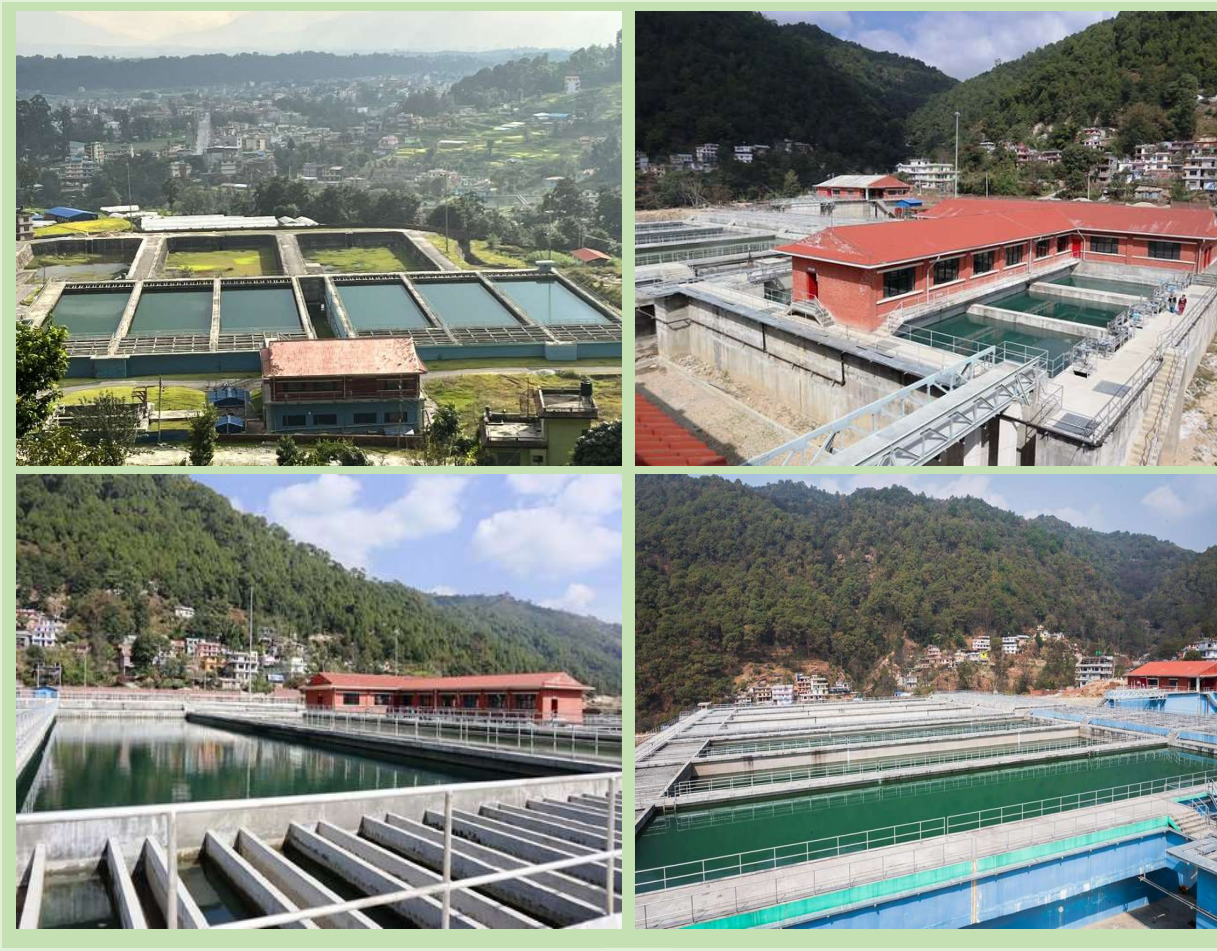
Kathmandu Upatyaka Khanepani Limited

Japan International Cooperation Agency

STANDARD OPERATING PROCEDURE

(Draft)



NEW SUNDARIJAL

WATER TREATMENT PLANT

The Project on Capacity Development of KUKL to Improve Overall Water Supply Service in Kathmandu Valley

Version 3.0 (2024.01)

Table of Content

1. Outline of the Facility

1.1 General Information

(1) Facility Name: New Sundarijal Water Treatment Plant
(2) Facility Type: Surface water treatment plant
(3) Establishment: 26th March 2021
(4) Water Source: Surface water from Melamchi river and Bagmati river
(5) Capacity: 170 MLD (Design)
(6) Access: 11 km (45 mins drive) from Chabahil, Ring Road
(7) Objective: Removal of turbidity, organic matter, bacteria, and other harmful matter

1.2 Components of the Treatment Process

There are eleven (11) unit processes and auxiliaries in the New Sundarijal WTP outlined below:

(1) Distribution Facilities
- Inlet Flow Chamber
- Mini- Hydro unit
- Distribution Chamber
- Rapid Mixing Chamber

(2) Flocculation/Sedimentation Basins
- Flocculation Basins
- Sedimentation Basins

(3) Filters
- Rapid Sand Filters
- Backwash Facility

(4) Clear Water Reservoirs
(5) Backwash Water Recovery Tank
(6) Sludge Lagoons
(7) PAC and Lime Feeding Facility
- PAC Solution Preparation and Transfer Unit
- Lime Solution Preparation and Transfer Unit

(8) Chlorination Facility
(9) Electrical and Panel Board Assembly
(10) SCADA System
(11) Water quality testing laboratory

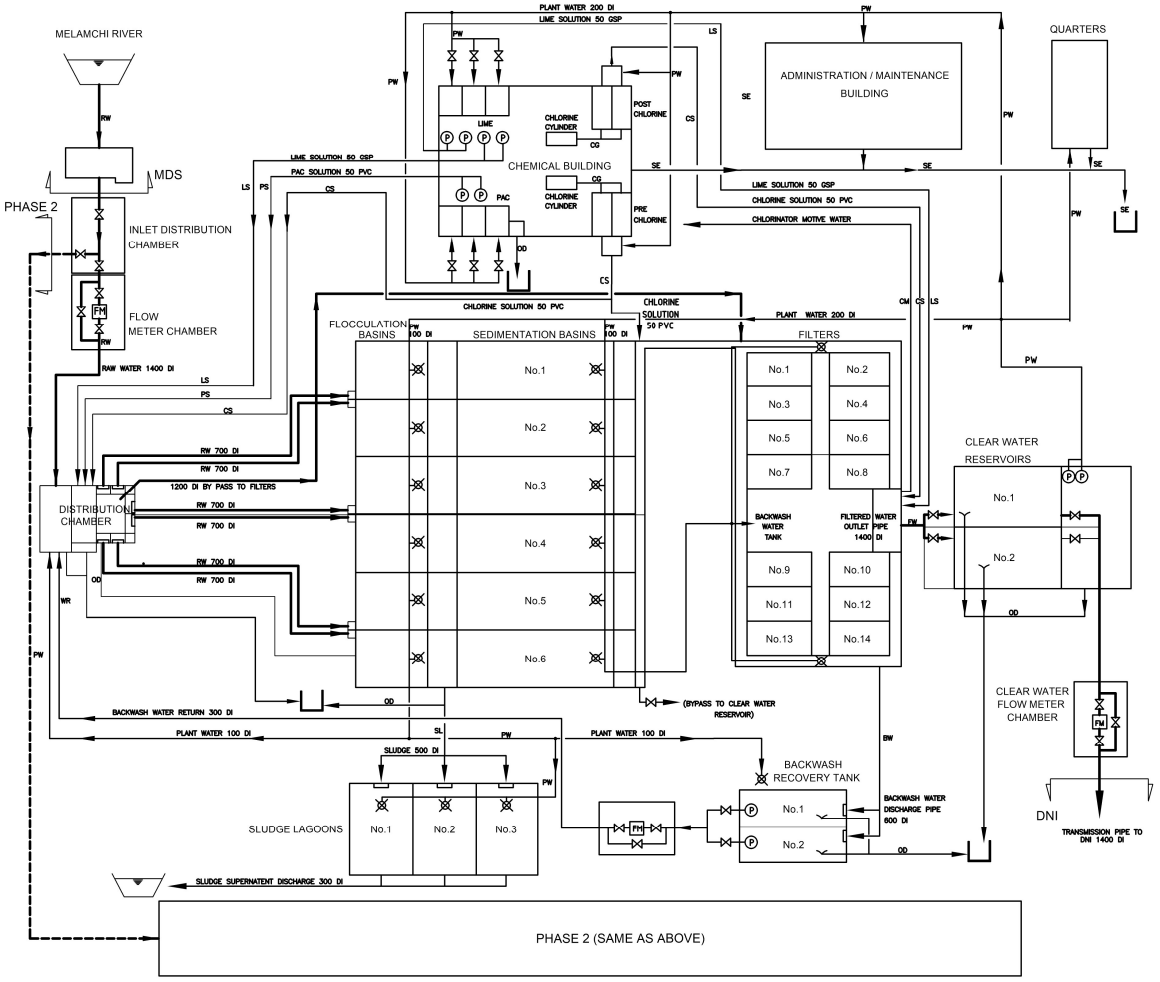


Figure 1: Line diagram of the treatment facility

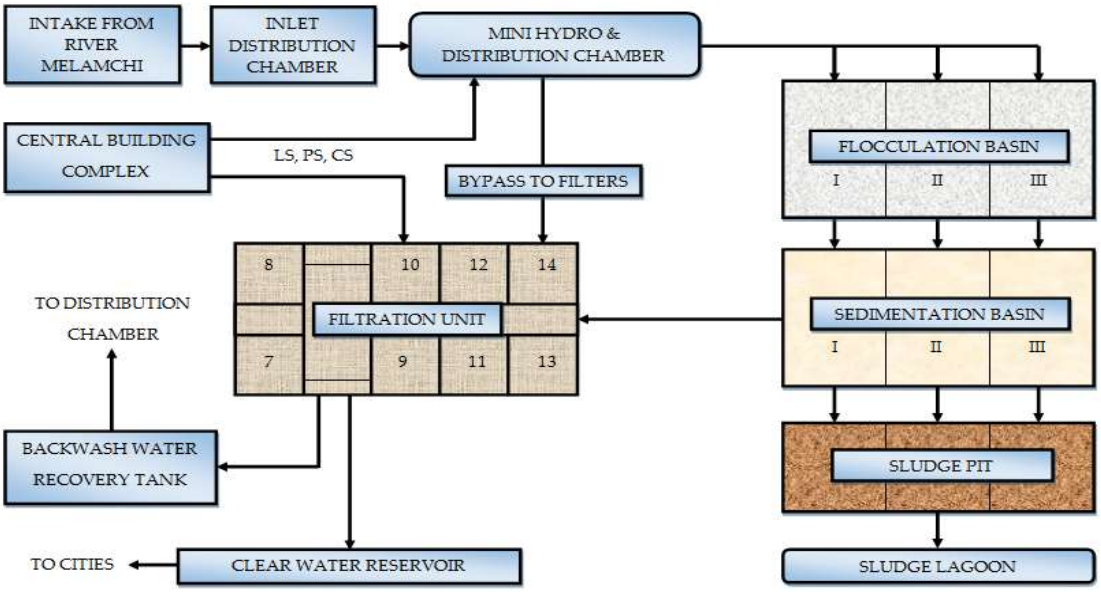


Figure 2: Schematic of the treatment facility

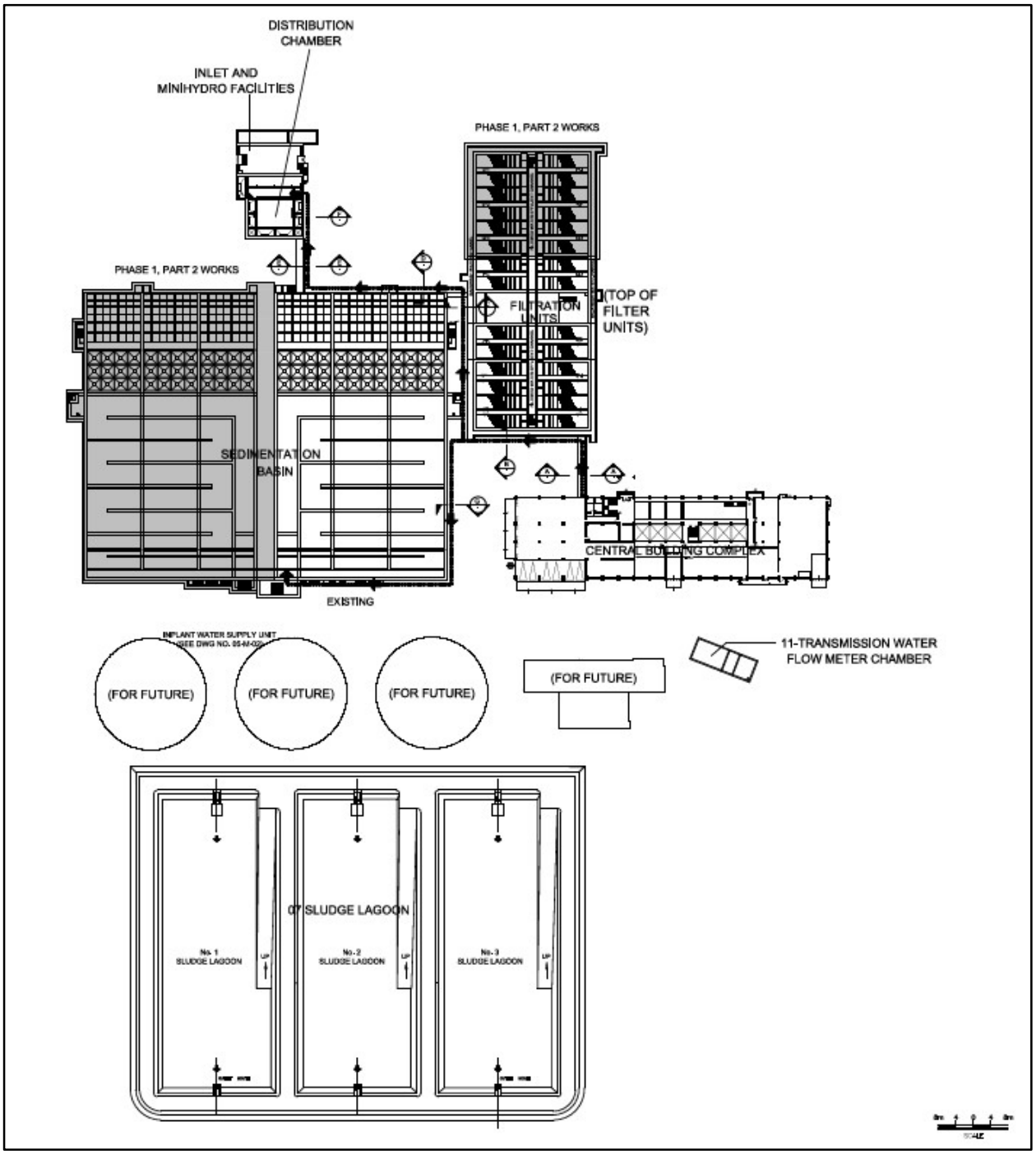


Figure 3: Layout of the treatment facility

2. SCADA System

2.1 General Information

SCADA (Supervisory Control and Data Acquisition System) shows the status of overall operation. It is used to monitor and control treatment processes and collect operational data.

