OPERATION AND MAINTENANCE MANUAL

For

HEROLD'S BAY COUNTRY ESTATE

WASTEWATER TREATMENT PLANT

JULY 2024

APPROVALS				
Revision	**Date**	**Issued to**	**Prepared by**	**Approved by**
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1 INTRODUCTION

1.1 PURPOSE OF THE MANUAL

The purpose of operating a wastewater treatment plant (WWTP) is to treat wastewater to an acceptable level to return the effluent to the natural water cycle. The water can either be returned to a receiving water body or the land via irrigation.

Therefore, proper operation and maintenance (O&M) of a wastewater treatment plant is critical to ensure effluent quality that is acceptable and safe to return to the water cycle. Proper O&M will also maximise the life of the mechanical and electrical equipment, and it is essential to ensure safe working conditions on the plant.

The purpose of this O&M Manual is to provide process controllers and personnel conducting routine maintenance tasks and checks on the WWTP with a better understanding of the functioning of the plant and to provide a guideline for biological process operational, maintenance, and monitoring activities.

There are five aspects involved in the successful operation of WWTP:

1. **Operation** – physical activities required to treat the water.
2. **Supervision** – overseeing of operating activities by a competent person.
3. **Control** – the processes and routines that ensure the operation of a suitable standard.
4. **Management** – the activities to ensure overall proper functioning and sustainability such as long-term planning (strategic planning) and tactical planning.
5. **Public relations** – an important function that provides feedback on the acceptability and quality of the treated wastewater and services.

Maintenance of a WWTP refers to the daily activities required to sustain the WWTP in proper working conditions, and can be divided into three categories:

1. **Preventative maintenance** – regular inspection and routine servicing to preserve assets and minimise breakdowns.
2. **Corrective maintenance** – minor repair and replacement of broken and worn-out parts to sustain reliable facilities.
3. **Crisis maintenance** – failure to conduct preventative and corrective maintenance leads to unplanned emergency breakdowns of equipment, which may compromise the WWTP's ability to ensure effective treatment.

1.2 SCOPE AND APPLICABILITY

1.2.1 SCOPE

The manual covers a range of topics to ensure the efficient and reliable functioning of the wastewater treatment plant. The scope includes:

1. **Operational Procedures:**
   - Start-up procedures, normal operating procedures, and shutdown procedures for the entire system.
   - Guidelines for routine operations, including daily inspections, process monitoring, and data logging.
   - Emergency response procedures to address equipment failures, environmental incidents, and other unforeseen events.
2. **Maintenance Procedures:**
   - Routine maintenance tasks, including daily, weekly, and monthly checks.
   - Preventive maintenance procedures for critical components such as pumps, and instrumentation.
   - Corrective maintenance procedures, troubleshooting guides, and solutions for common issues.
3. **Safety Procedures:**
   - Guidelines for ensuring the safety of personnel during all operational and maintenance activities.
   - Procedures for handling chemicals, using personal protective equipment (PPE), and responding to emergencies.
4. **Monitoring and Control:**
   - Overview of the instrumentation and control systems used in the plant.
   - Procedures for monitoring process parameters, analysing data, and responding to alarms.
5. **Quality Assurance and Quality Control:**
   - Sampling procedures and guidelines for laboratory analysis of treated effluent.
   - Procedures for compliance monitoring and documentation of results.
6. **Documentation and Record Keeping:**
   - Requirements for maintaining daily logs, maintenance records, incident reports, and regulatory compliance documentation.
   - Guidance on record-keeping practices to ensure accountability and traceability.
7. **Training and Personnel:**
   - Training requirements for operators and maintenance personnel.
   - Competency requirements for personnel involved in the operation and maintenance of the system.
   - Guidelines for conducting emergency response drills.
8. **Environmental Considerations:**
   - Overview of the environmental impact of the wastewater treatment process.
   - Regulatory compliance considerations and procedures for resource conservation.
9. **Appendices:**
   - Glossary of terms used in the manual.
   - References to equipment manuals, contact information, and other supplementary materials.

1.2.2 APPLICABILITY

This manual is designed for use by personnel directly involved in the day-to-day operations, maintenance, and management of the wastewater treatment plant. The primary users include:

1. **Operators**: Responsible for the routine operation of the system, adherence to operational procedures, and data monitoring.
2. **Maintenance Personnel:** Engaged in performing routine and preventive maintenance tasks, as well as addressing corrective maintenance issues.
3. **Management**: Involved in overseeing the overall functioning of the plant and ensuring regulatory compliance.
4. **Training Coordinators:** Responsible for organizing and conducting training sessions for operators and maintenance personnel.

It is imperative that all users familiarize themselves with the content of this manual and adhere to the specified procedures and guidelines to ensure the safe, efficient, and environmentally responsible operation of the wastewater treatment plant.

1.3 PROJECT INFORMATION

This section provides an overview of the essential project related details related to the Herold's Bay Country Estate WWTP.

CONSULTANT	Element Consulting Engineers
CLIENT	Urhwebo e-Transand Civil & Building Contractors
SITE AND COUNTRY	Herold's Bay, Western Cape, South Africa
SITE NAME	Herold's Bay Country Estate
COORDINATES	34°02'48.4"S 22°24'22.9"E
HYDRAULIC CAPCITY	30 m^3/d

The treatment plant consist of the following treatment steps:

Primary Treatment:

- 10mm coarse screen
- 2mm screw screen
- Buffer Tanks

Secondary Treatment:

- Anoxic Tank
- Aerobic Tank
- Membrane Bioreactor (MBR) System

Tertiary Treatment:

- Disinfection with UV and sodium hypochlorite

Sludge Management:

- Sludge Silo and dewatering bags

2 SYSTEM OVERVIEW

2.1 MEMBRANE BIOREACTOR (MBR) TECHNOLOGY

2.1.1 OVERVIEW OF MBR TECHNOLOGY

The membrane bioreactor (MBR) technology represents an advanced and innovative approach to wastewater treatment, integrating biological treatment processes with membrane filtration. The basic principles of MBR technology revolve around enhanced solid-liquid separation, which significantly improves the quality of treated effluent compared to conventional wastewater treatment methods.

2.1.2 BIOLOGICAL TREATMENT PROCESS

The heart of the MBR system lies in its biological treatment processes. Wastewater undergoes biological treatment within the bioreactor, where microorganisms, such as bacteria and protozoa, break down organic pollutants. This biological treatment is a crucial step in reducing the biochemical oxygen demand (BOD) and chemical oxygen demand (COD) of the wastewater.

2.1.3 SOLID-LIQUID SEPARATION WITH MEMBRANES

One of the distinguishing features of MBR technology is the use of membranes for solid-liquid separation. These membranes, typically made of polymeric materials, act as physical barriers that allow water molecules to pass through while retaining suspended solids, microorganisms, and other contaminants. The membranes effectively replace traditional secondary clarifiers, resulting in improved clarification and higher effluent quality.

2.1.4 FILTRATION PROCESS

The filtration process in MBR technology involves the continuous removal of solids from the mixed liquor through the membranes. As wastewater passes through the membranes, a permeate stream of clean water is produced, while solids are retained. The retained solids form a concentrated sludge, which can be periodically withdrawn from the system.

2.1.5 BENEFITS OF MBR TECHNOLOGY

- **High Treatment Efficiency:** MBR technology provides a higher degree of treatment compared to conventional processes, leading to superior removal of contaminants.
- **Compact Design:** MBR systems often have a more compact footprint than traditional wastewater treatment plants due to the elimination of secondary clarifiers.
- **Flexible Configurations:** MBR technology can be configured in various ways, allowing adaptation to different treatment requirements and site conditions.
- **Improved Effluent Quality:** The use of membranes results in effluent with low turbidity, reduced pathogens, and consistently high water quality.

- **Reduced Sludge Production:** MBR systems typically produce less sludge compared to conventional systems, reducing the burden on sludge handling and disposal.

Understanding these fundamental principles of MBR technology is essential for the effective operation and maintenance of the wastewater treatment plant, ensuring optimal performance and environmental compliance. Subsequent sections of this manual will provide detailed guidelines for the operation and maintenance of the MBR system based on these principles.

2.2 PROCESS DESCRIPTION

The Herold's Bay Country Estate Wastewater Treatment Plant (WWTP) is housed within an underground civil tank and an above ground equipment and screening room designed to efficiently treat raw sewage and produce high-quality effluent for reuse.

The treatment process begins at the gravity fed raw sewage screening channel, where the raw wastewater passes through a 10mm coarse and flows into a buffer tank. The buffer tank is split into two sections. The first section allows for further settling of large solids. The screened sewage overflows into the second chamber of the buffer tank from which the wastewater is pumped out of the buffer tank and through a 2mm screw screen to remove smaller particles from the water. The final screened water is passed back into the anoxic chamber. This ensures that equalized flow is fed to the treatment plant.

In the anoxic zone, a mixer ensures thorough mixing to enhance the denitrification process, removing nitrogen compounds. The wastewater then flows into an aerobic zone fitted with diffusers, where oxygen is supplied to promote the growth of aerobic microorganisms that break down organic matter. The mixed liquor from the aerobic zone enters the Membrane Bioreactor (MBR), which contains flat sheet membranes that separate clean water (permeate) from the mixed liquor, retaining suspended solids and microorganisms.

Return Activated Sludge (RAS) and Waste Activated Sludge (WAS) are managed by the RAS/WAS pump. RAS is returned to the biological process to maintain biomass concentration, while WAS is sent to sludge handling. These two processes do not happen at the same time. Permeate pumps draw the treated water through the membranes and forward it to the disinfection stages. Sodium hypochlorite is dosed into the permeate for primary disinfection, followed by UV disinfection to ensure complete pathogen removal, resulting in safe, treated effluent.

The disinfected water is stored in treated effluent tanks before being pumped to the dam. Booster pumps ensure that the treated effluent is delivered at the required pressure to the distribution point. A dedicated service water pump supplies water for various maintenance activities, including feeding the CIP (Clean-In-Place) tank and spraying scum in the aerobic and MBR tanks.

Sludge generated in the MBR tank is pumped to a sludge silo. The concentrated sludge is then dewatered using dewatering bags, and any overflow from the sludge silo is returned to buffer tank, maintaining process continuity and minimizing waste.

This comprehensive treatment process ensures efficient sewage treatment, producing high-quality effluent suitable for reuse and effectively managing sludge within the compact yet sophisticated facility of the Herold's Bay Country Estate WWTP.

2.3 COMPONENTS AND EQUIPMENT

The Membrane Bioreactor (MBR) wastewater treatment plant integrates various components and equipment across primary, secondary, and tertiary treatment stages, as well as sludge management. Understanding the role of each element is crucial for the effective operation and maintenance of the system. This section provides an overview of the key components and equipment specifications within the MBR system.

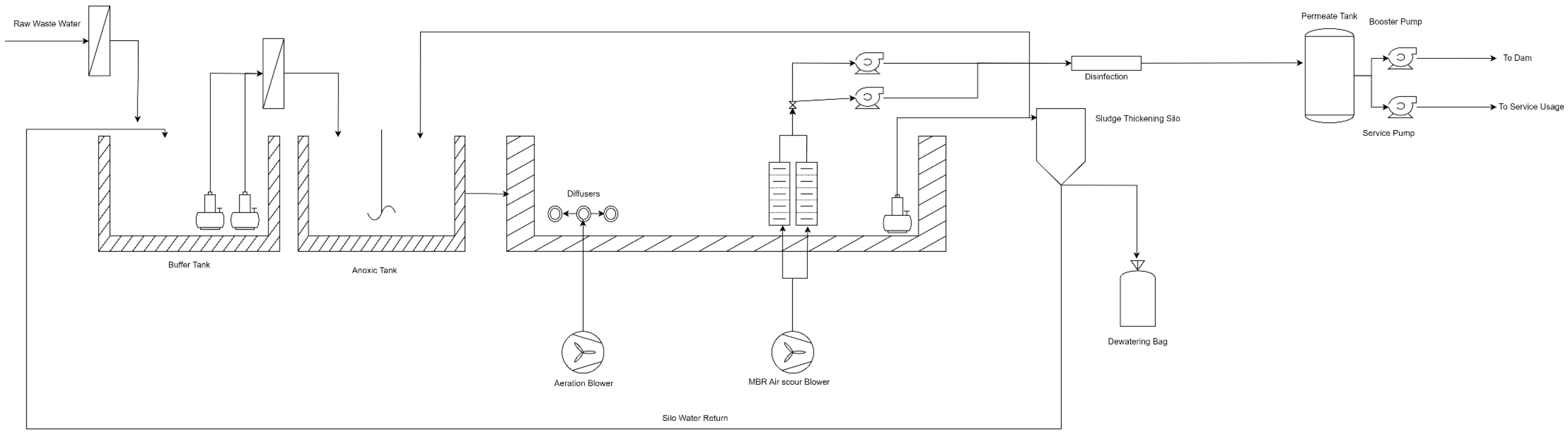
Overall Treatment Plant		
Description	**UOM**	**Value**
Average Dry Weather Flow	m^3/d	30
Peak Wet Weather Flow	m^3/d	150
Peak Factor	-	5
Organic Loading	kg COD/day	27
Biological Reactor		
Description	**UOM**	**Value**
Bioreactor Process Type	-	MLE Process
MBR included	-	Yes
Sludge Age	days	20
Reactor MLSS	mg/L	8000
Number of Reactor trains	#	1
Total Reactor Volume	m^3	27.2
Total Aerobic volume (including MBR)	m^3	19.7
Total Anoxic Volume	m^3	7.50
Sludge waste rate	m^3/d	1.08
Overall Oxygen Transfer Efficiency (OTE)	%	2.99
Air supply required	m^3/h	50
Aeration Device	-	Fine bubble diffuser
MBR SMU module flux	LMH	18.31
MBR total SMU Surface Area required	m^2	128
MBR SMU type	-	Megavision
Total MBR SMU modules	#	2
Pumps		
Description	**UOM**	**Value**
Buffer Pump Flow	m^3/h	1.25
Buffer Pump Head	m	10
RAS/WAS Pump Flow	m^3/h	5
RAS/WAS Pump Head	m	8
Permeate Pump Flow	m^3/h	1.9
Permeate Pump Head	m	8
Service Water Pump Flow	m^3/h	1.5
Service Water Pump Head	m	40
Booster Pump Flow	m^3/h	2
Booster Pump Head	m	80

Dosing Pumps		
Description	**UOM**	**Value**
PAC design dosage	mg/L	15
PAC design flow	mL/h	155
Chlorine design dosage	mg/L	2
Chlorine design flow	mL/h	40

Understanding the function and interdependence of these updated components and equipment is essential for operators and maintenance personnel to ensure the efficient and reliable operation of the comprehensive wastewater treatment plant. Subsequent sections of this manual will provide detailed guidance on the operation, maintenance, and troubleshooting of these integrated components.

THE PIPING AND INSTRUMENTATION DIAGRAM (P&ID) CAN BE FOUND IN APPENDIX B.

2.4 PROCESS FLOW DIAGRAM



3 OPERATING PROCEDURES

3.1 START-UP PROCEDURES

3.1.1 FRESH START-UP

a. Before initiating a fresh start, ensure that the plant has been completely reset or is starting anew.
b. Enter all necessary settings and setpoints into the system before activating any equipment.
c. Verify incoming voltage to ensure it meets operational requirements; the voltage monitor will indicate suitability.
d. Enable individual motorized equipment using their respective enable/disable buttons. For equipment with duty standby, both pumps must be enabled in auto mode for duty rotation. If only one pump is enabled, it will run continuously except during interlocks.
e. Use the auto/manual button for each piece of equipment. In auto mode, the equipment will operate according to setpoints and interlocks. Avoid manual mode unless necessary; use the start command button to initiate uninterrupted equipment operation without interlocks or setpoints. The equipment should generally remain in auto mode.
f. All equipment will stop or be prevented from starting if the Emergency Stop (E-stop) is engaged.
g. Note: Equipment with duty/rest intervals will start with the rest interval during the startup, so expect a delay before full operation.

