Flow Depth:

The value of bottom width (b) divided by depth of flow (d) should not exceed a value of 50. This b/d ratio of 50 has been arbitrarily selected as a maximum value to prevent a very shallow flow in a relatively wide rock chute which might result in non-uniform flow conditions.

The critical depth encountered at the junction of the entrance section and the chute section is dependent upon the flow depth in the inflow waterway or side inlet. For design purposes, the critical depth will be considered as 0.7 the flow depth in the waterway upstream.

With a free outlet condition for the chute, flows will go through a hydraulic jump in the outlet section. The height of the hydraulic jump and the location where the jump occurs, measured from the junction of the chute section and outlet section, depends upon the velocity and depth of flow in the chute section and the tailwater depth created by flow in the outlet channel. For design purposes, the height of the jump is considered to be twice the flow depth in the chute (2 d).

Design Charts:

With a known design Q and d50 rock size, the charts in Figure IN-6-9 will give a design chute bottom width (b), flow depth (d) and velocity (v) for nine d50 rock sizes (4", 5", 6", 7", 8", 9", 10", 11" and 12") for chute profile slopes from 5:1 to 10:1 with 2:1 and 3:1 side slopes. These values were determined using the "n" values from Figure IN-6-7. The flow depth (d) shown, from 0.5 feet (minimum recommended design depth) to 1.5 feet, assumes that uniform flow is attained in the chute section. Bottom width (b) shown is from 2 feet to 30 feet in 2 foot increments. Values in the tables exceeding 150 cfs or exceeding the allowable velocity shown in Figure IN-6-8 are shown for reference and should not be used.

Chute Section:

The constructed depth of the chute section should allow for 0.5 feet freeboard. This total depth (d + 0.5) is shown as "dc" on the data sheet (IN-ENG-36).

The horizontal chute section length (Lc) is equal to the chute profile slope (S) times the overfall (F).

The slope length of the chute section (Ls) is equal to $F(S^2 + 1)^{0.5}$.

ROCK LINED CHUTE CAPACITY

Rock d50 size: 4 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2																						
4																						
6																						
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
30																						

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Rock d50 size: 4 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2																						
4																						
6																						
8																						
10																						
12																						
14																						
16																						
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Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 1 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 4 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2																						
4																						
6																						
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
30																						

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Rock d50 size: 4 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d;	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.9	10																				
4																						
6																						
8																						
10																						
12																						
14																						
16																						
18																						
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Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 2 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 4 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.6	8																				
4	6.1	15																				
6																						
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
30																						

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ck d50 size: 4 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.5	10																				
4																						
6																						
8																						
10																						
12																						
14																						
16																						
18																						
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Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 3 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 4 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.3	8																				
4	5.7	14																				
6	5.9	21																				
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
30																						

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Rock d50 size: 4 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.1	9																				
4	5.5	15																				
6	5.8	22																				
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
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Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 4 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 4 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.0	7	5.8	11																		
4	5.4	13																				
6	5.6	20																				
8	5.7	26																				
10	5.8	32																				
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
30																						

Rock d50 size: 4 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.8	8	5.7	13																		
4	5.2	14																				
6	5.5	20																				
8	5.6	27																				
10	5.7	33																				
12	5.8	39																				
14	5.8	45																				
16	5.9	51																				
18																						
20																						
22																						
24																						
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 5 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 4 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.7	7	5.5	11																		
4	5.1	13	6.0	19																		
6	5.3	19																				
8	5.4	24																				
10	5.5	30																				
12	5.6	36																				
14	5.6	42																				
16	5.6	48																				
18	5.7	54																				
20	5.7	60																				
22	5.7	66																				
24	5.7	72																				
26																						
28																						
30																						

Rock d50 size: 4 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 5.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.6	8	5.4	12																		
4	5.0	14	5.8	20																		
6	5.2	19																				
8	5.3	25																				
10	5.4	31																				
12	5.5	37																				
14	5.5	43																				
16	5.6	49																				
18	5.6	55																				
20	5.6	61																				
22	5.7	66																				
24	5.7	72																				
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 6 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 5 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.9	9																				
4	6.4	16																				
6	6.6	23																				
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
30																						

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Rock d50 size: 5 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.7	10																				
4	6.2	17																				
6	6.5	24																				
8																						
10																						
12																						
14																						
16																						
18																						
20																						
22																						
24																						
26																						
28																						
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Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 7 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 5 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.4	8	6.4	12																		
4	5.8	15	6.9	22																		
6	6.0	21																				
8	6.2	28																				
10	6.3	35																				
12	6.3	41																				
14	6.4	48																				
16	6.4	55																				
18																						
20																						
22																						
24																						
26																						
28																						
30																						

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Rock d50 size: 5 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.2	9	6.2	14																		
4	5.7	16																				
6	5.9	22																				
8	6.1	29																				
10	6.2	35																				
12	6.2	42																				
14	6.3	49																				
16	6.3	56																				
18	6.4	62																				
20	6.4	69																				
22	6.4	76																				
24	6.5	82																				
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 8 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 5 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.0	7	5.9	11																		
4	5.4	13	6.4	20																		
6	5.6	20																				
8	5.7	26																				
10	5.8	32																				
12	5.9	38																				
14	5.9	44																				
16	6.0	51																				
18	6.0	57																				
20	6.0	63																				
22	6.0	69																				
24	6.0	76																				
26																						
28																						
30																						

Rock d50 size: 5 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.8	8	5.7	13																		
4	5.2	14	6.2	22																		
6	5.5	20																				
8	5.6	27																				
10	5.7	33																				
12	5.8	39																				
14	5.8	45																				
16	5.9	51																				
18	5.9	58																				
20	5.9	64																				
22	6.0	70																				
24	6.0	76																				
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 9 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 5 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.6	7	5.5	11	6.3	15																
4	5.0	13	6.0	19	6.9	26																
6	5.2	18	6.3	27																		
8	5.4	24	6.4	35																		
10	5.4	30																				
12	5.5	36																				
14	5.5	42																				
16	5.6	47																				
18	5.6	53																				
20	5.6	59																				
22	5.6	65																				
24	5.7	71																				
26																						
28																						
30																						

Rock d50 size: 5 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.5	8	5.4	12	6.1	18																
4	4.9	13	5.8	20																		
6	5.1	19	6.1	29																		
8	5.2	25	6.3	37																		
10	5.3	31	6.4	45																		
12	5.4	36	6.5	54																		
14	5.5	42																				
16	5.5	48																				
18	5.5	54																				
20	5.6	60																				
22	5.6	66																				
24	5.6	71																				
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 10 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

.ock d50 size: 5 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	
2	4.4	7	5.2	10	5.9	14																
4	4.7	12	5.7	18	6.5	25																
6	4.9	17	5.9	25																		
8	5.1	23	6.1	33																		
10	5.1	28	6.2	41																		
12	5.2	34	6.2	49																		
14	5.2	39	6.3	57																		
16	5.3	45	6.3	65																		
18	5.3	50	6.4	73																		
20	5.3	56	6.4	81																		
22	5.3	61	6.4	89																		
24	5.3	67																				
26																						
28																						
30																						

Rock d50 size: 5 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	
2	4.2	7	5.0	12	5.8	17																
4	4.6	13	5.5	19	6.3	27																
6	4.8	18	5.7	27																		
8	4.9	23	5.9	35																		
10	5.0	29	6.0	43																		
12	5.1	34	6.1	51																		
14	5.1	40	6.2	59																		
16	5.2	45	6.2	67																		
18	5.2	51	6.3	74																		
20	5.2	56	6.3	82																		
22	5.3	62	6.3	90																		
24	5.3	67	6.4	98																		
26			6.4	106																		
28			6.4	114																		
30			6.4	122																		

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 5 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.1	6	4.9	9	5.6	13	6.3	18														
4	4.5	11	5.4	17	6.2	23	6.9	31														
6	4.7	16	5.6	24	6.4	33																
8	4.8	22	5.7	32																		
10	4.9	27	5.8	39																		
12	4.9	32	5.9	47																		
14	5.0	37	6.0	54																		
16	5.0	42	6.0	62																		
18	5.0	48	6.0	70																		
20	5.0	53	6.1	77																		
22	5.0	58	6.1	85																		
24	5.1	63	6.1	92																		
26			6.1	100																		
28			6.1	107																		
30			6.1	115																		

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Rock d50 size: 5 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 6.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.0	7	4.8	11	5.5	16	6.2	22														
4	4.4	12	5.2	18	6.0	26																
6	4.6	17	5.4	25	6.3	36																
8	4.7	22	5.6	33	6.5	46																
10	4.8	27	5.7	40																		
12	4.8	33	5.8	48																		
14	4.9	38	5.9	56																		
16	4.9	43	5.9	63																		
18	4.9	48	5.9	71																		
20	5.0	53	6.0	78																		
22	5.0	59	6.0	86																		
24	5.0	64	6.0	93																		
26			6.1	101																		
28			6.1	109																		
30			6.1	116																		

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 12 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 6 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.2	8	6.3	12																		
4	5.7	14	6.8	21																		
6	5.9	21	7.1	31																		
8	6.0	27																				
10	6.1	34																				
12	6.2	40																				
14	6.2	47																				
16	6.3	53																				
18	6.3	60																				
20	6.3	66																				
22	6.4	73																				
24	6.4	80																				
26																						
28																						
30																						

Rock d50 size: 6 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	5.1	9	6.1	14																		
4	5.5	15	6.6	23																		
6	5.8	22	6.9	33																		
8	5.9	28																				
10	6.0	35																				
12	6.1	41																				
14	6.1	48																				
16	6.2	54																				
18	6.2	61																				
20	6.3	67																				
22	6.3	74																				
24	6.3	80																				
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 13 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 6 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.8	7	5.7	11	6.6	16																
4	5.2	13	6.2	19	7.2	27																
6	5.4	19	6.5	28																		
8	5.5	25	6.7	37																		
10	5.6	31	6.8	46																		
12	5.7	37	6.9	54																		
14	5.7	43	6.9	63																		
16	5.7	49																				
18	5.8	55																				
20	5.8	61																				
22	5.8	67																				
24	5.8	73																				
26																						
28																						
30																						

Rock d50 size: 6 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.6	8	5.6	13	6.5	19																
4	5.0	14	6.1	21																		
6	5.3	20	6.3	30																		
8	5.4	26	6.5	38																		
10	5.5	32	6.7	47																		
12	5.6	38	6.7	56																		
14	5.6	43	6.8	65																		
16	5.7	49	6.9	73																		
18	5.7	55	6.9	82																		
20	5.7	61	7.0	91																		
22	5.7	67	7.0	100																		
24	5.8	73																				
26																						
28																						
30																						

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 14 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 6 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.4	7	5.3	10	6.1	15	6.9	20														
4	4.8	12	5.8	18	6.7	25																
6	5.0	17	6.0	26	7.0	36																
8	5.1	23	6.2	34																		
10	5.2	28	6.3	42																		
12	5.2	34	6.4	50																		
14	5.3	40	6.4	59																		
16	5.3	45	6.5	67																		
18	5.3	51	6.5	75																		
20	5.4	56	6.5	83																		
22	5.4	62	6.6	91																		
24	5.4	67	6.6	99																		
26			6.6	108																		
28			6.6	116																		
30			6.6	124																		

Rock d50 size: 6 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.3	8	5.2	12	6.0	17	6.7	24														
4	4.7	13	5.6	20	6.5	28																
6	4.9	18	5.9	27	6.8	39																
8	5.0	24	6.0	36																		
10	5.1	29	6.2	44																		
12	5.1	35	6.2	52																		
14	5.2	40	6.3	60																		
16	5.2	46	6.4	68																		
18	5.3	51	6.4	76																		
20	5.3	57	6.4	84																		
22	5.3	62	6.5	93																		
24	5.3	68	6.5	101																		
26			6.5	109																		
28			6.5	117																		
30			6.6	125																		

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 15 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 6 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.1	6	5.0	10	5.7	14	6.5	19														
4	4.5	11	5.4	17	6.3	24	7.1	32														
6	4.7	16	5.6	24	6.6	34																
8	4.8	21	5.8	32	6.7	44																
10	4.8	27	5.9	40	6.9	55																
12	4.9	32	6.0	47	7.0	65																
14	4.9	37	6.0	55																		
16	5.0	42	6.1	62																		
18	5.0	47	6.1	70																		
20	5.0	53	6.1	78																		
22	5.0	58	6.1	85																		
24	5.0	63	6.2	93																		
26			6.2	101																		
28			6.2	108																		
30			6.2	116																		

Rock d50 size: 6 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.0	7	4.8	11	5.6	16	6.3	22														
4	4.4	12	5.2	18	6.1	26	6.9	35														
6	4.6	17	5.5	26	6.4	36																
8	4.7	22	5.7	33	6.6	46																
10	4.8	27	5.8	41	6.7	57																
12	4.8	32	5.8	48	6.8	67																
14	4.9	38	5.9	56	6.9	78																
16	4.9	43	6.0	64	7.0	88																
18	4.9	48	6.0	71																		
20	4.9	53	6.0	79																		
22	5.0	58	6.1	87																		
24	5.0	64	6.1	94																		
26			6.1	102																		
28			6.1	109																		
30			6.1	117																		

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 16 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 6 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.9	6	4.7	9	5.4	13	6.1	18	6.7	23												
4	4.2	11	5.1	16	5.9	22	6.7	30	7.4	39												
6	4.4	15	5.3	23	6.2	32	7.0	43														
8	4.5	20	5.5	30	6.4	42																
10	4.6	25	5.5	37	6.5	52																
12	4.6	30	5.6	44	6.6	62																
14	4.7	35	5.7	52	6.6	71																
16	4.7	40	5.7	59	6.7	81																
18	4.7	45	5.7	66	6.7	91																
20	4.7	50	5.8	73	6.8	101																
22	4.7	54	5.8	81	6.8	111																
24	4.7	59	5.8	88	6.8	121																
26			5.8	95	6.8	131																
28			5.8	102	6.8	141																
30			5.8	109	6.9	151																

Rock d50 size: 6 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.8	7	4.5	10	5.3	15	6.0	21	6.6	28												
4	4.1	11	4.9	17	5.7	24	6.5	33														
6	4.3	16	5.2	24	6.0	34	6.8	46														
8	4.4	21	5.3	31	6.2	44																
10	4.5	26	5.4	38	6.3	54																
12	4.5	31	5.5	46	6.4	63																
14	4.6	36	5.6	53	6.5	73																
16	4.6	40	5.6	60	6.6	83																
18	4.6	45	5.7	67	6.6	93																
20	4.7	50	5.7	74	6.7	103																
22	4.7	55	5.7	82	6.7	113																
24	4.7	60	5.7	89	6.7	123																
26			5.8	96	6.7	133																
28			5.8	103	6.8	143																
30			5.8	110	6.8	152																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 17 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 6 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.7	6	4.4	9	5.1	12	5.8	17	6.4	22	7.0	28										
4	4.0	10	4.8	15	5.6	21	6.3	28	7.0	37												
6	4.2	15	5.0	22	5.9	30	6.6	40														
8	4.3	19	5.2	29	6.0	40	6.8	52														
10	4.3	24	5.3	35	6.1	49	7.0	65														
12	4.4	28	5.3	42	6.2	58																
14	4.4	33	5.4	49	6.3	68																
16	4.4	38	5.4	56	6.3	77																
18	4.5	42	5.4	63	6.4	87																
20	4.5	47	5.5	70	6.4	96																
22	4.5	52	5.5	76	6.4	105																
24	4.5	56	5.5	83	6.5	115																
26			5.5	90	6.5	124																
28			5.5	97	6.5	134																
30			5.5	104	6.5	143																

Rock d50 size: 6 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 6.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.6	6	4.3	10	5.0	14	5.6	20	6.3	26	6.9	34										
4	3.9	11	4.7	16	5.4	23	6.1	31	6.8	41												
6	4.1	15	4.9	23	5.7	32	6.4	43														
8	4.2	20	5.1	30	5.9	42	6.6	55														
10	4.3	24	5.2	36	6.0	51	6.8	67														
12	4.3	29	5.2	43	6.1	60	6.9	80														
14	4.3	34	5.3	50	6.2	69	7.0	92														
16	4.4	38	5.3	57	6.2	79																
18	4.4	43	5.4	64	6.3	88																
20	4.4	48	5.4	71	6.3	98																
22	4.4	52	5.4	77	6.3	107																
24	4.5	57	5.4	84	6.4	116																
26			5.5	91	6.4	126																
28			5.5	98	6.4	135																
30			5.5	105	6.4	145																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 18 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 7 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.7	7	5.7	11	6.6	16																
4	5.1	13	6.2	19	7.3	27																
6	5.3	19	6.5	28	7.6	39																
8	5.4	24	6.6	37																		
10	5.5	30	6.8	45																		
12	5.6	36	6.8	54																		
14	5.6	42	6.9	63																		
16	5.6	48	6.9	72																		
18	5.7	54	7.0	80																		
20	5.7	60	7.0	89																		
22	5.7	66	7.0	98																		
24	5.7	71	7.1	107																		
26			7.1	116																		
28			7.1	124																		
30			7.1	133																		

Rock d50 size: 7 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.6	8	5.5	13	6.5	19	7.4	26														
4	4.9	14	6.0	21	7.0	30																
6	5.2	19	6.3	30	7.4	42																
8	5.3	25	6.5	38																		
10	5.4	31	6.6	47																		
12	5.5	37	6.7	56																		
14	5.5	43	6.8	64																		
16	5.6	49	6.8	73																		
18	5.6	54	6.9	82																		
20	5.6	60	6.9	91																		
22	5.6	66	7.0	99																		
24	5.7	72	7.0	108																		
26			7.0	117																		
28			7.0	126																		
30			7.1	135																		

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 19 of 54
(FSA Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 7 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.3	6	5.2	10	6.1	14	6.9	20														
4	4.6	12	5.7	18	6.6	25	7.5	34														
6	4.8	17	5.9	26	6.9	36																
8	4.9	22	6.1	33	7.1	47																
10	5.0	28	6.2	41	7.3	58																
12	5.1	33	6.2	49	7.4	69																
14	5.1	38	6.3	57	7.4	80																
16	5.1	44	6.3	65																		
18	5.2	49	6.4	73																		
20	5.2	54	6.4	82																		
22	5.2	60	6.4	90																		
24	5.2	65	6.5	98																		
26			6.5	106																		
28			6.5	114																		
30			6.5	122																		

Rock d50 size: 7 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.2	7	5.1	12	5.9	17	6.7	24	7.5	32												
4	4.5	12	5.5	19	6.4	27	7.3	37														
6	4.7	18	5.8	27	6.7	38																
8	4.8	23	5.9	35	6.9	49																
10	4.9	28	6.0	43	7.1	60																
12	5.0	34	6.1	51	7.2	71																
14	5.0	39	6.2	59	7.3	82																
16	5.1	44	6.2	67	7.4	93																
18	5.1	50	6.3	75	7.4	104																
20	5.1	55	6.3	83	7.5	115																
22	5.1	60	6.4	91	7.5	127																
24	5.2	66	6.4	99																		
26			6.4	107																		
28			6.4	115																		
30			6.4	123																		

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 20 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 7 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.0	6	4.8	9	5.6	13	6.4	18	7.1	24												
4	4.3	11	5.2	16	6.1	23	7.0	31	7.8	40												
6	4.5	16	5.5	24	6.4	33	7.3	44														
8	4.6	21	5.6	31	6.6	43	7.5	58														
10	4.6	26	5.7	38	6.7	54																
12	4.7	31	5.8	46	6.8	64																
14	4.7	35	5.8	53	6.9	74																
16	4.8	40	5.9	61	6.9	84																
18	4.8	45	5.9	68	7.0	95																
20	4.8	50	5.9	75	7.0	105																
22	4.8	55	6.0	83	7.0	115																
24	4.8	60	6.0	90	7.1	126																
26			6.0	98	7.1	136																
28			6.0	105	7.1	146																
30			6.0	113	7.1	157																

Rock d50 size: 7 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.8	7	4.7	11	5.5	16	6.2	22	6.9	29												
4	4.2	11	5.1	18	6.0	25	6.8	35														
6	4.4	16	5.3	25	6.2	35	7.1	48														
8	4.5	21	5.5	32	6.4	45	7.3	61														
10	4.6	26	5.6	40	6.6	56	7.5	74														
12	4.6	31	5.7	47	6.7	66																
14	4.7	36	5.7	54	6.7	76																
16	4.7	41	5.8	62	6.8	86																
18	4.7	46	5.8	69	6.9	97																
20	4.7	51	5.9	77	6.9	107																
22	4.8	56	5.9	84	6.9	117																
24	4.8	61	5.9	91	7.0	127																
26			5.9	99	7.0	138																
28			5.9	106	7.0	148																
30			6.0	114	7.0	158																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 21 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 7 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.7	6	4.5	9	5.2	12	6.0	17	6.6	23	7.3	29										
4	4.0	10	4.9	15	5.7	22	6.5	29	7.3	38	8.0	48										
6	4.2	15	5.1	22	6.0	31	6.8	42	7.6	53												
8	4.3	19	5.3	29	6.2	41	7.0	54														
10	4.3	24	5.3	36	6.3	50	7.2	67														
12	4.4	29	5.4	43	6.4	60	7.3	79														
14	4.4	33	5.5	50	6.4	69	7.4	92														
16	4.5	38	5.5	57	6.5	79	7.4	105														
18	4.5	42	5.5	64	6.5	89																
20	4.5	47	5.5	71	6.6	98																
22	4.5	52	5.6	78	6.6	108																
24	4.5	56	5.6	84	6.6	118																
26			5.6	91	6.6	127																
28			5.6	98	6.6	137																
30			5.6	105	6.7	146																

Rock d50 size: 7 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.6	6	4.4	10	5.1	15	5.8	20	6.5	27	7.1	36										
4	3.9	11	4.8	17	5.6	24	6.3	32	7.0	42												
6	4.1	15	5.0	23	5.8	33	6.6	45	7.4	58												
8	4.2	20	5.1	30	6.0	43	6.8	57														
10	4.3	25	5.2	37	6.1	52	7.0	69														
12	4.3	29	5.3	44	6.2	62	7.1	82														
14	4.4	34	5.4	51	6.3	71	7.2	95														
16	4.4	38	5.4	58	6.4	81	7.3	107														
18	4.4	43	5.4	65	6.4	90	7.3	120														
20	4.4	48	5.5	72	6.5	100	7.4	133														
22	4.5	52	5.5	79	6.5	110	7.4	145														
24	4.5	57	5.5	86	6.5	119	7.5	158														
26			5.5	92	6.5	129																
28			5.6	99	6.6	138																
30			5.6	106	6.6	148																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 22 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 7 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.5	5	4.2	8	4.9	12	5.6	16	6.2	21	6.8	27	7.4	34								
4	3.8	9	4.6	14	5.4	20	6.1	28	6.8	36	7.5	45										
6	3.9	14	4.8	21	5.7	29	6.4	39	7.2	50												
8	4.0	18	5.0	27	5.8	38	6.6	51	7.4	65												
10	4.1	23	5.0	34	5.9	47	6.8	63														
12	4.1	27	5.1	40	6.0	56	6.9	75														
14	4.2	31	5.1	47	6.1	65	6.9	87														
16	4.2	36	5.2	53	6.1	74	7.0	99														
18	4.2	40	5.2	60	6.2	84	7.0	111														
20	4.2	44	5.2	67	6.2	93	7.1	122														
22	4.2	49	5.3	73	6.2	102	7.1	134														
24	4.3	53	5.3	80	6.2	111	7.2	146														
26			5.3	86	6.3	120	7.2	158														
28			5.3	93	6.3	129																
30			5.3	99	6.3	138																

Rock d50 size: 7 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.4	6	4.1	9	4.8	14	5.5	19	6.1	26	6.7	34	7.3	43								
4	3.7	10	4.5	16	5.2	22	6.0	31	6.6	40	7.3	51										
6	3.8	14	4.7	22	5.5	31	6.3	42	7.0	55												
8	3.9	19	4.8	28	5.7	40	6.5	54	7.2	69												
10	4.0	23	4.9	35	5.8	49	6.6	65	7.4	84												
12	4.1	27	5.0	41	5.9	58	6.7	77														
14	4.1	32	5.1	48	6.0	67	6.8	89														
16	4.1	36	5.1	54	6.0	76	6.9	101														
18	4.2	41	5.1	61	6.1	85	6.9	113														
20	4.2	45	5.2	68	6.1	94	7.0	125														
22	4.2	49	5.2	74	6.1	103	7.0	137														
24	4.2	54	5.2	81	6.2	112	7.0	149														
26			5.2	87	6.2	121	7.1	161														
28			5.2	94	6.2	131																
30			5.3	100	6.2	140																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 23 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 7 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.3	5	4.0	8	4.7	11	5.3	15	5.9	20	6.5	26	7.0	33								
4	3.6	9	4.4	14	5.1	19	5.8	26	6.5	34	7.1	43	7.7	53								
6	3.7	13	4.6	20	5.4	28	6.1	37	6.8	48	7.5	60										
8	3.8	17	4.7	26	5.5	36	6.3	48	7.0	62												
10	3.9	21	4.8	32	5.6	45	6.4	60	7.2	76												
12	3.9	26	4.8	38	5.7	53	6.5	71	7.3	91												
14	4.0	30	4.9	45	5.8	62	6.6	82	7.4	105												
16	4.0	34	4.9	51	5.8	71	6.6	94	7.4	119												
18	4.0	38	4.9	57	5.8	79	6.7	105														
20	4.0	42	5.0	63	5.9	88	6.7	116														
22	4.0	46	5.0	69	5.9	96	6.8	128														
24	4.0	50	5.0	76	5.9	105	6.8	139														
26			5.0	82	5.9	114	6.8	150														
28			5.0	88	5.9	122																
30			5.0	94	6.0	131																

Rock d50 size: 7 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 7.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.2	6	3.9	9	4.6	13	5.2	18	5.8	25	6.4	32	6.9	40	7.5	50						
4	3.5	10	4.3	15	5.0	21	5.7	29	6.3	38	6.9	48										
6	3.7	14	4.5	21	5.2	30	5.9	40	6.6	52	7.3	65										
8	3.7	18	4.6	27	5.4	38	6.1	51	6.8	66												
10	3.8	22	4.7	33	5.5	47	6.3	62	7.0	80												
12	3.9	26	4.7	39	5.6	55	6.4	73	7.1	94												
14	3.9	30	4.8	45	5.6	64	6.4	85	7.2	108												
16	3.9	34	4.8	52	5.7	72	6.5	96	7.3	123												
18	4.0	39	4.9	58	5.7	81	6.6	107	7.4	137												
20	4.0	43	4.9	64	5.8	89	6.6	119	7.4	152												
22	4.0	47	4.9	70	5.8	98	6.7	130														
24	4.0	51	4.9	76	5.8	107	6.7	141														
26			5.0	83	5.9	115	6.7	153														
28			5.0	89	5.9	124																
30			5.0	95	5.9	132																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 24 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 8 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.2	6	5.2	10	6.1	15	7.0	20	7.8	27												
4	4.6	11	5.7	18	6.7	25	7.6	34	8.5	45												
6	4.8	17	5.9	26	7.0	36	8.0	49														
8	4.9	22	6.1	33	7.2	47																
10	4.9	27	6.2	41	7.3	58																
12	5.0	32	6.2	49	7.4	70																
14	5.0	38	6.3	57	7.5	81																
16	5.1	43	6.3	65	7.5	92																
18	5.1	48	6.4	73	7.6	103																
20	5.1	54	6.4	81	7.6	114																
22	5.1	59	6.4	89	7.7	126																
24	5.1	64	6.4	97	7.7	137																
26			6.5	106	7.7	148																
28			6.5	114	7.7	159																
30			6.5	122																		

Rock d50 size: 8 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	4.1	7	5.1	12	6.0	17	6.8	24	7.6	32												
4	4.5	12	5.5	19	6.5	28	7.4	38														
6	4.6	17	5.8	27	6.8	39	7.8	52														
8	4.8	23	5.9	35	7.0	49																
10	4.9	28	6.0	43	7.1	61																
12	4.9	33	6.1	51	7.3	72																
14	5.0	38	6.2	59	7.3	83																
16	5.0	44	6.2	67	7.4	94																
18	5.0	49	6.3	75	7.5	105																
20	5.1	54	6.3	83	7.5	116																
22	5.1	60	6.3	91	7.6	128																
24	5.1	65	6.4	99	7.6	139																
26			6.4	107	7.6	150																
28			6.4	115	7.6	161																
30			6.4	123																		

