CHAPTER 7

ENERGY DISSIPATION

7.6 Baffled Outlets

7.6.1 Uses

The baffled outlet (also known as the Impact Basin – USBR Type VI) is a boxlike structure with a vertical hanging baffle and an end sill, as shown in Figure 7.6.1-1. Energy is dissipated primarily through the impact of the water striking the baffle and, to a lesser extent, through the resulting turbulence. This type of outlet protection has been used with outlet velocities up to 50 ft per second and with Froude numbers from 1 to 9. Tailwater depth is not required for adequate energy dissipation, but a tailwater will help smooth the outlet flow.

7.6.2 Design Procedure

The following design .0procedure is based on physical modeling studies summarized from the U. S. Department of Interior (1978). The dimensions of a baffled outlet as shown in Figure 7.6.1-1 should be calculated as follows:

1. Determine input parameters, including:

   h = Energy head to be dissipated, in ft (can be approximated as the difference between channel invert elevations at the inlet and outlet)
   Q = Design discharge, in cfs
   V = Theoretical velocity, in ft/s = 2gh
   A = Q/v = Flow area, in square ft
   D = $A^{0.5}$ = Representative flow depth entering the basin, in ft (assumes square jet)
   Fr = v / $(gd)^{0.5}$ = Froude number, dimensionless

2. Calculate the minimum basin width, W, in ft, using the following equation, which is shown graphically in Figure 7.6.2-1:

$$W / d = 2.88 Fr^{0.566} \; or \; W = 2.88 Fr^{0.566} \qquad \textbf{Eq. 7.6.2-1}$$

   Where: W = minimum basin width, in ft
   d = depth of incoming flow, in ft
   Fr = v/$(gd)^{0.5}$ – Froude number, dimensionless

   The limits of the W/d ratio are from 3 to 10, which corresponds to Froude numbers 1 and 9. If the basin is much wider than W, flow will pass under the baffle and energy dissipation will not be effective.

3. Calculate the other basin dimensions as shown in Figure 7.6.1-1, as a function of W. Construction drawings for selected widths are available from the U. S. Department of the Interior (1978).

4. Calculate required protection for the transition from the baffled outlet to the natural channel based on the outlet width. A riprap apron should be added of width W, length W (or a 5-foot minimum), and depth f (W/6). The side slope should be 1.5;1, and median rock diameter should be at least W/20.

