0031

CO-OP MINING CO.

P.O. Box 15809
Salt Lake City, Utah 84115
Phone (801) 467-4003

July 28, 1983

John Whitehead
Division of Oil Gas and Mining
4241 State Office Building
Salt Lake City, Utah 84114

Dear Mr. Whitehead;

The following hydrology report prepared for the Co-op Mining Co. by Horrocks Engineers includes the calculations for the area referred to in NOV83-5-2-2, part 2 of 2 and will supercede the calculations submitted June 7, 1983 from Viking Engineering. A map with the additional information requested will be submitted under separate cover.

Yours Truly,

Wendell Owen

Wendell Owen

map rec'd 7-29-83 from Mel Conrad's wife

HORROCKS & CAROLLO ENGINEERS
A JOINT VENTURE
ONE WEST MAIN
P.O. BOX 377
AMERICAN FORK, UTAH 84003

July 8, 1983

Mr. Wendell Owen
Co-Op Mining Company
P.O. Box 1245
Huntington, Utah 84528

Subject: Bear Creek Canyon Mine Site
Hydrology Computations

Dear Mr. Owen:

As discussed with you in our meeting Monday, June 6, 1983, and subsequent discussions I have performed hydrologic calculations for sediment storage and runoff at the subject site and have the following results and conclusions:

1. The computed volume for sedimentation in Pond A (the larger pond) is 76,621 cubic feet. If the pond can be constructed 8' deep this would require a pond approximately 120 feet by 80 feet. If, however, the pond can only be constructed 6' deep it would require a pond of 140 feet by 91 feet. Pond B (the smaller pond) needs to have 9,309 cubic feet of storage and this pond could be 4' deep and approximately 50 feet by 50 feet.

2. Based on the calculations I would recommend that the downspout #1 (the upper downspout) be constructed to conform to the grade of the existing contours on the hillside and be constructed of 15" corragated metal pipe. Particular care should be paid to the construction of the inlet to this pipe as it will probably be subseptible to plugging from debris. The lower downspout should be constructed of 18" corragated metal pipe laid to conform to the existing ground contours.

3. The drainage berm or ditch to convey the water to the sediment pond for the "A" area could be constructed of a V-type ditch with one to one side slopes at least 1½ feet deep at a grade of 6%.

4. For the spillway needed on the sediment storage ponds, I would recommend an 18" riser pipe connected to an 18" CMP outlet pipe laid at a minimum of 6% slope.

5. The ditch to convey the water to the upper downspout could be constructed of a V-type ditch with one to one side slopes at least 1 foot deep at an average slope of 6%. A greater slope than 6% should be avoided to prevent errosion upstream of the downspout. If it is necessary to construct this channel at a greater slope, it should be riprapped or reinforced with Gabions to prevent errosion. The ditch to convey the water from the end of the upper downspout to the lower downspout can be constructed of V-type ditch with one to one side slopes at least 1½ feet deep. Again,this ditch will need to be riprapped if constructed at a greater slope than 6%. The area next to the 15" outlet from the 15" pipe will need to be riprapped to reduce the outlet velocity of 12.4 feet per second without creating errosion. This riprap should meet specifications for NCSA No. R-6 with an average partical size of 12", or by the use of Gabions.

6. The capacity of the 10" culverts on the upper access road is 3.76 cubic feet per second when flowing full, which is adequate.

7. The capacity of the 12" culverts on the upper access road is 6.12 cubic feet per second when full, which is adequate.

8. I have reviewed the calculations on the existing culverts which provided drainage for the undisturbed areas through the disturbed areas and find that the 18" culvert located near the middle of the plot plan on the north side of the stream is adequate to convey the flows with a minimum headwater over the top of pipe depth of 20". The existing 60" culvert in the mainstream channel is adequate to convey the flows with a minimum headwater depth of 84" over the top of the pipe.

I have attatched to this letter my engineering calculations and backup reference data for your files.

If you desire clarification or have additional questions or need additional information please contact me.

Very truly yours,

HORROCKS ENGINEERS

H. Lee Wimmer

H. Lee Wimmer, P.E.
Hydrologist

HLW:map

Enclosures

HORROCKS & CAROLLO ENGINEERS
A JOINT VENTURE
ONE WEST MAIN
P. O. BOX 377
AMERICAN FORK, UTAH 84003

June 30, 1983

CO-OP MINING COMPANY

BEAR CREEK CANYON SITE PLAN

HYDROLOGICAL CERTIFICATION

I, Harold Lee Wimmer, do certify that I am a registered professional engineer, and that I hold certificate No. 3535 as prescribed under the laws of the State of Utah. I further certify that I have a Bachelor of Engineering Science Degree in Civil Engineering from Brigham Young University and a Master of Science Degree in Civil Engineering from the University of Southern California, with an emphasis on Hydrology. I further certify that by authority of the owners I have reviewed or performed the attached hydrology computations for the existing Bear Creek Canyon Site Plan and that said calculation and computations have been correctly performed in accordance with professional standards of practice relating to hydrology and that the conclusions contained herein are true and correct and represent use of current hydrologic and climatological information.

Harold Lee Wimmer, P.E.
Utah P.E. No. 3535

[illegible] Mining Company | Lee Wimmer | 6-25-83

Bear Canyon Site Plan

Sediment Storage from disturbed area

Design data

Site elevation : 7150 feet (U.S.G.S.)
Runoff Area : see 1"=50' map for individual areas
Average Slope length : see table below
Average Slope gradient : " " "
6 hour - 10 year storm : 1.4 inches
Soil Characteristics : 12% silt, 24% fine sand, 36% sand, 0% organic matter, course graded soil, moderate permeability

Table

Area #	Area* (acres)	Average Slope length (feet)	Average Slope gradient (%)
A1	2.24	420	36
A2	4.96	560	14
A3	3.51	640	11
B	1.79	520	10

* By Planimeter

Determinations

Use Uniform Soil Loss Equation, A = RKLSPC

R : From figure 1 "Universal Soil Loss Equation", SCS, Jan. 1976
use R = 40

K : From "A soil erodability nomograph ...", where % silt plus % fine sand = 36%, % sand = 36%
K = 0.32

LS : From Table 1, "Universal soil Loss Equation", SCS Jan. 1976 (see table above) For A1, LS = 22.06
A2, LS = 5.42
A3, LS = 4.14
B, LS = 3.12

C : Assume bare ground, use C = 1
P : Assume no erosion control, use P = 1

$\Rightarrow$ $A_{A1} = (40)(0.32)(22.06)(1)(1) = 282.4$ tons/acre/year
$A_{A2} = (40)(0.32)(5.42)(1)(1) = 69.4$ " " "
$A_{A3} = (40)(0.32)(4.14)(1)(1) = 53.0$ " " "
$A_B = (40)(0.32)(3.12)(1)(1) = 39.9$ " " "

Bear Canyon Site Plan

Sediment Storage from disturbed areas cont.

for areas, 3 years (OSM regulations 817.46 (b)(1)),
Soil = 90 lbs / ft^3

$V_{A1} = (28.4)(2.24)(3)(\frac{2000}{1})(\frac{1}{90}) = 42,172\ ft^3$ *
$V_{A2} = (60.4)(4.96)(3)(\frac{2000}{1})(\frac{1}{90}) = 22,948\ ft^3$
$V_{A3} = (53.5)(3.51)(3)(\frac{2000}{1})(\frac{1}{90}) = 12,402\ ft^3$
$V_B = (39.9)(1.79)(3)(\frac{2000}{1})(\frac{1}{90}) = 4,761\ ft^3$

* To Wit, this calculated figure is higher than will ever occur in practice because the soil type for this hillside would consist of large rocks and other particle sizes being larger also. I would recommend reducing this figure to the amount calculated for one (1) year, 14,057 ft^3

⇒ For $A_1+A_2+A_3$, sediment storage volume =
14,057 + 22,948 + 12,402 = 49,407 ft^3

For B, sediment storage = 4,761 ft^3

Cooper Mining Company | Lee Wimmer | 6-25-83

Bear Canyon Site Plan

Runoff storage from disturbed area

Design Data

24 hour - 10 year storm : 2.25 inches

Determinations

CN = 80 ±, From Table 9.1, "SCS National Engineering Handbook", Section 4, "Hydrology"

Runoff from figure 10.1, reference as above = 0.7 inches

⇒ Volume of runoff in ft^3

$$\left.\begin{aligned} V_{A1} &= (2.24)(43{,}560)(0.7)(1/12) = 5{,}692\ ft^3 \\ V_{A2} &= (4.96)(43{,}560)(0.7)(1/12) = 12{,}603\ ft^3 \\ V_{A3} &= (3.51)(43{,}560)(0.7)(1/12) = 8{,}919\ ft^3 \\ V_{B} &= (1.79)(43{,}560)(0.7)(1/12) = 4{,}548\ ft^3 \end{aligned}\right\} 27{,}214\ ft^3$$

⇒ Total Volume in ponds required for sediment and runoff:

Pond A = 49,407 + 27,214 = 76,621 ft^3

Pond B = 4,761 + 4,548 = 9,309 ft^3

NATIONAL 42-381 50 SHEETS 5 SQUARE 42-382 100 SHEETS 5 SQUARE 42-389 200 SHEETS 5 SQUARE

Company | [illegible] Wimmer | 6-25-83

Bear Canyon Site Plan

Surface runoff into diversions around site

Design Data

Area : See previous table
Slope : " " "
Maximum length : $A_1 = 480'$, $A_2 = 660'$, $A_3 = 1040'$, $B = 520'$
Runoff coefficient : 0.40
25 yr-24 hr storm : Hiawatha data by E. Arlo Richardson, State Climatologist

Determinations

Use Rational equation, $Q = CIA$
For Area A_1 use $T_c = 5$ min $\Rightarrow I_{max} = 2.76$ in/hr
For other Areas use $T_c = 10$ min $\Rightarrow I_{max} = 2.10$ in/hr

$Q_{A1} = (0.40)(2.76)(2.24) = 2.47$ cfs

$\longrightarrow$ Use 15" CMP for downspout #1

check Headwater depth - UDOT chart 2-53
need H_w of 12 inches ±, OK

$Q_{A2} = (0.40)(2.10)(4.96) = 4.17$ cfs

Total Q @ downspout #2 $\approx Q_{A1} + Q_{A2} = 2.47 + 4.17 = 6.64$ cfs

$\longrightarrow$ Use 18" CMP for downspout #2

$H_w = 20"$ or 2" over top of pipe, OK

$Q_{A3} = (0.40)(2.10)(3.51) = 2.95$ cfs

Total Q in ditch $\approx Q_{A1} + Q_{A2} + Q_{A3} = \underline{9.6 \text{ cfs}}$

CO-OP Mining Company | Joe Wimmer | 6-23-83

Tour Canyon Site Plan

Surface runoff into diversions around site

For required ditch cross section area, use Manning equation, $Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

For earth lined channel, $n = 0.035$

Try channel of 1:1 side slopes, 2' deep
Average slope of ditch - 6%±

For shape shown, $P = 2\sqrt{8}$, $A = 4 ft^2 \Rightarrow R = 0.71$

$Q = \frac{1.486}{0.035}(4)(0.71)^{2/3}(0.06)^{1/2} = 33.0$ cfs

Try channel of 1:1 side slopes, 1½ feet deep, $P = 3$, $A = 2.25 ft^2$
$\Rightarrow R = 0.75$