3.1.2 START-UP AFTER LOSS OF POWER:

a. In the event of a power loss, the plant retains its previous operating state.
b. When power is restored, the system will automatically resume operation.
c. If any faults are present, use the reset button to clear them and start the equipment.
d. Monitor the system for any anomalies or unexpected behaviour during the startup after a power loss.

Note: Exercise caution and adherence to safety protocols during the start-up process. Familiarize operators with the control panel and functionalities to ensure a smooth and safe plant start-up. Regularly review and update the start-up procedures based on system modifications or improvements.

3.2 OPERATION OF THE INLET WORKS

3.2.1 COARSE SCREENING

The sewage enters the Herold's Bay Country Estate WWTP through a manually operated 20 mm coarse screen. This screen collects large objects and grit, which are then stored in bins for disposal.

The primary purpose of this screening process is to remove large debris and floating materials, protecting mechanical equipment and pumps and preventing blockages. Allowing biodegradable material, such as faecal matter, to pass through the screens is essential for downstream treatment and helps minimize disposal issues and fly breeding.

Routine Screening Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Checks:**
    a. Perform a visual inspection of the screening equipment to ensure it is free from debris, damage, or any obstructions.
    b. Verify that safety guards and barriers are in place and secure.
2. **Screen Inspection:**
    a. Inspect the coarse screen (S-1-01) for any accumulated debris or blockages.
3. **Screening Efficiency Check:**
    a. Monitor the efficiency of the screening process by visually inspecting the separated solids.
4. **Periodic Cleaning:**
    a. Schedule and perform routine cleaning of the screening equipment to prevent clogging or reduced efficiency.
    b. Document the cleaning frequency and any issues encountered during the process.
5. **Screen Replacement:**
    a. Regularly check the condition of screens for wear and tear.
    b. Replace screens as needed to maintain optimal screening performance.
6. **Safety Review:**
    a. Conduct safety briefings with relevant personnel on a regular basis.
    b. Remind operators of safety protocols and the importance of adhering to established procedures.

ALSO, THE APPROPRIATE PPE NEEDS TO BE WORN AT ALL TIMES TO ENSURE THAT THERE IS NO SKIN CONTACT OR INGESTION OF THE SEWAGE WATER.

3.2.2 FINE SCREENING

The screw screen at the Herold's Bay Country Estate Wastewater Treatment Plant (WWTP) is a crucial component for removing smaller particles from the wastewater after initial coarse screening. Positioned in the screening room, before the anoxic zone, the 2 mm screw screen helps to ensure the efficient operation of downstream processes. The following procedures outline the steps for the normal operation and maintenance of the screw screen system.

1. **Start-Up Procedure:**
    a. Initial Checks:
        i. Inspect the screw screen (S-1-02) for any visible damage, blockages, or debris that may impede operation.
        ii. Verify that all safety guards and protective covers are securely in place.
    b. System Activation:
        i. Start the screw screen system using the control panel.
        ii. Observe the initial operation to ensure the screen is functioning correctly and effectively.
        iii. Confirm that the flow of wastewater through the screen is consistent and unobstructed.
        iv. Ensure that no plugging occurs during operation. Plugging is when a significant amount of solids gets stuck in the screw and adds significant stress on the screw screen motor.
2. **Normal Operation:**
    a. Monitoring:
        i. Continuously monitor the screw screen to ensure it is effectively removing fine particles from the wastewater.
        ii. Use visual inspections to check for any signs of clogging or blockages.
        iii. Ensure that the wastewater is flowing evenly across the surface of the screen.
    b. Routine Inspections:
        i. Perform regular inspections of the screen and the surrounding area to check for build-up of debris or any operational issues.
        ii. Clean the screen as necessary to prevent clogging and maintain optimal performance. This helps prevent plugging of the screw screen.
3. **Quality Control:**
    a. Performance Checks:
        i. Periodically measure the amount and type of debris being collected by the screw screen.
        ii. Record data on the screen's effectiveness and adjust if necessary to maintain optimal performance.
    b. Cleaning and Maintenance:
        i. Schedule and perform regular cleaning of the screen to ensure efficient operation and prevent blockages.
        ii. Inspect and maintain mechanical components, such as motors and spray nozzles, for signs of wear and perform maintenance as needed.

iii. Keep detailed logs of inspections, cleanings, and any maintenance activities conducted.

4. **Safety Precautions:**
    a. Personal Protective Equipment (PPE):
        i. Ensure that all personnel involved in operating and maintaining the screw screen wear appropriate PPE, including gloves, safety glasses, and protective clothing.
        ii. Follow lock-out/tag-out procedures during maintenance to ensure the safety of staff.
    b. Training:
        i. Provide regular safety training for operators and maintenance personnel, emphasizing the importance of following safety protocols.
5. **Emergency Response:**
    a. Incident Handling:
        i. Develop and implement emergency response procedures for screen blockages, mechanical failures, or power outages.
        ii. Ensure all staff are familiar with emergency shut-off procedures for the screw screen system.
    b. Spare Parts and Tools:
        i. Maintain a supply of critical spare parts and tools to enable quick repairs in case of system failures.
6. **Communication:**
    a. Operator Coordination:
        i. Maintain clear communication between operators and maintenance staff regarding any issues or abnormalities observed during operation.
        ii. Document and report any deviations from normal operating conditions to management for further investigation and corrective action.

3.2.3 SCREENING CONTAINMENT

Screenings and removed grit are temporarily contained on site in bins. The purpose of containing screenings and grit in bins is to allow for easier removal and disposal and to ensure a neat inlet works.

The containers must be emptied on a regular basis to prevent excessive build up and nuisance conditions. The screenings and grit should either be taken to a landfill site, a burial site or combusted in a furnace.

3.3 OPERATION OF THE BUFFER CHAMBER

The buffer tanks and pumps play a crucial role in the preliminary treatment of wastewater at the Herold's Bay Country Estate WWTP. The buffer tank serves as the initial point of entry for effluent, facilitating gravity flow from the sewage pipe network. It also functions as an anaerobic chamber, fostering the breakdown of organic matter.

The buffer pumps, located within the second chamber, transfer wastewater from the buffer tank to the anoxic tank. The pumps are strategically set to manage peak flows by maintaining a steady flow of wastewater through the plant.

<u>Routine Buffer Chamber Operational Procedures:</u>

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Start-Up Procedure:**
    a. Ensure all inlet and outlet (V-1-1, V-1-2) valves on the buffer tank pumps are in the correct positions for operation.
    b. Verify that the duty/standby buffer pumps are operational and set to the appropriate configurations.
    c. Start the transfer pumps (P-1-01, P-1-02) to transfer the raw wastewater to the screw screen and into the anoxic tank.
    d. Observe the initial filling process to ensure smooth and unobstructed flow.
2. **Normal Operation:**
    a. Continuously monitor water levels in the buffer tanks using level sensors (LS-1-01, LS-1-02) and visual inspections.
    b. Ensure consistent flow rates to prevent overflows or low levels that could disrupt the treatment process.
    c. Check for any unusual noises or vibrations from the buffer pumps (P-1-10, P-1-02) indicating potential issues.
    d. Perform regular visual inspections of the tank interiors and exteriors to check for debris accumulation or structural issues.
    e. Verify that the buffer pumps are operating efficiently and without any faults.
3. **Quality Control:**
    a. Periodically sample water from both buffer tanks to monitor pH levels and overall water quality.
    b. Record data on water quality and flow rates to ensure compliance with treatment targets.
    c. Schedule and perform regular cleaning of both buffer tanks to prevent sediment build-up and ensure efficient operation.
    d. Inspect and maintain mechanical components, such as pumps and valves, for signs of wear and perform maintenance as needed.
    e. Keep detailed logs of inspections, cleanings, and any maintenance activities conducted.
4. **Safety Precautions:**

   a. Ensure that all personnel involved in operating and maintaining the buffer tanks wear appropriate PPE, including gloves, safety glasses, and protective clothing.
   b. Follow lock-out/tag-out procedures during maintenance to ensure the safety of staff.
   c. Provide regular safety training for operators and maintenance personnel, emphasizing the importance of following safety protocols.

5. **Emergency Response:**
   a. Develop and implement emergency response procedures for incidents such as tank overflows, pump failures, or chemical spills.
   b. Ensure all staff are familiar with emergency shut-off procedures for the buffer tanks and associated systems.
   c. Maintain a supply of critical spare parts and tools to enable quick repairs in case of system failures.

6. **Communication:**
   a. Maintain clear communication between operators and maintenance staff regarding any issues or abnormalities observed during operation.
   b. Document and report any deviations from normal operating conditions to management for further investigation and corrective action.

3.4 OPERATION OF THE ACTIVATED SLUDGE PROCESS

3.4.1 ANOXIC TANK

The Anoxic Tank is a vital component in the wastewater treatment process, specializing in anoxic digestion to facilitate denitrification. This process deliberately deprives aerobic bacteria of oxygen, prompting the conversion of nitrogen compounds into nitrates and nitrites. The resulting denitrification releases Nitrogen gas into the atmosphere, contributing to the overall efficiency of the treatment system.

To ensure thorough mixing of solids and sludge within the tank, a timed mixer operates to maintain a homogeneous mixture, crucial for optimizing denitrification. The Anoxic Tank is seamlessly connected to Aeration Tanks through a throughflow weir, allowing for controlled transfer of treated wastewater and maintaining hydraulic balance between the interconnected tanks.

<u>Routine Anoxic Tank Operational Procedures:</u>

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
    a. Conduct a thorough visual inspection of the Anoxic Tank, including the inlet and outlet weirs, to check for and remove any restrictions.
    b. Ensure the tank and associated equipment are free from damage, leaks, or blockages.
    c. Verify the integrity of safety features and confirm that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
    a. Confirm the availability of power for the Anoxic Tank and associated equipment.
    b. Check the control panel to ensure all switches, timers, and indicators are in proper working condition.
3. **Mixer Activation and Continuous Operation:**
    a. Start the mixer (M-2-01) to initiate the mixing of solids and sludge within the Anoxic Tank.
    b. Ensure that anoxic mixers are in continuous operation, slowly mixing the contents.
    c. Report any issues with the mixers, including the formation of a vortex, to the supervisor.
4. **Denitrification Process Start-Up:**
    a. Commence the denitrification process by intentionally depriving aerobic bacteria of oxygen.
    b. Monitor the process to ensure the formation of nitrates and nitrites.
5. **Odor Sensitivity Check:**
    a. Be sensitive to smells at the Anoxic Tank, noting that a distinct, inoffensive "chemical" odour should be present if the tank is working correctly.
    b. If the odour is offensive, report the issue to the supervisor, and call in a process specialist to assist in rectifying the situation.
6. **Monitoring and Reporting:**
    a. Monitor the Anoxic Tank for unusual noises and check for oil leaks from motors and gearboxes.
    b. Report any unusual noises or oil leaks promptly to the supervisor for further investigation.
7. **Lubrication and Weekly Checks:**
    a. Grease bearings weekly to ensure smooth operation.

b. Check oil levels on gearboxes weekly and top up with the correct grade of oil if required.

8. **Emergency Shutdown Procedures:**
   a. Familiarize personnel with emergency shutdown procedures.
   b. Verify the functionality of emergency stop buttons and other safety features.
9. **Record Keeping:**
   a. Maintain comprehensive records of Anoxic Tank operations, including mixer activation times, nitrogen gas release observations, and any deviations from normal operating conditions.
   b. Document any adjustments made during routine operations.

3.4.2 AEROBIC TANK

The Aerobic Tank constitutes a pivotal stage in the wastewater treatment process, employing advanced technology to facilitate the reduction of Chemical Oxygen Demand (COD). Positioned within the tank are fine bubble diffusers strategically installed on the tank floor. These diffusers play a vital role in the aeration process by diffusing low-pressure, high-volume air into the aeration chamber. The aeration chamber is constantly supplied with oxygen-rich air, crucial for sustaining aerobic bacteria within the tank.

The heart of the aeration system is the air blower, housed in the equipment room, which tirelessly propels air through the fine bubble diffusers. This continuous aeration process ensures that aerobic bacteria thrive, enabling them to effectively reduce the COD load in the wastewater to below 50 mg/L. The blower, a key component, operates throughout the day to maintain optimal oxygen levels within the tank, with a scheduled one-hour cool-down period in the evening to promote efficient system performance.

Routine Aerobic Tank Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
    a. Conduct a visual inspection of the Aerobic Tank, including fine bubble diffusers (D-2-1) and the biomass, to ensure there are no blockages, damage, or signs of wear.
    b. Check the colour, smell, and appearance of the biomass, using these parameters as an indication of the working condition of the reactor.
    c. Confirm that safety protocols are in place and that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
    a. Verify the availability of power for the Aerobic Tank and associated equipment.
    b. Check the control panel to ensure all switches, timers, and indicators are in proper working condition.
3. **Air Blower Activation:**
    a. Activate the air blower (BL-2-1) to initiate the continuous supply of low-pressure, high-volume air through the fine bubble diffusers.
    b. Confirm that the blower is set to operate throughout the day, apart from the designated one-hour cool-down period in the evening.
4. **Aeration Process Monitoring:**
    a. Monitor the aeration process to ensure the consistent oxygenation of water within the Aerobic Tank.
    b. Confirm that aerobic bacteria receive sufficient oxygen to effectively reduce the COD load to below 50 mg/L.
    c. Check the flow into the bioreactor to ensure even distribution and identify any obstructions.
5. **Fine Bubble Diffuser and Water Surface Checks:**
    a. Regularly inspect fine bubble diffusers to ensure they are functioning optimally.
    b. Address any issues related to diffuser performance promptly to maintain efficient aeration.
    c. Check for any floating debris on the water surface and remove as necessary.

6. **Scum Formation and Sludge Test:**
    a. Inspect for excessive scum formation and hose down if needed to prevent unpleasant odours and discourage fly breeding.
    b. Perform a sludge test to determine whether the correct amount of sludge is being maintained, as prescribed by the supervisor or engineer.
7. **Emergency Shutdown Procedures:**
    a. Familiarize personnel with emergency shutdown procedures.
    b. Verify the functionality of emergency stop buttons and other safety features.
8. **Regular Monitoring of System Parameters:**
    a. Regularly monitor and record system parameters, including oxygen levels, COD concentrations, and any deviations from normal operating conditions.
    b. Adjust operational parameters as needed to optimize wastewater treatment.
9. **Lubrication and Maintenance:**
    a. Schedule routine lubrication of bearings associated with the air blower.
    b. Perform regular maintenance checks on the air blower, diffusers, and associated components to identify and address any issues promptly.
10. **Record Keeping:**
    a. Maintain comprehensive records of Aerobic Tank operations, including air blower activation times, aeration process observations, sludge test results, and any adjustments made during routine operations.
    b. Document any issues, irregularities, or observations related to biomass colour, smell, and appearance for further investigation and resolution.

3.4.3 MEMBRANE FILTRATION UNIT

The MBR (Membrane Bioreactor) filtration unit within the wastewater treatment plant serves as the final clarifier, employing advanced membrane filters to ensure thorough clarification before the treated effluent is discharged from the WWTP. This innovative technology not only enhances the quality of the treated effluent but also enables the efficient return of sludge to the anoxic tank through the Return Activated Sludge (RAS) pump.

