APPENDIX 7-7

Calculations
for
Future Diversions and Culverts

(See Appendix 7-11 for <u>Existing</u> Diversions and Culverts)

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

I hereby certify that the design contained herein was reviewed by myself and is true and correct to the best of my knowledge.

R. Jay Marshall

2/25/94

APPENDIX 7-7

Calculations
for
Future Diversions and Culverts

(See Appendix 7-11 for <u>Existing</u> Diversions and Culverts)

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

I hereby certify that the design contained herein was reviewed by myself and is true and correct to the best of my knowledge.

R. Jay Marshall

2/25/94

— DESIGN OF RECLAMATION CHANNELS —

Design of RD-1

Watershed draining to RD-1 ⟶ WS-1 + adjacent undisturbed and reclaimed area

Undisturbed area = 95.2 ac (WS-1) − 0.2 ac (adjacent) = 95.4 ac

Reclaimed area = 0.3 ac (Adjacent)

Total = 95.7 ac = 0.150 mi

$l = 4110$ ft

$$\overline{CN} = \frac{(95.4)(69) + (0.3)(75)}{95.7} = 69$$

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

$$Y = \left[\frac{(55{,}700 \text{ ft})(40 \text{ ft})}{(95.7 \text{ ac})(43{,}560 \text{ ft}^2/\text{ac})}\right](100) = 53.4\%$$

$$L = \frac{(4110)^{0.8}(1 - 4.49/53.4)^{0.7}}{(1900)(53.4)^{0.5}}$$

$= 0.18$ hr

$T_c = (1.67)(0.18)$

$= \underline{0.31 \text{ hr}}$

Design storm ⟶ 50-yr 24-hr. USFS designs culverts for road crossings with 10- to 20-yr return period. Since this channel will empty into such a culvert, a 50-yr return period is a conservative design for the channel.

$P = 3.25$ in (Miller et al. 1973)

Hydrograph results:

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

IDENTIFICATION: WATERSHED DRAINING TO RD-1

INPUT SUMMARY:

```
STORM:                          WATERSHED:
   DIST. = SCS TYPE II             AREA =  0.150 SQ. MI.
   DEPTH =  3.25 IN.               CN = 69.0
   DURATION = 24.0 HR.             TIME OF CONC. =  0.31 HR.
```

OUTPUT SUMMARY:

```
TOTAL RUNOFF DEPTH =  0.8079 INCHES
INITIAL ABSTRACTION =  0.8986 INCHES
PEAK FLOW =     61.21 CFS  ( 0.6323 IN/HR)
TIME TO PEAK =  12.09 HOURS
RUNOFF VOLUME CHECK =  0.8095 INCHES
```

Maximum slope of channel = $\frac{10}{24}$ = 0.42 ft/ft

Minimum slope of channel = $\frac{10}{75}$ = 0.13 ft/ft

Use maximum slope for design of riprap, minimum slope for design of cross section.

Run TRAP1 with bottom widths of 3 ft and 5 ft, assuming n=0.0[illegible] and side slopes of 2h:1v. Check required riprap size, adjust roughness coefficient, and re-run TRAP1.

Bed Slope =	.42	
Manning's N =	.04	
Bottom Width =	3	feet
Channel Side Slope =	.5	
Flow Depth =	.8082538	feet
Cross Sectional Area =	3.73131	square feet
Wetted Perimeter =	6.614621	feet
Hydraulic Radius =	.5641003	feet
Discharge =	61.2	cubic feet/sec
Velocity =	16.40175	feet/sec
Froude Number =	3.215054	

Bed Slope =	.42	
Manning's N =	.04	
Bottom Width =	5	feet
Channel Side Slope =	.5	
Flow Depth =	.6358769	feet
Cross Sectional Area =	3.988063	square feet
Wetted Perimeter =	7.843728	feet
Hydraulic Radius =	.5084398	feet
Discharge =	61.2	cubic feet/sec
Velocity =	15.3458	feet/sec
Froude Number =	3.391368	

Determine riprap sizing from the figure on page 27c of this calc. Determine new n value from the equation:

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

where d_{50} = median stone diameter (ft)

For b = 3 ft ⟶ d_{50} = 2.3 ft (ft 2:1 sideslopes)
n = 0.045

For b = 5 ft ⟶ d_{50} = 2.1 ft
n = 0.045

Rerun w/ n = 0.044

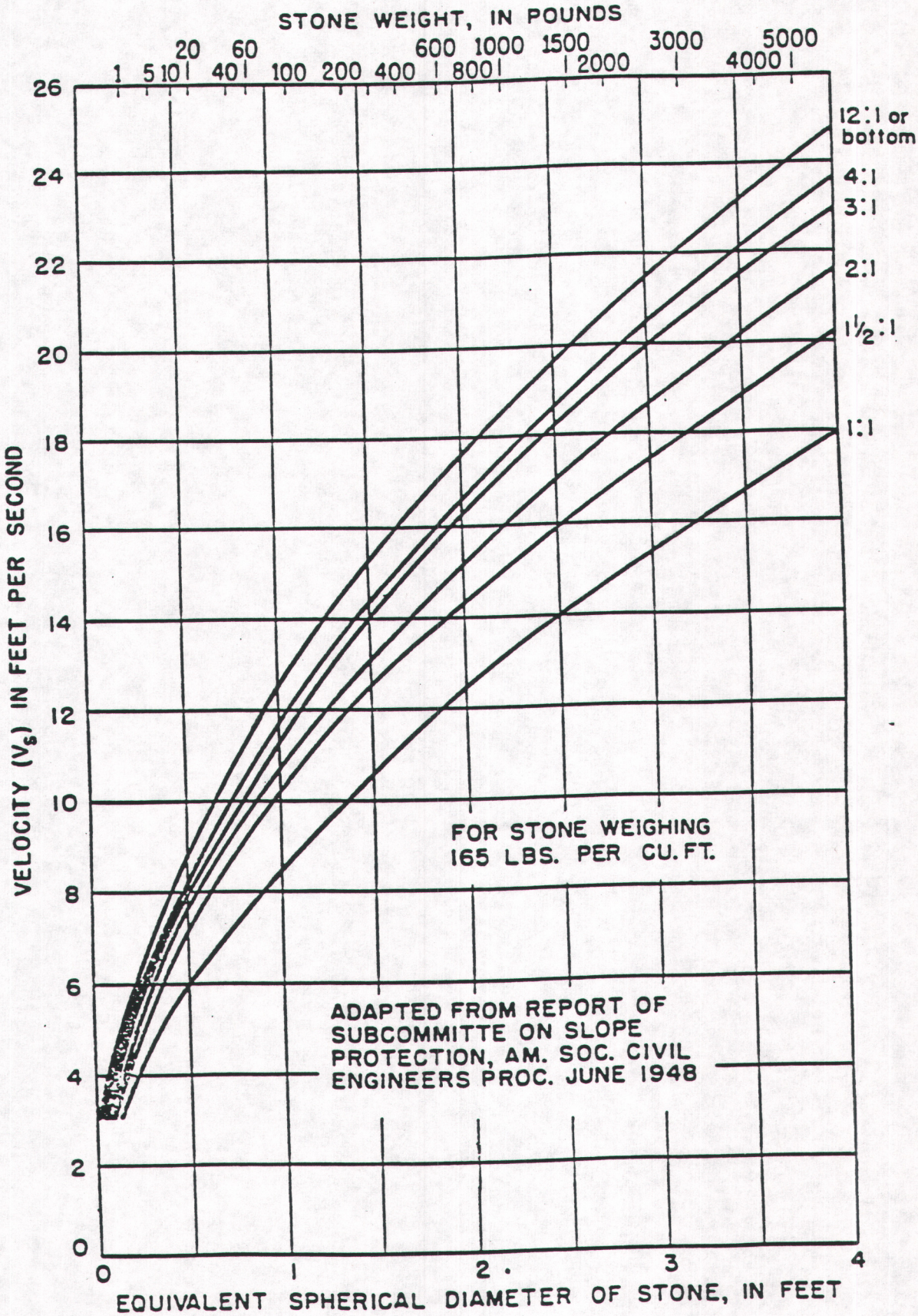


FIG. 2-SIZE OF STONE THAT WILL RESIST DISPLACEMENT FOR VARIOUS VELOCITIES AND SIDE SLOPES

Source: HEC-11

Bed Slope =	.42	
Manning's N =	.044	
Bottom Width =	3	feet
Channel Side Slope =	.5	
Flow Depth =	.8459342	feet
Cross Sectional Area =	3.969013	square feet
Wetted Perimeter =	6.783133	feet
Hydraulic Radius =	.5851297	feet
Discharge =	61.2	cubic feet/sec
Velocity =	15.41945	feet/sec
Froude Number =	2.954423	

Bed Slope =	.42	
Manning's N =	.044	
Bottom Width =	5	feet
Channel Side Slope =	.5	
Flow Depth =	.6708703	feet
Cross Sectional Area =	4.254486	square feet
Wetted Perimeter =	8.000223	feet
Hydraulic Radius =	.5317959	feet
Discharge =	61.2	cubic feet/sec
Velocity =	14.38482	feet/sec
Froude Number =	3.094975	

For b = 3 ft → d_s = 2.1 ft, n = 0.045
For b = 5 ft → d_s = 1.6 ft, n = 0.043

} Design w/ b = 5 ft. Rerun w/ n = 0.043

Bed Slope =	.42	
Manning's N =	.043	
Bottom Width =	5	feet
Channel Side Slope =	.5	
Flow Depth =	.6622636	feet
Cross Sectional Area =	4.188504	square feet
Wetted Perimeter =	7.961733	feet
Hydraulic Radius =	.5260795	feet
Discharge =	61.2	cubic feet/sec
Velocity =	14.61142	feet/sec
Froude Number =	3.164092	

d_{so} = 1.8 ft → n = 0.044

Use $d_{so} = \frac{1.6 + 1.8}{2} = \underline{\underline{1.7 \text{ ft}}}$

$= \underline{\underline{20 \text{ inches}}}$

Channel cross section → determine from reach with minimum slope:

Bed Slope =	.13	
Manning's N =	.043	
Bottom Width =	5	feet
Channel Side Slope =	.5	
Flow Depth =	.9184562	feet
Cross Sectional Area =	6.279405	square feet
Wetted Perimeter =	9.107462	feet
Hydraulic Radius =	.6894792	feet
Discharge =	61.2	cubic feet/sec
Velocity =	9.746146	feet/sec
Froude Number =	1.792156	

Design cross section: Construct with finished depth of 1.5 ft (providing approx. 0.6 ft freeboard – see Barfield et al., 1981). See cross section on page 27f of this calc.

Riprap gradation → see pg. 27g of this calc. (based on dimensionless curve provided by Barfield et al., 1981).

Filter-blanket design:

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{7.5\text{ in}}{2.0\text{ in}} = 3.75 < 5 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{7.5\text{ in}}{0.2\text{ in}} = 37.5 < 40 \quad \underline{\underline{OK}}$$

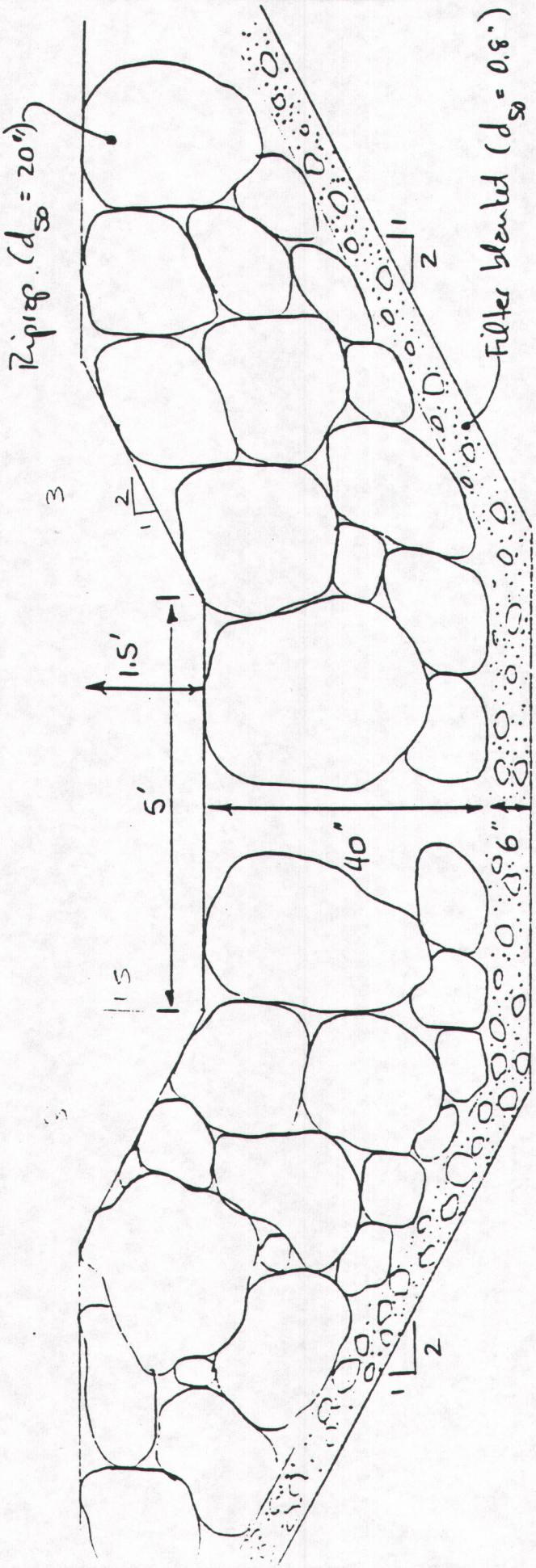
$$\frac{D_{15}\text{ (filter)}}{D_{85}\text{ (bed)}} = \frac{0.2\text{ in}}{0.94\text{ in}} = 0.2 < 5 \quad OK$$

$$\frac{D_{15}\text{ (filter)}}{D_{15}\text{ (bed)}} = \frac{0.2\text{ in}}{0.0021\text{ in}} = 95.2 > 40$$

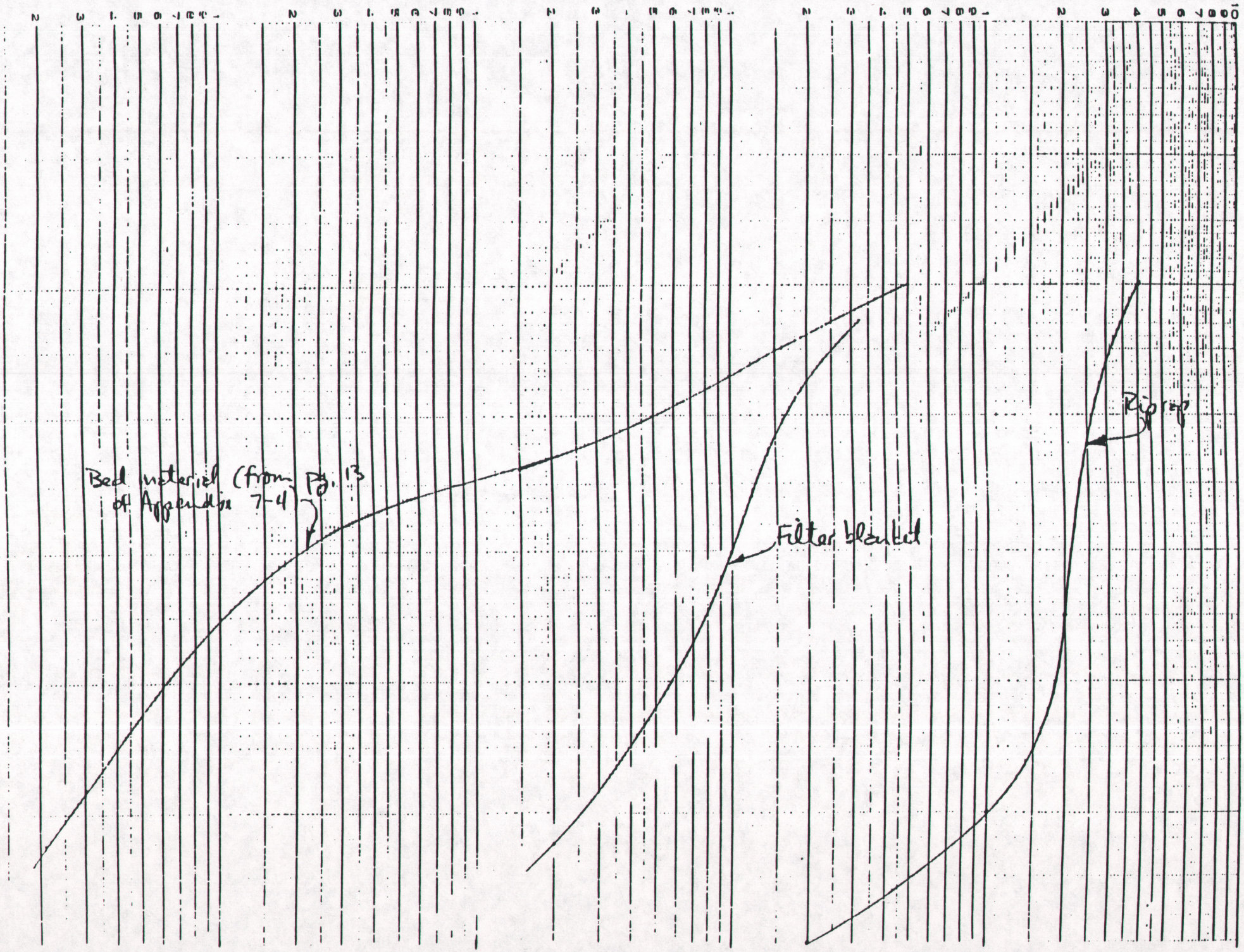
Although this final value is outside of the normal range, this filter blanket will be accepted due to the high factor of safety inherent in the runoff estimate (compare with the discussion in Appendix 7-5).

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

PROJECT C-27 PAGE 27f OF
COMPUTED TBW DATE 8 Jul 1986
CHECKED DATE



RD-1 ELEVATION VIEW
SCALE: 1" = 2'


Bed material (from Pg. 13 of Appendix 7-4)
Filter blanket
Riprap

RD-1 will be constructed during Phase I of final reclamation but will divert water from WS-1 only during Phase II. WS-1 will continue to flow through UD-1 during Phase I to allow more time for RD-1 and the surrounding area to stabilize.

During Phase I RD-1 will discharge into RD-2, thus causing site water to flow to the sedimentation pond. During Phase II, UD-1 will be removed to the USFS road and RD-1 will discharge to this culvert. The culvert will be maintained by the USFS as part of the post-mining land use. RD-1 will be extended to the head of the existing UD-1.

Design of RD-2

Contributing watershed → WS-2 + WS-4 + portion of reclaimed area east of UD-1 and west of RD-4.

Area → Undisturbed = 0.9 (WS-2) + 5.5 (WS-4) = 6.4 ac

Reclaimed = 0.3 (WS-2) + 0.3 (WS-4) + 1.9 ac (site) = 2.5 ac

Total = 6.4 + 2.5 = 8.9 ac
= 0.014 mi²

$l = 1020$ ft

$$\bar{CN} = \frac{(6.4)(69) + (2.5)(75)}{8.9} = 71$$

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

$$Y = \left[\frac{(3010\text{ ft})(40\text{ ft})}{(8.9\text{ ac})(43{,}560\text{ ft}^2/\text{ac})}\right](100) = 31.1\%$$

$$L = \frac{(1020)^{0.8}(1+4.08)^{0.7}}{(1900)(31.1)^{0.5}}$$

$= 0.08$ hr

$T_c = (1.67)(0.08)$
$= \underline{0.13}$ hr

Design storm → 50-yr, 24-hr = 3.25 in.

Hydrograph results → see pg 27i of this calc.

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

IDENTIFICATION: WATERSHED DRAINING TO RD-2

INPUT SUMMARY:

```
*************************************************************
    STORM:                        WATERSHED:
       DIST. = SCS TYPE II            AREA =  0.014 SQ. MI.
       DEPTH =  3.25 IN.              CN = 71.0
       DURATION = 24.0 HR.            TIME OF CONC. =  0.13 HR.
*************************************************************
```

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

OUTPUT SUMMARY:

```
*************************************************************
    TOTAL RUNOFF DEPTH =  0.9083 INCHES
    INITIAL ABSTRACTION =  0.8169 INCHES
    PEAK FLOW =      8.04 CFS   ( 0.8901 IN/HR)
    TIME TO PEAK =  12.01 HOURS
    RUNOFF VOLUME CHECK =  0.9101 INCHES
*************************************************************
```

Maximum channel slope = $\frac{10}{95}$ = 0.11 ft/ft (for riprap design)

Minimum slope = $\frac{10}{160}$ = 0.063 ft/ft (for cross section design

Initially assume n = 0.035. Run TRAP1 and compare riprap requirements with roughness coefficient.

Bed Slope =	.11	
Manning's N =	.035	
Bottom Width =	2	feet
Channel Side Slope =	.5	
Flow Depth =	.431134	feet
Cross Sectional Area =	1.234021	square feet
Wetted Perimeter =	3.92809	feet
Hydraulic Radius =	.3141529	feet
Discharge =	8.04	cubic feet/sec
Velocity =	6.515287	feet/sec
Froude Number =	1.748636	

Bed Slope =	.11	
Manning's N =	.035	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.3024303	feet
Cross Sectional Area =	1.392649	square feet
Wetted Perimeter =	5.35251	feet
Hydraulic Radius =	.2601862	feet
Discharge =	8.04	cubic feet/sec
Velocity =	5.77317	feet/sec
Froude Number =	1.850009	

For b = 2 ft → d_{50} = 0.30 ft = 3.6 in

For b = 4 ft → d_{50} = 0.25 ft = 3.0 in

See pg. 27c of this calc

n_2 = 0.032
n_4 = 0.031

Rerun w/ n = 0.033

Bed Slope =	.11	
Manning's N =	.033	
Bottom Width =	2	feet
Channel Side Slope =	.5	
Flow Depth =	.4175808	feet
Cross Sectional Area =	1.183909	square feet
Wetted Perimeter =	3.867478	feet
Hydraulic Radius =	.3061192	feet
Discharge =	8.04	cubic feet/sec
Velocity =	6.791062	feet/sec
Froude Number =	1.851994	

Required d_{50} = 0.35 ft
= 4.2 in

Bed Slope =	.11	
Manning's N =	.033	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.2923076	feet
Cross Sectional Area =	1.340118	square feet
Wetted Perimeter =	5.30724	feet
Hydraulic Radius =	.2525076	feet
Discharge =	8.04	cubic feet/sec
Velocity =	5.999472	feet/sec
Froude Number =	1.955532	

Required d_{50} = 0.30 ft
= 3.6 in

n = 0.032 ⟹ OK

Determine cross section using b = 2 ft, n = 0.033

Bed Slope =	.063	
Manning's N =	.033	
Bottom Width =	2	feet
Channel Side Slope =	.5	
Flow Depth =	.4840931	feet
Cross Sectional Area =	1.436878	square feet
Wetted Perimeter =	4.16493	feet
Hydraulic Radius =	.3449946	feet
Discharge =	8.04	cubic feet/sec
Velocity =	5.595464	feet/sec
Froude Number =	1.417241	

Riprap gradation → see pg 27l of this calc.

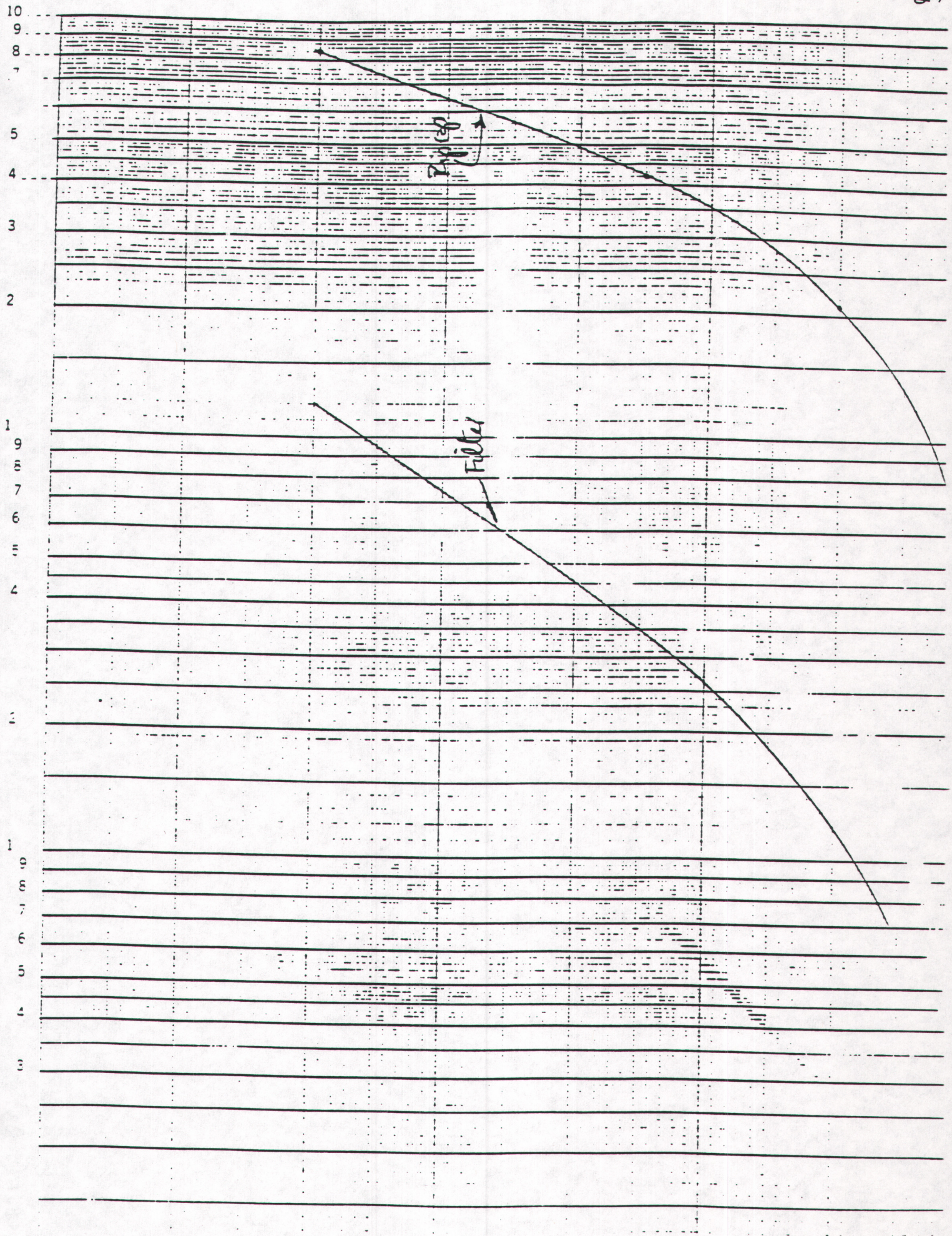
Filter blanket design (see also pg. 27g of this calc.):

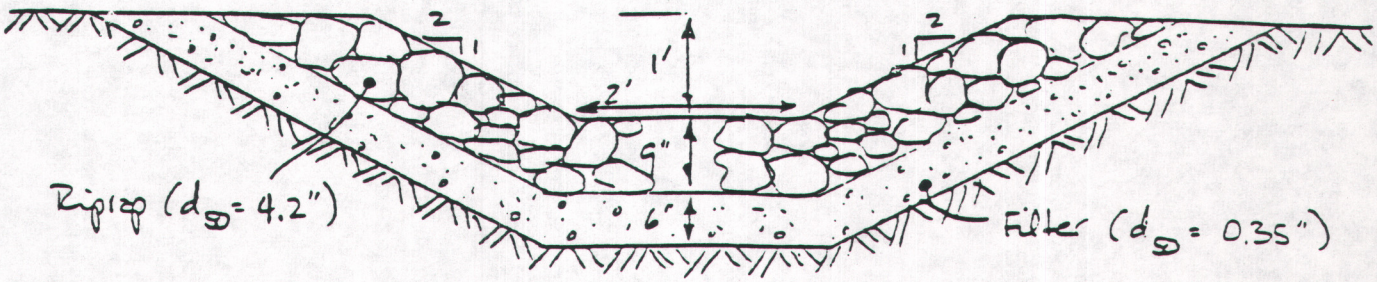
$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{1.7\text{ in}}{0.85\text{ in}} = 2.0 < 5 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{1.7\text{ in}}{0.08\text{ in}} = 21.3 < 40 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (filter)}}{D_{85}\text{ (bed)}} = \frac{0.08\text{ in}}{0.94\text{ in}} = 0.09 < 5 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (filter)}}{D_{15}\text{ (bed)}} = \frac{0.08\text{ in}}{0.2021\text{ in}} = 38.1 < 40 \quad \underline{\underline{OK}}$$


10
9
8
7
5
4
3
2
1
9
8
7
6
5
4
3
1
9
8
7
6
5
4
3
Filled
Filled



RD-2 ELEVATION VIEW

SCALE: 1" = 2'

Design of RD-3

Ultimate drainage area = WS-5 + site reclaimed area

Undisturbed area = 2.1 ac (WS-5)
Reclaimed area = 0.6 ac (site)
Total = 2.7 ac = 0.004 mi

$l = 750$ ft

$\bar{C}_N = \frac{(2.1)(69) + (0.6)(75)}{2.7} = 71$

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

$Y = \left[\frac{(1990\ ft)(40\ ft)}{(2.7\ ac)(43{,}560\ ft^2/ac)}\right](100) = 67.7\%$

$L = \frac{(750)^{0.8}(1+4.08)^{0.7}}{(1900)(67.7)^{0.5}}$

$= 0.04$ hr

$T_c = (1.67)(0.04)$

$= 0.07$ hr

Design storm → 50-yr, 24-hr = 3.25 in

Hydrograph results → see pg 27n of this calc.

RD-3 no longer to be used.

TDowlite
1 Dec 1989

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

IDENTIFICATION: WATERSHED DRAINING TO RD-3

INPUT SUMMARY:

```
*****************************************************
    STORM:                      WATERSHED:
       DIST. = SCS TYPE II          AREA =  0.004 SQ. MI.
       DEPTH =  3.25 IN.            CN = 71.0
       DURATION = 24.0 HR.          TIME OF CONC. =  0.07 HR.
*****************************************************
```

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

OUTPUT SUMMARY:

```
*****************************************************
    TOTAL RUNOFF DEPTH =  0.9083 INCHES
    INITIAL ABSTRACTION =  0.8169 INCHES
    PEAK FLOW =      2.45 CFS   ( 0.9473 IN/HR)
    TIME TO PEAK =  12.00 HOURS
    RUNOFF VOLUME CHECK =  0.9101 INCHES
*****************************************************
```

Maximum channel slope = $\frac{10}{30}$ = 0.33 ft/ft

Minimum channel slope = 0.01 ft/ft (design condition along base of cut

Initially assume n = 0.033. Run w/ b = 2 ft.