Figure 7.6.1-1
Schematic of Baffled Outlet

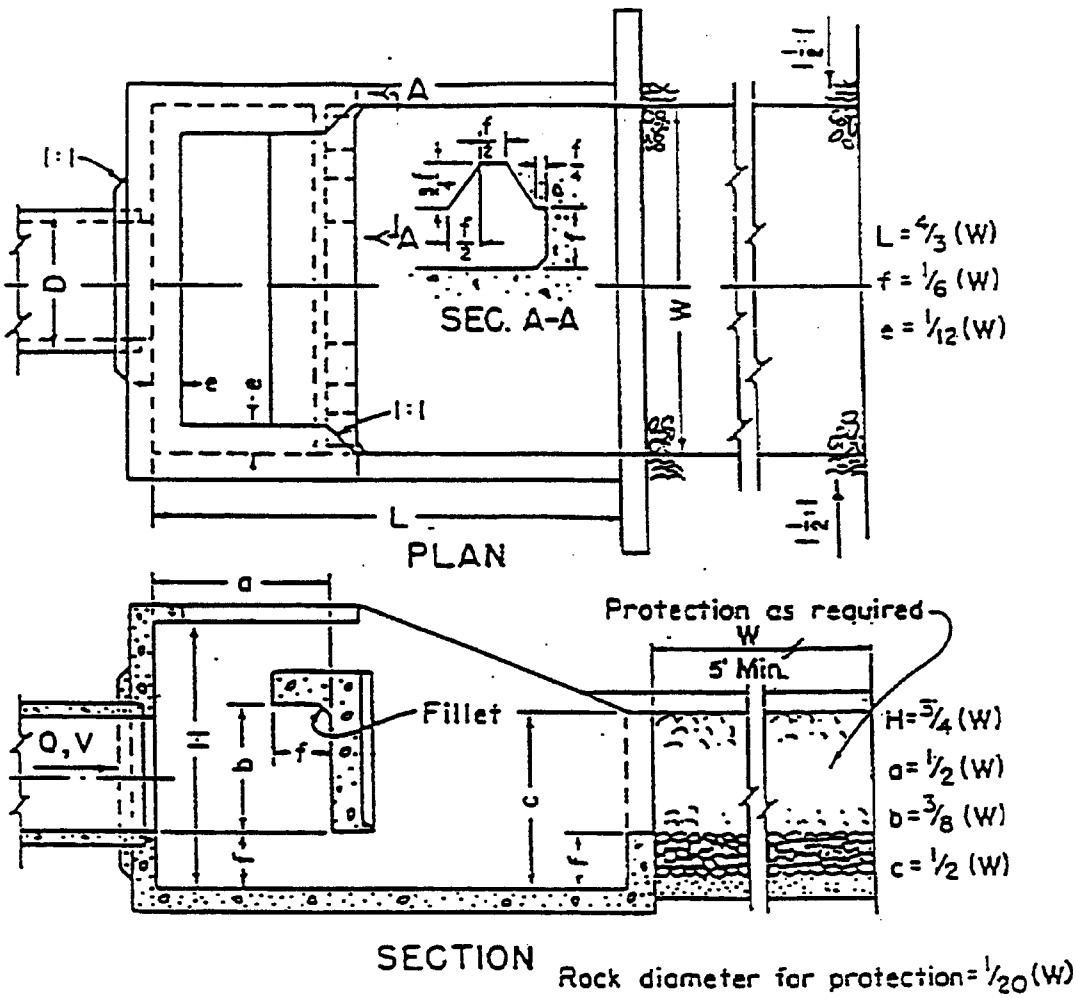
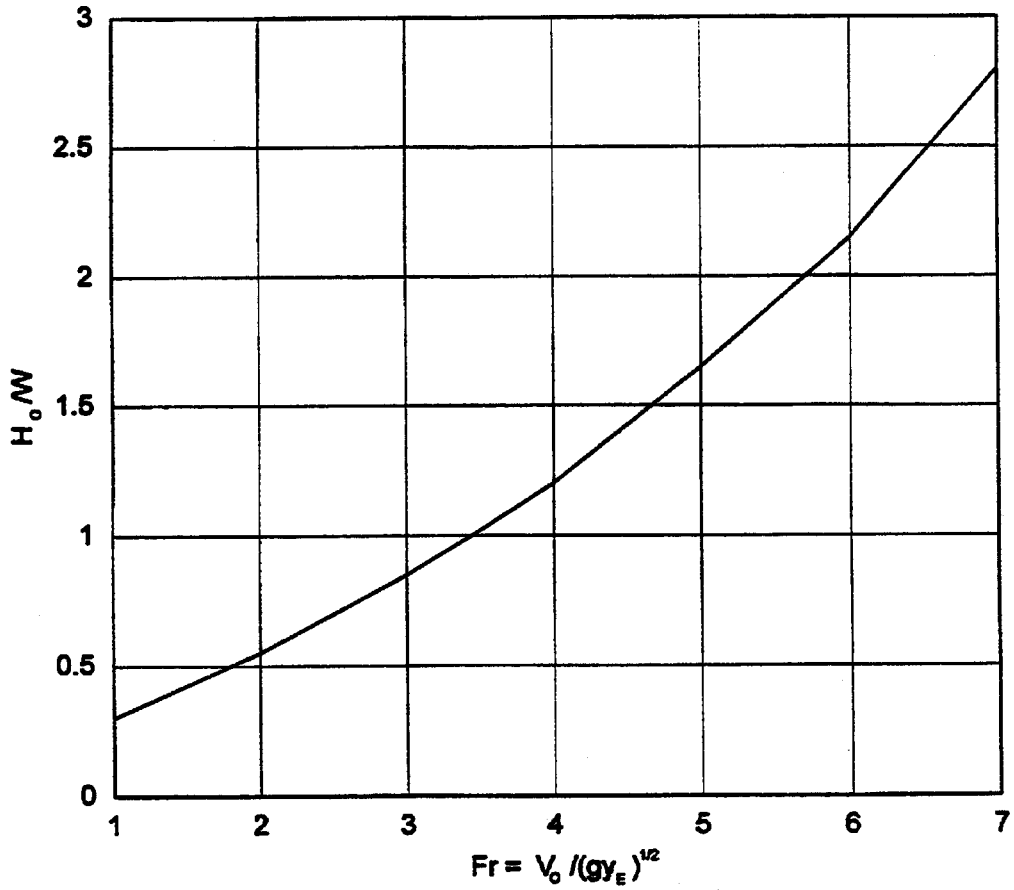


