Standard Operating Procedure

Operation of Bansbari Water Treatment Plant

(As of 2023/12/25)

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1. Overview of the facility

1.1 General Information

(1) Facility Name: Water Treatment Plant of the Maharajgunj Branch

(2) Facility type: Surface and Ground water treatment plant

(3) Establishment: 1994

(4) Water Source: Surface water from Shivapuri and Bishnumati and ground water from BB0, BB1, BB2 wells in the vicinity of the treatment plant area

(5) Capacity: 25 MLD (Design)
20.1 MLD (Actual)

(6) Access: 700m (3 mins drive) from Narayangopal Chowk, Ring Road

(7) Objective: Removal of ammonia, turbidity, organic matter, bacteria, and other harmful matter

1.2 Components of the process

There are seven (7) unit process in Bansbari WTP as outlined below:

1. Bio filter process and caustic soda feeding equipment
2. Flocculation and Sedimentation basins, PAC and slaked lime feeding equipment
3. Rapid Sand Filter (RSF)
4. Clear Water Reservoir (CWR) and Transmission pump equipment
5. Sludge and drainage equipment
6. Sodium hypochlorite generator and feeding, bleaching powder feeding equipment
7. Water quality testing laboratory

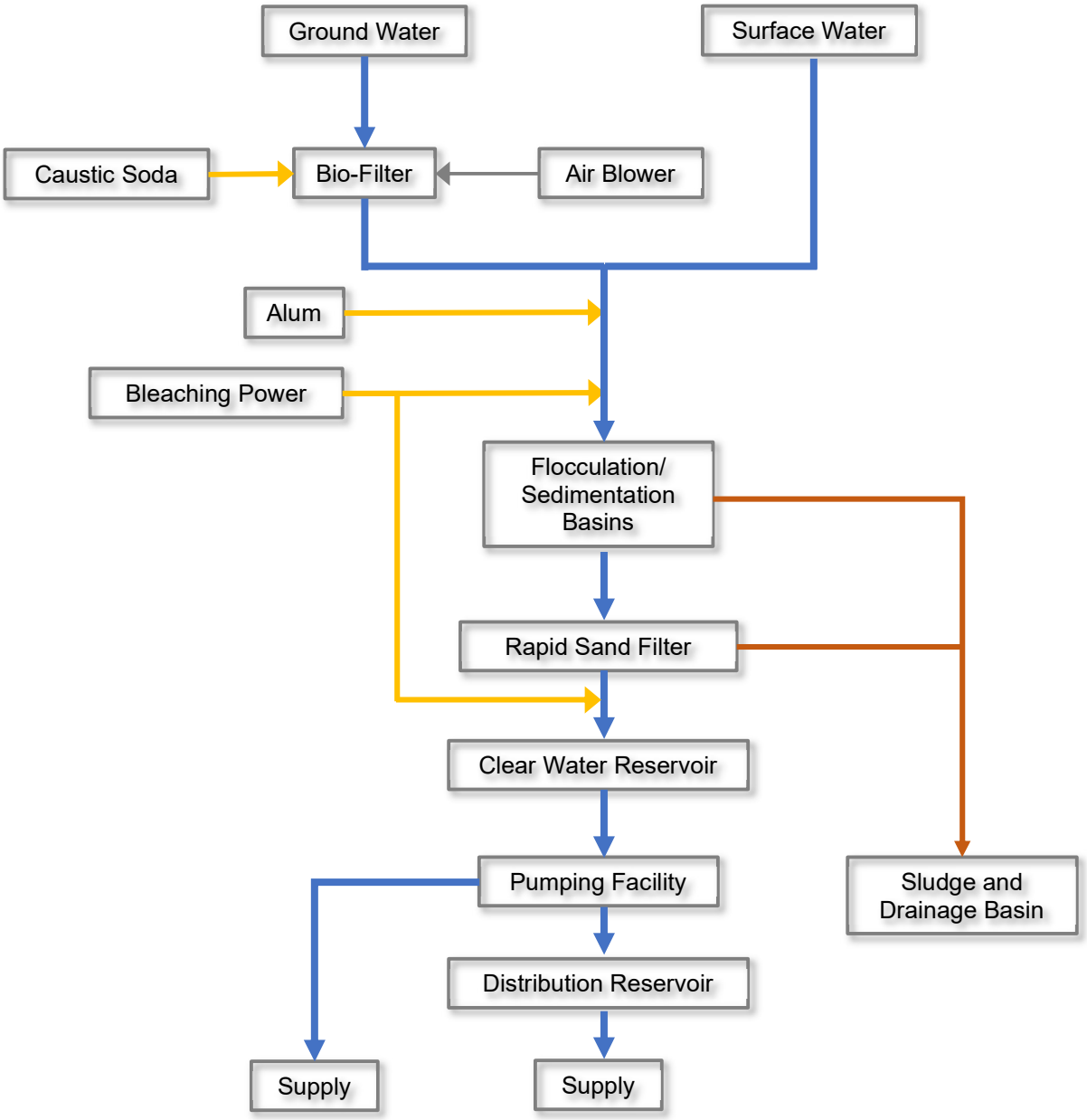


Figure 1: Schematics of Bansbari Water Treatment Plant

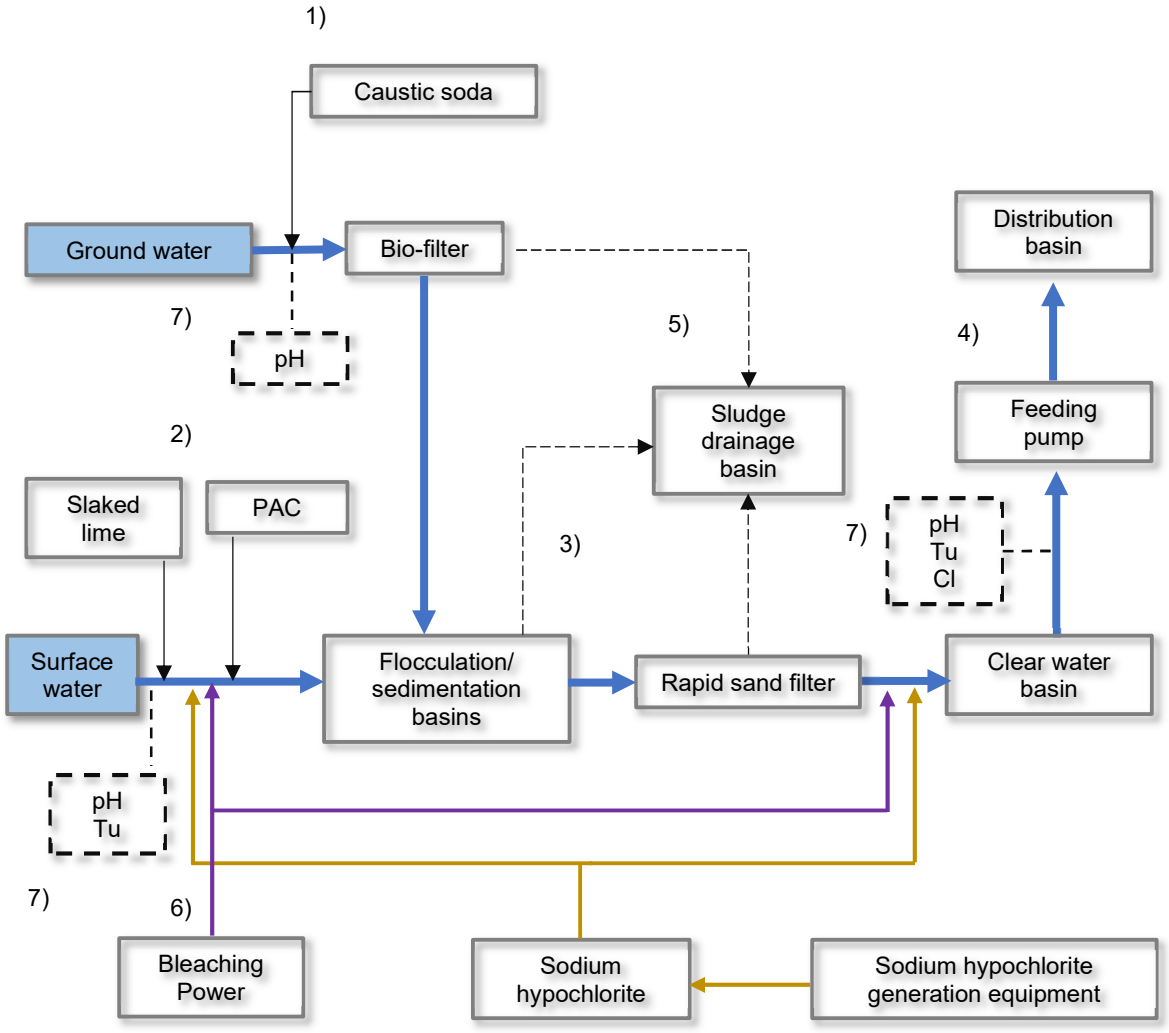


Figure 2: Schematics of Chemical System in Bansbari WTP

Prior to the understanding of operation and maintenance of individual process, it is important to keep daily record of total inflow of water into the system.

(1) Surface water inflow: Record readings from the flowmeter

(2) Groundwater inflow: Record individual pumps inflow rate

2. Bio filter and Caustic Soda Feeding Equipment

2.1 Bio Filter Equipment

This equipment is not in use.

The following sections is an extract from the original Operational Manual.

Purpose: To remove ammonia from the ground water by using nitrification action of aerobic microorganisms.

Mechanism: Filter media is filled into the bio-filter tank for proper propagation of the microorganism. Air blowers provide air under pressure for diffusion of oxygen. Ammonia is nitrified (converted to nitrite and nitrate) by microorganism and removed from water.

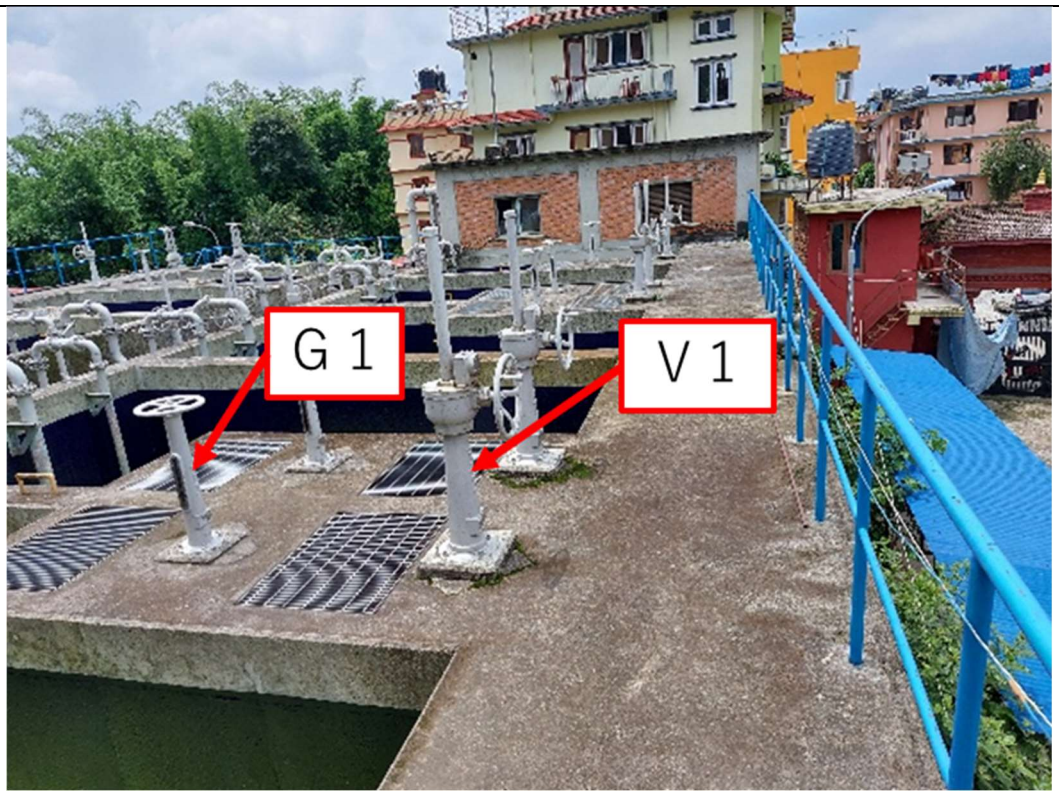
Equipment outline:

Equipment	Type	Size	No
Receiving well	Reinforced Cement Concrete	Front well: 4.5 m x 4.0-2.4 m x 2.2 m x approx.5.2 m Rear well: 2.1 m x 1.9 m x approx. 5.2 m Capacity: 87.00 m^3 Detention period: 7.1-24.1 minutes Incidental equipment: Air diffuser: 1 set Overflow weir: 1.9 m (width) x 0.3 m (length), 1 unit (synthetic lumber)	1 basin
Bio-filter tank	Reinforced Cement Concrete	Filter basin size: 2.46 m (width) x 5.94 m (length) Filter Area: 14.6 m^2/basin Filter medium: Artificial, light, pelleted filter media (pellet dia: 5 – 15 mm, layer depth: 1.3 m) Supporting layer: Gravel (size=6 – 20 mm, layer depth 0.2 m) Underdrain: Leopold block (automatically washable), combined type for water and air Washing: Back washing rate: 1 m^3/m^2/min Back washing period: 8 min Air washing rate: 0.8 m^3/m^2/min Air washing period: 6 min	10 basins
Make-up water quantity and make up pumps	Submersible pump	Capacity: ϕ 250 x 7 m^3/min x 8.5 m Motor: 400V x 50 Hz x 15 kW	2 pumps
Make up water tanks		3.0 m (w) x 15.2 m (l) x 3.5 m (effective water depth) Capacity: V_2 = 3.0 x 15.2 x 3.5 = 159.6 m^3 During normal filtration, a part of the treated water shall be stored in the make-up tanks	

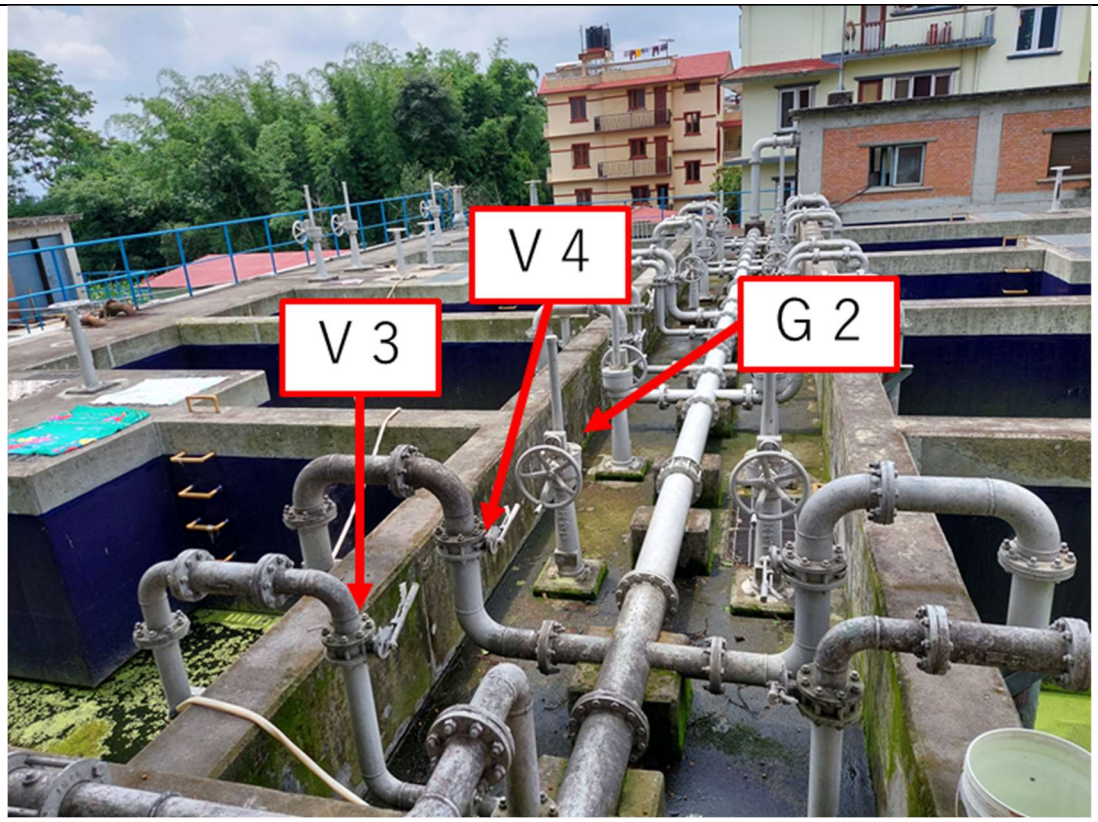
Equipment	Type	Size	No
Air blower	Roots blower	Capacity: ϕ 125 x 11.0 m^3/min x 0.6 kg/cm^2 Motor: 400 V x 50 Hz x 22 kW	3 pumps (2 duty + 1 spare)

Valves and air blower operation

Op. stage / Op. items	During filtration	During backwashing	During inspection of the basin
Raw water inflow valve (V1)	Open	Closed	Closed
Water discharge gate (G1)	Closed	Open	Open
Clear water gate (G2)	Open	Open	Closed
Drainage valve (V2)	Closed	Closed	Open
Air supply valve (V3)	Open	Closed	Closed
Back washing valve (V4) (air washing)	Closed	Closed	Closed
Air blower	Operate 1 unit	Operate 1 unit	-
Makeup pumps	-	Operate 1 unit	-

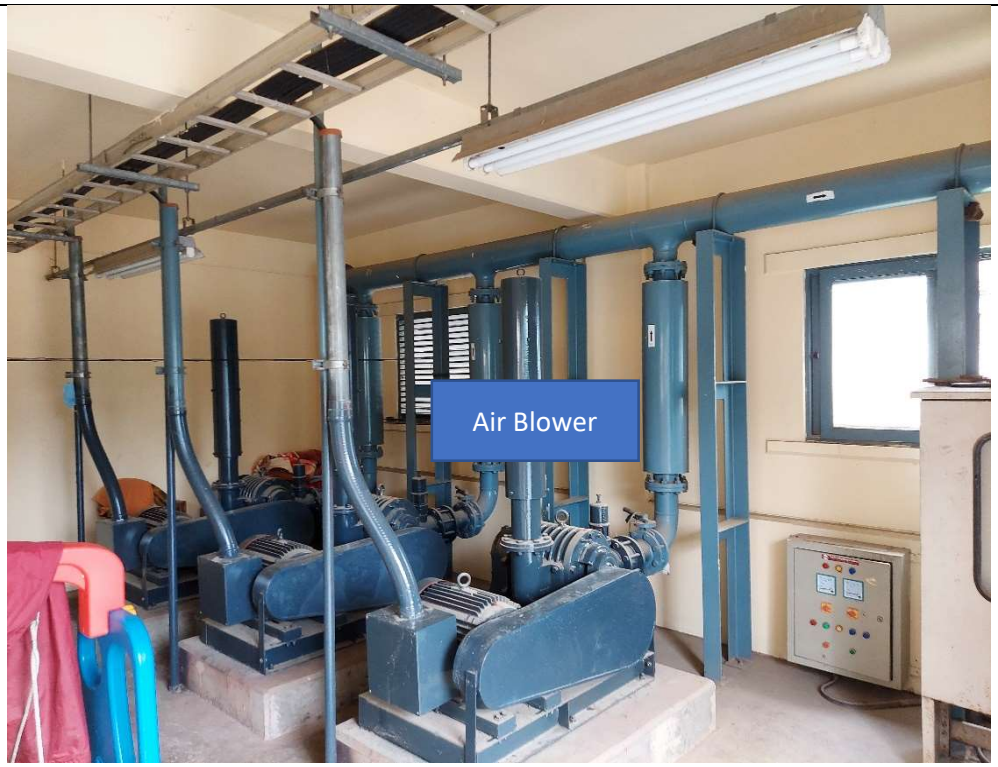


Valve and gate



Valves and gates

Backwash/ makeup pumps



Air blowers

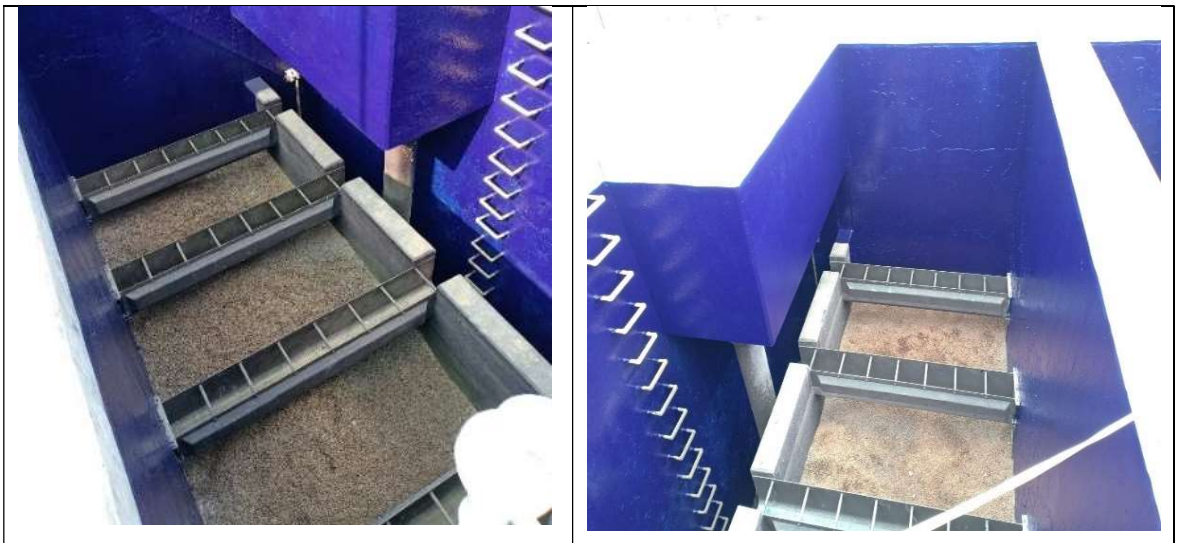
On-Off panel of makeup pumps

On-Off panel of air blowers

Filtering process

Monitoring of filtering operation conditions

a. Check inflow condition by checking the water level of inflow channel.
b. Confirm that the air is distributed evenly by visual inspection.
c. Check head loss condition in filter by checking water level of filters.
d. Check the treatment process by checking air feeding to filters and head loss by water level of filters.