Bed Slope =	.33	
Manning's N =	.033	
Bottom Width =	2	feet
Channel Side Slope =	.5	
Flow Depth =	.1564641	feet
Cross Sectional Area =	.3618902	square feet
Wetted Perimeter =	2.699729	feet
Hydraulic Radius =	.1340469	feet
Discharge =	2.45	cubic feet/sec
Velocity =	6.77001	feet/sec
Froude Number =	3.416156	

Required d_{50} = 0.35 ft
= 4.2 in

RD-3 no longer

Cross section design:

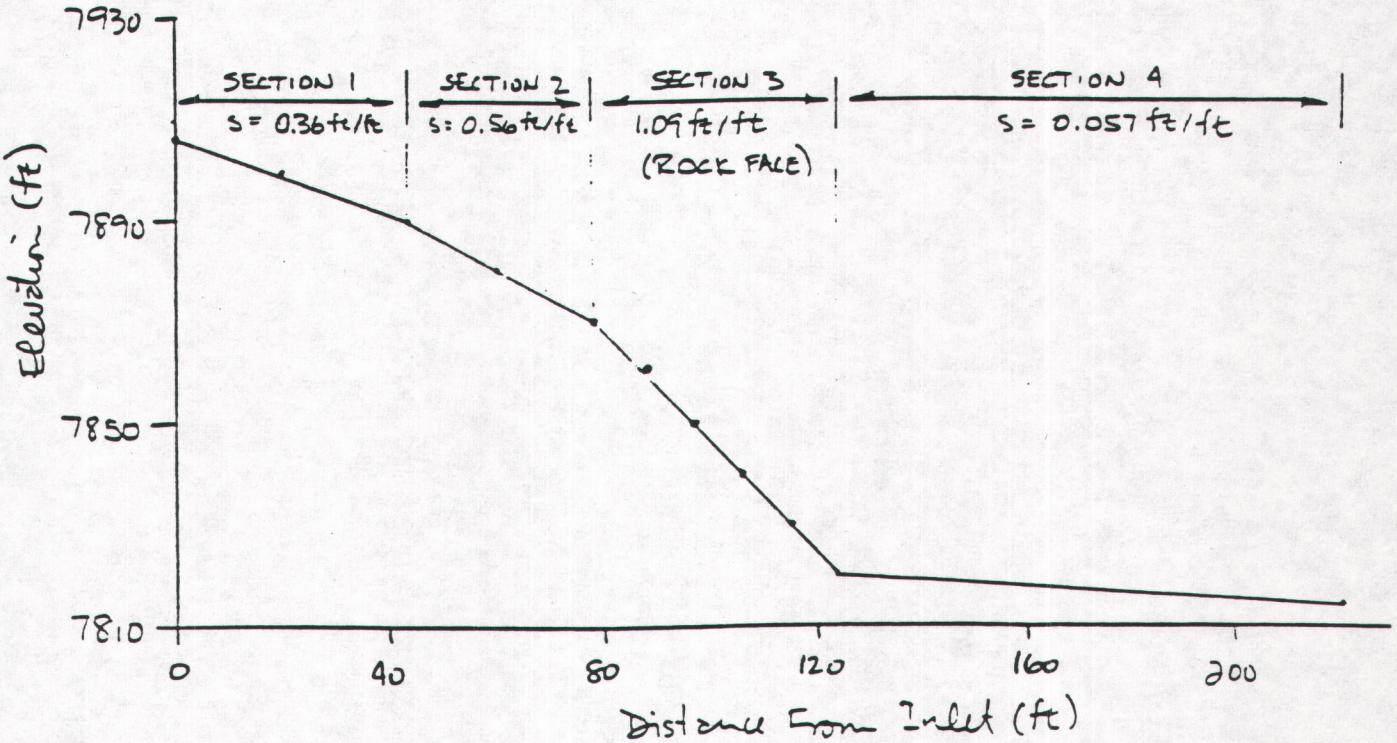
Bed Slope =	.01	
Manning's N =	.033	
Bottom Width =	2	feet
Channel Side Slope =	.5	
Flow Depth =	.4199953	feet
Cross Sectional Area =	1.192783	square feet
Wetted Perimeter =	3.878276	feet
Hydraulic Radius =	.3075549	feet
Discharge =	2.45	cubic feet/sec
Velocity =	2.05402	feet/sec
Froude Number =	.5585404	

Use the same cross section designed for RD-2.

RD-3 no longer to be use
REW 12/1/89

Design of RD-4

Longitudinal profile:



Determine peak flow and design the channel by section

Watershed draining to RD-4 → WS-3 + portion of reclaimed area

Drainage area = 8.8 ac (WS-3) + 0.2 ac (site) = 9.0 ac
= 0.014 mi^2

$l = 1540$ ft

$$\bar{CN} = \frac{(8.8)(69) + (0.2)(75)}{9.0} = 70$$

$$S = \frac{1000}{70} - 10 = 4.29$$

$$Y = \left[\frac{(1600\text{ ft})(40\text{ ft})}{(9.0\text{ ac})(43{,}560\text{ ft}^2/\text{ac})}\right](100) = 16.3\%$$

$$L = \frac{(1540)^{0.8}(1+4.29)^{0.7}}{(1900)(16.3)^{0.5}}$$

$= 0.15$ hr

$T_L = (1.67)(0.15)$

$= \underline{0.25}$ hr

Design storm → 50-yr, 24-hr = 3.25 in

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

IDENTIFICATION: WATERSHED DRAINING TO RD-4

INPUT SUMMARY:

```
*************************************************************
     STORM:                          WATERSHED:
        DIST. = SCS TYPE II             AREA =  0.014 SQ. MI.
        DEPTH =  3.25 IN.               CN = 70.0
        DURATION = 24.0 HR.             TIME OF CONC. =  0.25 HR.
*************************************************************
```

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

OUTPUT SUMMARY:

```
*************************************************************
     TOTAL RUNOFF DEPTH =  0.8573 INCHES
     INITIAL ABSTRACTION =  0.8571 INCHES
     PEAK FLOW =      6.62 CFS   ( 0.7323 IN/HR)
     TIME TO PEAK =  12.05 HOURS
     RUNOFF VOLUME CHECK =  0.8590 INCHES
*************************************************************
```

Above the rock face, design riprap size based on section 2 and channel cross section based on section 1.

Section 2 run (assume n = 0.037, b = 4 ft):

Bed Slope =	.56	
Manning's N =	.037	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.1736899	feet
Cross Sectional Area =	.7550959	square feet
Wetted Perimeter =	4.776765	feet
Hydraulic Radius =	.1580768	feet
Discharge =	6.62	cubic feet/sec
Velocity =	8.767098	feet/sec
Froude Number =	3.707154	

Required d_{50} (from pg 27c) = 0.70 ft
= 8.4 in

n = 0.037 ⇒ OK

Section 1 run:

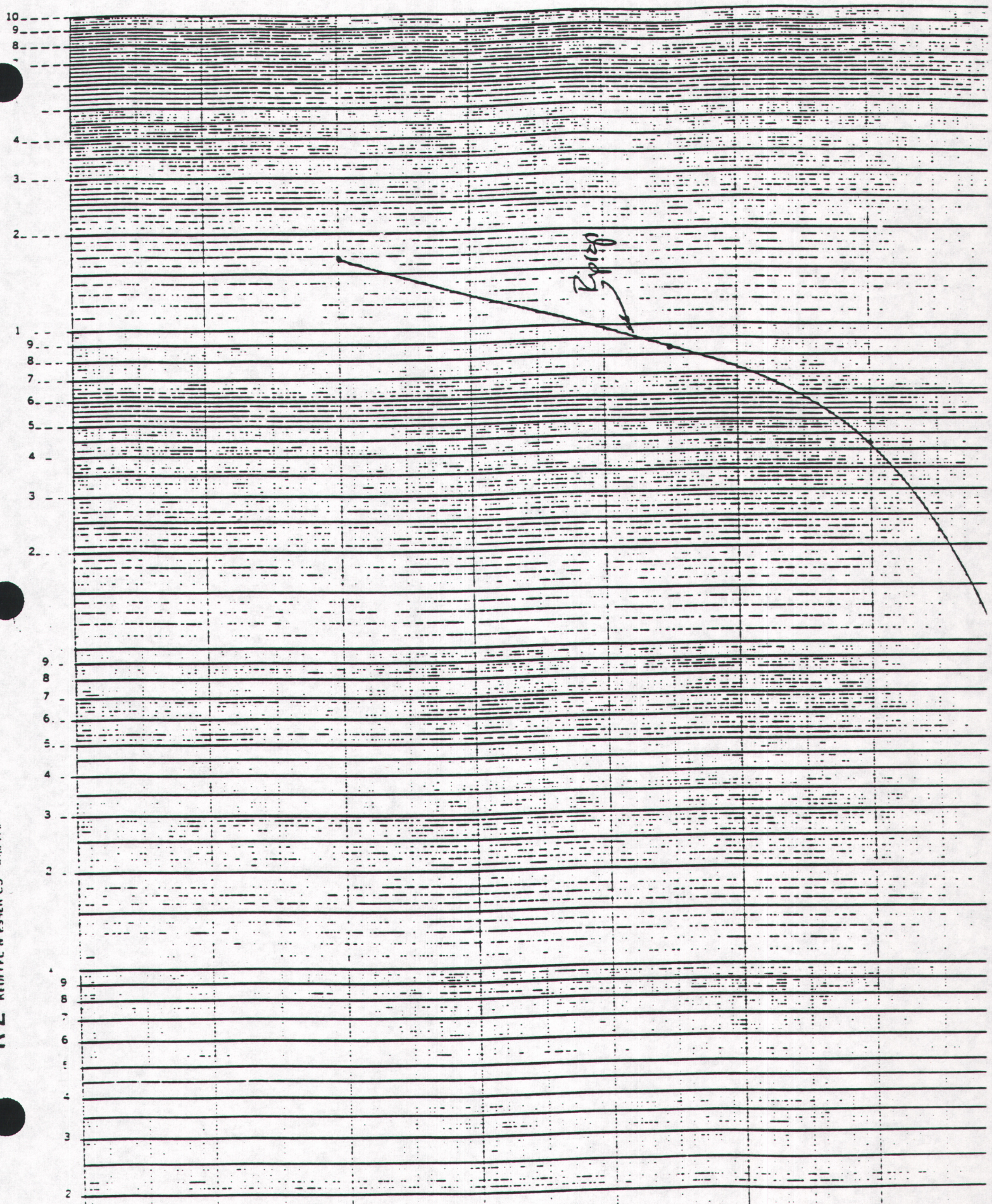
Bed Slope =	.36	
Manning's N =	.037	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.1975886	feet
Cross Sectional Area =	.8684367	square feet
Wetted Perimeter =	4.883643	feet
Hydraulic Radius =	.1778256	feet
Discharge =	6.62	cubic feet/sec
Velocity =	7.622893	feet/sec
Froude Number =	3.022115	

