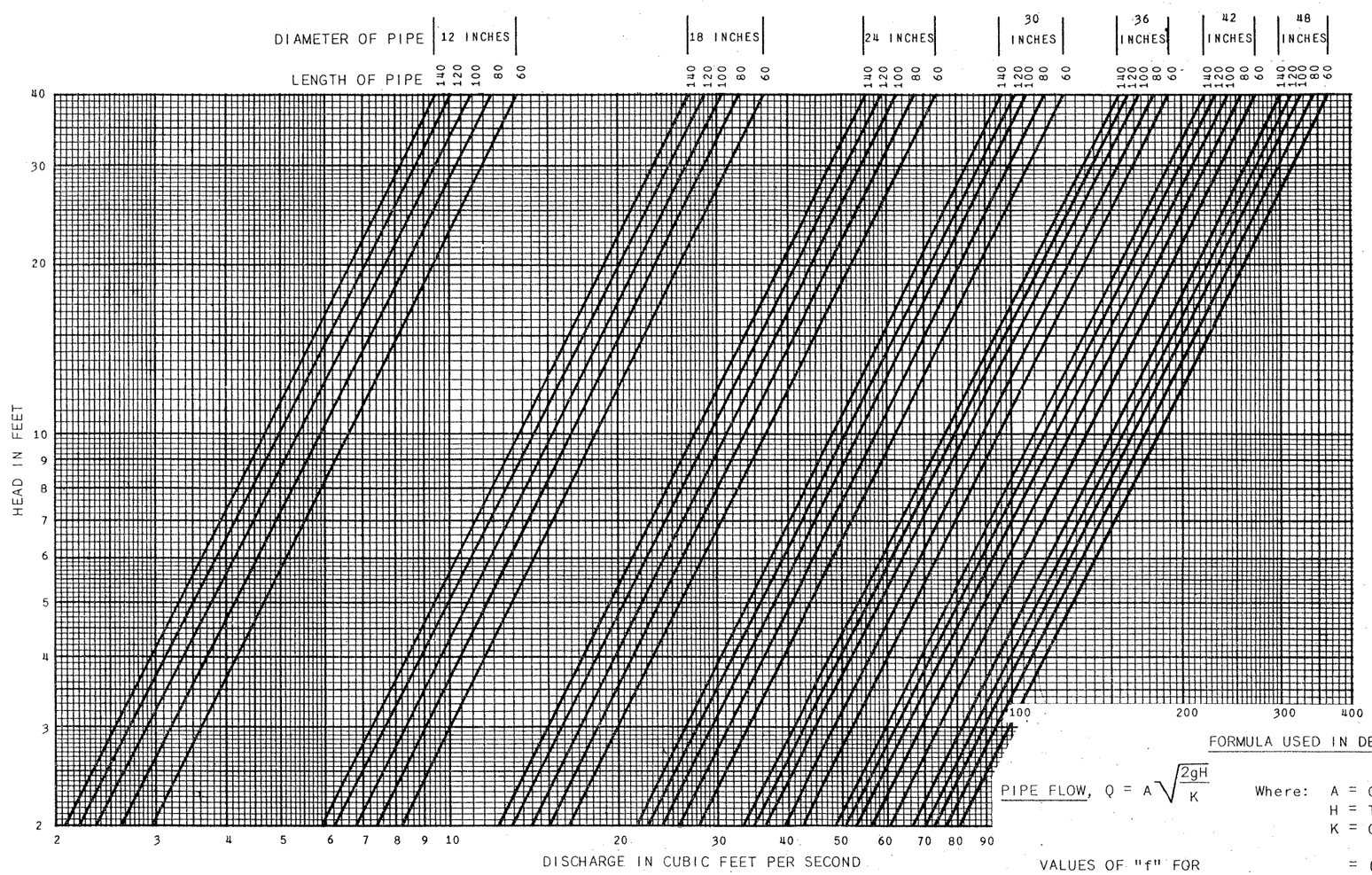


FORMULA USED IN DEVELOPING CURVES

PIPE FLOW, $Q = A\sqrt{\frac{2gH}{K}}$

Where: A = Cross-Sectional Area of Pipe in Sq.Ft.
H = Total Head
K = Coefficient of Losses

$= (1 + K_r + f\frac{L}{D})$ Where:

K_r = Riser Loss Coeff. (Value of 1.0 Used for Pipe Curves)
f = Friction Factor
L = Length of Pipe in Feet
D = Diameter of Pipe in Feet

VALUES OF "f" FOR CORRUG. METAL PIPE

Pipe Dia.	"f" value
1.5'	0.101
2.0'	0.092
2.5'	0.085
3.0'	0.080
3.5'	0.076
4.0'	0.073
4.5'	0.070
5.0'	0.068