Screen shots of SCADA system existing in New Sundarijal WTP is shown below.

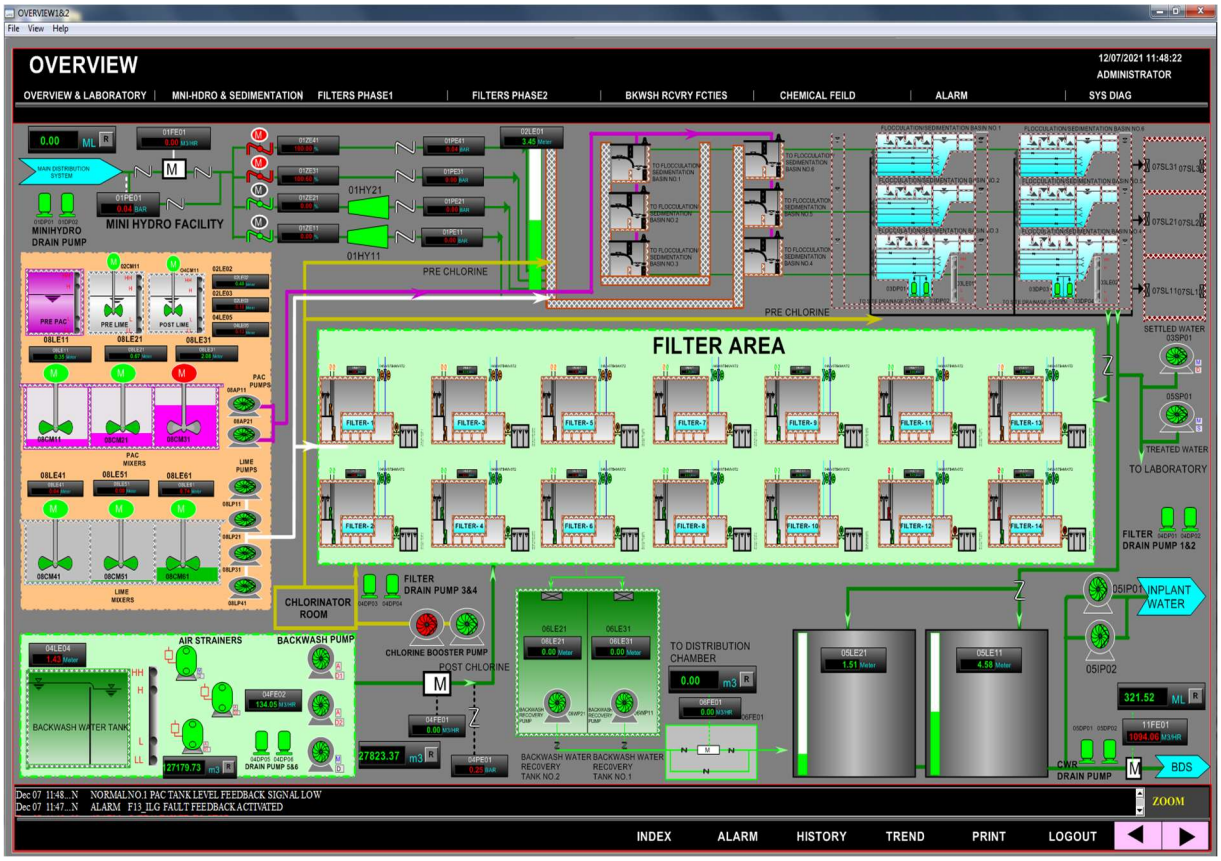


Figure 4: Overview of SCADA system in New Sundarijal WTP (Home Screen)

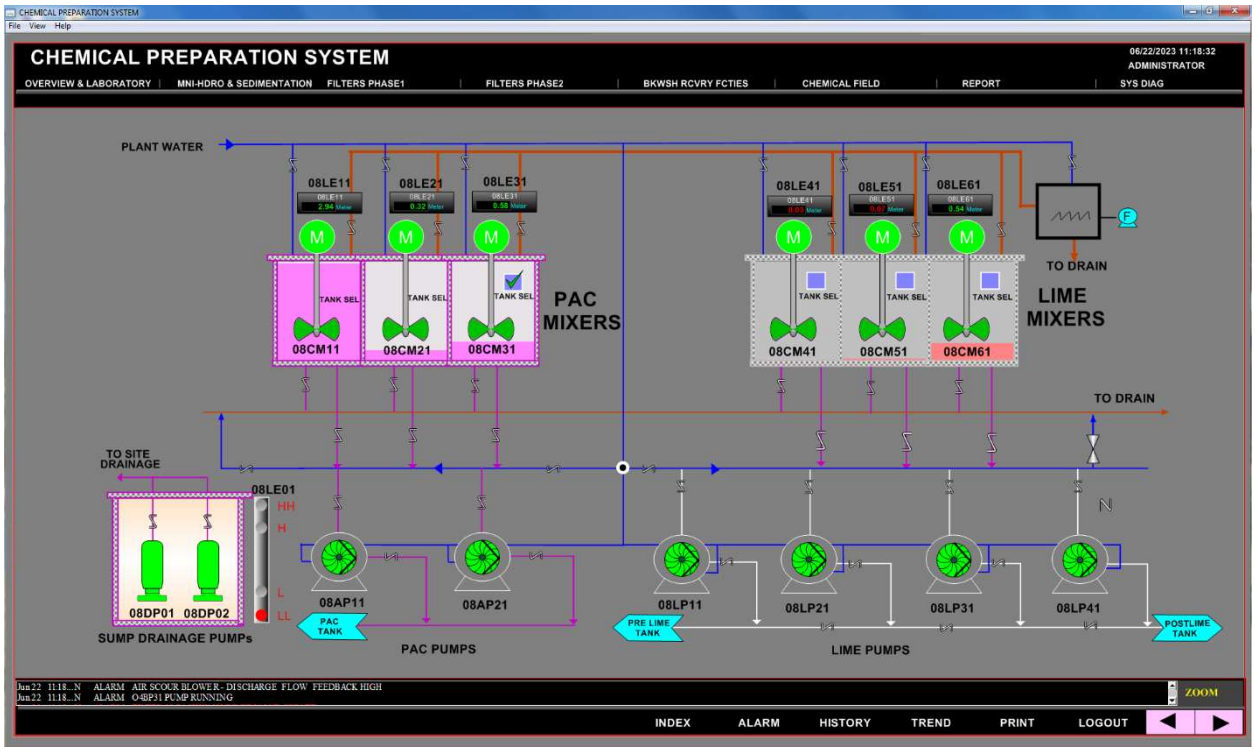


Figure 5: Chemical preparation system

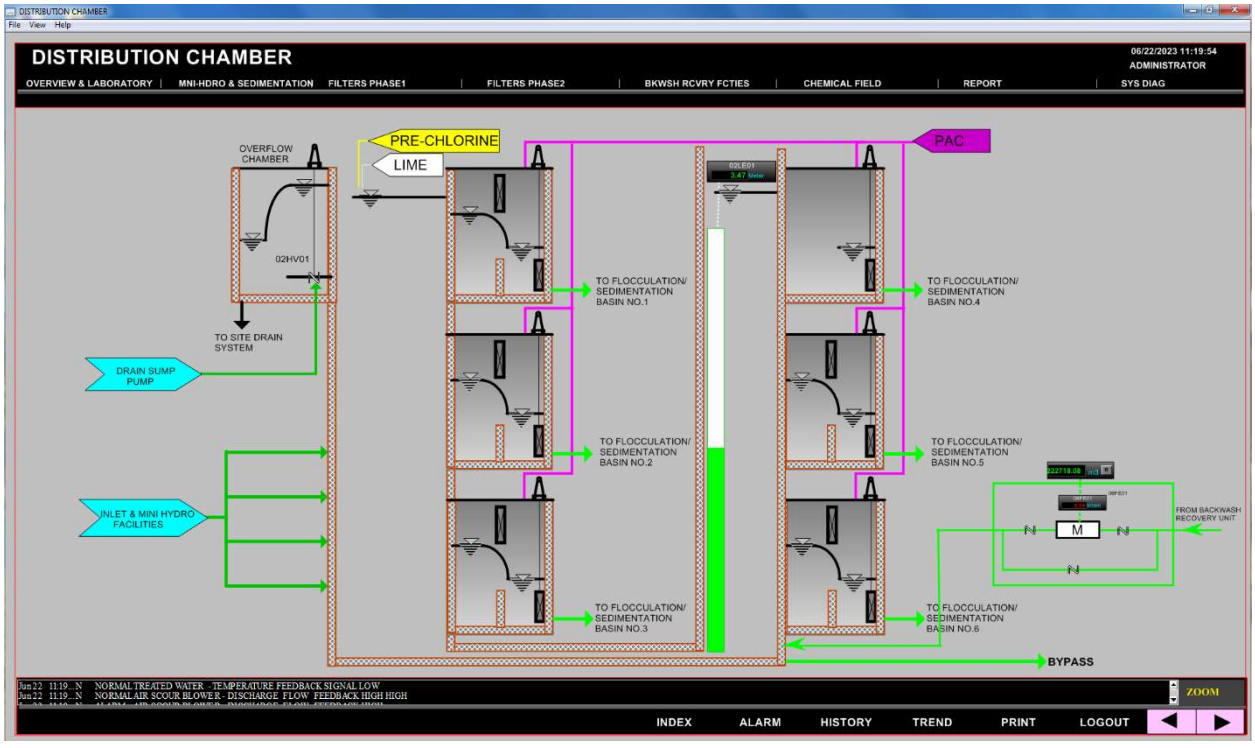


Figure 6: Distribution chamber

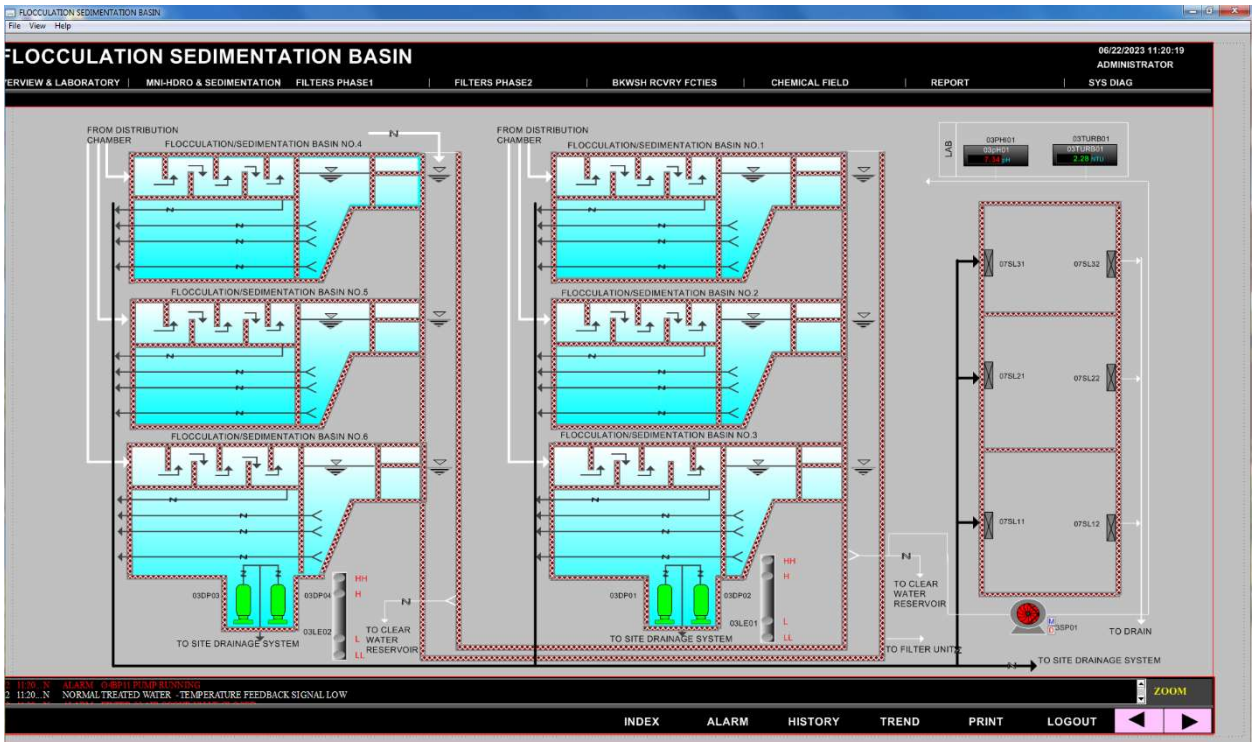


Figure 7: Flocculation and sedimentation basins

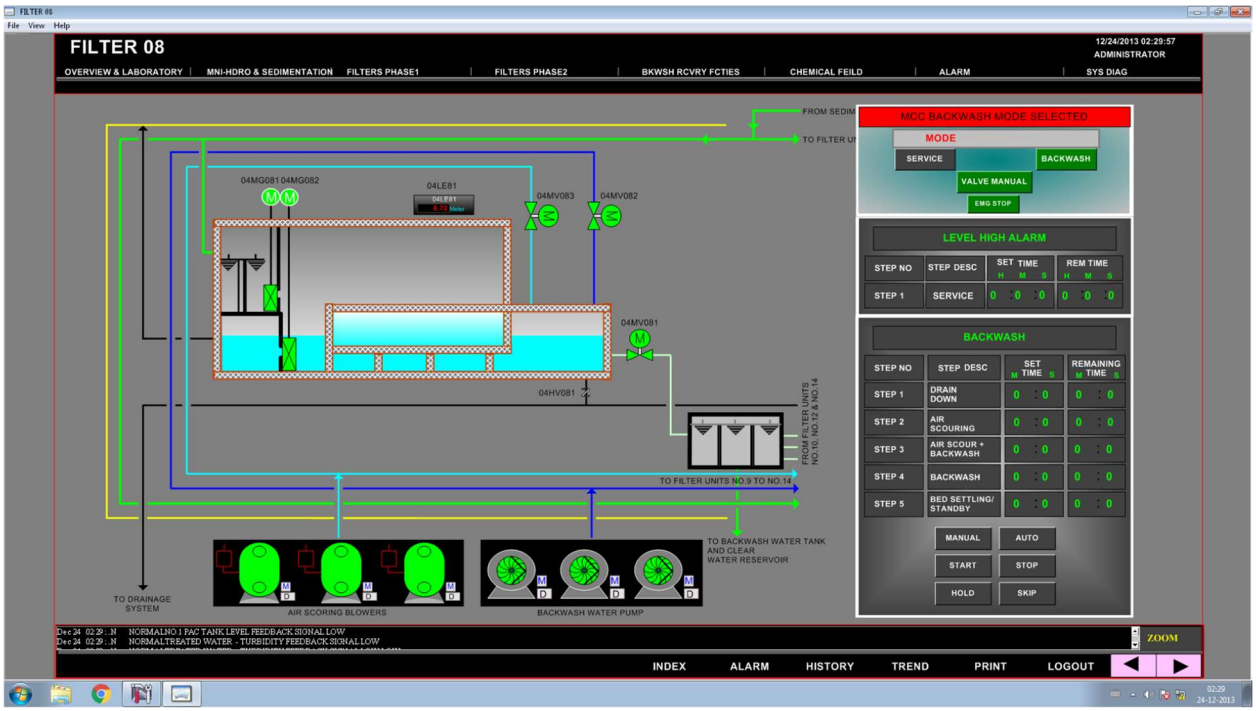


Figure 8: Filter (focusing on a particular filter)

