

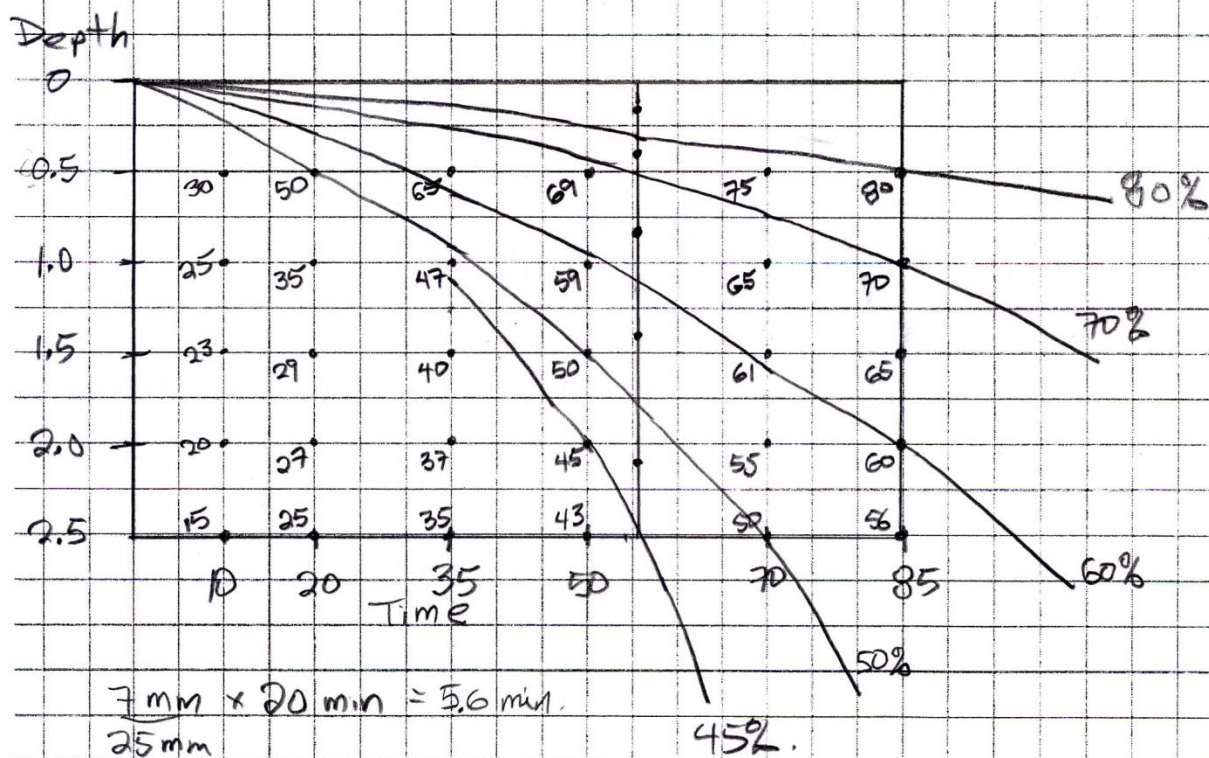
① Initial conc. = 20 mg/L To remove 60%

Depth	Time (min)											
	10		20		35		50		70		85	
0.5	14	30	10	50	7	65	6.2	69	5	75	4	80
1.0	15	25	13	35	10.6	47	8.2	59	7	65	6	70
1.5	15.4	23	14.2	29	12	40	10	50	7.8	61	7	65
2.0	16	20	14.6	27	12.6	37	11	45	9	55	8	60
2.5	17	15	15	25	13	35	11.4	43	10	50	8.8	56

Measured concentrations given in mg/L
 $\% \text{ Removal} = \frac{C_0 - C_i}{C_0} (100\%)$ calculated

For example $\frac{20 - 17}{20} (100\%) = 15\%$ at 2.5m depth and at 10 min.

% Removal plotted for depths and times given.



①

Finding % removed at 55.6 m
Scale: 64 mm = 2.5 m

$$\begin{aligned}R_{745} &= 45\% + \frac{2.09}{2.50} (50 - 45) + \frac{1.39}{2.50} (60 - 50) \\ &+ \frac{0.820}{2.50} (70 - 60) + \frac{0.390}{2.50} (80 - 70) \\ &+ \frac{0.156}{2.5} (100 - 80) \\ &= 45 + 4.18 + 5.56 + 3.28 + 1.56 + 1.25 \\ &= 60.83\%\end{aligned}$$

If one is too far off 60% then an additional time needs to be calculated and one would interpolate between the two times to find the time for 60% removal.

Detention time \geq 56 minutes

$$\begin{aligned}V_0 &= \frac{H}{t} = \frac{2.5 \text{ m}}{56 \text{ min}} \times 60 \times 24 \frac{\text{min}}{\text{d}} \\ &= 64.3 \frac{\text{m}}{\text{d}}\end{aligned}$$

(2) $Q = 25,000 \text{ m}^3/\text{d}$ Take 7-5 applies.
 $v_0 = 40 \text{ m}^3/\text{d} \cdot \text{m}^2$
 $T = 12^\circ\text{C}$

$$A_p = \frac{Q}{v_0} = \frac{25,000 \text{ m}^3/\text{d}}{40 \text{ m}^3/\text{d} \cdot \text{m}^2} = 625 \text{ m}^2$$

Try 3 basins $A_p = \frac{625 \text{ m}^2}{3} = 208.3 \text{ m}^2/\text{basin}$

Use chain-and-flight for sludge removal
 so W is a multiple of 0.3 m

Try $W = 3.6 \text{ m}$

$$L = \frac{625 \text{ m}^2}{3 \text{ basins}} \times \frac{1 \text{ basin}}{3.6 \text{ m}} = 57.9 \text{ m, use } 58 \text{ m}$$

$$L/W = 58/3.6 = 16.1:1 \geq 6:1 \text{ so OK}$$

Let $SWD = 3.5 \text{ m}$ and $D = 2.5 \text{ m}$.

$$L/D = 58/2.5 = 23.2:1 \geq 15:1 \text{ O.K.}$$

$$v_{fc} = v_H = \frac{Q}{A_x} = \frac{25,000 \text{ m}^3/\text{d}}{3 \text{ basins } (3.6 \text{ m} \times 2.5 \text{ m}) (60 \times 60 \times 24 \text{ s/d})}$$

$$= 0.0107 \text{ m/s. (OK, } 0.005 - 0.018 \text{ m/s)}$$

Check Re (F_r not required for $Q < 40,000 \text{ m}^3/\text{d}$)

$$R_h = \frac{A_x}{P_w} = \frac{(3.6 \text{ m} \times 2.5 \text{ m})}{2.5 \text{ m} + 2.5 \text{ m} + 3.6 \text{ m}} = \frac{9}{8.6} = 1.05 \text{ m}$$

at 12°C $\nu = 0.001236 \text{ m}^2/\text{s}$

$$Re = \frac{v_H R_h}{\nu} = \frac{(0.0107 \text{ m/s})(1.05 \text{ m})}{0.001236} = 9.09 \text{ OK } < 20,000$$

(3)

Let launders be $\frac{1}{3}$ basin length and
2 per basin

$$58/3 = 19.3 \text{ m}; \quad \text{use } 19 \text{ m.}$$

$$\begin{aligned} WL &= \frac{25,000 \text{ m}^3/\text{d}}{(3 \text{ basins})(2 \text{ launders/basin})(19 \text{ m})(2 \text{ sides/launder})} \\ &= 109.64 \text{ m}^3/\text{d}\cdot\text{m}, \quad \text{OK, } \leq 250 \text{ m}^3/\text{d}\cdot\text{m} \end{aligned}$$

$$\begin{aligned} Q_{\text{design}} &= \sqrt[3]{A_p} = \frac{40 \text{ m}^3}{\text{d}\cdot\text{m}^2} (58.0 \text{ m})(3.6 \text{ m})(3 \text{ basins}) \\ &= 25,056 \text{ m}^3/\text{d} \end{aligned}$$

Summary:

3 basins

$$L = 58 \text{ m}; \quad W = 3.6 \text{ m}; \quad D = 2.5 \text{ m}$$

$$S_{\text{WD}} = 3.5 \text{ m}$$

$$\text{Sludge zone depth} = 1.0 \text{ m}$$

$$L:D = 58:2.5 = 23.2:1$$

$$V_F = 0.0107 \text{ m/s}$$

$$Re = 9.09$$

2 launders / basin

$$WL = 110 \text{ m}^3/\text{d}\cdot\text{m}$$

Chain-and-fight sludge removal.

$$3) \quad Q = 25,000 \text{ m}^3/\text{d}$$

$$T = 12^\circ\text{C}$$

settler tubes at 60° with horizontal
with hydraulic diameter = 0.05 m
floc has excellent settling characteristics

Let $V_0 = 150 \text{ m}^3/\text{d} \cdot \text{m}^2$ because of settling capacity
of floc ($V_0 = 60 - 180 \text{ m}^3/\text{d} \cdot \text{m}^2$)

$$A_p = \frac{Q}{V_0} = \frac{25,000 \text{ m}^3/\text{d}}{150 \text{ m}^3/\text{d} \cdot \text{m}^2} = 167 \text{ m}^2$$

$$\text{Try 2 basins } \frac{167 \text{ m}^2}{2} = 83.5 \text{ m}^2 = A_p / \text{basin.}$$

$$Q = 25,000 \frac{\text{m}^3}{\text{d}} \times \frac{\text{d}}{86,400 \text{ s}} = 0.289 \text{ m}^3/\text{s}$$

$$\text{Try } w = 3.6 \text{ m (multiple of } 0.3 \text{ m)}$$

$$L_{\text{settlers}} = \frac{83.5 \text{ m}^2}{3.6 \text{ m}} = 23.2 \text{ m}$$

$$L_{\text{basin}} = \frac{23.2 \text{ m}}{0.75} = 30.9 \text{ m} \rightarrow \text{use } 31 \text{ m.}$$

$$\text{Sludge zone depth} = 2.0 \text{ m (Fig. 7-14)}$$

$$\text{Settler height} = 1.4 \text{ m (0.5 - 2.0 m range)}$$

$$\text{Top settler to top launder} = 1.0 \text{ m (0.6 - 1.0 m range)}$$

$$\text{SWD} = 2.0 \text{ m} + 1.4 \text{ m} + 1.0 \text{ m} = 4.4 \text{ m}$$

$$\text{Total D with freeboard} = 4.5 \text{ m} + 0.6 \text{ m} = 5.0 \text{ m}$$

Use D, not SWD to find approach velocity, v_H

(5)

$$V_H = \frac{Q}{A_x} = \frac{0.289 \text{ m}^3/\text{s}}{(2 \text{ basins}) (2.4 \text{ m}) (3.6 \text{ m})} = 0.01672 \text{ m/s} \neq 0.01 \text{ m/s} \text{ not O.K.}$$

Increase settler height to 2.0 m
and D to 3.0 m so SWD ≤ 5.0 m

$$V_H = \frac{Q}{A_x} = 0.01672 \text{ m/s} \left(\frac{2.4 \text{ m}}{3.0 \text{ m}} \right) = 0.0134 \text{ m/s} \text{ better but still not O.K.}$$

Before trying more basins or a greater W
test V_{fc}

$$V_{fc} = \frac{Q}{A \sin \theta} = \frac{0.289 \text{ m}^3/\text{s}}{(167 \text{ m}^2) (\sin 60^\circ)} = 0.00208 \text{ m/s} \text{ low because}$$

V_{fc} preferred range = 0.0025 - 0.0033 m/s

We can let $v_0 = 180 \text{ m}^3/\text{d} \cdot \text{m}^2$ because of the excellent settling characteristics.

