STRAIGHT INLETS

Design Criteria of Straight Inlet. The straight inlet terminates in the downstream direction at the origin of the upper curve. (See Fig. 5.) The actual depth of flow at the origin of the vertical curve if positive floor pressures are maintained on the vertical curve is between d_c and 0.715 d_c.[1] The depth is governed by entrance conditions to the vertical curve and will generally be between 0.80 d_c and 0.715 d_c. If no vertical curve were provided downstream from the inlet--that is, a sharp break in grade existed at the downstream end of the inlet--the depth of flow could be less than 0.715 d_c because of the occurrence of negative floor pressures immediately downstream from the break in grade. The critical depth of flow occurs at a section approximately 3 d_c upstream from the vertical curve which provides positive floor pressures. Supercritical flow exists in the portion of the inlet downstream from the section at which critical depth occurs. This portion of the inlet will be a prismatic channel to insure favorable flow conditions at the vertical curve section. The floor (or crest) of the straight inlet where supercritical flow exists should be paved for two reasons:

a. Earth channel bottoms are unstable in regions of supercritical flow and will cause disturbed flow conditions in the steep chute.

b. A concrete floor along with the anti-seep collar provides a means of constructing a cutoff of flow by piping.

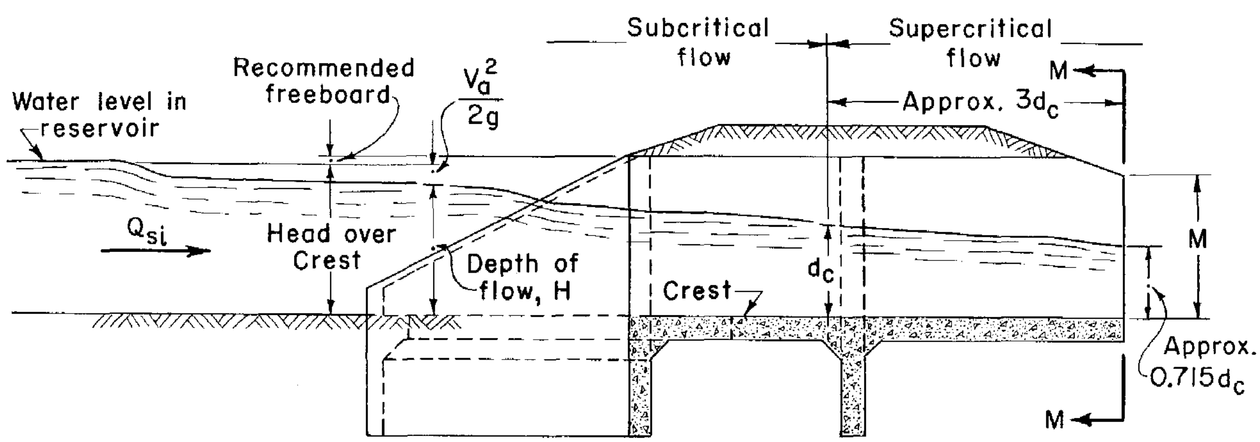

FIGURE 5

Discharge-Head Relationship for a Straight Inlet. The discharge-head relationship of a straight inlet is given by the weir formula

$$Q = 3.1\ W \left[H + \frac{v_a^2}{2g}\right]^{3/2} = 3.1\ W\ H_e^{3/2} \qquad 2.4$$

where Q = discharge of inlet in cfs
W = width of chute or inlet in ft

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[1]M. R. Carstens, Free Overflow has Rapidly Varying Characteristics, Civil Engineering, June 1955, Page 64.

H = depth of flow over the crest (or floor) of inlet in ft (See Fig. 5.)
H_e = specific energy head referenced to the crest of the inlet or the head over the crest of the inlet in ft
v_a = mean velocity of approach at which the depth H is measured in ft/sec
g = 32.16 ft/sec^2

The coefficient 3.1 will vary for various entrance conditions to the vertical curve section. Its value is slightly larger when the channel conveying water to the inlet is wider than the width of the inlet. The value 3.1 is conservative and its use is predicated on the assumption that H_e and v_a are measured in a section having subcritical flow.

