APPENDIX 7-11

Calculations for Existing Diversions and Culverts

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MAR 25 1994
UTAH DIVISION OIL, GAS AND MINING

REGISTERED PROFESSIONAL ENGINEER
No. 7933
R. JAY MARSHALL
STATE OF UTAH

APR 5 1994

I hereby certify that the design contained herein was prepared under my supervision and is true and correct to the best of my knowledge.

R. Jay Marshall

2/25/94

AS-BUILT REVIEW OF DIVERSIONS AND CULVERTS
– CRANDALL CANYON MINE –

Undisturbed Areas

No alteration occurred to watersheds draining to proposed undisturbed-area diversions. Thus, check to determine that correct sizing was used.

Diversion No.	Proposed Size	Actual Size
UD-1	42" CMP	42" CMP
UD-2	V-ditch, 1.5:1 sides, 1' deep	See below
UD-3	18" CMP	18" PVC

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Summary:

UD-1 → Constructed as designed **OK**

UD-2 → See cross sections F-F' and G-G' on Plate 3
In both cases, the actual cross section is larger than the design cross section. Thus, the actual velocity will be lower than the design velocity. **OK**

UD-3 → PVC has a lower roughness than CMP. Thus, the diversion as installed has a higher capacity than the design condition, making the diversion adequate. **OK**

Silting Basin at Downstream End of UD-2

Item	Design	Actual	
Surface area (ft^2)	150	152	OK
Depth (ft)	3.0	4.4	OK
Volume (ft^3)	130	660	OK
Overflow device	12" CMP	12" CMP	OK

Basin is adequately sized.

Areas and Curve Number Determination
for
Diversion Ditches

Model Input: (a)

Watershed Area (ac)

Diversion No.	Undisturbed	Disturbed	Reclaimed	Paved	Total	Average Curve Number
DD-1	0.11	0.00	0.10	0.00	0.21	72
DD-3[b]	0.28	0.60	0.36	0.00	1.24	81
DD-4	0.00	0.00	0.00	0.18	0.18	95
DD-5[c]	3.70	1.46	1.10	0.00	6.26	75
DD-7	0.05	0.09	0.31	0.00	0.45	77
DD-8	3.36	0.44	0.23	0.00	4.03	72
DD-9	0.00	0.13	0.13	0.00	0.26	82
DD-11	1.94	0.02	0.15	0.00	2.11	70

(a) Based on: CN=69 for Undisturbed
CN=90 for Disturbed
CN=75 for Reclaimed
CN=95 for Paved

(b) Includes WSDD-1 through WSDD-3 (See Plate 7-5c)

(c) Includes drainage to DD-3, DD-4 and DD-8 plus WSDD-5.

Design Storm = P=2.50 in. (10yr. - 24hr.).
Storm Distribution = SCS Type II.

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DESIGN OF DIVERSIONS AND CULVERTS — CRANDALL CANYON MINE

Design of UD-1

Watersheds draining to UD-1 ⟶ WS-1 and WS-2

WS-1 ⟶ Area = 95.2 ac = 0.149 mi²

$l = 3850$ ft

CN = 69 (undisturbed)

$$S = \frac{1000}{69} - 10 = 4.49$$

$$Y = \left[\frac{(55{,}600\ ft)(40\ ft)}{(95.2\ ac)(43{,}560\ ft^2/ac)}\right](100)$$

$$= 53.6\%$$

$$L = \frac{(3850)^{0.8}(1+4.49)^{0.7}}{(1900)(53.6)^{0.5}} = 0.17\ hr$$

$$T_c = (1.67)(0.17) = 0.29\ hr$$

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WS-2 ⟶ Area = 0.9 ac undisturbed
+ 0.3 ac reclaimed
1.2 ac = 0.002 mi²

$l = 650$ ft

CN = 69 for undisturbed area
= 75 for reclaimed area

$$\overline{CN} = \frac{(69)(0.9) + (75)(0.3)}{1.2} = 71$$

$$S = \frac{1000}{71} - 10 = 4.08$$

$$Y = \left[\frac{(1000\ ft)(40\ ft)}{(1.2\ ac)(43{,}560\ ft^2/ac)}\right](100) = 76.5\%$$

$$L = \frac{(650)^{0.8}(1+4.08)^{0.7}}{(1900)(76.5)^{0.5}} = 0.03\ hr$$

Design storm → use 25-yr, 24-hr storm. P = 2.92 in (Miller et al., 1973).

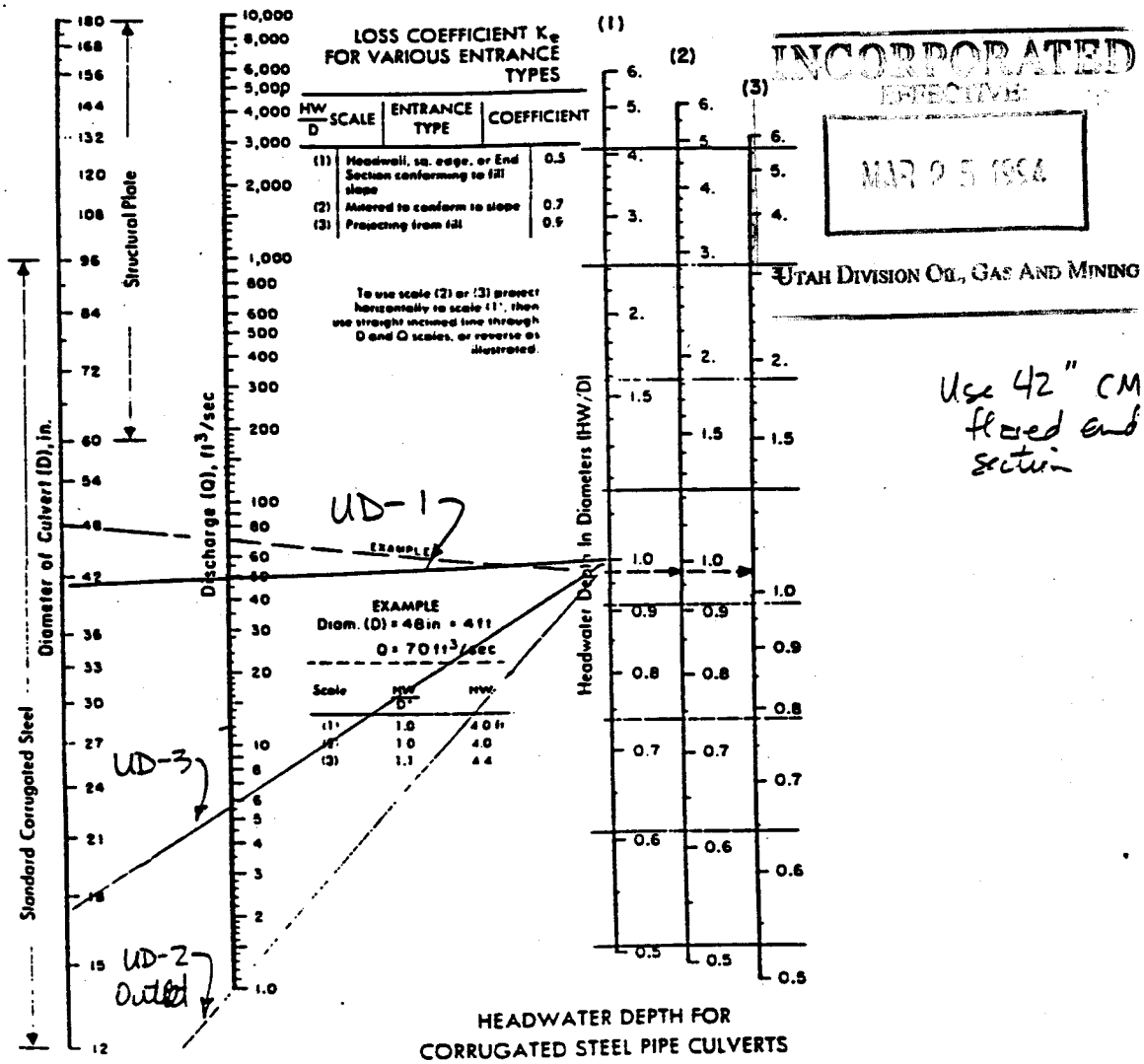
Rainfall distribution → SCS Type II

Hydrograph results (from Hawkins & Marshall model) – see page 3 of this calc.:

WS-1 → q = 46.7 cfs @ 12.08 hr
WS-2 → q = 1.0 cfs @ 12.00 hr

→ q_{Total} = 46.7 + 1.0 = 47.7 cfs

This flow will be diverted into a CMP. Required size:



HEADWATER DEPTH FOR CORRUGATED STEEL PIPE CULVERTS WITH INLET CONTROL

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

IDENTIFICATION: WS-1 - TYPE II

INPUT SUMMARY:

```
*****************************************************************
     STORM:                          WATERSHED:
        DIST. = SCS TYPE II             AREA =  0.149 SQ. MI.
        DEPTH =  2.92 IN.               CN = 69.0
        DURATION = 24.0 HR.             TIME OF CONC. =  0.29 HR.
*****************************************************************
```

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

OUTPUT SUMMARY:

```
*****************************************************************
     TOTAL RUNOFF DEPTH =  0.6273 INCHES
     INITIAL ABSTRACTION =  0.8986 INCHES
     PEAK FLOW =     46.72 CFS  ( 0.4858 IN/HR)
     TIME TO PEAK =  12.08 HOURS
     RUNOFF VOLUME CHECK =  0.6285 INCHES
*****************************************************************
```

IDENTIFICATION: WS-2 25-YR 24-HR STORM

INPUT SUMMARY:

```
*****************************************************************
     STORM:                          WATERSHED:
        DIST. = SCS TYPE II             AREA =  0.002 SQ. MI.
        DEPTH =  2.92 IN.               CN = 71.0
        DURATION = 24.0 HR.             TIME OF CONC. =  0.05 HR.
*****************************************************************
```

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

OUTPUT SUMMARY:

```
*****************************************************************
     TOTAL RUNOFF DEPTH =  0.7148 INCHES
     INITIAL ABSTRACTION =  0.8169 INCHES
     PEAK FLOW =      0.99 CFS  ( 0.7637 IN/HR)
     TIME TO PEAK =  12.00 HOURS
     RUNOFF VOLUME CHECK =  0.7163 INCHES
*****************************************************************
```

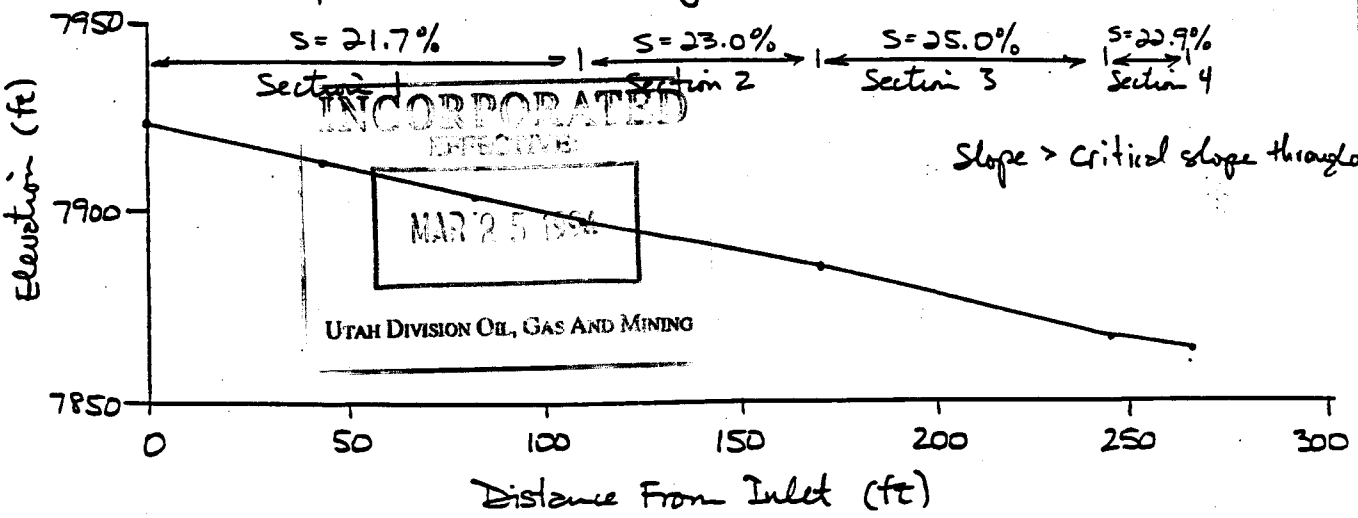
Determine critical slope for UD-1 — From nomographs in NEH-5:

$$\frac{Q}{D^{2.5}} = \frac{47.7 \text{ cfs}}{(3.5)^{2.5}} = 2.081 \Longrightarrow \frac{d_c}{D} = 0.616$$

When $\frac{d_n}{D} = 0.616$, $\frac{nQ}{D^{8/3} S_c^{\frac{1}{2}}} = 0.324$

With $\left.\begin{array}{l} n = 0.024 \\ Q = 2025 \\ D - 2.5 \end{array}\right\}$ $S_c = \left[\frac{(0.024)(47.7)}{(3.5)^{8/3}(0.324)}\right]^2 = 0.016$ ft/ft

Culvert profile (from survey):



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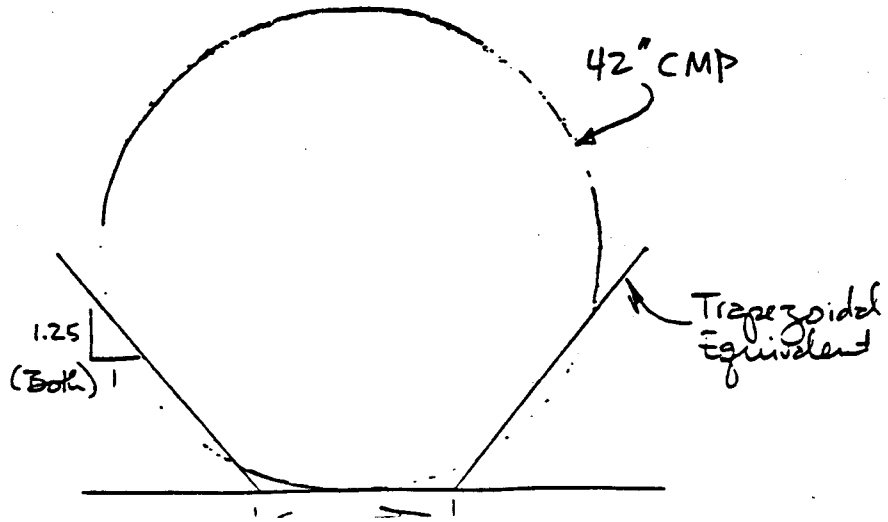
Approximate flow depths in each section → treat the culvert as a trapezoidal channel and use TRAP1 from the OSM Hydro. package:



Section 1:

Bed Slope =	.217	
Manning's N =	.024	
Bottom Width =	1.4	feet
Channel Side Slope =	1.25	
Flow Depth =	1.056449	feet
Cross Sectional Area =	2.371896	square feet
Wetted Perimeter =	4.105829	feet
Hydraulic Radius =	.5776898	feet
Discharge =	47.7	cubic feet/sec
Velocity =	20.1105	feet/sec
Froude Number =	3.448027	

Section 2:

Bed Slope =	.23	
Manning's N =	.024	
Bottom Width =	1.4	feet
Channel Side Slope =	1.25	
Flow Depth =	1.040392	feet
Cross Sectional Area =	2.32248	square feet
Wetted Perimeter =	4.064703	feet
Hydraulic Radius =	.5713776	feet
Discharge =	47.7	cubic feet/sec
Velocity =	20.53839	feet/sec
Froude Number =	3.548461	