$Q = \frac{1.486}{0.035}(2.25)(0.75)^{2/3}(0.06)^{1/2} = 19.3$ cfs, ok

→ Use a ditch with 1:1 side slopes at least 1½ feet deep

- - - - -

For spillway on sediment storage pond,

Use a 18" riser and 18" CMP outlet, pipe at 6% grade ±
$\Rightarrow Q = 13.97$ cfs ok
(see computer printout)

UNIFORM FLOWS IN CIRCULAR CONDUITS PARTIALLY FULL KDB 7/7/83

DATA

n	SLOPE	Dia (in)	LIMIT
.024	.060000	18.0	.001000

DEPTH IS KNOWN; Velocity and flow are found

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
13.97	6,273	9.03	18.0	7.91	0.3750	254	1

UNIFORM FLOW$ IN CIRCULAR CONDUITS PARTIALLY FULL KDB 7/7/83

DATA

n	SLOPE	Dia (in)	LIMIT
.024	.440000	15.0	.010000

FLOW IS KNOWN; depth and velocity are found

VELOCITY EXCEEDS RANGE OF MANNING'S EQUATION

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
2.47	1,109	1.60	3.3	12.38	0.1647	29	4

DATA

n	SLOPE	Dia (in)	LIMIT
.024	.310000	18.0	.010000

FLOW IS KNOWN; depth and velocity are found

VELOCITY EXCEEDS RANGE OF MANNING'S EQUATION

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
6.64	2,980	4.29	5.6	14.16	0.2621	68	6

Bear Canyon Site Plan

Ditch Size to convey runoff to downspouts

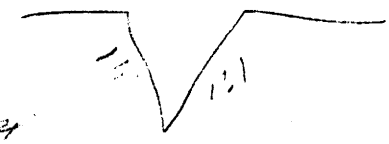
Design Data

As before, $Q_1 = 2.47$ cfs, $Q_2 = 6.64$ cfs

Determination:

For ditch size to convey runoff to upper downspout
use Manning Equation, $Q = \frac{1.486}{n} A R^{2/3} S^{1/2}$

For earth lined channel, $n = 0.035$



Try channel of 1:1 side slopes, 1 deep
Try average slope of 6%± (greater slope will probably cause erosion)

For shape shown, $\Gamma = 2\sqrt{2}$, $A = 1$ ft² $\Rightarrow R = A/P = 0.35$

$Q = \frac{1.486}{0.035}(1)(0.35)^{2/3}(0.06)^{1/2} = 5.16$ cfs, ok

→ Use a ditch with 1:1 side slopes at least 1 feet deep with slope of 6% to channel runoff to upper downspout

Check need for riprap below downspout

outlet velocity = 12.4 ft/sec (see computer printout)

⇒ Need riprap NCSA No. R-6 (average particle size of 12 inches) or use Gabions

To convey runoff to lower downspout

→ Use a ditch with 1:1 side slopes at least 1½ feet deep with slope of 6%

Bear Canyon Site Plan

Surface runoff from undisturbed hillsides

Design Data:

Area : LA = 953 acres , LB = 21.4 acres

Average Elevation : (8,200 + 7,200)/2 = 8,200 feet (USGS)

Design Charts : Utah Department of Transportation (UDOT) Roadway Drainage Manual

Flood Frequency : 20 year return period (USC 25)

Determinations

Use UDOT small area runoff method, Q = (Qc)(LF)(FF)

1 hour - 25 year rainfall = 0.78 in/hr.

From Table 2-05 , K = 0.13

From chart 2-07 , Qc = 202 cfs for LA

Qc = 10 cfs for LB

From Table 2-08 , LF = 1.2

FF = I(design)/I25 = 1 for 25 year return period

⇒ Q = (202)(1.2)(1) = 242 cfs for LA (60" CMP)

Q = (10)(1.2)(1) = 12 cfs for LB (18" CMP)

From computer print out

for 60" CMP full , Qmax = 261 cfs , OK

check headwater depth for 242 cfs

UDOT chart 2.53

→ Hw = 44 inches or 24" over top of pipe

for 18" CMP full , Q max = 12 cfs , OK

check headwater depth for 12 cfs

→ Hw = 38 inches or 20" over top of pipe

UNIFORM FLOWS IN CIRCULAR CONDUITS PARTIALLY FULL HLW 7/6/83

DATA

n	SLOPE	Dia (in)	LIMIT
.024	.100000	10.0	.001000

DEPTH IS KNOWN; Velocity and flow are found

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
3.76	1,689	2.43	10.0	6.90	0.2083	79	1

DATA

n	SLOPE	Dia (in)	LIMIT
.024	.100000	12.0	.001000

DEPTH IS KNOWN; Velocity and flow are found

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
6.12	2,747	3.95	12.0	7.79	0.2500	113	1

DATA

n	SLOPE	Dia (in)	LIMIT
.024	.150000	18.0	.001000

DEPTH IS KNOWN; Velocity and flow are found

VELOCITY EXCEEDS RANGE OF MANNING'S EQUATION

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
22.10	9,918	14.28	18.0	12.50	0.3750	254	1

DATA

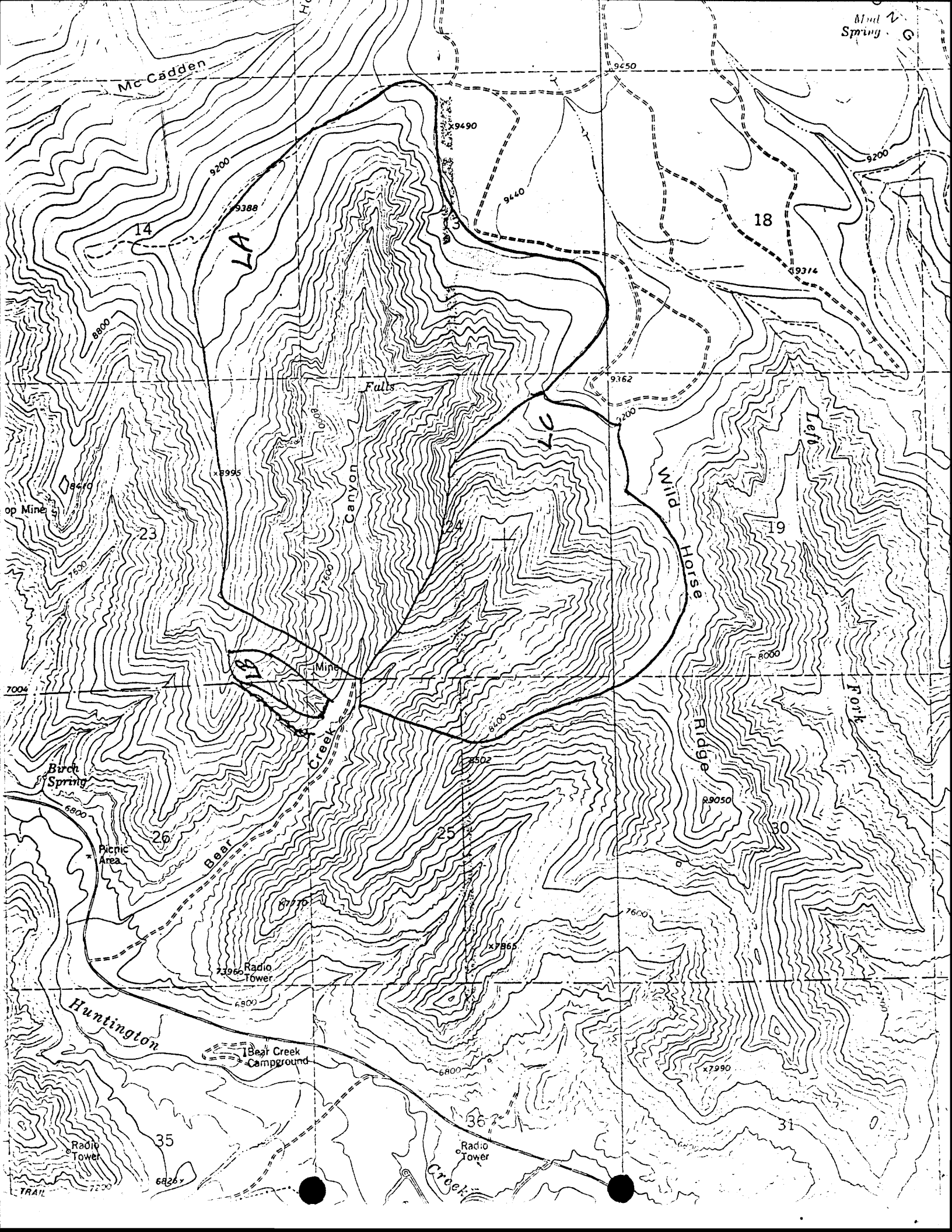
n	SLOPE	Dia (in)	LIMIT
.024	.034000	60.0	.001000

DEPTH IS KNOWN; Velocity and flow are found

VELOCITY EXCEEDS RANGE OF MANNING'S EQUATION

RESULTS

Q (cfs)	Q (gpm)	Q (MGD)	DEPTH (in)	VELOCITY (fps)	R	AREA sq in	ITER
260.83	117,074	168.58	60.0	13.28	1.2500	2827	1



Mud Spring
Mc Cadden
9450
9490
9200
9388
9440
14
13
18
9314
LA
8800
9362
Falls
LC
Left
Canyon
Wild
Horse
Ridge
Fork
8995
8410
op Mine
23
24
19
7600
Mine
7004
8000
8400
Creek
Birch Spring
8502
9050
6800
26
25
30
Picnic Area
Bear
7770
7600
7865
Radio Tower
Huntington
Bear Creek Campground
6800
7990
36
31
35
Radio Tower
Radio Tower
Creek
TRAIL
7200
6826

2. SMALL AREA RUNOFF

The small area method is effectively used for drainage areas of less than about two square miles and loses reliability for those larger than this. Discharges for areas larger than five square miles are not justifiable by this method. The following equation gives the relation used:

$$Q_f = Q_c \times LF \times FF$$

where Q_f = design discharge in c.f.s.,
Q_c = discharge taken from the chart,
LF = the land factor determined as explained below,
FF = the frequency factor determined as explained below.

First the 25-year rainfall intensity is determined as outlined in the preceding article. After investigating the topography of the area, Table 2-05 is used to find the K-factor corresponding to the intensity. Chart 2-06 or 2-07, at the intersection of the drainage area and the line of the chosen K-factor, gives Q_c. Next, Table 2-08 can be used to estimate a land factor. Finally, the rainfall intensity is found for design frequency, and divided by the 25-year intensity as determined above. $FF = i_d/i_{25}$ is the required frequency factor. The example below illustrates the procedure.

(Example)

GIVEN: Drainage area = 1000 acres of sandy shale near Escalante.

FIND: The design discharge for a 10-year secondary project through a very mountainous region.

SOLUTION:

1. From Chart 2-02, i_2 = 0.8 in/hr; i_{100}/i_2 = 2.7,
2. Calculate i_{100} = 2.16 in/hr,
3. Enter Chart 2-03: i_{25} = 1.63 in/hr; i_{10} = 1.35,
4. Enter Table 2-05 and find K = 0.42,
5. Enter Chart 2-07 and find Q_c = 680 c.f.s.,
6. Enter Table 2-08 and estimate LF = 2.0,
7. Calculate FF = 1.35/1.63 = 0.83,
8. Calculate Q_{10} = (680) (2.0) (0.83) = 1129 c.f.s.