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 25 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 8 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.9	6	4.7	9	5.6	13	6.4	18	7.1	24	7.8	31										
4	4.2	10	5.2	16	6.1	23	7.0	31	7.8	41	8.6	51										
6	4.3	15	5.4	23	6.4	33	7.3	44	8.2	57												
8	4.4	20	5.5	31	6.6	43	7.5	58														
10	4.5	25	5.6	38	6.7	53	7.7	71														
12	4.6	30	5.7	45	6.8	63	7.8	85														
14	4.6	34	5.7	52	6.8	74	7.9	98														
16	4.6	39	5.8	60	6.9	84	7.9	112														
18	4.6	44	5.8	67	6.9	94																
20	4.7	49	5.8	74	7.0	104																
22	4.7	54	5.9	82	7.0	115																
24	4.7	59	5.9	89	7.0	125																
26			5.9	96	7.0	135																
28			5.9	104	7.1	145																
30			5.9	111	7.1	156																

Rock d50 size: 8 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.7	7	4.6	11	5.4	16	6.2	22	7.0	29	7.7	38										
4	4.1	11	5.0	17	5.9	25	6.8	35	7.6	46												
6	4.2	16	5.3	25	6.2	35	7.1	48	7.9	62												
8	4.4	21	5.4	32	6.4	45	7.3	61														
10	4.4	25	5.5	39	6.5	55	7.5	74														
12	4.5	30	5.6	46	6.6	65	7.6	88														
14	4.5	35	5.6	54	6.7	76	7.7	101														
16	4.6	40	5.7	61	6.8	86	7.8	115														
18	4.6	45	5.7	68	6.8	96	7.9	128														
20	4.6	50	5.8	75	6.9	106	7.9	142														
22	4.6	54	5.8	83	6.9	116	8.0	155														
24	4.6	59	5.8	90	6.9	127																
26			5.8	97	7.0	137																
28			5.9	105	7.0	147																
30			5.9	112	7.0	157																

Figure IN-6-9 - Rock Lined Chute Capacity

Sheet 26 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 8 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.6	5	4.4	8	5.2	12	5.9	17	6.6	23	7.3	29	7.9	36								
4	3.9	10	4.8	15	5.6	21	6.5	29	7.2	38	7.9	48	8.6	59								
6	4.0	14	5.0	22	5.9	31	6.8	41	7.6	53												
8	4.1	19	5.1	28	6.1	40	7.0	53	7.8	69												
10	4.2	23	5.2	35	6.2	49	7.1	66	8.0	85												
12	4.2	27	5.3	42	6.3	59	7.2	78														
14	4.3	32	5.3	49	6.3	68	7.3	91														
16	4.3	36	5.4	55	6.4	78	7.4	104														
18	4.3	41	5.4	62	6.4	87	7.4	116														
20	4.3	45	5.4	69	6.5	97	7.4	129														
22	4.3	50	5.4	76	6.5	106	7.5	141														
24	4.3	54	5.4	82	6.5	116	7.5	154														
26			5.5	89	6.5	125																
28			5.5	96	6.5	135																
30			5.5	103	6.6	144																

Rock d50 size: 8 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.5	6	4.3	10	5.0	14	5.8	20	6.5	27	7.1	36	7.8	45								
4	3.8	10	4.6	16	5.5	23	6.3	32	7.0	42	7.7	54										
6	3.9	15	4.9	23	5.7	33	6.6	44	7.4	58												
8	4.0	19	5.0	29	5.9	42	6.8	56	7.6	73												
10	4.1	24	5.1	36	6.0	51	6.9	69	7.8	89												
12	4.2	28	5.2	43	6.1	61	7.0	81	7.9	105												
14	4.2	33	5.2	50	6.2	70	7.1	94														
16	4.2	37	5.3	56	6.3	79	7.2	106														
18	4.3	41	5.3	63	6.3	89	7.3	119														
20	4.3	46	5.3	70	6.4	98	7.3	131														
22	4.3	50	5.4	77	6.4	108	7.4	144														
24	4.3	55	5.4	83	6.4	117	7.4	156														
26			5.4	90	6.4	127																
28			5.4	97	6.5	136																
30			5.4	104	6.5	146																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 27 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 8 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.3	5	4.1	8	4.8	11	5.5	16	6.2	21	6.8	27	7.4	34	8.0	42						
4	3.6	9	4.5	14	5.3	20	6.0	27	6.7	35	7.4	45	8.1	55								
6	3.8	13	4.7	20	5.5	29	6.3	38	7.1	50	7.8	63										
8	3.9	17	4.8	26	5.7	37	6.5	50	7.3	64	8.1	81										
10	3.9	22	4.9	33	5.8	46	6.6	62	7.5	79												
12	4.0	26	4.9	39	5.9	55	6.7	73	7.6	94												
14	4.0	30	5.0	45	5.9	64	6.8	85	7.7	109												
16	4.0	34	5.0	52	6.0	73	6.9	97	7.7	124												
18	4.0	38	5.0	58	6.0	82	6.9	109	7.8	139												
20	4.0	42	5.1	64	6.0	90	7.0	120	7.9	154												
22	4.1	47	5.1	71	6.1	99	7.0	132														
24	4.1	51	5.1	77	6.1	108	7.0	144														
26			5.1	83	6.1	117	7.0	156														
28			5.1	90	6.1	126																
30			5.1	96	6.1	135																

Rock d50 size: 8 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.2	6	4.0	9	4.7	14	5.4	19	6.0	26	6.7	33	7.3	42	7.8	53						
4	3.5	10	4.3	15	5.1	22	5.9	30	6.6	40	7.2	51	7.9	63								
6	3.7	14	4.5	21	5.4	30	6.1	41	6.9	54	7.6	68										
8	3.8	18	4.7	28	5.5	39	6.3	53	7.1	68	7.8	86										
10	3.8	22	4.8	34	5.7	48	6.5	64	7.3	83												
12	3.9	26	4.8	40	5.7	57	6.6	76	7.4	98												
14	3.9	30	4.9	46	5.8	65	6.7	88	7.5	113												
16	4.0	35	4.9	53	5.9	74	6.7	99	7.6	128												
18	4.0	39	5.0	59	5.9	83	6.8	111	7.7	143												
20	4.0	43	5.0	65	5.9	92	6.9	123	7.7	158												
22	4.0	47	5.0	72	6.0	101	6.9	135														
24	4.0	51	5.0	78	6.0	110	6.9	146														
26			5.1	84	6.0	119	7.0	158														
28			5.1	91	6.0	127																
30			5.1	97	6.1	136																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 28 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 8 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.1	5	3.9	7	4.6	11	5.2	15	5.8	20	6.4	26	7.0	32	7.5	40						
4	3.4	9	4.2	13	5.0	19	5.7	25	6.4	33	7.0	42	7.6	52	8.2	63						
6	3.6	12	4.4	19	5.2	27	6.0	36	6.7	47	7.4	59	8.0	72								
8	3.6	16	4.5	25	5.4	35	6.1	47	6.9	61	7.6	76										
10	3.7	20	4.6	31	5.5	44	6.3	58	7.0	75	7.8	93										
12	3.7	24	4.7	37	5.5	52	6.4	69	7.2	89	7.9	111										
14	3.8	28	4.7	43	5.6	60	6.4	80	7.2	103												
16	3.8	32	4.7	49	5.6	69	6.5	91	7.3	117												
18	3.8	36	4.8	55	5.7	77	6.5	102	7.4	131												
20	3.8	40	4.8	61	5.7	85	6.6	113	7.4	145												
22	3.8	44	4.8	67	5.7	94	6.6	125	7.4	159												
24	3.8	48	4.8	73	5.7	102	6.6	136														
26			4.8	79	5.8	110	6.6	147														
28			4.8	85	5.8	119	6.7	158														
30			4.8	91	5.8	127																

Rock d50 size: 8 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.1	5	3.8	9	4.4	13	5.1	18	5.7	24	6.3	31	6.8	40	7.4	50	7.9	61				
4	3.3	9	4.1	14	4.8	21	5.5	28	6.2	37	6.8	48	7.4	60	8.0	73						
6	3.5	13	4.3	20	5.1	29	5.8	39	6.5	51	7.2	64	7.8	80								
8	3.6	17	4.4	26	5.2	37	6.0	50	6.7	65	7.4	81										
10	3.6	21	4.5	32	5.3	45	6.1	61	6.9	78	7.6	98										
12	3.7	25	4.6	38	5.4	53	6.2	72	7.0	92	7.7	116										
14	3.7	29	4.6	44	5.5	62	6.3	83	7.1	106	7.8	133										
16	3.7	33	4.7	50	5.5	70	6.4	94	7.2	120	7.9	150										
18	3.7	37	4.7	56	5.6	78	6.4	105	7.2	135												
20	3.8	40	4.7	62	5.6	87	6.5	116	7.3	149												
22	3.8	44	4.7	68	5.6	95	6.5	127	7.3	163												
24	3.8	48	4.8	74	5.7	103	6.5	138														
26			4.8	80	5.7	112	6.6	149														
28			4.8	85	5.7	120	6.6	160														
30			4.8	91	5.7	128																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 29 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 8 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.0	4	3.7	7	4.3	10	4.9	14	5.5	19	6.1	24	6.6	31	7.1	38	7.6	46				
4	3.2	8	4.0	13	4.7	18	5.4	24	6.0	32	6.6	40	7.2	49	7.8	60	8.3	72				
6	3.4	12	4.2	18	4.9	26	5.7	34	6.3	45	7.0	56	7.6	69	8.2	83						
8	3.4	16	4.3	24	5.1	33	5.8	45	6.5	58	7.2	72	7.9	83								
10	3.5	19	4.4	29	5.2	41	5.9	55	6.7	71	7.4	89	8.1	108								
12	3.5	23	4.4	35	5.2	49	6.0	66	6.8	84	7.5	105										
14	3.6	27	4.5	41	5.3	57	6.1	76	6.9	98	7.6	122										
16	3.6	30	4.5	46	5.3	65	6.2	87	6.9	111	7.7	138										
18	3.6	34	4.5	52	5.4	73	6.2	97	7.0	124	7.7	155										
20	3.6	38	4.5	58	5.4	81	6.2	108	7.0	138												
22	3.6	42	4.5	63	5.4	89	6.3	118	7.1	151												
24	3.6	45	4.6	69	5.4	97	6.3	129														
26			4.6	75	5.5	105	6.3	139														
28			4.6	80	5.5	113	6.3	150														
30			4.6	86	5.5	121	6.3	160														

Rock d50 size: 8 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 7.9 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.9	5	3.6	8	4.2	12	4.8	17	5.4	23	6.0	30	6.5	38	7.0	47	7.5	58				
4	3.1	9	3.9	14	4.6	20	5.2	27	5.9	35	6.5	45	7.0	56	7.6	69						
6	3.3	12	4.1	19	4.8	27	5.5	37	6.2	48	6.8	61	7.4	76	8.0	92						
8	3.4	16	4.2	25	5.0	35	5.7	47	6.4	61	7.0	77	7.6	95								
10	3.4	20	4.3	30	5.1	43	5.8	58	6.5	74	7.2	93	7.8	115								
12	3.5	23	4.3	36	5.1	51	5.9	68	6.6	88	7.3	110	8.0	134								
14	3.5	27	4.4	41	5.2	59	6.0	78	6.7	101	7.4	126										
16	3.5	31	4.4	47	5.2	66	6.0	89	6.8	114	7.5	143										
18	3.6	35	4.4	53	5.3	74	6.1	99	6.9	128	7.6	159										
20	3.6	38	4.5	58	5.3	82	6.1	110	6.9	141												
22	3.6	42	4.5	64	5.3	90	6.2	120	6.9	154												
24	3.6	46	4.5	70	5.4	98	6.2	131														
26			4.5	75	5.4	106	6.2	141														
28			4.5	81	5.4	114	6.2	152														
30			4.5	87	5.4	122																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 30 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 9 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.8	6	4.8	9	5.6	13	6.5	19	7.3	25	8.1	32										
4	4.1	10	5.2	16	6.2	23	7.1	32	8.0	42	8.8	53										
6	4.3	15	5.4	23	6.5	33	7.4	45	8.4	59												
8	4.4	20	5.5	31	6.6	44	7.7	59	8.6	76												
10	4.5	25	5.6	38	6.8	54	7.8	73														
12	4.5	29	5.7	45	6.8	64	7.9	86														
14	4.5	34	5.8	53	6.9	75	8.0	100														
16	4.6	39	5.8	60	7.0	85	8.1	114														
18	4.6	44	5.8	67	7.0	95	8.1	128														
20	4.6	48	5.9	75	7.0	106	8.2	142														
22	4.6	53	5.9	82	7.1	116	8.2	155														
24	4.6	58	5.9	89	7.1	126																
26			5.9	97	7.1	137																
28			5.9	104	7.1	147																
30			5.9	111	7.2	157																

Rock d50 size: 9 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.7	6	4.6	11	5.5	16	6.3	22	7.1	30	7.9	39										
4	4.0	11	5.0	18	6.0	26	6.9	35	7.7	47												
6	4.2	16	5.3	25	6.3	36	7.2	49	8.1	64												
8	4.3	20	5.4	32	6.5	46	7.5	62	8.4	81												
10	4.4	25	5.5	39	6.6	56	7.6	76														
12	4.4	30	5.6	46	6.7	66	7.8	89														
14	4.5	35	5.7	54	6.8	76	7.9	103														
16	4.5	39	5.7	61	6.8	87	7.9	117														
18	4.5	44	5.7	68	6.9	97	8.0	131														
20	4.6	49	5.8	76	6.9	107	8.1	144														
22	4.6	54	5.8	83	7.0	118	8.1	158														
24	4.6	59	5.8	90	7.0	128																
26			5.9	98	7.0	138																
28			5.9	105	7.1	149																
30			5.9	112	7.1	159																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 31 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 9 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.5	5	4.3	8	5.2	12	5.9	17	6.6	23	7.4	29	8.0	37								
4	3.8	9	4.7	15	5.6	21	6.5	29	7.3	38	8.0	48	8.8	60								
6	3.9	14	4.9	21	5.9	31	6.8	41	7.6	54	8.5	68										
8	4.0	18	5.1	28	6.1	40	7.0	54	7.9	70												
10	4.1	22	5.1	35	6.2	49	7.1	66	8.1	86												
12	4.1	27	5.2	41	6.3	59	7.2	79	8.2	102												
14	4.1	31	5.3	48	6.3	68	7.3	91	8.3	118												
16	4.2	35	5.3	55	6.4	77	7.4	104	8.4	134												
18	4.2	40	5.3	61	6.4	87	7.4	117	8.4	150												
20	4.2	44	5.3	68	6.4	96	7.5	129														
22	4.2	49	5.4	75	6.5	106	7.5	142														
24	4.2	53	5.4	81	6.5	115	7.5	154														
26			5.4	88	6.5	125																
28			5.4	95	6.5	134																
30			5.4	102	6.5	144																

Rock d50 size: 9 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.4	6	4.2	10	5.0	14	5.8	20	6.5	28	7.2	36	7.9	46								
4	3.7	10	4.6	16	5.5	23	6.3	32	7.1	43	7.8	55										
6	3.8	14	4.8	22	5.7	32	6.6	44	7.4	58	8.2	74										
8	3.9	19	4.9	29	5.9	42	6.8	57	7.7	74	8.5	93										
10	4.0	23	5.0	36	6.0	51	7.0	69	7.9	90												
12	4.0	27	5.1	42	6.1	60	7.1	82	8.0	106												
14	4.1	32	5.2	49	6.2	70	7.2	94	8.1	122												
16	4.1	36	5.2	56	6.3	79	7.2	107	8.2	138												
18	4.1	40	5.2	62	6.3	89	7.3	119	8.3	154												
20	4.2	45	5.3	69	6.3	98	7.4	132														
22	4.2	49	5.3	76	6.4	108	7.4	144														
24	4.2	53	5.3	82	6.4	117	7.4	157														
26			5.3	89	6.4	126																
28			5.4	96	6.4	136																
30			5.4	103	6.5	145																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 32 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 9 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.2	5	4.0	8	4.8	11	5.5	16	6.2	21	6.8	27	7.4	34	8.0	42						
4	3.5	9	4.4	14	5.2	20	6.0	27	6.7	35	7.5	45	8.1	55	8.8	67						
6	3.6	13	4.6	20	5.5	28	6.3	38	7.1	50	7.8	63	8.6	77								
8	3.7	17	4.7	26	5.6	37	6.5	50	7.3	64	8.1	81										
10	3.8	21	4.8	32	5.7	46	6.6	61	7.5	79	8.3	99										
12	3.8	25	4.8	38	5.8	54	6.7	73	7.6	94	8.4	118										
14	3.8	29	4.9	44	5.8	63	6.8	85	7.7	109												
16	3.9	33	4.9	51	5.9	72	6.8	96	7.7	124												
18	3.9	37	4.9	57	5.9	80	6.9	108	7.8	139												
20	3.9	41	5.0	63	6.0	89	6.9	120	7.8	154												
22	3.9	45	5.0	69	6.0	98	7.0	131														
24	3.9	49	5.0	75	6.0	107	7.0	143														
26			5.0	82	6.0	116	7.0	155														
28			5.0	88	6.0	124																
30			5.0	94	6.1	133																

Rock d50 size: 9 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.1	5	3.9	9	4.6	13	5.4	19	6.0	25	6.7	33	7.3	43	7.9	53						
4	3.4	9	4.3	15	5.1	22	5.8	30	6.5	39	7.2	51	7.9	63								
6	3.5	13	4.5	21	5.3	30	6.1	41	6.9	54	7.6	68	8.3	85								
8	3.6	17	4.6	27	5.5	39	6.3	52	7.1	68	7.9	87										
10	3.7	21	4.7	33	5.6	47	6.4	64	7.3	83	8.1	105										
12	3.7	25	4.7	39	5.7	56	6.6	75	7.4	98	8.2	123										
14	3.8	29	4.8	45	5.7	65	6.6	87	7.5	113	8.3	142										
16	3.8	33	4.8	52	5.8	73	6.7	99	7.6	128	8.4	160										
18	3.8	37	4.9	58	5.8	82	6.8	110	7.7	143												
20	3.9	41	4.9	64	5.9	91	6.8	122	7.7	157												
22	3.9	45	4.9	70	5.9	100	6.8	134														
24	3.9	50	4.9	76	5.9	108	6.9	145														
26			4.9	83	6.0	117	6.9	157														
28			5.0	89	6.0	126																
30			5.0	95	6.0	135																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 33 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 9 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.0	5	3.8	7	4.5	11	5.1	15	5.8	20	6.4	25	6.9	32	7.5	40	8.1	48				
4	3.3	8	4.1	13	4.9	18	5.6	25	6.3	33	7.0	42	7.6	52	8.2	63	8.8	76				
6	3.4	12	4.3	18	5.1	26	5.9	36	6.6	47	7.3	59	8.0	72	8.7	87						
8	3.5	16	4.4	24	5.2	35	6.1	47	6.8	60	7.6	76	8.3	93								
10	3.5	19	4.5	30	5.3	43	6.2	57	7.0	74	7.7	93	8.5	114								
12	3.6	23	4.5	36	5.4	51	6.3	68	7.1	88	7.9	110										
14	3.6	27	4.6	42	5.5	59	6.3	79	7.2	102	8.0	128										
16	3.6	31	4.6	47	5.5	67	6.4	90	7.2	116	8.1	145										
18	3.6	35	4.6	53	5.5	75	6.4	101	7.3	130	8.1	162										
20	3.6	38	4.6	59	5.6	83	6.5	112	7.3	144												
22	3.7	42	4.6	65	5.6	92	6.5	123	7.4	158												
24	3.7	46	4.7	71	5.6	100	6.5	134														
26			4.7	76	5.6	108	6.6	145														
28			4.7	82	5.6	116	6.6	156														
30			4.7	88	5.7	124																

Rock d50 size: 9 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.9	5	3.7	8	4.3	12	5.0	18	5.6	24	6.2	31	6.8	40	7.4	50	8.0	61	8.5	74		
4	3.2	9	4.0	14	4.7	20	5.4	28	6.1	37	6.8	47	7.4	59	8.0	73						
6	3.3	12	4.2	19	5.0	28	5.7	38	6.4	50	7.1	64	7.8	79	8.4	97						
8	3.4	16	4.3	25	5.1	36	5.9	49	6.6	64	7.4	81	8.0	100								
10	3.5	20	4.4	31	5.2	44	6.0	60	6.8	78	7.5	98	8.2	121								
12	3.5	24	4.4	37	5.3	52	6.1	71	6.9	92	7.7	115	8.4	141								
14	3.5	27	4.5	42	5.4	60	6.2	81	7.0	105	7.8	132										
16	3.6	31	4.5	48	5.4	69	6.3	92	7.1	119	7.9	150										
18	3.6	35	4.5	54	5.5	77	6.3	103	7.2	133	8.0	167										
20	3.6	39	4.6	60	5.5	85	6.4	114	7.2	147												
22	3.6	43	4.6	66	5.5	93	6.4	125	7.3	161												
24	3.6	46	4.6	71	5.5	101	6.4	136														
26			4.6	77	5.6	109	6.5	147														
28			4.6	83	5.6	118	6.5	158														
30			4.7	89	5.6	126																

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 9 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.8	4	3.5	7	4.2	10	4.8	14	5.4	19	6.0	24	6.6	30	7.1	37	7.6	45	8.1	54		
4	3.1	8	3.9	12	4.6	17	5.3	24	5.9	31	6.6	39	7.2	49	7.7	60	8.3	71	8.8	84		
6	3.2	11	4.0	17	4.8	25	5.5	34	6.2	44	6.9	55	7.6	68	8.2	82	8.8	98				
8	3.3	15	4.1	23	4.9	33	5.7	44	6.4	57	7.1	71	7.8	88	8.5	105						
10	3.3	18	4.2	28	5.0	40	5.8	54	6.6	70	7.3	88	8.0	107								
12	3.4	22	4.3	34	5.1	48	5.9	64	6.7	83	7.4	104	8.1	127								
14	3.4	25	4.3	39	5.2	56	6.0	75	6.8	96	7.5	120	8.2	147								
16	3.4	29	4.3	45	5.2	63	6.0	85	6.8	109	7.6	137	8.3	167								
18	3.4	33	4.3	50	5.2	71	6.1	95	6.9	123	7.7	153										
20	3.4	36	4.4	56	5.3	79	6.1	105	6.9	136												
22	3.4	40	4.4	61	5.3	86	6.1	116	7.0	149												
24	3.5	43	4.4	66	5.3	94	6.2	126	7.0	162												
26			4.4	72	5.3	102	6.2	136														
28			4.4	77	5.3	110	6.2	147														
30			4.4	83	5.3	117	6.2	157														

Rock d50 size: 9 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

.	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.8	5	3.4	8	4.1	12	4.7	17	5.3	22	5.9	29	6.4	38	7.0	47	7.5	58	8.0	70		
4	3.0	8	3.8	13	4.5	19	5.1	26	5.8	35	6.4	45	7.0	56	7.5	69	8.1	83				
6	3.1	12	3.9	18	4.7	27	5.4	36	6.1	47	6.7	60	7.3	75	7.9	91	8.5	109				
8	3.2	15	4.0	24	4.8	34	5.6	46	6.3	60	6.9	76	7.6	94	8.2	114						
10	3.3	19	4.1	29	4.9	42	5.7	56	6.4	73	7.1	92	7.8	114	8.4	137						
12	3.3	22	4.2	35	5.0	49	5.8	67	6.5	86	7.2	109	7.9	133								
14	3.3	26	4.2	40	5.1	57	5.9	77	6.6	99	7.3	125	8.0	153								
16	3.4	29	4.3	45	5.1	65	5.9	87	6.7	113	7.4	141										
18	3.4	33	4.3	51	5.1	72	6.0	97	6.7	126	7.5	157										
20	3.4	37	4.3	56	5.2	80	6.0	108	6.8	139												
22	3.4	40	4.3	62	5.2	88	6.0	118	6.8	152												
24	3.4	44	4.3	67	5.2	96	6.1	128														
26			4.4	73	5.2	103	6.1	138														
28			4.4	78	5.3	111	6.1	149														
30			4.4	84	5.3	119	6.1	159														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 35 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 9 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.7	4	3.4	6	4.0	9	4.6	13	5.2	18	5.7	23	6.2	29	6.7	35	7.2	43	7.7	52	8.2	61
4	2.9	7	3.7	11	4.4	16	5.0	22	5.6	29	6.2	37	6.8	46	7.4	56	7.9	68	8.4	80	8.9	93
6	3.0	11	3.8	17	4.6	24	5.3	32	5.9	42	6.6	52	7.2	65	7.7	78	8.3	93	8.8	109		
8	3.1	14	3.9	22	4.7	31	5.4	42	6.1	54	6.8	68	7.4	83	8.0	100	8.6	119				
10	3.2	17	4.0	27	4.8	38	5.5	51	6.2	66	6.9	83	7.6	102	8.2	122						
12	3.2	21	4.0	32	4.8	45	5.6	61	6.3	79	7.0	99	7.7	121	8.4	145						
14	3.2	24	4.1	37	4.9	53	5.7	71	6.4	91	7.1	114	7.8	139	8.5	167						
16	3.2	27	4.1	42	4.9	60	5.7	81	6.5	104	7.2	130	7.9	158								
18	3.2	31	4.1	48	5.0	67	5.8	90	6.5	116	7.3	145										
20	3.3	34	4.1	53	5.0	75	5.8	100	6.6	129	7.3	161										
22	3.3	38	4.2	58	5.0	82	5.8	110	6.6	141												
24	3.3	41	4.2	63	5.0	89	5.8	120	6.6	154												
26			4.2	68	5.0	97	5.9	129														
28			4.2	73	5.1	104	5.9	139														
30			4.2	79	5.1	111	5.9	149														

Rock d50 size: 9 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 8.4 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.6	5	3.3	7	3.9	11	4.5	16	5.0	21	5.6	28	6.1	36	6.6	44	7.1	55	7.6	66	8.1	79
4	2.8	8	3.6	12	4.2	18	4.9	25	5.5	33	6.1	42	6.6	53	7.2	65	7.7	79	8.2	94		
6	3.0	11	3.7	17	4.4	25	5.1	34	5.8	45	6.4	57	7.0	71	7.5	87	8.1	104				
8	3.0	14	3.8	23	4.6	32	5.3	44	5.9	57	6.6	72	7.2	89	7.8	108	8.3	129				
10	3.1	18	3.9	28	4.7	40	5.4	53	6.1	70	6.7	88	7.4	108	8.0	130						
12	3.1	21	4.0	33	4.7	47	5.5	63	6.2	82	6.9	103	7.5	126	8.1	152						
14	3.2	25	4.0	38	4.8	54	5.6	73	6.3	94	7.0	118	7.6	145								
16	3.2	28	4.0	43	4.8	61	5.6	83	6.3	107	7.0	134	7.7	164								
18	3.2	31	4.1	48	4.9	69	5.7	92	6.4	119	7.1	149										
20	3.2	35	4.1	53	4.9	76	5.7	102	6.4	132	7.2	165										
22	3.2	38	4.1	59	4.9	83	5.7	112	6.5	144												
24	3.2	41	4.1	64	5.0	91	5.8	122	6.5	157												
26			4.1	69	5.0	98	5.8	131														
28			4.2	74	5.0	105	5.8	141														
30			4.2	79	5.0	113	5.8	151														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 36 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 10 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.4	5	4.4	8	5.2	12	6.0	17	6.8	23	7.6	30	8.3	38								
4	3.7	9	4.8	15	5.7	22	6.6	30	7.5	39	8.3	50	9.1	62								
6	3.9	14	5.0	21	6.0	31	6.9	42	7.9	55	8.7	70										
8	4.0	18	5.1	28	6.1	40	7.1	55	8.1	71	9.0	90										
10	4.0	22	5.2	35	6.3	50	7.3	68	8.3	88												
12	4.1	26	5.2	41	6.3	59	7.4	80	8.4	104												
14	4.1	31	5.3	48	6.4	69	7.5	93	8.5	121												
16	4.1	35	5.3	55	6.5	79	7.5	106	8.6	137												
18	4.1	39	5.3	62	6.5	88	7.6	119	8.6	154												
20	4.2	44	5.4	68	6.5	98	7.6	132														
22	4.2	48	5.4	75	6.6	107	7.7	145														
24	4.2	52	5.4	82	6.6	117	7.7	158														
26			5.4	89	6.6	127																
28			5.4	95	6.6	136																
30			5.4	102	6.6	146																