Capacity of a Straight Inlet. The capacity without freeboard Q_{mi} of a straight inlet is determined by the dimensions h, M, and W of the inlet. The value of h will determine the capacity without freeboard at the crest q_{mh} per foot width of chute. The value of M will determine the capacity without freeboard q_{mM} at the downstream section of the inlet. The lower value of q_{mh} and q_{mM} is the capacity of the inlet without freeboard q_{mi}.

The capacity without freeboard at the crest q_{mh} of the inlet is given by Eq. 2.4, page 2.10, when the head over the crest is equal to the height of the sidewalls.

$$q_{mh} = 3.1\, h^{3/2} \qquad 2.5$$

where q_{mh} = the capacity at the crest of the inlet without freeboard in cfs/ft
h = height of sidewalls over the crest in ft

Values of q_{mh} for various values of h are given by Table 1, ES-82, page 2.14.

The section at the downstream end of the straight inlet has a sidewall height M equal to the height of the sidewall of the vertical curve section at this section. The criteria for determining the capacity q_{mM} is given in the discussion of Vertical Curve Sections, page 2.121. Values of q_{mM} for various values of M are given by Table 1, ES-88, page 2.125.

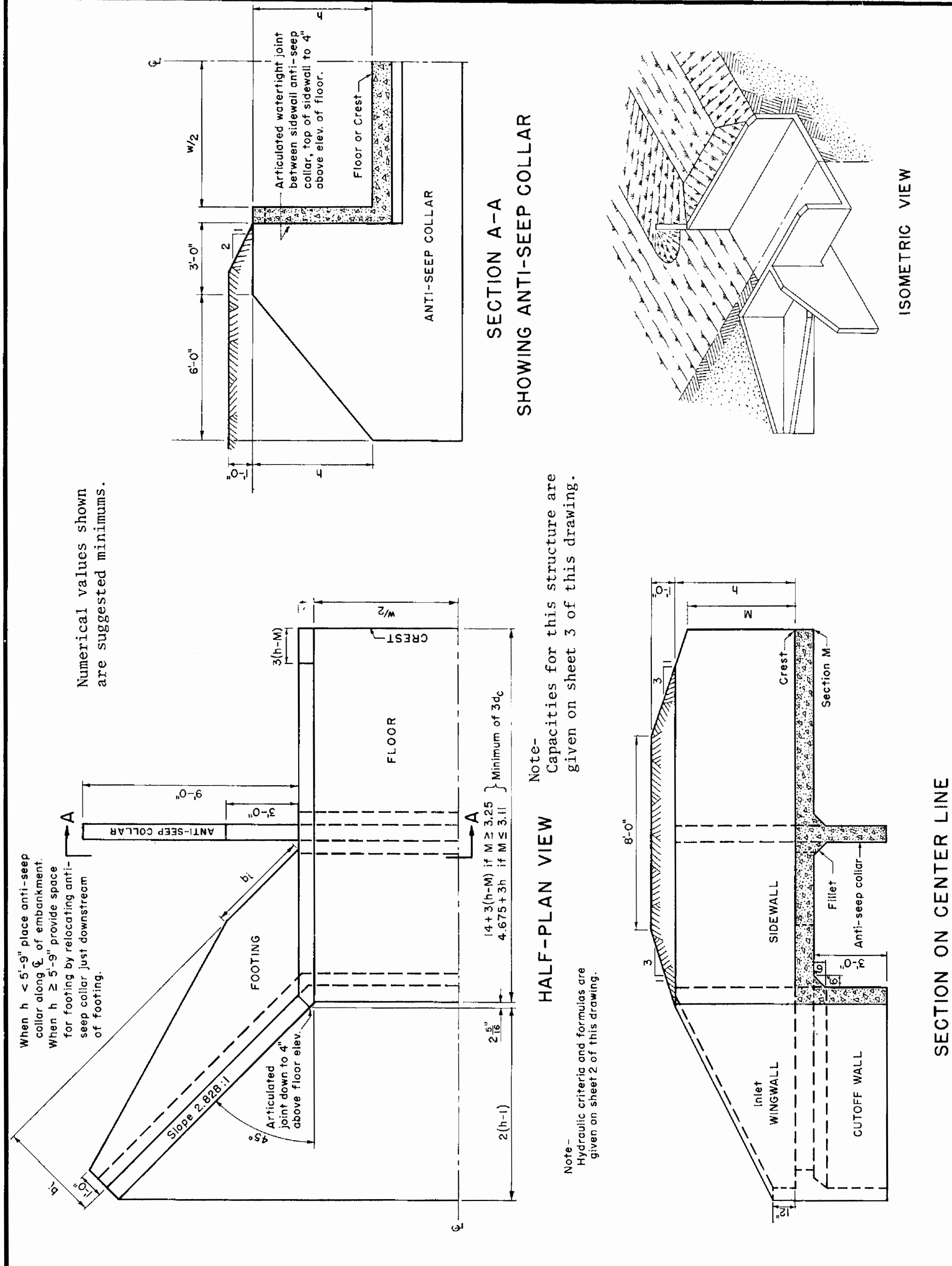
As stated before, capacity of the inlet without freeboard q_{mi} is equal to or slightly greater than the required capacity without freeboard q_{fr}. Two types of straight inlets are given in the drawing of ES-82, page 2.13. The essential difference of the two types of inlets is the length of the inlet. For inlets having a capacity without freeboard of q_{mi} = 20.196 cfs/ft, the value of M is 3.108 ft. When the capacity of the inlet without freeboard is equal to or less than q_{mi} = 16.108 cfs/ft, the value of M is equal to h. Values of q_{mi} are given by Table 2, ES-82, page 2.14. The capacities of inlets without freeboard Q_{mi} can be read from the graph of ES-82, page 2.15. The capacity q_{si} of the inlet can be determined by the relations