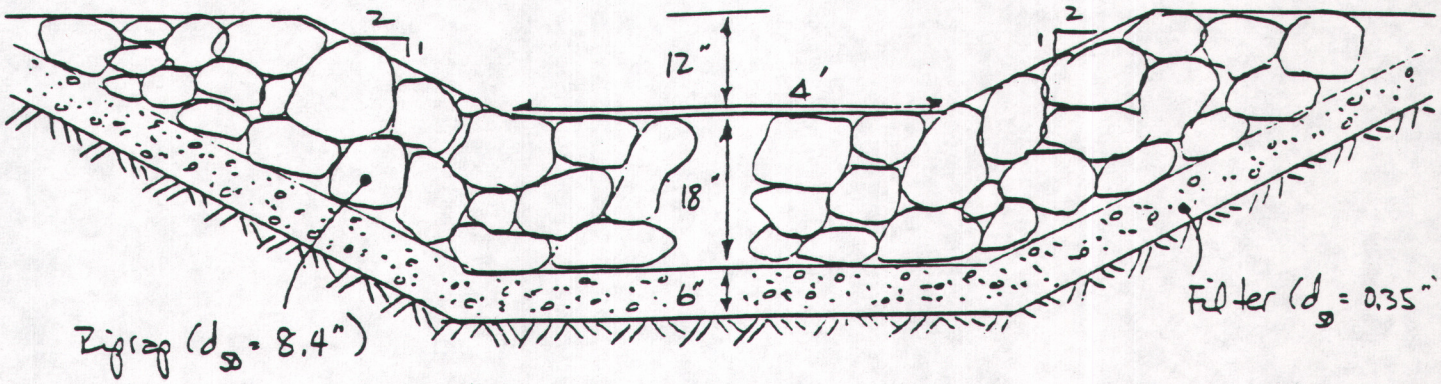
Riprap gradation → see pg 27r of this calc.

Check filter blanket design using the blanket designed for RD-2:

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{3.2\text{ in}}{0.85\text{ in}} = 3.8 < 5 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{3.2\text{ in}}{0.08\text{ in}} = 40 = 40 \quad \underline{\underline{OK}}$$


10
9
8
4
3
2
1
9
8
7
6
5
4
3
2
9
8
7
6
5
4
3
2
9
8
6
4
3
2
Expired

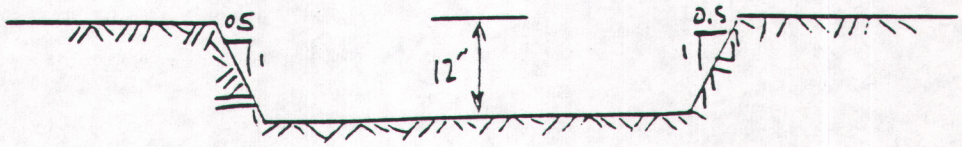


SECTION 1 / SECTION 2
RD-4 ELEV. VIEW
SCALE: 1" = 2'

Section 3 of this channel will be blasted into rock. The U.S. Soil Conservation Service (1956) suggests a range of roughness coefficients for similar channels of 0.035 to 0.045. Assume n = 0.040.

Bed Slope =	1.09	
Manning's N =	.04	
Bottom Width =	4	feet
Channel Side Slope =	2	
Flow Depth =	.1521696	feet
Cross Sectional Area =	.6202561	square feet
Wetted Perimeter =	4.340262	feet
Hydraulic Radius =	.1429075	feet
Discharge =	6.62	cubic feet/sec
Velocity =	10.67301	feet/sec
Froude Number =	4.821644	

This velocity is considered acceptable for rock (see U.S. Army Corps of Engineers, 1970).



SECTION 3
RD-4 ELEV. VIEW
SCALE: 1" = 2'

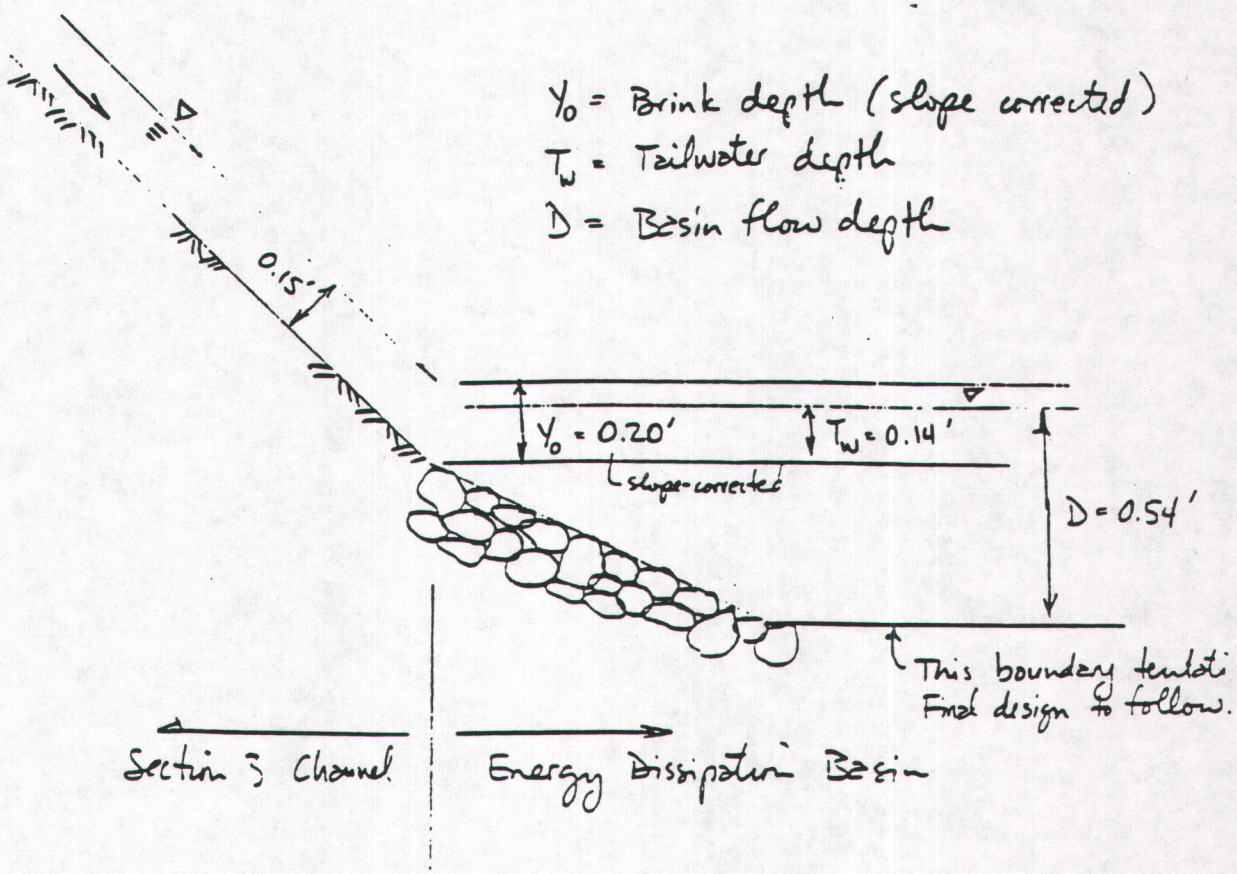
Design of Energy Dissipation Basin at Downstream Edge of Section 3 Channel (where rock face meets pad) – use the design procedure of Corry et al. (1975):
↳ HEC-14

Depth of flow in basin – Assume 1% slope on basin floor
4 ft bottom width
2:1 sideslope:

TRAP1 results:

Bed Slope =	.01	
Manning's N =	.035	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.5392388	feet
Cross Sectional Area =	2.738512	square feet
Wetted Perimeter =	6.41155	feet
Hydraulic Radius =	.4271218	feet
Discharge =	6.62	cubic feet/sec
Velocity =	2.417371	feet/sec
Froude Number =	.5801293	

General schematic:



$\frac{T_W}{\ }$ $\frac{0.14}{\ }$ = 0.72 < 0.75 OK

Determine riprap sizing for basin — see pg 27s4 of this calc:

Select d_{50} such that $0.25 < \frac{d_{50}}{Y_e} < 0.45$

AND

$2 < \frac{h_s}{d_{50}} < 4$

Y_e = equivalent depth = $(A/2)^{1/2}$ where A is for Section 3 channel

$= \frac{(2.74/2)^{1/2}}{\sin 47.5°}$

$= 1.59$ ft

To meet the design criteria ($0.25 < d_{50}/Y_e < 0.45$), select $d_{50}/Y_e = 0.35 \Rightarrow d_{50} = (0.35)(1.59') = 0.56$ ft (min)

However, the Division has requested the use of $d_{50} = 1.25$ ft (see pg 2
Thus, this size will be used. Filter blanket calculations included on page 27s8 of this calc.

