IMPACT BASINS AND ENERGY DISSIPATORS

At the downstream or exit section of spillways and culverts often need to be protected from the erosive forces of the high velocity water being discharged. Typically, some time type of energy dissipation structure, either a stilling or impact basin, to promote sub-critical, quiescent flow, often by forcing a hydraulic jump within a well-protected, lined channel section. By its nature, energy dissipation involves substantial turbulence, which is difficult to predict from first principles. Therefore, energy dissipation structures are almost always designed using empirically derived dimensional guides, which are available in most hydraulic engineering references. By way of example, we will present the widely used nomographs from the US Bureau of Reclamation's *Design of Small Dams* (1977). The Froude number (*Fr*) determines which type of stilling basin to use:

$$Fr = \frac{v}{\sqrt{y_1 g}} \tag{1}$$

where v is the flow velocity and y_c is the critical depth:

$$y_c = \sqrt[3]{\frac{q^2}{g}} \tag{2}$$

where q is the discharge per unit width.

If Fr < 2.5, simply line the downstream reach for a length >6y_2 (this is called a type I basin), where y_2 is the flow depth after energy dissipation via a hydraulic jump:

$$y_2 = \frac{y_1}{2}\left(\sqrt{1+8Fr^2} - 1\right) \tag{3}$$

where y_1 is the flow depth (or effective flow depth) entering the dissipation structure.

For Fr > 2.5 designs are based on the attached nomographs and the, so called, drop number, $\overline{D}$:

$$\overline{D} = \frac{q^2}{gY^3} \tag{4}$$

where Y is drop height (see schematics on attached nomograph). The following are selected text and nomographs for designing a variety of stilling basins (note slightly different notation).

A. Type II basin, Fr > 4.5 and v_1 > 15 m/s (50 ft/s)
B. Type III basin, Fr > 4.5 and v_1 < 15 m/s (50 ft/s)
C. Type IV basin, 2.4> Fr > 4.5
D. Impact Block Basin