Table 2-05: K-FACTORS

25-year 60-minute rainfall intensity	TOPOGRAPHY			
	Mountainous slope over 30%	Rough-hilly 15% - 30%	Rolling 5% - 15%	Flat to rolling 0% - 5%
0.65	0.16	0.11	0.08	0.05
0.70	0.17	0.12	0.08	0.06
0.90	0.22	0.15	0.11	0.07
1.00	0.25	0.17	0.12	0.08
1.10	0.27	0.19	0.13	0.09
1.25	0.31	0.21	0.15	0.10
1.30	0.32	0.22	0.16	0.10
1.40	0.35	0.24	0.17	0.11
1.55	0.39	0.26	0.19	0.12
1.80	0.45	0.31	0.22	0.14
2.00	0.50	0.34	0.24	0.16
2.25	0.56	0.38	0.27	0.18
2.50	0.62	0.42	0.30	0.20

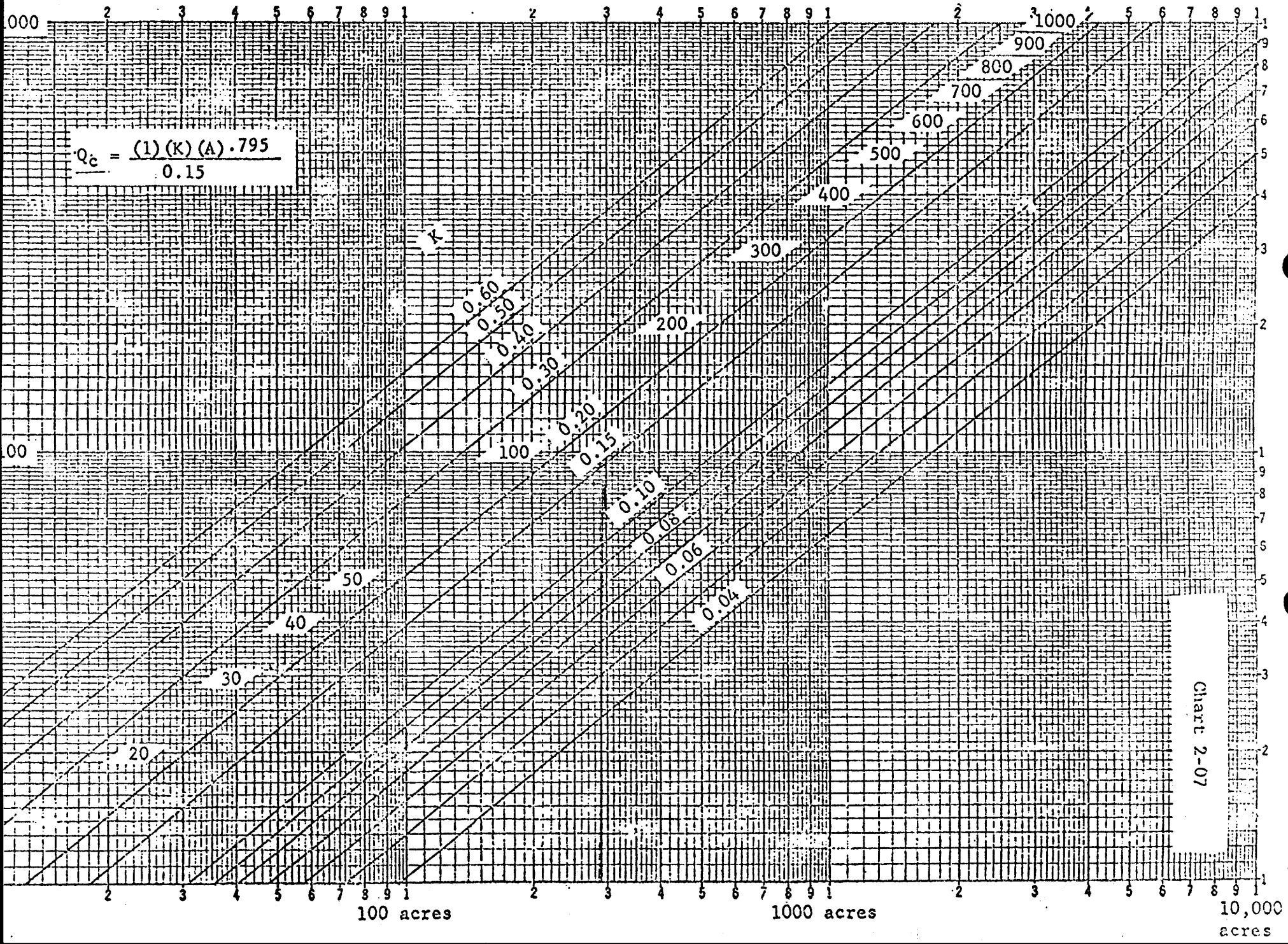

$Q_c = \frac{(1)(K)(A) \cdot .795}{0.15}$
K
0.60
0.50
0.40
0.30
0.20
0.15
0.10
0.08
0.06
0.04
1000
900
800
700
600
500
400
300
200
100
50
40
30
20
100 acres
1000 acres
10,000 acres

Chart 2-07

Table 2-08: LAND FACTORS FOR SMALL WATERSHEDS.

TYPICAL GEOGRAPHIC LOCATIONS	TYPICAL TERRAIN CHARACTERISTICS	LAND FACTORS
	ALLUVIAM	
	(CLEAN)	
Farmington	Fans from granitic uplifts	0.3
Salt Lake Bench Lands	Spits, bars, glacial till, etc.	0.8
	(DIRTY)	
Sevier Valley	Fans and pediment plains from shale areas, etc.	1.0
Echo Canyon	Conglomerate	
Salt Lake Valley	Lake deposits - flood plain areas	1.5
	IGNEOUS	
	(RIOLITIC - POROUS)	
N.W. of St. George	Cinder areas (Small areas)	0.5
Fish Lake area	Basalt and lava flows	
Marysville Canyon	Riolitic flows	1.5
	(SHISTOS OR GRANITIC)	
Bald Mountain - Uintahs	Rubbled uplifts	0.3
Farmington Canyon	Metamorphic shales	
Little Cottonwood Canyon	Batholitic uplifts - granitic	1.2
Salt Lake City		
	LIMESTONE	
Logan Canyon	Hard, pure limestone or dolomite (breaks up in blocks; talus slopes may be present)	0.5
		1.0
	SANDSTONE	
Brigham City	Massive (well-cemented) quartzite, etc. abundant talus slopes - rubble piles	0.5
Bryce Canyon	Friable (poorly-cemented) dirty sand dunes may be present	2.0
	SHALE	
San Rafael Swell	Sandy shale - alternating clayey sand and shale members	1.5
Green River	Clayey shale	2.5

3. LARGE AREA RUNOFF

When relatively large areas of drainage are encountered, the method of flood determination used by the Geological Survey (Ref. 10, 25, & 26) furnishes a means of perdicting the storm runoff from the area. These reports: a. Outline the homogeneous flood regions in Utah and present a composite flood-frequency curve for each; b. outline hydrologic areas and present graphs showing the variation of mean annual flood with drainage area and altitude. The results of these studies may be used to estimate the magnitude and frequency of floods, with recurrence intervals up to 50 years, for any drainage area in the State with the exception of the Snake River Basin.

The relationships of the hydrologic features of the drainage basins were defined from the records on streams with natural flows. To obtain the magnitude of any flood on any regulated stream, adjustments should be made for man-made development. Also, the varying effects of geology and vegetal cover were not given detailed consideration in this study. An investigation and evaluation of these factors may be justified in some specific area.

The results obtained from the flood-frequency study are limited by the basic data available. The degree of confidence that can be placed in the results is closely related to the quantity of data used in defining the various curves. Extrapolation of curves beyond the limits shown is not recommended, but this has been done for a means of comparison with other methods. (On the graphs, a dotted line indicates where this extrapolation has been made.) It should be kept in mind, however, that values obtained by such practice may be greatly in error. To obtain the magnitude and frequency of floods for any basin within the study area, except on major rivers, the procedure is as follows:

1. Determine the drainage area above the site.

2. Locate the site on Charts 2-11 and 2-12 and determine the flood region and hydrologic area involved.

3. Determine the mean altitude for the drainage basin above the selected site. This can be done by placing a transparent rectangular grid system overlay on a contour map and recording the altitude of the intersections within the drainage basin. The arithmetic average of the values represents the mean altitude of the drainage basin.

4. Using Charts 2-13 to 2-21, & 2-26 to 2-28, determine the mean annual flood for the site from the hydrologic area curve selected in step 2.

5. Using Chart 2-22 & 2-29, determine the ratio of the design flood to the mean annual flood, for the selected recurrence interval, from the appropriate flood-frequency curve selected in step 2. When the drainage area above the site is near another flood region or lies in two regions with widely different flood ratios, it is suggested that a weighted average of the two flood ratios be used.

6. Estimate the magnitude of the flood by multiplying the mean annual flood by the flood ratio.

On many larger streams, records are available to enable the engineer to predict a magnitude of flood for a given design frequency. This method, using special Gumbel probability paper for plotting station frequency curves, is explained on Page 4 of (Ref. 10.) A large number of these curves have already been prepared and are on file in the Hydraulics Department.

Chart 2-11: FLOOD REGIONS

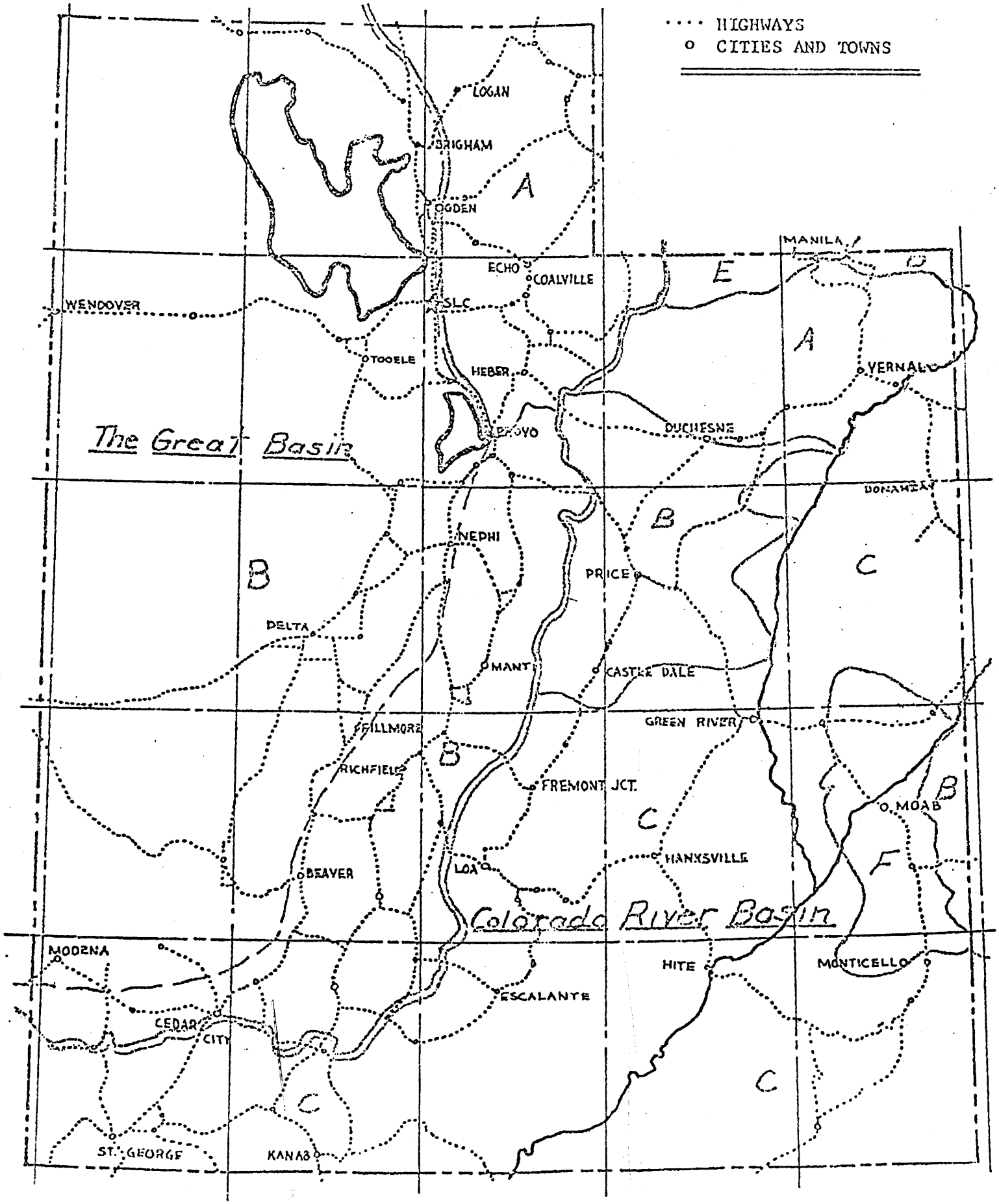


Chart 2-12: HYDROLOGIC AREAS

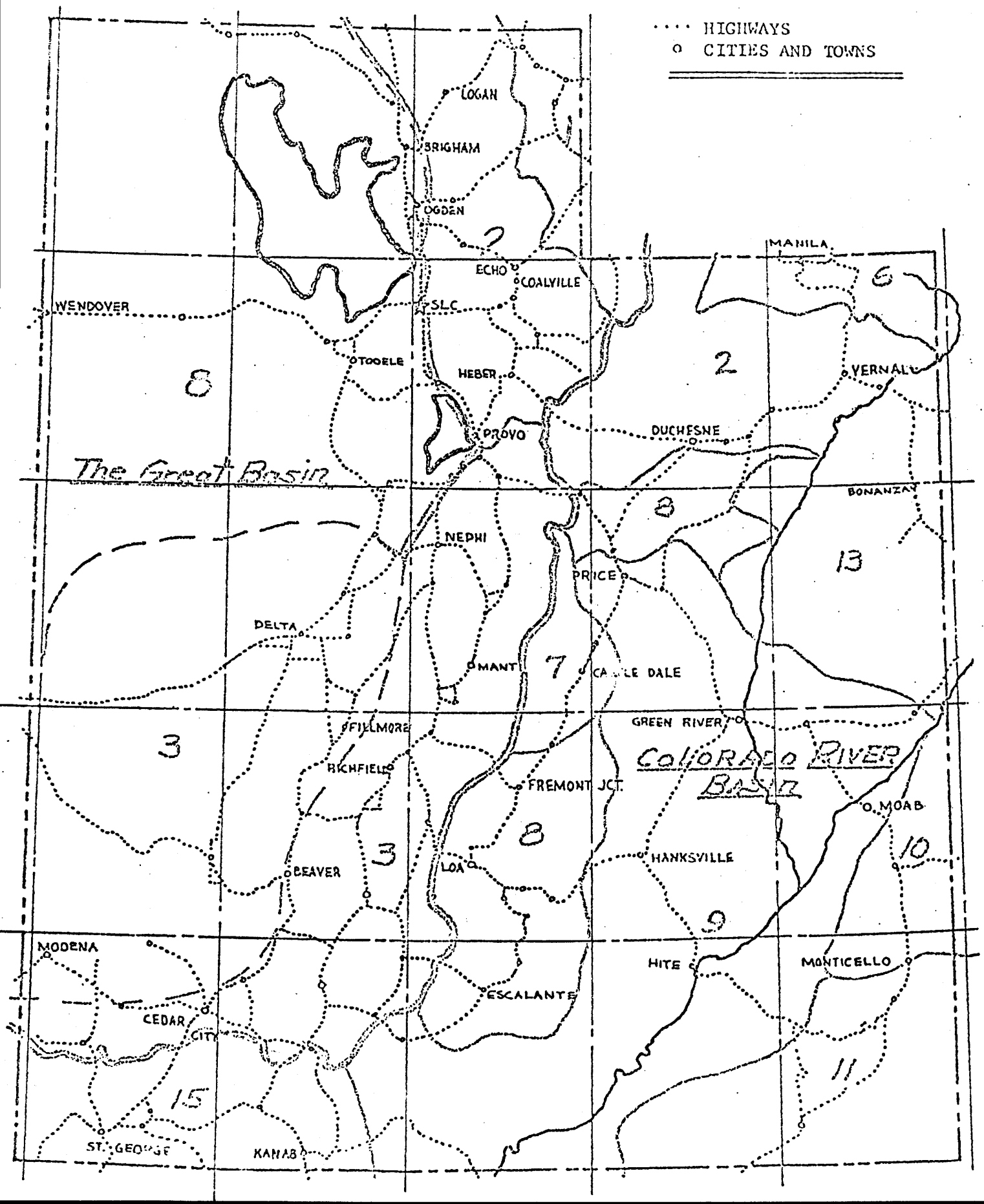


CHART 2-15: FLOOD FREQUENCY RELATIONS FOR HYDROLOGIC AREA 7
(COLORADO RIVER BASIN)

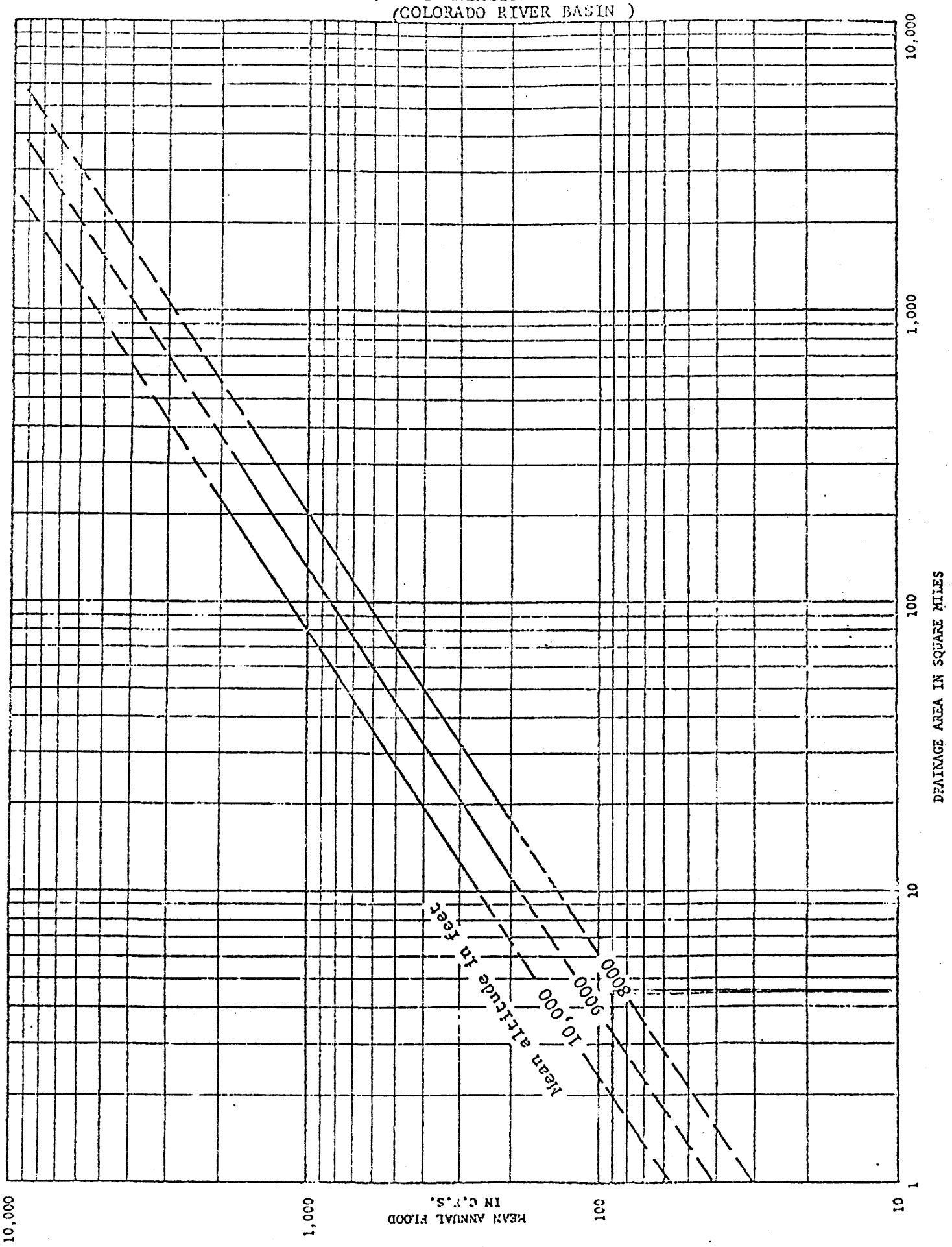


CHART 2-22A: COMPOSITE FLOOD FREQUENCY CURVE FOR REGIONS A,B,& E
(COLORADO RIVER BASIN)

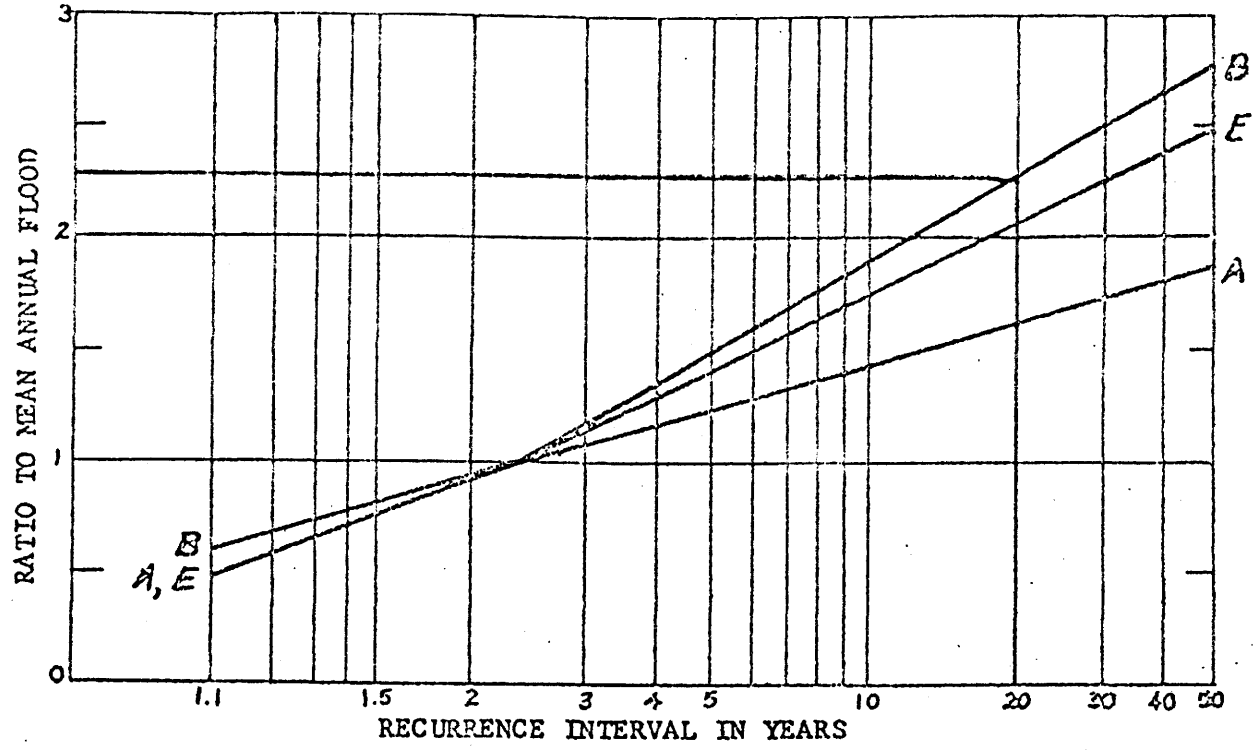


CHART 2-22B: COMPOSITE FLOOD FREQUENCY CURVES FOR REGIONS C & F
(COLORADO RIVER BASIN)