$$q_{mi} = (1.20 + 0.003\, Z)\, q_{si} \qquad 2.6$$

The capacity q_{si} of inlets will be equal to or slightly larger than the design discharge q_r.

CHUTE SPILLWAYS: STRAIGHT INLETS

The General Layout Drawing



REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION-DESIGN SECTION	STANDARD DWG. NO. ES-82 SHEET 1 OF 4 DATE 2-2-54

CHUTE SPILLWAYS: STRAIGHT INLETS

Definition of symbols, Formulas, Dimensions, and Capacities

HYDRAULIC FORMULA

Capacity of straight inlet without freeboard

$$Q_{mi} = Q_{si}\ (1.20 + 0.003\ Z) = 3.1\ Wh^{3/2}$$

Table 1
Capacities at
Crest of Inlet

h	q_{mh}
2.00	8.768
2.25	10.462
2.50	12.254
2.75	14.137
3.00	16.108
3.25	18.162
3.50	20.298
3.75	22.511
4.00	24.800
4.25	27.161
4.50	29.592
4.75	32.092
5.00	34.659
5.25	37.290
5.50	39.986
5.75	42.742
6.00	45.560
6.25	48.437
6.50	51.372
6.75	54.364
7.00	57.412
7.25	60.515
7.50	63.672
7.75	66.882

