOR OUTSLOPE OF POND:

$V_s = V = 6.76$ ft/s for $K/d > 1$

$D_{50} = 0.4$ ft = 5"

A SEDCAD RUN WAS MADE SHOWING EMERGENCY SPILLWAY FLOW DURING THE 24 YEAR - 6 HR STORM ASSUMING THE PRIMARY SPILLWAY WAS NOT FUNCTIONING.

RESULTS: MAX. Q OUT = 6.59 CFS (USED ABOVE)

MAX. FLOW DEPTH = 0.6 FT

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND 011 OUTLET

Comment: POND 011 SPILLWAY

Solve For Depth

Given Input Data:

Bottom Width.....	6.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.035
Channel Slope....	0.3300 ft/ft
Discharge.....	6.59 cfs

Computed Results:

Depth.....	0.15 ft
Velocity.....	6.76 fps
Flow Area.....	0.98 sf
Flow Top Width...	6.62 ft
Wetted Perimeter.	6.69 ft
Critical Depth...	0.32 ft
Critical Slope...	0.0276 ft/ft
Froude Number....	3.10 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

POND 011 - EMERGENCY SPILLWAY ONLY

by

Name: ANTHONY MAGLIOCCHINO

Company Name: EarthFax Engineering INC.
File Name: G:\TONY\UC150\0112NDTR

Date: 06-22-1992

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0112NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-22-1992 Time: 16:31:30
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	5.24	90	F	0.066	0.000	0.000	0.0	0.33	3.85
111	2	7.36	90	F	0.151	0.000	0.000	0.0	0.47	4.89
		Type: Pond Label: POND 011								
111	Structure	12.60							0.80	
111	Total IN	12.60							0.80	8.37
111	Total OUT								0.80	6.59

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0112NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-22-1992 Time: 16:31:30
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

POND INPUT/OUTPUT TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 12.6 acres
Total Contributing Drainage Area: 12.6 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	98.0
Crest Length (ft)	10.0
Z:1 (Left and Right)	2 2
Bottom Width (ft)	6.0

POND RESULTS:

Permanent Pool (ac-ft)
1.1

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	0.80	8.37
OUT	0.80	6.59

Peak Elevation	Hydrograph Detention Time (hrs)
98.6	0.00

****

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0112NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-22-1992 Time: 16:31:30
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-DISCHARGE TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 12.6 acres
Total Contributing Drainage Area: 12.6 acres

Elevation	Emergency Spillway (cfs)	Total Discharge (cfs)
81.50	0.0	0.0
82.00	0.0	0.0
82.50	0.0	0.0
83.00	0.0	0.0
83.50	0.0	0.0
84.00	0.0	0.0
84.50	0.0	0.0
85.00	0.0	0.0
85.50	0.0	0.0
86.00	0.0	0.0
86.50	0.0	0.0
87.00	0.0	0.0
87.50	0.0	0.0
88.00	0.0	0.0
88.50	0.0	0.0
89.00	0.0	0.0
89.50	0.0	0.0
90.00	0.0	0.0
90.50	0.0	0.0
91.00	0.0	0.0
91.50	0.0	0.0
92.00	0.0	0.0
92.50	0.0	0.0
93.00	0.0	0.0
93.50	0.0	0.0
94.00	0.0	0.0
94.50	0.0	0.0
95.00	0.0	0.0
95.50	0.0	0.0
96.00	0.0	0.0
96.50	0.0	0.0
97.00	0.0	0.0
97.50	0.0	0.0
98.00	0.0	0.0
98.50	5.9	5.9

98.60	7.1	7.1
98.70	9.5	9.5
98.80	12.3	12.3
98.90	15.4	15.4
99.00	18.4	18.4

****

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0112NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-22-1992 Time: 16:31:30
POND 011 - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J1, B1, S1
POND 011

Drainage Area from J1, B1, S1, SWS(s)1-2: 12.6 acres
Total Contributing Drainage Area: 12.6 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
81.50	0.00	0.02	0.00	0.00	
82.00	0.50	0.02	0.01	0.00	
82.50	1.00	0.02	0.02	0.00	
83.00	1.50	0.03	0.03	0.00	
83.50	2.00	0.03	0.05	0.00	
84.00	2.50	0.03	0.06	0.00	
84.50	3.00	0.03	0.08	0.00	
85.00	3.50	0.03	0.09	0.00	
85.50	4.00	0.04	0.11	0.00	
86.00	4.50	0.04	0.13	0.00	
86.50	5.00	0.04	0.15	0.00	
87.00	5.50	0.04	0.17	0.00	
87.50	6.00	0.05	0.19	0.00	
88.00	6.50	0.05	0.22	0.00	
88.50	7.00	0.06	0.24	0.00	
89.00	7.50	0.06	0.27	0.00	
89.50	8.00	0.06	0.30	0.00	
90.00	8.50	0.07	0.34	0.00	
90.50	9.00	0.07	0.37	0.00	
91.00	9.50	0.07	0.41	0.00	
91.50	10.00	0.08	0.45	0.00	
92.00	10.50	0.08	0.49	0.00	
92.50	11.00	0.08	0.53	0.00	
93.00	11.50	0.09	0.57	0.00	
93.50	12.00	0.09	0.61	0.00	
94.00	12.50	0.09	0.66	0.00	
94.50	13.00	0.10	0.71	0.00	
95.00	13.50	0.10	0.76	0.00	
95.50	14.00	0.11	0.81	0.00	
96.00	14.50	0.12	0.87	0.00	
96.50	15.00	0.13	0.93	0.00	
97.00	15.50	0.14	1.00	0.00	
97.50	16.00	0.15	1.07	0.00	
98.00	16.50	0.16	1.15	0.00	Stage of SW#1
98.50	17.00	0.17	1.23	5.88	

98.56	17.06	0.17	1.24	6.59	Peak Stage
98.60	17.10	0.17	1.25	7.06	
98.70	17.20	0.18	1.26	9.52	
98.80	17.30	0.18	1.28	12.29	
98.90	17.40	0.18	1.30	15.35	
99.00	17.50	0.18	1.32	18.37	

****

APPENDIX 3.4H

AS-BUILT CALCULATIONS FOR PONDS 012A AND 012B

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH
2/2/94

APPENDIX 3.4 H

Pond 012 - Sediment Calcs

Basin to Pond	R	K	Slope length (ft)	% Slope	m	$LS = \left(\frac{650 + 150s + 65s^2}{10000 + s^2}\right)\left(\frac{l}{72.6}\right)^m$	VM	A = R·K·LS·VM (ton/Ac/yr)	Area (Ac)	Sed Yield (ft³/yr)
Pond 012 A - upper Pond										
CGWS-D3a	I	.15	220'	63.6%	0.6	40.46	.01	.668	3.6	53.4
D3b	I	.15	1650'	3.0%	0.3	0.659	1.20	1.305	10.88	315.6
D7	II	.15	450'	77.2%	.6	79.15	.01	1.306	1.56	45.3
									Total =	414.3 ft³/year
Pond 012 B - Lower Pond										
CGWS-D4a	II	.15	370'	75.7%	0.6	68.77	0.13 (a)	14.75	5.79	1898.0
D4b	II	.15	500'	8.0%	0.5	2.19	1.20	4.34	4.26	411.1
D4c	II	.15	1950	1.9%	0.3	.467	1.20	0.924	4.68	96.1
									Total =	2405.2 ft³/yr

(a) 10% road, 90% undisturbed area, Ave VM = .1·(1.2) + .9(.01) = .13

Ref: Israelson, et al, 1984.

Runoff volume from 10-year, 24-hour storm. P=1.8"

Pond 012A

1) watershed CGWS-D3

P=1.8"
Area = 14.48 Ac
CN = 90

$S = \frac{1000}{CN} - 10 = 1.11$

$Q = \frac{(1.8 - .2(1.11))^2}{1.8 + .8(1.11)} = 0.926" = .077'$

Volume = .077 (14.48 Ac) (43,560 ft²/Ac) = 48,692.2 ft³

2) Watershed CGWS-D7

P=1.8
Area = 1.56 Ac
CN = 85

$S = \frac{1000}{85} - 10 = 1.76$

$Q = \frac{(1.8 - .2(1.76))^2}{1.8 + .8(1.76)} = 0.654" = .054$ ft

Volume = .054 (1.56) (43,560) = 3,701.1 ft³

Runoff volume = 52,393.3 ft³

Capacity @ Spillway = 56,205 ft³
10 YEAR-24 HOUR STORM RUNOFF = 52,393 FT³
3,812 FT³ = ROOM FOR SEDIMENT

TOTAL SEDIMENT YIELD = 414 FT³/YEAR
ROOM FOR SEDIMENT = 3812 FT³ = 9.2 YEARS OF STORAGE
ELEVATION = 92.6'

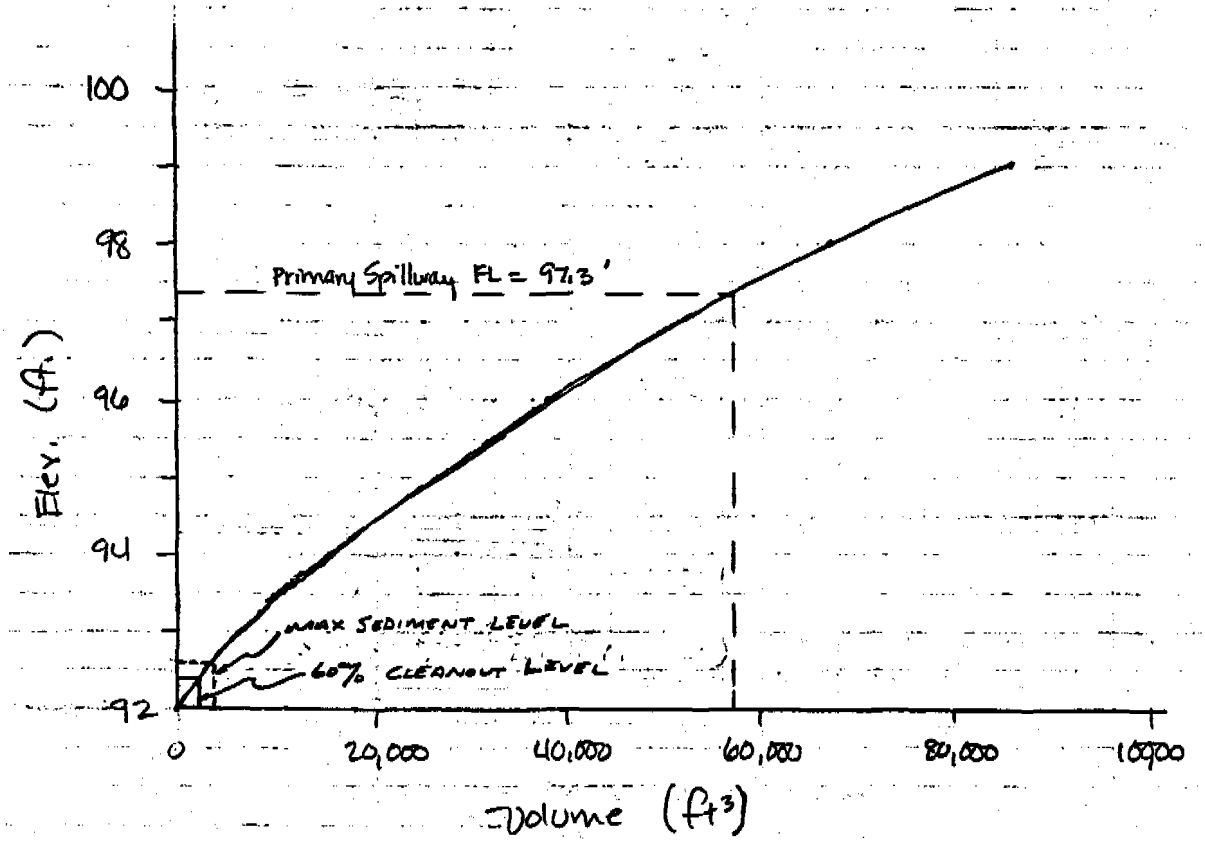
60% CLEANOUT VOLUME = 2287 FT³

ELEVATION = 92.4'

Pond 012 A =

Pond capacity at Spillway FL = 56,205 ft^3
req'd runoff volume = 52,393 ft^3
3,812 ft^3
remaining for Sed. Storage.

Note: the calculated annual sed. yield is 414 ft^3/year. Therefore this represents approx. 9 years of storage.



Runoff volume = Pond 012B

1) Watershed CGWS-D4b + c

P = 1.8"
Area = 8.94 Ac
CN = 90

$S = \frac{1000}{CN} - 10 = 1.11$

$Q = \frac{(1.8 - .2(1.11))^2}{1.8 + .8(1.11)} = .976" = .077'$

Volume = .077 (8.94 Ac)(43560 ft²/Ac) = 29,986 ft³

2) Watershed CGWS-D4a

P = 1.8
Area = 5.79 Ac
CN = 85

$S = \frac{1000}{85} - 10 = 1.76$

$Q = \frac{(1.8 - .2(1.76))^2}{1.8 + .8(1.76)} = .654" = .054'$

Volume = .054 (5.79)(43560) = 13,619 ft³

Total runoff volume = 43,605 ft³

POND CAPACITY @ SPILLWAY = 53,123 FT³
0 YEAR-24 HOUR STORM RUNOFF = 43,605 FT³
9,518 FT³ = ROOM FOR SEDIMENT.

TOTAL SEDIMENT YIELD = 2,405 FT³/YR
ROOM FOR SEDIMENT = 9,518 FT³ = 4 YEARS STORAGE

ELEVATION = 86.1 FT

60% CLEANOUT VOLUME = 5,711 FT³

ELEVATION = 85.4'

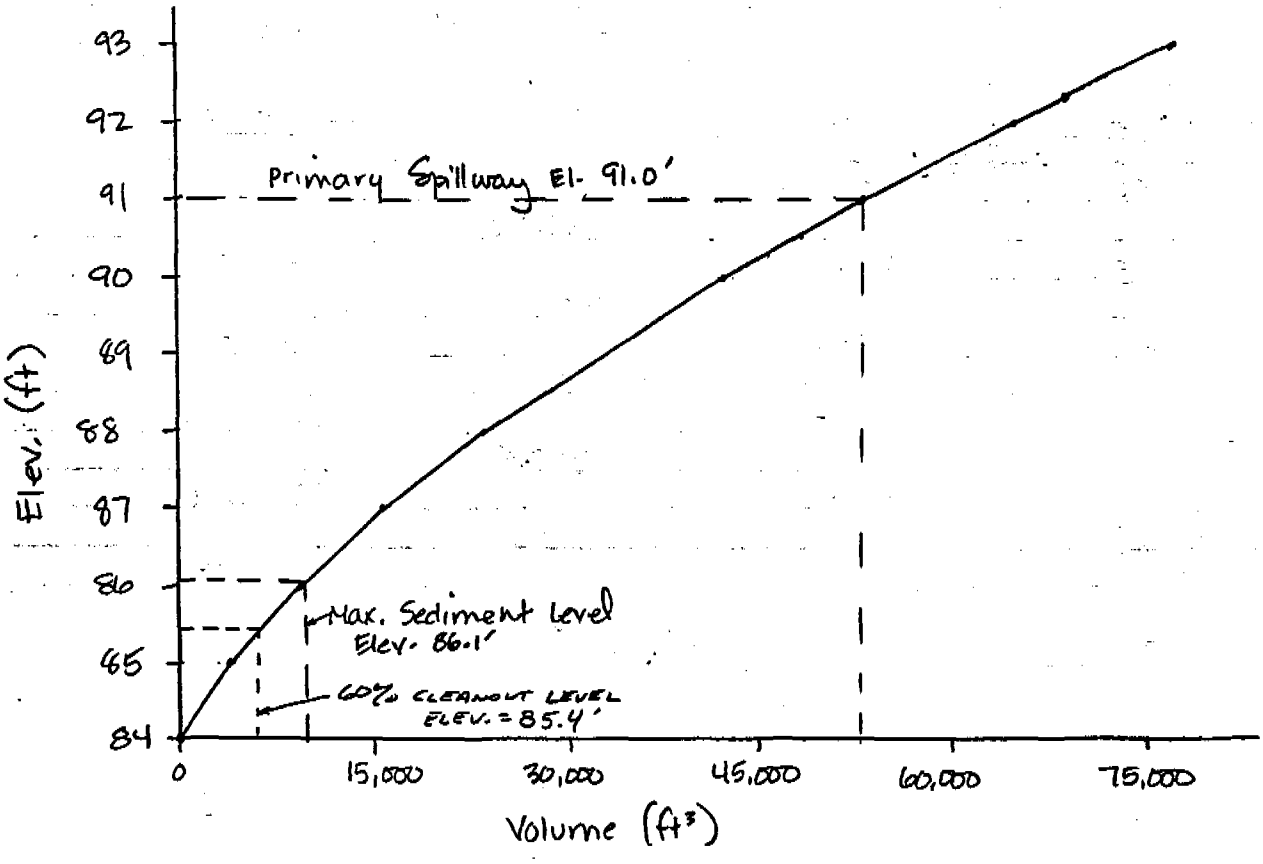
Pond 012B

* Note: Pond Spillway FL @ elev. 91.0.

Pond Capacity at Spillway = 53,123 ft³
reqd runoff volume = 43,605 ft³

allowable Sediment volume = 9,518 ft³

annual Sed. Yield = 2405 ft³/year
Therefore Sediment Storage volume represents approx. 4 years of Sediment accumulation.



Pond 012A - As Constructed

	Elev	Area	Δvol	cum. vol
	92	5997		0
			15,244	
	94	9247		15,244
			22,351	
	96	13104		37,595
			18,610	
Primary Spillway FL →	97.3	15,527		56,205
			11,325	
	98	16831		67,530
			5,132	
Emergency Spillway →	98.3	17381		72,662
			12,616	
	99	18664		85,278
			19,581	
MINIMUM TOP OF EMBANKMENT →	100	20,497		104,859

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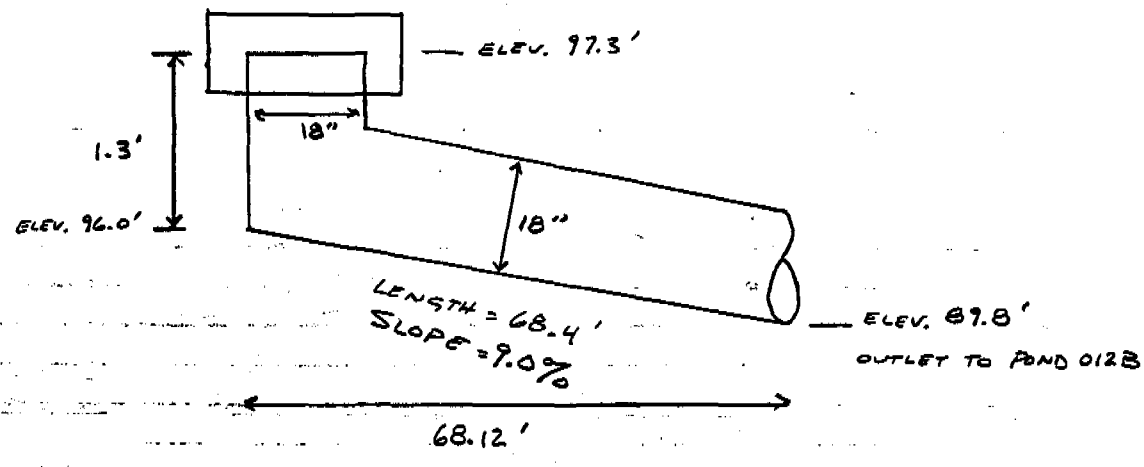
Pond 012B - As Constructed

	Elev	Area	Δvol	cum. vol
	84	3325		0
			3929.5	
	85	4534		3929.5
			5170	
	86	5806		9099.5
			6473	
	87	7140		15,572.5
			7828.5	
	88	8517		23,401.0
			18,893	
	90	10376		42,294
			10,829	
Primary Spillway FL →	91	11282		53,123
			6932	
	91.6	11,826		60,055
			4803	
	92.0	12,188		64,858
			10,040	
MINIMUM EMBANKMENT ELEVATION →	92.8	12,913		74,898

POND 012A PRIMARY SPILLWAY DATA



PONDS 012A AND 012B
SEDCAD VERSION 3 INPUT DATA

INPUT

TIME INCREMENT = 0.1 HR
STORM TYPE = SCS 6HOUR
DESIGN STORM = 25YEAR - 6HOUR
RAINFALL DEPTH = 1.6 IN

NO. OF JUNCTIONS = 1
NO. OF BRANCHES = 1
NO. OF STRUCTURES = 2

JUNCTION 1, BRANCH 1, STRUCTURE 1:

NO. OF SUBWATERSHEDS = 2
SUBWATERSHEDS LOCATED @ STRUCTURE = 1 AND 2
CONTROL STRUCTURE TYPE = RETENTION BASIN
LABEL = POND 012A

SWS	AREA (AC)	Tc (HRS)	CN	H'GRAPH RESPONSE
1 (CGWS-D3)	14.48	0.142	90	F (FAST)
2 (CGWS-D7)	1.56	0.038	85	F

JUNCTION 1, BRANCH 1, STRUCTURE 2

NO. OF SUBWATERSHEDS = 1
CONTROL STRUCTURE TYPE = RETENTION BASIN
LABEL = POND 012B

SWS	AREA (AC)	Tc (HRS)	CN	H'GRAPH RESPONSE
1 (CGWS-4)	14.73	0.217	90	F

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CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

PONDS 012A AND 012B - CASTLE GATE MINE

by

Name: ANTHONY MAGLIOCCHINO

Company Name: EarthFax Engineering INC.
File Name: G:\TONY\UC150\012TRIAL

Date: 06-25-1992

Civil Software Design -- SEDCAD+ Version 3.1
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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\012TRIAL User: ANTHONY MAGLIOCCHINO
Date: 06-25-1992 Time: 17:21:42
PONDS 012A AND 012B - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	14.48	90	F	0.142	0.000	0.000	0.0	0.92	9.63
111	2	1.56	85	F	0.038	0.000	0.000	0.0	0.07	0.78
		Type: Pond			Label: POND 012A					
111	Structure	16.04							0.99	
111	Total IN	16.04							0.99	9.85
111	Total OUT								0.99	5.85
112	1	14.73	90	F	0.217	0.000	0.000	0.0	0.94	9.20
		Type: Pond			Label: POND 012B					
112	Structure	14.73							1.92	
112	Total IN	30.77							1.92	14.32
112	Total OUT								1.92	12.30
111 to 112 Routing						0.000	0.000			

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Date: 06-25-1992 Time: 17:21:42
PONDS 012A AND 012B - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

POND INPUT/OUTPUT TABLE

J1, B1, S1
POND 012A

Drainage Area from J1, B1, S1, SWS(s)1-2: 16.0 acres
Total Contributing Drainage Area: 16.0 acres

DISCHARGE OPTIONS:

	Drop Inlet
Riser Diameter (in)	18.0
Riser Height (ft)	1.30
Barrel Diameter (in)	18.0
Barrel Length (ft)	68.40
Barrel Slope (%)	9.00
Manning's n of Pipe	0.024
Spillway Elevation	97.3
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	----
Crest Length (ft)	----
Z:1 (Left and Right)	-- --
Bottom Width (ft)	----

POND RESULTS:

Permanent Pool (ac-ft)
1.3

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	0.99	9.85
OUT	0.99	5.85

Peak Elevation	Hydrograph Detention Time (hrs)
97.9	0.00

****

J1, B1, S2
POND 012B

Drainage Area from J1, B1, S2, SWS(s)1: 14.7 acres
Total Contributing Drainage Area: 30.8 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	91.0
Crest Length (ft)	14.0
Z:1 (Left and Right)	2 2
Bottom Width (ft)	7.0

POND RESULTS:

	Permanent Pool (ac-ft)

==========
1.2

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	1.92	14.32
OUT	1.92	12.30

Peak Elevation	Hydrograph Detention Time (hrs)
91.8	0.13

****

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\012TRIAL User: ANTHONY MAGLIOCCHINO
Date: 06-25-1992 Time: 17:21:42
PONDS 012A AND 012B - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-DISCHARGE TABLE

J1, B1, S1
POND 012A

Drainage Area from J1, B1, S1, SWS(s)1-2: 16.0 acres
Total Contributing Drainage Area: 16.0 acres

Elevation	Drop Inlet (cfs)	Total Discharge (cfs)
92.00	0.0	0.0
92.50	0.0	0.0
93.00	0.0	0.0
93.50	0.0	0.0
94.00	0.0	0.0
94.50	0.0	0.0
95.00	0.0	0.0
95.50	0.0	0.0
96.00	0.0	0.0
96.50	0.0	0.0
97.00	0.0	0.0
97.30	0.0	0.0
97.50	1.3	1.3
98.00	7.1	7.1
98.50	9.3	9.3
99.00	11.1	11.1
99.50	12.6	12.6
100.00	14.0	14.0

****

J1, B1, S2
POND 012B

Drainage Area from J1, B1, S2, SWS(s)1: 14.7 acres
Total Contributing Drainage Area: 30.8 acres

Elevation	Emergency Spillway (cfs)	Total Discharge (cfs)
84.00	0.0	0.0
84.50	0.0	0.0
85.00	0.0	0.0
85.50	0.0	0.0

86.00	0.0	0.0
86.50	0.0	0.0
87.00	0.0	0.0
87.50	0.0	0.0
88.00	0.0	0.0
88.50	0.0	0.0
89.00	0.0	0.0
89.50	0.0	0.0
90.00	0.0	0.0
90.50	0.0	0.0
91.00	0.0	0.0
91.50	6.4	6.4
91.60	7.7	7.7
91.70	10.2	10.2
91.80	13.3	13.3
91.90	16.5	16.5
92.00	20.0	20.0
92.50	43.5	43.5
92.80	61.4	61.4

****

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Date: 06-25-1992 Time: 17:21:42
PONDS 012A AND 012B - CASTLE GATE MINE
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J1, B1, S1
POND 012A

Drainage Area from J1, B1, S1, SWS(s)1-2: 16.0 acres
Total Contributing Drainage Area: 16.0 acres

SW#1: Drop Inlet

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
92.00	0.00	0.14	0.00	0.00	
92.50	0.50	0.16	0.07	0.00	
93.00	1.00	0.17	0.16	0.00	
93.50	1.50	0.19	0.25	0.00	
94.00	2.00	0.21	0.35	0.00	
94.50	2.50	0.23	0.46	0.00	
95.00	3.00	0.25	0.58	0.00	
95.50	3.50	0.28	0.71	0.00	
96.00	4.00	0.30	0.86	0.00	
96.50	4.50	0.32	1.01	0.00	
97.00	5.00	0.34	1.18	0.00	
97.30	5.30	0.36	1.28	0.00	Stage of SW#1
97.50	5.50	0.36	1.36	1.31	
97.89	5.89	0.36	1.50	5.85	Peak Stage
98.00	6.00	0.39	1.54	7.12	
98.50	6.50	0.41	1.74	9.32	
99.00	7.00	0.43	1.95	11.09	
99.50	7.50	0.45	2.17	12.62	
100.00	8.00	0.47	2.40	13.98	

J1, B1, S2
POND 012B

Drainage Area from J1, B1, S2, SWS(s)1: 14.7 acres
Total Contributing Drainage Area: 30.8 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)
84.00	0.00	0.01	0.00	0.00
84.50	0.50	0.04	0.01	0.00
85.00	1.00	0.10	0.05	0.00

85.50	1.50	0.12	0.10	0.00	
86.00	2.00	0.13	0.17	0.00	
86.50	2.50	0.15	0.24	0.00	
87.00	3.00	0.16	0.31	0.00	
[illegible].50	3.50	0.18	0.40	0.00	
[illegible].00	4.00	0.20	0.49	0.00	
88.50	4.50	0.21	0.59	0.00	
89.00	5.00	0.22	0.70	0.00	
89.50	5.50	0.23	0.81	0.00	
90.00	6.00	0.24	0.93	0.00	
90.50	6.50	0.25	1.05	0.00	
91.00	7.00	0.26	1.17	0.00	Stage of SW#1
91.50	7.50	0.27	1.31	6.42	
91.60	7.60	0.27	1.33	7.70	
91.70	7.70	0.27	1.36	10.22	
91.77	7.77	0.27	1.38	12.30	Peak Stage
91.80	7.80	0.28	1.39	13.27	
91.90	7.90	0.28	1.42	16.51	
92.00	8.00	0.28	1.44	19.98	
92.50	8.50	0.29	1.59	43.46	
92.80	8.80	0.30	1.67	61.40	

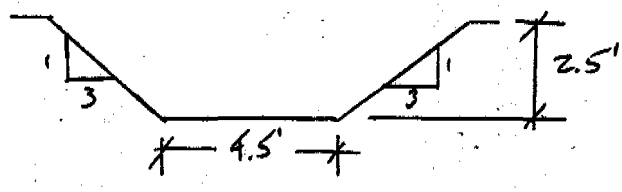
****

CASTLE GATE PREP PLANT - PONDS

POND 012A INLET CHANNEL RIPRAP

Q = 9.85 CFS
(25-6 FLOW FROM SEDCAD OUTPUT)

SLOPE = 3 %



N.T.S.

ASSUME $D_{50} = K = 2'' = 0.17$

$$n = 0.0395\, D_{50}^{1/6}$$
$$= 0.0395(0.17)^{1/6}$$
$$= 0.030$$

USE FLOWMASTER TO DETERMINE VELOCITY

V = 4.1 FPS
DEPTH = 0.41 FT << 2.5' OK

USE U.S.D.O.T. FIGURES TO SIZE D50

$$\frac{K}{d} = \frac{0.17}{0.41} = 0.41$$

FROM FIG. 1, $\frac{V_s}{V} = 0.73$

$$V_s = V(0.73)$$
$$= (4.1)(0.73)$$
$$= 3.0 \text{ FPS}$$

VERY LOW

FROM FIG 2, WITH $V_s = 3.3$, 3:1 S.S.

D50 = 1"

IF THERE IS SUFFICIENT VEGETATION IN THE INLET CHANNEL, RIPRAP IS NOT NECESSARY.

IF THERE IS NO VEGETATION, USE D50 = 1"

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 012A INLET

Solve For Depth

Given Input Data:

Bottom Width.....	4.50 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	9.85 cfs

Computed Results:

Depth.....	0.41 ft
Velocity.....	4.13 fps
Flow Area.....	2.38 sf
Flow Top Width...	6.99 ft
Wetted Perimeter.	7.12 ft
Critical Depth...	0.47 ft
Critical Slope...	0.0186 ft/ft
Froude Number....	1.25 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

CASTLE GATE PREP PLANT
OPERATION HYDROLOGY
PONDS

POND 012A INLET CULVERT TRIPRAP

CULVERT DIAMETER = 12" CMP

CULVERT SLOPE = 60% (18/3 = 1)

Q = 0.78 CFS (SEE CAD RESULT FOR SUBWATERSHED #2, 25-YR 6-HR INFLOW)

n ~ 0.024 (CMP)

USE FLOWMASTER

V = 10.05 FPS
DEPTH = 0.16 << 1.0 FT OK

USE USDOT FIGURES TO SIZE RIPRAP

ASSUME D50 = K = 12" = 1.0'

$\frac{K}{d} = \frac{1.0}{0.16} >> 1$ SO $\frac{V_s}{V_1} = 1$

$V_s = V = 10.05$ FPS

USE FIG 2, WITH $V_s = 10.05$, SLOPE = 1:1 (POND INSLOPE)

$D_{50} = 16"$

SEVERAL LARGE ROCKS IN THE 18 ± 24" RANGE WOULD BE SUFFICIENT TO DISSIPATE THE ENERGY AND PREVENT EROSION.

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 012A INLET

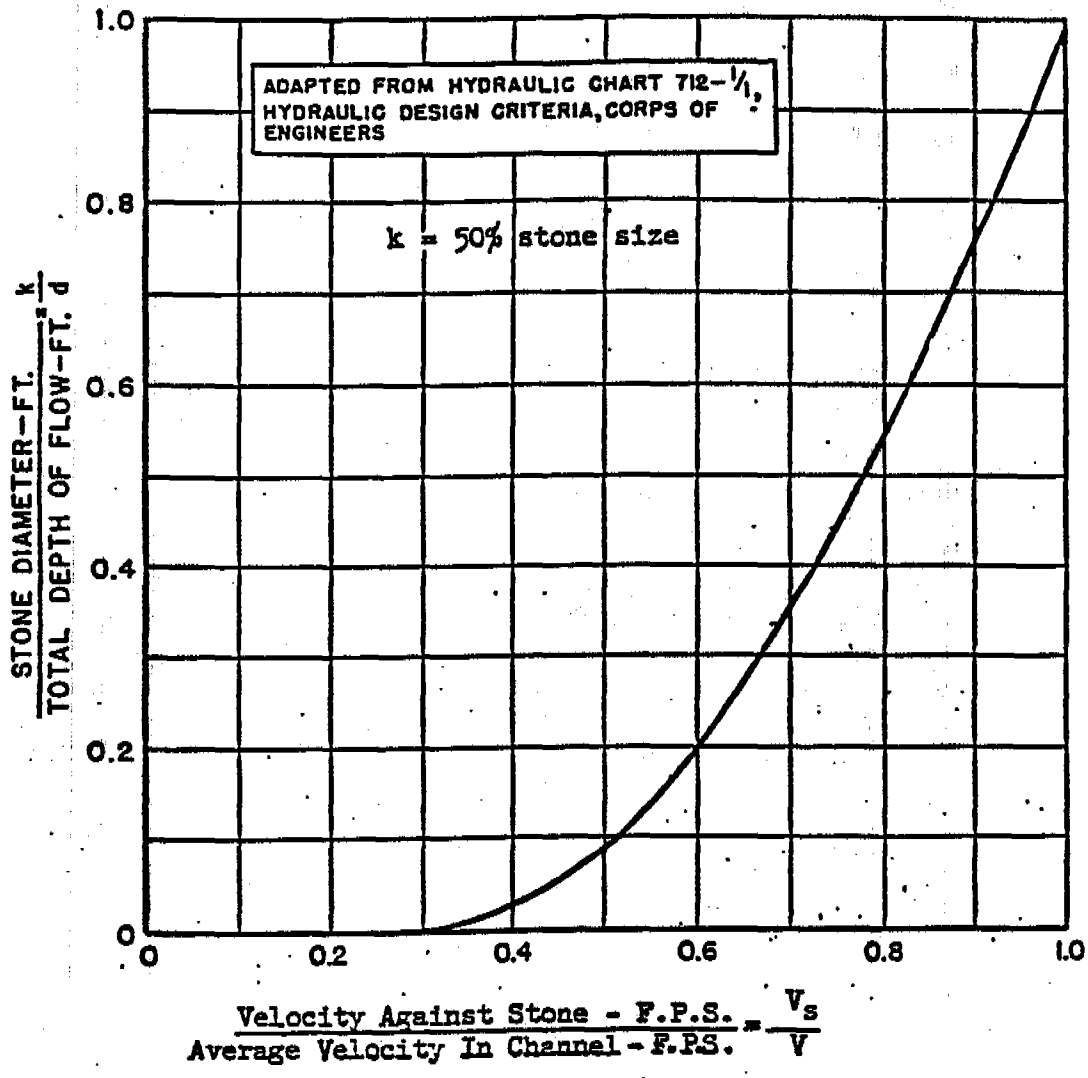
Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.6000 ft/ft
Manning's n.....	0.024
Discharge.....	0.78 cfs

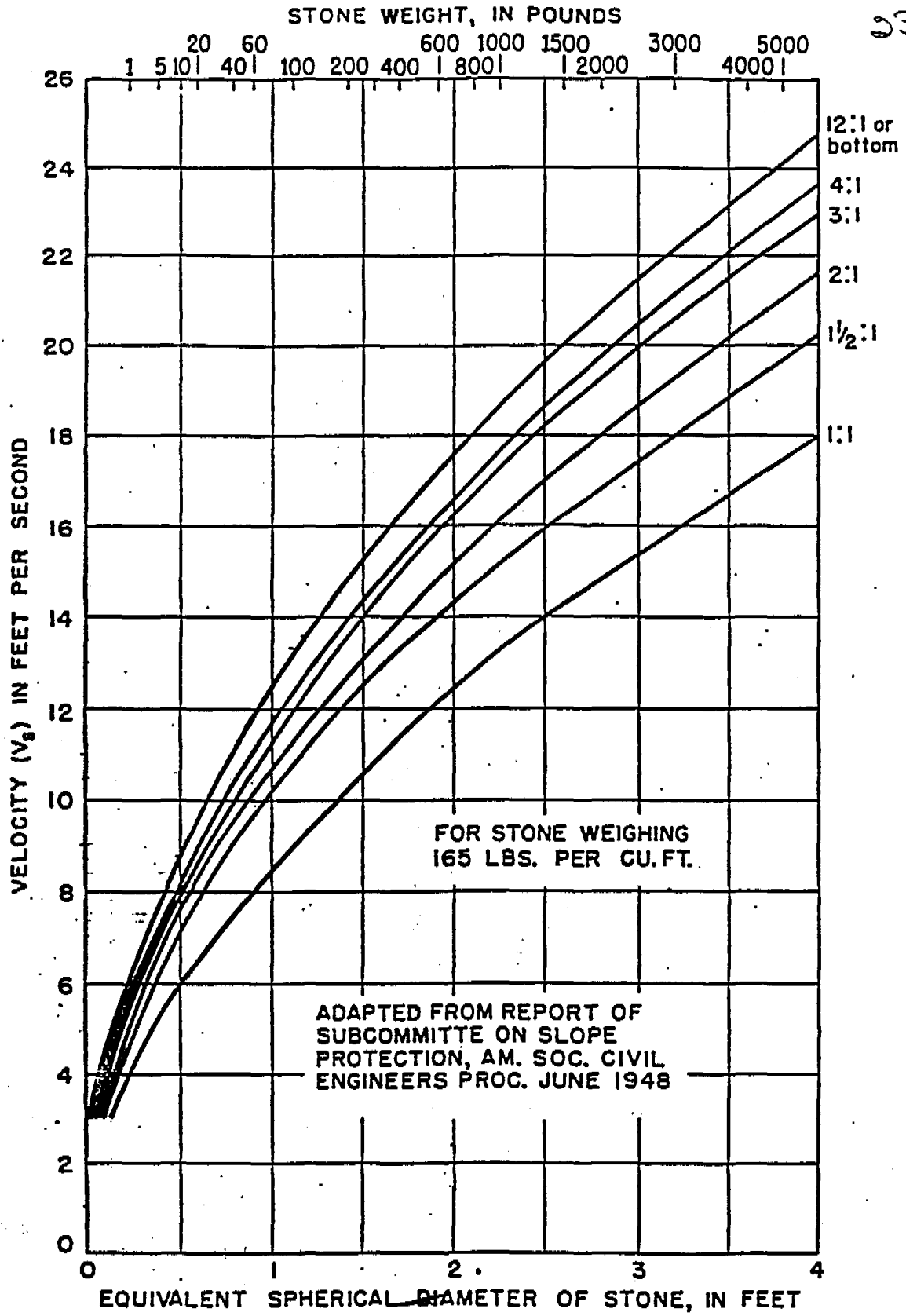
Computed Results:

Depth.....	0.16 ft
Velocity.....	10.05 fps
Flow Area.....	0.08 sf
Critical Depth....	0.37 ft
Critical Slope....	0.0194 ft/ft
Percent Full.....	15.52 %
Full Capacity.....	14.95 cfs
QMAX @.94D.....	16.08 cfs
Froude Number.....	5.41 (flow is Supercritical)



VELOCITY AGAINST STONE ON CHANNEL BOTTOM

FIGURE 1



SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

FIGURE 2

CASTLE GATE
PREP PLANT PONDS
OPERATIONAL HYDROLOGY

POND 012A – PRIMARY SPILLWAY RIPRAP

CULVERT DIAMETER = 18"

SLOPE OF CULVERT = 10%

Q = 5.85 CFS (SEDCAD, 25 YR - 6 HR STORM)
n = 0.024

USE FLOWMASTER TO CALCULATE EXIT VELOCITY

V = 9.1 FPS, DEPTH = 0.59' < 1.5' ok

USE SLOPE OF POND 012B WHERE WATER EXITS PRIMARY SPILLWAY FOR RIPRAP CALCULATION.
SLOPE = 5/12 = 42%
USE USDOT FIGURES

ASSUME D50 = K = 6" = 0.5'

$$\frac{K}{d} = \frac{0.5}{0.59} = 0.85$$

FROM FIG 1, $\frac{V_s}{V} = 0.95$

$$\text{so } V_s = V(0.95) = (9.1)(0.95) = 8.6 \text{ FPS}$$

FROM FIG 2, USE CURVE FOR 2:1 SLOPE (50%)

D50 = 7"

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 12A PRIMARY SPILLWAY

Solve For Actual Depth

Given Input Data:

Diameter.....	1.50 ft
Slope.....	0.1000 ft/ft
Manning's n.....	0.024
Discharge.....	5.85 cfs

Computed Results:

Depth.....	0.59 ft
Velocity.....	9.10 fps
Flow Area.....	0.64 sf
Critical Depth....	0.93 ft
Critical Slope....	0.0209 ft/ft
Percent Full.....	39.23 %
Full Capacity.....	17.99 cfs
QMAX @.94D.....	19.36 cfs
Froude Number.....	2.42 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
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CASTLE GATE PREP PLANT
OPERATIONAL HYDROLOGY
PONDS

POND 012A EMERGENCY SPILLWAY TRIPRAP

GEOMETRY: TRAPEZOIDAL
DEPTH = 1 FT
B.W = 6 FT
SS = 2:1
SLOPE OF SPILLWAY OUTSLOPE = 7%

Q = 5.70 CFS (SEDCAD EMERGENCY-SPILLWAY-ONLY RESULTS)

ASSUME D50 = 3" = K = 0.25'

$$n = 0.0395\ D50^{1/6}$$
$$= 0.0395\ (0.25)^{1/6}$$
$$= 0.031$$

USE FLOWMASTER

V_{max} = 4.24 FPS

DEPTH = 0.21 FT < 1.0 FT OK

US USDOT FIGURES.

$\frac{K}{d} = \frac{0.25}{0.21} > 1$ SO $\frac{V_s}{V} = 1$ SO $V_s = V$

$V_s = V$ = 4.24 FPS

FROM FIG 2, WITH 2:1 SIDE SLOPES

D50 = 2"

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 12A EMERGENCY SPILLWAY

Solve For Depth

Given Input Data:

Bottom Width.....	6.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.031
Channel Slope....	0.0700 ft/ft
Discharge.....	5.70 cfs

Computed Results:

Depth.....	0.21 ft
Velocity.....	4.24 fps
Flow Area.....	1.34 sf
Flow Top Width...	6.84 ft
Wetted Perimeter.	6.94 ft
Critical Depth...	0.29 ft
Critical Slope...	0.0223 ft/ft
Froude Number....	1.69 (flow is Supercritical)

CIVIL SOFTWARE DESIGN

SEDCAD+ Version 3

POND 012A EMERGENCY SPILLWAY ONLY

by

Name: ANTHONY MAGLIOCCHINO

Company Name: EarthFax Engineering INC.
File Name: G:\TONY\UC150\0122NDTR

Date: 06-26-1992

Civil Software Design -- SEDCAD+ Version 3.1
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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0122NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-26-1992 Time: 10:14:03
POND 012A EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

SUBWATERSHED/STRUCTURE INPUT/OUTPUT TABLE

-Hydrology-

JBS	SWS	Area (ac)	CN	UHS	Tc (hrs)	K (hrs)	X	Base-Flow (cfs)	Runoff Volume (ac-ft)	Peak Discharge (cfs)
111	1	14.48	90	F	0.142	0.000	0.000	0.0	0.92	9.63
111	2	1.56	85	F	0.038	0.000	0.000	0.0	0.07	0.78
		Type: Pond			Label: POND 012A					
111	Structure	16.04							0.99	
111	Total IN	16.04							0.99	9.85
111	Total OUT								0.99	5.70
112	1	14.73	90	F	0.217	0.000	0.000	0.0	0.94	9.20
		Type: Pond			Label: POND 012B					
112	Structure	14.73							1.92	
112	Total IN	30.77							1.92	14.24
112	Total OUT								1.92	12.31
111 to 112 Routing						0.000	0.000			

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0122NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-26-1992 Time: 10:14:03
POND 012A EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

POND INPUT/OUTPUT TABLE

J1, B1, S1
POND 012A

Drainage Area from J1, B1, S1, SWS(s)1-2: 16.0 acres
Total Contributing Drainage Area: 16.0 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	98.3
Crest Length (ft)	14.0
Z:1 (Left and Right)	2 2
Bottom Width (ft)	6.0

POND RESULTS:

Permanent Pool (ac-ft)
1.7

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	0.99	9.85
OUT	0.99	5.70

Peak Elevation	Hydrograph Detention Time (hrs)
98.8	0.00

****

J1, B1, S2
POND 012B

Drainage Area from J1, B1, S2, SWS(s)1: 14.7 acres
Total Contributing Drainage Area: 30.8 acres

DISCHARGE OPTIONS:

	Emergency Spillway
Riser Diameter (in)	----
Riser Height (ft)	----
Barrel Diameter (in)	----
Barrel Length (ft)	----
Barrel Slope (%)	----
Manning's n of Pipe	----
Spillway Elevation	----
Lowest Elevation of Holes	----
# of Holes/Elevation	----
Entrance Loss Coefficient	----
Tailwater Depth (ft)	----
Notch Angle (degrees)	----
Weir Width (ft)	----
Siphon Crest Elevation	----
Siphon Tube Diameter (in)	----
Siphon Tube Length (ft)	----
Manning's n of Siphon	----
Siphon Inlet Elevation	----
Siphon Outlet Elevation	----
Emergency Spillway Elevation	91.0
Crest Length (ft)	10.0
Z:1 (Left and Right)	2 2
Bottom Width (ft)	7.0

POND RESULTS:

	Permanent Pool (ac-ft)

==========
1.2

	Runoff Volume (ac-ft)	Peak Discharge (cfs)
IN	1.92	14.24
OUT	1.92	12.31

Peak Elevation	Hydrograph Detention Time (hrs)
91.7	0.12

****

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Company Name: EarthFax Engineering INC.
Filename: G:\TONY\UC150\0122NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-26-1992 Time: 10:14:03
POND 012A EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-DISCHARGE TABLE

J1, B1, S1
POND 012A

Drainage Area from J1, B1, S1, SWS(s)1-2: 16.0 acres
Total Contributing Drainage Area: 16.0 acres

Elevation	Emergency Spillway (cfs)	Total Discharge (cfs)
92.00	0.0	0.0
92.50	0.0	0.0
93.00	0.0	0.0
93.50	0.0	0.0
94.00	0.0	0.0
94.50	0.0	0.0
95.00	0.0	0.0
95.50	0.0	0.0
96.00	0.0	0.0
96.50	0.0	0.0
97.00	0.0	0.0
97.50	0.0	0.0
98.00	0.0	0.0
98.30	0.0	0.0
98.50	2.2	2.2
98.90	6.7	6.7
99.00	8.9	8.9
99.10	11.6	11.6
99.20	14.5	14.5
99.30	17.5	17.5
99.50	25.0	25.0
99.80	38.6	38.6
100.00	49.1	49.1

****

J1, B1, S2
POND 012B

Drainage Area from J1, B1, S2, SWS(s)1: 14.7 acres
Total Contributing Drainage Area: 30.8 acres

Elevation	Emergency Spillway (cfs)	Total Discharge (cfs)

84.00	0.0	0.0
84.50	0.0	0.0
85.00	0.0	0.0
85.50	0.0	0.0
86.00	0.0	0.0
86.50	0.0	0.0
87.00	0.0	0.0
87.50	0.0	0.0
88.00	0.0	0.0
88.50	0.0	0.0
89.00	0.0	0.0
89.50	0.0	0.0
90.00	0.0	0.0
90.50	0.0	0.0
91.00	0.0	0.0
91.50	6.8	6.8
91.60	8.1	8.1
91.70	10.9	10.9
91.80	14.1	14.1
91.90	17.5	17.5
92.00	20.9	20.9
92.50	45.7	45.7
92.80	64.0	64.0

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Filename: G:\TONY\UC150\0122NDTR User: ANTHONY MAGLIOCCHINO
Date: 06-26-1992 Time: 10:14:03
POND 012A EMERGENCY SPILLWAY ONLY
Storm: 1.60 inches, 25 year- 6 hour, SCS 6 Hour
Hydrograph Convolution Interval: 0.1 hr

ELEVATION-AREA-CAPACITY-DISCHARGE TABLE

J1, B1, S1
POND 012A

Drainage Area from J1, B1, S1, SWS(s)1-2: 16.0 acres
Total Contributing Drainage Area: 16.0 acres

SW#1: Emergency Spillway

Elev	Stage (ft)	Area (ac)	Capacity (ac-ft)	Discharge (cfs)	
92.00	0.00	0.14	0.00	0.00	
92.50	0.50	0.16	0.07	0.00	
93.00	1.00	0.17	0.16	0.00	
93.50	1.50	0.19	0.25	0.00	
94.00	2.00	0.21	0.35	0.00	
94.50	2.50	0.23	0.46	0.00	
95.00	3.00	0.25	0.58	0.00	
95.50	3.50	0.28	0.71	0.00	
96.00	4.00	0.30	0.86	0.00	
96.50	4.50	0.32	1.01	0.00	
97.00	5.00	0.34	1.18	0.00	
97.50	5.50	0.36	1.36	0.00	
98.00	6.00	0.39	1.54	0.00	
98.30	6.30	0.40	1.66	0.00	Stage of SW#1
98.50	6.50	0.41	1.74	2.23	
98.81	6.81	0.41	1.87	5.70	Peak Stage
98.90	6.90	0.42	1.91	6.69	
99.00	7.00	0.43	1.95	8.90	
99.10	7.10	0.43	1.99	11.59	
99.20	7.20	0.44	2.04	14.46	
99.30	7.30	0.44	2.08	17.54	
99.50	7.50	0.45	2.17	25.03	
99.80	7.80	0.46	2.31	38.59	
100.00	8.00	0.47	2.40	49.12	

J1, B1, S2
POND 012B

Drainage Area from J1, B1, S2, SWS(s)1: 14.7 acres
Total Contributing Drainage Area: 30.8 acres

SW#1: Emergency Spillway

Elev	Stage	Area	Capacity	Discharge

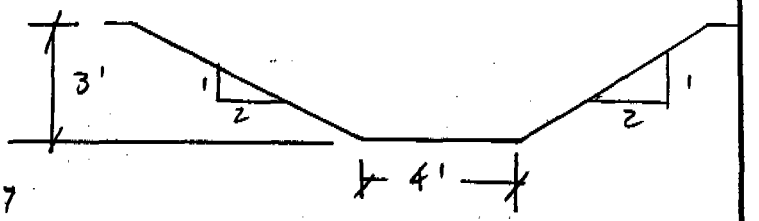
	(ft)	(ac)	(ac-ft)	(cfs)	
84.00	0.00	0.01	0.00	0.00	
84.50	0.50	0.04	0.01	0.00	
85.00	1.00	0.10	0.05	0.00	
85.50	1.50	0.12	0.10	0.00	
86.00	2.00	0.13	0.17	0.00	
86.50	2.50	0.15	0.24	0.00	
87.00	3.00	0.16	0.31	0.00	
87.50	3.50	0.18	0.40	0.00	
88.00	4.00	0.20	0.49	0.00	
88.50	4.50	0.21	0.59	0.00	
89.00	5.00	0.22	0.70	0.00	
89.50	5.50	0.23	0.81	0.00	
90.00	6.00	0.24	0.93	0.00	
90.50	6.50	0.25	1.05	0.00	
91.00	7.00	0.26	1.17	0.00	Stage of SW#1
91.50	7.50	0.27	1.31	6.76	
91.60	7.60	0.27	1.33	8.12	
91.70	7.70	0.27	1.36	10.92	
91.74	7.74	0.27	1.37	12.31	Peak Stage
91.80	7.80	0.28	1.39	14.05	
91.90	7.90	0.28	1.42	17.51	
92.00	8.00	0.28	1.44	20.91	
92.50	8.50	0.29	1.59	45.68	
92.80	8.80	0.30	1.67	64.02	

CASTLE GATE PREP PLANT
OPERATIONAL HYDROLOGY
PONDS

POND 012B - INLET CHANNEL

SLOPE = 3%

Q = 14.32 CFS
(SEDCAD RESULTS)



ASSUME D50 = K = 2" = 0.17

$n = 0.0395\, D50^{1/6}$
$= 0.0395(0.17)^{1/6}$
$= 0.30$

USE FLOWMASTER

$V_{MAX} = 4.98$ FPS

DEPTH = 0.56 FT

US USDOT FIGURES

$\frac{K}{d} = \frac{0.17}{0.56} = 0.30$

FROM FIG. 1, $\frac{V_s}{V} = 0.67$

$V_s = 0.67(V)$
$= 0.67(4.98)$
$= 3.3$ FPS

FROM FIG 2, WITH $V_s = 3.3$ FPS, 2:1 S.S.