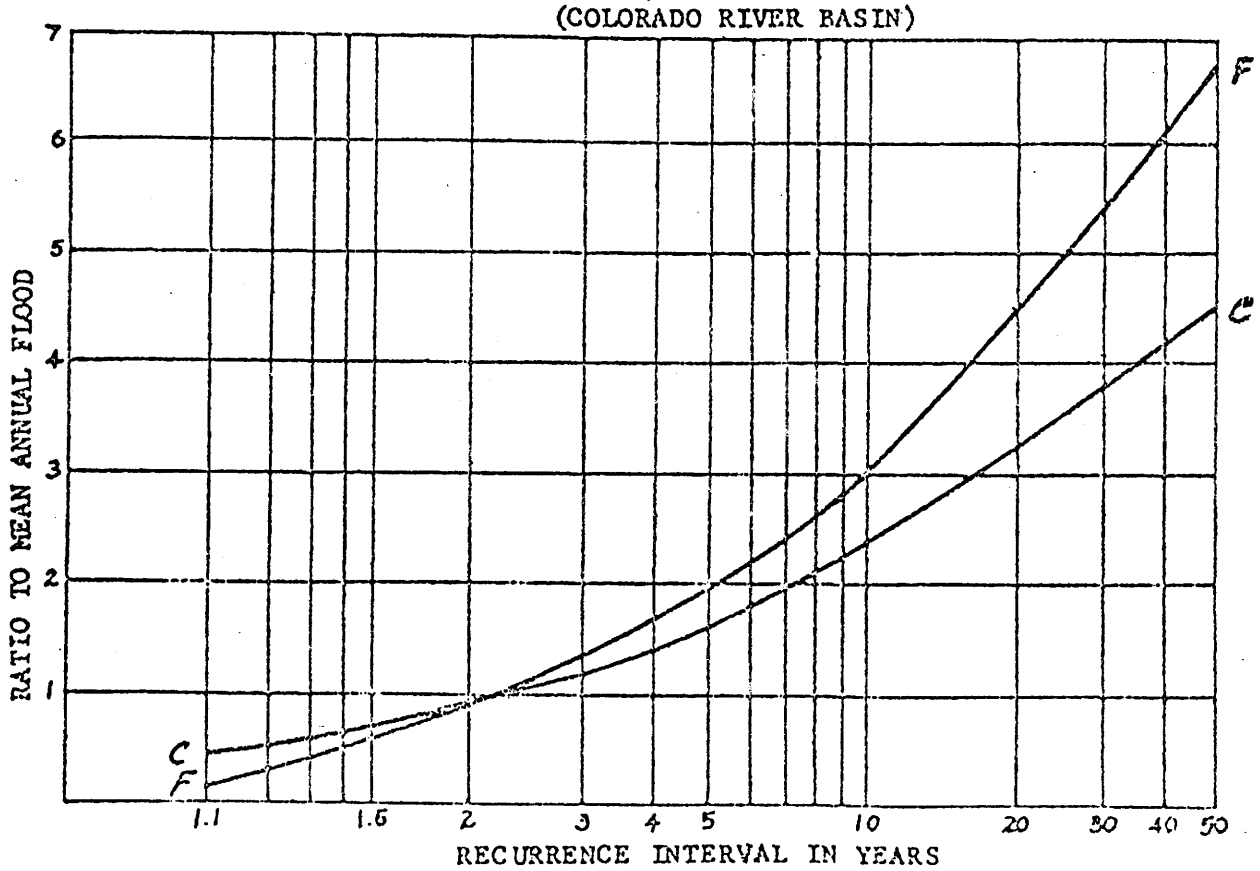
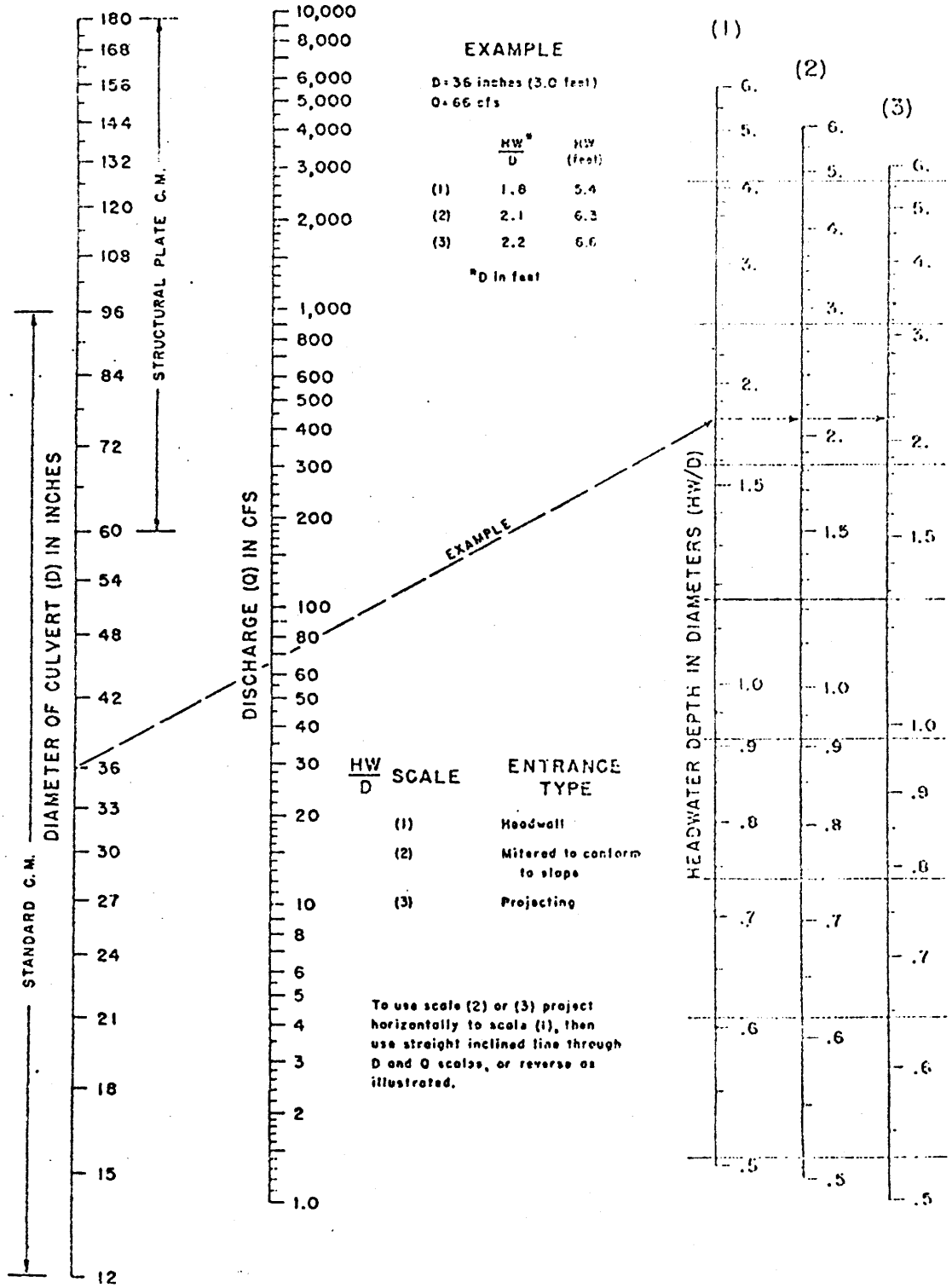


Chart 2-53: HEADWATER DEPTH FOR C.M.P. CULVERTS WITH INLET CONTROL



ESTIMATED RETURN PERIODS FOR SHORT DURATION PRECIPITATION
(inches)

Station: Clear Creek Summit
Latitude: 39° 39'

Elevation: 9630
Longitude: 111° 12'

DURATION

RETURN PERIOD (years)	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	24 Hr
1	.10	.16	.20	.28	.35	.46	.57	.84	1.08	1.33
2	.12	.19	.25	.34	.43	.57	.70	1.04	1.34	1.65
5	.16	.24	.31	.43	.54	.72	.90	1.34	1.73	2.14
10	.19	.29	.37	.51	.65	.86	1.06	1.55	1.99	2.45
25	.24	.38	.48	.66	.84	1.08	1.31	1.88	2.39	2.92
50	.25	.38	.48	.67	.85	1.13	1.40	2.07	2.67	3.29
100	.27	.42	.53	.73	.93	1.24	1.54	2.29	2.96	3.65

ESTIMATED RETURN PERIODS FOR SHORT DURATION PRECIPITATION
(inches)

Station: Hiawatha
Latitude: 39° 29'

Elevation: 7230
Longitude: 111° 01'

DURATION

RETURN PERIOD (years)	5 Min	10 Min	15 Min	30 Min	1 Hr	2 Hr	3 Hr	6 Hr	12 Hr	24 Hr
1	.03	.04	.05	.07	.09	.24	.39	.76	1.09	1.43
2	.07	.10	.13	.18	.23	.40	.55	.95	1.30	1.67
5	.13	.20	.25	.35	.44	.62	.79	1.22	1.60	2.00
10	.16	.25	.31	.43	.55	.75	.93	1.40	1.82	2.25
25	.23	.35	.44	.62	.78	.99	1.19	1.69	2.14	2.60
50	.26	.40	.50	.70	.88	1.11	1.33	1.89	2.38	2.90
100	.31	.48	.60	.84	1.06	1.30	1.54	2.12	2.64	3.18

Open Channel Hydraulics - Ven Te Chow, Ph.D. © 1959 McGraw-Hill, Inc.