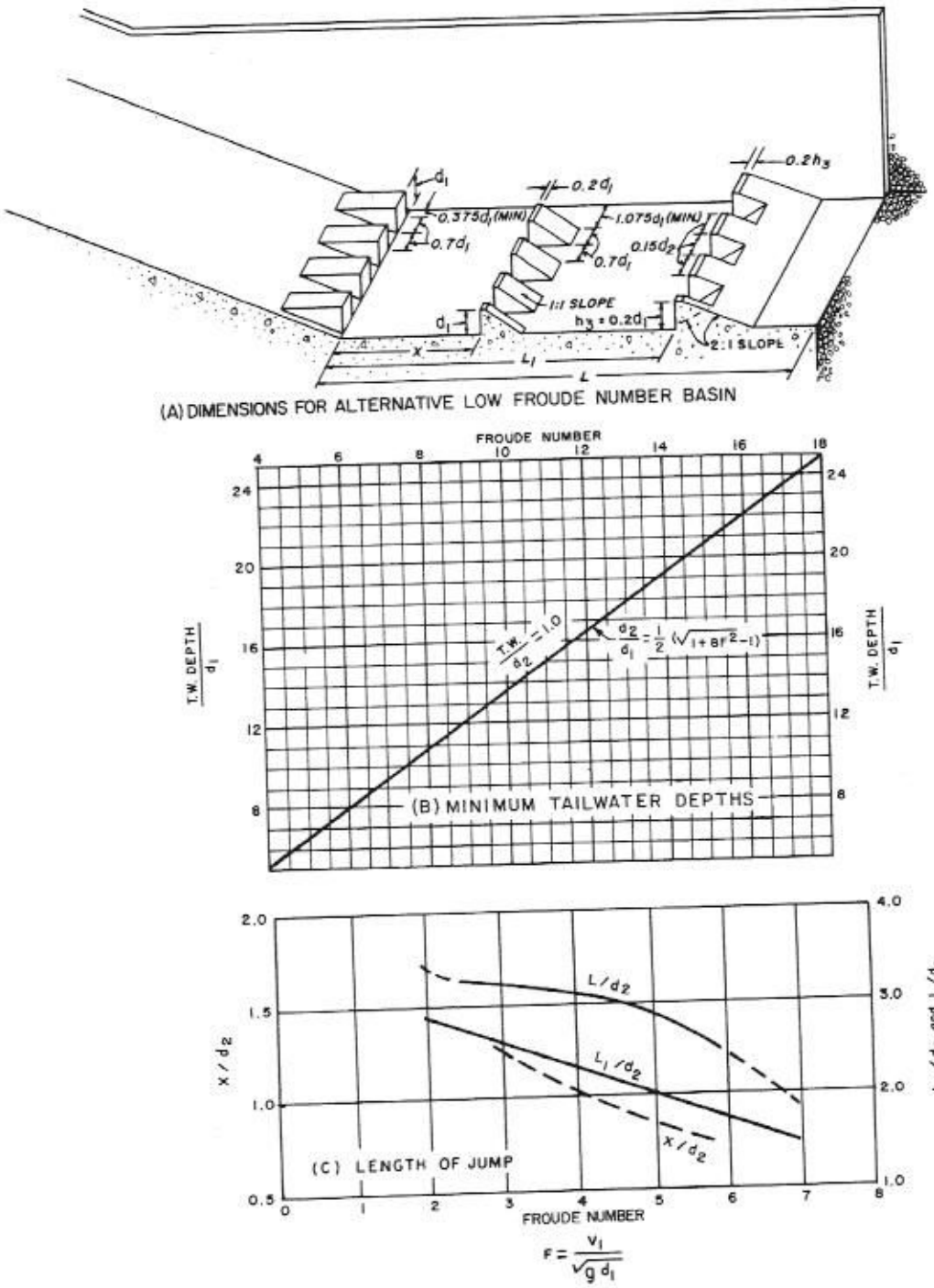

Figure 9-40.—Characteristics for alternative low Froude number stilling basins. 103-D-1876.