D50 = 1.5"

USE D50 = 2"

BUT, IF INLET CHANNEL IS REASONABLY VEGETATED, THEN NO RIPRAP IS REQUIRED.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE

Comment: PREP PLANT - POND 12B INLET

Solve For Depth

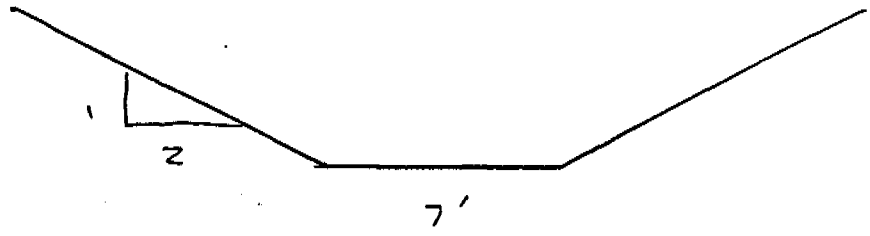
Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0300 ft/ft
Discharge.....	14.32 cfs

Computed Results:

Depth.....	0.56 ft
Velocity.....	4.98 fps
Flow Area.....	2.88 sf
Flow Top Width...	6.25 ft
Wetted Perimeter.	6.51 ft
Critical Depth...	0.66 ft
Critical Slope...	0.0173 ft/ft
Froude Number....	1.29 (flow is Supercritical)

POND 012B SPILLWAY OUTFLOW
RIP RAP SIZING



EXISTING RIPRAP D50 = 9" = 0.75'
Q MAX OUT = 12.30 CFS (SEDCAD, 25YR-6HR STORM RESULTS)

MANNINGS $n = 0.0395\, D_{50}^{1/6} = 0.0395\left(9''/12''/FT\right)^{1/6} = 0.038$

MAX SLOPE ON SPILLWAY OUTSLOPE = 0.5 FT/FT

RESULTS (SEE FOLLOWING PAGE):

VELOCITY = 8.77 FPS

DEPTH = 0.19 FT

FROM FIGURES 1 AND 2:

$\frac{K}{d} > 1 \therefore V_s = V = 8.77$ FPS
(ASSUME 3:1 SLOPE)

REQUIRED RIPRAP D50 = 9"

EXISTING RIPRAP IS ADEQUATE

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND 012-B

Comment: SPILLWAY OUTSLOPE

Solve For Depth

Given Input Data:

Bottom Width.....	7.00 ft
Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.038
Channel Slope....	0.5000 ft/ft
Discharge.....	12.30 cfs

Computed Results:

Depth.....	0.19 ft
Velocity.....	8.77 fps
Flow Area.....	1.40 sf
Flow Top Width...	7.76 ft
Wetted Perimeter.	7.85 ft
Critical Depth...	0.44 ft
Critical Slope...	0.0296 ft/ft
Froude Number....	3.64 (flow is Supercritical)

APPENDIX 3.4I

AS-BUILT CALCULATIONS FOR POND 013

REGISTERED PROFESSIONAL ENGINEER
No. 8435
CAROL A.
BJORK
STATE OF UTAH

Carol A. Bjork
2/1/94

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT C150 PAGE 1 OF 22
COMPUTED CAB DATE 6/90
CHECKED DATE

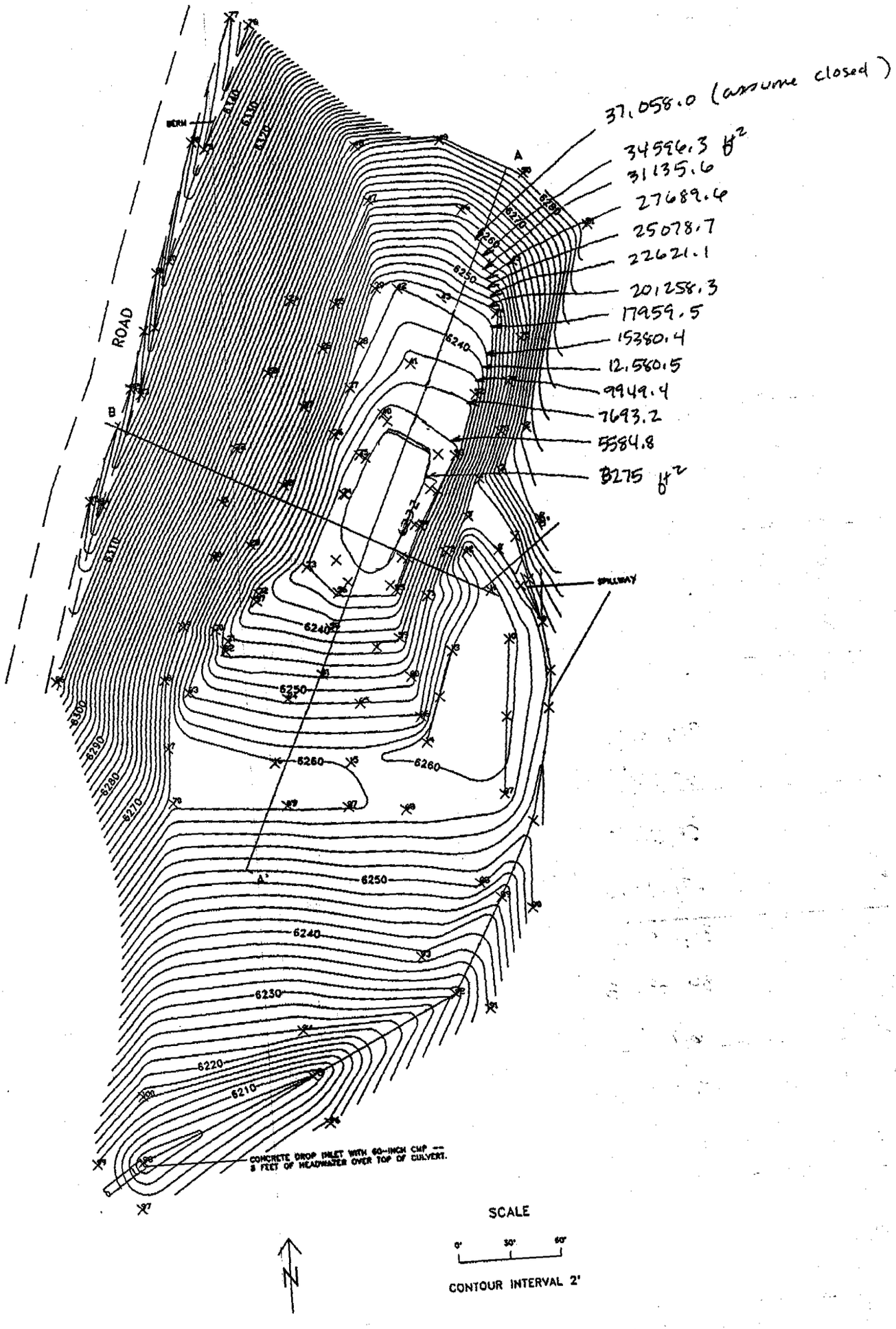
Pond 013

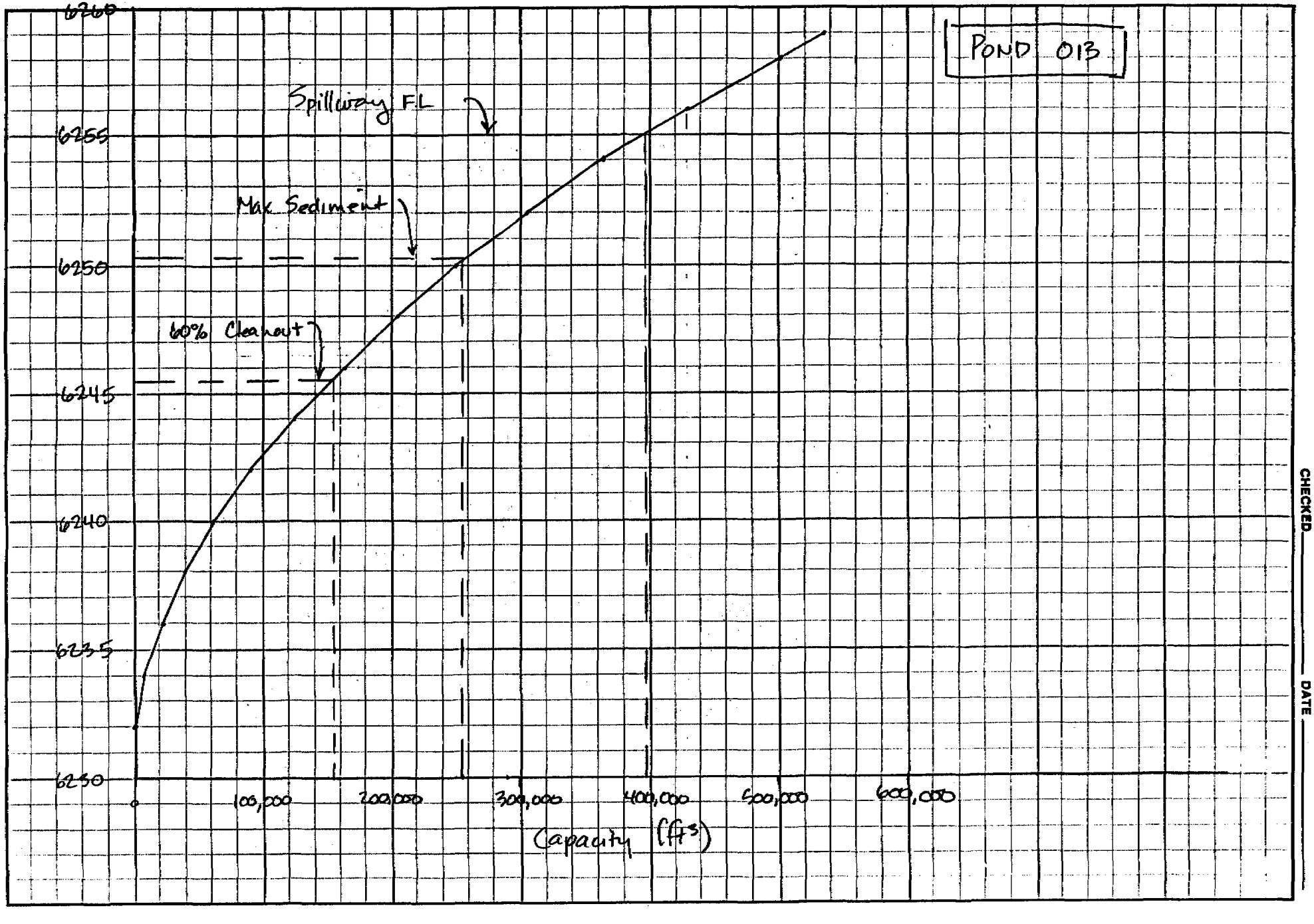
Stage - Capacity Data

Elev	Area (ft²)	Δ vol (ft³)	Cum. vol (ft³)	Cum. vol (Ac-ft)
6232	3275.0		0	0
		8,859.8		
6234	5584.8		8859.8	0.203
		13,278.0		
6236	7693.2		22,137.8	0.508
		17,642.6		
6238	9949.4		39,780.4	0.913
		22,529.4		
6240	12,580.5		62,309.8	1.430
		27,960.9		
6242	15,380.4		90,270.7	2.072
		33,339.9		
6244	17,959.5		123,610.6	2.838
		38,217.8		
6246	20,258.3		161,828.4	3.715
		42,879.4		
6248	22,621.1		204,707.8	4.699
		47,699.8		
6250	25,078.7		252,407.6	5.794
		52,768.3		
6252	27,689.6		305,175.9	7.006
		58,825.2		
6254	31,135.6		364,001.1	8.356
		65,731.9		
6256	34,596.3		429,733.0	9.865
		70,833.7		
6258	36,237.4		500,566.7	11.49
		36,647.7		
6259	37,058.0		537,214.4	12.33

Min. Crest

Pond 013


37,058.0 (assume closed)
34596.3 ft²
31135.6
27689.4
25078.7
22621.1
20,258.3
17959.5
15380.4
12,560.5
9949.4
7693.2
5584.8
3275 ft²
BERM
ROAD
SPILLWAY
A
A'
B
6310
6300
6290
6280
6270
6260
6250
6240
6230
6220
6210
CONCRETE DROP INLET WITH 60-INCH CMP -- 3 FEET OF HEADWATER OVER TOP OF CULVERT.
SCALE
0'
30'
60'
CONTOUR INTERVAL 2'
N



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PAGE 3 OF 6/90
DATE
DATE

Pond 013 - Sediment Calcs.

Basin to Pond	R	K	Slope length	% Slope	m	$LS = \left(\frac{650+450s+65s^2}{10,000+s^2}\right)\left(\frac{l}{72.6}\right)^m$	VM	A = R·K·LS·VM (ton/Ac/yr)	Area (Ac)	Sed Yield (ft³/yr)
D2A	11	.15	2900'	84.5	.6	268.1	.01	4.42	41.10	4039.8
D2B	11	.15	270'	65	.6	47.1	.01	.78	7.60	131.2
D2C	11	.15	1000'	57.2	.6	86.9	.26 (a)	37.28	23.81	19,725.0
D2D	11	.15	600'	66.6	.6	78.5	.01	1.29	4.66	134.0
D2E	11	.15	700'	50.2	.6	58.2	.01	0.96	2.26	48.2
								Total =		24,078.2 ft³/yr

3-year Sediment Storage = 72,234.6 ft³

(a) 5.0 Ac disturbed, VM = 1.20
18.81 Ac undist, VM = .01 Ave VM ± .2600

(Ref: Israelson, et al, 1984)

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Pond 013 – runoff calc's

BASIN	Area (Ac)	CN
CGWS-D2A	41.10	78
D2B	7.60	82
D2C	23.81	85
D2D	4.66	85
D2E	2.26	82
	79.43	

Weighted Average CN = 81

Runoff volume: (10-yr, 24-hr storm ⇒ P = 1.8")

$Q = \frac{(P - .2S)^2}{P + .8S}$ $S = \frac{1000}{CN} - 10 = 2.35$

$Q = .481'' = .040$ ft

Volume = .040 (79.43 Ac) (43,560 ft²/Ac) = 138,595 ft³

From 25-year, 24-hour storm: P = 2.3"

$Q = .801'' = .067$ ft

Volume = .067 (79.43 Ac) (43,560 ft²/Ac) = 231,003 ft³

Runoff + Max Sediment volume =

138,595 ft³ runoff
72,234.6 ft³ sediment
210,829.6 ft³ total

Capacity @ Spillway Flowline = 396,000 ft³

∴ pond fully contains 10-year, 24-hour Storm.

Calculate Max. Sediment level assuming 10-year 24-hour Storm water level @ spillway.

☆ Max Sed. Volume = 396,000 − 138,595 ft³
= 257,405 ft³

Elev. = 6250.2′ (4.8′ below spillway FL)

☆ 60% cleanout volume = 154,443 ft³

Elev. = 6245.5′ (9.5′ below Spillway FL)

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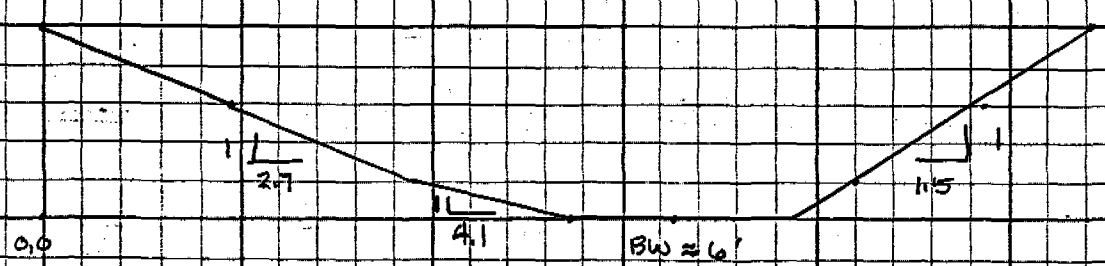
Spillway Section
Pond 013

Sta	Elev
0	6260
4.75	6258
9.5	6256
13.6	6255
16.3	6255
21	6256
24.4	6258
27.1	6260
31.2	6262



Riprap d_{50} = 18"

Scale: 1" = 5'

Calculate the discharge relationship from trapezoidal channel spillway =

Based on 100-ft wide rectangular section =

$$q_r = (.544)g^{1/2}(H_{ec})^{1.5}(100) = 308.69\ H_{ec}^{1.5}$$

Using Attached Figure = L = ~30'

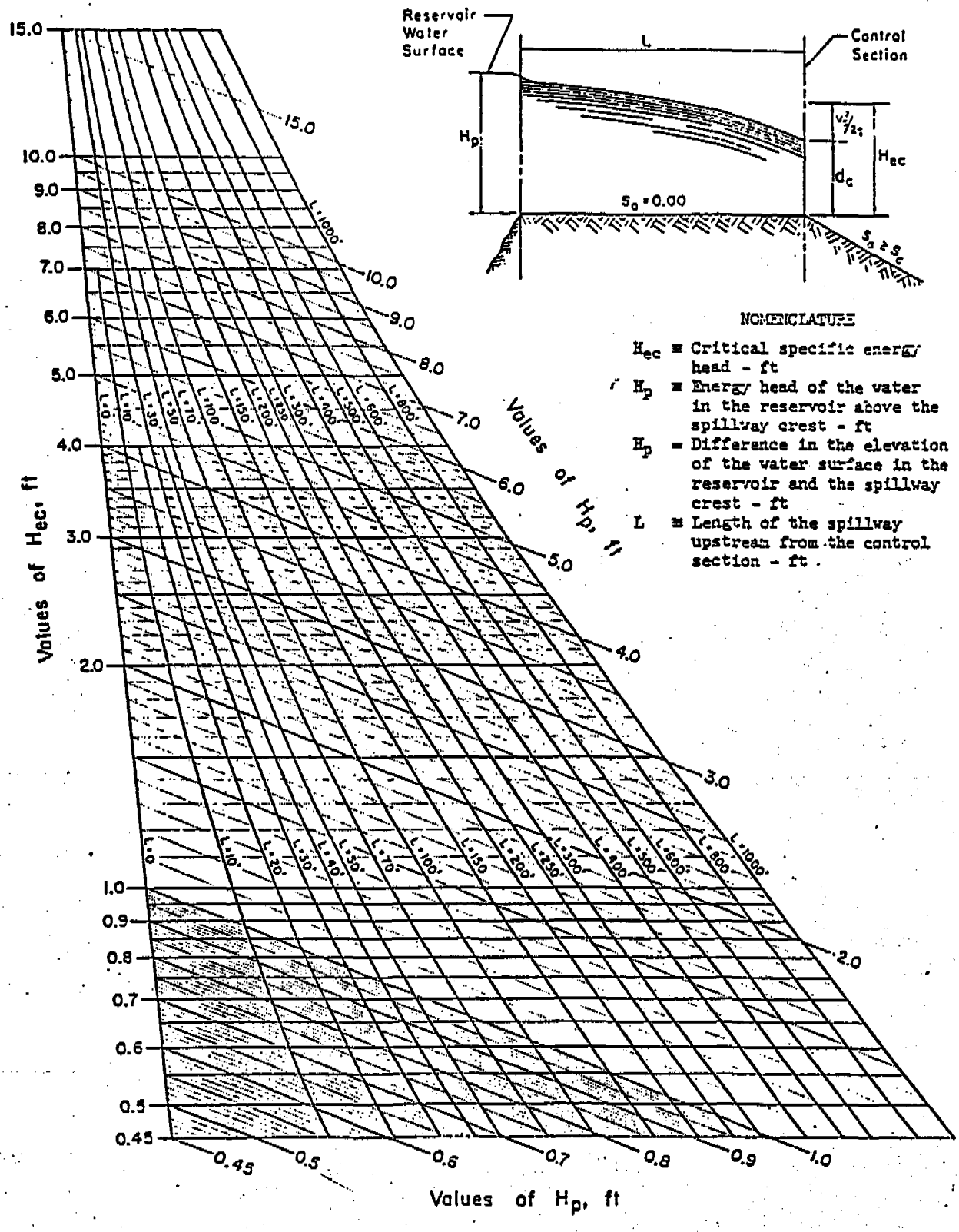
H_p (ft)	H_{ec} (ft)	q_r (ft^3/s)
1.0	.77	208.57
2.0	1.73	702.41
3.0	2.70	1369.5
4.0	3.70	2197.0

Convert to Trap channel Section by =

$$q_{trap} = \left[(1.5b + 2H_{ec})/150\right](q_r)$$

b = bottom width ~6'
z = side slope (run/rise) = 2.1/1 = 2.1

Elev	H_{ec} (ft)	q_r (ft^3/s)	q_{trap} (cfs)
6256	.77	208.6	14.8
6257	1.73	702.4	59.2
6258	2.7	1369.5	133.9
6259	3.7	2197.0	245.6



Head relationships for selected broad-crest weirs (from U.S. Soil Conservation Service, 1968)

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Pond 013

Assume pond full of Sediment up to Max. Sed. level.

	Elev (ft)	Stage	Area (ft²)	Area (Ac)	Discharge
	6250.15	0	0	0	0
	6250.2	.05	25,339.8	.582	0
	6252	1.85	27,689.6	.636	0
	6254	3.85	31,139.6	.715	0
Spillway →	6255	4.85	32,866.0	.754	0
	6256	5.85	34,596.3	.794	14.8
	6258	7.85	36,237.4	.832	133.9
Min. Crest Elev →	6259	8.85	37,058.0	.851	245.6

Sub-Basin

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SEDIMOT INPUT

Watershed Data

	Area (Ac)	CN	T_c (hr)
CGWS-D2A	41.1	78	.144
D2B	7.6	82	.099
D2C	23.81	85	.143
D2D	4.66	85	.052
D2E	21.26	82	.081

- SCS Type II distribution.
- Refer to Stage - discharge data + Input in SEDIMOT II

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*****************************************************************
                        -- SEDPC --
              SEDIMOT II MODEL FOR THE IBM PC/XT
              CONVERTED BY TECH ENGINEERING INC.
                 VERSION 1.10 NOVEMBER 17,1983
*****************************************************************


*****************************************************************
*****************************************************************

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*****************************************************************


*****************************************************************
*                                                               *
*     THE FOLLOWING VALUES ARE NOW PREDICTED BY SEDIMOT II.     *
*     THEY CAN BE FOUND IN SUMMARY TABLES.                      *
*      1. PERIOD OF SIGNIFICANT CONCENTRATION                   *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION      *
*         DURING PEAK 24 HOUR PERIOD                            *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION            *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION           *
*         DURING PEAK 24 HOUR PERIOD                            *
*                                                               *
*     ALL CONCENTRATIONS ARE IN ML/L.                           *
*                                                               *
*****************************************************************
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****

WATERSHED IDENTIFICATION CODE

POND 013, INPUT A STAGE-DISCHARGE CURVE

****

INPUT PARTICLE SIZE-PERCENT FINER DISTRIBUTIONS

SIZE,MM	.250	.100	.050	.010	.005	.001
	.000					
PCT FINER NO. 1	100.000	50.000	35.000	19.000	15.000	6.000
	.000					

**********INPUT VALUES**********

STORM DURATION	=	24.00	HOURS
PRECIPATION DEPTH	=	2.30	INCHES
SPECIFIC GRAVITY	=	2.50	
LOAD RATE EXPONENT FACTOR	=	1.50	
SUBMERGED BULK SPECIFIC GRAVITY	=	1.25	

* *

JUNCTION 1, BRANCH 1, STRUCTURE 1

* *

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	41.10	78.00	.144	.000	.000	.00	3.0
2	7.60	82.00	.099	.000	.000	.00	.0
3	23.81	85.00	.143	.000	.000	.00	1.0
4	4.66	85.00	.052	.000	.000	.00	.0
5	2.26	82.00	.081	.000	.000	.00	.0

*** SEDIMENT INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	SEG NUM	SOIL K	LENGTH FEET	SLOPE PCT	CP VALUE	PART OPT	SURF COND
1	1	.00	.0	.00	.000	1.0	.0
2	1	.00	.0	.00	.000	1.0	.0
3	1	.00	.0	.00	.000	1.0	.0
4	1	.00	.0	.00	.000	1.0	.0
5	1	.00	.0	.00	.000	1.0	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)	SEDIMENT TONS	DIAM (MM)	DELIVERY RATIO 1	DELIVERY RATIO 2
1	14.61	.66	.00	.040	.654	1.000
2	7.06	.85	.00	.100	1.000	1.000
3	23.53	1.02	.00	.087	.939	1.000
4	5.06	1.02	.00	.100	1.000	1.000
5	2.10	.85	.00	.100	1.000	1.000

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	5.3898	ACRE-FT
PEAK DISCHARGE	=	49.3731	CFS
AREA	=	79.4300	ACRES
TIME OF PEAK DISCHARGE	=	12.00	HRS
BETA	=	1.0000	
RAINFALL EROSITIVITY FACTOR	=	29.51	EI UNIT
PEAK CONCENTRATION	=	.00	MG/L
PEAK SETTLEABLE CONCENTRATION	=	.00	ML/L
PEAK SETTLEABLE CONCENTRATION	=	.00	MG/L
TOTAL SEDIMENT YIELD	=	.0000	TONS
REPRESENTATIVE PARTICLE SIZE	=	.0001	MM
TIME OF PEAK CONCENTRATION	=	.00	HRS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-26.30	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

* *

POND RESULTS

* *

***** CONTROL VARIABLES OPTIONS *****

FLOW	FRACTN	ISDO	NRHP	NSP	NCSTR
3	0	1	500	8	1

***** BASIN GEOMETRY *****

STAGE (FT)	AREA (ACRES)	AVERAGE DEPTH (FT)	DISCHARGE (CFS)	CAPACITY (ACRES-FT)
.00	.000	.00	.00	.00
.05	.582	.03	.00	.01
1.85	.636	1.78	.00	1.11
3.85	.715	3.68	.00	2.46
4.85	.754	4.60	.00	3.20
5.85	.794	5.50	14.80	3.97
7.85	.832	7.32	133.90	5.60
8.85	.851	8.23	245.60	6.44

16/

***** STORM EVENT SUMMARY *****

TURBULENCE FACTOR	=	1.00	
PERMANENT POOL CAPACITY	=	3.196	ACRE-FT
DEAD STORAGE	=	20.00	PERCENT
TIME INCREMENT OUTFLOW	=	.10	HRS
VISCOSITY	=	.009	CM**2/SEC
INFLOW RUNOFF VOLUME	=	5.390	ACRE-FT
OUTFLOW ROUTED VOLUME	=	5.390	ACRE-FT
STORM VOLUME DISCHARGED (PLUG FLOW)	=	5.390	ACRE-FT
POND VOLUME AT PEAK STAGE	=	4.202	ACRE-FT
PEAK STAGE	=	6.135	FT
PEAK INFLOW RATE	=	49.373	CFS
PEAK DISCHARGE RATE	=	31.781	CFS
PEAK INFLOW SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.0000	ML/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.00	MG/L
STORM AVERAGE EFFLUENT CONCENTRATION	=	.00	MG/L
AVERAGE EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
BASIN TRAP EFFICIENCY	=**********		PERCENT
DETENTION TIME OF FLOW WITH SEDIMENT	=	.58	HRS
DETENTION TIME FROM HYDROGRAPH CENTERS	=	.58	HRS
DETENTION TIME INCLUDING STORED FLOW	=	.58	HRS
SEDIMENT LOAD DISCHARGED	=	.00	TONS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-29.50	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

Elev. = 6050.15 + 6.14 = 6056.29 ft

Freeboard = 6059 - 6056.3 = 2.7 ft > 1.0 ft OK

*** RUN COMPLETED ****

Pond 013

Rainfall Distribution - SCS Type B - 6 hour, 100 year

Time (%)	Depth (%)	Time (Hrs.)	Depth (in)	30-min. intensity
0	0	0	0	
8.33	3.5	0.5	.07	.07
16.67	8.0	1.0	.16	.09
25.0	13.5	1.5	.27	.11
33.33	23.0	2.0	.46	.19
41.67	60.0	2.5	1.20	.74 Peak
50.0	70.0	3.0	1.40	.2
58.33	78.0	3.5	1.56	.16
66.67	83.5	4.0	1.67	.11
75.0	88.5	4.5	1.77	.10
83.33	92.5	5.0	1.85	.08
91.67	96.5	5.5	1.93	.08
100	100.0	6.0	2.0	.07

Run Sedimot II again to check spillway design for the 100-year 6-hour storm.

16C

1 **********

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SEDIMOT II MODEL FOR THE IBM PC/XT
CONVERTED BY TECH ENGINEERING INC.
VERSION 1.10 NOVEMBER 17,1983

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*************************************************************
*                                                           *
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*      1. PERIOD OF SIGNIFICANT CONCENTRATION               *
*      2. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION  *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION        *
*      3. VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION  *
*         DURING PEAK 24 HOUR PERIOD                        *
*      4. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION       *
*         DURING PERIOD OF SIGNIFICANT CONCENTRATION        *
*      5. ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION       *
*         DURING PEAK 24 HOUR PERIOD                        *
*                                                           *
*     ALL CONCENTRATIONS ARE IN ML/L.                       *
*                                                           *
*************************************************************
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WATERSHED IDENTIFICATION CODE

POND 013 - 100 YEAR, 6-HOUR STORM

****

********** INPUT RAINFALL PATTERN **********

VALUE	DEPTH	TIME
1	.00	.00
2	.07	.50
3	.16	1.00
4	.27	1.50
5	.46	2.00
6	1.20	2.50
7	1.40	3.00
8	1.56	3.50
9	1.67	4.00
10	1.77	4.50
11	1.85	5.00
12	1.93	5.50
13	2.00	6.00

INPUT PARTICLE SIZE-PERCENT FINER DISTRIBUTIONS

SIZE,MM	.250	.100	.050	.010	.005	.001
	.000					
PCT FINER NO. 1	100.000	50.000	35.000	19.000	15.000	6.000
	.000					

**********INPUT VALUES**********

STORM DURATION	=	6.00	HOURS
PRECIPATION DEPTH	=	2.00	INCHES
SPECIFIC GRAVITY	=	2.50	
LOAD RATE EXPONENT FACTOR	=	1.50	
SUBMERGED BULK SPECIFIC GRAVITY	=	1.25	

* *
JUNCTION 1, BRANCH 1, STRUCTURE 1
* *

*** HYDRAULIC INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	AREA ACRES	CURVE NUMBER	TC HR	TT HR	ROUTING COEFFICIENTS K-HRS	X	UNIT HYDRO
1	41.10	78.00	.144	.000	.000	.00	1.0
2	7.60	82.00	.099	.000	.000	.00	.0
3	23.81	85.00	.143	.000	.000	.00	1.0
4	4.66	85.00	.052	.000	.000	.00	.0
5	2.26	82.00	.081	.000	.000	.00	.0

*** SEDIMENT INPUT VALUES FOR SUBWATERSHEDS ***

WATER SHED	SEG NUM	SOIL K	LENGTH FEET	SLOPE PCT	CP VALUE	PART OPT	SURF COND
1	1	.00	.0	.00	.000	1.0	.0
2	1	.00	.0	.00	.000	1.0	.0
3	1	.00	.0	.00	.000	1.0	.0
4	1	.00	.0	.00	.000	1.0	.0
5	1	.00	.0	.00	.000	1.0	.0

* * * COMPUTED VALUES FOR INDIVIDUAL WATERSHEDS * * *

WATERSHED	PEAK FLOW (CFS)	RUNOFF (INCHES)	SEDIMENT TONS	DIAM (MM)	DELIVERY RATIO 1	DELIVERY RATIO 2
1	15.18	.48	.00	.073	.867	1.000
2	4.76	.65	.00	.100	1.000	1.000
3	16.21	.80	.00	.083	.919	1.000
4	3.59	.80	.00	.100	1.000	1.000
5	1.41	.65	.00	.100	1.000	1.000

NOTE: SEDIMENT DOES NOT INCLUDE POSSIBLE DEPOSITION BY DELIVERY RATIO 2

***** SUMMARY TABLE FOR TOTAL WATERSHED *****

RUNOFF VOLUME	=	4.0785	ACRE-FT
PEAK DISCHARGE	=	35.9536	CFS
AREA	=	79.4300	ACRES
TIME OF PEAK DISCHARGE	=	2.50	HRS
BETA	=	1.0000	
RAINFALL EROSITIVITY FACTOR	=	11.99	EI UNIT
PEAK CONCENTRATION	=	.00	MG/L
PEAK SETTLEABLE CONCENTRATION	=	.00	ML/L
PEAK SETTLEABLE CONCENTRATION	=	.00	MG/L
TOTAL SEDIMENT YIELD	=	.0000	TONS
REPRESENTATIVE PARTICLE SIZE	=	.0001	MM
TIME OF PEAK CONCENTRATION	=	.00	HRS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-6.60	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

* *

POND RESULTS

* *

***** CONTROL VARIABLES OPTIONS *****

FLOW	FRACTN	ISDO	NRHP	NSP	NCSTR
3	0	1	500	8	1

***** BASIN GEOMETRY *****

STAGE (FT)	AREA (ACRES)	AVERAGE DEPTH (FT)	DISCHARGE (CFS)	CAPACITY (ACRES-FT)
.00	.000	.00	.00	.00
.05	.582	.03	.00	.01
1.85	.636	1.78	.00	1.11
3.85	.715	3.68	.00	2.46
4.85	.754	4.60	.00	3.20
5.85	.794	5.50	14.80	3.97
7.85	.832	7.32	133.90	5.60
8.85	.851	8.23	245.60	6.44

***** STORM EVENT SUMMARY *****

TURBULENCE FACTOR	=	1.00	
PERMANENT POOL CAPACITY	=	3.196	ACRE-FT
DEAD STORAGE	=	20.00	PERCENT
TIME INCREMENT OUTFLOW	=	.10	HRS
VISCOSITY	=	.009	CM**2/SEC
INFLOW RUNOFF VOLUME	=	4.079	ACRE-FT
OUTFLOW ROUTED VOLUME	=	4.079	ACRE-FT
STORM VOLUME DISCHARGED (PLUG FLOW)	=	4.079	ACRE-FT
POND VOLUME AT PEAK STAGE	=	4.034	ACRE-FT
PEAK STAGE	=	5.929	FT
PEAK INFLOW RATE	=	35.954	CFS
PEAK DISCHARGE RATE	=	19.488	CFS
PEAK INFLOW SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.0000	ML/L
PEAK EFFLUENT SETTLEABLE CONCENTRATION	=	.00	MG/L
STORM AVERAGE EFFLUENT CONCENTRATION	=	.00	MG/L
AVERAGE EFFLUENT SEDIMENT CONCENTRATION	=	.00	MG/L
BASIN TRAP EFFICIENCY	=**********		PERCENT
DETENTION TIME OF FLOW WITH SEDIMENT	=	.62	HRS
DETENTION TIME FROM HYDROGRAPH CENTERS	=	.62	HRS
DETENTION TIME INCLUDING STORED FLOW	=	.62	HRS
SEDIMENT LOAD DISCHARGED	=	.00	TONS
PERIOD OF SIGNIFICANT CONCENTRATION	=	-12.10	HRS
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
VOLUME WEIGHTED AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PERIOD OF SIGNIFICANT CONCENTRATION	=	.00	ML/L
ARITHMETIC AVERAGE SETTLEABLE CONCENTRATION DURING PEAK 24 HOUR PERIOD	=	.00	ML/L

POND 013 – SUMMARY

25-year, 24-hour Storm:

Peak Stage = 6.135'

Elev = 6256.29'
Freeboard = 2.7 ft

Peak inflow rate = 49.4 cfs
Peak discharge rate = 31.8 cfs

100-year, 6-hour Storm:

Peak Stage = 5.929'

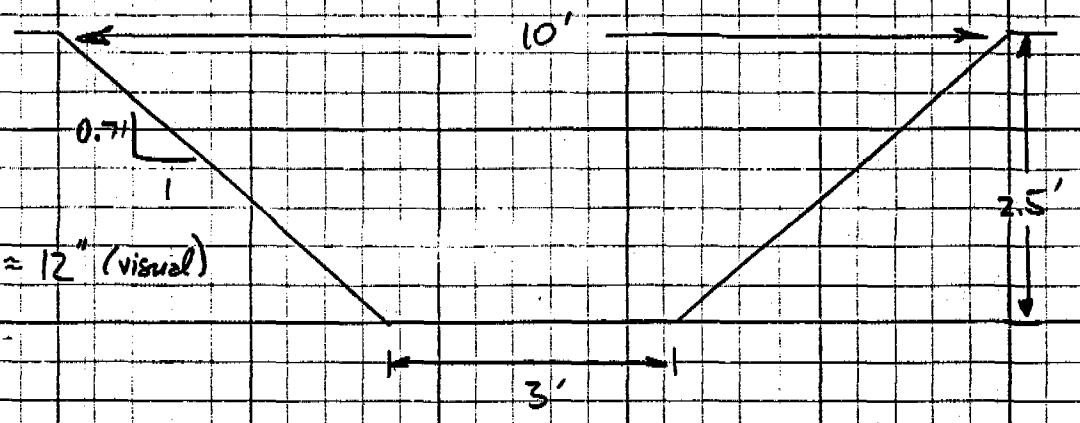
Elev = 6256.08'
Freeboard = 2.92'

Peak inflow rate = 35.95 cfs
Peak discharge rate = 19.5 cfs

Since the 25-year, 24-hour storm is the larger of the two – check the spillway disigns with the larger event.

Pond 013 – Inlet channels

Typical cross section (both east and west):



$d_{50} \approx 12''$ (visual)

West Inlet channel:

Uniform slope $= \frac{30'}{72'} = 0.42$

Peak inflow (25-yr, 24-hr) = 23.53 cfs (SEDIMOT II Subwatershed #3)

n = 0.040 (w/ d_{50} = 12")

Bed Slope =	.42	
Manning's N =	.04	
Bottom Width =	3	feet
Channel Side Slope =	.71	
Flow Depth =	.4945018	feet — OK
Cross Sectional Area =	1.827916	square feet
Wetted Perimeter =	4.708354	feet
Hydraulic Radius =	.3882283	feet
Discharge =	23.53	cubic feet/sec
Velocity =	12.87258	feet/sec
Froude Number =	3.225922	→ Check riprap adequacy

Riprap check → see pg 18 & 19 of this calc.

$\frac{k}{d} > 1.0$. Therefore, $V_s = V = 12.9$ ft/s

Due to steep slope of channel bottom, use curve for slope = 2:1

Req'd $d_{50} \approx 1.4 = 16.8''$. Existing riprap is undersized, based on 25-year, 24-Hour Storm.

Re-calculate using 25-year, 6-Hour Storm ⟹

a

```
*******************************
* EARTHFAX ENGINEERING, INC.  *
*                             *
* HYDROGRAPH GENERATION MODEL *
*   USING SCS CURVE NUMBER    *
*         METHODOLOGY         *
*******************************
```

** 25-year, 6-hour Storm for West Inlet Channel

IDENTIFICATION: CG SUBWATERSHED 3

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = SCS TYPE B          AREA =  0.037 SQ. MI.
        DEPTH =  1.60 IN.           CN = 85.0
        DURATION =  6.0 HR.         TIME OF CONC. =  0.14 HR.
*************************************************************
```

```
*************************************************************
```

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  0.5164 INCHES
     INITIAL ABSTRACTION =  0.3529 INCHES
     PEAK FLOW =    10.84 CFS  ( 0.4541 IN/HR)
     TIME TO PEAK =   2.51 HOURS
     RUNOFF VOLUME CHECK =  0.5174 INCHES
*************************************************************
```

Check velocity of West inlet channel using the 25-year 6-hour Storm:

Q = 10.8 cfs
Slope = .42
n = .040

Bottom width = 3'
Side Slopes = 1H : .71V

Results: depth = .32' OK ✓
Velocity = 9.95 ft/sec

Check Riprap — $\frac{k}{d} \geq 1$ therefore $\frac{V}{V_s} = 1$ + $V = V_s = 10$ ft/s

Reqd $D_{50} = 0.8$ ft $= 9.6''$

$\boxed{\text{Existing riprap } d_{50} = 12'' \text{ is Adequate}}$

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: POND 013 WEST INLET

Comment: POND 013 WEST INLET CHANNEL

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.41:1 (H:V)
Right Side Slope.	1.41:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.4200 ft/ft
Discharge.....	10.80 cfs

Computed Results:

Depth.....	0.32 ft
Velocity.....	9.95 fps
Flow Area.....	1.09 sf
Flow Top Width...	3.89 ft
Wetted Perimeter.	4.09 ft
Critical Depth...	0.66 ft
Critical Slope...	0.0321 ft/ft
Froude Number....	3.32 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

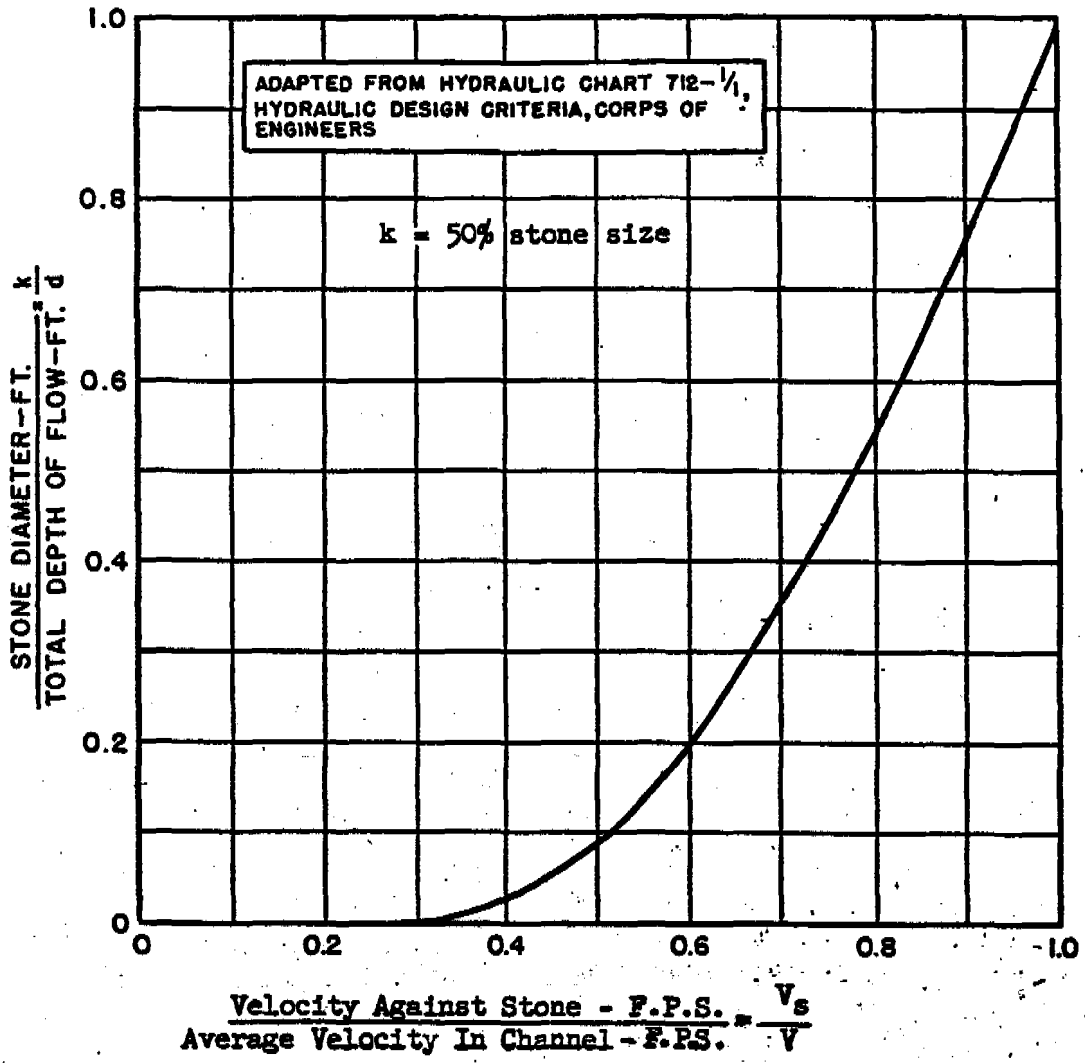


FIG. 1 - VELOCITY AGAINST STONE ON CHANNEL BOTTOM

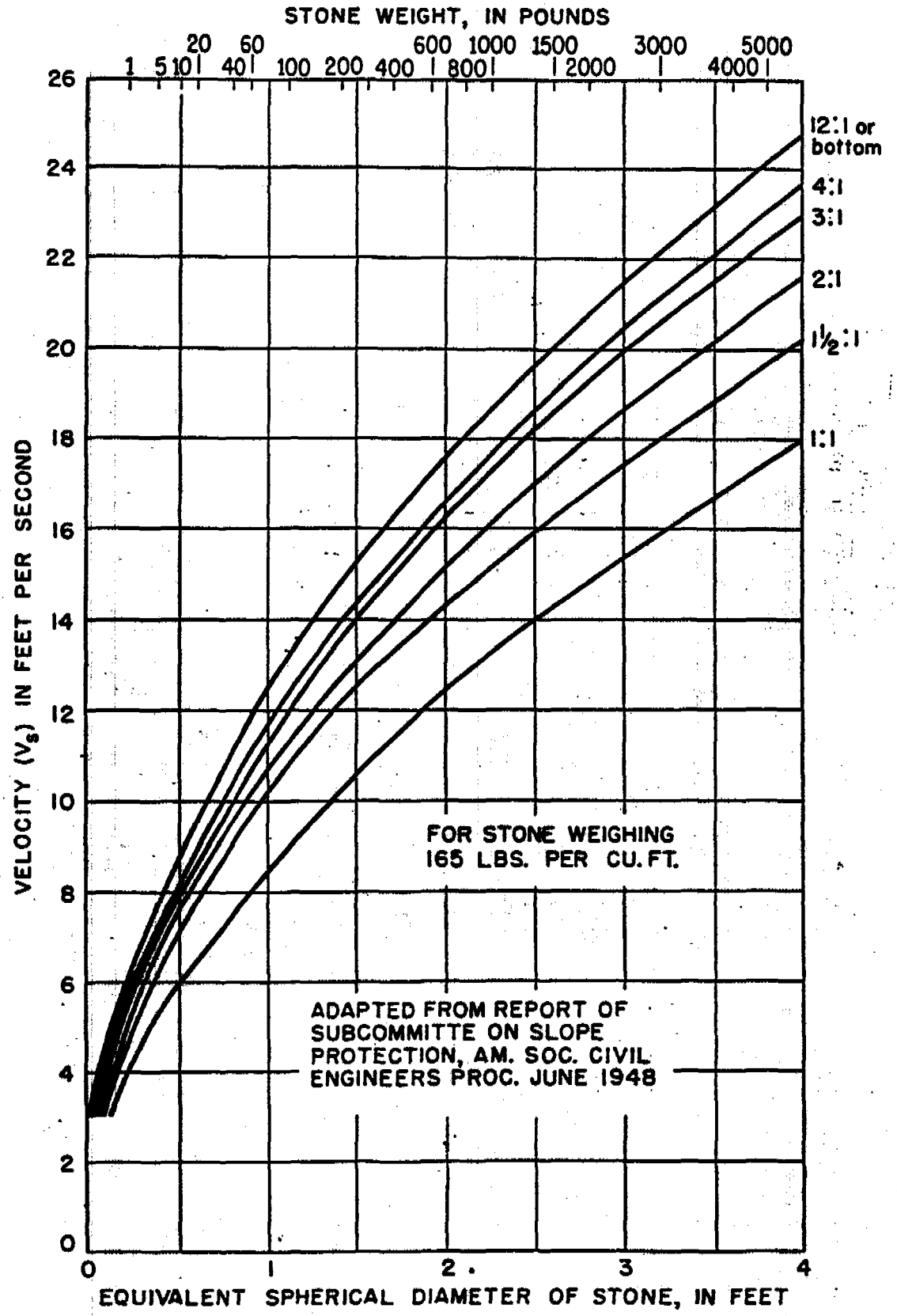


FIG. 2-SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

East Inlet Channel

Uniform slope = $\frac{20}{41}$ = 0.49

Peak inflow (25-yr, 24-hr) = 5.06 cfs (SEDIMOT II Subwatershed #4)
n = 0.040 (for d_{50} = 12")

Bed Slope =	.49	
Manning's N =	.04	
Bottom Width =	3	feet
Channel Side Slope =	.71	
Flow Depth =	.1917146	feet — ok
Cross Sectional Area =	.6269107	square feet
Wetted Perimeter =	3.662316	feet
Hydraulic Radius =	.1711788	feet
Discharge =	5.06	cubic feet/sec
Velocity =	8.071325	feet/sec
Froude Number =	3.248548	

→ Check riprap adequacy.

