CHAPTER 5

OPEN CHANNEL HYDROLOGY

5.6 Vegetative Design

5.6.1 Introduction

A two-part procedure is recommended for final design of temporary and vegetative channel linings. Part 1, the design stability component, involves determining channel dimensions for low vegetative retardance conditions, using Class D as defined in Table 5.4.4-3. Part 2, the design capacity component, involves determining the depth increase necessary to maintain capacity for higher vegetative retardance conditions, using Class C as defined in Table 5.4.4-3. If temporary lining is to be used during construction, vegetative retardance Class E should be used for the design stability calculations.

If the channel slope exceeds 10 percent, or a combination of channel linings will be used, additional procedures not presented below are required. References include HEC-15 (USDOT, FHWA, 1986) and HEC-14 (USDOT, FHWA, 1983).

5.6.2 Design Stability

The following are the steps for design stability calculations:

5.6.2.1 Determine appropriate design variables, including discharge, Q, bottom slope, S, cross section parameters, and vegetation type.

5.6.2.2 Use Table 5.3-2 to assign a maximum velocity, v_m, based on vegetation type and slope range.

5.6.2.3 Assume a value of n and determine the corresponding value of vR from the n versus vR curves in Figure 5.4.4-1. Use retardance Class D for permanent vegetation and E for temporary construction.

5.6.2.4 Calculate the hydraulic radius using the equation:

$$R = (vR) / vm \qquad \textbf{(Eq. 5.6.2.4-1)}$$

Where: R = hydraulic radius of flow (ft)
vR = value obtained from figure 5-1 in Step 3
v_m = maximum velocity from Step 2 (ft/s)

5.6.2.5 Use the following form of Manning's Equation to calculate the value of vR:

$$vR = (1.49 R^{\wedge}(5/3) S(1/2)) / n \qquad \textbf{(Eq. 5.6.2.5-1)}$$

Where: vR = calculated value of vR product
R = hydraulic radius value from Step 4 (ft)
S = channel bottom slope (ft/ft)
n = Manning's n value assumed in Step 3

5.6.2.6 Compare the vR product value obtained in Step 5 to the value obtained from Figure 5.4.4-1 for the assumed n value in Step 3. If the values are not reasonably close, return to Step 3 and repeat the calculations using a new assumed n value.

5.6.2.7 For trapezoidal channels, find the flow depth using Figures 5.3-2 or 5.4.7-1, as described in Section 5.4.5. The depth of flow for other channel shapes can be evaluated using the trial and error procedure described in Section 5.4.5.

5.6.2.8 If bends are considered, calculate the length of downstream protection, L_p., for the bend using Figure 5.6.4-1. Provide additional protection, such as gravel or riprap in the bend and extending downstream for length, L_p.

5.6.3 Design Capacity

The following are the steps for design capacity calculations:

5.6.3.1 Assume a depth of flow greater than the value from Step 7 above and compute the waterway area and hydraulic radius (see Figure 5.5.2-1 for equations).

5.6.3.2 Divide the design flow rate, obtained using appropriate procedures from the Hydrology Chapter, by the waterway area from Step 1 to find the velocity.

5.6.3.3 Multiply the velocity from Step 2 by the hydraulic radius from Step 1 to find the value of vR.

5.6.3.4 Use Figure 5.4.4-1 to find a Manning's n value for retardance Class C based on the vR value from Step 3.

5.6.3.5 Use Manning's Equation (equation 5.4.2-1) or Figure 5.4.5-1 to find the velocity using the hydraulic radius from Step 1, Manning's n value from Step 4, and appropriate bottom slope.

5.6.3.6 Compare the velocity values from Steps 2 and 5. If the values are not reasonably close, return to Step 1 and repeat the calculations.