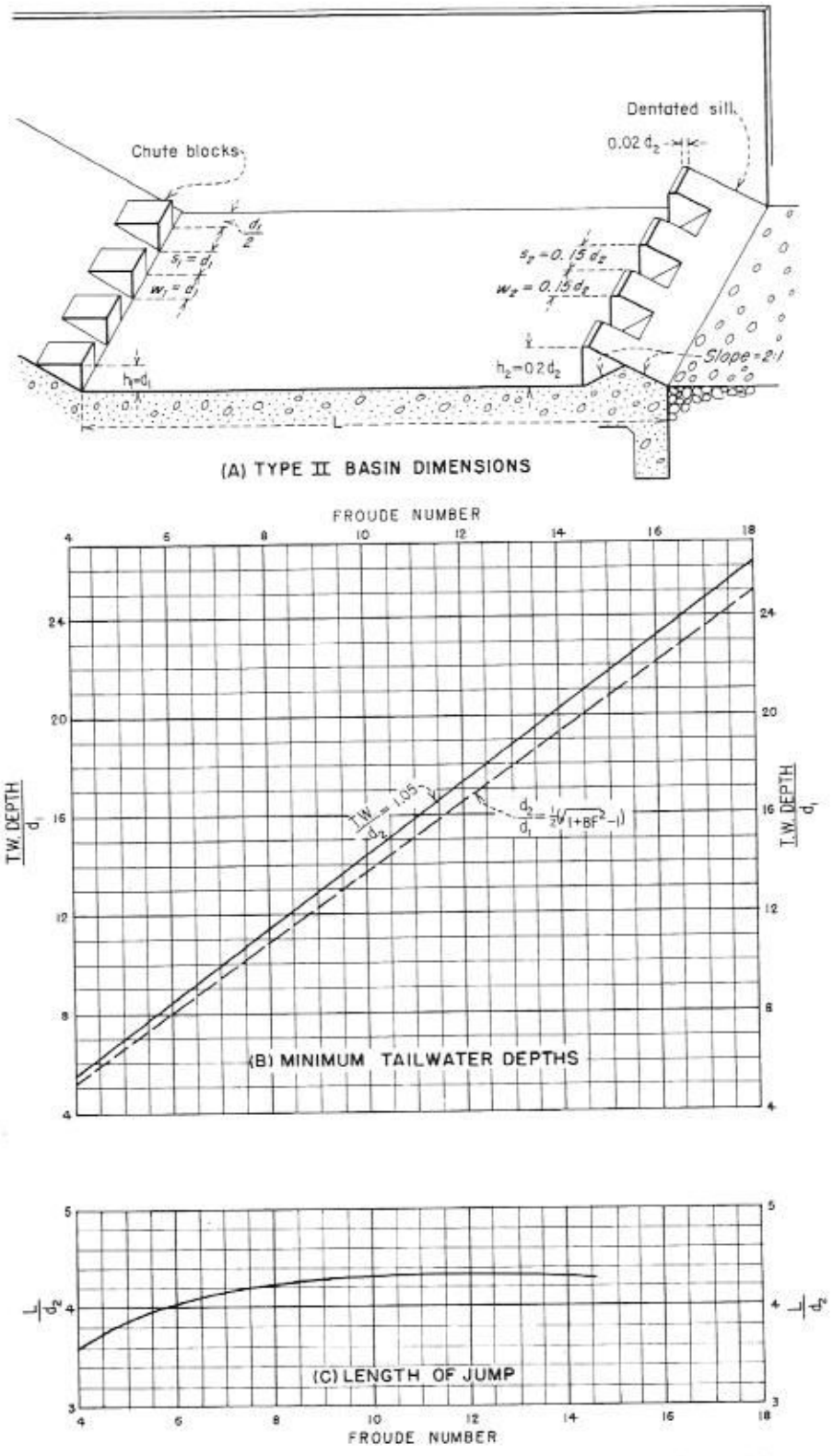

Figure 9-42.—Stilling basin characteristics for Froude numbers above 4.5. 288-D-2427.

