# Assignment 5

(Due: 6 December, 2017 by 17:00)

**Q1.** A 5 m wide rectangular channel has a mild bed slope and conveys a discharge of 8m$^3$/s at a uniform flow depth of 1.25 m.

a) Determine the critical depth in the channel;

b) Neglecting energy losses and taking $\alpha$ = 1, calculate the height of a broad crested weir that will just cause the flow over the weir to become critical (without choking);

c) Show that if the flow at the crest of the weir becomes critical, the structure can be used as a flow-measuring device using only an upstream depth measurement;

d) Determine the crest height of the weir that will cause a hydraulic jump to form downstream of the weir with a sequent depth equal to the depth of uniform flow;

e) For the crest height of the weir calculated in d) determine the depth upstream of the weir (neglecting energy losses and taking $\alpha$ = 1).

**Q2.** A rectangular spillway discharges 10 m$^3$/s and has a width of 10.5 m. At the point where the flow enters the stilling basin, the velocity is 9.1 m/s. Select an adequate USBR stilling basin and determine:

a) the sequent depth of the hydraulic jump;

b) the length of the jump;

c) the energy loss in the jump;

d) the efficiency of the jump defined as the ratio of specific energy after the hydraulic jump to the specific energy before the jump (assume $\alpha$ = 1).

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**Q3.** A wide rectangular channel has a bed slope of 0.0001. The channel bed is composed of sediment with mean diameter of 0.4 mm and density of 2650 kg/m$^3$.

a) Find the limiting depth of flow at which the bed material just begins to move;

b) Find the corresponding mean velocity in the stream.

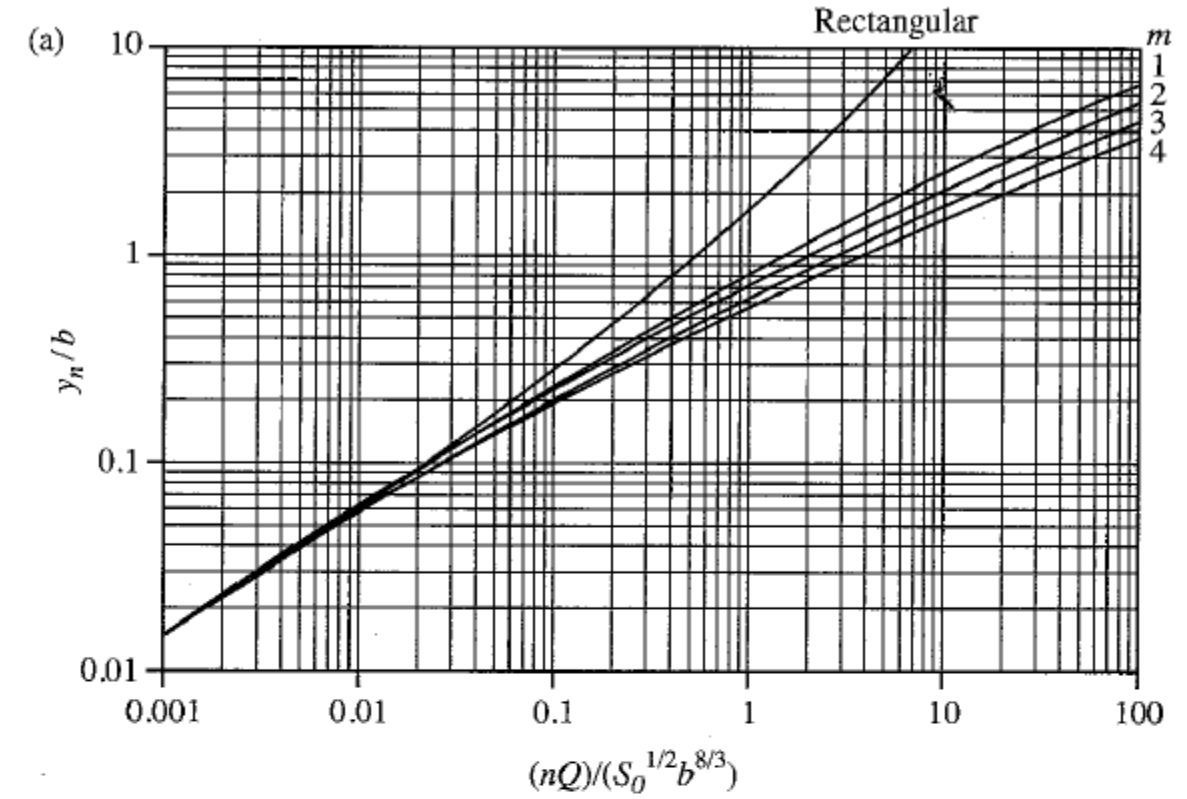
Assume: $\rho$ = 1000 kg/m$^3$ and $\nu$ = $10^{-6}$ m$^2$/s.

