- For culverts discharging to a reservoir, wadi, tidal bay, or other major water body; the expected high water elevation of the particular water body or wadi for the same size or frequency storm may establish the culvert TWL.
- Where tidal conditions occur at the outlet, the mean high water shall be used.

d) Determine the type of control that exists at the design flows, either inlet or outlet control:

- There are two basic types of flow control, i.e., inlet control and outlet control. Two different methods are used to determine the HW, one for inlet and one for outlet control.

Design of the culvert is made using a trial-and-error process, wherein an initial size is selected and HW depths are calculated for both flow control conditions. If the higher HW elevation control exceeds the allowable level, then another culvert size is selected and the calculations repeated until an acceptable HW depth is obtained.

- For inlet control, the HW to diameter ratio is readily obtained from the appropriate nomographs, as contained in the FHWA publication HDS-5 (21). Otherwise, HW can be solved for using a tube-type orifice equation, adjusted for different inlet conditions, as described in most hydraulic engineering texts.
- For outlet control, the total amount of head loss in the barrel of the pipe, including the minor losses at the entrance and the exit of the pipe. Head loss can be determined by using Equation .

$$H = \left[1 + K_e + \frac{19.63n^2L}{R^{1.33}}\right]\frac{V^2}{2g}$$

Equation 2.1 Head loss equation

Where:

H = Head loss (m)

K_e = entrance loss coefficient (Refer to additional information in Table A5-7:).

n = Manning's equation roughness value 'n' (Refer to Table A5-6: for more information)

L = length of the culvert barrel (m)

R = hydraulic radius (m/sec.), or cross-sectional flow area (m^2) divided by the wetted perimeter (m)

V = velocity of flow (m/second), or flow rate (m^3/second) divided by the cross sectional flow area (m^2)

g = acceleration of gravity, or 9.81 m/$second^2$

- The head loss (H) may also be determined by the outlet control nomographs shown in the FHWA publication HDS 5 and as presented in Vol-II of this manual Appendix C. Both the nomographs and the equation are based on the assumption that the barrel is flowing completely full or nearly full.
- Depth of HW above the culvert invert resulting from outlet control is determined by Equation 2.2: HW equation 2.2.

$$HW_o = H + h_o$$

Equation 2.2: HW equation

Where: