3) A 1370 mm diameter pipe is flowing 2/3rds full and carrying a flow of 3,000 L/s. The Manning roughness coefficient for the pipe is 0.013. Find
   a) the pipe slope,
   b) the depth of flow, and
   c) the velocity of flow.

.33

$\phi = 1370$ mm $A/A_f = 2/3 = 0.667$, $Q = 3000$ L/s $n = 0.013$.

$\frac{y}{r} = 1.264$ $\frac{d}{D} = 0.632$

$\frac{V}{V_f} = 0.9$ $\frac{Q}{Q_f} = 0.6$; $Q_f = \frac{Q}{0.6} = \frac{3000 \text{ L/s}}{0.6} = 5000 \frac{L}{S}$.

$Q_f = 5000 \frac{L}{S} \times \frac{m^3}{1000L} \times \frac{60s}{min} = 300 \frac{m^3}{S}$

.10

a) slope $= 0.0077$ or 0.77%.

b) $\frac{d}{D} = 0.632$; $d = 0.632 \times 1370$ mm $= 866$ mm.

c) $V_f = 3.38 \frac{m}{S}$; $V = 0.9 \times 3.38 = 3.042$ m/s.

.12

2)

Summer $Q = 225{,}000 \frac{m^3}{d}$ $T = 18°C$ $\frac{80 L}{m^2 \cdot h} = J_{summer}$

winter $Q = 165{,}000 \frac{m^3}{d}$ $T = 5°C$

$$\frac{Q}{J} = A \quad \frac{225{,}000\ m^3}{d} \times \frac{m^2 \cdot h}{80 L} \times \frac{d}{24 h} \times \frac{1000 L}{m^3} = 117{,}187.5\ m^2$$

$$J_s = J_m \left(\frac{\mu_m}{\mu_s}\right) = \frac{80 L}{m^2 \cdot h} \left(\frac{1.053}{1.002}\right) = 84.07 \text{ at } 20°C.$$

$$J_m = J_s \left(\frac{\mu_s}{\mu_m}\right) = 84.07 \left(\frac{1.002}{1.519}\right) = 55.46 \text{ at } 5°C.$$

$$\frac{Q}{J} = A \quad 165{,}000 \frac{m^3}{d} \times \frac{m^2 \cdot h}{55.46 L} \times \frac{d}{24 h} \times \frac{1000 L}{m^3} = 123{,}963\ m^2.$$

So winter flow conditions govern and area required is $123{,}963\ m^2$

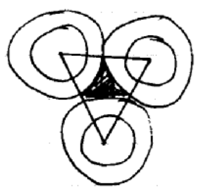
3)

a) 10,000 HFs, OD = 1.8 mm, ID = 0.85 mm, L = 1.1 m.

Total area outside $= (10{,}000)(\underset{m}{\overset{L}{1.1}})(\overset{\pi}{\pi})(\overset{D}{0.0018\ m}) = 62.2\ m^2$

$Q_P = JA$; $J = \frac{Q_P}{A} = \frac{60\ m^3}{d} \times \frac{}{62.2\ m^2} \times \frac{1000\ L}{m^3} \times \frac{d}{24\ h} = 40.19\ \frac{L}{m^2 \cdot h}$

b)



For 3 HFs together, 1/6th of each HF or 1/6 × 3 or 1/2 of a HF inside area contributes to area when "inside to outside."

The space between them contributes to area when flow is from "outside to inside"

A inside HFs $= \frac{\pi r^2}{2} = \frac{\pi (0.425)^2}{2} = 0.284$

A entire HFs $= \frac{\pi r^2}{2} = \frac{\pi (0.9)^2}{2} = 1.272$

A triangle $= \frac{1}{2} bh = \frac{(1.8)(1.5588)}{2} = 1.403$

$(0.866)(1.8) = 1.5588$

shaded area $= 1.403 - 1.2721 = 0.131$

$\frac{0.131}{0.284} = 0.46$, $\simeq 50\%$.

going from outside to inside occupies 50% of other HB area.