From pg 27s4 $\rightarrow \frac{h_s}{Y_e} = 0.90 \Rightarrow h_s = (0.90)(1.59)$
$= 1.43$ ft (scour hole depth

$$\frac{h_s}{d_{50}} = \frac{1.43}{0.70} = 2.04 \Rightarrow \underline{\underline{OK}}$$

Basin length = $10 h_s = 14.3$ ft $\Rightarrow$ use 15 ft

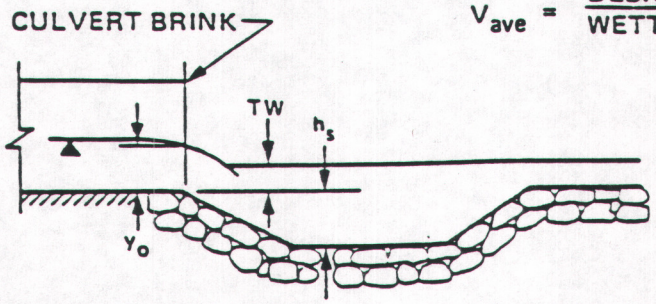
Apron length = $5 h_s = 7.15$ ft $\Rightarrow$ use 7.5 ft

Freeboard = 1.0 ft

Total basin depth = $h_s + Y_o + 1.0$
$= 1.43 + 0.20 + 1.00$
$= 2.63$ ft $\Rightarrow$ Construct with depth = $\underline{\underline{2.75 \text{ ft}}}$

Design sections $\rightarrow$ see pg 27s5 and 27s6 of this calc.

$$V_{ave} = \frac{\text{DESIGN DISCHARGE} - Q}{\text{WETTED AREA AT BRINK OF CULVERT}}$$

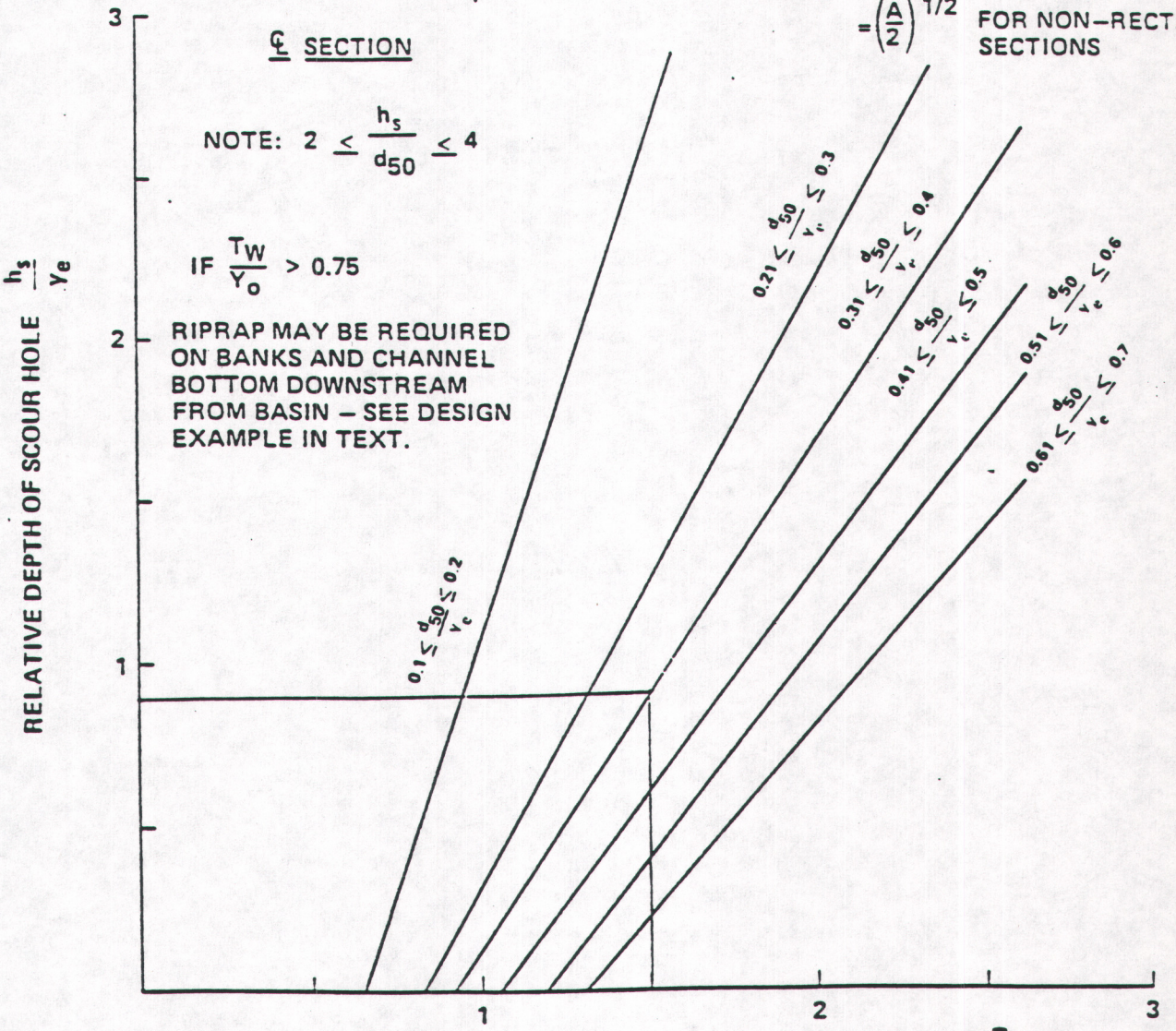


d_{50} = THE MEDIAN SIZE OF ROCK BY WEIGHT. ROUNDED ROCK OR ANGULAR ROCK.

Y_e = EQUIVALENT BRINK DEPTH

= BRINK DEPTH FOR BOX CULVER

$= \left(\frac{A}{2}\right)^{1/2}$ FOR NON-RECTANGULA SECTIONS

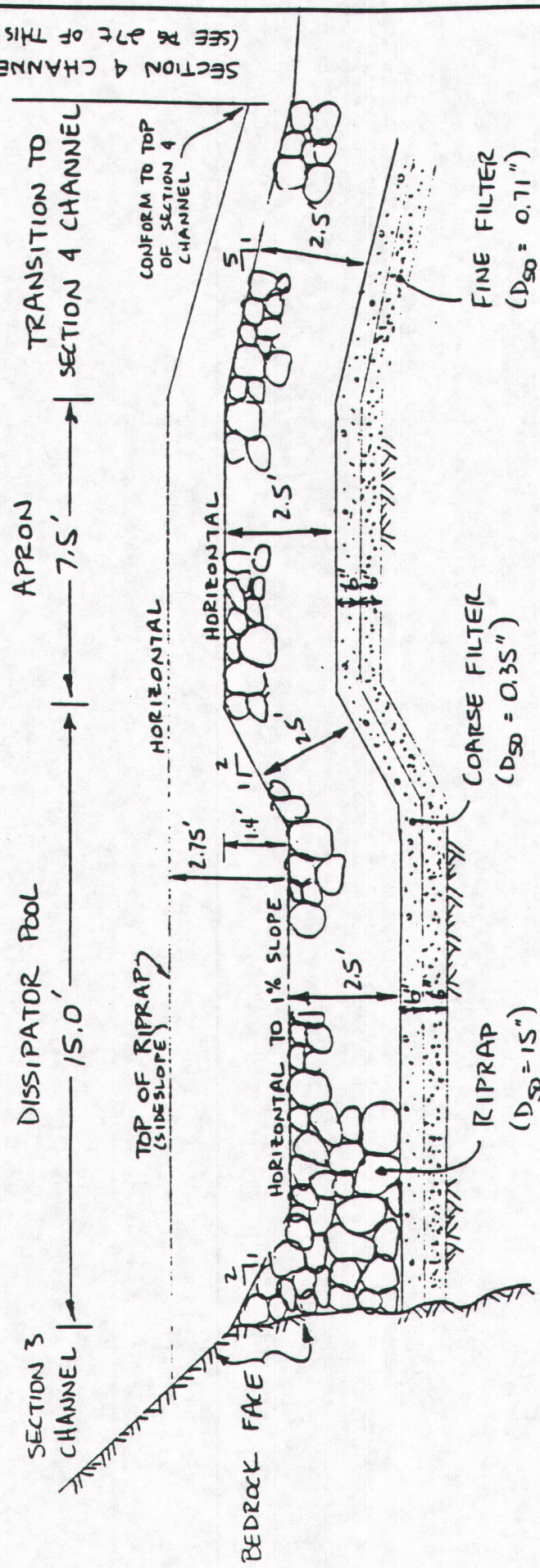


$$\text{FROUDE NUMBER} = \frac{V_{ave}}{\sqrt{(32.2)(Y_e)}} = \frac{10.7}{\sqrt{(32.2)(1.59)}} = 1.50$$ for section channel

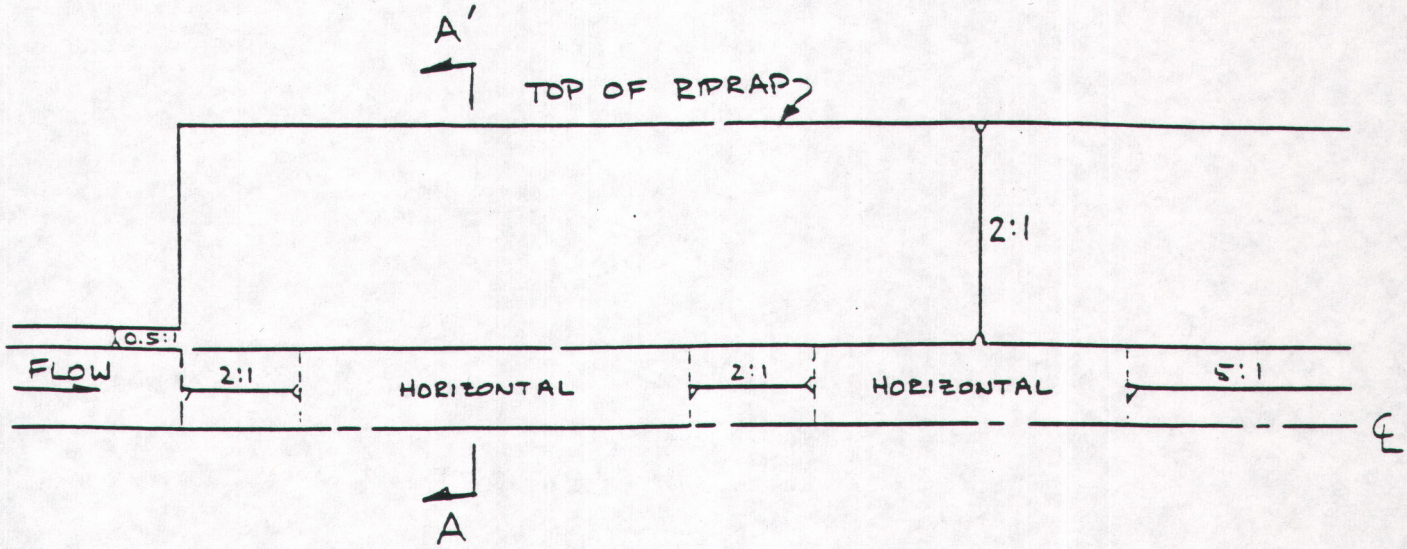
Source: Corry et al. (1975) (HEC-14)