Attempts[1] were made early to define a mean velocity that would cause neither silting nor scouring. From the present-day viewpoint, however, it is doubtful whether such a velocity actually exists. In 1915,

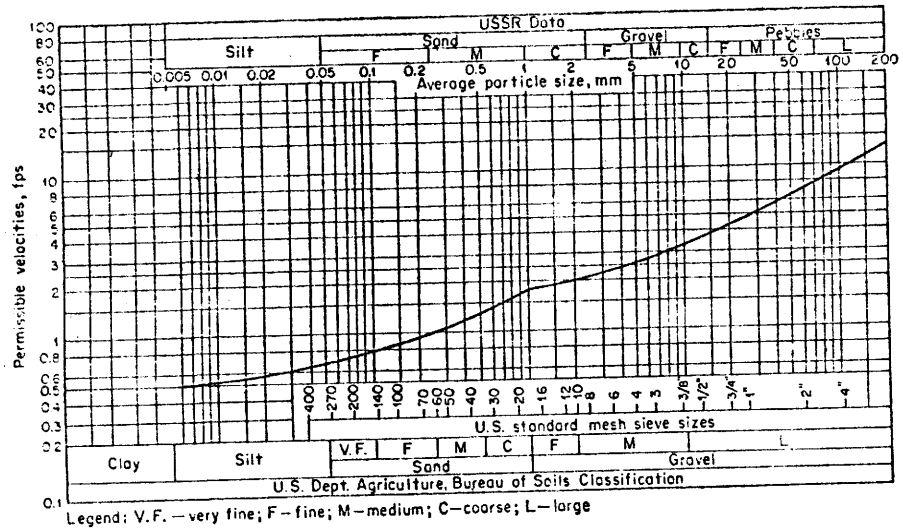


FIG. 7-3. U.S. and U.S.S.R. data on permissible velocities for noncohesive soils.

Etcheverry [26] published probably the first table of maximum mean velocities that are safe against erosion. In 1925, Fortier and Scobey [27] published the well-known table of "Permissible Canal Velocities" shown in Table 7-3. The values in this table are for well-seasoned channels of small slopes and for depths of flow less than 3 ft. The table also shows

[1] The first famous formula for this nonsilting and noneroding velocity for silt-laden water was published in 1895 by Kennedy [10]. From a study of the discharge and depth of 22 canals of the Upper Bari Doab irrigation system in Punjab, India, the Kennedy formula was developed as

$$V_0 = Cy^x \tag{7-4}$$

where V_0 is the nonsilting and noneroding mean velocity in fps; y is the depth of flow in ft; $C = 0.84$, depending primarily on the firmness of the material forming the channel body; and $x = 0.64$, an exponent which varies only slightly. Based on later studies by other engineers, the values of C generally recommended are 0.56 for extremely fine soils such as those found in Egypt; 0.84 for fine light sand soils such as those found in the Punjab, India; 0.92 for coarse light sandy soils; 1.01 for sandy loamy silts; and 1.09 for coarse silt or hard-soil debris. For clear water, a value of $x = 0.5$ has been suggested.

For the design of canals carrying sediment-laden water, the Kennedy formula is now practically obsolete and is being replaced by methods based on Lacey's regime theory [11-16], Einstein's bed-load function [17], and Maddock-Leopold's principle of channel geometry [18]. There are voluminous writings on these methods. Comprehensive bibliographies can be found in [19] to [25].

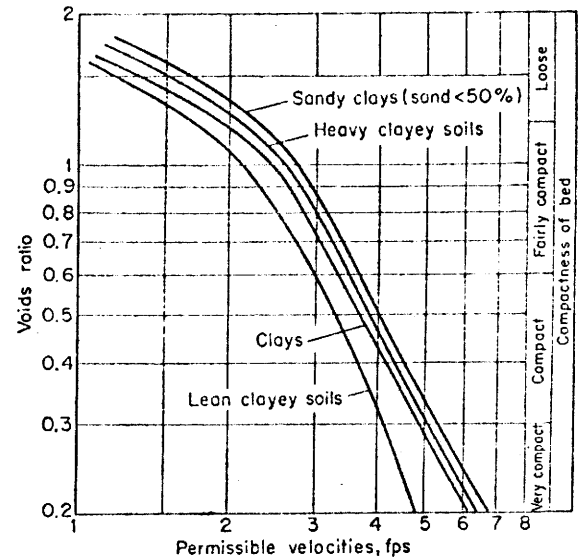


FIG. 7-4. Curves showing U.S.S.R. data on permissible velocities for cohesive soils.

suitable n values for various materials and the converted values for the corresponding permissible tractive force, which will be discussed later (Art. 7-13). In 1936, a Russian magazine [28] published values of maximum permissible velocities (Figs. 7-3 and 7-4) above which scour would be produced in noncohesive material of a wide range of particle sizes and various kinds of cohesive soil. It also gave the variation of these velocities with channel depth (Fig. 7-5).

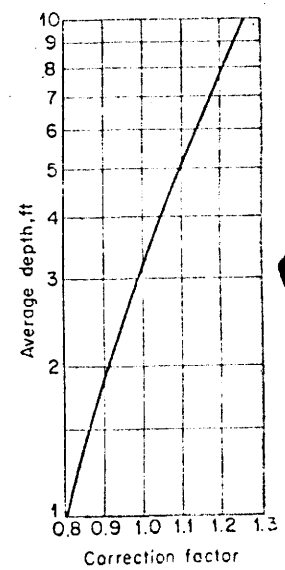


FIG. 7-5. Curves showing U.S.S.R. corrections of permissible velocity for depth for both cohesive and noncohesive materials.

The maximum permissible velocities mentioned above are with reference to straight channels. For sinuous channels, the velocities should be lowered in order to reduce scour. Percentages of reduction suggested by Lane [29] are 5% for slightly sinuous canals, 13% for moderately sinuous canals, and 22% for very sinuous canals. These percentage values, however, are very approximate, since no accurate data are available at the present time.

7-10. Method of Permissible Velocity. Using the maximum permissible velocity as a criterion, the design procedure for a channel section, assumed to be trapezoidal, consists of the following steps:

SPEC DATA®

This Spec-Data Sheet conforms to editorial style prescribed by The Construction Specifications Institute. The manufacturer is responsible for technical accuracy.

1. PRODUCT NAME

Quarried stone for riprap, armor stone and filter stone for erosion and sediment control. (See glossary on page 4.)

2. MANUFACTURER

For a list of leading producers write or call:

NATIONAL CRUSHED STONE ASSOCIATION, 1415 Elliot Place, N.W., Washington, D.C. 20007; Phone: (202) 342-1100.

3. PRODUCT DESCRIPTION

Basic Use: Quarried Stone, in a wide range of sizes for various needs and applications, provides, when properly installed, an effective and economical barrier and/or structure to control unwanted soil erosion. (Note: Armor stone will not be covered in this unit because of its specialized usage)

Areas of application for quarried stone include, *but are not limited to*:

1. Banks of Creeks, Streams and Rivers
2. Bodies of Water Subject to Wave Action from Boat Traffic
3. Drainage Facilities
4. Earth Dams
5. Sediment Basins
6. Shorelines-Ponds, Lakes and Coastal Waters
7. Slope Protection
8. Wave Energy Absorbers in Docking Areas

The 32-page NCSA publication—"Quarried Stone Erosion and Sediment Control" listed in Item 10 of this document provides more detailed information on the five areas of application discussed here under Item 4, plus similar details for Canals, Earth Dams and Wave Energy Absorbers.

Limitations: Inspection should be at a level in keeping with standard practices in the geographic area for uses of stone; for many small commercial projects, quality control procedures usually involve determination of particle size analysis by mechanical screening methods. Erosion control sometimes involves use of stone sizes too large for such analysis and is more often accepted on visual examination. It is advantageous to producers and end users to accept erosion control stone at the quarry.

Composition and Materials: "Crushed Stone" is a generic term defined as the product resulting from the quarrying process, essentially all faces of which possess well defined edges.

Quarried stone discussed herein will include listings of and recommendations for suggested sizes for specific purposes. These sizes are discussed in two categories—I—Open-Graded Riprap and II—Filter Stone.

I. OPEN-GRADED RIPRAP or "dumped riprap" as it is sometimes called. NCSA graded riprap is designated R-1 to R-8 and is described in the following Table A. The exact sizes of Riprap may not be the most economically available in certain local areas. Other and larger sizes may usually be substituted provided the "average size" criteria, as defined in Footnote (1) and under Special Design Considerations below, are met.

SPECIAL DESIGN CONSIDERATIONS

Note that each designation in the table above shows an "average" as well as a maximum and minimum size. This average, defined as that size exceeded by at least 50 per cent of the total tonnage shipped, is the most important governing factor in selecting the proper size designation for the given wave heights or stream velocities. Even though all pieces might be larger than the minimum size of a particular designation, if the average size is too small, the installation might not function as intended.

II. FILTER STONE. Densely graded filter stone is the sublayer under the larger protection stone, such as either graded riprap or armor stone. NCSA filter stone is designated FS-1 to FS-3 and is described in the following Table B:

Table B
FILTER STONE

NCSA No.	Size Inches (sq. openings) Max.	Avg. (1)	Min. (2)
FS-1	3/8	No. 30	No. 100
FS-2	2	No. 4	No. 100
FS-3	6 1/2	2.5	No. 16

(1) "Average size" is that size exceeded by at least 50% of the total weight of the tonnage shipped; i.e., 50 per cent of the tonnage shall consist of pieces larger than the "average" size (normally 1/2 the specified nominal top size).

(2) Pieces smaller than the minimum size shown shall not exceed 15% of the tonnage shipped.

Table A
GRADED RIPRAP STONE

NCSA No.	Size Inches (sq. openings) Max.	Avg. (1)	Min (2)	Wave Height(3) (ft.)	Velocity (4) (ft./sec.)	Corresponding Filter Stone NCSA Size No.
R-1	1 1/2	3/4	(No. 8)	—	2.5	FS-1
R-2	3	1 1/2	1	0.3	4.5	FS-1
R-3	6	3	2	0.5	6.5	FS-2
R-4	12	6	3	1.0	9.0	FS-2
R-5	18	9	5	1.5	11.5	FS-2
R-6	24	12	7	2.0	13.0	FS-3
R-7	30	15	12	2.5	14.5	FS-3
R-8	48	24	15	4.0	—	FS-3

(1) "Average size" is that size exceeded by at least 50% of the total weight of the tonnage shipped; i.e. 50 percent of the tonnage shall consist of pieces larger than the "average" size (normally 1/2 the specified nominal top size).

(2) Pieces smaller than the minimum size shown shall not exceed 15% of the tonnage shipped.

(3) Wave Height is the vertical distance from wave crest to wave trough. The wave height given in the table is the average height of the one-third highest waves in the incident wave train.

(4) The stream velocity is the velocity at mid-stream or at a point 10 feet from the bank, whichever is closest to the bank.

(5) The Table assumes a stone dry density of 165 pounds per cu. ft.

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National Crushed Stone Association August 1982 | 2p | EARTHWORK Erosion and Sediment Control with Quarried Stone

Applicable Standards: Various federal agencies, the U.S. Corps of Engineers and the U.S. Soil Conservation Service in particular, have "Guide Specifications" to aid their local or regional offices in setting actual Job Specification requirements. ASTM is endeavoring to develop a specification for stone for erosion control.

Various state and local government—transportation agencies, highways, water conservation, environmental etc.—may have specifications covering use of stone for erosion and sediment control. Use of stone from "an approved source" (as identified by some state highway or transportation department, federal agency, conservation agency, etc.) is recommended.