Filtering Process with air feeding

Operation process of the bio-filter

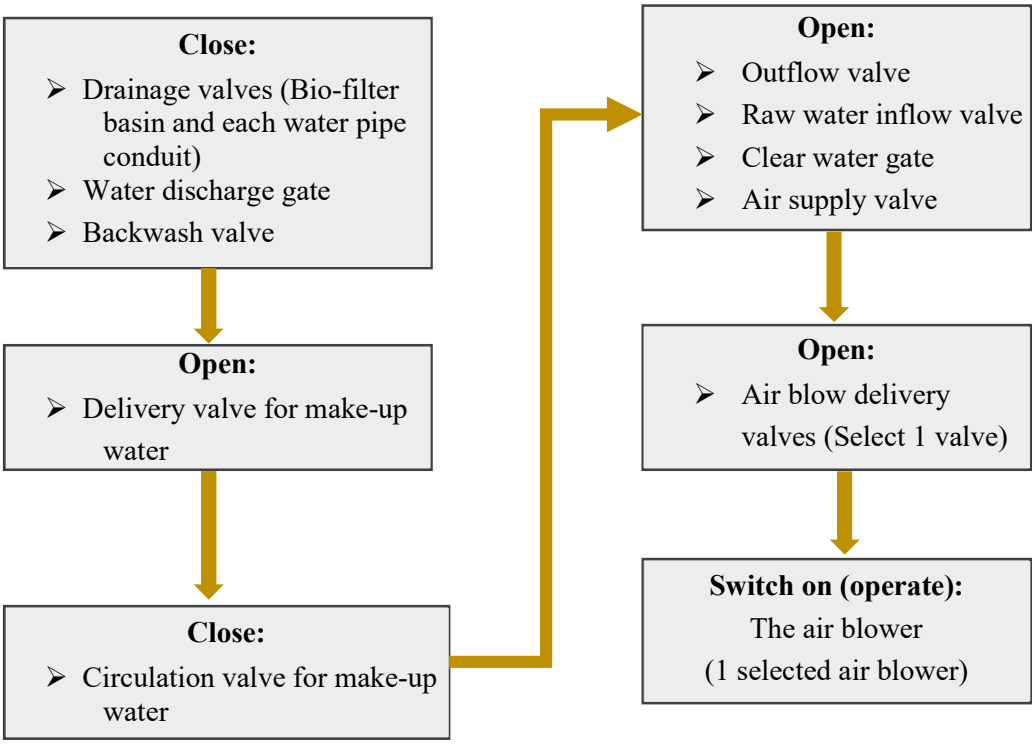


Figure 3: Operation process of the bio-filter

Bio-Filter Backwashing

Monitoring of backwashing requirement

a. By checking head loss of filtering condition, by checking water level of filters.
b. Checking filtering hours. If the filtering hour exceeds pre-determined or water level of filter is high, start backwashing.
c. Follow the procedures described in Figure 4: Bio-Filter Backwashing Process.
d. Backwashing shall be continued for pre-determined minutes depending on the clearness of filter bed as shown in the following photos.

Operation process for backwashing

1. Select the basin to be washed
⇩
2. Open the raw water inflow valve of the respective basin
⇩
3. Open the water discharge gate of the respective basin
⇩
4. Close the clear water gate of the respective basin
⇩
5. Open the back-washing vale of the respective basin (125A)
⇩
6. Open the delivery valve of the air blower (add one unit for a total of two)
⇩
7. Operate the air blowers (Operate the selected two air blowers)
⇩
8. Close the back-washing valve after a fixed time
⇩
9. Stop the air blower (Stop one blower and operate the remaining one blower)
⇩
10.Close the air supply vale of the respective basin (80A)
⇩
11. Open the clear water gate
⇩
12. Operate the make-up pump
⇩
13. Stop the make-up pump after a fixed time
⇩
14. Close the water discharge gate after a fixed time
⇩
15 Open the air supply valve
⇩
16. Open the raw water inflow valve
⇩
17. Follow the same procedure to wash the other basins.

Figure 4: Bio-Filter Backwashing Process

The followings are photos of start/stop of backwashing of rapid sand filter for reference.

Dirty water (initially)	Clear water (completion of backwash)
	

Process of various operations

Stopping water

Close the raw water inflow valve of the respective basin → Close the clear water gate → Close the air supply valve

Draw-off (whole filter)

Close the raw water inflow valve → Close the clear water gate → Close the air supply valve → Open the water discharge valve → Open the drainage valve

Draw-off (individual units)

For Receiving Well

Stop inflow of well water → Open the drainage valve of the receiving well

For raw water conduit

Stop inflow of well water → Open the drainage valve of the raw water conduit

Draw-off for the clear water and outflow conduit

Stop inflow of well water → Stop bio filter basins (all 10) → Close outflow valves → Open drainage valve of the clear water conduit → Open drainage valve of the outflow conduit

Circulation Operation

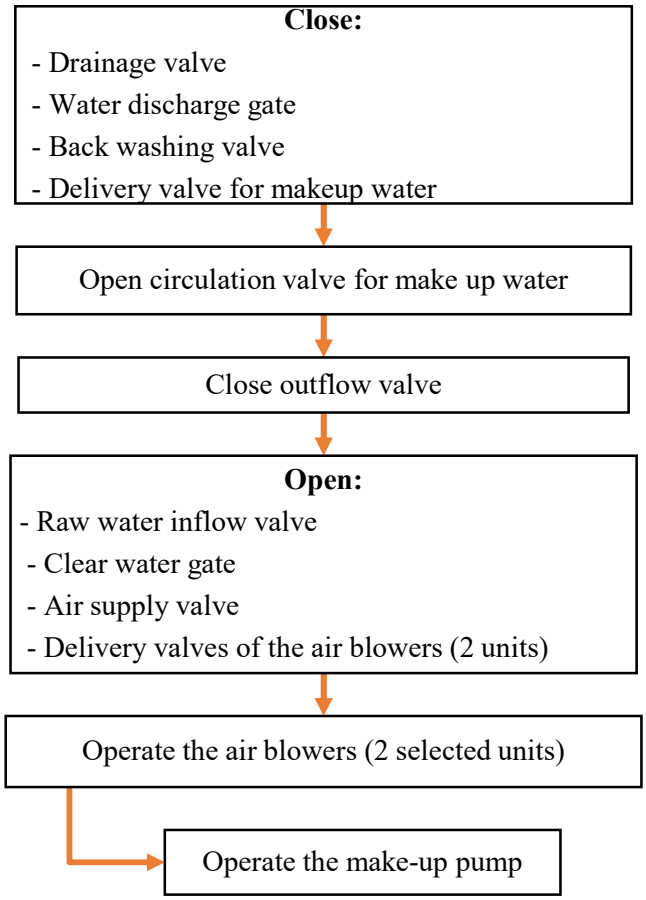


Figure 5: Circulation system

2.2 Caustic Soda Feeding Equipment

This equipment is not in use.

Purpose: To adjust pH value for the bio-filter tank using caustic soda.

Feeding mechanism: The caustic soda is first dissolved in the dissolution tank, then transferred by the transmission pump to the storage tank from where fixed quantities are fed by the feeding equipment at suitable intervals. The caustic soda is fed as a 20% solution from lumps of sodium hydroxide with an NaOH content of 95% -98%. The feeding point is at the inflow of bio-filter tank.

Equipment List

Item	Type	Size/Details	No. of units
Dissolution tanks	Open vertical cylindrical (heat resistant polyethylene)	Dia (ϕ) approx. 900 mm x height 880 mm Capacity: 0.5 m^3 (500L) Accessories (per tank) Fittings: 1 set; Agitator stand: 1 stand	2 tanks
Agitators	Reciprocal rotary agitator	200 rpm Motor: 0.75 kW x 400 V x 50 Hz	2 units
Transmission pumps	Magnet pump	40 A x 30 L/min x 10 m Motor: 0.4 kW x 400 V x 50 Hz	2 units
Caustic soda storage tanks	Closed vertical cylindrical tank (polyethylene)	ϕ approx. 1425 mm x height 1570 mm Capacity: 2 m^3 (2000L) Accessories Fittings: 1 set; Direct-reading liquid level gauge: 1 unit; Manhole: 1 location; Air vent: 1 location; Agitator: 1 set	2 units
Feeding equipment	Diaphragm pump	Capacity: a. 15A x 0.46 L/min x 2 kg/cm^2 x 1 unit b. 15A x 0.9 L/min x 2 kg/cm^2 x 1 units Motor: 0.2 kW x 400V x 50 Hz Accessories Back pressure valve: 1 piece. Safety valve: 3 pieces; Air chamber: 1 unit; Pressure gauge: 3 pieces	3 units (pump a. supplied as spare)
Piping and valves		Pipes, valves, hard polyvinyl tubes for city water, ball valves, diaphragm valves Bore: 50-15 A	1 set

Item	Type	Size/Details	No. of units
Instrument panel		BM-2	

Operation of Caustic Soda Feeding Equipment

Lumps of NaOH are dissolved to produce a NaOH solution with a concentration of 20%.

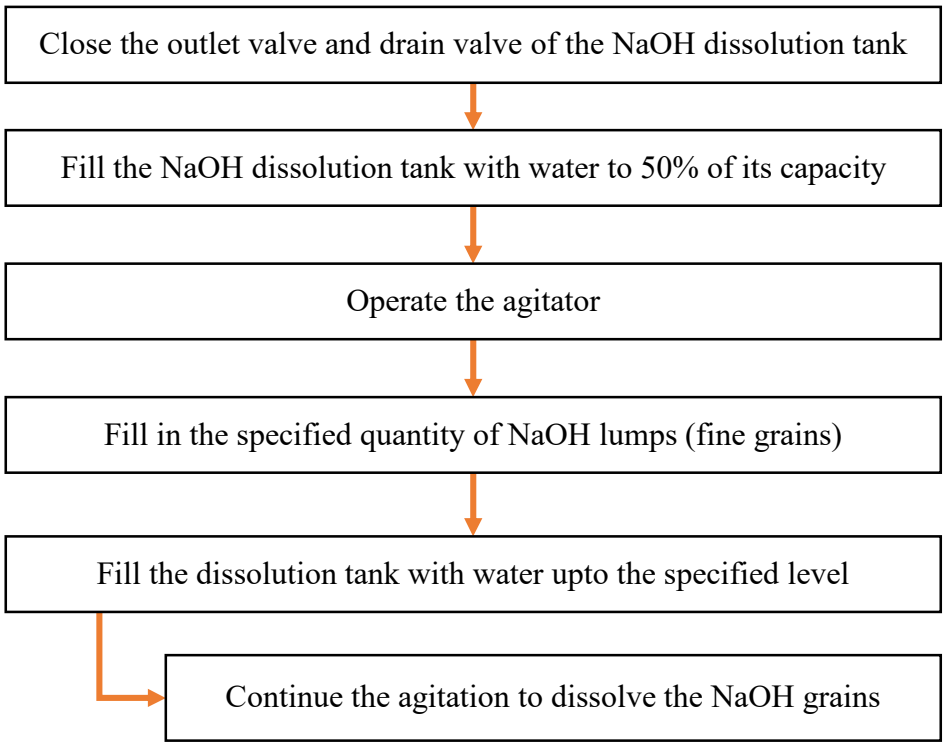


Figure 6: Operation of Caustic Soda Feeding Equipment

Feeding of the NaOH solution

The prepared NaOH solution with an NaOH concentration of 20% is fed to the NaOH tank by the transmission pump.

Figure 7: NaOH solution storage and feeding equipment

Transferring of NaOH solution from dissolution tank to storage tank

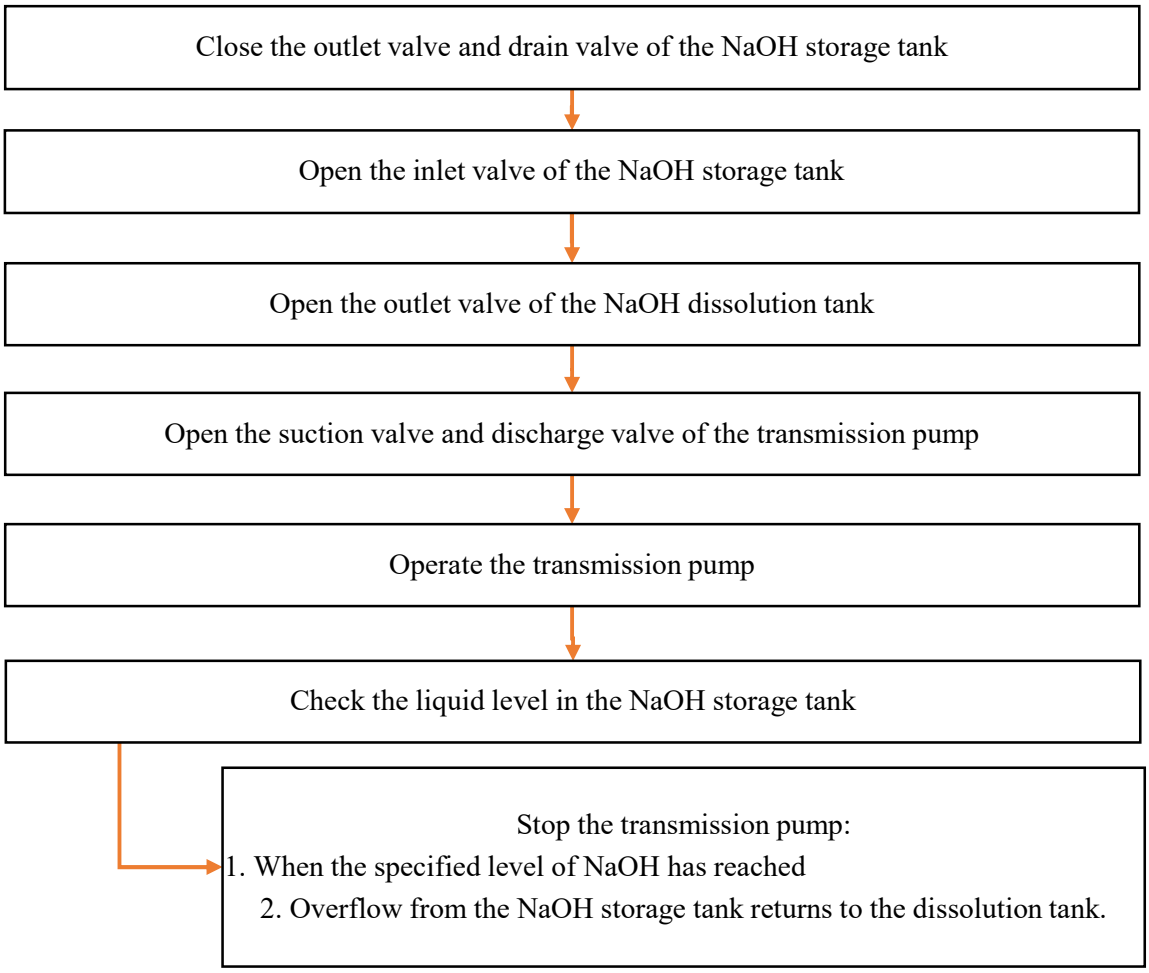
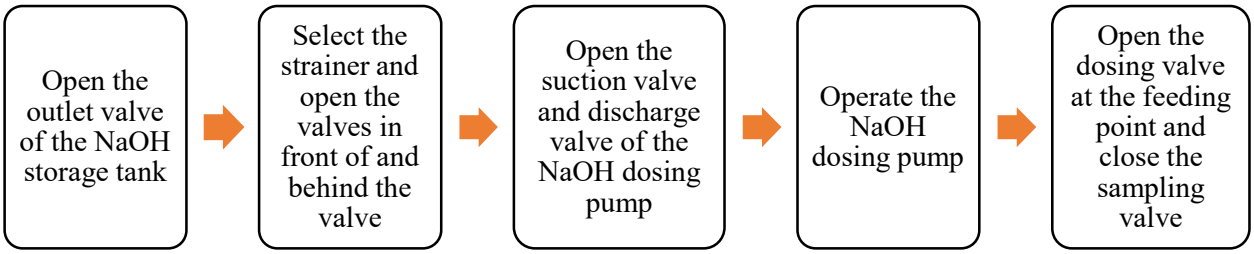


Figure 8: Transferring process of NaOH solution to storage tank

Caustic Soda Feeding Process

The specified quantity is fed by the NaOH dosing pump at the feeding point.

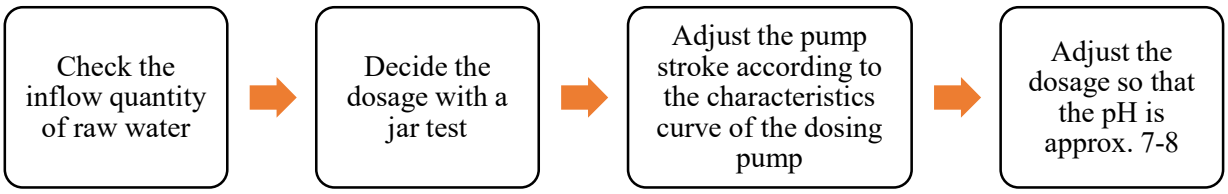


NaOH solution feeding rate (and thus corresponding dosage) is checked by measuring feeding rate of the prepared solution. For this, dosing valve is closed and sampling valve is opened and the solution sample for a known time period is collected and measured. Adjustment of the feeding rate is done by the valve.

Adjustment of the NaOH dosage

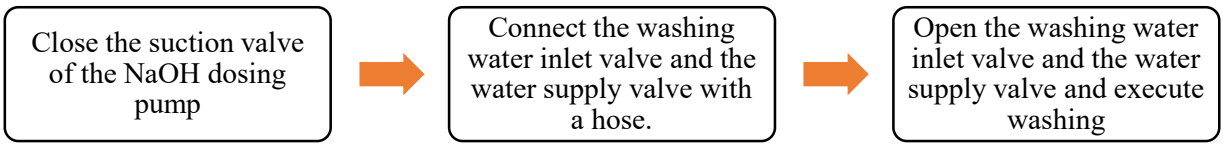
Use the NaOH dosing pump to adjust the dosage.

Operation procedure



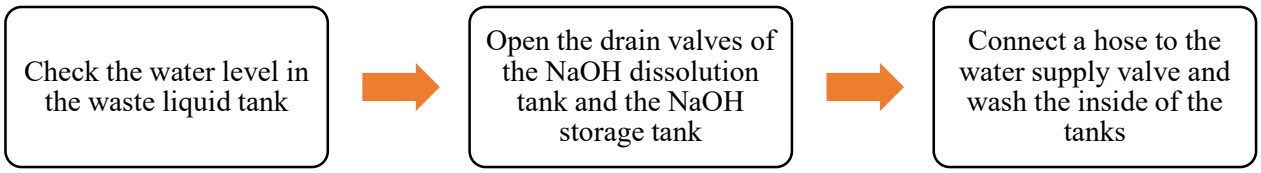
Washing of dosing pump and feed pipe

When feeding is to be stopped for a long time, wash the dosing pump and the feed pipe.



Washing of NaOH dissolution tank and NaOH storage tank

When feeding is to be stopped for a long time, wash the NaOH dissolution tank and the NaOH storage tank.



Dosing pump switching

Pump switching may be required depending on the treated water quantity and the dosage rate.

Refer to the following table for selection and use of the dosing pumps.

Quantity of NaOH (20% solution) Unit: mL/min

Quantity (Q) (m^3/Day)	Feeding Rate (p)									
	5	10	15	20	25	30	35	40	45	50
5,200	74	148	222	296	370	444	518	592	666	740
5,500	78	157	235	313	391	470	548	626	704	783
6,000	85	171	256	342	427	512	598	683	768	854
6,500	92	185	277	370	462	555	647	740	832	925
7,000	100	199	299	398	498	598	697	797	897	996
7,500	107	213	320	427	534	640	747	854	961	1067
8,000	114	228	342	455	569	683	797	911	1025	1138
8,500	121	242	363	484	605	726	847	968	1089	1210
9,000	128	256	384	512	640	768	897	1025	1153	1281
9,500	135	270	406	541	676	811	946	1082	1217	1352
10,000	142	285	427	569	712	854	996	1138	1281	1423
11,000	157	313	470	626	783	939	1096	1252	1409	1565
12,000	171	342	512	683	854	1025	1195	1366	1537	1708
13,000	185	370	555	740	925	1110	1295	1480	1665	1850
14,000	199	398	598	797	996	1195	1395	1594	1793	1992
15,000	213	427	640	854	1067	1281	1494	1708	1921	2135
16,000	228	455	683	911	1138	1366	1594	1821	2049	
17,000	242	484	726	968	1210	1452	1693	1935	2177	
17,600	250	501	751	1002	1252	1503	1753	2004	2254	

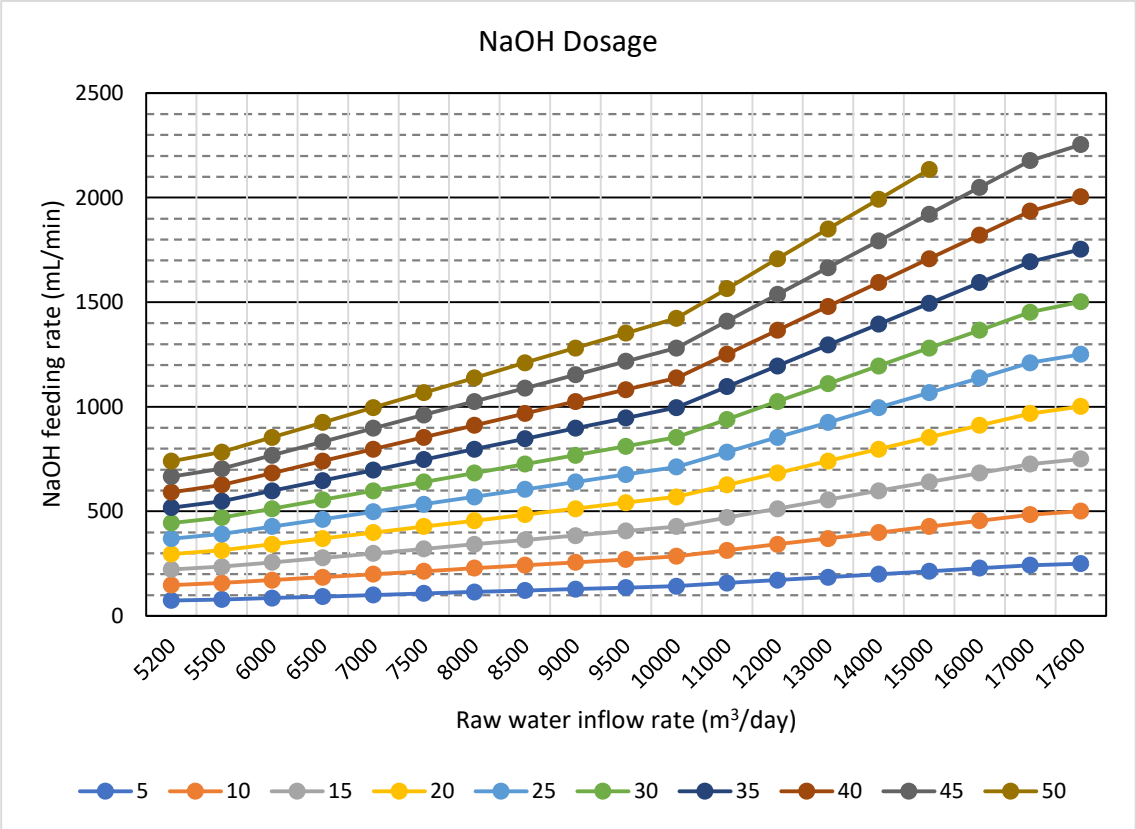


Figure 9: NaOH dosage calculation chart

For example, if the raw water inflow is 7,500 m3/d and the required dosage is 20 ppm, then the feeding rate of 20% NaOH solution will be 427 mL/min.

NaOH dosing pump selection

Dosing pump capacity:

a. 0.9 L/min x 1 unit

b. 1.8 L/min x 2 units

Depending on the feeding rate requirement, one of the following combinations of the pump should be used.

(1) Use of one pump a.

(2) Use of one pump b.

(3) Use of one pump a. and one pump b.

(4) Use of two pumps b.

(5) Use of one pump a. and two pumps b.

3. Flocculation and Sedimentation Equipment, PAC feeding equipment, Slaked lime feeding equipment

3.1 Flocculation and Sedimentation equipment

Purpose: This equipment is used for flocculation and sedimentation of the surface water and the effluent of bio-filter.

Mechanism: PAC or Alum as a coagulant is fed into the raw water flowing in from the receiving well and passed through the rapid mixing system (hydraulic jump or rapid mixer). Sometimes when the pH of the raw water is less than 7, lime solution is also fed with the coagulant to adjust the pH and bring it to the alkaline range (more than 7). The rapidly mixed water is then fed to the coagulation flocculation basins and from there to the sedimentation basins.