From pp 18 & 19 of this calc:

$\frac{k}{d} > 1 \Rightarrow V_s = V = 8.1$ ft/s (Slope = 2:1)

Req'd $d_{50} \approx 0.6'$ ⇒ Therefore, Riprap ok
= 7.2"

POND 013 Outlet structure (velocity check)

Peak outflow = 31.78 cfs

Stage-discharge curve for channel (see cross section on pg 7 of this calc.):

Depth Above Channel Bottom (ft)	Wetted Perimeter (ft)	Flow Area (ft²)	Hydraulic Radius (ft)	Flow Velocity[a] (ft/s)	Flow Rate[a] (cfs)
0.1	6.60	0.63	0.10	5.23	3.29
0.2	7.20	1.31	0.18	7.73	10.13
0.3	7.80	2.05	0.26	9.88	20.25
0.4	8.40	2.85	0.34	11.82	33.69
0.5	9.00	3.70	0.41	13.39	49.54
0.6	9.60	4.61	0.48	14.87	68.55

[a] Based on channel slope = 0.47 ft/ft and n = 0.042

Design velocity = 11.4 ft/s. (See pg 22 of this calc.) Based on the graphs presented on pg 18 and 19 of this calc.:

$\frac{k}{d} > 1 \quad \therefore V_s = V$

Slope ≈ 2:1 (steep bottom slope)

Req'd d_{50} = 1.2 ft = 14.4"

Actual d_{50} = 18" ⟹ Riprap OK

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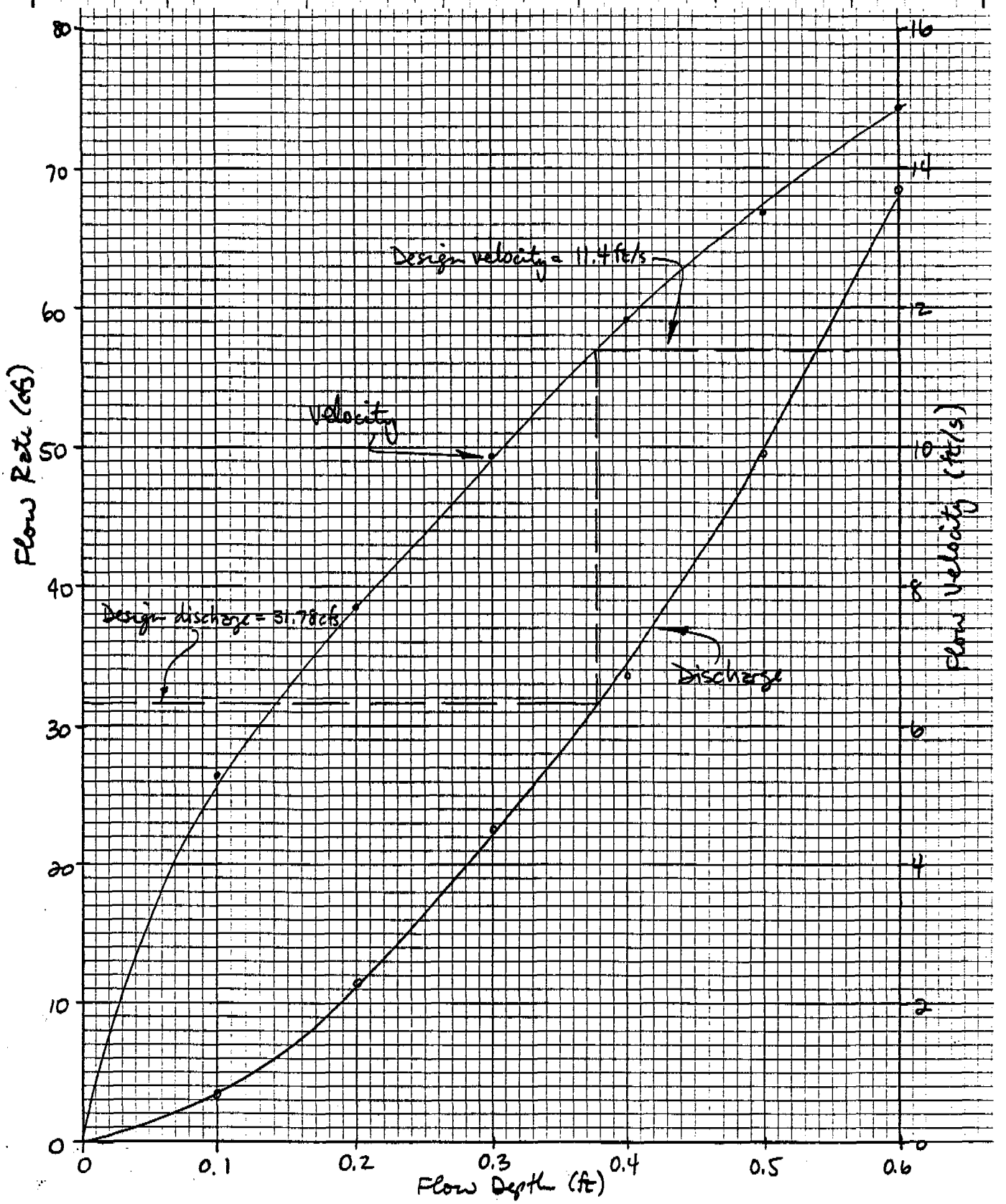

Chapter 3, Section 3.4
Castle Gate Mine
Preparation Plant

January 1995

SUPPLEMENT TO

APPENDIX 3.4J

DRAINAGE CONTROL DESIGN CALCULATIONS
FOR SCHOOL HOUSE CANYON REFUSE SITE DIVERSION STRUCTURES -
CURRENT OPERATION, FINAL OPERATION, AND RECLAMATION PHASES

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REGISTERED PROFESSIONAL ENGINEER
No. 8435
CAROL A.
BJORK
STATE OF UTAH
Carol A. Bjorkman
1/17/95

007/004

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA
GENERAL ASSUMPTIONS FOR CHANNEL DESIGN.

1.) RIPRAP SIZING IS BASED ON A METHOD DEFINED BY THE U.S. DEPT OF TRANSPORTATION (1978) SEE ATTACHED FIGURES.

2.) DESIGN CAPACITY OF CHANNEL BASED ON THE 100-YR, 6 HOUR STORM EVENT AND THE MINIMUM CHANNEL SLOPE.

3.) DESIGN RIPRAP D_{50} (MAX FLOW VELOCITY) BASED ON THE 100-YR, 6 HOUR STORM EVENT AND THE MAXIMUM CHANNEL SLOPE.

4.) THE ROUGHNESS COEFFICIENT (MANNINGS "n") FOR RIPRAPPED CHANNELS WAS DETERMINED ACCORDING TO THE EQUATION (BARFIELD et. al., 1981):

$$n = 0.0395\, D_{50}^{1/6}$$

WHERE: n = MANNING'S ROUGHNESS COEFFICIENT.
D_{50} = MEDIAN RIPRAP DIAMETER (FT.).

5.) MINIMUM CHANNEL + RIPRAP SIZING BASED ON THE MAXIMUM PEAK FLOW FROM EITHER THE CURRENT OPERATION, FINAL OPERATION OR FINAL RECLAMATION DESIGN VALUES.

CASTLEGATE AREA
SCHOOL HOUSE CANYON REFUSE AREA

CURRENT OPERATION PEAK DISCHARGE CALCULATIONS

3.4.1

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

CURRENT OPERATION CHANNEL WATERSHED AREA.

WATERSHED I.D.	AREA (AC.)
CGWS-D2A	41.1
CGWS-D2B	8.0
CGWS-D2C	14.7
CGWS-D2D	4.7
CGWS-D2E.	6.3
TOTAL AREA	74.8 AC.

CGWS-U3B 172.9

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CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA
CURRENT OPERATION
DETERMINE AVERAGE WATERSHED SLOPE

$$WS = 0.25\,(EM - EN)\,(LC_{25} + LC_{50} + LC_{75}) \,/\, AREA$$

EM = MAX. ELEVATION
EN = MIN. ELEVATION
LC = CONTOUR LENGTH @ 25, 50, 75 % OF EM - EN.
WS = WATERSHED SLOPE

WATERSHED	EM	EN	LC_{25}	LC_{50}	LC_{75}	AREA (AC.)	WS (%)
CGWS-D2A	7740	6350	1350	1400	900	41.1	70.9
CGWS-D2B	6570	6300	440	1360	900	8.0	52.7
CGWS-D2C	7220	6380	1000	600	150	14.7	57.4
CGWS-D2D	6700	6184	400	350	250	4.7	63.0
CGWS-D2E	6386	6306	100	300	400	6.3	5.8

REF: CHANG, M., S.P. WATTERS AND A.K. SAYOK. 1989. A COMPARISON OF METHODS OF ESTIMATING MEAN WATERSHED SLOPE. WATER RESOURCES BULLETIN. VOL 25, NO. 2.

NOTE: SEE ~~APPENDIX~~ 3.4D FOR CGWS-U3B PARAMETERS.

3.4J

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA
CURRENT OPERATION
CURVE NUMBERS

WATERSHED	CN
CGWS-D2A	78
CGWS-D2B	82
CGWS-D2C	85
CGWS-D2D	85
CGWS-D2E	90
CGWS-D3B	75

CURVE NUMBERS WERE TAKEN FROM APPENDIX 3.4D, "DISTURBED AND UNDISTURBED AREA RUNOFF CALCULATIONS", CASTLE GATE PREP PLANT, OPERATIONS PHASE.

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CASTLE GATE SCHOOL HOUSE CANYON
CURRENT OPERATION

TIME OF CONCENTRATION CALC'S

WATERSHED I.D.	HYD. LENGTH (ℓ) (Ft.)	CN	$S = \frac{1000}{CN} - 10$	Y % SLOPE	$L = \frac{(\ell^{0.8})(S+1)^{0.7}}{1900\,(Y)^{0.5}}$ (Hr)	$T_c = 1.67L$ (Hr).
CGWS-D2A	2900	78	2.82	70.9	0.094	0.157
CGWS-D2B	1800	82	2.20	52.7	0.066	0.110
CGWS-D2C	1900	85	1.76	57.4	0.059	0.099
CGWS-D2D	1000	85	1.76	63.0	0.034	0.057
CGWS-D2E	1200	90	1.11	5.8	0.107	0.179

NOTE: SEE APPENDIX 3.4D FOR CGWS-U3B PARAMETERS.

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PROJECT UC-150 PAGE 7 OF
COMPUTED TJC DATE 6-22-92
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CASTLE GATE SCHOOL HOUSE CANYON

PEAK DISCHARGE VALUES

100 YEAR - 6 HOUR PRECIPITATION = 2.1 INCHES
SCS TYPE B DISTRIBUTION.

WATERSHED	CN	AREA (AC)	TIME OF CONC. (HR)	Q (100-6) (CFS)
CGWS-D2A	78	41.1	0.157	18.51
CGWS-D2B	82	8.0	0.110	5.28
CGWS-D2C	85	14.7	0.099	12.00
CGWS-D2D	85	4.7	0.057	3.99
CGWS-D2E	90	6.3	0.179	6.61
CGWS-U3B	75	172.9	0.386	33.93

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3.4J

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

CURRENT OPERATION HYDROLOGY

DIVERSION DISCHARGE SUMMARY

DIVERSION DITCH	CONTRIBUTORY WATERSHED (EXHIBIT 3.4-2)	TOTAL DRAINAGE AREA (Acres)	DESIGN DISCHARGE (100 Yr-6 Hr)(cfs)
CGD-6 (upper)	CGWS-D2A,D2B,D2E	55.4	30.40
CGD-6 (lower)	CGWS-D2A,D2B,D2E	55.4	30.40
CGD-7 (upper)	CGWS-D2C,D2E	21.0	18.61
CGD-7 (lower)	CGWS-D2C,D2D,D2E	25.7	22.60
CGD-19	CGWS-D2A,D2B,D2E	55.4	~~10.22~~ 30.4
CGD-5	CGWS-U3B	172.9	33.93

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HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

CURRENT OPERATIONS (100 YR - 6 HR STORM)

INPUT FOR: CGWS-D2A

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 41.10 acres
Depth = 2.10 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.157 hrs

OUTPUT SUMMARY

Runoff depth	0.54150	inches		
Initial abstr	0.56410	inches		
Peak flow =	18.51	cfs	(0.44669	iph)
at time	2.554	hrs		

INPUT FOR: CGWS-D2B

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 8.00 acres
Depth = 2.10 inches	CN = 82.00
Duration = 6.00 hrs	Time conc.= 0.110 hrs

OUTPUT SUMMARY

Runoff depth	0.71545	inches		
Initial abstr	0.43902	inches		
Peak flow =	5.28	cfs	(0.65505	iph)
at time	2.523	hrs		

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HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

CURRENT OPERATIONS (100 YR - 6 HR STORM)

INPUT FOR: CGWS-D2C

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 14.70 acres
Depth = 2.10 inches	CN = 85.00
Duration = 6.00 hrs	Time conc.= 0.099 hrs

OUTPUT SUMMARY

Runoff depth	0.86914	inches	
Initial abstr	0.35294	inches	
Peak flow =	12.00	cfs	(0.80945 iph)
at time	2.521	hrs	

INPUT FOR: CGWS-D2D

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 4.70 acres
Depth = 2.10 inches	CN = 85.00
Duration = 6.00 hrs	Time conc.= 0.057 hrs

OUTPUT SUMMARY

Runoff depth	0.86914	inches	
Initial abstr	0.35294	inches	
Peak flow =	3.99	cfs	(0.84168 iph)
at time	2.508	hrs	

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

CURRENT OPERATIONS (100 YR - 6 HR STORM)

INPUT FOR: CGWS-D2E

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 6.30 acres
Depth = 2.10 inches	CN = 90.00
Duration = 6.00 hrs	Time conc.= 0.179 hrs

OUTPUT SUMMARY

Runoff depth	1.17972	inches	
Initial abstr	0.22222	inches	
Peak flow =	6.61	cfs	(1.04070 iph)
at time	2.530	hrs	

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3.4.2

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

INPUT FOR: CGWS-U3B 10 YEAR STORM P=1.4"

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 172.90 acres
Depth = 1.40 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.386 hrs

OUTPUT SUMMARY

Runoff depth	0.13224	inches	
Initial abstr	0.66667	inches	
Peak flow =	7.44	cfs	(0.04267 iph)
at time	3.603	hrs	

OPERATIONS PHASE

INPUT FOR: CGWS-U3B 100 YEAR STORM P=2.0"

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 172.90 acres
Depth = 2.00 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.386 hrs

OUTPUT SUMMARY

Runoff depth	0.38095	inches	
Initial abstr	0.66667	inches	
Peak flow =	33.93	cfs	(0.19459 iph)
at time	2.728	hrs	

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CASTLEGATE AREA
SCHOOL HOUSE CANYON REFUSE AREA

FINAL OPERATION PEAK DISCHARGE CALCULATIONS

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CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA.

FINAL OPERATION CHANNEL WATERSHED AREA.

WATERSHED I.D.	AREA (AC)
CGWS- D2 A	40.3
CGWS - D2 B	0.9
CGWS- D2 C	9.4
CGWS- D2 D	4.4
CGWS- D2 E	13.2
CGWS- D2 F	9.2
TOTAL AREA	77.4

CGWS- U3B	172.9

CASTLE GATE

SCHOOL HOUSE CANYON REFUSE AREA.

FINAL OPERATION

DETERMINE AVERAGE WATERSHED SLOPE

$$WS = 0.25\ (EM-EN)\ (LC_{25} + LC_{50} + LC_{75})\ /AREA$$

EM = MAX. ELEVATION
EN = MIN. ELEVATION
LC = CONTOUR LENGTH @ 25, 50, 75 % OF EM-EN
WS = WATERSHED SLOPE.

WATERSHED	EM	EN	LC_{25}	LC_{50}	LC_{75}	AREA (AC.)	WS(%)
CGWS-D2A	7680	6550	1250	1000	500	26.5	67.3
CGWS-D2B	7740	6550	375	500	325	14.7	55.7
CGWS-D2C	6570	6550	1000	900	700	9.4	3.2
CGWS-D2D	6580	6200	300	600	450	4.4	66.9
CGWS-D2E.	6550	6200	300	400	550	13.2	19.0
CGWS-D2F	6920	6184	200	500	150	9.2	39.0

REF: CHANG, M., S.P. WATTERS AND A.K. SAYOK. 1989. A COMPARISON OF METHODS OF ESTIMATING MEAN WATERSHED SLOPE. WATER RESOURCES BULLETIN. VOL 25, NO. 2.

NOTE: SEE APPENDIX 3.4D FOR CGWS-U3B PARAMETERS.

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA.

FINAL OPERATION.

CURVE NUMBER

WATERSHED	CN
CGWS-D2A	78
CGWS-D2B	78
CGWS-D2C	90
CGWS-D2D	82
CGWS-D2E	90
CGWS-D2F	85
CGWS-U3B	75

CURVE NUMBERS WERE TAKEN FROM APPENDIX 3.4D, "DISTURBED AND UNDISTURBED AREA RUNOFF CALCULATIONS", CASTLE GATE PREP PLANT OPERATIONS PERMIT.

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CASTLE GATE SCHOOL HOUSE CANYON

FINAL OPERATIONS DESIGN

TIME OF CONCENTRATION. CALC'S

WATERSHED I.D.	HYD. LENGTH (l). (Ft).	CN	$S = \frac{1000}{CN} - 10$	Y %SLOPE	$L = \frac{l^{(0.8)}(S+1)^{0.7}}{1900(Y)^{0.5}}$ (Hr)	$T_c = 1.67L$ (Hr).
CGWS-D2A	1500	78	2.82	67.3	0.057	0.095
CGWS-D2B	2000	78	2.82	55.7	0.079	0.132
CGWS-D2C	900	90	1.11	3.2	0.114	0.191
CGWS-D2D	1300	82	2.20	66.9	0.045	0.075
CGWS-D2E	1050	90	1.11	19.0	0.053	0.089.
CGWS-D2F	1500	85	1.76	39.0	0.060	0.099

NOTE: SEE APPENDIX 3.4D FOR CGWS-U3B CALCULATIONS.

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CASTLE GATE SCHOOL HOUSE CANYON

FINAL OPERATIONS

PEAK DISCHARGE VALUES

100 YEAR - 6 HOUR PRECIPITATION = 2.1 INCHES
SCS TYPE 'B' DISTRIBUTION

WATERSHED	CN	AREA (AC.)	TIME OF CONC. (HR)	Q (100-6) (CFS)
CGWS- D2A	78	26.5	0.095	13.05
CGWS- D2B	78	14.7	0.132	6.89
CGWS- D2C	90	9.4	0.191	9.77
CGWS- D2D	82	4.4	0.075	3.02
CGWS- D2E	90	13.2	0.089	14.52
CGWS- D2F	85	9.2	0.099	7.51
CGWS- D3	75	172.9	0.386	33.93

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CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

FINAL OPERATION HYDROLOGY

DIVERSION DISCHARGE SUMMARY

DIVERSION DITCH	CONTRIBUTORY WATERSHED (EXHIBIT 3.4-2C)	TOTAL DRAINAGE AREA (Acres)	DESIGN DISCHARGE (100 Yr-6 Hr)(cfs)
CGD-18	CGWS-D2B	14.7	6.89
CGD-19	CGWS-D2B,D2C,D2D,D2E	41.7	~~15.58[a]~~ 34.20
CGD-6 (upper)	CGWS-D2B,D2C	24.1	16.66
CGD-6 (lower)	CGWS-D2B,D2C,D2D,D2E	41.7	34.20
CGD-7 (upper)	CGWS-D2A,D2C	35.9	22.82
CGD-7 (lower)	CGWS-D2A,D2C,D2E,D2F	58.3	44.85
CGD-5 based on the	CGWS-43B	172.9	33.93

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

FINAL OPERATION (100 YR- 6 HR STORM)

INPUT FOR: CGWS-D2A

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 26.50 acres
Depth = 2.10 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.095 hrs

OUTPUT SUMMARY

Runoff depth	0.54150	inches	
Initial abstr	0.56410	inches	
Peak flow =	13.05	cfs	(0.48831 iph)
at time	2.521	hrs	

INPUT FOR: CGWS-D2B

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 14.70 acres
Depth = 2.10 inches	CN = 78.00
Duration = 6.00 hrs	Time conc.= 0.132 hrs

OUTPUT SUMMARY

Runoff depth	0.54150	inches	
Initial abstr	0.56410	inches	
Peak flow =	6.89	cfs	(0.46494 iph)
at time	2.534	hrs	

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BASED ON SCS CURVE NUMBER METHODOLOGY

FINAL OPERATION (100 YR - 6 HR STORM)

INPUT FOR: CGWS-D2C

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 9.40 acres
Depth = 2.10 inches	CN = 90.00
Duration = 6.00 hrs	Time conc.= 0.191 hrs

OUTPUT SUMMARY

Runoff depth	1.17972	inches	
Initial abstr	0.22222	inches	
Peak flow =	9.77	cfs	(1.03054 iph)
at time	2.547	hrs	

INPUT FOR: CGWS-D2D

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 4.40 acres
Depth = 2.10 inches	CN = 82.00
Duration = 6.00 hrs	Time conc.= 0.075 hrs

OUTPUT SUMMARY

Runoff depth	0.71545	inches	
Initial abstr	0.43902	inches	
Peak flow =	3.02	cfs	(0.68170 iph)
at time	2.510	hrs	

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HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

FINAL OPERATION (100 YR- 6 HR STORM.)

INPUT FOR: CGWS-D2E

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 13.20 acres
Depth = 2.10 inches	CN = 90.00
Duration = 6.00 hrs	Time conc.= 0.089 hrs

OUTPUT SUMMARY

Runoff depth	1.17972	inches	
Initial abstr	0.22222	inches	
Peak flow =	14.52	cfs	(1.09115 iph)
at time	2.516	hrs	

INPUT FOR: CGWS-D2F

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 9.20 acres
Depth = 2.10 inches	CN = 85.00
Duration = 6.00 hrs	Time conc.= 0.099 hrs

OUTPUT SUMMARY

Runoff depth	0.86914	inches	
Initial abstr	0.35294	inches	
Peak flow =	7.51	cfs	(0.80945 iph)
at time	2.521	hrs	

CASTLEGATE AREA
SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION PEAK DISCHARGE CALCULATIONS

3.4 J

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION WATERSHED AREA

WATERSHED I.D.	AREA (AC)
CGRWS- USA	28.6
CGRWS- USB	26.6
CGRWS- USC	12.3
CGRWS- USD	15.8
TOTAL AREA	83.3
CGRWS- U6	174.6

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CASTLEGATE
SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION

DETERMINE AVERAGE WATERSHED SLOPE

$$WS = 0.25\ (EM - EN)\ (LC_{25} + LC_{50} + LC_{75})\ /\ AREA$$

EM = MAX. ELEVATION
EN = MIN. ELEVATION
LC = CONTOUR LENGTH @ 25, 50, 75 % OF EM - EN
WS = WATERSHED SLOPE.

WATERSHED	EM	EN	LC_{25}	LC_{50}	LC_{75}	AREA(AC)	WS(%)
CGRWS-USA	7720	6550	600	600	400	28.6	37.6
CGRWS-USB	7660	6550	1000	1000	600	26.6	62.3
CGRWS-USC	6570	6190	400	1100	1200	12.3	47.9
CGRWS-USD	6900	6190	1050	1100	500	15.8	68.3

REF: CHANG, M., S.P. WATTERS AND A.K. SAYOK. 1989. A COMPARISON OF METHODS OF ESTIMATING MEAN WATERSHED SLOPE. WATER RESOURCES BULLETIN. VOL 25, NO. 2.

NOTE: SEE APPENDIX 3.4L FOR CGRWS-US6 PARAMETERS.

3.4 J

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION

CURVE NUMBER

WATERSHED	CN
CGRWS- USA	80
CGRWS- USB	80
CGRWS- USC	80
CGRWS- USD	80
CGRWS- U6	75

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SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION DESIGN

TIME OF CONCENTRATION CALCULATIONS

WATERSHED I.D.	HYD. LENGTH (ℓ) (FT.)	CN	$S = \frac{1000}{CN} - 10$	Y % SLOPE	$L = \frac{\ell^{(0.8)}(S+1)^{0.7}}{1900(Y)^{0.5}}$ (Hr)	$T_c = 1.67L$ (Hr)
CGRWS-USA	1600	80	2.5	37.6	0.075	0.126
CGRWS-USB	1400	80	2.5	62.3	0.053	0.089
CGRWS-USC	1400	80	2.5	47.9	0.060	0.100
CGRWS-USD	1000	80	2.5	68.3	0.038	0.064

NOTE: SEE APPENDIX 3.4L FOR CGRWS-UG PARAMETERS

3.4

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CASTLE GATE

SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION

PEAK DISCHARGE VALUES

100 YEAR - 6 HOUR PRECIPITATION = 2.1 INCHES
SCS TYPE B DISTRIBUTION.

WATERSHED	CN	AREA (AC.)	TIME OF CONC. (HR)	Q(100-6) (CFS)
CGRWS-USA	80	28.6	0.126	15.91
CGRWS-USB	80	26.6	0.089	15.52
CGRWS-USC	80	12.3	0.100	7.08
CGRWS-USD	80	15.8	0.064	9.52
CGRWS-UG	75	174.6	0.346 (a)	36.55 (b)

(a) SEE APPENDIX 3.4 L.

(b) BASED ON 100-YR, 6-HR STORM OF 2.0 INCHES. SEE TABLE 7-7.

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CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

FINAL RECLAMATION HYDROLOGY

DIVERSION DISCHARGE SUMMARY

DIVERSION DITCH	CONTRIBUTORY WATERSHED (EXHIBIT 3.4-3)	TOTAL DRAINAGE AREA (Acres)	DESIGN DISCHARGE (100 Yr-6 Hr) (cfs)
CGRD-3A	CGRWS-U5B,U5D	42.4	25.04
CGRD-7	CGRWS-U5B	26.6	15.52
CGRD-8	CGRWS-U5A	28.6	15.91
CGRD-9 (upper)	CGRWS-U5A,U5C	40.9	22.99
CGRD-9 (lower)	CGRWS-U5A,U5C	40.9	22.99
CGRD-4	CGRWS-U6	174.6	36.55

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HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

FINAL RECLAMATION (100 YR - 6 HR STORM)

INPUT FOR: CGRWS-U5A

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 28.60 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.126 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches		
Initial abstr	0.50000	inches		
Peak flow =	15.91	cfs	(0.55182	iph)
at time	2.520	hrs		

INPUT FOR: CGRWS-U5B

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 26.60 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.089 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches		
Initial abstr	0.50000	inches		
Peak flow =	15.52	cfs	(0.57853	iph)
at time	2.516	hrs		

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

FINAL RECLAMATION (100 YR - 6 HR STORM)

INPUT FOR: CGRWS-U5C

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 12.30 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.100 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches	
Initial abstr	0.50000	inches	
Peak flow =	7.08	cfs	(0.57062 iph)
at time	2.520	hrs	

INPUT FOR: CGRWS-U5D

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 15.80 acres
Depth = 2.10 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.064 hrs

OUTPUT SUMMARY

Runoff depth	0.62439	inches	
Initial abstr	0.50000	inches	
Peak flow =	9.52	cfs	(0.59739 iph)
at time	2.509	hrs	

3.4)

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HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

RECLAMATION PHASE
100-YR, 6-HR STORM, P=2.0"

INPUT FOR: CGRWS-U6

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 174.58 acres
Depth = 2.00 inches	CN = 75.00
Duration = 6.00 hrs	Time conc.= 0.346 hrs

OUTPUT SUMMARY

Runoff depth	0.38095	inches	
Initial abstr	0.66667	inches	
Peak flow =	36.55	cfs	(0.20763 iph)
at time	2.722	hrs	

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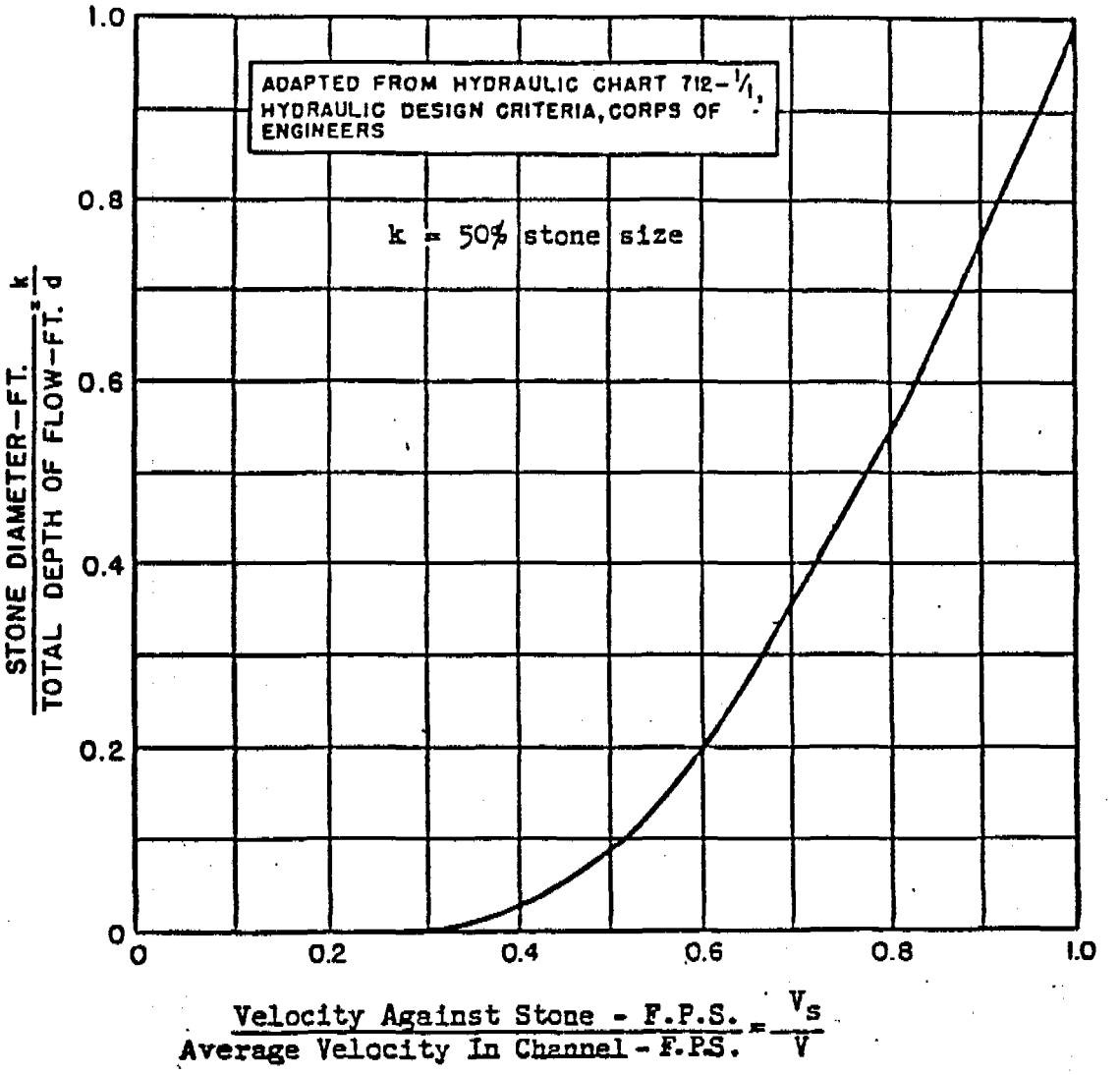
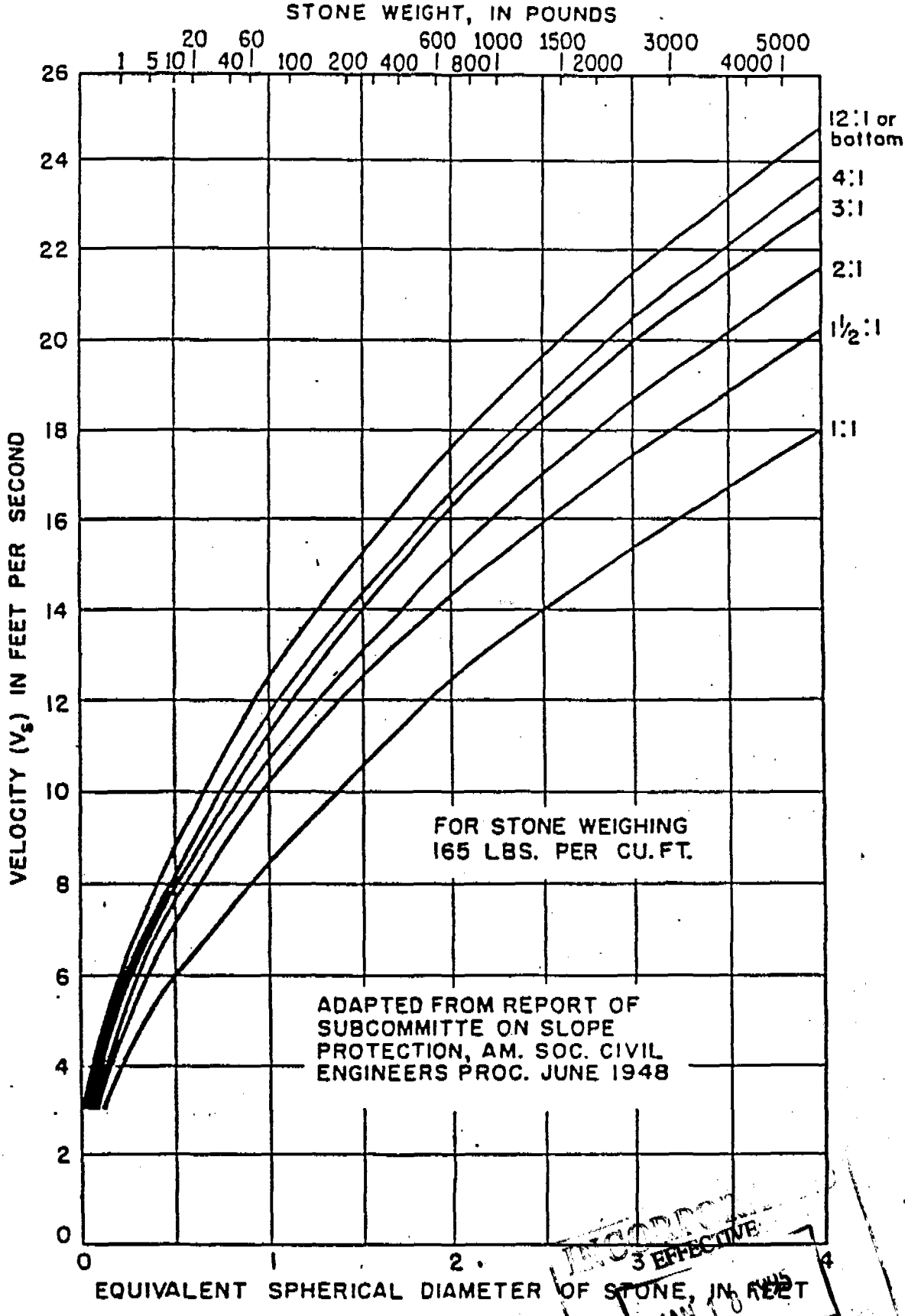


Velocity Against Stone on Channel Bottom (U.S. Department of Transportation, 1978).



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Size of Stone that will Resist Displacement for Various Velocities and Side Slopes (U.S. Department of Transportation, 1978).

32B

3.4 J

D/pc

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE COAL

Comment: CGD-5/CGRD-4

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft *	
Left Side Slope..	1.00:1 (H:V)	
Right Side Slope.	1.00:1 (H:V)	
Manning's n.....	0.040	(BEDROCK ROUGHNESS)
Channel Slope....	0.0200 ft/ft	(MIN SLOPE)
Discharge.....	36.55 cfs	

Computed Results:

Depth.....	1.21 ft	← MAX FLOW DEPTH
Velocity.....	4.87 fps	
Flow Area.....	7.51 sf	
Flow Top Width...	7.42 ft	
Wetted Perimeter.	8.42 ft	
Critical Depth...	1.10 ft	
Critical Slope...	0.0280 ft/ft	
Froude Number....	0.85 (flow is Subcritical)	

* DIVERSION IS CONSIDERABLY WIDER IN MOST LOCATIONS.

Open Channel Flow Module, Version 3.2 (c) 1990
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32 C

3.4 J

10/94

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE COAL

Comment: CGD-5/CGRD-4

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft *
Left Side Slope..	1.00:1 (H:V)
Right Side Slope.	1.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.2000 ft/ft (UPPER END MAX SLOPE)
Discharge.....	36.55 cfs

Computed Results:

Depth.....	0.61 ft
Velocity.....	10.62 fps ← MAX VELOCITY
Flow Area.....	3.44 sf
Flow Top Width...	6.23 ft
Wetted Perimeter.	6.73 ft
Critical Depth...	1.10 ft
Critical Slope...	0.0280 ft/ft
Froude Number....	2.52 (flow is Supercritical)

* DIVERSION IS CONSIDERABLY WIDER IN MOST LOCATIONS

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CGD-7(lower)/CGRD-3A

Comment: FINAL OPERATION PEAK FLOW DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.1300 ft/ft ← MIN.
Discharge.....	44.85 cfs

Computed Results:

Depth.....	0.71 ft ← DEPTH OF FLOW
Velocity.....	8.82 fps
Flow Area.....	5.08 sf
Flow Top Width...	9.27 ft
Wetted Perimeter.	9.50 ft
Critical Depth...	1.09 ft
Critical Slope...	0.0264 ft/ft
Froude Number....	2.10 (flow is Supercritical)

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CASTLE GATE PREP PLANT
SCHOOL HOUSE CANYON

CGD-7 (Upper) / CGTD-3A RIPRAP DESIGN

CHANNEL GEOMETRY - TRAPAZOIDAL
BOTTOM WIDTH : 5'
SIDE SLOPES : 3 : 1
MAX. CHANNEL SLOPE: 40%
MAX. DESIGN DISCHARGE, Q : 44.9 CFS (FINAL OPER. PHASE)

REFERENCE: OSM / TR-82/2 SURFACE MINING WATER DIVERSION DESIGN MANUAL, PREPARED BY SIMONS, LI & ASSOC. 1982.

SINCE SLOPE IS ≥ 10%, IT CLASSIFIES AS A STEEP SLOPE.

USE DESIGN CURVES FOR 6' BOTTOM WIDTH, 2:1 SIDE SLOPES TO DETERMINE D_{50} OF RIPRAP.

NOTES, 1. IDEALLY, CURVES WOULD BE AVAILABLE FOR A 5' BOTTOM WIDTH, BUT THEY ARE NOT. ACCORDING TO SIMONS (PG 5.22), LINEAR INTERPOLATION CAN BE USED FOR BOTTOM WIDTHS OTHER THAN THOSE THAT HAVE GRAPHS. HOWEVER, THE GRAPH COVERING TRIANGULAR CHANNELS (BOTTOM WIDTH = 0), HAS NO CURVE FOR A SLOPE OF 40%. THEREFORE, USE GRAPH FOR 6' BOTTOM WIDTH.

2. ALSO, IDEALLY THE GRAPHS WOULD BE ESTABLISHED FOR 3:1 SIDE SLOPES INSTEAD OF 2:1. HOWEVER, UTILIZING THE GRAPHS SET UP FOR 2:1 SIDE SLOPES WILL YIELD A MORE CONSERVATIVE ASSESSMENT OF D_{50} RIPRAP, SINCE THE FLOW AREA WILL ACTUALLY BE GREATER IN A CHANNEL WITH 3:1 SIDE SLOPES, COMPARED A CHANNEL WITH 2:1 SIDE SLOPES. A LARGER AREA CORRESPONDS TO LOWER ACTUAL VELOCITIES (Q=VA) IN THE 3:1 S.S. CHANNEL.

USING FIGURE 5.4 WITH : Q = 44.9 CFS
SLOPE = 40%

YIELDS:
D_{50} = 1.75'

FROM TABLE 5.2, WITH $1.51 \le D_{50} \le 1.75$ ⟹ D_{50} = 1.75' = 21"

FROM TABLE 5.1 FOR STEEP SLOPES,

$\frac{D_{MAX}}{D_{50}} = 1.25$ SO $D_{MAX} = 1.25\ D_{50}$
$= 1.25\,(21")$
$= 26"$

SIMONS RECOMMENDS RIPRAP THICKNESS = D_{MAX}

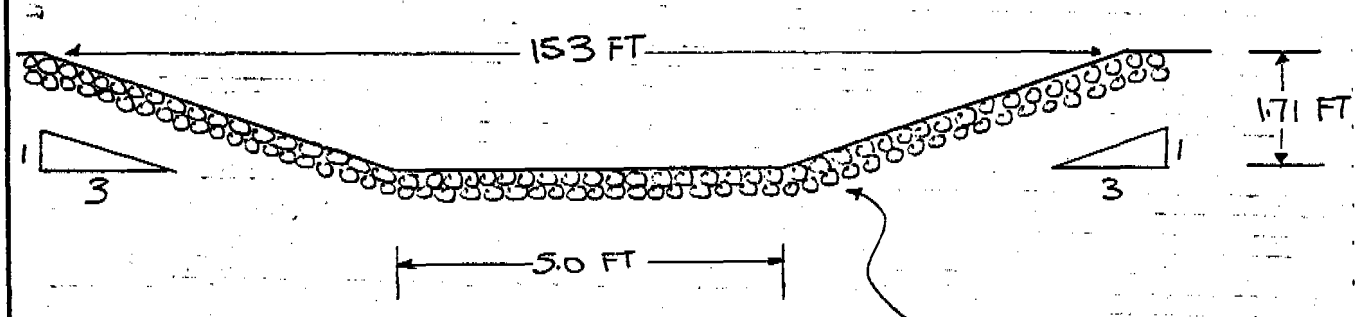
SO THICKNESS = 26"

SIMONS RECOMMENDS A FILTER BLANKET THICKNESS EQUAL TO DMAX OF THE FILTER BUT NOT LESS THAN 9".

BANFIELD ET AL (1983) RECOMMENDS THAT THE FILTER BE ONE HALF THE THICKNESS OF THE RIPRAP, BUT NOT LESS THAN 6".

USE FILTER BLANKET THICKNESS = 13 INCHES

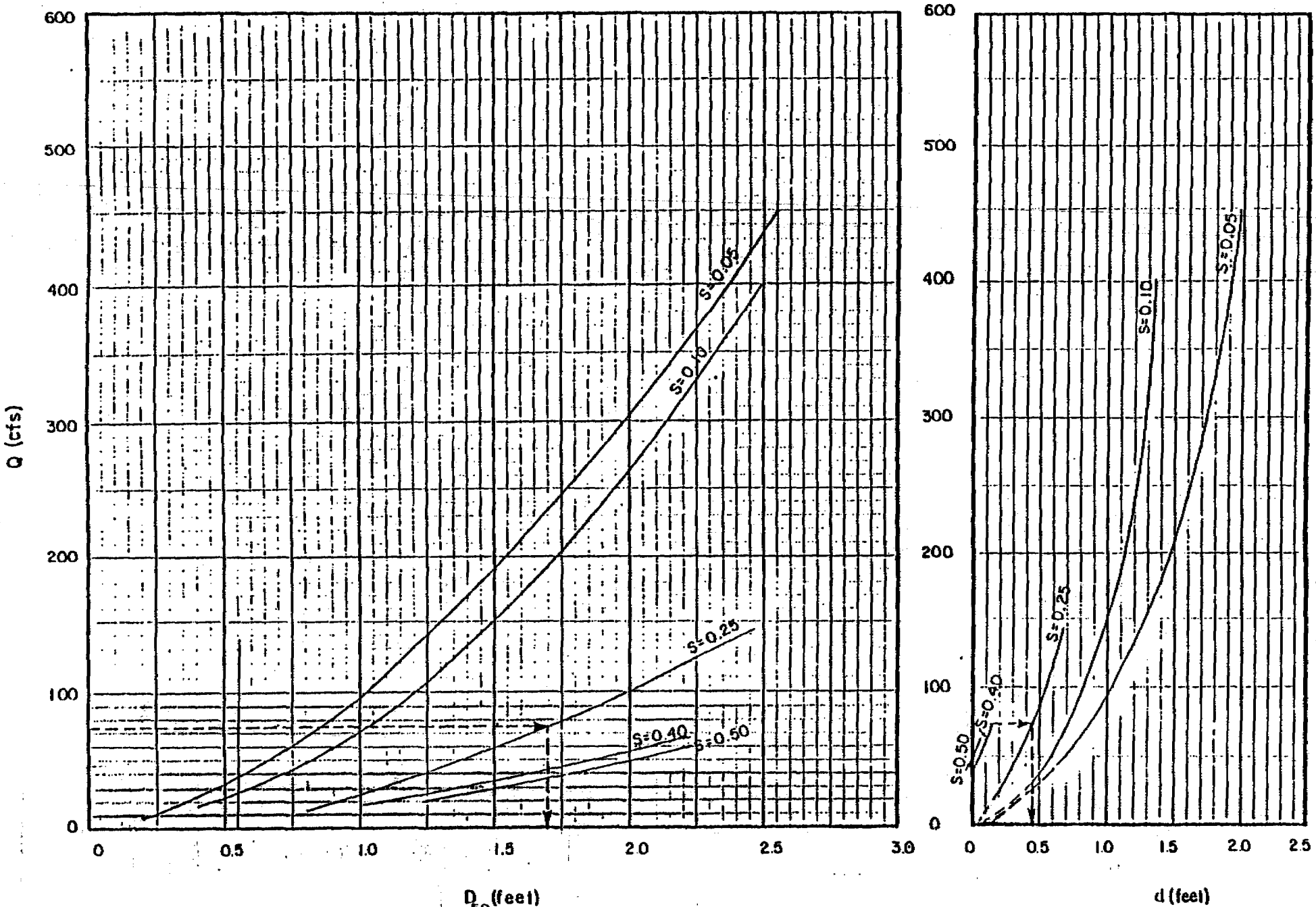
CROSS-SECTION OF CGD-7 (LOWER) / CGZD-3A



WATER FLOW DEPTH = 0.71 FT.
FREEBOARD = 1.00 FT
TOTAL DEPTH = 1.71 FT.
SLOPE ⇒ MAX = 0.40 FT/FT.
MIN = 0.13 FT/FT.
η = 0.040

D_{50} REQUIRED = 21 IN

RIPRAP THICKNESS = 26 IN
FILTER THICKNESS = 13 IN



SOURCE: OSM/TR-8222, SURFACE MINING WATER DIVERSION DESIGN MANUAL, PREPARED 5.17 BY SIMONS, LI & ASSOC. SEPT. 1982.