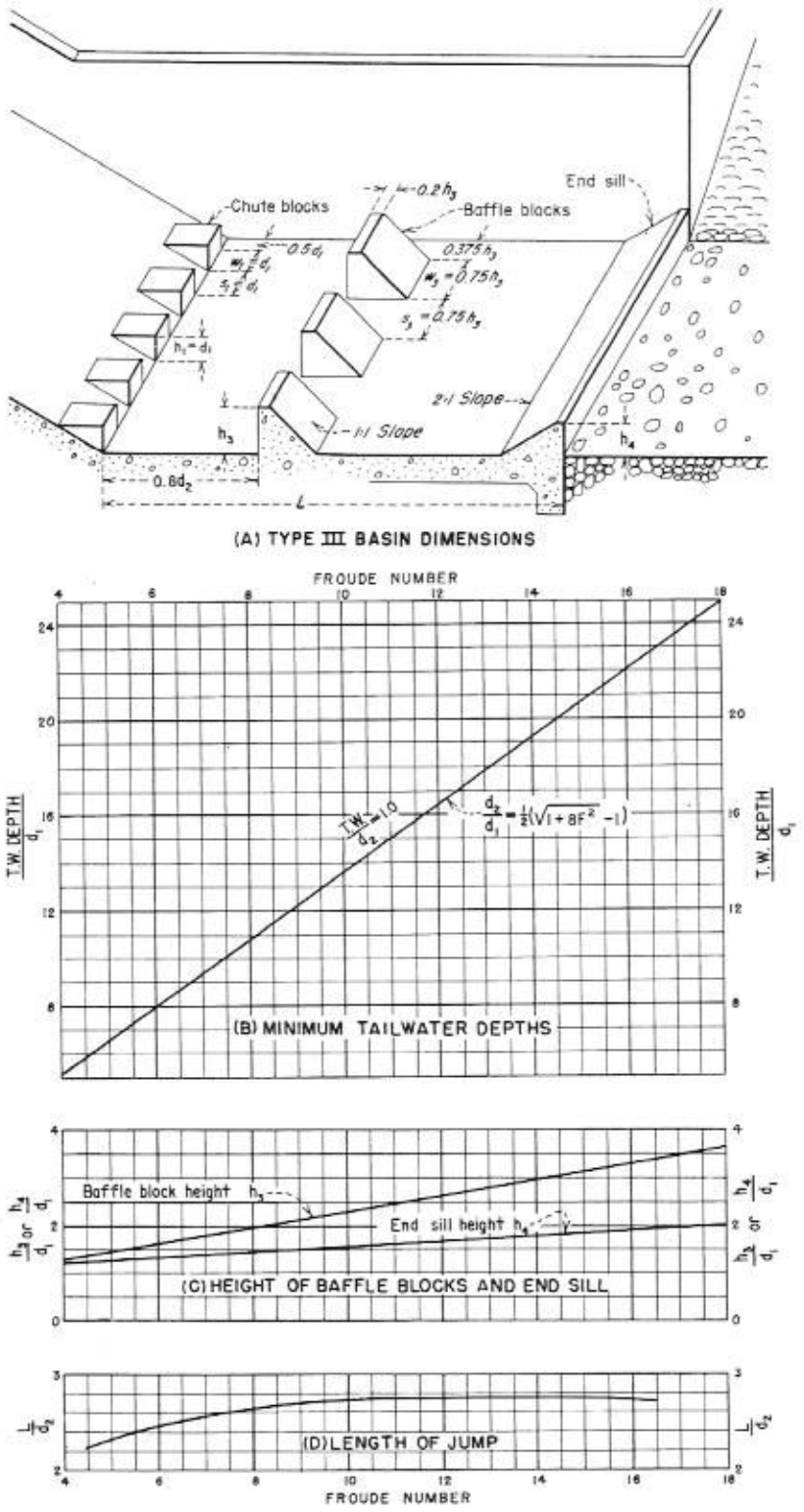

Figure 9-41.—Stilling basin characteristics for Froude numbers above 4.5 where incoming velocity, $V_1 \leq 60$ ft/s. 288-D-2426.