To distribute the coagulated water to sedimentation basins or select which basin to use and which one to bypass according to the raw water quantity, the gates at the distribution weir shall be used (opened or closed).

Equipment Outline

Item	Type	Size/Details	No. of units
Receiving well	RCC	2.5 m (w) x 1.8 m (l) x 3.7 m (approx. water depth)	1 well
Mixing well	RCC	2.5 m (w) x 2.0 m (l) x 3.7 m (approx. water depth) Effective capacity: 18.5 m^3 Incidental equipment: 1 overflow weir	1 well
Flocculation basin	Horizontal and vertical baffling type	Basin A: 6.1 m (w) x 9.9 m (l) x 3.1 – 2.8 m (approx. water depth) Basin B: 4.6 m (w) x 9.0 m (l) x 3.1 – 2.8 m (approx. water depth) Capacity: 1 line: V_1= 0.9 x 0.9 x (3.1 +3.0) x ½ x 18 =44.5 m^3 4 line: V_B= 1.2 x 0.9 x (3.0+ 2.9) x ½ x 12 =38.2 m^3	5 basins Basin A x 2, Basin B x 3

Item	Type	Size/Details	No. of units
		6 line: V_B= 1.4 x 0.9 x (2.9+ 2.8) x ½ x 12 =43.1 m^3 Total Volume = 125.8 m^3 Incidental equipment: 1 set of weir plates Synthetic lumber (FFU) Retention period = 25 to 40 minutes	
Sedimentation Bain	Horizontal flow type	Basin A: 6.1 m (w) x 40.4 m (l) x water depth approx. 2.8 m No. of Basin = 4 Basins Surface area: S= 6.1 m x 40.4 m =246.4 m^2 Surface loading rate=15-30 mm/min Cross section area: S=6.1 m x 2.8 m = 17.1 m^2 Trough: Dimensions: 0.3 m (w) x 4.25 m (l) x 0.35 m (d) Quantity: 2 trough / Basin	5 basins (Basin A x 2, Basin B x 3)

Operation of the Flocculation and Sedimentation Equipment

The raw water quantity differs each month because of the limitation of the biologically treated water (March-June), thus A and B type basins are used in combination.

Attention: To prevent mixing of ground and surface waters, attention should be paid to opening and closing of the conduit gates.

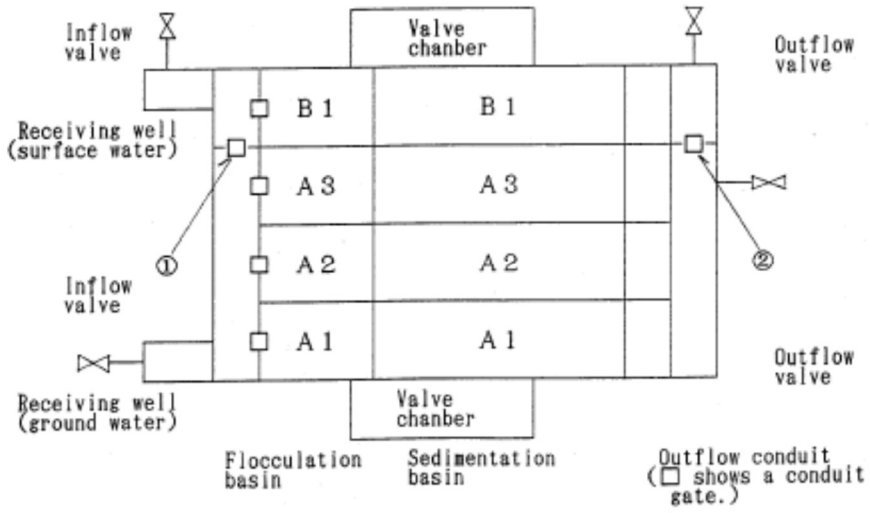


Figure 10: Illustration of the flocculation and sedimentation basin

Sedimentation Basin

Sedimentation basins allow suspended particles as called floc to settle out of water as it flows slowly through the tank. A layer of accumulated solids, called sludge, forms at the bottom of the tanks, and is periodically removed.

To confirm the proper function of sedimentation basins, the followings shall be carried regularly.

a. Check floc formation at inflow of Sedimentation Basin

b. Check floc outflow from Sedimentation Basin (Tough)

c. Sludge removal by sludge valves

d. Check sludge accumulation at the bottom.

Floc Formation

Floc formation at inflow of Sedimentation Basin 3-4 times in a day.

- Morning before chemical dosing adjustment
- 30-40 minutes after of chemical dosing adjustment
- 3-4 hours after in afternoon
- Second time in the afternoon, if possible
-

Jar Test

Floc formation
Floc formation shall be confirmed at inflow of Sedimentation Basin.

Sludge removal Floc Outflow
Floc outflow from Sedimentation Basin (Tough) at the same time when check floc formation.

Inlet of Sedimentation Basin

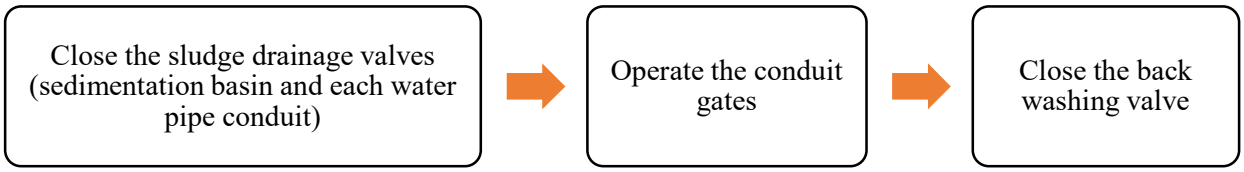
Outlet of Sedimentation Basin

Sludge accumulation at the bottom
Floc outflow from Sedimentation Basin (Tough) at the same time when check floc formation.

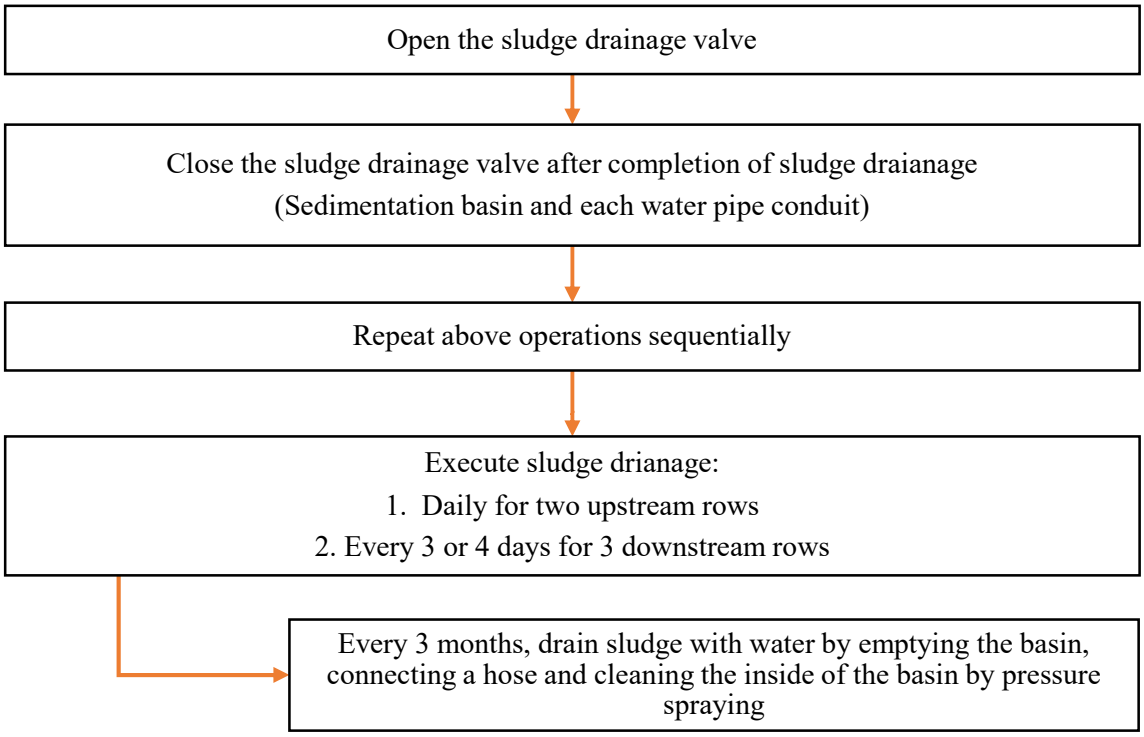
In order to minimize the settled sludge, sludge valves shall be operated.

The valves shall be open and kept for 30 seconds, then close.

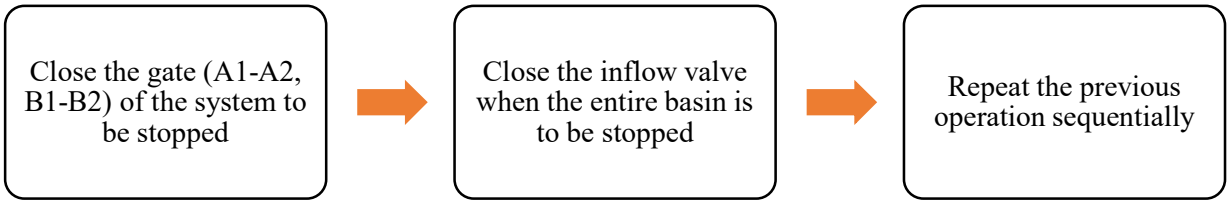
Operation Procedures



Sludge draining operation



Stop operation



Sludge draining operation

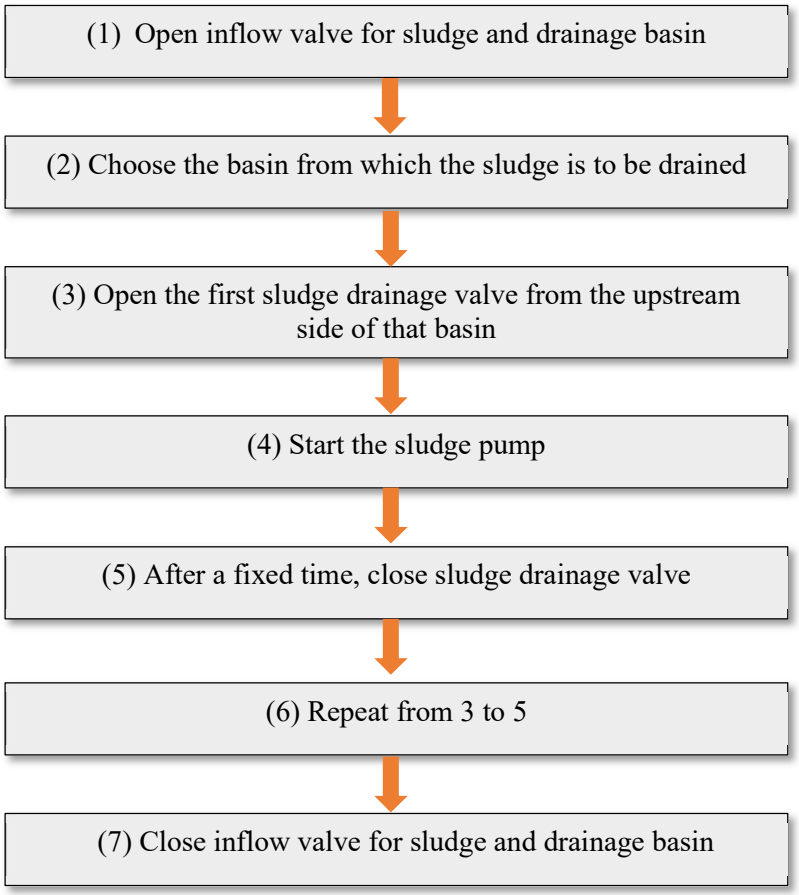
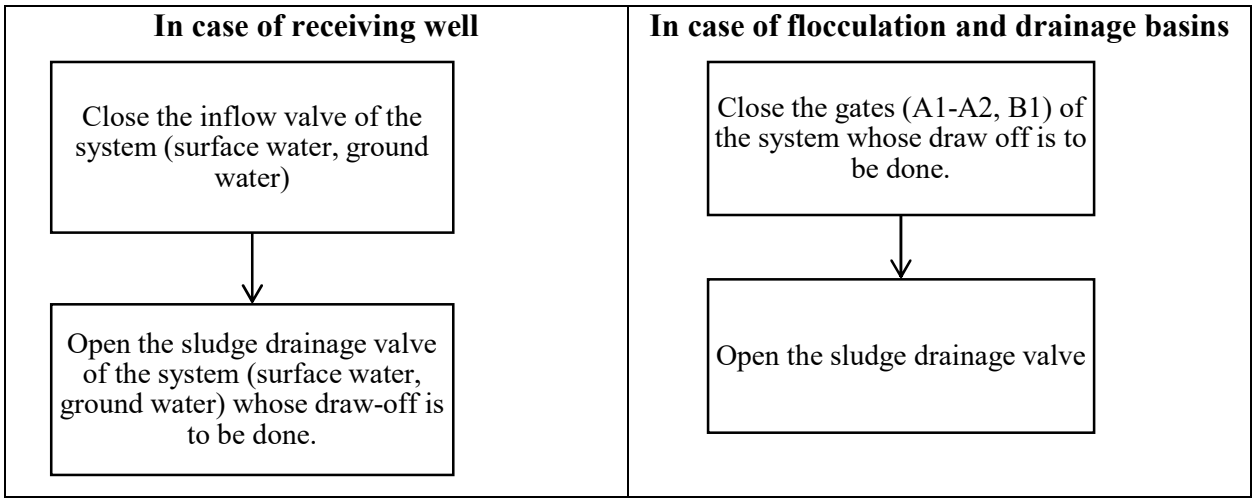


Figure 11: Sludge draining operation

Draw-off operation



Time (duration) for sludge drainage

- Sludge drainage time differs according to the inflowing sludge.
- Decide the sludge drainage time according to the time required for change of turbidity (reduction in turbidity) of sludge water flowing into the sludge basin.
- Sludge drainage time will be about 1 minute.

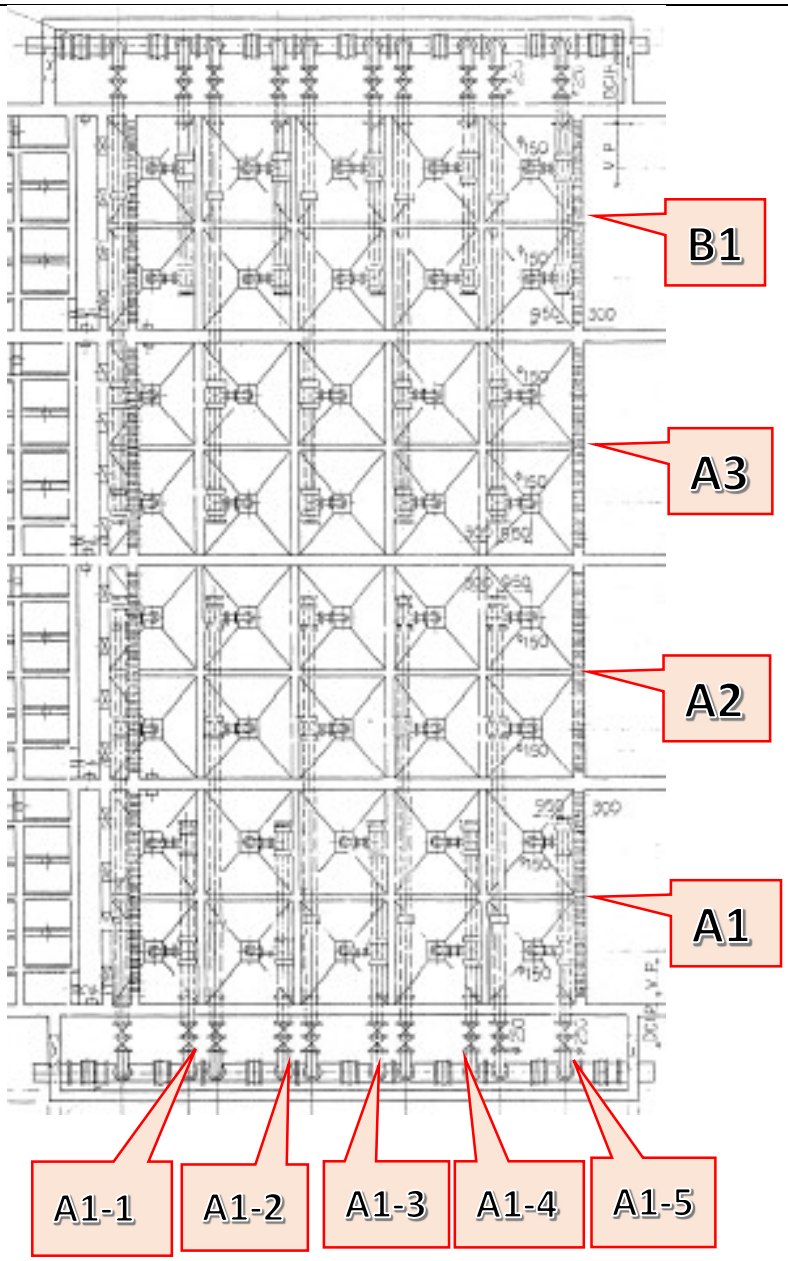


Figure 12: De-Sludging Valves - Plan

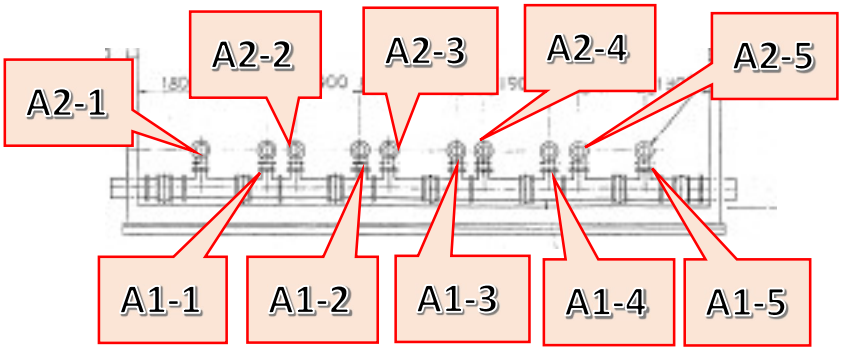


Figure 13: De-Sludging Valves - Section

3.2 PAC Feeding Equipment

Purpose: To dissolve PAC powder in water and feed the solution to raw water for effective coagulation, flocculation, and sedimentation process.

Feeding mechanism: PAC powder is dissolved in the dissolution tank to the specified concentration, pumped by the transmission pump to the storage tank for storage at suitable intervals, and fed to the raw water at fixed quantities.

Equipment Outline

Item	Type	Size/Details	No. of units
Dissolution tank	Open vertical cylindrical tank (polyethylene)	ϕ 890 mm approx. x 1040 mm (h) Capacity: 0.5 m^3 Accessories: Fittings: 1 set Agitator: 1 stand	2 tanks
Agitator	Reciprocating rotary agitator	Reciprocating cycles: 200 cpm Motor: 0.75 kW x 400 V x 50 Hz	2 units
Transmission pumps	Magnet pump	Capacity: 40 A x 30 L/min x 10m Motor: 0.4 kW x 400 V x 50 Hz	2 motors
PAC storage tanks	Closed vertical cylindrical tank (polyethylene)	ϕ 1065 mm approx. x 1265 mm (h) Capacity: 1 m^2 Accessories: Fittings: 1 set; Direct sight level gauge: 1 gauge; Manhole: 1 location; Air vent: 1 location	2 tanks
Feeding equipment	Diaphragm pump	Capacity: a. 15 A x 0.14 L/min x 2 kg/cm^2 b. 15 A x 0.46 L/min x 2 kg/cm^2 Motor: 0.2 kW x 400 V x 50 Hz Accessories: Back pressure valve: 2 units; Safety valve: 6 units; Air chamber: 2 units; Pressure gauge: 6 units	4 units (2 units x 2)

Item	Type	Size/Details	No. of units
Piping and valves		Pipes, valves, hard polyvinyl pipes for city water; ball valves, diaphragm valves Diameter: 50 – 15 A	1 set
Instrument panel		BM-3	

3.2.1 PAC Solution Preparation

PAC solution is prepared in such a way that the solution will contain 20% concentration of PAC.

a. Prepare PAC solution containing 20% concentration of PAC as shown below.

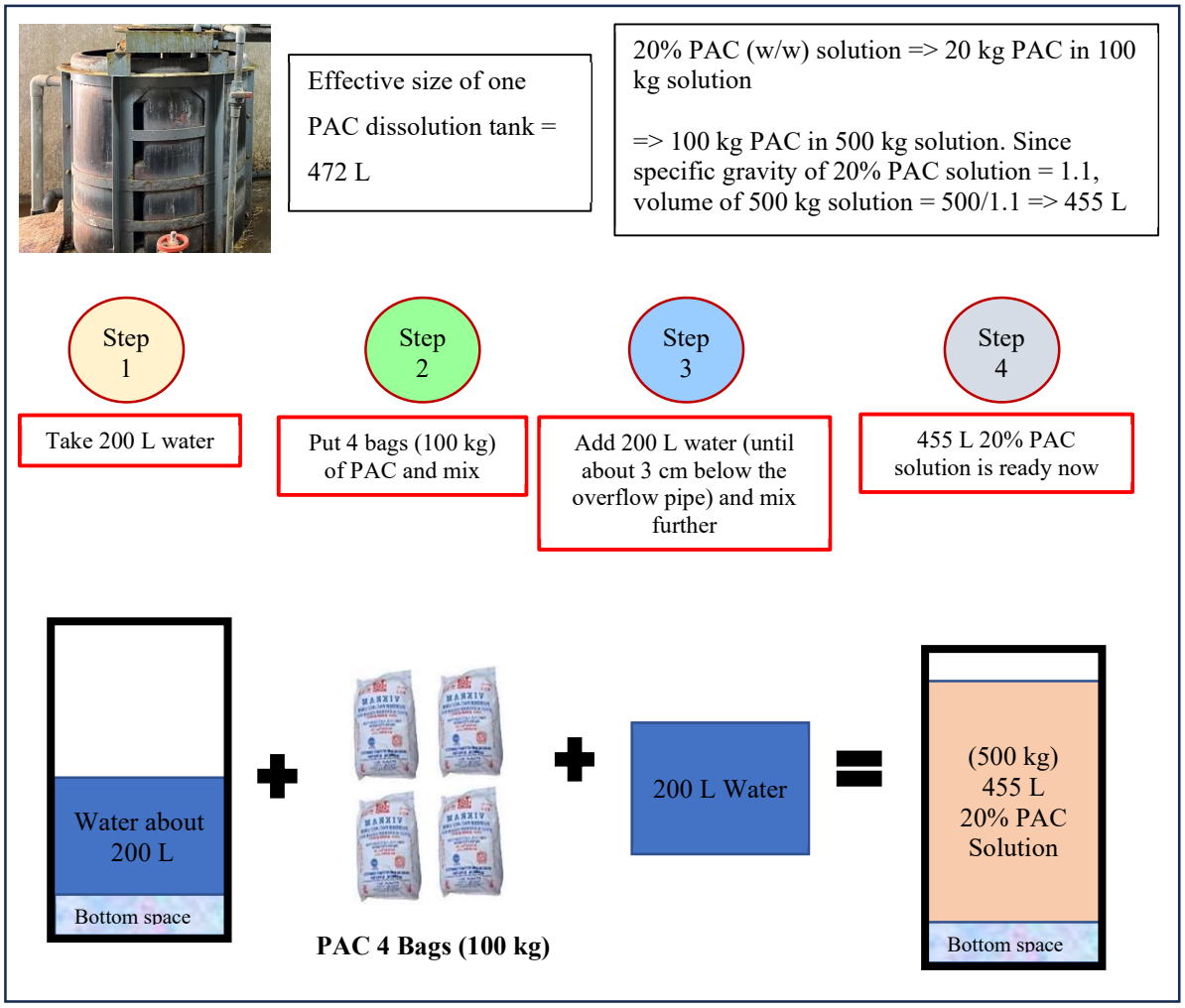


Figure 14: Schematics of 20% concentration PAC solution preparation

Operation procedure

1. Close the outlet valve and the drainage valve of the PAC dissolution tank (LWL)

⇩

2. Fill about 50% (200 L) of the tank with water

⇩

3. Add 4 bags (100 kg) of PAC

⇩

4. Operate the agitator

⇩

5. Add 200 L water (until the level reaches about 3 cm below the overflow pipe), continue agitating for about 2-3 hours

b. Transfer PAC solution to PAC storage tanks

Operation procedure

1. Close the outlet valve and the drainage valve of the PAC storage tank

⇩

2. Open the inlet valve of the PAC storage tank

⇩

3. Open the outlet valve of the PAC dissolution tank

⇩

4. Open the suction valve of the transmission pump

⇩

5. Open the delivery valve of the transmission pump

⇩

6. Operate the transmission pump

⇩

7. Check the liquid level of the PAC storage tank and stop the transmission pump if:

Specified level has reached, or

PAC storage tank overflows and the overflow returns to the PAC dissolution tank

3.2.2 Deciding Dosage (Feeding Rate)

PAC dosage (feeding rate) shall be decided in the following manner.