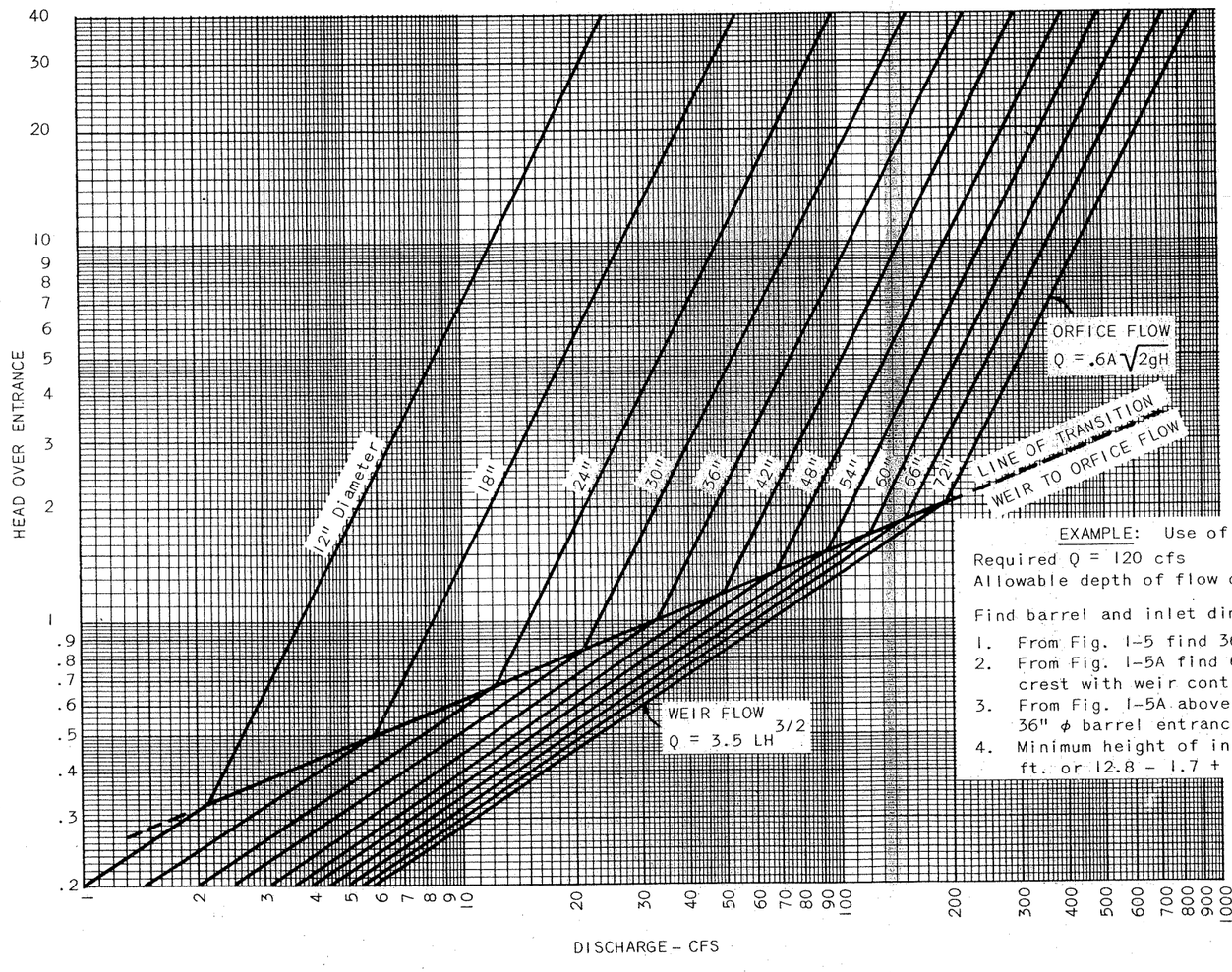
Figure 1-5

CORRUGATED METAL PIPE CAPACITIES FOR DROP INLETS

U.S. DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, Temple, Texas

PAPER NO. 64-725

2-64 4-N-18795-1 of 2



EXAMPLE: Use of Figures 1-5 and 1-5A.

Required Q = 120 cfs Total H = 18.5 ft. Length of barrel = 80 ft.
Allowable depth of flow over inlet crest = 1.8 ft.

Find barrel and inlet dimensions:

1. From Fig. 1-5 find 36" ϕx80 ft. barrel will discharge 121 cfs at 18.5 ft. of head.
2. From Fig. 1-5A find 60" ϕ inlet will pass 121" cfs with 1.7 ft. of head over inlet crest with weir control.
3. From Fig. 1-5A above the line of transition find 12.8 ft. of head from center of 36" ϕ barrel entrance is required for a 121 cfs discharge.
4. Minimum height of inlet above center of barrel entrance: 12.8 ft. – 1.7 = 11.1 ft. or 12.8 – 1.7 + 1.5 = 12.6' from invert of barrel entrance.