Figure 5.4. Steep slope riprap design, trapezoidal channels, 2:1 sideslopes, 6 ft base width.

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGD-7 (lower) (GROUTED SECTION)

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.3300 ft/ft ← MAX.
Discharge.....	22.60 cfs

Computed Results:

Depth.....	0.44 ft
Velocity.....	14.12 fps
Flow Area.....	1.60 sf
Flow Top Width...	4.31 ft
Wetted Perimeter.	4.58 ft
Critical Depth...	1.01 ft
Critical Slope...	0.0164 ft/ft
Froude Number....	4.09 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGD-7 (lower) (GROUTED SECTION)

Solve For Depth

Given Input Data:

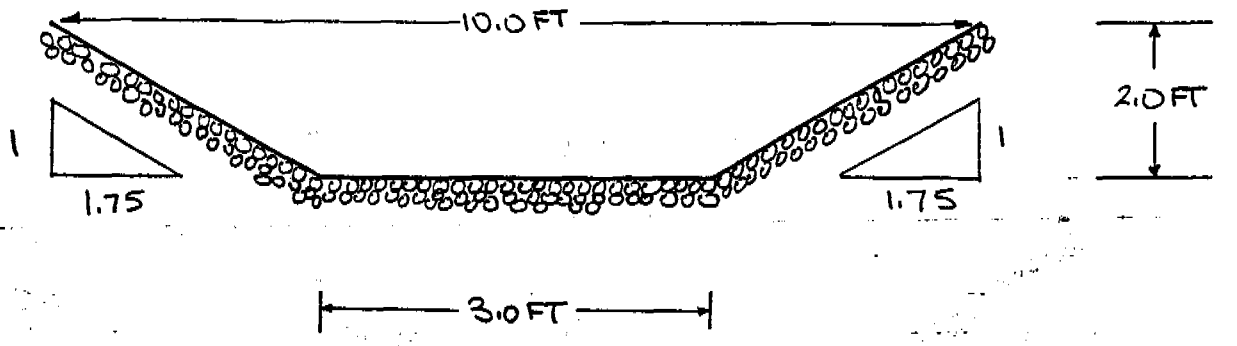
Bottom Width.....	3.00 ft
Left Side Slope..	1.50:1 (H:V)
Right Side Slope.	1.50:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1500 ft/ft ← MIN
Discharge.....	22.60 cfs

Computed Results:

Depth.....	0.55 ft
Velocity.....	10.78 fps
Flow Area.....	2.10 sf
Flow Top Width...	4.65 ft
Wetted Perimeter.	4.98 ft
Critical Depth...	1.01 ft
Critical Slope...	0.0164 ft/ft
Froude Number....	2.83 (flow is Supercritical)

CGD-7 (LOWER) (CHANNEL & RIPRAP DESIGN)
(GROUTED SECTION)

D = 0.55 FT (BASED ON MIN. CHANNEL SLOPE, VELOCITY = 10.78 FPS)
V = 14.12 FPS (BASED ON MAX. CHANNEL SLOPE, DEPTH = 0.44 FT.)



WATER FLOW DEPTH = 0.55 FT
FREEBOARD = 1.45 FT
TOTAL DEPTH = 2.00 FT.
CHANNEL SLOPE => MAX = 0.33 FT/FT.
MIN = 0.15 FT/FT.
$n = 0.030$.

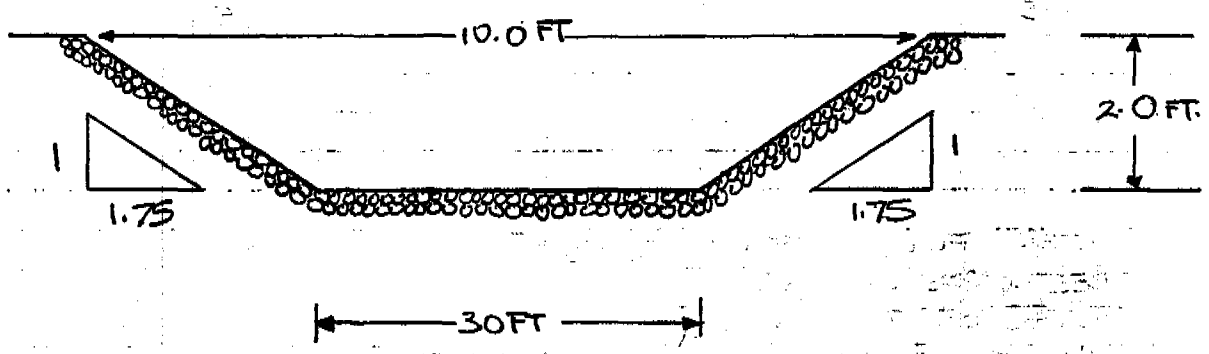
d_{50} ACTUAL = 6-8" GROUTED RIPRAP.

BASED ON THE MAXIMUM CHANNEL VELOCITY OF 14.12 FPS THE 6-8" GROUTED RIPRAP IS ADEQUATE FOR CGD-7 LOWER.

TRANSITION BETWEEN CGD-7 (LOWER) & CGRD-3A

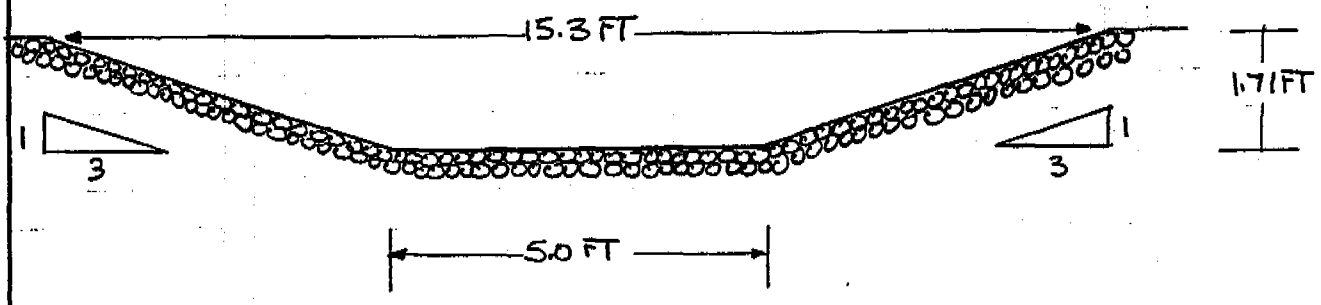
CROSS SECTION CGD-7 (LOWER) (GROUTED)

WATER FLOW DEPTH = 0.55 FT
FREEBOARD = 1.45 FT.
TOTAL DEPTH = 2.00 FT.



CROSS SECTION CGRD-3A.

WATER FLOW DEPTH = 0.71 FT
FREEBOARD = 1.00 FT.
TOTAL DEPTH = 1.71 FT.



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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGD-7 Lower (GROUTED)

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	1.75:1 (H:V)
Right Side Slope.	1.75:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.4000 ft/ft
Discharge.....	22.60 cfs (COMMENT OPERATION Q_{MAX})

Computed Results:

Depth.....	0.41 ft
Velocity.....	14.87 fps
Flow Area.....	1.52 sf
Flow Top Width...	4.43 ft
Wetted Perimeter.	4.65 ft
Critical Depth...	0.99 ft
Critical Slope...	0.0162 ft/ft
Froude Number....	4.47 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGRD-3a

Solve For Depth

Given Input Data:

Bottom Width.....	5.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.040 (D_{50} = 21" RIPRAP)
Channel Slope....	0.3000 ft/ft
Discharge.....	44.90 cfs

Computed Results:

Depth.....	0.57 ft
Velocity.....	11.82 fps
Flow Area.....	3.80 sf
Flow Top Width...	8.40 ft
Wetted Perimeter.	8.59 ft
Critical Depth...	1.09 ft
Critical Slope...	0.0264 ft/ft
Froude Number....	3.10 (flow is Supercritical)

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TRANSITION ZONE RIPRAP SIZING (CGD-7 lower → CGRD-3a)

GIVEN: Q = 22.60 cfs (current operation Q_{max})

SLOPE = 40% = 0.40 FT/FT.

∴ USING OSM / TR - 82.2 - SURFACE MINING WATER DIVERSION DESIGN MANUAL.

∴ SINCE NO 3.0' BOTTOM WIDTH NOMOGRAPH A CONSERVATIVE APPROACH OF d_{50} = 1.50 FT WILL BE USED IN THE TRANSITION ZONE FROM CGD-7 lower TO CGRD-3a.

d_{50} = 1.50' = 18"

SIMONS RECOMMENDS RIPRAP THICKNESS = D_{MAX}

$$\frac{D_{MAX}}{D_{50}} = 1.25$$

∴ D_{MAX} = (1.25)(1.50) = 23 INCH RIPRAP.

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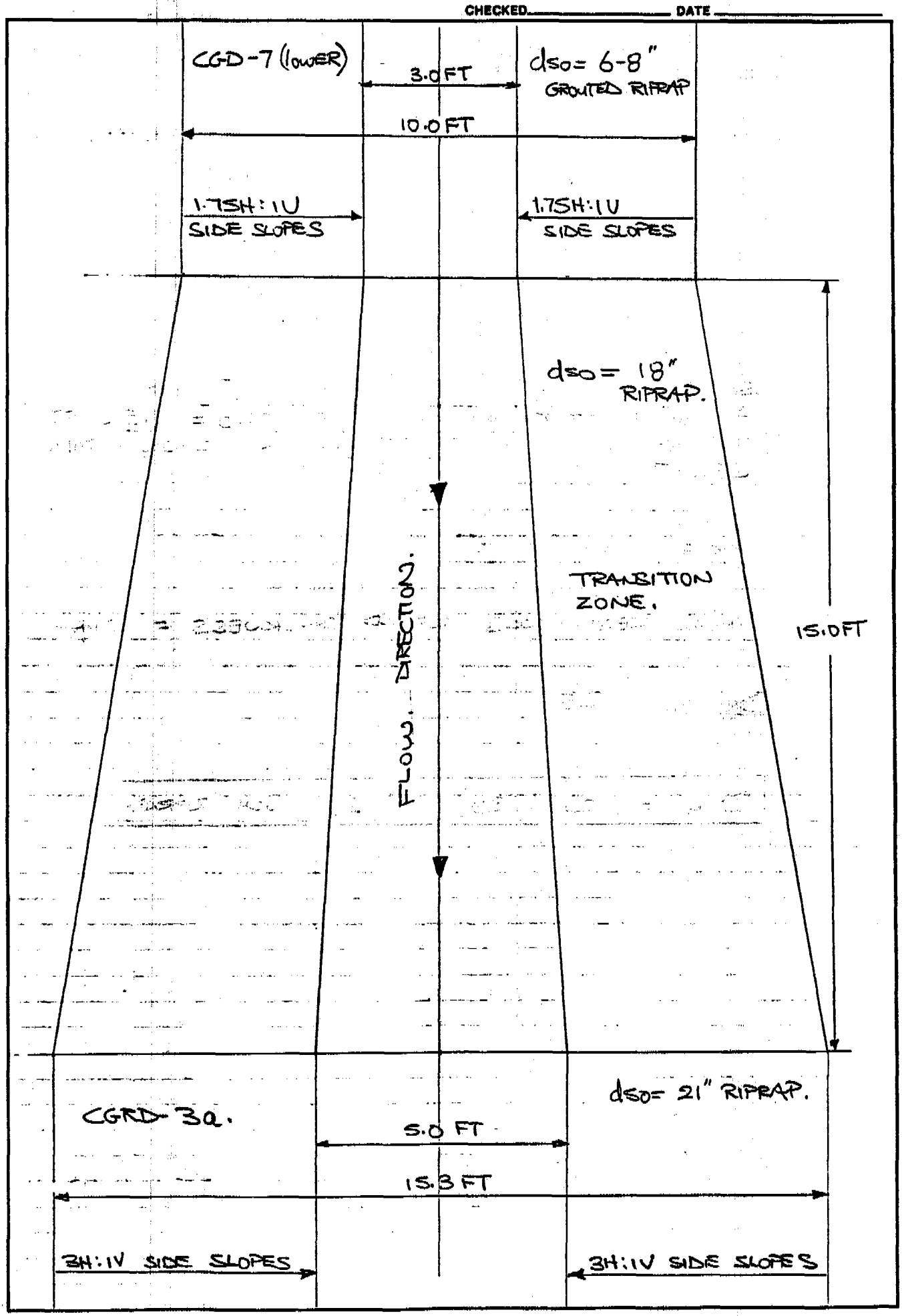
CHECKED DATE



Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CGD-18

Comment: FINAL OPERATION PEAK FLOW DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.1700 ft/ft
Discharge.....	6.89 cfs

Computed Results:

Depth.....	0.26 ft ← FLOW DEPTH
Velocity.....	7.17 fps ← RIPRAP DESIGN VELOCITY
Flow Area.....	0.96 sf
Flow Top Width...	4.53 ft
Wetted Perimeter.	4.61 ft
Critical Depth...	0.47 ft
Critical Slope...	0.0192 ft/ft
Froude Number....	2.75 (flow is Supercritical)

OPERATIONAL DIVERSION ONLY

Open Channel Flow Module, Version 3.2 (c) 1990
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CGD- 18 (MINIMUM CHANNEL + RIPRAP SIZING)

CGD-18 IS EXCLUSIVELY AN OPERATIONAL DIVERSION, SO USE U.S. D.O.T. (MILD SLOPE) RIPRAP DESIGN METHODOLOGY.

D = 0.26 FT (BASED ON AVERAGE CHANNEL SLOPE)
V = 7.17 FPS

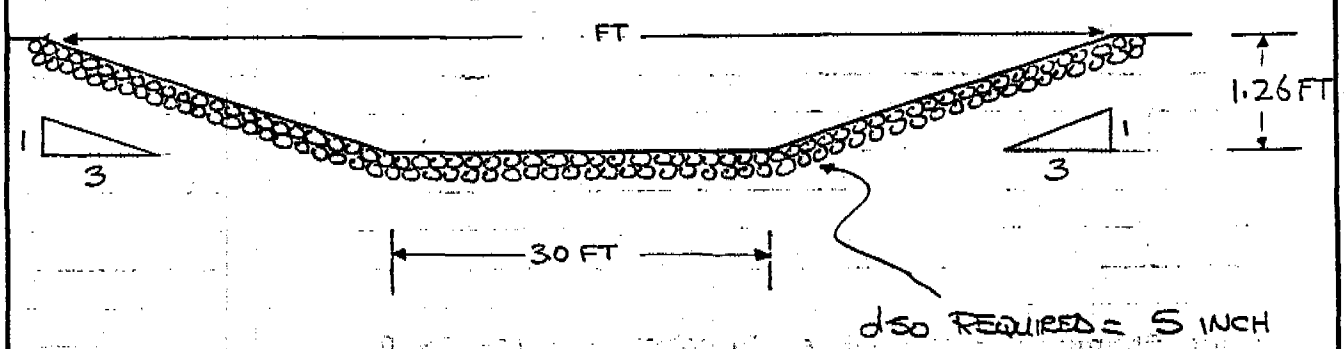
ASSUME $K = 0.40'$ $\therefore \frac{K}{D} = \frac{0.40'}{0.26'}$ $\therefore \frac{K}{D} > 1$

SIDE SLOPES ARE 3H:1V FOR THIS CALCULATION

$\therefore \frac{V_s}{V} = 1$, $V_s = (1)(7.17)$, $V_s = 7.17$ FPS.

$\therefore$ **d50 REQUIRED = 0.40' = 5 INCH RIPRAP.**

CROSS-SECTION:



WATER FLOW DEPTH = 0.26 FT
FREEBOARD = 1.00 FT
TOTAL DEPTH = 1.26 FT.
SLOPE ⇒ AVG = 0.17 FT/FT.
$n = 0.030$

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CGD-7(upper)/CGRD-7

Comment: FINAL OPERATION PEAK FLOW DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	22.82 cfs

Computed Results:

Depth.....	1.01 ft
Velocity.....	3.72 fps
Flow Area.....	6.13 sf
Flow Top Width...	9.09 ft
Wetted Perimeter.	9.42 ft
Critical Depth...	0.90 ft
Critical Slope...	0.0162 ft/ft
Froude Number....	0.80 (flow is Subcritical)

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CGD-7 (UPPER)
CGRD-7

(MINIMUM CHANNEL & RIPRAP SIZING)

SLOPE = 1% < 10%, SO USE U.S. D.O.T. (MILD SLOPE) RIPRAP DESIGN.
(BASED ON AVERAGE CHANNEL SLOPE)

D = 1.01 FT
V = 3.72 FPS

ASSUME $K = 0.10'$ $\therefore \frac{K}{D} = \frac{0.10'}{1.01}$ $\therefore \frac{K}{D} = 0.10$

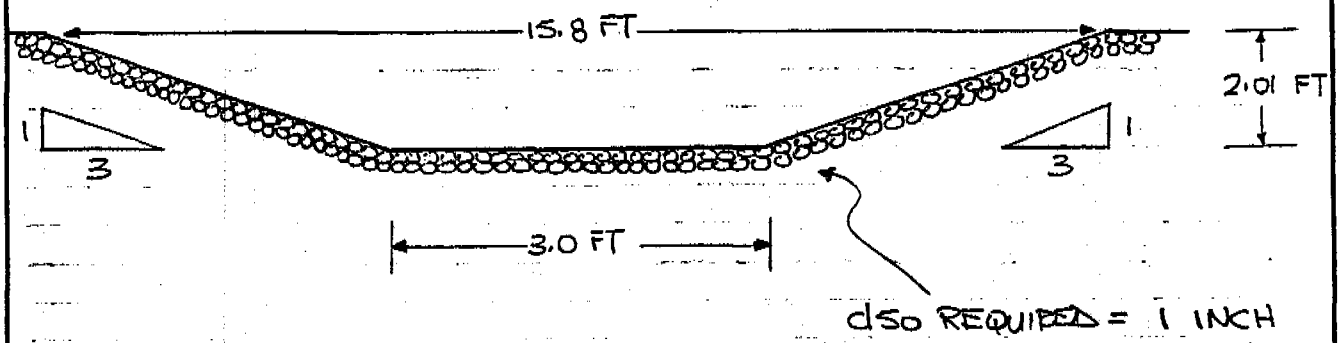
SIDE SLOPES ARE 3H:1V FOR THIS CALCULATION

$\therefore \frac{V_s}{V} = 0.5$, $V_s = (0.5)(3.72)$, $V_s = 1.86$ FPS.

$\therefore$ $\boxed{d_{50} \text{ REQUIRED} = 0.10' = 1 \text{ INCH RIPRAP.}}$

CROSS-SECTION:

FILTER BLANKET MATERIAL = 6 INCHES
(LOCATED UNDER RIPRAP).



WATER FLOW DEPTH = 1.01 FT.
FREEBOARD = 1.00 FT.
TOTAL DEPTH = 2.01 FT.
SLOPE => AVG. = 0.01 FT/FT.
η = 0.030.

* HOWEVER, RIPRAP SHOULD BE PLACED TO A DEPTH OF 6 INCHES.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CGD-6(upper)/CGRD-8

Comment: CURRENT OPERATION PEAK FLOW DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0100 ft/ft
Discharge.....	30.40 cfs

Computed Results:

Depth.....	1.17 ft
Velocity.....	4.02 fps
Flow Area.....	7.57 sf
Flow Top Width...	9.99 ft
Wetted Perimeter.	10.37 ft
Critical Depth...	1.05 ft
Critical Slope...	0.0156 ft/ft
Froude Number....	0.81 (flow is Subcritical)

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CGD-6 (UPPER) (MINIMUM CHANNEL & RIPRAP SIZING)
CGRD-8

SLOPE = 1% < 10%, SO USE U.S. D.O.T. (MILD SLOPE) RIPRAP DESIGN.
D = 1.17 FT (BASED ON AVERAGE CHANNEL SLOPE)
V = 4.02 FPS

ASSUME $K = 0.10'$ $\therefore \frac{K}{D} = \frac{0.10'}{1.17'}$ $\therefore \frac{K}{D} = 0.085$

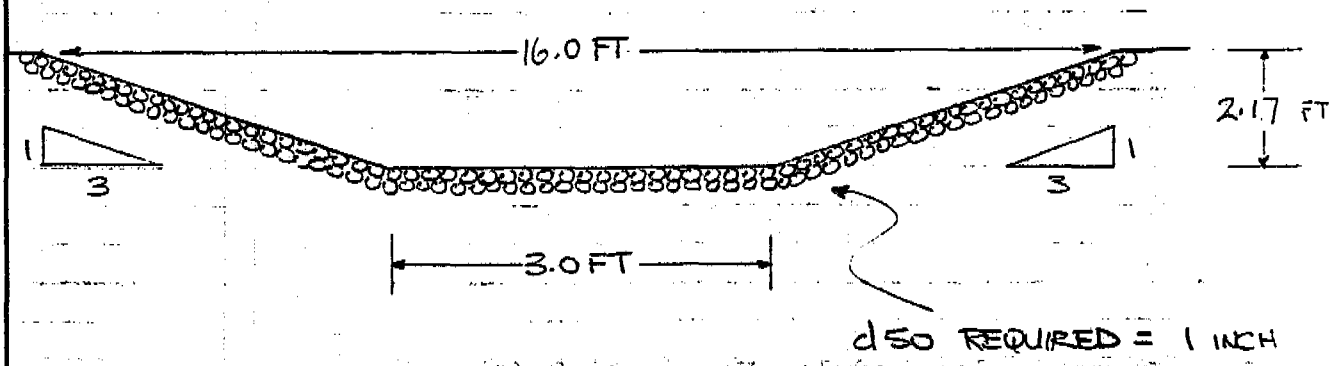
SIDE SLOPES ARE 3H:1V FOR THIS CALCULATION

$\therefore \frac{V_s}{V} = 0.5$, $V_s = (0.50)(4.02)$, $V_s = 2.00$ FPS

$\therefore$ $\boxed{d_{50} \text{ REQUIRED} = 0.10' = 1 \text{ INCH RIPRAP}}$

CROSS-SECTION:

FILTER BLANKET MATERIAL = 6 INCHES
(LOCATED UNDER RIPRAP).



WATER FLOW DEPTH = 1.17 FT
FREEBOARD = 1.00 FT.
TOTAL DEPTH = 2.17 FT.
SLOPE ⇒ AVG. = 0.010 FT/FT.
$n = 0.030$.

* HOWEVER RIPRAP SHOULD BE PLACED TO A DEPTH OF 6 INCHES.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CGD-6(1)/CGRD-9(u)

Comment: FINAL OPERATION PEAK FLOW DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.0800 ft/ft ← MIN.
Discharge.....	34.20 cfs

Computed Results:

Depth.....	0.85 ft ← FLOW DEPTH
Velocity.....	7.19 fps
Flow Area.....	4.76 sf
Flow Top Width...	8.13 ft
Wetted Perimeter.	8.41 ft
Critical Depth...	1.11 ft
Critical Slope...	0.0272 ft/ft
Froude Number....	1.66 (flow is Supercritical)

MIN. SLOPE USED TO SIZE CHANNEL. HOWEVER, RIPRAP SIZED FOR MAX SLOPE WILL BE PLACED ALONG ENTIRE LENGTH OF CHANNEL.

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CGD-6 (LOWER) / CGRD-9 (UPPER) CHANNEL DESIGN

CHANNEL GEOMETRY - TRAPAZOIDAL

BOTTOM WIDTH = 3 FT
SIDE SLOPES = 3:1
MAX CHANNEL SLOPE = 40%
MAX DESIGN DISCHARGE, Q = 34.2 CFS

SINCE MAX CHANNEL SLOPE ≥ 10%, USE SIMONS, LEE & ASSOC STEEP SLOPE DESIGN METHODOLOGY TO SIZE RIPRAP. SEE NOTE 2 ON PAGE 40 OF THESE CALCS FOR A DISCUSSION OF THE USE OF 2:1 S.S GRAPHS FOR CALCULATIONS OF RIPRAP FOR CHANNELS WITH 3:1 S.S.

SEE OSM/TR-82/2 (PG 5.22). SIMONS ET. AL RECOMMENDS INTERPOLATION FOR CHANNEL BOTTOM WIDTHS FOR WHICH THERE IS NO GRAPH. HOWEVER, FIGURE 5.3 DOES NOT HAVE A CURVE FOR SLOPE = 40%. USE FIGURE 5.4 FOR 6 FT BASE WIDTH AND ROUND UP WHEN SIZING D_{50}. (THIS APPROACH IS REASONABLE SINCE FLOW VELOCITY WILL NOT BE MUCH HIGHER IN A CHANNEL WITH A 3 FOOT BOTTOM WIDTH COMPARED TO ONE WITH A 6' B.W)

FROM FIGURE 5.4 WITH,

$Q = 34.2$ CFS
SLOPE = 40%

YIELDS:

$D_{50} = 1.45$

FROM TABLE 5.2, WITH $1.26 \le D_{50} \le 1.50$,

$D_{50} = 1.50 = 18"$

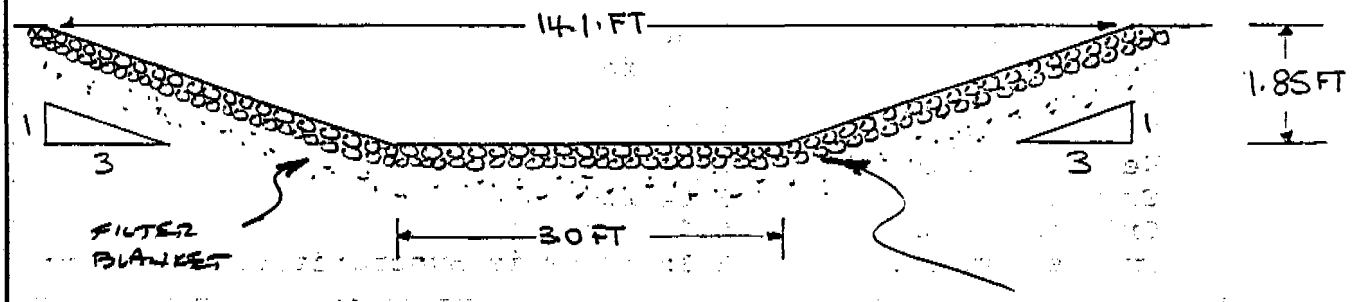
$D_{max} = 1.25\, D_{50}$
$= 1.25\,(18")$
$= 23"$

SET RIPRAP THICKNESS $= D_{MAX} = 23"$

USE FILTER BLANKET THICKNESS = 0.5 (RIPRAP THICKNESS)
(NO LESS THAN 9")
$= 0.5(23)$
$= 11"$

CGD-6 (LOWER) / CGRD-9 (UPPER) CONT.

CROSS-SECTION:



WATER FLOW DEPTH = 0.85 FT
FREEBOARD = 1.00 FT.
TOTAL DEPTH = 1.85 FT.
SLOPE ⇒ MAX = 0.40 FT/FT
MIN = 0.08 FT/FT.
n = 0.040

D_{50} REQUIRED = 18 IN

RIPRAP THICKNESS = 23 IN

FILTER THICKNESS = 11 IN

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGD-6 (lower)

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	1.75:1 (H:V)
Right Side Slope.	1.75:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.0800 ft/ft ← MIN. SLOPE.
Discharge.....	30.40 cfs

Computed Results:

Depth.....	0.66 ft
Velocity.....	8.95 fps
Flow Area.....	3.40 sf
Flow Top Width...	6.31 ft
Wetted Perimeter.	6.66 ft
Critical Depth...	1.04 ft
Critical Slope...	0.0156 ft/ft
Froude Number....	2.15 (flow is Supercritical)

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Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLEGATE AREA

Comment: CGD-6 (lower)

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft
Left Side Slope..	1.75:1 (H:V)
Right Side Slope.	1.75:1 (H:V)
Manning's n.....	0.030
Channel Slope....	0.5000 ft/ft ← MAX SLOPE.
Discharge.....	30.40 cfs

Computed Results:

Depth.....	0.39 ft
Velocity.....	16.65 fps
Flow Area.....	1.83 sf
Flow Top Width...	5.36 ft
Wetted Perimeter.	5.57 ft
Critical Depth...	1.04 ft
Critical Slope...	0.0156 ft/ft
Froude Number....	5.03 (flow is Supercritical)

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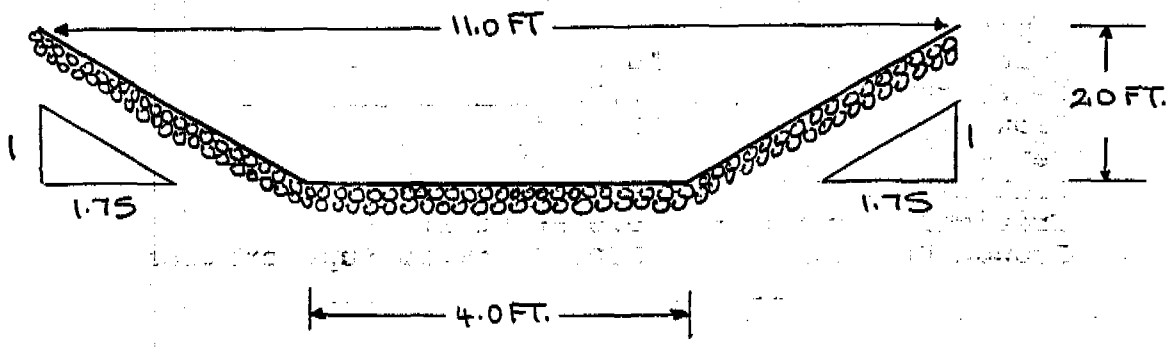
CGD-6 (LOWER) (CHANNEL + RIPRAP DESIGN).

D = 0.66 FT (BASED ON MIN. CHANNEL SLOPE, VELOCITY = 8.95 FPS)

U = 16.65 FPS (BASED ON MAX. CHANNEL SLOPE, DEPTH = 0.39 FT.).



WATER FLOW DEPTH = 0.66 FT.
FREEBOARD = 1.34 FT.
TOTAL DEPTH = 2.00 FT.
CHANNEL SLOPE => MAX = 0.50 FT/FT.
MIN = 0.08 FT/FT.

n = 0.030.
d_{50} ACTUAL = 6-8" GROUTED RIPRAP.

BASED ON THE MAXIMUM CHANNEL VELOCITY OF 16.65 FPS THE 6-8" GROUTED RIPRAP IS CONSIDERED ADEQUATE FOR CGD-6 LOWER.

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PROJECT LE-150 PAGE 57 OF
COMPUTED WJH DATE 4/16/93
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CASTLE GATE COAL MINE
PREPARATION PLANT AREA
SCHOOL HOUSE CANYON

DESIGN DIVERSION CGD-19 (SEE EXHIBIT 3.4-2)

- USE 100-YEAR 6-HOUR STORM RUNOFF
- SELECT LARGEST OF THE FLOWS CALCULATED FROM CURRENT AND FINAL OPERATIONAL PHASES.

CURRENT OPERATION PHASE

REFERENCE EXHIBIT 3.4-2 FOR WATERSHED BOUNDARIES

CONTRIBUTING WATERSHED	PEAK FLOW[a]
CGWS - D2A	18.51 CFS
CGWS - D2B	5.28 CFS
CGWS - D2E	6.61 CFS
TOTAL	30.4 CFS

(a) BASED ON 100-YR 6-HR STORM, SCS TYPE 'B' DISTRIBUTION

FINAL OPERATION PHASE

REFERENCE EXHIBITS 3.4-2C AND 3.4-2D FOR WATERSHED BOUNDARIES

CONTRIBUTING WATERSHED	PEAK FLOW[a] (CFS)
CGWS - D2B	6.89
CGWS - D2C	9.77
CGWS - D2D	3.02
CGWS - D2E	14.52
TOTAL	34.20

USE A PEAK DESIGN FLOW OF 34.20 CFS.

INCORPORATED
EFFECTIVE
JAN 18 1993
DIVISION OF OIL, GAS & MINING

REVISED 10/94

3.4 J

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE COAL

Comment: CGD-19, FINAL OPERATION PHASE

Solve For Depth

Given Input Data:

Bottom Width.....	4.00 ft	
Left Side Slope..	1.75:1 (H:V)	
Right Side Slope.	1.75:1 (H:V)	← BASED ON D_{50} = 7"
Manning's n.....	0.036	
Channel Slope....	0.1000 ft/ft	← UNIFORM SLOPE
Discharge.....	34.20 cfs	← 100-YEAR, 6-HR PEAK FLOW

Computed Results:

Depth.....	0.73 ft	← FLOW DEPTH
Velocity.....	8.83 fps	← MAX VELOCITY
Flow Area.....	3.87 sf	
Flow Top Width...	6.57 ft	
Wetted Perimeter.	6.95 ft	
Critical Depth...	1.11 ft	
Critical Slope...	0.0221 ft/ft	
Froude Number....	2.03 (flow is Supercritical)	

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3.4)

CGD-19 (MINIMUM CHANNEL + RIPRAP SIZING).

THIS DIVERSION IS EXCLUSIVELY FOR OPERATION, SO USE U.S. DOT (MILD SLOPE) RIPRAP DESIGN METHOD.

D = 0.73 FT (BASED ON AVERAGE CHANNEL SLOPE OF 10%
V = 8.83 FPS AND n = 0.036)

ASSUME $D_{50} = K = 7'' = 0.58' \therefore \frac{K}{D} = \frac{0.58'}{0.73} = 0.8$

FROM DOT FIG 1, WITH $K/D = 0.8$, $V_s/V = 0.92$

SO $V_s = 0.92 V \Rightarrow V_s = 0.92(8.83) = 8.1$ FPS

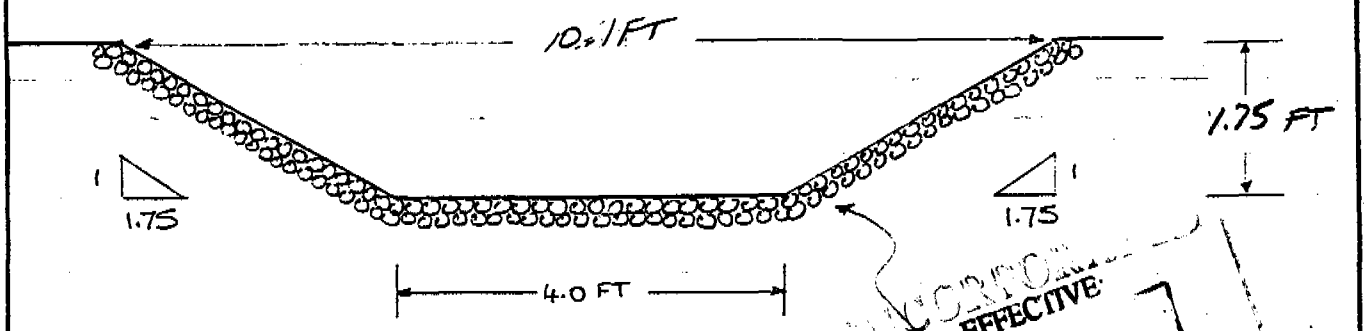
WITH 1.75:1 SIDE SLOPES, $V_s = 8.1$ FPS

$D_{50} = 7''$

CHECK n: $n = 0.0395 D_{50}^{1/6}$
$= 0.0395 (7/12)^{1/6}$
$= 0.036$ ✓

USE $D_{50} = 7''$ (14" THICK)

CROSS-SECTION



D_{50} REQUIRED 7 INCH
THICKNESS = 14 INCH

EFFECTIVE JAN 10 1995

WATER FLOW DEPTH = 0.73 FT
FREEBOARD = 1.02
TOTAL DEPTH = 1.75 FT
SLOPE => AVG = 0.10 FT/FT.
n = 0.036.

Trapezoidal Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CGRD-9(lower)

Comment: FINAL RECLAMATION PEAK FLOW DESIGN

Solve For Depth

Given Input Data:

Bottom Width.....	3.00 ft
Left Side Slope..	3.00:1 (H:V)
Right Side Slope.	3.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.2000 ft/ft ← MIN
Discharge.....	22.99 cfs

Computed Results:

Depth.....	0.55 ft ← FLOW DEPTH
Velocity.....	8.95 fps
Flow Area.....	2.57 sf
Flow Top Width...	6.31 ft
Wetted Perimeter.	6.49 ft
Critical Depth...	0.91 ft
Critical Slope...	0.0287 ft/ft
Froude Number....	2.47 (flow is Supercritical)

MIN. SLOPE USED TO SIZE CHANNEL. HOWEVER, RIPRAP SIZED FOR MAX SLOPE WILL BE PLACED ALONG ENTIRE LENGTH OF CHANNEL.

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CGRD - 9 (LOWER) CHANNEL & RIPRAP DESIGN

CHANNEL GEOMETRY - TRAPAZOIDAL

BOTTOM WIDTH = 3 FT
SIDE SLOPES = 3:1
MAX. CHANNEL SLOPE = 50 %
MAX DESIGN DISCHARGE = 23.0 CFS

RIPRAP

SINCE CHANNEL SLOPE $\geq$ 10%, USE SIMONS ET AL / OSM DESIGN METHODOLOGY FOR STEEP SLOPES.

SEE NOTE 2 ON PAGE 40 OF THESE CALCS FOR USE OF 2:1 S.S GRAPHS FOR 3:1 APPLICATION.

FIG 5.3 (OSM / TR - 82-2, SIMONS ET AL) DOES NOT INCLUDE A CURVE FOR 50% CHANNEL SLOPE FOR TRIANGULAR CHANNELS. USE GRAPH FOR BOTTOM WIDTH = 6 FEET AND ROUND UP FOR RIPRAP SIZE.

FROM FIGURE 5.4 WITH:

$Q = 23.0$ CFS
SLOPE = 50%

YIELDS $D_{50} = 1.35'$

FROM TABLE 5.2, WITH $1.26 \leq D_{50} \leq 1.50$

$D_{50} = 1.50' = 18''$

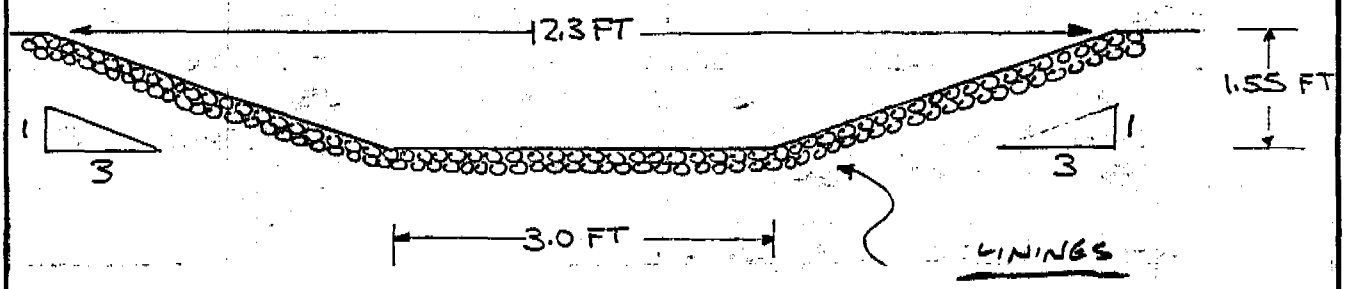
RIPRAP THICKNESS = $D_{MAX} = 1.25 (D_{50})$
$= 1.25 (1.50)$
$= 1.875' = 23''$

THICKNESS = 23"

USE AN 11" THICK FILTER BLANKET.

CGRD-9 (LOWER) CONT.

CROSS- SECTION:



D_{50} REQUIRED = 18 IN.

WATER FLOW DEPTH = 0.55 FT
FREEBOARD = 1.00 FT
TOTAL DEPTH = 1.55 FT
SLOPE ⇒ MAX = 0.50 FT/FT
MIN = 0.20 FT/FT
n = 0.040.

RIPRAP THICKNESS = 23 IN.

FILTER THICKNESS = 11 IN

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CASTLE GATE
SCHOOL HOUSE REFUSE AREA

DIVERSION SUMMARY BASED ON MAXIMUM PEAK FLOW DESIGN[1]

REFUSE AREA CHANNEL	BOTTOM WIDTH (FT)	SIDE SLOPES (H:V)	DEPTH (FT)	MIN CHANNEL SLOPE (%)	MAX CHANNEL SLOPE (%)	MAX. FLOW DEPTH (FT).	FREEBOARD (FT)	MAX. FLOW VELOCITY (FPS)[1]	MIN. D50 (in)
CGD-6 (UPPER)/CGRD-8	3.0	3:1	2.17	1	1	1.17	1.00	4.02	1
CGD-6 (LOWER)/CGRD-9 (UPPER)	3.0	3:1	1.85	8	40	0.85	1.00	—	18
CGD-7 (UPPER)/CGRD-7	3.0	3:1	2.01	1	1	1.01	1.00	3.72	1
CGD-7 (LOWER)/CGRD-3A	5.0	3:1	1.71	13	40	0.71	1.00	—	21
CGRD-9 (LOWER)	3.0	3:1	1.55	20	50	0.55	1.00	—	18
CGD-18	3.0	3:1	1.26	17	17	0.26	1.00	7.17	5
CGD-19	4.0	1.75:1	1.65	17	17	0.65	1.00	10.2	10

[1] MAXIMUM FLOW VELOCITY CALCULATED ONLY FOR U.S. DOT DESIGN PROCEDURE.

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CASTLE GATE
SCHOOL HOUSE REFUSE AREA

PERMANENT CHANNEL RIPRAP VOLUMES

CHANNEL	THICKNESS (FT)	WIDTH * (FT)	LENGTH (FT)	VOLUME (FT^3)	WEIGHT ** (TONS)	D_{50} (in).
CGD-6 (UPPER)/ CGRD-8	0.5	16.7	1000	8350	585	1
CGD-6 (LOWER)/ CGRD-9 (UPPER)	1.92	14.7	1000	28,224	1976	18
CGD-7 (UPPER)/ CGRD-7	0.5	15.7	1150	9028	632	1
CGD-7 (LOWER)/ CGRD-3A	2.17	15.8	1300	44,572	3120	21
CGRD-9 (LOWER)	1.92	12.8	450	11,059	774	18
TOTAL				101,233 FT^3	7087 TONS	

* WIDTH MEASURED ALONG THE SURFACE OF THE CHANNEL, THIS WIDTH IS USED TO CALCULATE RIPRAP SURFACE AREA.

** WEIGHT IS BASED ON AN IN-PLACE BULK DENSITY OF 140 PCF.

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CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA
FILTER BLANKET MATERIAL VOLUME.

CHANNEL	THICKNESS (FT.)	WIDTH (FT)	LENGTH (FT.)	VOLUME (FT^3)	WEIGHT (TONS) *
CGD-6 (UPPER)/ CGRD-8	0.5	16.7	1000	8350	543
CGD-6 (LOWER)/ CGRD-9 (UPPER)	0.92	14.7	1000	13524	879
CGD-7 (UPPER)/ CGRD-7	0.5	15.7	1150	9028	587
CGD-7 (LOWER)/ CGRD-3A	1.1	15.8	1300	22594	1469
CGRD-9 (LOWER)	0.92	12.8	450	5300	344
TOTAL				58,796 FT^3	3,822 TONS

* WEIGHT IS BASED ON AN IN-PLACE BULK DENSITY OF 130 PCF.

CASTLEGATE AREA
SCHOOL HOUSE CANYON REFUSE AREA

DIVERSION CULVERT CALCULATIONS

REVISED 4/93

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

CURRENT OPERATION HYDROLOGY

CULVERT SUMMARY

CULVERT	CONTRIBUTORY WATERSHED (Exhibit 3.4-2)	TOTAL DRAINAGE AREA (Acres)	DESIGN DISCHARGE ~~(10 Yr-6 Hr)~~(cfs) (100-yr 6-hr)
CGC-4	CGWS-D2A,D2B,D2E	55.4	30.4 ~~10.22~~

REVISED 4/93

6-

CASTLE GATE
SCHOOL HOUSE CANYON REFUSE AREA

FINAL OPERATION HYDROLOGY

CULVERT SUMMARY

CULVERT	CONTRIBUTORY WATERSHED (Exhibit 3.4-2C)	TOTAL DRAINAGE AREA (Acres)	DESIGN DISCHARGE ~~(10 Yr-6 Hr)~~(cfs) (100-YR 6-HR)
CGC-4	CGWS-D2B,D2C,D2D,D2E	27.9	~~13.90~~ 34.2

USE Q = 34.2 CFS AS THE PEAK DESIGN FLOW FOR CULVERT DESIGN.

REVISED 4/93

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT UC-150-19 PAGE 69 OF
COMPUTED TJC DATE 4-9-93
CHECKED DATE

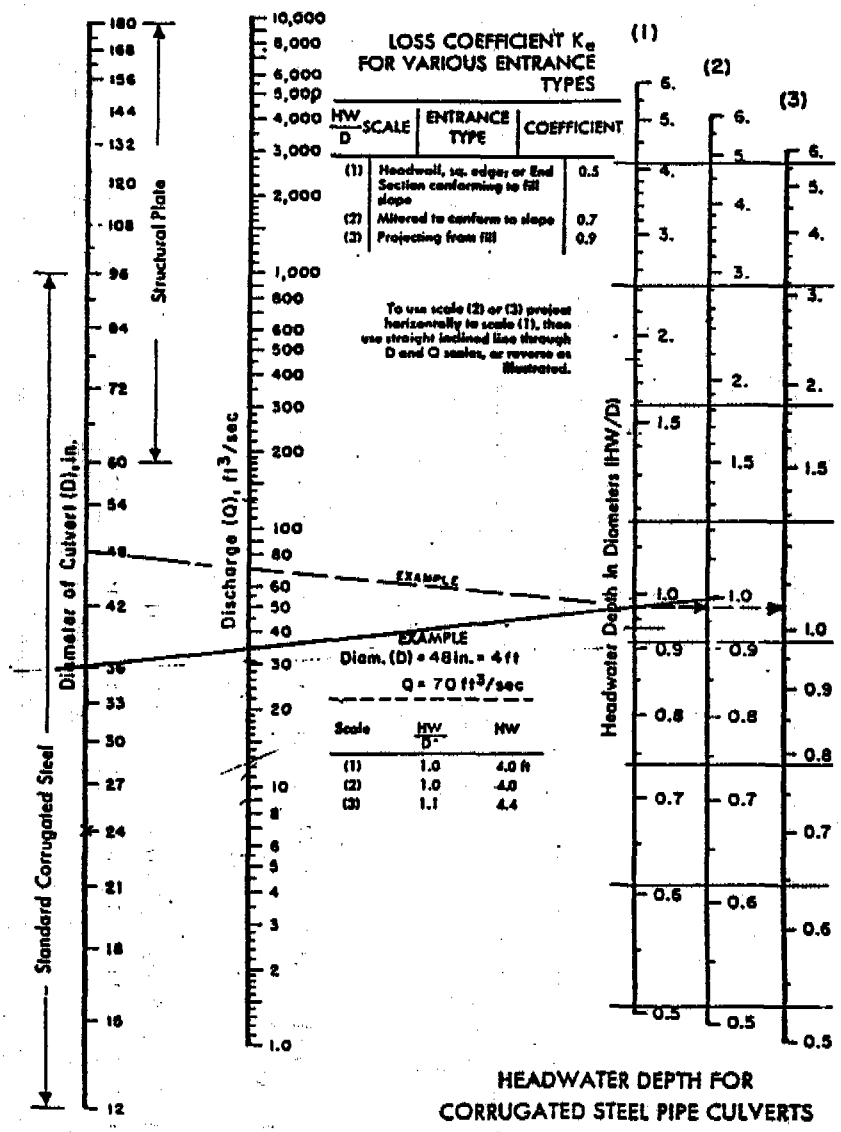
CASTLEGATE
SCHOOL HOUSE CANYON REFUSE AREA

CULVERT CAPACITY.

CULVERT IDENTIFICATION	SIZE	INLET TYPE	AVALIABLE HEADWATER OVER CULVERT TOP.	INLET CONTROL CAPACITY (a) (CFS)	CONTRIBUTING WATERSHEDS: (FINAL OPERATION	PEAK FLOW (b) (CFS)	
CGC-4. (UNDER ROAD)	36" (CMP)	PROJECTING	2.5'	65	CGWS - D2B, D2C, D2D, D2E	34.20	OK.

NOTES: (a) SEE NOMOGRAPH ON THE FOLLOWING PAGE OF THIS CALCULATION. CAPACITY BASED ON FULL HW.

(b) SEE RUNOFF CALCULATIONS. MULTIPLE WATERSHEDS ADDED NUMERICALLY. (ie, ASSUMES ALL PEAK FLOWS ARE TEMPORALLY CONCURRENT.) PEAK FLOW BASED ON 100 YR - 6 HR STORM EVENT.



FHWA HEC 5

Figure 4-28 *Inlet control* nomograph for corrugated steel *pipe* culverts. The manufacturers recommended keeping *HW/D* to a maximum of 1.5 and preferably to no more than 1.0.

CASTLE GATE MINE
SCHOOL HOUSE CANYON
OPERATIONS PHASE

CULVERT CGC-4 (CONT).

DESIGN AN EXTENSION TO CULVERT CGC-6 TO CONVEY FLOW TO POND 013.

THE CULVERT UNDER THE ROAD IS A 36" Ø CMP CULVERT. THE DESIGN OF THAT CULVERT WAS DICTATED BY INLET CONTROL. THE HDPE CULVERT EXTENSION WILL NOT BE GOVERNED BY INLET CONTROL, SO IT CAN BE SMALLER IN DIAMETER.