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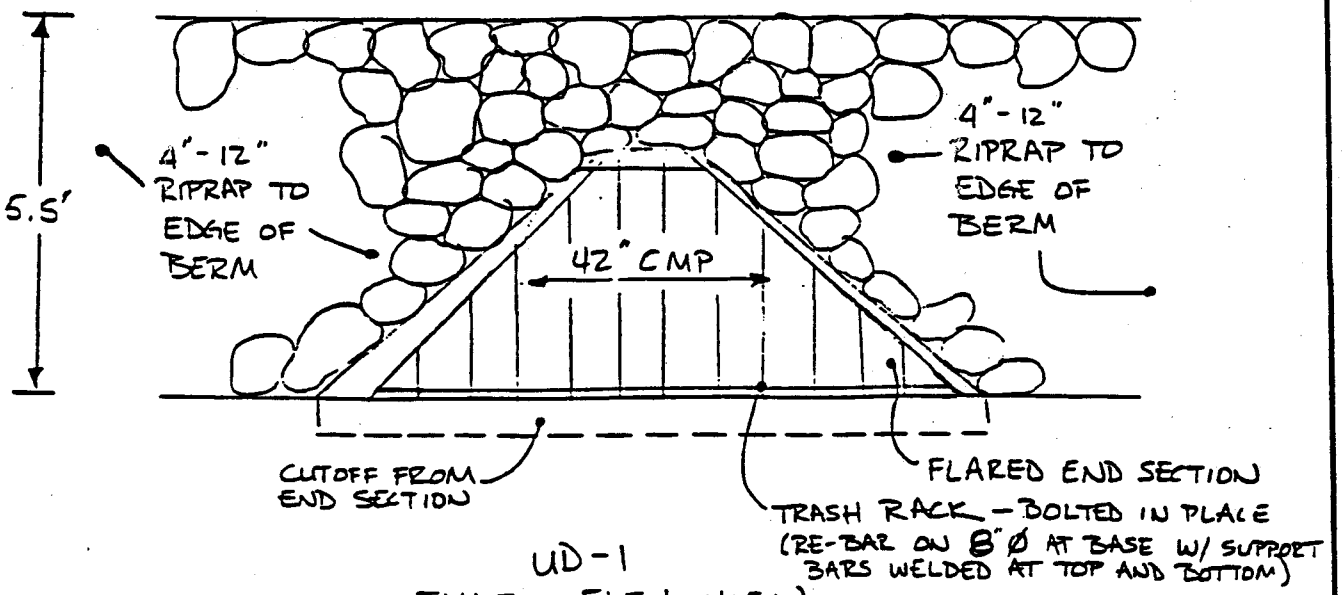
Section 3:

Bed Slope =	.25	
Manning's N =	.024	
Bottom Width =	1.4	feet
Channel Side Slope =	1.25	
Flow Depth =	1.017745	feet
Cross Sectional Area =	2.253487	square feet
Wetted Perimeter =	4.006699	feet
Hydraulic Radius =	.5624298	feet
Discharge =	47.7	cubic feet/sec
Velocity =	21.1672	feet/sec
Froude Number =	3.697566	

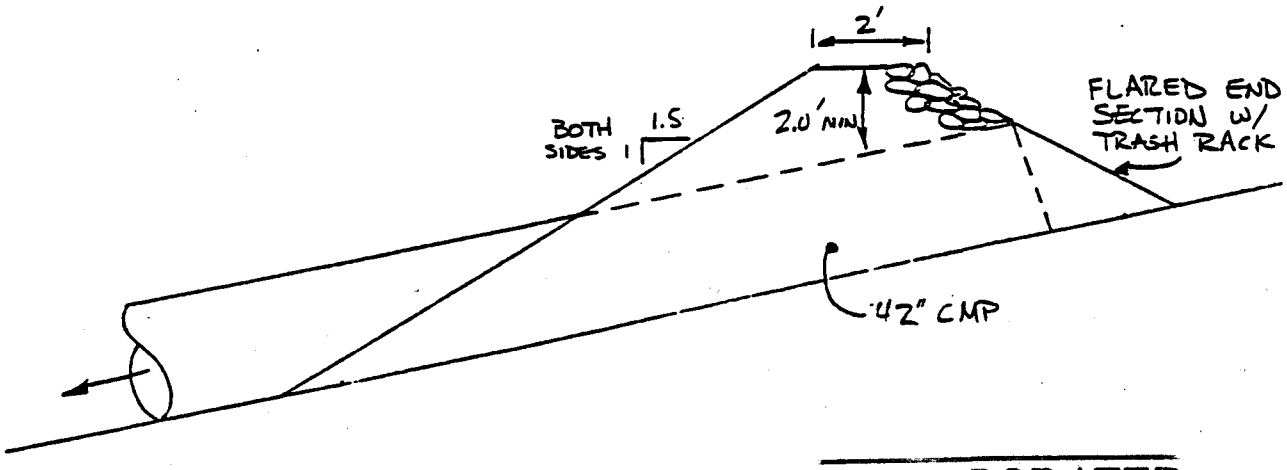
Section 4:

Bed Slope =	.229	
Manning's N =	.024	
Bottom Width =	1.4	feet
Channel Side Slope =	1.25	
Flow Depth =	1.041587	feet
Cross Sectional Area =	2.326144	square feet
Wetted Perimeter =	4.067764	feet
Hydraulic Radius =	.5718483	feet
Discharge =	47.7	cubic feet/sec
Velocity =	20.50604	feet/sec
Froude Number =	3.540839	

Diversion inlet:
(UD-1)



UD-1
INLET ELEV. VIEW



UD-1
INLET SIDE VIEW

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UD-1 to remain as a full-round culvert through its entire length. Typical elev. and side views of the culvert at the USFS road crossing are shown on page 8 of this calc.

Exit velocity from UD-1 → use the pipe flow equation:

$$V = \frac{(2gH)^{1/2}}{(1 + K_e + K_b + K_c L)^{1/2}}$$

where H = total head (elevation head + velocity head)

K_e = entrance loss coefficient

K_b = bend loss coefficient

$K_c = \frac{5087\, n^2}{d_i^{4/3}}$

L = length (ft)

Elevation head = 22.5 ft (see page 8 of this calc)

Velocity head = $\frac{V^2}{2g} = \frac{(20.5)^2}{(2)(32.2)}$ → (from page 5 of this calc.)

$= 6.5$ ft

L = 25 ft

H = 22.5 + 6.5 = 29.0 ft

$K_e = 1.0$, $K_b = 0.5$ } Barfield et al. (1981)

$K_c = \frac{5087\, n^2}{d_i^{4/3}}$ (Assume n = 0.024)

$= \frac{(5087)(0.024)^2}{(42)^{4/3}} = 0.020$

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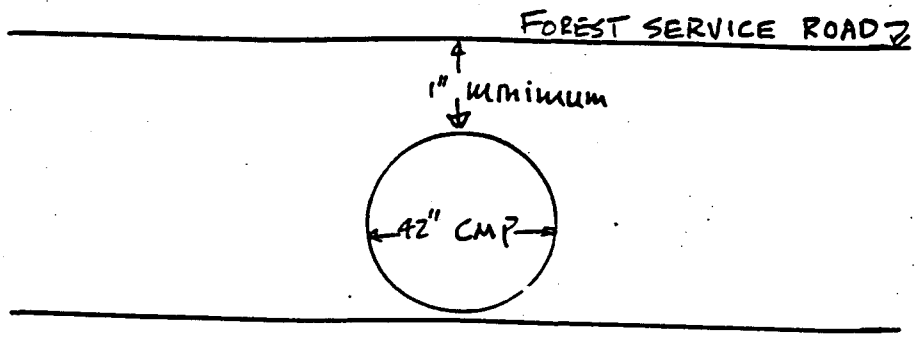
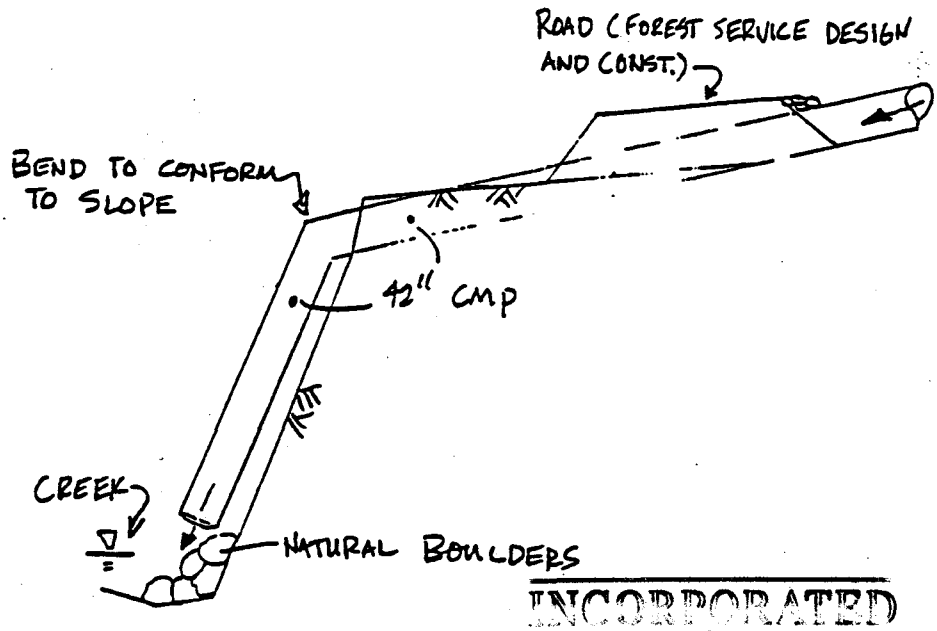
Diversion outlet:



UD-1

DOWNSTREAM INLET ELEVATION VIEW



UD-1

DOWNSPOUT SIDE VIEW

Scale: 1" = 10'

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Design of UD-2

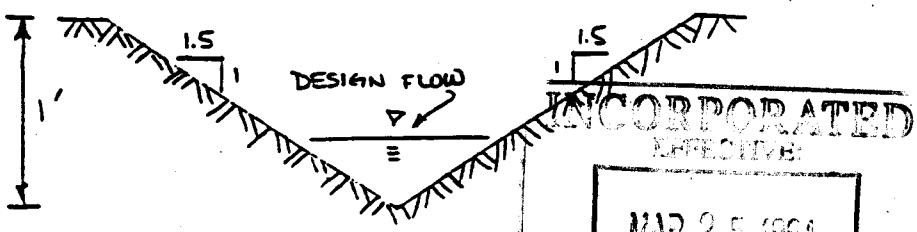
Contributing watershed → WS-2

25-yr, 24-hr storm peak flow → q = 0.99 cfs (see page 5 of this calc.)

Slope along substation pad = (2.8 ft / 115 ft)(100) = 2.4%
Assume n = 0.040 (see Barfield et al., 1981 — Their pg. 159, Table 3.1, design n value for "small drainage ditches".)
Max. permissible velocity = 5.0 ft/s (see Barfield et al., 1981 — Their pg. 162, Table 3.2, value for "graded loam to cobbles when noncolloidal. Compare with gradation curve on pg. 13 of Appendix 7 L).

DESIGN USING TRAD1:

Bed Slope =	.024	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.6667	
Flow Depth =	.5516454	feet
Cross Sectional Area =	.4564462	square feet
Wetted Perimeter =	1.988917	feet
Hydraulic Radius =	.2294948	feet
Discharge =	.99	cubic feet/sec
Velocity =	2.168931	feet/sec
Froude Number =	.5146213	- Acceptable



UD-2 AT SUBSTATION PAD - ELEV.
SCALE: 1" = 1'

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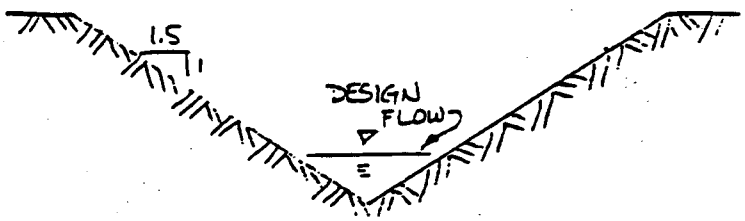
Along the road leading to the substation pad, the slope of UD-2 will increase. Using this new slope, the following results were obtained from TRAP1:

Bed Slope =	.172	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.6667	
Flow Depth =	.3811063	feet
Cross Sectional Area =	.2178521	square feet
Wetted Perimeter =	1.374051	feet
Hydraulic Radius =	.1585474	feet
Discharge =	.99	cubic feet/sec
Velocity =	4.544368	feet/sec
Froude Number =	1.297246	Acceptable



UD-2 AT SUBSTATION ROAD – ELEV.
SCALE: 1" = 1'

Note → same size used throughout UD-2

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Design of UD-3

Contributing watershed → WS-3

$\ell = 1320$ ft

$S = \frac{1000}{69} - 10 = 4.49$

$Y = \left(\frac{160 \text{ ft}}{230 \text{ ft}}\right)(100) = 69.6\%$

$L = \frac{(1320)^{0.8}(5.49)^{0.7}}{(1900)(69.6)^{0.5}} = 0.07 \text{ hr}$

$T_c = (1.67)(0.07) = 0.12$ hr

Area = 8.8 ac = 0.014 mi^2

Design of Stilling Basin at the Downstream End of UD-2

This stilling basin will provide erosion protection during the period that vegetation is being established on the substation pad. Sufficient space exists for as basin with surface dimensions of 15'x10'. The outlet from this basin will consist of a 12" CMP that will stub into UD-1 a sufficient distance downstream from the stilling basin to ensure that the elevation of the top of UD-1 is lower than the invert of the outlet culvert from the stilling basin. See Appendix 7-9 for design details.

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*                             *
* HYDROGRAPH GENERATION MODEL *
*   USING SCS CURVE NUMBER    *
*        METHODOLOGY          *
*******************************
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IDENTIFICATION: UD-3

INPUT SUMMARY:

```
*************************************************************
     STORM:                        WATERSHED:
        DIST. = SCS TYPE B            AREA =  0.014 SQ. MI.
        DEPTH =  1.90 IN.            *CN = 69.0
        DURATION = 6.0 HR.            TIME OF CONC. =  0.12 HR.
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OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  0.1825 INCHES
     INITIAL ABSTRACTION =  0.8986 INCHES
     PEAK FLOW =    0.78 CFS   ( 0.0861 IN/HR)
     TIME TO PEAK =   2.55 HOURS
     RUNOFF VOLUME CHECK =  0.1829 INCHES
*************************************************************
```

From calculations on pages 16 and 17 of this appendix a 12" pipe is adequate to handle storm runoff from WS-3. An 18" PVC inlet structure (as shown on p. 12) and a reducer (18" to 12") will be used. The 12" pipe will run along the face of the highwall and discharge into an existing channel east of the portal pad. The 12" pipe shall be fastened to the highwall with metal straps, roof bolts, and other braces as required.

* The CN of 69 for WS-3 is based on undisturbed area and is consistant with numbers used for WS-1 and WS-2 for undisturbed area.

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Genwall UD-3

Comment: 12" CMP - Outlet velocity

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.0800 ft/ft
Manning's n.....	0.024
Discharge.....	0.78 cfs

Computed Results:

Depth.....	0.26 ft
Velocity.....	4.93 fps ← Outlet Velocity OK ✓
Flow Area.....	0.16 sf
Critical Depth....	0.37 ft
Critical Slope....	0.0194 ft/ft
Percent Full.....	25.54 %
Full Capacity.....	5.46 cfs
QMAX @.94D.....	5.87 cfs
Froude Number.....	2.04 (flow is Supercritical)

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

Circular Channel Analysis & Design
Solved with Manning's Equation

Open Channel - Uniform flow

Worksheet Name: Genwall UD-3

Comment: 12" CMP - 24-year, 6-hour storm

Solve For Actual Depth

Given Input Data:

Diameter.....	1.00 ft
Slope.....	0.0100 ft/ft
Manning's n.....	0.024
Discharge.....	0.78 cfs

Computed Results:

Depth.....	0.44 ft ← Maximum Depth OK ✓
Velocity.....	2.33 fps
Flow Area.....	0.34 sf
Critical Depth....	0.37 ft
Critical Slope....	0.0194 ft/ft
Percent Full.....	44.24 %
Full Capacity.....	1.93 cfs
QMAX @.94D.....	2.08 cfs
Froude Number.....	0.71 (flow is Subcritical)