EARTHFAX ENGINEERING, INC.
ENGINEERS / SCIENTISTS

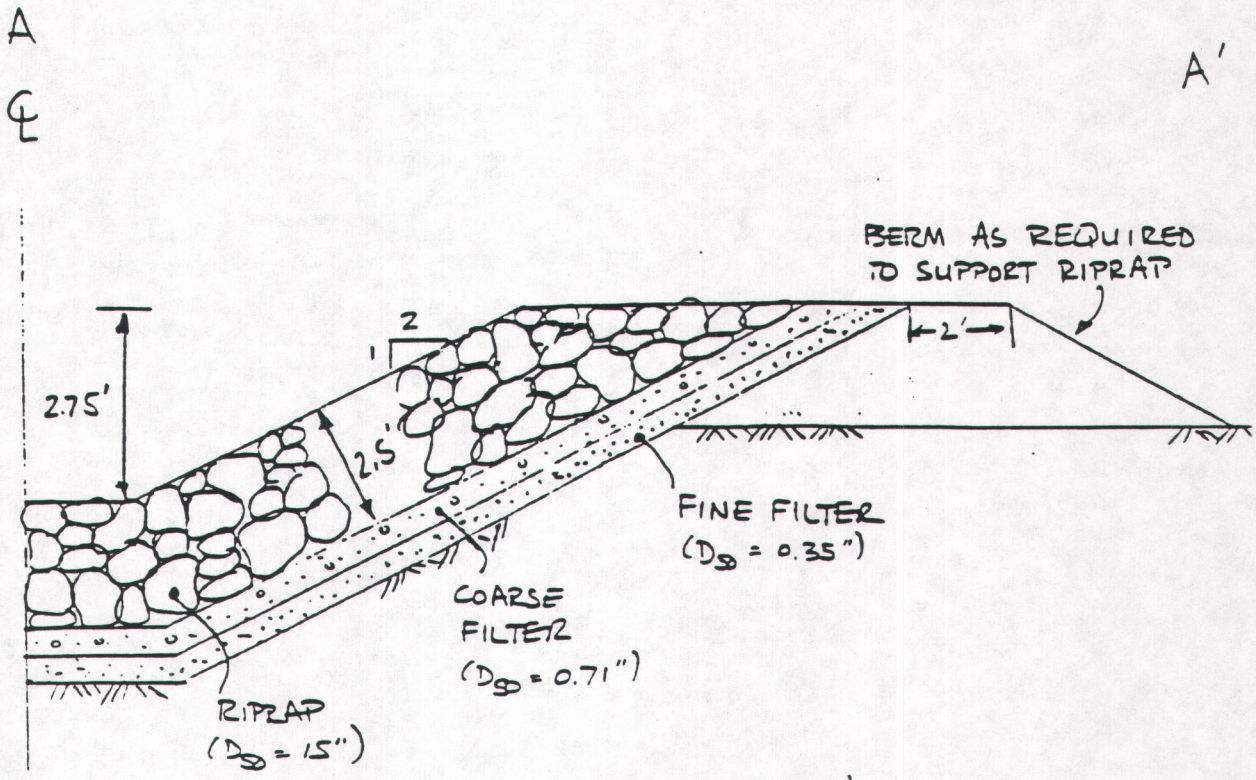
PROJECT C-27 PAGE 27 55 OF
COMPUTED TBW DATE 2 Dec 1987
CHECKED DATE



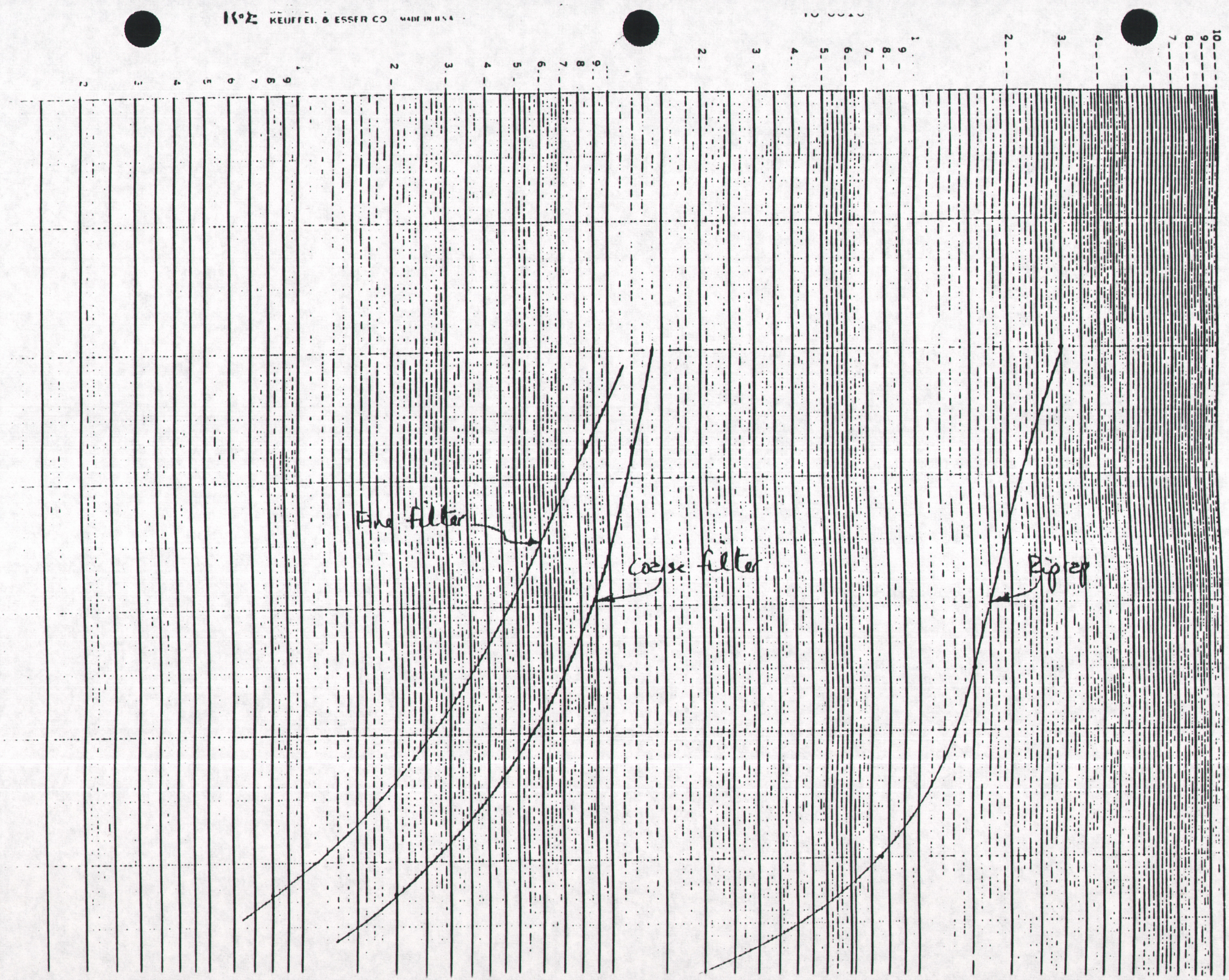
ENERGY DISSIPATION BASIN
CENTER LINE SECTION
SCALE: 1" = 4'



ENERGY DISSIPATION BASIN
HALF PLAN
SCALE: 1" = 50'



ENERGY DISSIPATION BASIN


KEUFFEL & ESSER CO. MADE IN U.S.A.
Fine filter
Coarse filter
Riprap

C 157

Check filter blanket design using the RD-2 blanket (see pg. 27l of this calc.):

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{5.7\text{ in}}{0.85\text{ in}} = 6.7 > 5.0$$

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{5.7\text{ in}}{0.08\text{ in}} = 71.2 > 40$$

Unacceptable

New filter blanket design (see pg. 27s7 of this calc.):

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{5.7\text{ in}}{1.2\text{ in}} = 4.8 < 5.0 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{5.7\text{ in}}{0.2\text{ in}} = 28.5 < 40 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (filter)}}{D_{85}\text{ (bed)}} = \frac{0.2\text{ in}}{0.94\text{ in}} = 0.2 < 5.0 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (filter)}}{D_{15}\text{ (bed)}} = \frac{0.2\text{ in}}{0.0021\text{ in}} = 95.2 > 40 \quad \underline{\underline{\text{Unacceptable}}}$$

Include two filter blankets (the coarse blanket above and the RD-2 blanket). Check design between the two:

$$\frac{D_{15}\text{ (coarse)}}{D_{85}\text{ (fine)}} = \frac{0.2\text{ in}}{0.85\text{ in}} = 0.24 < 5.0 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (coarse)}}{D_{15}\text{ (fine)}} = \frac{0.2\text{ in}}{0.08\text{ in}} = 2.5 < 40 \quad \underline{\underline{OK}}$$

Section 4 → assume n = 0.031

Bed Slope =	.057	
Manning's N =	.031	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.3047183	feet
Cross Sectional Area =	1.40458	square feet
Wetted Perimeter =	5.362742	feet
Hydraulic Radius =	.2619145	feet
Discharge =	6.62	cubic feet/sec
Velocity =	4.713154	feet/sec
Froude Number =	1.504646	

Required d_{50} = 0.25 ft
= 3.0 in

n = 0.031 ⇒ OK

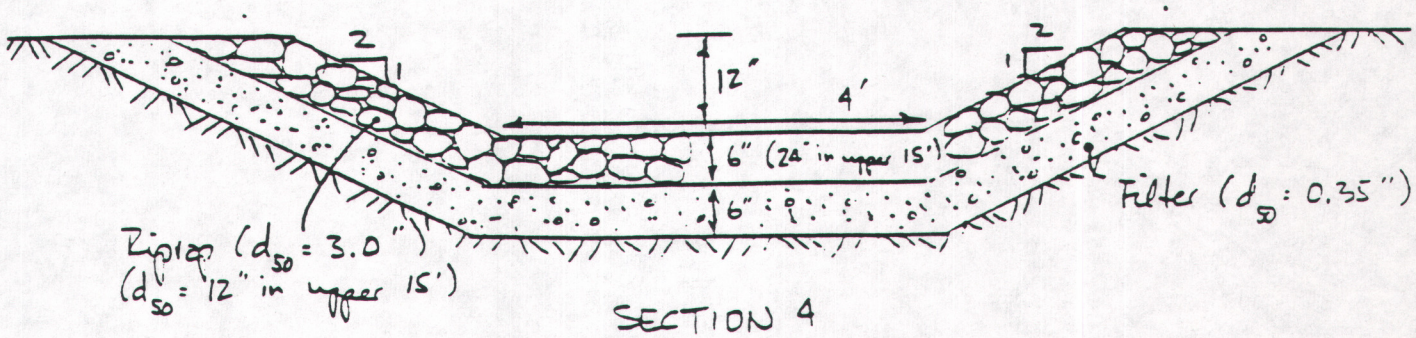
Gradation of Section 4 riprap → see pg. 27u of this calc

Filter blanket requirement → compare with filter blanket designed for RD-2.