USE FLOWMASTER I TO CALCULATE THE MINIMUM DIAMETER PIPE.

SLOPE OF HILL BELOW REFUSE HAUL ROAD ≈ 60%
USE HDPE PIPE, n = 0.010 (HANCOR MANUF. DATA, 12"-24" Ø CORR. PIPE)

Q_{PEAK} = 34.2 CFS (100-YR, 6-HR STORM)

RESULTS: AN 18" Ø HDPE CULVERT WILL ADEQUATELY CONVEY 34.2 CFS TO POND 013.

CULVERT OUTLET:

VELOCITY = 53.4 CFS (SEE FLOWMASTER RESULTS)

THIS VELOCITY IS TOO HIGH FOR A REASONABLE RIPRAP DESIGN.

USE A PREFABRICATED STILLING BASIN AT THE BASE OF THE CULVERT TO FORCE THE PIPE TO FLOW FULL AND REDUCE VELOCITY AT THE OUTLET.

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CASTLE GATE AREA

Comment: HDPE EXTENSION TO CULVERT CGC-4

Solve For Actual Depth

Given Input Data:

Diameter.....	1.50 ft
Slope.....	0.6000 ft/ft
Manning's n.....	0.010
Discharge.....	34.20 cfs

Computed Results:

Depth.....	0.59 ft
Velocity.....	53.40 fps ← WOW! TOO FAST FOR RIPRAP
Flow Area.....	0.64 sf
Critical Depth....	1.50 ft
Critical Slope....	0.0601 ft/ft
Percent Full.....	39.11 %
Full Capacity.....	105.78 cfs
QMAX @.94D.....	113.78 cfs
Froude Number.....	14.23 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

CASTLE GATE MINE
SCHOOL HOUSE CANYON

CULVERT CGC-4 EXTENSION (CONT.)

USE FLOWMASTER I TO CHECK CULVERT SIZE ASSUMING PIPE FLOWS FULL NEAR THE BOTTOM.

ASSUME - ATMOSPHERIC PRESSURE AT BOTH ENDS OF PIPE
- USE $\phi = 18"$
- HDPE PIPE → HAZEN-WILLIAMS COEFF = 130
- PIPE LENGTH 175 FT

RESULTS : ONLY 9.68 FT OF ELEVATION HEAD IS NECESSARY TO FORCE PIPE TO FLOW FULL. SINCE THERE IS 90 FT OF ELEVATION HEAD ON THIS CULVERT, A 18 INCH DIAMETER CULVERT WILL WORK FINE.

DESIGN STILLING BASIN

REFERENCE: US DEPT OF TRANSPORTATION, DECEMBER 1975, HYDRAULIC DESIGN OF ENERGY DISSIPATORS FOR CULVERTS AND CHANNELS, HYDRAULIC ENGINEERING CIRCULAR NO. 14, FEDERAL HIGHWAY ADMINISTRATION, P. X-B-1.

CORPS OF ENGINEERS STILLING WELL

USE CULVERT DIAMETER = 1.5 FT
$Q = 34.2$ CFS

USING FIGURE X-B-1, AND EXTRAPOLATING SLIGHTLY,

$$D_W = 6D$$

WHERE D_W = STILLING WELL DIAMETER

SO $D_W = 6(1.5')$
$= 9$ FT

Pressure Pipe Analysis & Design
Circular Pipe

Worksheet Name: CASTLE GATE AREA

Comment: CULVERT CGC-4 EXTENSION

Solve For Elevation @ 1

Given Input Data:

Pressure @ 1.....	14.70 psi	(ATMOSPHERIC PRESSURE)
Elevation @ 2.....	0.00 ft	
Pressure @ 2.....	14.70 psi	
Discharge.....	15349.00 gpm	$(34.2 \frac{FT^3}{sec} \times 60 \frac{sec}{min} \times 7.48 \frac{gal}{FT^3})$
Diameter.....	18.00 in	
Length.....	175.00 ft	
Hazen-Williams C..	130.00	

Computed Results:

Elevation @ 1.....	9.68 ft	<< 90' OF HEAD OK
Velocity.....	19.35 fps	
Headloss.....	9.68 ft	
Energy Grade @ 1..	49.42 ft	
Energy Grade @ 2..	39.74 ft	
Friction Slope....	55.337 ft/1000 ft	

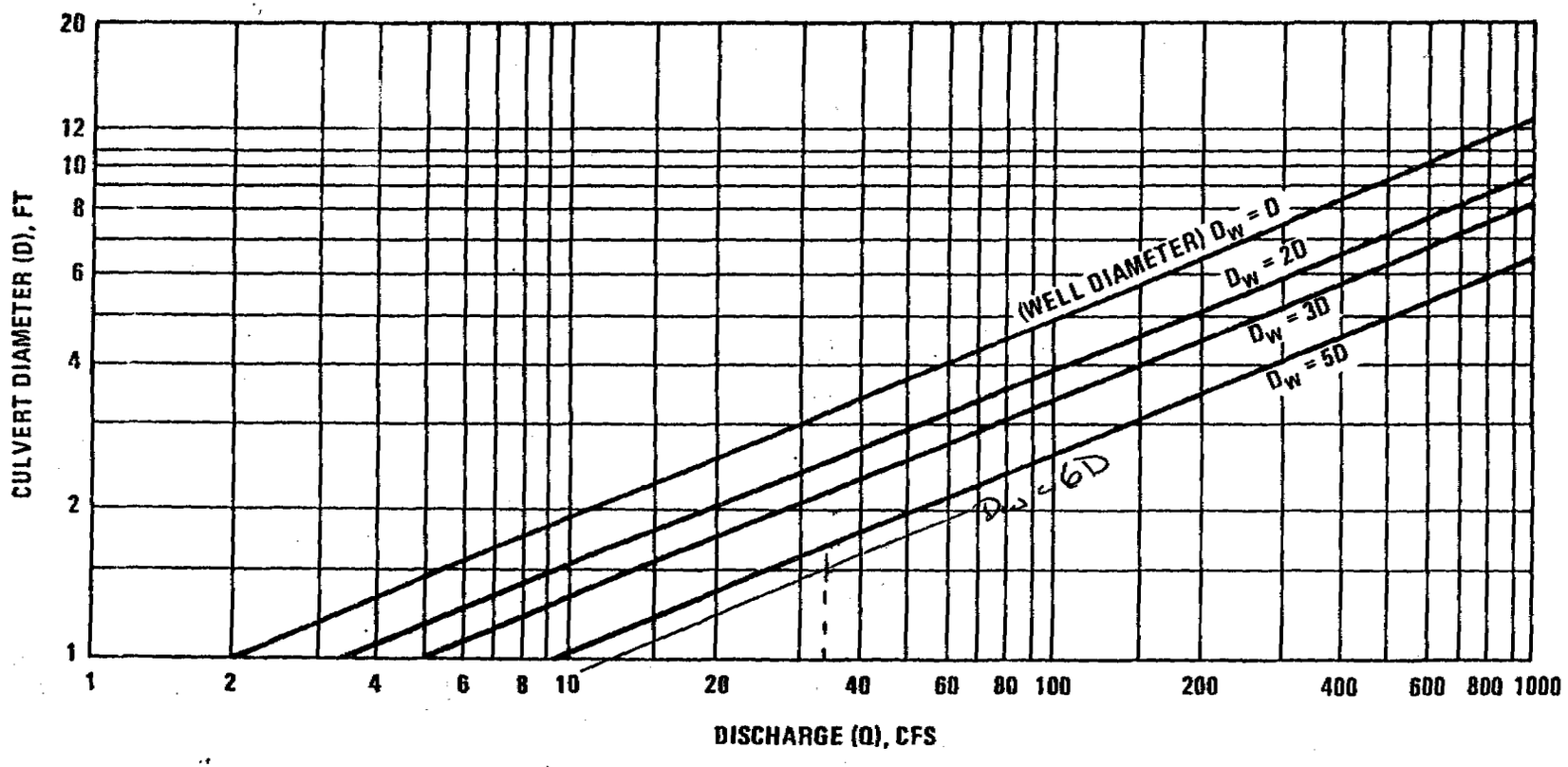


FIGURE X-B-1. STILLING WELL DIAMETER (D_W) FROM REFERENCE X-B-1

CASTLE GATE MINE
SCHOOL HOUSE CANYON

CULVERT CCC-4 EXTENSION OUTLET (CONT.)

DETERMINE THE DEPTH OF THE WELL BELOW THE CULVERT INLET.

CULVERT SLOPE = 0.60 FT/FT (EXH 3.4-2)

FROM FIGURE X-B-2, WITH SLOPE = 0.60 FT/FT,

$$\frac{h_1}{D_w} = 0.46$$

$$h_1 = 0.46 D_w$$
$$= 0.46 (9 \text{ FT})$$
$$= 4.1 \text{ FT}$$

SET $h_2 = 2(D)$
$= 2(1.5 \text{ FT})$
$= 3 \text{ FT}$ (MINIMUM)

TOTAL HEIGHT OF WELL $= h_1 + h_2$
$= 4.1 + 3$
$= 7.1$

USE A 7 FT DEEP WELL

CALCULATE FLOW VELOCITY OUT OF TOP OF WELL

$$Q = VA$$
$$34.2 \text{ CFS} = V\left(\pi (9/2)^2\right)$$

$V = 0.54$ CFS LOW

NO RIPRAP REQUIRED AROUND WELL

INSTALL STILLING WELL WITH A STEEL GRATE WITH A MINIMUM FREE AREA OF 75%.

INSTALL WELL ABOVE MAXIMUM SEDIMENT LEVEL OF THE POND.

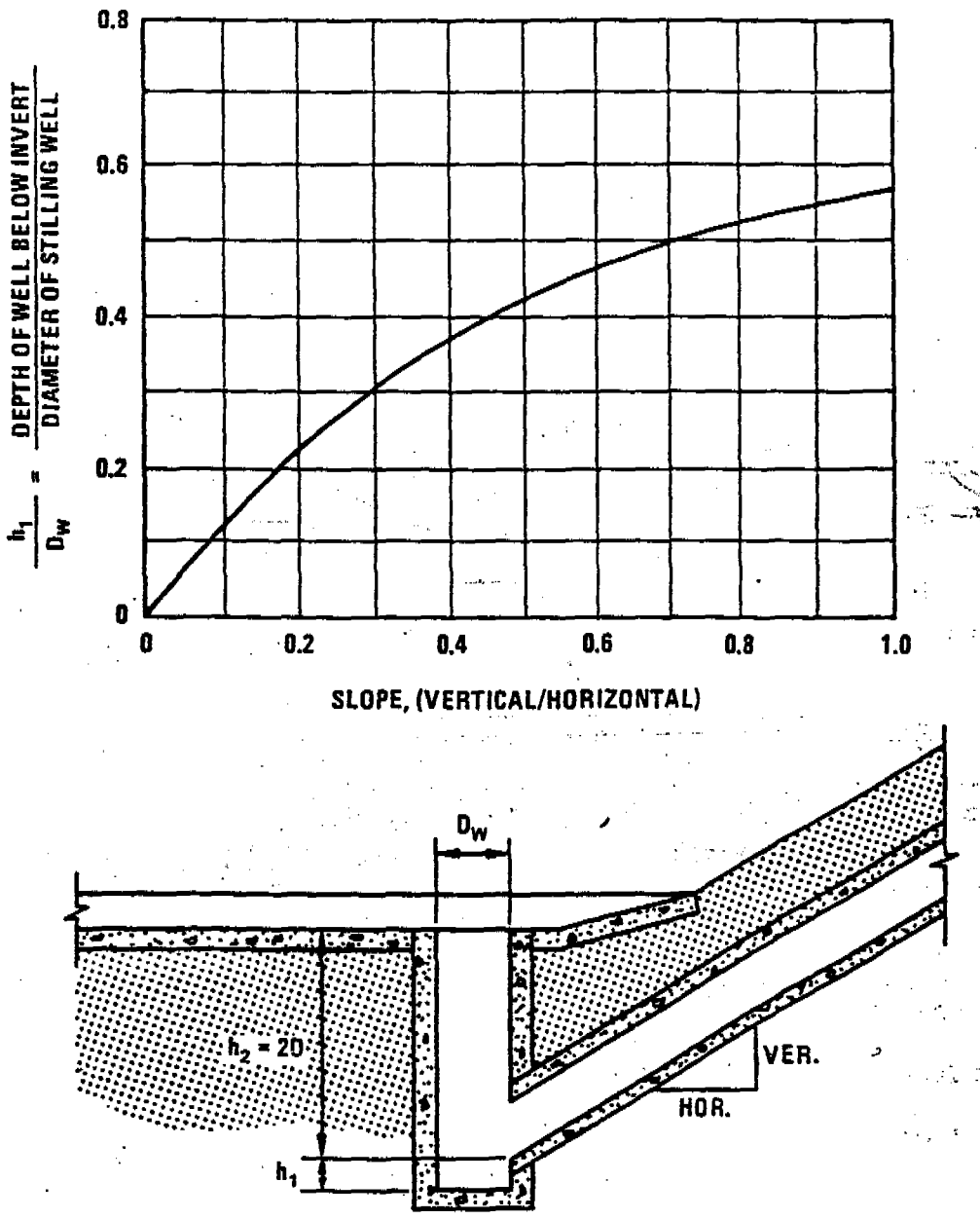
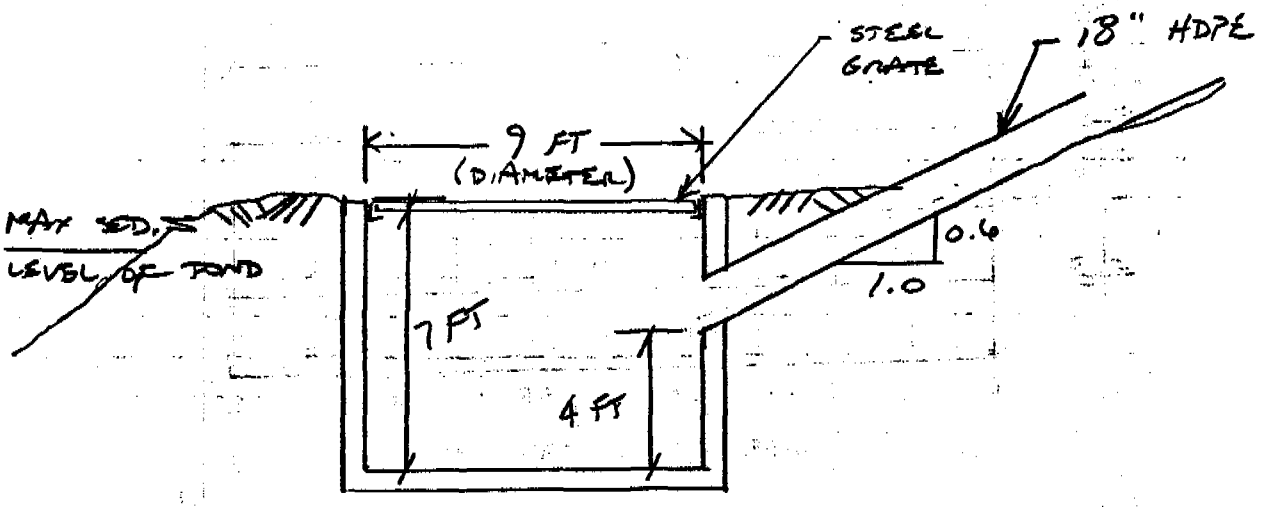


FIGURE X-B-2. STILLING WELL HEIGHT FROM REFERENCE X-B-1

CASTLE GATE MINE
SCHOOL HOUSE CANYON

STILLING WELL AT BASE OF
CULVERT CGC-4 EXTENSION



STILLING WELL CAN BE CONCRETE OR
CORRUGATED METAL (ANY SECTIONS).

April 26, 1993

APPENDIX 3.4J - SUPPLEMENT

DRAINAGE CONTROL DESIGN CALCULATIONS FOR SCHOOL HOUSE CANYON REFUSE SITE DIVERSION STRUCTURES - CURRENT OPERATION, FINAL OPERATION, AND RECLAMATION PHASES

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH

4/26/93

CASTLE GATE COAL
PREPARATION PLANT / REFUSE PILE
OPERATION PHASE HYDROLOGY
SUPPLEMENT TO APPENDIX 3.4.1

CULVERT CGC-4 OUTLET IN POND 013 - ALTERNATIVE DESIGN

RUN 18" Ø HDPE PIPE TO THE 60% CLEANOUT LEVEL IN POND 013, APPROXIMATE ELEV 6246. (SEE EXHIBIT 11.10).

SINCE THE BOTTOM OF THE POND IS AT 6234, THE SLOPE MUST BE PROTECTED FROM THE CULVERT OUTLET TO THE BOTTOM OF THE POND. ACCESS TO THIS LOCATION BY VEHICLES IS VERY DIFFICULT. THEREFORE, THE PLACEMENT OF LARGE RIPRAP (D50 = 48" +) IS NOT FEASIBLE. THE OUTLET STRUCTURE MUST BE ABLE TO BE TRANSPORTED TO THE BOTTOM OF THE POND BY NON-VEHICULAR MEANS.

SOLUTION: A HALF-ROUND CMP CULVERT CAN BE PLACED FROM THE BASE OF THE 18" Ø HDPE CULVERT TO THE BOTTOM OF THE POND.

SIZE THE 1/2-ROUND CMP CULVERT

USE FLOWMASTER I (HAESTAD METHODS, INC) TO DETERMINE FLOW DEPTH IN THE 1/2-ROUND CMP.

OPEN-CHANNEL CIRCULAR CHANNEL
TRY DIAMETER = 2.5 FT
SLOPE = 0.60 FT/FT
MANNING'S "n" = 0.024 (BARFIELD, ET AL, 1981)
Q_{PEAK} = 34.20 CFS

RESULTS:

FLOW DEPTH = 0.76 FT
VELOCITY = 27.32 FPS

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: CASTLE GATE AREA

Comment: CULVERT CGC-4 EXTENSION

Solve For Actual Depth

Given Input Data:

Diameter.....	2.50 ft
Slope.....	0.6000 ft/ft
Manning's n.....	0.024
Discharge.....	34.20 cfs

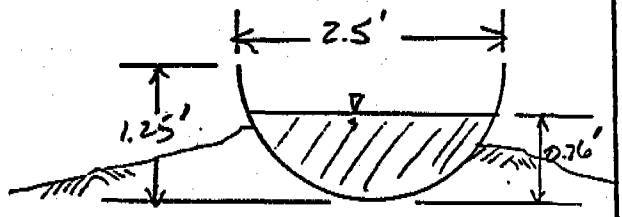
Computed Results:

Depth.....	0.76 ft ←
Velocity.....	27.32 fps ←
Flow Area.....	1.25 sf
Critical Depth....	1.99 ft
Critical Slope....	0.0251 ft/ft
Percent Full.....	30.23 %
Full Capacity.....	172.10 cfs
QMAX @.94D.....	185.13 cfs
Froude Number.....	6.52 (flow is Supercritical)

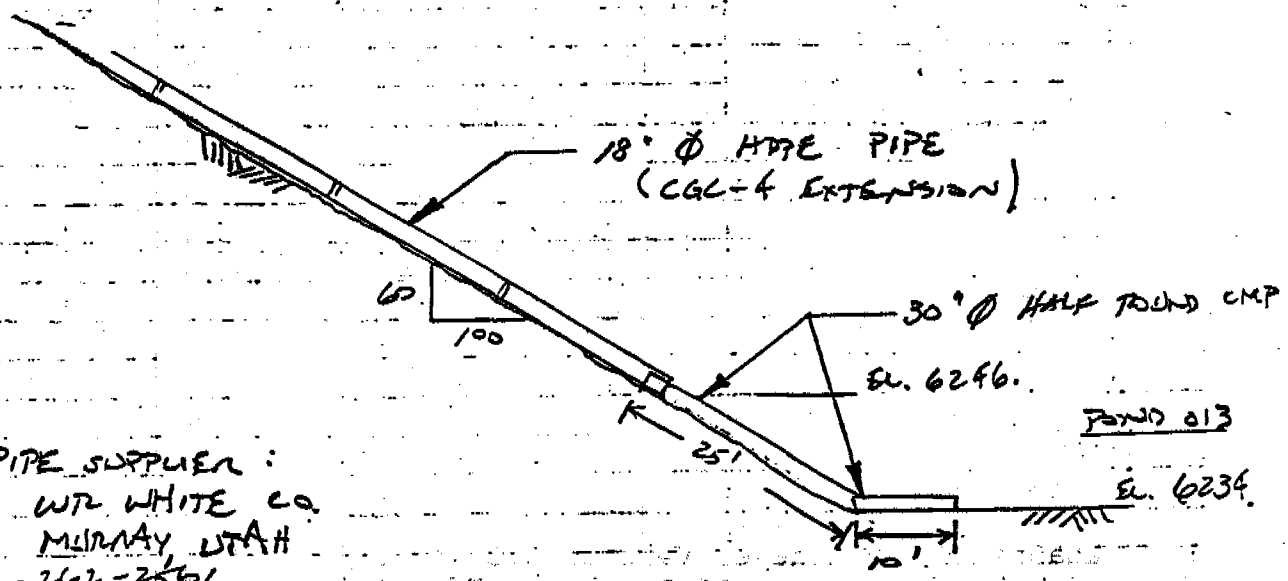
Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

CASTLE GATE COAL
PREP. PLANT / REFUSE PILE

FREEBOARD = 1.25 − 0.76
= 0.49 FT OK



USE A 2.5 FT DIAMETER HALF-ROUND CMP CULVERT PARTIALLY BEDDED IN THE GROUND AND SECURED TO THE SLOPE. RUN CULVERT 10' ACROSS THE FLAT ON THE BOTTOM OF THE POND.



PIPE SUPPLIER:
WR WHITE CO.
MURRAY UTAH
262-2561

30" Ø CMP (FULL) ⇒ $13.95/FT
(20' SECTIONS)
18" Ø HDPE ⇒ $9.66/F
(20' SECTIONS)

CUT CULVERT IN HALF LONGITUDINALLY PRIOR TO DELIVERY TO SITE.

SUPPLEMENTAL CALCULATIONS

TO

APPENDIX 3.4 d

CASTLE GATE PREPARATION PLANT

SCHOOL HOUSE CANYON

RIPRAP AND FILTER GRADATION DESIGN

RIPRAP GRADATION CALCULATIONS
SCHOOL HOUSE CANYON

CGD-7 (LOWER) / CGRD-3A

REFERENCE: OSM/TR-82/2. SURFACE MINING DIVERSION DESIGN MANUAL. PREPARED BY SIMONS, LI & ASSOC. 1982.

SINCE THE CHANNEL SLOPE ≥ 10%, USE STEEP SLOPE CHANNEL METHODOLOGY TO DESIGN RIPRAP GRADATION. FROM PREVIOUS CALCS, $D_{50} = 21"$

FROM FIGURE 5.1,

USING STEEP SLOPE DESIGN GRADATION CURVE,

$D_{MAX} = 1.25\, D_{50}^{*} = 1.25\,(21) = 26"$

$D_{85} = 1.20\, D_{50} = 1.20\,(21) = 25"$

$D_{20} = 0.5\,(D_{50}) = 0.5\,(21) = 10.5"$

$D_{10} = 0.33\,(D_{50}) = 0.33\,(21) = 7"$

* THE MULTIPLIER NOTED ON FIGURE 5.1 IS INCORRECT. HOWEVER, THE CALCULATED VALUE FOR D_{MAX} FOR THE EXAMPLE CURVE IS CORRECT. FOR STEEP SLOPES, THIS METHODOLOGY USES $D_{MAX}/D_{50} = 1.25$.
(SEE TABLE 5.1 FOR VERIFICATION)

NOTE: SINCE D_{10} FACTOR = 1/3 AND

D_{20} FACTOR = 1/2

ASSUME D_{15} FACTOR = 1/2.5

FILTER BLANKET GRADATION CALCULATIONS
SCHOOL HOUSE CANYON

CGD-7 (LOWER) / CGRD -3A (CONT):

SIMONS, LI & ASSOC PRESENTS TWO FILTER BLANKET GRADATION PROCEDURES, BUT THEY USE THE CORPS OF ENGINEER / BUREAU OF REC. METHOD (ANDERSON ET AL, 1970) IN THE EXAMPLE PROBLEM PG 5.24. THIS CRITERIA IS THE SAME AS PRESENTED IN BANFIELD ET AL. (1983), SO USE BANFIELD ET AL. PROCEDURE.

1) $\frac{D_{50}\ (\text{FILTER})}{D_{50}\ (\text{BASE})} < 40$ AND $\frac{D_{50}\ (\text{RIPRAP})}{D_{50}\ (\text{FILTER})} < 40$

2) $5 < \frac{D_{15}\ (\text{FILTER})}{D_{15}\ (\text{BASE})} < 40$ AND $5 < \frac{D_{15}\ (\text{RIPRAP})}{D_{15}\ (\text{FILTER})} < 40$

3) $\frac{D_{15}\ (\text{FILTER})}{D_{85}\ (\text{BASE})} < 5$ AND $\frac{D_{15}\ (\text{RIPRAP})}{D_{85}\ (\text{FILTER})} < 5$

ALSO NO MORE THAN 5% BY WEIGHT SHOULD PASS THE NO. 200 SCREEN (OSM/TR-82/2)

CHECK FOR NECESSITY OF FILTER BLANKET.

IS $\frac{D_{50}\ (\text{RIPRAP})}{D_{50}\ (\text{BASE})} > 40$?

$D_{50}\ (\text{BASE}) = 6.5\ \text{mm} = 0.65\ \text{cm} \times \frac{1\ \text{in}}{2.54\ \text{cm}} = 0.256\ \text{IN}$

$\frac{D_{50}\ (\text{RIPRAP})}{D_{50}\ (\text{BASE})} = \frac{21}{0.256} = 82 > 40$ SO <u>FILTER IS REQUIRED</u>

CGD-7 (LOWER) / CGRD-3A FILTER (CONT)

GANCO TESTING LABORATORIES WAS CONTRACTED TO PERFORM A SIEVE ANALYSIS ON A SAMPLE TAKEN FROM THE REFUSE PILE ADJACENT TO EXISTING DIVERSION CGD-7 (LOWER). THE RESULTS OF THAT TEST ARE PRESENTED ON PAGE 77 OF THESE CALCS.

A SEMI-LOG GRAPH OF THE RESULTS OF THE BASE MATERIAL SIEVE ANALYSIS IS PRESENTED ON PAGE 78.

A SPREADSHEET (LOTUS 1-2-3) WAS DEVELOPED TO CALCULATE THE FILTER BLANKET GRADATION. BASED ON THE CRITERIA PRESENTED IN BANFIELD, AND THE D_{15}, D_{50} AND D_{85} OF THE BASE MATERIAL FROM THE GRADATION PLOT. THE SPREADSHEET ALSO PRESENTS A RIPRAP GRADATION SPECIFICATION IN ADDITION TO THE FILTER BLANKET GRADATION. THE SPREADSHEET IS INCLUDED AS PAGE 79 OF THESE CALCS. THE FORMULAS USED IN THE SPREADSHEET ARE PRESENTED ON PAGE 80.

A GRAPHICAL REPRESENTATION OF THE RIPRAP AND FILTER BLANKET GRADATIONS ARE PRESENTED ON PAGE 78. (A CONVERSION FACTOR OF 25.4 MM/IN HAS BEEN USED TO CALCULATE & PLOT VALUES.)

SUMMARY

	D_{50} (IN)	D_{100} (IN)	THICKNESS (IN)
BASE MATERIAL	0.26	2	—
FILTER	3/4	13	13
RIPRAP	21	26	26

83

GARCO TESTING LABORATORIES

NVLAP Accredited

532 West 3560 South
Salt Lake City, Utah 84115
Phone 266-4498

5826 South 1900 West
Roy, Utah 84067
Phone 776-5355

0091 11/02/92

EARTH FAX ENGINEERING, INC.
7324 S 1300 E STE 100
MIDVALE UT 84047

LAB NO.: 51269
MATERIAL:
PIT/PLANT:

PROJECT: AMEX COAL CO.
IDENTIFICATION: CASTLE RK COAL PILE
SPECIFICATION:

TEST DATE: 10/30/92
SAMPLE BY: CUST RUN BY: DENA

USA SIEVE NUMBER	GRAMS RETAINED	% RETAINED	ACCUM. % RETAINED	% PASSING	SPECIFICATION % PASSING
2"	0			100.0	
1"	291.5	13.1	13.1	86.9	
3/8"	606.9	27.3	40.4	59.6	
#4	377.9	17.0	57.4	42.6	
#10	298.9	13.4	70.8	29.2	
#40	310.0	13.9	84.7	15.3	
#200	132.7	6.0	X 90.7	9.3	

ORIGINAL WT. 2222.6
WASHED WT. 2024.5
-#200 W.O. 198.1
-#200 S.O. 6.4
TOTAL -#200 204.5 = 9.2%

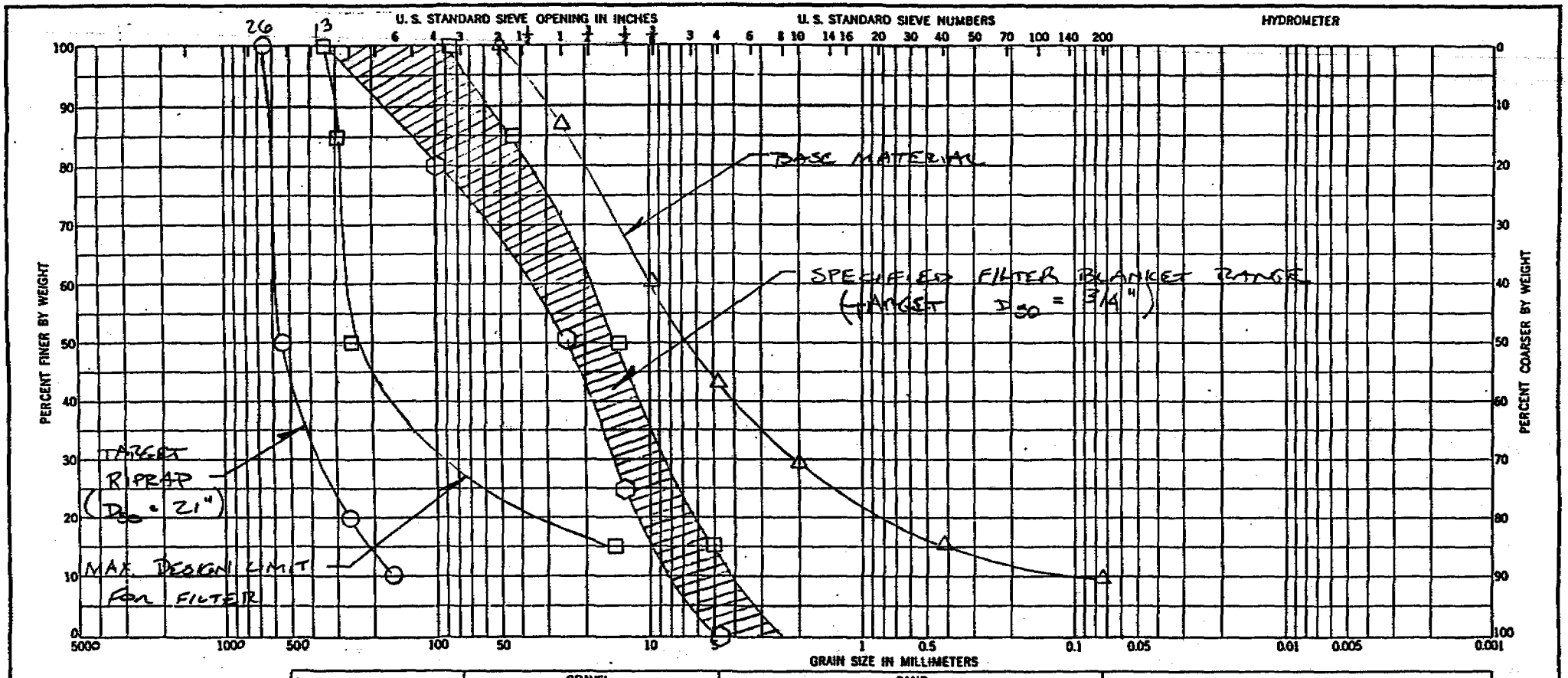
F.M. 2.66
DESIGN F.M.

SINCERELY,

D. Watson

MANAGER

CASTLE GATE REFUSE PILE DIVERSION CGD-7 (LOWER)/CGRD-3A
RIPRAP AND FILTER BLANKET GRADATIONS



COBBLES	GRAVEL		SAND			SILT OR CLAY
	COARSE	FINE	COARSE	MEDIUM	FINE	

Sample No.	Elev or Depth	Classification	Nat w %	LL	PL	PI
REFUSE	SURFACE	GW				

Project CASTLE GATE MINE REFUSE PILE DIVERSION
Area CGD-7 (LOWER)/CGRD-3A
Boring No. SIMONS ET AL/OSM METHOD
Date DECEMBER 1992

GRADATION CURVES

GPO 926-250

STEEP SLOPE RIPRAP AND FILTER BLANKET DESIGN: CASTLE GATE CGRD-3A

	D10 (MM)	D15 (MM)	D50 (MM)	D85 (MM)	D100 (MM)
DEFINE BASE MATERIAL	–	0.40	6.5	24.0	50.0
DEFINE RIPRAP D50			533		
CALCULATED RIPRAP	178	213		640	666

IS A FILTER BLANKET REQUIRED? YES
SINCE D50(RIPRAP) / D50(BASE) = 82.0 > 40

CALCULATED FILTER BLANKET RANGE				
MINIMUM	5	13	43	86
MAXIMUM	16	260	297	333
AVERAGE	11	137	170	209

NOTE: VALUES ARE PARTICLE SIZES IN MILLIMETERS
D15 REFERS TO THE PARTICLE SIZE (IN MM) FOR WHICH
15% OF THE MATERIAL IS FINER.

RIPRAP GRADATION

PARTICLE SIZE (MM)	PARTICLE SIZE (IN)	% PASSING (TARGET)	% PASSING MIN	% PASSING MAX
666	26	100	90	100
640	25	85	75	95
533	21	50	40	60
213	8	15	5	25
178	4.2	0	0	10

FILTER BLANKET GRADATION
(INPUT SCREEN SIZE IN INCHES AND MAXIMUM PERCENT FINER FROM GRADATION PLOT)

SCREEN (INCHES)	SCREEN (MM)	MAXIMUM % FINER	MINIMUM % FINER	TARGET % FINER
13	330	100	100	100
4	102	100	80	90
1	25	72	52	62
0.5	13	45	25	35
#4	0	15	0	7.5

filename: FILT-OSM.WK1

STEEP SLOPE RIPRAP AND FILTER BLANKET DESIGN FORMULAS – CASTLE GATE

	D10 (MM)	D15 (MM)	D50 (MM)	D85 (MM)	D100 (MM)
DEFINE BASE MATERIAL	–	+C4	+D4	+E4	+F4
DEFINE RIPRAP D50			+D6		
CALCULATED RIPRAP	+D6/3	+D6/2.5		+D6*1.2	+D6*1.25
IS A FILTER BLANKET REQUIRED?		@IF(+C11>40,"YES","NO")			
SINCE D50(RIPRAP) / D50(BASE)=		+D6/D4	@IF(+C11>40,"> 40","<40")		
CALCULATED FILTER BLANKET RANGE					
MINIMUM		@MAX(+C4*5+0.1,+C8/40+0.1)	+D6/40+0.1	+C8/5+0.1	+E14*2+0.1
MAXIMUM		@MIN(+C4*40,+C8/5,+E4*5)	+D4*40	@AVG(+D15,+F15)	+F8*0.5
AVERAGE		@AVG(C14,C15)	@AVG(D14,D15)	@AVG(E14,E15)	@AVG(F14,F15)

NOTE: VALUES ARE PARTICLE SIZES IN MILLIMETERS
D15 REFERS TO THE PARTICLE SIZE (IN MM) FOR WHICH
15% OF THE MATERIAL IS FINER.

RIPRAP GRADATION

PARTICLE SIZE (MM)	PARTICLE SIZE (IN)	% PASSING (TARGET)	% PASSING MIN	% PASSING MAX
+F8	+F8/25.4	100	+E27–10	+E27
+E8	+E8/25.4	85	+E28–10	+E28+10
+D6	+D6/25.4	50	+E29–10	+E29+10
+C8	+C8/25.4	15	+E30–10	+E30+10
+B8	+D6*0.2/25.4	0	+E31	+E31+10

FILTER BLANKET GRADATION
(INPUT SCREEN SIZE IN INCHES AND MAXIMUM PERCENT FINER FROM GRADATION PLOT)

SCREEN (INCHES)	SCREEN (MM)	MAXIMUM % FINER	MINIMUM % FINER	TARGET % FINER
13	+B39*25.4	100	100	100
4	+B40*25.4	100	+D40–20	@AVG(+D40,E40)
1	+B41*25.4	72	+D41–20	@AVG(+D41,E41)
0.5	+B42*25.4	45	+D42–20	@AVG(+D42,E42)
#4	+B43*25.4	15	@MAX(0,+D43–20)	@AVG(+D43,E43)

filename: FORM–OSM.WK1

007/004

APPENDIX 3.4J - SUPPLEMENT

DRAINAGE CONTROL DESIGN CALCULATIONS FOR SCHOOL HOUSE CANYON REFUSE SITE DIVERSION STRUCTURES - CURRENT OPERATION, FINAL OPERATION, AND RECLAMATION PHASES

CASTLE GATE COAL
PREPARATION PLANT - REFUSE PILE
RECLAMATION HYDROLOGY
SUPPLEMENT TO APPENDIX 3.4:

TASK:

EVALUATE THE POTENTIAL FOR EROSION ON THE FACE OF THE COMPLETED REFUSE PILE WITHOUT DIVERSIONS ON TERRACES TO DIRECT RUNOFF TO DIVERSIONS CORD-3A, 9.

ANALYSIS METHOD SUMMARY:

FOR ANALYSIS PURPOSES, EVALUATE A ONE FOOT WIDE STRIP ON THE FACE OF THE REFUSE PILE EXTENDING FROM POND 013 TO THE TOP OF THE PILE. USE THE PRECIPITATION FROM A 100-YEAR 6-HOUR STORM EVENT (2.0 INCHES, CH 7, TABLE 7-7) TO CALCULATE A PEAK FLOW OVER THAT AREA USING 'SCS HYDRO.' USE 'FLOWMASTER I' (HAESTAD METHODS, INC, 1991) TO DETERMINE A FLOW VELOCITY. DETERMINE IF THE FLOW VELOCITY IS LESS THAN A PERMISSIBLE NON-ERODING VELOCITY BASED ON VALUES PRESENTED BY BARFIELD, ET AL., (1981).

REFERENCE EXHIBIT 3.4-3 FOR RECLAMATION TOPOGRAPHY.

MIN. ELEV. = 6190 FT
MAX. ELEV. = 6548 FT
MIN. SLOPE = 10% (TERRACE)
MAX SLOPE = 50% (2H:1V)
LENGTH OF STRIP = 1100 FT
WIDTH OF STRIP = 1 FT

AREA = 1100 SF = 0.025 ACRES
CN = 80
STORM DISTRIBUTION: SCS TYPE 'B' 6 HOUR
STORM: 100-YR, 6-HR
P = 2.0 INCHES

T_c: (CALCULATED FOR 1 FOOT WIDE STRIP)

$T_L = 1.67 T_c$

$$T_c = \frac{L^{0.8}(S+1)^{0.7}}{1900 Y^{0.5}}$$

$S = \frac{1000}{CN} - 10$

$= \frac{1000}{80} - 10$

$= 2.5$

USE AVERAGE SLOPE TO DETERMINE WATERSHED SLOPE FOR 1 FT X 1100 FT VERTICAL STRIP.

$S = \frac{\Delta V}{H} = \frac{6548 - 6180}{1100} \times 100\% = 32.5\%$

SO,

$T_L = \frac{1100^{0.8} (2.5+1)^{0.7}}{1900 \cdot (32.5)^{0.5}}$

$= 0.06$ HRS

$T_c = 1.67 (0.06)$

$= 0.1$ HRS

USING SCS HYDRO,

$Q_{PEAK} = 0.01$ CFS (SEE PG 3 OF TABLE CALCS)

CALCULATE OVERLAND FLOW VELOCITY DOWN ONE FOOT STRIP.

ASSUME A RECTANGULAR CHANNEL 1 FT WIDE

SLOPE = 50% (2H:1V)

MANNING'S 'n' : CONSIDERING THAT THE FACE OF THE REFUSE PILE WILL BE VEGETATED AND THAT THE FLOW DEPTH WILL BE VERY, VERY SHALLOW COMPARED TO HEIGHT OF VEGETATION, AN 'n' VALUE OF 0.030 IS PROBABLY REASONABLE. HOWEVER, TO BE CONSERVATIVE, USE AN 'n' VALUE OF 0.020.

RESULTS

VELOCITY = 1.70 FPS

EARTHFAX ENGINEERING, INC.
HYDROGRAPH GENERATION PROGRAM OUTPUT
BASED ON SCS CURVE NUMBER METHODOLOGY

CASTLE GATE COAL - RECLAMATION PLAN

INPUT FOR: REFUSE PILE FACE

STORM :	WATERSHED :
Dist.=SCS Type 'b' - 6 Hr	Area = 0.03 acres
Depth = 2.00 inches	CN = 80.00
Duration = 6.00 hrs	Time conc.= 0.100 hrs

OUTPUT SUMMARY

Runoff depth	0.56250	inches	
Initial abstr	0.50000	inches	
Peak flow =	0.01	cfs	(0.51050 iph)
at time	2.520	hrs	

Rectangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: CASTLE GATE COAL

Comment: FACE OF REFUSE PILE - FINAL RECLAMATION

Solve For Depth

Given Input Data:

Bottom Width.....	1.00 ft
Manning's n.....	0.020 ← CONSERVATIVE 'n'
Channel Slope....	0.5000 ft/ft (2H:1V)
Discharge.....	0.01 cfs

Computed Results:

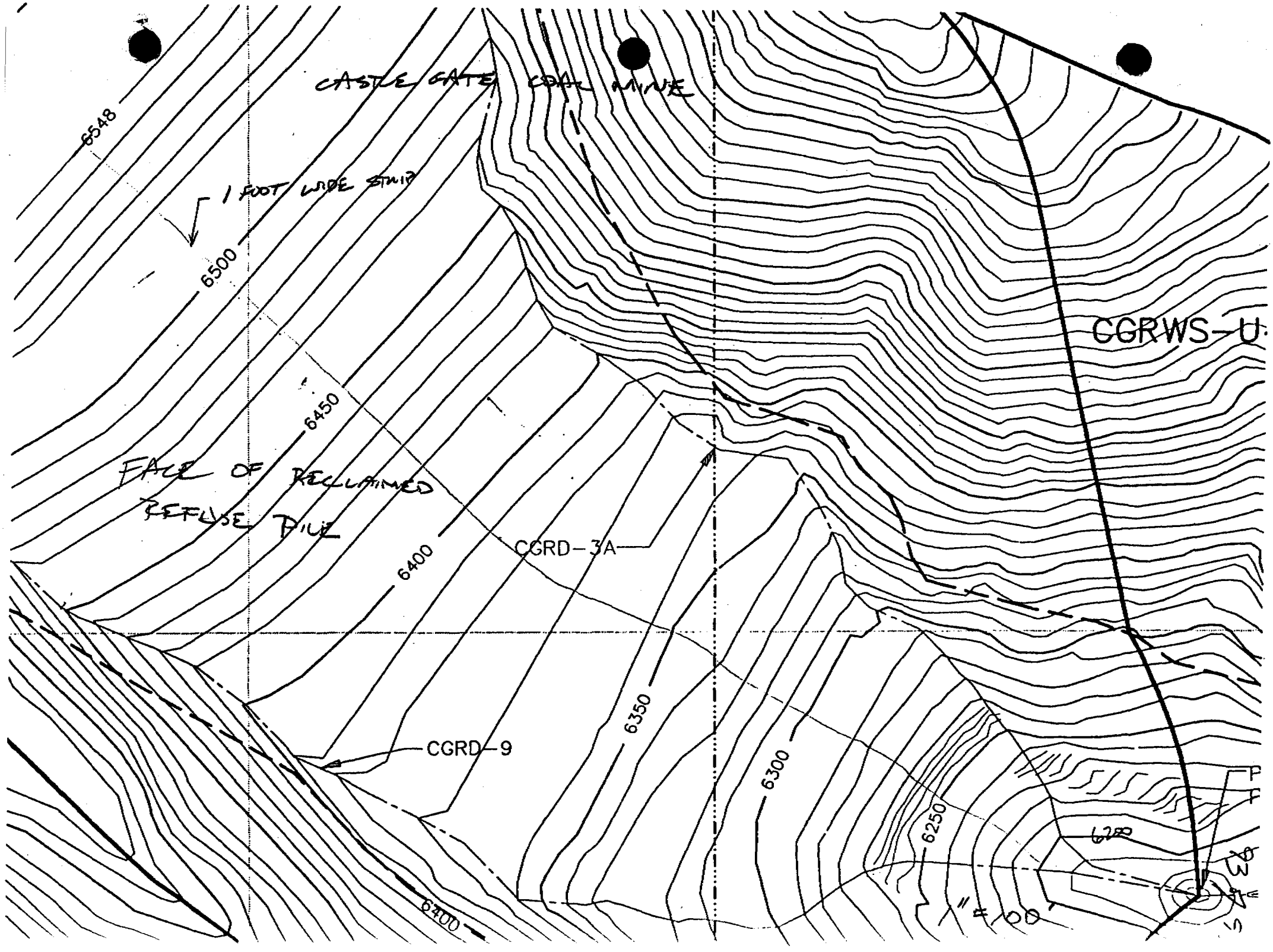
Depth.....	0.00 ft ← VERY SHALLOW
Velocity.....	1.70 fps ← FLOW VELOCITY
Flow Area.....	0.01 sf
Flow Top Width...	1.00 ft
Wetted Perimeter.	1.01 ft
Critical Depth...	0.01 ft
Critical Slope...	0.0248 ft/ft
Froude Number....	3.90 (flow is Supercritical)

Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708

ACCORDING TO BARFIELD, ET AL. (1981), TABLE 3.2,

THE LIMITING VELOCITY FOR CLEAR WATER ON A FINE GRAVEL IS 2.50 FPS. THIS IS HIGHER THAN THE CALCULATED VELOCITY OF 1.70 FPS. IN ADDITION, THE TERRACES WILL SLOW THE RUNOFF ON THE FACE OF THE REFUSE PILE.

CONCLUSION: DIVERSIONS ON THE TERRACES TO DIRECT FLOW OFF THE FACE OF THE REFUSE PILE TO THE DRAINAGES ALONG THE EDGE OF THE REFUSE PILE ARE NOT NECESSARY. THE AMOUNT OF RAIN THAT WILL FALL ON THE FACE OF THE REFUSE PILE IS NOT SIGNIFICANT ENOUGH TO CAUSE SUBSTANTIAL EROSION TO THE SOIL, ASSUMING THAT THE VEGETATION IS ESTABLISHED.


CASTLE GATE COAL MINE
6548
1 FOOT WIDE STRIP
6500
6450
FACE OF RECLAIMED REFUSE PILE
6400
CGRD-3A
CGRWS-U
6350
6300
6250
CGRD-9
6400
1" = 100'

SUPPLEMENT TO

APPENDIX 3.4J

DRAINAGE CONTROL DESIGN CALCULATIONS
FOR SCHOOL HOUSE CANYON REFUSE SITE DIVERSION STRUCTURES -
CURRENT OPERATION, FINAL OPERATION, AND RECLAMATION PHASES

REGISTERED PROFESSIONAL ENGINEER
No. 8435
CAROL A.
BJORK
STATE OF UTAH

Carol A. Bjork
1/17/95

As-built Culvert inlet calculations for CGC-4

- Improved / flared culvert inlet.
- Assume the improved inlet can be simulated using the design charts for side-tapered inlets to pipe culverts (attached)
  (Ref: U.S. DOT, 1972. Hydraulic Design for Improved Inlets for Culverts. Hydraulic Engineering Circular No. 13. Federal Hwy. Administration, Washington, D.C.)
- Test inlet control at face AND throat of side-tapered inlet.