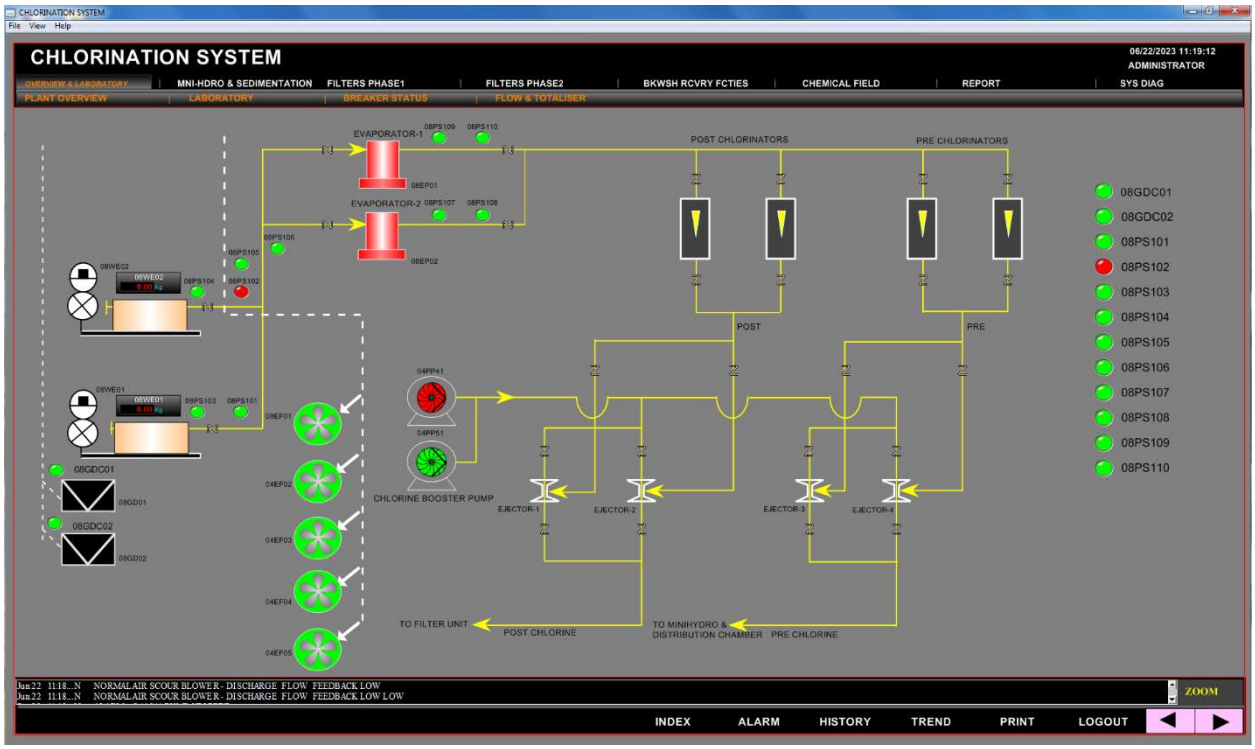


Figure 9: Chlorination system

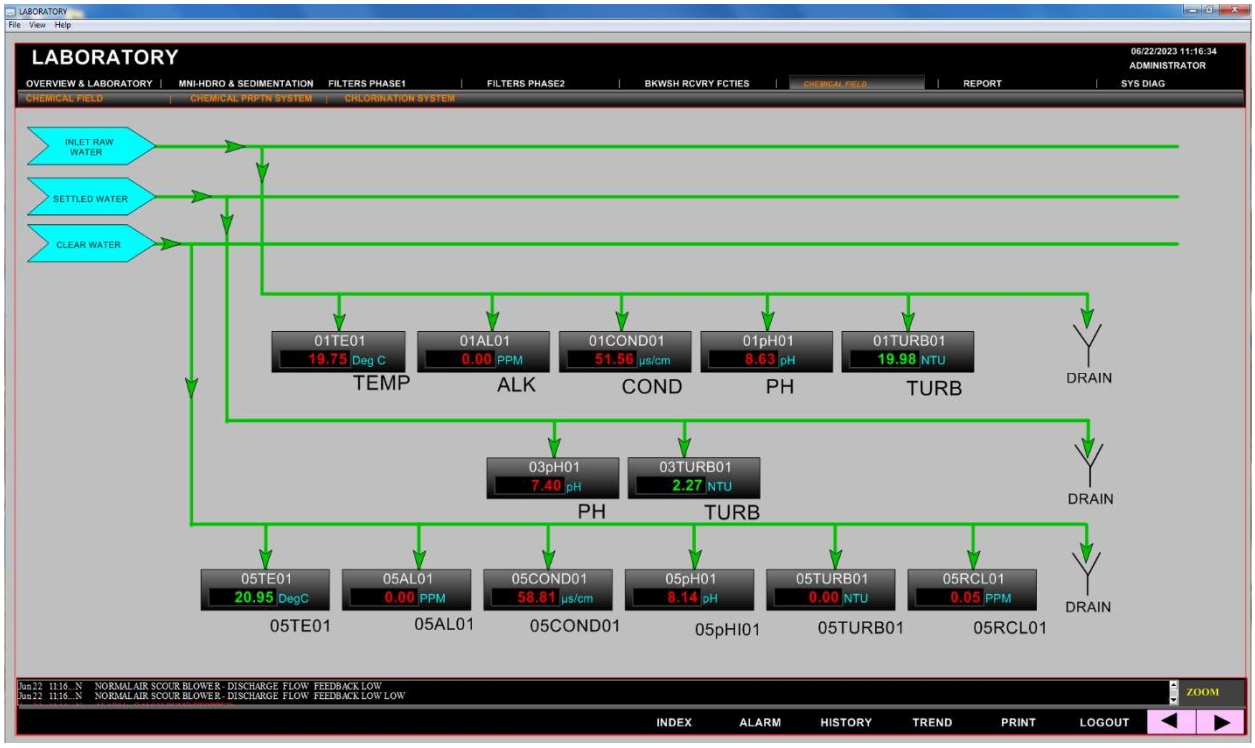


Figure 10: Laboratory (water quality data)

3. Flow Measurement

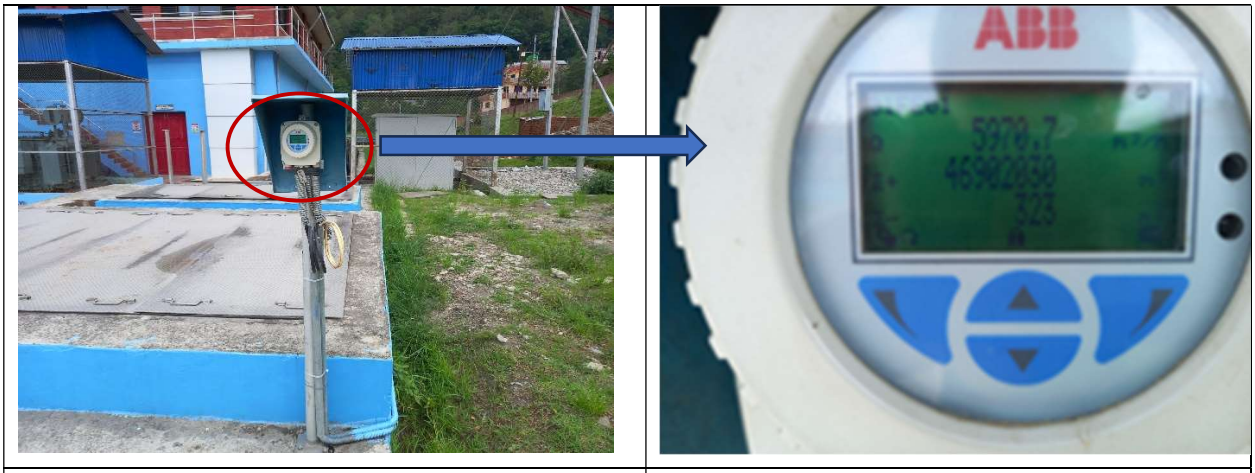
3.1 General Information

Inlet flow to WTP is one of the key parameters for WTP operation.
This flow is used for various purposes, such as;

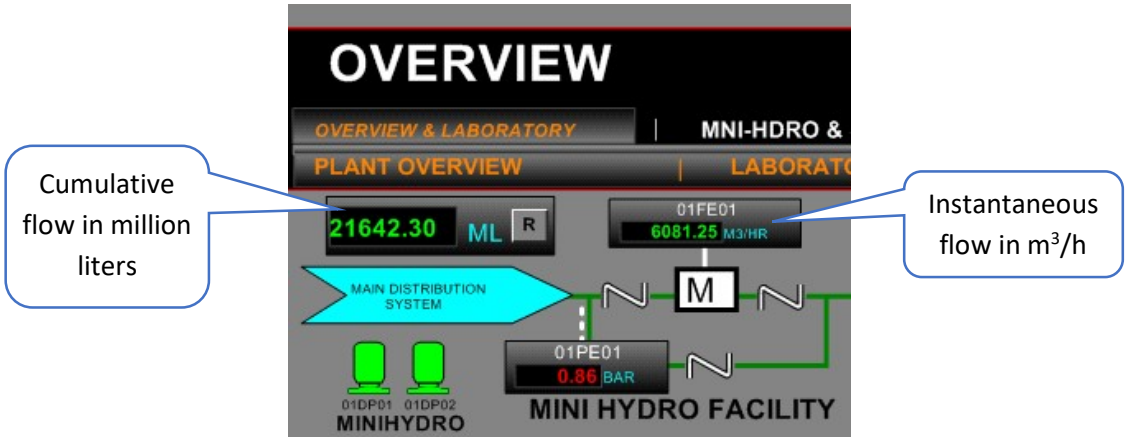
a. To check the margin by comparing it with the designed capacity of the WTP
b. To determine the chemical dosage
c. To estimate the treated water flow etc.

3.2 Measurement Method

Electromagnetic flowmeter is installed at WTP inlet.



Inlet Flowmeter | Flowmeter display



Flow display in SCADA system

Photo 1: Flowmeter and flow display system

The flow values can be read from both the display on the flowmeter and the SCADA system.
It shows instantaneous (current) flowrate as well as cumulative flow.

1. The instantaneous flowrate is indicated as "XXXX.XX m^3/h". Usually inlet flow of this plant is about "7,080 m^3/h" which is equal to 170,000 m^3/day or 170 MLD.
2. Cumulative flow is indicated as "XXXXXXXXX m^3" on the flowmeter display and XXXXX.XX ML in the SCADA system.
3. Total daily total flow can be calculated from the cumulative flow taken at the same time on each day. For this, subtract the previous day's cumulative flow value from that of current day.
4. The cumulative flow can be reset by clicking on 'R' on the right side of the display.

4. Daily Operation

4.1 General

Operators shall regularly observe the WTP.

4.2 Daily activities during Regular Turbidity of raw water

a. WTP operation check time

6:00 / 10:00 / 14:00 /18:00

b. Check the WTP operation concerning the following items.

- Raw Water: flow
- Raw water quality: turbidity/color, pH
- Floc formation at inlet of sedimentation basins
- Floc leakage at outlet of sedimentation basins
- Settled water quality: turbidity, pH
- Treated water quality: turbidity, residual chlorine

4.3 Activities during High Turbidity of raw water

a. Check the WTP Operation concerning the following items.

- Observation – high turbidity / less floc formation
- Raw water - measure turbidity, pH
- Treated water - measure residual chlorine
- Check “Raw Water Turbidity – PAC Feeding Rate” chart
- Adjust PAC dosage (feeding rate)
- Adjust lime dosage if required
- Check floc formation after 20 min
- Check floc leakage after 60 min
- Treated water - measure turbidity
- Treated water - measure residual chlorine – after 30 min

b. Report to Lab Chemist on **High Raw Water Turbidity**

5. Water Quality Measurement

5.1 General

Inlet (raw) water quality is a key parameter for WTP operation. There is a provision to automatically measure and display some water quality parameters as shown below.

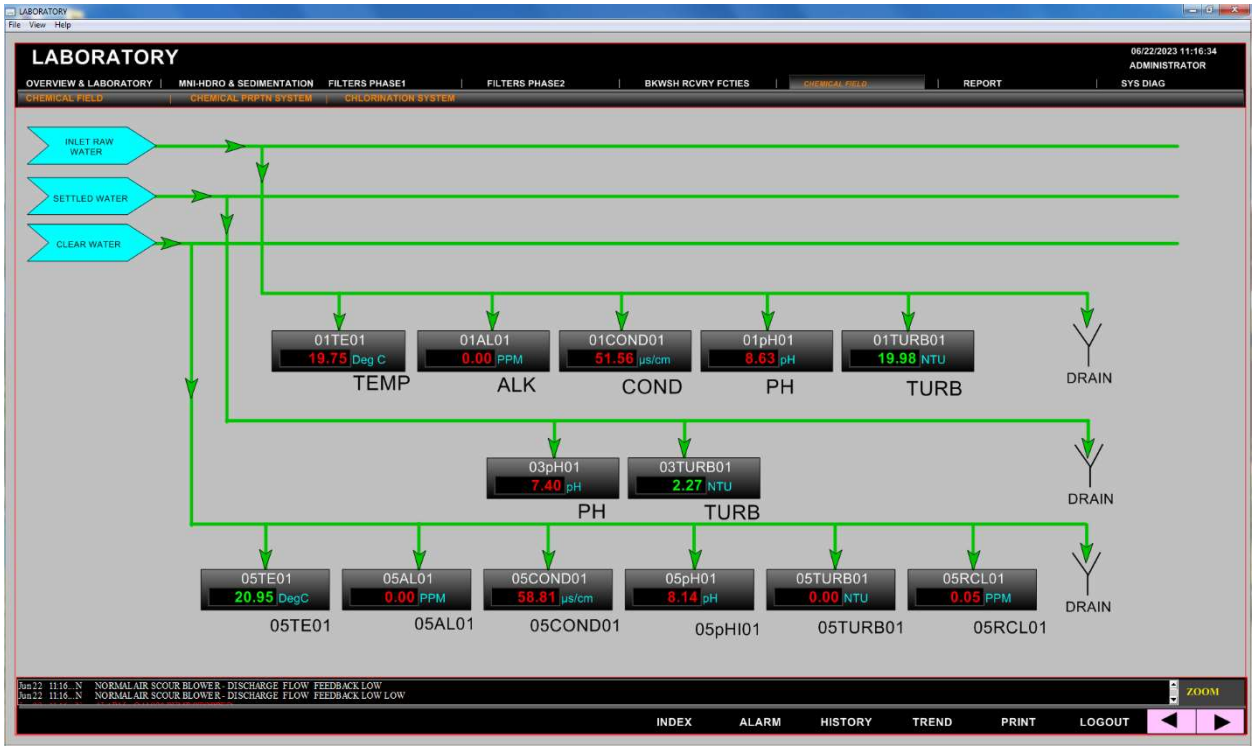


Figure 11: Water quality parameters display in SCADA system

Automatically measured and displayed parameters of ***inlet (raw) water*** are:

- ✧ Temperature (℃)
- ✧ Alkalinity
- ✧ Electric Conductivity (EC)
- ✧ pH
- ✧ Turbidity (NTU)

These water quality parameters are used for setting the chemical dosage, such as;

- ✧ PAC
- ✧ Lime
- ✧ Chlorine (Pre- and Post-)

With the measurement of raw water flowrate and turbidity, the operator can easily determine the dosing (feeding) rate of PAC, lime, and chlorine by referring to the charts/ tables provided with this SOP. The operators may also take the advice of the Lab Chemist on dosages of the chemicals.