Rock d50 size: 10 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.3	6	4.2	10	5.1	15	5.9	21	6.7	28	7.4	37	8.2	48	8.9	60						
4	3.6	10	4.6	16	5.5	24	6.4	33	7.3	44	8.1	56	8.8	71								
6	3.8	14	4.8	23	5.8	33	6.7	45	7.6	60	8.5	76										
8	3.9	18	5.0	29	6.0	42	7.0	58	7.9	76	8.8	96										
10	4.0	23	5.1	36	6.1	52	7.1	71	8.1	92												
12	4.0	27	5.1	43	6.2	61	7.2	83	8.2	109												
14	4.0	31	5.2	49	6.3	71	7.3	96	8.3	125												
16	4.1	36	5.2	56	6.3	80	7.4	109	8.4	141												
18	4.1	40	5.3	63	6.4	90	7.5	122	8.5	158												
20	4.1	44	5.3	69	6.4	99	7.5	135														
22	4.1	49	5.3	76	6.5	109	7.6	147														
24	4.1	53	5.3	83	6.5	119	7.6	160														
26			5.4	90	6.5	128																
28			5.4	96	6.5	138																
30			5.4	103	6.6	147																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 37 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 10 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.1	5	4.0	8	4.8	11	5.5	16	6.2	21	6.9	28	7.6	35	8.2	43	8.8	53				
4	3.4	9	4.3	14	5.2	20	6.0	27	6.8	36	7.6	45	8.3	57	9.0	69						
6	3.5	12	4.5	20	5.5	28	6.3	39	7.2	50	8.0	64	8.7	79								
8	3.6	16	4.6	26	5.6	37	6.5	50	7.4	65	8.2	82	9.0	101								
10	3.7	20	4.7	32	5.7	46	6.7	62	7.6	80	8.4	101										
12	3.7	24	4.8	38	5.8	54	6.7	73	7.7	95	8.6	120										
14	3.7	28	4.8	44	5.8	63	6.8	85	7.8	110	8.7	139										
16	3.8	32	4.9	50	5.9	72	6.9	97	7.8	125	8.7	157										
18	3.8	36	4.9	56	5.9	81	6.9	109	7.9	141												
20	3.8	40	4.9	62	6.0	89	7.0	120	7.9	156												
22	3.8	44	4.9	69	6.0	98	7.0	132														
24	3.8	48	4.9	75	6.0	107	7.0	144														
26			5.0	81	6.0	116	7.1	156														
28			5.0	87	6.0	124																
30			5.0	93	6.1	133																

Rock d50 size: 10 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.0	5	3.9	9	4.7	13	5.4	19	6.1	26	6.8	34	7.4	43	8.1	54	8.7	67				
4	3.3	9	4.2	15	5.1	22	5.9	30	6.6	40	7.4	51	8.1	65	8.7	80						
6	3.5	13	4.4	21	5.3	30	6.2	41	7.0	54	7.7	70	8.5	87								
8	3.5	17	4.5	27	5.5	39	6.3	53	7.2	69	8.0	88	8.8	109								
10	3.6	21	4.6	33	5.6	47	6.5	64	7.4	84	8.2	106										
12	3.7	25	4.7	39	5.7	56	6.6	76	7.5	99	8.3	125										
14	3.7	29	4.7	45	5.7	65	6.7	88	7.6	114	8.5	144										
16	3.7	33	4.8	51	5.8	73	6.8	99	7.7	129	8.6	163										
18	3.7	36	4.8	57	5.8	82	6.8	111	7.7	144												
20	3.8	40	4.8	63	5.9	91	6.9	123	7.8	159												
22	3.8	44	4.9	69	5.9	100	6.9	135														
24	3.8	48	4.9	76	5.9	108	6.9	146														
26			4.9	82	6.0	117	7.0	158														
28			4.9	88	6.0	126																
30			4.9	94	6.0	135																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 38 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 10 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.9	4	3.7	7	4.4	11	5.1	15	5.8	20	6.4	26	7.0	32	7.6	40	8.2	49	8.7	59		
4	3.2	8	4.0	13	4.8	18	5.6	25	6.3	33	7.0	42	7.7	52	8.3	64	8.9	77	9.5	91		
6	3.3	11	4.2	18	5.1	26	5.9	36	6.6	47	7.4	59	8.1	73	8.8	88						
8	3.4	15	4.3	24	5.2	34	6.0	46	6.8	60	7.6	76	8.4	94	9.1	113						
10	3.4	19	4.4	29	5.3	42	6.2	57	7.0	74	7.8	93	8.6	115								
12	3.4	22	4.4	35	5.4	50	6.2	68	7.1	88	7.9	111	8.7	136								
14	3.5	26	4.5	41	5.4	58	6.3	79	7.2	102	8.0	128	8.8	157								
16	3.5	30	4.5	46	5.5	66	6.4	90	7.3	116	8.1	146										
18	3.5	33	4.5	52	5.5	75	6.4	101	7.3	130	8.2	163										
20	3.5	37	4.5	58	5.5	83	6.5	112	7.4	144												
22	3.5	41	4.6	63	5.5	91	6.5	122	7.4	158												
24	3.5	44	4.6	69	5.6	99	6.5	133														
26			4.6	75	5.6	107	6.5	144														
28			4.6	81	5.6	115	6.6	155														
30			4.6	86	5.6	123																

Rock d50 size: 10 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.8	5	3.6	8	4.3	12	5.0	18	5.6	24	6.3	31	6.9	40	7.5	50	8.1	62	8.6	75		
4	3.1	8	3.9	14	4.7	20	5.4	28	6.1	37	6.8	48	7.5	60	8.1	74	8.7	89				
6	3.2	12	4.1	19	4.9	28	5.7	38	6.4	50	7.2	64	7.8	80	8.5	98						
8	3.3	16	4.2	25	5.1	36	5.9	49	6.7	64	7.4	81	8.1	101	8.8	123						
10	3.3	19	4.3	30	5.2	44	6.0	60	6.8	78	7.6	99	8.3	122								
12	3.4	23	4.3	36	5.2	52	6.1	70	6.9	92	7.7	116	8.5	143								
14	3.4	26	4.4	42	5.3	60	6.2	81	7.0	106	7.8	133	8.6	164								
16	3.4	30	4.4	47	5.4	68	6.3	92	7.1	120	7.9	151										
18	3.5	34	4.5	53	5.4	76	6.3	103	7.2	134												
20	3.5	37	4.5	59	5.4	84	6.3	114	7.2	148												
22	3.5	41	4.5	64	5.5	92	6.4	125	7.3	162												
24	3.5	45	4.5	70	5.5	100	6.4	136														
26			4.5	76	5.5	108	6.4	146														
28			4.5	81	5.5	116	6.5	157														
30			4.6	87	5.5	125																

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 10 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.7	4	3.4	7	4.1	10	4.8	14	5.4	18	6.0	24	6.6	30	7.1	38	7.6	46	8.2	55	8.7	65
4	3.0	7	3.8	12	4.5	17	5.2	23	5.9	31	6.6	39	7.2	49	7.8	60	8.4	72	8.9	85	9.5	99
6	3.1	11	3.9	17	4.7	24	5.5	33	6.2	44	6.9	55	7.6	68	8.2	83	8.8	98				
8	3.1	14	4.0	22	4.9	32	5.6	43	6.4	56	7.1	71	7.8	88	8.5	106						
10	3.2	18	4.1	27	4.9	39	5.8	53	6.5	69	7.3	87	8.0	107	8.7	129						
12	3.2	21	4.1	33	5.0	47	5.8	64	6.6	82	7.4	104	8.1	127	8.8	153						
14	3.2	24	4.2	38	5.1	55	5.9	74	6.7	96	7.5	120	8.3	147								
16	3.3	28	4.2	43	5.1	62	6.0	84	6.8	109	7.6	136	8.3	167								
18	3.3	31	4.2	49	5.1	70	6.0	94	6.8	122	7.6	153										
20	3.3	35	4.2	54	5.2	77	6.0	104	6.9	135												
22	3.3	38	4.3	59	5.2	85	6.1	114	6.9	148												
24	3.3	41	4.3	65	5.2	92	6.1	125	6.9	161												
26			4.3	70	5.2	100	6.1	135														
28			4.3	75	5.2	108	6.1	145														
30			4.3	81	5.2	115	6.1	155														

Rock d50 size: 10 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.6	5	3.4	8	4.0	12	4.7	16	5.3	22	5.9	29	6.4	38	7.0	47	7.5	58	8.1	70	8.6	84
4	2.9	8	3.6	13	4.4	19	5.1	26	5.7	35	6.4	45	7.0	56	7.6	69	8.1	84	8.7	100		
6	3.0	11	3.8	18	4.6	26	5.3	36	6.0	47	6.7	60	7.3	75	8.0	92	8.5	110				
8	3.1	15	3.9	23	4.7	33	5.5	46	6.2	60	6.9	76	7.6	94	8.2	115	8.9	137				
10	3.1	18	4.0	28	4.8	41	5.6	56	6.4	73	7.1	92	7.8	114	8.4	138						
12	3.2	21	4.1	34	4.9	48	5.7	66	6.5	86	7.2	108	7.9	133	8.6	161						
14	3.2	25	4.1	39	5.0	56	5.8	76	6.6	99	7.3	125	8.1	153								
16	3.2	28	4.1	44	5.0	64	5.8	86	6.6	112	7.4	141										
18	3.2	32	4.2	50	5.1	71	5.9	96	6.7	125	7.5	157										
20	3.3	35	4.2	55	5.1	79	5.9	106	6.8	138												
22	3.3	38	4.2	60	5.1	86	6.0	117	6.8	151												
24	3.3	42	4.2	65	5.1	94	6.0	127														
26			4.2	71	5.2	101	6.0	137														
28			4.3	76	5.2	109	6.1	147														
30			4.3	81	5.2	117	6.1	157														

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 10 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.6	4	3.2	6	3.9	9	4.5	13	5.1	17	5.6	23	6.2	29	6.7	35	7.2	43	7.7	52	8.2	61
4	2.8	7	3.5	11	4.3	16	4.9	22	5.6	29	6.2	37	6.8	46	7.3	56	7.9	68	8.4	80	8.9	94
6	2.9	10	3.7	16	4.5	23	5.2	31	5.9	41	6.5	52	7.1	64	7.7	78	8.3	93	8.9	109		
8	3.0	13	3.8	21	4.6	30	5.3	41	6.0	53	6.7	67	7.4	83	8.0	100	8.6	119				
10	3.0	17	3.9	26	4.7	37	5.4	50	6.2	65	6.9	82	7.5	101	8.2	122	8.8	144				
12	3.0	20	3.9	31	4.7	44	5.5	60	6.3	78	7.0	98	7.7	120	8.3	144						
14	3.1	23	3.9	36	4.8	51	5.6	70	6.3	90	7.1	113	7.8	139	8.5	167						
16	3.1	26	4.0	41	4.8	59	5.6	79	6.4	102	7.1	129	7.9	157								
18	3.1	29	4.0	46	4.8	66	5.7	89	6.4	115	7.2	144										
20	3.1	33	4.0	51	4.9	73	5.7	98	6.5	127	7.2	159										
22	3.1	36	4.0	56	4.9	80	5.7	108	6.5	140												
24	3.1	39	4.0	61	4.9	87	5.7	118	6.5	152												
26			4.0	66	4.9	94	5.8	127														
28			4.1	71	4.9	102	5.8	137														
30			4.1	76	4.9	109	5.8	146														

Rock d50 size: 10 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.5	4	3.2	7	3.8	11	4.4	15	5.0	21	5.5	28	6.1	35	6.6	44	7.1	55	7.6	66	8.1	79
4	2.7	7	3.4	12	4.1	18	4.8	25	5.4	33	6.0	42	6.6	53	7.1	65	7.7	79	8.2	94	8.7	111
6	2.8	11	3.6	17	4.3	25	5.0	34	5.7	44	6.3	57	6.9	71	7.5	86	8.1	104	8.6	123		
8	2.9	14	3.7	22	4.5	32	5.2	43	5.9	57	6.5	72	7.2	89	7.8	108	8.3	129				
10	2.9	17	3.8	27	4.6	39	5.3	53	6.0	69	6.7	87	7.3	107	8.0	130	8.6	155				
12	3.0	20	3.8	32	4.6	46	5.4	62	6.1	81	6.8	102	7.5	126	8.1	152						
14	3.0	23	3.9	37	4.7	53	5.5	72	6.2	93	6.9	117	7.6	144								
16	3.0	27	3.9	42	4.7	60	5.5	81	6.3	105	7.0	133	7.7	163								
18	3.1	30	3.9	47	4.8	67	5.6	91	6.3	118	7.1	148										
20	3.1	33	4.0	52	4.8	74	5.6	100	6.4	130	7.1	164										
22	3.1	36	4.0	57	4.8	81	5.6	110	6.4	143												
24	3.1	39	4.0	62	4.8	88	5.7	120	6.4	155												
26			4.0	67	4.9	96	5.7	129														
28			4.0	72	4.9	103	5.7	139														
30			4.0	77	4.9	110	5.7	148														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 41 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 10 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.4	4	3.1	6	3.7	9	4.3	12	4.8	17	5.4	21	5.9	27	6.4	34	6.8	41	7.3	49	7.8	58
4	2.6	7	3.4	10	4.0	15	4.7	21	5.3	28	5.9	35	6.4	44	7.0	53	7.5	64	8.0	76	8.5	89
6	2.7	10	3.5	15	4.2	22	4.9	30	5.6	39	6.2	49	6.8	61	7.3	74	7.9	88	8.4	104	8.9	120
8	2.8	13	3.6	20	4.3	29	5.1	39	5.7	51	6.4	64	7.0	78	7.6	95	8.2	112	8.7	132		
10	2.8	16	3.7	25	4.4	35	5.2	48	5.8	62	6.5	78	7.2	96	7.8	116	8.4	137	8.9	160		
12	2.9	19	3.7	29	4.5	42	5.2	57	5.9	74	6.6	93	7.3	114	7.9	137	8.5	162				
14	2.9	22	3.7	34	4.5	49	5.3	66	6.0	85	6.7	107	7.4	131	8.0	158						
16	2.9	25	3.8	39	4.6	56	5.3	75	6.1	97	6.8	122	7.5	149								
18	2.9	28	3.8	44	4.6	62	5.4	84	6.1	109	6.8	137	7.5	167								
20	2.9	31	3.8	48	4.6	69	5.4	93	6.2	121	6.9	151										
22	3.0	34	3.8	53	4.6	76	5.4	102	6.2	132												
24	3.0	37	3.8	58	4.7	83	5.4	112	6.2	144												
26			3.8	63	4.7	90	5.5	121	6.2	156												
28			3.8	67	4.7	96	5.5	130														
30			3.9	72	4.7	103	5.5	139														

Rock d50 size: 10 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 8.8 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.4	4	3.0	7	3.6	10	4.2	15	4.7	20	5.3	26	5.8	34	6.3	42	6.7	52	7.2	63	7.7	75
4	2.6	7	3.3	11	3.9	17	4.5	23	5.1	31	5.7	40	6.2	50	6.8	62	7.3	75	7.8	89	8.3	105
6	2.7	10	3.4	16	4.1	23	4.8	32	5.4	42	6.0	54	6.6	67	7.1	82	7.6	98	8.2	117	8.7	137
8	2.7	13	3.5	21	4.2	30	4.9	41	5.6	54	6.2	68	6.8	84	7.4	103	7.9	123	8.5	144		
10	2.8	16	3.6	25	4.3	37	5.0	50	5.7	65	6.3	82	7.0	102	7.6	123	8.1	147	8.7	173		
12	2.8	19	3.6	30	4.4	43	5.1	59	5.8	77	6.5	97	7.1	119	7.7	144	8.3	171				
14	2.9	22	3.7	35	4.4	50	5.2	68	5.9	88	6.6	111	7.2	137	7.8	165						
16	2.9	25	3.7	40	4.5	57	5.2	77	5.9	100	6.6	126	7.3	155								
18	2.9	28	3.7	44	4.5	64	5.3	86	6.0	112	6.7	141										
20	2.9	31	3.7	49	4.5	70	5.3	95	6.0	123	6.7	155										
22	2.9	34	3.8	54	4.6	77	5.3	104	6.1	135												
24	2.9	37	3.8	59	4.6	84	5.4	113	6.1	147												
26			3.8	63	4.6	91	5.4	123	6.1	159												
28			3.8	68	4.6	97	5.4	132														
30			3.8	73	4.6	104	5.4	141														

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 11 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.1	5	4.0	8	4.8	12	5.6	16	6.4	22	7.1	29	7.9	36	8.5	45	9.2	55				
4	3.4	8	4.4	14	5.3	20	6.2	28	7.0	37	7.8	47	8.6	59	9.3	72	10.0	86				
6	3.5	12	4.6	20	5.5	29	6.5	39	7.4	52	8.2	66	9.0	82								
8	3.6	16	4.7	26	5.7	37	6.7	51	7.6	67	8.5	85	9.4	105								
10	3.6	20	4.7	32	5.8	46	6.8	63	7.8	83	8.7	104										
12	3.7	24	4.8	38	5.9	55	6.9	75	7.9	98	8.8	124										
14	3.7	28	4.8	44	5.9	64	7.0	87	8.0	114	8.9	143										
16	3.7	32	4.9	50	6.0	73	7.0	99	8.1	129	9.0	163										
18	3.7	36	4.9	57	6.0	82	7.1	111	8.1	145												
20	3.8	39	4.9	63	6.1	91	7.1	123	8.2	160												
22	3.8	43	5.0	69	6.1	100	7.2	135														
24	3.8	47	5.0	75	6.1	109	7.2	147														
26			5.0	81	6.1	117	7.2	159														
28			5.0	87	6.1	126																
30			5.0	94	6.2	135																

Rock d50 size: 11 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	3.0	5	3.9	9	4.7	14	5.5	19	6.3	27	7.0	35	7.7	45	8.4	56	9.1	70				
4	3.3	9	4.2	15	5.1	22	6.0	31	6.8	41	7.6	53	8.4	67	9.1	83						
6	3.4	13	4.4	21	5.4	31	6.3	42	7.2	56	8.0	72	8.8	90								
8	3.5	17	4.6	27	5.6	39	6.5	54	7.4	71	8.3	91	9.1	113								
10	3.6	21	4.6	33	5.7	48	6.6	66	7.6	87	8.5	110										
12	3.6	24	4.7	39	5.8	57	6.8	78	7.7	102	8.6	129										
14	3.7	28	4.8	45	5.8	66	6.8	90	7.8	117	8.7	149										
16	3.7	32	4.8	51	5.9	75	6.9	102	7.9	133	8.8	168										
18	3.7	36	4.8	58	5.9	83	7.0	114	8.0	148												
20	3.7	40	4.9	64	6.0	92	7.0	126	8.0	164												
22	3.7	44	4.9	70	6.0	101	7.1	138														
24	3.7	48	4.9	76	6.0	110	7.1	150														
26			4.9	82	6.0	119	7.1	162														
28			4.9	88	6.1	128																
30			5.0	95	6.1	137																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 43 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 11 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.8	4	3.7	7	4.4	11	5.2	15	5.9	20	6.5	26	7.2	33	7.8	41	8.4	50	9.0	60		
4	3.1	8	4.0	12	4.8	18	5.6	25	6.4	33	7.1	43	7.8	53	8.5	65	9.2	79	9.8	93		
6	3.2	11	4.2	18	5.1	26	5.9	36	6.7	47	7.5	60	8.3	74	9.0	90	9.7	108				
8	3.3	15	4.3	24	5.2	34	6.1	47	6.9	61	7.8	78	8.5	96	9.3	116						
10	3.3	18	4.3	29	5.3	42	6.2	58	7.1	75	7.9	95	8.7	117								
12	3.4	22	4.4	35	5.4	50	6.3	69	7.2	89	8.1	113	8.9	139								
14	3.4	25	4.4	40	5.4	58	6.4	80	7.3	104	8.2	131	9.0	161								
16	3.4	29	4.5	46	5.5	67	6.4	91	7.4	118	8.2	148										
18	3.4	32	4.5	52	5.5	75	6.5	102	7.4	132	8.3	166										
20	3.4	36	4.5	57	5.5	83	6.5	113	7.5	146												
22	3.4	40	4.5	63	5.6	91	6.5	124	7.5	161												
24	3.5	43	4.5	69	5.6	99	6.6	135														
26			4.5	74	5.6	107	6.6	146														
28			4.6	80	5.6	115	6.6	157														
30			4.6	85	5.6	123																

Rock d50 size: 11 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.8	5	3.6	8	4.3	12	5.0	18	5.7	24	6.4	32	7.0	41	7.7	52	8.3	64	8.9	77		
4	3.0	8	3.9	13	4.7	20	5.5	28	6.2	38	6.9	49	7.6	61	8.3	76	8.9	92				
6	3.1	12	4.0	19	4.9	28	5.7	39	6.5	51	7.3	66	8.0	82	8.7	100						
8	3.2	15	4.2	24	5.1	36	5.9	49	6.8	65	7.5	83	8.3	103	9.0	126						
10	3.3	19	4.2	30	5.2	44	6.1	60	6.9	79	7.7	100	8.5	124	9.3	151						
12	3.3	22	4.3	36	5.3	52	6.2	71	7.0	93	7.9	118	8.7	146								
14	3.3	26	4.4	41	5.3	60	6.2	82	7.1	107	8.0	136	8.8	167								
16	3.4	29	4.4	47	5.4	68	6.3	93	7.2	121	8.1	153										
18	3.4	33	4.4	52	5.4	76	6.4	104	7.3	136												
20	3.4	36	4.4	58	5.4	84	6.4	115	7.3	150												
22	3.4	40	4.5	64	5.5	92	6.4	126	7.4	164												
24	3.4	44	4.5	69	5.5	100	6.5	137														
26			4.5	75	5.5	109	6.5	148														
28			4.5	81	5.5	117	6.5	159														
30			4.5	86	5.6	125																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 44 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 11 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.6	4	3.4	6	4.1	10	4.8	14	5.4	19	6.0	24	6.6	31	7.2	38	7.8	46	8.3	56	8.8	66
4	2.8	7	3.7	12	4.5	17	5.2	23	5.9	31	6.6	40	7.3	50	7.9	61	8.5	73	9.1	86	9.6	101
6	3.0	10	3.8	17	4.7	24	5.5	33	6.2	44	7.0	56	7.6	69	8.3	84	9.0	100	9.6	118		
8	3.0	14	3.9	22	4.8	32	5.6	43	6.4	57	7.2	72	7.9	89	8.6	107	9.3	128				
10	3.1	17	4.0	27	4.9	39	5.8	53	6.6	70	7.3	88	8.1	109	8.8	131						
12	3.1	20	4.1	32	5.0	47	5.8	64	6.7	83	7.5	105	8.2	129	9.0	155						
14	3.1	23	4.1	37	5.0	54	5.9	74	6.7	96	7.6	121	8.3	149								
16	3.2	27	4.1	43	5.1	62	6.0	84	6.8	109	7.6	137	8.4	169								
18	3.2	30	4.2	48	5.1	69	6.0	94	6.9	122	7.7	154										
20	3.2	33	4.2	53	5.1	77	6.0	104	6.9	135												
22	3.2	37	4.2	58	5.1	84	6.1	114	6.9	149												
24	3.2	40	4.2	63	5.2	92	6.1	125	7.0	162												
26			4.2	69	5.2	99	6.1	135														
28			4.2	74	5.2	107	6.1	145														
30			4.2	79	5.2	114	6.1	155														

Rock d50 size: 11 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.5	4	3.3	8	4.0	11	4.7	16	5.3	22	5.9	30	6.5	38	7.1	48	7.7	59	8.2	71	8.8	85
4	2.8	8	3.6	12	4.3	19	5.1	26	5.8	35	6.4	45	7.1	57	7.7	70	8.3	85	8.9	102		
6	2.9	11	3.7	18	4.6	26	5.3	36	6.1	47	6.7	61	7.4	76	8.1	93	8.7	112	9.3	133		
8	3.0	14	3.9	23	4.7	33	5.5	46	6.3	60	7.0	77	7.7	95	8.3	116	9.0	139				
10	3.0	17	3.9	28	4.8	41	5.6	56	6.4	73	7.1	93	7.9	115	8.6	140	9.2	167				
12	3.1	21	4.0	33	4.9	48	5.7	66	6.5	86	7.3	109	8.0	135	8.7	164						
14	3.1	24	4.0	38	4.9	56	5.8	76	6.6	99	7.4	126	8.1	155								
16	3.1	27	4.1	43	5.0	63	5.8	86	6.7	112	7.5	142										
18	3.1	30	4.1	49	5.0	70	5.9	96	6.7	125	7.5	158										
20	3.1	34	4.1	54	5.0	78	5.9	106	6.8	139												
22	3.2	37	4.1	59	5.1	86	6.0	116	6.8	152												
24	3.2	40	4.1	64	5.1	93	6.0	127														
26			4.2	69	5.1	101	6.0	137														
28			4.2	75	5.1	108	6.0	147														
30			4.2	80	5.1	116	6.1	157														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 45 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 11 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.5	4	3.2	6	3.8	9	4.5	13	5.1	17	5.6	23	6.2	29	6.7	36	7.3	43	7.8	52	8.3	62
4	2.7	7	3.5	11	4.2	16	4.9	22	5.6	29	6.2	37	6.8	46	7.4	57	7.9	68	8.5	81	9.0	95
6	2.8	10	3.6	16	4.4	23	5.1	31	5.8	41	6.5	52	7.2	65	7.8	78	8.4	94	9.0	110	9.5	129
8	2.8	13	3.7	20	4.5	30	5.3	41	6.0	53	6.7	67	7.4	83	8.0	100	8.7	120	9.3	140		
10	2.9	16	3.8	25	4.6	37	5.4	50	6.1	65	6.9	82	7.6	102	8.2	123	8.9	146				
12	2.9	19	3.8	30	4.6	44	5.5	59	6.2	77	7.0	98	7.7	120	8.4	145	9.1	172				
14	2.9	22	3.8	35	4.7	51	5.5	69	6.3	90	7.1	113	7.8	139	8.5	168						
16	2.9	25	3.9	40	4.7	58	5.6	78	6.4	102	7.1	129	7.9	158								
18	3.0	28	3.9	45	4.8	65	5.6	88	6.4	114	7.2	144										
20	3.0	31	3.9	50	4.8	72	5.6	97	6.5	127	7.3	160										
22	3.0	34	3.9	54	4.8	79	5.7	107	6.5	139												
24	3.0	37	3.9	59	4.8	86	5.7	117	6.5	151												
26			3.9	64	4.8	93	5.7	126														
28			3.9	69	4.9	100	5.7	136														
30			4.0	74	4.9	107	5.7	145														

Rock d50 size: 11 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.4	4	3.1	7	3.7	11	4.4	15	5.0	21	5.5	28	6.1	36	6.6	45	7.2	55	7.7	67	8.2	80
4	2.6	7	3.3	12	4.1	17	4.7	24	5.4	32	6.0	42	6.6	53	7.2	65	7.7	79	8.3	95	8.8	112
6	2.7	10	3.5	16	4.3	24	5.0	33	5.7	44	6.3	57	6.9	71	7.5	87	8.1	105	8.7	124	9.2	146
8	2.8	13	3.6	21	4.4	31	5.1	43	5.8	56	6.5	72	7.2	89	7.8	109	8.4	130	9.0	154		
10	2.8	16	3.7	26	4.5	38	5.3	52	6.0	68	6.7	87	7.4	108	8.0	131	8.6	156				
12	2.9	19	3.7	31	4.6	45	5.3	62	6.1	81	6.8	102	7.5	126	8.2	153						
14	2.9	22	3.8	36	4.6	52	5.4	71	6.2	93	6.9	117	7.6	145								
16	2.9	25	3.8	41	4.7	59	5.5	80	6.2	105	7.0	133	7.7	164								
18	2.9	29	3.8	45	4.7	66	5.5	90	6.3	117	7.1	148										
20	2.9	32	3.8	50	4.7	73	5.5	99	6.3	130	7.1	164										
22	3.0	35	3.9	55	4.7	80	5.6	109	6.4	142												
24	3.0	38	3.9	60	4.8	87	5.6	118	6.4	154												
26			3.9	65	4.8	94	5.6	128														
28			3.9	70	4.8	101	5.7	137														
30			3.9	75	4.8	108	5.7	147														