4. TECHNICAL DATA

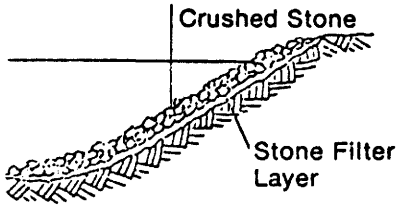
The sizes suggested in the following tables depend on both the technical and engineering factors involved in the final decision for each product and on which crushed stone products are generally available in that geographic location.

Specific information for five areas of application, A-E follow.

A. Banks of Creeks, Streams and Rivers

Factors involved:

1. There is little if any erosion if water velocity is less than 1.5 ft./sec
2. Erosion protection stone must extend from top of bank to deepest part of the stream.
3. Protection must extend upstream and downstream from the main problem area.
4. Riprap can be used on slopes of 1 1/2 horizontal to 1 vertical or flatter. Stone-filled wire baskets ie. Gabions should be used on slopes steeper than 1 1/2 to 1. (See "Gabions under item 5 on page 4.)



ELEVATION VIEW

Flow Velocity (ft./sec.)	GRADED RIPRAP STONE Size Inches (sq. openings) NCSA No.	Max.	Ave.	Min.	Corresponding Size of Filter Stone NCSA No.
2.5	R-1	1½	¾	No. 8	FS-1
4.5	R-2	3	1½	1	FS-1
6.5	R-3	6	3	2	FS-1
9.0	R-4	12	6	3	FS-2
11.5	R-5	18	9	5	FS-2
13.0	R-6	24	12	7	FS-3
14.5	R-7	30	15	12	FS-3

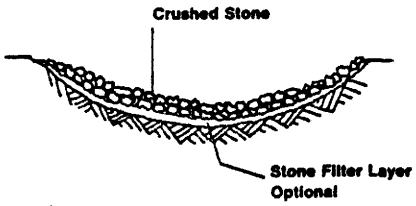
B. DRAINAGE FACILITIES

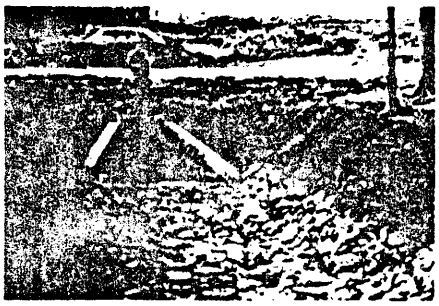
- **Ditches—**

  Factors involved:

  1. Estimate the flow velocity, depth of the channel and ditch slope or gradient.
  2. At same water velocity, a deep ditch requires more protection than a wider, shallower ditch.
  3. V-shaped ditches have lower capacity than wide channels and they erode more easily.

Flow Velocity (ft./sec.)	GRADED RIPRAP STONE Size Inches (sq. openings) NCSA No.	Max.	Avg.	Min.	Corresponding Size of Filter Stone NCSA No.
4.5	R-2	3	1½	1	FS-1
6.5	R-3	6	3	2	FS-2
9.0	R-4	12	6	3	FS-2



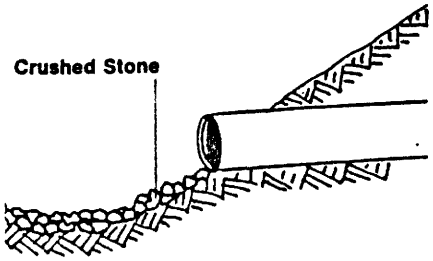


Scouring Basin Full Flow Velocity (ft./sec.)	GRADED RIPRAP STONE Size Inches (sq. openings) NCSA No.	Max.	Avg.	Min.
5.5	R-3	6	3	2
8.5	R-4	12	6	3
9.1	R-5	18	9	5

- **Pipe Outlets—**

  Factors involved:

  1. Estimate flow rate and tail water depth and know culvert size.
  2. A stone filter layer is generally not required as some siltation between stone particles is anticipated.

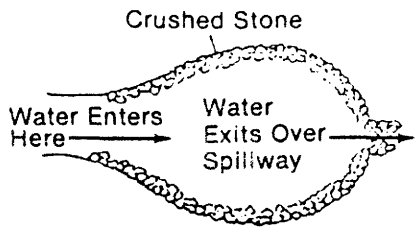


SCOURING

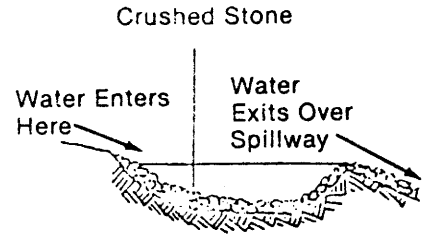
C. SEDIMENT BASINS

Factors involved:

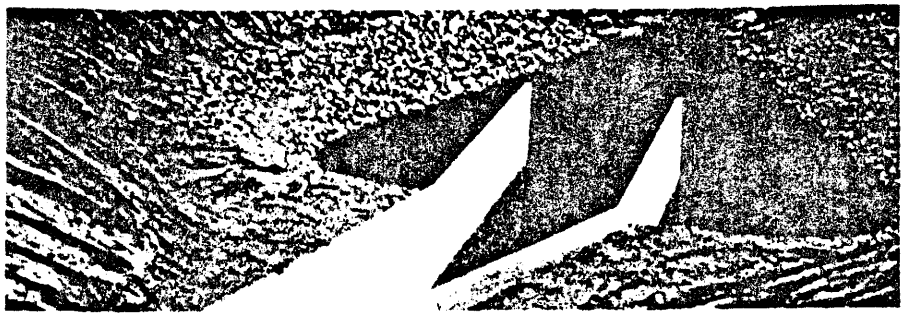
1. These basins allow silt to settle out as water slowly discharges over the discharge or spillway.
2. They may be temporary or permanent, and should be designed and built accordingly.
3. Local regulations relative to safety need to be considered.
4. Size and volume must be developed to meet the run-off control demands.



PLAN VIEW



ELEVATION VIEW



GRADED RIPRAP STONE

Size Inches (sq. openings)

NCSA No.	Max.	Avg.	Min.
R-2	3	1½	1
R-3	6	3	2
R-4	12	6	3

D. SHORELINES, PONDS AND LAKES

Factors involved:

1. Wind-generated waves cause most of the erosion problems on non-flowing bodies of water.
2. Degree of erosion results from the size and frequency of wind and storms causing various wave heights and the action of power boats.
3. For major bodies of water, subject to intense wave action, a sound engineering study is usually in order before doing any construction with stone.
4. A stone filter layer is usually required if the protective layer of graded riprap is 6 inches or more in thickness.

Height (in Ft.) of Waves at End of Fetch

Wind Velocity (miles/hr.)	300 ft.	1,000 ft.	5 miles
20	0.25	0.40	1.5
30	0.40	0.70	2.4
40	0.65	0.90	3.1
50	0.75	1.2	3.8
60	0.85	1.5	4.5

(Cross section drawing same as in A).

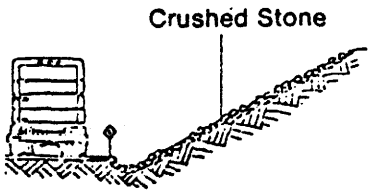
GRADED RIPRAP STONE

Wave Height (ft.)	NCSA No.	Size Inches (sq. openings) Max.	Avg.	Min.	Filter Stone NCSA No.
1.0	R-4	12	6	3	FS-2
1.5	R-5	18	9	5	FS-2
2.0	R-6	24	12	7	FS-3
4.0	R-8	48	24	15	FS-3

E. SLOPE PROTECTION:

Factors involved:

1. Since rainfall run-off, and also snow melt, are the major sources of water for slope erosion, information on local rainfall is important in solving the problem.
2. A uniform layer of stone, properly placed, prevents formation of small rills and gulleys which do become major problems.
3. Size of stone particles and layer thickness vary with slope angle, distance down the slope, type of soil and run-off intensity.
4. Sizes suggested are adequate for slopes not steeper than 1 1/2 horz. to 1 vert.



GRADED RIPRAP STONE

Size Inches (sq. openings)

NCSA No.	Max.	Avg.	Min.
R-2	3	1½	1
R-3	6	3	2
R-4	12	6	3

Special Note:
Crushed stone mulch in a size range of 1½" to 1/4", with about 50% larger than 3/4", is effective in control of erosion on construction slopes. Tests have evaluated results in application from 60 tons per acre to 240 tons per acre. A rate of about 135 tons per acre, which amounts to depths less than one inch, is considered optimum. Stone mulch stays in place, resists breakdown and allows for the growth of grass for appearance as desired. NCSA No. R-1 is recommended.

The complete Universal Soil Loss Equation is: A = RKLSCP

Where A is the computed soil loss (sheet and rill erosion) in tons per acre per year;

R, the rainfall factor, is the number of erosion - index unit computed from the characteristics of rainfall during a normal year, for a given geographical area;

K, the soil erodibility factor, is the erosion rate per unit of erosion - index for a specific soil in cultivated continuous fallow, on a 9 percent slope 72.6 feet long;

L, the slope - length factor, is the ratio of the soil loss from the field slope length to that from a 72.6 feet length on the same soil type and gradient;

S, the slope - gradient factor, is the ratio of soil loss from the field gradient to that from a 9 percent slope;

C, the cropping management factor, is the ratio of soil loss from a field with specified cropping and management, or type of vegetative cover to that from the fallow condition on which the K factor is evaluated;

P, the erosion - control practice factor, is the ratio of soil loss with contouring, stripcropping or terracing to that with straight-row farming, up-and-down slope (generally applies only to cropland).