5.2 Measurement

This water quality measurement is done by "Automatic Water Quality Measuring Devices" and the result is displayed on a display of each device. The parameters are also displayed on SCADA system as shown in the previous section.

Raw water - turbidity

Raw water - pH

Photo 2: Examples of automatic water quality measurement and display

6. Distribution Facilities

6.1 Inlet Flow Chamber

The WTP has Melamchi Riveras a source of raw water. In this facility raw water from the Main Distribution Station (MDS) is received and distributed through Mini-Hydro Turbines for generation of Power. Inlet flow chamber has Electromagnetic Flow meter [01 FE 01] is employed for measuring the inlet flow. Inlet flow can be bypassed from flow Meter through a bypass arrangement facilitated by valves [01HV02, 01HV03, O1HV04].

6.2 Mini- Hydro unit

Mini-hydro power generation is to convert kinetic energy of water to power, as raw Water from the tunnel outlet will have pressure higher than the necessary for the WTP. Therefore the raw water is discharged into four separate pipe lines, two containing mi-hydro generators and two containing pressure-reducing valves.

Each Mini-hydro generator provided with dedicated control panel will start automatically by turning the relevant Switch " OPEN-STOP-CLOSE" in Generator Control Panel to "OPEN " , to open the Valve.

Mini-hydro power generation

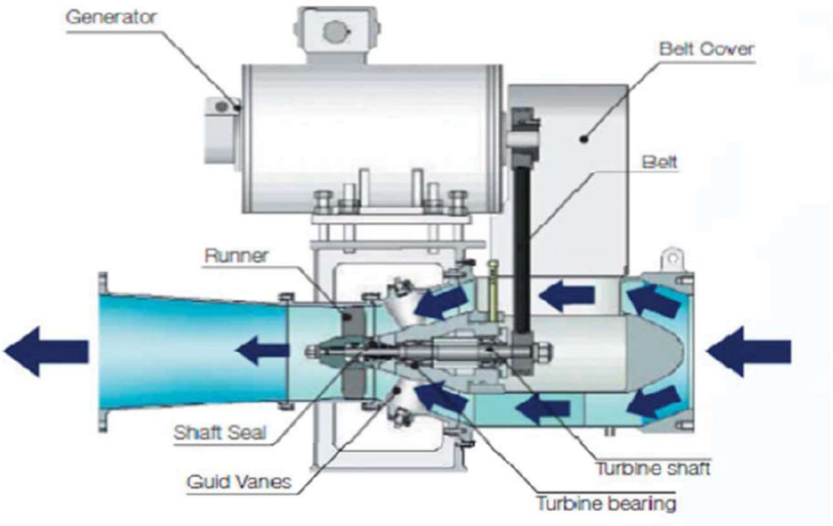


Figure 12: Flow schematics of the mini-hydro generation system


Photo 3: Mini-hydro generator and its control panel

Equipment

Facility/ Equipment		Tag No.	Q'TY		Specification	
			D'Y	SB		
1	Mini hydro	01HY11/21	2	0	Hydro power generator	400V; 50Hz;100 kW /125 kVA
2	Manual hoist	01HH01	1	0	Hand operated overhead hoist	5-ton capacity

Note:

Q'TY: Quantity

D'Y: Duty

SB: Standby

6.3 Distribution Chamber

Raw water is distributed form Mini Hydro Facility to the treatment facility through distribution chamber. In the distribution chamber six weirs are provided, one for each flocculation basin. Water level is monitored by level detector (02 LE 01). An emergency overflow to discharge excess water to the Bagmati River is also provided.

The coagulant Poly Aluminum Chloride (PAC) is dosed in the distribution chamber.

Photo 4: Distribution Chamber

6.4 Rapid Mixing Chambers

The primary purpose of the flash mixing process is to rapidly mix the coagulant chemical such as PAC with the incoming raw water and equally distribute the coagulant chemical throughout the water.

Six numbers of rapid mixing chambers are provided in this WTP.

Theory of flash mixing /rapid mixing:
The flash mixing is a process to induce the coagulation to agglomerate the suspended particles in the raw water.

The term coagulation describes the effect produced when certain chemicals are added to raw water containing slowly settling or non-settleable particles. The chemicals hydrolyze and neutralize the electrical charges on the colloidal particles, which begin to form agglomerations termed floc which will be removed by clarification and filtration.
The entire process of rapid mixing or flash mixing occurs in a very short time (a few seconds), and the first results are the formation of very small particles of floc, often referred to as 'microflocs'.

Equipment

Facility/ equipment		Tag no.	Q'TY		Specification	
			D'Y	SB		
1	By pass gate	02HG01	1	0	Hand operated sluice	1200x1200
2	Sluice gate	02HG11/21/31/41/51/61	6	0	Hand operated sluice	700x700
3	Stop log	02SL11/21/31/41/51/61	6	0	Manual SS logs	2000x1500
4	Submersible pumps	01DP01/02	2	0	Dewatering	04LPS (14.4 m^3/hr) @ 15m; 3 phase; 415 V; 2.2 kW

7. Flocculation/Sedimentation Basins

7.1 Introduction

The suspended solids aggregate into flocs from coagulation and flocculation process, settle down and slide downwards and fall into hopper portion of the sedimentation tank as the water flows slowly through the basin. The settled flocs, called sludge, accumulate at the bottom of the tanks, which should be removed periodically.

7.2 Flocculation Basins

The raw water after the chemical dosing flow into the Flocculation Tank. slow mixing of chemicals with raw water results in the formation of macro flocs.

Particles reacting to the coagulation chemicals previously added are subjected rapid flash mixture and progressing to a gentle mixing, allowing particles to collide with one another, increasing their density so that they can more effectively fall out of suspension in the next treatment step. The flocculated raw water passes through the openings provided on the outlet end walls of the Flocculation Tanks and enter into the sedimentation tanks.

Photo 5: Flocculation Basins

7.3 Sedimentation Basins

Most of the water treatment process is completed by coagulation/flocculation and sedimentation before the water even reaches the filtration process.

In order to confirm that the coagulation/flocculation and sedimentation processes are functioning well, take a water sample after about two hours of the flow through the sedimentation tank and check its turbidity. It shall be less than 5 NTU. In case the turbidity is more than 5 NTU, find out the reasons. Ensure the settled water conforms to desired quality. In case of high turbidity of settled water, check for correct chemical dosing rate and sludge bleed.

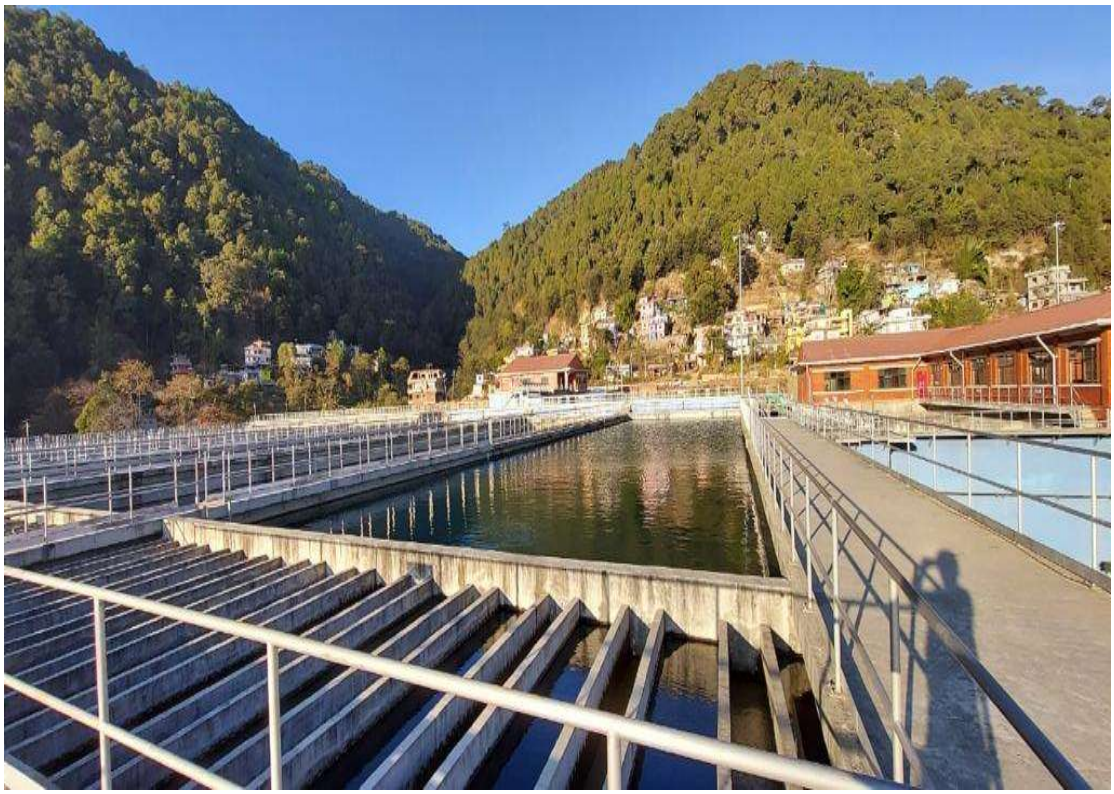


Photo 6: Sedimentation Basins

The water enters from flocculation chambers (3 Units) and moves to the sedimentation basins where in the flocs formed during the coagulation/flocculation process settle down by gravity.

The suspended solids in the form of flocs settle down and slide downwards and fall into hopper portion of the sedimentation tank which are provided in the bottom of the settler. The mass of settled flocs is called sludge. The sludge accumulates in sludge pits of respective chambers. Each sedimentation basin consists of 12 number of sludge pits of trapezoidal shape.

The settled sludge is periodically withdrawn by opening sludge drainage valves and sent to the sludge lagoon. Withdrawal frequency of sludge form sedimentation tanks shall be scheduled as per the incoming raw water turbidity and the settled water overflow quality.

The clarified water, with most of the particles removed, moves on to the filtration step where the finer particles are removed.

Outline of the equipment

Facility/ Equipment		Tag No.	Q'TY		Specification	
			D'Y	SB		
1	Desludging valve	03MG 101 -612	72	0	Manually operated ball valve	150 mm
2	Backwash sluice gates	04MG 113 -613	6	0	Manually operated gate valve	300 mm
3	Sampling pump	03SP 01	1	0	Settled water sampling pump	1.1 kW; 3 phase; 415 V;
4	Submersible pumps	03DP 01/02	2	0	Dewatering	04 LPS (14.4 m^3/hr) @ 15 m; 3 phase; 415 V; 2.2 kW

7.4 Checking of Floc Formation

To confirm the proper function of sedimentation basins, the following actions shall be carried out regularly.

a. Check floc formation at inflow of Sedimentation Basin

b. Check floc outflow from Sedimentation Basin (Trough)

c. Check sludge accumulation at the bottom

d. Remove sludge by sludge valves.

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

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

7.5 Checking of Floc Outflow

Check the floc outflow from Sedimentation Basin (Trough) at the same time when checking floc formation.

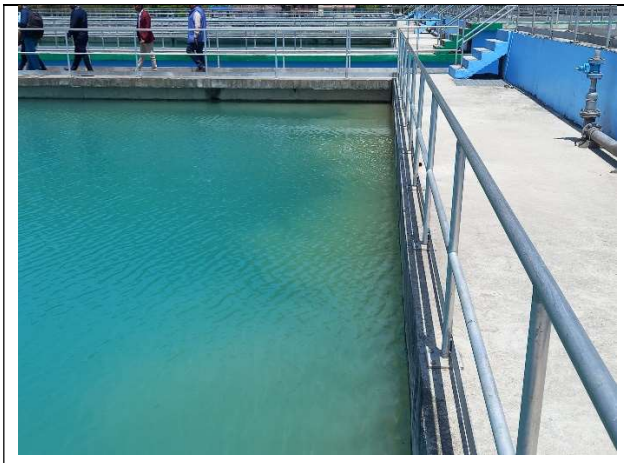
	
Inlet of Sedimentation Basin	Outlet of Sedimentation Basin

Photo 7: Floc formation at the inlet of Sedimentation basin (left) and outlet of Sedimentation basin

- Collect samples of clarified water and ascertain that the Sedimentation Outlet (settled) water quality conforms to the required quality with respect to pH and turbidity in the laboratory.
- In case of any shortfall, adjust the dosing rate of the PAC solution and lime solution.
- In case the turbidity of 5 NTU is not achieved, analyze the possible reasons. Check for correct chemical dosing rate and sludge bleed (outflow).
- Ensure that Sedimentation tank outlet water overflows from the entire length of the Troughs uniformly by visual inspection.

7.6 Sludge Accumulation and Desludging Process

The sludge will collect at the bottom of the Sedimentation tank where the sludge settling hoppers are provided. The sludge accumulation should be checked and taken out (desludging) periodically.

1. Draw out sludge samples from the bottom of all the settler and find approximately at what interval the sludge consolidates to the desired consistency, depending upon the TSS present in the raw water.

⇩

2. The batches of sludge withdrawal are scheduled at varying intervals according to the incoming solid load, in case of varying turbidity conditions of raw water.

⇩

3. De-sludge the Sedimentation tank manually by opening sludge draining (desludging) valves for 1- min and ensure that the sludge flows up to Sludge Lagoon.

Photo 8: Sludge draining (desludging) valves of coagulation and sedimentation tanks

The following photos show the visual appearance of sludge during start and end time of draining, for reference. Usually, the sludge is discharged to Sludge Lagoon.