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 11 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.3	3	3.0	6	3.6	9	4.2	12	4.8	16	5.3	21	5.9	27	6.4	34	6.9	41	7.3	49	7.8	59
4	2.5	6	3.3	10	3.9	15	4.6	21	5.2	27	5.8	35	6.4	44	7.0	53	7.5	64	8.0	76	8.5	89
6	2.6	9	3.4	15	4.1	21	4.8	29	5.5	39	6.1	49	6.7	61	7.3	74	7.9	88	8.4	104	9.0	121
8	2.7	12	3.5	19	4.2	28	5.0	38	5.7	50	6.3	63	7.0	78	7.6	95	8.2	113	8.8	132	9.3	154
10	2.7	15	3.5	24	4.3	35	5.1	47	5.8	62	6.5	78	7.1	96	7.8	116	8.4	137	9.0	161		
12	2.7	18	3.6	28	4.4	41	5.1	56	5.9	73	6.6	92	7.3	113	7.9	137	8.5	162				
14	2.8	21	3.6	33	4.4	48	5.2	65	6.0	85	6.7	107	7.4	131	8.0	158						
16	2.8	24	3.6	38	4.5	54	5.3	74	6.0	96	6.7	121	7.4	149								
18	2.8	27	3.7	42	4.5	61	5.3	83	6.1	108	6.8	136	7.5	167								
20	2.8	29	3.7	47	4.5	68	5.3	92	6.1	119	6.8	150										
22	2.8	32	3.7	51	4.5	74	5.3	101	6.1	131												
24	2.8	35	3.7	56	4.5	81	5.4	110	6.1	143												
26			3.7	61	4.6	88	5.4	119	6.2	154												
28			3.7	65	4.6	94	5.4	128														
30			3.7	70	4.6	101	5.4	137														

Rock d50 size: 11 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.2	4	2.9	7	3.5	10	4.1	14	4.7	20	5.2	26	5.8	34	6.3	42	6.8	52	7.3	63	7.7	75
4	2.4	7	3.2	11	3.8	16	4.5	23	5.1	31	5.7	40	6.2	50	6.8	62	7.3	75	7.8	90	8.3	106
6	2.5	10	3.3	15	4.0	23	4.7	32	5.3	42	6.0	54	6.5	67	7.1	82	7.7	99	8.2	117	8.7	137
8	2.6	12	3.4	20	4.1	29	4.8	40	5.5	53	6.2	68	6.8	84	7.4	103	7.9	123	8.5	145	9.0	169
10	2.7	15	3.5	25	4.2	36	5.0	49	5.6	65	6.3	82	6.9	102	7.6	123	8.1	147	8.7	173		
12	2.7	18	3.5	29	4.3	42	5.0	58	5.7	76	6.4	96	7.1	119	7.7	144	8.3	172				
14	2.7	21	3.6	34	4.3	49	5.1	67	5.8	88	6.5	111	7.2	137	7.8	165						
16	2.7	24	3.6	38	4.4	56	5.2	76	5.9	99	6.6	125	7.3	154								
18	2.8	27	3.6	43	4.4	62	5.2	85	5.9	111	6.7	140										
20	2.8	30	3.6	47	4.4	69	5.2	94	6.0	122	6.7	154										
22	2.8	33	3.6	52	4.5	75	5.3	103	6.0	134												
24	2.8	36	3.7	57	4.5	82	5.3	112	6.1	145												
26			3.7	61	4.5	89	5.3	121	6.1	157												
28			3.7	66	4.5	95	5.3	130														
30			3.7	70	4.5	102	5.3	139														

Figure IN-6-9 - Rock Lined Chute Capacity

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 11 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.2	3	2.8	5	3.4	8	4.0	12	4.5	16	5.1	20	5.6	26	6.0	32	6.5	39	7.0	47	7.4	56
4	2.4	6	3.1	10	3.7	14	4.4	20	5.0	26	5.5	33	6.1	41	6.6	51	7.1	61	7.6	72	8.1	85
6	2.5	9	3.2	14	3.9	20	4.6	28	5.2	37	5.8	47	6.4	58	7.0	70	7.5	84	8.0	99	8.5	115
8	2.5	11	3.3	18	4.0	27	4.7	36	5.4	47	6.0	60	6.6	74	7.2	90	7.8	107	8.3	126	8.8	146
10	2.6	14	3.4	23	4.1	33	4.8	45	5.5	58	6.1	74	6.8	91	7.4	110	8.0	130	8.5	153	9.1	177
12	2.6	17	3.4	27	4.2	39	4.9	53	5.6	69	6.2	87	6.9	108	7.5	130	8.1	154				
14	2.6	20	3.4	31	4.2	45	4.9	62	5.6	80	6.3	101	7.0	124	7.6	150						
16	2.6	22	3.5	36	4.2	52	5.0	70	5.7	91	6.4	115	7.1	141	7.7	170						
18	2.6	25	3.5	40	4.3	58	5.0	79	5.7	102	6.4	129	7.1	158								
20	2.7	28	3.5	44	4.3	64	5.0	87	5.8	113	6.5	143										
22	2.7	31	3.5	49	4.3	70	5.1	96	5.8	124	6.5	157										
24	2.7	33	3.5	53	4.3	77	5.1	104	5.8	135												
26			3.5	57	4.3	83	5.1	113	5.9	147												
28			3.5	62	4.3	89	5.1	121	5.9	158												
30			3.5	66	4.4	96	5.1	130														

Rock d50 size: 11 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 9.2 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.1	4	2.8	6	3.3	10	3.9	14	4.4	19	5.0	25	5.5	32	5.9	40	6.4	49	6.9	60	7.3	71
4	2.3	6	3.0	10	3.6	16	4.2	22	4.8	29	5.4	38	5.9	47	6.4	59	6.9	71	7.4	85	7.9	100
6	2.4	9	3.1	15	3.8	22	4.5	30	5.1	40	5.6	51	6.2	63	6.7	78	7.3	94	7.8	111	8.3	130
8	2.5	12	3.2	19	3.9	28	4.6	38	5.2	50	5.8	64	6.4	80	7.0	97	7.5	116	8.1	138	8.6	161
10	2.5	15	3.3	23	4.0	34	4.7	47	5.4	61	6.0	78	6.6	96	7.2	117	7.7	140	8.3	164		
12	2.6	17	3.3	28	4.1	40	4.8	55	5.4	72	6.1	91	6.7	113	7.3	137	7.9	163				
14	2.6	20	3.4	32	4.1	46	4.8	63	5.5	83	6.2	105	6.8	130	7.4	157						
16	2.6	23	3.4	36	4.2	53	4.9	72	5.6	94	6.3	119	6.9	146								
18	2.6	26	3.4	41	4.2	59	4.9	80	5.6	105	6.3	133	7.0	163								
20	2.6	28	3.4	45	4.2	65	5.0	89	5.7	116	6.4	146										
22	2.6	31	3.5	49	4.2	72	5.0	97	5.7	127	6.4	160										
24	2.6	34	3.5	54	4.3	78	5.0	106	5.7	138												
26			3.5	58	4.3	84	5.0	114	5.8	149												
28			3.5	62	4.3	90	5.1	123	5.8	160												
30			3.5	67	4.3	97	5.1	132														

Figure IN-6-9 - Rock Lined Chute Capacity

Sheet 48 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 12 inches; Chute side slope: 2 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.8	4	3.7	7	4.5	11	5.3	15	6.0	21	6.8	27	7.4	34	8.1	43	8.8	52	9.4	63		
4	3.0	8	4.0	13	4.9	19	5.8	26	6.6	34	7.4	44	8.1	56	8.9	68	9.6	82	10.3	98		
6	3.2	11	4.2	18	5.1	27	6.1	37	6.9	49	7.8	62	8.6	77	9.3	94	10.1	113				
8	3.2	15	4.3	24	5.3	35	6.2	48	7.2	63	8.0	80	8.9	99	9.7	121						
10	3.3	18	4.4	29	5.4	43	6.4	59	7.3	78	8.2	99	9.1	122								
12	3.3	22	4.4	35	5.5	51	6.5	70	7.4	92	8.3	117	9.2	144								
14	3.3	25	4.5	41	5.5	59	6.5	82	7.5	107	8.5	135	9.4	167								
16	3.4	29	4.5	46	5.6	68	6.6	93	7.6	121	8.5	154										
18	3.4	32	4.5	52	5.6	76	6.6	104	7.6	136												
20	3.4	36	4.5	58	5.6	84	6.7	115	7.7	151												
22	3.4	39	4.5	63	5.6	93	6.7	127														
24	3.4	43	4.6	69	5.7	101	6.7	138														
26			4.6	75	5.7	109	6.8	149														
28			4.6	80	5.7	117	6.8	161														
30			4.6	86	5.7	126																

Rock d50 size: 12 inches; Chute side slope: 3 to 1; Chute profile slope: 5 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.7	5	3.6	8	4.4	13	5.2	18	5.9	25	6.6	33	7.3	43	8.0	54	8.6	66	9.3	81		
4	3.0	8	3.9	14	4.8	20	5.6	29	6.4	39	7.2	50	7.9	64	8.6	79	9.3	96				
6	3.1	12	4.1	19	5.0	28	5.9	40	6.7	53	7.5	68	8.3	85	9.1	105						
8	3.2	15	4.2	25	5.2	36	6.1	51	7.0	67	7.8	86	8.6	107	9.4	131						
10	3.2	19	4.3	30	5.3	45	6.2	62	7.1	81	8.0	104	8.8	129	9.6	157						
12	3.3	22	4.3	36	5.4	53	6.3	73	7.3	96	8.1	122	9.0	151								
14	3.3	26	4.4	42	5.4	61	6.4	84	7.3	110	8.3	140										
16	3.3	29	4.4	47	5.5	69	6.5	95	7.4	125	8.4	159										
18	3.3	33	4.4	53	5.5	77	6.5	106	7.5	140												
20	3.4	36	4.5	58	5.5	86	6.6	118	7.6	154												
22	3.4	40	4.5	64	5.6	94	6.6	129														
24	3.4	43	4.5	70	5.6	102	6.6	140														
26			4.5	75	5.6	111	6.7	151														
28			4.5	81	5.6	119																
30			4.6	87	5.7	127																

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 49 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 12 inches; Chute side slope: 2 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.6	4	3.4	6	4.1	10	4.8	14	5.5	19	6.2	25	6.8	31	7.4	39	8.0	48	8.6	58	9.1	69
4	2.8	7	3.7	11	4.5	17	5.3	24	6.0	31	6.7	40	7.4	51	8.1	62	8.7	75	9.4	89	10.0	105
6	2.9	10	3.8	16	4.7	24	5.5	34	6.3	44	7.1	57	7.8	71	8.5	86	9.2	103	9.9	122		
8	3.0	13	3.9	22	4.8	32	5.7	44	6.5	58	7.3	73	8.1	91	8.8	110	9.5	132				
10	3.0	16	4.0	27	4.9	39	5.8	54	6.7	71	7.5	90	8.3	111	9.0	135	9.8	160				
12	3.0	20	4.0	32	5.0	47	5.9	64	6.8	84	7.6	107	8.4	132	9.2	159						
14	3.1	23	4.1	37	5.0	54	6.0	74	6.9	98	7.7	123	8.5	152								
16	3.1	26	4.1	42	5.1	62	6.0	85	6.9	111	7.8	140										
18	3.1	29	4.1	47	5.1	69	6.1	95	7.0	124	7.9	157										
20	3.1	33	4.1	53	5.1	77	6.1	105	7.0	138												
22	3.1	36	4.2	58	5.2	84	6.1	116	7.1	151												
24	3.1	39	4.2	63	5.2	92	6.1	126														
26			4.2	68	5.2	100	6.2	136														
28			4.2	73	5.2	107	6.2	147														
30			4.2	79	5.2	115	6.2	157														

Rock d50 size: 12 inches; Chute side slope: 3 to 1; Chute profile slope: 6 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.5	4	3.3	7	4.0	12	4.7	17	5.4	23	6.0	30	6.7	39	7.3	49	7.9	61	8.5	74	9.0	88
4	2.7	7	3.6	12	4.4	19	5.1	26	5.9	35	6.6	46	7.2	58	7.9	72	8.5	87	9.1	105		
6	2.8	11	3.7	17	4.6	26	5.4	36	6.1	48	6.9	62	7.6	78	8.3	95	8.9	115	9.6	137		
8	2.9	14	3.8	22	4.7	33	5.6	46	6.4	61	7.1	78	7.9	98	8.6	119	9.3	143				
10	2.9	17	3.9	28	4.8	41	5.7	56	6.5	74	7.3	95	8.1	118	8.8	144	9.5	172				
12	3.0	20	4.0	33	4.9	48	5.8	66	6.6	88	7.4	111	8.2	139	9.0	168						
14	3.0	23	4.0	38	4.9	56	5.8	77	6.7	101	7.5	128	8.3	159								
16	3.0	26	4.0	43	5.0	63	5.9	87	6.8	114	7.6	145										
18	3.0	30	4.1	48	5.0	71	6.0	97	6.8	128	7.7	162										
20	3.1	33	4.1	53	5.1	78	6.0	107	6.9	141												
22	3.1	36	4.1	59	5.1	86	6.0	118	6.9	154												
24	3.1	39	4.1	64	5.1	93	6.1	128														
26			4.1	69	5.1	101	6.1	138														
28			4.1	74	5.1	108	6.1	149														
30			4.2	79	5.2	116	6.1	159														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 50 of 54

(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 12 inches; Chute side slope: 2 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.4	4	3.1	6	3.8	9	4.5	13	5.1	17	5.7	23	6.3	29	6.9	36	7.4	44	7.9	53	8.5	63
4	2.6	6	3.4	11	4.2	16	4.9	22	5.6	29	6.2	37	6.9	47	7.5	58	8.1	69	8.7	83	9.2	97
6	2.7	9	3.5	15	4.4	23	5.1	31	5.9	41	6.6	53	7.2	65	7.9	80	8.5	95	9.1	113	9.7	131
8	2.7	12	3.6	20	4.5	29	5.3	41	6.0	53	6.8	68	7.5	84	8.2	102	8.8	122	9.5	143		
10	2.8	15	3.7	25	4.6	36	5.4	50	6.2	66	6.9	83	7.7	103	8.4	125	9.1	148	9.7	174		
12	2.8	18	3.7	30	4.6	43	5.5	59	6.3	78	7.1	99	7.8	122	8.5	147	9.2	175				
14	2.8	21	3.8	34	4.7	50	5.5	69	6.4	90	7.1	114	7.9	141	8.7	170						
16	2.8	24	3.8	39	4.7	57	5.6	78	6.4	103	7.2	130	8.0	160								
18	2.9	27	3.8	44	4.7	64	5.6	88	6.5	115	7.3	146										
20	2.9	30	3.8	49	4.8	71	5.6	97	6.5	127	7.3	161										
22	2.9	33	3.8	54	4.8	78	5.7	107	6.5	140												
24	2.9	36	3.9	58	4.8	85	5.7	117	6.6	152												
26			3.9	63	4.8	92	5.7	126														
28			3.9	68	4.8	99	5.7	136														
30			3.9	73	4.8	106	5.7	145														

Rock d50 size: 12 inches; Chute side slope: 3 to 1; Chute profile slope: 7 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.3	4	3.0	7	3.7	11	4.4	15	5.0	21	5.6	28	6.2	36	6.8	45	7.3	56	7.8	68	8.4	82
4	2.5	7	3.3	11	4.0	17	4.7	24	5.4	33	6.1	42	6.7	54	7.3	67	7.9	81	8.4	97	9.0	115
6	2.6	10	3.4	16	4.2	24	5.0	33	5.7	45	6.4	57	7.0	72	7.7	88	8.3	107	8.9	127	9.5	149
8	2.7	13	3.5	21	4.4	31	5.1	43	5.9	57	6.6	73	7.3	90	7.9	110	8.6	133	9.2	157		
10	2.7	16	3.6	26	4.5	38	5.3	52	6.0	69	6.8	88	7.5	109	8.1	133	8.8	159				
12	2.8	19	3.7	30	4.5	45	5.3	62	6.1	81	6.9	103	7.6	128	8.3	155						
14	2.8	22	3.7	35	4.6	52	5.4	71	6.2	93	7.0	119	7.7	147								
16	2.8	25	3.7	40	4.6	59	5.5	80	6.3	106	7.1	134	7.8	166								
18	2.8	27	3.8	45	4.7	65	5.5	90	6.3	118	7.1	150										
20	2.8	30	3.8	49	4.7	72	5.6	99	6.4	130	7.2	165										
22	2.8	33	3.8	54	4.7	79	5.6	109	6.4	143												
24	2.9	36	3.8	59	4.7	86	5.6	118	6.5	155												
26			3.8	64	4.7	93	5.6	128														
28			3.8	69	4.8	100	5.7	138														
30			3.8	73	4.8	107	5.7	147														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 51 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 12 inches; Chute side slope: 2 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.2	3	2.9	6	3.6	8	4.2	12	4.8	16	5.3	21	5.9	27	6.4	34	6.9	41	7.4	50	7.9	59
4	2.4	6	3.2	10	3.9	15	4.6	20	5.2	27	5.8	35	6.4	44	7.0	54	7.6	65	8.1	77	8.6	91
6	2.5	9	3.3	14	4.1	21	4.8	29	5.5	39	6.1	49	6.8	61	7.4	74	8.0	89	8.5	105	9.1	123
8	2.6	12	3.4	19	4.2	28	4.9	38	5.7	50	6.3	63	7.0	79	7.6	95	8.3	114	8.9	134	9.4	156
10	2.6	14	3.4	23	4.3	34	5.0	47	5.8	61	6.5	78	7.2	96	7.8	117	8.5	139	9.1	163		
12	2.6	17	3.5	28	4.3	41	5.1	56	5.9	73	6.6	92	7.3	114	8.0	138	8.6	164				
14	2.6	20	3.5	32	4.4	47	5.2	64	5.9	84	6.7	107	7.4	132	8.1	159						
16	2.7	23	3.5	37	4.4	54	5.2	73	6.0	96	6.8	122	7.5	150								
18	2.7	25	3.6	41	4.4	60	5.2	82	6.0	108	6.8	136	7.5	168								
20	2.7	28	3.6	46	4.4	67	5.3	91	6.1	119	6.9	151										
22	2.7	31	3.6	50	4.5	73	5.3	100	6.1	131												
24	2.7	34	3.6	55	4.5	80	5.3	109	6.1	143												
26			3.6	59	4.5	86	5.3	118	6.2	154												
28			3.6	64	4.5	93	5.4	127														
30			3.6	68	4.5	99	5.4	136														

Rock d50 size: 12 inches; Chute side slope: 3 to 1; Chute profile slope: 8 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.1	4	2.8	6	3.5	10	4.1	14	4.7	20	5.2	26	5.8	34	6.3	42	6.8	52	7.3	64	7.8	76
4	2.3	6	3.1	11	3.8	16	4.4	23	5.1	31	5.7	40	6.3	50	6.8	62	7.4	76	7.9	91	8.4	107
6	2.4	9	3.2	15	4.0	22	4.7	31	5.3	42	6.0	54	6.6	67	7.2	83	7.7	100	8.3	119	8.8	139
8	2.5	12	3.3	19	4.1	29	4.8	40	5.5	53	6.2	68	6.8	85	7.4	103	8.0	124	8.6	147	9.2	172
10	2.5	15	3.4	24	4.2	35	4.9	49	5.6	64	6.3	82	7.0	102	7.6	124	8.2	149	8.8	176		
12	2.6	17	3.4	28	4.2	42	5.0	58	5.7	76	6.4	97	7.1	120	7.8	145	8.4	174				
14	2.6	20	3.5	33	4.3	48	5.1	66	5.8	87	6.5	111	7.2	137	7.9	167						
16	2.6	23	3.5	37	4.3	55	5.1	75	5.9	99	6.6	126	7.3	155								
18	2.6	26	3.5	42	4.4	61	5.2	84	5.9	110	6.7	140										
20	2.7	28	3.5	46	4.4	68	5.2	93	6.0	122	6.7	155										
22	2.7	31	3.6	51	4.4	74	5.2	102	6.0	134												
24	2.7	34	3.6	55	4.4	81	5.2	111	6.0	145												
26			3.6	60	4.4	87	5.3	120	6.1	157												
28			3.6	64	4.5	94	5.3	129														
30			3.6	69	4.5	100	5.3	138														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 52 of 54
(EFM Notice IN-53, November 1989)

ROCK LINED CHUTE CAPACITY

Rock d50 size: 12 inches; Chute side slope: 2 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.1	3	2.7	5	3.4	8	3.9	11	4.5	15	5.0	20	5.5	26	6.0	32	6.5	39	7.0	47	7.5	56
4	2.3	6	3.0	9	3.7	14	4.3	19	4.9	26	5.5	33	6.1	41	6.6	51	7.1	61	7.6	73	8.1	85
6	2.4	8	3.1	13	3.8	20	4.5	27	5.2	36	5.8	46	6.4	58	7.0	70	7.5	84	8.1	99	8.6	116
8	2.4	11	3.2	18	3.9	26	4.7	36	5.3	47	6.0	60	6.6	74	7.2	90	7.8	107	8.4	126	8.9	147
10	2.4	13	3.3	22	4.0	32	4.7	44	5.4	58	6.1	73	6.8	91	7.4	110	8.0	131	8.6	154	9.1	178
12	2.5	16	3.3	26	4.1	38	4.8	52	5.5	69	6.2	87	6.9	108	7.5	130	8.1	155				
14	2.5	19	3.3	30	4.1	44	4.9	61	5.6	80	6.3	101	7.0	124	7.6	150						
16	2.5	21	3.3	35	4.1	50	4.9	69	5.7	91	6.4	115	7.1	141								
18	2.5	24	3.4	39	4.2	57	4.9	78	5.7	101	6.4	128	7.1	158								
20	2.5	27	3.4	43	4.2	63	5.0	86	5.7	112	6.5	142										
22	2.5	29	3.4	47	4.2	69	5.0	94	5.8	123	6.5	156										
24	2.5	32	3.4	51	4.2	75	5.0	103	5.8	134												
26			3.4	56	4.2	81	5.0	111	5.8	145												
28			3.4	60	4.3	87	5.1	120	5.8	156												
30			3.4	64	4.3	94	5.1	128														

Rock d50 size: 12 inches; Chute side slope: 3 to 1; Chute profile slope: 9 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.0	4	2.7	6	3.3	9	3.8	14	4.4	19	4.9	25	5.5	32	6.0	40	6.4	49	6.9	60	7.4	72
4	2.2	6	2.9	10	3.6	15	4.2	21	4.8	29	5.4	37	5.9	47	6.4	59	7.0	71	7.5	86	7.9	101
6	2.3	9	3.0	14	3.7	21	4.4	30	5.0	39	5.6	51	6.2	63	6.8	78	7.3	94	7.8	112	8.3	131
8	2.4	11	3.1	18	3.8	27	4.5	38	5.2	50	5.8	64	6.4	80	7.0	97	7.6	117	8.1	138	8.6	162
10	2.4	14	3.2	23	3.9	33	4.6	46	5.3	61	6.0	77	6.6	96	7.2	117	7.8	140	8.3	165		
12	2.4	16	3.2	27	4.0	39	4.7	54	5.4	71	6.1	91	6.7	113	7.3	137	7.9	164				
14	2.5	19	3.3	31	4.0	45	4.8	63	5.5	82	6.2	105	6.8	130	7.4	157						
16	2.5	22	3.3	35	4.1	52	4.8	71	5.5	93	6.2	118	6.9	146								
18	2.5	24	3.3	39	4.1	58	4.9	79	5.6	104	6.3	132	7.0	163								
20	2.5	27	3.3	44	4.1	64	4.9	88	5.6	115	6.3	146										
22	2.5	29	3.3	48	4.2	70	4.9	96	5.7	126	6.4	160										
24	2.5	32	3.4	52	4.2	76	4.9	105	5.7	137												
26			3.4	56	4.2	82	5.0	113	5.7	148												
28			3.4	60	4.2	89	5.0	121	5.7	159												
30			3.4	65	4.2	95	5.0	130														

Figure IN-6-9 - Rock Lined Chute Capacity
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ROCK LINED CHUTE CAPACITY

Rock d50 size: 12 inches; Chute side slope: 2 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	2.0	3	2.6	5	3.2	8	3.7	11	4.3	15	4.8	19	5.3	24	5.7	30	6.2	37	6.6	45	7.1	53
4	2.2	5	2.8	9	3.5	13	4.1	18	4.7	24	5.2	31	5.8	39	6.3	48	6.8	58	7.3	69	7.7	81
6	2.2	8	3.0	13	3.6	19	4.3	26	4.9	34	5.5	44	6.1	55	6.6	67	7.1	80	7.6	94	8.1	110
8	2.3	10	3.0	17	3.7	25	4.4	34	5.1	45	5.7	57	6.3	70	6.8	85	7.4	102	7.9	120	8.4	139
10	2.3	13	3.1	21	3.8	30	4.5	42	5.2	55	5.8	70	6.4	86	7.0	104	7.6	124	8.1	146	8.7	169
12	2.3	15	3.1	25	3.9	36	4.6	50	5.3	65	5.9	83	6.5	102	7.1	123	7.7	147	8.3	172		
14	2.4	18	3.1	29	3.9	42	4.6	58	5.3	76	6.0	96	6.6	118	7.2	142	7.8	169				
16	2.4	20	3.2	33	3.9	48	4.7	66	5.4	86	6.0	109	6.7	134	7.3	162						
18	2.4	23	3.2	37	4.0	54	4.7	74	5.4	96	6.1	122	6.7	150								
20	2.4	25	3.2	41	4.0	60	4.7	82	5.4	107	6.1	135	6.8	166								
22	2.4	28	3.2	45	4.0	65	4.7	90	5.5	117	6.2	148										
24	2.4	30	3.2	49	4.0	71	4.8	98	5.5	127	6.2	161										
26			3.2	53	4.0	77	4.8	106	5.5	138												
28			3.2	57	4.0	83	4.8	114	5.5	148												
30			3.2	61	4.0	89	4.8	121	5.5	159												

Rock d50 size: 12 inches; Chute side slope: 3 to 1; Chute profile slope: 10 to 1;
Maximum allowable velocity: 9.6 feet per second Maximum allowable Q = 150 cfs

d:	0.5		0.6		0.7		0.8		0.9		1.0		1.1		1.2		1.3		1.4		1.5	
b	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q	V	Q
2	1.9	3	2.5	6	3.1	9	3.7	13	4.2	18	4.7	23	5.2	30	5.7	38	6.1	47	6.6	57	7.0	68
4	2.1	6	2.8	10	3.4	14	4.0	20	4.5	27	5.1	36	5.6	45	6.1	56	6.6	68	7.1	81	7.5	96
6	2.2	8	2.9	13	3.5	20	4.2	28	4.8	37	5.3	48	5.9	60	6.4	74	6.9	89	7.4	106	7.9	125
8	2.2	11	3.0	17	3.6	26	4.3	36	4.9	47	5.5	61	6.1	76	6.6	92	7.2	111	7.7	131	8.2	154
10	2.3	13	3.0	21	3.7	32	4.4	44	5.0	58	5.7	73	6.2	91	6.8	111	7.4	133	7.9	157		
12	2.3	16	3.1	25	3.8	37	4.5	51	5.1	68	5.8	86	6.4	107	6.9	130	7.5	155				
14	2.3	18	3.1	29	3.8	43	4.5	59	5.2	78	5.8	99	6.5	123	7.1	149						
16	2.3	21	3.1	33	3.9	49	4.6	67	5.3	88	5.9	112	6.5	139	7.1	168						
18	2.4	23	3.1	37	3.9	55	4.6	75	5.3	99	6.0	125	6.6	155								
20	2.4	25	3.2	41	3.9	61	4.6	83	5.3	109	6.0	138										
22	2.4	28	3.2	45	3.9	66	4.7	91	5.4	119	6.1	151										
24	2.4	30	3.2	49	4.0	72	4.7	99	5.4	130												
26			3.2	53	4.0	78	4.7	107	5.4	140												
28			3.2	57	4.0	84	4.7	115	5.5	151												
30			3.2	61	4.0	90	4.7	123														

Figure IN-6-9 - Rock Lined Chute Capacity
Sheet 54 of 54

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Entrance Section:

It is important that the rock lined entrance section provide a suitable transition from the upstream waterway into the chute section. Figure 6-19 on page 6-29 of the Engineering Field Manual is illustrative of the manner in which the entrance section should be shaped. It is also important that the side slope shoulders of the entrance section be high enough to train all the flow into the chute section.

To allow for freeboard above the critical depth use a total depth of rock on the entrance side slopes equal to the inflow waterway depth, but not less than (d + 1). This depth of entrance is shown as "de" on the data sheet (IN-ENG-36).

The entrance length (Le) must provide for an effective transition from the inflow waterway to the chute channel. Use minimum entrance length (Le) equal to 5(de).

The width at the upstream end of the entrance (be) should be at least equal to the chute bottom width, but should be widened as necessary to provide an effective transition from the inflow waterway to the chute. If there is no distinct waterway, make upstream end of entrance section (be) equal to (b + Le).

Outlet Section:

The length and depth required for the outlet section depends upon the velocity leaving the chute section and the outlet conditions. Normally a chute will discharge into a relatively flat outlet grade that could be considered as a free outlet except that the flow from the chute provides a tailwater effect in the outlet channel. For this in-line condition, a minimum length (Lo) of 6 feet of lined outlet should be provided for chute velocities (V) less than 5 feet per second. For chute velocities (V) greater than 5 feet per second, the minimum length (Lo) of the lined outlet is recommended as [6 + 3(V-5)] feet.