Figure 1-5A

HEAD-DISCHARGE RELATIONSHIPS FOR CORRUGATED METAL DROP INLETS

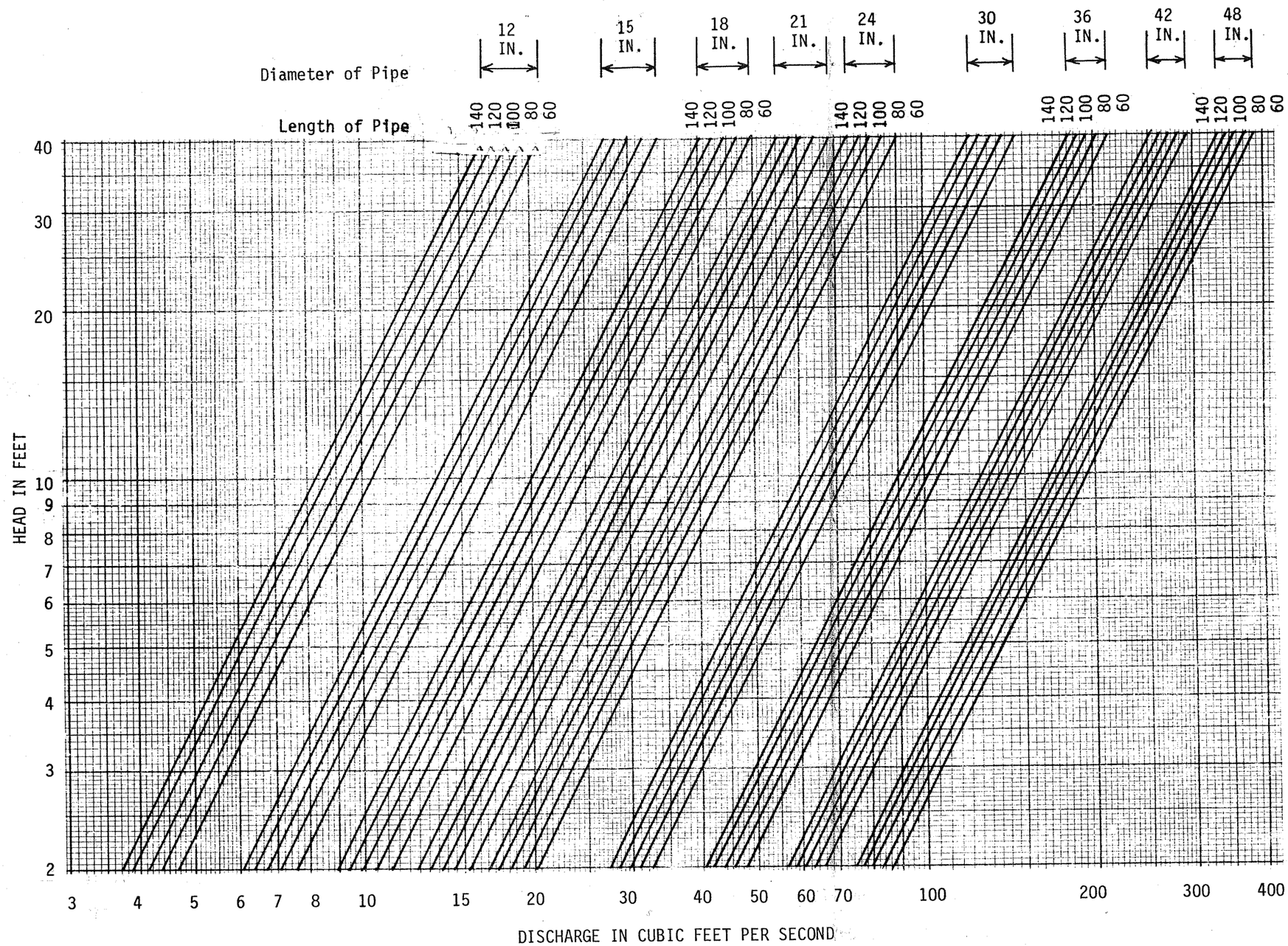


Figure 1-5 B
HELICAL CORRUGATED METAL PIPE CAPACITIES FOR DROP INLETS

FORMULA USED IN DEVELOPING CURVES

Pipe Flow, $Q = A\sqrt{\frac{2gH}{K}}$ where

A = Cross-sectional area of pipe in square feet

H = total head in feet

K = Coefficient of Losses

$= (1 + K_r + f\frac{L}{D})$

K_r = Riser Loss Coeff. (Value of 1.0)

f = Friction Factor

L = Length of Pipe in feet

D = Diameter of Pipe in feet

Values of "f" for HELICAL Corrug. metal pipe

Pipe Diameter (In)	"f" Value*
12	0.027
15	0.029
18	0.032
21	0.035
24	0.038
30	0.039
36	0.042
42	0.044
48	0.047

* Based on 2-2/3" X 1/2" corrugations.