Sludge appearance at the time of startup of sludge draining form sedimentation tanks

Sludge appearance at the end of sludge draining form sedimentation tanks

Photo 9: Sludge appearance at the beginning and end of draining (desludging) from sedimentation tanks

7.7 Floc Formation and Outflow

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

Inlet of Sedimentation Basin

Outlet of Sedimentation Basin

Photo 10: Inlet and outlet of Sedimentation Basin showing floc formation at the inlet

8. Rapid Sand Filter (RSF)

8.1 General

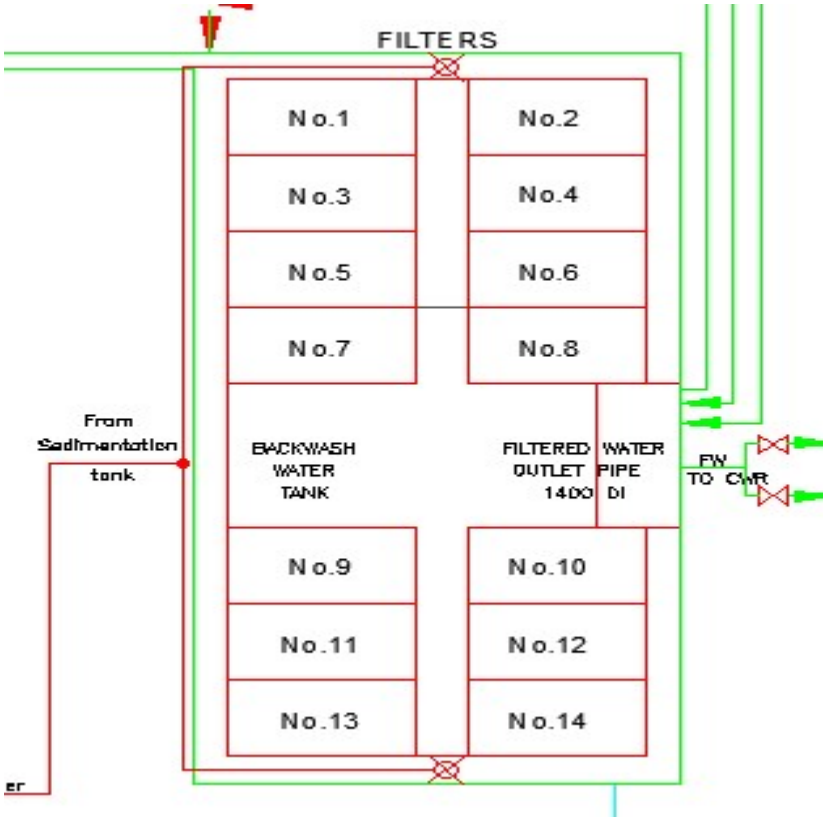
Rapid sand filters in this WTP contain silica sand as the filter media. When the flocculated water is put over the filter the particles and impurities trapped in flocs are removed by the filter by straining, adsorption, and absorption mechanism. After a certain time, the capacity of the filter to remove the impurities reduces. The filter sand is then cleaned by washing with air and clean water (backwashing). This restores the capacity of the filter.

Type of RSF in this WTP: Open, natural gravity filter

Outline of the equipment

- Number of basins: 14 basins (Area: 12m x 3.6m)
- Filter media: Sand only

Filter Media	Effective Diameter (mm)	Depth (mm)
Sand	1.0 to 1.2 mm	1200



Monthly treated water quantities and which basin should be used are provided in the

following tables:

a. In case of completion and 12 months running of Melamchi phase I

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Flow (MLD)	170	170	170	170	170	170	170	170	170	170	170	170
Used basins	14	14	14	14	14	14	14	14	14	14	14	14

b. In case of no water from Melamchi phase I but operation of WTP with Bagmati water in monsoon seasons

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Flow (MLD)	170	170	170	170	170	0	0	40	40	40	40	40
Used basins	14	14	14	14	14	0	0	4	4	4	4	4

8.2 Facilities / Equipment

Filter Gates

Filter Valves

Filter Valves

Backwash Pumps

Air Blowers

Photo 11: Filter equipment and facilities

Outline of the equipment

Facility/ equipment		TAG NO.	Q'TY		Specification	
			D'Y	SB		
1	Raw water inlet gate	04MG 011 -141	14	0	Electrically operated settled water inlet sluice gate	500x500
2	Backwash water outlet gate	04MG 012 -142	14	0	Electrically operated backwash sluice gates	600x600
3	Filtered water outlet valve	04MV 011 -141	14	0	Electrically operated filtered water outlet valve	500mm
4	Backwash water inlet valve	04MV 012 -142	14	0	Electrically operated filtered water outlet valve	500mm
5	Air scouring valve	04MV 013 -143	14	0	Electrically operated filtered water outlet valve	400mm

Facility/ equipment		TAG NO.	Q'TY		Specification	
			D'Y	SB		
6	Backwash pumps	04BP11/21/31	2	1	Backwashing/cleaning of filter sand/media	1300 m^3/hr @ 11 m; 55 kW; 3 phase; 415 V;
7	Air blower	04AB11/21/31	2	1	Positive displacement twin lobe air blower for filter backwash	720 LPS @ 3500 mm aq; 45 kW; 3-phase; 415 V;
8	Submersible pumps	04DP01/02	2	0	Dewatering	04 LPS (14.4 m^3/hr) @ 15 m; 3-phase; 415 V; 2.2 kW
9	Submersible pumps	04DP05/06	2	0	Dewatering	04 LPS (14.4 m^3/hr) @ 15 m; 3-phase; 415 V; 2.2 kW
10	Stop logs	04SL071/081/ 091/101/111/1 21/131/141	8	0	Manually operated ss logs	1000x1000

8.3 Operation

The inflow of the Melamchi water seems to be limited to the period from Jan to mid of June due to landslide and its affect at the Melamchi Source. Attention should be paid to the opening and closing of the gates to prevent mixing of high turbid water if landslide occurs at the source.

a) Open/closed condition of valves and air blower operation

The open/closed condition of the conduit gates according to the operation condition of the RSF is shown in the following table.

Table 1: Open/ closed condition of valves and air blower operation during RSF operation

Equipment	During filtration	During washing	During inspection in the basin
Raw water inlet gate	Open	Closed	Open
Filtered water outlet valve	Open	Closed	Open
Air Souring valve	Closed	Operation	Closed
B/W water inlet valve	Closed	Closed	Open
B/W water outlet gate	Closed	Open	Closed
Drain Valve	Closed	Closed	Open
Backwash Pump 1	Stop	Operation	Stop
Backwash Pump 2	Stop	Operation after pump 1	Stop
Air Blower 1/2	Stop	Operation	Stop

8.3.1 Filtration / Backwash Process

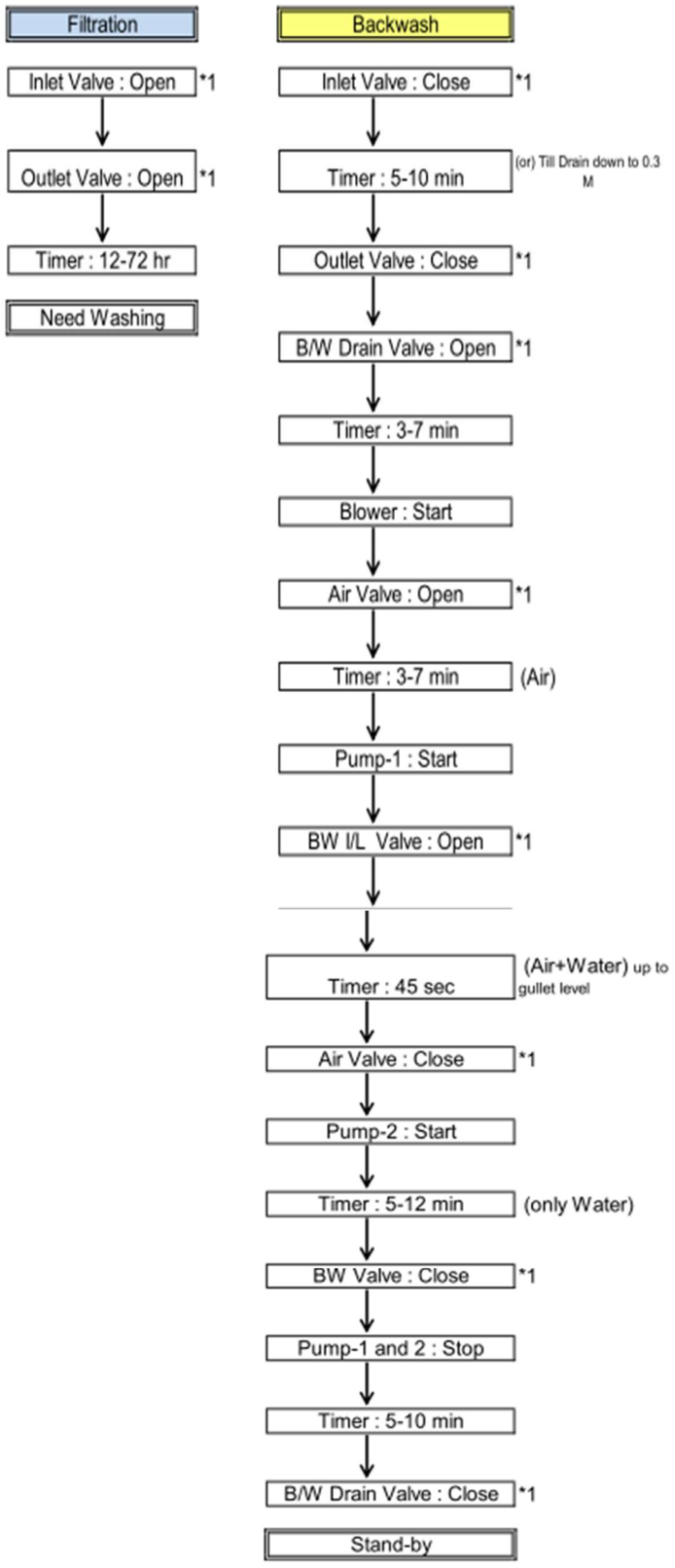


Figure 13: Sequence of operations in filtration/ backwash process

8.3.2 Operation During Filtration Mode

Semi-Auto Mode for Filtration

1. Ensure that the inlet channel to Filters is charged with the clarified water from the sedimentation Tanks.

⇩

2. Keep the outlet valves of the Filters and backwash water outlet gates, closed.

⇩

3. Push "Start" of Filter local console panel.

Photo 12: Local console panel of filters

Manual Mode for Filtration

Manual mode is required at the start-up.

1. Ensure that the inlet channel to Filters is charged with the clarified water from the sedimentation Tanks.

⇩

2. Keep the outlet valves of the Filters and backwash water outlet gates, closed.

⇩

3. Open the inlet gate of each Filter, one after the other, after an interval of 1 hour.

⇩

4. The clarified water falls into the central gullet in between the twin beds and the water level rises in the filter bed. When the level reaches the operating level, put the level control valve into operation and allow the filtration of clarified water to proceed through the filter beds (open the outlet valves).

⇩

5. Check the filtration rate by measuring the flow over the weir in the filter water box.

⇩

6. Receive the filtered water into the Backwash Sump. Allow the filtered water to the Clear Water Reservoir by gravity.

⇩

7. When the water level in the filter reaches about 1.5 m (which indicates the filter is clogged) take the filter out of filtration cycle by closing its inlet valve. The filter can be isolated automatically when the filter plant is put under auto mode.

⇩

8. Initially, operate the Filters under manual mode and then when the filter operation is streamlined the filter operation can be made automatic through PLC.

8.3.3 Operation During Backwashing Mode

Photo 13: Backwashing in progress

<u>Semi-Auto Mode for Backwashing</u>

Photo 14: Button for selecting semi-auto mode for filter backwashing in local console panel

1. When the filter is clogged the filter head will increase. When the head increases up to 1.5 m or filtration for 72 hours, it indicates that filter is to be taken out of service for backwashing operation.

⇩

2. Prior to backwashing operation during start-up, ensure adequate amount of water is available in the backwash sump.

⇩

3. Select the Filter, which is clogged, for backwashing.

⇩

4. Close the inlet gate of the selected Filter.

⇩

5. Allow the water on the twin beds to filter through the bed and the level to fall close to 300 mm above the sand.

⇩

6. The backwashing operation comprises of air scouring followed by water wash.
The backwash operation is carried out for entire filter (twin beds) at a time.
Ensure that the Air blowers are ready.

⇩

7. Open the drain in the delivery line of Blowers, to drain out any water.

⇩

8. Open the delivery valves of the Blowers.

⇩

9. Start one of the Air Blowers, keeping 2nd Blower in assist and 3rd in standby. Carry the air scouring for a sufficient time, say 3 to 5 minutes, to loosen the bed.

⇩

10. As the air scouring of the filter is under progress open the backwash inlet valve of the filter which has been under air scouring.

⇩

11. Also open the outlet gate of the Filter under backwash mode.

⇩

12. Operate one filter backwash pump.

⇩

13. Backwash the filter bed for duration of about 5 secs, with the backwash water and air. The water is the filtered water from the Back wash Sump. The backwash water rises upwards from the Top of the filter bed through the nozzles and flushes out all the loosened out particles from the pores of the filter media.

⇩

14. Stop the air blower once the water level is just about to overflow through the central gullet and allow to run another backwash pump in parallel with previous pump which is already on line (two backwash pumps online) for 10 – 12 mints. The dirty wash water flows into the backwash water recovery tank.

⇩

15. Close the backwash inlet valve of filter bed for which the backwash is completed.

⇩

16. Once the backwash of the filter is completed, close the filter drain gate. Open the inlet gate of the filter and allow the settled water to enter the filter which is just backwashed. Also open the filtered water outlet effluent valve to start the service of the filter. This backwashed filter is then put on filtration mode.

⇩

17. Repeat the backwashing of Filters, one after the other till all the Filters, which have shown high differential head loss (1.5 m) is backwashed.

⇩

18. Schedule the backwashing operation of each Filter, once a day or as and when required. Schedule the backwashing operations, preferably during the day shift.

⇩

19. Initially, operate the backwashing operation of the Filters under manual mode and then when the filter operation is streamlined, it shall be carried out automatic through PLC. The Air Blowers and Filter Backwash Pumps also, upon selection, start and stop automatically during the filter cleaning cycles of filters.

⇩

20. Collect samples of filtered water and ascertain that the filtered water quality conforms to the required quality with respect to turbidity and pH in the laboratory.