Throat Control

- See attached sketch of culvert + design chart
- Peak Q (100 yr, 6 hr) = 34.2 cfs
- D = 24 inches (2.0')
- E = 30 inches (2.5')
- L_1 = 4.0 feet N = # of culverts = 1

$$\frac{Q}{ND^{5/2}} = \frac{34.2 \text{ cfs}}{(1)(2)^{5/2}} = 6.05$$

from chart, $\frac{H_t}{D} = 2.05$ for smooth inlets (concrete)

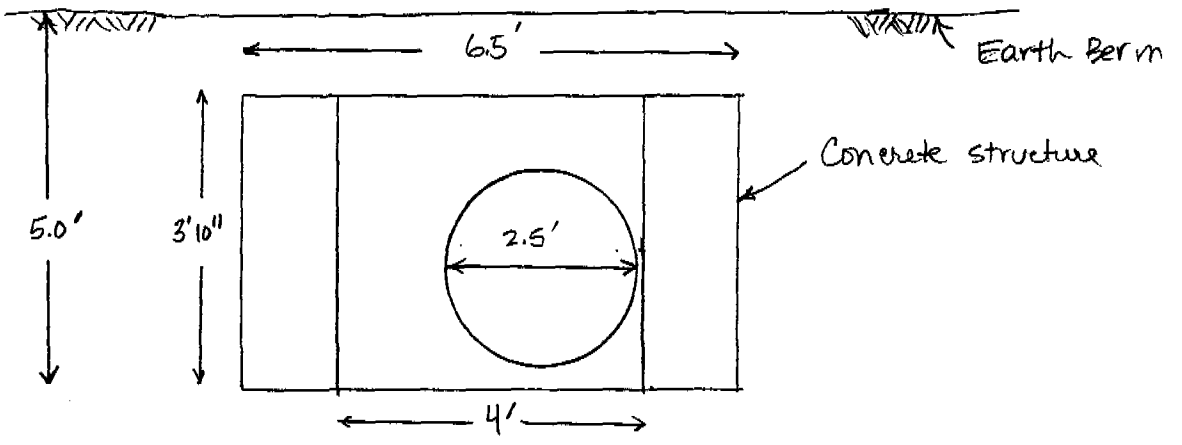
$$H_t = 2.05D = 4.1 \text{ feet}$$

EFFECTIVE
JAN 10 1995

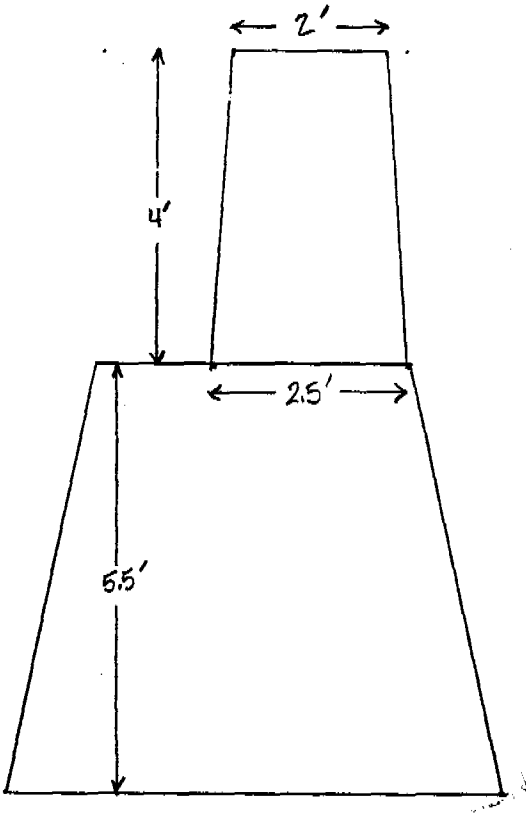
EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT UC412-05 PAGE 2 OF
COMPUTED CAB DATE 10/94
CHECKED DATE

Culvert CGC-4 Improved Inlet



ELEVATION VIEW



PLAN VIEW

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Face Control

$$\frac{Q}{A_f E^{1/2}} \qquad A_f = \pi(1.25)^2 = 4.91 \text{ ft}^2$$

$$\frac{34.2}{(4.91)(2.5)^{1/2}} = 4.41$$

$$\frac{H_f}{E} = 1.75 \qquad H_f = 1.75(2.5) = 4.4 \text{ feet}$$

Summary

Limiting Criteria @ Face control.
$H_f = 4.4$ feet. Add freeboard → 6".
$H \sim 5.0$ feet.
Existing $H = 5.0$ feet.
Therefore, Inlet is adequate.

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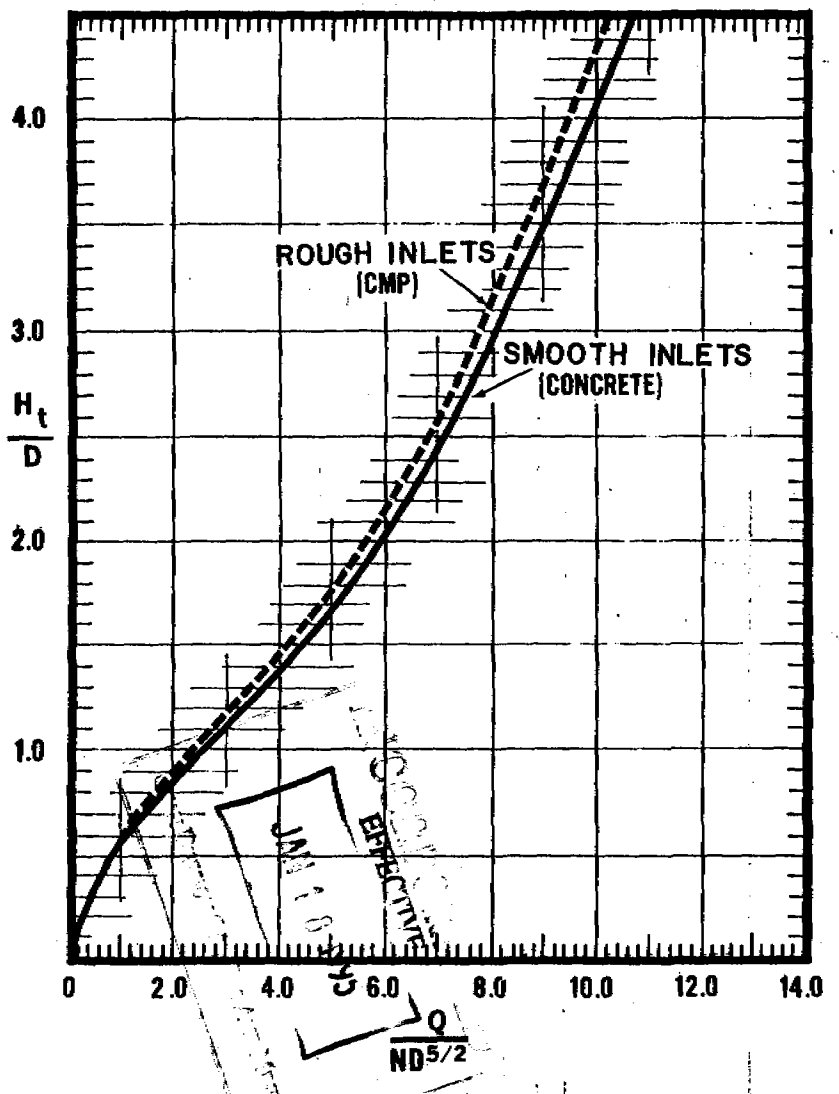
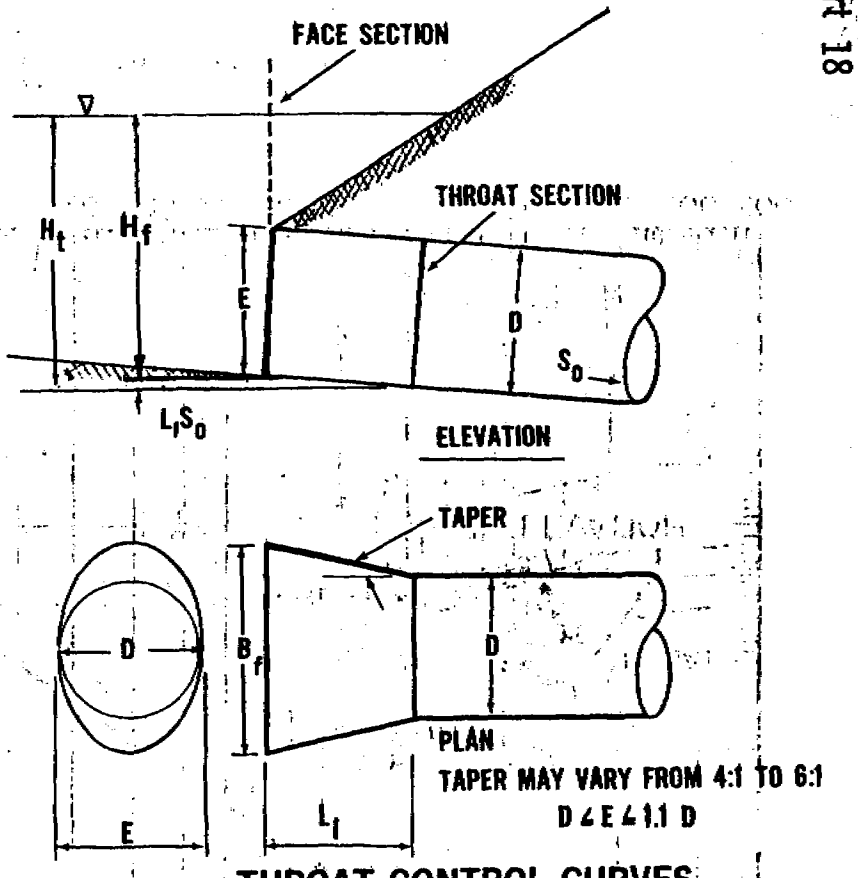
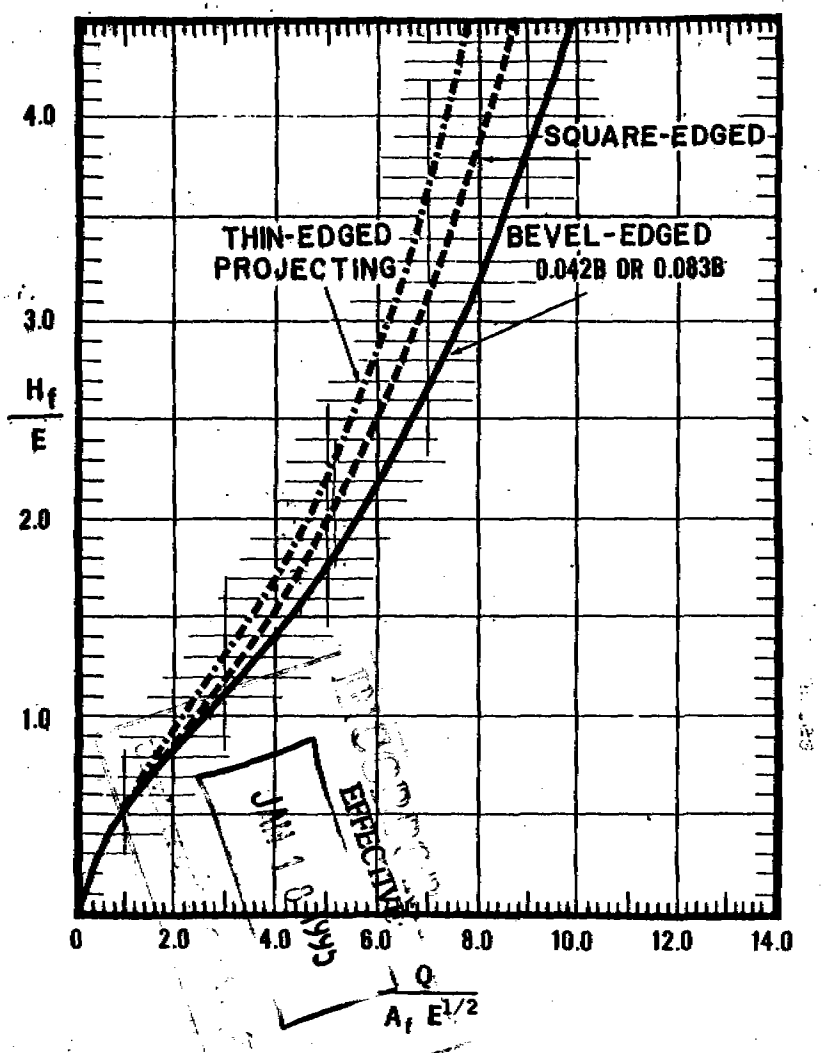
Chart 18

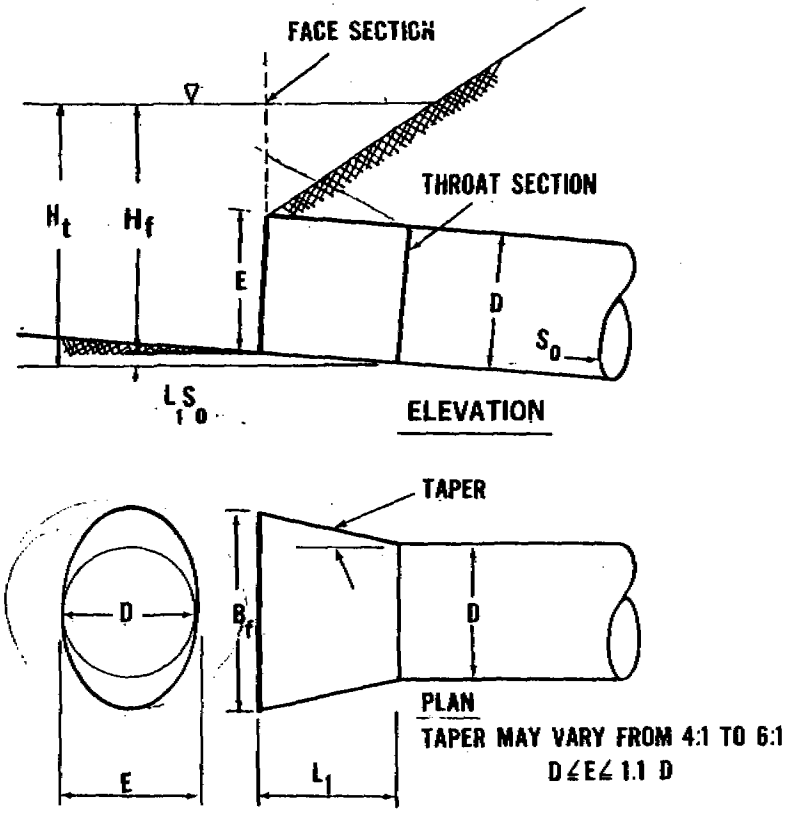




THROAT CONTROL CURVES FOR SIDE-TAPERED INLETS TO PIPE CULVERT (CIRCULAR SECTIONS ONLY)

FEDERAL HIGHWAY ADMINISTRATION
OCTOBER 1971





FACE CONTROL CURVES FOR SIDE- TAPERED INLETS TO PIPE CULVERTS (NON-RECTANGULAR SECTIONS ONLY)

NOTE: FOR MULTIPLE BARRELS, DESIGN SIDE-TAPERED INLETS AS INDIVIDUAL STRUCTURES

Chart 19

FEDERAL HIGHWAY ADMINISTRATION
OCTOBER 1971

APPENDIX 3.4K

SLOPE STABILITY ANALYSIS

REGISTERED PROFESSIONAL ENGINEER
NO. 11350
WILLIAM S. HENDRICKSON
STATE OF UTAH

William S. Hendrickson
2/2/94

SLOPE STABILITY ANALYSES
CASTLE GATE PREP PLANT
CARBON COUNTY, UTAH

AMAX COAL COMPANY
Castle Gate Mine
Carbon County, Utah

Prepared by

EARTHFAX ENGINEERING, INC.
Midvale, Utah

May 1, 1992

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SLOPE STABILITY ANALYSES
CASTLE GATE PREP PLANT
CARBON COUNTY, UTAH

1.0 INTRODUCTION

AMAX Coal Company owns and manages The Castle Gate Mine in Carbon County, Utah in the vicinity of the town of Helper. As part of the procedure to maintain a current permit with the Utah Division of Oil, Gas, and Mining, the Reclamation Plan has recently undergone review by AMAX personnel. This report has been prepared by EarthFax Engineering, Inc., at the request of AMAX Coal, to summarize a geotechnical evaluation of the cut slopes and fills at the Castle Gate Coal Preparation (Prep) Plant. Conclusions presented herein support the revised Reclamation Topography Plan that accompanies this report.

The work described in and associated with this report includes field observations, surface soil sample collection, reviews of field data, photo documentation, and geotechnical analyses. This report presents an expression of professional opinions and recommendations based on the results of field observations, engineering analyses, and professional judgement. Once earthwork reclamation construction begins in the Prep Plant area, a qualified engineer or geologist should be at the site to monitor field conditions and make field decisions as necessary.

This document is divided into six sections including this introduction. The methods used to analyze the cut and fill slopes are summarized in Section 2.0. A compilation of the field survey data are presented in Section 3.0, followed by slope stability analyses of five chosen slopes in Section 4.0. Conclusions are presented in Section 5.0, followed by the cited references in Section 6.0.

2.0 METHODS OF ANALYSES

A field survey of the Castle Gate Prep Plant area was conducted on January 22, 1992 by EarthFax personnel accompanied by representatives of AMAX. The field survey consisted of visually evaluating cut slopes and fills that were constructed for the purposes of the mining operation. Photographs were taken of all representative slopes to document their current condition. Soil samples for field descriptions were taken from the slopes as required for further visual analysis. The following items were noted during the field survey: general soil and rock types and their condition; height, length, and angle of the slopes; presence of water; sloughing; and the presence of slope vegetation. Information regarding the age of the cut slopes was gathered from the AMAX representatives. In addition, natural cliff/ledge formations in the immediate area were visually evaluated and photographed.

Based on the information gathered during the field survey and engineering judgement, several "worst case" cut slopes were chosen to be analyzed by GEOSLOPE, a slope stability computer software program. The purpose of the slope stability analysis was to determine an in-situ factor of safety for each of the cut slopes designated for analysis. The criterion for designating a slope as stable was a static factor of safety that exceeds 1.30, as required by section R645-301-553.600 of the Utah Coal Mining Regulations.

GEOSLOPE is a computer program based on the FORTRAN program STABL3 which was developed at Purdue University. GEOSLOPE utilizes the limit equilibrium procedure of slices to determine the safety factor of potential circular (Simplified Bishop's Method) and non-circular failure surfaces (Janbu's Method). Because of the nature of the layered sedimentary deposits in Carbon County, both the Janbu Method as well as the Bishop's Method were used to evaluate the slopes. Both deep failure surfaces and surfaces that generally fail through the toe of the slopes were analyzed. Only results from the scenario that exhibited the lowest factor of safety for each slope are included in this report.

Since lab testing of soil sampled from the slopes in question is not included in the scope of this analysis, soil and rock properties were assumed. The basis for those assumptions were visual identification performed in the field, visual classification of soil samples brought back to the EarthFax office, and typical soil and rock properties presented by Hoek (1981). Soil parameter assumptions made in this analysis are generally conservative because of the absence of lab data.

3.0 FIELD SURVEY

3.1 General

The Castle Gate Prep Plant is located two miles north of Helper, Utah on the east side of the Price River, which parallels State Route 6. The Prep Plant area has been the site of coal mining operations since the turn of the century, when coal was extracted from the Ketchum Mine, located in the draw northeast of the guard shack. Many of the miners who worked in the local mines lived in the town of Castle Gate. In the mid 1970's, the old coal processing plant was demolished, as were the remaining town structures, and the current Prep Plant Facility was constructed. The current owners, AMAX Coal Company, processed coal in the Prep Plant until it was idled in 1989 due to reductions in local coal mining.

3.2 Geology and Vegetation

The geology of the Prep Plant area consists of the Mesaverde Group of upper Cretaceous sedimentary rocks. Most of the coal mined in the area is extracted from seams of the Blackhawk Formation. The Blackhawk Formation is overlain by the Castlegate Sandstone and the Price River Formation, respectively.

The Blackhawk Formation, a middle member of the Mesaverde Group, consists of light to medium gray sandstone, light gray to black shale, light to medium gray siltstone, and coal (Davis and Doelling, 1977). The sandstones are mostly fine grained and form ledges and cliffs. The shales and siltstones are generally carbonaceous and underlie covered slopes. The sediments of the Blackhawk Formation are typically 400 to 1,100 feet thick.

The Castlegate Sandstone is a gray, fine to medium grained sandstone, 100 to 500 feet in thickness, with subordinate shale layers. The Price River Formation consists of yellow-

gray to white medium grained sandstone and shaley sandstone. Formation thickness ranges from 500 to 1500 feet.

The vegetation on the natural slopes surrounding the Prep Plant area consists of grasses and sagebrush, with sparse coverage of pinyon and juniper trees. The small side canyons support locally dense stands of conifers.

3.3 Background Soil Information

Although the soils and rock formations vary throughout the area in the vicinity of the Prep Plant, they can generally be categorized as sandstones, shale, siltstones, and a colluvial silty sand with some boulder-size particles. In the silty sand material and in the siltstones, calcium carbonate acts as a cementing agent. Thus, the undisturbed soil strength is greater than the disturbed strength. This cementation, coupled with inherent slope stability provided by roots and capillarity (inter-particle moisture), enables steep slopes to remain stable in the Prep Plant area. In addition, intermediate layers of fairly competent sandstone allow both natural and cut slopes to stand at steep angles. Depending on the relative influence of these factors and the localized geomorphic processes, the natural side slopes in the Prep Plant area range from an angle of 25° to near vertical where sandstones predominate the strata.

3.4 Photo Documentation

Since most of the coal processing facilities are located on the naturally level ground adjacent to the Price River, there are relatively few cut and fill slopes on the permit property. Photographs #1 through #8, taken during the field survey, document representative cut and fill slopes (Appendix A). Each one of these slopes was analyzed for long term slope stability.

A short description, location reference, and appropriate characteristics of each slope are included in the caption below each picture. The locations of the slopes in each picture are identified in Exhibit 3.4-2A.

To document the similarities between the existing cut slopes and the natural cliff/ledge formations, pictures #9 through #12 (Appendix A) are presented with appropriate captions. The locations of the cliff formations, and the direction from which each photograph was taken, are shown in Exhibit 3.4-8.

3.5 Highwall Evaluation

Within the context of underground coal mining activities, a highwall is a face of exposed overburden at the entry to an underground mining operation (R645-100-200). There are no highwalls in the vicinity of the Prep Plant area of the Castle Gate Mine.

3.6 Resident Land Forms

In conjunction with the field survey of cut slopes for the stability analysis, EarthFax Engineering Inc. observed and photographed natural cliffs and ledges in the Prep Plant area. The purpose of this evaluation was to determine if the retention of the cut slopes constitutes compliance with the approximate original contour requirements of the Utah mining regulations.

3.6.1 Methods

The investigation was conducted by visually scanning the study area for exposed bedrock from several vantage points near the processing plant and in Gravel Canyon, and by studying topographic maps of the surrounding area. Approximate height, length, and location of natural cliffs/ledge formations were noted and photographs taken to document the

existence of these formations in the Prep Plant area. A total of four locations were chosen to represent the results of the geomorphic processes that affected the area.

In general, the natural cliffs vary from 500 to greater than 1500 feet in length, with heights of 40 to 400 feet. In comparison, the man-made cut slopes range from 200 to 500 feet in length, and 20 to 80 feet in height.

Stream downcutting is the dominant cliff forming geomorphic process in the study area. Subsequent cliff erosional processes include rock fall, ravelling, slope wash, rainfall impact, rock sliding, and landsliding. To varying degrees, evidence of these geomorphic processes were identified at each cliff/ledge. Given time, all of the cliffs and ledges, including portions of the canyons near the Prep Plant, will degrade to slopes. Thus, the geomorphic processes acting on the cut slopes are identical to the geomorphic processes of the area.

3.6.2 Documentation of Natural Cliffs/Ledges

The four natural cliff/ledge formations chosen to represent the land forms common to the Castle Gate Prep Plant area are described below. The locations of the cliffs, designated as A through D, are shown on Exhibit 3.4-8.

<u>Cliffs/ledges - Location A</u>

General Location: Northeast of lower access road to Castle Gate permit area.

Length: 1000 feet

Maximum Height: 40 feet

Aspect: Southwest

Rock Type:	Weathered but competent sandstone stratum.
Slope:	Nearly vertical, with 40° talus slope below.
Vegetation:	No vegetation on rock face.
Picture Reference:	#9

Cliffs/ledges - Location B

General Location:	1. West side of Schoolhouse Canyon above diversion ditch. 2. Southeastern ridge of Schoolhouse Canyon.
Length:	1. 1000 feet 2. 1000 feet
Maximum Height:	1. 300 feet 2. 300 feet
Aspect:	1. Southeast 2. Southwest
Rock Type:	Sandstone
Slope:	70° to 90°
Vegetation:	Some vegetation on rock ledges (grasses, junipers, etc.), but essentially no vegetation on rock faces.
Picture Reference:	#10

Cliffs/ledges - Location C

General Location:	Upper Barn Canyon
Length:	1500 feet
Maximum Height:	400 feet
Aspect:	West
Rock Type:	Sandstone. Talus slope at base of cliff.
Slope:	50° to 80°
Vegetation:	Grasses and junipers on ledges.
Picture Reference:	#11

Cliffs/ledges - Location D

General Location:	Upper Gravel Canyon
Length:	2000 feet
Maximum Height:	400 feet
Aspect:	Southeast, east and northeast
Rock Type:	Sandstone
Slope:	70° to 90°

Vegetation: No vegetation on vertical rock faces. Talus slopes are only sparsely vegetated with sage and some grasses.

Picture Reference: #12

4.0 STABILITY ANALYSIS

4.1 General

Based on the interpretation of the information gathered during the field survey and engineering judgement, five locations were identified to represent the "worst case slopes" in terms of long term stability. These locations (Sections A through E) are noted in Exhibit 3.4-2A, as is the orientation of the section taken to analyze these slopes. These five slopes are located as follows:

Section A - Southeast facing slope along the lower end of the refuse haul road.
Section B - Northeast facing slope along the middle section of the refuse haul road.
Section C - Small south facing cut slope near the northeast thickner overflow pond.
Section D - South facing slope adjacent to Pond #13 embankment.
Section E - Northeast facing slope above the diversion ditch above the refuse area.

GEOSLOPE was used to model these five slopes and determine the existing factor of safety of each one.

4.2 Section A

As indicated in Exhibit 3.4-2A, a 320 foot section was analyzed through the southeast facing slope along the refuse haul road. This section, as drawn in Figure 4-1, is characterized by an approximate 30' high, 69° cut slope beneath a 55° cut slope. The naturally vegetated hillside above the cut along the haul road slopes back at 40° from the horizontal. Sandstone outcroppings are visible slightly higher up the natural slope. The slope is comprised of a sandstone layer overlain by a colluvial silty sand with gravel and some boulders. The wide range of grain sizes is indicative of a material with a fairly high angle of internal friction (Hoek, 1981). The silt component of the soil does exhibit cohesion, in the forms of cementation and

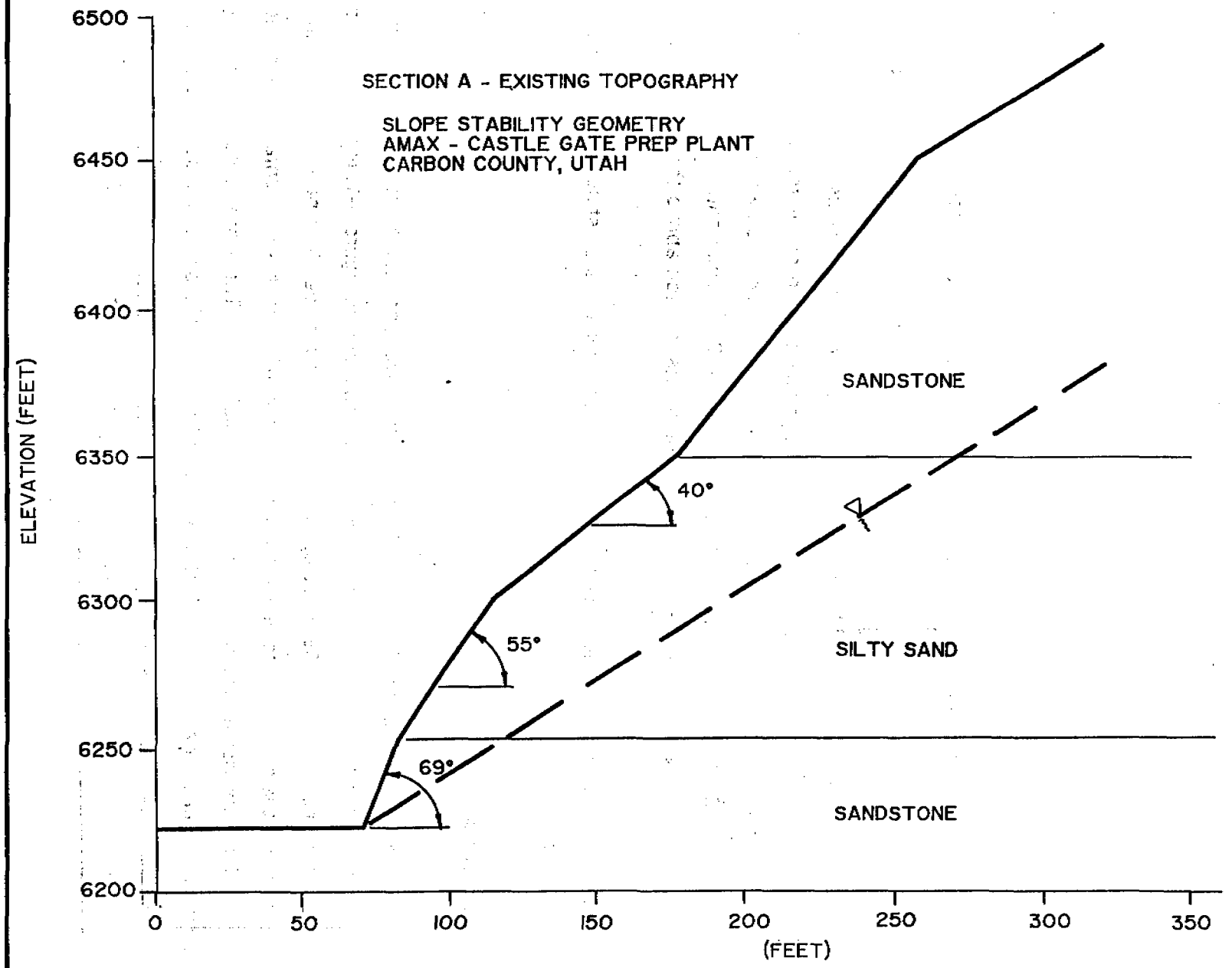


FIGURE 4-1. SECTION A EXISTING SLOPE GEOMETRY

EarthFax

capillarity, and this contributes to the inherent stability of the slope. For this reason, a cohesion value of 250 psf was assumed for the analysis. Although there was no evidence of groundwater seepage at the face or bottom of the cut slope, a phreatic surface as shown on Figure 4-1 was assumed for conservative analysis purposes.

The slope parameters assumed to perform the slope stability analyses of Section A through E are contained in Table 4-1.

TABLE 4-1

SLOPE PARAMETERS

Section	Soil Type	Moist Unit Weight (pcf)	Saturated Unit Weight (pcf)	Cohesion (psf)	Angle of Internal Friction (°)	Pore Pressure Parameter	Pore Pressure Constant
B	Siltstone /Shale	100	140	2000[1]	25[1]	0	0
A,B,D,E	Sandstone	120	150	20000[1]	25[1]	0	0
A,C	Silty sand	100	140	250	42[1]	0	0

[1] Hoek, 1981. Table 1 - Typical Soil and Rock Properties. pg 23.

As indicated by the analyses contained in Appendix B, the existing slope is stable with a factor of safety of 1.304 under static conditions. The underlying layer of sandstone in this slope does add to the inherent stability of the slope, as does the minimal cohesion.

There will be some surface sloughing as a result of surface water runoff and freeze - thaw cycles, but the slope will not experience a deep-seated stability failure.

4.3 Section B

As indicated in Exhibit 3.4-2A, a 300 foot section through the northeast facing slope along the middle section of the refuse haul road was analyzed. This section, as drawn in Figure 4-2, is characterized by a 45° slope consisting of alternating layers of shale and sandstone. There was no evidence of water seepage at the face or base of the cut, but a phreatic surface was assumed, to provide a worst case scenario. The slope parameters assumed to perform the slope stability analyses of Section B are contained in Table 4-1.

The existing cut slope is stable with a factor of safety of 2.87 under static conditions (See Appendix C). The intermediate layers of sandstone in this slope add considerably to the inherent stability of the slope. While some surface sloughing will probably occur as a result of surface water runoff and freeze - thaw cycles, the slope will not experience a deep-seated stability failure.

4.4 Section C

As indicated in Exhibit 3.4-2A, a 210 foot section was analyzed through the south facing cut slope close to the northeast thickner pond. This section, as drawn in Figure 4-3, is characterized by a 60° cut into a silty sand material, with some eroded material deposited at the bottom of the cut. The particles are held together by cohesion forces, as explained in Section 3.3 above. The hillside above the cut slope is naturally vegetated and slopes back at approximately 45°. There was no evidence of groundwater seepage at the face or base of the cut, but a phreatic surface was assumed for the analysis. The slope parameters assumed to perform the slope stability analysis of Section C are contained in Table 4-1.

The existing cut slope is stable with a factor of safety of 1.32 under static conditions (See Appendix D). While some surface sloughing will probably occur as a result of surface

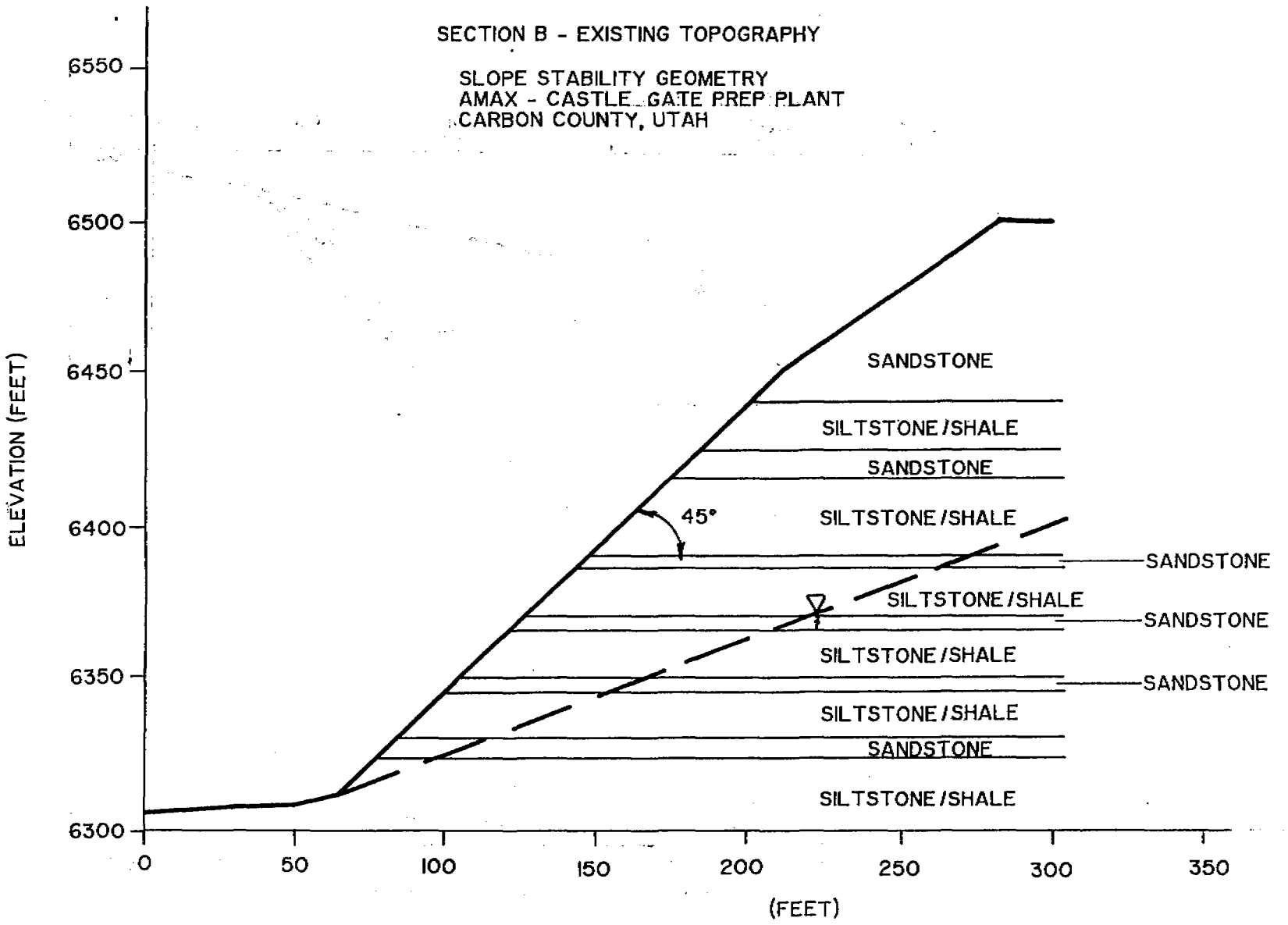


FIGURE 4-2. SECTION B EXISTING SLOPE GEOMETRY

EarthFax

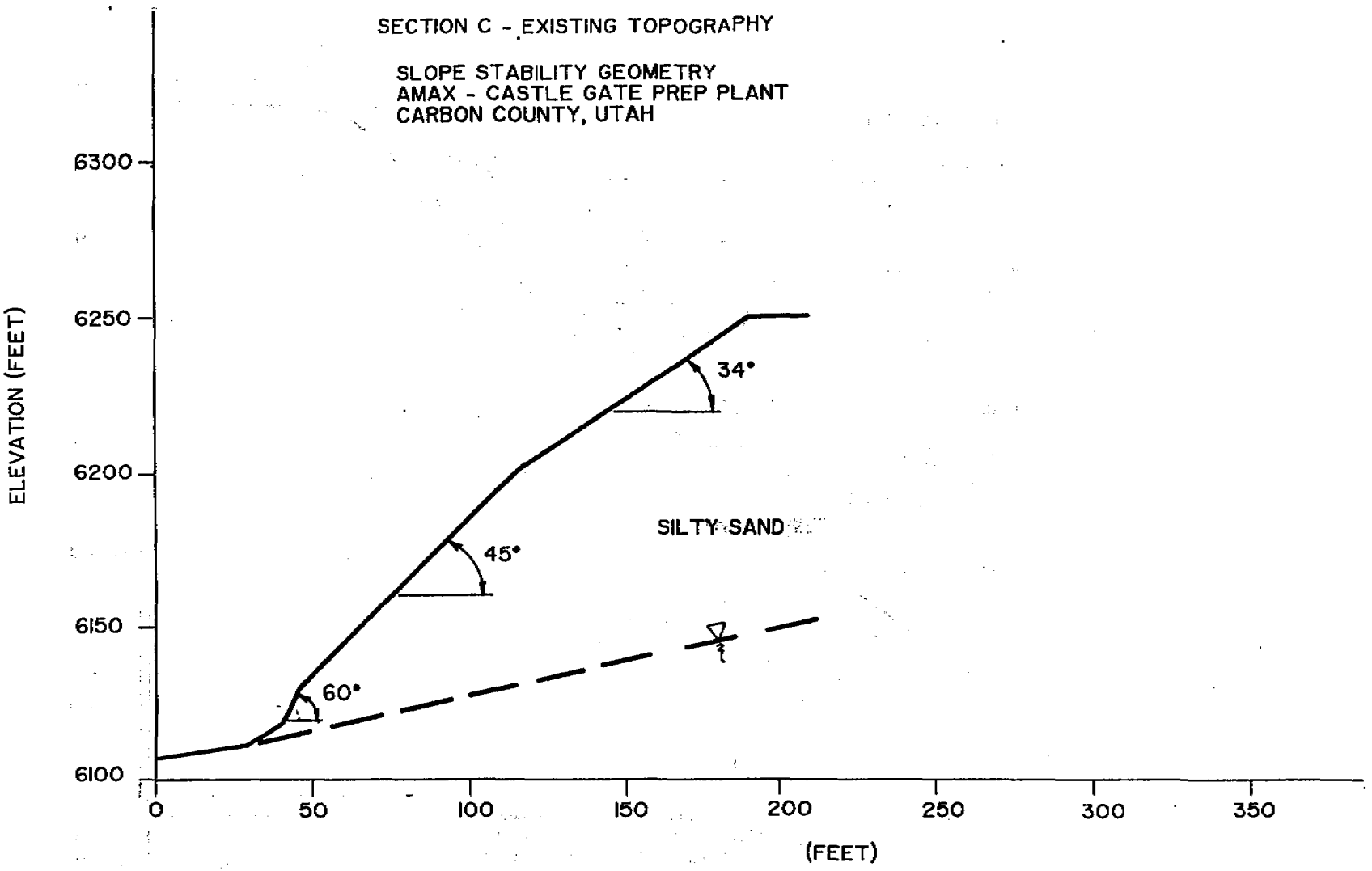


FIGURE 4-3. SECTION C EXISTING SLOPE GEOMETRY

EarthFax

water runoff and freeze - thaw cycles, the slope will not experience a deep-seated stability failure.

4.5 Section D

As indicated in Exhibit 3.4-2A, a 400 foot section was analyzed through the south facing slope adjacent to the embankment of Pond No. 13. This slope is characterized by a 56° cut in sandstone strata. See Figure 4-4 for slope geometry. The hillside above the cut is naturally vegetated and slopes back at approximately 34°. There was no evidence of groundwater seepage at the face or base of the cut, but a phreatic surface was assumed for the analysis. The soil parameters assumed to perform the slope stability analyses of Section D are contained in Table 4-1.

As noted in Appendix E, the slope is stable with a factor of safety of 6.16 under static conditions. There will be some rockfall as a result of surface water runoff and freeze - thaw cycles, but the slope will not experience a deep-seated stability failure.

4.6 Section E

As indicated in Exhibit 3.4-2A, a 300 foot section through the northeast facing slope adjacent to the upper diversion ditch above the Refuse Area was analyzed. This slope is characterized by a 46° cut in competent sandstone strata. The natural sandstone is nearly vertical above the rock cuts. See Figure 4-5 for slope geometry. There was no evidence of groundwater seepage at the face or base of the cut, and very little surface area through which rainfall can infiltrate. Thus, the phreatic surface was assumed to be horizontal. The soil parameters assumed to perform the slope stability analyses of Section D are contained in Table 4-1.

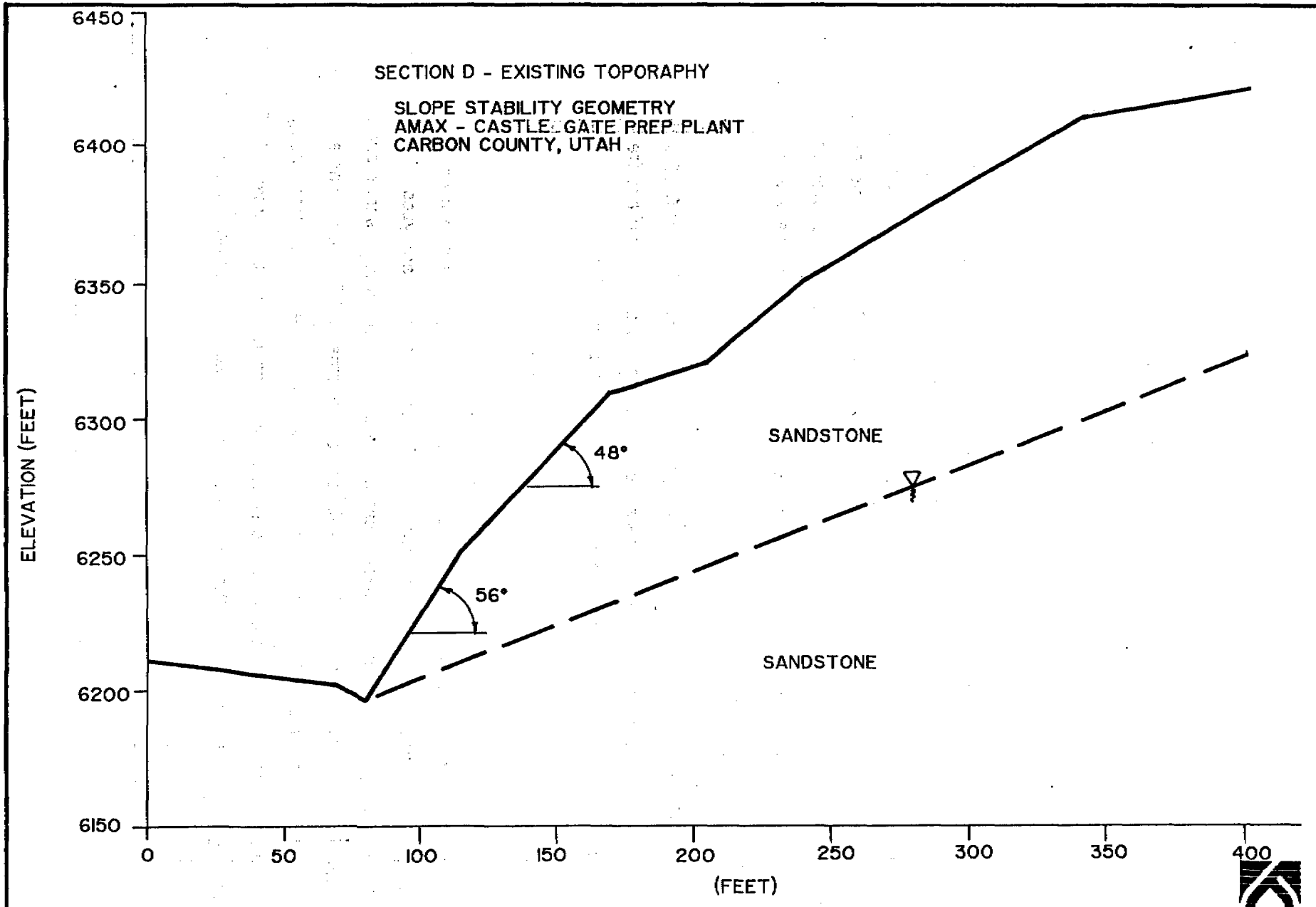


FIGURE 4-4. SECTION D EXISTING SLOPE GEOMETRY

EarthFax

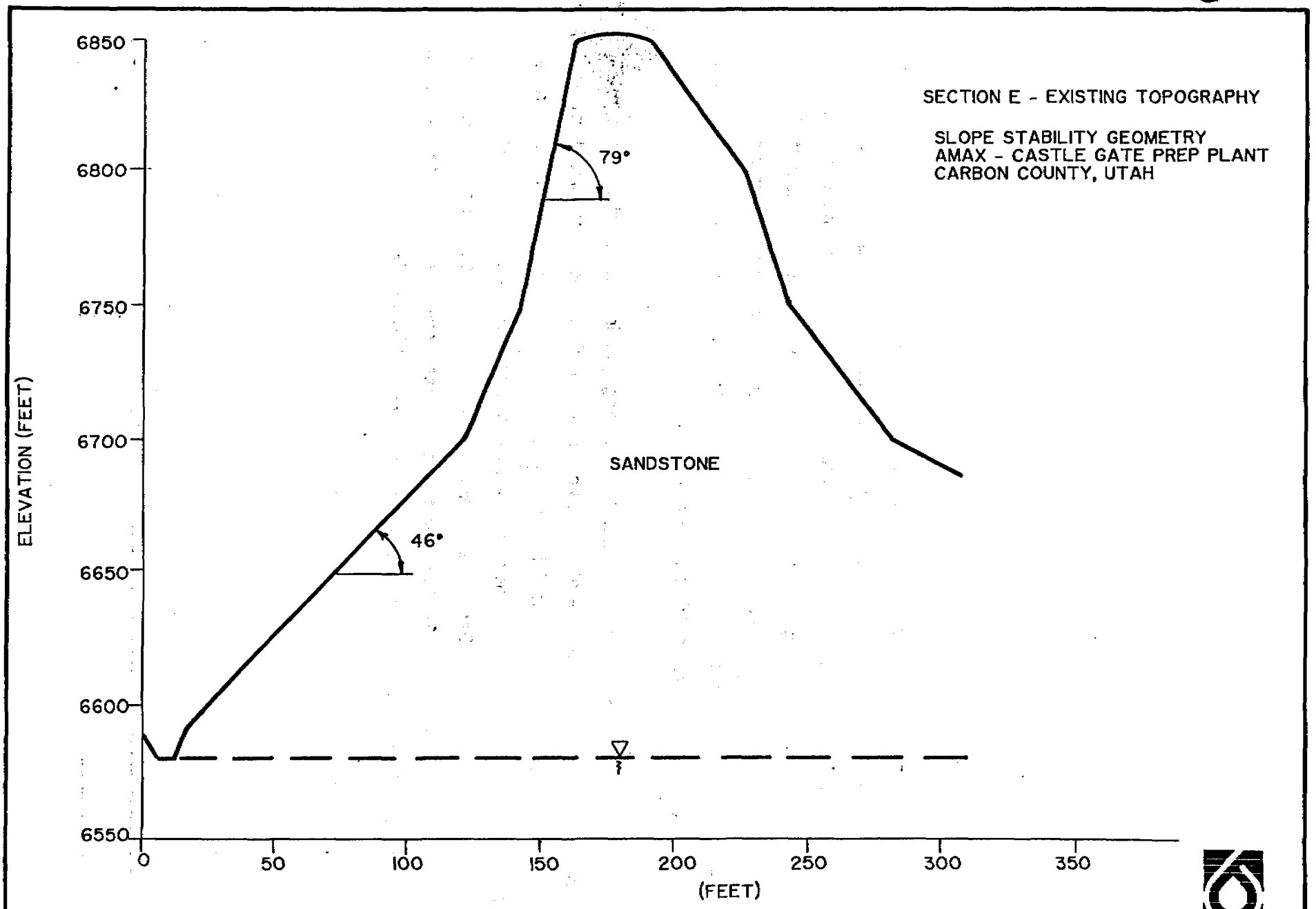


FIGURE 4-5. SECTION E EXISTING SLOPE GEOMETRY

The reclaimed topography slope is stable with a factor of safety of 4.58 under static conditions (See Appendix F). Relatively small rockfalls are probable as a result of freeze - thaw cycles, but the slope will not experience a deep-seated stability failure.