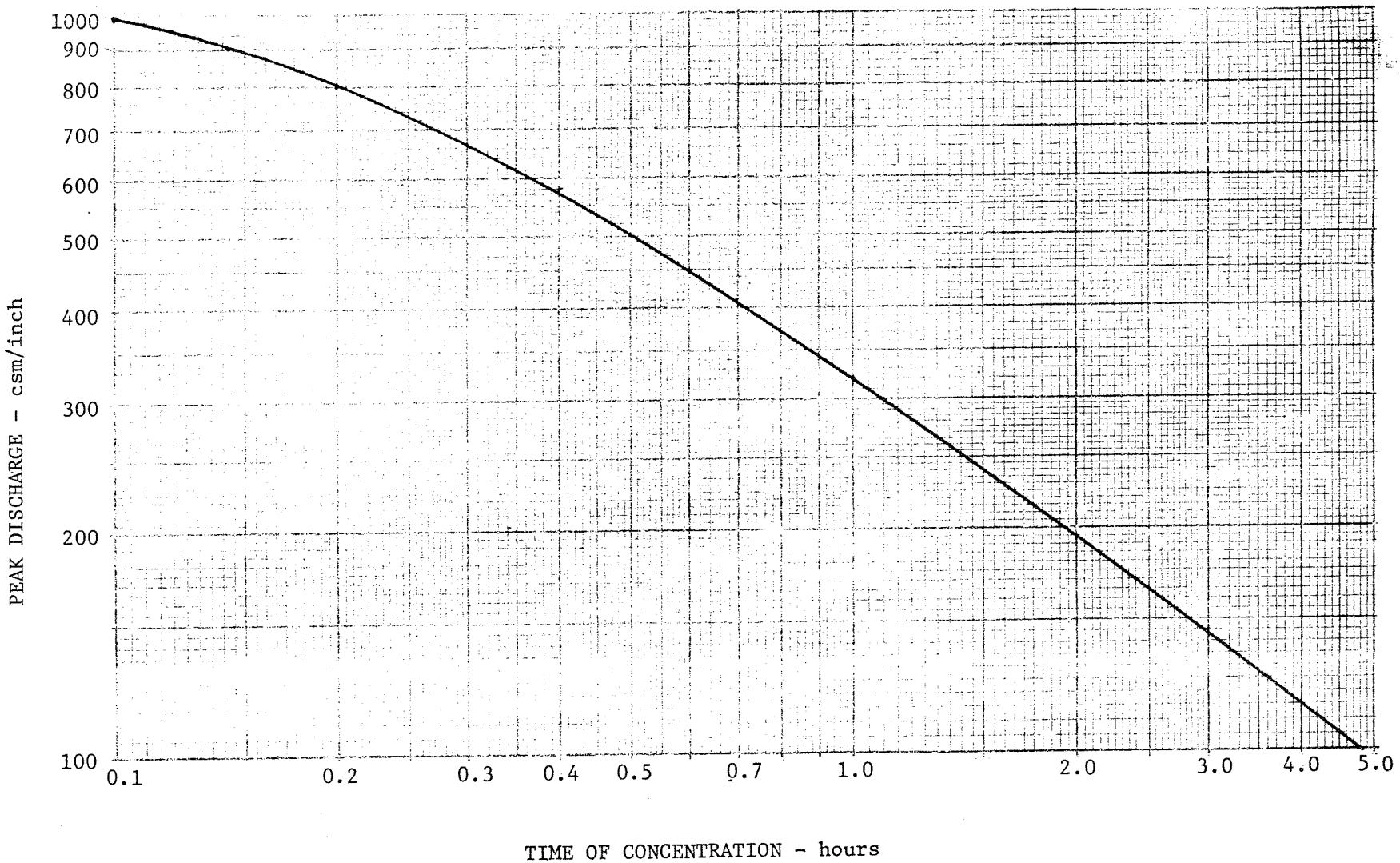
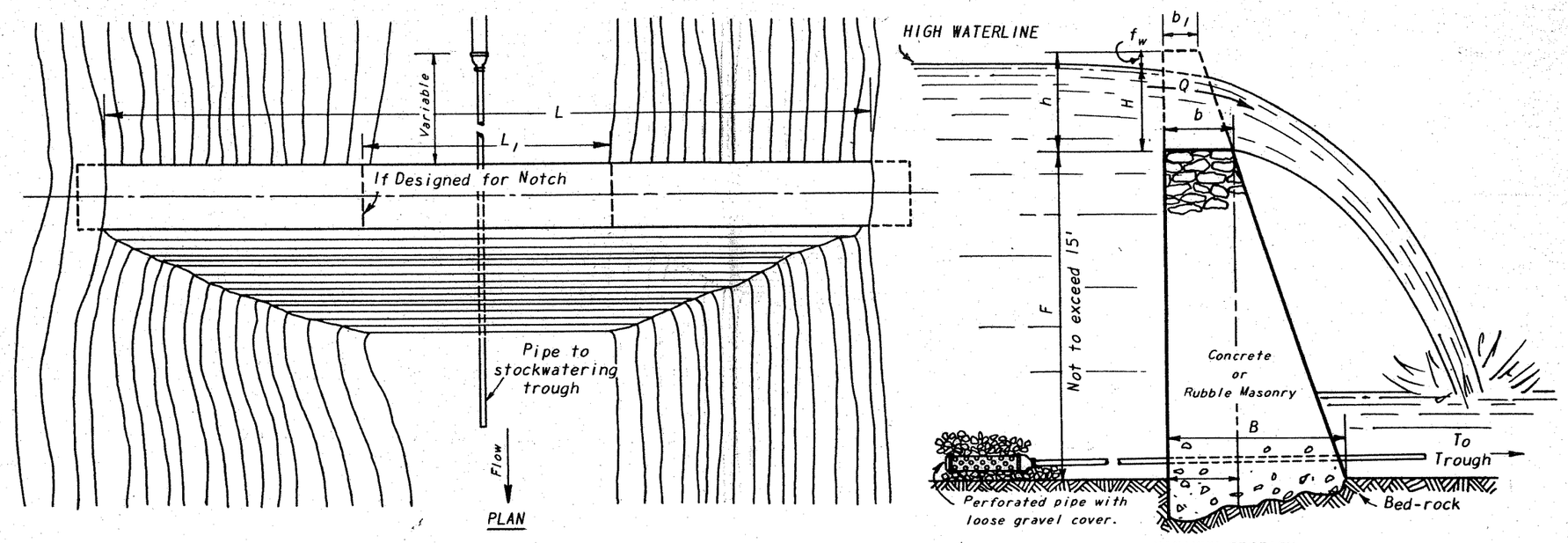


Figure 1-6 -- Peak discharge in csm per inch of runoff versus time of concentration (T_c) for 24-hour type-II storm distribution.



Without Weir Notch Overflow Full Length of Dam

- F — Height of Dam or Headwall
- Q — Discharge Over Crest in C.F.S.
- B — Width of Dam at Base 0.65 (F + H)
- b — 0.65 H (To be not less than 12" for concrete and 18" for masonry)
- H — Head on crest (Does not include velocity head)
- L — Length of Dam at Crest

With Weir Notch and Headwall Extensions

- B — 0.65 (F + h)
- b — 0.65 h (To be not less than 12" concrete and 18" masonry)
- F — Height of Dam or Headwall
- Q — Discharge Through Weir Notch in C.F.S.
- b_1 — Minimum width of Headwall Extension (12" for concrete and 15" for Masonry)
- h — Depth of Weir Notch = $H + f_w$
- f_w — Freeboard
- L_1 — Length of Weir Notch

Note: This type of dam is best adapted to low wide sites where foundations can be carried into solid rock.

$$Q = CL\left(H + \frac{v^2}{2g}\right)^{3/2} \text{ with velocity of approach}$$

$$Q = CLH^{3/2} \text{ without velocity of approach}$$

$$Q = \frac{CLh^{3/2}}{1.10 + 0.01F} \text{ for values of } h$$

or

$$h = \left[\frac{Q\,(1.10 + 0.01F)}{CL}\right]^{2/3}$$

$c = 3.1$ for all cases

Note: If F exceeds 15 feet special design should be prepared.

Reference: 6-N-12103-1 New Mexico, Old Regional Handbook, Section III.

