HPG

Backwater computation

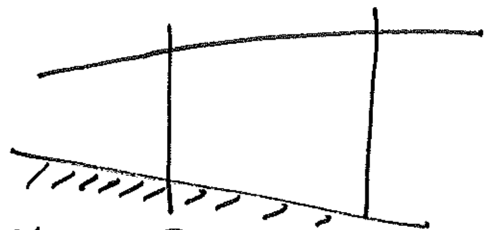
arithmetic method

$$\boxed{\bar{S}_f = \frac{S_{f1} + S_{f2}}{2}}$$

(1)

$$E_1 = E_2 + \bar{S}_f \, \Delta x$$

$$f(y_1) = E_2 - E_1 + \bar{S}_f \, \Delta x$$



1 2

station known

$$f(y_1) = \underbrace{E_2}_{\text{known}} - E_1 + \frac{S_{f1}}{2}\Delta x + \underbrace{\frac{S_{f2}}{2}\Delta x}_{\text{known}}$$

$$E_1 = y_1 + z_1 + \frac{V_1^2}{2g} \quad \ldots (1)$$

$$\boxed{\frac{df}{dy} = -\left(1 + 0 + \frac{d}{dy}\left(\frac{V_1^2}{2g}\right)\right) + \frac{dS_{f1}}{dy}\,\frac{\Delta x}{2}}$$

$K_S = 1.49$ (English units)

$K_S = 1.0$ (Metric units)

$$\frac{d}{dy}\left(\frac{V_1^2}{2g}\right) = -\frac{Q^2 T_1}{g A_1^3}$$

$$S = \left[\frac{Q n P^{2/3}}{K_S A^{5/3}}\right]^2$$

$$\frac{dS_{f1}}{dy} = \frac{Q^2 n^2}{K_S^2}\frac{d}{dy}\left(P^{4/3} A^{-10/3}\right)$$

$$\frac{dS_{f1}}{dy} = \frac{Q^2 n^2}{K_S^2}\left[-\frac{10}{3} P^{4/3} A^{-13/3} \frac{dA}{dy} + A^{-10/3}\left(\frac{4}{3}\right) P^{1/3} \frac{dP}{dy}\right]$$

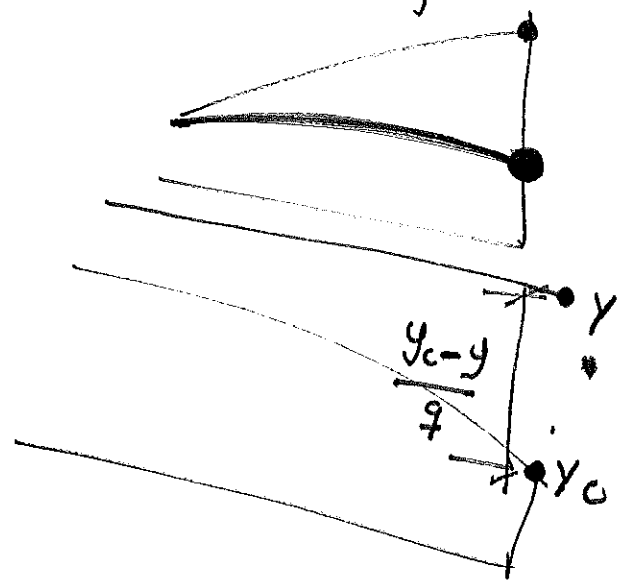
$$\frac{dA}{dy} = T$$

$$\frac{dP}{dy} = \frac{2}{\sqrt{1 - \left(1 - \frac{2y}{d}\right)^2}}$$

$$\frac{d\partial f_1}{dy} = \frac{Q^2 n^2}{k_s^2}\left[\underbrace{-\frac{10}{3} P^{4/3} A^{-13/3} T + \frac{8}{3} A^{-10/3} P^{1/3}\left[1-\left(1-\frac{2y}{d}\right)^2\right]^{-1/2}}_{M} \right]$$