$$A_p = \frac{Q}{v_0} = \frac{25,000 \text{ m}^3/\text{d}}{180 \text{ m}^3/\text{d} \cdot \text{m}^2} = 139 \text{ m}^2$$

$$V_{fc} = \frac{0.289 \text{ m}^3/\text{s}}{(139 \text{ m}^2) (\sin 60^\circ)} = 0.00240 \text{ m/s} \text{ this is better and will be considered acceptable.}$$

$$\text{let } V_H = 0.01 \text{ m/s} = \frac{0.289 \text{ m}^3/\text{s}}{(2 \text{ basins}) (3.0 \text{ m}) (W)} ; W = 4.82$$

width of $W = 4.80 \text{ m}$ gives $V_H = 0.01003 \text{ m/s}$ which is considered acceptable and rounds off to 0.01 m/s

4.80 m is a multiple of 0.3 m

$$A_p = 139 \text{ m}^2$$

$$\text{For 2 basins } \frac{A_p}{\text{basin}} = \frac{139 \text{ m}^2}{2} = 69.5 \text{ m}^2$$

$$L_{\text{settlers}} = \frac{69.5}{4.80 \text{ m}} = 14.5 \text{ m}$$

$$L_{\text{basin}} = \frac{14.5 \text{ m}}{0.75 \text{ m}} = 19.3; \text{ say } 19.4 \text{ m}$$

$$\text{At } 12^\circ\text{C } \nu = 1.236 \times 10^{-6} \text{ m}^2/\text{s}$$

$$\text{Hydraulic diameter of tubes} = 0.05 \text{ m}$$

$$R_h = \frac{A_c}{P_w} = \frac{\pi r^2}{2\pi r} = \frac{r}{2} = \frac{0.025 \text{ m}}{2} = 0.0125 \text{ m}$$

$$Re = \frac{V_{fc}}{\nu} R_h = \frac{(0.0024 \text{ m/s}) (0.0125 \text{ m})}{1.236 \times 10^{-6} \text{ m}^2/\text{s}} = 24.3 < 50 \text{ O.K.}$$

$$Fr = \frac{V_{fc}^2}{g R_h} = \frac{(0.0024 \text{ m/s}) (0.0024 \text{ m/s})}{(9.81 \text{ m/s}^2) (0.0125 \text{ m})} = 4.69 \times 10^{-5} > 10^{-5} \text{ OK}$$

$$L_{\text{laundery}} = L_{\text{settler}} = 14.5 \text{ m} \text{ Try 2/basin equally spaced}$$

$$WL = \frac{25,000 \text{ m}^3/\text{d}}{(2 \text{ basins}) (2 \text{ laundery}) (14.5 \text{ m}) (2 \text{ sides})} = 215.5 \frac{\text{m}^3}{\text{d} \cdot \text{m}^2}$$

$$< 300 \text{ m}^3/\text{d} \cdot \text{m}^2 \rightarrow \text{O.K.}$$

Summary:

2 basins

$$W = 4.80 \text{ m}$$

$$L = 19.4 \text{ m}$$

$$L_{\text{settles}} = 14.5 \text{ m}$$

$$S\&D = 5.0 \text{ m}$$

$$\text{Total } D = 5.0 \text{ m} + 0.6 \text{ freeboard.}$$

$$V_H = 0.01 \text{ m/s}$$

$$V_{fc} = 0.0024 \text{ m/s}$$

$$Re = 24.3$$

$$Fr = 4.69 \times 10^{-5}$$

$$L_{\text{launders}} = 14.5 \text{ m}$$

2 launders/basin equally spaced.

$$Q_{\text{design}} = 25,000 \frac{\text{m}^3}{\text{day}} = A_p V_o = (14.5 \text{ m})(4.80 \text{ m})(180$$

$$= A_p V_o = (14.5 \text{ m})(4.80 \text{ m})(180 \text{ m}^3/\text{d} \cdot \text{m}^2)(2 \text{ basins})$$
$$= 25,056 \frac{\text{m}^3}{\text{day}} \quad (\text{check})$$

Showing V_H calculation:

$$V_H = \frac{0.289 \text{ m}^3/\text{s}}{(2 \text{ basins})(3.0 \text{ m})(4.80 \text{ m})} = 0.0100 \text{ m/s}$$

$D \qquad \qquad \qquad W$

For redundancy 3 basins in total are necessary