Figure 1-6A

SMALL MASONRY GRAVITY DAM FOR ROCK FOUNDATIONS

U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE

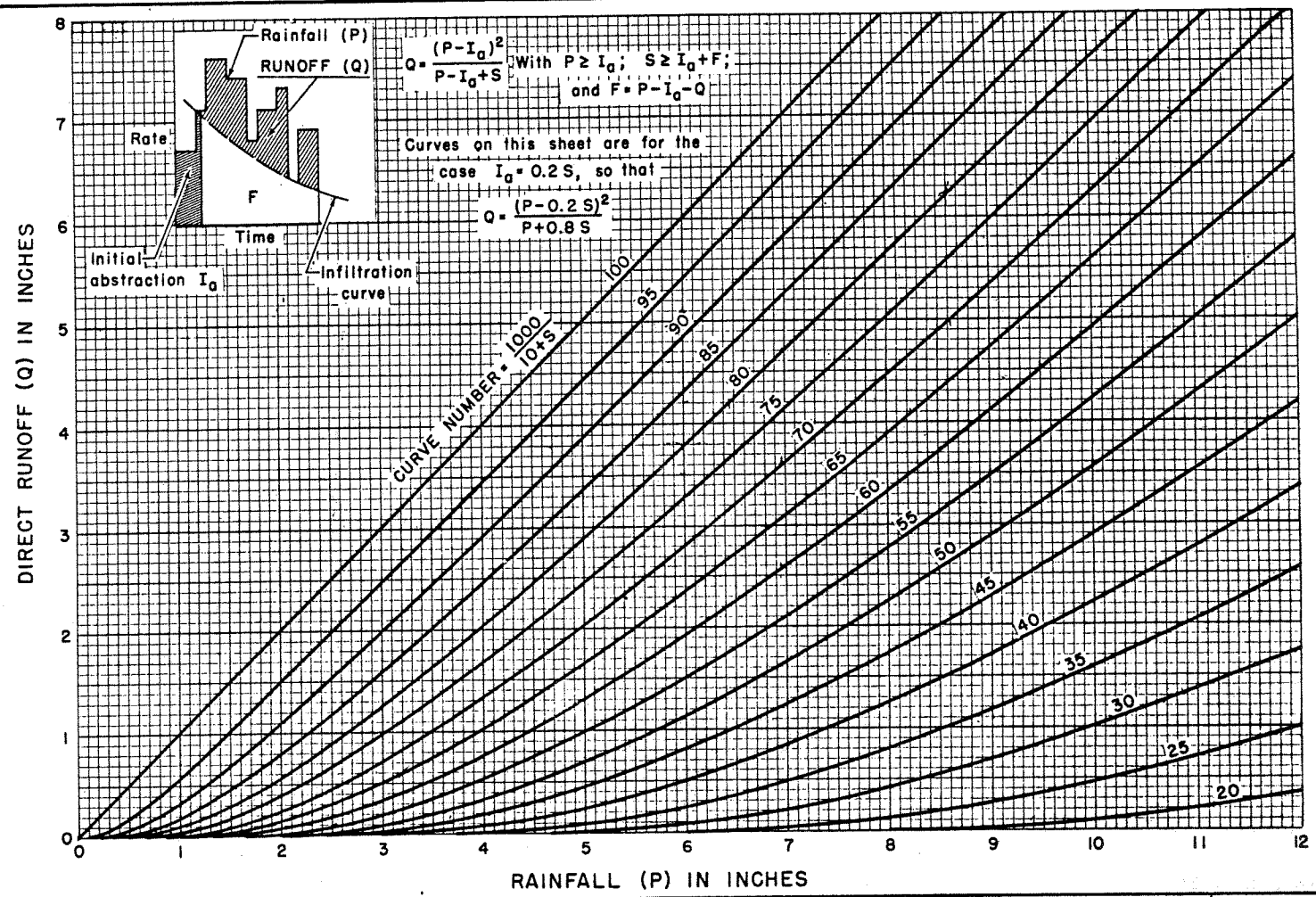
		Date
Designed	H.C.N.-C.M.M.	8-57
Drawn	C.F.L.	7-57
Traced		
Checked	H.C.N.-C.M.M.	

Approved by: Howard Matson
Title: Head, E.&W.P.U.
P.M. Price
Title: State Conc. Engr.
Sheet No. 1 of 1
Drawing No. 4-N-11739

USDA SCS-FORT WORTH, TEX. 1957

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

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

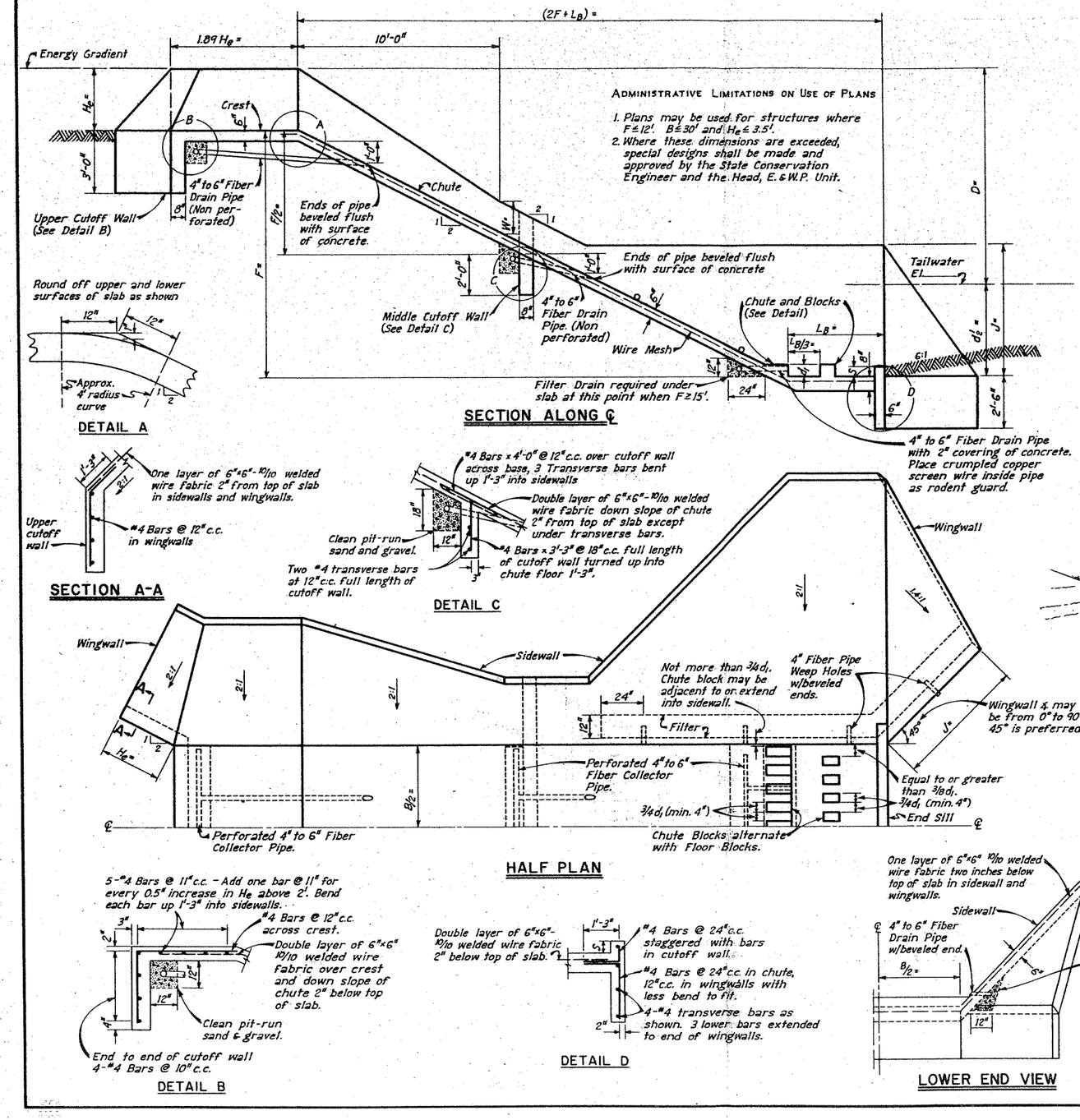


REFERENCE
Mockus, Victor; Estimating direct runoff amounts from storm rainfall: Central Technical Unit, October 1955

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

STANDARD DWG. NO.
ES- 1001
SHEET 1 OF 2
DATE 6-29-56
REVISED 10-1-64

Figure - 1-7

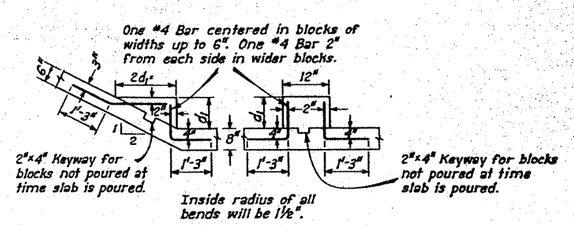


Administrative Limitations on Use of Plans

1. Plans may be used for structures where $F \leq 12'$, $B \leq 30'$ and $H_e \leq 3.5'$.
2. Where these dimensions are exceeded, special designs shall be made and approved by the State Conservation Engineer and the Head, E. & W.P. Unit.

Symbols

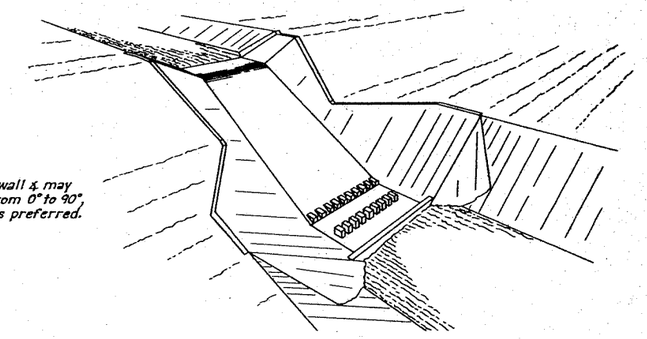
B - Bottom width of chute, in feet.
D - Difference in elevation from energy gradient at crest section to tailwater surface below stilling basin, in feet.
d_1 - Entrance depth of water at stilling basin immediately above chute blocks. Also height of blocks, in feet. Depth measured normal to chute floor.
d_2 - Elevation of tailwater surface above stilling basin floor, in feet.
F - Difference in elevation between crest of chute and stilling basin, in feet.
H_e - Energy head at crest = depth of water + velocity head ($V^2/2g$), in feet.
J - Height of sidewalls of stilling basin, in feet.
L_B - Length of stilling basin, in feet.
Q - Designed capacity of chute spillway, in c.f.s.
s - Height of transverse end sill, in feet.
w - Height of walls of chute 10' downstream from crest, in feet.
v_1 - Velocity in chute section immediately above chute blocks, in feet/second.



CHUTE BLOCK DETAIL FLOOR BLOCK DETAIL

Notes

1. Floor and chute blocks should be poured at time slab is poured.
2. Floor blocks must occupy from 40% to 55% of the stilling basin width at the location of the floor blocks.
3. An Alternate procedure may be used as follows:
   a. Blocks to be formed and poured after the slab is poured.
   b. Steel from the slab to be turned up for use in the floor and chute blocks prior to forming for the blocks.



PERSPECTIVE VIEW

Design based on Engineering Handbook, Section 14, Chute Spillways, except sidewalls are laid back on a 2:1 slope.

FORMLESS CONCRETE CHUTE SPILLWAY
STRUCTURE DETAILS

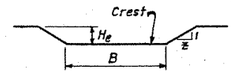
U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	B.H.B. & C.M.M.	3-61	Approved by: Head, Engineering & Watershed Planning Div., Fort Worth, Texas
Drawn	E.C.B. & N.J.P.	6-62	State Conservation Engineer
Traced	N.J.P.	6-62	Sheet No. 1 of 2 — Drawing No. 4-E-15,030
Checked	E.C.B. & C.M.M.	7-62	

Design Procedure

Step 1:
Determine the following items from field investigations:
a. Q
b. Tailwater elevation
c. Crest elevation

Step 2:
Choose "H_e" and "B" from the following chart based on $Q = 3.1\ B\ H_e^{3/2} + 2.17\ H_e^{5/2} \times Z$.