If the chute outlets side drainage into a channel or ditch, or into standing water, so that a high tailwater condition will exist during flows in the chute, a shorter length of lined outlet section may be adequate. A minimum length (Lo) of 6 feet of lined outlet should be provided for side inlet channels. Where the tailwater is shallow, or the downstream drainage channel or ditch is narrow, increase the length (Lo) of the lined outlet as recommended for an in-line channel.

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The height of the hydraulic jump is considered to be at least twice the flow depth in the chute. However, the tailwater depth created in the outlet channel will determine actual depth. A freeboard of 0.5 feet should be provided above the tailwater elevation. Use a total depth equal to (2 d + 0.5), shown as "do" on the data sheet (IN-ENG-36), unless otherwise determined.

Emergency Spillway:

An emergency spillway should be provided if feasible. The crest of the emergency spillway is established above the flow depth in the approach channel or waterway for the chute design flow. The minimum design flow for the emergency spillway is the difference between the "total capacity" shown in Table 1 of Technical Guide Specification 410 and the actual capacity of the rock lined chute. The design of an emergency spillway is discussed in Chapter 11 of the EFM, which includes design information and aids.

Top of Settled Fill:

The top of fill adjacent to the rock lined chute should be at least 0.5 feet above the rock in the chute entrance channel (de). If an emergency spillway is provided, the top of fill should be 0.5 feet above the flow depth in the emergency spillway (Hp), but not less than 1.0 foot above the emergency spillway crest elevation.

Rock Lining:

There is little data available about the thickness required for a rock lining (tr) used in a short duration, full flow chute application. For design purposes, the thickness of the rock lining (tr) should be 2 times the d50 rock size, but not less than 12 inches (1 foot) nor more than 24 inches (2 feet).

The rock lining, to be effective, must be fairly well graded, with smaller rocks, chips and spalls incorporated uniformly throughout the rock mass to prevent soil movement between the stones while allowing ground water seepage to flow out from behind the rock lining without building up a hydrostatic head. For design purposes, the maximum rock size (d100) should be twice the d50 rock size, but not greater than 18 inches, and the maximum d15 size should be one-third the d50 rock size.

In-place rock density (Dr) will vary with the locale, the size and quality of the rock particles, and the technique and compactive effort used in placement of the riprap. Specific gravity of quality rock is approximately 2.64. In-place density of riprap will vary from 95 to 115 pounds per cubic foot (pcf). A reasonable value to use for estimating purposes is 110 pcf.

Bedding:

Where the rock lined chute is placed on highly erosive soils, such as SP's, SM's, ML's and CL-ML's, a suitable bedding must be placed beneath the rock. The bedding must prevent migration of the base soils, and must not itself migrate through the rock lining. A bedding using graded gravel with a d85 size equal to one-twelfth the d50 rock size of the chute lining can be effective. Geotextiles can also be used effectively, and may be needed where the gravel bedding gradation will not prevent the migration of the base soils. If a gravel bedding is used, the thickness (tb) should be a minimum of 6 inches. For estimating purposes, a value of 110 pcf can be used to estimate the in-place density of the bedding (Db). See step 16 of Design Procedure for details of bedding and geotextiles.

Design Example:

The following example will illustrate how an economical rock chute may be selected by use of the figures. Only selected rock sizes and chute slopes will be evaluated for the example. The in-place density and costs of the rock delivered and placed should be determined to ascertain the most economical combination of chute slope, width and d50 rock size.

From Technical Guide Specification 410, Table 1, determine the required storm frequency for the chute spillway design. From EFM Chapter 2, determine the peak discharge for the applicable 24 hour storm frequency, which will be the design flow (Q).

For this example, use design flow (Q) = 35 cfs.

To figure the end area of the rock section, use:

$$\text{Area} = (tr)[b + 2d(z^2 + 1)^{0.5}]$$

where:

Area = end area of the rock lining - square feet
tr = rock lining thickness - feet
b = bottom width of the flow section - feet
d = total depth of the flow section - feet (de, dc, or do)
z = chute side slope ratio (normally 3:1)

Try d50 rock size = 12 inches:

From Figure IN-6-8, find that the allowable velocity for 12 inch stone is 9.6 ft./sec.

From Figure IN-6-9, Sheet 49 of 54, for Q = 36 cfs, chute profile slope (S) = 5:1, chute side slopes (z) = 3:1, bottom width (b) = 8 feet, flow depth (d) = 0.70 feet, velocity (V) = 5.2 fps

de = 0.7 + 1 = 1.7 feet
dc = 0.7 + 0.5 = 1.2 feet
do = 2(0.7) + 0.5 = 1.9 feet
Entrance length (Le) = 5(1.7) = 8.5 feet; Use 9 feet
Upstream entrance width (be) = b + Le = 8 + 9 = 17 feet
Chute slope length (Ls) = 6 $(5^2 + 1)^{0.5}$] = 6 (5.1)
= 30.6 feet
Outlet length (Lo) = 6 + 3(5.2 - 5.0) = (6 + 0.6)
= 6.6 feet; Use 7 feet

Determine volume of rock:
Use rock thickness (tr) = 2.0 feet

Entrance Section:
Average rock section area
= 2 [(0.5)(17+8)+(2)(1.7)$(3^2 + 1)^{0.5}$]
= 2 [12.5 + 3.4(3.16)]
= 2 [12.5 + 10.7] = 2 [23.2] = 46.4 sq.ft.
Entrance length (Le) = 9 feet
Volume of rock = 9 x 46.4 = 418 cu.ft.

Chute Section:
Rock section area
= 2 [8 + (2)(1.2)$(3^2 + 1)^{0.5}$]
= 2 [8 + 2.4(3.16)]
= 2 [8 + 7.6] = 2 [15.6] = 31.2 sq.ft.
Volume of rock = 31.2 x 30.6 = 955 cu.ft.

Outlet Section:
Rock section area
= 2 [8 + (2)(1.9)$(3^2 + 1)^{0.5}$]
= 2 [8 + 3.8(3.16)]
= 2 [8 + 12.0] = 2 [20.0] = 40.0 sq.ft.
Outlet length (Lo) = 7 feet
Volume of rock = 7 x 40.0 = 280 cu.ft.

Total volume = 418 + 955 + 280 = 1653 cu.ft.
(1653 cu. ft.)(110 pcf/2000 lbs per ton) = 91 tons

(EFM Notice IN-53, November 1989)

Try d50 rock size = 9 inches:

From Figure IN-6-8, find that the allowable velocity for 9 inch stone is 8.4 ft./sec.

From Figure IN-6-9, Sheet 31 of 54, For Q = 36 cfs, chute profile slope (S) = 5:1, chute side slopes (z) = 3:1, bottom width (b) = 6 feet, flow depth (d) = 0.70 feet, velocity (V) = 6.3 fps

de = 0.7 + 1 = 1.7 feet
dc = 0.7 + 0.5 = 1.2 feet
do = 2(0.7) + 0.5 = 1.9 feet
Entrance length (Le) = 5(1.7) = 8.5 feet; Use 9 feet
Upstream entrance width (be) = b + Le = 6 + 9 = 15 feet
Chute slope length (Ls) = $6(5^2 + 1)^{0.5}$] = 6 x 5.1
= 30.6 feet
Outlet length (Lo) = 6 + 3(6.3 - 5.0) = 6 + 3.9
= 9.9 feet; Use 10 feet

Determine volume of rock:
Use rock thickness (tr) = 1.5 feet

Entrance Section:
Average rock section area
= $1.5\,[(0.5)(15+6)+(2)(1.7)(3^2 + 1)^{0.5}]$
= 1.5 [10.5 + 3.4(3.16)]
= 1.5 [10.5 + 10.7] = 1.5 [21.2]
= 31.8 sq.ft.
Entrance length (Le) = 9 feet
Volume of rock = 9 x 31.8 = 286 cu.ft.

Chute Section:
Rock section area
= $1.5\,[6 + (2)(1.2)(3^2 + 1)^{0.5}]$
= 1.5 [6 + 2.4(3.16)]
= 1.5 [6 + 7.6] = 1.5 [13.6] = 20.4 sq.ft.
Volume of rock = 20.4 x 30.6 = 624 cu.ft.

Outlet Section:
Rock section area
= $1.5\,[6 + (2)(1.9)(3^2 + 1)^{0.5}]$
= 1.5 [6 + 3.8(3.16)]
= 1.5 [6 + 12.0] = 1.5 [18.0] = 27.0 sq.ft.
Outlet length (Lo) = 10 feet
Volume of rock = 10 x 27.0 = 270 cu.ft.

Total volume = 286 + 624 + 270 = 1180 cu. ft.
(1180 cu. ft.)(110 pcf/2000 lbs per ton) = 65 tons

Try d50 rock size = 7 inches

From Figure IN-6-8, find that the allowable velocity for 7 inch stone is 7.4 ft./sec.

From Figure IN-6-9, Sheet 19 of 54, For Q = 38 cfs, chute profile slope (S) = 5:1, chute side slopes (z) = 3:1, bottom width (b) = 8 feet, flow depth (d) = 0.60 feet, velocity (V) = 6.5 fps

de = 0.6 + 1 = 1.6 feet
dc = 0.6 + 0.5 = 1.1 feet
do = 2(0.6) + 0.5 = 1.7 feet
Entrance length (Le)= 5(1.6) = 8 feet
Upstream entrance width (be) = b + Le = 8 + 8 = 16 feet
Chute slope length (Ls) = $6(5^2 + 1)^{0.5}$] = 6 x 5.1
= 30.6 feet
Outlet length (Lo) = 6 + 3(6.5 - 5) = 6 + 4.5
= 10.5 feet; Use 11 feet

Determine volume of rock:
Use rock thickness (tr) = 1.2 feet

Entrance Section:
Average rock section area
= 1.2 [(0.5)(16+8)+(2)(1.6)$(3^2 + 1)^{0.5}$]
= 1.2 [12 + 3.2(3.16)]
= 1.2 [12 + 10.1] = 1.2 [22.1]
= 26.5 sq.ft.
Entrance length (Le) = 8 feet
Volume of rock = 8 x 26.5 = 212 cu. ft.

Chute Section:
Rock section area
= 1.2 [8 + (2)(1.1)$(3^2 + 1)^{0.5}$]
= 1.2 [8 + 2.2(3.16)]
= 1.2 [8 + 7.0] = 1.2 [15.0] = 18.0 sq.ft.
Volume of rock = 18.0 x 30.6 = 551 cu. ft.

Outlet Section:
Rock section area
= 1.2 [8 + (2)(1.7)$(3^2 + 1)^{0.5}$]
= 1.2 [8 + 3.4(3.16)]
= 1.2 [8 + 10.7] = 1.2 [18.7] = 22.4 sq.ft.
Outlet length (Lo) = 11 feet
Volume of rock = 11 x 22.4 = 246 cu. ft.

Total volume = 212 + 551 + 246 = 1009 cu. ft.
(1009 cu. ft.)(110 pcf/2000 lbs per ton) = 55 tons

(EFM Notice IN-53, November 1989)

Try d50 rock size = 4 inches:

From Figure IN-6-8, find that the allowable velocity for 4 inch stone is 5.8 ft./sec.

From Figure IN-6-9, Sheet 6 of 54, For Q = 37 cfs, chute profile slope (S) = 10:1, chute side slopes (z) = 3:1, bottom width (b) = 12 feet, flow depth (d) = 0.50 feet, velocity = 5.5 fps

de = 0.5 + 1 = 1.5 feet
dc = 0.5 + 0.5 = 1.0 feet
do = 2(0.5) + 0.5 = 1.5 feet
Entrance length (Le) = 5(1.5) = 7.5 feet; Use 8 feet
Upstream entrance width (be) = b + Le = 12 + 8 = 20 feet
Chute slope length (Ls) = $6(10^2 + 1)^{0.5}$] = 6 x 10.05
= 60.3 feet
Outlet length (Lo) = 6 + 3(5.5 - 5) = 6 + 1.5
= 7.5 feet; Use 8 feet

Determine volume of rock:
Use rock thickness (tr) = 1.0 feet

Entrance Section:
Average rock section area
= 1 [(0.5)(20+12)+(2)(1.5)$(3^2 + 1)^{0.5}$]
= 1 [16 + 3.0(3.16)]
= 1 [16 + 9.5] = 1 [25.5] = 25.5 sq.ft.
Entrance length = 8 feet
Volume of rock = 8 x 25.5 = 204 cu. ft.

Chute Section:
Rock section area
= 1 [12 + (2)(1.0)$(3^2 + 1)^{0.5}$]
= 1 [12 + 2.0(3.16)]
= 1 [12 + 6.3] = 1 [18.3] = 18.3 sq.ft.
Volume of rock = 18.3 x 60.3 = 1103 cu. ft.

Outlet Section:
Rock section area
= 1 [12 + (2)(1.5)$(3^2 + 1)^{0.5}$]
= 1 [12 + 3.0(3.16)]
= 1 [12 + 9.5] = 1 [21.5] = 21.5 sq.ft.
Outlet length (Lo) = 8 feet
Volume of rock = 8 x 21.5 = 172 cu. ft.

Total volume = 204 + 1103 + 172 = 1479 cu. ft.
(1479 cu. ft.)(110 pcf/2000 lbs per ton) = 81 tons

(EFM Notice IN-53, November 1989)

SUMMARY:

Rock quantity required vs: Rock size d50:

Rock size d50	Profile Slope S	Bottom Width b - feet	Rock tons
12"	5:1	8	91
9"	5:1	6	65
7"	5:1	8	55
4"	10:1	12	81

CONCLUSION: In this example, all other factors being equal, the use of the d50 rock size of 7" will result in the least tonnage of rock. Final selection of rock size to be designed for and used would have to consider the availability (and cost) of the other rock sizes, and consideration of other installation costs and site conditions.

* *

WEIGHT OF EQUIVALENT SPHERICAL ROCK

gs = 2.64 density = 165 pcf

Rock Size inches	Weight pounds
3	1
4	3
5	6
6	11
7	17
8	26
9	36
10	50
11	67
12	86
13	110
14	137
15	169
16	205
17	246
18	292
19	343
20	400
21	463

Figure IN-6-10 - Weight of Equivalent Spherical Rock

(EFM Notice IN-53, November 1989)

CONSTRUCTION

There are several factors that must be considered and accomplished during construction to produce a rock lined chute grade stabilization structure that will be stable and a quality product. Some of these factors are:

1. Before placement, make sure that rock delivered to the site has at least 50% by weight larger than d50 size rock used in design. See Figure IN-6-10 for weights of equivalent spherical rock.

2. Wherever possible, place rock-lined chute in natural ground in lieu of on compacted backfill. Shape hole with as nearly vertical sides and ends as possible to set bedding and rock into ground. A backhoe or hydraulic excavator are efficient pieces of equipment to use.

3. Place bedding as required by design and spread to depth required.

4. Dump riprap as near to final location as possible. Don't dump at upper end and push into place with a dozer. This separates large rocks from fines. Best to place with excavator bucket. If placing rock on geotextile, do NOT drop rock more than 3 feet to avoid puncturing fabric. Be sure that there are no large voids in the stone mass.

5. Tamp rock with a backhoe bucket or track rock in place or use similar method to interlock rock into place.

6. Keep chute, entrance and outlet bottoms flat and to proper width.

7. Make sure adequate stone is placed on side slopes.

8. Avoid leaving protruding and isolated large rocks along edges of chute that will interfere with future maintenance, such as mowing.

9. Fertilize and seed the chute when the adjacent disturbed area is fertilized and seeded. A thin layer of topsoil may be placed over the rock and into the voids between the rocks before seeding. See Technical Guides for appropriate seed mixtures to be used.

DESIGN PROCEDURE FOR ROCK LINED CHUTES

1. Determine drainage area from USGS maps, aerial photos, soils maps, and/or field observations.

2. Determine controlled drop or overfall (F) from survey data, establishing entrance and outlet elevations.

3. Determine design storm frequency from Technical Guide Section IV, Specification 410, Table 1, for drainage area and F required at structure site for rock chutes. Unless a vegetated emergency spillway will be provided, use "total" capacity frequency for design of rock lined chute.

4. Determine peak discharge in cfs for design storm from EFM Chapter 2.

5. Select rock size d50 to be used for lining. Use rock available from local sources whenever possible.

6. Determine maximum allowable velocity (Vs) for selected rock size d50 using Figure IN-6-8.

7. Select chute profile slope (S) and side slopes (z) of structure.

8. From Figure IN-6-9, for selected rock size d50, chute profile slope (S), chute side slope (z), and for required design discharge (Q), determine chute design bottom width (b), flow depth (d) and velocity (V). Check that V is less than Vs and b/d is less than 50.

9. Determine dimensions of Entrance Section:

A. Determine entrance section depth (de)-

de = inflow waterway depth,
but not less than (d + 1)

B. Determine length of entrance section (Le) - the entrance length will be that needed for an effective transition. Use a minimum length of five times the entrance section depth or 5(de).

C. Determine bottom width of entrance section - bottom width of entrance section will be tapered to provide a transition from upstream waterway to selected chute bottom width as determined in step 10. The width at the upstream end of the entrance (be) should be at least equal to the chute bottom width, but should be widened as necessary to provide an effective transition from the inflow waterway to the chute. If there is no distinct waterway, make upstream end of entrance section (be) equal to (b + Le).

10. Determine dimensions of Chute Section:

A. Determine total chute depth (dc):

$dc = d + 0.5$

where:

d = design flow depth in chute (as selected in step 11)

0.5 = freeboard

B. Determine bottom width (b) of chute section: (as selected from step 11)

C. Determine length of chute section:

Horizontal length (Lc) = F x S

Slope length (Ls) = $F(S^2 + 1)^{0.5}$]

where:

F = controlled drop or overfall

S = chute profile slope (S:1) (as selected in step 11)

11. Determine dimensions of Outlet Section:

A. Determine depth of outlet section (do).

$do = 2d + 0.5$

where:

d = design depth of chute (as selected in step 11)

0.5 = freeboard

B. Determine bottom width of outlet section: Use b, same as chute section width as determined in step 11.

C. Determine length of outlet section (Lo) -

i. If chute is an in-line structure or where the tailwater depth is shallow or the downstream drainage channel or ditch is narrow, use a minimum Lo = 6 feet of lined channel when chute flow velocity is 5 fps or less; use minimum Lo = [6 + 3(V-5)] feet for chute flow velocities (V) greater from 5 feet per second. Use design velocity (V) determined in step 10.

ii. If the chute is a side drainage outlet into a channel or ditch, or into standing water, where there will be a high tailwater condition when chute flow occurs, use a minimum Lo = 6 feet of lined channel. If tailwater depth is shallow or the outlet channel or ditch is narrow, see A. above.

(EFM Notice IN-53, November 1989)

12. Design Emergency Spillway:

Note: An emergency spillway is usually not practical. If an emergency spillway is not included in the design, proceed to step 20. If an emergency spillway is feasible, see EFM Chapter 11 for discussion and design information and aids.

A. Determine emergency spillway elevation. Add the flow depth in the incoming channel or waterway to the entrance elevation to establish the emergency spillway elevation. The flow to determine the flow depth is the Q equal to the flow capacity of the rock lined chute.

B. Determine required emergency spillway capacity (Qe). Repeat steps 4, 5 and 6 above to determine "total" capacity peak discharge. Subtract rock lined chute capacity from "total" peak discharge to determine required emergency spillway capacity (Qe).

C. Determine length of level section (L) to be used.

D. Determine slope of outlet section (So) of emergency spillway from surveyed profile along centerline of emergency spillway.

E. Determine erosion resistance of soil to be excavated into for emergency spillway.

F. Select vegetal type to be seeded for cover.

G. Determine permissible velocity for outlet slope, erosion resistance of soil and type of vegetation.

H. Select vegetal retardance to be used based on condition of stand and height.

I. Determine Hp (0.5 foot minimum) and discharge in cfs per foot (q) for permissible velocity (step 19.G) in emergency spillway using selected retardance (step 19.H) and length of level section (L), step 19.C. Check that the outlet slope (step 19.D) falls within the acceptable slope range.

J. Determine bottom width (bs) to be used. Divide required capacity Qe, (step 19.B), by discharge per foot, q, (step 19.I).

(EFM Notice IN-53, November 1989)

13. Determine settled fill elevation adjacent to chute:

A. If there is an emergency spillway, design top of fill elevation is 0.5 feet above the Hp value (step 19.I) above the emergency spillway crest elevation, but at least 0.5 feet above the rock in the side slopes of the entrance section.

B. If there is no emergency spillway, design top of fill elevation is 0.5 feet above the rock in the side slopes of the entrance section.

14. Determine rock lining thickness (tr) - Use two times the selected d50 rock size but not less than 1 foot nor more than 2 feet.

15. Determine rock riprap gradation.

Use: Maximum rock size (d100)
= two times d50 (18" maximum)
Maximum d50 (as selected in step 8)
Maximum d15 = one-third d50

16. Determine bedding material requirements - Identify the soil on which the chute will be placed. If chute is on highly erosive soils, or large d50 rock size is used, a graded gravel bedding or a geotextile lining is required to prevent migration of soils through the rock lining. The bedding must permit groundwater seepage without hydraulic head build-up.

A 6 inch layer (tb) of graded gravel bedding can be used. The d85 of the gravel should equal one-twelfth the d50 rock size used. The following Indiana Department of Highways standard coarse aggregate graded sizes are normally available in Indiana. (No. 53 stone is not acceptable.)

Indiana Department of Highways (IDOH)

Sieve Size	Coarse Aggregate Sizes (Percent Passing by Wt.) #5	#8	#9	#11
1-1/2"	100			
1"	85-98	100		
3/4"	60-85	75-95	100	
1/2"	30-60	40-70	60-85	100
3/8"	15-45	20-50	30-60	75-95
No. 4	0-15	0-15	0-15	10-30
No. 8	0-10	0-10	0-10	0-10
Use with d50 rock size	10"-12"	7"-10"	6"-7"	4"-6"

(EFM Notice IN-53, November 1989)

A geotextile lining can be used. The geotextile must be strong enough to prevent puncturing by the placement of rock riprap, be able to prevent the migration of the soil base, and porous enough to allow groundwater to travel through the geotextile to prevent build-up of water pressures behind the chute. The geotextile should be non-woven, needle-punched (NOT heat bonded), with a tensile strength = 120 lbs. minimum, bursting strength = 210 psi minimum, elongation = 100% maximum, puncture strength = 40 lbs., an Apparent Opening Size (AOS) = #40 maximum, and permitivity = 0.70 sec^{-1}.

17. Calculate material quantities.

18. Complete data sheets for plan. Use IN-ENG-36, IN-ENG-42 and other sheets as appropriate.

19. Check all work for omissions and errors.

20. Get required reviews and approval of plan.

(4) Total volume of rock riprap:
198 + 472 + 139 = 809 cu. ft.

(5) Quantity of riprap required:
(809 cu. ft. x 110 #/cu.ft.)/2000 #/ton
= 45 tons

B. Bedding:

A. Volume = (6" bedding/18" riprap)(809 cu.ft)
= 270 cu. ft.
= 10.0 cu. yds.

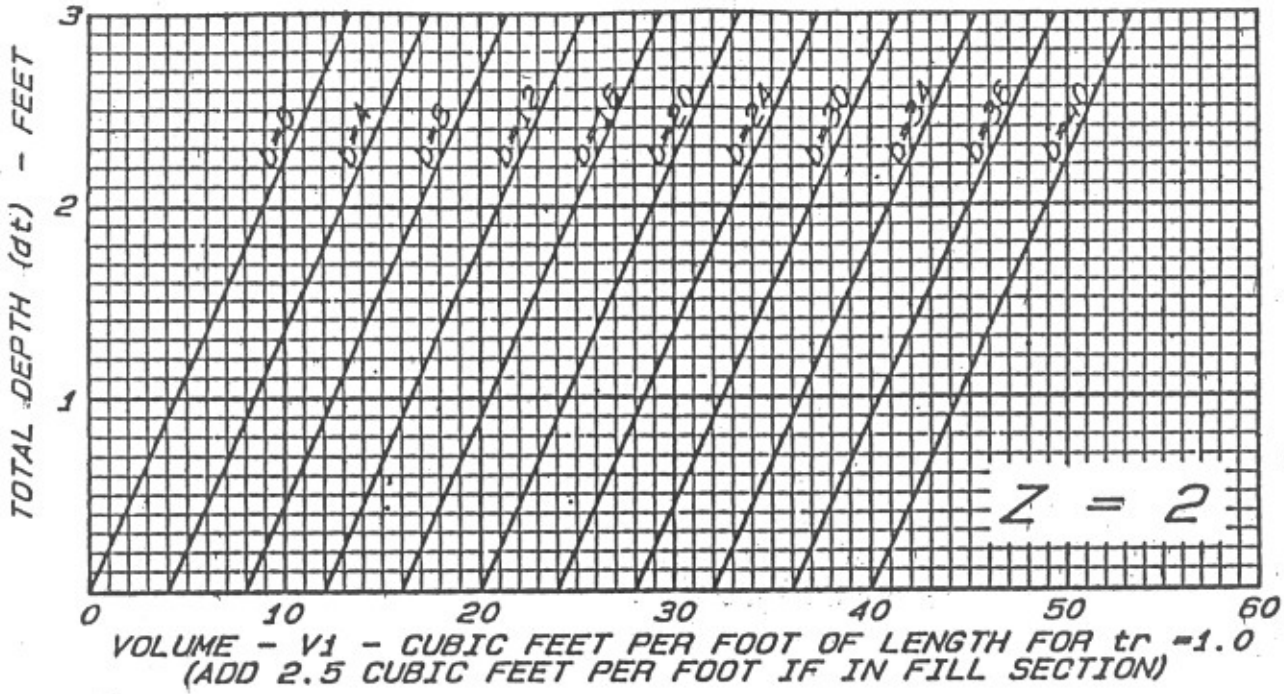
B. Quantity of bedding required:
(270 cu. ft x 110 #/cu.ft)/2000 #/ton
= 15 tons

NOTE: Figure IN-6-11 may be used to calculate the material volumes in cubic feet per foot of length for tr = 1.0 feet. See example in Exhibit IN-6-6.

18. Use appropriate data sheets:
IN-ENG-36D may be used for design.
IN-ENG-36Q may be used to determine material quantities.
IN-ENG-36 should be used for construction drawings.
See Exhibit IN-6-6.