Procedure of deciding PAC dosage (feeding rate)

1. Flow measurement (m^3/day or m^3/hr) (by WTP Engineer)
(Automatic measurement record can be taken when this system is installed and ready)

⇩

2. Find out the required PAC dosing rate by Jar Test (by Central Lab) OR
(Refer to the Turbidity versus PAC dosing rate chart)

⇩

3. Calculate PAC dosage (feeding rate)/ PAC pump setting (by WTP Engineer)

⇩

4. Adjust PAC pump setting (by WTP operator)

⇩

5. Check Floc formation (by Central Lab/WTP)

Calculation to determine the dosage (feeding rate)

PAC content in 20% PAC solution

100 kg PAC in 455 L solution => 100×10^6 mg / 455 L ≅ 220,000 mg/L

$$\text{Feeding rate of PAC solution} = \frac{Q\ m^3/h \times D\ mg/L}{220}\ L/h$$

Where,
Q = Raw water flow (m^3/h)
D = PAC dosing rate (mg/L)

For example, if:
Q = 900 (m^3/h)
D = 10 (mg/L)

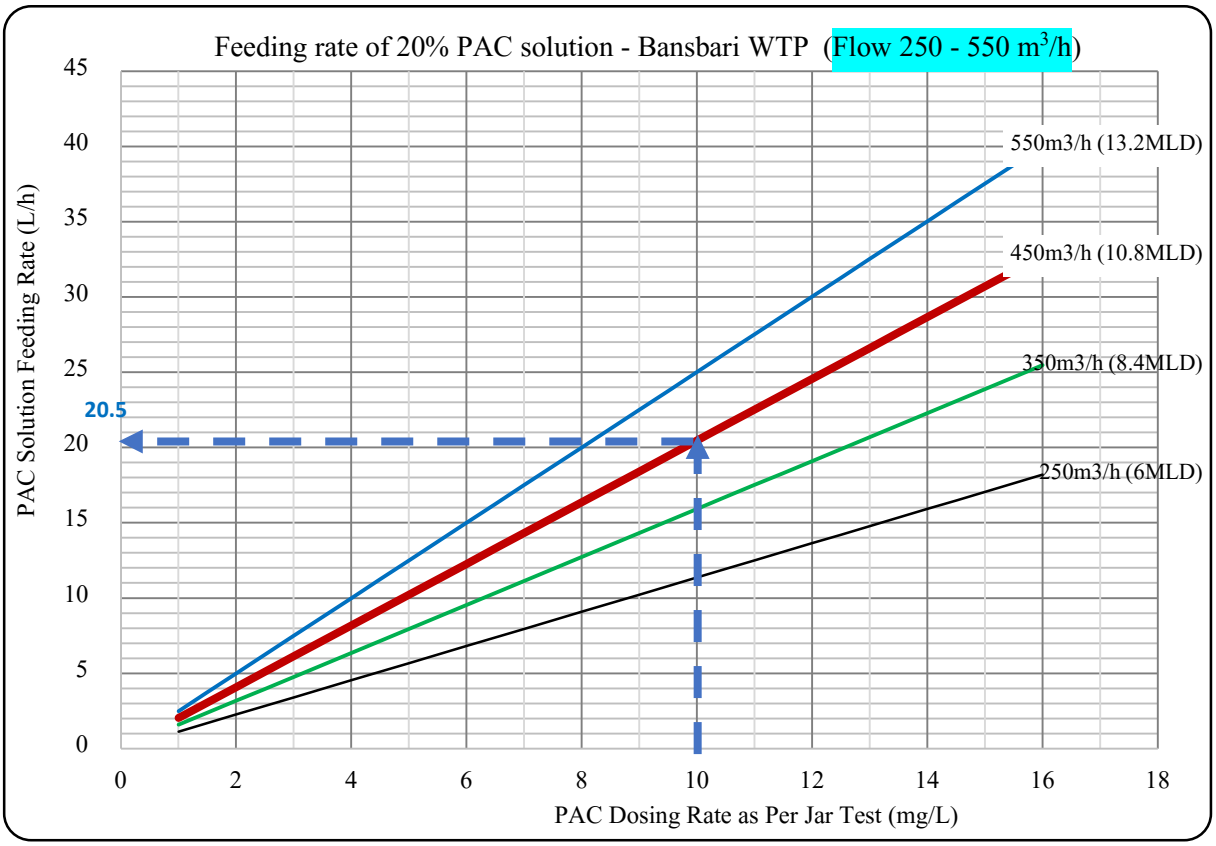
$$\text{Feeding rate of PAC solution} = \frac{900\ m^3/h \times 10\ mg/L}{220} = 41\ L/h$$

Estimate from Chart

- Find the PAC dosing rate (mg/L PAC) on the X-axis
- Go up to meet the raw water inflow rate
- Go left to meet the Y-axis

This value on Y-axis is the PAC dosage (feeding rate) for 20% PAC solution.

The following figures and tables show the examples of PAC solution feeding rates for 10 mg/L PAC dosing rate for 10.8 MLD and 21.6 MLD water flows.



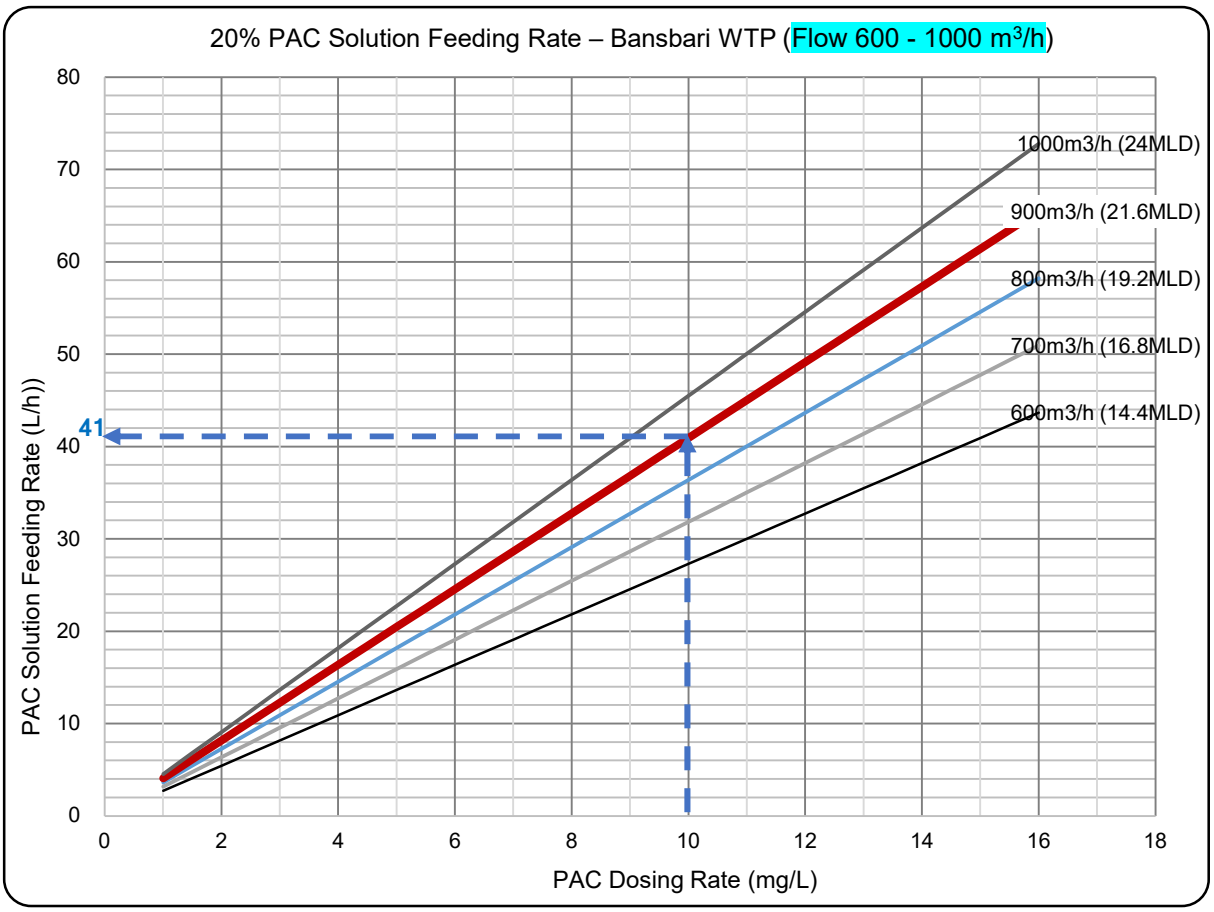


Figure 15: Chart of 20% concentration PAC solution dosages (feeding rates)

Estimate from Table

- Find the PAC dosing rate (mg/L PAC) on the first column
- Go right to meet the raw water inflow rate
- The value in that cell is the PAC dosage (feeding rate).

Table 1: 20% concentration PAC solution dosages (feeding rates)

PAC Dosing Rate (mg/L)	Required daily volume of solution for 450 m^3/h flow (L/day)	Feeding rate of PAC solution (L/h) (Flow 250 - 550 m^3/h)						
		250m3/h (6MLD)	300m3/h (7.2MLD)	350m3/h (8.4MLD)	400m3/h (9.6MLD)	450m3/h (10.8MLD)	500m3/h (12MLD)	550m3/h (13.2MLD)
1	48	1	1	2	2	2	2	3
2	96	2	3	3	4	4	5	5
3	144	3	4	5	5	6	7	8
4	192	5	5	6	7	8	9	10
5	240	6	7	8	9	10	11	13
6	288	7	8	10	11	12	14	15
7	336	8	10	11	13	14	16	18
8	384	9	11	13	15	16	18	20
9	432	10	12	14	16	18	20	23
10	480	11	14	16	18	20.5	23	25
11	552	13	15	18	20	23	25	28
12	600	14	16	19	22	25	27	30
13	648	15	18	21	24	27	30	33
14	696	16	19	22	25	29	32	35
15	744	17	20	24	27	31	34	38
16	792	18	22	25	29	33	36	40
17	840	19	23	27	31	35	39	43
18	888	20	25	29	33	37	41	45
19	936	22	26	30	35	39	43	48
20	984	23	27	32	36	41	46	50

Dosing Rate (mg/L)	Required daily volume of solution for 900 m^3/h flow (L/day)	Feeding rate of PAC (L/h) (Flow 600 - 1000 m^3/h)								
		600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
1	96	3	3	3	3	4	4	4	4	5
2	192	5	6	6	7	7	8	8	9	9
3	288	8	9	10	10	11	12	12	13	14
4	384	11	12	13	14	15	15	16	17	18
5	480	14	15	16	17	18	19	20	22	23
6	600	16	18	19	20	22	23	25	26	27
7	696	19	21	22	24	25	27	29	30	32

		Feeding rate of PAC (L/h) (Flow 600 - 1000 m^3/h)								
Dosing Rate (mg/L)	Required daily volume of solution for 900 m^3/h flow (L/day)	600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
8	792	22	24	25	27	29	31	33	35	36
9	888	25	27	29	31	33	35	37	39	41
10	984	27	30	32	34	36	39	41	43	46
11	1,080	30	33	35	38	40	43	45	48	50
12	1,176	33	35	38	41	44	46	49	52	55
13	1,272	35	38	41	44	47	50	53	56	59
14	1,368	38	41	45	48	51	54	57	61	64
15	1,464	41	44	48	51	55	58	61	65	68
16	1,584	44	47	51	55	58	62	66	69	73
17	1,680	46	50	54	58	62	66	70	73	77
18	1,776	49	53	57	61	66	70	74	78	82
19	1,872	52	56	61	65	69	73	78	82	86
20	1,968	55	59	64	68	73	77	82	86	91

3.2.3 PAC Dosing (feeding) Pump Setting

Rotameter (left) and PAC Pump

PAC Pump Control Knob

Photo 1: PAC dosing pump setting methods

- Refer to the pump 'Rotation' versus 'Flow' chart given below
- Locate the Flow on the Y-axis
- Go to right to meet the line
- Go down to meet the X-axis. This gives the number of rotation required,
- Set the pump rotation to this value.

For example, if the flow is 41 L/h, the required number of rotation is 2.2.

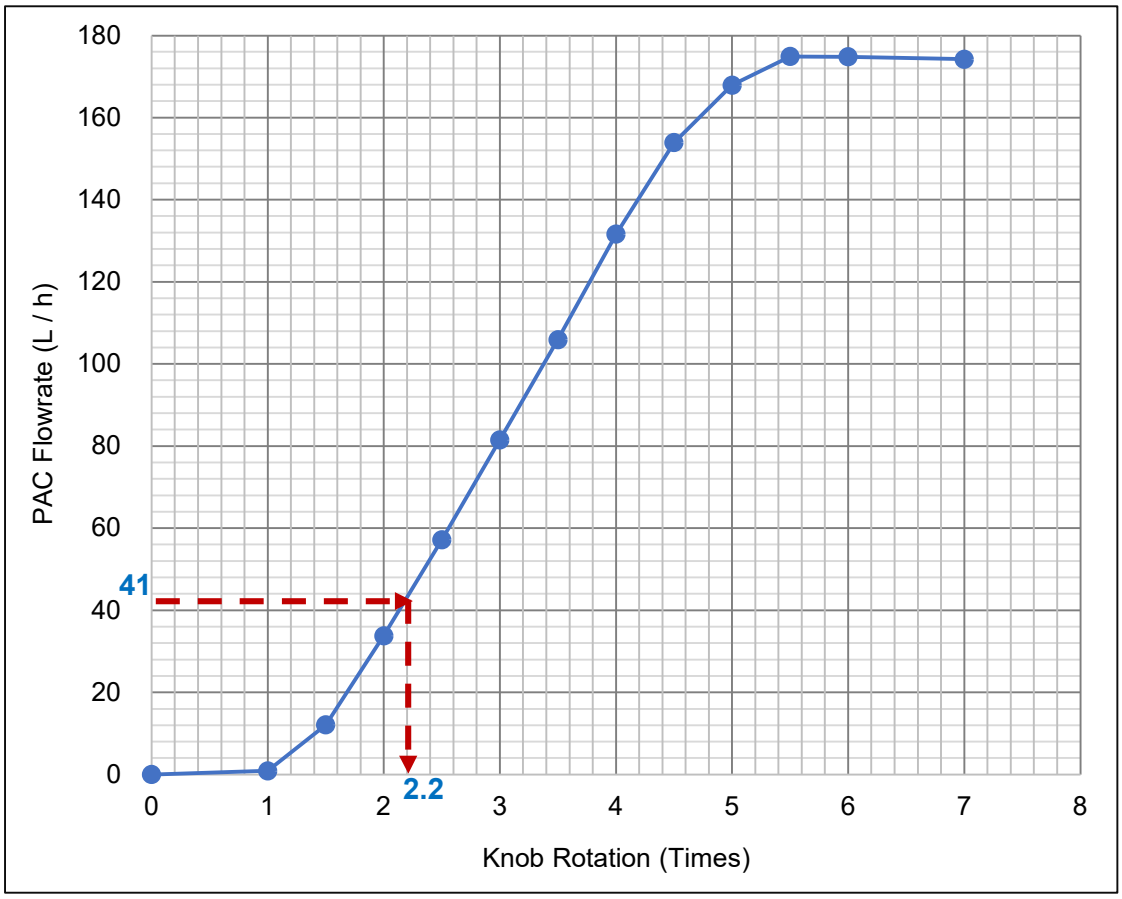


Figure 16: PAC solution flow adjusting dial graph

Symbol		Discharge of Pump
(+ve) Sign on Knob	Clockwise Rotation	Increase
(-ve) Sign on Knob	Anti-Clockwise Rotation	Decrease

Table 2: PAC flowrate adjustment by knob rotation

Steps	Description	Rotation	Discharge of Pump (L/h)	Remarks
1	When pump valve is tight	0.0	0	
2	When valve is open - Fully Open (0 - 1.0) - 1st time	1.0	0.06	
3	When valve is open - 1/2 Open (1.0 - 1.5) - 2nd time	1.5	13.2	
4	When valve is open - 1/2 Open (1.5 - 2.0) - 3rd time	2.0	30.6	
5	When valve is open - 1/2 Open (2.0 - 2.5) - 4th time	2.5	48.6	
6	When valve is open - 1/2 Open (2.5 - 3.0) - 5th time	3.0	66.6	
7	When valve is open - 1/2 Open (3.0 - 3.5) - 6th time	3.5	86.4	
8	When valve is open - 1/2 Open (3.5 - 4.0) - 7th time	4.0	105.6	
9	When valve is open - 1/2 Open (4.0 - 4.5) - 8th time	4.5	123.6	
10	When valve is open - 1/2 Open (4.5 - 5.0) - 9th time	5.0	141.6	
11	When valve is open - 1/2 Open (5.0 - 5.5) - 10th time	5.5	145.2	Flow is almost similar from step 11 onward
12	When valve is open - 1/2 Open (5.5 - 6.0) - 11th time	6.0	147	
13	When valve is open - Full Open (6.0 - 7.0) - 12th time	7.0	147	
14	When valve is open - Full Open (7.0 - 8.0) - 13th time	8.0	147	

Due to the difference in the specific gravity between water (1.0) and PAC solution (1.1), PAC solution is thicker than water, a float in the Rotameter indicates the water flow (Rotameter indication), but PAC flow (Actual Flow) is less.

PAC dosage (feeding rate) using Rotameter shall be decided referring to the following graph.

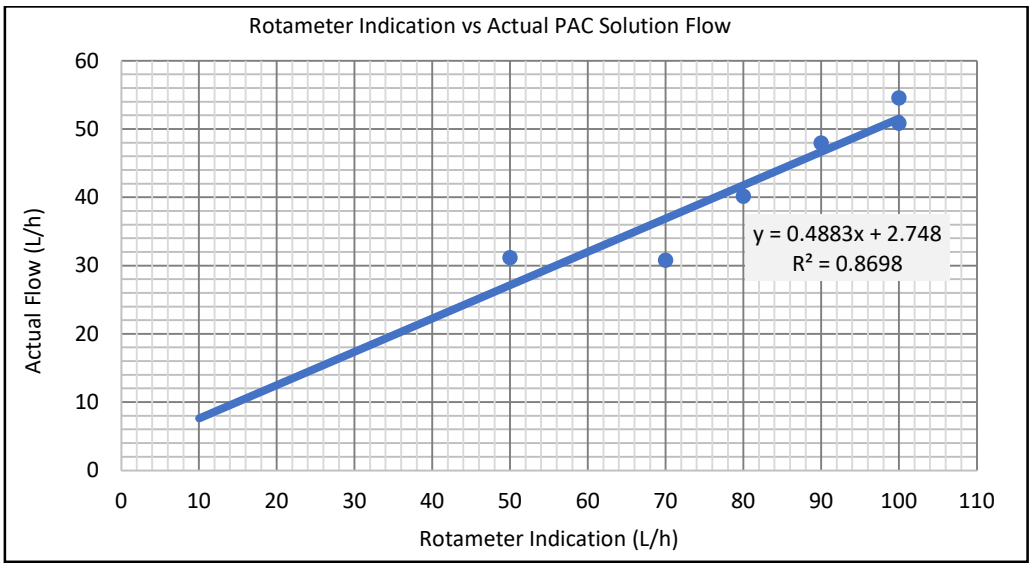


Figure 17: Rotameter indication and actual PAC solution flow rate

To set the Rotameter, use the following chart or table.

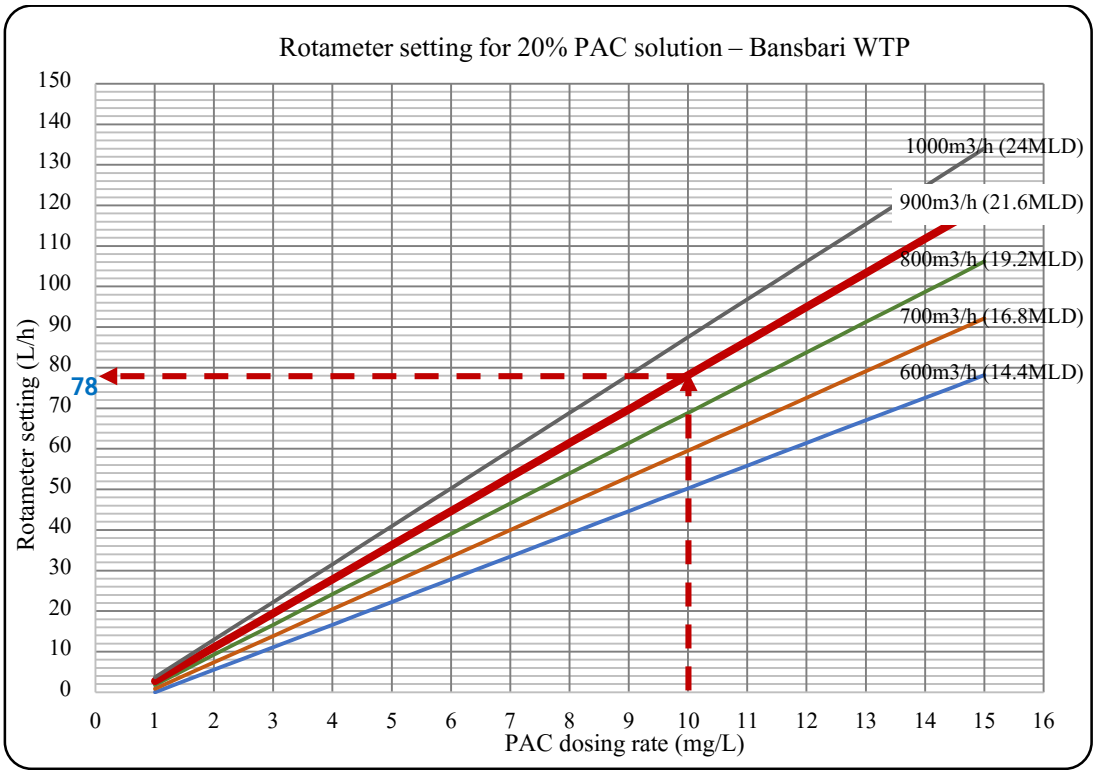


Figure 18: Rotameter setting for various PAC dosing rates

Table 3: Dosing rate of 20% PAC solution and corresponding Rotameter setting

PAC dosing rate (mg/L)	Rotameter setting for 20% PAC solution (L/h)								
	600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
1	0	0.4	0.9	1.4	1.8	2.3	2.8	3.2	3.7
2	5.6	6.5	7.4	8.3	9.3	10.2	11.1	12.1	13
3	11.1	12.5	13.9	15.3	16.7	18.1	19.5	20.9	22.3
4	16.7	18.6	20.5	22.3	24.2	26.1	27.9	29.8	31.6
5	22.3	24.7	27	29.3	31.6	34	36.3	38.6	41
6	27.9	30.7	33.5	36.3	39.1	41.9	44.7	47.5	50.3
7	33.5	36.8	40	43.3	46.6	49.8	53.1	56.3	59.6
8	39.1	42.8	46.6	50.3	54	57.7	61.5	65.2	68.9
9	44.7	48.9	53.1	57.3	61.5	65.7	69.8	74	78.2
10	50.3	54.9	59.6	64.3	68.9	73.6	78.2	82.9	87.6
11	55.9	61	66.1	71.2	76.4	81.5	86.6	91.7	96.9
12	61.5	67.1	72.6	78.2	83.8	89.4	95	100.6	106.2
13	67.1	73.1	79.2	85.2	91.3	97.3	103.4	109.5	115.5
14	72.6	79.2	85.7	92.2	98.7	105.3	111.8	118.3	124.8
15	78.2	85.2	92.2	99.2	106.2	113.2	120.2	127.2	134.1

There is not enough Jar test data available for Bansbari WTP. The following is a sample chart from New Sundarijal WTP done on Bagmati River water. Required PAC dosing rate can be estimated from the chart similar to this for various turbidities. When further data becomes available from Bansbari WTP this cart shall be updated.

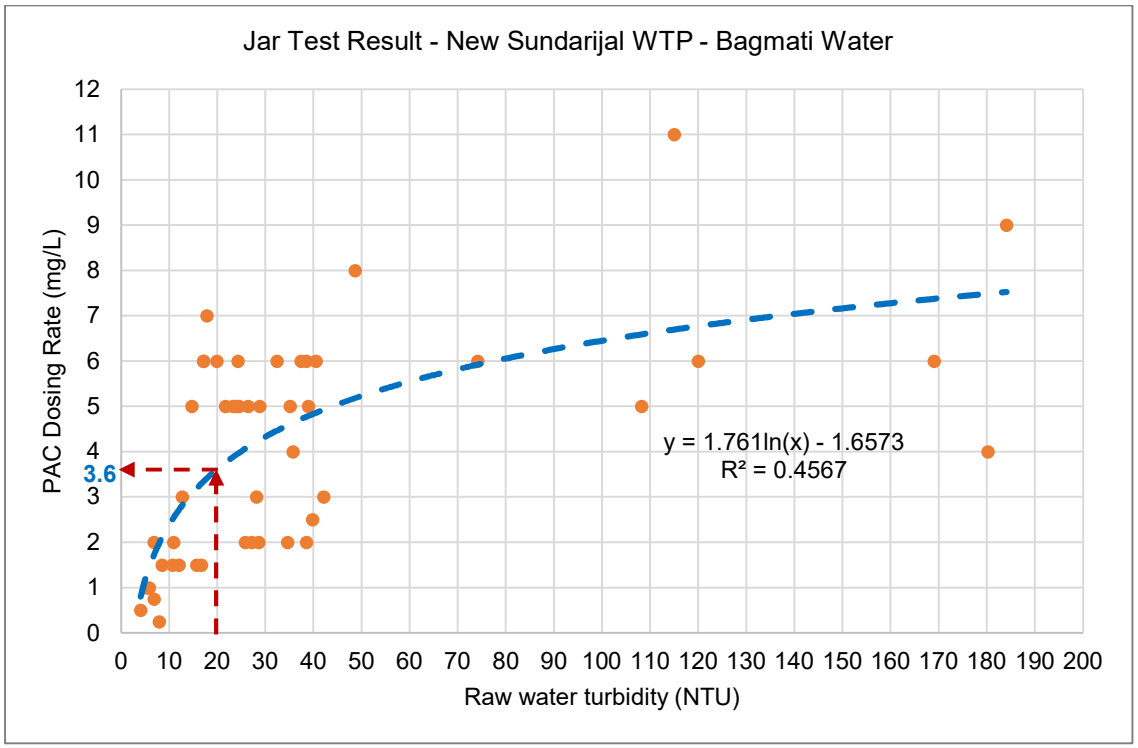


Figure 19: Jar Test Result of Bagmati River water done at New Sundarijal WTP

(The above example shows if the turbidity is 20 NTU, the required PAC dosing rate is about 3.6 mg/L)

3.2.4 Floc Formation

Floc formation at inlet of Sedimentation Basin and no floc leakage at outlet of Sedimentation Basin shall be checked and confirmed.

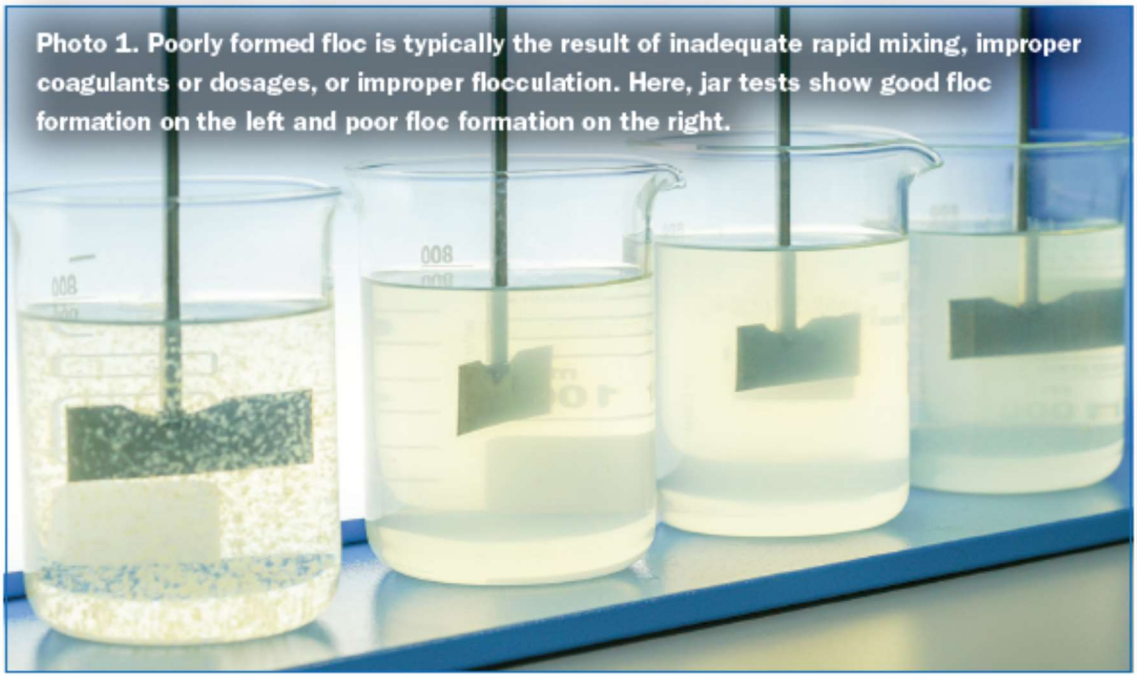
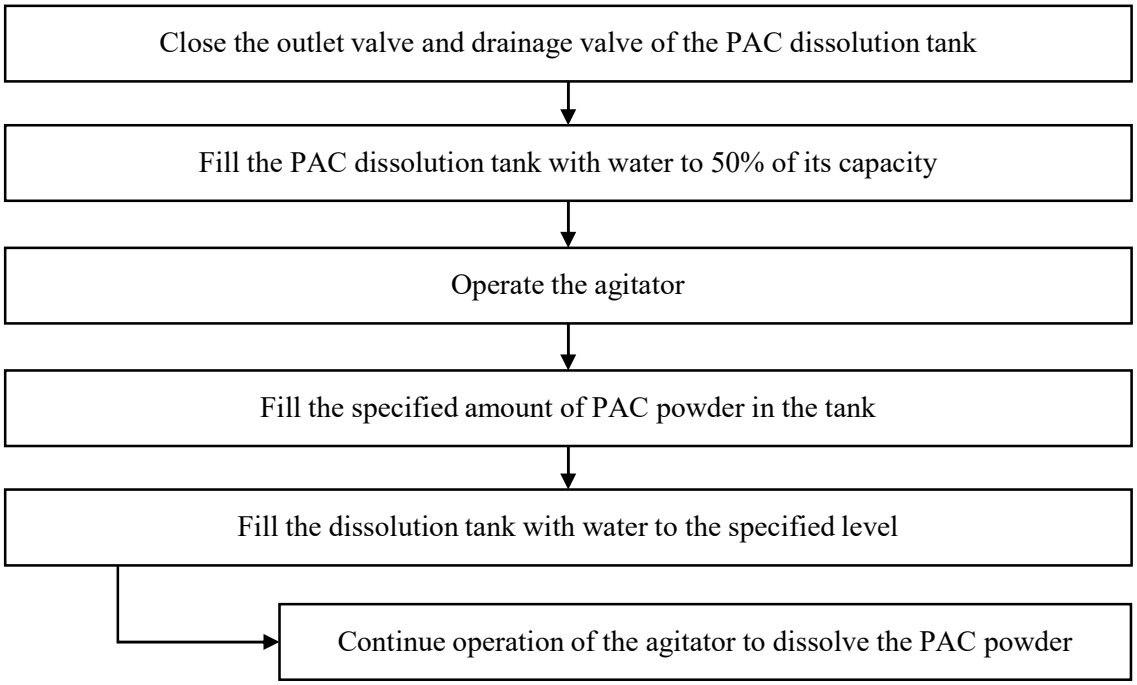


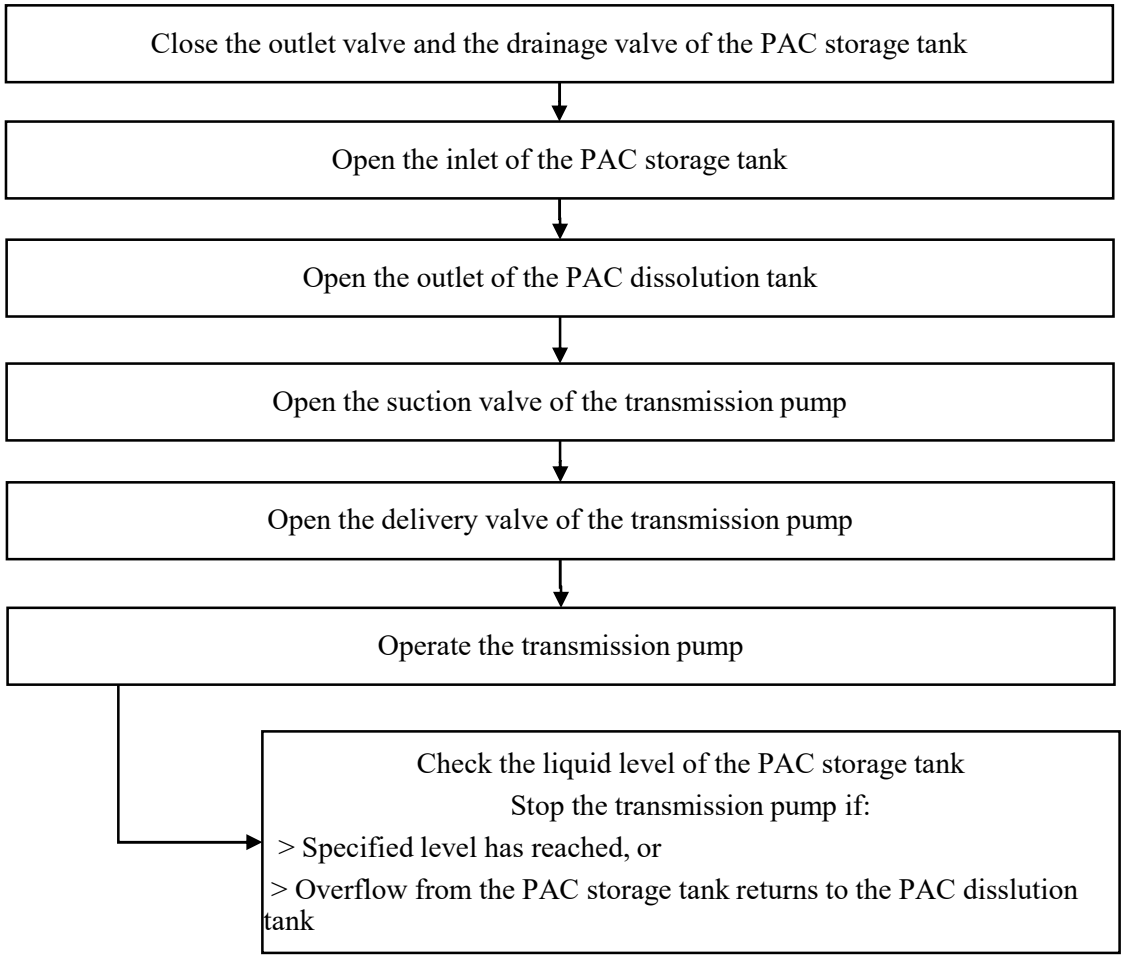
Photo 2: Example of well-formed and poorly formed flocs (Source: AWWA, Opflow, March 2022)

	
PAC dissolution tank	PAC solution storage tanks

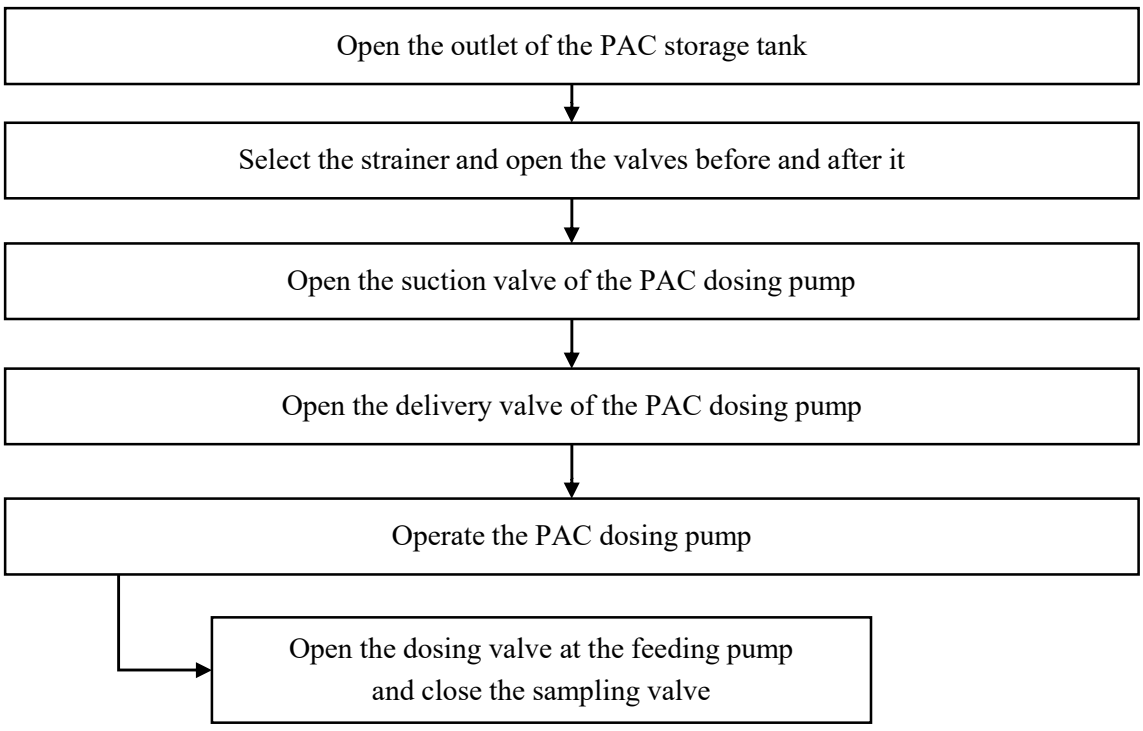
Process of preparing PAC solution



Process of transferring PAC solution to the storage tanks



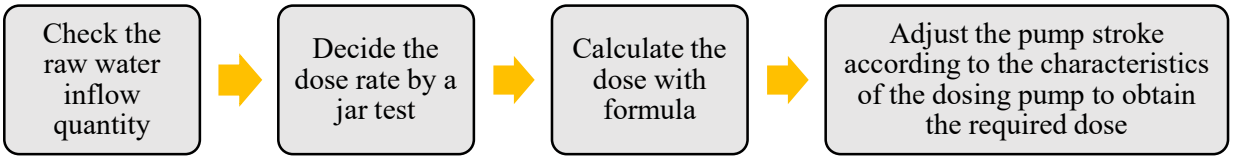
Process of PAC solution feeding



(Note: For feed confirmation and measuring of the dosage, take sample from the sampling points and analyze it. For this close the dosing valve and open the sampling valve.)

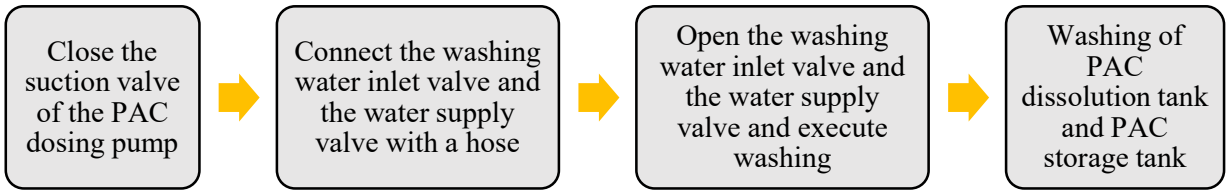
Adjustment of the PAC dosage

(Dosage must be set separately for surface and ground water)

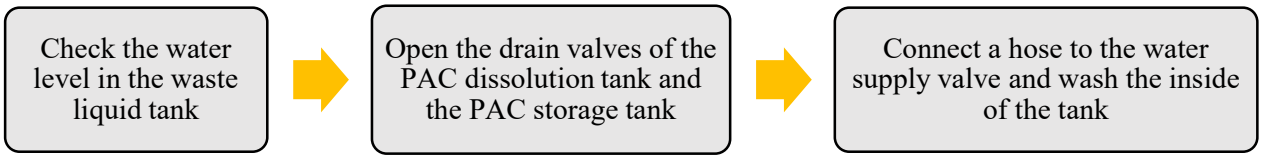


Washing of dosing pump and feeding pipe

(When the feeding is to be stopped for long time, wash the dosing pump and feeding pipe)



When the feeding is to be stopped for a long time, wash the PAC dissolution tank and the PAC storage tank.



Dosing pump switching

Pump switching becomes necessary depending on the raw water quantity and the dosage rate. Refer to the above tables for selection and use of dosing pumps.

3.3 Slaked Lime Feeding Equipment

Purpose: To adjust the pH of the surface water.

Mechanism: Pre-determined quantity of slaked lime is dissolved in water to give a desired concentration lime solution, transferred by transmission pump to the storage tank, and fed at suitable intervals by the feeding equipment at the inlet of the flocculation and sedimentation tank from the storage tank.

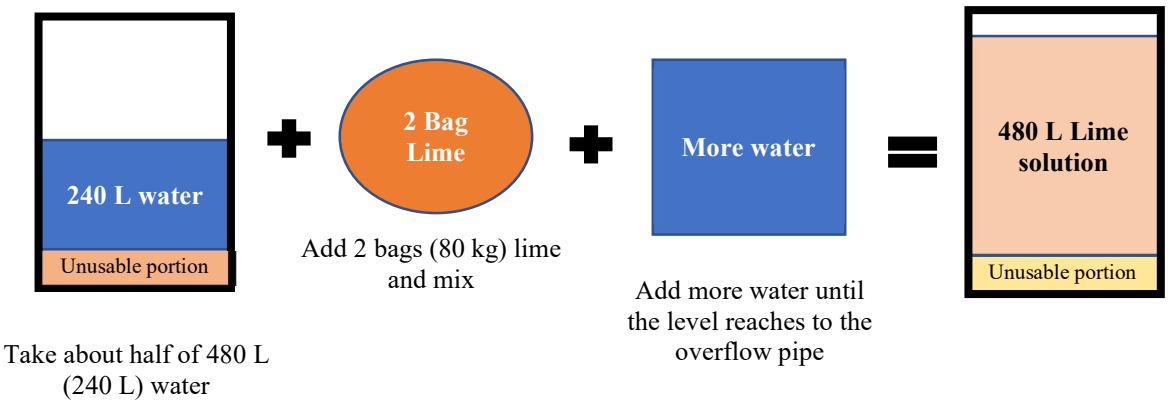
Equipment outline

Item	Type	Size/Details	No. of units
Dissolution tank	Open vertical cylindrical tank (polyethylene)	ϕ 900 mm x 1040 mm (h) Capacity: 0.5 m^3 Accessories: Fittings: 1 set Agitator: 1 stand	2 tanks
Agitator	Reciprocating rotary agitator	Reciprocating cycles: 200 cpm Motor: 0.75 kW x 400 V x 50 Hz	2 units
Transmission pumps	Magnet pump	Capacity: 40 A x 30 L/min x 15 m Motor: 0.75 kW x 400 V x 50 Hz	2 pumps
Slaked lime storage tanks	Open vertical cylindrical tank (polyethylene)	Approx. ϕ 1150 mm x 1200 mm (h) Capacity: 1 m^2 Accessories (per tank) Fittings – 1 set; Direct reading level gauge – 1 gauge; Manhole – 1 location; Air vent– 1 location; Agitator stand and agitator– 1 set	2 tanks
Feeding equipment	Diaphragm pump	Capacity: a. 20 A x 0.14 L/min x 3 kg/cm^2 (1 units) b. 20 A x 0.46 L/min x 3 kg/cm^2 (3 units) c. 20 A x 0.9 L/min x 3 kg/cm^2 (1 units) Motor: 0.2 kW x 400 V x 50 Hz Accessories: Back pressure valve- 1 unit; Safety valve - 3 units; Air chamber – 1 unit; Pressure gauge – 3 units	3 units
Piping and valves		Pipes, valves, hard polyvinyl pipes for city water; ball valves, diaphragm valves, etc. Diameter: 50 – 15 A	1 set
Instrument panel		BM-4	

3.3.1 Lime Solution Preparation

Lime solution is prepared as described below.

Effective volume of the lime dissolution tank = 480 L.