At the heart of the MBR filtration unit are the specialized membranes that continually scour the water with air supplied by a dedicated blower. This continuous scouring process is essential to prevent blockages on the membrane surfaces, ensuring the longevity and optimal functioning of the filtration system. The MBR unit operates in tandem with the aeration and denitrification processes, contributing to the overall effectiveness of the wastewater treatment system.

The dedicated blower, responsible for supplying air to scour the membranes, plays a crucial role in maintaining the MBR filtration unit's efficiency. The blower is designed to be operational most of the time, ensuring consistent and effective membrane cleaning. However, a scheduled hour-long cool-down period in the evenings allows for system maintenance and optimization.

<u>Routine Membrane Filtration Unit Operational Procedures:</u>

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
    a. Conduct a visual inspection of the MBR Filtration Unit (SMU-2-1, SMU-2-2), focusing on the membrane surfaces and associated equipment, to identify any damage, fouling, or wear.
    b. Verify the condition of the Return Activated Sludge (RAS) pump and associated components.
    c. Confirm that safety protocols are in place and that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
    a. Verify the availability of power for the MBR Filtration Unit, including the dedicated blower.
    b. Check the control panel to ensure all switches, timers, and indicators are in proper working condition.
3. **Membrane Scouring Activation:**
    a. Activate the membrane scouring process by starting the dedicated blower (BL-2-2) to supply air to the MBR membrane surfaces.
    b. Confirm that the scouring process is continuous to prevent blockages and maintain optimal membrane performance.
4. **Return Activated Sludge (RAS) Pump Operation:**
    a. Ensure the RAS pump (P-2-3) is operational and set to facilitate the return of sludge to the anoxic tank.
    b. Monitor the sludge return process to ensure it aligns with the prescribed operational parameters.

5. **Flow and Clarification Monitoring:**
    a. Check the flow into the MBR Filtration Unit to ensure it is even and without obstructions.
    b. Monitor the clarification process to ensure treated effluent meets the required quality standards.
6. **Inspection of Membrane Surfaces:**
    a. Regularly inspect the condition of membrane surfaces for fouling, scaling, or any abnormalities.
    b. Address any issues related to membrane condition promptly to maintain efficient filtration.
7. **Scum and Debris Removal:**
    a. Check for excessive scum formation and debris in the MBR tank.
    b. Remove any scum or floating debris to prevent interference with the membrane filtration process.
8. **Periodic RAS Pump and Blower Cool-Down:**
    a. Initiate the scheduled cool-down period for the RAS pump and the dedicated blower in the evening.
    b. Confirm that the RAS pump and blower are properly turned off during this cool-down phase.
9. **Emergency Shutdown Procedures:**
    a. Familiarize personnel with emergency shutdown procedures.
    b. Verify the functionality of emergency stop buttons and other safety features.
10. **Regular Maintenance:**
    a. Schedule routine maintenance for the MBR Filtration Unit, including membrane inspections, RAS pump checks, and blower maintenance.
    b. Address any identified issues promptly to prevent downtime and maintain optimal system performance.
11. **Record Keeping:**
    a. Maintain comprehensive records of MBR Filtration Unit operations, including membrane scouring times, RAS pump activities, and any adjustments made during routine operations.
    b. Document any issues, irregularities, or observations related to membrane condition for further investigation and resolution.

3.4.4 RETURN ACTIVATED SLUDGE

The Return Activated Sludge (RAS) process is a vital component within the wastewater treatment system, designed to harness the microbial richness of sludge accumulated at the bottom of the aeration chamber. This sludge, teeming with beneficial bacteria, serves as a valuable resource for processing waste within the treatment plant. The mechanism facilitating the transfer of this sludge is the low-level submersible pump known as the Return Activated Sludge (RAS) pump.

Operating seamlessly, the RAS pump extracts sludge from the aeration chamber and efficiently transports it to the anoxic chamber. The returned sludge plays a crucial role in seeding the bacterial processes within the anoxic chamber, enhancing the overall efficiency of denitrification and waste reduction. This symbiotic relationship between the aeration and anoxic chambers underscores the interconnected nature of the treatment process.

Routine RAS Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
    a. Perform a visual inspection of the RAS pump (P-2-3), ensuring there are no signs of damage, leaks, or wear.
    b. Verify the condition of the anoxic reactor level indicator and the associated control system.
    c. Confirm that safety protocols are in place, and all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
    a. Verify the availability of power for the RAS pump and associated control systems.
    b. Check the control panel to ensure all switches, timers, and indicators are in proper working condition.
3. **Regular Monitoring of System Parameters:**
    a. Regularly monitor system parameters, including anoxic reactor levels and RAS pump operation.
    b. Adjust operational parameters as needed to optimize sludge transfer and maintain efficient biological processes.
4. **Emergency Shutdown Procedures:**
    a. Familiarize personnel with emergency shutdown procedures.
    b. Verify the functionality of emergency stop buttons and other safety features.
5. **Record Keeping:**
    a. Maintain comprehensive records of RAS pump operations, including duty rotations, intervals, and any adjustments made during routine operations.
    b. Document any issues, irregularities, or observations related to anoxic reactor levels and RAS pump performance for further investigation and resolution.

3.4.5 WASTE ACTIVATED SLUDGE

The Waste Activated Sludge (WAS) process is an essential component within the wastewater treatment system, designed to efficiently manage and remove the sludge that accumulates during the treatment process. As part of the regular maintenance program, the accumulated sludge undergoes removal, and the Waste Activated Sludge pump plays a pivotal role in this crucial task.

Initiating the waste removal process is a manual operation that involves starting the WAS pump through the Human-Machine Interface (HMI).

Routine WAS Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
   a. Perform a visual inspection of the WAS Pump (P-2-3), ensuring there are no signs of damage, leaks, or wear.
   b. Verify the condition of the anoxic reactor level indicator and the associated control system.
   c. Confirm that safety protocols are in place and that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
   a. Verify the availability of power for the WAS Pump and associated control systems.
   b. Check the Human-Machine Interface (HMI) to ensure proper functionality for manual initiation of the WAS Pump.
3. **Manual Start of WAS/RAS Pump:**
   a. Initiate the WAS/RAS Pump manually on the HMI for the removal of accumulated sludge.
   b. Monitor the pump's performance during the sludge transfer process.
4. **Anoxic Reactor Level Control:**
   a. Monitor the anoxic reactor level indicator (LS-2-02), which reflects the MBR level.
   b. Ensure that the MBR Low Level Setpoint is functioning correctly to stop the duty WAS Pump when necessary.
5. **Sludge Age and Concentration Control:**
   a. Control sludge age and concentration monthly to maintain bio-digestion and treated water quality.
   b. Conduct sludge wastage periodically, typically weekly, or monthly, based on wastewater characterization.
   c. Perform Sludge Volume Index (SVI) measurements to determine settleability and suspended solids concentration.
6. **SVI Measurement Procedure:**
   a. Use a graded glass cylinder of a minimum volume of 1 litre for settling sludge.
   b. Take a 1 litre sample of mixed liquor under well-mixed conditions.
   c. Allow the well-mixed sludge to settle for 30 minutes.
   d. Determine the volume occupied by the settled sludge after 30 minutes.

7. **Suspended Solids Concentration Measurement Procedure:**
    a. Take a well-mixed sample from the aeration basin.
    b. Record the volume of the sample collected.
    c. Filter the sample, collect and dry the filter solids.
    d. Weigh the mass of the filtered solids.
    e. Calculate the suspended solids concentration as the mass of solids divided by the volume of the sample.
8. **SVI Results Interpretation:**
    a. SVI < 80 mL/g: Increase sludge wastage to remove old sludge.
    b. 80 mL/g < SVI < 150 mL/g: Maintain the current sludge wastage rate for healthy sludge.
    c. SVI > 150 mL/g: Decrease sludge wastage to manage young and active sludge.
9. **Emergency Shutdown Procedures:**
    a. Familiarize personnel with emergency shutdown procedures.
    b. Verify the functionality of emergency stop buttons and other safety features.
10. **Record Keeping:**
    a. Maintain comprehensive records of WAS Pump operations, sludge wastage activities, SVI measurements, and suspended solids concentrations.
    b. Document any issues, irregularities, or observations related to sludge age and concentration for further investigation and resolution.

3.5 OPERATION OF THE DISINFECTION UNITS

3.5.1 SODIUM HYPOCHLORITE DOSING

The Sodium Hypochlorite (NaOCl) Dosing Process is a critical step in the final disinfection stage of the wastewater treatment system, aiming to eliminate bacteria and pathogens from the permeate water. Sodium Hypochlorite, a potent disinfection agent, is strategically dosed into the permeate line, ensuring the treated water meets stringent quality standards.

The key component facilitating the precise dosing of Sodium Hypochlorite is the Hypochlorite Dosing Pump. This pump is designed to operate in tandem with the Permeate Pump, ensuring synchronization with the water flow through the permeate line. The dosing rate is manually controlled through the dosing pump interface, allowing operators to tailor the disinfection process to meet specific requirements.

Routine Sodium Hypochlorite Dosing Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
    a. Conduct a visual inspection of the NaOCl dosing pump (P-3-3) and associated equipment to ensure there are no signs of damage, leaks, or wear.
    b. Verify the condition of the NaOCl dosing tank (T-3-1), including the level switch.
    c. Confirm that safety protocols are in place and that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
    a. Verify the availability of power for the NaOCl dosing pump and associated control systems.
    b. Check the dosing pump interface to ensure all switches, timers, and indicators are in proper working condition.
3. **NaOCl Dosing Pump Duty/Stand-By Cycle:**
    a. Monitor the totalized running hours of the NaOCl dosing pump.
    b. Initiate the rotation of duty when the totalized running hours exceed the Hypo Dosing Pump Duty Cycle.
    c. Confirm that the stand-by NaOCl dosing pump is ready for operation after the rotation.
4. **Permeate Pump Synchronization:**
    a. Confirm that the duty NaOCl dosing pump operates when the Permeate Pump is running.
    b. Verify that the synchronization is maintained for effective disinfection.
5. **Manual Control of Dosing Rate:**
    a. Adjust the dosing rate manually on the dosing pump interface as needed.
    b. Monitor the dosing rate to ensure it aligns with the specified disinfection requirements.
6. **Hypochlorite Dosing Tank Level Monitoring:**
    a. Regularly check the level switch (LS-3-01) inside the NaOCl dosing tank.
    b. If the level drops below the set level, acknowledge the Low Hypochlorite Level alarm.
    c. Promptly address the low-level situation by refilling the dosing tank to ensure continuous dosing capability.

7. **Emergency Shutdown Procedures:**
    a. Familiarize personnel with emergency shutdown procedures.
    b. Verify the functionality of emergency stop buttons and other safety features.
8. **Record Keeping:**
    a. Maintain comprehensive records of NaOCl dosing pump operations, including duty rotations, dosing rates, and level switch monitoring.
    b. Document any issues, irregularities, or observations related to the dosing process for further investigation and resolution.

3.5.2 UV DISINFECTION

The UV Disinfection Unit is a critical stage in the wastewater treatment process, employing ultraviolet (UV) lights to ensure the thorough disinfection of permeate water. Unlike intermittent systems, the ultraviolet light in this unit operates continuously, providing a consistent and reliable means of microbial control. The unit features an ultraviolet light control box, which acts as a monitoring mechanism for the UV lights. In the event of any issues with the light bulb, the control box is designed to flash red, indicating the need for attention and potential service.

The effectiveness of the UV disinfection process is crucial for maintaining treated water quality. Therefore, microbial growth is routinely monitored through monthly water sampling. This proactive approach allows for the early detection of excessive microbial activity in the treated water. If microbial levels surpass acceptable thresholds, it may signal a decline in UV-light effectiveness. In such cases, the UV disinfection unit may require a service to address any issues affecting its performance.

Routine UV Disinfection Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
    a. Conduct a visual inspection of the UV disinfection unit (UV-3-1), checking for any signs of damage, leaks, or wear.
    b. Verify the condition of the UV lights and the UV control box.
    c. Confirm that safety protocols are in place and that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
    a. Verify the availability of power for the UV disinfection unit and associated control systems.
    b. Check the UV control box to ensure all switches, timers, and indicators are in proper working condition.
3. **UV Disinfection Operation in Automatic Mode:**
    a. Ensure that the UV disinfection unit is set to automatic mode.
    b. Confirm that the UV lights run concurrently with the duty Permeate Pump (P-3-1, P-3-2), adhering to the interval timer function.
    c. Monitor the UV control box for any red flashing indicators, signifying issues with the UV lights.

4. **UV Disinfection Stoppage Criteria:**
    a. If the Permeate Pumps have not operated for a duration greater than the UV Cool-Down period, ensure that the UV disinfection unit (in automatic mode) stops.
    b. Verify that the UV disinfection unit ceases operation when the specified criteria are met.
5. **UV Disinfection Operation in Manual Mode:**
    a. If required, switch the UV disinfection unit to manual mode.
    b. Confirm that, in manual mode, the UV lights operate continuously.
6. **Monitoring Microbial Growth:**
    a. Conduct monthly water sampling to monitor microbial growth.
    b. Analyse the results to ensure that the UV disinfection process is effectively controlling microbial activity.
7. **UV Disinfection Unit Cool-Down Period:**
    a. If necessary, initiate the UV disinfection unit cool-down period after a designated duration of inactivity.
    b. Confirm that the UV lights cease operation during the cool-down phase.
8. **Emergency Shutdown Procedures:**
    a. Familiarize personnel with emergency shutdown procedures.
    b. Verify the functionality of emergency stop buttons and other safety features.
9. **Record Keeping:**
    a. Maintain comprehensive records of UV disinfection unit operations, including automatic and manual modes, UV stoppage criteria, and microbial growth monitoring.
    b. Document any issues, irregularities, or observations related to UV disinfection performance for further investigation and resolution.

3.6 OPERATION OF THE PERMEATE PUMPS

The Permeate Pump plays a pivotal role in the wastewater treatment process, serving as the force behind the extraction of clean, filtered water. Positioned to apply suction pressure over the membranes, this pump facilitates the passage of water through the membrane filtration system, resulting in the production of treated, high-quality water.

Operational efficiency is ensured through the implementation of a duty/stand-by cycle for the Permeate Pumps. These pumps seamlessly alternate duties, with the rotation initiated after the totalized running hours surpass the predefined Permeate Pump Duty Cycle. This strategic approach not only optimizes pump performance but also contributes to the longevity of the equipment.

To monitor the effectiveness of the treatment process and ensure accurate performance tracking, a water meter is installed on the permeate line. This meter records the cumulative volume of water treated by the plant. Regular monitoring of the meter readings provides valuable data for assessing daily water treatment volumes. Recording these readings from one day to the next serves as a reliable indicator of the overall plant performance and operational consistency.