Filtration

Air Scouring

Backwashing

Washing Completed

Photo 15: Filters at different stages of operation

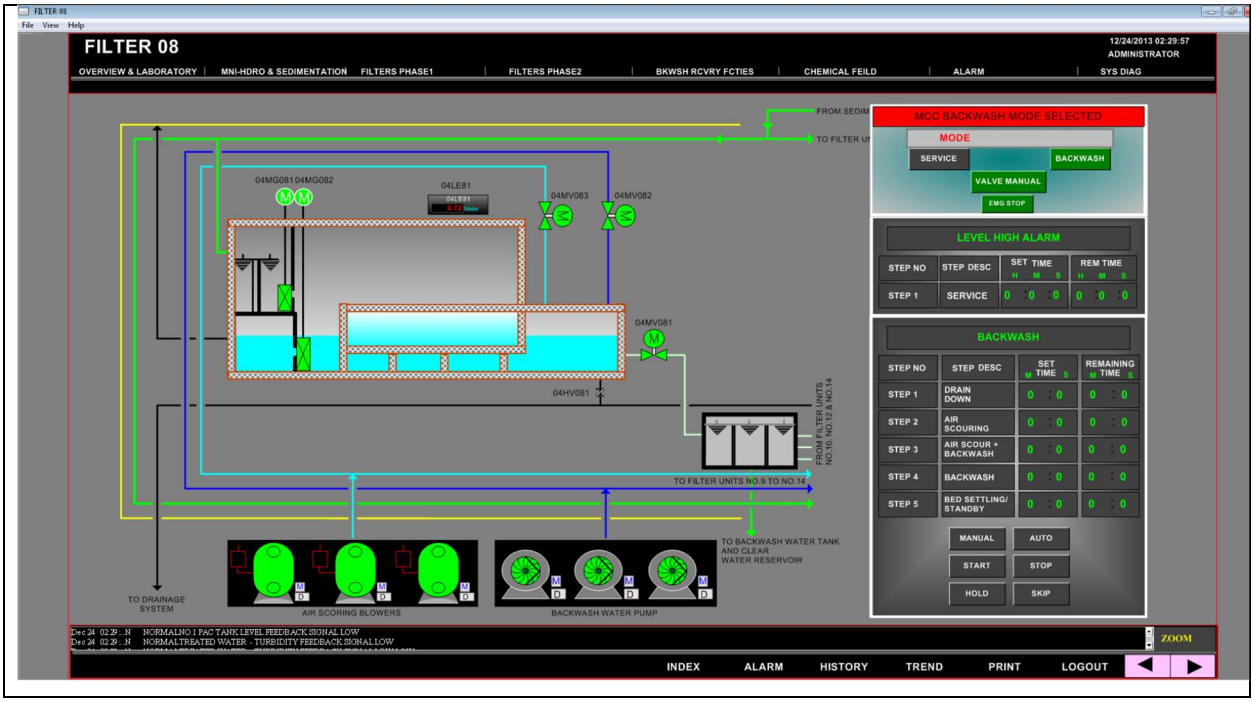


Photo 16: SCADA display of individual filter unit

Photo 17: Filter's local console and panel screens

9. PAC Feeding Equipment

9.1 PAC Solution preparation

About 5% PAC solution should be prepared as described below.

≅ 5% PAC solution => 2,500 kg PAC in 50,000 kg solution

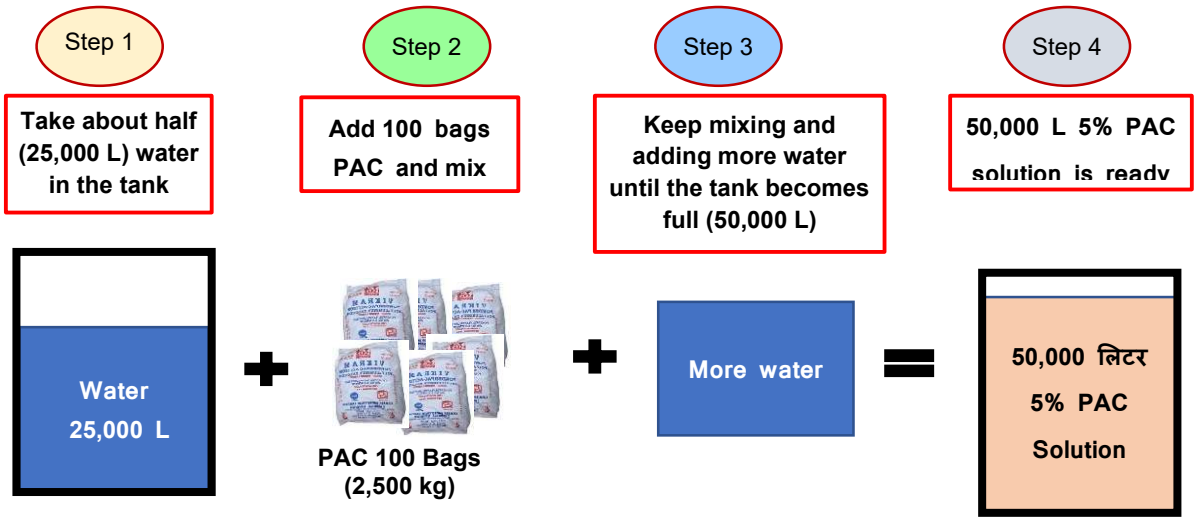
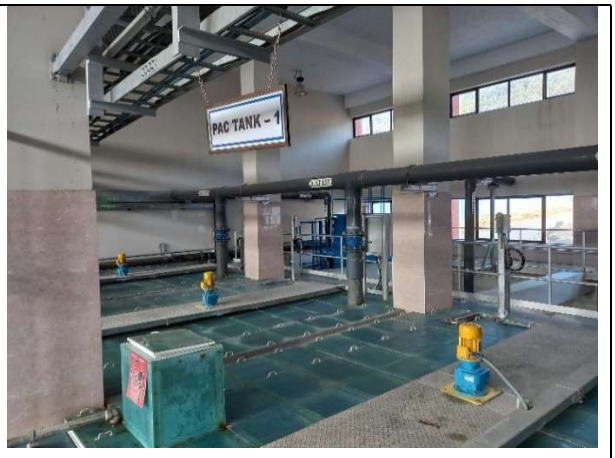


Figure 14: Schematics of preparing about 5% PAC solution

	
PAC Storages	PAC Mixing Tanks

PAC Transfer Pumps

Photo 18: PAC mixing tanks and transfer pumps

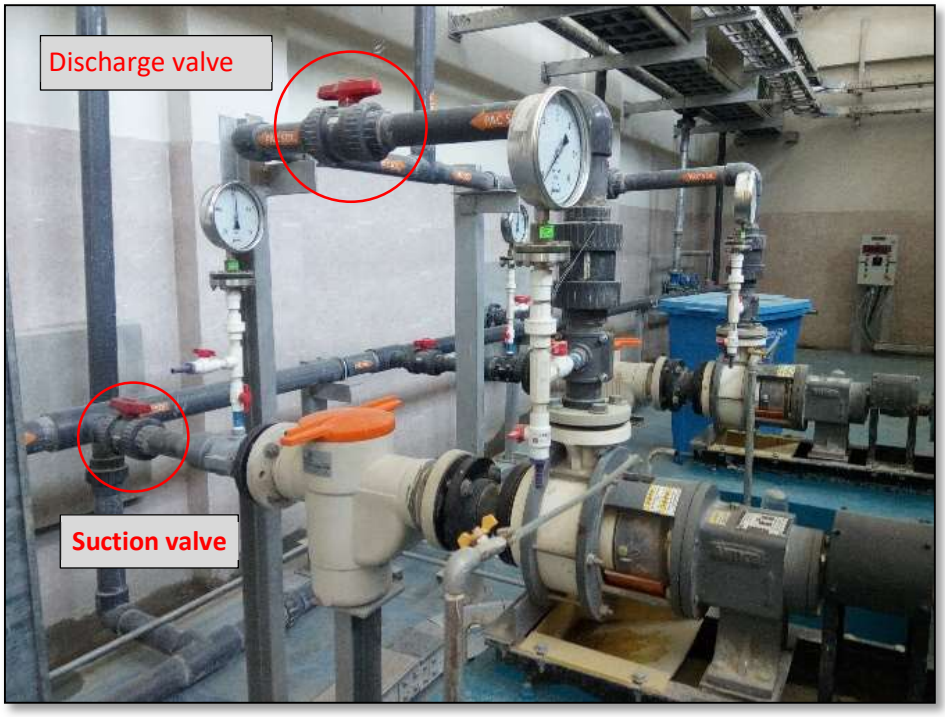


Photo 19: PAC pump

Level Indicator transmitter of PAC dosing system

PAC dosing line to individual rapid mixing chambers

Rotameters of PAC dosing system

Photo 20: PAC dosing equipment

Outline of the equipment

Facility/ Equipment		TAG NO.	Q'TY		Specification	
			D'Y	SB		
1	PAC Tank		3	0	Concrete tank	50 m^3
2	PAC Agitators	08CM41/51/61	3	0	Mixing of PAC solution	2-stage; 3-impellar; vertical type propeller mixer; 0.75 kW; 3 phase; 415 V;
3	PAC transfer pumps	08AP11/21	1	1	Transfer of PAC chemical solution	2.5 L/s 9 m^3/hr @ 30 m; 5.5 kW; 3 Phase; 415 V.
PAC dosing facility at distribution chamber						
4	PAC head tank	02AT11	1	0	PAC dosing at inlet	1.2 dia X 1.2

Facility/ Equipment		TAG NO.	Q'TY		Specification	
			D'Y	SB		
5	PAC disribution tank	02AT12	1	0	To segregate PAC for dosing in diff rapid mixing chambers	
6	PAC feeding rotameter		1	1	Rotameter	

Operation procedure

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

⇩

2. Fill up one of the tanks with water about half with the help of the level indicator and by opening the water inlet line valve.

⇩

3. Close the water inlet line valve, add 100 bags (2,500 kg) of PAC.

⇩

4. Start (operate) the agitator

⇩

5. Add more water until the level reaches 50 m^3 (50,000 L)

- Bagged PAC will be manually transported from the storage area to the dissolving tank area using the overhead crane (08 MC 01). Bags will be manually opened, and the PAC powder emptied into the dissolving tanks.
- The tanks are provided with mixers (08 CM 11, 08 CM 21 and 08 CM 31) to assist in dissolving the PAC in water. Water is added to the dissolving tanks through manually operated valves (08 HV 11, 08HV 21 and 08 HV 31) from the plant water system.
- PAC solution is discharged from each tank through a manually operated valve (08 HV 12, 08 HV 22and 08 HV 32) to the solution pump header pipe. Solution is pumped to the distribution chamber by pumps 08 AP 11 and 08 AP 21. Each pump system comprises a suction valve (08 HV 14 and 08 HV24) discharge valve (08 HV 15 and 08 HV 25) and check valve (08 CV 11 and 08 CV 21).

9.2 Calculation of PAC dosage (feeding rate)

Item	Description
Flow	170,000 m^3/d => 7,083 m^3/h => 7.083 $\times 10^6$ L/h
PAC Solution	PAC ≅ 5% => 2,500 kg PAC in 50,000 L solution (s.g. ≅ 1) => 2,500 $\times 10^6$ mg /50,000 L => 0.05×10^6 mg/L
Dosing rate by Jar Test	2.0 mg/L as PAC (as an example)
Required PAC dosage	2.0 mg/L x 7.083 $\times 10^6$ L/h = 14.166 $\times 10^6$ mg/h
Required PAC Solution Feeding Rate	$= \frac{14.166 \times 10^6 \text{ mg/h}}{0.05 \times 10^6 \text{mg/L}}$ = 283 L/h
Simplified formula	$= \frac{7083 \text{ m}^3/\text{h} \times 2.0 \text{ mg/L}}{50}$ = 283 L/h

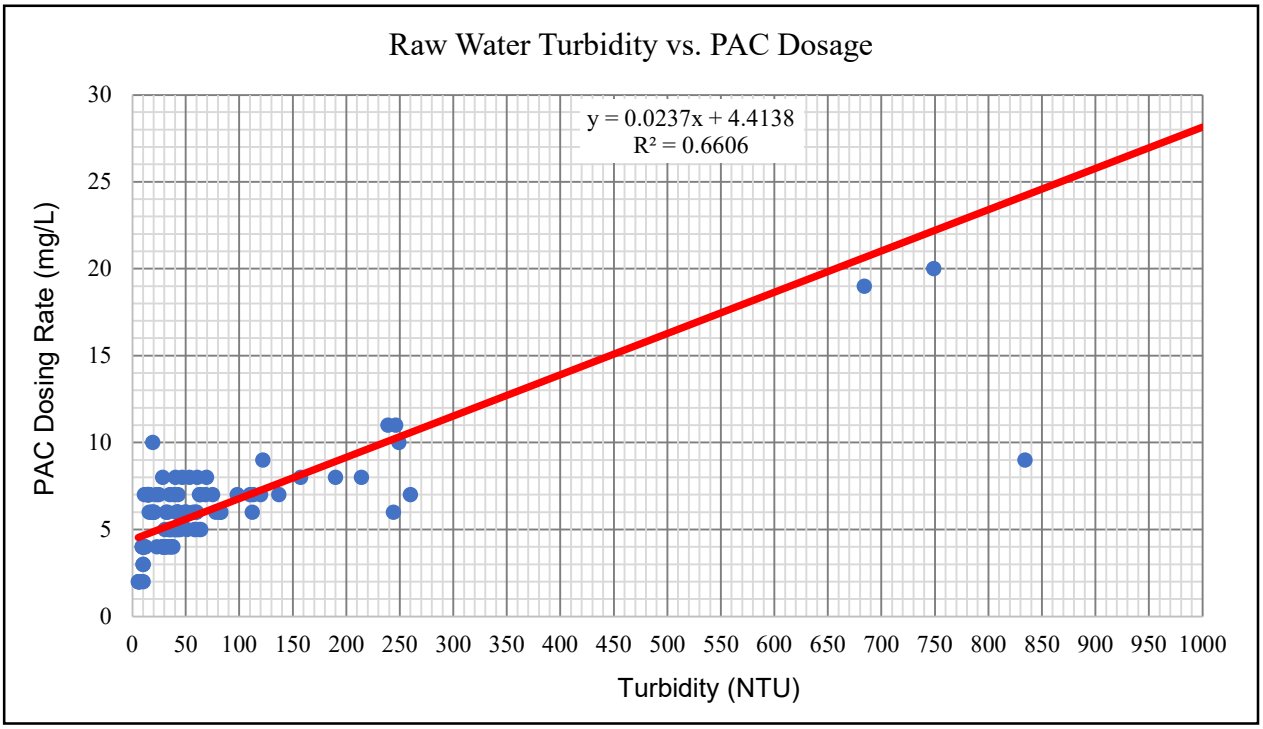


Figure 15: Raw water turbidity versus PAC dosage (Melamchi River water)