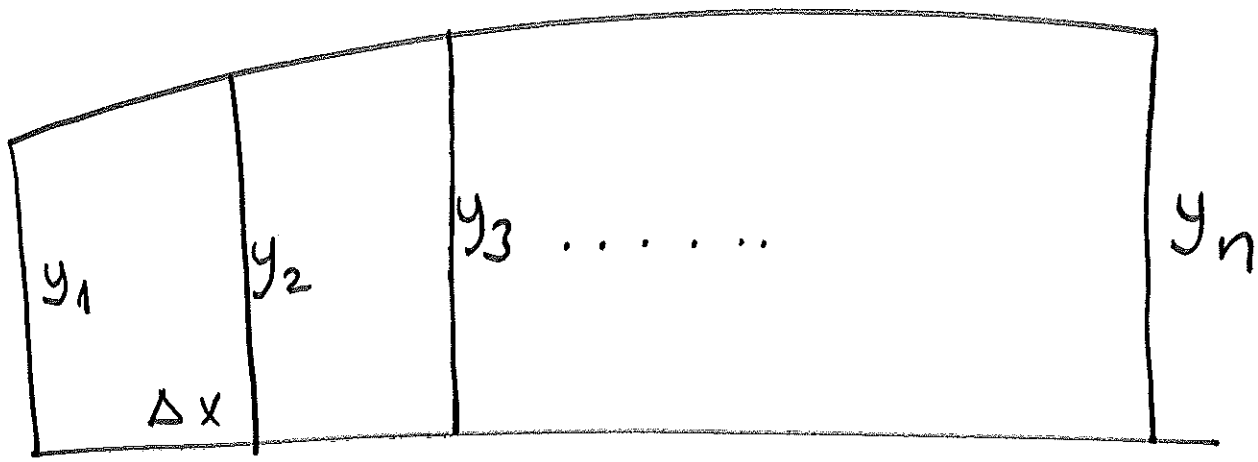
$$\therefore \frac{df}{dy} = -1 + \frac{Q^2 T_1}{g A_1^3} + \frac{\Delta x}{2}\frac{Q^2 n^2}{k_s^2}\left(M \right)$$

$$\boxed{y^{**} = y^{*} - \frac{f}{d_f}}$$



Volume computation

$y = \text{Area}$



$$V = \left(\frac{y_1+y_2}{2}\right)\Delta x + \left(\frac{y_2+y_3}{2}\right)\Delta x + \cdots \left(\frac{y_{n-1}+y_n}{2}\right)\Delta x$$

$$V = \left(\frac{y_1 + 2y_2 + 2y_3 + \cdots + 2y_{n-1} + y_n}{2}\right)\Delta x$$

$$V = \left(\frac{y_1}{2} + y_2 + y_3 + \cdots + y_{n-1} + \frac{y_n}{2}\right)\Delta x$$

$$\boxed{V = \left[\left(\frac{y_1+y_n}{2}\right) + y_2 + y_3 + \cdots + y_{n-1}\right]\Delta x}$$

or

$$V = (y_1 + y_2 + y_3 + \cdots + y_n)\Delta x - \left(\frac{y_1+y_n}{2}\right)$$

check → both English units

$Q = 2\ m^3/s$

$n = 0.01111$

$S = 0.002$

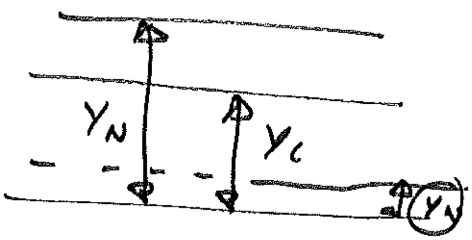
~~L = 200 m~~

$d = 1.25\ m$

$\boxed{Y_c = 0.7687}\ m$

$\boxed{Y_N = 0.9093\ m}$

$$\frac{Y_c}{Y_N} = 0.7682$$

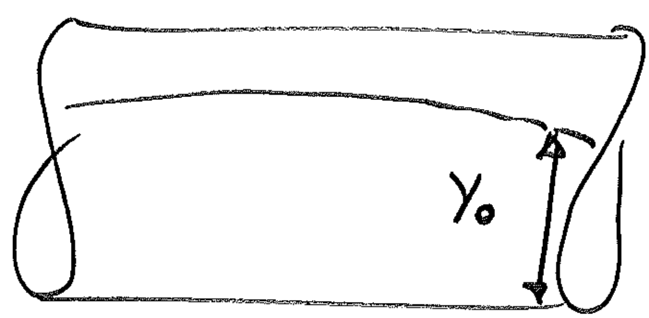


$$\frac{y_N}{D} = 0.727$$

$$\lambda = \left[1 - 1.1\left(\frac{Y_N}{D}\right)^2\right]^{1/2}$$

$$\lambda = 0.647$$

for $y_0 = 1.10$



$$Y_0 = \frac{y_0}{y_N} = \frac{1.10}{0.9093} = 1.210$$

$$Y_c = \frac{y_c}{y_N} = \frac{0.7687}{0.9093} = 0.845$$

fig 8.7 Hager

$$\lambda(X_0) = 0.5$$

$$\boxed{X_0^* = 0.538}$$

$$x_0^* = \lambda X_0$$

$$X_0 = \frac{0.538}{0.647} = 0.832$$

$$x_0 = \frac{X_0 Y_n}{S_0} = \frac{0.832 \times 0.9093}{0.002}$$

$$x_0 = 378.27$$

$Y_d = 1.10 \rightarrow h_d = 1.10$

$Y_u = 0.9093 \rightarrow h_u = 0.9093 + 378.27 \times 0.002$

$h_u = 1.665 \rightarrow 1.67$

for english units

$Q = 70.63$ cfs

$n = 0.0111$

$S = 0.002$

$L = 1241$ feet

$d = 4.10$ feet

$h_d =$ [redacted] 3.60 ft

$h_u = 5.48$ ft.