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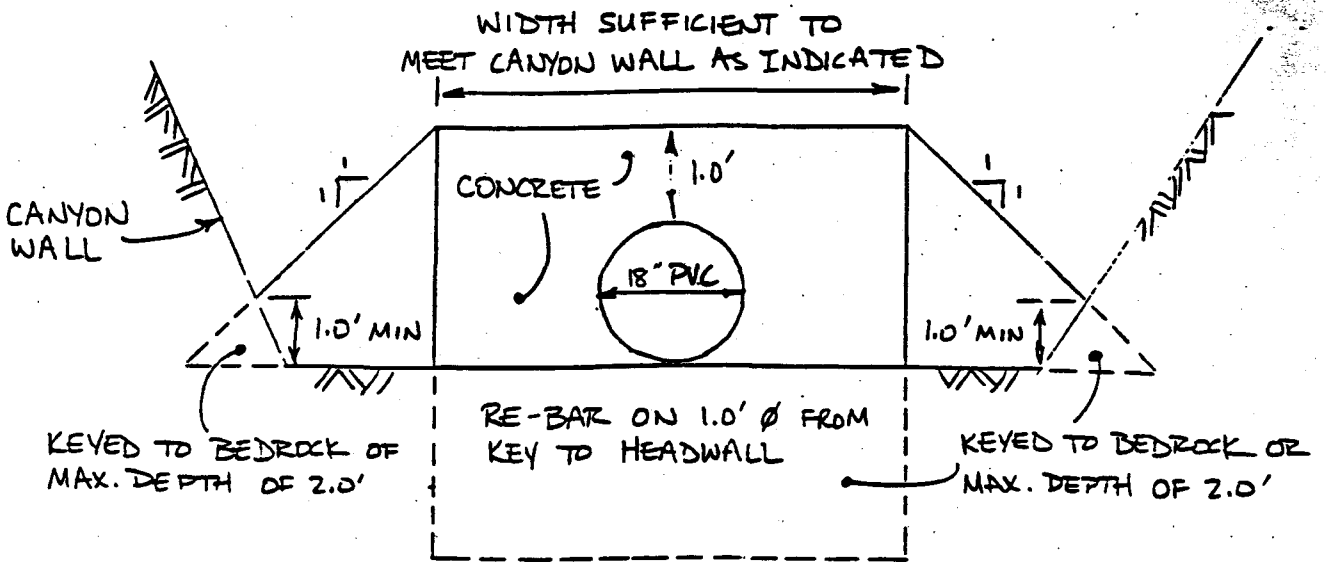
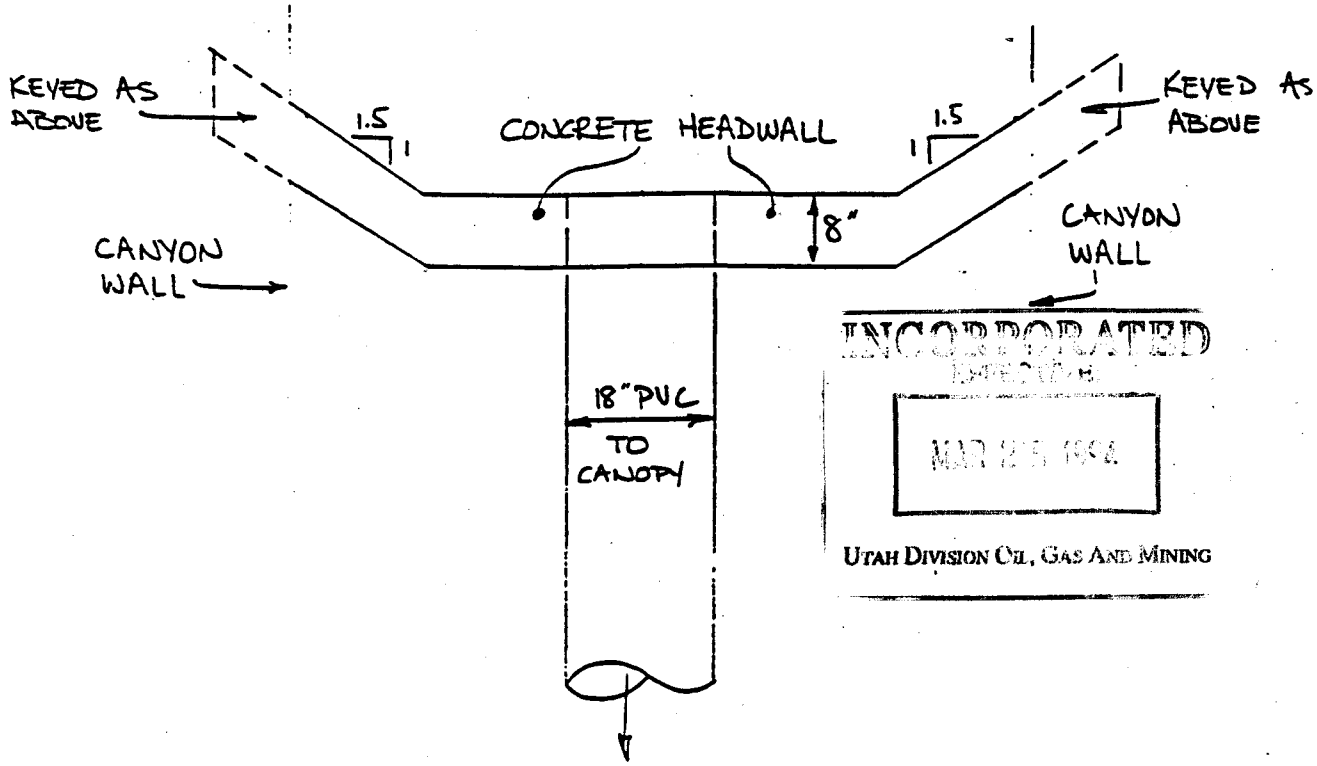
Open Channel Flow Module, Version 3.2 (c) 1990
Haestad Methods, Inc. * 37 Brookside Rd * Waterbury, Ct 06708



UD-3
INLET ELEVATION
SCALE: 1" = 2'



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UD-3
INLET PLAN
SCALE: 1" = 2'

Time of concentration calculations (use CN and upland methods):

DD-1 → $l = 165$ ft
$\bar{CN} = 72 \Rightarrow S = 3.89$
$Y = 39.9\%$

$$L = \frac{(165)^{0.8}(4.89)^{0.7}}{(1900)(39.9)^{0.5}} = 0.02 \text{ hr}$$

$T = (1.67)(0.02) = 0.03$ hr

DD-3 → $l = 330$ ft
$\bar{CN} = 81 \Rightarrow S = 2.35$
$Y = 29.8\%$

$L = 0.02$ hr

$T_c = (1.67)(0.02) = \underline{0.04 \text{ hr}}$

DD-4 → Travel distance = 210 ft (down channel)
Velocity = 6.4 ft/s (see attached chart for "small upland gullies", 10% slope)

$$T_c = \frac{210 \text{ ft}}{6.4 \text{ ft/s}} = \underline{0.01 \text{ hr}}$$

DD-5 → To the end of DD-8, $T_c = 0.13$ hr (see DD-8 calcs.)