4.7 Placement of Fill Material

The proposed fill slopes of the reclamation topography range up to a maximum grade of two (horizontal) to one (vertical). In general, the fill material will consist of material native to the site that was used to form berms, road fills and other operational mine features. As part of the reclamation grading plan, these current fill areas will be cut and the material used to fill low areas and to be placed at the base of some cut slopes, thus yielding a somewhat uniform post-reclamation grade. Thus, the fill slopes will contain a range of soils from a silty sand and shale to fractured sandstone particles.

Spangler and Handy (1982) state that the angle of internal friction is essentially equivalent to the angle of repose of a cohesionless material. Based on tabulated values in Hoek (1981), the angle of internal friction ranges from 30° for shale to 35° for broken sandstone to 45° for mixed sand and gravel. A silty sand can have an angle of internal friction as low as 28°, according to Gardiner and Dackombe (1983). Thus, the proposed maximum grading slope of two to one (26.6°) is less than the lowest angle of repose of the proposed fill materials. Therefore, fill slopes graded to two to one will remain stable.

5.0 CONCLUSIONS

There are a several man-made cut slopes in the vicinity of the Castle Gate Prep Plant that were constructed as part of the coal mining and processing operation. The five slopes that appear least stable were analyzed using a slope stability computer software program. All five slopes are stable with a factor of safety that exceeds the required minimum of 1.30 (R645-301-553.600). These slopes represent the "worst case" slopes in terms of stability, and thus all cut slopes in the Prep Plant area can be assumed to be stable. No buttressing of the toe of any of the cut or fill slopes is necessary for the purposes of slope stability. The stability can be attributed in most cases to the presence of sandstone strata. The fact that many of these cut slopes have stood in their present state for over 15 years reinforces the conclusion that the cut slopes will remain stable for the near future.

The cut slopes at the Castle Gate Prep Plant were compared to natural cliff formations in the immediate area. The cut slopes can be classified into two categories, those that are predominately sandstone and those that are not. Slopes B, D and E, depicted in Exhibit 3.4-2A, are essentially rock cuts, while slopes A and C were cut into colluvial soil deposits. The sandstone cuts are similar in structural composition and geometry, and are aesthetically compatible with the surrounding topography because of the numerous natural sandstone outcroppings and near vertical cliffs in the area. Fill need not be placed at the base of or against these slopes for them to blend in to the surrounding terrain. Slopes A and C, however, require that some fill be placed at the base of them to allow for proper overland drainage flow (R645-301-553.522), and to allow the cut slopes to aesthetically blend into the adjacent natural slopes. Fill need not be placed to the full height of the cut. The amount of fill sufficient to allow for proper drainage will result in a ground surface that does closely resemble the surrounding terrain. In addition, the lack of available fill material in the general vicinity of cut slope A precludes the option of backfilling that slope to the top of the exposed cut.

6.0 REFERENCES

Davis and Doelling. 1977. Coal Drilling at Trail Mountain, North Horn Mountain, and Johns Peak Areas, Wasatch Plateau. Utah Geological and Mineral Survey Bulletin 112. Salt Lake City, Utah.

Gardiner, V. and Dackombe, R.. 1983. Geomorphological Field Manual. George Allen and Unwin. London. p. 212.

Geocomp Corporation. 1988. Geoslope, Version 4.2. Concord, MA.

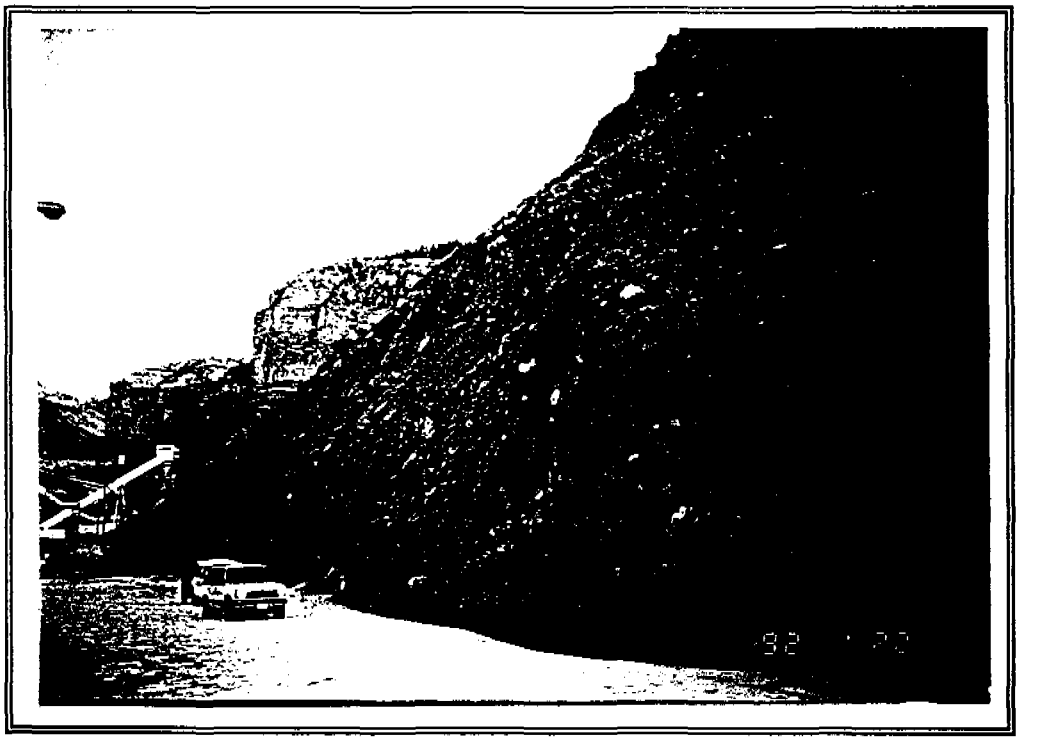
Hoek, Evert and Bray, John. 1981. Rock Slope Engineering. Third edition. The Institute of Mining and Metallurgy. London. p. 23.

Spangler, Merlin G. and Handy, Richard L.. 1982. Soil Engineering. Fourth Edition. Harper and Row Publishers. New York. p. 424.

State of Utah. Department of Natural Resources. Division of Oil, Gas and Mining. Utah Coal Mining Regulations. R645 - Coal Mining Rules. Revised August 23, 1991.

APPENDIX A

Slope Photographs



PICTURE #1

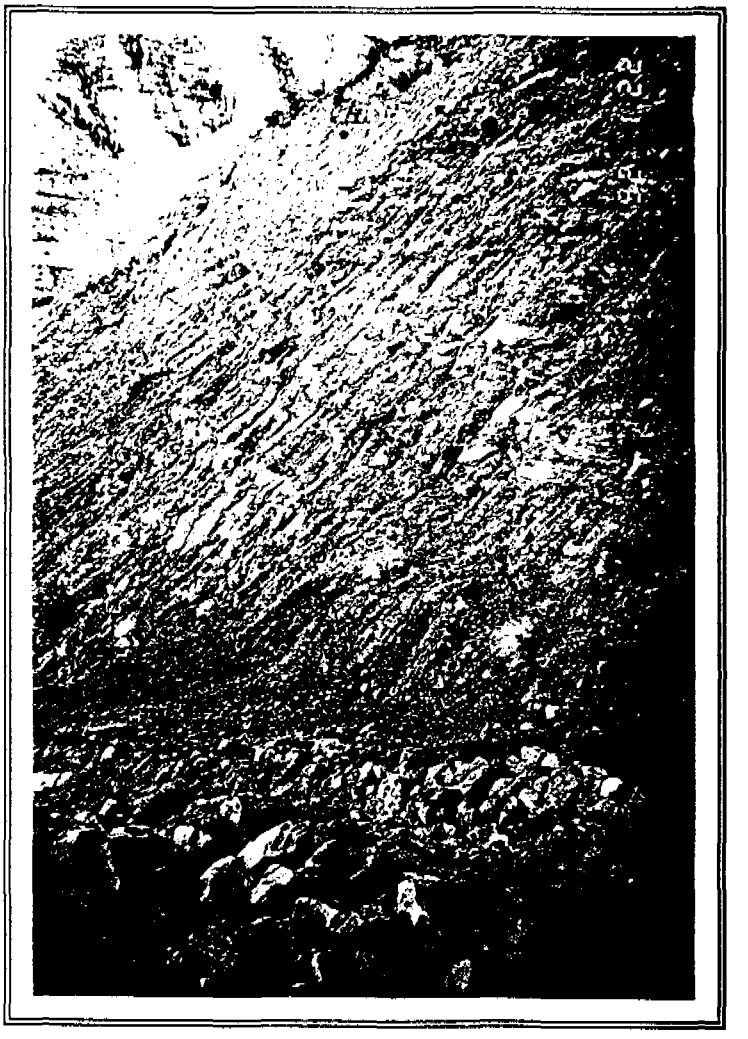
Southeast facing slope along the lower end of the refuse haul road. Section A slope stability analysis. Note relaxation of slope at two-fifths of the height of the cut.

PICTURE #2

Southeast facing slope along the lower end of the refuse haul road. Section A slope stability analysis. Note the colluvial silty sand material of mixed grain size underlain by a sandstone stratum.

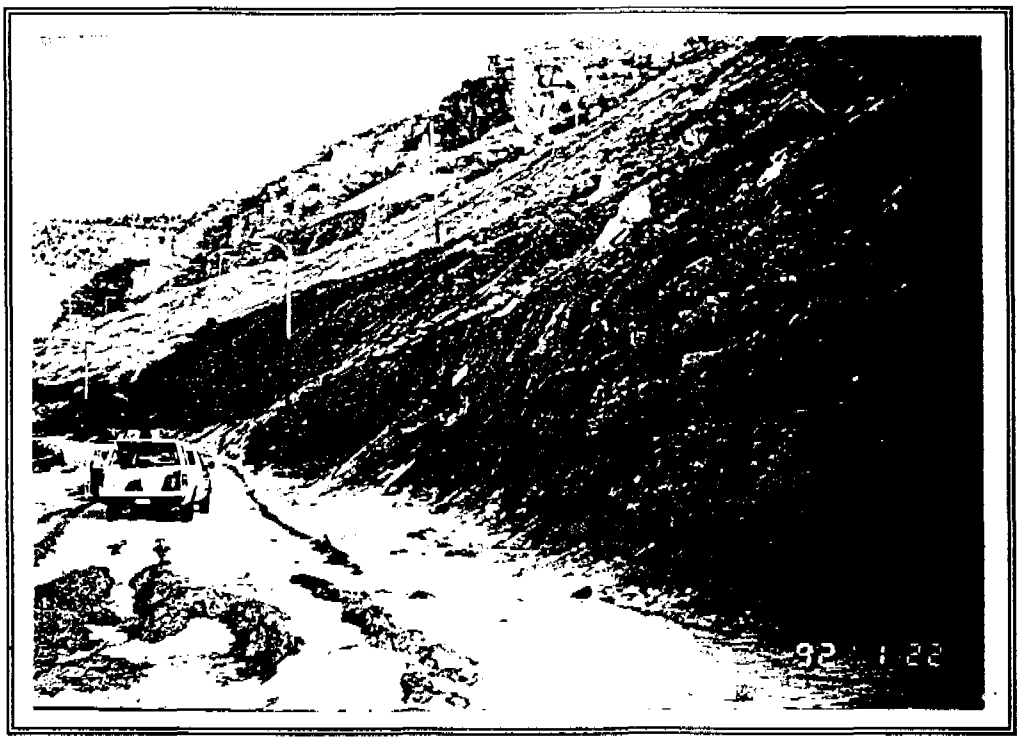
PICTURE #3

Northeast facing slope along the middle section of the refuse haul road. Section B slope stability analysis.



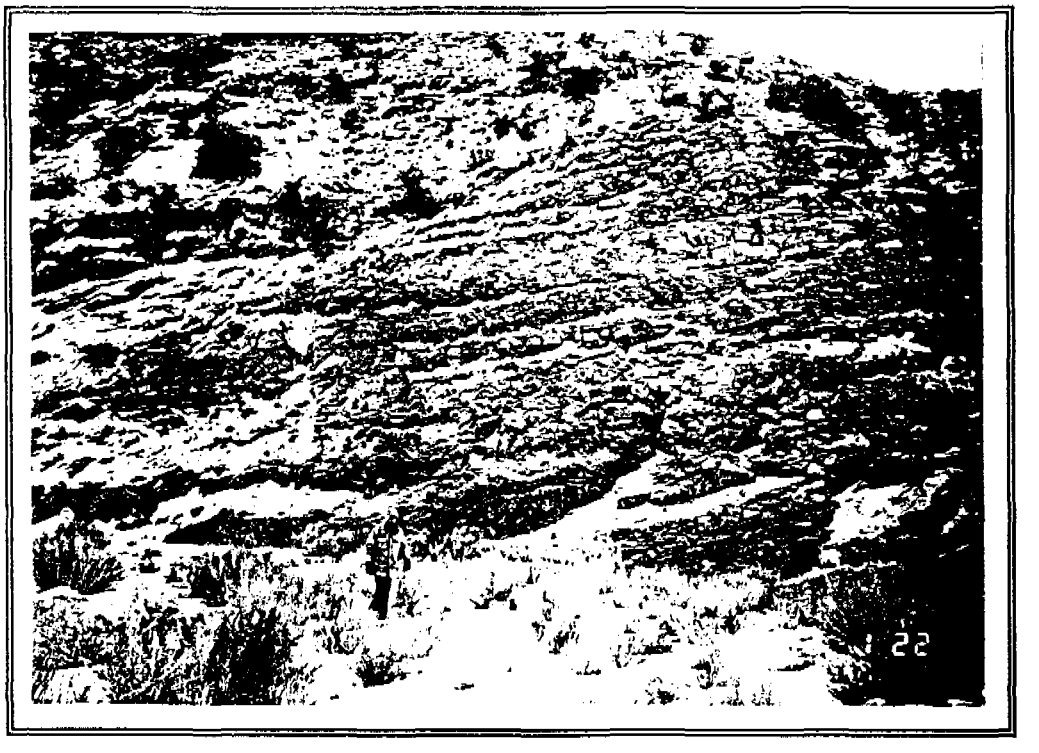
PICTURE #4

Northeast facing slope along the middle portion of the refuse haul road. Section B slope stability analysis. Note layering of sandstone and shale.



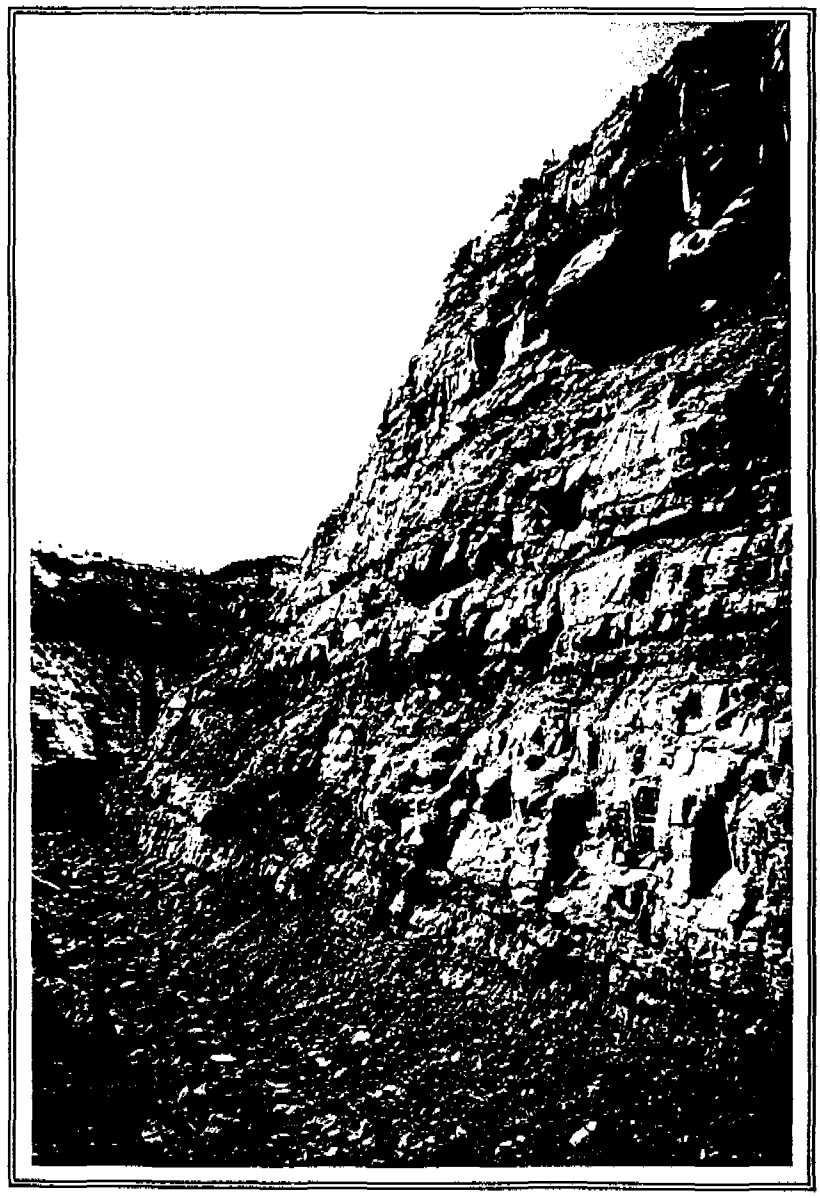
PICTURE #5

Small south facing cut slope near the northeast thickner overflow pond. Section C slope stability analysis. The majority of the cut is in a silty sand material.



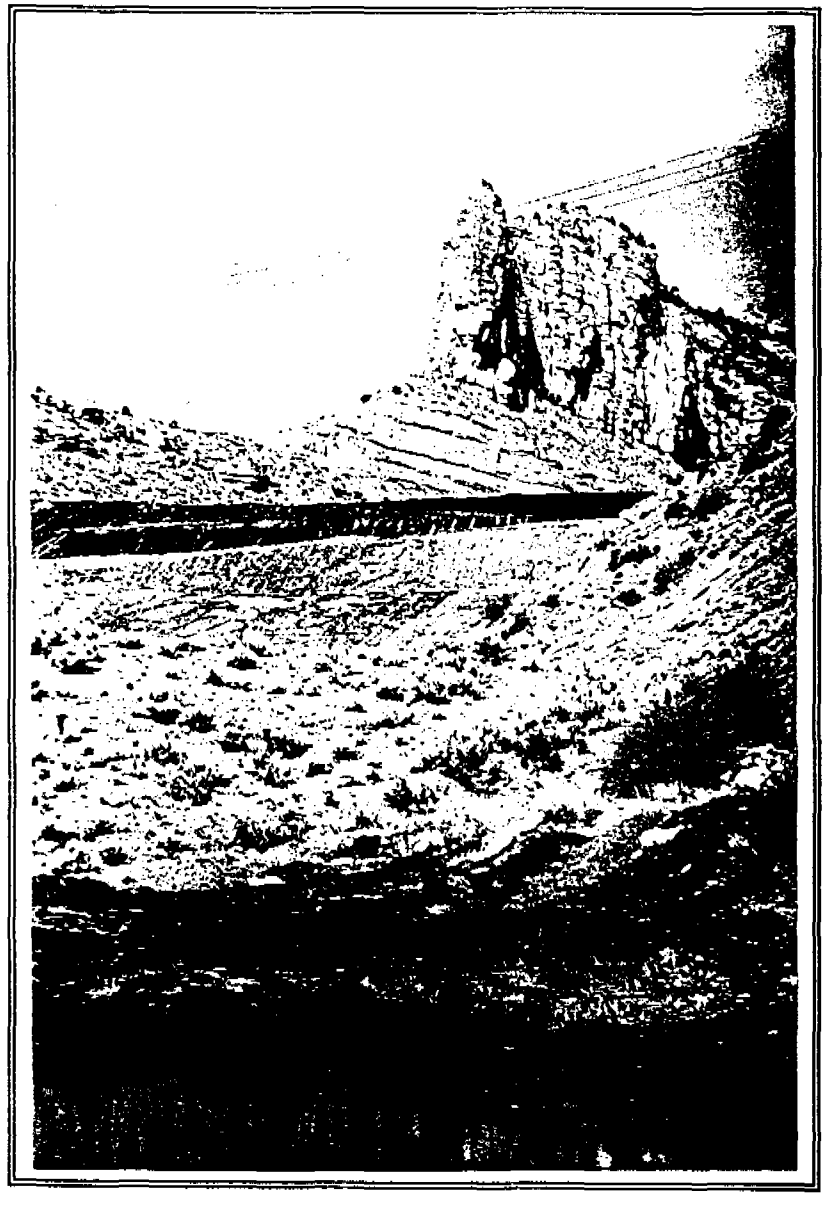
PICTURE #6

South facing slope adjacent to Pond #13 embankment. Section D slope stability analysis. Note predominance of sandstone.



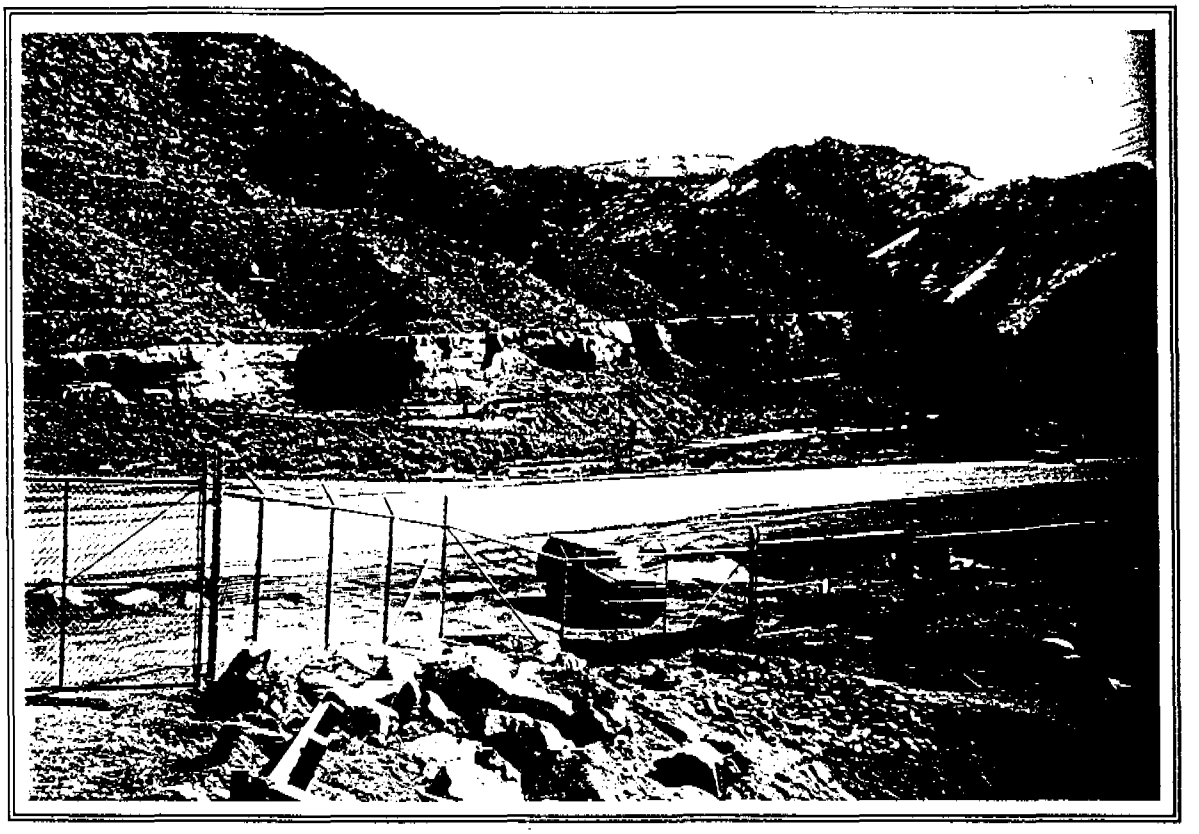
PICTURE #7

Northeast facing slope above the diversion ditch above the Refuse Area. Predominately sandstone.



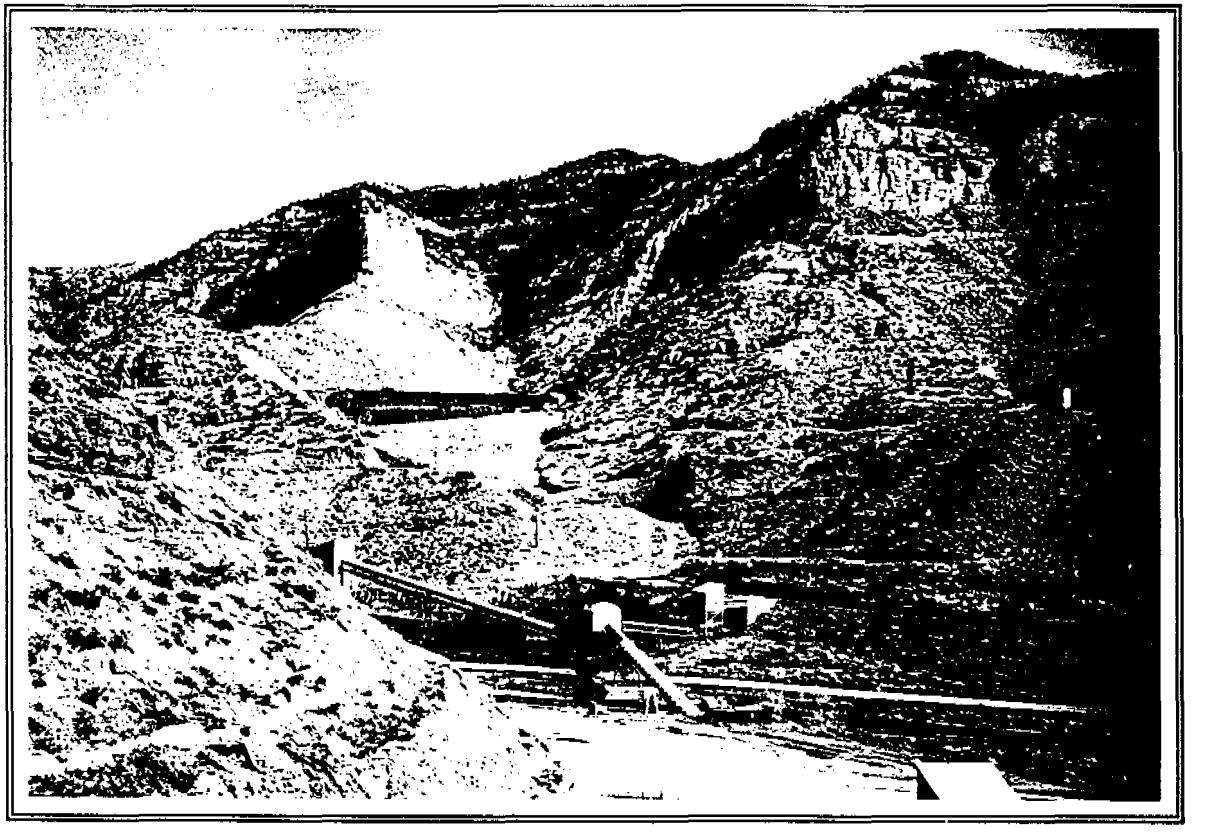
PICTURE #8

Northeast facing slope above the diversion ditch above the Refuse Area. Man-made cut can be seen at the base of the vertical spire.



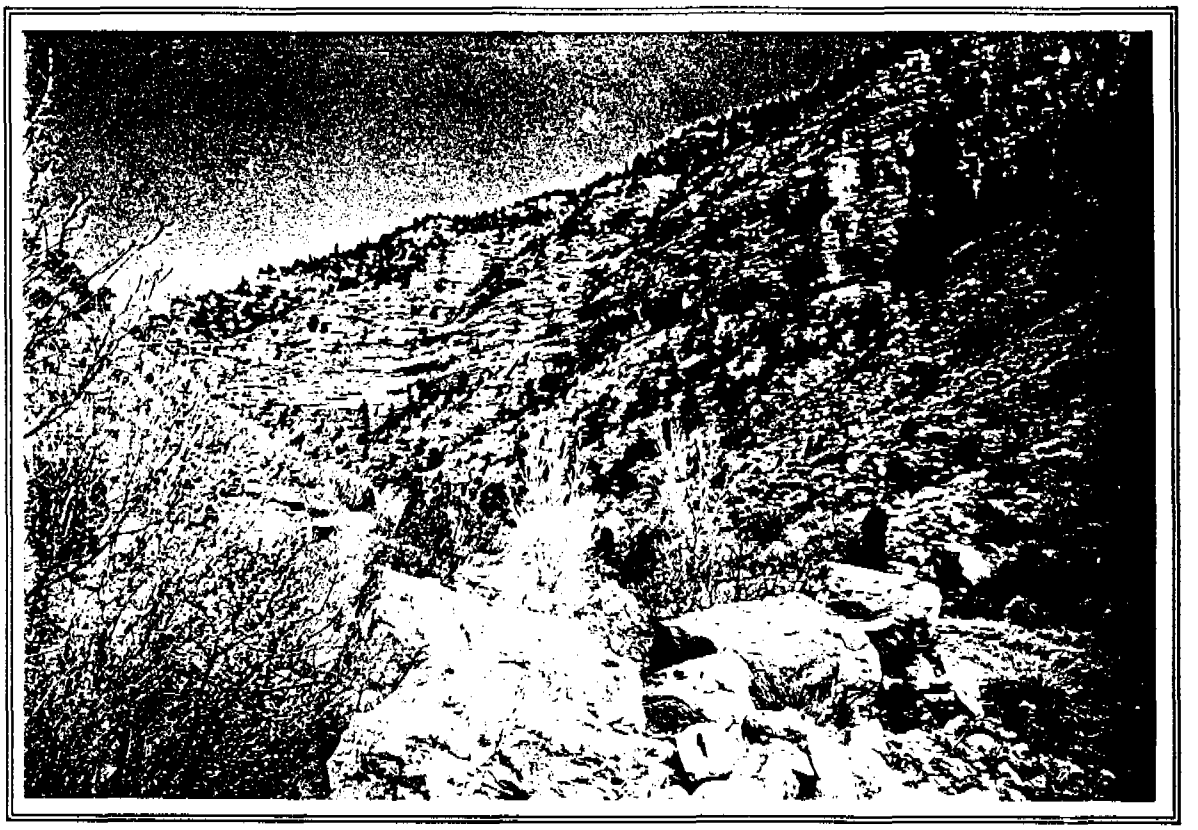
PICTURE #9

Southwest facing naturally exposed stratum northeast of lower access road into the Castle Gate permitted area.



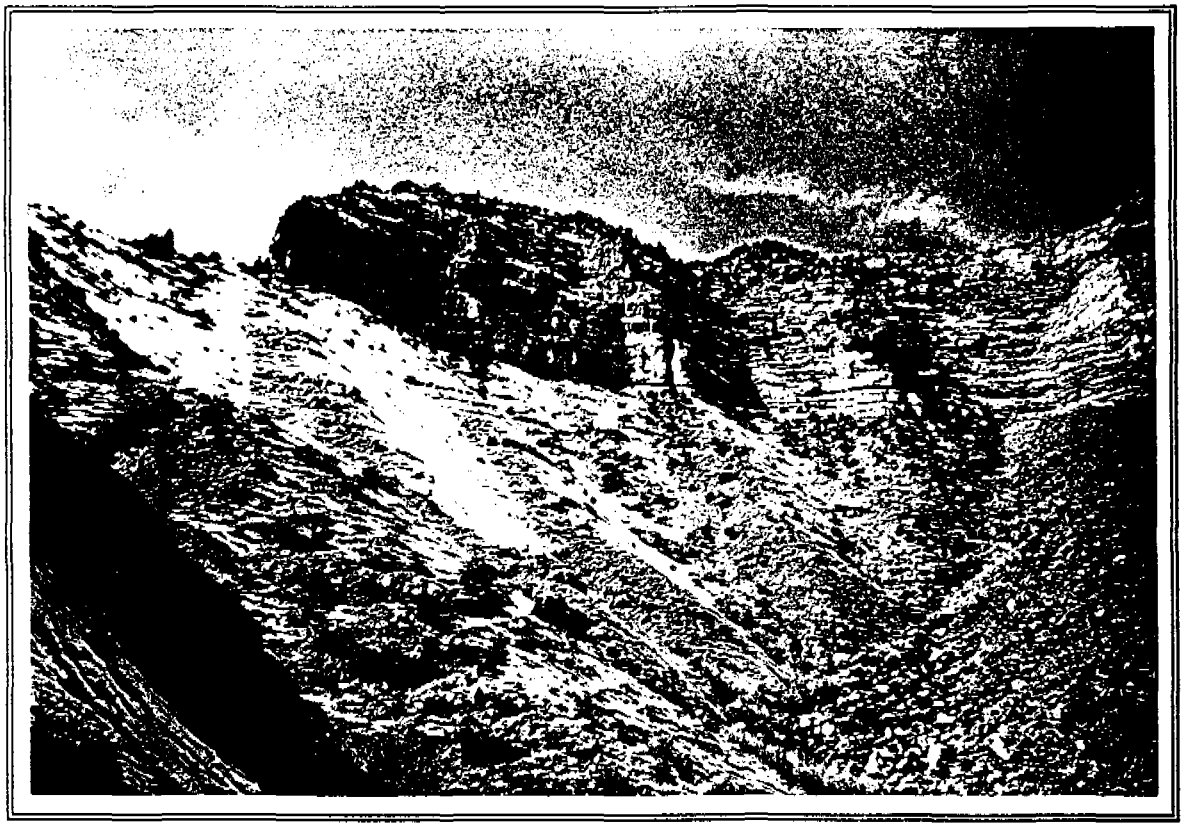
PICTURE #10

Natural cliffs above the Refuse Area in Schoolhouse Canyon. Note cliffs on both sides of the canyon. The picture was taken from the Adit Area.



PICTURE #11

Natural cliffs in upper Barn Canyon.



PICTURE #12

Natural cliffs in Gravel Canyon, on the west side of Route 6.

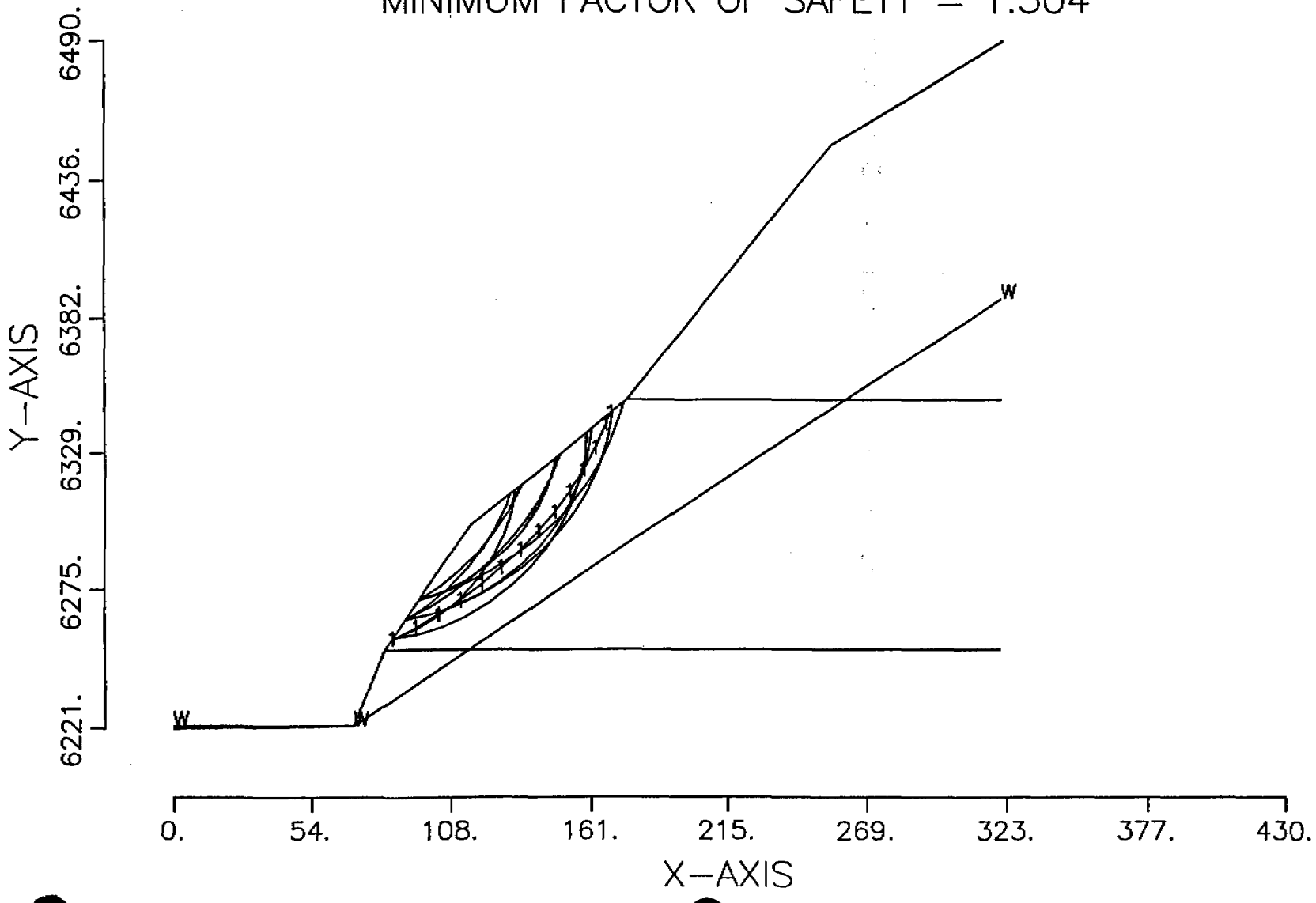
APPENDIX B

Slope Stability Analysis for Section A - Computer Output

EarthFax Engineering
7324 S.Union Park Midvale, UTAH 84047

AMAX – CASTLE GATE PREP PLANT, SECTION A

100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.304



GEOSLOPE
Version 4.20

Supplied by GEOCOMP Corp.
342 Sudbury Rd., Concord, MA. 01742
(617) 369-8304

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GEOCOMP Corp. has modified the program to run on various microcomputers and plotting devices.

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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION AMAX - CASTLE GATE PREP PLANT, SECTION A

BOUNDARY COORDINATES

6 TOP BOUNDARIES
8 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	6221.00	70.00	6222.00	1
2	70.00	6222.00	82.00	6252.00	1
3	82.00	6252.00	115.00	6300.00	2
4	115.00	6300.00	175.00	6350.00	2
5	175.00	6350.00	255.00	6450.00	1
6	255.00	6450.00	320.00	6490.00	1
7	175.00	6350.00	320.00	6350.00	2
8	82.00	6252.00	320.00	6252.00	1

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	120.0	150.0	20000.0	25.0	.00	.0	0
2	100.0	140.0	250.0	42.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	6222.00
2	70.00	6222.00
3	320.00	6390.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 70.00
AND X = 115.00

EACH SURFACE TERMINATES BETWEEN X = 125.00
AND X = 255.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

10.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

EarthFax Engineering
7324 S.Union Park Midvale, UTAH 84047

FAILURE SURFACE # 1 SPECIFIED BY 14 COORDINATE POINTS

SAFETY FACTOR = 1.304

X-CENTER = 21.54
Y-CENTER = 6400.40
RADIUS = 157.39

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	85.00	6256.36	25.60
2	94.02	6260.69	29.24
3	102.74	6265.57	32.88
4	111.14	6271.00	36.52
5	119.18	6276.95	40.16
6	126.82	6283.40	43.81
7	134.04	6290.32	47.45
8	140.80	6297.69	51.09
9	147.08	6305.47	54.73
10	152.86	6313.64	58.37
11	158.10	6322.15	62.01
12	162.79	6330.98	65.65
13	166.92	6340.09	69.29
14	168.67	6344.72	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	89.51	9.02	3966.69	.00	.00	2614.67	3723.15
2	98.38	8.73	11081.93	.00	.00	8385.11	7708.19
3	106.94	8.40	16793.44	.00	.00	12967.91	10873.07
4	113.07	3.86	9553.52	.00	.00	7414.44	6040.77
5	117.09	4.18	11006.21	.00	.00	8572.85	6917.48
6	123.00	7.64	20244.58	.00	.00	15713.91	12769.41
7	130.43	7.22	18761.21	.00	.00	14531.50	11952.89
8	137.42	6.76	16688.25	.00	.00	12890.92	10819.91
9	143.94	6.28	14156.43	.00	.00	10866.22	9421.65
10	149.97	5.77	11310.80	.00	.00	8539.05	7814.53
11	155.48	5.24	8306.48	.00	.00	5999.30	6060.57
12	160.45	4.69	5306.04	.00	.00	3347.96	4229.56
13	164.85	4.12	2477.56	.00	.00	701.53	2401.96
14	167.79	1.75	277.55	.00	.00	-610.47	527.48

```
PROFIL
AMAX - CASTLE GATE PREP PLANT, SECTION A
8
0.0 6221.0 70.0 6222.0 1
70.0 6222.0 82.0 6252.0 1
82.0 6252.0 115.0 6300.0 2
115.0 6300.0 175.0 6350.0 2
175.0 6350.0 255.0 6450.0 1
255.0 6450.0 320.0 6490.0 1
175.0 6350.0 320.0 6350.0 2
82.0 6252.0 320.0 6252.0 1
SOIL
2
120.0 150.0 20000.0 25.0 0.0 0.0 0
100.0 140.0 250.0 42.0 0.0 0.0 0
WATER
1 0.0
3
0.0 6222.0
70.0 6222.0
320.0 6390.0
CIRCL2
10 10
70.0 115.0
125.0 255.0
0.0
10.0
0.0
0
```

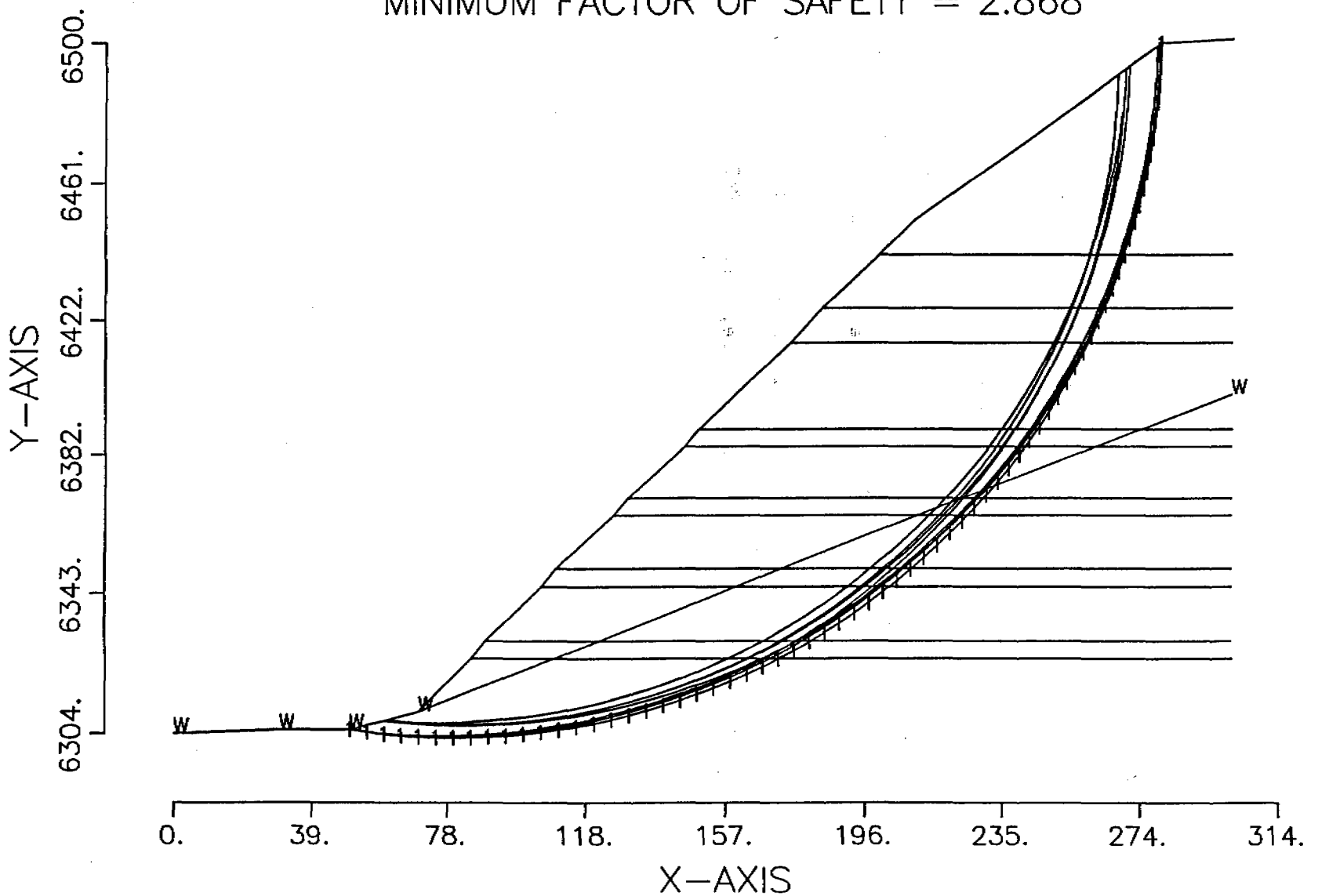
APPENDIX C

Slope Stability Analysis for Section B - Computer Output

EarthFax Engineering
7324 S.Union Park Midvale, UTAH 84047

AMAX – CASTLE GATE PREP PLANT, SECTION B

100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 2.868



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GEOCOMP Corp. has modified the program to run on various microcomputers and plotting devices.