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{1.25\text{ in}}{0.85\text{ in}} = 1.5 < 5 \qquad \underline{\underline{OK}}$$

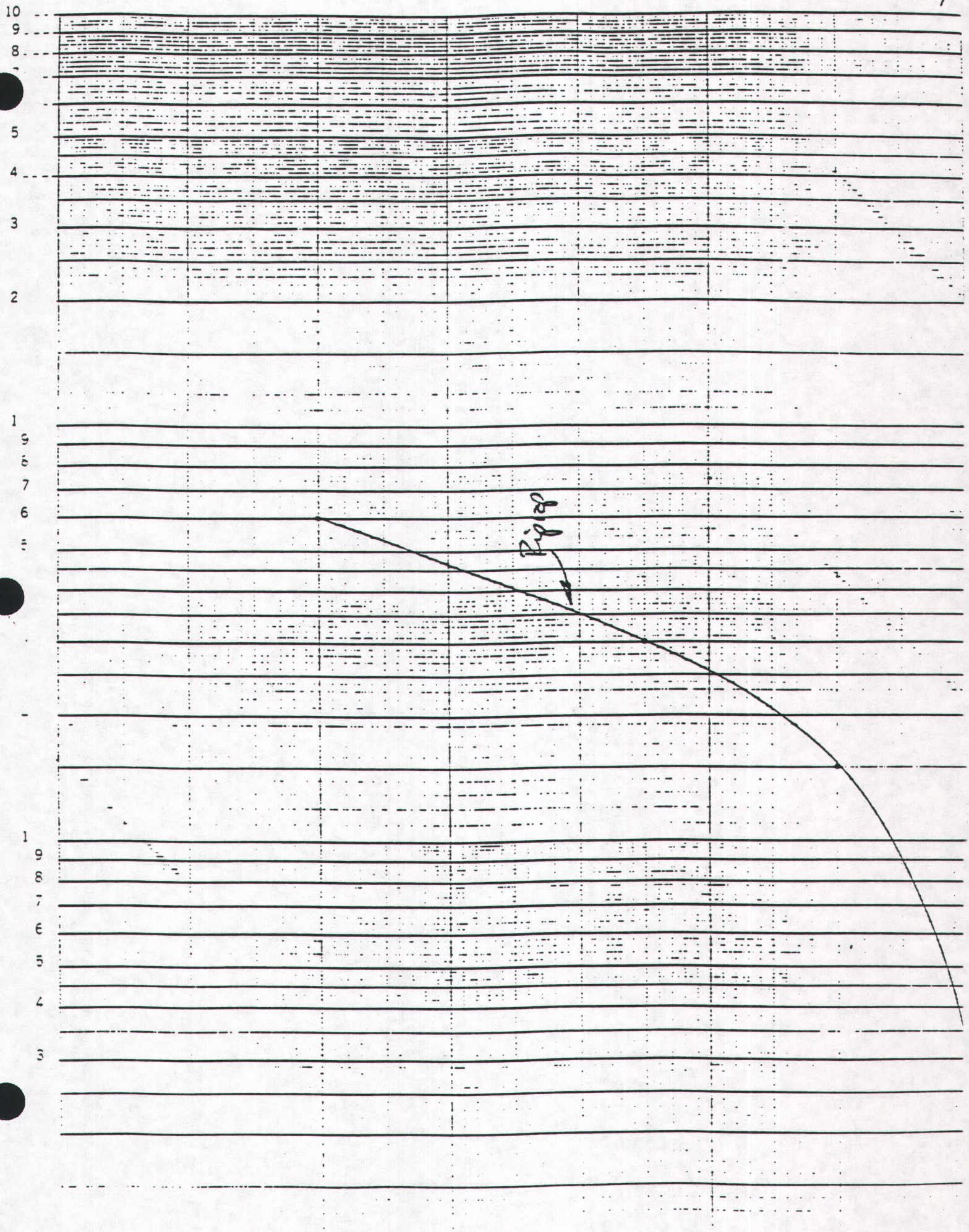
$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{1.25\text{ in}}{0.08\text{ in}} = 15.6 < 40 \qquad \underline{\underline{OK}}$$

Use the filter blanket designed for RD-2.



SECTION 4
RD-4 ELEV. VIEW
SCALE 1" = 2'

27u/



Design of RD-5

Contributing area → all areas contributing to RD-2 and RD-4 plus the reclaimed area between RD-3 and RD-5.

Undisturbed area = 6.4 (RD-2) + 8.8 (RD-4) = 15.2 ac

Reclaimed area = 2.5 (RD-2) + 0.2 (RD-4) + 0.3 (site) = 3.0 ac

Total = 18.2 ac = 0.028 mi²

$l = 1730$ ft

$$\overline{CN} = \frac{(15.2)(69) + (3.0)(75)}{18.2} = 70$$

$$S = \frac{1000}{70} - 10 = 4.29$$

$$Y = \left[\frac{(4770\text{ ft})(40\text{ ft})}{(18.2\text{ ac})(43{,}560\text{ ft}^2/\text{ac})}\right](100) = 24.1\%$$

$$L = \frac{(1730)^{0.8}(1+4.29)^{0.7}}{(1900)(24.1)^{0.5}} = 0.13\text{ hr}$$

$$T_c = (1.67)(0.13) = 0.22\text{ hr}$$

Design storm → 50-yr, 24-hr = 3.25 in

```
IDENTIFICATION:  WTERSHED DRAINING TO RD-5

INPUT SUMMARY:
*****************************************************************
     STORM:                          WATERSHED:
        DIST. = SCS TYPE II             AREA =  0.028 SQ. MI.
        DEPTH =  3.25 IN.               CN = 70.0
        DURATION = 24.0 HR.             TIME OF CONC. =  0.22 HR.
*****************************************************************

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

OUTPUT SUMMARY:
*****************************************************************
     TOTAL RUNOFF DEPTH =  0.8573 INCHES
     INITIAL ABSTRACTION =  0.8571 INCHES
     PEAK FLOW =     13.69 CFS   ( 0.7576 IN/HR)
     TIME TO PEAK =  12.04 HOURS
     RUNOFF VOLUME CHECK =  0.8590 INCHES
*****************************************************************
```

Channel slope = 0.031 ft/ft. Assume n = 0.032

Bed Slope =	.031	
Manning's N =	.032	
Bottom Width =	4	feet
Channel Side Slope =	.5	
Flow Depth =	.561434	feet
Cross Sectional Area =	2.876153	square feet
Wetted Perimeter =	6.51081	feet
Hydraulic Radius =	.4417504	feet
Discharge =	13.69	cubic feet/sec
Velocity =	4.759831	feet/sec
Froude Number =	1.119475	

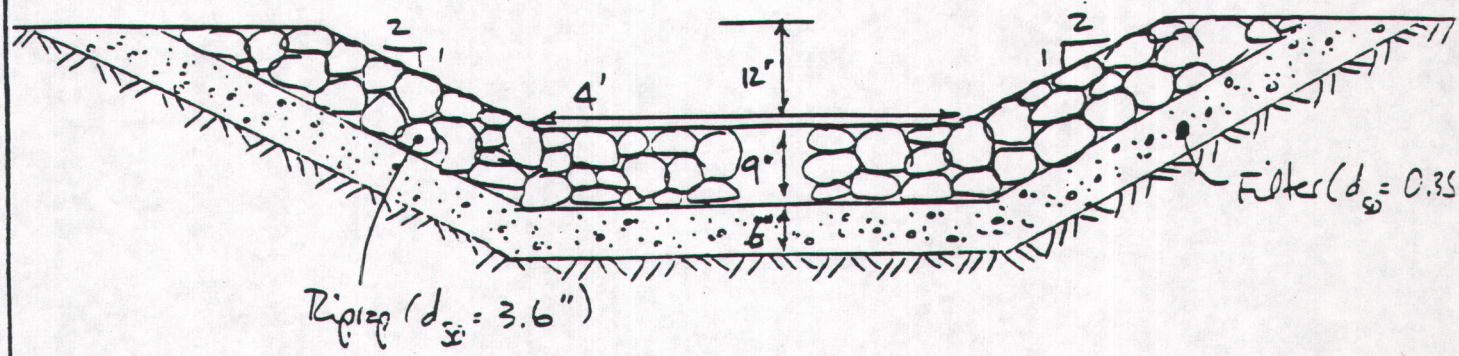
Required d_{50} = 0.30 ft (from pg. 27c)
= 3.6 in

n = 0.032 ⇒ OK See gradation on pg. 27x

Check RD-2 filter:

$$\frac{D_{15}\text{ (riprap)}}{D_{85}\text{ (filter)}} = \frac{1.4\text{ in}}{0.85\text{ in}} = 1.6 < 5 \quad \underline{\underline{OK}}$$

$$\frac{D_{15}\text{ (riprap)}}{D_{15}\text{ (filter)}} = \frac{1.4\text{ in}}{0.08\text{ in}} = 17.5 < 40 \quad \underline{OK}$$



RD-5 ELEV. VIEW
SCALE: 1" = 2'