From DD-8 to end of DD-5, travel distance = 370 ft @ 10% slope
Velocity = 6.4 ft/s

$$(T_c)_2 = \frac{370 \text{ ft}}{6.4 \text{ ft/s}} = 0.02 \text{ hr}$$

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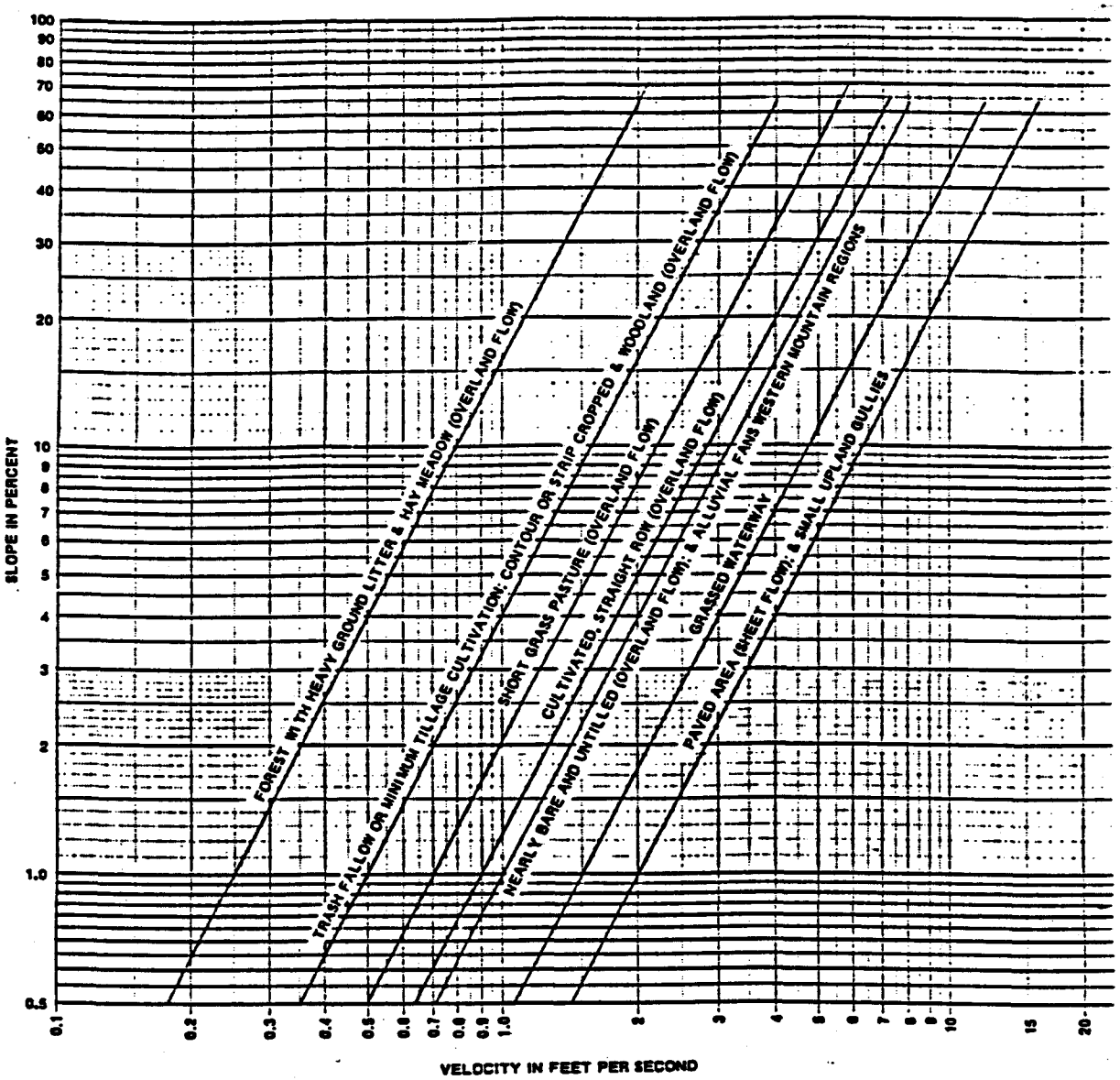

Figure 15.2.—Velocities for upland method of estimating T_c

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Source: NEH-4

DD-7 → Travel distance = 110 ft
Velocity = 5.8 ft/s (see attached chart for "short pasture grass", 70% slope)

$$T_c = \frac{110 ft}{5.8 ft/s} = \underline{\underline{0.01 hr}}$$

DD-8 → Undisturbed travel distance = 750 ft @ 66.1% slope
Velocity = 2.1 ft/s ("Forest w/ heavy litter")

$$(T_c)_1 = \frac{750 ft}{2.1 ft/s} = 360 s$$

Disturbed travel distance = 540 ft @ 5.4% slope
velocity = 4.6 ft/s

$$(T_c)_2 = \frac{540 ft}{4.6 ft/s} = 120 s$$

$$T_c = (360 s + 120 s) = 480 s = \underline{\underline{0.13 hr}}$$

DD-9 → Travel distance = 310 ft @ 6.7% slope
velocity = 5.2 ft/s ("small upland gullies")

$$T_c = \frac{310 ft}{5.2 ft/s} = \underline{\underline{0.02 hr}}$$

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DD-11 → Travel distance = 550 ft @ 70% slope
Velocity = 2.1 ft/s ("Forest w/ heavy litter")

$$T_c = \frac{550 ft}{2.1 ft/s} = \underline{\underline{0.07 hr}}$$

Hydrograph results → attached (pg. 21 - 26 of this calc.)

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

IDENTIFICATION: DIVERSION DD-1

INPUT SUMMARY:

```
*****************************************************************
     STORM:                          WATERSHED:
        DIST. = SCS TYPE II              AREA =  0.001 SQ. MI.
        DEPTH =  2.50 IN.                CN = 72.0
        DURATION = 24.0 HR.              TIME OF CONC. =  0.03 HR.
*****************************************************************
```

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

OUTPUT SUMMARY:

```
*****************************************************************
     TOTAL RUNOFF DEPTH =  0.5286 INCHES
     INITIAL ABSTRACTION =  0.7778 INCHES
     PEAK FLOW =      0.37 CFS   ( 0.5781 IN/HR)
     TIME TO PEAK =  12.00 HOURS
     RUNOFF VOLUME CHECK =  0.5297 INCHES
*****************************************************************
```

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UTAH DIVISION OIL, GAS AND MINING

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

IDENTIFICATION: DIVERSION DD-3

INPUT FOR: Genwall - Diversion Ditch DD-3

STORM :	WATERSHED :
Dist.=SCS Type II - 24 Hr	Area = 1.24 acres
Depth = 2.50 inches	CN = 81.00
Duration = 24.00 hrs	Time conc.= 0.040 hrs

OUTPUT SUMMARY

Runoff depth	0.94239	inches	
Initial abstr	0.46914	inches	
Peak flow =	1.30	cfs	(1.03691 iph)
at time	12.005	hrs	

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INPUT FOR: Genwall - Diversion DD-4

STORM :	WATERSHED :
Dist.=SCS Type II - 24 Hr	Area = 0.18 acres
Depth = 2.50 inches	CN = 95.00
Duration = 24.00 hrs	Time conc.= 0.020 hrs

OUTPUT SUMMARY

Runoff depth	1.96325	inches	
Initial abstr	0.10526	inches	
Peak flow =	0.32	cfs	(1.77764 iph)
at time	12.002	hrs	

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

IDENTIFICATION: DIVERSION DD-5

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = SCS TYPE II          AREA =  0.010 SQ. MI.
        DEPTH =  2.50 IN.            CN = 75.0
        DURATION = 24.0 HR.          TIME OF CONC. =  0.15 HR.
*************************************************************
```

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

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  0.6505 INCHES
     INITIAL ABSTRACTION =  0.6667 INCHES
     PEAK FLOW =     4.02 CFS  ( 0.6228 IN/HR)
     TIME TO PEAK =  12.01 HOURS
     RUNOFF VOLUME CHECK =  0.6518 INCHES
*************************************************************
```

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```
*******************************
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*                             *
* HYDROGRAPH GENERATION MODEL *
*   USING SCS CURVE NUMBER    *
*         METHODOLOGY         *
*******************************
```

IDENTIFICATION: DIVERSION DD-7

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = SCS TYPE II          AREA =  0.001 SQ. MI.
        DEPTH =  2.50 IN.            CN = 77.0
        DURATION = 24.0 HR.          TIME OF CONC. =  0.01 HR.
*************************************************************
```

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

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  0.7403 INCHES
     INITIAL ABSTRACTION =  0.5974 INCHES
     PEAK FLOW =      0.52 CFS  ( 0.8125 IN/HR)
     TIME TO PEAK =  12.00 HOURS
     RUNOFF VOLUME CHECK =  0.7418 INCHES
*************************************************************
```

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IDENTIFICATION: DIVERSION DD-8

INPUT SUMMARY:

```
*************************************************************
     STORM:                    WATERSHED:
        DIST. = SCS TYPE II          AREA =  0.006 SQ. MI.
        DEPTH =  2.50 IN.            CN = 72.0
        DURATION = 24.0 HR.          TIME OF CONC. =  0.13 HR.
*************************************************************
```

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

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  0.5286 INCHES
     INITIAL ABSTRACTION =  0.7778 INCHES
     PEAK FLOW =      1.97 CFS  ( 0.5078 IN/HR)
     TIME TO PEAK =  12.01 HOURS
     RUNOFF VOLUME CHECK =  0.5297 INCHES
*************************************************************
```

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

IDENTIFICATION: DIVERSION DD-9

INPUT SUMMARY:

```
*****************************************************************
     STORM:                      WATERSHED:
        DIST. = SCS TYPE II            AREA =  0.001 SQ. MI.
        DEPTH =  2.50 IN.              CN = 82.0
        DURATION = 24.0 HR.            TIME OF CONC. =  0.02 HR.
*****************************************************************

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

OUTPUT SUMMARY:

```
*****************************************************************
     TOTAL RUNOFF DEPTH =  0.9980 INCHES
     INITIAL ABSTRACTION =  0.4390 INCHES
     PEAK FLOW =      0.67 CFS  ( 1.0313 IN/HR)
     TIME TO PEAK =  12.00 HOURS
     RUNOFF VOLUME CHECK =  1.0000 INCHES
*****************************************************************
```

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

IDENTIFICATION: DIVERSION DD-11

INPUT SUMMARY:

```
*****************************************************************
     STORM:                          WATERSHED:
        DIST. = SCS TYPE II             AREA =  0.003 SQ. MI.
        DEPTH =  2.50 IN.               CN = 70.0
        DURATION = 24.0 HR.             TIME OF CONC. =  0.07 HR.
*****************************************************************
```

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

OUTPUT SUMMARY:

```
*****************************************************************
     TOTAL RUNOFF DEPTH =  0.4552 INCHES
     INITIAL ABSTRACTION =  0.8571 INCHES
     PEAK FLOW =      0.91 CFS   ( 0.4688 IN/HR)
     TIME TO PEAK =  12.00 HOURS
     RUNOFF VOLUME CHECK =  0.4562 INCHES
*****************************************************************
```

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Determine adequacy of actual cross sections based on flow rates presented on pg. 21-26 of this calc. See cross sections on Plate 3. For ease of calculation, initially assume equal side slopes on both sides of channel, with both side slopes being equal to the minimum actual slope (thus making the cross section conservatively small). If the velocity as calculated with this condition is acceptable, the channel design will be considered adequate. If the velocity is > 5 ft/s under this conservative condition, calculate velocity using actual non-uniform cross section.

TRAP1 results:

DD-1 (cross section H-H'):

Bed Slope =	.25	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.5	
Flow Depth =	.2172315	feet
Cross Sectional Area =	9.437906E-02	square feet
Wetted Perimeter =	.9714888	feet
Hydraulic Radius =	9.714889E-02	feet
Discharge =	.37	cubic feet/sec
Velocity =	3.920361	feet/sec
Froude Number =	1.482302	< 5.0 ⇒ OK

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Elimination of Ditch DD-2

Disturbed Diversion Ditch DD-2 has been eliminated. The ditch previously flowed to the confluence of Ditches DD-1 and DD-3. Under the present situation, the drainage formerly in ditch DD-2, now sheet flows across the main pad area and goes into ditch DD-3, to Culvert C-7 and then to Culvert C-1. The quantity of the previous ditch DD-2 flow (0.58 cfs) is included in the existing design and calculations for ditch DD-3, and Culverts C-7 and C-1; therefore, no changes are required to the hydrology calculations. The existing ditch and culvert configuration is shown on Plate 7-5A.

DD-3 (cross section I-I'):

Bed Slope =	.03	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.833	
Flow Depth =	.650971	feet
Cross Sectional Area =	.5087193	square feet
Wetted Perimeter =	2.034179	feet
Hydraulic Radius =	.2500859	feet
Discharge =	1.3	cubic feet/sec
Velocity =	2.555437	feet/sec
Froude Number =	.558157	<5.0 ok

Triangular Channel Analysis & Design
Open Channel - Uniform flow

Worksheet Name: Genwall

Comment: DD-4 (cross section c-c')

Solve For Depth

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Given Input Data:

Left Side Slope..	2.00:1 (H:V)
Right Side Slope.	2.00:1 (H:V)
Manning's n.....	0.040
Channel Slope....	0.0950 ft/ft
Discharge.....	0.32 cfs

Computed Results:

Depth.....	0.25 ft	→ FLOW DEPTH < CHANN!
Velocity.....	2.63 fps	→ < 5.0 FPS OK
Flow Area.....	0.12 sf	
Flow Top Width...	0.99 ft	
Wetted Perimeter.	1.10 ft	
Critical Depth...	0.28 ft	
Critical Slope...	0.0524 ft/ft	
Froude Number....	1.32 (flow is Supercritical)	

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

DD-5 (cross section E-E'):

Bed Slope =	.08	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.7143	
Flow Depth =	.7700968	feet
Cross Sectional Area =	.830252	square feet
Wetted Perimeter =	2.649814	feet
Hydraulic Radius =	.3133246	feet
Discharge =	4.02	cubic feet/sec
Velocity =	4.841903	feet/sec
Froude Number =	.9723341	<5.0 OK

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Insert

Ditch DD-7

Title of run: DITCH DD-7 (cross-section L-L')

Solving for	=	Depth Normal
Triangle		
Flow depth (ft.)	=	0.67
First Side slope	=	1.0
Second Side slope	=	1.0
Slope of diversion	=	0.0500
Manning's n	=	0.040
CFS	=	1.43
Cross section area (soft)	=	0.45
Hydraulic radius	=	0.24
fps	=	3.19
Froude number	=	1.16

DD-8 (cross section B-B'):

Bed Slope =	.051	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.4167	
Flow Depth =	.5064729	feet
Cross Sectional Area =	.6155863	square feet
Wetted Perimeter =	2.633479	feet
Hydraulic Radius =	.233754	feet
Discharge =	1.97	cubic feet/sec
Velocity =	3.200202	feet/sec
Froude Number =	.7924489	< 5.0 OK

DD-9 (cross section K-K'):

Bed Slope =	.065	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	.4762	
Flow Depth =	.3413474	feet
Cross Sectional Area =	.244683	square feet
Wetted Perimeter =	1.587882	feet
Hydraulic Radius =	.154094	feet
Discharge =	.67	cubic feet/sec
Velocity =	2.738237	feet/sec
Froude Number =	.825933	< 5.0 ok

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DD-11 (cross section O-O'):

Bed Slope =	.03	
Manning's N =	.04	
Bottom Width =	0	feet
Channel Side Slope =	1	
Flow Depth =	.6230584	feet
Cross Sectional Area =	.3882018	square feet
Wetted Perimeter =	1.762275	feet
Hydraulic Radius =	.2202844	feet
Discharge =	.91	cubic feet/sec
Velocity =	2.344142	feet/sec
Froude Number =	.5233492	

Disturbed Ditch Summary Sheet

Ditch	Peak Flow (cfs)	Velocity (fps)	Flow Depth (ft.)
DD-1	0.37	3.92	0.22
DD-3	1.30	2.55	0.65
DD-4	0.32	2.63	0.25
DD-5	4.02	4.84	0.77
DD-7	*1.43	1.04	0.70
DD-8	1.97	3.20	0.51
DD-9	0.67	2.74	0.25
DD-11	0.91	2.34	0.62

* New flow with C-5

Notes:

(1) Ditch DD-2 has been eliminated. Drainage flows to DD-3, Culvert C-7 and Culvert C-1.

(2) Ditch DD-6 has also been eliminated. The ditch was replaced by Culvert C-2. Flows are included in DD-5 and Culvert C-2.

(3) Ditch DD-10 has also been eliminated. It was also replaced with Culbert C-2. Flows are carried by Culverts C-2, C-3 and C-4.

(4) Summary is based on revisions and Plate 7-5A (Revised 10/12/93).

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Re-routing of culvert C-5 to DD-7 to C-3

Culvert	Type	Inflow (cfs)	Req'd Diam Diameter (ft.)	Adequacy
C-3	12" cmp	1.43 (a)	0.49	O.K.
C-4	24" cmp	0.52 (b)	0.34	O.K.

(a) Flow from DD-7, C-5 and D-11.
(b) Flow from culvert C-10.
(c) Based on Manning's Formula: $D = \left(\frac{2.16\ Qn}{\sqrt{S}}\right)^{0.35}$

Where: D = Required culvert diameter (feet)
Q = Peak inflow (cfs)
N = Roughness factor (0.02 for cmp)
S = Slope (ft. per ft.)

Note: Slope on culverts = 0.23 ft./ft. based on C-4 (page 20 of Appendix 7-7).

Ditch DD-7

Previous flow = 0.52 cfs.
New flow with addition of C-5 = 1.43 cfs.
New flow depth = 0.67 ft.
Ditch is adequate to handle new flow.
(See attached computer print-out).

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Addition of Culvert C-9

Disturbed area Culvert C-9, located in Ditch DD-4 to provide access to trash dumpsters.

Culvert	Type		Inflow	Req'd Diam.	Slope	Adequacy
	Design	Actual	(cfs)	(ft.)	(%)	
C-9	12"cmp	12"cmp	*0.32	**0.34	9.50	O.K.

* Based on flow from DD-4

** Based on Manning's Formula: $D = \left(\frac{2.16\ Qn}{\sqrt{S}}\right)^{0.35}$

Where:
D = Required Culvert Diameter (feet)
Q = Peak Inflow (cfs)
n = Roughness Factor (0.02 for cmp)
S = Slope (ft. per ft.)

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Addition of Culvert C-10

Addition of Culvert C-10 under Temporary Storage Area east of Loadout.

Culvert	Type		Inflow	Req'd Diam.	Slope	Adequacy
	Design	Actual	(cfs)	(ft.)	(%)	
C-10	24"cmp	24"cmp	*0.52	**0.45	5.00	O.K.

* Based on previous DD-7 flow.

** Based on Manning's Formula: $D = \left(\frac{2.16\ Qn}{\sqrt{S}}\right)^{0.35}$

Where:
D = Required Culvert Diameter (feet)
Q = Peak Inflow (cfs)
n = Roughness Factor (0.02 for cmp)
S = Slope (ft. per ft.)

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Culvert Summary Sheet

Culvert	Size	Length (ft.)	Slope (%)	Inflow (cfs)	Source	Req'd Diam (Diam.ft.)	Adequacy	Velocity (fps)
C-1	18"cmp	60	16.67	3.27	DD-3+DD-8	0.69	O.K.	10.12
C-2	24"cmp	360	8.00	4.02	DD-5	0.84	O.K.	7.93
C-3	24"cmp	56	3.43	1.43	DD-7+DD-11	0.68	O.K.	4.15
C-4	24"cmp	69	25.07	0.52	C-10	0.34	O.K.	5.11
C-5	12"pvc	120	57.14	0.91	DD-11	0.36	O.K.	10.63
C-6	12"cmp	12	17.20	0.99	UD-2	0.45	O.K.	7.50
C-7	12"cmp	80	3.00	1.30	DD-3	0.67	O.K.	4.34
C-8	24"cmp	97	17.53	0.67	DD-9	0.39	O.K.	5.07
C-9	12"cmp	18	3.50	0.32	DD-4	0.40	O.K.	3.00
C-10	24"cmp	56	2.53	0.52	DD-7(previous)	0.50	O.K.	2.56

Note: Summary is based on revision and Plate 7-5A (Revised 10/12/93).

* Based on Manning's Formula: $D = \left(\frac{2.16\ Qn}{\sqrt{S}}\right)^{0.35}$

Where:
- D = Required Culvert Diameter (feet)
- Q = Peak Inflow (cfs)
- n = Roughness Factor (0.02 for cmp)
- S = Slope (ft. per ft.)

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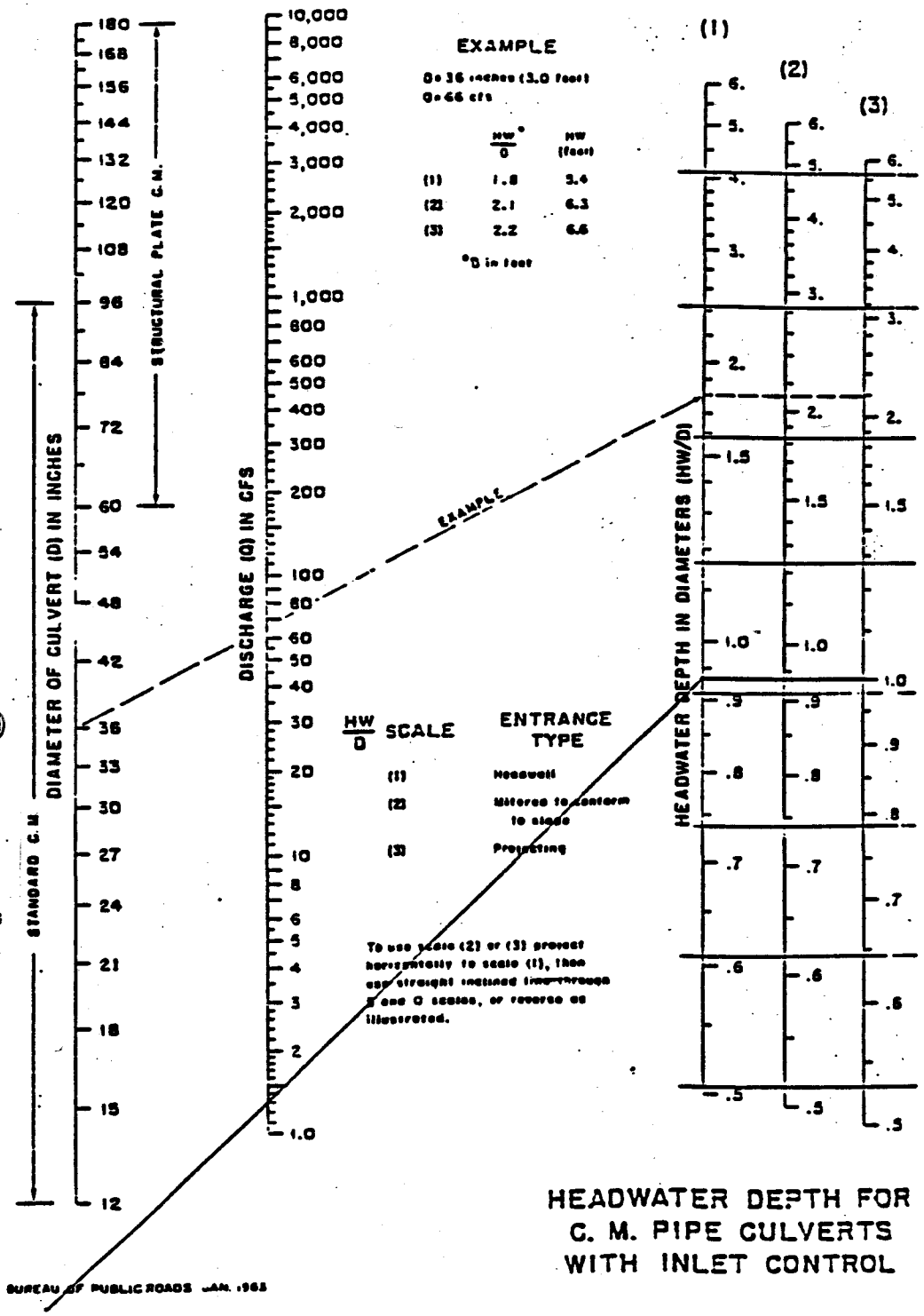
Note: Adequacy can also be checked with nomograph chart provided in this section.

C-7

O.K.

CHART 5



HEADWATER DEPTH FOR C. M. PIPE CULVERTS WITH INLET CONTROL

BUREAU OF PUBLIC ROADS JAN. 1965

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Source: Hydraulic Charts for the Selection of Highway Culverts. U.S. Dept. of Transportation. Hydraulic Engineering Circular 5.