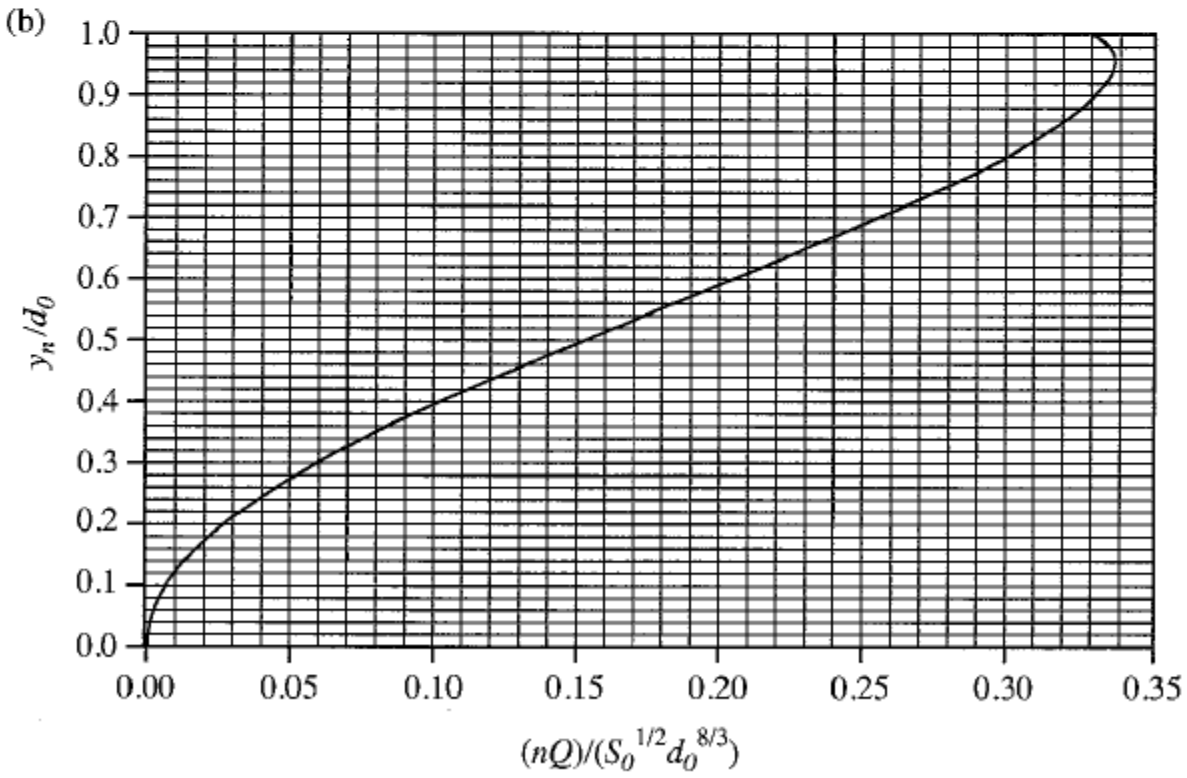
**Q4.** A circular concrete barrel ($n$ = 0.013) culvert of length 12 m and diameter 50 cm is installed on a slope of 3 percent. The culvert is designed for flood conditions where the head water depth is 1.5 m and the tail water depth is 1.0 m. Local losses through the culvert include an entrance loss ($k_L$ = 0.5) and an exit loss of one velocity head.

a) **Determine the flood flow rate** that passed through the culvert. Assume the stream depths are measured above the culvert inverts on the upstream and downstream ends.

b) Determine the **flow rate through the culvert if the outlet was not submerged**. (Assume $C_d$ = 0.62)

*Hint:* Use the attached nomographs to determine the normal depth through the culvert.




Normal depth solution procedure: (a) trapezoidal channels ($m$ = side slope) and (b) circular channels ($d_0$ = diameter)