Q, c.f.s. for Z = 2:1

	H_e	2.0	2.5	3.0	3.5	4.0	4.5	5.0
	10	112.3	165.3	228.9	302.5	386.9	482.5	589.2
	15	156.2	226.6	309.5	404.0	510.9	630.5	762.5
	20	200.0	287.8	390.1	505.6	634.9	778.5	935.8
B	25		349.0	470.7	607.1	758.9	926.5	1109.1
	30			551.3	708.6	882.9	1074.6	1282.3
	35				810.1	1006.9	1222.6	1455.6
	40					1130.9	1370.6	1628.9

Step 3:
Find D from the following formula:
D = (Crest elevation + H_e) − Water surface elevation below stilling basin.

Step 4:
Solve for the following dimensions using the chart of formula constants as needed.
Note: 1. "F" must be between 5' and 20'.
2. All Negative signs must be observed in using the formulas.

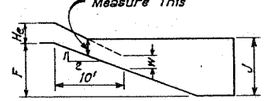
$F = aD + b$ $\quad d_1 = -lD + k$
$L_B = -cD + f$ $\quad d_2' = H_e + (F - D)$
$J = gD + h$ $\quad w = 0.3 + 0.4\ H_e$
$s = 0.10\ d_2'$

Chart of Formula Constants

Dimensions		F		L_B		J		d_1	
Constants		a	b	c	f	g	h	l	k
	2.0	1.027	0.22	.0489	3.93	.0394	3.13	.01022	.484
	2.5	1.041	0.83	.0710	5.38	.0684	4.53	.01468	.646
	3.0	1.047	1.00	.0933	6.74	.0872	5.28	.01866	.821
H_e	3.5	1.052	1.09	.1066	8.08	.0927	6.13	.02341	1.020
	4.0	1.069	1.10	.1389	9.51	.1160	6.84	.02675	1.176
	4.5	1.079	1.15	.1493	10.86	.1182	7.77	.03341	1.414
	5.0	1.096	1.29	.1855	12.40	.1538	8.35	.04047	1.620

Step 5:
If $H_e + (5 - w) \geq H_e + (F - J)$, draw a scale section to find height of sidewall at beginning of stilling basin wall. Otherwise use formula in step 4 above.

Example:
Measure This



Quantities of Materials **

Steel Bars

H_e	Fall (F)-Ft 5: Sides	5: Per Ft. B	10: Sides	10: Per Ft. B	15: Sides	15: Per Ft. B	20: Sides	20: Per Ft. B
	Linear Feet of #4 Bars							
2.0	106.48	46.90	108.98	48.13	111.23	49.93	112.48	52.68
2.5	137.95	46.13	142.07	47.13	146.07	48.57	149.95	50.50
3.0	160.84	56.13	166.07	47.18	171.19	48.24	176.44	49.84
3.5	184.46	55.66	189.96	56.98	195.58	58.72	201.08	49.86
4.0	207.15	56.30	214.03	57.39	220.78	58.80	227.65	60.81
4.5	231.76	56.81	238.51	57.74	245.51	59.01	252.26	60.76
5.0	249.62	57.86	262.00	58.70	270.75	59.88	279.50	61.58

Example:
$H_e = 3.5'$, $F = 20'$, $B = 18'$.
Total length required = 201.08 + (49.86 × 18) = 1098.56'.

Notes Concerning Steel Bars:
1. All bars are #4, Wt. = Length (Ft) × 0.668 $\left(\frac{\text{Pounds}}{\text{Ft.}}\right)$
2. Lengths above heavy line include one bar each per chute block and floor block. Lengths below heavy line include two bars each per chute block and floor block.
3. Bars should be cut and bent as they are placed.

Wire Mesh

H_e	Fall (F)-Ft. 5: Sides	5: Per Ft. B	10: Sides	10: Per Ft. B	15: Sides	15: Per Ft. B	20: Sides	20: Per Ft. B
	Square Yards of 6"×6"-10/10 Wire Mesh							
2.0	25.08	3.77	28.68	6.21	34.48	8.64	40.28	11.07
2.5	44.48	4.30	48.26	6.71	56.34	9.11	64.46	11.52
3.0	61.30	4.79	65.56	7.18	75.64	9.56	85.70	11.95
3.5	81.72	5.29	86.10	7.66	97.40	10.04	109.04	12.41
4.0	103.78	5.79	109.78	8.13	122.12	10.47	136.14	12.81
4.5	130.92	6.30	137.54	8.63	149.82	10.96	165.32	13.29
5.0	157.12	6.38	166.68	9.13	180.74	11.42	200.02	13.72

Example:
$H_e = 3.5'$, $F = 20'$, $B = 18'$.
Total area of mesh required = 109.04 + (12.41 × 18) = 332.42 Sq. Yds.

Notes Concerning Wire Mesh:
1. These numbers indicate the actual area to be covered by wire mesh, including a double thickness on the channel bottom. Consult with contractor or supplier to estimate the additional amount that is ordinarily wasted.
2. Experience indicates that the first layer of mesh should be placed in strips running across the channel.
3. If practical, get rolls 5'-6" wide for second layer in bottom and lay lengthways.