Figure 7.6.2-1
W/d vs. Froude Number for Baffled Outlet Basins
Source: U.S. Department of the Interior (1978)



5. Calculate the baffled outlet invert elevation based on expected tailwater. The maximum distance between expected tailwater elevation and the invert should be b + f or some flow will go over the baffle with no energy dissipation. If the tailwater is known and fairly controlled, the baffled outlet invert should be a distance, b/2 + f, below the calculated tailwater elevation. If tailwater is uncontrolled, the baffled outlet invert should be a distance, f, below the downstream channel invert.

6. Calculate the outlet pipe diameter entering the basin assuming a velocity of 12 ft per second flowing full.

7. If the entrance pipe slope steeple downward, the outlet pipe should be turned horizontal for at least 3 ft before entering the baffled outlet.

8. If it is possible that both the upstream and downstream ends of the pipe will be submerged, provide an air vent of diameter approximately 1/6 the pipe diameter near the upstream end to prevent pressure fluctuations and possible surging flow conditions.

7.6.3 Example Design

A cross-drainage pipe structure has a design flow rate of 150 cfs, a head, h, of 15 ft from invert of pipe, and a tailwater depth, TW, of 3 ft above ground surface. Find the baffled outlet basin dimensions and inlet pipe requirements.

1. Compute the theoretical velocity from
   $v = (2gh)^{0.5} = [2(32.2\ ft/sec^2)(15\ ft)]^{0.5} = 31.1\ ft/s$
   This is less than 50 ft/s, so a baffled outlet is suitable.

2. Determine the flow area using the theoretical velocity as follows:
   $A = Q/v = 150\ cfs/31.1\ ft/sec = 4.8$ square ft

3. Compute the flow depth using the area from Step 2.
   $d = (A)^{0.5} = (4.8\ ft^2)^{0.5} = 2.12\ ft$

4. Compute the Froude number using the results from Steps 1 and 3.
   $Fr = v/(gd)^{0.5} = 31.1\ ft/sec/[32.2\ ft/sec^2)(2.12\ ft)]^{0.5} = 3.8$

5. Determine the basin width using equation 7.6.2-1 with the Froude number from Step 4.
   $W = 2.88\ dFr^{0.566} = 2.88\ (2.12)\ (3.8)^{0.566} = 13.0$ ft (minimum)
   Use 13 ft as the design width.

6. Compute the remaining basin dimensions (as shown in figure 7.6.1-1):
   L = 4/3 (W) = 17.3 ft, use L + 17 ft, 4 in
   f = 1/6 (W) = 2.17 ft, use f = 2 ft, 2 in
   e = 1/12 (W) = 1.08 ft, use e = 1 foot, 1 in
   H = ¾ (W) = 9.75 ft, use H + 9 ft, 9 in
   a = ½ (W) = 6.5 ft, use a = 6 ft. 6 in
   b = 3/8 (W) = 4.88 ft, use b = 4 ft, 11 in
   c = ½ (W) = 6.5 ft, use c =6 ft, 6 in
   Baffle opening dimensions would be calculated as shown in Figure 7.6.1-1

7. Basin invert should be at b/2 + f below tailwater, or
   (4 ft, 11 in)/2 + 2 ft, 2 in = 4.63 ft
   Use 4 ft 8 in; therefore, invert should be 2 ft, 8 in below ground surface.

8. The riprap transition from the baffled outlet to the natural channel should be 13 ft long by 13 ft wide by 2 ft, 2 in deep (W x W x f). Median rock diameter should be of diameter W/20, or about 8 in.

9. Inlet pipe diameter should be sized for an inlet velocity of about 12 ft/s.
$(3.14d)^2/4 = Q/v$; $d = [(4Q)/3.14v)]^{0.5} = [(4(15\text{- cfs})/3.14(12\ \text{ft/sec})]^{0.5} = 3.99$ ft
Use 48-inch pipe. If a vent is required, it should be about 1/6 of the pipe diameter or 8 in.

END OF SECTION 7.6