DEFINITION OF SYMBOLS

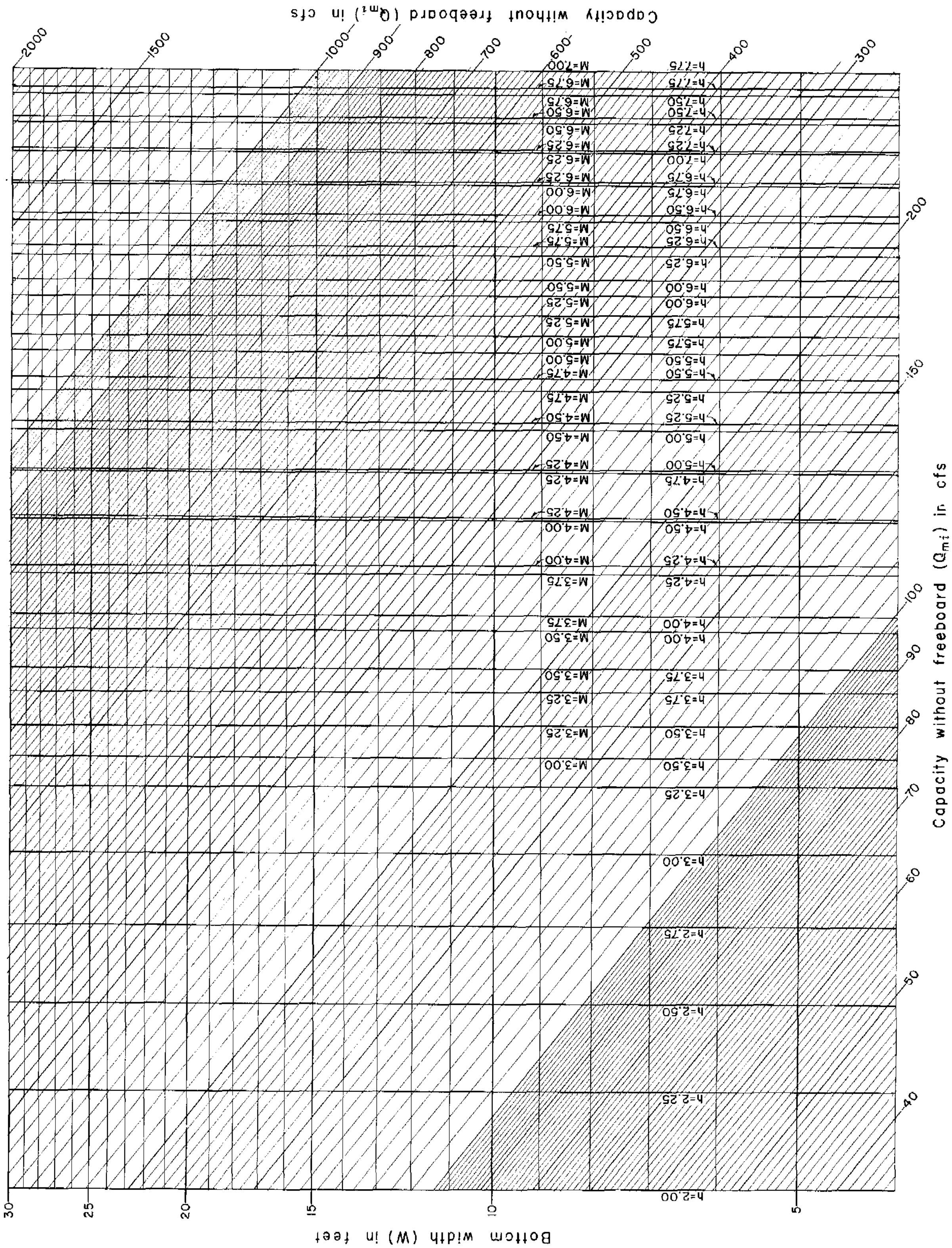
- h = Height of sidewalls and wingwalls above floor in ft
- h_r = Specific energy head at the crest of the inlet corresponding to design discharge Q_r in ft
- h_{fr} = Specific energy head at the crest of the inlet corresponding to the discharge Q_{fr} in ft
- M = Height of sidewall above floor at junction with vertical curve section in ft
- b_i = Required width of footing at junction of sidewall and wingwall in ft
- W = Width of inlet in ft
- Z = Vertical drop from crest of inlet and floor of SAF outlet in ft
- H_e = Specific energy head at crest of inlet corresponding to any discharge Q the inlet is capable of conveying in ft
- Q_i = Design discharge in cfs
- Q_{fr} = Required capacity without freeboard in cfs
- Q_{si} = Capacity of inlet in cfs
- Q_{mi} = Capacity of inlet without freeboard in cfs
- Q_{mh} = Capacity of inlet without freeboard at the crest in cfs
- Q_{mM} = Capacity of inlet without freeboard at the origin of the upper vertical curve in cfs
- Q = Discharge in cfs
- q_{si} = Capacity per foot width of inlet in cfs/ft
- q_{mi} = Capacity per foot width of inlet without freeboard in cfs/ft

