DESIGN EXAMPLE
OF
WATER TREATMENT SYSTEM

(Modular Water Treatment Plant)

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(WEG)

OBJECTIVES OF WATER SUPPLY SYSTEM

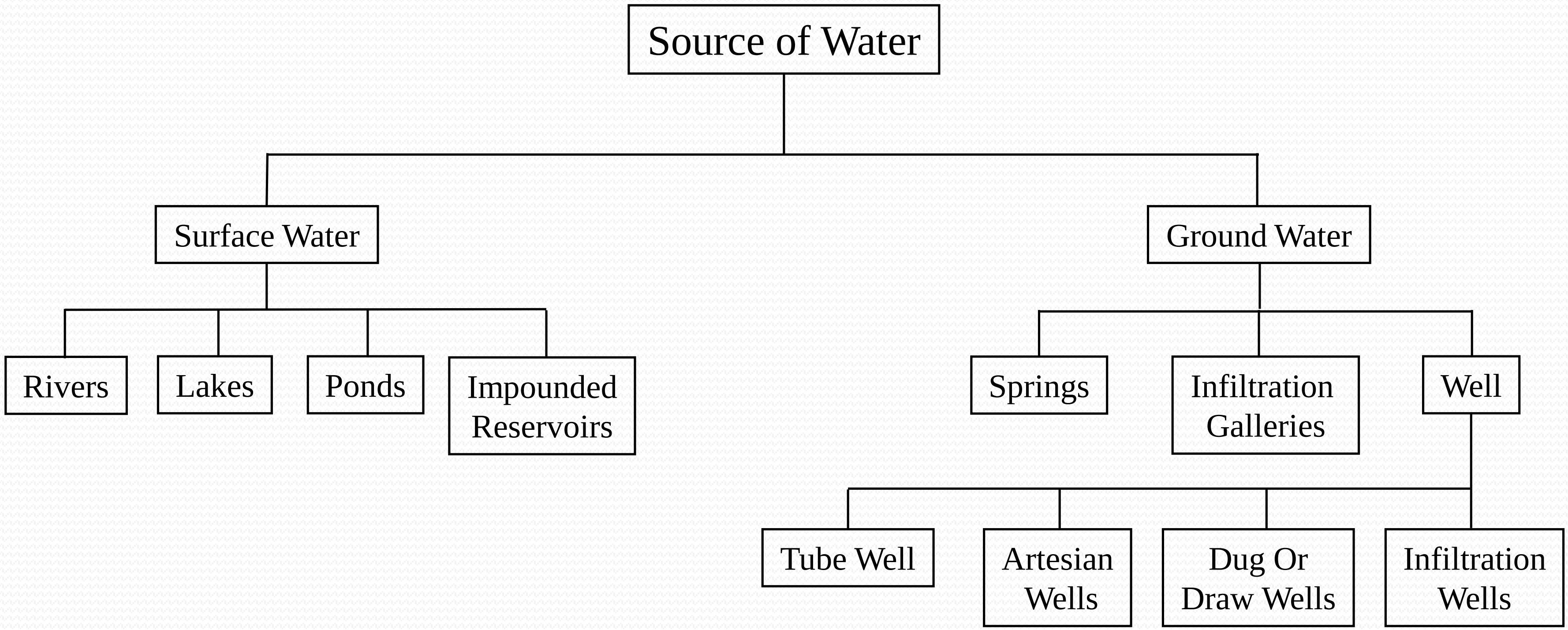
The broad objectives underlying any water supply system are:

1) To supply safe and wholesome water to consumers
2) To supply water in adequate quantity
3) To make water easily available to consumers so as to encourage personal and household cleanliness.

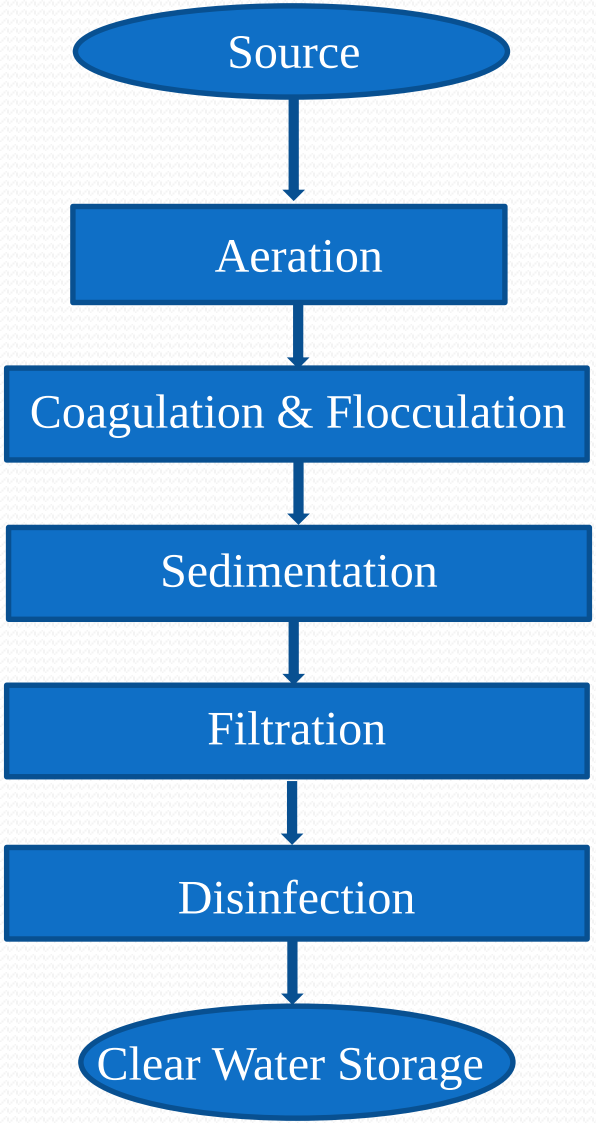
FESIBILITY STUDY

1) Planning Period
2) Water Supply Areas
3) Future Population
4) Maximum Daily Water Demand
5) Evaluation and Selection of the Water Source
6) Size of the Water Treatment Plant
7) Treatment Plant Site
8) Financing

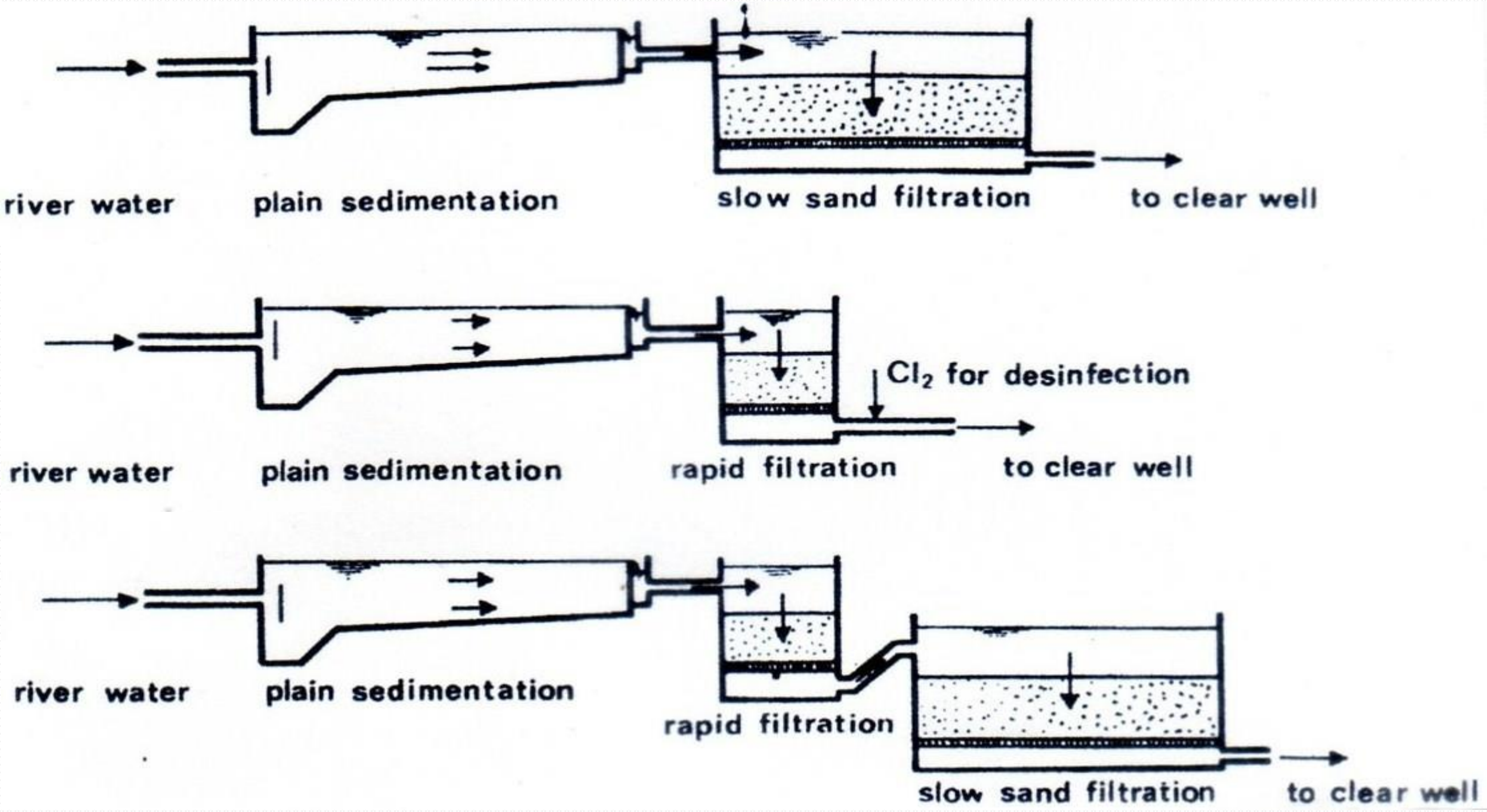
SOURCE OF WATER



WATER TREATMENT PROCESS



SOME TYPES OF WATER TREATMENT SYSTEM
(Conventional Treatment Systems)



SOME TYPES OF WATER TREATMENT SYSTEM
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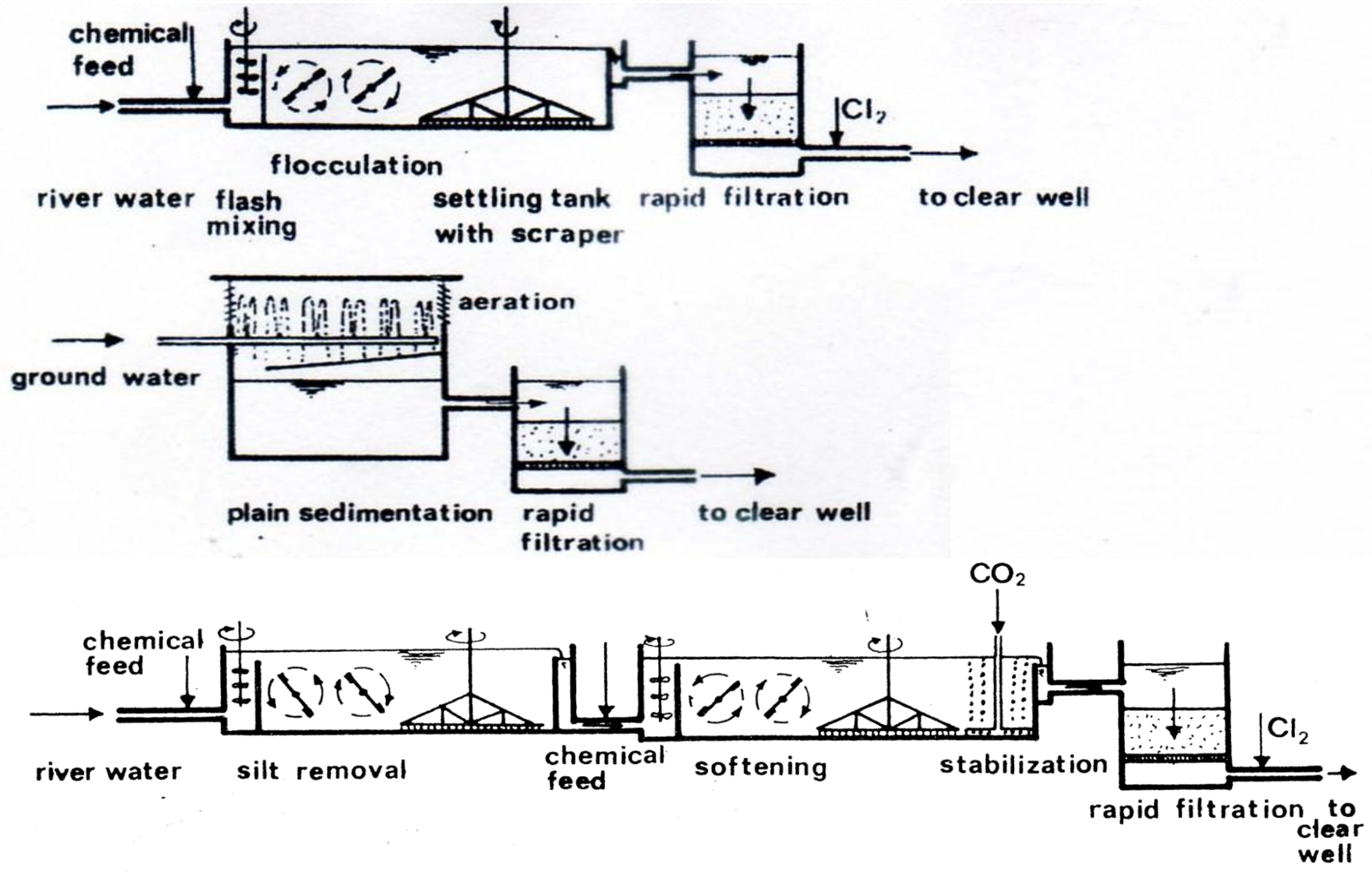
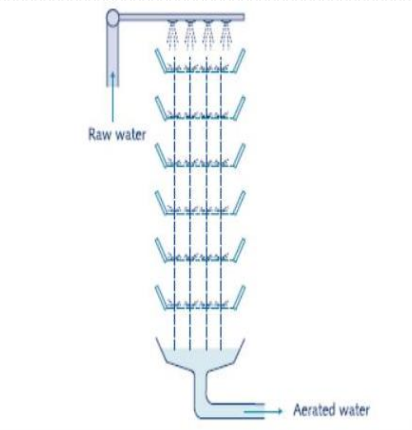
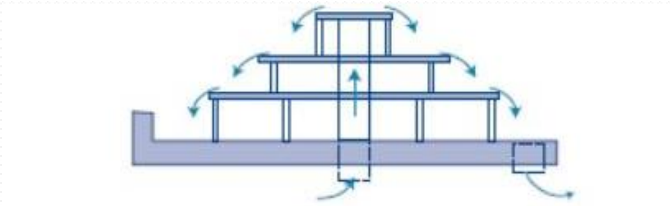


1. AERATION

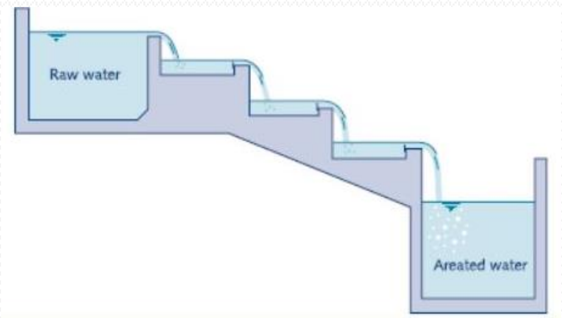
- **Multi Tray Aerator**



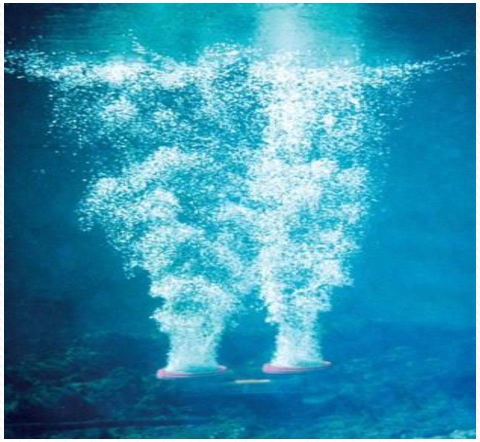
- **Multi Platform Aerator**



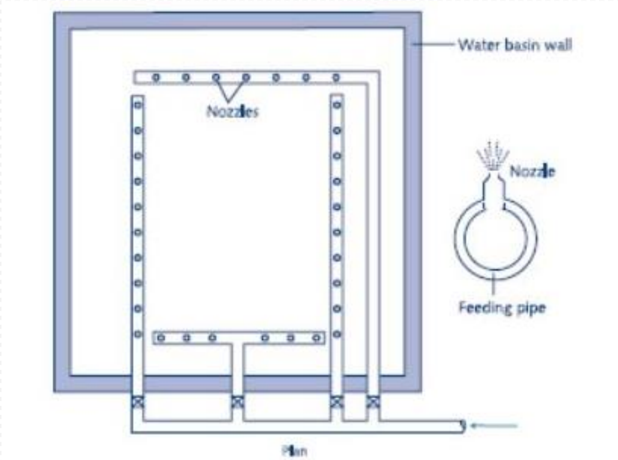
- **Cascade Aeration**



- **Aeration with Diffuser**



- **Nozzled Spray Aerator**



Ref : Small Community Water Supplies

➢ Multi Tray Aerator

Criteria

Ref: Compilation of Water Supply and Treatment (India)

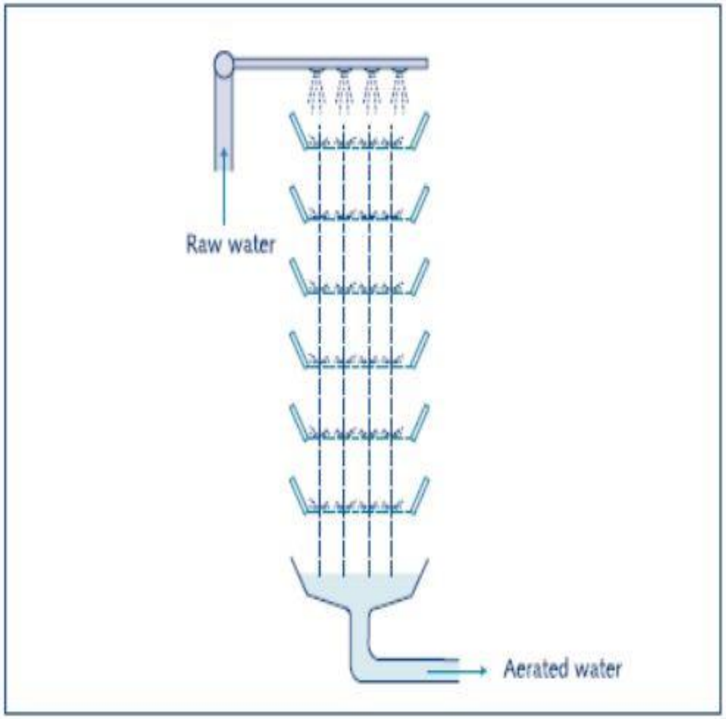
- No of Trays - 4 ~ 9 Nos
- Height of Tray - 30 ~ 75 cm
- Required space - 0.013~0.042 m2 per m3/hr
- (8~26 gpm per sq.ft)

Ref: Small Community Water Supplies

- No of Trays - 4 ~ 8 Nos
- Height of Tray - 30 cm
- Required space - 0.02 m3/s per m2 (25 gpm per sq.ft)

Ref: Water Supply and Sewage

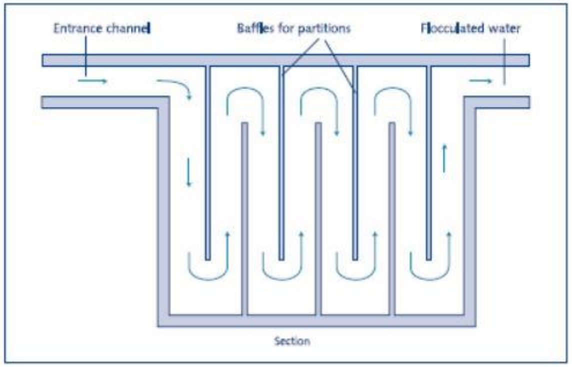
- Materials - coke, slag, stone, ceramic ball
- Size - 2~6 in (High rate), 1.5~2.5 in (Low rate)
- Perforation - 1/2~3/16 in dia:, 3 in c/c spacing
- Required space - 1~5 gpm per sq.ft



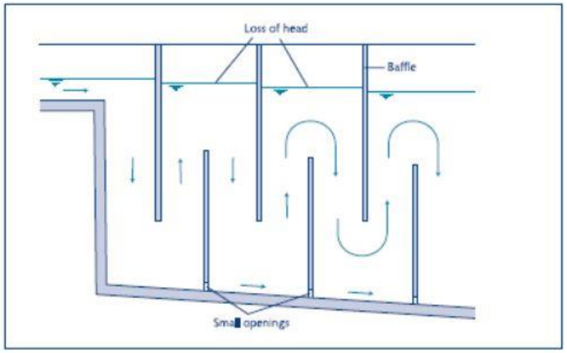
Ref : Small Community Water Supplies

2. COAGULATION & FLOCCULATION

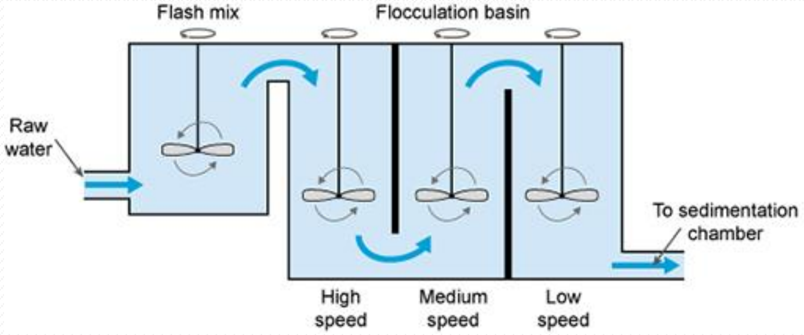
- **Horizontal-flow Baffled Flocculator**



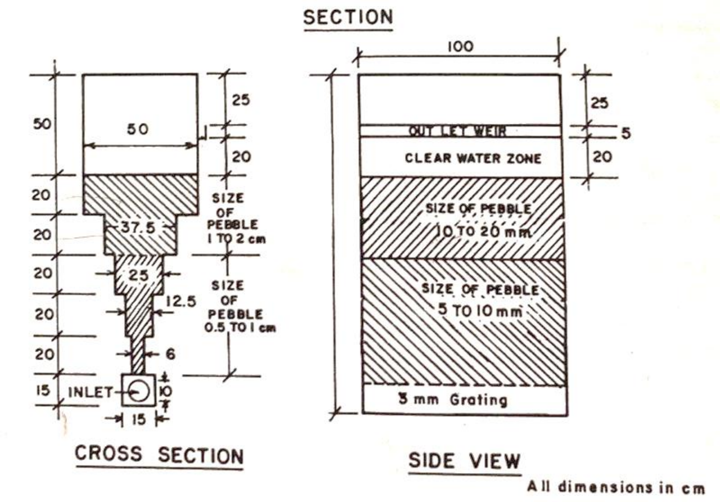
- **Vertical-flow Baffled Flocculator**



- **Mechanical Flocculator**



- **Gravel-bed Flocculator**

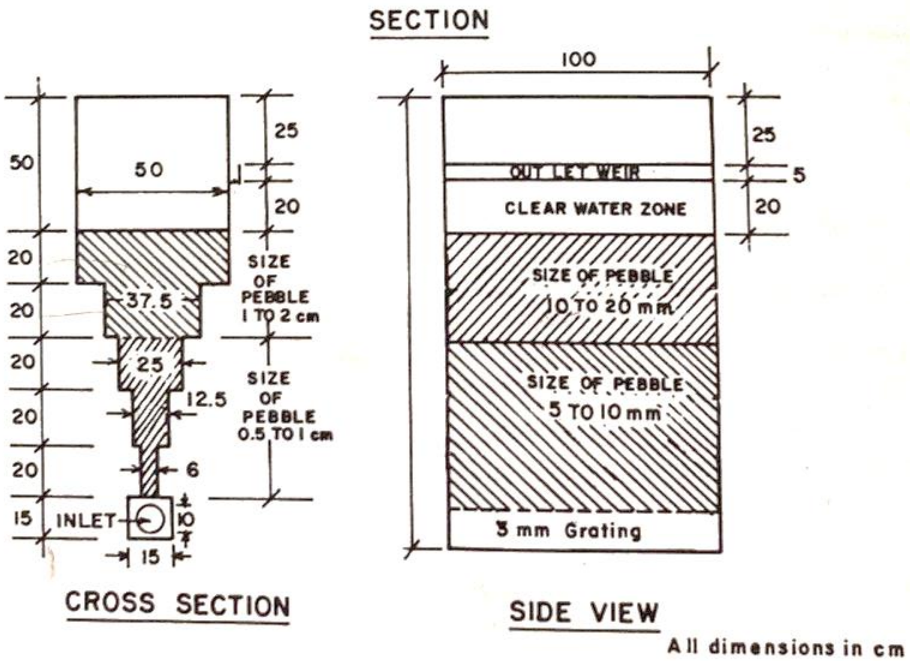


Ref : Small Community Water Supplies

➢ Gravel-bed Flocculator

Criteria

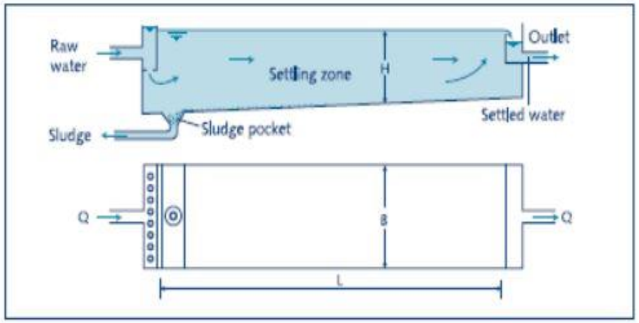
- Flow rate - 10~200 m3/h
- Velocity gradient
  - Rapid - 130~1230 s^{-1}
  - Slow - 35~40 s^{-1}
- Alum dose - 20~60 mg/L
- Flocculation time - 3~5 min
- Gravel size - 10~60 mm
- Raw water turbidity - 10~300 NTU
- Bed depth - 1.5~3 m
- Head loss - 0.01~0.2 m



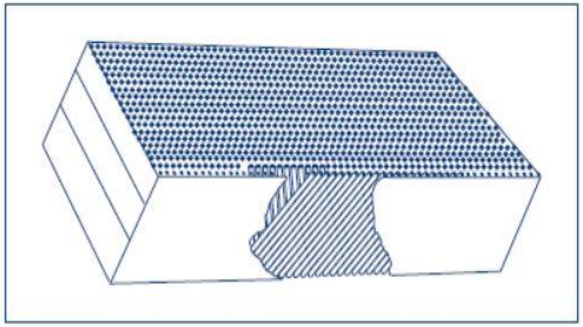
Ref : Water Treatment Processes

3. SEDIMENTATION

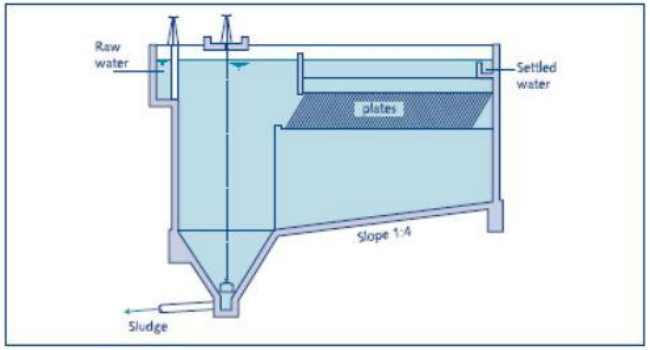
- **Plain Sedimentation Tank (Chemical Sedimentation Tank)**



- **Tube Settler**



- **Plate Settler**

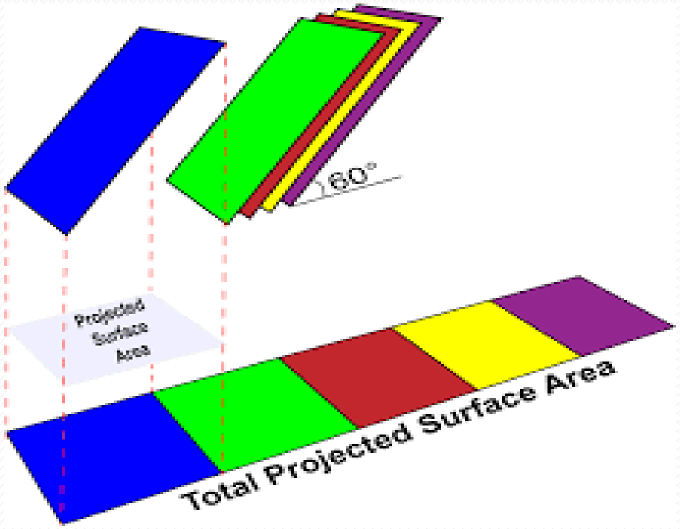


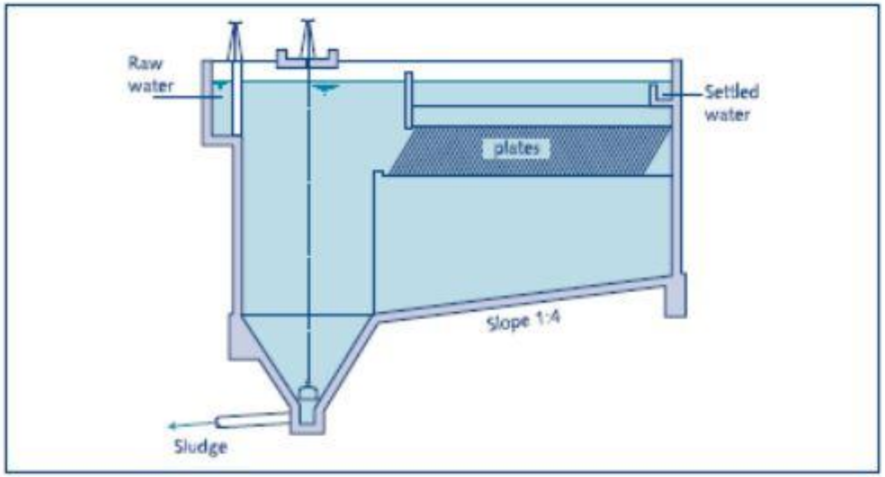
Ref : Small Community Water Supplies

➢ PLATE SETTLER

Criteria

- Typical loading rates - 0.3~1gpm/ft2
- (0.7~2 m/h)
- Overall basin loading - 2~6 gpm/ft2
- (5~15 m/h)
- Detention time - 30 min
- Plate settler angle of inclination - 35˚~60˚
- Gap between plates - 50~100 mm
- Liquid depth - 3~5 m





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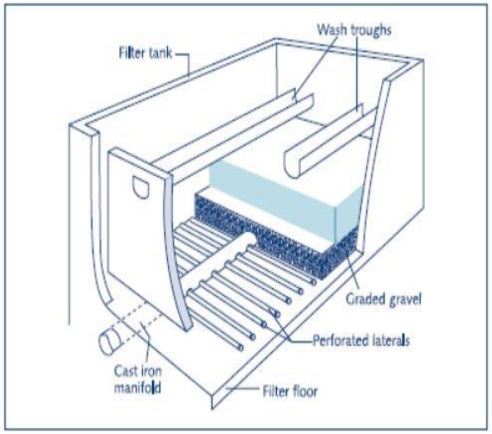
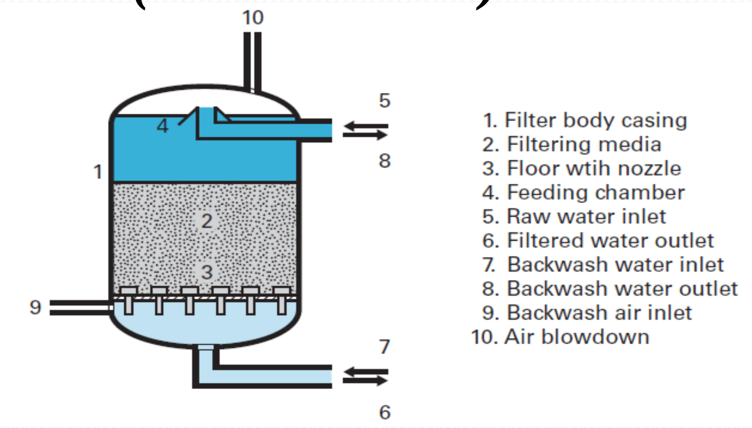
4. FILTRATION

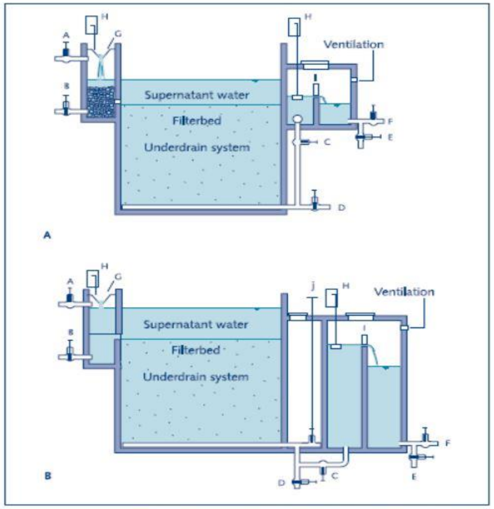
- **Rapid Sand Filter**
  (***Rapid Gravity Filter***)



- **Rapid Sand Filter**
  (Pressure Filter)



- **Slow Sand Filter**

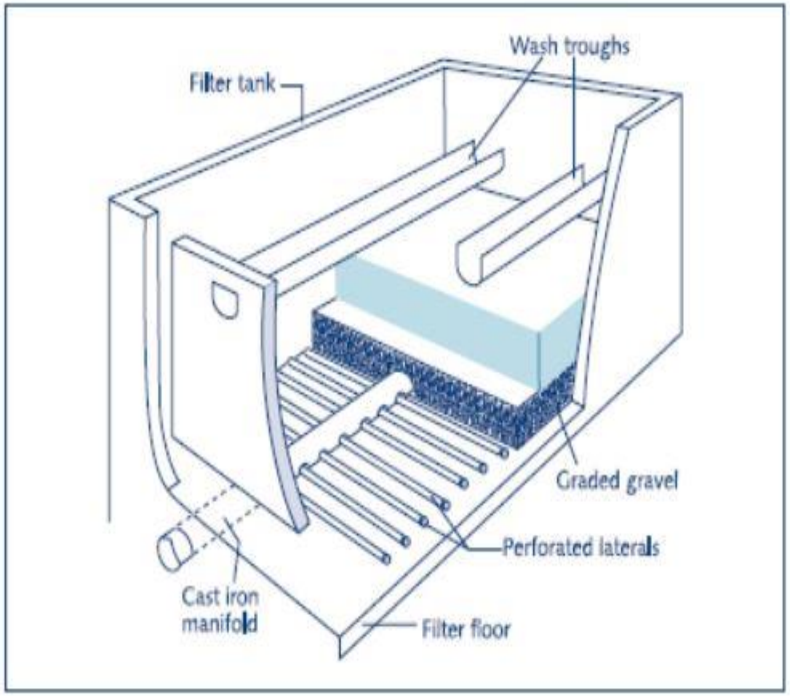


Ref : Small Community Water Supplies

➢ Rapid Sand Filter
(*Rapid Gravity Filter*)

<u>Criteria</u>

- Flow rate - $5\sim15\ m^3/m^2/h$
- Grain size - 0.4~1.2 mm
- Length- Width ratio - 1: (1.25~1.33)
- Length of filter run - 1~2 day



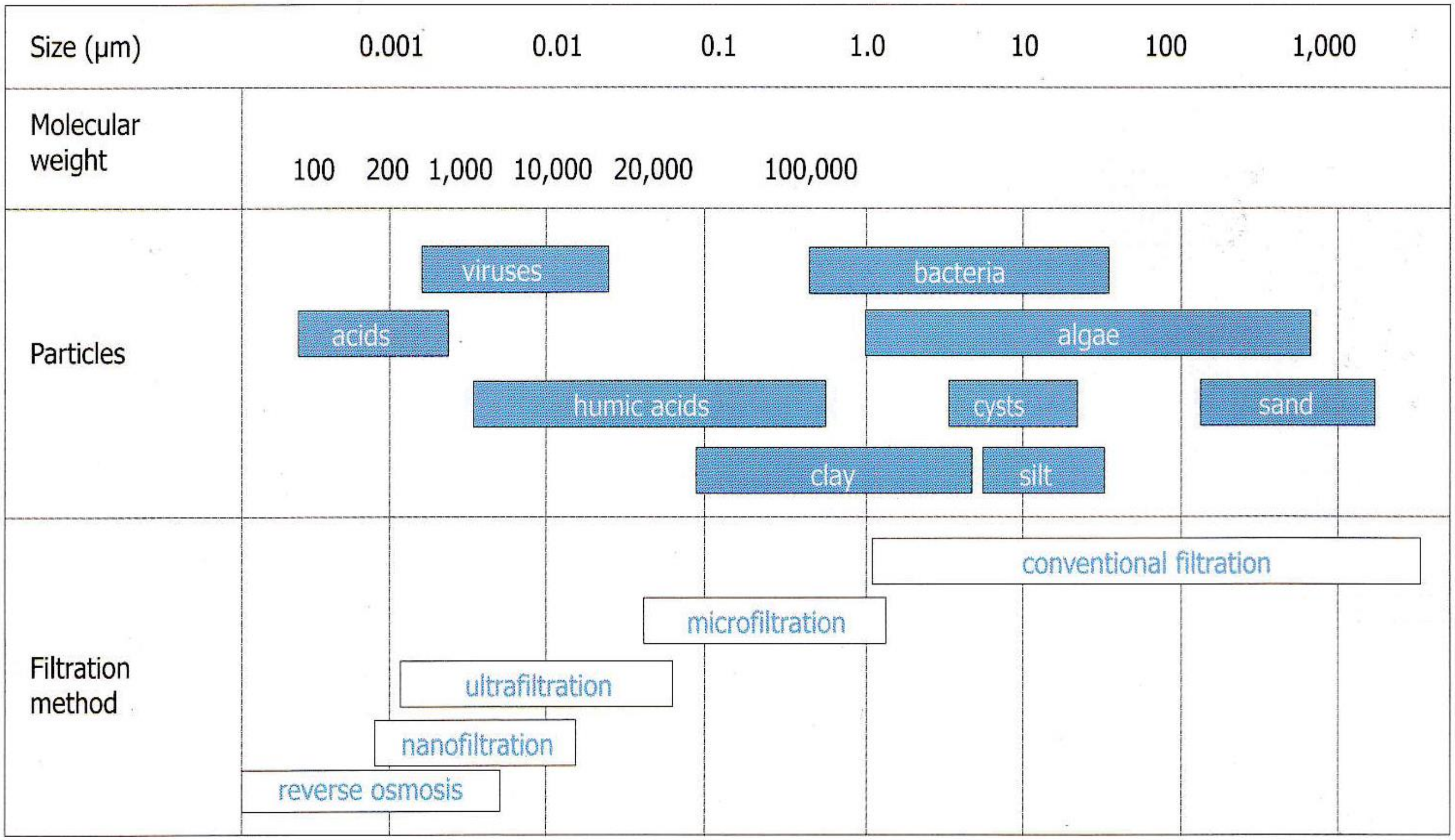
Ref : Small Community Water Supplies

COMPARISON OF SLOW SAND AND RAPID GRAVITY FILTERS

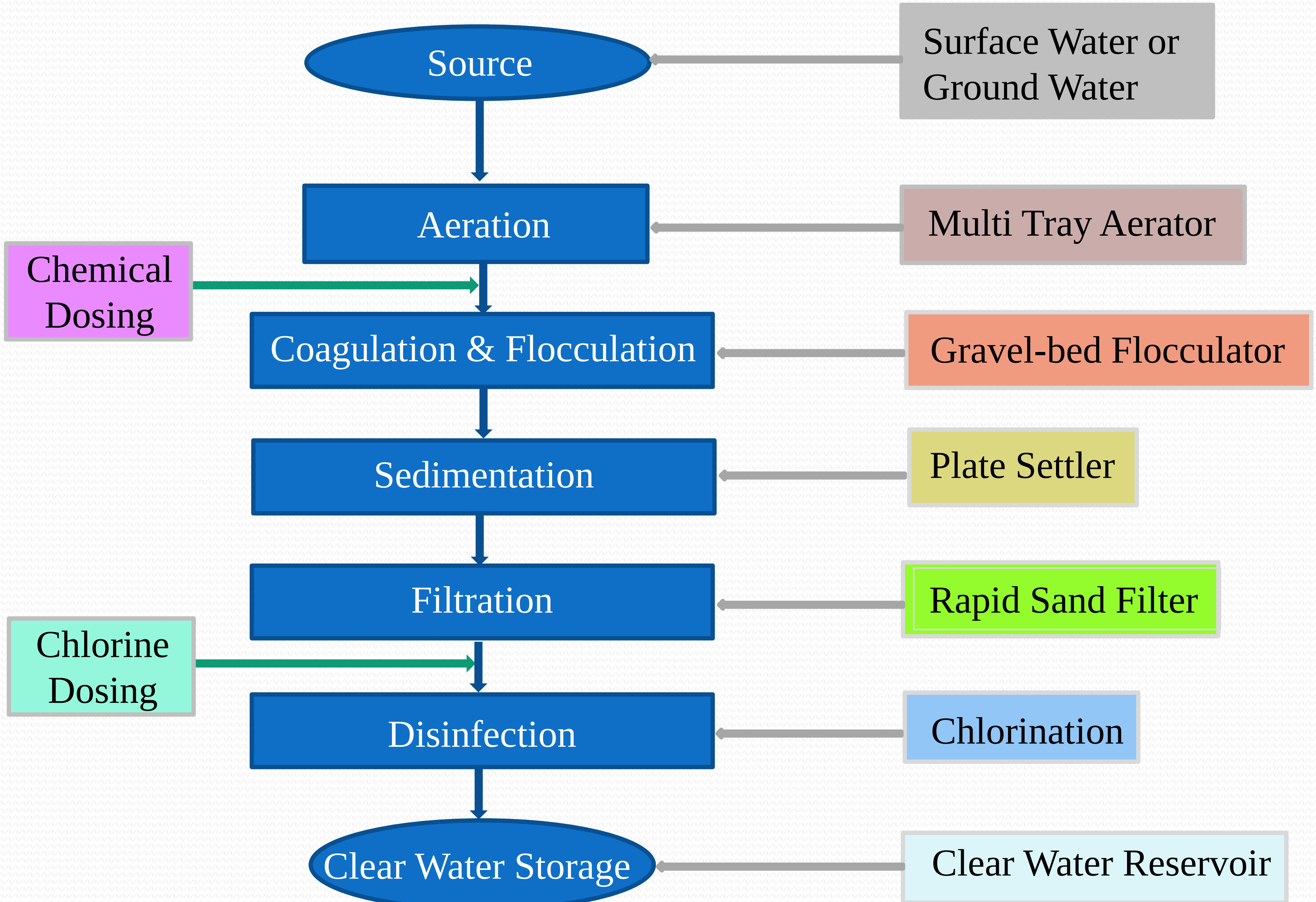
Sr.No	***Item***	***Slow Sand Filter***	***Rapid Gravity Filter***
1	Rate of Filtration	100 to 200 lit/hour/sq.m of filter area	3000 to 6000 liters/hour/ sqm. of filter area
2	Size of one unit	30m x 60m are varies from 500 to 2000 sq.m.	6m x 8m To 8m x 10m are varies from 40 to 80 sq.m
3	Depth of Filter Media	30cm.gravel 90-105cm. sand	45cm.grvel 75cm.or less sand.
4	Effective size of sand	0.25 to 0.35 mm. C_u=1.75	0.45 to 0.8mm. C_u=1.6
5	Distribution of Particles	Uniform	Stratified smallest at top coarsest at bottom
6	Under-drainage system	Open jointed pipes or covered drains	Strainer pipes, laterals discharging in C.I main.
7	Loss of head	9cm. initial to 1.2m final	0.3 m initial 2.1 m final
8	Length of run between cleanings	20-60 days	24-60 hours
9	Method of cleaning	Scrapping of surface and washing down by hoses	Scour by back washing and removal of dislodged particles by upward flow
10	Penetration of suspended matter	Very Small	Deep

Sr.No	Item	Slow Sand Filter	Rapid Gravity Filter
11	Amount of wash water used in cleaning	0.2 to 0.6% of water filter	1 to 4% of water filter
12	Preparatory treatment	Aeration alone or with flocculation and setting	Aeration flocculation and setting.
13	Cost of construction	Higher	Lower
14	Cost of operation	Lower	Higher
15	Depreciation of plant	Lower	Higher
16	Quality of raw water	It may not be treated with chemicals, but should not have turbidity more than 50 ppm.	Treatment with coagulants is essential.
17	Area	Very Large	Small Area
18	Construction	Simple	Complicated.
19	Flexibility in operation	Not possible	Possible
20	Skilled supervision	Not required	Most essential

APPLICATION FIELDS FOR MEMBRANE FILTRATION



COMPONENTS OF WATER TREATMENT PROCESS



DESIGN CALCULATION EXAMPLE

Given Data

Source	- Surface water or Ground water
Turbidity	- High NTU value
Iron & Manganese	- Highly Content
Design population	- 5000 inh:
Per Capita water supply	- 40 lpd *****
Power available duration	- 4 a.m. to 10 a.m. and 2 p.m. to 12 p.m.
Pumping hours	- 8 hrs (4 a.m. to 8 a.m. and 2 p.m. to 6 p.m.)
Peak factor	- 2.16 **
Peak hours	- 6 a.m. to 10 a.m., 1 p.m. to 2 p.m., 5 p.m. to 6 p.m.

Peak hours and hourly demands are as follow:

i. 20% of average hourly demand: 11 p.m. to 4 a.m.
ii. 40% of average hourly demand: 4 a.m. to 5 a.m. and 10 p.m. to 11 p.m.
iii. 60% of average hourly demand: 12 noon to 1 p.m.
iv. 70% of average hourly demand: 2 p.m. to 5 p.m. and 8 p.m. to 10 p.m.
v. 80% of average hourly demand: 5 a.m. to 6 a.m.
vi. 90% of average hourly demand: 6 a.m. to 8 a.m.
vii. 100% of average hourly demand: 10 a.m. to 12 noon

Water supply is continuous.

Continued Given Data

System Component	Design Capacity
Water source	Peak day water demand
Raw water main	Peak day water demand
* Treatment plant	Peak day water demand
Transmission main	Peak day water demand
Distribution system	Peak hour water demand

* For communities with population up to 20,000 and without flushing system;
1. Water supply through stand post – Min: 9 gpcd (40 Lpcd)…..(Ref : MNBC)

$Q_{\text{average day}}$ = Water demand x Population

$Q_{\text{peak day}} = 1.2 \times Q_{\text{average day}}$

$Q_{\text{average hour on peak day}} = \dfrac{Q_{\text{peak day}}}{24}$

** $Q_{\text{peak hour}} = 1.8 \times Q_{\text{peak day}}$

$= 1.8 \times 1.2 \times Q_{\text{average day}}$

$= 2.16 \times Q_{\text{average day}}$

In case of considering leakage percentage,

$$Q_{\text{peak hour}} = \frac{Q_{\text{average day}}}{f}\left(k_1\, k_2\, \frac{l}{100-l}\right)$$

f = Unit conversion factor

k_1 , k_2 = Constant

l = Leakage percentage

CALCULATION

- Total demand = 5000 x 40 L/d = 200,000 L/d
- Peak day demand* = 1.2 × 200,000 L/d = 240,000 L/d = 240 m^3/d
- Average hourly demand = 240/8 = 30 m^3/h (Note: 1 day = 8 hrs)
- Peak hour demand = 2.16 × average hourly demand = 2.16 × 25,000 L/h = 54,000 L/h = 54 m^3/h

➢ Receiving Tank

Population = 5000 Person
Peak day demand = 240 m^3/d
Pumping Hour = 8 hr
Design Flow = 30 m^3/hr
= 0.5 m^3/min

Choose,
Detention time = 1.5 min
Required Volume = 1.5 min × 0.5 m^3/min
= 0.75 m^3

Assume,
Length = 1.0 m
Width = 1.0 m
So, Height = 0.75 m

Ref : Small Community Water Supplies

➢ Aeration Tank

Inhabitant = 5000 Person
Water Demand = 40 lpcd
= 0.04 m^3/d
Pumping Hour = 8 hr
Design Flow = 30 m^3/hr

Assume,
Length = 1.0 m
Width = 1.0 m
Height of each Step = 0.3 m

Check,
Area = 1 m^2
Area/Flow = 0.033 m^2/m^3/hr
(Criteria 0.013~0.042 m^2/m^3/hr)

➢ **Gravel-bed Flocculator**

Design Flow, Q = 240 m^3/d

Using 2 units duty,

Q of each = 240/2 = 120 m^3 /d

= 15 m^3/h (Pumping Hour = 8 hr)

= 0.0042 m^3/s

Total volume of flocculator = 0.21 + 0.18 + 0.12 + 0.09 + 0.06

= 0.66 m^3

Nominal flocculation time, t $= \frac{V}{Q}$

$= \frac{0.66}{0.0042}$

= 157 s = 2.6 min (3~5 min)

Slow-mix for Gravel-bed flocculator

Section I

Area = 1m × 0.7m = 0.7 m^2

Face velocity, v = Q/A = 0.0042/0.7 = 0.00595 m/s

Continued Gravel-bed Flocculator

Reynolds Number, Rn $= d v \rho / \mu$

$$= \frac{(0.015 \times 0.00595 \times 998)}{1.01 \times 10^{-3}} = 88$$

Friction Factor, f $= 150 \left(\frac{(1-\alpha)}{Rn} \right) + 1.75$

$$= 150 \left(\frac{(1-0.4)}{88} \right) + 1.75$$

$$= 2.77$$

Head loss, h $= \frac{f}{\theta} \left(\frac{(1-\alpha)}{\alpha^3} \right) \frac{L}{d} \times \frac{v^2 L}{g}$

$$= \frac{2.77}{0.8} \times \left(\frac{(1-0.4)}{0.4^3} \right) \times \frac{0.3}{0.015} \times \frac{0.00595^2}{9.81}$$

$$= 0.0024 \text{ m}$$

Volume of Section (I) $= 0.21$ m3

Velocity Gradient, G $= \left(\frac{h \rho g Q}{\mu \alpha V} \right)^{1/2}$

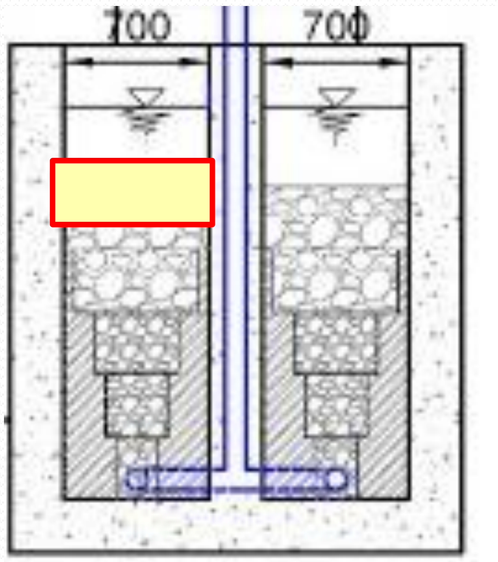
$$= \left(\frac{0.0024 \times 998 \times 9.81 \times 0.0042}{1.01 \times 10^{-3} \times 0.4 \times 0.21} \right)^{1/2}$$

$$= 34 \text{ s}^{-1}$$

Continued Gravel-bed Flocculator

Summary

Section-1	h = 0.0023 m	G = 34 s^{-1}
Section-2	h = 0.003 m	G = 41 s^{-1}
Section-3	h = 0.015 m	G = 113 s^{-1}
Section-4	h = 0.024 m	G = 165 s^{-1}
Section-5	h = 0.048 m	G = 285 s^{-1}



Length	Width	Height
(m)	(m)	(m)
1.0	0.70	0.3
1.0	0.60	0.3
1.0	0.40	0.3
1.0	0.30	0.3
1.0	0.20	0.3

Ref : Water Treatment Processes

Gravel-Bed Flocculator Design Calculation (5000 Capita)

f	θ	α	L	d	v	g	f/θ	$(\frac{1-\alpha}{\alpha^3})$	L/d	v^2/g	h
	m3/min		(m)	(m)	(m/s)	(m/sq.s)					(m)
2.77	0.8	0.4	0.3	0.015	0.0059524	9.8	3.4626503	9.375	20	0.00000362	0.002347
2.62	0.8	0.4	0.3	0.015	0.0069444	9.8	3.28048597	9.375	20	0.00000492	0.003027
2.92	0.8	0.4	0.3	0.0075	0.0104167	9.8	3.64481463	9.375	40	0.00001107	0.015133
2.62	0.8	0.4	0.3	0.0075	0.0138889	9.8	3.28048597	9.375	40	0.00001968	0.024215
2.33	0.8	0.4	0.3	0.0075	0.0208333	9.8	2.91615731	9.375	40	0.00004429	0.048432

Gravel size, d		Velocity, v	ρ	μ	dvρ	Rn
(in)	(m)	(m/s)	(kg/cu.m)	(kg/m.s)		
0.59058	0.015	0.00595	998	0.00101	0.0891071	88
0.59058	0.015	0.00694	998	0.00101	0.1039583	103
0.29529	0.0075	0.01042	998	0.00101	0.0779688	77
0.29529	0.0075	0.01389	998	0.00101	0.1039583	103
0.29529	0.0075	0.02083	998	0.00101	0.1559375	154

α	Rn	$\frac{1-a}{Rn}$	f
0.4	88.2	0.006800802	2.77
0.4	102.9	0.005829259	2.62
0.4	77.2	0.007772345	2.92
0.4	102.9	0.005829259	2.62
0.4	154.4	0.003886172	2.33

Length	Width	Height	Area	Volume	Flow, Q	Velocity, v
(m)	(m)	(m)	(sq.m)	(cu.m)	(cu.m/s)	(m/s)
1.0	0.70	0.3	0.70	0.21	0.0042	0.00595
1.0	0.60	0.3	0.60	0.18	0.0042	0.00694
1.0	0.40	0.3	0.40	0.12	0.0042	0.01042
1.0	0.30	0.3	0.30	0.09	0.0042	0.01389
1.0	0.20	0.3	0.20	0.06	0.0042	0.02083
			Total	0.66		

Nominal Flocculation Time	Unit	
158	sec	
2.6	min	(3~5 min)

Capital	Design Flow (cum/d)	Pumping hour (hour/day)
5000	240	8
	120	(Using 2 units)

h	ρ	g	Q	μ	α	V	hρgQ	μαV	hρgQ/μαV	$G = (hrgQ/\mu\alpha V)^{\frac{1}{2}}$	
(m)	(kg/cu.m)	(m/sq.s)	(cu.m/s)	(kg/m.s)		(cu.m)				(sec^{-1})	
0.002347	998	9.8	0.0042	0.00101	0.4	0.21	0.09565565	0.00008484	1127	34	35~40
0.003027	998	9.8	0.0042	0.00101	0.4	0.18	0.12334847	0.00007272	1696	41	35~40
0.015133	998	9.8	0.0042	0.00101	0.4	0.12	0.61671363	0.00004848	12721	113	130~1230
0.024215	998	9.8	0.0042	0.00101	0.4	0.09	0.98678777	0.00003636	27139	165	130~1230
0.048432	998	9.8	0.0042	0.00101	0.4	0.06	1.97369046	0.00002424	81423	285	130~1230

Can be calculated as follow;

Length	Width	Height
(m)	(m)	(m)
1.0	0.70	0.3
1.0	0.60	0.3
1.0	0.40	0.3
1.0	0.30	0.3
1.0	0.20	0.3

Area	Volume	Flow, Q	Velocity, v
(sq.m)	(cu.m)	(cu.m/s)	(m/s)
0.70	0.21	0.0042	0.00595
0.60	0.18	0.0042	0.00694
0.40	0.12	0.0042	0.01042
0.30	0.09	0.0042	0.01389
0.20	0.06	0.0042	0.02083
Total	0.66		

Nominal Flocculation Time	Unit	
158	sec	
2.6	min	(3~5 min)

Capital	Design Flow (cum/d)	Pumping hour (hour/day)
5000	240	8
	120	(Using 2 units)

Gravel size, d		Velocity, v	ρ	μ	dvr	Rn
(in)	(m)	(m/s)	(kg/cu.m)	(kg/m.s)		
0.59058	0.015	0.00595	998	0.00101	0.0891071	88
0.59058	0.015	0.00694	998	0.00101	0.1039583	103
0.29529	0.0075	0.01042	998	0.00101	0.0779688	77
0.29529	0.0075	0.01389	998	0.00101	0.1039583	103
0.29529	0.0075	0.02083	998	0.00101	0.1559375	154

α	Rn	$\frac{1-a}{Rn}$	f
0.4	88.2	0.006800802	2.77
0.4	102.9	0.005829259	2.62
0.4	77.2	0.007772345	2.92
0.4	102.9	0.005829259	2.62
0.4	154.4	0.003886172	2.33

f	θ	α	L	d	v	g	f/q	$(\frac{1-\alpha}{\alpha^3})$	L/d	v^2/g	h
	m3/min		(m)	(m)	(m/s)	(m/sq.s)					(m)
2.77	0.8	0.4	0.3	0.015	0.0059524	9.8	3.4626503	9.375	20	0.00000362	0.002347
2.62	0.8	0.4	0.3	0.015	0.0069444	9.8	3.28048597	9.375	20	0.00000492	0.003027
2.92	0.8	0.4	0.3	0.0075	0.0104167	9.8	3.64481463	9.375	40	0.00001107	0.015133
2.62	0.8	0.4	0.3	0.0075	0.0138889	9.8	3.28048597	9.375	40	0.00001968	0.024215
2.33	0.8	0.4	0.3	0.0075	0.0208333	9.8	2.91615731	9.375	40	0.00004429	0.048432

h	ρ	g	Q	μ	α	V	hrgQ	maV	hrgQ/maV	$G = (hrgQ/\mu\alpha V)^{\frac{1}{2}}$
(m)	(kg/cu.m)	(m/sq.s)	(cu.m/s)	(kg/m.s)		(cu.m)				(sec^{-1})
0.002347	998	9.8	0.0042	0.00101	0.4	0.21	0.09565565	0.00008484	1127	34
0.003027	998	9.8	0.0042	0.00101	0.4	0.18	0.12334847	0.00007272	1696	41
0.015133	998	9.8	0.0042	0.00101	0.4	0.12	0.61671363	0.00004848	12721	113
0.024215	998	9.8	0.0042	0.00101	0.4	0.09	0.98678777	0.00003636	27139	165
0.048432	998	9.8	0.0042	0.00101	0.4	0.06	1.97369046	0.00002424	81423	285

➢ **Plate Settler**

Flow, Q = 30 m^3/h

Detention time = 30 min

Tank Volume $= \dfrac{(30 \times 30)}{60} = 15\ m^3$

Assume liquid depth = 2 m

Surface area of tank = 15/2 = 7.5 m^2

For Plates Design

Total flow rate = 30 m^3/h

Surface loading = 1 m/h (0.7~2 m/h)

Required area of plate =30/1 = 30 m^2

Size of plate = 1.2 m × 1.2 m (0.8 mm thick)

Angle of inclination = 55°

Projection area of plate $= 1.2 \times 1.2 \cos 55^\circ \times 0.9 = 0.74\ m^2$

(Considering 90% efficiency)

No: of plate required = 30/0.74 = 40 Nos

Continued Plate Settler

Using 2 units duty,

Nos of plates of each = 40/2 = 20 Nos

Assume gap between plate = 61 mm

Length of clarifier = $(19 \times 0.061) + (20 \times 0.008) + 1.2 \cos 55^\circ$

= 2.00m

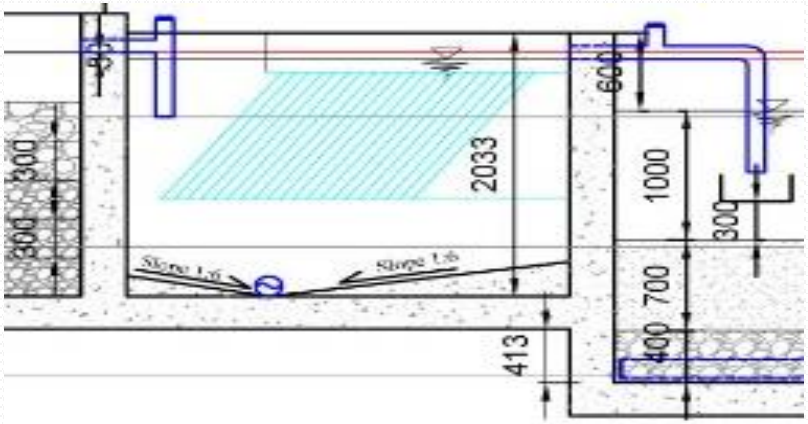
Total length of settler = 0.25 m + 2.00 m + 0.25 m

= 2.5 m

Width of settler = $1.2 \text{ m} \times 2 = 2.4$ m

Surface Area provided = $2.5 \text{ m} \times 2.4 \text{ m} = 6.0 \text{ m}^2 < 7.5 \text{ m}^2$ (Required Area)

Actual overall basin loading = 30/6.0 = 5.0 m/h (5~15 m/h) (OK)



Ref: Water Supply, Waste Disposal and Environmental Engineering By A.K. Chatterjee

Rapid Sand Filter

(a) Design Water Treatment Capacity required,

Q = Domestic + 3% For back washing

$= 30\ m^3/h + 0.9\ m^3/h$

$= 30.9\ m^3/h$

(b) Using (2) Units

For each (1) unit $= 30.9/2 = 15.45\ m^3/h$

$= 15.45\ m^3/h$

(c) Filtration Rate $= 6\ m/h$

Required Area for Filter Unit $= (15.45\ m^3/h)/(6\ m/h)$

$= 2.575\ m^2$

Assume, (L/B) Ratio = 1:1

Length $= \sqrt{2.575}$

$L = B = 1.6\ m$

Continued Rapid Sand Filter

(d) Under Drain Design System

Total area of perforation = 0.2 % of total filter area

= 0.2/100 × (1.6m x 1.6m)

= 0.00512 m^2

(Note: 13 mm Ø Dia perforation)

(e) The area of manifold would be (4) times the total area of perforation

Manifold Area = 4 × 0.00512 m^2

= 0.02048m^2

Diameter Of Manifold Pipe, $A = \pi d^2/4$

$\pi d^2/4 = 0.02048$

$d^2 = (0.02048 \times 4)/\pi$

$= 0.026076$

$d = \sqrt{0.026076}$

= 0.161 m Ø = 150 mm Ø

Say, d = 150 mm Ø

Continued Rapid Sand Filter

(f) Laterals may be assumed to have a spacing of 20 cm (Maximum 30 cm)

Therefore, Total no of Laterals = (1.6m x 100cm)/20cm = 8 Nos

Therefore, Both Side of Manifold = 8 Nos × 2

= 16 Nos

(g) Length of a Lateral, = 1/2 × width of filter - 1/2 × dia of manifold

= (1.6m x 100cm)/2 - (15cm)/2

= 80 cm – 7.5 cm

= 72.5 cm

= 0.725 m

(h) Let 'N' be the total no of perforation of 13 mm dia,

Total area of perforation = 0.00512 m^2

= 51.2 cm^2

$N \times \pi d^2/4$ = 51.2 cm^2

N = $(51.2 \times 4)/ \pi d^2$

= 39 Nos

Continued Rapid Sand Filter

(i) Area of perforation

13 mm Dia , Area $= \pi d^2/4$

$= (3.14 \times (1.3)^2)/4$

$= 1.3266\ cm^2$

Say, $= 1.33\ cm^2$

(j) No of perforation per lateral,

(total no of perforation)/(total no of laterals)= (39 Nos)/(16 Nos)

= 2.43 Nos

= 3 Nos

(k) Area of perforation per lateral,

$= 2.5\ Nos \times 1.33\ cm^2$

$= 3.325\ cm^2$

(l) Area of lateral = 3 x area of perforation per lateral

$= 3 \times 3.325\ cm^2$

$= 9.975\ cm^2$

Continued Rapid Sand Filter

Dia of Lateral,

$\pi d^2/4 = 9.975\ cm^2$

$d^2 = (9.975 \times 4)/\pi = 12.70$

$d = \sqrt{12.7} = 3.56$ cm

$d = 35.6$ mm Ø

Use, $d = 40$ mm Ø , (4 cm)

Check,

(Length of lateral)/(Dia of lateral) = (72.5 cm)/(4 cm)

= 18.125 (18.125 < 60) (ok)

Assume rate of washing = 45 cm/min

= 0.45 m/min = 27 m/hr

Therefore, Volume of w/water discharge in,

$Q = AV$

$= (1.6 \times 1.6)\ m^2 \times 27$ min /hr

$= 69.12\ m^3/hr = 1.152\ m^3/min$

$= 0.0192\ m^3/s$

Continued Rapid Sand Filter

Therefore,

Velocity of lateral, v = Q/A

$= (0.0192\ m^3/s)/(16 \times \pi d^2/4)$

$= (0.0192\ m^3/s)/(16 \times \pi /4 \times (40/1000)^2)$

$= (0.0192\ m^3/s)/(0.020096)$

$= 0.955\ m/s$

Velocity of flow in manifold, v = (Q)/A

$= (0.0192\ m^3/s)/0.02048 m^2$

$= 0.9375\ m/s$

This velocity of flow in manifold is less than (1.8 ~ 2.4 m/s) (maximum permissible)

Wash water trough

Trough are generally not more than 1.8m apart.

Therefore, No of troughs = (1.6 m)/1.8m

= 0.88 Nos, Say = 1 No

Discharge per trough $= (0.0192\ m^3/s)/(1\ No)$

$= 0.0192\ m^3/s$

Continued Rapid Sand Filter

For a flat bottom trough, Q $= 0.76\ b\ y^{3/2}$

b = width of trough in (m)

y = depth of water at the upper end of trough in (m)

Let b = 0.4 m (width of trough)

Q = 0.76 b y3/2

$y^{3/2}$ = (Q)/0.76 × b = $(0.0192\ m^3/s)/(0.76 \times 0.4)$

$y^{3/2}$ = 0.0192/0.304

y = 0.158 m (Say 0.16 m)

In case cleaning one unit,

When 1 unit is in cleaning process and only 1 unit is in operation,

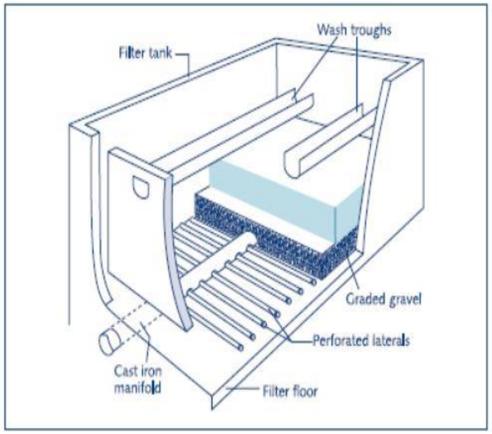
Total flow, Q = $30\ m^3/h$

Area of each filter = $1.6 \times 1.6 = 2.56\ m^2$

Total area = $2 \times 2.56 = 5.12\ m^2$

Actual filtration rate = $(30\ m^3/h)/(5.12\ m^2)$

= 5.85 m/h (5 ~ 7.5 m/h) (OK)



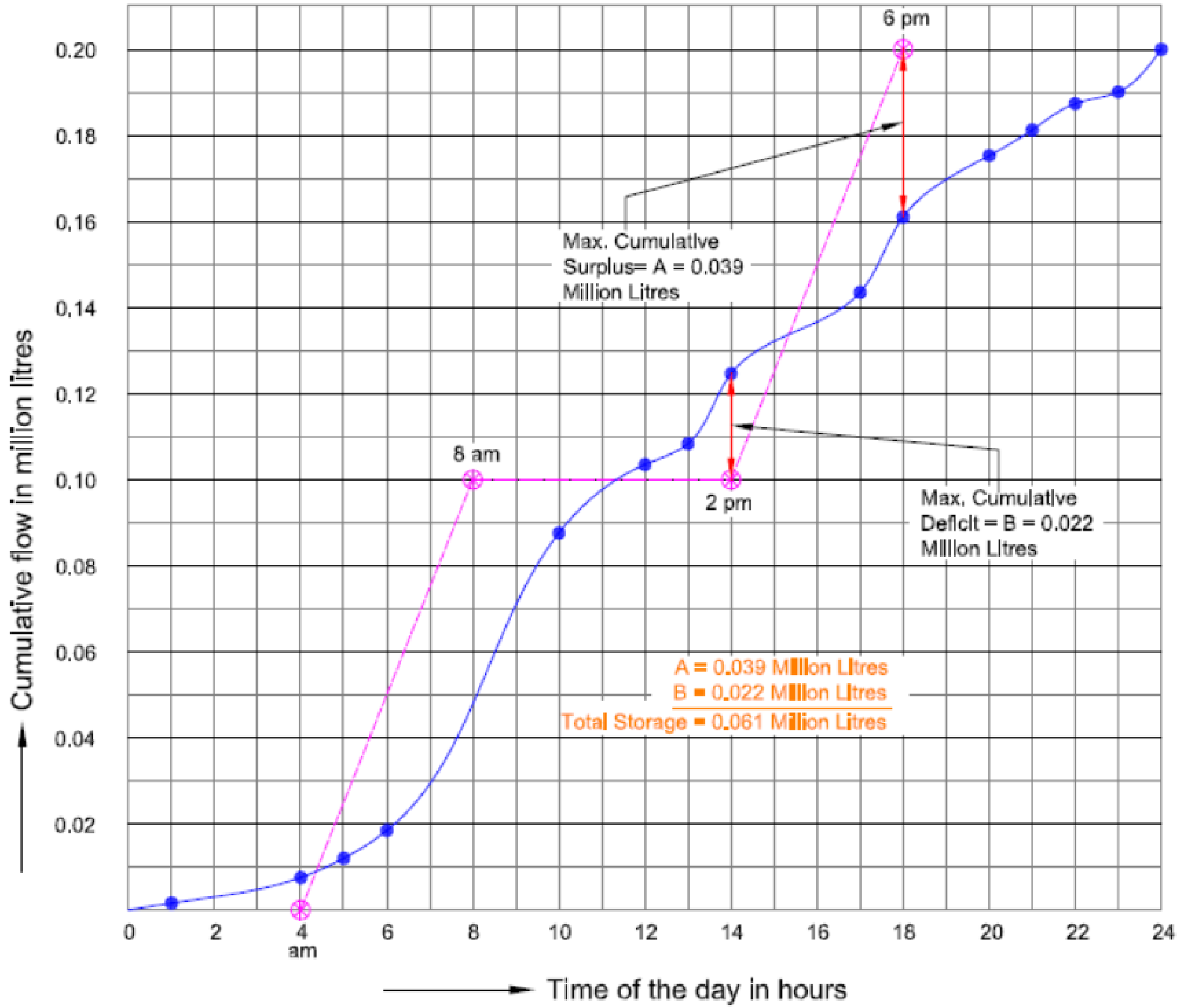
Ref : Elements of Public Health Engineering

➢ Storage Reservoir

Calculation Table for Average Hourly Demand

COMPUTATION FOR CAPACITY OF SERVICE RESERVOIR									
Given Data						8 Hours Pumping Rate			
Period in Hours	Total Hour	Hourly Demand		Cumulative Demand		Cumulative Pumping		Cumulative deficit or surplus	
(1)	(2)	(3)		(4) = Σ (3)		(5)		(6) = (5) - (4)	
04-05	1	0.55	a	0.55	a	3.00	a	2.46	a
05-06	1	0.80	a	1.35	a	6.00	a	4.66	a
06-10	4	2.16	a	9.99	a	12.00	a	2.02	a
10-12	2	1.00	a	11.99	a	12.00	a	0.01	a
12-13	1	0.60	a	12.59	a	12.00	a	-0.59	a
13-14	1	2.16	a	14.75	a	12.00	a	-2.75	a
14-17	3	0.75	a	17.00	a	21.00	a	4.01	a
17-18	1	2.16	a	19.16	a	24.00	a	4.85	a
18-20	2	0.90	a	20.96	a	24.00	a	3.05	a
20-21	1	0.75	a	21.71	a	24.00	a	2.30	a
21-22	1	0.75	a	22.46	a	24.00	a	1.55	a
22-23	1	0.40	a	22.86	a	24.00	a	1.15	a
23-01	2	0.20	a	23.26	a	24.00	a	0.75	a
01-04	3	0.25	a	24.00	a	24.00	a	0.00	a

➢ Demand Curve for 5000 Population



DEMAND CURVE (5000 POPULATION)

SOLUTION (FOR 5000 POPULATION):

- Total Demand = 5000 x 40 lpd = 200000 lpd = 0.20 mld
- Average Hourly Demand = 0.20/24 = 0.008 ml = a
- Peak Hourly Demand = 2.16 x Average Hourly Demand = 2.16 a

CAPACITY OF SERVICE RESERVOIR (5000 PE)

Pumping hours	Maximum Cumulative surplus	Maximum Cumulative deficit	Capacity of Storage Reservoir	Capacity of Storage Reservoir in ml (a=0.008 ml)
8	4.85a	2.75a	7.6a	0.061

➢ Calculation for Size of Service Reservoir

Required Volume $= 61\ m^3$

$= 2155\ ft^3$

Assume Depth $= 8$ ft

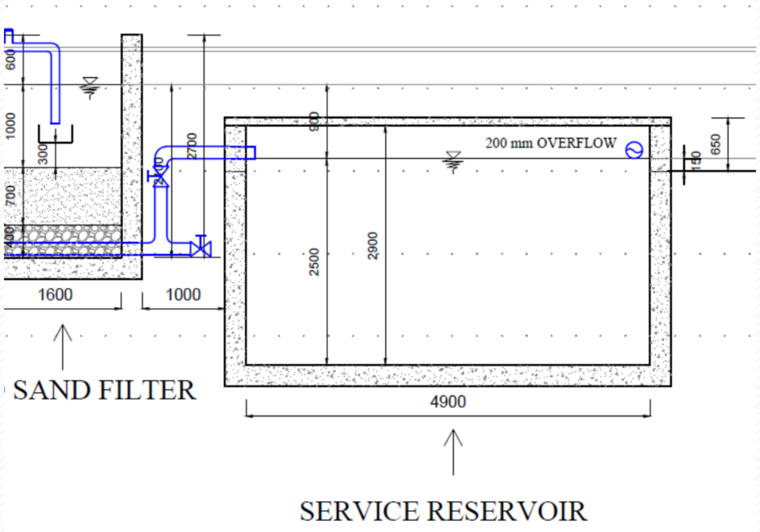
Required Area $= 2155/8$

$= 269.4\ ft^2$

Take L=B $= \sqrt{269.4}$

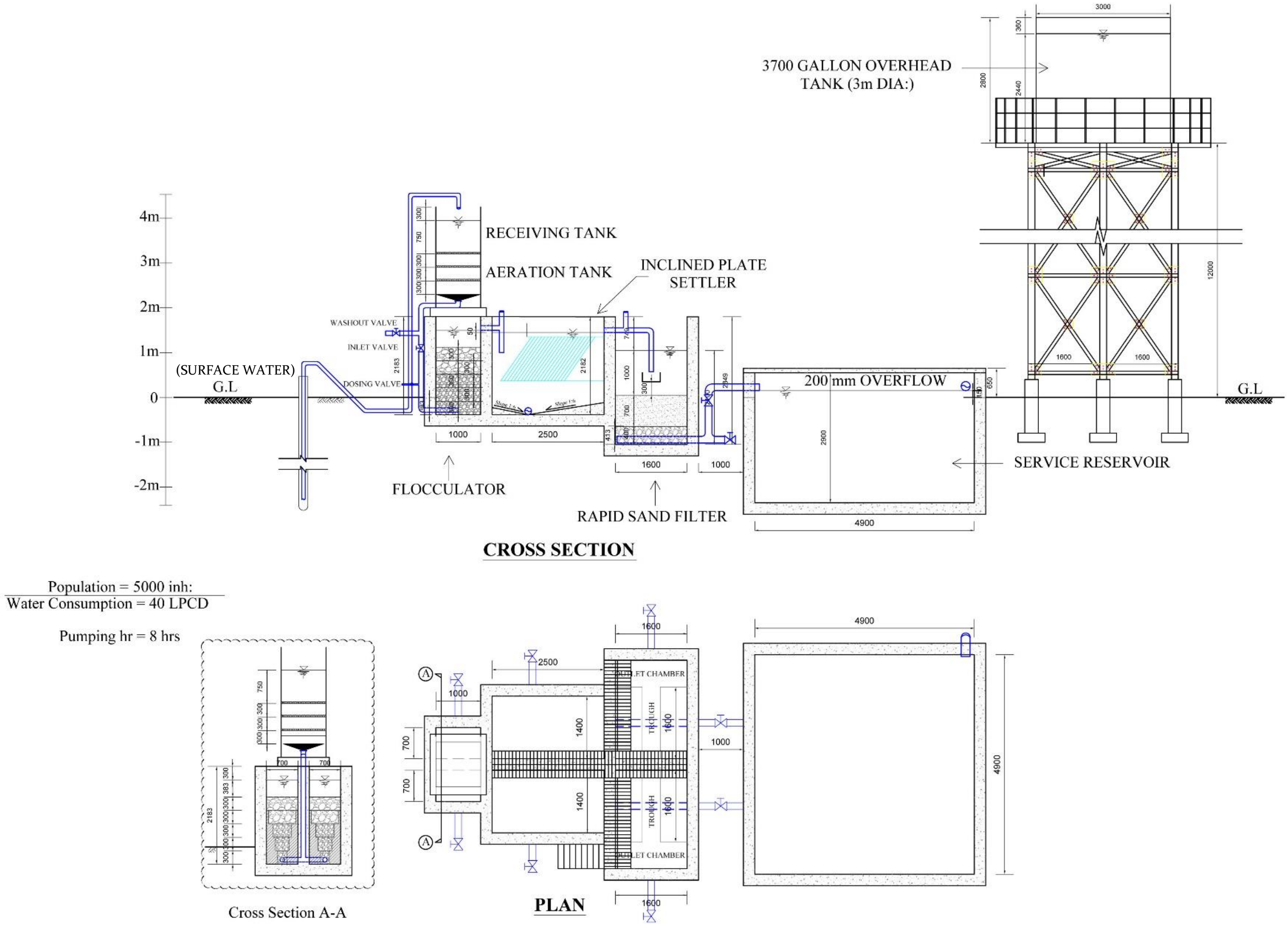
$= 16.4$ ft (Say 16 ft)

Tank Dimension = 16 ft × 16 ft × 8 ft (Free board 1.5 ft)

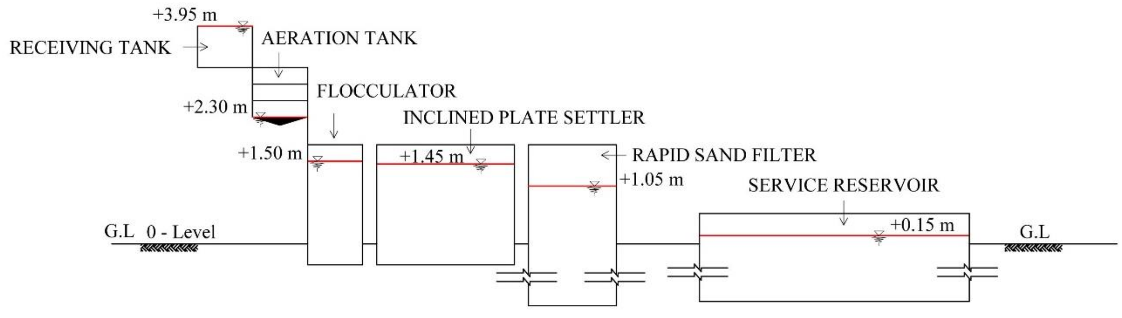


Ref : Compilation of Water Supply and Treatment

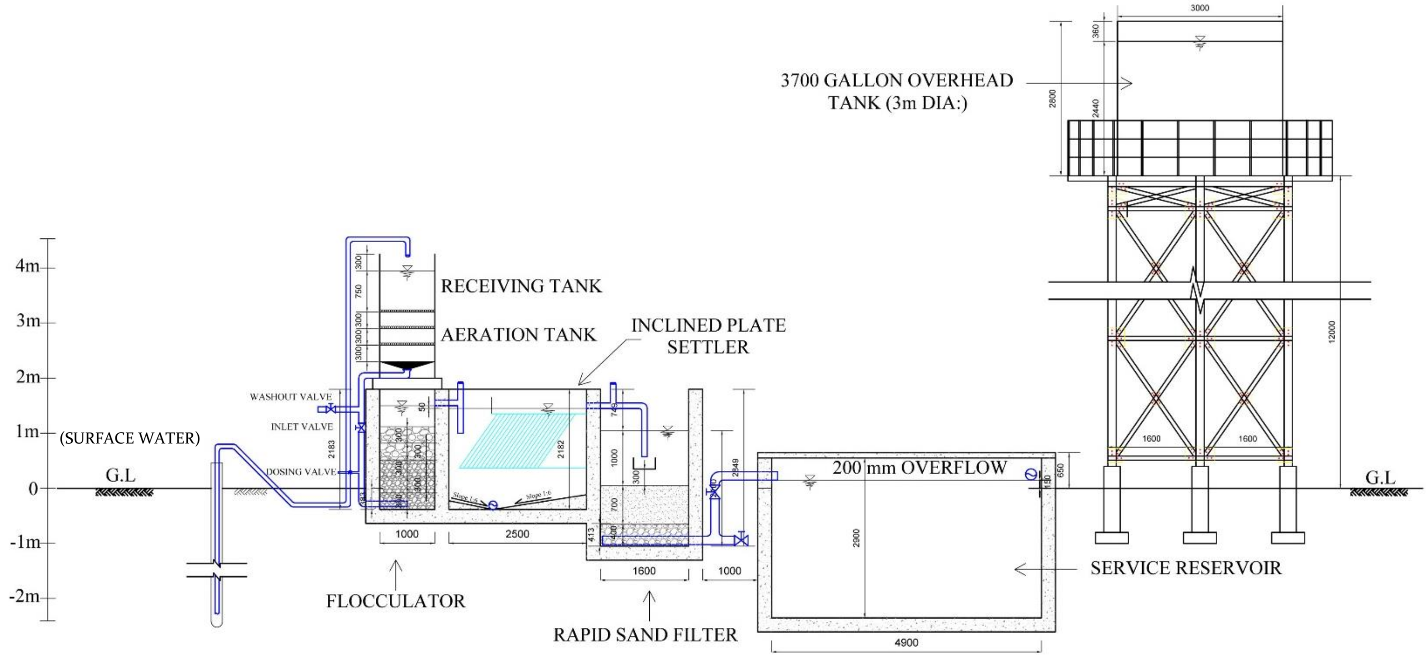
WATER TREATMENT PLANT PLAN & SECTION



WATER TREATMENT PLANT PLAN & SECTION

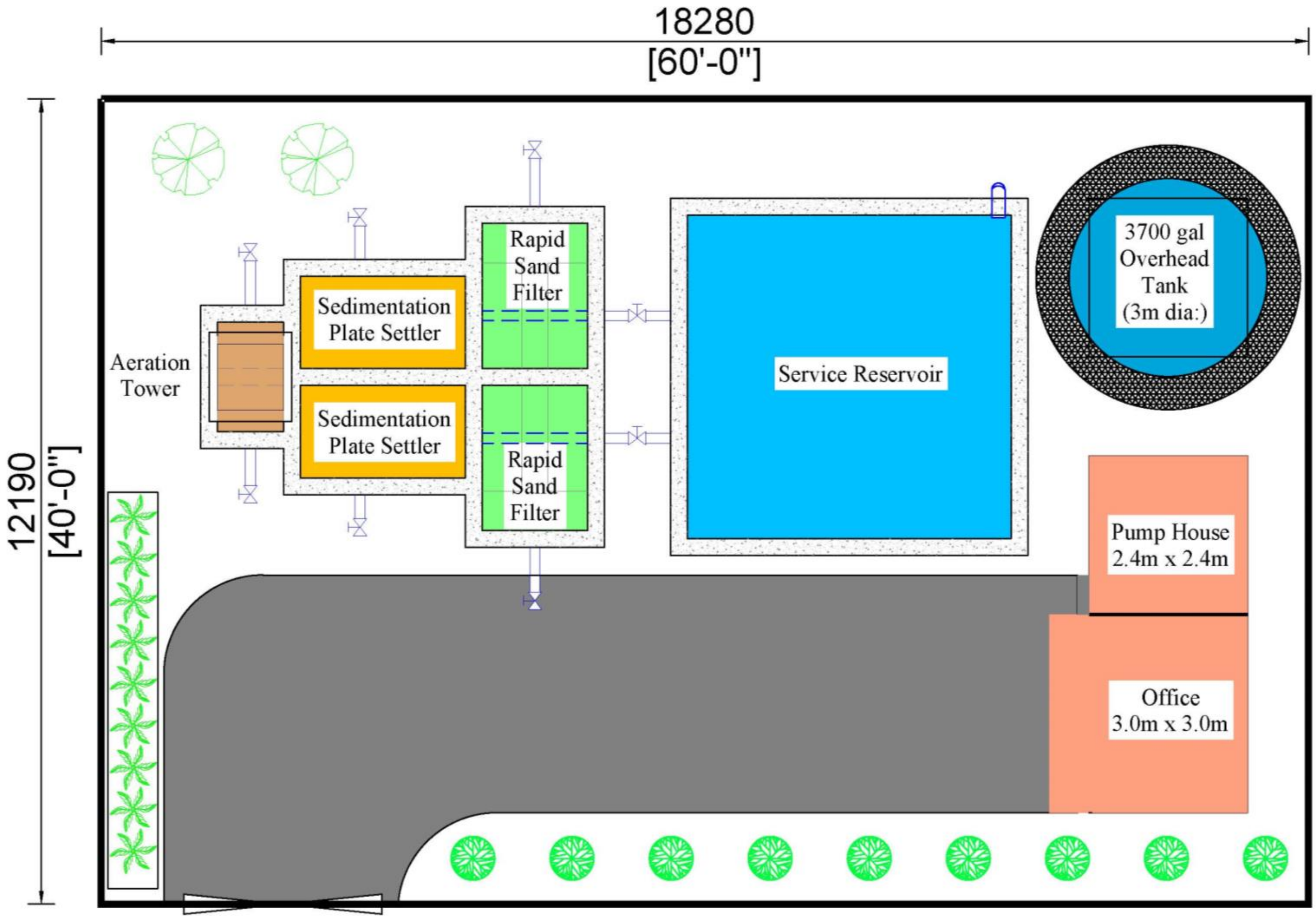


DIFFEERENCE WATER LEVEL (HYDRAULIC PROFILE) OF FILTER PLANT



CROSS SECTION

WATER TREATMENT PLANT LAYOUT



LAYOUT PLAN OF TREATMENT PLANT (DRAFT)

REFERENCE BOOKS

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Santosh Kumar Garg

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6) **Compilation of Water Supply and Treatment**
Akalank's Publications (India)

7) **Surface Water Treatment for Communities in Development Counties**
Christopher R.Schulz and Daniel A.Okun

THANK YOU

FOR YOUR TIME & INTEREST