Take about half of 480 L (240 L) water

Add 2 bags (80 kg) lime and mix

Add more water until the level reaches to the overflow pipe

3.3.2 Dosing Rate Instruction

Lime solution dosing rate shall be in the following manner:

1. Flow measurement (m^3/day or m^3/hr) (by WTP Engineer)
   (Automatic measurement record can be taken when this system is installed and ready)

⇩

2. Find out the required Lime dosing rate by Jar Test (by Central Lab)

⇩

3. Calculate Lime dosage (feeding rate)/ Lime pump setting (by WTP Engineer)

⇩

4. Adjust Lime pump setting (by WTP operator)

⇩

5. Check pH and floc formation (by Central Lab/WTP)

3.3.3 Dosing Rate Calculation

Item	Description
Flow	900 m^3/h = (21.6 MLD) => 0.9 ×10^6 L/h
Lime content in lime solution	=> 2 bags (80 kg) Lime in 480 L solution => 80 ×10^6/480 => 167,000 mg/L
Dosing rate	10 mg/L (For example)
Required mass dosage	10 mg/L x 0.9×10^6 L/h = 9.0×10^6 mg/h
Required feeding rate	$= \frac{9.0 \times 10^6 \text{ mg/h}}{167{,}000 \text{ mg/L}}$ = 54 L/h = 0.9 L/min

Easy formula	$= \frac{900\ m^3/h \times 10\ mg/L}{167} = 54\ L/h$

Reference chart and table for Lime solution dosage (feeding rate) calculation:

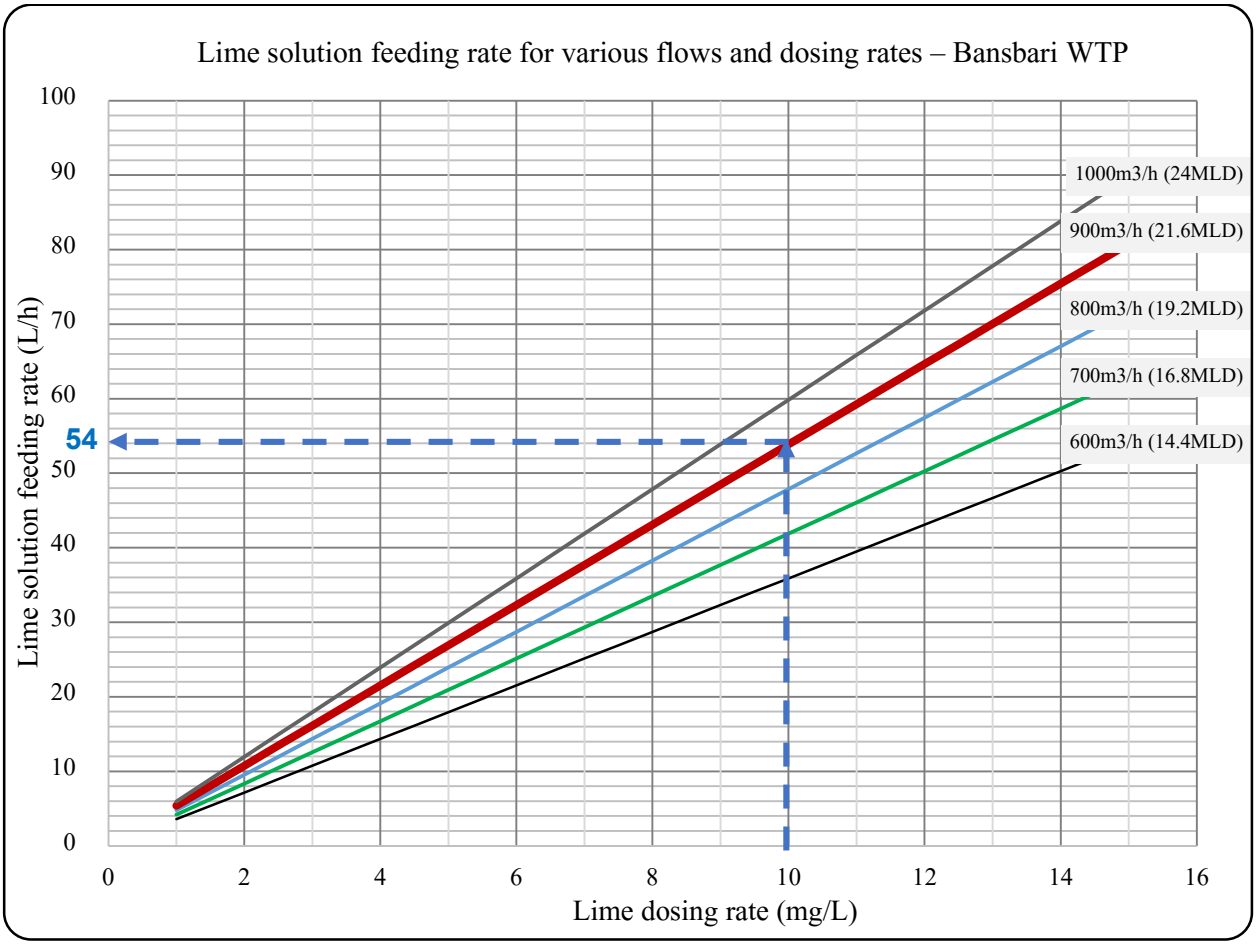


Figure 20: Lime solution feeding rates

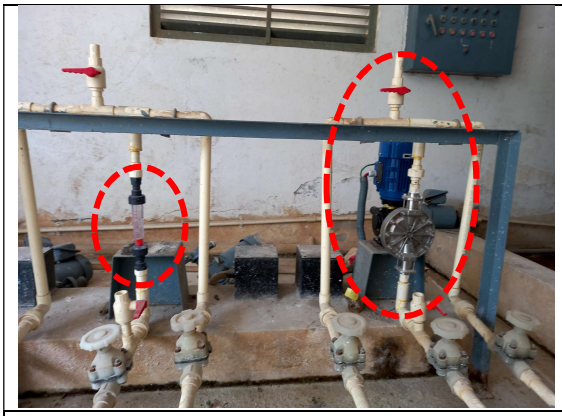
The feeding rates can also be calculated from the following Table.

Table 4: Lime solution feeding rates

Lime dosing rate (mg/L)	Daily required volume of lime solution for 900 m^3/h flow (L/day)	Lime solution feeding rates (L/h) - Bansbari WTP								
		600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
1	120	4	4	4	4	5	5	5	6	6
2	264	7	8	8	9	10	10	11	11	12

Lime dosing rate (mg/L)	Daily required volume of lime solution for 900 m^3/h flow (L/day)	Lime solution feeding rates (L/h) - Bansbari WTP								
		600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
3	384	11	12	13	13	14	15	16	17	18
4	528	14	16	17	18	19	20	22	23	24
5	648	18	19	21	22	24	25	27	28	30
6	768	22	23	25	27	29	31	32	34	36
7	912	25	27	29	31	34	36	38	40	42
8	1,032	29	31	34	36	38	41	43	46	48
9	1,176	32	35	38	40	43	46	49	51	54
10	1,296	36	39	42	45	48	51	54	57	60
11	1,416	40	43	46	49	53	56	59	63	66
12	1,560	43	47	50	54	57	61	65	68	72
13	1,680	47	51	54	58	62	66	70	74	78
14	1,800	50	54	59	63	67	71	75	80	84
15	1,944	54	58	63	67	72	76	81	85	90
16	2,064	57	62	67	72	77	81	86	91	96
17	2,208	61	66	71	76	81	87	92	97	102
18	2,328	65	70	75	81	86	92	97	102	108
19	2,448	68	74	80	85	91	97	102	108	114
20	2,592	72	78	84	90	96	102	108	114	120

3.3.4 Lime Dosing Pump Setting



Rotameter (left) and Pump (right) for feeding lime solution

Control nob of lime pump

Photo 3: Lime dosing pump setting methods

Symbol		Discharge of Pump
(+ve) Sign on Knob	Clockwise Rotation	Increase
(-ve) Sign on Knob	Anti-Clockwise Rotation	Decrease

Table 5: Number of rotation and average flowrate of Lime dosing pump

Steps	Description	Rotation	Average Flow (L/h)	Remarks
1	When Pump Valve is Tight	0.0	0	
2	When valve is open - Fully Open (0 - 1.0) - 1st time	1.0	0.9	
3	When valve is open - 1/2 Open (1 - 1.5) - 2nd time	1.5	12.1	
4	When valve is open - Full Open (1.5 - 2.0) - 3rd time	2.0	33.8	
5	When valve is open - 1/2 Open (2.0 - 2.5) - 4th time	2.5	57.2	
6	When valve is open - 1/2 Open (2.5 - 3.0) - 5th time	3.0	81.5	
7	When valve is open - 1/2 Open (3.0 - 3.5) - 6th time	3.5	105.9	
8	When valve is open - 1/2 Open (3.5 - 4.0) - 7th time	4.0	131.6	
9	When valve is open - 1/2 Open (4.0 - 4.5) - 8th time	4.5	153.9	
10	When valve is open - 1/2 Open (4.5 - 5.0) - 9th time	5.0	167.9	
11	When valve is open - 1/2 Open (5.0 - 5.5) - 10th time	5.5	174.9	Flow is almost similar from step 11 onward
12	When valve is open - 1/2 Open (5.5 - 6) - 11th time	6.0	174.8	
13	When valve is open - Full Open (6.0 - 7.0) - 12th time	7.0	174.2	

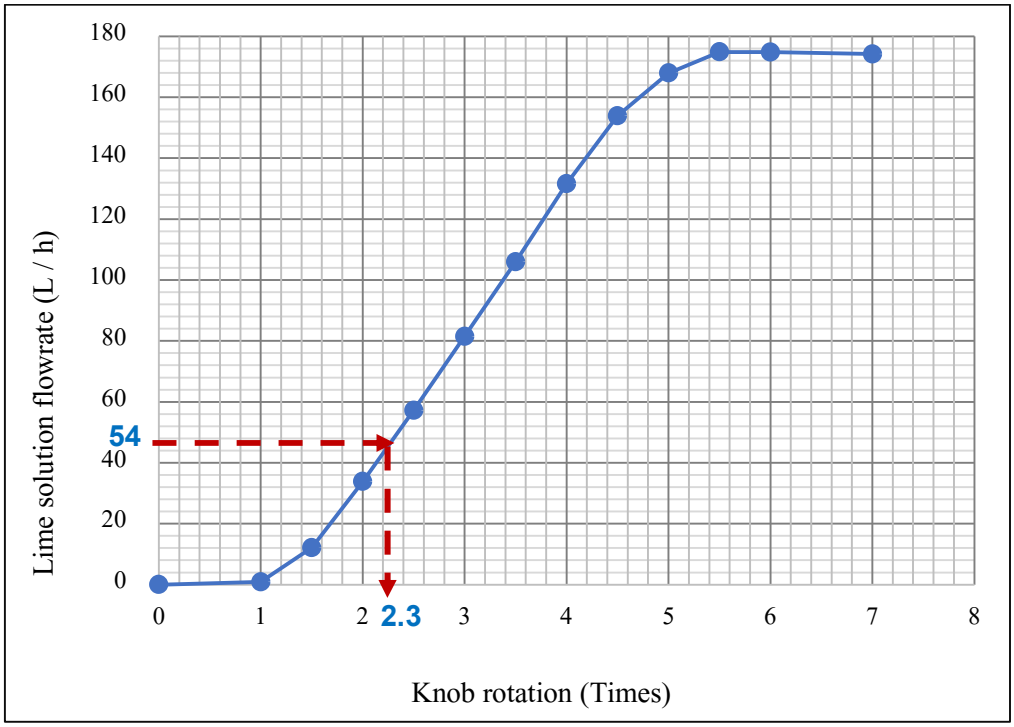
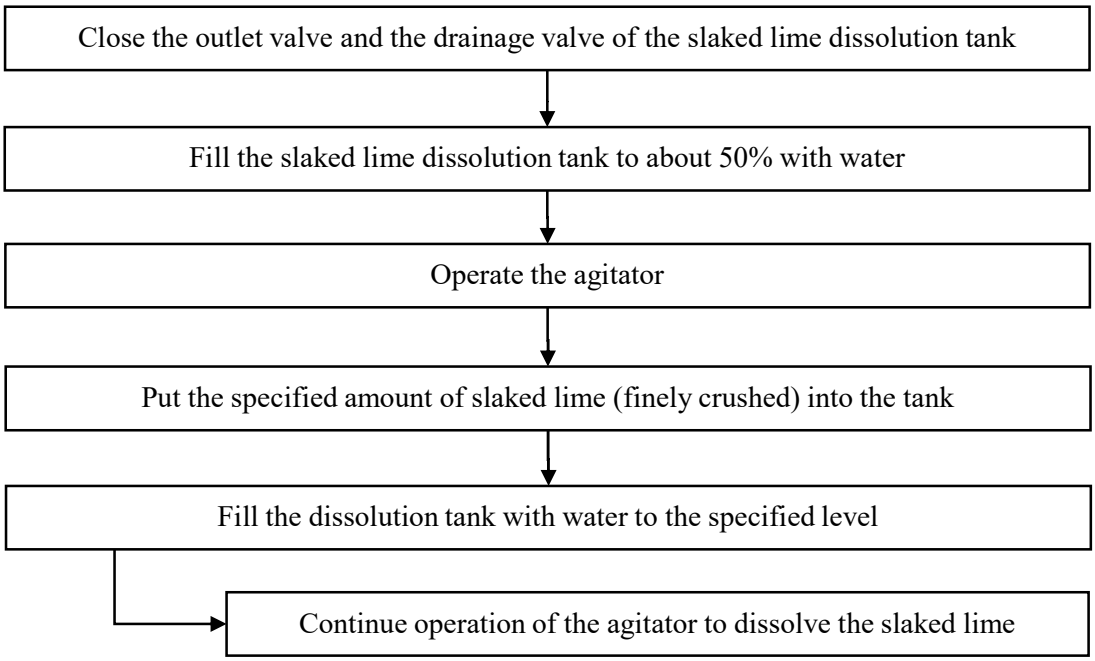
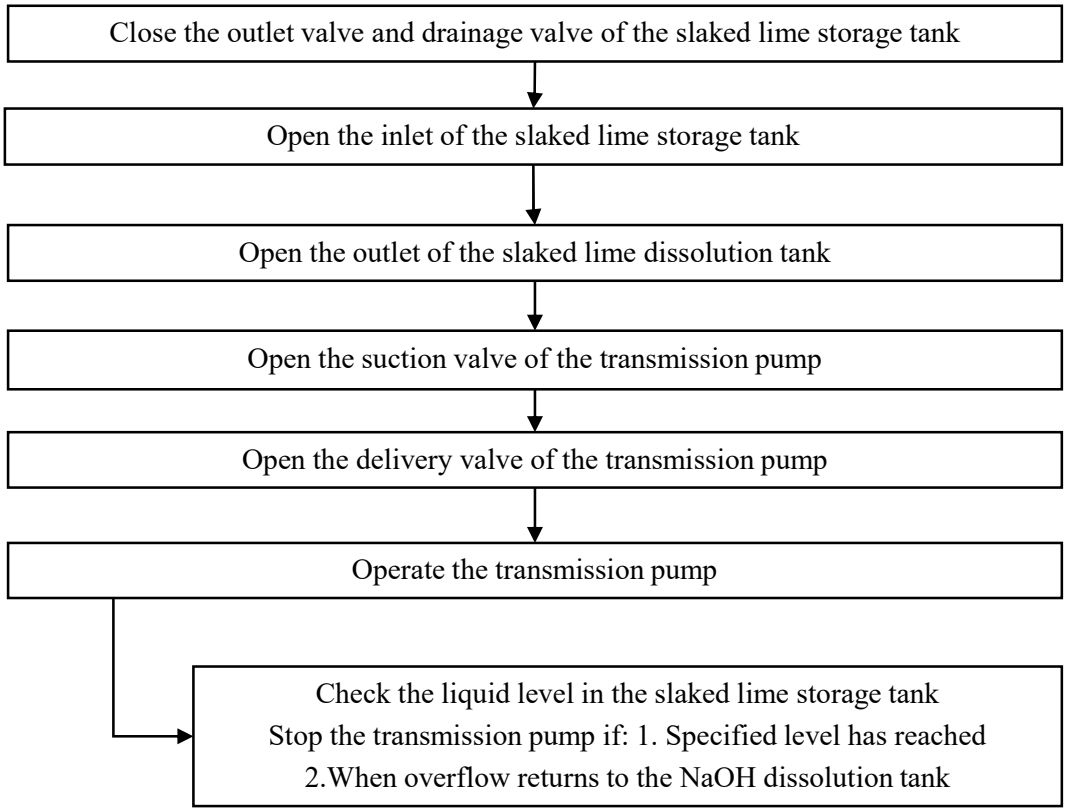


Figure 21: Average flowrate against number of rotation of knob

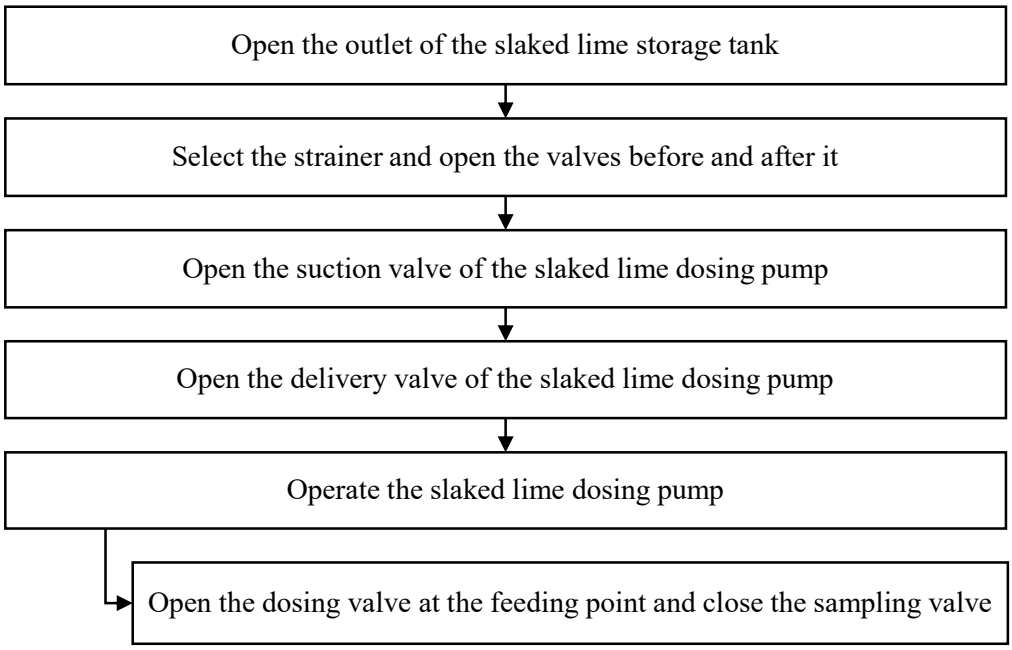
Slaked lime dosing adjustment process



Slaked lime solution transfer process



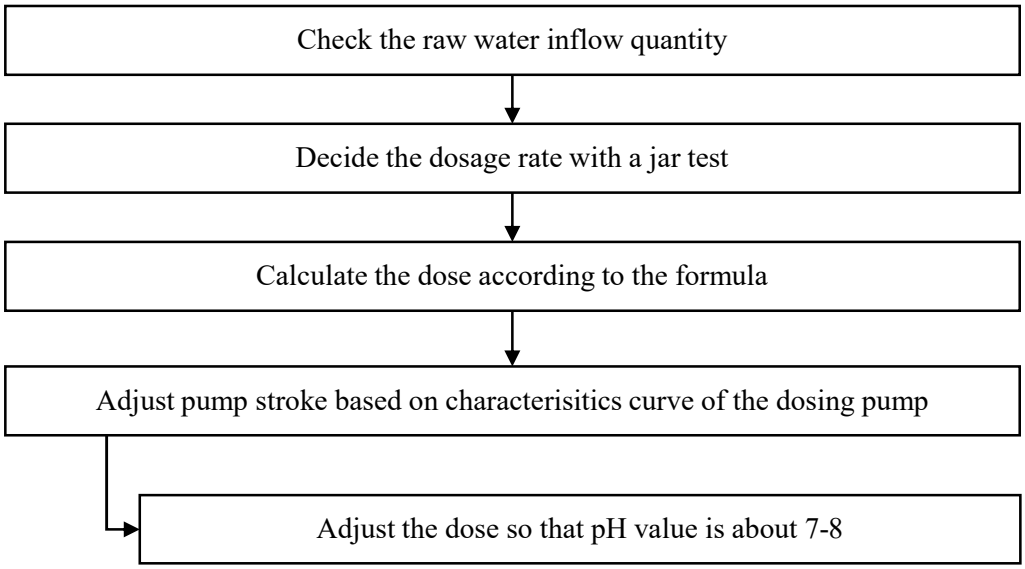
Process of slaked lime feeding



(Note: For checking and confirming dosage, take samples from sampling line after closing the dosing valve and opening the sampling valve)

The slaked lime feeding pipe may become clogged by calcium carbonate. Clean the feeding pipe periodically.

Process of adjusting the slaked lime dosage



Washing of the dosing pump and feeding pipe

When feeding is to be stopped for a long time, wash the dosing pump and the feeding pipe.

Close the suction valve of the slaked lime dosing pump → Connect the washing water inlet valve and the water supply valve with a hose → Open the washing water inlet valve and the water supply valve and execute washing

Washing of slaked lime dissolution tank and slaked lime storage tank

When feeding is to be stopped for a long time, wash the slaked lime dissolution tank and the slaked lime storage tank.

Check the water level in the waste liquid tank → Open the drain valves of the slaked lime dissolution tank and the slaked lime storage tank → Connect a hose to the water supply valve and wash the inside of the tanks

Dosing pump switching

Pump should be switched depending on the treated water quantity and the dosage rate. Refer to the table for selection and use of dosing pumps.

Please refer to the following table for lime solution feeding rates for various dosing rates and raw water flow rates.

(Concentration of lime solution when prepared as mentioned in SSOP is about 15.6%)

Lime dosing rate (mg/L)	Lime solution feeding rates (L/h) – Bansbari WTP								
	600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
1	4	4	4	4	5	5	5	6	6
2	7	8	8	9	10	10	11	11	12
3	11	12	13	13	14	15	16	17	18
4	14	16	17	18	19	20	22	23	24
5	18	19	21	22	24	25	27	28	30
6	22	23	25	27	29	31	32	34	36
7	25	27	29	31	34	36	38	40	42
8	29	31	34	36	38	41	43	46	48
9	32	35	38	40	43	46	49	51	54
10	36	39	42	45	48	51	54	57	60
11	40	43	46	49	53	56	59	63	66

Lime dosing rate (mg/L)	Lime solution feeding rates (L/h) – Bansbari WTP								
	600m3/h (14.4MLD)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)
12	43	47	50	54	57	61	65	68	72
13	47	51	54	58	62	66	70	74	78
14	50	54	59	63	67	71	75	80	84
15	54	58	63	67	72	76	81	85	90
16	57	62	67	72	77	81	86	91	96
17	61	66	71	76	81	87	92	97	102
18	65	70	75	81	86	92	97	102	108
19	68	74	80	85	91	97	102	108	114
20	72	78	84	90	96	102	108	114	120

4. Rapid Sand Filtration Equipment

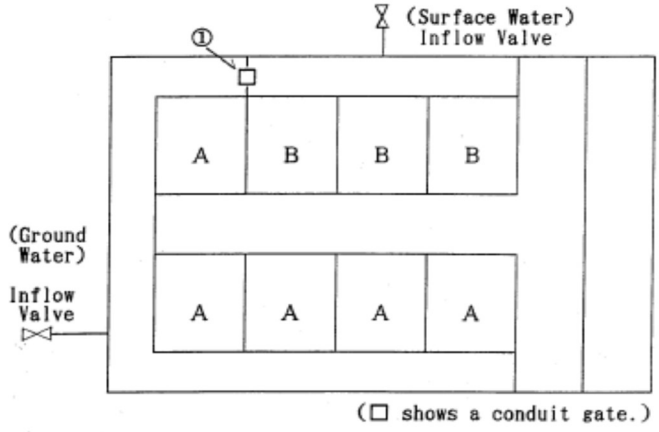
4.1 General

Purpose: The Rapid Sand Filter (RSF) is used to remove turbidity, iron, and manganese from the raw water which is subjected to flocculation and sedimentation.