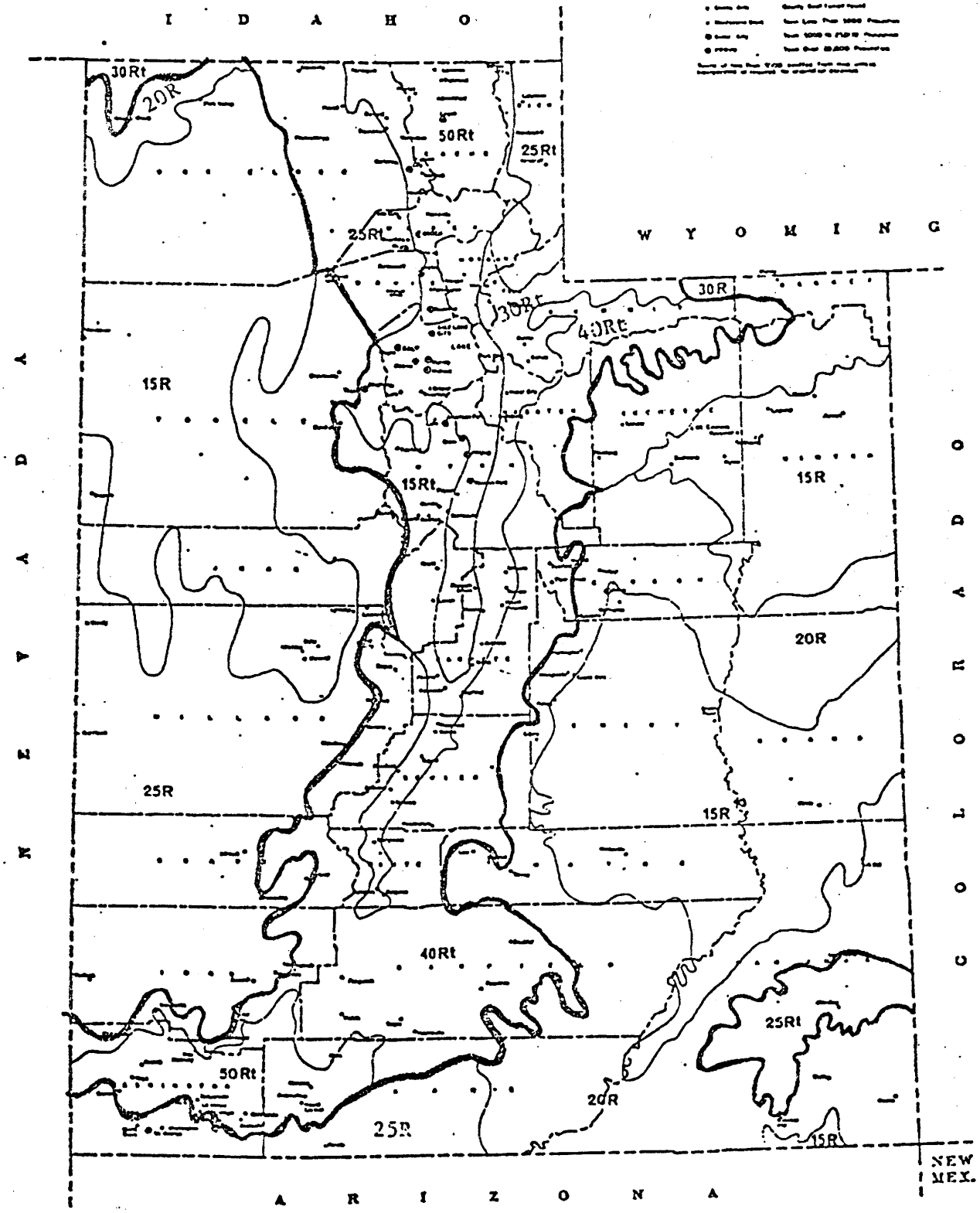
Management decisions generally influence erosion losses by changes in the C and P factors in the USLE. The L factor is modified by terracing. The other three factors, R, K, and S, are fixed for a given location.

FIGURE 1

SOIL CONSERVATION SERVICE

UNIVERSAL SOIL LOSS EQUATION

AVERAGE ANNUAL VALUES FACTOR R and Rt



R - Rainfall Only

Rt - Rainfall and Snowmelt

UTAH

TABLE 1 (Continued)

Percent Slope	Slope Length in Feet 300	400	500	600	700	800	900	1000	1100	1200	1300	1500	1700	2000
0.2	0.11	0.12	0.13	0.14	0.15	0.15	0.16	0.16	0.17	0.17	0.18	0.19	0.19	0.20
0.3	0.12	0.13	0.14	0.15	0.16	0.16	0.17	0.18	0.18	0.18	0.19	0.20	0.21	0.22
0.4	0.13	0.14	0.15	0.16	0.17	0.17	0.18	0.19	0.19	0.20	0.20	0.21	0.22	0.23
0.5	0.14	0.15	0.16	0.17	0.18	0.18	0.19	0.20	0.20	0.21	0.21	0.22	0.23	0.24
1.0	0.18	0.20	0.21	0.22	0.23	0.24	0.25	0.26	0.27	0.27	0.28	0.29	0.30	0.32
2.0	0.28	0.31	0.33	0.34	0.36	0.38	0.39	0.40	0.41	0.42	0.43	0.45	0.47	0.49
3.0	0.40	0.44	0.47	0.49	0.52	0.54	0.56	0.57	0.59	0.61	0.62	0.65	0.67	0.71
4.0	0.62	0.70	0.76	0.82	0.87	0.92	0.96	1.01	1.04	1.08	1.12	1.18	1.24	1.33
5.0	0.93	1.07	1.20	1.31	1.42	1.52	1.61	1.69	1.78	1.86	1.93	2.07	2.21	2.40
6.0	1.17	1.35	1.50	1.65	1.78	1.90	2.02	2.13	2.23	2.33	2.43	2.61	2.77	3.01
8.0	1.72	1.98	2.22	2.43	2.62	2.81	2.98	3.14	3.29	3.44	3.58	3.84	4.09	4.44
10.0	2.37	2.74	3.06	3.36	3.62	3.87	4.11	4.33	4.54	4.74	4.94	5.30	5.65	6.13
12.0	3.13	3.61	4.04	4.42	4.77	5.10	5.41	5.71	5.99	6.25	6.51	6.99	7.44	8.07
14.0	3.98	4.59	5.13	5.62	6.07	6.49	6.88	7.26	7.61	7.95	8.27	8.89	9.46	10.26
16.0	4.92	5.68	6.35	6.95	7.51	8.03	8.52	8.98	9.42	9.83	10.24	11.00	11.71	12.70
18.0	5.95	6.87	7.68	8.41	9.09	9.71	10.30	10.86	11.39	11.90	12.38	13.30	14.16	15.36
20.0	7.07	8.16	9.12	9.99	10.79	11.54	12.24	12.90	13.53	14.13	14.71	15.80	16.82	18.24
25.0	10.20	11.78	13.17	14.43	15.59	16.66	17.67	18.63	19.54	20.41	21.24	22.82	24.29	26.35
30.0	13.78	15.91	17.79	19.48	21.04	22.50	23.86	25.15	26.38	27.55	28.68	30.81	32.80	
40.0	21.92	25.31	28.30	31.00	33.48									
50.0	30.87													
60.0														

Table 9.1.--Runoff curve numbers for hydrologic soil-cover complexes

(Antecedent moisture condition II, and $I_a = 0.2\ S$)

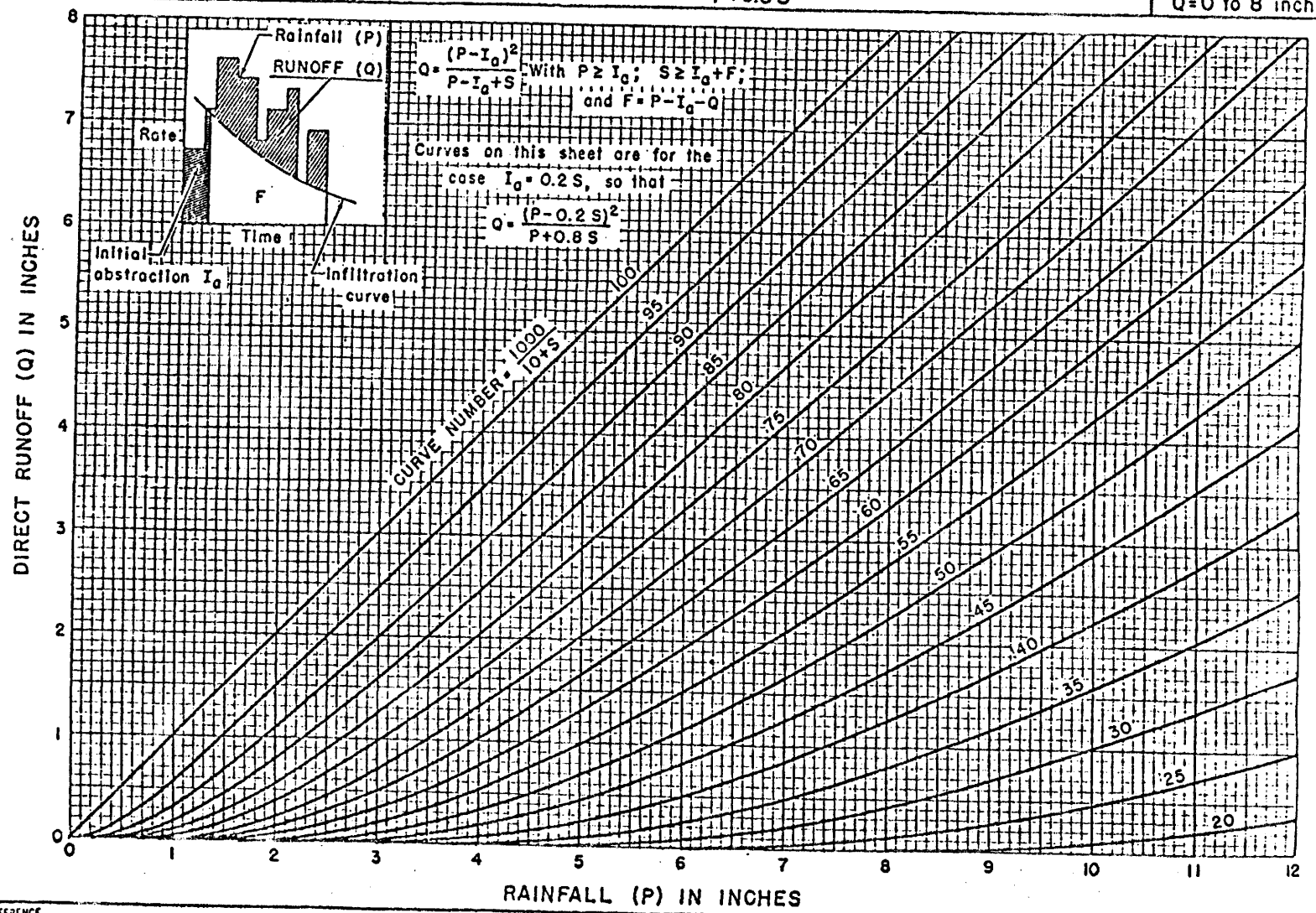
Land use	Cover: Treatment or practice	Cover: Hydrologic condition	Hydrologic soil group A	B	C	D
Fallow	Straight row	----	77	86	91	94
Row crops	"	Poor	72	81	88	91
	"	Good	67	78	85	89
	Contoured	Poor	70	79	84	88
	"	Good	65	75	82	86
	"and terraced	Poor	66	74	80	82
	" " "	Good	62	71	78	81
Small grain	Straight row	Poor	65	76	84	88
		Good	63	75	83	87
	Contoured	Poor	63	74	82	85
		Good	61	73	81	84
	"and terraced	Poor	61	72	79	82
		Good	59	70	78	81
Close-seeded legumes 1/ or rotation meadow	Straight row	Poor	66	77	85	89
	" "	Good	58	72	81	85
	Contoured	Poor	64	75	83	85
	"	Good	55	69	78	83
	"and terraced	Poor	63	73	80	83
	"and terraced	Good	51	67	76	80
Pasture or range		Poor	68	79	86	89
		Fair	49	69	79	84
		Good	39	61	74	80
	Contoured	Poor	47	67	81	88
	"	Fair	25	59	75	83
	"	Good	6	35	70	79
Meadow		Good	30	58	71	78
Woods		Poor	45	66	77	83
		Fair	36	60	73	79
		Good	25	55	70	77
Farmsteads		----	59	74	82	86
Roads (dirt) 2/		----	72	82	87	89
(hard surface) 2/		---	74	84	90	92

1/ Close-drilled or broadcast.
2/ Including right-of-way.

use 80

HYDROLOGY: SOLUTION OF RUNOFF EQUATION $Q = \frac{(P-0.2S)^2}{P+0.8S}$

P = 0 to 12 inches
Q = 0 to 8 inches



REFERENCE

Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
ENGINEERING DIVISION – HYDROLOGY BRANCH

STANDARD DWG. NO.
ES- 1001
SHEET 1 OF 2
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Figure – 10.1 (1 of 2)