Table 2
Dimensions and Capacities

h	M	q_{mi}
2.00	2.00	8.768
2.25	2.25	10.462
2.50	2.50	12.254
2.75	2.75	14.137
3.00	3.00	16.108
3.25	3.11	18.162
3.50	3.11	20.196
3.50	3.25	20.298
3.75	3.25	21.580
3.75	3.50	22.511
4.00	3.50	24.120
4.00	3.75	24.800
4.25	3.75	26.740
4.25	4.00	27.161
4.50	4.00	29.470
4.50	4.25	29.592
4.75	4.25	32.092
5.00	4.25	32.27
5.00	4.50	34.659
5.25	4.50	35.16
5.25	4.75	37.290
5.50	4.75	38.130
5.50	5.00	39.986
5.75	5.00	41.180
5.75	5.25	42.742
6.00	5.25	44.310
6.00	5.50	45.560
6.25	5.50	47.510
6.25	5.75	48.437
6.50	5.75	50.78
6.50	6.00	51.372
6.75	6.00	54.140
6.75	6.25	54.364
7.00	6.25	57.412
7.25	6.25	57.56
7.25	6.50	60.515
7.50	6.50	61.08
7.50	6.75	63.672
7.75	6.75	64.59
7.75	7.00	66.882

CHUTE SPILLWAYS: STRAIGHT INLETS

Capacities without freeboard in cfs; Q_{mi}



REFERENCE	U. S. DEPARTMENT OF AGRICULTURE SOIL CONSERVATION SERVICE ENGINEERING DIVISION-DESIGN SECTION	STANDARD DWG. NO. ES-82 SHEET 3 OF 4 DATE 2-3-54 Rev. 11-1-54

Revised 10/77

CHUTE SPILLWAYS: STRAIGHT INLETS; Example

EXAMPLE

Given: Design discharge $Q_r = 320$ cfs for a chute width of W = 12 ft. The vertical drop of the chute from the crest of the inlet to the floor of the SAF outlet is 31 ft. No wave action is anticipated in the channel upstream from the inlet.

Determine:
1. Dimensions of straight inlet for this chute
2. Recommended freeboard in ft
3. Actual freeboard in ft
4. Capacity of this inlet in cfs

Solution: 1. The discharge Q_{fr} the inlet is required to convey without freeboard is

$$Q_{fr} = (1.20 + 0.003\ Z)\ Q_r$$

$$Q_{fr} = [1.20 + (0.003)(31)]\ (320) = 413.76 \text{ cfs}$$

a. The available inlet having a width of W = 12 ft capable of conveying this discharge without freeboard as read from sheet 3 is h = 5.00 ft; M = 4.50 ft. This inlet is capable of conveying 416 cfs without freeboard

b. This calculation can also be made by determining the value of $q_r = \frac{Q_r}{W}$, then

$$q_{fr} = (1.20 + 0.003\ Z)\ q_r$$

$$q_{fr} = [1.20 + (0.003)(31)] \left(\frac{320}{12}\right) = 34.48 \text{ cfs/ft width}$$

The available inlet capable of conveying this discharge according to table 2 sheet 2 is again h = 5.00 ft; M = 4.50 ft

2. The recommended freeboard is the difference in the specific energy heads at the crest required to discharge Q_{fr} and Q_r. The specific energy head h_r at the crest required to discharge the design discharge Q_r is

$$Q_r = 3.1\ W h_r^{3/2}$$

$$h_r = \left[\frac{Q_r}{3.1\ W}\right]^{2/3} = \left[\frac{320}{(3.1)(12)}\right]^{2/3} = 4.20 \text{ ft}$$

The specific energy head h_{fr} at the crest required to discharge the recommended freeboard discharge Q_{fr} is

$$h_{fr} = \left[\frac{Q_{fr}}{3.1\ W}\right]^{2/3} = \left[\frac{413.76}{(3.1)(12)}\right]^{2/3} = 4.97 \text{ ft}$$

The recommended freeboard is $h_{fr} - h_r = 4.97 - 4.20 = 0.77$ ft

3. The actual freeboard is the difference in the height of the sidewall above the crest and the specific energy head h_r at the crest required to discharge the design discharge Q_r

$$h - h_r = 5.0 - 4.20 = 0.80 \text{ ft}$$

4. The capacity of the inlet Q_{si} is the discharge the inlet is capable of discharging with the recommended freeboard

$$Q_{mi} = 3.1\ Wh^{3/2}$$

$$Q_{mi} = (3.1)(12)(5)^{3/2} = 415.9 \text{ cfs}$$

$$Q_{mi} = (1.20 + 0.003\ Z)\ Q_{si}$$

$$Q_{si} = \frac{415.9}{1.20 + 0.003\ (31)} = 321 \text{ cfs}$$