Equipment Outline:

<table>
<tr><th>Item</th><th>Type</th><th>Size/Details</th><th>No. of units</th></tr>
<tr><td>Filter basins</td><td>Open natural gravity</td><td>2.65 m (w) x 7.55 m (l)
Area: 20 m^2
Filter media:
<table>
<tr><th>Media</th><th>Diameter (mm)</th><th>Depth (mm)</th></tr>
<tr><td>Sand</td><td>0.6</td><td>600</td></tr>
<tr><td rowspan="3">Gravel (for support)</td><td>2-4</td><td>50</td></tr>
<tr><td>4-6</td><td>50</td></tr>
<tr><td>6-10
10-20</td><td>50
50</td></tr>
</table></td><td>8 basins</td></tr>
<tr><td>Surface washing pumps – 2 nos.</td><td>Suction Volute</td><td>Capacity: ϕ200 x ϕ150 x 4 m^3/min x 24 m
Motor: 22 kW x 400V x 50 Hz</td><td>2 pumps</td></tr>
<tr><td>Make up pumps – 2 nos.</td><td>Centrifugal</td><td>Capacity: ϕ200 x 4.2 m^3/min x 7 m
Motor: 7.5 kW x 400 V x 50 Hz</td><td>2 pumps</td></tr>
<tr><td>Water discharge trough</td><td>Basin</td><td>300 (w) x 300 (d) x 2900 (l)</td><td>4 nos.</td></tr>
<tr><td>Raw water inflow valve (V1)</td><td>Valve</td><td>ϕ 350</td><td></td></tr>
<tr><td>Water discharge gate (G1)</td><td>Gate</td><td>ϕ 450</td><td></td></tr>
<tr><td>Clear water gate (G2)</td><td>Gate</td><td>ϕ 450</td><td></td></tr>
<tr><td>Drainage valve (V2)</td><td>Valve</td><td>ϕ 150</td><td></td></tr>
<tr><td>Surface washing valve (V3)</td><td>Valve</td><td>ϕ 250</td><td></td></tr>
</table>

*: All units are in mm unless specified



4.2 Operation

The inflow of the biologically treated water is limited to the period from March to June and as the quantity of water differs according to the month, the equipment is divided into 8 filters which are used in combination. Attention should be paid to the opening and closing of the conduit gates to prevent mixing of ground and surface waters.

Open/closed condition of the conduit gates

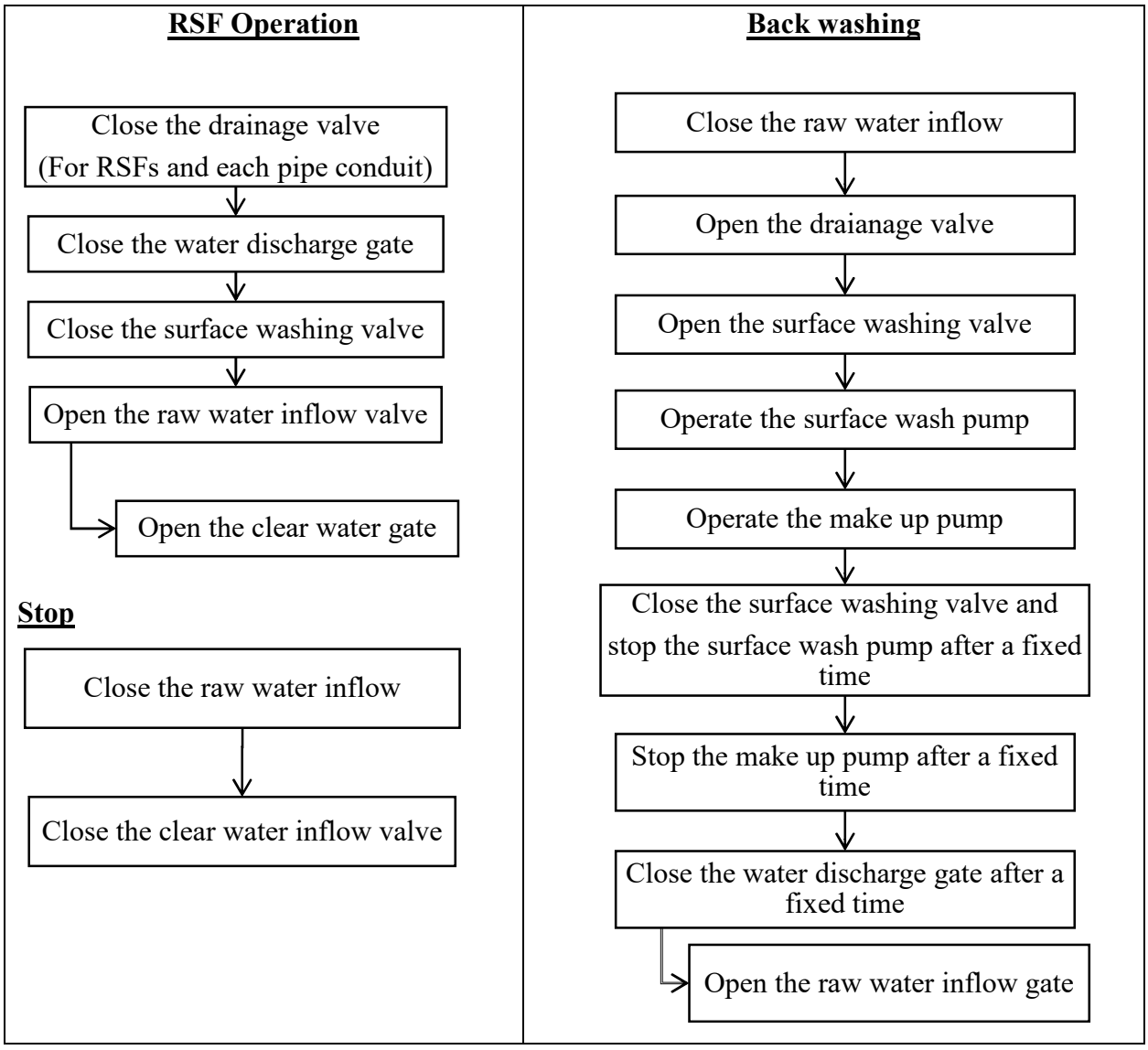
The open/closed condition of the conduit gates according to the operation condition of the RSF is shown in the following table. Surface and ground water should not be mixed.

Equipment	Feb-June	July-Dec	January
Surface water inflow valve	Open	Open	Open
Ground water inflow valve	Open	Closed	Closed
Gate 1	Closed	Open	Closed

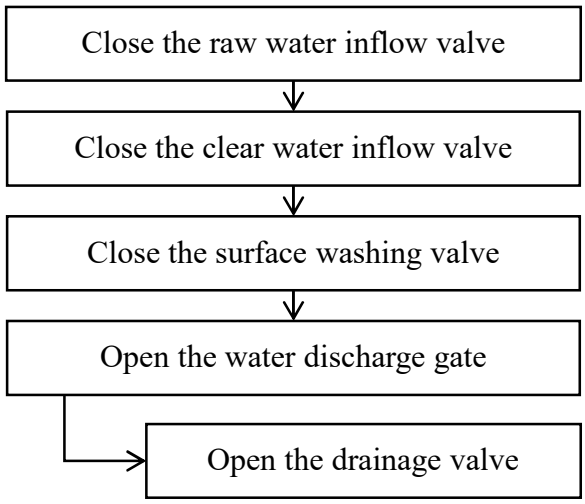
Open/closed condition of valves and air blower operation

Equipment	During filtration	During washing	During inspection in the basin
Raw water inflow valve (V1)	Open	Closed	Closed
Water discharge gate (G1)	Closed	Open	Open
Clear water gate (G2)	Open	Open	Closed
Drainage valve (V2)	Closed	Closed	Open
Surface washing valve (V3)	Closed	Open	Closed
Surface washing pump	-	Operation of 1pump	-
Make up pump	-	Operation of 1pump	-

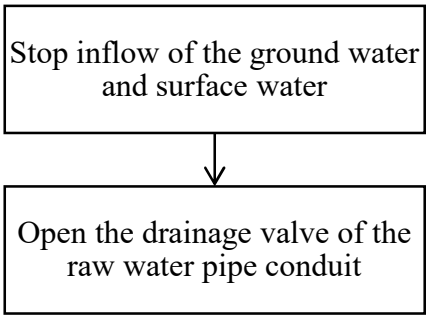
Operation procedure



Draw-off



For draw off of the raw water pipe conduit



For draw off of the clear water conduit and the outflow conduit

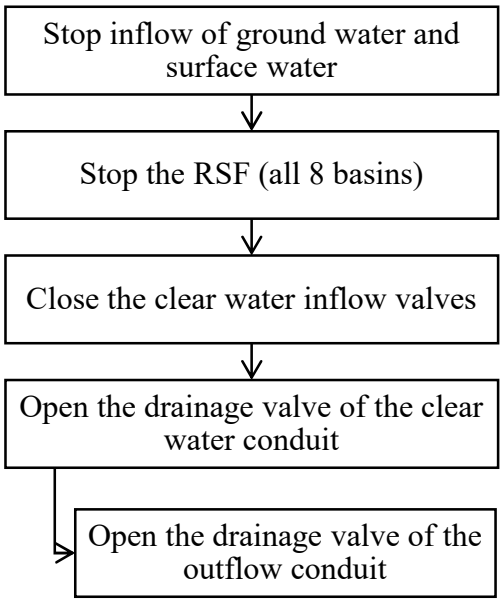


Illustration of water inside the RSF during backwash

Dirty water (initially)	Clear water (completion of backwash)
	

5. Clear-Water Reservoir and Water Transmission Pump equipment

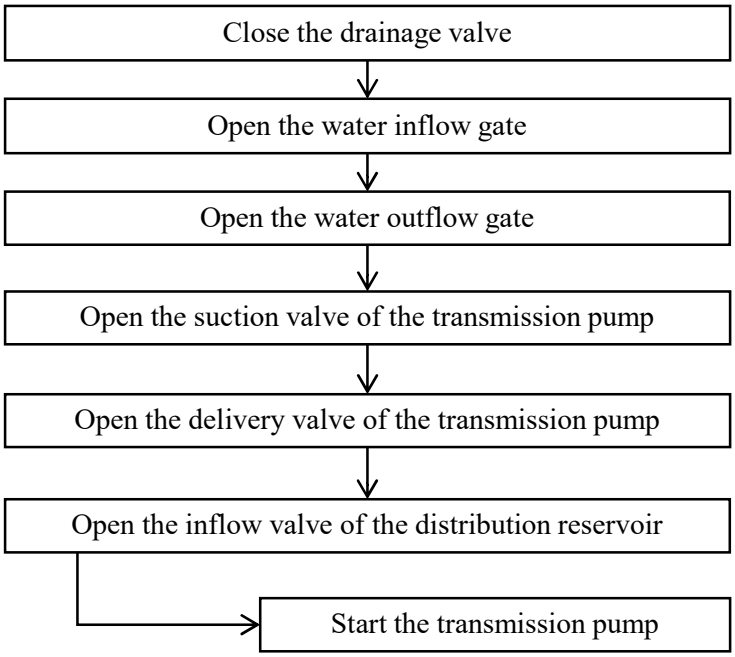
Purpose: To adjust and relief the unbalance between the filtered water and the water supply volume at the time of water transmission caused by rapid fluctuation of the demand. Also, functions as a surface washing pump well and a water supply pump well.

Item	Type	Size/Details	No. of units
Basins	Reinforced Cement Concrete	Dimensions: a. 2.85 m (w) x 8.7 m (l) x 3.3 m (d) x 2 Nos. b. 2.85 m (w) x 10.15 m (l) x 3.3 m (d) x 4 Nos. c. 2.85 m (w) x 4.2 m (l) x 3.3 m (d) x 2 Nos. Effective capacity: 1235.6 m^3 Retention time: 65 minutes	2 basins
Transmission pumps	Suction Volute Pump	Capacity: ϕ250 x ϕ200 x 5.3 m^3/min x 9m Motor: 18.5 kW x 400 V x 50 Hz	4 pumps
Water supply pumps	Pressure type automatic supply unit	Capacity: ϕ50 x ϕ65 x 0.6 m^3/min Motor: 3.7 kW x 400 V x 50 Hz	1 set (2 pumps)
Bed drainage pumps	Submersible pumps for soil water	Capacity: ϕ50 x 0.1 m^3/min x 10 m Motor: 0.4 kW x 400 V x 50 Hz	1 set (2 pumps)

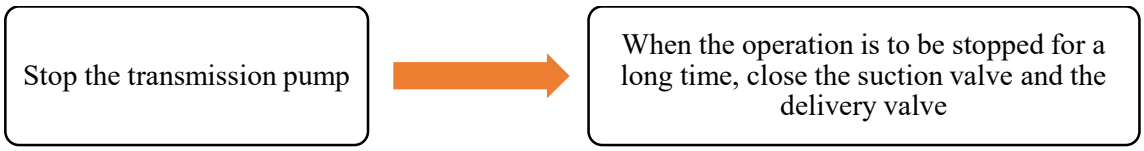
Operation:

1. Confirmation of the open/closed condition of the conduit gate.
2. The CWR is composed of two basins, and operation with one basin is possible. In case of operation of one basin, operate the inflow and the outflow gate of the respective basin.

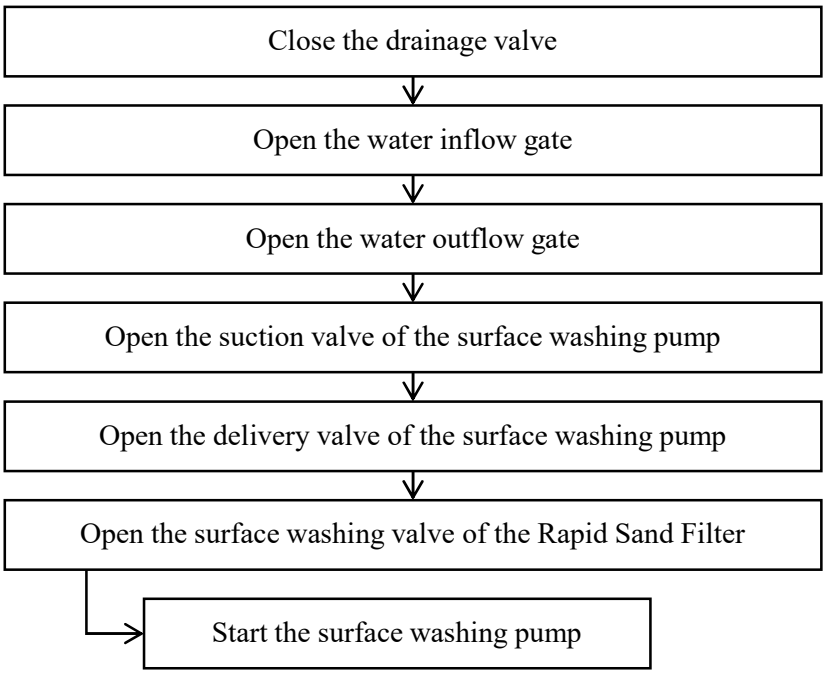
Transmission pump operation procedure



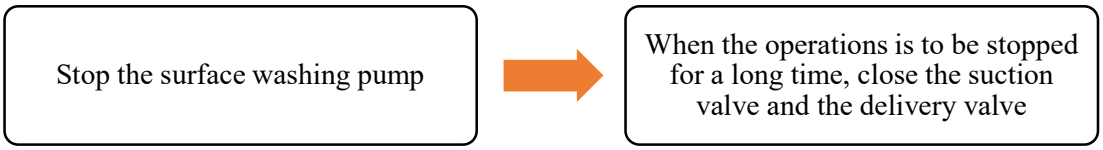
Stopping of the transmission pump



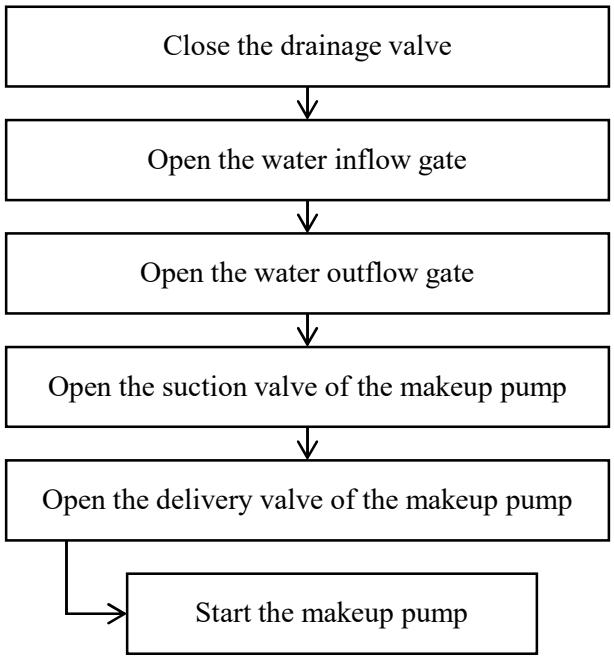
Operation of the surface washing pump



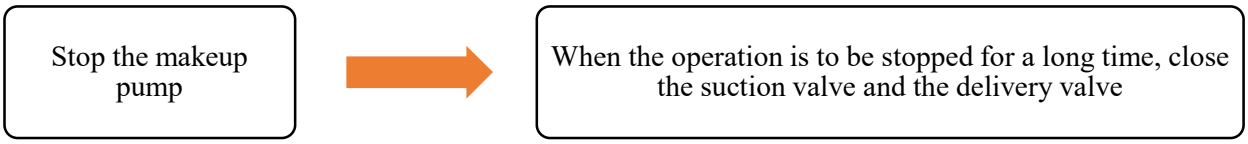
Stopping of the surface washing pump



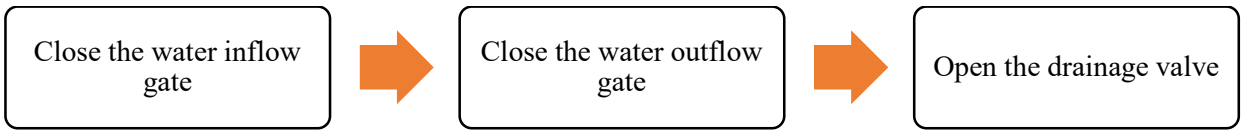
Operation of the makeup pump



Stopping of the makeup pump

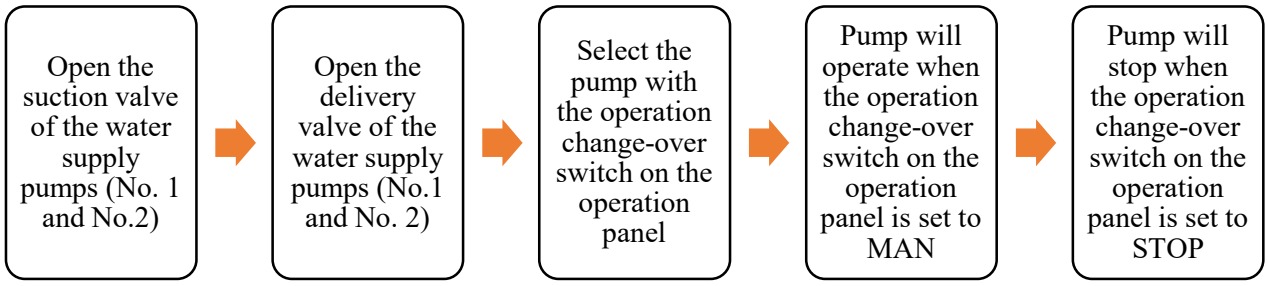


Draw off for the CWR

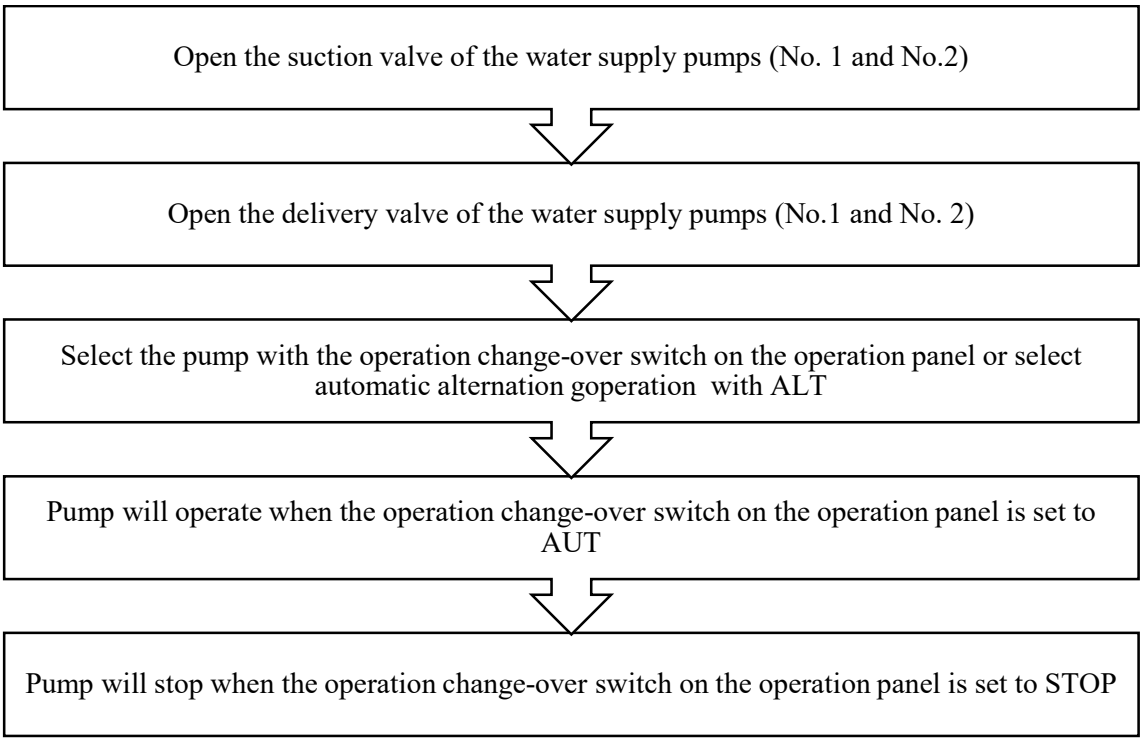


(Note: Do not execute draw off operation for the CWR when washing operation, sludge drainage, or draw off operation is being executed for the bio filter equipment or the RSF equipment)

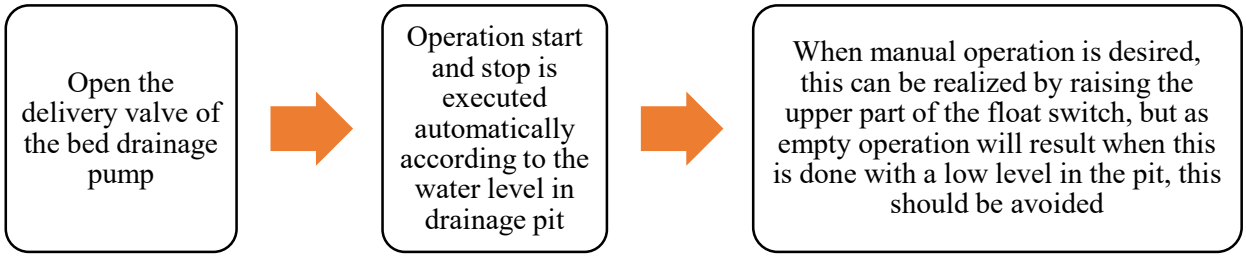
Manual Operation of the water supply pump



Automatic Operation of the water supply pump



Operation of the bed drainage pump



6. Sludge and Drainage Equipment

Purpose: To receive a large quantity of drainage in a short time when the rapid sand filter is being washed.