Concrete

H_e	Fall (F)-Ft. 5: Sides	5: Per Ft. B	10: Sides	10: Per Ft. B	15: Sides	15: Per Ft. B	20: Sides	20: Per Ft. B
	Cubic Yards of Concrete							
2.0	4.36	0.537	4.98	0.739	6.02	0.940	7.04	1.140
2.5	7.62	0.589	8.28	0.788	9.68	0.987	11.10	1.185
3.0	10.46	0.639	11.18	0.835	12.92	1.032	14.66	1.228
3.5	13.90	0.689	14.64	0.883	16.58	1.078	18.58	1.273
4.0	17.60	0.738	18.60	0.930	20.72	1.120	23.12	1.310
4.5	22.16	0.788	23.26	0.978	25.36	1.169	28.00	1.359
5.0	26.56	0.841	28.16	1.028	30.54	1.215	33.80	1.401

Example:
$H_e = 3.5'$, $F = 20'$, $B = 18'$.
Vol. of Concrete = 18.58 + (18 × 1.273) = 18.58 + 22.91 = 41.49 Cu. Yds.

Notes Concerning Concrete:
Volumes shown above are to line and grades and do not include over-run due to rough grading, over-cutting, etc. Volumes should be adjusted depending on accuracy of grading operations.

** Tables used for computing quantities apply only to 2:1 bottom slope of chute and 2:1 side slopes.

General Construction Notes

1. Concrete will be Class "C". Strength at 28 day test to be not less than 2500 #/in².
2. Wire mesh will be:
   a. 6"×6"-10/10 welded wire fabric or equivalent.
   b. Single layer in wingwalls and sidewalls.
   c. Double layer in floor of chute and apron.
   d. Lapped one square.
   e. Placed on brick or concrete blocks for support.
3. All splices of reinforcing bars to be 15" min.
4. Fiber pipe will conform to Standard Material Specification 120-58.
5. All steel reinforcement will conform to Standard Material Specification 103-58.
6. Construction Joints shall be no closer than 10' horizontally and Steel shall be continuous through the joints.

Complete Examples

Design:
Step 1: Q = 500 c.f.s., Tailwater Elev. = 750.0', Crest Elev. = 757.5'.
Step 2: $H_e = 3.5'$, $B = 20'$
Step 3: D = (757.5 + 3.5) − 750.0 = 11.0'
Step 4: F = (1.052 × 11.0) + 1.09 = 11.57 + 1.09 = 12.66'
L_B = (−0.1066 × 11.0) + 8.08 = −1.17 + 8.08 = 6.91'
J = (0.0927 × 11.0) + 6.13 = 1.02 + 6.13 = 7.15'
d_1 = (−0.02341 × 11.0) + 1.020 = −0.258 + 1.020 = .76'
d_2' = 3.5 + (12.66 − 11.0) = 5.16'
w = 0.3 + 0.4 × 3.5' = 0.3 + 1.40 = 1.70'
s = 0.10 × 5.16 = 0.52'
Step 5: 3.5 + (5 − 1.70) = 6.8'
3.5 + (12.66 − 7.15) = 9.01'
6.8' < 9.01'
∴ w = 1.70' is correct

Quantities: When F is not equal to 5', 10', 15', or 20', quantities must be interpolated.

Steel Bars (Let F = 12.7', B = 20', H_e = 3.5')
Total Length = "Sides" + "Per Ft. B"
(1) Find "Sides" for F of 12.7' (interpolate between F = 10 and F = 15).
Subtract: 195.58' − 189.96' = 5.62'
Construct the ratio or constant: $\frac{12.7 - 10}{15 - 10} = \frac{2.7}{5} = .54$; 5.62 × .54 = 3.03'
Add: 189.96' + 3.03' = 192.99'
(2) Find "Per Ft. B" for F of 12.7' (interpolate between F = 10 and F = 15).
Subtract: 58.72' − 56.98' = 1.74'
Using the constant derived in step (1) above: 1.74' × .54 = 0.94'
Add: 56.98' + 0.94' = 57.92'
Total Length = 192.99' + 20 (57.92) = 1351.39'
Weight = 1352 ft. × 0.668 lbs./ft. = 903 lbs.

Wire Mesh (Let F = 12.7', B = 20', H_e = 3.5')
Total Area = "Sides" + "Per Ft. B"
(1) Find "Sides" for F of 12.7' (interpolate between F = 10 and F = 15 as above, using table of Wire Mesh Quantities).
Area = 92.20 sq. yds.
(2) Find "Per Ft. B" for F of 12.7' (interpolate between F = 10 and F = 15 as above, using table of Wire Mesh Quantities).
Area = 20 (8.95) = 179.00 sq. yds.
Total Area = 92.20 sq. yds. + 179.00 sq. yds. = 271.20 sq. yds.

Concrete (Let F = 12.7', B = 20', H_e = 3.5')
Total Volume = "Sides" + "Per Ft. B"
(1) Find "Sides" for F of 12.7' (interpolate between F = 10 and F = 15 as above, using table of Concrete Quantities).
Volume = 15.69 cu. yds.
(2) Find "Per Ft. B" for F = 12.7' (interpolate between F = 10 and F = 15 as above, using table of Concrete Quantities).
Volume = 20 (0.988) = 19.76 cu. yds.
Total Volume = 15.69 cu. yds. + 19.76 cu. yds. = 35.45 cu. yds.
Increase estimate of concrete by approximately 5% to compensate for overcutting, waste, etc.

Revised 2-14-63
Revised 9-26-62

Range of Application of This Design

H_e = 2.0' to 5.0'
B = 10.0' to 40'
F = 5.0' to 20'

Notes:
Administrative approval limited to F ≤ 12'
B ≤ 30' and H_e ≤ 3.5'. Special design required where these limitations are exceeded.

Tailwater depth must be accurately determined in all cases.

FORMLESS CONCRETE CHUTE SPILLWAY
DESIGN DATA

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

		Date	
Designed	B.H.B. & C.M.M.	3-61	Approved by ... HEAD, ENGINEERING & WATERSHED PLANNING UNIT, FORT WORTH, TEXAS
Drawn	E.C.B. & N.J.P.	6-62	STATE CONSERVATIONIST, TULSA, O. K.
Traced	N.J.P.	6-62	Sheet No. 2 of 2 — Drawing No. 4-E-15,030
Checked	E.C.B. & C.M.M.	7-62	