Routine Permeate Operational Procedures:

As a routine practice during a shift, the process controller or operator must carry out the following inspections and operational procedures:

1. **Pre-Operation Inspection:**
   a. Conduct a visual inspection of the permeate pumps (P-3-1, P-3-2) and associated equipment for any signs of damage, leaks, or wear.
   b. Verify the condition of the MBR blower (BL-2-2) and the overall integrity of the membrane filtration system.
   c. Confirm that safety protocols are in place and that all personnel are wearing the necessary personal protective equipment (PPE).
2. **Power and Control Checks:**
   a. Verify the availability of power for the permeate pumps and associated control systems.
   b. Check the control panel to ensure all switches, timers, and indicators are in proper working condition.
3. **Permeate Pump Duty/Stand-By Cycle:**
   a. Monitor the totalized running hours of the permeate pumps.
   b. Initiate the rotation of duty when the totalized running hours exceed the Permeate Pump Duty Cycle.
   c. Confirm that the stand-by permeate pump is ready for operation after the rotation.
4. **Permeate Pump Alternation and Duration:**
   a. Implement a 10-minute cycle for alternating permeate pumps, with each pump allowed to run for a maximum of 8 minutes.
   b. Include a mandatory 2-minute rest time in every 10-minute cycle to prevent extended continuous operation.
5. **MBR Level Setpoints:**
   a. Set the Permeate Pump to stop when the MBR level reaches the MBR Low Level Setpoint.
   b. Initiate the Permeate Pump when the MBR level reaches the MBR High Level Setpoint.

6. **Permeate Pump Duty/Rest Intervals:**
    a. Operate the permeate pumps for the specified Permeate Pump Duty Interval duration.
    b. Stop the permeate pumps for the designated Permeate Pump Rest Interval duration.
7. **CIP Start Cycle and MBR Blower Interlocks:**
    a. Ensure that the permeate pumps do not operate during the CIP Start Cycle.
    b. Verify that the permeate pumps do not operate if the MBR blower is not in operation.
8. **Permeate Pumps Low Suction Pressure Sequence:**
    a. If the measured suction pressure is lower or equal to the Low Permeate Suction Pressure setpoint, with a duration greater than the Low Permeate Suction Pressure Delay period, stop the duty permeate pump and start the stand-by pump.
    b. If the stand-by pump undergoes the same low-pressure condition, activate the CIP Required alarm but allow the permeate pump to continue operating.
9. **Permeate Pumps Critical Low Suction Pressure Sequence:**
    a. If the measured suction pressure is lower or equal to the Critical Low Permeate Suction Pressure setpoint, with a duration greater than the Critical Low Permeate Suction Pressure Delay period, immediately stop the duty permeate pump.
    b. Activate the CIP Required Fault immediately at Critical Low Permeate Suction Pressure.
10. **Permeate Pump No-Flow Sequence:**
    a. If the measured flow is lower or equal to the Low Permeate Flow setpoint, with a duration greater than the Low Permeate Flow Delay period, stop the duty permeate pump and start the stand-by pump.
    b. If the stand-by pump undergoes the same low flow condition, activate the No Flow Fault, and stop the Permeate Pump.
11. **Monitoring for Blockage and Overheating:**
    a. Switch the pump control to the Manual ON position.
    b. Check for flow on the rotameter to ensure proper pump operation.
    c. Monitor each pump for signs of blockage and overheating.
12. **Recordkeeping:**
    a. Record discharge pressure and flow from the permeate pumps.
    b. Record suction pressure from the membranes.
    c. Document the data for future analysis and comparison.
13. **Throttling Valve Adjustment:**
    a. Turn the throttling valve (GV-3-1) on the discharge of the pumps to achieve the required 122 l/min rate.
    b. Ensure that the flow does not exceed the specified flow rate.
14. **Suction Pressure Management:**
    a. Monitor the water level in the MBR tank using the indicator on the HMI.
    b. Calculate the allowable suction pressure based on the water level, following the specified guidelines.
    c. If the suction pressure deviates by more than 0.05 bar from the allowable setpoint, contact Alveo Water for a chemical clean of the membranes to prevent potential permanent damage.

15. **Anti-Foam Service Pump Check:**
    a. Verify that the anti-foam service pump is operational.
    b. Check the functionality of the ball float valve controlling the level in the service tank.
    c. Inspect the spray nozzles to ensure they are free from blockages.
    d. Confirm that the tank is filled with permeate water from the permeate pumps.

3.7 OPERATION OF THE SLUDGE TREATMENT PROCESS

The sludge treatment process at the Herold's Bay Country Estate Wastewater Treatment Plant (WWTP) involves handling and processing sludge generated from the Membrane Bioreactor (MBR) tank. This process includes transferring sludge to a sludge silo, dewatering using Geobags, and managing overflow.

Efficient sludge treatment is essential for maintaining overall plant performance and compliance with environmental regulations. The following procedures outline the steps for the normal operation and maintenance of the sludge treatment system.

Routine Sludge Treatment Operational Procedures:

1. **Start-Up Procedure:**
    a. Ensure that the sludge transfer pumps are operational and properly configured.
    b. Inspect the sludge silo (T-2-4) for any signs of leaks, structural damage, or obstructions.
    c. Verify that the Geobags (GB-2-1) are correctly positioned and secured for sludge dewatering.
    d. Start the RAS/WAS pump (P-2-3) to transfer sludge from the MBR tank to the sludge silo.
    e. Monitor the initial transfer to ensure smooth operation and avoid overfilling the sludge silo.
    f. Check that the overflow system from the sludge silo is correctly directed to Buffer Tank 2.
2. **Normal Operation:**
    a. Continuously monitor sludge levels in the sludge silo using level sensors and visual inspections.
    b. Ensure that the transfer of sludge from the MBR tank to the sludge silo is consistent and controlled.
    c. Regularly inspect the Geobags for any signs of damage or leaks.
    d. Perform regular visual inspections of the sludge silo, transfer pumps, and associated piping for any issues.
    e. Check the condition of the Geobags and ensure they are effectively dewatering the sludge.
    f. Verify that the overflow system is functioning correctly and directing excess sludge to Buffer Tank 2.
3. **Quality Control:**
    a. Periodically sample sludge from the sludge silo to monitor its composition and quality.
    b. Record data on sludge volume and quality to ensure compliance with treatment targets.
    c. Adjust the operation of the RAS/WAS pump based on sludge quality and volume measurements.
    d. Schedule and perform regular cleaning of the sludge silo to prevent sediment build-up and ensure efficient operation.

e. Inspect and maintain mechanical components, such as pumps and valves, for signs of wear and perform maintenance as needed.
f. Replace Geobags as necessary to maintain effective dewatering performance.

4. **Safety Precautions:**
    a. Ensure that all personnel involved in operating and maintaining the sludge treatment system wear appropriate PPE, including gloves, safety glasses, and protective clothing.
    b. Follow lock-out/tag-out procedures during maintenance to ensure the safety of staff.
    c. Provide regular safety training for operators and maintenance personnel, emphasizing the importance of following safety protocols.
5. **Emergency Response:**
    a. Develop and implement emergency response procedures for incidents such as pump failures, sludge spills, or Geobag ruptures.
    b. Ensure all staff are familiar with emergency shut-off procedures for the sludge treatment system.
    c. Maintain a supply of critical spare parts and tools to enable quick repairs in case of system failures.
6. **Communication:**
    a. Maintain clear communication between operators and maintenance staff regarding any issues or abnormalities observed during operation.
    b. Document and report any deviations from normal operating conditions to management for further investigation and corrective action.

3.8 FAULT FINDING

In the intricate realm of wastewater treatment, maintaining operational efficiency is paramount. The fault-finding section serves as a guide to systematically identify and address potential issues that may arise within the treatment plant. Leveraging the capabilities of the Human-Machine Interface (HMI) and a comprehensive understanding of equipment functionality, operators can navigate through this section to troubleshoot, diagnose, and resolve issues promptly. From monitoring pump statuses to addressing sensor malfunctions and tackling Variable Speed Drive (VSD) faults, this section provides a structured approach to ensure the seamless operation of the plant. By following these fault-finding procedures, operators can proactively manage challenges, minimize downtime, and uphold the reliability of the wastewater treatment system.

1. **Monitoring on HMI:**
    a. Utilize the Human-Machine Interface (HMI) to check the current operating status of pumps.
    b. Identify operational status through colour indications; green indicates 'on,' and red signifies a tripped breaker in the panel.
2. **Auto Mode Troubleshooting:**
    a. For equipment in auto mode that should be operational, investigate potential issues.
    b. Check for tripped breakers or active interlock alarms. If the HMI shows green but equipment is not functioning onsite, suspect a mechanical problem.
3. **CIP Tank Valve and Permeate Line:**
    a. Detect issues with CIP (Clean-In-Place) tank valves by observing fluctuating flow on the permeate line.
    b. Fluctuations, such as a drop from 25 cubes to around 0 and then back up to 25, may indicate open CIP tank valves during operation.
4. **Analog Display Issues:**
    a. If analogs on the screen fail to display or show errors (######), use the reset button to attempt resolution.
    b. If the problem persists, consider a faulty sensor that may require attention or replacement.
5. **Screen Sprayer Operation:**
    a. Check the functionality of sprayers (SPV-2-1, SPV-2-2) at the screen if they are not spraying:
        i. Verify the service tank level; low levels may affect sprayer operation.
        ii. Check if the service pump is in standby due to low level or faults.
        iii. Use the reset button on the pump for troubleshooting.
6. **VSD Faults:**
    a. Reset any Variable Speed Drive (VSD) faults using the MCC (Motor Control Centre) reset button.
    b. Investigate and address the cause of VSD faults to prevent reoccurrence.

Note: During fault-finding, prioritize safety and follow proper shutdown procedures if required. Regularly update the fault-finding procedures based on system modifications or improvements. Document all findings, actions taken, and resolutions for future reference.

4 CHEMICAL MAKE-UP PROCEDURES

Chemical dosing is a critical component of the treatment process at the Herold's Bay Country Estate Wastewater Treatment Plant (WWTP). Proper preparation and handling of chemicals, such as poly-aluminium chloride (PAC) (for flocculation) and sodium hypochlorite (for disinfection), ensure effective treatment and compliance with environmental regulations. The following procedures outline the steps for safely making up and handling these chemicals.

4.1 SODIUM HYPOCHLORITE FOR DISINFECTION

4.1.1 SAFETY PRECAUTIONS

- Ensure all personnel handling sodium hypochlorite wear appropriate PPE, including gloves, safety goggles, and protective clothing.
- Work in a well-ventilated area to avoid inhaling fumes.

4.1.2 MATERIALS AND EQUIPMENT

- Sodium hypochlorite concentrate.
- Clean, designated mixing tank.
- Stirring rod.
- Water source.

4.1.3 PROCEDURE

- **Preparation:**
  - Prepare 10 L of sodium hypochlorite
  - Set the dosing rate on dosing pump (P-3-3) to 265 mg/L (or adjust percentage dosage)
- **Mixing:**
  - Fill the mixing tank (T-3-1) with 90 L of water.
  - Slowly add sodium hypochlorite concentrate to the water while continuously stirring.
  - Continue stirring until the solution is thoroughly mixed.
- **Storage and Handling:**
  - Label the tank with the concentration and date of preparation.
  - Clean and rinse the measuring beaker and stirring rod thoroughly after use.

4.2 GENERAL GUIDELINES FOR ALL CHEMICALS

4.2.1 DOCUMENTATION

- Maintain accurate records of all chemical preparations, including quantities, concentrations, preparation dates, and batch numbers.
- Ensure that all chemical containers are properly labelled with relevant information.

4.2.2 STORAGE

- Store chemicals in designated areas that are cool, dry, and well-ventilated.
- Ensure that storage areas are equipped with appropriate spill containment measures.

4.2.3 SPILL RESPONSE

- Follow the plant’s spill response procedures in case of chemical spills.
- Ensure that spill kits are readily available in all areas where chemicals are handled and stored.

5 MAINTENANCE PROCEDURES

5.1 ROUTINE MAINTENANCE

Routine maintenance is a critical aspect of ensuring the ongoing and reliable performance of the wastewater treatment plant. This section outlines the regular tasks and checks that operators and maintenance personnel should perform on a scheduled basis. These routine maintenance activities are designed to prevent issues, optimize system efficiency, and prolong the lifespan of components.

Table 5.1 provides a summary of tasks and frequencies at which different maintenance actions should be taken:

Table 5.1: Tasks and frequencies of routine maintenance tasks

EQUIPMENT	STEP PROCEDURE	DETAILS	FREQUENCY				
			DAILY	WEEKLY	MONTHLY	6 MONTLY	YEARLY
PIPE WORK							
Pipes	Inspect for leaks	Stop pump and rectify any leak immediately		■			
	Bolts & Nuts	Check & fasten if needed			■		
	Clean	Scour pipe work with clean water				■	
	Maintain	Paint external area					■
Air Release Valves	Inspect and test for proper operation	Open and close valve – if stuck or leak replace with new				■	
	Routine service	Call Service Provider for routine maintenance					■
Isolation Valves	Inspect and test for proper operation	Open and close valve – if stuck or leak replace with new				■	
Non-Return Valves	Inspect and test for proper operation	Open and close valve – if stuck or leak replace with new				■	
Valve Chambers	Perform routine wash down	Hose down floor and walls		■			
MECHANICAL							
Blowers	Pressure	Check differential pressure	■				
	Fittings	Check connections for tightness		■			
	Electrical	Check Electrical Connections			■		
	Acoustic Hood	Clean inlet/outlet openings				■	
	Belts	Replace V-belts if necessary				■	
	Oil, grease, filters	Replace oil, grease, and filters					■
	Pipes	Check flexible pipe connections					■
	Valves	Check non-return valve function					■

Pumps	Inspect impeller, shafts & bearings	Clean and grease bearings					
	Casings	Clean and remove dirt and debris					
	Mounting plates	Check for loose bolts and nuts and rectify					
	Gland packing’s	Insert new packing and hand tight only					
	Gauges	Test for correctness and clean					
		Inspect piping					
	Service	Perform pump service in accordance with the manufacturer’s recommendation					
Air Diffusion Equipment	Inspect	Visually inspect the aeration basin surface pattern for signs of failure or fouling.					
	Diffusers	Drain aeration basin & remove excess solids.					
		Clean Diffusers					
		Inspect support hardware, pipe connections, purge assembly, etc.					
ELECTRICAL							
Motors	Inspect motor, shafts & bearings	Clean and grease bearings					
	Casings	Clean and remove dirt and debris					
	Mounting plates	Check for loose bolts and nuts and rectify					
	Windings	Test					
	Fans	Ensure proper wind flow over motor					
Main Incomer	Inspect for proper operation	Call Service Provider for routine maintenance					
	Control Panels	Wipe clean with wet cloth					
Transformer	Inspect for proper operation	Call Service Provider for routine Transformer maintenance					
Motor Control Panels	Control Panels	Wipe clean with wet cloth					
	Inspect for proper operation	Call Service Provider for routine maintenance					
	Control Panels	Wipe clean with wet cloth					
	Connection points	Isolate and fasten all connection points					
	Test cables for damage or earth fault	Replace with new if faulty					
	Test earth wiring	Ensure proper grounding					
INSTRUMENTATION							
Flow Meters	Inspect	Inspect and clean					
	Calibrate	Calibrate instrument to ensure accurate readings					
Float Switches	Inspect	Verify proper operation					
STRUCTURAL							
Floors	Perform routine wash down	Hose floor down with clean water only					
	Obstacles	Remove all loose standing items from floor area					

5.2 PREVENTIVE MAINTENANCE

To minimise mechanical and electrical breakdowns, it is necessary to carry out preventative maintenance rather than corrective maintenance. Preventative maintenance combines both the manufacturer's recommendations and the process controllers' experience acquired over time.

Preventative maintenance includes a detailed inspection, reasonability checking, cleaning, lubrication, replacement of defective parts, and calibration. Task schedules must be planned for maintenance that needs to be done by the process controller or his assistants. Certain equipment must be checked daily, others at a set time interval or during the actual running hours of the equipment.

The efficiency of the process controllers could be maximised by keeping charts that show equipment maintenance requirements (i.e., what and when maintenance is to be done) (see Table 5.1) thereby prioritizing work to be done. A copy of the chart can be kept at a convenient spot for the process controller and his assistants.