Equipment Outline

Item	Type	Size/Details	No. of units
Sludge and Drainage Basins	RCC	8 m (w) x 8 m (l) x 3.5 m (d) Effective capacity: 224 m^3/basin x 2 = 448 m^3	2 basins
Drainage pumps	Submersible sewage pump	Capacity: ϕ100 x 2.0 m^3/min x 12 m H Motor: 11 kW x 400V x 50 Hz	2 pumps

Sludge drainage basins

Sludge drainage basin (1 of 4)

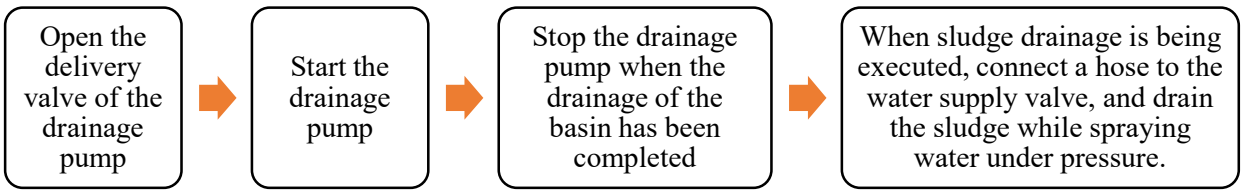
Cleaning of sludge drainage basin

Suction pipe for recycling of sludge

Checking the state of the conduit gates

As there are 2 sludge and drainage basins, operation with a single basin is possible. In case of operation of a single basin, operate the water inflow valve of the respective basin.

Operation of the drainage pump



7. Chlorine Feeding Equipment

7.1 Sodium Hypochlorite Generation and Feeding Equipment

This equipment is not in use.

7.2 Bleaching Powder Feeding Equipment

6.2.1 Specifications for the bleaching powder feeding equipment

① Bleaching powder dissolution tanks

Type: Vertical open cylindrical type (made of PE)

Dimensions: ϕ 1150 mm x height 1200 mm

Capacity: 1.0 m^3

Quantity: 2 tanks

Accessories (per tank)

Fittings 1 set

Agitator stand 1 stand

② Agitators

Type: Reciprocating rotary agitator

Reciprocating cycles: 200 cpm

Motor: 0.75 kW x 400 V x 50 Hz

Quantity: 2 units

③ Transmission pumps

Type: Magnet pump

Capacity: 40 A x 30 L/min x 10 m

Motor: 0.4 kW x 400 V x 50 Hz

Quantity: 2 pumps

④ Bleaching powder storage tanks

Type: Vertical enclosed cylindrical type (made of polyethylene)

Dimensions: ϕ 1425 mm x height 1570 mm

Capacity: 2.0 m^3

Quantity: 2 tanks

Accessories (per tank)

Fittings 1 set

Direct-reading level meter 1 unit

Manhole	1 location
Air vent	1 location

⑤ Feeding equipment

Type: Diaphragm pump

Capacity:

(for oxygenation)

a. 15 A x 0.46 L/min x 3 kg/cm^2 x 2

b. 15 A x 1.8 L/min x 3 kg/cm^2 x 2

(for sterilization)

c. 15 A x 0.23 L/min x 3 kg/cm^2 x 1

d. 15 A x 0.9 L/min x 3 kg/cm^2 x 1

Motor: 0.2 kW x 400 V x 50 Hz

Quantity: 6 units

Accessories:

Back-pressure valve	3 units
Safety valve	6 units
Air chamber	3 units
Pressure gauge	6 units

⑥ Piping and valves

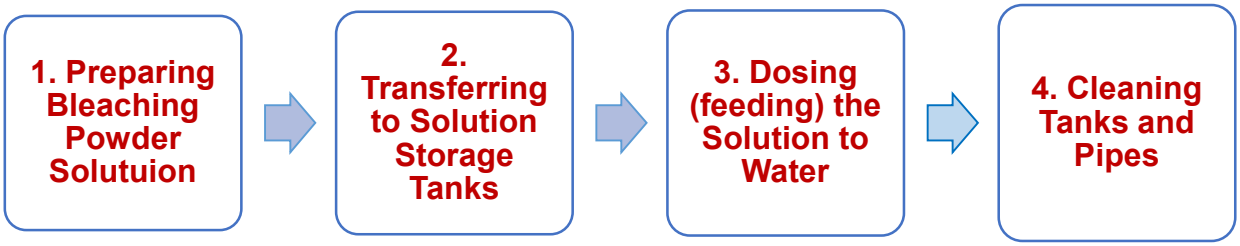
Pipes, valves, hard polyvinyl pipe for city water, ball valves, diaphragm valves, etc.

Diameter: 50 ~ 15 A

Quantity: 1 set

⑦ Instrument panel: BM-6

Main steps



7.3 Preparing Bleaching Powder Solution

Effective size of dissolution tank = 480 L.

Desired concentration of chlorine in bleaching powder solution = about 5% Cl_2.

Prepare bleaching powder solution following the schematics and details shown below.

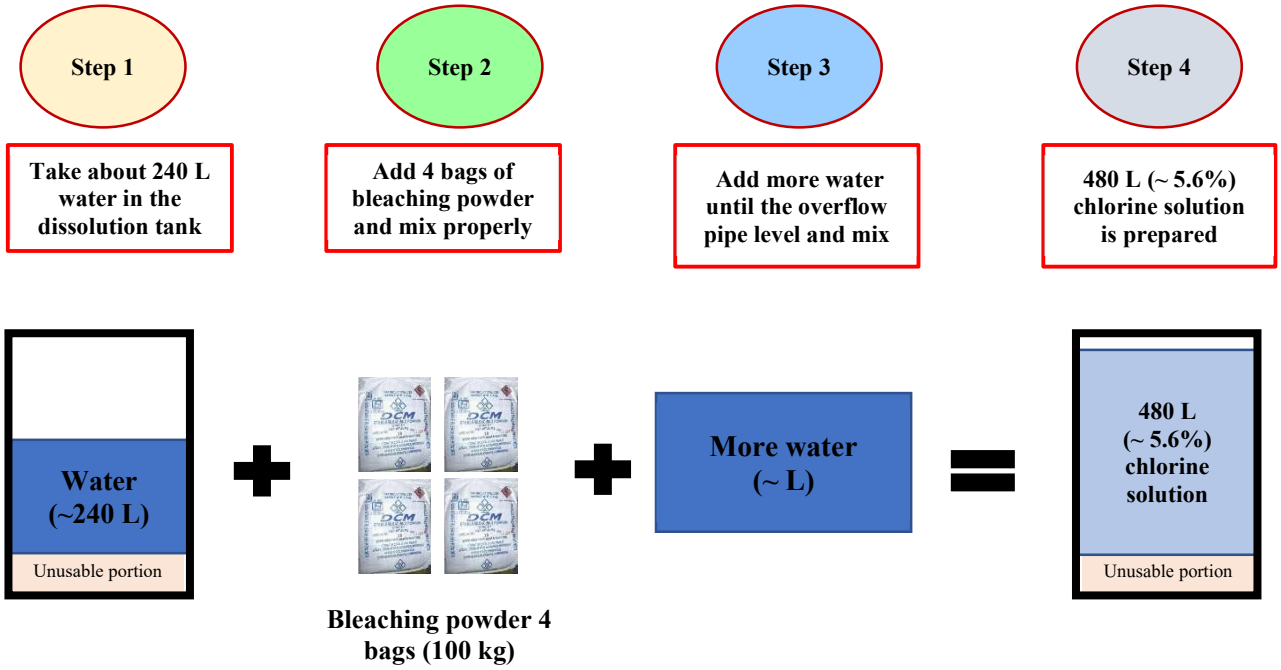


Figure 22: Schematics chloring solution preparation using bleaching powder

Operation procedure

1. Close the outlet valve and the drainage valve of the dissolution tank
2. Fill about 50% (240 L) of the tank with water
3. Add 4 bags (100 kg) of bleaching power
4. Operate the agitator
5. Add water until the level reaches the overflow pipe, continue agitating for about 20 minutes

6. Allow 30 minutes to settle

⇩

7. Transfer the solution to the storage tank with the transmission pump

⇩

8. Repeat the Steps 1-7 in another tank or in the same tank after cleaning it

7.4 Transferring the Bleaching Powder Solution to Storage Tanks

Operation procedure

1. Close the outlet valve and the drainage valve of the bleaching powder storage tank

⇩

2. Open the inlet valve of the bleaching powder storage tank

⇩

3. Open the outlet valve of the bleaching powder dissolution tank

⇩

4. Open the suction valve of the transmission pump

⇩

5. Open the delivery valve of the transmission pump

⇩

6. Operate the transmission pump

⇩

7. Check the liquid level of the storage tank and stop the transmission pump when the maximum storage level has been reached or liquid in the dissolution tank has been finished

7.5 Dosing (Feeding) the Bleaching Powder Solution to Water

Process flow

1. Find out chlorine demand (how many mg of chlorine to be dosed per L of water) from lab test

⇩

2. Calculate the required chlorine dosing rate (mg/L) = Chlorine demand (mg/L) + Desired residual chlorine (mg/L) = D mg/L,

OR

Measure the residual chlorine of treated water and decide dosing rate.

⇩

3. Check the raw water inflow quantity or find out daily filtered water volume Q (m^3/day or m^3/h)

⇩

4. Calculate dosage (feeding rate) for the prepared solution according to Formula, Chart, or Table

⇩

5. Adjust the dosage (feeing rate) as per calculated feeding rate

⇩

6. Measure residual chlorine (minimum FRC should be 1 ppm) after about 30 minutes and adjust the dosage (feeding rate) if required so that the required FRC is obtained

a) Methods of calculating chlorine dosage (feeding rate)

Three methods; (1) By using formula, (2) By using Chart, or (3) From the Table

(1) By using formula

$$\text{Bleaching powder solution feeding rate} = \frac{Q\ m^3/h \times D\ mg/L}{62.5}\ L/h$$

For example, if the flow is 900 m^3/h and the chlorine dosing rate is 3 mg/L, then,

$$\text{Bleaching powder solution feeding rate} = \frac{900\ m^3/h \times 3\ mg/L}{62.5} = 43.2\ L/h$$

For understanding

The bleaching powder contains 30% chlorine. That means 100 kg bleaching powder contains 30 kg Cl_2.

According to preparation 30 kg Cl_2 is in 480 L solution => Chlorine content of the solution = 30,000,000 mg/480 L = **62,500 mg/L Cl_2**. If the number of bags of bleaching powder or volume of water is changed, this value will change.

(2) By using Chart

Refer to the following Chart to determine dosage (feeding rate) of prepared bleaching powder solution for various flows and chlorine dosing rates.

First read the Cl_2 dosing rate (mg/L) along the X-axis → go up to the daily flow line → go left to Y-axis and read the dosage (feeding rate).

For example, if the Cl_2 dosing rate is 3 mg/L and the daily water flowrate is 900 m^3/h (21.6 MLD), then the dosage (feeding rate) comes out to be about 43 L/h.

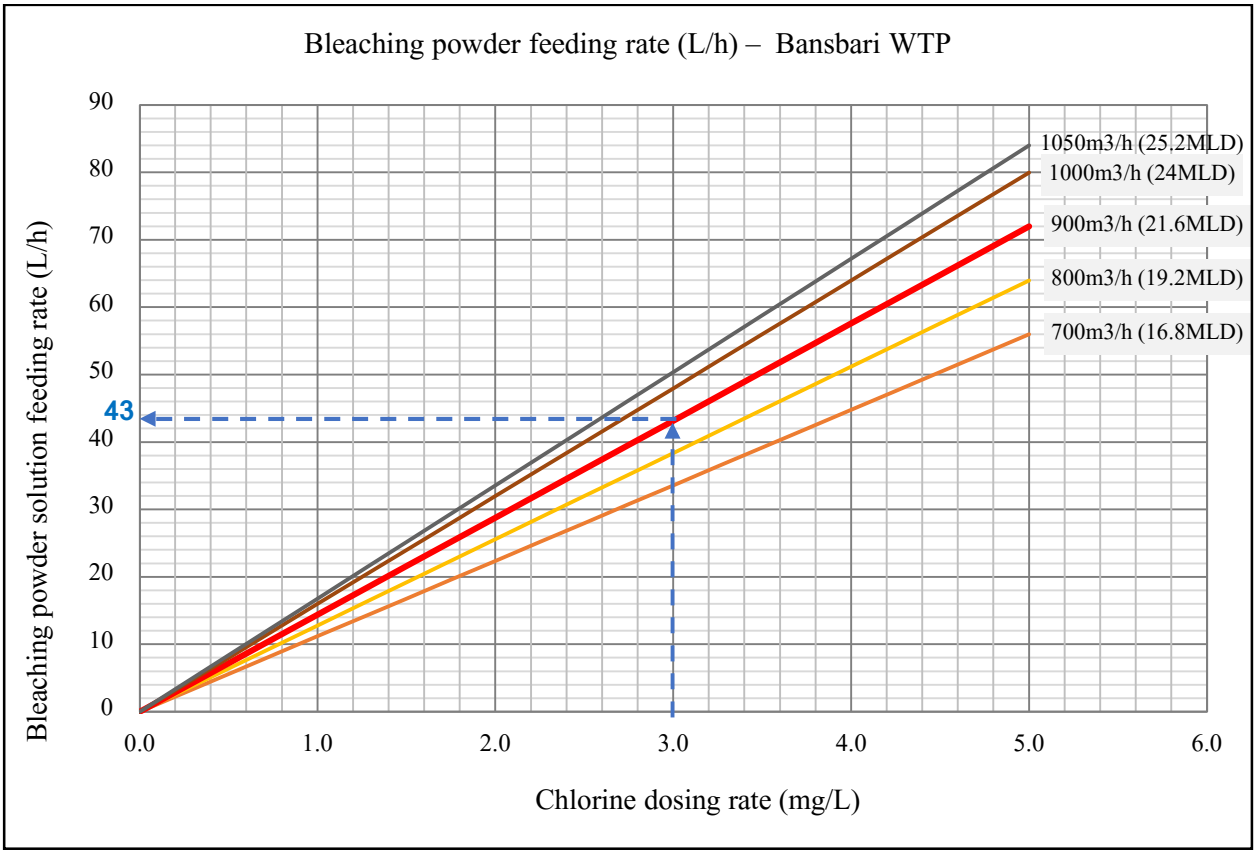


Figure 23: Bleaching powder solution dosages (feeding rates)

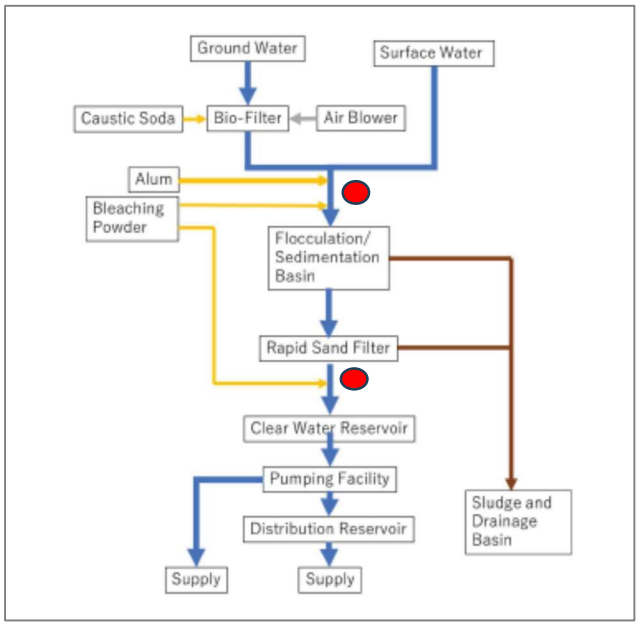
(3) By using Table

Find the row of dosing rate from the leftmost column → Go right on that row until meeting the water flow rate → The value in intercepting cell is the feeding rate.

Table 6: Dosages (feeding rates) of bleaching powder solution

	Bleaching powder solution feeding rate (L/h) - Bansbari WTP								
Chlorine dosing rate (mg/L)	650m3/h (15.6MLD)	700m3/h (16.8MLD)	750m3/h (18MLD)	800m3/h (19.2MLD)	850m3/h (20.4MLD)	900m3/h (21.6MLD)	950m3/h (22.8MLD)	1000m3/h (24MLD)	1050m3/h (25.2MLD)
0.0	0	0	0	0	0	0	0	0	0
1.0	10	11	12	13	14	14	15	16	17
1.5	16	17	18	19	20	22	23	24	25
2.0	21	22	24	26	27	29	30	32	34
2.5	26	28	30	32	34	36	38	40	42
3.0	31	34	36	38	41	43	46	48	50
3.5	36	39	42	45	48	50	53	56	59
4.0	42	45	48	51	54	58	61	64	67
4.5	47	50	54	58	61	65	68	72	76
5.0	52	56	60	64	68	72	76	80	84
5.5	57	62	66	70	75	79	84	88	92
6.0	62	67	72	77	82	86	91	96	101
6.5	68	73	78	83	88	94	99	104	109

b) Chlorine dosing location



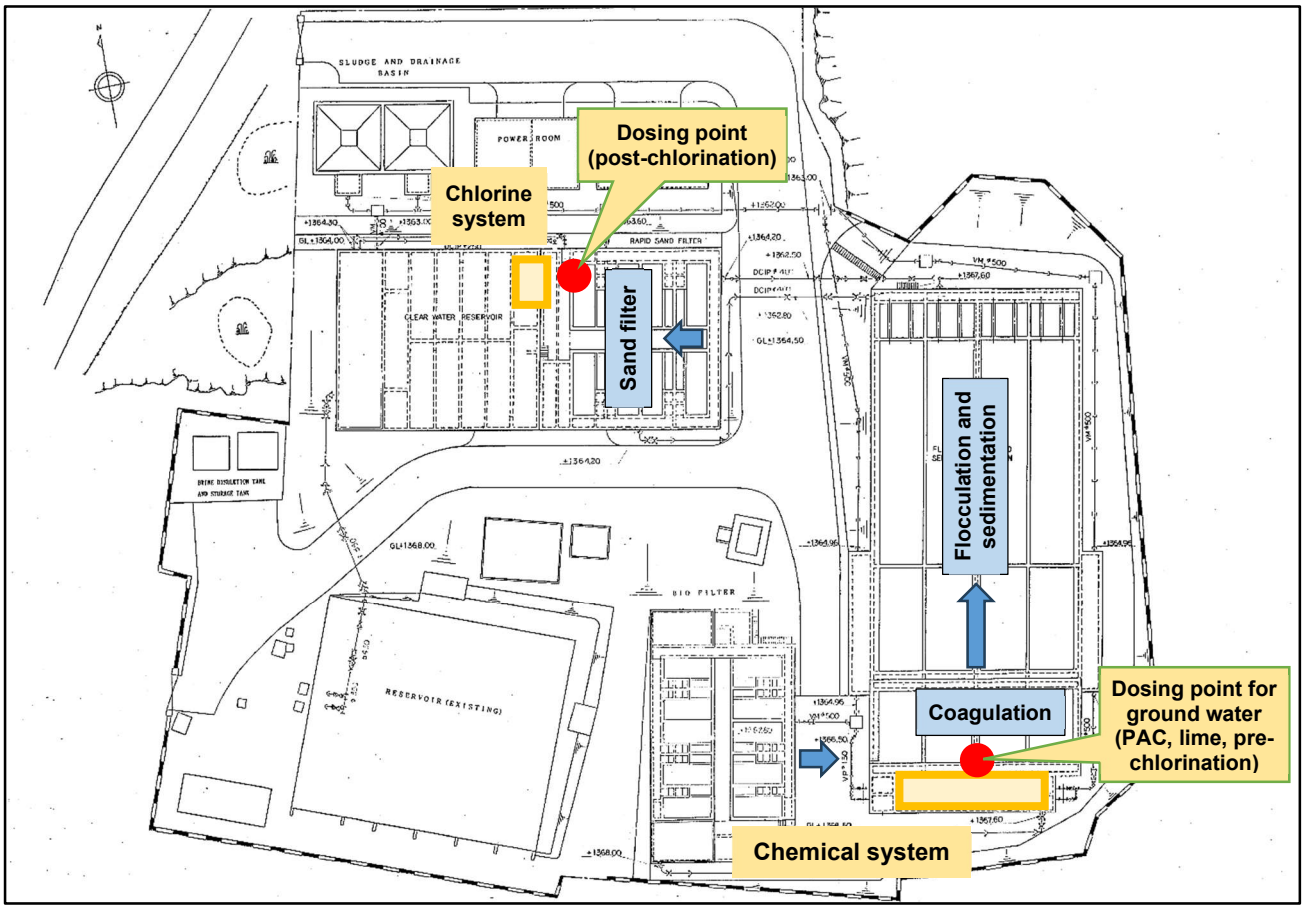


Figure 24: Chlorine dosing location – Bansbari WTP

c) Operation procedure of bleaching powder solution feeding system

The specified quantity (as determined above) is fed by gravity at the feeding point with the following process.

Operation procedure

1. Close the outlet valve of the bleaching powder solution storage tank
⇩
2. Select the strainer and open the vales before and after it
⇩
3. Open the suction valve of the bleaching powder solution feeding unit
⇩
4. Open the delivery valve of the bleaching powder solution feeding unit
⇩
5. To confirm the feeding rate, close the feeding valve and open the sampling valve
⇩

6. Adjust the feeding rate by adjusting the delivery valve of the feeding unit

⇩

7. Open the feeding valve at the feeding point and close the sampling valve

d) Operation procedure for adjusting the dosage (feeding rate)

Operation procedure

1. Adjust the pump stroke according to feeding pump characteristic curve to obtain the required feeding rate

⇩

2. Or, adjust the rotameter to obtain the required feeding rate

⇩

3. Check residual chlorine level and adjust the feeding rate if necessary

7.6 Cleaning Tanks and Pipes

a) Washing of dosing pump and the feed pipe

When feeding is to be stopped for a long time, wash the dosing pump and the feed pipe.

Operation procedure

1. Close the suction valve of the bleaching powder feeding pump

⇩

2. Connect the washing water inlet valve and the water supply valve with a hose

⇩

3. Open the washing water inlet valve and the water supply valve and execute washing

b) Drainage of bleaching powder dissolution tank

Undissolved material remaining at the bottom of the tank does not contain any chlorine. It should be drained out.

The clear water drainage pipe is used for drainage.

Operation procedure

1. Check the water level of the clear water basin

⇩

2. Open the drainage valve of the bleaching powder dissolution tank

⇩

3. Connect a hose to the water supply valve and execute drainage while washing the inside of the tank with water

⇩

4. Open the clear water basin drainage valve

⇩

5. Open the drainage valve connected to the clear water basin drainage pipe

c) Washing of bleaching powder dissolution tank and the solution storage tank

When feeding is to be stopped for a long time, wash the bleaching powder dissolution tank and the solution storage tank.

Operation procedure

1. Check the water level of the clear water basin

⇩

2. Open the drainage valve of the bleaching powder dissolution tank

⇩

3. Connect a hose to the water supply valve and execute drainage while washing the inside of the tank with water

⇩

4. Open the clear water basin drainage valve

⇩

5. Open the drainage valve connected to the clear water basin drainage pipe

Photo 4: Bleaching powder dissolution and storage tanks in Bansbari WTP

d) Dosing pump selection

Depending on capacity and number of dosing pumps, treated water quantity, and the dosage (feeding rate), different pump combinations may be required.

Existing dosing pump capacity at Bansbari WTP:

a. 0.9 L/min x 1 unit

b. 1.8 L/min x 2 units

Possible various combinations are as follows:

(1) Use of one pump a.

(2) Use of one pump b.

(3) Use of one pump a and one pump b.

(4) Use of two pumps b.

(5) Use of one pump a and two pumps b.

For example, if the required dosage (feeding rate) is 43 L/h (0.72 L/min), then case '(1) Use of one pump a' will be required.

End of the SOP.