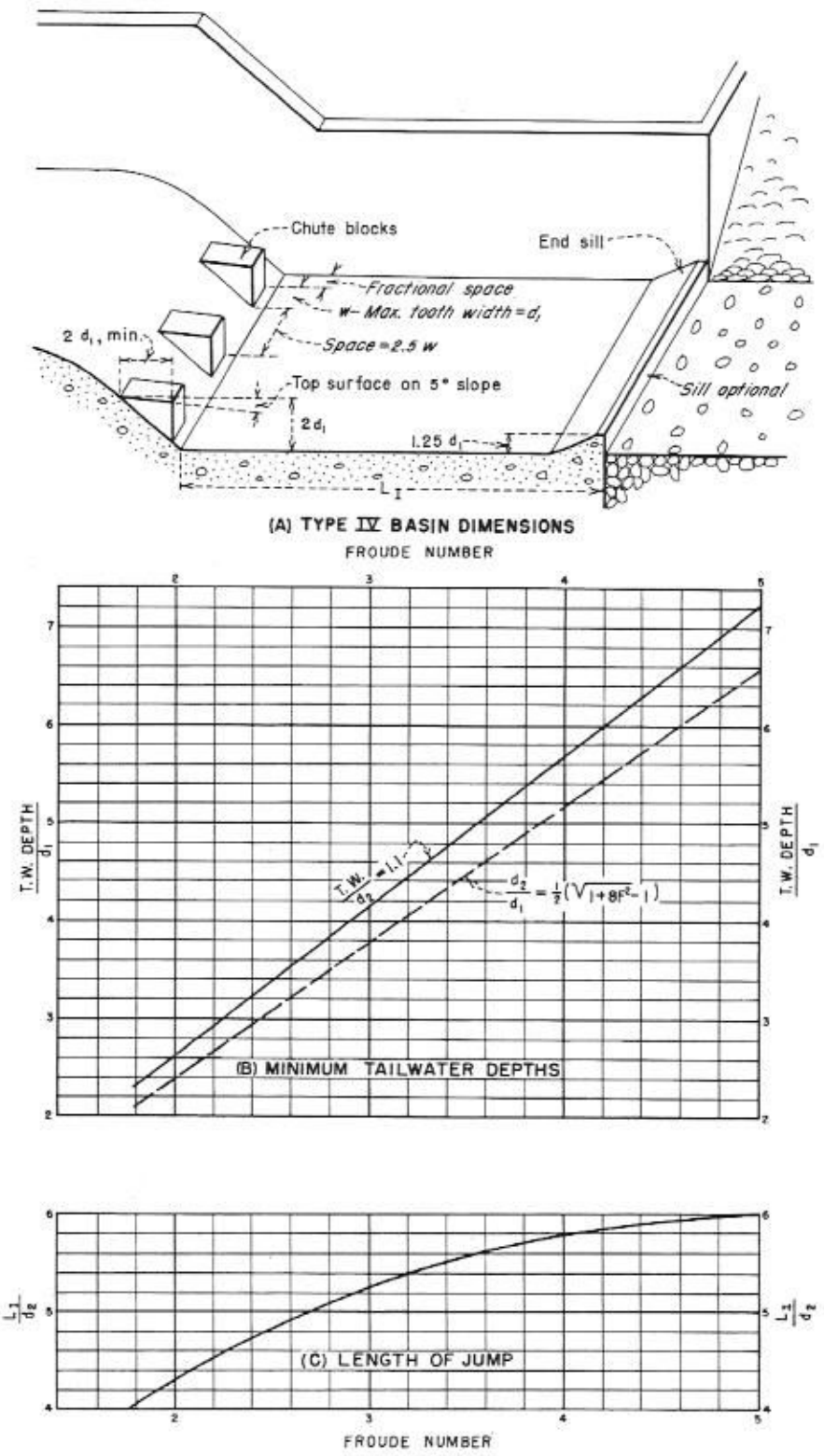

Figure 9-39.—Stilling basin characteristics for Froude numbers between 2.5 and 4.5. 288-D-2425.