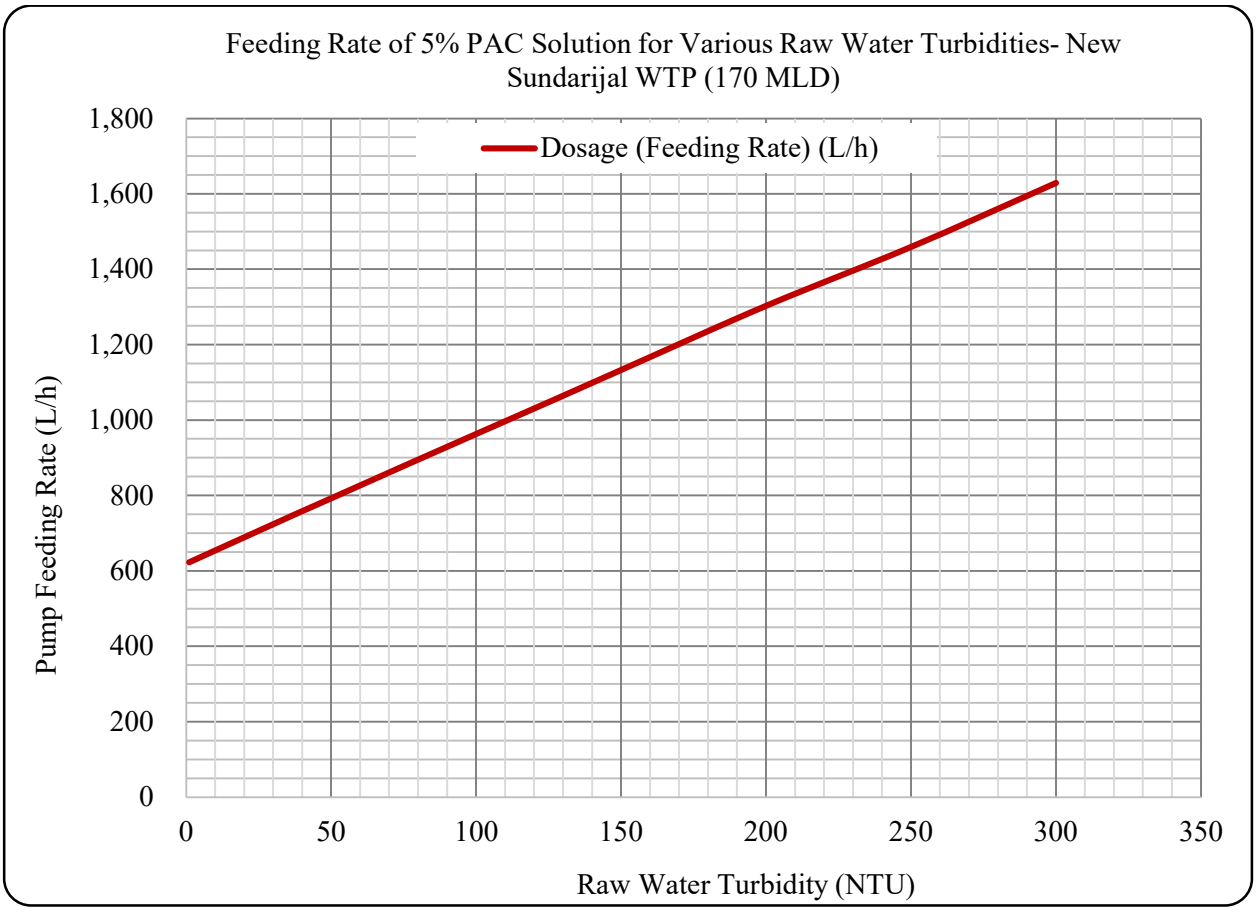
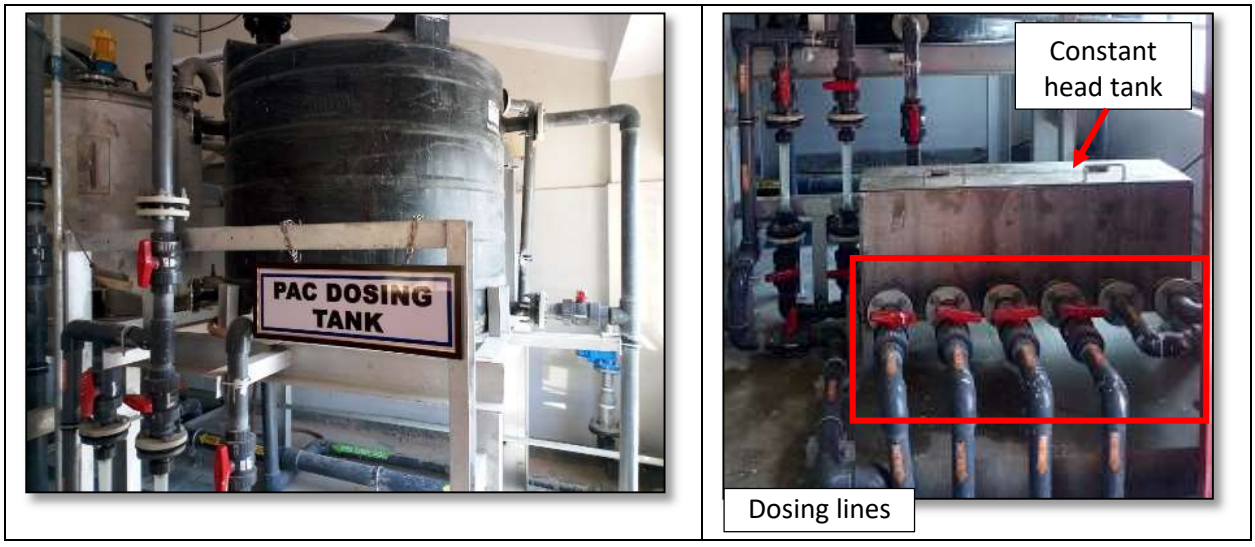


Figure 16: Raw water turbidity and PAC solution feeding rate



	
PAC dosing Rotameter	PAC Dosing through Constant head tank

Photo 21: PAC dosing facilities

Key steps for proper PAC dosing:

- Check the pH, turbidity, alkalinity and conductivity of raw water in the laboratory.
- Check the proper pre-chlorination.
- Correct the lime dosage rates if required.
- Ensure the PAC solution feeding is being done optimally, as per Jar test. Correct the dosage rates as required.

10. Lime Feeding Equipment

10.1 Lime Solution Preparation and Transfer

Mostly 5% lime solution (SG =1.04) is used to adjust the pH of the raw water for effective coagulation and flocculation. Lime is also used to adjust the pH of treated water when necessary.

a) Preparation of lime solution

1. Close the outlet valve of the lime preparation tank
⇩
2. Open the water inlet line valve
⇩
3. Fill up the tank with water until 100 mm below the overflow line with the help of the level indicator
⇩
4. Start the agitator
⇩
5. Add the lime and continue agitating until about 20 minutes

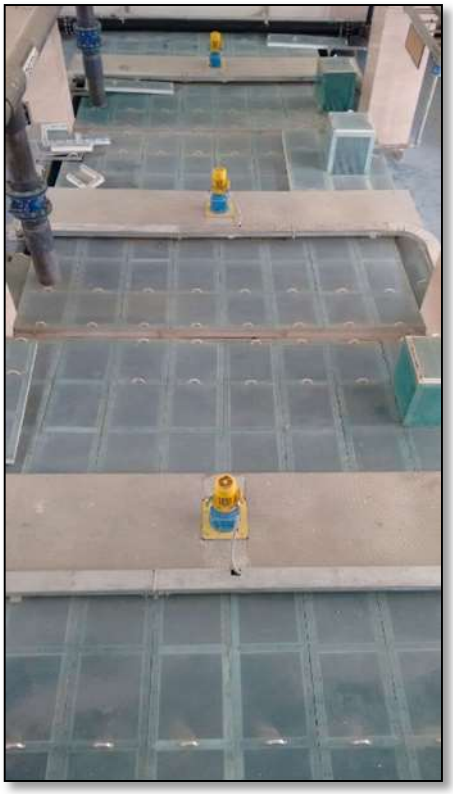


Photo 22: Lime preparation tanks (left) and transfer pumps

b) Transferring lime solution to storage tank

- Lime solution is pumped to the lime dosing tank 02 LT 21 at the distribution chamber and to the lime dosing tank 04 LT 11 at the filters.
- Lime solution is discharged from each tank through a manually operated valve (08 HV 42, 08 HV 52 and 08 HV 62) to the solution pump header pipe. Solution is pumped to the Dosing tanks at the intake area as well as in the filter building (Post lime dosing tank) by pumps.
- The pumps (08 LP 11, 08 LP 21, 08 LP 31 and 08 LP 41) are controlled automatically. Two pumps feed lime solution to the lime dosing tank in the intake area and two pumps to the Post lime dosing tank situated in filter area. The pumps are manually set as one duty and one standby for each system at 08 MCC 01. The standby pump will automatically operate on failure of the duty pump. The duty pumps operate when the levels in the field dosing tanks drop and are shut-off on manually pre-set high levels. The levels in the local dosing tanks are monitored by level indicators 02 LE 02 and 04 LE 05 respectively.

1. Select one of the Transferring pumps as working and other as standby.

⇩

2. Fully open the suction and discharge valves

⇩

3. Check the suction strainer and ensure that it is free from any foreign materials

⇩

4. Start the pump

⇩

5. When the service lime preparation Tank is nearing exhaustion, keep the second tank ready, preparing the 5% lime solution.

⇩

6. Change over to the second tank, as required.

⇩

7. Periodically change over to the standby pump and clean up the suction strainer, for smooth running of the dosing pumps. Schedule the changeover of lime dosing Tanks tentatively on Level basis.

Outline of the equipment

Facility/ Equipment		Tag No.	Q'TY		Specification	
			D'Y	SB		
1	Lime tank		3	0	Concrete tank	50 m^3
2	Lime Agitators	08CM11/21/31	3	0	Mixing of lime solution	2-stage; 3-impellar; vertical type propeller mixer; 0.75 kW; 3-phase; 415 V;
3	Lime transfer pumps	08LP11/21	1	1	Pre lime transfer pumps	2.5 LPS, 9 m^3/hr @ 30 m; 5.5 kW; 3-phase; 415 V.
4	Lime transfer pumps	08LP31/41	1	1	Post lime transfer pumps	2.5 LPS, 9 m^3/hr @ 30 m; 5.5 kW; 3-phase; 415 V.
5	Lime dust extraction system		1	0	Dust extraction of chemical dosed	No of bag filters-49; 2800 m^3/hr gas volume
6	Air compressor		1	0	Integral part of dust extraction system	
7	Air drier		1	0	Integral part of dust extraction system	
Lime dosing facility at distribution chamber						
8	Lime head tank	02LT11	1	0	Pre lime dosing tank	1.2 dia x1.2 cylindrical
9	Agitator for lime head tank	02CM11	1	0	Mixing of lime solution before dosing	3 phase; 415V; 0.37 kW; 1450 rpm
10	Lime feeding rotameter		1	1	Rotameter	

10.2 Lime Dosing Overall Process

1. Flow measurement (take flow data) (by WTP Engineer)

⇩

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

⇩

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

⇩

4. Adjust rotameter (by WTP operator)

⇩

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

⇩

6. Adjust the dosage (feeding rate) if necessary (by Lab/WTP)

10.3 Dosing Rate Calculation

$$\text{Lime solution (5\%) feeding rate} = \frac{Q\ (m^3/h) \times \text{Dosing Rate (mg/L)}}{52.083}\ \text{L/h}$$

In the case of New Sundarijal WTP,

Q = 170,000 m^3/day = 7,083 m^3/h

Dosing rate = 5 mg/L (as example)

Then,

$$\text{The feeding rate} = \frac{7{,}083 \times 5}{52.083} = 680\ \text{L/h}$$

Table 2: Lime solution feeding rates and daily volume required for various dosing rates

Dosing rate (mg/L)	Daily volume of solution required for 170 MLD flow (L/day)	Lime solution feeding rate (L/h)
1	3,264	136
2	6,528	272
3	9,792	408
4	13,055	544
5	16,319	680
6	19,583	816
7	22,847	952
8	26,111	1,088
9	29,375	1,224
10	32,639	1,360

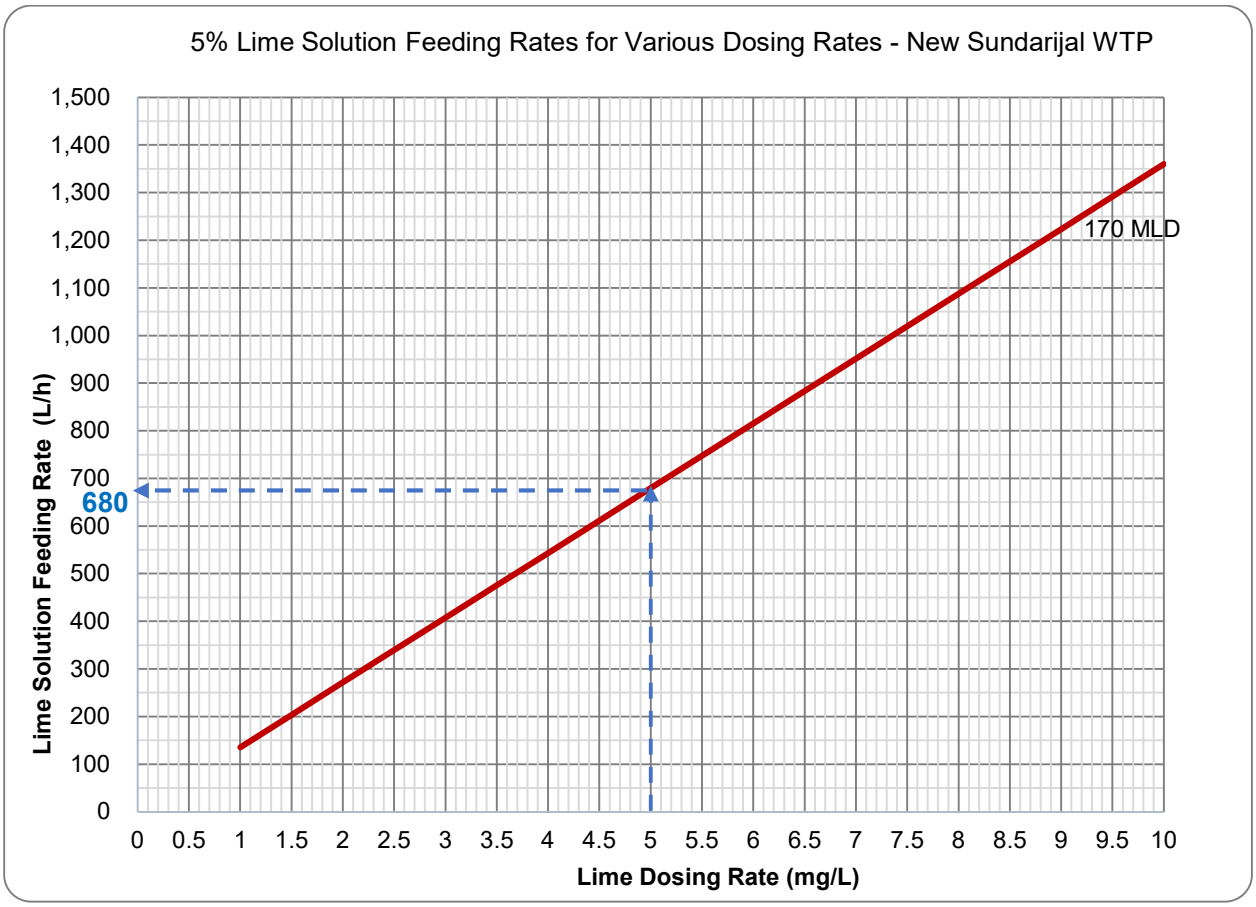


Figure 17: Lime dosing rates versus 5% lime solution feeding rate

(The above example shows the required lime solution feeding rate for 5 mg/L lime dosing rate)

10.4 Lime Dosing (feeding) Process

1. Lime solution is discharged from the dosing tank at the distribution chamber through valve 02 HV202 by adjusting the flow meter. Tank drainage is provided through valve 02 HV 203 and the tank inlet is controlled by ball valve 02 HV 201.