19. Check all work.

20. Get required reviews and approvals.



BASED ON $V = L(tr)[b+2dt(Z^2+1)^{0.5}]$ WITH L=1.0 AND tr=1.0

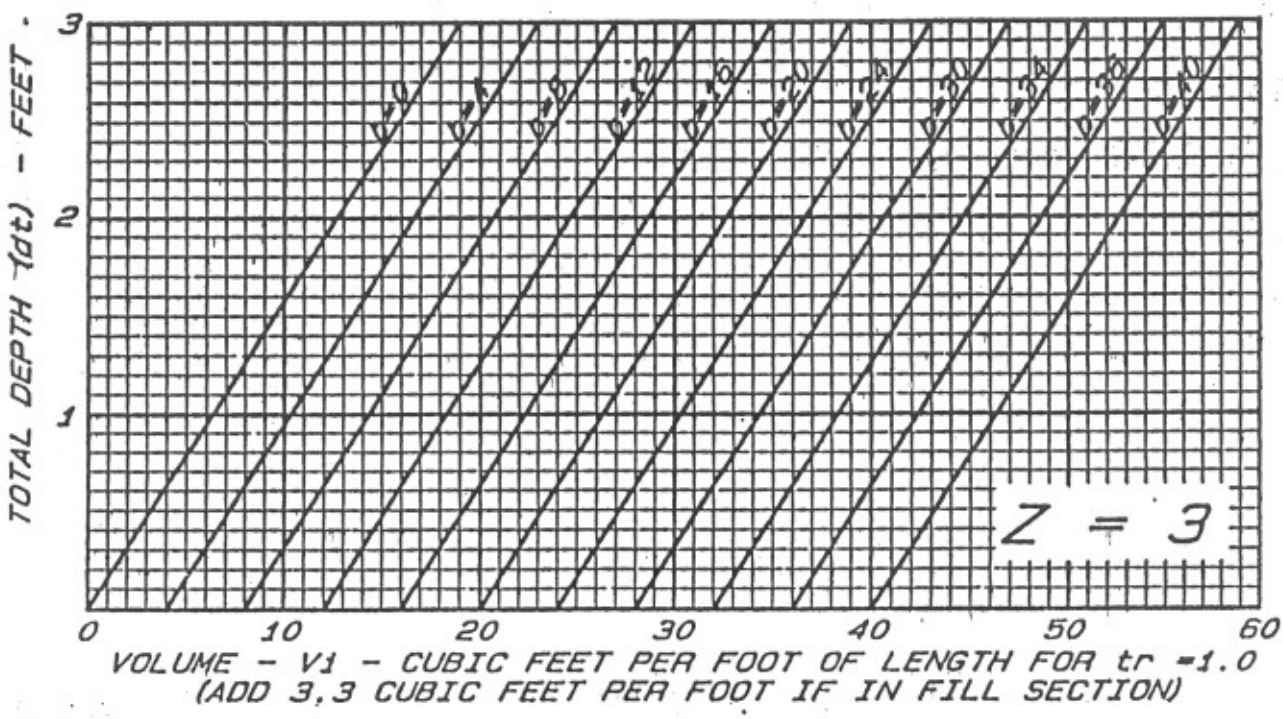


FIGURE IN-6-11 - ROCK VOLUMES FOR ROCK LINED CHUTES

EXHIBIT IN-6-6

U. S. Department of Agriculture
Soil Conservation Service

IN-ENG-36D
10/89
File Code 210-11

ROCK LINED CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Designed by CET date: 11-9-89; Checked by _____ date _____

D E S I G N

Rock Lined Chute:
Controlled Drop (F):
Entrance El 105.0 - Outlet El 100.0 = 5.0 Feet (F)
From IN-ENG-10A; Q (chute) = 13 cfs
d50 = 9 inches; Allowable velocity (Vs) = 8.4 fps (d50)
Chute Profile Slope (S) = 5:1; side slope (z) = 3:1 (S,z)
Bottom width (b) = 6 ft; Chute flow depth (d) = 0.5 ft (b,d)
Check b/d<50; b/d = 12 ✓
Design velocity (V) = Q/A = Q/[d(b+zd)] = 4.2 fps ✓ (V)
Entrance Section:
Total depth at entrance (de) ≥ (d+1) = 1.5 ft. (de)
Entrance length (Le) ≥ 5(de) = 8 ft. (Le)
Upstream entrance width (be) ≥ b = 8 ft. (be)
Chute Section:
Total depth in chute (dc) ≥ (d+0.5) = 1.0 ft. (dc)
Chute length (Lc) = (F 5.0)(S 5) = 25.0 ft. (Lc)
Outlet Section:
Total Depth in outlet (do) ≥ (2d+0.5) = 1.5 ft. (do)
Outlet length (Lo) ≥ [6+3(V-5)] = 6 ft. (Lo)

Approach Channel:
Grade = _____ %; n = _____; or Retardance _____;
Bottom width (bw) = _____ ft.; Side slopes = ___:1;
or Top width (T) = _____ ft.;
Depth (D) = _____ ft.;

Emergency Spillway (ES): none
From IN-ENG-10A; Q(total) = _____ cfs;
Qe (design) = Q (total) _____ - Q(chute) _____ = _____ cfs
ES Crest El = Entrance El _____
+ Approach channel depth (D) ___ = _____
Level Section (L) = _____ ft.; Exit Slope (so) = _____%;
Erosion resistant soil? - yes-no (circle one);
Cover, stand & height - _____;
Retardance - ___; Velocity (V) (maximum) = _____fps;
Hp = _____ ft.; Discharge per ft.(q) = _____ cfs/ft.;
Bottom Width (bs) = Q/q = _____ ft.

Top of Fill:
Top of Settled Fill Elevation =
Entrance El 105.0 + de 1.5 + freeboard (0.5') = 107.0
Or ES Crest El _____ + Hp _____ + freeboard (0.5') = _____
Use Top of Settled Fill Elevation 107.0

EXHIBIT IN-6-6 (continued)

U. S. Department of Agriculture
Soil Conservation Service

IN-ENG-36Q
10/89
File Code 210-11

ROCK LINED CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Calculated by CET date: 11-9-89; Checked by _____ date ...

Q U A N T I T I E S

Chute Parameters:
b = 6 '; d = 0.5 '; S = 5 :1; z = 3 :1; F = 5.0 '
d50 size: 9 ": Thickness (tr) = 1.5 '; Density (Dr) = 110 pcf
Bedding: Thickness (tb) = 0.5 '; Density (Db) = 110 pcf

Volume of Rock:
Vl = Cubic feet of rock per foot of length for (tr = 1.0')
$Vl = b + 2(dt)(z^2+1)^{0.5} + A$
Where A = correction for fill section
or see EFM Figure IN-6-11

Entrance Section: de = 1.5 '; Le = 8 '; be = 8 '
upstream end (for be & de); Vlu = 17.5
downstream end (for b & de); Vld = 15.5
VE = (Vlu 17.5 + Vld 15.5)(0.5)(tr 1.5)(Le 8)
= 198 cu. ft.

Chute Section: dc = 1.0 '; Lc = 25.0 '
(for b & dc); Vlc = 12.4
$VC = (Vlc\ 12.4)(tr\ 1.5)(F\ 5)((S^2+1)^{0.5}\ 5.1)$
= 474 cu. ft.

Outlet Section: do = 1.5 '; Lo = 6 '
(for b & do); Vlo = 15.5
VO = (Vlo 15.5)(tr 1.5)(Lo 6) = 139 cu. ft.

Total volume of rock:
Vr = (VE 198) + (VC 474) + (VO 139) = 811 cu. ft.

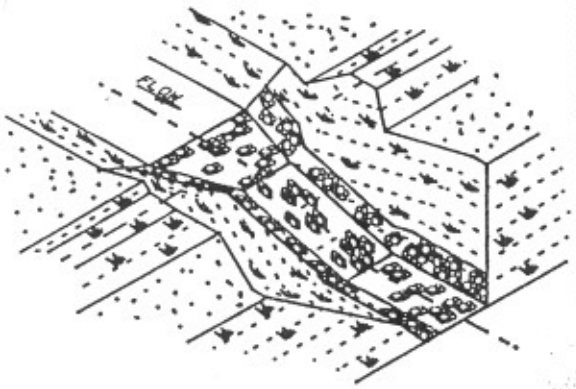
Quantity of rock: (Vr 811)(Dr 110 /2000) = 45 tons

Volume of Bedding:
Vb = (Vr 811)(tb 0.5/tr 1.5) = 270 cu. ft.
Vb/27 = 10 cu. yds.

Quantity of bedding: (Vb 270)(Db 110 /2000) = 15 tons

Quantity of Geotextile Fabric:
gf = (Vr 811)/(tr 1.5) = 541 sq. ft.
Add >10% for laps, ends, waste, etc.
Geotextile fabric required (Gf) = (1.1)(gf 541)
= 595 sq.ft.
or Gf/9 = 66 sq.yds.

EXHIBIT IN-6-6



ROCK LINED CHUTE

RIPRAP GRADATION

d_{50} - 9 INCHES

SIZE	% PASSING BY WEIGHT
18"	100%
9"	50%
3"	15%

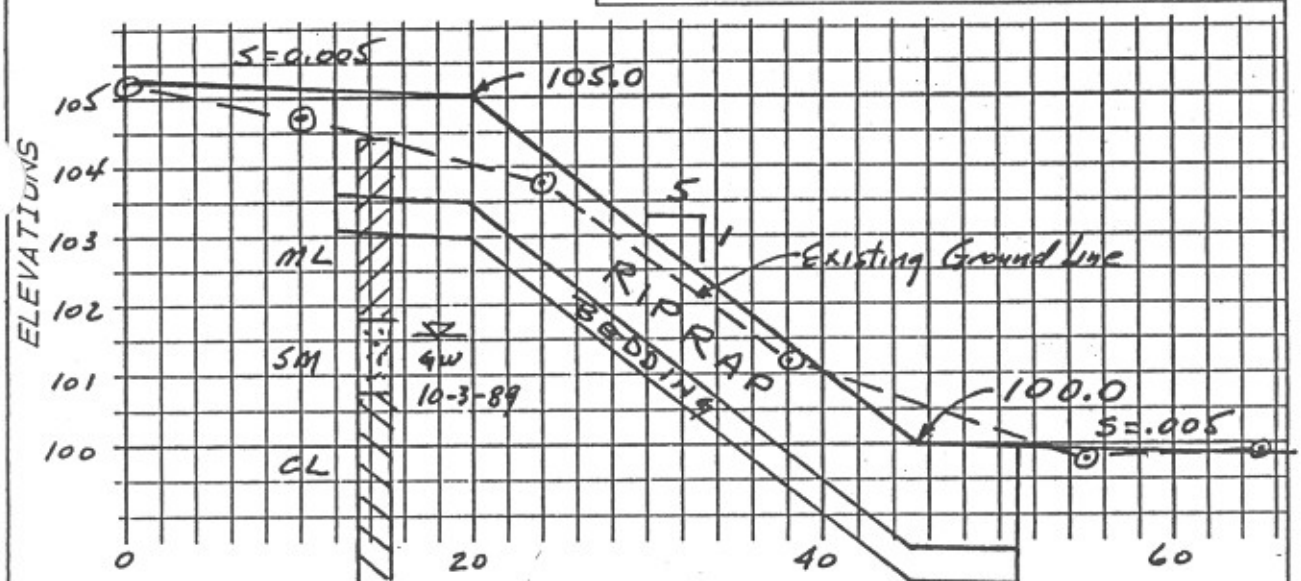
BEDDING GRADATION

EQUIVALENT TO IDOH AGGREGATE NO. 8

SIZE	% PASSING BY WEIGHT
1"	100%
3/4"	75-95%
1/2"	40-70%
3/8"	20-50%
#4	0-15%

GEOTEXTILE FABRIC
(NON-WOVEN, NEEDLEPUNCHED)

TENSILE STRENGTH. . . . 120 LBS. MIN.
BURSTING STRENGTH. . . . 210 PSI MIN.
ELONGATION AT FAILURE. . 100 % MIN.
ULTRAVIOLET LIGHT RESISTANCE -
70% TENSILE STRENGTH RETAINED
PUNCTURE. . . . . 40 LBS.
AOS - STANDARD SIEVE SIZE OPENING -
#40 MAX.
PERMITIVITY. . . . . 0.70 $SEC.^{-1}$



PROFILE ALONG CENTERLINE OF CHUTE
(SHOW SOIL BORINGS)

COOPERATOR EFM EXAMPLE DESIGN
AUY COUNTY SWCD, INDIANA
LOCATION FIELD A

ROCK LINED CHUTE
(SHEET 1 OF 3)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/89
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Traced
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Approved By
Title
Sheet No. of
Drawing No.

IN-ENG-36

ESTIMATE OF QUANTITIES

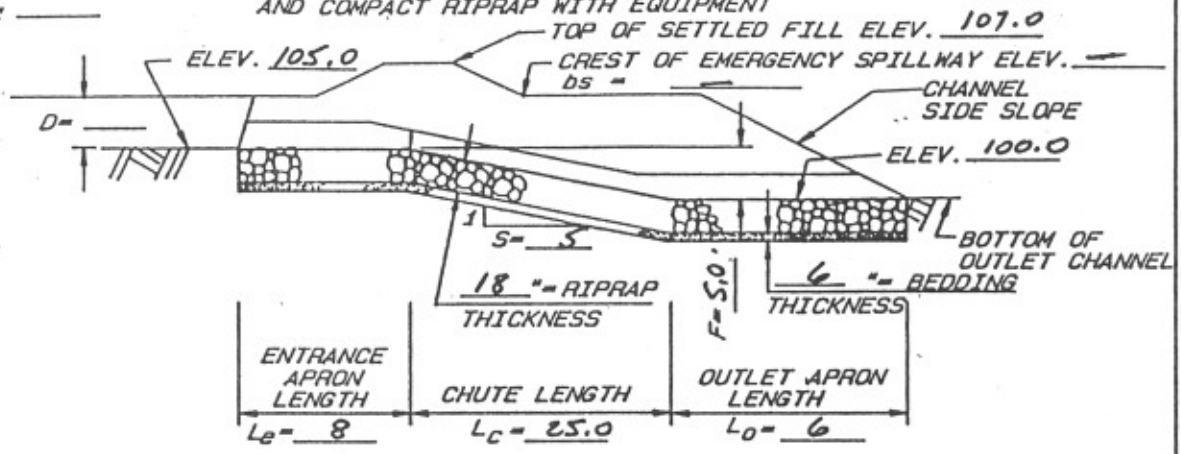
CLEARING		ACRES
EXCAVATION		CU. YDS.
RIPRAP	45	TONS
BEDDING	15	TONS
GEOTEXTILE FABRIC	66	SQ. YDS.
REVEGETATION		ACRES

REVISED 10/89

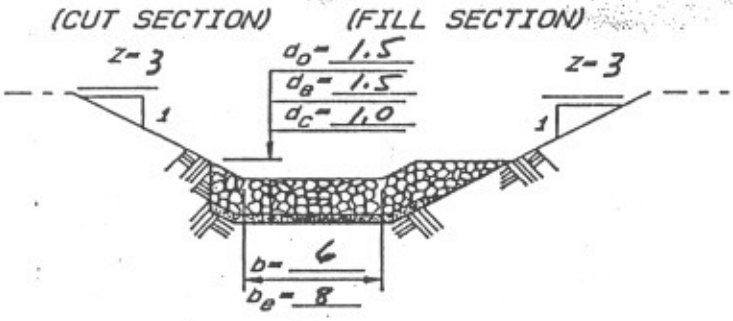
EXHIBIT IN-6-6

GRASSED WATERWAY
GRADE= ____ %
bw= ____
or T= ____

AFTER PLACEMENT OF RIPRAP, SPREAD ENOUGH SMALL FRAGMENTS OR BEDDING MATERIAL OVER ENTIRE SURFACE OF THE CHUTE TO FILL THE VOIDS IN RIPRAP AND COMPACT RIPRAP WITH EQUIPMENT



SECTION ON CENTERLINE



TYPICAL CROSS SECTION

LEGEND

F — CONTROLLED DROP
b — BOTTOM WIDTH OF CHUTE
b_e — WIDTH AT ENTRANCE UPSTREAM
d_e — ENTRANCE APRON DEPTH
d_c — CHUTE DEPTH
d_o — OUTLET DEPTH

APPROACH CHANNEL

bw — BOTTOM WIDTH
T — TOP WIDTH
D — FLOW DEPTH

EMERGENCY SPILLWAY

bs — BOTTOM WIDTH

NOTES:
CHUTE SLOPE "S" NOT STEEPER THAN 5:1.
SIDE SLOPES "Z" NOT STEEPER THAN 2:1.
THE ENTRANCE APRON WIDTH WILL VARY FROM "b_e" 8 to "b" 6 .
PROVIDE AN EMERGENCY SPILLWAY, ONE ON EACH SIDE IF FEASIBLE, WITH CREST ELEVATION 0.3' TO 0.5' BELOW TOP OF ROCK ON ENTRANCE SIDE SLOPES.
GEOTEXTILE FABRIC MAY BE USED IN LIEU OF BEDDING.

REVISED 10/89

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

ROCK LINED CHUTE
(SHEET 2 OF 3)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

CONSTRUCTION DATA

LAYOUT BY ____ DATE ____
CONTRACTOR ____ COMPLETED DATE ____

PRACTICE (DOES) (DOES NOT) MEET STANDARDS AND SPECIFICATIONS
CHECKED BY ____ DATE ____

Designed CET 11/89
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Title
Date
Sheet
Drawing No.

IN-ENG-36

GENERAL

Construction operations shall be carried out such a manner and sequence that erosion and r and water pollution will be minimized and held within acceptable limits. Construction methods that enhance wildlife habitat will be used where practical.

The completed job shall present an appearance of good workmanship and shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

SITE PREPARATION

All trees, stumps, brush, and similar materials are to be removed from the construction area and disposed of in a manner consistent with environmental concerns and proper functioning of the structure.

EXCAVATION

To the extent needed, all suitable materials removed from the specified excavation shall be used in the construction of the earth fill areas of the structure. All spoil deposited adjacent to the structure and in the adjacent area shall have a positive grade to drain toward the structure.

MOISTURE CONTROL

The minimum moisture content of the fill terial and foundation shall be such that hen kneaded in the hand the fill material will form a ball which does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compacting equipment.

MAINTENANCE RECOMMENDATIONS:

A maintenance program shall be established by the land user to maintain capacity and vegetative cover. Items to consider are as follows:

1-Do not graze seeded areas during establishment and when soil conditions are to wet.

2- Protect structure from damage by farm equipment and vehicles.

3-Maintain structure inlet and outlet areas free of any obstructions.

4-Repair structure as soon as possible after damage is noted.

5- Reestablish vegetative cover immediately where erosion has removed established seeding.

6-Maintain effective erosion control of the contributing watershed to prevent siltation and the resulting loss of capacity.

CONSTRUCTION TOLERANCES

Depth at centerline: Grade to 0.1 foot below
Width: 10% wider not to exceed 1.0 foot
Top of levee: Grade or above.
Side slopes: ±0.1 ft./ft.

FINISH AND CLEANUP

The structure area and the designated spoil areas will be finished in a relatively smooth condition ready for seeding. All rocks 3 inches in diameter or larger and roots shall be removed from the surface areas.

VEGETATIVE ESTABLISHMENT

Excess water shall be directed away until vegetation is established, if possible. Any protective works shall be removed and the disturbed areas shall be seeded for permanent grass.

Apply lime to raise the ph to _____ at rate of _____ tons per acre.

Fertilize according to soil tests or at a minimum rate of 1000 pounds of 12-12-12 fertilizer (or its equivalent) per acre as soon as the structure has been constructed if within the seeding dates.

Work the fertilizer and lime into the soil to a depth of 2 - 3 inches with a harrow or disk. Seeding will be done at the following rates:

Seed: _____ Rate: _____ lbs./acre
_____ Rate: _____ lbs./acre

When construction is completed between May 11 and August 9, a temporary cover crop should be established using the following seeding:

Seed: _____ Rate: _____ lbs./acre

Dormant seeding may be done between December 10 and February 28. Liming, fertilizing, seedbed preparation and mulching may be done ahead of the dormant seeding, with the seed being broadcast on top of the mulch.

Apply mulch at the rate of _____ tons of straw per acre.

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

ROCK LINED CHUTE
(SHEET 3 OF 3)
SPECIFICATIONS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/89
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Drawing No.

Revised 10-89

IN-ENG-36

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CONCRETE BLOCK CHUTE

The concrete block chute is another economical structure for grade stabilization. It is similar in configuration to the rock lined chute, but uses unmortared standard nominal 8" x 8" x 16" concrete building blocks (holes up) for the lining material. See Figure IN-6-12. It is installed on a 3H:1V slope, and therefore has the advantage of not protruding as far into the field as a rock-lined chute when used as a surface water inlet to a channel. It is a very labor-intensive structure installation, and can be used when the landuser wants to install a structure using his own labor forces to reduce his out-of-pockets costs. The building blocks can be "seconds" or used blocks as long as they are not broken. The blocks in the floor section are placed longitudinally (long dimension parallel to the direction of flow) and the blocks on the side slopes (2H:1V) are place transversely (long dimension perpendicular to the direction of flow). The structure was modeled and tested at the Hydraulic Laboratory of the University of Illinois at Urbana-Champaign, and the results used to establish the capacity and configuration.

DESIGN ELEMENTS

Design Flow:

The capacity of this structure is dependent upon the depth of flow at the inlet (Hp). The capacity was determined in the model studies to be:

$$q = 1.455\ Hp^{1.832}$$

where:

q = unit discharge in cfs per foot of bottom width

Hp = ponded head above the crest, ft.

Hp is determined by the depth of flow in a defined inlet channel outletting into the chute or by the allowable ponding depth that can be allowed in the field above the structure.

Only whole blocks are used in the installation. Table A of Figure IN-6-12 shows the capacity in cfs for various values of Hp using standard building block dimensions of 7-5/8" x 7-5/8" x 15-5/8" (0.635' x 0.635' x 1.302'). The model studies indicated that the minimum bottom width should be five times the Hp value. The maximum allowable capacity is limited to 150 cfs at this time.

TABLE A - CONCRETE BLOCK CHUTE CAPACITY - Q - CFS																						
BOTTOM WIDTH		H_p - FEET																				
ROWS	FEET	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	2.1	2.2	2.3	2.4	2.5	2.6	2.7	2.8	2.9	3.0
8	5.1	7																				
9	5.7	8	10																			
10	6.4	9	11	13																		
11	7.0	10	12	14	16																	
12	7.6	11	13	15	18	21	23															
13	8.3	12	14	17	19	22	25	28														
14	8.9	13	15	18	21	24	27	31	34													
15	9.5	14	17	19	22	26	29	33	37	41	45											
16	10.2	15	18	21	24	27	31	35	39	43	48	53										
17	10.8	16	19	22	25	29	33	37	42	46	51	56	61									
18	11.4	17	20	23	27	31	35	39	44	49	54	59	65	71								
19	12.1	18	21	25	28	33	37	42	46	52	57	63	68	74	81	87						
20	12.7	18	22	26	30	34	39	44	49	54	60	66	72	78	85	92	99					
21	13.3	19	23	27	31	36	41	46	51	57	63	69	76	82	89	97	104	112				
22	14.0	20	24	28	33	38	43	48	54	60	66	72	79	86	94	101	109	117	125			
23	14.6	21	25	30	34	39	45	50	56	62	69	76	83	90	98	106	114	122	131	140	150	
24	15.3	22	26	31	36	41	47	52	59	65	72	79	86	94	102	110	119	128	137	146	156	
25	15.9	23	28	32	37	43	49	55	61	68	75	82	90	98	106	115	124	133	143	152		
26	16.5	24	29	34	39	45	51	57	64	71	78	86	94	102	111	120	129	138	148	159		
27	17.2	25	30	35	40	46	52	59	66	73	81	89	97	106	115	124	134	144	154			
28	17.8	26	31	36	42	48	54	61	68	76	84	92	101	110	119	129	139	149	160			
29	18.4	27	32	37	43	50	56	63	71	79	87	95	104	114	123	133	144	154				
30	19.1	28	33	39	45	51	58	66	73	81	90	99	108	118	128	138	149	160				
31	19.7	29	34	40	46	53	60	68	76	84	93	102	112	122	132	143	154					
32	20.3	30	35	41	48	55	62	70	78	87	96	105	115	125	136	147	159					
@ 0.635' PER BLOCK																						

TABLES A & B ARE BASED ON:
$q = 1.455L\ H_p^{1.632}$
CONCRETE BLOCKS THAT ARE 7-5/8" X 7-5/8" X 15-5/8"
OR 0.635' X 0.635' X 1.302'
OR 0.8274 SQ. FT.

TABLE B						
F	X	Z		NUMBER OF BLOCKS		
			#ROWS	Z+INLET+OUTLET		
FEET	FEET	FEET	DOWN	PER ROW ACROSS	PER FOOT b	SIDES
2.50	7.41	8.03	6	16	25.18	118
2.91	8.65	9.32	7	17	26.75	126
3.32	9.88	10.63	8	18	28.33	134
3.74	11.12	11.93	9	19	29.90	142
4.15	12.35	13.23	10	20	31.48	150
4.56	13.59	14.53	11	21	33.05	158
4.97	14.82	15.83	12	22	34.62	166
5.38	16.06	17.14	13	23	36.20	174
5.79	17.29	18.44	14	24	37.77	182
6.21	18.53	19.74	15	25	39.34	190
6.62	19.76	21.04	16	26	40.92	198
7.03	21.00	22.35	17	27	42.49	202
7.44	22.23	23.65	18	28	44.07	210
7.85	23.47	24.95	19	29	45.64	218
8.27	24.71	26.25	20	30	47.21	226
8.68	25.94	27.55	21	31	48.79	234
9.09	27.18	28.86	22	32	50.36	242
9.50	28.41	30.16	23	33	51.93	250
9.91	29.65	31.46	24	34	53.51	258
10.32	30.88	32.76	25	35	55.08	266
10.74	32.12	34.06	26	36	56.66	274
11.15	33.35	35.37	27	37	58.23	282
11.56	34.59	36.67	28	38	59.80	290
11.97	35.82	37.97	29	39	61.38	298

 # @ 1.302' PER BLOCK

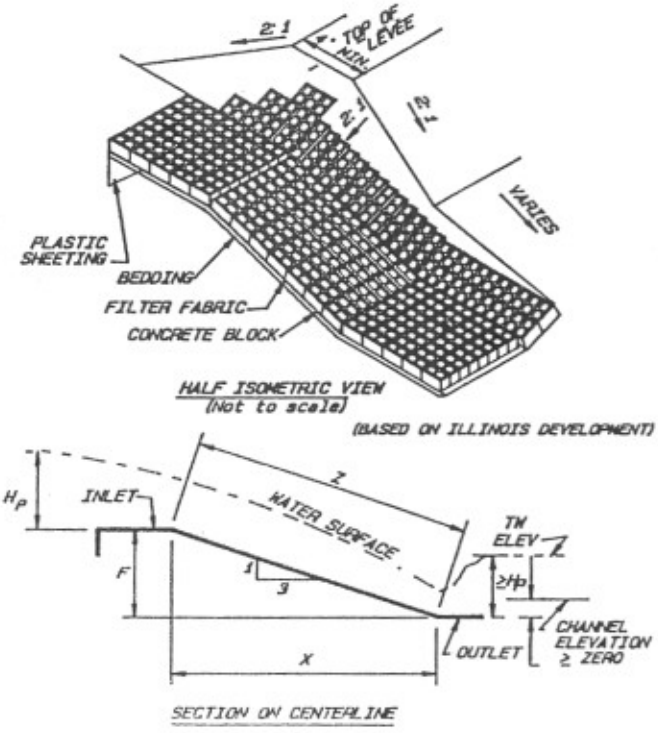


FIGURE IN-6-12 - CONCRETE BLOCK CHUTE

Controlled Drop:

Although the controlled drop of the structure is the difference in elevation between the inlet and outlet channel, the vertical dimension of the concrete block chute (F) is also dependent on Hp and tailwater (TW). The outlet section of the structure should be at least Hp below the TW expected at design flow, but not above the outlet channel elevation. The "F" dimension is shown in increments of the long dimension of a whole block placed on the 3H:1V slope. Table B of Figure IN-6-12 shows the increments of "F" that can be used and the "X" (horizontal length), "Z" (slope length) and number of rows of blocks down the slope.

Chute Geometry:

The model studies determined the configuration of the structure. See Figure IN-6-12. The inlet and outlet sections are horizontal and each are 5 blocks in length (6.5 feet). Because of the limited range of Hp and Q that should be used with this structure type, the blocks in the inlet section side slopes are installed with three blocks placed perpendicular to the flow on 2H:1V side slopes at the control section. Since the depth of flow decreases in the chute section, only two blocks are placed on the side slopes of the chute section. Only two blocks were determined to be needed in the outlet section side slopes. Table B of Figure IN-6-12 shows the number of blocks needed for the bottom width of the chute (in blocks per row across and in feet of width) for various values of "F", and the total number of blocks in the side slopes for various values of "F".

Emergency Spillway:

An emergency spillway should be provided if feasible. The crest of the emergency spillway is placed above the design Hp value. See discussion about an emergency spillway for the rock lined chute.

Top of Settled Fill:

The top of fill elevation adjacent to the block chute should be at least one foot above the HP value, but not less than 1.0 feet above the top of the 3 blocks in the side slopes at the control section, or 2.75 feet minimum above the inlet elevation. See discussion about the top of settled fill elevation for the rock lined chute.

INSTALLATION

The chute should be placed on an excavated base. If it is necessary to place fill, the fill should be compacted to a density greater than the adjacent natural material.

A gravel/sand bedding should be placed over the graded earth for the bottom and side slopes of the chute. This gravel/sand bedding should be from one to three inches in thickness to provide a leveling base for the concrete blocks, and to prevent tearing of a filter fabric to be placed under the concrete blocks. Thicker lifts of gravel/sand will act as a drain and tend to undermine the blocks. The gravel/sand bedding must be sized to prevent migration of the underlying soil particles.

A filter fabric is placed to cover all of the gravel/sand bedding. It must be sized to permit water to flow through it without migration of the gravel/sand bedding and be thick enough to withstand construction loads. The fabric should extend beyond the limits of the gravel/sand bedding on the side slopes and be anchored in a shallow earth trench above the blocks. A minimum of a 12 inch lap, shingled in the direction of flow, should be provided where adjacent sheets join.

A plastic (polyvinyl) cutoff is required at the inlet to the chute. Half of a 4'-0' width of 6 mil (minimum) plastic is inserted into a two foot deep trench across the entire width of the chute bottom and side slopes, and shingled over the gravel/sand bedding and filter fabric. A similar cutoff is required at the outlet if the chute is an in-line structure (the outlet of the chute is into a channel flowing in the same direction as the chute).