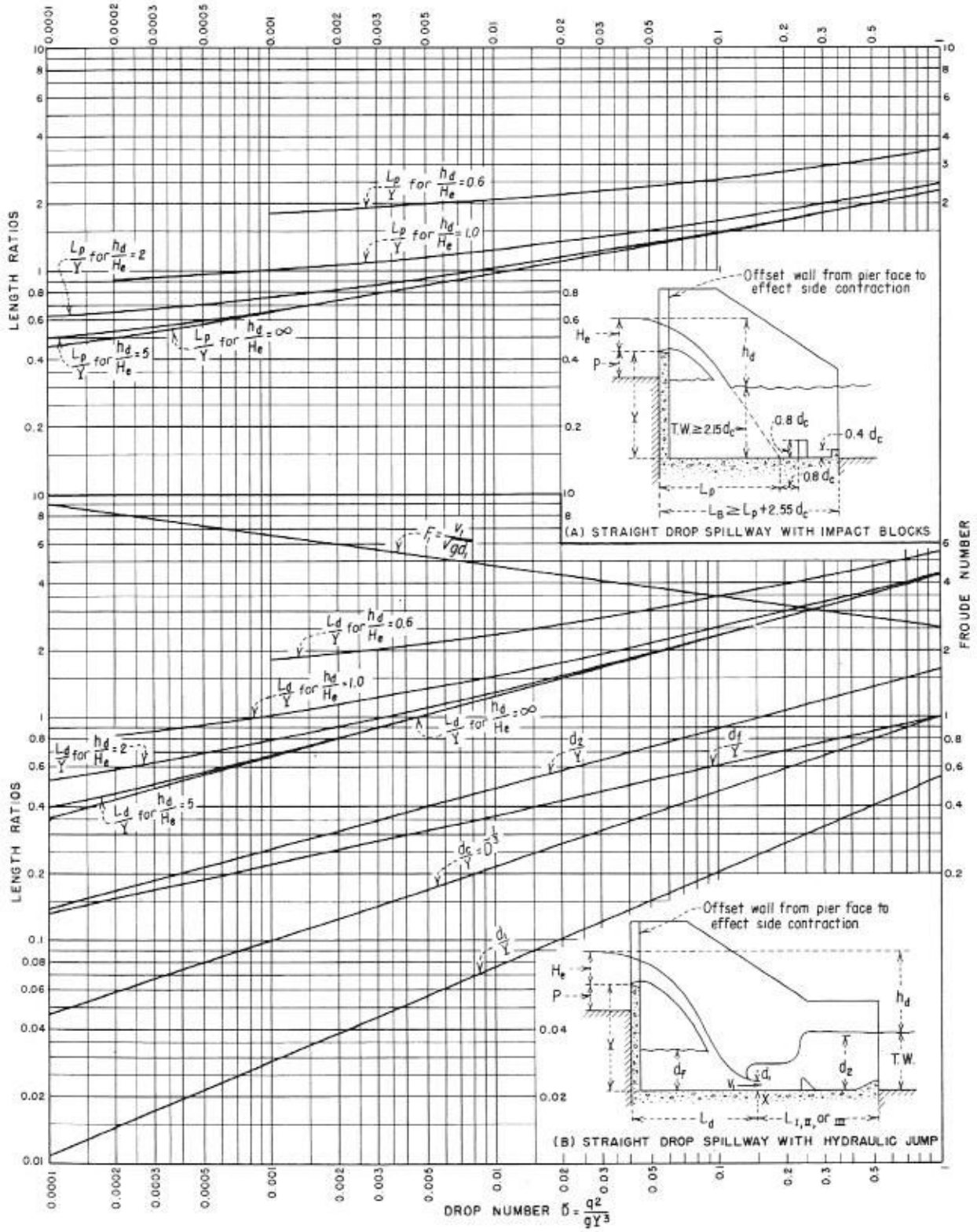

Figure 9-53.—Hydraulic characteristics of straight drop spillways with hydraulic jump or with impact blocks. 288-D-2437.

References:

For energy dissipation nomographs:

[*]US Dept. of the Interior, Bureau of Reclamation. 1977. *Design of Small Dams*. US Government Printing Office, Washington, DC. pp. 816.

Davis, C.V. 1952. *Handbook of Applied Hydraulics.* McGraw-Hill Book Company, Inc. New York. pp.1272.

[*]Montes, S. *Hydraulics of Open Channel Flow*. ASCE Press, Reston. pp. 697.

For further information:

Chin, D.A. *Water Resources Engineering*. Prentice Hall. Upper Saddle River. pp. 750.

[*]Chow, V.T. 1959. *Open Channel Hydraulics*. McGraw-Hill Company, New York. pp. 680.

[†]Haan, C.T., B.J. Barfield, J.C. Hayes. 1994. *Design Hydrology and Sedimentology for Small Catchments*. Academic Press, New York. pp. 588.

[†]Schwab, G.O., D.D. Fangmeier, W.J. Elliot, R.K. Frevert. 1993. *Soil and Water Conservation Engineering*, 4th Ed. John Wiley & Sons, Inc. New York. pp.508.

[†]Tollner, E.W. 2002. *Natural Resources Engineering*. Iowa State Press, Ames. pp. 576.

[*] Particularly good books for this topic

[†] These texts were previously used for this course