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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION AMAX - CASTLE GATE PREP PLANT, SECTION B

BOUNDARY COORDINATES

16 TOP BOUNDARIES
28 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	6304.00	30.00	6305.00	2
2	30.00	6305.00	50.00	6305.00	2
3	50.00	6305.00	70.00	6310.00	2
4	70.00	6310.00	85.00	6325.00	2
5	85.00	6325.00	89.00	6330.00	1
6	89.00	6330.00	105.00	6345.00	2
7	105.00	6345.00	109.00	6350.00	1
8	109.00	6350.00	125.00	6365.00	2
9	125.00	6365.00	129.00	6370.00	1
10	129.00	6370.00	145.00	6385.00	2
11	145.00	6385.00	149.00	6390.00	1
12	149.00	6390.00	175.00	6415.00	2
13	175.00	6415.00	184.00	6425.00	1
14	184.00	6425.00	200.00	6440.00	2
15	200.00	6440.00	210.00	6450.00	1
16	210.00	6450.00	280.00	6500.00	1
17	280.00	6500.00	300.00	6501.00	1
18	200.00	6440.00	300.00	6440.00	2
19	184.00	6425.00	300.00	6425.00	1
20	175.00	6415.00	300.00	6415.00	2
21	149.00	6390.00	300.00	6390.00	1
22	145.00	6385.00	300.00	6385.00	2
23	129.00	6370.00	300.00	6370.00	1
24	125.00	6365.00	300.00	6365.00	2
25	109.00	6350.00	300.00	6350.00	1
26	105.00	6345.00	300.00	6345.00	2
27	89.00	6330.00	300.00	6330.00	1
28	85.00	6325.00	300.00	6325.00	2

ISOTROPIC SOIL PARAMETERS

2 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	120.0	150.0	20000.0	25.0	.00	.0	0
2	120.0	150.0	2000.0	25.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 5 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	6304.00
2	30.00	6305.00
3	50.00	6305.00
4	70.00	6310.00
5	300.00	6400.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 50.00
AND X = 140.00

EACH SURFACE TERMINATES BETWEEN X = 150.00
AND X = 280.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL

FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

EarthFax Engineering
7324 S.Union Park Midvale, UTAH 84047

FAILURE SURFACE # 1 SPECIFIED BY 70 COORDINATE POINTS

SAFETY FACTOR = 2.868

X-CENTER = 80.08
Y-CENTER = 6501.90
RADIUS = 199.19

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	50.00	6305.00	-7.97
2	54.95	6304.31	-6.53
3	59.92	6303.74	-5.09
4	64.90	6303.29	-3.66
5	69.89	6302.98	-2.22
6	74.89	6302.78	-.79
7	79.89	6302.71	.65
8	84.89	6302.77	2.08
9	89.88	6302.95	3.52
10	94.87	6303.26	4.95
11	99.85	6303.69	6.39
12	104.82	6304.25	7.82
13	109.78	6304.93	9.26
14	114.71	6305.73	10.69
15	119.62	6306.66	12.13
16	124.51	6307.71	13.57
17	129.37	6308.88	15.00
18	134.20	6310.18	16.43
19	139.00	6311.59	17.87
20	143.76	6313.13	19.31
21	148.48	6314.78	20.74
22	153.15	6316.55	22.18
23	157.78	6318.44	23.61
24	162.36	6320.44	25.05
25	166.89	6322.56	26.48
26	171.37	6324.79	27.92
27	175.79	6327.13	29.36
28	180.14	6329.58	30.79
29	184.44	6332.14	32.22
30	188.67	6334.81	33.66
31	192.83	6337.58	35.09
32	196.92	6340.45	36.53
33	200.94	6343.43	37.97
34	204.88	6346.50	39.40
35	208.75	6349.68	40.84

36	212.53	6352.95	42.27
37	216.23	6356.31	43.71
38	219.84	6359.77	45.14
39	223.37	6363.31	46.58
40	226.81	6366.94	48.01
41	230.15	6370.66	49.45
42	233.40	6374.46	50.88
43	236.56	6378.34	52.32
44	239.61	6382.29	53.76
45	242.57	6386.33	55.19
46	245.42	6390.43	56.62
47	248.17	6394.61	58.06
48	250.82	6398.85	59.50
49	253.36	6403.16	60.93
50	255.79	6407.53	62.37
51	258.10	6411.96	63.80
52	260.31	6416.44	65.24
53	262.41	6420.98	66.67
54	264.39	6425.58	68.11
55	266.25	6430.22	69.54
56	268.00	6434.90	70.98
57	269.63	6439.63	72.41
58	271.14	6444.39	73.85
59	272.53	6449.20	75.28
60	273.80	6454.03	76.72
61	274.95	6458.90	78.16
62	275.97	6463.79	79.59
63	276.88	6468.71	81.03
64	277.66	6473.65	82.46
65	278.31	6478.60	83.90
66	278.84	6483.58	85.33
67	279.25	6488.56	86.77
68	279.53	6493.55	88.20
69	279.69	6498.55	89.64
70	279.70	6499.78	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	52.48	4.95	573.90	.00	.00	1092.16	3663.87
2	57.44	4.97	1690.53	.00	.00	2140.25	3834.24
3	62.41	4.98	2740.41	.00	.00	3106.99	3991.41
4	67.40	4.99	3720.43	.00	.00	3992.27	4135.32
5	69.94	.11	92.63	.00	.00	96.28	92.46
6	72.44	4.89	5608.88	.00	.00	5781.86	4349.45
7	77.39	5.00	8781.79	.00	.00	8850.44	4925.12
8	82.39	5.00	11785.67	.00	.00	11725.34	5392.48
9	84.94	.11	304.96	.00	.00	300.48	128.82
10	87.00	4.00	11833.59	.00	.00	11670.98	4688.23
11	89.44	.88	2908.51	.00	.00	2871.09	1082.19
12	92.38	4.99	18002.90	.00	.00	17645.86	6354.99
13	97.36	4.98	20542.70	.00	.00	20035.35	6743.43

14	102.34	4.97	22978.05	.00	.00	22324.66	7115.62
15	104.91	.18	864.03	.00	.00	836.34	260.60
16	106.67	3.33	17030.53	.00	.00	16499.64	5028.04
17	108.67	.67	3587.22	.00	.00	3478.70	1035.08
18	109.39	.78	4237.88	.00	.00	4110.79	1214.69
19	112.24	4.93	28253.48	.00	.00	27333.57	7929.91
20	117.17	4.91	30340.17	.00	.00	29318.04	8252.49
21	120.37	1.49	9602.21	.00	.00	9269.75	2566.99
22	122.81	3.40	22699.74	.00	.00	21930.34	5991.50
23	124.76	.49	3333.38	.00	.00	3218.46	872.76
24	127.00	4.00	28410.70	.00	.00	27456.73	7332.71
25	129.19	.37	2746.77	.00	.00	2656.80	699.59
26	131.79	4.83	36559.80	.00	.00	35374.43	9237.13
27	136.60	4.80	38119.67	.00	.00	36943.53	9492.14
28	141.38	4.76	39541.41	.00	.00	38408.75	9730.43
29	144.38	1.24	10599.67	.00	.00	10321.81	2596.23
30	146.74	3.48	30449.68	.00	.00	29674.54	7392.28
31	148.74	.52	4703.24	.00	.00	4598.18	1138.24
32	151.08	4.15	37980.13	.00	.00	37152.93	9135.54
33	155.47	4.63	43739.35	.00	.00	42965.16	10471.06
34	158.61	1.66	16043.16	.00	.00	15831.25	3838.43
35	160.90	2.92	28600.94	.00	.00	28236.70	6811.99
36	164.63	4.53	45402.59	.00	.00	45062.72	10812.04
37	169.13	4.48	46014.87	.00	.00	45950.53	10956.37
38	171.57	.40	4167.77	.00	.00	4188.66	996.67
39	172.00	.45	4732.03	.00	.00	3185.33	4094.98
40	173.61	2.78	29234.40	.00	.00	19764.67	25136.91
41	175.39	.79	8352.84	.00	.00	5675.75	7128.16
42	177.97	4.36	47035.17	.00	.00	31477.37	39980.70
43	180.50	.70	7712.35	.00	.00	5081.39	6538.74
44	182.42	3.15	34913.08	.00	.00	35662.63	8355.87
45	184.22	.44	4916.89	.00	.00	5024.32	1173.65
46	186.55	4.23	47672.46	.00	.00	49121.19	11471.81
47	190.75	4.16	47511.45	.00	.00	49411.64	11519.16
48	194.88	4.09	47217.00	.00	.00	49592.98	11548.51
49	198.46	3.08	35813.90	.00	.00	38013.30	8850.56
50	200.47	.94	10982.67	.00	.00	11659.50	2710.92
51	201.95	2.01	23621.79	.00	.00	25356.35	5903.57
52	203.92	1.93	22708.20	.00	.00	13754.29	19285.64
53	206.81	3.86	45770.41	.00	.00	26989.97	39251.05
54	208.93	.37	4424.48	.00	.00	2528.88	3840.27
55	209.56	.88	10505.68	.00	.00	11558.64	2692.61
56	210.28	.56	6607.23	.00	.00	7269.53	1693.35
57	211.54	1.97	23440.17	.00	.00	25787.14	6010.48
58	214.38	3.70	43730.18	.00	.00	48728.03	11407.98
59	218.03	3.61	42375.11	.00	.00	47852.55	11265.74
60	221.59	3.49	40529.42	.00	.00	46410.63	10995.68
61	223.35	.04	415.90	.00	.00	476.08	113.00
62	224.17	1.60	18411.96	.00	.00	21396.62	5100.25
63	225.89	1.84	21035.68	.00	.00	9305.17	20156.37
64	228.18	2.75	31219.38	.00	.00	12528.27	30726.12
65	229.85	.59	6669.64	.00	.00	7863.73	1895.65
66	231.44	2.58	28887.10	.00	.00	34617.08	8399.49
67	233.07	.67	7388.18	.00	.00	8848.12	2153.02

68	234.98	3.15	34614.80	.00	.00	42152.02	10338.93
69	238.08	3.06	32913.93	.00	.00	40753.68	10111.52
70	240.60	1.98	21000.04	.00	.00	26460.28	6641.30
71	242.08	.97	10180.80	.00	.00	1290.32	11677.36
72	243.84	2.55	26358.84	.00	.00	1059.48	31366.60
73	245.27	.30	3063.75	.00	.00	3922.16	1004.61
74	246.80	2.75	27647.54	.00	.00	36064.90	9349.24
75	249.50	2.65	25863.15	.00	.00	34341.43	9069.23
76	252.09	2.54	24077.30	.00	.00	32538.17	8776.08
77	254.57	2.43	22298.33	.00	.00	30657.20	8470.17
78	256.94	2.32	20534.02	.00	.00	28700.99	8152.20
79	258.85	1.50	12824.98	.00	.00	18224.71	5326.36
80	259.96	.71	5967.73	.00	.00	-6990.66	10090.52
81	261.36	2.09	17081.88	.00	.00	-25726.67	30679.34
82	263.27	1.73	13517.21	.00	.00	-26553.59	26171.04
83	264.26	.25	1892.48	.00	.00	2733.97	881.99
84	265.32	1.86	13784.55	.00	.00	20144.55	6761.32
85	267.12	1.75	12213.67	.00	.00	17829.75	6384.79
86	268.81	1.63	10705.37	.00	.00	15448.93	5997.86
87	269.69	.12	748.38	.00	.00	1068.96	446.25
88	270.44	1.39	8518.69	.00	.00	-48381.68	24271.56
89	271.83	1.39	7906.17	.00	.00	-58901.11	25287.98
90	273.16	1.27	6630.19	.00	.00	-65868.77	24154.41
91	274.37	1.15	5446.11	.00	.00	-73425.52	22925.73
92	275.46	1.03	4361.11	.00	.00	-81676.23	21585.11
93	276.43	.90	3381.80	.00	.00	-90745.38	20109.07
94	277.27	.78	2514.75	.00	.00	-100842.10	18470.42
95	277.98	.66	1765.94	.00	.00	-112168.30	16626.30
96	278.58	.53	1141.50	.00	.00	-125103.60	14525.21
97	279.05	.41	647.08	.00	.00	-140091.30	12088.44
98	279.39	.28	287.90	.00	.00	-157845.30	9203.26
99	279.61	.16	69.11	.00	.00	-179396.90	5698.85
100	279.69	.01	.58	.00	.00	-50956.33	323.08

```
PROFIL
AMAX - CASTLE GATE PREP PLANT, SECTION B
28 16
0.0 6304.0 30.0 6305.0 2
30.0 6305.0 50.0 6305.0 2
50.0 6305.0 70.0 6310.0 2
70.0 6310.0 85.0 6325.0 2
85.0 6325.0 89.0 6330.0 1
89.0 6330.0 105.0 6345.0 2
105.0 6345.0 109.0 6350.0 1
109.0 6350.0 125.0 6365.0 2
125.0 6365.0 129.0 6370.0 1
129.0 6370.0 145.0 6385.0 2
145.0 6385.0 149.0 6390.0 1
149.0 6390.0 175.0 6415.0 2
175.0 6415.0 184.0 6425.0 1
184.0 6425.0 200.0 6440.0 2
200.0 6440.0 210.0 6450.0 1
210.0 6450.0 280.0 6500.0 1
280.0 6500.0 300.0 6501.0 1
200.0 6440.0 300.0 6440.0 2
184.0 6425.0 300.0 6425.0 1
175.0 6415.0 300.0 6415.0 2
149.0 6390.0 300.0 6390.0 1
145.0 6385.0 300.0 6385.0 2
129.0 6370.0 300.0 6370.0 1
125.0 6365.0 300.0 6365.0 2
109.0 6350.0 300.0 6350.0 1
105.0 6345.0 300.0 6345.0 2
89.0 6330.0 300.0 6330.0 1
85.0 6325.0 300.0 6325.0 2
SOIL
2
120.0 150.0 20000.0 25.0 0.0 0.0 0
120.0 150.0 2000.0 25.0 0.0 0.0 0
WATER
1 0.0
5
0.0 6304.0
30.0 6305.0
50.0 6305.0
70.0 6310.0
300.0 6400.0
CIRCL2
10 10
50.0 140.0
150.0 280.0
0.0
5.0
0.0
0.0
```

APPENDIX D

Slope Stability Analysis for Section C - Computer Output

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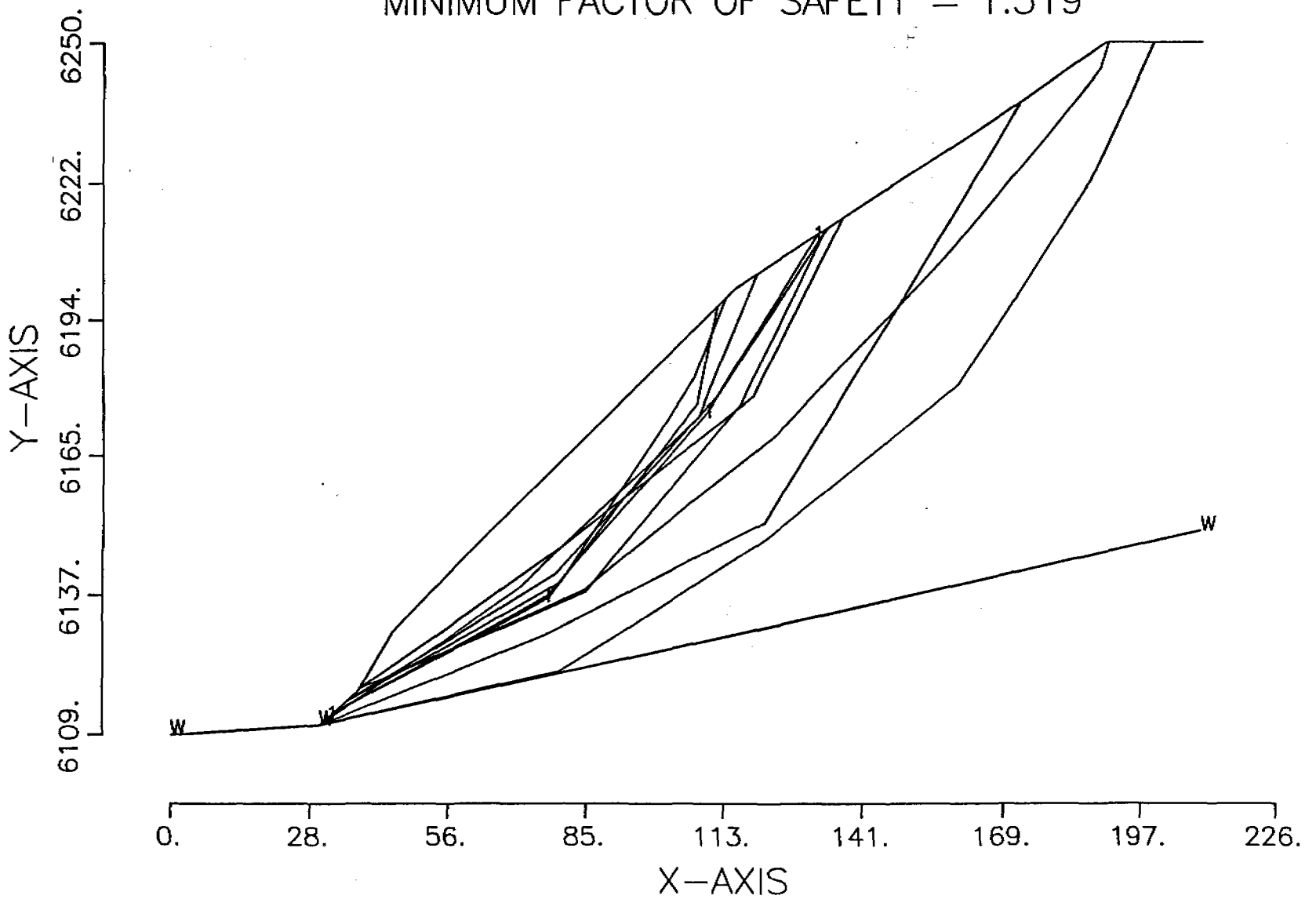
AMAX – CASTLEGATE PLANT, SECTION C,
IRREGULAR FAILURE SURFACES
100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 1.319



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--SLOPE STABILITY ANALYSIS--
JANBU METHOD OF SLICES
IRREGULAR FAILURE SURFACES

PROBLEM DESCRIPTION AMAX - CASTLEGATE PLANT, SECTION C,
IRREGULAR FAILURE SURFACES

BOUNDARY COORDINATES

6 TOP BOUNDARIES
6 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	6109.00	30.00	6111.00	1
2	30.00	6111.00	38.00	6118.00	1
3	38.00	6118.00	45.00	6130.00	1
4	45.00	6130.00	115.00	6200.00	1
5	115.00	6200.00	190.00	6250.00	1
6	190.00	6250.00	210.00	6250.00	1

ISOTROPIC SOIL PARAMETERS

1 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	100.0	140.0	250.0	42.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER

1	.00	6109.00
2	30.00	6111.00
3	210.00	6150.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING IRREGULAR SURFACES, HAS BEEN SPECIFIED

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED ALONG THE GROUND SURFACE BETWEEN X = 30.00
AND X = 55.00

EACH SURFACE TERMINATES BETWEEN X = 75.00
AND X = 210.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

50.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

* * SAFETY FACTORS ARE CALCULATED BY THE JANBU METHOD * *

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FAILURE SURFACE # 1 SPECIFIED BY 4 COORDINATE POINTS

SAFETY FACTOR = 1.319

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	32.78	6113.43	28.37
2	76.77	6137.19	48.81
3	109.70	6174.82	58.55
4	132.05	6211.37	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr

1	35.39	5.22	456.39	.00	.00	-64.74	1080.30
2	41.50	7.00	4100.88	.00	.00	2810.70	3425.53
3	60.89	31.77	54886.24	.00	.00	42880.18	36104.75
4	93.24	32.93	73195.71	.00	.00	56365.92	47939.75
5	112.35	5.30	9646.99	.00	.00	7250.82	6873.61
6	123.53	17.05	14076.80	.00	.00	7966.38	11628.60

```
PROFIL
AMAX - CASTLEGATE PLANT, SECTION C,     IRREGULAR FAILURE SURFACES
6 6
0.0 6109.0 30.0 6111.0 1
30.0 6111.0 38.0 6118.0 1
38.0 6118.0 45.0 6130.0 1
45.0 6130.0 115.0 6200.0 1
115.0 6200.0 190.0 6250.0 1
190.0 6250.0 210.0 6250.0 1
SOIL
1
100.0 140.0 250.0 42.0 0.0 0.0 0
WATER
1 0.0
3
0.0 6109.0
30.0 6111.0
210.0 6150.0
RANDOM
10 10
30.0 55.0
75.0 210.0
0.0
50.0
0.0
0.0
```

APPENDIX E

Slope Stability Analysis for Section D - Computer Output

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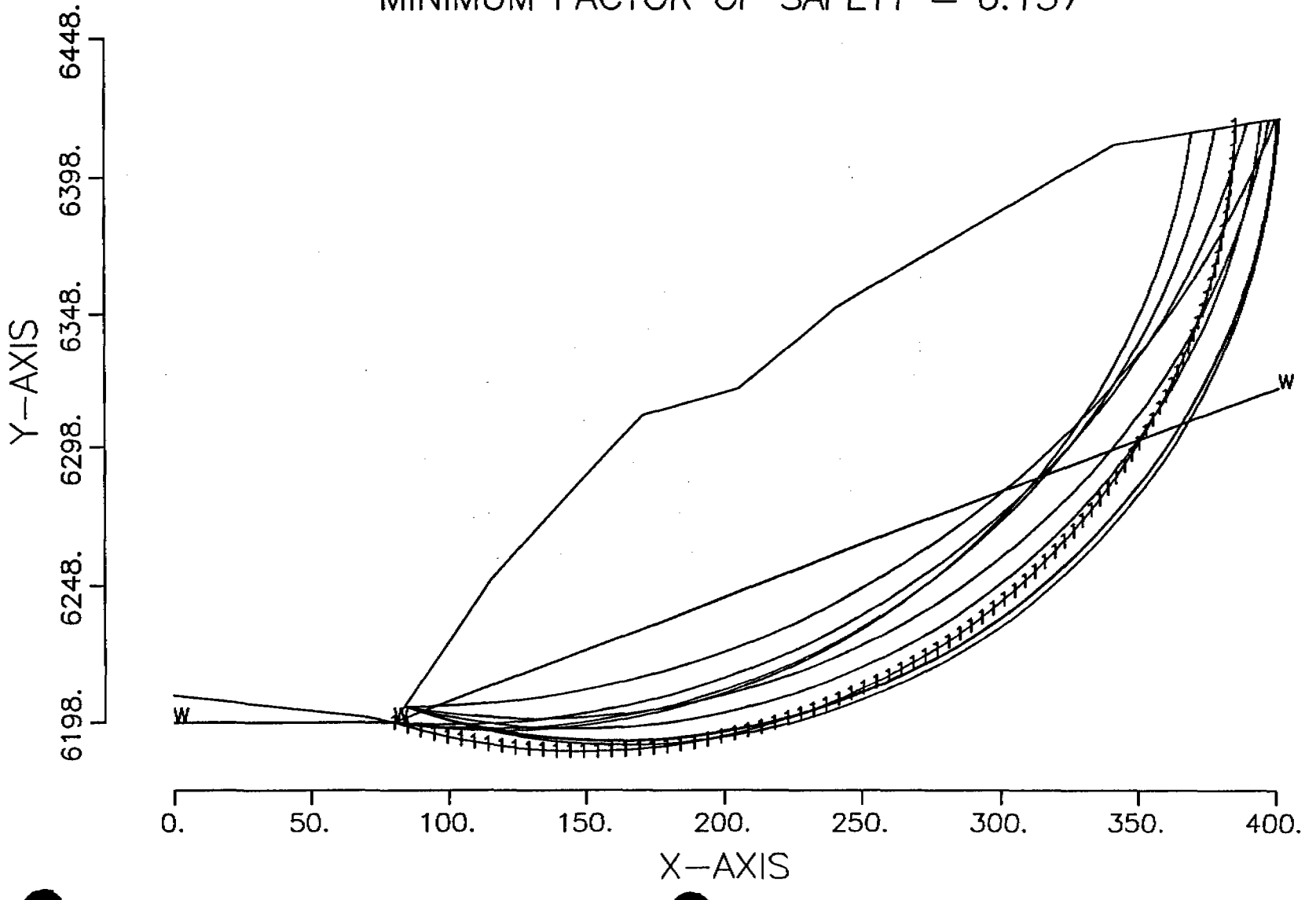
AMAX – CASTLEGATE PLANT, SECTION D

100 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 6.157



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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION AMAX - CASTLEGATE PLANT, SECTION D

BOUNDARY COORDINATES

8 TOP BOUNDARIES
8 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	6208.00	70.00	6200.00	1
2	70.00	6200.00	80.00	6198.00	1
3	80.00	6198.00	115.00	6250.00	1
4	115.00	6250.00	170.00	6310.00	1
5	170.00	6310.00	205.00	6320.00	1
6	205.00	6320.00	240.00	6350.00	1
7	240.00	6350.00	340.00	6410.00	1
8	340.00	6410.00	400.00	6420.00	1

ISOTROPIC SOIL PARAMETERS

1 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	120.0	150.0	20000.0	25.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 3 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER

1	.00	6198.00
2	80.00	6198.00
3	400.00	6320.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED
ALONG THE GROUND SURFACE BETWEEN X = 80.00
AND X = 115.00

EACH SURFACE TERMINATES BETWEEN X = 170.00
AND X = 400.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION
AT WHICH A SURFACE EXTENDS IS Y = .00

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

FOLLOWING ARE DISPLAYED THE TEN MOST CRITICAL OF THE TRIAL FAILURE SURFACES EXAMINED. THEY ARE ORDERED - MOST CRITICAL FIRST.

SAFETY FACTORS ARE CALCULATED BY THE MODIFIED BISHOP METHOD.

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FAILURE SURFACE # 1 SPECIFIED BY 88 COORDINATE POINTS

SAFETY FACTOR = 6.157

X-CENTER = 149.18
Y-CENTER = 6422.01
RADIUS = 234.45

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	80.00	6198.00	-16.55
2	84.79	6196.58	-15.33
3	89.62	6195.25	-14.11

4	94.46	6194.04	-12.89
5	99.34	6192.92	-11.67
6	104.24	6191.91	-10.45
7	109.15	6191.00	-9.23
8	114.09	6190.20	-8.00
9	119.04	6189.50	-6.78
10	124.00	6188.91	-5.56
11	128.98	6188.43	-4.34
12	133.97	6188.05	-3.12
13	138.96	6187.78	-1.90
14	143.96	6187.61	-.68
15	148.96	6187.56	.54
16	153.96	6187.60	1.76
17	158.95	6187.76	2.98
18	163.95	6188.02	4.21
19	168.93	6188.38	5.42
20	173.91	6188.86	6.65
21	178.88	6189.43	7.87
22	183.83	6190.12	9.09
23	188.77	6190.91	10.31
24	193.69	6191.80	11.53
25	198.59	6192.80	12.75
26	203.46	6193.91	13.98
27	208.31	6195.11	15.20
28	213.14	6196.43	16.42
29	217.94	6197.84	17.64
30	222.70	6199.35	18.86
31	227.43	6200.97	20.08
32	232.13	6202.69	21.30
33	236.79	6204.50	22.52
34	241.41	6206.42	23.74
35	245.98	6208.43	24.96
36	250.51	6210.54	26.18
37	255.00	6212.75	27.40
38	259.44	6215.05	28.63
39	263.83	6217.44	29.85
40	268.17	6219.93	31.07
41	272.45	6222.51	32.29
42	276.68	6225.18	33.51
43	280.84	6227.94	34.73
44	284.95	6230.79	35.95
45	289.00	6233.73	37.17
46	292.99	6236.75	38.40
47	296.90	6239.85	39.61
48	300.76	6243.04	40.84
49	304.54	6246.31	42.06
50	308.25	6249.66	43.28
51	311.89	6253.09	44.50
52	315.46	6256.59	45.72
53	318.95	6260.17	46.94
54	322.36	6263.83	48.16
55	325.70	6267.55	49.38
56	328.95	6271.35	50.60
57	332.13	6275.21	51.83

58	335.22	6279.14	53.05
59	338.22	6283.14	54.27
60	341.14	6287.20	55.49
61	343.98	6291.32	56.71
62	346.72	6295.50	57.93
63	349.37	6299.73	59.15
64	351.94	6304.02	60.37
65	354.41	6308.37	61.59
66	356.79	6312.77	62.81
67	359.07	6317.22	64.03
68	361.26	6321.71	65.26
69	363.36	6326.25	66.48
70	365.35	6330.84	67.70
71	367.25	6335.46	68.92
72	369.05	6340.13	70.14
73	370.75	6344.83	71.36
74	372.34	6349.57	72.58
75	373.84	6354.34	73.80
76	375.24	6359.14	75.02
77	376.53	6363.97	76.24
78	377.72	6368.83	77.47
79	378.80	6373.71	78.69
80	379.78	6378.61	79.91
81	380.66	6383.53	81.13
82	381.43	6388.47	82.35
83	382.10	6393.43	83.57
84	382.65	6398.40	84.79
85	383.11	6403.38	86.01
86	383.46	6408.37	87.23
87	383.70	6413.36	88.45
88	383.80	6417.30	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	80.00	.00	.00	.00	.00	1.42	4.79
2	82.40	4.79	2457.40	.00	.00	7558.76	16808.69
3	87.20	4.82	7399.85	.00	.00	12381.60	17178.56
4	92.04	4.85	12361.11	.00	.00	17153.91	17539.99
5	96.90	4.87	17331.78	.00	.00	21874.86	17897.60
6	101.79	4.90	22302.26	.00	.00	26541.95	18251.13
7	106.69	4.92	27262.70	.00	.00	31152.33	18600.32
8	111.62	4.94	32203.92	.00	.00	35703.76	18945.01
9	114.54	.91	6478.69	.00	.00	7038.18	3525.18
10	117.02	4.04	30251.54	.00	.00	32761.28	15729.94
11	121.52	4.97	40457.41	.00	.00	43061.14	19502.02
12	126.49	4.98	44110.23	.00	.00	46240.31	19742.80
13	131.47	4.99	47700.46	.00	.00	49354.07	19978.67
14	136.46	4.99	51222.74	.00	.00	52399.60	20209.28
15	141.46	5.00	54669.27	.00	.00	55376.12	20434.72
16	146.46	5.00	58034.21	.00	.00	58282.34	20654.83
17	151.46	5.00	61311.75	.00	.00	61116.80	20869.49

18	156.45	5.00	64495.55	.00	.00	63877.38	21078.57
19	161.45	4.99	67579.49	.00	.00	66561.98	21281.84
20	166.44	4.99	70558.89	.00	.00	69169.88	21479.40
21	169.47	1.07	15492.85	.00	.00	15123.16	4627.18
22	171.96	3.91	57196.69	.00	.00	55840.86	16988.00
23	176.39	4.97	73114.11	.00	.00	71089.25	21624.67
24	181.35	4.95	73382.93	.00	.00	71091.65	21624.96
25	186.30	4.94	73550.16	.00	.00	71026.27	21620.04
26	191.23	4.92	73616.68	.00	.00	70893.46	21609.94
27	196.14	4.90	73582.11	.00	.00	70692.15	21594.62
28	201.02	4.88	73447.69	.00	.00	70422.76	21574.13
29	204.23	1.54	23196.64	.00	.00	22204.45	6829.89
30	206.66	3.31	50392.82	.00	.00	48259.71	14747.63
31	210.73	4.83	74774.03	.00	.00	71599.09	21663.37
32	215.54	4.80	75913.77	.00	.00	72732.16	21749.19
33	220.32	4.76	76925.83	.00	.00	73780.11	21828.76
34	225.07	4.73	77809.34	.00	.00	74742.30	21901.50
35	229.78	4.70	78563.02	.00	.00	75617.30	21967.93
36	234.46	4.66	79186.95	.00	.00	76404.74	22027.50
37	238.39	3.21	55318.34	.00	.00	53519.19	15352.84
38	240.70	1.41	24331.80	.00	.00	23552.10	6724.86
39	243.69	4.58	79522.56	.00	.00	77161.34	22084.73
40	248.25	4.53	79124.48	.00	.00	77002.98	22072.89
41	252.76	4.49	78616.41	.00	.00	76761.55	22054.00
42	257.22	4.44	78001.07	.00	.00	76439.30	22029.78
43	261.64	4.39	77278.97	.00	.00	76033.41	21999.26
44	266.00	4.34	76454.25	.00	.00	75544.01	21961.89
45	270.31	4.28	75528.59	.00	.00	74971.02	21918.38
46	274.56	4.23	74505.19	.00	.00	74314.45	21868.95
47	278.76	4.17	73386.55	.00	.00	73572.13	21812.49
48	282.90	4.11	72176.27	.00	.00	72745.26	21750.21
49	286.98	4.05	70877.20	.00	.00	71831.42	21680.97
50	290.99	3.98	69493.93	.00	.00	70831.05	21604.94
51	294.95	3.92	68029.71	.00	.00	69744.66	21523.20
52	298.83	3.85	66488.88	.00	.00	68568.67	21433.60
53	302.65	3.78	64874.93	.00	.00	67305.24	21338.29
54	306.40	3.71	63192.99	.00	.00	65951.02	21235.14
55	310.07	3.64	61447.11	.00	.00	64508.06	21126.46
56	313.67	3.57	59641.80	.00	.00	62972.19	21009.81
57	317.20	3.49	57783.02	.00	.00	61345.17	20886.62
58	320.66	3.41	55873.94	.00	.00	59624.00	20756.61
59	324.03	3.34	53920.88	.00	.00	57807.16	20618.70
60	327.33	3.26	51928.71	.00	.00	55894.56	20474.07
61	330.54	3.17	49903.16	.00	.00	53883.63	20321.45
62	333.67	3.09	47848.30	.00	.00	51772.15	20161.89
63	336.72	3.01	45771.19	.00	.00	49558.66	19994.25
64	339.11	1.78	26682.65	.00	.00	28904.50	12074.96
65	340.57	1.14	16959.59	.00	.00	18282.31	7739.27
66	342.56	2.83	41192.21	.00	.00	44213.37	19589.61
67	345.35	2.74	38692.61	.00	.00	41027.50	19348.71
68	348.05	2.65	36230.82	.00	.00	37753.34	19099.63
69	349.75	.75	9989.18	.00	.00	10246.86	5514.98
70	351.03	1.82	23823.09	.00	.00	24140.78	13329.92
71	353.17	2.47	31441.66	.00	.00	30924.94	18582.82

72	355.60	2.38	29123.84	.00	.00	27359.52	18313.01
73	357.93	2.28	26863.75	.00	.00	23684.89	18035.04
74	360.17	2.19	24666.31	.00	.00	19894.82	17747.10
75	362.31	2.09	22536.39	.00	.00	15977.16	17451.20
76	364.35	2.00	20478.30	.00	.00	11923.86	17143.92
77	366.30	1.90	18496.46	.00	.00	7719.58	16825.58
78	368.15	1.80	16595.34	.00	.00	3348.05	16495.04
79	369.90	1.70	14778.86	.00	.00	-1207.44	16149.56
80	371.54	1.60	13051.25	.00	.00	-5973.92	15788.68
81	373.09	1.50	11416.17	.00	.00	-10977.24	15408.95
82	374.54	1.39	9877.27	.00	.00	-16265.10	15009.84
83	375.88	1.29	8438.49	.00	.00	-21866.48	14584.66
84	377.12	1.19	7102.94	.00	.00	-27852.67	14131.10
85	378.26	1.09	5873.73	.00	.00	-34302.32	13643.23
86	379.29	.98	4753.96	.00	.00	-41308.94	13112.47
87	380.22	.88	3746.20	.00	.00	-49018.66	12529.32
88	381.04	.77	2853.31	.00	.00	-57607.06	11878.99
89	381.76	.67	2077.35	.00	.00	-67341.84	11141.19
90	382.38	.56	1420.79	.00	.00	-78613.82	10287.94
91	382.88	.45	885.51	.00	.00	-91993.20	9274.49
92	383.28	.35	473.21	.00	.00	-108403.70	8030.91
93	383.58	.24	185.33	.00	.00	-129426.00	6439.04
94	383.75	.11	25.00	.00	.00	-124420.50	3381.23

```
'PROFIL
AMAX - CASTLEGATE PLANT, SECTION D
8 8
0.0 6208.0 70.0 6200.0 1
70.0 6200.0 80.0 6198.0 1
80.0 6198.0 115.0 6250.0 1
115.0 6250.0 170.0 6310.0 1
170.0 6310.0 205.0 6320.0 1
205.0 6320.0 240.0 6350.0 1
240.0 6350.0 340.0 6410.0 1
340.0 6410.0 400.0 6420.0 1
SOIL
1
120.0 150.0 20000.0 25.0 0.0 0.0 0
WATER
1 0.0
3
0.0 6198.0
80.0 6198.0
400.0 6320.0
CIRCL2
10 10
80.0 115.0
170.0 400.0
0.0
5.0
0.0
0.0
```

APPENDIX F

Slope Stability Analysis for Section D - Computer Output

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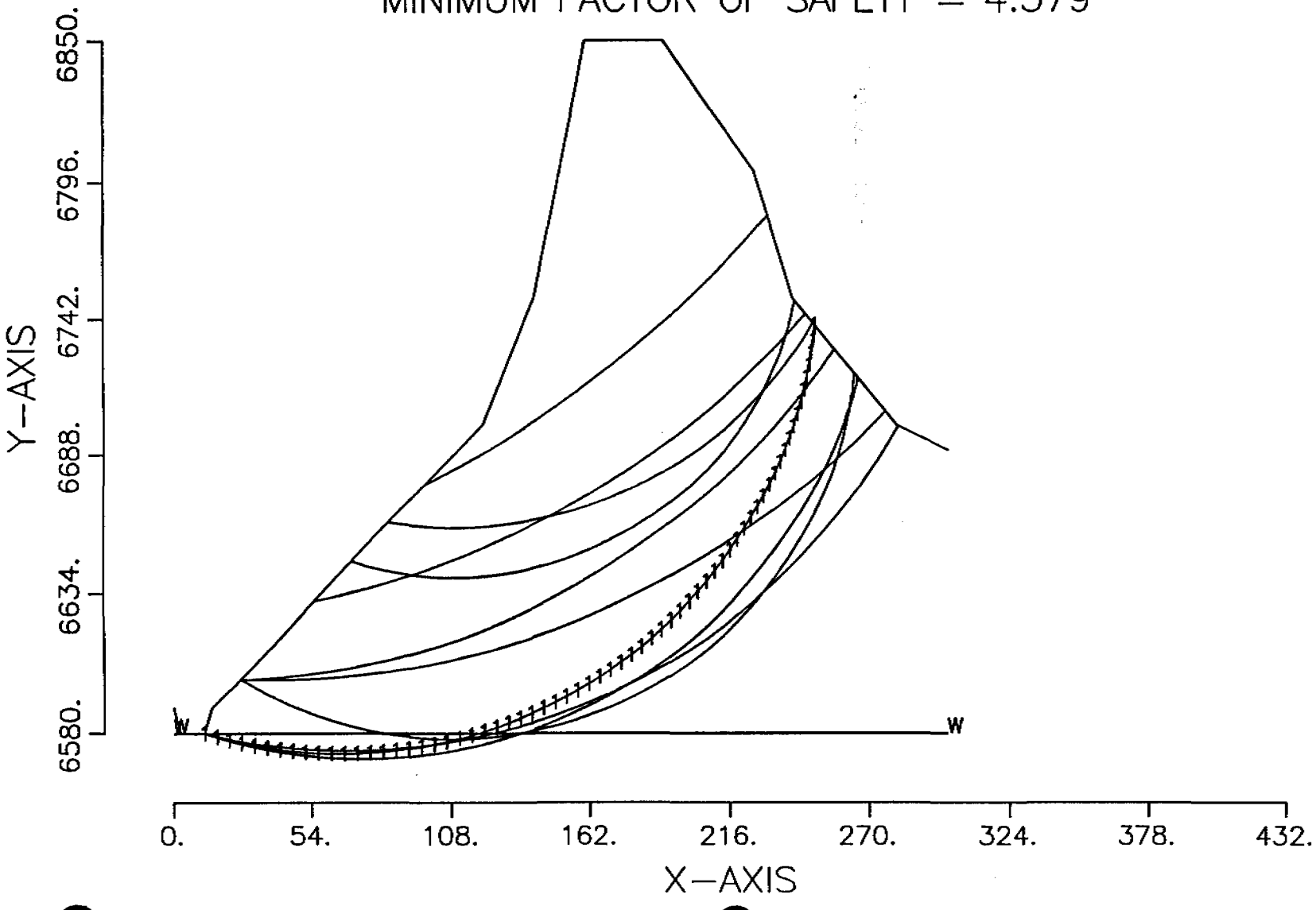
AMAX – CASTLEGATE PLANT, SECTION E

91 SURFACES HAVE BEEN GENERATED
10 MOST CRITICAL OF SURFACES GENERATED
MINIMUM FACTOR OF SAFETY = 4.579



GEOSLOPE
Version 4.20

Supplied by GEOCOMP Corp.
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(617) 369-8304

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--SLOPE STABILITY ANALYSIS--
MODIFIED BISHOP METHOD OF SLICES
CIRCULAR FAILURE SURFACES

PROBLEM DESCRIPTION AMAX - CASTLEGATE PLANT, SECTION E

BOUNDARY COORDINATES

12 TOP BOUNDARIES
12 TOTAL BOUNDARIES

BOUNDARY NO.	X-LEFT	Y-LEFT	X-RIGHT	Y-RIGHT	SOIL TYPE BELOW BND
1	.00	6590.00	3.00	6580.00	1
2	3.00	6580.00	12.00	6580.00	1
3	12.00	6580.00	15.00	6590.00	1
4	15.00	6590.00	25.00	6600.00	1
5	25.00	6600.00	120.00	6700.00	1
6	120.00	6700.00	140.00	6750.00	1
7	140.00	6750.00	160.00	6850.00	1
8	160.00	6850.00	190.00	6850.00	1
9	190.00	6850.00	225.00	6800.00	1
10	225.00	6800.00	240.00	6750.00	1
11	240.00	6750.00	280.00	6700.00	1
12	280.00	6700.00	300.00	6690.00	1

ISOTROPIC SOIL PARAMETERS

1 TYPE(S) OF SOIL

SOIL TYPE NO.	TOTAL UNIT WT.	SATURATED UNIT WT.	COHESION INTERCEPT	FRICTION ANGLE (DEG)	PORE PRESSURE PARAMETER	PRESSURE CONSTANT	PIEZOMETRIC SURFACE NO.
1	120.0	150.0	20000.0	25.0	.00	.0	0

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

UNITWEIGHT OF WATER = 62.40

PIEZOMETRIC SURFACE NO. 1 SPECIFIED BY 2 COORDINATE POINTS

POINT NO.	X-WATER	Y-WATER
1	.00	6580.00
2	300.00	6580.00

A CRITICAL FAILURE SURFACE SEARCHING METHOD, USING A RANDOM TECHNIQUE FOR GENERATING CIRCULAR SURFACES, HAS BEEN SPECIFIED.

100 TRIAL SURFACES HAVE BEEN GENERATED.

10 SURFACES INITIATE FROM EACH OF 10 POINTS EQUALLY SPACED ALONG THE GROUND SURFACE BETWEEN X = 12.00
AND X = 140.00

EACH SURFACE TERMINATES BETWEEN X = 141.00
AND X = 300.00

UNLESS FURTHER LIMITATIONS WERE IMPOSED, THE MINIMUM ELEVATION AT WHICH A SURFACE EXTENDS IS Y = .00

5.00 FT. LINE SEGMENTS DEFINE EACH TRIAL FAILURE SURFACE.

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FAILURE SURFACE # 1 SPECIFIED BY 67 COORDINATE POINTS

SAFETY FACTOR = 4.579

X-CENTER = 65.15
Y-CENTER = 6756.51
RADIUS = 184.34

POINT NO.	X-SURF	Y-SURF	ALPHA (DEG)
1	12.00	6580.00	-15.98
2	16.81	6578.63	-14.43
3	21.65	6577.38	-12.87
4	26.52	6576.27	-11.31
5	31.43	6575.28	-9.75
6	36.35	6574.44	-8.20
7	41.30	6573.72	-6.64
8	46.27	6573.15	-5.09
9	51.25	6572.70	-3.53

10	56.24	6572.40	-1.97
11	61.24	6572.22	-.41
12	66.24	6572.19	1.14
13	71.24	6572.29	2.70
14	76.23	6572.52	4.25
15	81.22	6572.89	5.81
16	86.19	6573.40	7.37
17	91.15	6574.04	8.92
18	96.09	6574.82	10.48
19	101.01	6575.73	12.03
20	105.90	6576.77	13.59
21	110.76	6577.94	15.15
22	115.58	6579.25	16.71
23	120.37	6580.69	18.26
24	125.12	6582.25	19.82
25	129.82	6583.95	21.37
26	134.48	6585.77	22.93
27	139.08	6587.72	24.49
28	143.63	6589.79	26.04
29	148.13	6591.99	27.60
30	152.56	6594.30	29.16
31	156.92	6596.74	30.71
32	161.22	6599.29	32.27
33	165.45	6601.96	33.83
34	169.60	6604.75	35.39
35	173.68	6607.64	36.94
36	177.68	6610.65	38.50
37	181.59	6613.76	40.05
38	185.42	6616.98	41.61
39	189.16	6620.30	43.16
40	192.80	6623.72	44.72
41	196.36	6627.24	46.28
42	199.81	6630.85	47.84
43	203.17	6634.56	49.39
44	206.42	6638.35	50.95
45	209.57	6642.24	52.51
46	212.62	6646.20	54.06
47	215.55	6650.25	55.62
48	218.37	6654.38	57.18
49	221.08	6658.58	58.73
50	223.68	6662.85	60.29
51	226.16	6667.20	61.84
52	228.52	6671.60	63.40
53	230.75	6676.07	64.96
54	232.87	6680.60	66.52
55	234.86	6685.19	68.07
56	236.73	6689.83	69.63
57	238.47	6694.52	71.18
58	240.08	6699.25	72.74
59	241.57	6704.02	74.30
60	242.92	6708.84	75.85
61	244.14	6713.69	77.41
62	245.23	6718.56	78.97
63	246.19	6723.47	80.52

64	247.01	6728.40	82.08
65	247.70	6733.36	83.64
66	248.26	6738.33	85.19
67	248.36	6739.55	

SLICE NO.	X	DX	DW	DQ	DU	DN	DSr
1	12.00	.01	.01	.00	.00	7.12	24.85
2	13.50	2.99	1954.06	.00	.00	6106.38	14226.06
3	15.90	1.81	2606.79	.00	.00	5215.05	8742.42
4	19.23	4.84	9429.02	.00	.00	15766.88	23445.58
5	23.32	3.35	8574.84	.00	.00	12517.11	16286.18
6	25.76	1.52	4455.54	.00	.00	6276.71	7467.81
7	28.98	4.90	16714.68	.00	.00	21861.09	24066.35
8	33.89	4.93	20399.24	.00	.00	24888.96	24374.49
9	38.83	4.95	24037.15	.00	.00	27839.69	24674.94
10	43.79	4.97	27617.28	.00	.00	30710.11	24967.23
11	48.76	4.98	31128.53	.00	.00	33499.58	25251.48
12	53.75	4.99	34559.72	.00	.00	36198.76	25526.27
13	58.74	5.00	37900.86	.00	.00	38810.40	25792.25
14	63.74	5.00	41141.38	.00	.00	41330.71	26048.95
15	68.74	5.00	44272.27	.00	.00	43757.09	26296.06
16	73.73	4.99	47283.99	.00	.00	46086.14	26533.27
17	78.72	4.99	50167.99	.00	.00	48317.38	26760.41
18	83.70	4.97	52915.21	.00	.00	50442.60	26976.99
19	88.67	4.96	55519.02	.00	.00	52466.63	27183.07
20	93.62	4.94	57971.69	.00	.00	54383.84	27378.18
21	98.55	4.92	60266.42	.00	.00	56189.68	27562.38
22	103.45	4.89	62397.56	.00	.00	57887.09	27734.93
23	108.33	4.86	64359.28	.00	.00	59468.27	27896.31
24	113.17	4.83	66146.55	.00	.00	60934.97	28045.43
25	116.83	2.50	35091.12	.00	.00	32232.32	14677.02
26	119.04	1.92	27330.26	.00	.00	25139.91	11310.43
27	120.19	.37	5346.08	.00	.00	4922.33	2196.76
28	122.75	4.75	71446.66	.00	.00	65817.30	28542.78
29	127.47	4.70	76528.30	.00	.00	70874.22	29057.79
30	132.15	4.66	81305.30	.00	.00	75743.98	29553.46
31	136.78	4.60	85765.84	.00	.00	80420.84	30030.02
32	139.54	.92	17675.87	.00	.00	16649.72	6088.94
33	141.82	3.63	74205.79	.00	.00	70331.85	24609.53
34	145.88	4.49	101622.60	.00	.00	97578.94	31777.18
35	150.34	4.43	110898.00	.00	.00	107972.20	32835.38
36	154.74	4.37	119560.70	.00	.00	118019.20	33858.82
37	158.46	3.08	90292.77	.00	.00	90279.72	24819.51
38	160.61	1.22	36850.83	.00	.00	36936.74	9975.91
39	163.34	4.23	126510.80	.00	.00	127623.10	34836.59
40	167.53	4.15	122934.90	.00	.00	124832.80	34553.38
41	171.64	4.08	119262.80	.00	.00	121951.90	34260.08
42	175.68	4.00	115503.00	.00	.00	118979.20	33956.59
43	179.63	3.91	111664.90	.00	.00	115917.30	33644.70
44	183.50	3.83	107757.80	.00	.00	112761.80	33322.88

45	187.29	3.74	103791.10	.00	.00	109514.70	32992.92
46	189.58	.84	23226.49	.00	.00	24739.76	7574.35
47	191.40	2.80	75874.10	.00	.00	80584.90	24991.19
48	194.58	3.55	92927.42	.00	.00	99158.61	31938.66
49	198.08	3.46	86838.14	.00	.00	92913.40	31302.66
50	201.49	3.36	80906.05	.00	.00	86666.66	30665.71
51	204.79	3.25	75140.56	.00	.00	80418.83	30029.56
52	208.00	3.15	69551.59	.00	.00	74165.87	29392.47
53	211.09	3.04	64148.28	.00	.00	67906.75	28756.22
54	214.08	2.93	58938.20	.00	.00	61634.23	28116.90
55	216.96	2.82	53929.40	.00	.00	55345.45	27476.10
56	219.73	2.71	49128.55	.00	.00	49033.50	26833.38
57	222.38	2.60	44541.79	.00	.00	42690.13	26188.09
58	224.34	1.32	21712.64	.00	.00	19857.48	13667.58
59	225.58	1.16	18308.38	.00	.00	16185.71	11843.32
60	227.34	2.36	34770.03	.00	.00	27623.62	24652.38
61	229.64	2.24	29741.01	.00	.00	18955.09	23769.71
62	231.81	2.12	25130.29	.00	.00	10366.05	22894.68
63	233.87	1.99	20932.76	.00	.00	1832.76	22026.99
64	235.80	1.87	17141.40	.00	.00	-6663.38	21160.98
65	237.60	1.74	13748.74	.00	.00	-15157.50	20295.19
66	239.24	1.53	10231.83	.00	.00	-22345.06	18423.08
67	240.04	.08	514.05	.00	.00	-1352.27	1003.83
68	240.83	1.48	8425.91	.00	.00	-31553.93	18626.53
69	242.24	1.35	6619.65	.00	.00	-39072.63	17860.99
70	243.53	1.22	5033.30	.00	.00	-47042.39	17048.01
71	244.69	1.09	3663.85	.00	.00	-55619.75	16175.90
72	245.71	.96	2508.03	.00	.00	-64972.84	15223.50
73	246.60	.82	1561.81	.00	.00	-75364.64	14164.10
74	247.36	.69	820.38	.00	.00	-87194.59	12959.18
75	247.98	.55	278.32	.00	.00	-101046.50	11549.36
76	248.31	.10	8.37	.00	.00	-28833.87	2433.61

```
PROFIL
[illegible]X - CASTLEGATE PLANT, SECTION E
12 12
0.0 6590.0 3.0 6580.0 1
3.0 6580.0 12.0 6580.0 1
12.0 6580.0 15.0 6590.0 1
15.0 6590.0 25.0 6600.0 1
25.0 6600.0 120.0 6700.0 1
120.0 6700.0 140.0 6750.0 1
140.0 6750.0 160.0 6850.0 1
160.0 6850.0 190.0 6850.0 1
190.0 6850.0 225.0 6800.0 1
225.0 6800.0 240.0 6750.0 1
240.0 6750.0 280.0 6700.0 1
280.0 6700.0 300.0 6690.0 1
SOIL
1
120.0 150.0 20000.0 25.0 0.0 0.0 0
WATER
1 0.0
2
0.0 6580.0
300.0 6580.0
CIRCL2
10 10
12.0 140.0
141.0 300.0
[illegible]
5.0
0.0
0.0
```