The blocks should be laid with the small end of the holes up. Begin laying the blocks at the downstream end of the chute bottom, progressing upstream to the inlet. This will provide a good working surface without disturbing the filter fabric and gravel/sand bedding.

After all the blocks are placed, fill the holes in the blocks with soil and seed with the same seed mixture as that used for adjacent disturbed ares. Lime, fertilize, seed and mulch all disturbed areas.

(EFM Notice IN-53, November 1989)

DESIGN PROCEDURE FOR CONCRETE BLOCK CHUTES

1. Determine drainage area from USGS maps, aerial photos, soils maps, and/or field observations.

2. Determine controlled drop or overfall from survey data, establishing inlet and outlet elevations.

3. Determine design storm frequency from Technical Guide Section IV, Specification 410, Table 1, as required for rock chutes for drainage area and controlled drop at structure site. Unless a vegetated emergency spillway will be provided, use "total" capacity frequency for design of concrete block chute.

4. Determine peak discharge in cfs for design storm from EFM Chapter 2.

5. Determine Hp: design flow in defined approach channel or allowable ponding elevation above inlet elevation in area above structure.

6. Determine bottom width of chute from Table A, Figure IN-6-12.

7. Determine tailwater (TW) elevation in outlet channel downstream of chute.

8. Determine "F" dimension of chute: equal to or greater than (inlet elevation + Hp - TW elevation) and (inlet elevation - outlet channel elevation).

9. Design emergency spillway with crest above the Hp value if one is feasible. See Step 12 of Design Procedure for Rock Lined Chutes for discussion and procedure.

10. Determine settled fill elevation adjacent to chute - 1.0 feet above Hp, but a minimum of 2.75 feet above the inlet elevation. See Step 13 of Design Procedure for Rock Lined Chutes for discussion.

11. Determine material quantities.

12. Complete data sheets for plan. Use IN-ENG-46, IN-ENG-42 and other sheets as appropriate.

13. Check all work for omissions and errors.

14. Get required reviews and approvals of plan.

(EFM Notice IN-53, November 1989)

Example Design: CONCRETE BLOCK CHUTE
(w/o Emergency Spillway)

1. Determine drainage area; for this example, use 12 acres.

2. Controlled drop: Inlet Elevation = 105.0
- Channel Outlet Elevation = 100.0
Controlled drop = 5.0 feet

3. From footnote 6, Technical Guide Specification 410, Table 1, for Drainage Area = 12 acres, controlled drop = 5', with no emergency spillway, design storm frequency = 24 hour 10 year storm.

4. Determine peak Discharge (Q).
For this example, use Q = 13 cfs

5. Determine Hp: for this example, use Hp = 1.0 foot

6. Determine bottom width of chute:
from Table A - Figure IN-6-12,
for Hp = 1.0 and Q = 13 cfs
Use 14 rows or 8.9 feet

7. Determine TW elevation: For this example, use depth in outlet channel = 1.5 feet, or elevation 101.5

8. Determine F: Inlet + HP - TW
= 105.0 + 1.0 - 101.5 = 4.5'
or Inlet elev - channel outlet elev
= 105.0 - 100.0 = 5.0'
From Table B, Figure IN-6-12 - Use F = 5.38'
X = 16.06'
Z = 17.14'
or 13 blocks down the slope

9. There will be no emergency spillway

10. Settled fill elevation = inlet elevation + Hp + 1.0, but not less than inlet elevation + 2.75
= 105.0 + 1.0 + 1.0 = 107.0
or 105.0 + 2.75 = 107.75
Use Top of Settled Fill = 107.8

11. Determine material quantities:

a. Number of blocks:

From Table B, Figure IN-6-12:
blocks per row across = 23

From Step 6:
rows across bottom = 14
Total blocks in bottom = 23 x 14 = 322

From Table B, Figure IN-6-12:
Blocks in sides = 174
Total blocks required = 496

b. Filter Fabric:

The face of each block is 0.635' x 1.302'
or 0.827 sq. ft. or 0.092 sq. yds.
For 496 blocks, 45.6 sq. yds required.
Add 10%+ for laps, edges, etc. Use 51 sq. yds

c. Plastic Sheeting:

For side drainage structure,
use 1 cutoff at inlet end.
Cutoff is (b + 4.6') long or (8.9'+4.6') or 13.5'
Plastic sheeting required:
13.5' x 4.0'/9 sq. ft. per sq. yd.
= 13.5' x 0.445
= 6.0 sq. yds. minimum
For an in line structure, 2 cutoffs would be required, each 4 feet wide x 13.5 feet long,at inlet and outlet ends, or
12.0 sq. yds. minimum

d. Bedding:

Area of blocks = 496 x 0.827 sq. ft = 410.2 sq. ft
Use 3" thickness of bedding,
or 0.207 cu. ft. per block
or 0.00766 cu. yds per block
For 496 blocks = 3.8 cu. yds
or at 1.5 tons per cu. yd., 5.7 tons

e. Revegetation area - Use twice bedding area
or 860 sq. ft.
plus other disturbed area

12. Use appropriate data sheets:
IN-ENG-46D may be used for design.
IN-ENG-46Q may be used to compute material quantities.
IN-ENG-46 should be used for construction drawings;
See Exhibit IN-6-7.

13. Check all work.

14. Get required reviews and approvals.

(EFM Notice IN-53, November 1989)

EXHIBIT IN-6-7

U. S. Department of Agriculture
Soil Conservation Service

IN-ENG-46D
10/89
File Code 210-11

CONCRETE BLOCK CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Designed by CET date: 11-9-89; Checked by _____ date _____

D E S I G N

Concrete Block Chute:
Controlled Drop:
Inlet El 105.0 - Channel El 100.0 = 5.0 Feet
From IN-ENG-10A; Q (chute) = 13 cfs

Determine Hp:
A. Depth of flow in inlet approach channel for Q:
dc = _____ ft.
or B. Allowable water ponding elevation = _____
minus inlet elevation = _____
df = _____ ft.
SELECT Hp ≥ dc or df: Use Hp = 1.0 feet

Determine b:
From EFM Figure 6-12, Table A,
for required Q and selected Hp -
Find b = 14 rows across = 8.9 feet

Determine Tailwater (TW) Elevation:
Depth of flow in outlet channel for Q:
d = 1.5 ft. + Channel El = 100.0 = TW El 101.5

Determine F:
F1 = Inlet El 105.0 + Hp 1.0 - TW El 101.5 = 4.5 ft
F2 = Inlet El 105.0 - Out. Channel El 100.0 = 5.0 ft
From EFM Figure 6-12, Table B,
SELECT F ≥ F1 & F2; Use F = 5.38 ft
X = 16.06 ft
Z = 17.14 ft

Emergency Spillway (ES): none
From IN-ENG-10A; Q(total) = _____ cfs;
Qe (design) = Q (total) ____ - Q(chute) ____ = ____ cfs
ES Crest El = Entrance El ____
+ Approach channel depth (dc) ____ = _____
Level Section (L) = ____ ft.; Exit Slope (so) = ____%;
Erosion resistant soil? - yes-no (circle one);
Cover, stand & height - _____;
Retardance - ___; Velocity (V) (maximum) = _____fps;
Hpe = _____ ft.; Discharge per ft.(q) = _____ cfs/ft.;
Bottom Width (bs) = Q/q = _____ ft.

Top of Fill:
Top of Settled Fill Elevation ≥
Inlet El 105.0 + 2.75' = 107.75
Or Inlet El 105.0 + Hp 1.0 + freeboard (1.0') = 107.0
Or ES Crest El — + Hpe — + freeboard — = —
Use Top of Settled Fill Elevation 107.8

EXHIBIT IN-6-7 (continued)

U. S. Department of Agriculture
Soil Conservation Service

IN-ENG-46Q
10/89
File Code 210-11

CONCRETE BLOCK CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Designed by CET date: 11-9-89; Checked by _____ date _____

Q U A N T I T I E S

Concrete Blocks (from EFM Figure 6-12, Table B):
Blocks per row across 23 x Rows across 14 = 322
plus blocks in sides = 174
= No. blocks = 496

Filter Fabric:
No. blocks 496 x 0.092 = 45.6 sq yds min.
Add ≥ 10 % for laps and edges; Use 51 sq yds

Plastic sheeting:
1 required at inlet for side drainage structure
2 required (1 at each end) for in-line structure
Each is 4 feet wide x (b 8.9 ft + 4.6 ft)
or 13.5 ft. long
Use 0.445 x length 13.5 = 6.0 sq yds min. each

Bedding (stone/sand):
No. blocks 496 x 0.00766 = 3.8 cu yds min.
at 1.5 tons per cu yd = 5.7 tons min.

Revegetation area = _____ acres

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

COST ESTIMATE

ITEM	QUANTITY	UNIT	PRICE	AMOUNT
Clearing	_____	Acres	$____	$_____
Excavation & Backfill	_____	cu.yds.	$____	$_____
Blocks	496	each	$____	$_____
Filter Fabric	51	sq.yds.	$____	$_____
Plastic Sheeting	6.0	sq.yds.	$____	$_____
Bedding	5.7	tons	$____	$_____
Revegetation	_____	acres	$____	$_____
Other	_____	_____	$____	$_____
	TOTAL			$_____
	Contingencies - __%			$_____
	COST ESTIMATE			$_____

EXHIBIT IN-6-7 (continued)

CONSTRUCTION DATA

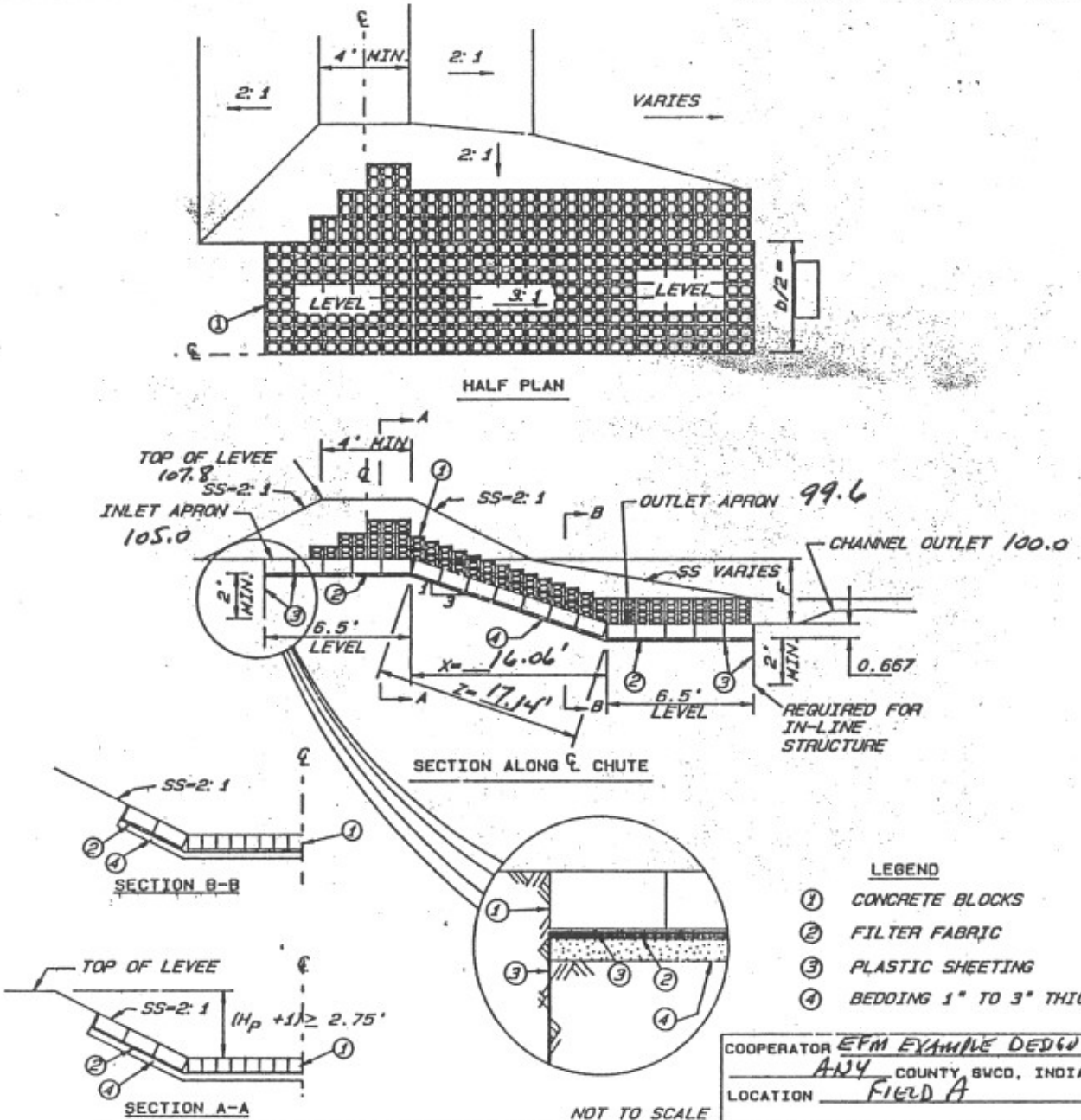
LAYOUT BY _____ DATE _____

CONTRACTOR _____ COMPLETED DATE _____

PRACTICE (DOES)(DOES NOT) MEET STANDARDS AND SPECIFICATIONS.

CHECKED BY _____ DATE _____

PROVIDE AN EMERGENCY SPILLWAY, ONE ON EACH SIDE IF FEASIBLE, 1.3' TO 1.5' BELOW TOP OF LEVEE.



LEGEND

1. CONCRETE BLOCKS
2. FILTER FABRIC
3. PLASTIC SHEETING
4. BEDDING 1" TO 3" THICK

NOT TO SCALE

COOPERATOR EFM EXAMPLE DESIGN

ANY COUNTY SWCD, INDIANA

LOCATION FIELD A

ELEVATIONS		STRUCTURE DIMENSIONS	
TOP OF LEVEE	107.8	Q=	13 CFS
EMERGENCY SPILLWAY	—	Hp=	1.0 FT
INLET APRON	105.0	F=	5.38 FT
OUTLET APRON	99.6	b=	8.9 FT
CHANNEL OUTLET	100.0		

BENCH MARK

ELEVATION _____

DESCRIPTION _____

CONCRETE BLOCK CHUTE
(SHEET 1 OF 3)
GENERAL LAYOUT

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/87 | Approved by | Title | Drawn | Title | Traced | Sheet | Drawing No. | Checked DC 11-89 | No. of

REVISED 10-89

IN-ENG-46

EXHIBIT IN-6-7 (continued)

CONSTRUCTION NOTES

1- Site preparation:
- A- Remove all vegetation, roots and topsoil from chute site.
- B- Excavate and/or place compacted fill to chute slope and side slope subgrade approximate 0.8 ft. below finished grade. Compacted fill shall be denser than adjacent undisturbed material.

2- Excavate cutoff trench:
- A- Cutoff trench shall be excavated upstream of inlet apron to 24 inches minimum below stone/sand bedding grade. Excavate similar cutoff trench downstream of outlet apron for in-line structure.
- B-Cutoff trenches shall extend to full width of block placement (2.3 feet outside bottom width "b" on each side).

3- Place polyvinyl sheet in cutoff trenches:
- A- Plastic sheeting shall be 6 mil minimum thickness.
- B- Place plastic to bottom of trench and backfill.
- C- Fold plastic above trench (24 inches minimum) away from structure.

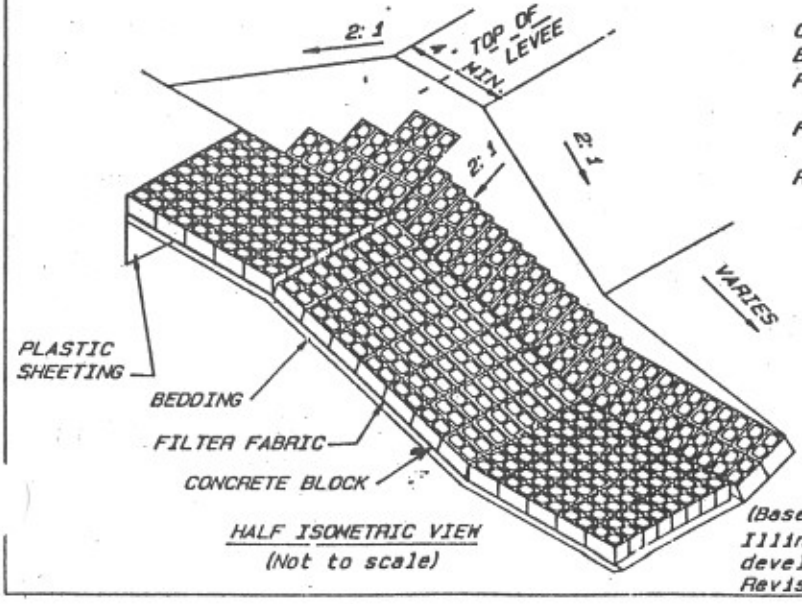
4- Bedding:
- Place 1 to 3 inches thickness of stone/sand, such as IDOH no. 23, 24, or 15 over entire chute bottom and side slope to grade required.

5- Place filter fabric:
- A- Filter fabric shall be nonwoven, needlepunched (not heat bonded), with openings between 0.15 mm and 0.42 mm (U.S. Standard Sieve Size between #40 and #100), tensile strength 120 lbs. minimum, bursting strength 210 lbs. minimum, puncture resistance 40 lbs. minimum, and be ultraviolet resistant.
- B- Place filter fabric over and outside of entire stone/sand bedding and anchor with pins or staples in accordance with manufacturer's recommendations. Use minimum lap of 24 inches if filter fabric is installed in more than one piece.
- C- Place fabric in trench outside of stone/sand bedding and anchor with earth.
- D- Do not place stone/sand or earth on fabric under block.

6- Fold plastic cutoff material over filter fabric.

7- Place concrete blocks starting at downstream end of sloping section and proceed upstream and downstream.
- A- Concrete blocks shall be nominal 8"x8"x16", in good condition and free of excess mortar.
- B- Concrete blocks shall be placed with small end of holes up.
- C- Concrete blocks in floor shall be placed with length parallel to direction of flow.
- D- Concrete blocks in side slopes shall be placed with length perpendicular (90 degrees) to direction of flow.
- E- Concrete blocks shall not be driven on by any machinery during or after placement.

8- Finish operations:
- A- Fill holes in concrete blocks with soil. Seed with same mixture used on disturbed areas.
- B- Lime, fertilize, seed and mulch all disturbed areas.



HALF ISOMETRIC VIEW
(Not to scale)

QUANTITIES

Concrete blocks	496	Each
Bedding	5.7	Tons
Plastic sheeting	6.0	Sq. Yds.
(4.0 feet wide X 13.5 lin. ft. long)		
Filter fabric	51	Sq. Yds.
(Add additional for laps and edges)		
Revegetation		Acres

COOPERATOR EFM EXAMPLE DEVLP
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

CONCRETE BLOCK CHUTE
(SHEET 2 OF 3)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/89
Drawn
Traced
Checked DC 11-89

(Based on Illinois development)
Revised 10-89

EXHIBIT IN-6-7 (continued)

GENERAL

Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance wildlife habitat will be used where practical.

The completed job shall present an appearance of good workmanship and shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

SITE PREPARATION

All trees, stumps, brush, and similar materials are to be removed from the construction area and disposed of in a manner consistent with environmental concerns and proper functioning of the spillway.

EXCAVATION

To the extent needed, all suitable materials removed from the specified excavation shall be used in the construction of the earth fill areas of the structure. All spoil deposited adjacent to the structure and in the adjacent area shall have a positive grade to drain toward the structure.

MOISTURE CONTROL

The minimum moisture content of the fill material and foundation shall be such that when kneaded in the hand the fill material will form a ball which does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compacting equipment.

MAINTENANCE RECOMMENDATIONS:

A maintenance program shall be established by the land user to maintain capacity and vegetative cover. Items to consider are as follows:

1-Do not graze seeded areas during establishment and when soil conditions are to wet.

2- Protect structure from damage by farm equipment and vehicles.

3-Maintain structure inlet and outlet areas free of any obstructions.

4-Repair structure as soon as possible after damage is noted.

5- Reestablish vegetative cover immediately where erosion has removed established seeding.

6-Maintain effective erosion control of the contributing watershed to prevent siltation and the resulting loss of capacity.

CONSTRUCTION TOLERANCES

Depth at centerline: Grade to 0.1 foot below
Width: 10% wider not to exceed 1.0 foot
Top of levee: Grade or above.
Side slopes: ±0.1 ft./ft.

FINISH AND CLEANUP

The structure area and the designated spoil areas will be finished in a relatively smooth condition ready for seeding. All rocks 3 inches in diameter or larger and roots shall be removed from the surface areas.

VEGETATIVE ESTABLISHMENT

Excess water shall be directed away until vegetation is established, if possible. Any protective works shall be removed and the disturbed areas shall be seeded for permanent grass.

Apply lime to raise the ph to _____ at rate of _____ tons per acre.

Fertilize according to soil tests or at a minimum rate of 1000 pounds of 12-12-12 fertilizer (or its equivalent) per acre as soon as the structure has been constructed if within the seeding dates.

Work the fertilizer and lime into the soil to a depth of 2 - 3 inches with a harrow or disk. Seeding will be done at the following rates:

Seed: _____ Rate: _____ lbs./acre
_____ Rate: _____ lbs./acre

When construction is completed between May 11 and August 9, a temporary cover crop should be established using the following seeding:

Seed: _____ Rate: _____ lbs./acre

Dormant seeding may be done between December 10 and February 28. Liming, fertilizing, seedbed preparation and mulching may be done ahead of the dormant seeding, with the seed being broadcast on top of the mulch.

Apply mulch at the rate of _____ tons of straw per acre.

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

CONCRETE BLOCK CHUTE
(SHEET 3 OF 3)
SPECIFICATIONS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/89
Drawn
Traced
Checked DC 11-89
Approved By
Title
Title
Sheet
Drawing No.

Revised 10/89

IN-ENG-46

REINFORCED VEGETATED CHUTE

The reinforced vegetated chute is an economical method of providing grade stabilization for smaller drainage areas with intermittent flow where a flatter slope and longer length is acceptable and/or it is not desired or practical to use either rock or concrete blocks. It is similar in configuration to the rock lined chute, but uses soil erosion matting (SEM) and erosion control blankets (ECB) to reinforce the vegetation in the water flow area. The SEM is placed in the bottom of the chute and the ECB placed on the side slopes. It can be installed on chute profile slopes not steeper than 5H:1V, and is normally not used on slopes flatter than 10H:1V. Side slopes of the chute are from 2:1 to 4:1. It can be used in a waterway or channel to take up grade between two flatter stable segments of the channel without changing the vegetation in the channel. Installation is a more labor-intensive than a rock-lined chute but less labor-intensive than a concrete block chute.

The SEM (soil erosion matting) is defined as a flexible, non woven, geotextile fabric made from randomly oriented polymer monofilaments thermally welded together into a three-dimensional matrix or porous web and specifically designed for erosion control and earth reinforcement applications. Acceptable materials include, but not limited to, "ENKAMAT" as manufactured by Akzo Industrial Systems Company, "Tensar Mat" as manufactured by The Tensar Corporation, "Erolan 2010" as distributed by Hydro-Turf & Associates, and "GREENSTREAK PEC-MAT" as manufactured by Greenstreak Plastic Products Company, Inc.

The ECB (erosion control blanket) is defined as a flexible, non structural, interwoven layer of biodegradable material (straw, excelsior, etc.) or photodegradable material (such as nylon fibers) sewn to or between photodegradable netting, designed to reduce rainfall impact, reduce soil loss, increase moisture retention, and enhance grass plant growth. Acceptable materials include, but not limited to, "Erosion Control Blankets" as manufactured by North American Green, "Curlex Blankets" as manufactured by American Excelsior Company, and "ERO-MAT" as distributed by Contech Construction Products, Inc. The specific style or type must be selected to fit the site conditions.

(EFM Notice IN-53, November 1989)

A reinforced vegetated chute is readily installed by a landuser with his own equipment and labor. It is not effective immediately upon completion of installation as is a rock or concrete block chute. It will require more frequent observation and maintenance than a rock or concrete block chute, but repairs and maintenance are easily done by the landuser.

DESIGN ELEMENTS

Design Flow:

The design of the reinforced vegetated chute is similar to that for a trapezoidal grassed waterway with "C" retardance. Allowable velocity (Vs) for easily eroded soils is 5 fps; for erosion resistant soils is 7 fps. Stability of the structure is determined as for an "E" retardance with the allowable velocity being 8 and 10 fps respectively. See EFM Chapter 7. For purposes of this practice, an erosion resistant soil shall have a plasticity index (PI) equal to 15 or greater. Soils not meeting this requirement, and soils with known dispersive characteristics, shall be considered easily eroded.

Chute Geometry:

The reinforced vegetated chute configuration, profile and cross-section are similar to that of a rock chute. The bottom width of the chute is made to utilize full widths of the SEM with required overlaps. The inlet and outlet section lengths are determined as for the rock chute. See rock lined chute discussion for background and criteria. To help in maintaining stability, a 24" x 24" gravel or crushed stone drain is installed at the upper end of the inlet with a drain tile or tubing outletting below the chute to intercept seepage that would inhibit the growth of vegetation and/or encourage erosion. A 4' length of riprap is installed at the downstream end of the outlet section to help in dissipating the energy from the steep chute section without erosion. See Exhibit IN-6-8.

Emergency Spillway:

An emergency spillway should be provided if feasible. The crest of the emergency spillway is placed above the design Hp value. See discussion about an emergency spillway for the rock lined chute.

Top of Settled Fill:

The top of fill elevation adjacent to the chute should be at least one foot above the design flow in the approach channel. See discussion about the top of settled fill elevation for the rock lined chute.

INSTALLATION

The chute should be placed on an excavated base. If it is necessary to place fill to bring the chute section to grade, it is extremely important that the fill be compacted to a density greater than the adjacent natural material.

Place drain tile or tubing outside the chute area, including outlet pipe section with animal guard. Leave upstream end of drain tile or tubing exposed for later attachment or placement in trench.

Prepare a seedbed, apply lime, fertilizer and seed as appropriate.

Cut trenches for gravel drain on upstream end (24"x24") and for riprap toe at downstream end (4' long x 2 d50 minimum deep). Cut slots to anchor SEM and ECB in accordance with manufacturer's recommendations.

Place SEM in bottom of chute, including entrance and outlet aprons. Extend SEM into trenches for gravel drain and riprap toe. Place ECB on side slopes to at least one-half foot higher than design depth of flow in chute. SEM and ECB are placed with lengths parallel to the direction of flow in the channel. The ECB is placed so it shingles down the side slope of the channel. Overlap adjacent strips and anchor in accordance with manufacturer's recommendations. Overlap the SEM and ECB a minimum of 6 inches at the break between the bottom and side slope of the chute and anchor securely. Fill slots with compacted earth fill and complete installation of SEM and ECB.

Extend perforated drain tile or tubing in trench across inlet and place gravel or stone around drain tile or tubing.

Install riprap toe in trench at outlet. Use minimum d50 rock size based on velocity in the chute. See Figure IN-6-8.

Cover disturbed areas not protected by SEM, ECB or stone with mulch or ECB.

(EFM Notice IN-53, November 1989)

DESIGN PROCEDURE FOR REINFORCED VEGETATED CHUTES

1. Determine drainage area from USGS maps, aerial photos, soils maps, and/or field observations.

2. Determine controlled drop or overfall from survey data, establishing inlet and outlet elevations.

3. Determine design storm frequency from Technical Guide Section IV, Specification 410, Table 1, as required for rock chutes for drainage area and controlled drop at structure site. Unless a vegetated emergency spillway will be provided, use "total" capacity frequency for design of the reinforced vegetated chute.

4. Determine peak discharge (Q) in cfs for design storm from EFM Chapter 2.

5. Determine soil type in chute area and allowable velocity in chute.

*6. Select chute profile slope (S) and chute side slopes (z).

*7. Determine bottom width and depth of flow in chute, and check for $b/d \leq 50$.

*8. Determine velocity in chute and check that it less than allowable.

9. Determine chute dimensions. Length and depth factors are the same as for rock lined chutes.

10. Determine depth of design flow in upstream channel.

11. Design emergency spillway with crest above the flow depth in the upstream channel if one is feasible. See Step 12 of Design Procedure for Rock Lined Chutes for discussion and procedure.

12. Determine settled fill elevation adjacent to chute. If no emergency spillway is used, place top of settled fill 1.0 feet above the flow depth in the upstream channel. See Step 13 of Design Procedure for Rock Lined Chutes for discussion.