5.6.3.7 Add an appropriate freeboard to the final depth from Step 6. Generally, 20 percent is adequate.

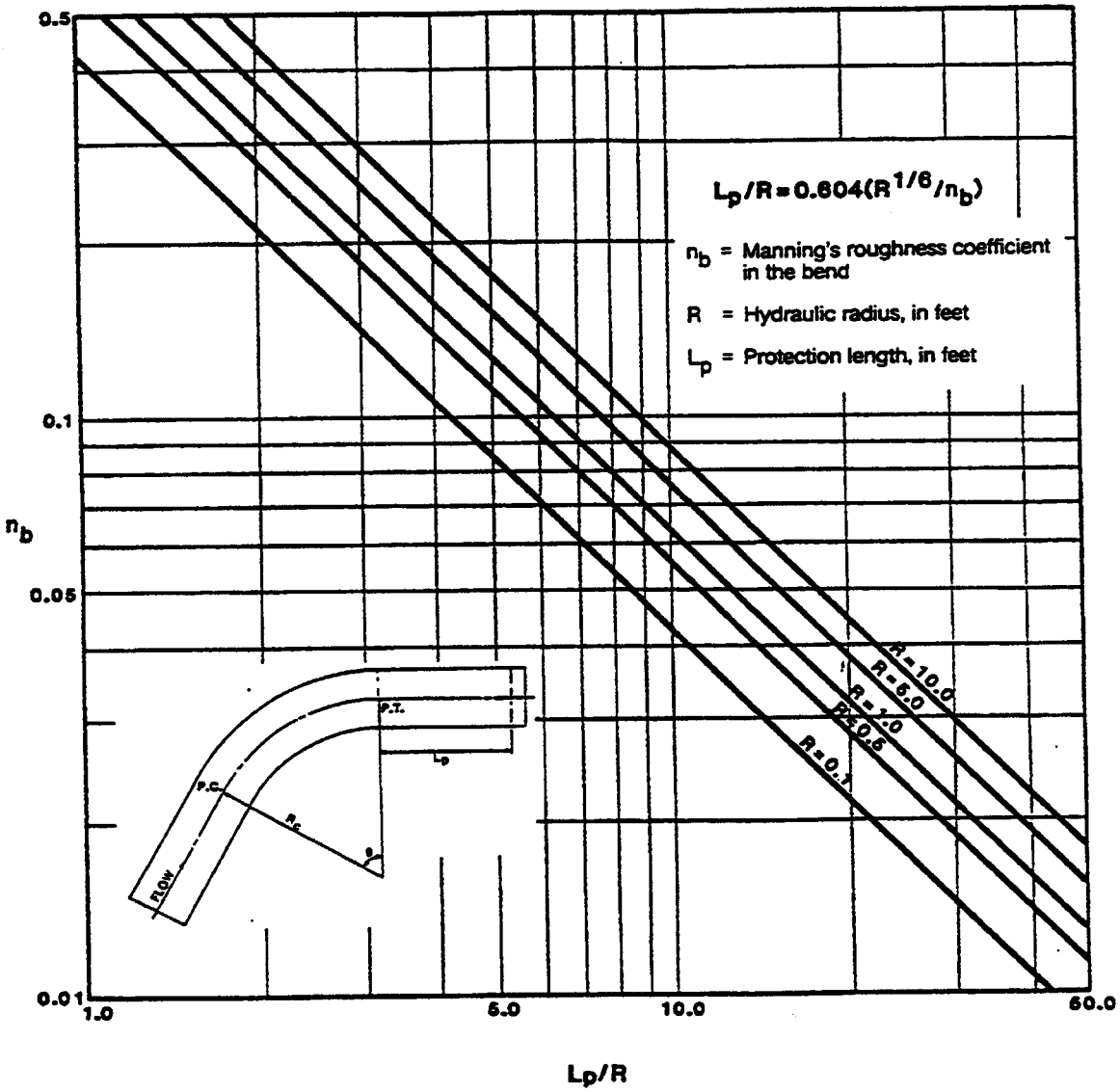
5.6.3.8 If bends are considered, calculate Superelevation of the water surface profile at the bend using the equation:

$$delta\, d = (v\text{^}2T)/(gRc) \qquad \textbf{(Eq. 5.6.3.8-1)}$$

Where: delta d = superelevation of the water surface profile due to the bend (ft)
v = average velocity from Step 6 (ft/s)
T = top width of flow (ft)
g = acceleration of gravity (32.2 ft/sec^2)
R_c= mean radius of the bend (ft)

Note: Add freeboard consistent with the calculated delta d.

Figure 5.6.4-1
Protection Length, Lp, Downstream of Channel Bend



Reference: USDOT, FHWA, HEC-15 (1986).

END OF SECTION 5.6