

1.

We first assume all the particles is under laminar flow condition and use Re parameter to readjusts the equation due to different flow type, then

$$Re = \frac{\rho v_s d_p}{\mu} \quad \text{and} \quad v_s = \frac{g(\rho_p - \rho_w)d_p^2}{18\mu}$$

where Re = Reynolds number, dimensionless

μ = dynamic viscosity, $N \cdot s/m^2$ or $kg/m \cdot s = 1.307 \times 10^{-3} kg/m \cdot s$

Then, in terms of different Re (Clark, 1996), readjusts our equation to fit different conditions

$$Cd = \frac{Re}{24} \quad (Re < 2) = \frac{18.5}{Re^{0.6}} \quad (2 < Re < 500) = 0.44 \quad (500 < Re < 2 \times 10^5)$$

$$v_{re} = \sqrt{\frac{4g(\rho_p - \rho_w)d_p}{3C_d\rho_w}} \quad \text{and} \quad Re_{re} = \frac{\rho v_s d_p}{\mu}$$

Make a table:

| Particle | Re(laminar flow) | Actual Flow Type | Re _{re} | v _{re} |
|----------|------------------|------------------|------------------|-----------------|
| A | 0.07 | Laminar Flow | 0.040 | 0.002 |
| B | 2.01 | Turbulent Flow | 1.939 | 0.005 |
| C | 0.43 | Laminar Flow | 0.423 | 0.002 |
| D | 1.72 | Laminar Flow | 1.068 | 0.015 |
| E | 2.07 | Turbulent Flow | 1.562 | 0.013 |

* detailed calculation process by Matlab programming

2.

$$V_f = 20 \text{ cm/s} = 0.2 \text{ m/s} \quad \text{And} \quad a = 4 \text{ m}, b = 0.6 \text{ m}, c = 0.9 \text{ m}$$

$$v_s = \frac{b}{t} = \frac{b}{a/V_f} = \frac{0.6}{4/0.2} = 0.03 \text{ m/s}$$

$$\text{Then } OR = \frac{a}{c/v_s} = \frac{4}{0.9/0.03} = 0.13 \text{ m/s}$$

$$OR = \frac{h_o}{\tau} = \frac{h_o Q}{h_o A} = \frac{Q}{A} = \frac{OR \times S}{A} =$$

3.

$$OR = \frac{h_o}{\tau} = \frac{h_o Q}{h_o A} = \frac{Q}{A} = 50.47 \text{ m/d}$$

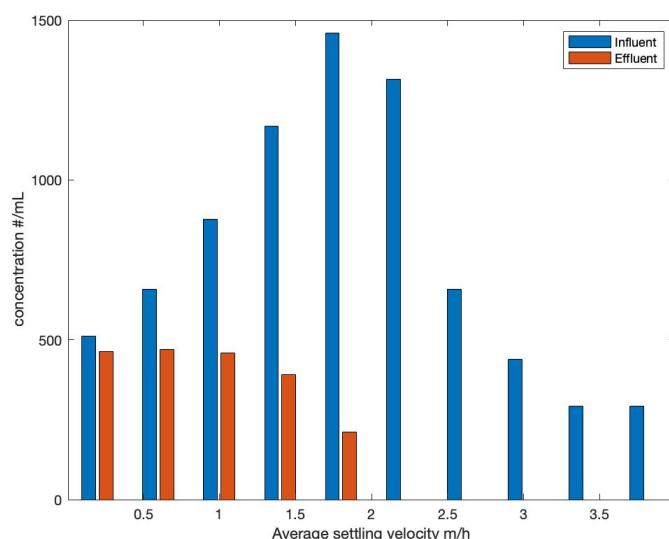
$$\text{Removal efficiency} = \frac{\sum N_i^0 \times (1 - \frac{v_i}{OR})}{N}$$

where N is the total particles amount and vi is the average settling velocity

| Settling Velocity | Average Velocity | Number of Influent | Fraction of Removed | Number of Removed | Number in Effluent |
|-------------------|------------------|--------------------|---------------------|-------------------|--------------------|
| 0 - 0.4 | 0.2 | 511 | 0.10 | 49 | 462 |
| 0.4-0.8 | 0.6 | 657 | 0.29 | 187 | 470 |
| 0.8-1.2 | 1.0 | 876 | 0.48 | 417 | 459 |
| 1.2-1.6 | 1.4 | 1168 | 0.67 | 778 | 390 |
| 1.6-2.0 | 1.8 | 1460 | 0.86 | 1250 | 210 |
| 2.0-2.4 | 2.2 | 1314 | 1.00 | 1314 | 0 |
| 2.4-2.8 | 2.6 | 657 | 1.00 | 657 | 0 |
| 2.8-3.2 | 3.0 | 438 | 1.00 | 438 | 0 |
| 3.2-3.6 | 3.4 | 292 | 1.00 | 292 | 0 |
| 3.6-4.0 | 3.8 | 292 | 1.00 | 292 | 0 |

* detailed calculation process by Matlab programming

$$\text{Removal efficiency} = \frac{\sum N_i^0 \times (1 - \frac{v_i}{OR})}{N} = 74 \%$$



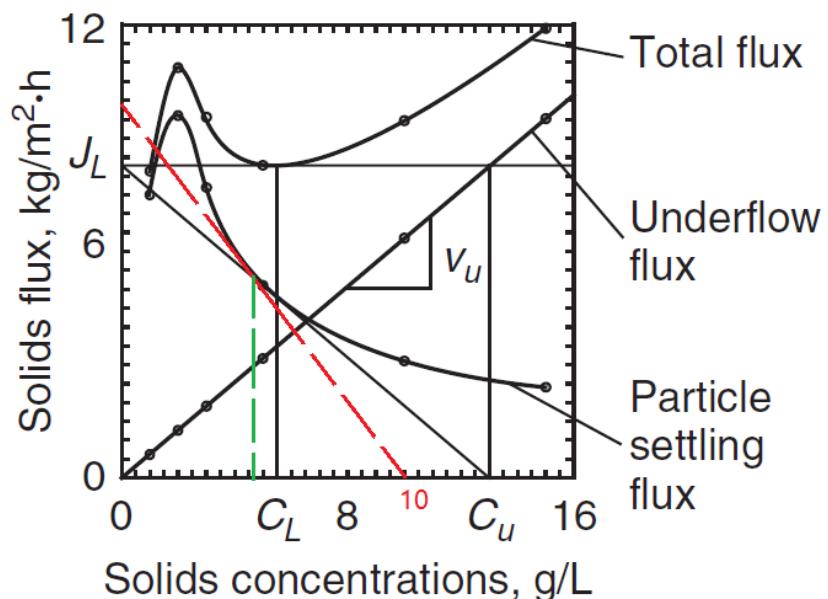
4.

Influent flow rate = 3000 m³ / h

Influent solid concentration = 500 mg / L

Underflow solid concentration = 10000mg / L

Determine J_L and C_L . From the data plotted on Fig. 10-8b and an underflow solids concentration of $C_u = 10000$ mg/L, the gravity flux is determined by drawing a line from the x axis at a solids concentration of 10,000 mg/L to the y axis such that it is tangent to the solids flux curve and intersects the y axis. The point at which the line intersects the y axis is the limiting gravity flux and is equal to $9.90 \text{ kg/m}^2 \cdot \text{h}$. The value for C_L can also be determined by drawing a vertical line from the tangent point to the x axis and is equal to 4600 mg/L.



Then

$$J_L = 9.9 \text{ kg/m}_2 \cdot \text{h}$$

$$C_L = 4600 \text{ mg/L}$$

$$Q_u = \frac{Q_i C_i}{C_u} = \frac{3000 \text{ m}^3/\text{h} \times 500 \text{ mg/L}}{10000 \text{ mg/L}} = 150 \text{ m}^3/\text{h}$$

5.

Determine the number of basins: Two basins would satisfy the minimum requirement for maintenance purposes. According to the small flow in the requirement, two basins will be selected.

SIZE: The basin width will be governed by the standard size of sludge removal equipment. The standard maximum width of the chain-and-flight sludge collector is 6 m, so basin widths in increments of 3 m will be considered, starting with 6 m. Water depths from 3 to 5 m are appropriate, according to the design criteria listed in Table 10-4. As previously mentioned, deeper basins are recommended over shallower basins, so a depth of 4 m will be selected.

Determine the basin area: I assume The water is coagulated with alum and the alum floc was measured to have a settling velocity of 2.2 m/h at 10°C (50°F). The dynamic viscosity of water at 10°C is 0.00131 kg/m s and the density of water is 999.7 kg/m³.

$$A = \frac{Q}{v_c} = \frac{0.1736 m^3/s}{2.2 m/h \times \frac{1 h}{3600 s}} = 284.1 m^2$$

$$ratio = \frac{A}{2 \times 3m} \times \frac{1}{3m} = 4.0$$

The length-to-width ratio is greater than the minimum recommendation of 4:1 to 5:1.

Check the various design parameters listed in Table 10-4

$$Q_{max} = \frac{(6 \times A \times 4) \times 2 \text{ basins}}{OR \times \frac{1 h}{3600 s}} = 21.82 \text{ h}$$

6.

Countercurrent settlers

$$\frac{V_s}{V_{f\theta}} = \frac{d}{L_p \cos\theta + d \sin\theta}$$

Where V_s is settling velocity

d is the distance between two parallel plates

θ = inclination angle of plates from horizon

L_p = length of plate

$V_{f\theta}$ = fluid velocity in channel

Then

$$\frac{Q}{A \sin\theta} = V_{f\theta} = \frac{d}{V_s (L_p \cos\theta + d \sin\theta)}$$

Thus

$$A = \left[\frac{\sin\theta d}{V_s Q (L_p \cos\theta + d \sin\theta)} \right]^{-1} =$$

(II)

$$A_{cover} = \frac{h}{\sin\theta} \times \frac{A}{\frac{d}{\sin\theta}} =$$

7.

Assume temperature is 25 C

$$C_{fl} = \frac{Y}{H_{YC}} = 24.28 \text{ mg/L}$$

$$C_r = C_{fl} \times \frac{P}{P_0} =$$

Where

Y = the density of air at 20 C and 1 atm = 1.204 g / L

H_{YC} = the value of the dimensionless Henry's constant at 20 C and 1 atm = 49.58

P = operating pressure = 650 KP

P_0 = 101.325 KPa = standard air pressure

C_r = mass concentration of air in recycle flow, mg/L = 143.9 mg / L

C_{fl} = mass concentration of air in floc tank effluent = 24.2 mg / L

$$C_b = \frac{e(C_r - C_{fl})r - k}{1 + r}$$

Where

C_b = mass concentration of air released, mg/L

e = efficiency factor, dimensionless = 0.9

r = mg/L recycle ratio, dimensionless = 0.08

k = factor to account for air deficit in incoming flocculated water 2 mg / L

$$\Phi_b = \frac{C_b}{\rho_{air}} = \quad \text{and} \quad N_b = \frac{10^{12} \times 6\Phi_b}{\pi d_b^3} =$$

ρ_{air} = 1200 mg/L

d_b = the mean bubble diameter = 40 μm

N_p = floc particle concentration = 1000 particles / mL

$$\frac{N_b}{N_p} =$$