⇩

2. Pre-lime: the solution is fed by gravity to the distribution chamber through rotameters 02 FE 03 and 02 FE 04.

⇩

3. Post-lime: From the lime dosing tank at the filters the solution is fed to the filtered water tank by gravity.

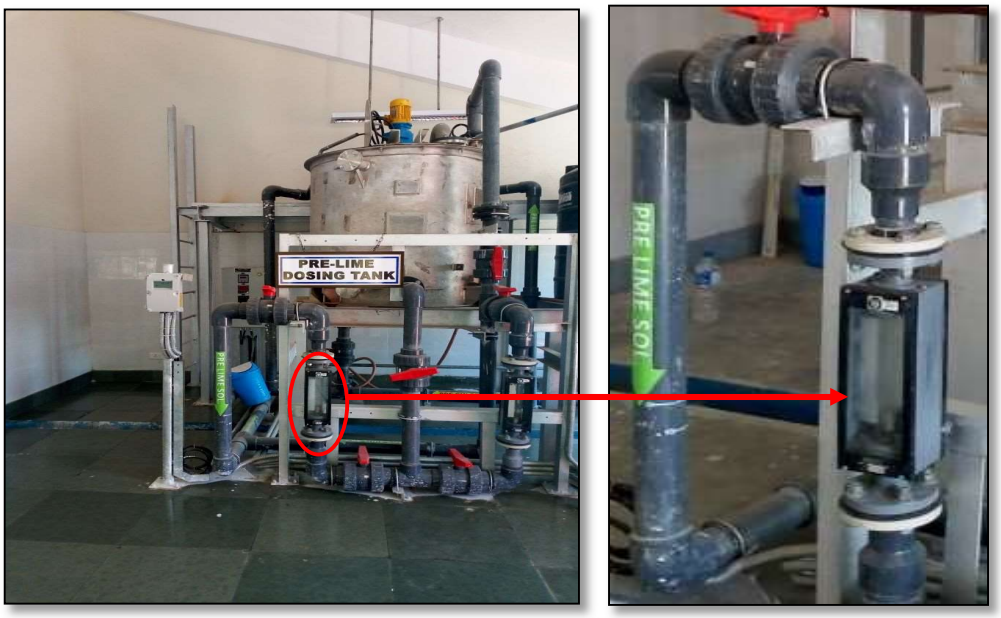
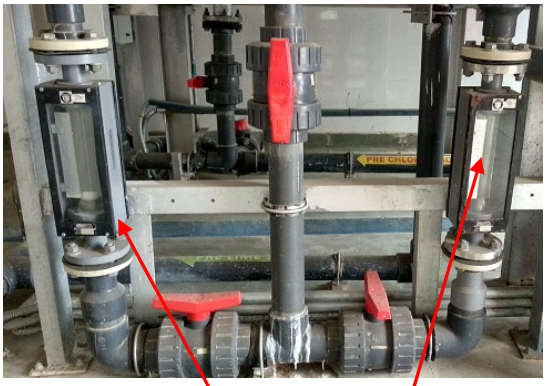


Photo 23: Pre lime dosing tank and rotameter

Post-lime dosing tank



Rotameters

Photo 24: Post-lime dosing tank and rotameters

11.Chlorine Feeding Equipment

11.1 Introduction

Chlorine destroys harmful organisms (mainly bacteria) that remain after coagulation/flocculation, sedimentation, and filtration. This process is called disinfection. If only a small amount of chlorine is added it may be consumed in other processes such as oxidation of iron, manganese, organics, and ammonia and may not provide sufficient disinfection effect. If there is still some chlorine left after oxidation and disinfection (residual chlorine), it provides protection against harmful organisms which may appear in the distribution pipeline.

11.2 Chlorine system and equipment in New Sundarijal WTP

The chlorine plant of New Sundarijal WTP consists of:

- Chlorine tonners
- Chlorinators
- Chlorine gas leak detector
- Ejectors
- Chlorination water booster pumps
- Switch Room

- Chlorine Tonner is arranged in two battery/Sets (1W+1S).
- Each battery will have two (2) number of one ton Chlorine Tonner.
- The tonner is placed in Horizontal orientation above Weigh Bridge for easy extraction of Liquid Chlorine and weight measurement.
- Both the tonner batteries are connected to from a common network with Automatic Switch over Unit which comprises of Automatic Change over Controller and motorized Valve.

1. Chlorine is stored in one tonne containers. Two containers will be coupled to the system. The duty cylinder will be placed on weighing device using overhead crane. Change over from the duty to the other cylinder will be effected automatically when the chlorine in the duty cylinder is finished.

Photo 25: Chlorine cylinders

2. Liquid chlorine is drawn off from the bottom valves of the cylinders and gas is drawn from the top valve of the tonner through flexible pipes from where it is fed to two evaporators (08 EP 01, 08 EP 02) where it is gasified and fed to four chlorinators.

Chlorine in Gas connection	Chlorine in Liquid connection

Photo 26: Chlorine gas and liquid connections

3. Two chlorinators (08 CL 11 and 08 CL 12) are manually selected as duty/standby to regulate the amount of chlorine solution delivered for pre-chlorination at the distribution chamber, or upstream of the filters, and two chlorinators (08 CL 21 and 08 CL 22) for post chlorination at the filtered water channel prior to discharge to the clear water reservoir.

Photo 27: Chlorine Evaporators and Chlorinators

Photo 28: Chlorine Ejectors

4. Solution water is supplied from the plant water system to injectors 08 IJ 11 and 08 IJ 12 into which chlorine is drawn from the respective chlorinators to form a solution for pre-chlorination. Injectors 08 IJ 21 and 08 IJ 22 are for post-chlorination.
5. Pre-chlorination solution is controlled into the distribution chamber by manually operated valve 02 HV 301 and into the sedimentation tank outlet chamber by manually operated valve 03 HV 13. Post chlorination is controlled into the filtered water outlet by manually operated valve 04 HV 301.

Photo 29: Chlorine Booster Pumps (Filter Gallery)

Facility/ Equipment		Tag No.	Q'TY		Specification	
			D'Y	SB		
1	Pre-chlorinator	08CL11/12	1	1	Chlorine dosing for water purification	75 kg/hr
2	Post-chlorinator	08CL21/22	1	1	Chlorine dosing for water purification	40 kg/hr

Note: D'Y: Duty, SB: Stand-by

11.3 Chlorine dosing process at clear water reservoir

1. Check and ensure that post chlorinator is working, and monitor chlorine dosage.

⇩

2. Monitor the level in clear water reservoir by the level transmitter.

⇩

3. Open the manual valves of Post chlorination lines.

⇩

4. Control the chlorine dosage at the Post Chlorinator so that FRC is maintained at 0.5 to 1 mg/L at the Outlet of CWR (As per the end user after the distribution the dosage may vary).

⇩

5. Collect treated water samples delivered at laboratory and carry out the required tests. At the Clear water Reservoir, Pressure Transmitter is provided in the plant water line for monitoring and starting / stopping the plant water pumps.

11.4 Calculation of chlorine dosage (feeding rates)

Example dosage calculation of pre-chlorination:

Average dosing rate, say **2 mg/L** (2 ppm)

Raw water flow = 7437 m^3/hr

Mass flow required = (7437 × 2) / 1000 kg/hr

Chlorine gas required per hour = 14.87 kg/hr

Example dosage calculation of post-chlorination:

Average dosing rate, say **1 mg/L** (1 ppm)

Clear water flow = 7083 m^3/hr

Mass Flow required kg/hr = (7083 × 1) / 1000

Chlorine gas required per hour = 7.1 kg/hr

The above dosing of pre and post chlorination to be done manually by adjusting the rotameter of the respective chlorinators at site. The status of chlorination system can also be monitored from the SCADA system.

Photo 30: Automatic Stream selection panel

The Automatic Switch Control Panel unit has the following Controls and Monitoring Function

1. Indication of Motorized Valve Position.
2. " Battery-1/Battery-2 " Selector Switch
3. " Auto/Manual "Selector Switch

   In Auto Mode – Battery Change Over happens automatically based on Pressure Switch Input and Weigh Bridge Input

   In Manual Mode – Operator can change the Duty/Standby Battery.

Figure 18: Chlorine Gas leak detector Control unit

The below listed gas detectors are given to identify the chlorine gas leak and chlorine gas leak detector control unit is provide to monitor the gas leak .The alarms gas leak alarms will be displayed in both field as well as in SCADA.

1. Chlorine Gas Detectors [08 GD 01/02/03]

Gas Detector 08 GD 01 & 08 GD 02 is located in Tonner Room

Gas detector 08 GD 03 is located in Chlorinator Room

2. Chlorine Gas Exhaust Fans

Exhaust Fan 08 EF 02/03/04/05 is located in Tonner Room

Exhaust Fan 08 EF 06 is located in Chlorinator Room.

One dedicated tonner storage bay provided to keep the filled tonner as well as empty tonner after the use.

Photo 31: Chlorine Tonners Storage bay

11.5 Points of chlorination

1) Pre-chlorination

Pre-chlorination is the application of chlorine to water prior to any unit treatment process. The point of application as well as dosage will be determined by the objectives viz.:

→ To control biological growth in raw water conduits

→ To control the growth of algae and other microorganisms that might interfere with coagulation and flocculation and to reduce the coagulant dose

→ To control the growth of algae in the sedimentation tanks well as in the clarified water **Overflow Troughs** , if allowed unchecked

→ Keeping filter media free of slime growths and mud balls which not only impair the filtration efficiency but also interfere with proper backwashing

→ Reduction of odour and colour.

→ Minimizing the post chlorination dosage, when dealing with heavily polluted water

The Pre-chlorine is applied to the raw water at the point of raw water inlet section of distribution chamber of WTP.

Example dosing calculation at Pre-chlorination:

For the Average 2 mg/L:

Raw water Flow	= 7437 m^3/hr
Required Dosage	= 2 ppm
Mass Flow required	= (7437 X 2) / 1000 kg/hr
Chlorine gas required per hour	= 14.87 kg/hr

Intermediate Chlorination:

One more intermediate chlorination also provided at the common outlet channel of the Sedimentation tanks to avoid the algal growth in the clarified water conveyance channel to filters.

2) Post-chlorination

Post-chlorination is the application of chlorine to water before it enters to the Public distribution system to maintain the amount of free chlorine to achieve the desired efficiency of disinfection.

The Post-chlorine is applied to filter water at the back wash water tank after the overflow weir.

Example dosing calculation at Post-chlorination:

Raw water Flow = 7437 m^3/hr

Required Dosage = 1 ppm

Mass Flow required = (7437 X 1) / 1000 kg/hr

Chlorine gas required per hour = 7.4 kg/hr

The above dosing of pre- and post-chlorination to be done manually by adjusting the rotameter of the respective chlorinators at site.

11.6 Process of changing chlorine cylinders

This work procedure requires that only competent employees change cylinders. A Filtered Half Face Respirator shall be worn when chlorine cylinders are being changed, during general maintenance, etc. The following safe work procedure for changing cylinders is for a non-emergency situation, when the alarm has not been activated. (If the alarm has been activated, workers would follow the emergency procedures)

1. Turn on the exhaust ventilation before entering the room.
2. Put on appropriate personal protective equipment if a leak is known or suspected.
3. Close the main chlorine container valve.
4. Loosen the chlorinator (auxiliary valve or vacuum regulator) and remove it from the empty cylinder.
5. Replace the cylinder cap on the empty chlorine cylinder and remove the cylinder to secured storage.
6. Secure the new cylinder into place.
7. Remove the protective hood from the new cylinder.
8. Ensure that there is no chlorine leaking from the packing gland. Use ammonia vapor from the ammonia test bottle, which contains a strong ammonia solution.
9. Ensure that the cylinder valve is closed. Do not open the valve yet.
10. Remove the cylinder outlet cap and check that the cylinder outlet face is clean and smooth.
11. Using a new washer, connect the vacuum regulator or the yoke assembly to the valve outlet using the supplied wrench only.
12. Crack open the chlorine cylinder valve and then quickly close it again. This will let enough chlorine into the lines to charge them. The valve should open with no more than a sharp rap from the heel of your hand. Never use a “helper” wrench or a larger wrench than the one supplied. If the valve will not open, carefully loosen the packing gland slightly.

13. Check all the connections you have made to ensure there are no leaks. Use the vapor from the ammonia test bottle (see step 8). If a leak is indicated, activate the leak control procedure.
14. When no leaks are indicated, open the chlorine cylinder valve no more than half a turn and leave the cylinder wrench on the valve.
15. Open any additional system valves and test for leaks as each stage is charged with chlorine.
16. Check for leaks again with the ammonia test bottle to be sure that everything is in order.
17. Ensure that the alarm system is functioning.
18. Turn off the exhaust ventilation and lights and close the door when you leave.
19. Remove your respirator or other personal protective equipment.

12. Backwash Water Recovery Tank

As a water conservation measure, filter backwash water is recycled and returned to the beginning of the plant. Filter backwash water is discharged and stored in backwash water recovery tanks. All backwash water is returned to distribution tank by backwash recovery pumps controlling water level.

Outline of the equipment

Facility/ Equipment		Tag No.	Q'ty		Specification	
			D'Y	SB		
1	Backwash recovery pumps	06WP11/21	2	2	To recover the backwash water back into the mainstream and minimise the water loss	79 LPS, 285 m^3/hr @ 16 m; 3-phase; 415 V; 18.5 kW
2	Sluice gates	06HG11/21	2	0	Manually operated sluice gate inflow of water from backwash channel	600X600

Photo 32: Backwash Water Recovery System

13. Sludge Lagoon

The settled sludge on the floor of sedimentation basins is normally removed under hydrostatic pressure through the bottom drain pipes. Sludge discharged from the sedimentation basins is drained to sludge lagoons through manually operated valve 03 HV 08, which is normally Closed.

Sludge from the flocculation tanks and sedimentation tanks are drained by gravity through dedicated manual gate valve provided 1 no in each flocculation tank and 12 nos of butterfly valves provided in each sedimentation tank.

Two numbers of sludge lagoons are provided. One sludge lagoon by-pass line is also provided to drain the sludge form the flocculators as well as sedimentation tanks. Periodically the sludge needs to be discharged outside when the turbidity of the sedimentation tank overflow exceeds the design limit due to high turbidity of the recycled sludge.

Photo 33: Sludge Lagoon

The following photos show the visual appearance of sludge during start and end time of draining, for reference. Usually, the sludge is discharged to Sludge Lagoon.

	
Sludge appearance at the time of startup of sludge draining form sedimentation tanks	Sludge appearance at the end of sludge draining form sedimentation tanks

Photo 34: Sludge appearance at the beginning and end of draining (desludging) from sedimentation tanks

Outline of the equipment

Facility/ Equipment		Tag No.	Q'Ty		Specification	
			D'Y	Sb		
1	Sluice Gates	07HG11/21	3	0	Sludge inlet gate to sludge lagoons	500x500
2	Stop Logs	07SL11/21	3		SS logs for maintenance purpose	1400x1400
3	Stop Logs	07SL12/22	3		SS logs for maintenance purpose	1400x1400

End of the SOP.