5.2.1 MEMBRANE CLEANING

Preventive membrane cleaning is essential to maintain the hydraulic capacity and filtration efficiency of the flat sheet membranes. Regular cleaning minimizes fouling, scaling, and biological buildup on the membrane surface. On-site cleaning of the membrane elements is achieved using an installed CIP system. This CIP system consists of a sodium hypochlorite tank with a valve on the pipeline to the membranes. Cleaning of the membranes must be done on a **monthly (or as needed)** basis.

Typical first-line maintenance comprises the following actions:

- Follow manufacturer guidelines for chemical cleaning procedures.
- Conduct visual inspections of the membranes before and after cleaning to identify any signs of damage or wear.
- Monitor differential pressure during and after cleaning to ensure optimal performance.
- Document cleaning parameters, including chemicals used, cleaning duration, and results.

The Standard Operating Procedure for CIP of the membranes is provided in Appendix C.

5.2.2 MECHANICAL AND ELECTRICAL MAINTENANCE

All mechanical, electrical and instrumentation should be serviced and maintained on a regular basis in accordance with the requirements in the Contractor's Operation and Maintenance manual, as well as manuals supplied by the equipment suppliers. All damaged or defective equipment must be reported to the WWTP supervisor immediately and must be repaired or replaced as soon as possible.

All equipment must be kept in top class condition. Failure to do so will reduce life expectancy of the equipment and eventually affect the quality of the treated waste produced.

5.2.2.1 Mechanical Maintenance

Proper mechanical maintenance of equipment contributes to the efficiency and life span of the equipment. In general, on wastewater treatment plants, the following maxim should always apply:

"If it breaks today, fix it today!"

The process controller should do a routine check of mechanical equipment for problems such as leaks, overheating, vibrations, noise, or any other abnormalities. The PC should also check that the equipment is free of obstruction, properly aligned and moving at normal speed.

Typically, first–line maintenance is a function of the Operational staff while preventative maintenance is either outsourced to specialists or conducted in-house by the municipal mechanical staff.

Typical first-line maintenance comprises the following actions:

- Cleaning of pump stations
- Wiping off of electrical panel enclosures
- Washing off accumulated sludge and debris from sump and structure walls
- Scrubbing algae and accumulated debris from clarifier scum baffles plates, weirs, and overflow launders.
- Removal and safe disposal of screenings and floating rags from the screen and all other unit processes.
- Upkeep and maintenance of the plant grounds such as keeping the plant neat and tidy, mowing the lawns, etc.

In addition to the above, regular maintenance should be conducted on mechanical equipment such as pumps, gearboxes, electrical motors, and electrical control panels.

Typical maintenance on the mechanical equipment includes the following:

- Check for undue temperature and vibration on rotating equipment.
- Listen for irregular noises on all rotating equipment.
- Check the oil levels on pumps and gearboxes on a weekly basis and top up with the correct grade of oil.
- Check condition and tension on V-belts and pulleys.

- Apply grease with a grease gun on all equipment fitted with grease nipples on a weekly basis.
- Read the operation and maintenance manuals on special equipment and ensure that specialist services are conducted as scheduled.

Maintenance on a **weekly basis** consists of basic inspections, checks, and care for lubricating fluids such as oil and grease which are critical to the smooth operation of mechanical and electrical equipment.

Maintenance ***MUST be conducted on a weekly, monthly, and annual basis*** as per the recommendations of the equipment manufacturer to ensure that the equipment reaches its expected life cycle and also to enable constant and consistent treatment of the wastewater coming into the plant.

Lack of consistent maintenance will very quickly result in plant equipment failure and then poor treated water quality which will impact negatively on both the environment and public health.

The following set of procedures should be followed diligently on a regular basis to ensure efficient and continuous operations of the Herold's Bay Country Estate wastewater treatment plant.

It is recommended that mechanical maintenance be conducted by an experienced maintenance artisan who has either qualified as a Mechanical Fitter, a Pump Fitter, a Fitter and Turner or as a Millwright.

This person should have qualified with a trade test conducted at an accredited technical training institution and have a minimum of 5 years maintenance experience on mechanical equipment.

Work conducted by unqualified or inexperienced staff may lead to both damage of municipal equipment and or loss of life or limbs of the artisan.

5.2.2.2 Electrical Maintenance

Maintenance on a wastewater treatment plant entails the work involved to keep all electrical equipment operational to constantly be able to treat the incoming wastewater to the required standard.

Typically, first –line maintenance is a function of the Operational staff while preventative maintenance is either outsourced to specialists or conducted in-house by the municipal mechanical and electrical staff.

Typical first-line maintenance comprises the following actions:

- Wiping off electrical panel enclosures
- Monitoring incoming Line Voltages to ensure that sufficient supply is available.
- Cleaning of instruments such as ultrasonic level sensors, dissolved oxygen probes, etc
- Reporting of equipment that trips the circuit breakers or overload switches on a regular basis.
- Reporting of non-working grounds equipment such as site lighting, geysers, plugs and domestic outlet sockets.

In addition to the above, regular maintenance should be conducted on electrical equipment such as switchgear panels, instrumentation, data loggers and electrical drive motors on the treatment plant.

Read the operation and maintenance manuals on special equipment and ensure that specialist services are conducted as scheduled.

Typical electrical maintenance on switchgear and instrumentation includes the following basic actions:

- Check operation of all soft starters and DOL starters
- Check protective equipment settings such as the overload, over- and under-voltage settings.
- Start the equipment and check the operating current and instruments such as the Ammeters and Voltmeters on the panel.
- Check that all indication lamps on the panel are functioning.
- Check whether instruments such as ultrasonic level sensors are operating at the correct levels and that correct switching of equipment takes place.
- Check that the Mains Failure Unit on the standby generator is correctly set and functioning.

Maintenance on a **weekly basis** consists of basic inspections and checks on electrical equipment which are critical to the smooth operation of mechanical equipment.

Maintenance **MUST be conducted on a weekly, monthly, and annual basis** as per the recommendations of the equipment manufacturer to ensure that the equipment reaches its expected life cycle and to enable constant and consistent treatment of the wastewater coming into the plant.

Lack of consistent maintenance will very quickly result in plant equipment failure and then poor treated water quality which will impact negatively on both the environment and public health.

The following set of procedures should be followed diligently on a regular basis to ensure efficient and continuous operations of the Herold's Bay Country Estate wastewater treatment plant.

It is recommended that electrical maintenance be conducted by an experienced maintenance artisan who has either qualified as an Electrician, as a Millwright or an Electrical Engineering Technician. Such an Artisan/Technician should preferably have a Wireman's License and be qualified for working on High Voltage installations.

This person should have qualified with a diploma or trade test conducted at an accredited technical training institution and have a minimum of 5 years maintenance experience on electrical equipment.

Electrical power is dangerous. Work conducted by unqualified or inexperienced staff may lead to both damage of municipal equipment and or loss of life or limbs of the artisan.

5.2.3 PUMP MAINTENANCE

Pumps on a wastewater treatment plant are used for various duties depending on the material being pumps. The maintenance program of pumps depends on the type of duty the pump performs. The pumps should regularly be checked for excessive noise, vibrations, overheating and leaks. Pump maintenance schedules should be done according to the manual supplied by the manufacturers. Basic pump maintenance procedures are shown below.

5.2.3.1 Bearings

- The life of the bearings depends upon the care that is given.
- It is important that the proper grade of lubricant be used and that is kept free of dirt and moisture.
- If it is over greased, it will cause excessive preloading and overheating which will shorten the bearing life.
- No pump bearing is used on close coupled pumps which have the impeller mounted directly on the motor shaft.
- Oil lubricated bearings should be drained and refilled annually under normal conditions.
- The oil level should be checked regularly.
- A sudden increase in temperature is an indication of an impending failure and should be investigated.
- When pumps are first started, the bearing seem to run extremely hot.
- Most pumps use bearings which are grease lubricated when the pump is assembled and normally require no further lubrication until the pump is overhauled.
- Bearing overheating can also be caused by unnecessary load such as coupling misalignment, excessive vibration or operating the pump against a closed discharge valve.

5.2.3.2 Seals

- Make sure that the vented plug on top of the housing is not clogged.
- When the oil appears milky in colour, drain and the seal cavity and refill using recommended oil.
- To adjust the gland, slightly loosen the nuts that secure the packing gland.
- The oil must be checked frequently.
- It may become diluted when the oil becomes approximately 50%
- A slight leakage is necessary for proper lubrication.
- Do not tighten the gland so much that all leakage from the seal stops.

- The cavity must not be overfilled.
- After the gland has been adjusted the pump shaft should rotate freely by hand
- If the seal leakage cannot be controlled by adjusting the packing gland the packing must be replaced.

5.2.3.3 Filters

- The total area of the holes in the mesh should not be less than three times the sectional area of the pipe.
- If the strainer is clogged or not deep enough under water, the pump may stop delivering water.
- It is important that you ensure that the strainer is completely submerged under water.

6 CORRECTIVE MAINTENANCE (TROUBLESHOOTING)

Corrective maintenance involves responsive actions taken to address unexpected equipment failures, malfunctions, or deviations from normal operating conditions within the MBR wastewater treatment plant. This section outlines the procedures and considerations for corrective maintenance, emphasizing efficient troubleshooting, rapid problem resolution, and the restoration of normal plant operations.

6.1 BUFFER CHAMBER

Problem	Possible Cause	Corrective Action
BUFFER CHAMBER		
Low liquid levels in the buffer tank.	Excessive influent flow, causing rapid drainage. Pump or valve malfunctions affecting proper filling.	Adjust influent flow rates to align with the buffer tank's capacity. Inspect and repair malfunctioning pumps or valves. Implement alarms to notify operators of low levels.
Abnormally high liquid levels in the buffer tank.	Reduced influent flow, causing slow drainage. Obstruction in drain lines or valves.	Verify and adjust influent flow rates. Inspect drain lines and valves for blockages. Implement alarms for high-level conditions.
Visible leaks or dampness around the buffer tank.	Corrosion or deterioration of tank material. Seal or gasket failure.	Conduct a thorough inspection of tank material for signs of corrosion. Replace damaged or deteriorated seals and gaskets. Implement a routine maintenance schedule for tank inspection.
Fluctuations in pH or temperature within the buffer tank.	Inconsistent influent characteristics. Malfunctioning temperature control systems.	Optimize influent flow to achieve more consistent characteristics. Calibrate and maintain temperature control systems regularly.

Problem	Possible Cause	Corrective Action
BUFFER CHAMBER		
Presence of unusual odours, floating debris, or discoloration.	Introduction of contaminants from influent. Lack of adequate mixing or aeration.	Identify and address influent sources of contamination. Improve mixing or aeration to enhance tank homogeneity. Conduct regular cleaning and maintenance.
Poor distribution of influent within the buffer tank.	Malfunctioning mixing equipment. Design or layout issues affecting flow patterns.	Inspect and repair mixing equipment. Consider reconfiguring tank internals for improved flow distribution.

6.2 ANOXIX AND AERATION BASIN

6.2.1 ANOXIC BASIN

Problem	Possible Cause	Corrective Action
ANOXIC CHAMBER		
Elevated nitrate levels in the treated effluent.	Inadequate organic carbon availability for denitrifying bacteria. Suboptimal anoxic conditions.	Optimize influent flow to ensure sufficient organic carbon is available. Adjust mixing or aeration to enhance anoxic conditions.
Uneven distribution of influent or poor contact between wastewater and denitrifying bacteria.	Malfunctioning mixers or agitation systems. Design issues affecting flow patterns.	Inspect and repair mixers to ensure proper functioning. Modify basin design to enhance mixing efficiency.
Presence of scum or foam on the surface of the anoxic basin.	Excessive organic loading. Imbalance in the microbial population.	Adjust organic loading rates to prevent excessive scum or foam formation. Evaluate and optimize microbial population dynamics.
Variations in pH levels within the anoxic basin.	Changes in influent characteristics. Incomplete denitrification processes.	Monitor and adjust influent characteristics to stabilize pH. Enhance denitrification conditions through process optimization.
Insufficient reduction in nitrate levels despite anoxic conditions.	Low availability of organic carbon sources. Incomplete degradation of organic matter.	Evaluate and enhance the availability of organic carbon sources. Implement measures to improve organic matter degradation.
Fluctuations in temperature within the anoxic basin.	Seasonal variations affecting influent temperature. Insufficient insulation or temperature control.	Implement insulation measures to stabilize basin temperature. Adjust treatment processes based on seasonal variations.

6.2.2 AERATION BASIN

Problem	Possible Cause	Corrective Action
AERATION WITH DIFFUSERS		
Variations in dissolved oxygen levels across the aeration basin.	Malfunctioning or clogged diffusers. Inadequate mixing or flow patterns.	Inspect and clean diffusers regularly to ensure uniform oxygen distribution. Optimize diffuser layout and aeration system design for better mixing.
Reduced or uneven air release from diffusers.	Accumulation of debris, biological growth, or precipitates on diffuser membranes. Mechanical issues with diffuser components	Implement routine cleaning and maintenance of diffusers. Replace damaged or worn diffuser membranes and components.
Irregular air supply to diffusers or audible leaks in the air header.	Air header blockages or leaks. Malfunctioning valves or regulators.	Inspect and repair air headers for blockages or leaks. Replace faulty valves or regulators to ensure consistent air supply.
Accumulation of biofilm or other fouling on diffuser surfaces.	Nutrient imbalances promoting microbial growth. Inadequate cleaning or maintenance procedures.	Optimize nutrient levels to minimize microbial growth. Implement regular cleaning and maintenance of diffusers.
Decreased efficiency or performance of diffusers over time.	Wear and tear on diffuser materials. Aging of diffuser membranes.	Implement a proactive replacement schedule for aging diffusers. Upgrade diffuser materials to enhance durability.
Unusual levels of vibration or noise from diffusers.	Mechanical issues with diffuser motors or bearings. Misalignment or imbalance.	Inspect and repair or replace damaged diffuser motors or bearings. Align and balance diffuser components to minimize vibration.

6.3 MBR FILTRATION UNIT

Problem	Possible Cause	Corrective Action
MBR FILTRATION UNIT		
A sudden or gradual rise in differential pressure.	Membrane fouling due to biological growth, particulate accumulation, or scaling. Inadequate backwashing or air scouring.	Initiate membrane cleaning procedures, including chemical cleaning if necessary. Optimize backwashing and air scouring frequencies and intensities. Monitor and adjust the operational parameters to prevent fouling.
Visual inspection reveals visible tears, holes, or damage to the flat sheet membranes.	Physical damage during maintenance or cleaning procedures. Excessive pressure differentials during operation.	Implement careful handling protocols during maintenance and cleaning. Install pressure sensors to monitor and prevent pressure differentials beyond recommended levels. Replace damaged membranes promptly.
Variations in permeate flux across different membrane modules.	Uneven air scouring distribution. Fouling or scaling concentrated in specific membrane sections.	Adjust air scouring systems to ensure uniform distribution. Conduct membrane cleaning procedures with a focus on affected areas
Inadequate or uneven air scouring.	Malfunctioning air blowers. Clogging or damage to air diffusers.	Inspect and repair air blowers for proper functioning. Clean or replace clogged or damaged air diffusers.
Persistent wetting of membranes, reducing filtration efficiency.	Improper aeration or backwashing procedures. Issues with the permeate collection system.	Optimize aeration and backwashing sequences. Inspect and repair the permeate collection system to prevent membrane wetting.
Water quality parameters in the permeate do not meet desired standards	Membrane damage or degradation. Insufficient backwashing or cleaning.	Conduct membrane integrity tests and replace damaged membranes. Enhance backwashing and cleaning procedures to meet design criteria.

6.4 DISINFECTION

6.4.1 UV DISINFECTION

Problem	Possible Cause	Corrective Action
UV DISINFECTION		
Monitoring reveals persistent microbial presence in the treated effluent.	Insufficient UV exposure time. UV lamps not producing the required wavelength.	Verify that the UV system is operating for the recommended duration. Perform spectral analysis to ensure UV lamps emit the correct wavelength.
Visible deposits or fouling on the UV lamps.	Accumulation of organic or inorganic substances on lamp surfaces.	Regularly clean UV lamps according to manufacturer guidelines. Consider implementing automated cleaning systems.
Fluctuations or interruptions in the power supply to the UV system.	Electrical failures, such as tripped breakers or damaged wiring. Power surges or outages.	Conduct a thorough inspection of electrical components and wiring. Install surge protectors or uninterruptible power supply (UPS) systems.
Complete failure of one or more UV lamps.	End-of-life for aging lamps. Manufacturing defects or physical damage.	Replace failed lamps promptly with new, compatible units. Establish a regular replacement schedule for aging lamps.

6.4.2 SODIUM HYPOCHLORITE DISINFECTION

Problem	Possible Cause	Corrective Action
SODIUM HYPOCHLORITE DOSING		
Fluctuations in the concentration of chlorine in the treated effluent.	Variability in the flow rate of wastewater. Metering pump malfunctions.	Calibrate and maintain metering pumps to ensure accurate dosing. Implement flow control measures to stabilize wastewater flow.
Reduced effectiveness of sodium hypochlorite in disinfection.	Exposure to sunlight or heat. Aging or expired sodium hypochlorite.	Store sodium hypochlorite in opaque containers and away from heat sources. Regularly monitor expiration dates and replace as needed.
Restricted or blocked flow in the chemical feed lines.	Precipitation of salts or sediments. Accumulation of debris or foreign particles.	Flush chemical feed lines regularly to prevent sediment buildup. Install filters or strainers to capture debris before reaching the dosing system.
Complete failure or irregular operation of the dosing pump.	Mechanical issues, such as worn seals or diaphragms. Electrical malfunctions affecting pump motor.	Conduct regular maintenance on dosing pumps, replacing worn components. Inspect and repair electrical connections or components as needed.
Fluctuations in the pH level of the treated effluent	Overdosing or underdosing of sodium hypochlorite. Interference from other chemical reactions.	Adjust dosing rates to achieve the desired pH level. Conduct a thorough analysis of chemical interactions affecting pH.
Visible leaks or odours around the sodium hypochlorite storage and dosing system.	Corrosion or damage to storage tanks or dosing lines. Seal or gasket failures.	Inspect and repair damaged components, such as tanks, lines, seals, or gaskets. Implement routine inspections and maintenance.

6.5 CIP SYSTEM

Problem	Possible Cause	Corrective Action
CLEANING-IN-PLACE (CIP) SYSTEM		
Residual fouling or deposits despite CIP cycles.	Inadequate cleaning solution concentration. Improper contact time or flow rates.	Adjust cleaning solution concentrations based on manufacturer guidelines. Optimize CIP parameters, such as contact time and flow rates.
Uneven or restricted distribution of cleaning solution.	Accumulation of debris or scaling on spray nozzles. Blockages in supply lines.	Regularly inspect and clean spray nozzles. Flush supply lines to remove blockages.
Damage to equipment or components due to incompatible cleaning agents.	Use of cleaning solutions that are not compatible with system materials. Incorrect dosing of cleaning agents.	Verify the compatibility of cleaning agents with system materials. Ensure accurate dosing of cleaning solutions according to specifications.
Residual cleaning solution after the CIP cycle.	Insufficient rinsing. Drainage system blockages.	Extend rinse cycles to ensure thorough removal of cleaning agents. Inspect and clear drainage pathways regularly.
Persistent biofilm or microbial growth after CIP.	Inadequate cleaning solution strength against biofilm. Insufficient contact time during CIP.	Use specialized cleaning agents effective against biofilm. Adjust CIP parameters to ensure extended contact time.
CIP system components not operating as intended.	Mechanical failures in pumps, valves, or control systems. Electrical issues affecting system operation.	Regularly inspect and maintain CIP system components. Conduct preventive maintenance on pumps, valves, and control systems.

7 MONITORING OF THE TREATMENT PLANT

To efficiently operate a wastewater treatment plant, it is necessary to control the plant, because the character of the incoming wastewater can change suddenly without warning. To react to this, the plant process controller should continuously monitor the incoming wastewater as well as the various overflows from the different unit processes. This is done by regular sampling and analysis, and then reacting to the information obtained.

7.1 OPERATIONAL MONITORING

An operational monitoring plan is vital for the effective functioning of an MBR wastewater treatment plant. By continuously observing key parameters, establishing alert levels, and implementing real-time monitoring, the plan enables the optimization of treatment processes, early detection of issues, and compliance with regulatory standards. It supports preventive maintenance and efficient resource utilization, promoting data-driven decision-making and enhancing emergency response preparedness. The plan fosters a culture of continuous improvement by analysing historical data, adjusting alert levels, and adapting operational protocols to changing conditions. Furthermore, it contributes to the ongoing training and competency development of plant operators, ensuring a proactive and systematic approach to achieving treatment goals reliably and sustainably.

As part of ongoing monitoring of the Herold's Bay Country Estate WWTP, the following requirements should also be adhered to:

- What is the current condition of the Works?
- Does the Works comply with the license agreement?
- Is there monitoring and recording of the final effluent quality?
- Is there monitoring and recording of incoming sewage to the Works?
- Are monitoring records available on site?
- Is there compliance to the monitoring frequency?
- Are the monitoring results and records submitted to the relevant authorities?
- Does an external consultant visit the Works on a regular basis?
- How is the sludge managed and disposed?
- Is the plant fenced off with a proper entrance gate?
- Is the O&M manual up to date according to the operation of the Works?

Accurate and full records of all aspects of the operation and maintenance of the Wastewater Treatment Plant should always be kept. The operators on site should keep a pocketbook in which they should note any significant event on the works, such as a peculiar colour of the water, failure of equipment, or strange smells and they must record the date and time at which this event occurs.

The proposed operational monitoring program for the Herold's Bay Country Estate WWTP is shown in Table 7.1.

Table 7.1: Herold's Bay Country Estate WWTP Proposed Operational Monitoring Program

Sampling point	Type of sampling (grab/composite)	Sample bottle volume and type(glass/plastic)	Frequency of sampling	Analyses to be performed on the samples
Raw wastewater	Grab	Plastic	Daily	pH, COD, EC
Anoxic zone	Grab	Plastic	Daily	pH, TSS, ammonia
Aerobic zone	In-line	In the Reactor	Continuously	DO
Final effluent	Grab	Plastic	Daily	pH, COD, EC, DO, SS, ammonia
			Weekly	Nitrates, Orthophosphates, Faecal coliforms, E. Coli

7.2 COMPLIANCE MONITORING

A Compliance Monitoring Programme should be implemented by the Herold's Bay Country Estate. This consists of monthly sampling of the final effluent of the WWTP, and analyses of all the main quality criteria. The following measurements should be done on the final effluent monthly for compliance purposes:

- COD
- pH
- Electrical Conductivity
- Ammonia
- Total Suspended Solids
- Nitrate
- Orthophosphate
- Faecal coliforms

The final effluent discharged from the Herold's Bay Country Estate Wastewater Treatment Plant must comply with the Standards as indicated below:

• Chemical oxygen demand (COD)	Less than 75 mg/L
• Ammonia	Less than 6 mg/L as N
• pH	Not less than 5.5; not more than 9.5
• Total suspended solids (TSS)	Less than 25 mg/L
• Nitrate	Less than 15 mg/L as N
• Orthophosphate	Less than 10 mg/L as P
• Electrical conductivity (EC)	Less than 150 mS/m
• Faecal coliforms	Less than 1000 per 100 mL

7.3 SAMPLING PROCEDURES

7.3.1 SAMPLING PROCEDURE

Step 1:

At the sampling point, remove cap of sample bottle but do not contaminate inner surface of cap and neck of sample bottle with hands.

Step 2:

Take samples by holding bottle with your hand near the base and plunge the sample bottle, neck downward, below the water surface (wear gloves to protect your hands from contact with the water).

Step 3:

Turn bottle until the neck points slightly upward and the mouth is directed toward the current (can also be created artificially by pushing bottle forward horizontally in a direction away from the hand).

Step 4:

Fill sample bottle without rinsing and replace the cap immediately.

Before closing the sample bottle, leave ample air space in the bottle (at least 2,5 cm) to facilitate mixing by shaking before examination.

Step 5:

Complete label and sample sheet.

7.3.2 SAMPLE BOTTLES

Obtaining a representative water sample also means being careful in the choice of sample bottles. For example, if the water sample is being collected to determine the presence of trace metals (e.g., copper or zinc) in the water, do not use sample bottles with metal components (e.g., metal caps). When sampling for organics, avoid using sample bottles with plastic components, as the plasticizers may leach and contaminate the samples.

Below is an indication of the size and type of sample bottles needed to take samples with. **It is however recommended that the sampler inform the laboratory beforehand on the type of sample that is going to be collected. They will then also give advice on the desired type of sample bottle.**

NOTE: What to do if sample bottles are not available?

In the case of an **emergency**, when the sample must be taken as a matter of urgency, the following sample bottles can be used:

- 1L glass cold drink bottles
- 2L plastic cold drink bottles

It is extremely important that these bottles, together with their respective caps, be thoroughly cleaned before the water sample is taken. This can be achieved by rinsing the substitute water sample bottle at least five times with the water to be sampled. A good indication of whether the sample bottle and its cap are clean enough for sampling purposes is to smell the inside of the bottle after it has been rinsed. If it still has the smell of the original contents, then rinse the bottle a few more times and repeat the smell-test.

If enough sample bottles are not available and additional bottles are needed, sample bottles as indicated above can be used. However, clean the bottles and caps thoroughly with hot water. Let the bottles air-dry with the top of the bottle facing downwards. This will prevent dust or other particles collecting in the bottle. After all the bottles are dry, replace the caps and store with other sample bottles.

7.3.3 SAMPLE LABELS

It is crucial for each sample bottle to have a clearly identifiable label when arriving at the laboratory. Labels printed on special water-resistant paper should preferably be used. The label should be completed with a waterproof pen immediately after the sample is taken and tied to the neck of the bottle with a piece of string with the following information written on the label:

- A unique sample number and description.
- The date and time of sampling (remember day/month/year).
- The name of the sampler.

Consult with the local analytical laboratory for more information on these sample labels and how to obtain them.

7.3.4 DATA SHEETS

Data sheets make provision for recording the physical and environmental information of the sampling point. This information is needed to interpret water quality at a site especially if the water quality results obtained from the laboratory indicate a sudden change. The information on the data sheet must be handed in with the sample bottles at the laboratory. (The sampler must also make a copy for his/her own filing purposes).

DATA SHEETS FOR ALL EQUIPMENT ARE PROVIDED IN APPENDIX D.

8 DOCUMENTATION AND RECORD KEEPING

8.1 INTRODUCTION

Record keeping and reporting is a tiresome activity, but failure to do so may result in circumstances that might have been easily avoided had proper records been kept. Keeping an accurate record of the performance of the wastewater treatment facility is an integral part of good plant operation. Accurate and readily accessible records are necessary for regulator monitoring and for guiding operating personnel in locating and solving operational problems. These records constitute the proof of performance and serve to justify decisions, expenditures, and recommendations.

8.2 WHY KEEP RECORDS?

Accurate and full records of all aspects of the construction, operation, and maintenance of a sewage plant are vitally important for several reasons:

- **a.** ***Operation***: Only when the layout, process flow, size, characteristics, and history of all parts of the plant are known, can the process controller hope to be able to run his plant correctly. These records also reflect the overall efficiency of the treatment process. Records of effluent quality will show if the treatment plant is complying with regulations.
- **b.** ***Planning***: It is important to keep track of water and wastewater flows and strengths and the behaviour of the plant in relation to changing loads. These records will assist the authority to plan properly for future sewers or work. Problems can be detected well before they reach serious proportions.
- **c.** ***Maintenance***: As discussed earlier proper maintenance records assist greatly in the timely servicing and repair of plant equipment. This minimises mechanical breakdowns and down time.
- **d.** ***Costing***: For controlling and budgeting of expenses, it is important to have records of what work was done, by whom, and how much was spent on materials. Financial records can be useful when setting rates for customer.
- **e.** ***Research***: Full, accurate records are invaluable to are searcher studying aspects of the operation of a sewage plant. In many instances, long-term operating records are far more valuable than laboratory studies.

8.3 WHAT RECORDS SHOULD BE KEPT?

The following is a brief guide to the type of records that should be kept on a wastewater treatment plant. Some process controllers may keep more and others less. Unless it takes up too much working, though, more record keeping is better than less.

8.3.1 PLANS

There should be a full set of the final `as built` drawings of the plant showing the layout, size, shape, and details of all components, particularly for buried items such as pipelines and cables. These plans provide the plant personnel with records of the plant equipment regarding their location and their relationship with other plant equipment. The drawings are classified under the following categories: Plant layout, process flow and instrumentation, mechanical and electrical. The drawings can be obtained from the designers of the plant and must be carefully filed. The drawings should be updated when there are modifications to the plant because, when repairs or modifications are planned, they will be a most valuable source of information.

Plant plans should always be available to the operating personnel and should be in good usable condition.

8.3.2 DESIGN PARAMETERS

The plant process controller must know how his plant is expected to operate and the operating conditions. This will enable him to understand the plant and to know when certain components are under or overloaded. The design engineer should provide a report detailing the basis of design, design capacities, and parameters. The manufacturers' handbook, outlining recommended operating guidelines, installation procedure, and maintenance instructions, must be obtained.

8.3.3 DAILY LOG

A large, page-a-day diary or logbook will serve for this purpose and any information that does not logically fit in other records must be entered in the diary. Typical examples are staff movements, visitors, appointments, weather conditions, and any deliveries made.

Every process controller should keep a pocketbook in which he should know any significant event on the plant, such as a peculiar colour of the water, failure of equipment, or a strange smell, recording the date and time at which this occurs. These notes should be transferred to the Daily Log at the end of each shift.

8.3.4 WEEKLY AND MONTHLY RECORDS

These records will contain the operating date of the wastewater treatment for example, aeration, disinfection, sludge digestion as well as the information mentioned in the daily logs. The monthly report should contain a summary of all the data collected during the month. From this data, operating parameters reflecting the performance of the plant can be calculated which will assist in process control. Analysis of data monthly will also show any deviations from previously established operations.

Sampling or data collection points should be placed such that they are easily accessible to process controllers.

8.3.5 LABORATORY RECORDS

For purposes of presentation, experimental readings are often collected and presented in tabular form. The data can either be presented on sheets or in notebooks. Laboratory data sheets may be developed for recording test results and calculations. The records of laboratory data should be prepared such that recording, reviewing, or recovering of data is possible when necessary.

A copy of testing procedures should be provided in case there is a need to duplicate the laboratory test. Original readings when performing a test should always be recorded not just the calculated values.

8.3.6 FLOW RECORDS

Depending upon the size and complexity of the plant, this could vary from a few entries on a chart each day to a page full of figures. All flow meters on the plant should be fitted with integrators. These are then read at a fixed time each day and the figures recorded. The main incoming flow rate should also be recorded continuously on a chart so the exact variations in flow rate can be studied. The strips or discs from such a recorder must be carefully labelled and filed. These records are essential for planning purpose and often for troubleshooting on the plant. It can also be useful to plot daily flows on a wall chart as this can give a clue to trends in flow. A record of the maximum instantaneous flows that occurred during each month may be kept. This can assist the planners to assess how much of the sewage flow is groundwater or rainwater infiltration.

8.3.7 PERFORMANCE RECORDS

All analyses made on the sewage must be properly recorded. A log sheet for this purpose, in some cases, can be combined with the flow record sheet. The following is a guideline, where applicable, of information that might be kept for the evaluation of the performance of the wastewater treatment plant:

- Influent flow
- Hydraulic loading
- Organic loading
- Sludge age
- Sludge blanket level
- Sludge settleability
- Suspended solids
- Return sludge flow
- Waste sludge quantity
- Chemical dosages

In addition, information such as sewage temperature (inlet and outlet) and details of plant running times should be kept on the same log. It is a good idea to make the log sheet flexible in layout for the first year of operation.

This allows for more data to be added or for a better layout to be selected as the staff becomes used to working with the records. It may also be useful to get the process controllers to fill in a log sheet for each shift and then to transfer the important information for each day to the main log sheet.

8.3.8 EMERGENCY RECORDS

Documentation of emergency events and actions taken in response to these events will help plan future emergency responses. A record of all significant emergency events should be kept. This report includes the following points:

- Description and time of event
- How the event affected the process.
- Length of time it took to get the process back to normal.
- Location where the event first occurred.
- Action taken by process controllers/personnel in response to the emergency.
- Process equipment and structure affected.
- Description of repairs and replacements required.
- Costs of repairs and replacements.
- Emergency response plan in case of re-occurrence of a similar event.

8.3.9 MAINTENANCE

Maintenance records are of vital importance.

8.3.10 ACCOUNTING

Although it is unlikely that a sewage plant process controller would be expected to keep his own books, he must nevertheless have some record of and control over costs. The costs of labour, materials, spare parts, new equipment, electricity, and hired plant should all be recorded if possible. Delivery notes and invoices paid should be recorded so that any problems can be simply and quickly cleared up.

If good information on quotes is available, it can help the process controller to make the cheapest decision for future jobs. For example, it may be cheaper to buy a new pump than to have the various components overhauled and reassembled.

8.4 REPORT-BACK

One of the most important factors in good management is the ability to communicate effectively with others. This applies whether giving instructions or reporting events to a senior person. It is helpful to understand what is meant by communication.

The components are straightforward. The originator of the message will have a message that he or she will want to pass on to another.

The message may be a clear image in the mind of the sender but when translated into words it will lose some of its clarity. The words may be spoken or written and supported by a diagram or illustration. It may be sent electronically or simply through the medium of sound waves. The receiver, for whom the message is intended, will then have to assimilate what has been sent, translate it into images in his or her mind, and then act on the message, as it has been understood.

In the best of circumstances there is likely to be distortion of the original image or message as it was first thought of. There are many factors that will prevent the correct reception of the message. Some of these are considered below:

- The reason for the communication: It is necessary to consider why you are communicating and what the message is that you want to transmit. It is necessary to concentrate on what you want the receiver to understand and to make any allowances for possible distortion so that this can be eliminated.
- Language: It was once said that a common language divided Britain and America
- Even if the people who are communicating with one another can both speak the same language, it is important to realise that the same words can have different meanings to people of different cultures. Allowances must be made. It is also worthwhile to test the level of understanding once a message has been passed. Make the recipient repeat the message to ensure that there is no misunderstanding, which could lead to problems later.
- The level at which the language is used will also affect the clarity with which it is received. Do not use long words with people of limited education. Technical words need to be backed up by descriptions of what is intended.
- The circumstances in which the communications are made will affect the reception. Someone from a deprived background brought into a strange office, perhaps well-appointed, may pay more attention to the surroundings than the message. It is best to communicate in the same surroundings as the recipient is used to rather than the reverse.
- Voice tone and gestures: The tone of voice can distort a message quite badly. A caution delivered in a joking manner will not have the same effect as a caution given in a stern voice. The body language or gestures convey a message and the signals given by the body may undermine the spoken message.

- Written messages: These lack personality. Frequently information is conveyed by means of memoranda. These tend to lose impact as little distinction is made in the layout of the memoranda between the important and the trivial. In this way, the important may be consigned to a file without the recipient really reading it.

Great care must be taken with the written messages to compose these at the level of understanding of the recipient. Try and make them interesting rather than use standardised prose. Remember, when thinking of writing a memorandum, that eye contact contributes to the successful transmission of a message.

9 MANAGEMENT OF THE PLANT

9.1 STAFFING AND SUPERVISION

The staffing and supervision of an MBR wastewater treatment plant are integral to its successful and efficient operation, particularly considering the complexity and critical nature of the processes involved. Even on a very small treatment plant, the workload is substantial, making standby personnel essential. This necessitates a well-structured team, varying in roles from labourers to a comprehensive staff including a works manager, senior operators, operators, shift attendants, and support staff, especially in larger treatment plants. It's crucial to acknowledge that effective staffing contributes not only to routine operations but also to emergency response and maintenance.

9.1.1 MANAGEMENT OF LABOUR

The management of labour in an MBR wastewater treatment plant is a critical aspect in ensuring the seamless functioning of the facility. On a small treatment plant, the workforce is typically overseen by a Works Superintendent, responsible for coordinating various tasks and ensuring the smooth execution of operations. This workforce often includes a few relatively unskilled workers handling tasks such as removing screenings and grit, unloading goods, conducting sampling, and ensuring continuous equipment operation.

The importance of clear responsibilities and reporting structures cannot be overstated, even for seemingly straightforward tasks. Job rotation is implemented to enhance interchangeability for standby purposes, fostering a versatile and adaptable workforce. In small plants, shift work might be necessary, requiring additional staff capable of working independently without continuous supervision. This structured approach to labour management is essential for maintaining operational efficiency, addressing routine tasks, and responding effectively to unforeseen events, contributing to the overall success of the MBR plant.

9.1.2 MANAGEMENT OF PROCESS CONTROLLERS

In the management of process controllers at an MBR wastewater treatment plant, especially in medium to large facilities, operational efficiency is maintained through a structured shift system. A process controller or senior process controller typically oversees a shift, consisting of one or more shift attendants. Routine tasks like receiving chemicals, changing chlorine cylinders, and basic maintenance are often delegated to day staff, leveraging greater resources during standard working hours. It's imperative that all levels of process controllers, including the Superintendent, meet minimum qualification standards stipulated by Regulation 2834, with these standards aligning with the size and complexity of the wastewater treatment plant. To ensure clarity and accountability, each person on a shift team should have a job description outlining specific areas of responsibility, accompanied by defined activities and checklists. These checklists, incorporated into the shift log, are scrutinized daily by the Superintendent, fostering a structured and accountable approach to the management of process controllers and overall plant operations.

9.1.3 ANCILLARY STAFF

In addition to the core operational staff, ancillary personnel play a crucial role in ensuring the seamless functioning of an MBR wastewater treatment plant. These specialized individuals include mechanical fitters, electricians, instrument technicians, and laboratory technicians.

In technologically advanced plants with automation and computerized systems, an information technology technician or data processing specialist may also be required. Even on smaller plants, the investment in automation and instrumentation typically proves cost-effective through enhanced control and the potential reduction in staff.

The responsibilities of ancillary staff extend beyond the treatment works itself to encompass pump stations and sewer collection networks, necessitating additional specialized personnel. Supervision of ancillary staff requires careful consideration, as a Superintendent, often with minimal technical qualifications, may not be equipped to oversee specialist staff or laboratory technicians.

Depending on the size and capabilities of the wastewater treatment plant, certain staff may report directly to a technical manager, often based at an external office, ensuring efficient coordination and management of the diverse skill sets involved in maintaining the plant's functionality.

9.2 TRAINING

A well-trained and qualified workforce is the backbone of a successful membrane bioreactor (MBR) wastewater treatment plant. By adhering to qualification requirements, providing ongoing training opportunities, and implementing effective on-site training programs, authorities can cultivate a skilled team capable of maintaining operational excellence and adapting to the dynamic challenges of wastewater treatment. Regular oversight and a commitment to continuous improvement contribute to the long-term success and sustainability of the wastewater treatment plant.

9.2.1 ONGOING TRAINING OPPORTUNITIES

Given the dynamic nature of wastewater treatment technology, regular training is crucial for staying current with industry developments. Numerous institutions provide short courses in wastewater treatment, covering topics such as advanced treatment processes, regulatory updates, and emerging technologies. Authorities are encouraged to allocate budgets for staff to attend such courses, ensuring a continuously skilled workforce.

9.2.2 ON-SITE TRAINING PROGRAMS

In addition to formal qualifications, on-site training is imperative for new staff members. An orientation program acquaints them with the plant, its operation, and maintenance procedures. Subsequently, personnel should undergo rotation through various specific roles, allowing them to gain hands-on experience in line with the operating manual and best operational practices. This comprehensive on-site training ensures that staff members are well-equipped to handle diverse tasks and contribute to the efficient functioning of the wastewater treatment plant.

9.2.3 COMPLIANCE AND OVERSIGHT

Authorities must prioritize compliance with qualification requirements and registration mandates to uphold legal standards. The oversight of personnel training and qualification compliance is crucial for maintaining a skilled and proficient workforce. Regular audits and assessments ensure that staff members are adequately trained, and any gaps in knowledge or skills are addressed promptly.

9.2.4 CONTINUOUS IMPROVEMENT AND ADAPTATION

To meet evolving industry demands, it is essential to foster a culture of continuous improvement. Personnel should be encouraged to pursue advanced training, attend workshops, and stay informed about emerging trends in wastewater treatment. This proactive approach ensures that the workforce remains adaptable and capable of implementing the latest technologies and best practices.

10 SAFETY PROCEDURES

10.1 INTRODUCTION

The formulation of, and adherence to, safe-working procedures is in the best interest of all concerned with the operation and maintenance of treatment plants. On large plants, it is the responsibility of management to formulate and implement safety procedures. The operating and maintenance staff must actively support these. On smaller plants, the process controller himself may have to take the initiative in this regard.

10.2 REGULATIONS

The following legislation applies to wastewater treatment systems:

The Occupational Health and Safety Act (Act 8 of 1993)

10.3 SAFETY COMMITTEES

In terms of regulations framed under the Machinery and Occupational Safety Act 1983 (replaced by Occupational Health & Safety Act 85 of 1993), one safety representative must be appointed in writing at any workplace for every 50 persons employed, except where there are less than 20 employees (farm labourers are excluded). It is mandatory for this safety officer to carry out an inspection of the workplace to which he has been designated at least once a month. Any threat or potential threat to the safety of any employee must be reported to his employer and safety committee established in terms of the Act. Small works should at least be served by the engineer or responsible person, the superintendent or process controller, and a representative from the labour force and maintenance staff.

Meetings should be held regularly, or the purpose of the committee is lost. The committee's functions are to promote awareness of safety, investigate accidents, recommend safe practices and procedures, and ensure compliance with statutory requirements.

10.4 BASIC RULES

All persons visiting or employed at a wastewater treatment plant should always observe the following basic rules:

- Do not touch electrical equipment or switches and treat all equipment, which has not been isolated and locked as live.
- Do not touch moving machinery.
- Take care when standing near or working over tanks and channels, which may be deep or contain swiftly moving water.
- Do not enter the chlorination building without testing for a gas leak with a rag that has been soaked in ammonium hydroxide solution.

10.5 PROTECTIVE CLOTHING (PPE)

The items listed below make up the necessary basic clothing for all those employed in a treatment plant.

Hard hat - made of high-density polyethylene (wear only when necessary)

Overall - elastic in the waist and cuffs; zip down the front

Gumboots - lightweight with built-in tow protection and nonslip soles

Boots - leather, ankle-protection type with toe protection nonslip

Gloves - made of strong flexible PVC with roughened palm

10.6 SUPERVISION

There is no purpose in equipping a works with all the recommended safety equipment and the personnel with protective clothing if the equipment is not maintained. A fire extinguisher, which does not work, has no value.

Similarly, there is no purpose in drawing up a safety manual and recommended procedures if they are not followed.

The works manager, superintendent, or responsible person must therefore ensure that procedures are adhered to; that ladders, fire extinguishers, and respirators are inspected and tested on a routine basis; and that certain protective equipment such as the less popular earmuffs and eye protection, are in fact worn when necessary.

10.7 MACHINERY

When working with equipment and machinery (maintenance personnel), observe the following rules:

Ensure that it cannot be started or operated by either disconnecting the means of starting or by isolation at the panel and/or the local stop.

- Always use the correct tools for the job.
- Keep chisels in good condition.
- Wear visors or goggles when grinding.
- Use the correct grade of protective visors or goggles when welding or brazing.
- Do not manhandle heavy objects. Use lifting gear.
- Always replace belt guards and other safety shields.
- Always read the instructions carefully before carrying out any maintenance operation on specialized equipment.

10.8 ELECTRICAL EQUIPEMENT

Electrical equipment requires further attention:

- No unauthorized person should work on electrical equipment, open a panel, or enter a substation.
- All equipment to be handled should be properly isolated and locked so that it cannot be switched on. Suitable notices should be placed at the switch panel and adjacent to the equipment.
- All installations should be thoroughly tested by a competent person before being put back into service.

10.9 MATERIALS HANDLING

When handling materials, care should be taken especially when handling heavy or bulky objects. To reduce the number of injuries caused using incorrect material handling methods the following points should be considered:

- Use suitable lifting gear wherever possible.
- No person should attempt to lift more than can be handled comfortably.
- Wear gloves when possible. Otherwise ensure that the hands on the object are clean and not slippery and that it is free from jagged edges, metal silvers, nails, burrs, and splinters.
- Ensure firm footing and good visibility whilst maneuvering.

10.10 GUIDELINES FOR INCIDENT/ACCIDENT REPORTING

The ultimate responsibility and accountability for SSHEQ compliance as per the act, rests with the Institutional Manager, who then delegates responsibilities down the line. For SSHEQ to be taken seriously, a senior manager should be the SSHEQ driver. Depending on the number and distribution of the waterworks, several SSHEQ co-ordinators oversee the implementation, monitoring, and constant improvement of the SSHEQ system. The SSHEQ co-ordinator sets up an incident/accident reporting system as part of an integrated SSHEQ system. There are standard incident/accident reporting books that are filled out as soon as an incident or accident has occurred. A preliminary incident/accident report is completed and distributed to the Line Manager and SSHEQ co-ordinator within 24 hours. The system is such that reporting is encouraged and is followed by an investigation.

The incident/accident Investigator is trained in the process of investigation. An investigation report in the form of a comprehensive questionnaire is completed by the Investigator with the help of the person who reported the incident or accident. The main purpose of the investigation is to identify the cause of the incident/accident and then make recommendations to remove or reduce the risk to acceptable levels. The final report is sent to Senior Management for implementation of the recommendations.

In the case of an accident resulting in a disabling injury or death, the Department of Manpower and the Workman's Compensation Department must be informed who then conduct the accident investigation at a higher level. The Employer may be prosecuted if the investigation shows that the Employer was negligent by not mitigating an unsafe situation.

10.11 REGULAR SAFETY MEETINGS

For larger WWTPs, a safety committee comprising a chairman (rotational basis), safety representatives, the Plant Superintendent, and the Safety co-ordinator, meets monthly.

The agenda usually includes action items from previous minutes; inspection reports from safety representatives; Incidents and accidents; on on-the-job safety (safety tips, etc). The purpose of the meeting is to:

- Create an interest and awareness of safety issues amongst staff.
- Monitor safety in the workplace on a regular basis.
- Facilitate learning and growth by sharing practical safety-related experiences.
- Facilitate continuous improvement in safety.
- Encourage employee participation, responsibility, and buy-in with respect to safety in the workplace.

However, for smaller plants, safety meetings may be held less frequently (once a quarter may be more appropriate).

11 INCIDENT MANAGEMENT

Emergency response planning is an essential part of managing a wastewater treatment plant by which responsible staff explores responses to vulnerabilities, makes improvements, and establishes procedures to follow in an emergency. It is also a process that encourages people to form partnerships and better understand support capabilities.

11.1 EMERGENCY PROTOCOL MANAGEMENT

Every system must have a set of procedures to follow in the event of incidents leading to emergencies. These procedures should be in place well in advance of any event and should cover any number of incidents, as this will minimize the impacts on the community. Plans should involve consultation with relevant regulatory authorities and key agencies and should be consistent with existing government emergency response arrangements.

11.1.1 MANAGEMENT PROCEDURES FOR INCIDENTS AND EMERGENCIES

Significant deviations in the operational monitoring such as where critical limits are exceeded, are referred to as an "incident". It is any situation where loss of control over the system occurs, or where there is any reason to suspect non-compliance or danger to environmental and health. This section will focus on establishing management procedures for when incidents would occur.

Some incident triggers include:

- Non-compliance with operational monitoring data.
- Inadequate effluent quality for final discharge to resources.
- Loss of sewer during the reticulation and pumping of wastewater.
- Spillages or accidents during collection of non-reticulated sewage.
- Public health indicators such as outbreaks of diseases for which water is a suspect vector.
- Extreme rainfall and flooding etc.

11.1.2 UNFORESEEN INCIDENTS

Unforeseen incidents are situations that were not included in the incident report plans and were omitted because they were improbable, or it was not justifiable to be included. There is always a risk for such events to occur and the same incident protocol must be followed.

11.1.3 EMERGENCIES

In the case of emergency and serious incidents, a more specialised report and investigation may be required. The Disaster Management Plan usually comes into effect in such incidences. This plan considers natural disasters such as floods, earthquakes, lightning strikes, and large-scale accidents such as structural failures and incidences due to strikes and sabotage.

APPENDICES

APPENDIX A: GLOSSARY OF TERMS

Activated Sludge
Sludge particles produced by the growth of organisms in the aeration tank in the presence of dissolved oxygen.
Activated Sludge Process
A biological wastewater treatment process that converts non-settleable (suspended, dissolved, and colloidal solids) organic materials to a settleable product using aerobic and facultative microorganisms.
Aeration
The bringing about of intimate contact between air and a liquid by one or more of the following methods: (a) spraying the liquid in the air; (b) bubbling air through the liquid; and (c) agitating the liquid to promote surface absorption of air.
Aerobic
Requiring, or not destroyed by, the presence of free or dissolved oxygen in an aqueous environment.
Aerobic Digestion
The breakdown of suspended and dissolved organic matter in the presence of dissolved oxygen. An extension of the activated-sludge process, waste sludge is stored in an aerated tank where aerobic microorganisms break down the material.
Alkalinity
The capacity of water to neutralize acids; a property imparted by carbonates, bicarbonates, hydroxides, and occasionally borates, silicates, and phosphates. It is expressed in milligrams of equivalent calcium carbonate per litre (mg/L $CaCO_3$).
Ammonia (NH_3), Ammonium (NH_4)
Urea and proteins are degraded into dissolved ammonia and ammonium in raw wastewater. Typically, raw wastewater contains 30 to 50 mg/L of NH_3. Reactions between chlorine and ammonia are important in disinfection.
Anaerobic
(1) A condition in which free and dissolved oxygen are unavailable. (2) Requiring or not destroyed by the absence of air or free oxygen.
Anaerobic Digestion
The degradation of concentrated wastewater solids, during which anaerobic bacteria break down the organic material into inert solids, water, carbon dioxide, and methane.
Bacteria
A group of universally distributed rigid, essentially unicellular microscopic organisms lacking chlorophyll. They perform a variety of biological treatment processes including biological oxidation, sludge digestion, nitrification, and denitrification.
Biochemical Oxygen Demand (BOD)
A measure of the quantity of oxygen used in the biochemical oxidation of organic matter in a specified time, at a specific temperature, and under specified conditions.
Biofilm
Accumulation of microbial growth on the surface of a support material.
Biological Filtration
The process of passing a liquid through a biological filter containing fixed media on the surfaces of which develop zoogloeal films that absorb and adsorb fine suspended, colloidal, and dissolved solids and release end products of biochemical action.
Chemical Oxygen Demand (COD)
A quantitative measure of the amount of oxygen required for the chemical oxidation of carbonaceous (organic) material in wastewater using inorganic dichromate or permanganate salts as oxidants in a 2-hour test.
Chlorination
The application of chlorine or chlorine compounds to water or wastewater, generally for the purpose of disinfection, but frequently for chemical oxidation and odour control.

Chlorine Dose
The amount of chlorine applied to a wastewater, usually expressed in milligrams per litre (mg/L).
Chlorine Residual
The amount of chlorine in all forms remaining in water after treatment to ensure disinfection for a period.
Clarifier
Any large circular or rectangular sedimentation tank used to remove settleable solids in water or wastewater
Collection System
In wastewater, a system of conduits, generally underground pipes, which receives and conveys sanitary wastewater or stormwater
Colour
Any dissolved solids that impart a visible hue to water.
Debris
Generally, solid wastes from natural and man-made sources deposited indiscriminately on land and water.
Decomposition of wastewater
(1) The breakdown of organic matter in wastewater by bacterial action, either aerobic or anaerobic. (2) Chemical or biological transformation of the organic or inorganic materials contained in wastewater.
Denitrification
The anaerobic biological reduction of nitrate nitrogen to nitrogen gas; also, removal of total nitrogen from a system.
Design Flow
Engineering guidelines that typically specify the amount of influent flow that can be expected on a daily basis over the course of a year. Other design flows can be set for monthly or peak flows.
Detention Time - Retention Time, Residence Time
The period that a water or wastewater flow is retained in a basin, tank, or reservoir for storage or completion of physical, chemical, or biological reaction.
Dewatered Sludge
The solid residue remaining after removal of water from a wet sludge by draining or filtering. Dewatering is distinguished from thickening in that dewatered sludge may be transported by solids handling procedures.
Dewatering
The process of partially removing water; may refer to removal of water from a basin, tank, reservoir, or other storage unit, or the separation of water from solid material.
Digested Solids
Solids digested under either aerobic or anaerobic conditions until the volatile content has been reduced to the point at which the solids are relatively non-putrescible and inoffensive.
Digester
A tank or other vessel for the storage and anaerobic or aerobic decomposition of organic matter present in the sludge.
Discharge
The flow or rate of flow from a canal, conduit, pump, stack, tank, or treatment process.
Disinfection
The killing of waterborne faecal and pathogenic bacteria and viruses in potable water supplies or wastewater effluents with a disinfectant; an operational term that must be defined within limits, such as achieving an effluent with no more than 200 faecal coliform/100 mL
Dissolved Oxygen (DO)
The oxygen dissolved in liquid, usually expressed in milligrams per litre (mg/L) or percent saturation.
Dissolved Solids
Solids in solution that cannot be removed by filtration
Domestic Wastewater

Wastewater derived principally from dwellings, business buildings, institutions, and the like. It may or may not contain groundwater, surface water, or stormwater.
Drying Beds
Confined, shallow layers of sand or gravel on which wet sludge is distributed for draining and air drying
Dry Weather Flow (DWF)
The flow of wastewater in a combined sewer during dry weather. Such flow consists mainly of wastewater, with no stormwater included.
Effluent
Wastewater or other liquid, partially or completely treated or in its natural state, flowing out of a reservoir, basin, treatment plant, or industrial treatment plant, or part thereof.
Effluent Quality
The physical, biological, and chemical characteristics of wastewater or other liquid flowing out of a basin, reservoir, pipe, or treatment plant.
Escherichia coli (E. coli)
One of the species of bacteria in the faecal coliform group. It is found in large numbers in the gastrointestinal tract and faeces of warm-blooded animals and man. Its presence is considered indicative of fresh faecal contamination, and it is used as an indicator organism for the presence of less easily detected pathogenic bacteria.
Extended Aeration
A modification of the activated-sludge process using long aeration periods to promote aerobic digestion of the biological mass by endogenous respiration. The process includes stabilization of organic matter under aerobic conditions and disposal of the gaseous end products into the air. Effluent contains finely divided suspended matter and soluble matter.
Ferric Chloride ($FeCl_3$)
A soluble iron salt often used as a sludge conditioner to enhance precipitation or bind up sulphur compounds in wastewater treatment.
Filamentous growth
Bacterial, fungal, and algal species that grow in thread-like colonies resulting in a biological mass that will not settle and may interfere with drainage through a filter.
Final Effluent
The effluent from the final treatment unit of a wastewater treatment plant.
Grease and Oil
In wastewater, a group of substances including fats, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and certain other nonfatty materials
Grit
The heavy suspended mineral matter present in water or wastewater, such as sand, gravel, or cinders. It is removed in a pre-treatment unit called a grit chamber to avoid abrasion and wearing of subsequent treatment devices.
Humus Sludge
Sloughed particles of biomass from trickling media that are removed in the secondary clarifier.
Hydraulic Loading
The amount of water applied to a given treatment process, usually expressed as volume per unit time, or volume per unit time per unit surface area.
Industrial Wastewater Treatment
Wastewater derived from industrial sources or processes.
Influent
Water, wastewater, or other liquid flowing into a reservoir, basin, treatment plant, or treatment process.
Kjeldahl nitrogen (TKN)
The combined amount of organic and ammonia nitrogen.
Lime

Any of a family of chemicals consisting essentially of calcium hydroxide made from limestone (calcite) composed almost wholly of calcium carbonate or a mixture of calcium and magnesium carbonate; used to increase pH to promote precipitation reactions or for lime stabilization to kill parthenogenic organisms.
Mechanical Aeration
The mixing, by mechanical means, of wastewater and activated sludge in the aeration tank of the activated-sludge process brings fresh surfaces of liquid into contact with the atmosphere.
Mixed Liquor Suspended Solids (MLSS)
The concentration of suspended solids in activated-sludge mixed liquor, expressed in milligrams per litre (mg/L). Commonly used in connection with activated-sludge aeration units.
Nephelometric Turbidity Unit (NTU)
Units of a turbidity measurement using a nephelometer.
Nitrate (NO)
An oxygenated form of nitrogen.
Nitrite (NO_2)
An intermediate oxygenated form of nitrogen.
Nitrogen (N)
An essential nutrient that is often present in wastewater is ammonia, nitrate, nitrite, and organic nitrogen. The concentrations of each form and the sum (total nitrogen) are expressed as milligrams per litre (mg/L) of elemental nitrogen.
Nutrient
Any substance that is assimilated by organisms and promotes growth; is generally applied to nitrogen and phosphorus in wastewater, but also to other essential and trace elements.
Operators
Persons employed to operate a treatment facility.
Organic Loading
The amount of organic material, usually measured as BOD, applied to a given treatment process; expressed as weight per unit time per unit surface area or per unit weight.
pH
A measure of the hydrogen-ion concentration in a solution. On the pH scale (0 to 14), a value of 7 at 25 °C represents a neutral condition. Decreasing values indicate increasing hydrogen-ion concentration (acidity); increasing values indicate decreasing hydrogen-ion concentration (alkalinity).
Phosphorus (P)
An essential chemical element and nutrient for all life forms. Occurs in orthophosphate, pyrophosphate, tripolyphosphate, and organic phosphate forms. Each of these forms and their sum (total phosphorus) is expressed as milligrams per litre (mg/L)
Primary Wastewater Treatment
The first major treatment in a wastewater treatment facility is used for the purpose of sedimentation. This includes preliminary treatment such as screening, comminution, and grit removal, that prepare the wastewater for subsequent major treatment.
Raw Sewage
Wastewater before it receives any treatment.
Receiving Water
A river, lake, ocean, or other watercourse into which wastewater or treated effluent is discharged.
Reclaimed Wastewater
Wastewater used for some beneficial purpose usually after some degree of treatment.
Removal Efficiency
A measure of the effectiveness of a process in removing a constituent, such as BOD or TSS. Removal efficiency is calculated by subtracting the effluent value from the influent value and dividing it by the influent value.

Return Activated Sludge (RAS)
Settled activated sludge returned to mix with incoming raw or primary settled wastewater.
Scum
The extraneous or foreign matter that rises to the surface of a liquid and forms a layer or film there.
Secondary Wastewater Treatment
(1) Generally, a level of treatment that produces secondary effluent. (2) Sometimes used interchangeably with the concept of biological wastewater treatment, particularly the activated-sludge process.
Settling Tank
A tank or basin in which water, wastewater, or other liquid containing settleable solids is retained for a sufficient time, and in which the velocity of flow is sufficiently low to remove by gravity a part of the suspended matter.
Sludge
Any solid material containing large amounts of entrained water collected during water or wastewater treatment.
Sludge Drying
The process of removing a large percentage of moisture from sludge by drainage or evaporation by any method.
Sludge Volume Index (SVI)
The ratio of the volume (in millilitres) of sludge settled from a 1000-mL sample in 30 minutes to the concentration of mixed liquor (in mg/L) multiplied by 1000.
Sodium Hydroxide (NaOH)
A strong caustic chemical that is used in treatment processes to neutralize acidity, increase alkalinity, or raise the pH value. Also known as caustic soda, sodium hydrate, lye, and white caustic.
Supernatant
(1) The liquid remaining above a sediment or precipitate after sedimentation. (2) The most liquid stratum in a sludge digester.
Tertiary Wastewater Treatment
The treatment of wastewater beyond the secondary or biological stage; term normally implies the removal of nutrients, such as phosphorus and nitrogen, and a high percentage of suspended solids; the term is now being replaced by advanced waste treatment.
Total Dissolved Solids (TDS)
The sum of all dissolved solids (volatile and non-volatile).
Total Oxygen Carbon (TOC)
The amount of carbon bound in organic compounds in a sample. Because all organic compounds have carbon as the common element, total organic carbon measurements provide a fundamental means of assessing the degree of organic pollution.
Total Suspended Solids (TSS)
The number of insoluble solids floating and in suspension in the wastewater.
Turbidity
A condition in water or wastewater caused by the presence of suspended matter resulting in the scattering and absorption of light.
Venturi meter
A differential meter for measuring the flow of water or other fluid through closed conduits or pipes. It consists of a Venturi tube and one of several proprietary forms of flow-registering devices. The difference in velocity heads between the entrance and the contracted throat is an indication of the rate of flow.
Waste Activated Sludge (WAS)
Solids that are removed from the activated-sludge process to prevent an excessive build-up in the system.
Wastewater
The spent or used water of a community or industry containing dissolved and suspended matter.

APPENDIX B: PIPING AND INSTRUMENTATION DIAGRAM

APPENDIX C: STANDARD OPERATIONG PROCEDURES

1. Chemical Cleaning of SMUs

APPENDIX D: EQUIPMENT DATA SHEETS

1. Pump Station Pumps
2. Buffer Pumps
3. RAS/WAS Pumps
4. Permeate Pumps
5. Service Water Pumps
6. Booster Pumps
7. Blower
8. Mixer
9. Membranes
10. Dosing Pumps