13. Determine material quantities.

14. Complete data sheets for plan. Use IN-ENG-56, IN-ENG-42 and other sheets as appropriate.

15. Check all work for omissions and errors.

16. Get required reviews and approvals of plan.

* Figure IN-6-13 gives the capacity (Q) and velocity (V) o reinforced vegetated chutes for various combinations of bottom width (b) and flow depth (d) for various chute profile slopes (S) with side slopes (z) = 3:1.

Example Design: REINFORCED VEGETATED CHUTE
(w/o Emergency Spillway)

1. Determine drainage area; for this example, use 12 acres.

2. Controlled drop: Inlet Elevation = 105.0
- Channel Outlet Elevation = 100.0
Controlled drop = 5.0 feet

3. From footnote 6, Technical Guide Specification 410, Table 1, for Drainage Area = 12 acres, controlled drop = 5', with no emergency spillway, design storm frequency = 24 hour 10 year storm.

4. Determine peak Discharge (Q).
For this example, use Q = 13 cfs

5. Determine soil type in chute area and allowable velocity in chute. For this example, assume an easily eroded soil (PI <15), allowable velocity = 5 fps.

6. Select chute profile slope (S) and chute side slopes (z). For this example, use S = 5:1; z = 3:1.

7. Determine bottom width and depth of flow in chute, and check for $b/d \leq 50$. From Figure IN-6-13, find b = 6', d = 0.4'; $b/d = 6/0.4 = 15$; <50, OK

8. Determine velocity in chute and check that it less than allowable. From Figure IN-6-3, V = 4.6 fps; <5.0, OK

(EFM Notice IN-53, November 1989)

9. Determine chute dimensions.

Entrance Section:

Total depth at entrance (de) $\geq$ (d+1) = 1.4 ft.

Entrance length (Le) $\geq$ 5(de) = 5 x 1.4 = 7 ft.

Upstream entrance width (be) $\geq$ b = 10 ft.

Chute Section:

Total depth in chute (dc) $\geq$ (d+0.5) = 0.9 ft.

Chute length (Lc) = (F 5.0)(S 5) = 25 ft.

Slope Length (Ls)=(F)$(S^2+1)^{0.5}$ = 5x5.1 = 25.5 ft.

Outlet Section:

Total Depth in outlet (do) $\geq$ (2d+0.5) = 1.3 ft.

Outlet length (Lo) $\geq$ [6+3($\sqrt{C}$-5)] = 6 ft.

10. Determine depth of design flow in upstream channel.

Assume 4% grade. retardance c/d:

waterway T = 20', D = 0.6'

11. There will be no emergency spillway

12. Settled fill elevation = inlet elevation
+ flow depth in upstream channel + 1.0
= 105.0 + 0.6 + 1.0 = 106.6

13. Determine material quantities:

a. Perforated drain tile or tubing - use 4" or 5" diam.

minimum length = upstream entrance width - (be)
+ z x design inlet depth - z(de)
+ entrance apron length - (Le)
+ chute length - (Lc)
+ outlet apron length - (Lo)
+ z x design outlet depth - z(do)
+ distance to outlet if downstream of chute outlet apron

In this example, minimum length = be (10') + z(de) (3x1.4') + Le (7') + Lc (25') + Lo (6') + z(do) (3x1.3') = 56.1' ; Provide sufficient additional length of drain tile or tubing to place outlet downstream of chute area - use 65'

b. Tile outlet pipe - Use 10 lin ft of outlet pipe with same or larger diameter as drain tile or tubing with coupler and animal guard. For this example use same diameter PVC pipe.

c. Gravel or stone drain - Fill 2' x 2' trench across upstream end of entrance apron - 2' x 2' x be (10') = 40 cu. ft., or 1.5 cu. yds., or 2.2 tons at 110 pcf in place.

d. Riprap - use d50 = 7" with 2 x d50 depth across outlet channel - b (6') x 4' x 2 x d50 (7/12) = 28 cu. ft., or 1 cu. yd., or 1.5 tons at 110 pcf in place.

(EFM Notice IN-53, November 1989)

e. Soil Erosion Matting (SEM):

Area to be covered by SEM = b (6') x [Le (7') + Ls (25.5') + Lo (6')] or 6 x 38.5 = 231 sq. ft., or 26 sq. yds. If SEM is available in 3' wide (net) rolls, 77 lin. ft. is needed, plus additonal length to allow for laps and slots. For this example, use 100 lin. ft.

f. Erosion Control Blanket (ECB):

Area to be covered by ECB is 2 x [dc (0.9) x $(z^2 + 1)^{0.5}$ (3.16)] x [Le (7') + Ls (25.5') + Lo (6')] or 2 x 2.85 x 38.5 = 219 sq. ft., or 24.4 sq. yds. If ECB is available in 3' wide (net) rolls, 77 lin. ft. is needed plus additional length for laps and slots. For this example, use 100 lin. ft.

g. Provide sufficient staples and or stakes as recommended by the manufacturer to insure than the SEM and ECB is adequately staked.

h. Determine disturbed area to be revegetated with lime, fertilizer and seed. Areas outside of the area covered by SEM and ECB may need to be mulched.

14. Use appropriate data sheets:
    IN-ENG-56D may be used for design.
    IN-ENG-56Q may be used to compute material quantities.
    IN-ENG-56C may be used to prepare the cost estimate.
    IN-ENG-56 should be used for construction drawings;
    See Exhibit IN-6-8

15. Check all work.

16. Get required reviews and approvals.

CHUTE SLOPE = 5:1										
d	0.4		0.5		0.6		0.7		0.8	
b	Q	V	Q	V	Q	V	Q	V	Q	V
6	13	4.6	24	6.4	39	8.4				
9	21	5.0	37	7.1						
12	28	5.3	50	7.4						
15	35	5.4	64	7.7						
18										

CHUTE SLOPE = 6:1										
d	0.4		0.5		0.6		0.7		0.8	
b	Q	V	Q	V	Q	V	Q	V	Q	V
6	12	4.0	21	5.6	34	7.2				
9	18	4.4	32	6.1	52	8.0				
12	24	4.5	43	6.4	71	8.5				
15	30	4.7	55	6.7	89	8.9				
18	37	4.8	66	6.8	108	9.1				

CHUTE SLOPE = 8:1										
d	0.4		0.5		0.6		0.7		0.8	
b	Q	V	Q	V	Q	V	Q	V	Q	V
6	9	3.2	17	4.4	27	5.8	41	7.2		
9	14	3.4	25	4.8	41	6.4	62	8.0		
12	19	3.6	34	5.1	56	6.8	84	8.5		
15	24	3.7	44	5.3	71	7.0	106	8.9		
18	29	3.8	53	5.4	86	7.2				

CHUTE SLOPE = 10:1										
d	0.4		0.5		0.6		0.7		0.8	
b	Q	V	Q	V	Q	V	Q	V	Q	V
6	8	2.7	14	3.7	22	4.8	34	6.0	49	7.2
9	12	2.9	21	4.0	34	5.3	52	6.7	74	8.1
12	16	3.0	29	4.2	46	5.6	70	7.1		
15	20	3.1	36	4.4	59	5.8	89	7.4		
18	24	3.1	44	4.5	71	6.0	108	7.7		

V allowable for easily eroded soils = 5 fps
V allowable for erosion resistant soils = 7 fps

Figure IN-6-13 - REINFORCED VEGETATED CHUTE CAPACITY
(Based on Retardance C with side slopes (z) = 3:1)

EXHIBIT IN-6-8

U. S. Department of Agriculture
Soil Conservation Service

IN-ENG-56D
10/89
File Code 210-11

REINFORCED VEGETATED CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Designed by CGT date: 11-9-87; Checked by _____ date _____

D E S I G N

Reinforced Vegetated Chute:
Controlled Drop (F):
Entrance El 105.0 - Outlet El 100.0 = 5.0 Feet (F)
From IN-ENG-10A; Q (chute) = 13 cfs
Soil Type EASILY ERODIBLE (PI<15); Retardance - C/E
Allowable velocity (Vs): Easily Eroded Soils = 5 fps
Erosion Resistant Soils = 7 fps
Chute Profile Slope (S) = 5:1; side slope (z) = 3:1 (S,z)
Bottom Width (b) = 6 ft (b)
C Retardance: Chute flow depth (d) = 0.4 ft. (d)
Check b/d<50; b/d = 15 ✓
Velocity (VC) = Q/A
= Q/[d(b+zd)] = 4.5 fps ✓ (VC)

Entrance Section:
Total depth at entrance (de) ≥ (d+1) = 1.4 ft. (de)
Entrance length (Le) ≥ 5(de) = 7 ft. (Le)
Upstream entrance width (be) ≥ b = 10 ft. (be)

Chute Section:
Total depth in chute (dc) ≥ (d+0.5) = 0.9 ft. (dc)
Chute length (Lc) = (F 5.0)(S 5) = 25.0 ft. (Lc)
Slope Length (Ls) = (F 5.0)(S²+1)^0.5 5.1 = 25.5 ft.

Outlet Section:
Total Depth in outlet (do) ≥ (2d+0.5) = 1.3 ft. (do)
Outlet length (Lo) ≥ [6+3(VC-5)] = 6 ft. (Lo)

Approach Channel:
Grade = 4 %; n = _____; or Retardance C/D;
Bottom width (bw) = _____ ft.; Side slopes = ___:1;
or Top width (T) = 20 ft.;
Depth (D) = 0.6 ft.;

Emergency Spillway (ES):
From IN-ENG-10A; Q(total) = none cfs;
Qe (design) = Q (total) ____ - Q(chute) ____ = ____ cfs
ES Crest El = Entrance El ____
+ Approach channel depth (D) ___ = ____
Level Section (L) = ____ ft.; Exit Slope (so) = ____%;
Erosion resistant soil? - yes-no (circle one);
Cover, stand & height - _____;
Retardance - ___; Velocity (V) (maximum) = _____fps;
Hp = _____ ft.; Discharge per ft.(q) = _____ cfs/ft.;
Bottom Width (bs) = Q/q = _____ ft.

Top of Fill:
Top of Settled Fill Elevation =
Entrance El 105.0 + D 0.6 + freeboard (1.0) = 106.6
Or ES Crest El _____ + Hp _____ + freeboard (0.5) = _____

EXHIBIT IN-6-8 (continued)

U. S. Department of Agriculture
Soil Conservation Service

IN-ENG-56Q
10/89
File Code 210-11

REINFORCED VEGETATED CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Designed by CET date: 11-9-89; Checked by _____ date _____

Q U A N T I T I E S

Perforated drain tile or tubing - 4 " diam.:
min. length = be+z(de)+Le+Lc+Lo+z(do)
Use 60 lin. ft.

Tile outlet pipe (4 " diam), material PVC, 10 lin. ft.
with coupler and animal guard

Gravel or stone drain - 2' x 2' x be(10) = 40 cu. ft.
= 1.5 cu. yds.
@ 110 pcf = 2.2 tons

Riprap - d50 = 7 inches
b (6) x 4' x 2 x d50 (7)/12 = 28 cu. ft.
= 1.0 cu. yds.
@ 110 pcf = 1.5 tons

Soil erosion matting (SEM):
b (6) x (Le + Ls + Lo + laps + slots) = 231 sq. ft. min.
= 26 sq. yds. min
@ 3 ' net widths, 77 lin. ft or ____ rolls
min

Erosion Control Blanket (ECB):
width required = $[(z\ dc)^2 + 1]^{0.5}$ + laps + slots
= 3 ft.
length required = 2(Le + Ls + Lo + laps) = 219 ft.
@ 3 ' net widths, 219 lin. ft or ____ rolls
min

Staples and/or stakes for anchoring - _____

Revegetation area = _____ acres

EXHIBIT IN-6-8 (continued)

U. S. Department of Agriculture
Soil Conservation Service

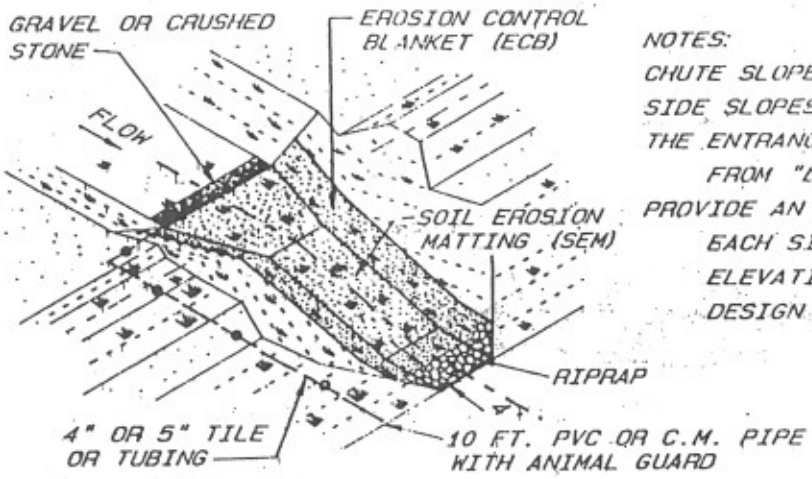
IN-ENG-56C
10/89
File Code 210-11

REINFORCED VEGETATED CHUTE for EFM EXAMPLE DESIGN
ANY County SWCD, Indiana
Designed by CET date: 11-9-89; Checked by _____ date _____

COST ESTIMATE

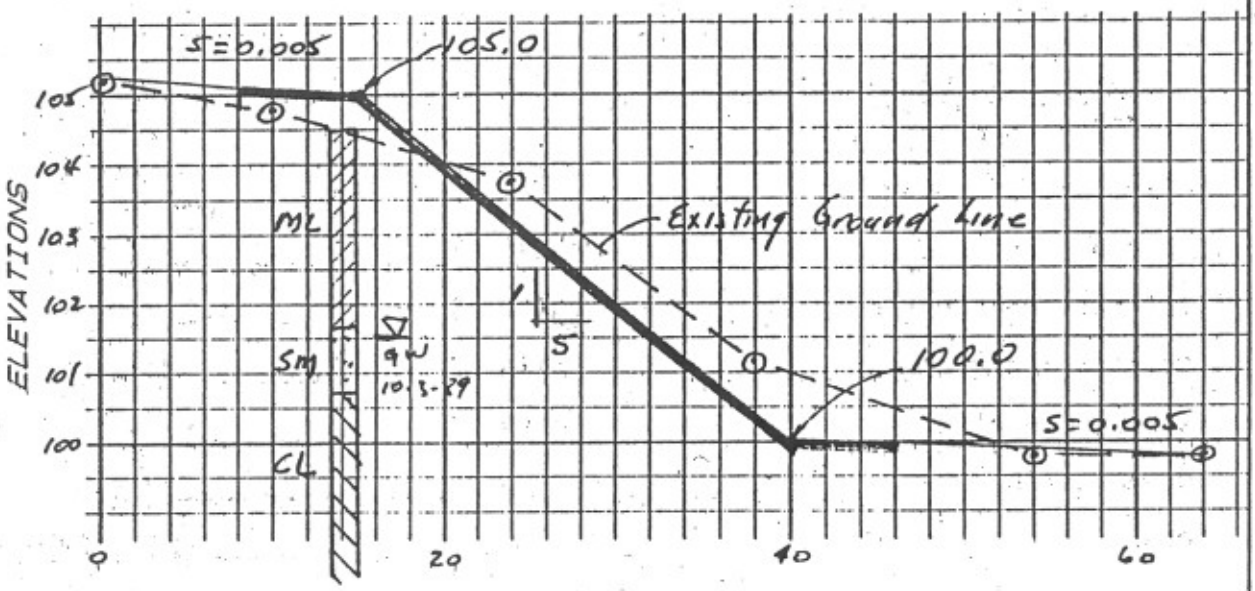
ITEM	QUANTITY	UNIT	PRICE	AMOUNT
Clearing	_____	Acres	$____	$_____
Excavation	_____	cu.yds.	$____	$_____
Tile or tubing, 4" diam	60	lin.ft.	$____	$_____
Tile outlet pipe - PVC 4" diam w/coupler and animal guard	10	lin.ft.	$____	$_____
Gravel or stone drain	2.2	tons	$____	$_____
Riprap - d50 = 7"	1.5	tons	$____	$_____
Soil Erosion Matting	_____	rolls	$____	$_____
Erosion Control Blanket	_____	rolls	$____	$_____
Staples or stakes	_____	boxes	$____	$_____
Revegetation	_____	acres	$____	$_____
Other	_____	_____	$____	$_____
	TOTAL			$_____
	Contingencies - __%			$_____
	COST ESTIMATE			$_____

EXHIBIT IN-6-8 (continued)



VEGETATED OVERFALL STRUCTURE

NOTES:
CHUTE SLOPE "S" NOT STEEPER THAN 5:1.
SIDE SLOPES "Z" NOT STEEPER THAN 2:1.
THE ENTRANCE APRON WIDTH WILL VARY FROM "b_e" 10 TO "b" 6.
PROVIDE AN EMERGENCY SPILLWAY, ONE ON EACH SIDE IF FEASIBLE, WITH CREST ELEVATION ABOVE APPROACH CHANNEL DESIGN FLOW DEPTH.



PROFILE ALONG CENTERLINE OF CHUTE
(SHOW SOIL BORINGS)

ESTIMATE OF QUANTITIES

CLEARING		ACRES
EXCAVATION		CU. YDS.
TILE OR TUBING, 4" DIAM.	60	LIN. FT.
TILE OUTLET PIPE - PVC 4" DIAM. WITH COUPLER AND ANIMAL GUARD	10	LIN. FT.
GRAVEL OR STONE DRAIN	2.2	TONS
RIPRAP - d_{50} = 7"	1.5	TONS
SOIL EROSION MATTING		ROLLS
EROSION CONTROL BLANKET		ROLLS
STAPLES OR STAKES		BOXES
REVEGETATION		ACRES

10/89

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

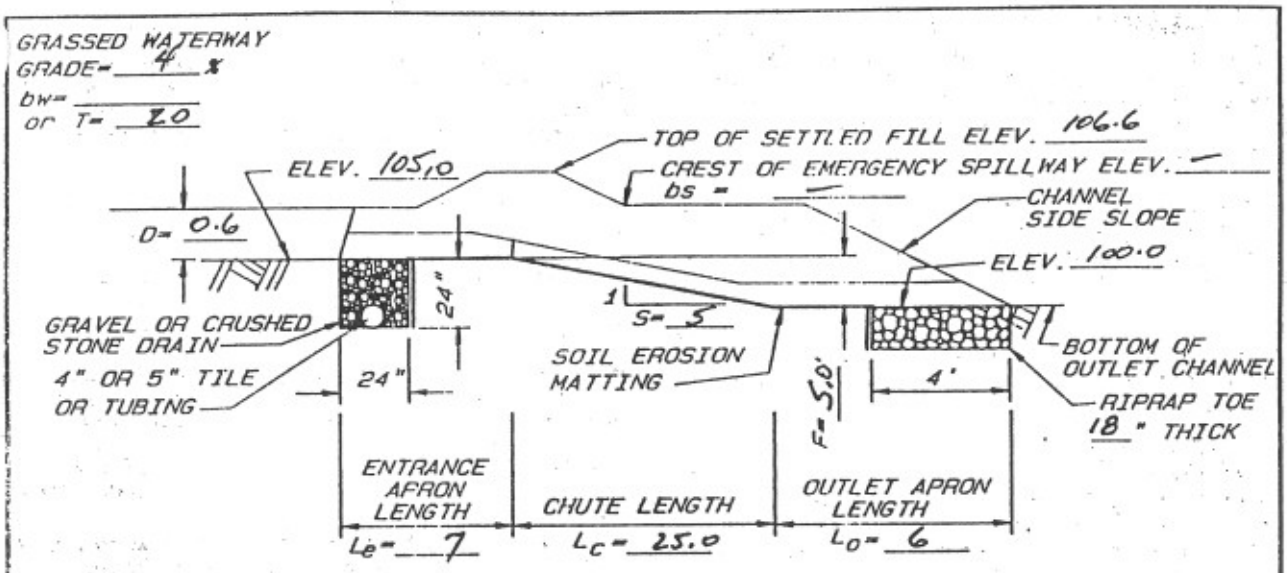
REINFORCED VEGETATED CHUTE
(SHEET 1 OF 4)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

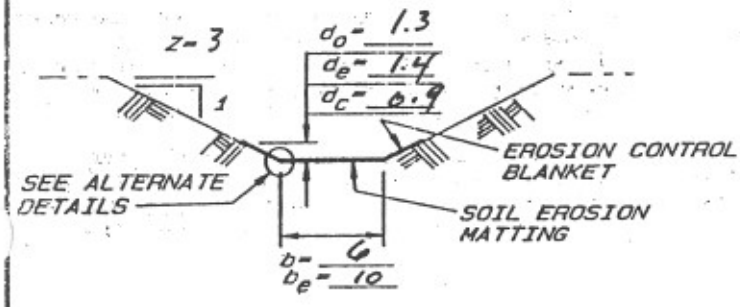
Designed CET 11/89
Drawn
Traced
Checked DC 11-89
Approved By
Title
Title
Sheet
Drawing No.

IN-ENG-56

EXHIBIT IN-6-8 (continued)



SECTION ON CENTERLINE



TYPICAL CROSS SECTION

LEGEND

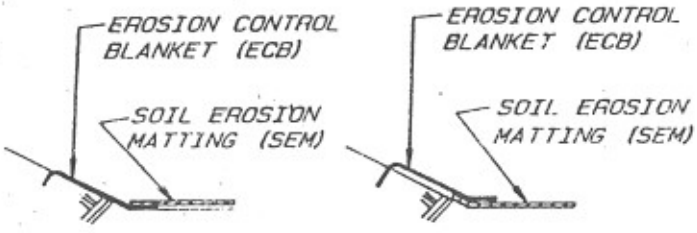
- F — CONTROLLED DROP
- b — BOTTOM WIDTH OF CHUTE
- b_e — WIDTH AT ENTRANCE UPSTREAM
- d_e — ENTRANCE APRON DEPTH
- d_c — CHUTE DEPTH
- d_o — OUTLET DEPTH
- SEM — SOIL EROSION MATTING
- ECB — EROSION CONTROL BLANKET

APPROACH CHANNEL

- bw — BOTTOM WIDTH
- T — TOP WIDTH
- D — FLOW DEPTH

EMERGENCY SPILLWAY

- bs — BOTTOM WIDTH



ALTERNATE DETAILS

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

REINFORCED VEGETATED CHUTE
(SHEET 2 OF 4)

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/89
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Title
Date
Sheet No. of
Drawing No.

IN-ENG-56

CONSTRUCTION DATA

LAYOUT BY _____ DATE _____

CONTRACTOR _____ COMPLETED DATE _____

PRACTICE (DOES) (DOES NOT) MEET STANDARDS AND SPECIFICATIONS

CHECKED BY _____ DATE _____

EXHIBIT IN-6-8 (continued)

GENERAL

1. Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within acceptable limits. Construction methods that enhance wildlife habitat will be used where practical.

2. The completed job shall present an appearance of good workmanship and shall conform to the lines, grades, and elevations shown on the drawings or as staked in the field.

3. All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

SITE PREPARATION

1. All trees, stumps, brush, and similar materials are to be removed from the construction area and disposed of in a manner consistent with environmental concerns and proper functioning of the structure.

2. Excavate and/or place compacted fill to finished grade of required section and slope. Compacted fill shall be denser than adjacent undisturbed material. Finished grade should be free of any clods, clumps, rocks or depressions that would prevent the soil erosion matting (SEM) or erosion control blanket (ECB) from lying flush to the surface.

3. To the extent needed, all suitable materials removed from the specified excavation shall be used in the construction of the earth fill areas of the structure. All spoil deposited in the area adjacent to the structure shall have a positive grade to drain toward the structure.

4. Place drain tile outside chute area, including outlet pipe section with animal guard. Leave upstream end of drain tile or tubing exposed for later attachment or placement in trench.

MAINTENANCE RECOMMENDATIONS:

A maintenance program shall be established by the land user to maintain capacity and vegetative cover. Items to consider are as follows:

1-Do not graze seeded areas during establishment and when soil conditions are to wet.

2- Protect structure from damage by farm equipment and vehicles.

3-Maintain structure inlet and outlet areas free of any obstructions.

4-Repair structure as soon as possible after damage is noted.

5- Reestablish vegetative cover immediately where erosion has removed established seeding.

6-Maintain effective erosion control of the contributing watershed to prevent siltation and the resulting loss of capacity.

VEGETATIVE ESTABLISHMENT

1. Prepare a seedbed.

2. Excess water shall be directed away until vegetation is established, if possible. Any protective works shall be removed and the disturbed areas shall be seeded for permanent grass.

3. Apply lime to raise the ph to _____ at rate of _____ tons per acre.

4. Fertilize according to soil tests or at a minimum rate of 1000 pounds of 12-12-12 fertilizer (or its equivalent) per acre.

5. Work the fertilizer and lime into the soil to a depth of 2 - 3 inches with a harrow or disk. Seeding will be done at the following rates:

Seed: _____ Rate: _____ lbs./acre
_____ Rate: _____ lbs./acre

6. When construction is performed between May 11 and August 9, a temporary cover crop should be established using the following seeding:

Seed: _____ Rate: _____ lbs./acre

7. Dormant seeding may be done between December 10 and February 28. Liming, fertilizing, seedbed preparation and mulching may be done ahead of the dormant seeding, with the seed being broadcast on top of the mulch.

8. On disturbed areas not covered with soil erosion matting (SEM) or erosion control blanket (ECB) apply mulch at the rate of _____ tons of straw per acre or use erosion control blanket (ECB).

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

REINFORCED
VEGETATED CHUTE
(SHEET 3 OF 4)
SPECIFICATIONS

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed CET 11/89
Drawn
Traced
Checked DC 11-89
Approved By
Title
Title
Sheet No. of
Drawing No.

IN-ENG-56

EXHIBIT IN-6-8 (continued)

PLACE SEM & ECB

1. Materials

Soil Erosion Matting (SEM) -

A flexible, non-woven, geotextile fabric made from randomly oriented polymer monofilaments thermally welded together into a three-dimensional matrix or porous web and specifically designed for erosion control and earth reinforcement applications. Acceptable materials include, but are not limited to, "ENKAMAT" as manufactured b Akzo Industrial Systems Company, "TENSAR MAT" as manufactured by The Tensar Corporation, "EROLIAN 2010" as distributed by Hydro-Turf & Associates, and "GREENSTREAK PEC-MAT" as manufactured by Greenstreak Plastic Products Company, Inc.

Erosion Control Blanket (ECB)

A flexible non-structural, interwoven layer of biogradable material (straw, excelsior, etc.) or photodegradable material (such as nylon fibers) sewn to or between photodegradable netting, designed to reduce rainfall impact, reduce soil loss, increase moisture retention, and enhance grass plant growth. Acceptable materials include, but not limited to, "EROSION CONTROL BLANKETS" as manufactured by North American Green, "CURLEX BLANKETS" as manufactured by American Excelsior Company, and "ERO-MAT" as distributed by Contech Construction Products, Inc. The specific style or type must be selected to fit the site conditions.

2. Cut trenches for gravel drain on upstream end and riprap toe at downstream end. Cut slots to anchor SEM and CEB in accordance with manufacturer's recommendations.

3. Place SEM in bottom of chute, including entrance and outlet aprons. Extend SEM into trenches for gravel drain and riprap toe. Place ECB on side slopes to at least 6 inches higher than design depth of flow. Overlap adjacent strips of SEM and ECB and stake in accordance with manufacturer's recommendation's. Fill slots with compacted earth fill and complete installation of SEM and ECB.

4. Extend perforated drain tile or tubing in trench across inlet and place gravel or stone drain around drain tile or tubing.

5. Install riprap toe in trench at outlet.

RIPRAP GRADATION

d_{50} = 7 inches

SIZE	% PASSING BY WEIGHT
15	100%
7	50%
3	15%

MOISTURE CONTROL

The minimum moisture content of the fill material and foundation shall be such that when kneaded in the hand the fill material will form a ball which does not readily separate. The maximum moisture content is when conditions are to wet for efficient use of the hauling and compacting equipment.

CONSTRUCTION TOLERANCES

Depth at centerline: Grade to 0.1 foot below
Width: 10% wider not to exceed 1.0 foot
Top of levee: Grade or above.
Side slopes: ±0.1 ft./ft.

FINISH AND CLEANUP

The structure area and the designated spoil areas will be finished in a relatively smooth condition ready for seeding. All rocks 3 inches in diameter or larger and roots shall be removed from the surface areas.

COOPERATOR EFM EXAMPLE DESIGN
ANY COUNTY SWCD, INDIANA
LOCATION FIELD A

REINFORCED VEGETATED CHUTE (SHEET 4 OF 4) SPECIFICATIONS - CONTINUED

U. S. DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE

Designed LET 11/89
Drawn
Traced
Checked DC 11-87
Approved By
Title
Title
Sheet
Drawing No.

IN-ENG-56