SECTION 3. TECHNICAL DESCRIPTIONS

1. Process Descriptions

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1.1 Main Pumping Station – 3 and 2 (MPS-3 and 2)

MPS-3 receives sewage from the Al Khoudh region and from vacuum stations to the east of A'Seeb Town. The grinded sewage will be distributed to 2 wet wells. 2 pumps will draw sewage from one wet well to the gravity discharge. MPS-2 receives sewage from MPS-2 and A'Seeb area. The grinded sewage will be distributed to 4 wet wells. 2 pumps will draw sewage from one wet well to the discharge header. All raw sewage pumps are equipped with a variable frequency drive.

1.2 Main Pumping Station – 1 (MPS-1)

Sewage to be treated in A'Seeb STP is conveyed to the MPS-1 by gravity. The grinded sewage is distributed to 4 wet wells via main compartment wet-well. Pumped sewage is conveyed through two common discharge headers, each equipped with a magnetic flow meter. This configuration is intended to enable one pipe to be removed under low inlet flow condition such as initial operation stage. The two pump discharge headers discharge into common channel in the adjacent pretreatment facility. All raw sewage pumps are equipped with a variable frequency drive.

1.3 Sewage Treatment Plant (STP)

The major processes in the STP will comprise of screening, grit and grease removal, SBR (Sequential Batch Reactor) system, Ultra-Filtration, Disinfection, TE storage, Aerobic Digestion and Centrifuge dewatering of surplus sludge. The associated unit processes are discussed in sections below.

<u>Screening</u>

The influent from the MPS-1 is conveyed to screen facility to 3 mm perforated screens for screening. The three screens (2 duties and 1 standby) are supported with two screenings wash press (1 duty and 1standby) to reduce the volume of screenings and to minimize the capture of organic material. Washed and compacted screenings are discharged directly to disposal containers.

The Screen operation principle is based upon the principle of a traveling screen. While the wastewater flows through the screen, the solids contained are retained at the screening elements. The water level in front of the screen rises. While the screening elements travel upwards, the solids are transported out of the channel. When the screening elements arrive at the upper turning point, they are continuously cleaned by a separately driven counter-rotating brush roller. This process is assisted by an interior spray nozzle bar. The screenings generated by screen backwash is transported to wash press via launder.

<u>Grit and Grease Removal (FOG)</u>

The effluent from the screening facility is conveyed to aerated grit & grease removal facility. The 2 duty aerated grit & grease removal chambers are supported with two grit washers to wash out the organic materials from grits. Washed grits are discharged directly to disposal containers.

In aerated grit chambers, air is introduced along one side of a grit chamber to create a spiral flow pattern perpendicular to the flow through the tank to accelerate the grit particles settling. The settled grit are removed by grit pump which are equipped with travelling bridge and then transported to grit washer. The oil and scum are floated in the grease channel and skimmed off with the scraper which is also equipped with travelling bridge.

1.4 Sequential Batch Reactor System (SBR)

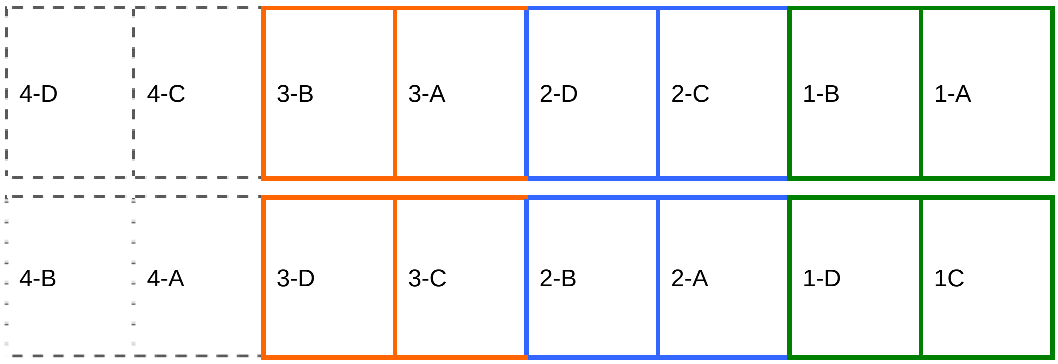
The effluent after pretreatment will flow by gravity to the Sequential Batch Reactor (SBR) system through a distribution chamber. The SBRs will be based on the Intermittent Cycle Extension Aeration System (ICEAS) technology developed by ABJ.

The ICEAS basin is typically divided into two zones, the pre-react zone and the main react zone. A non-hydrostatic baffle wall with openings at the bottom is constructed to divide the ICEAS basin into the two zones. The influent flows continuously into the pre-react zone and is directed down through engineered orifice openings at the bottom of the baffle wall into the main react zone. The pre-react wall baffles the incoming flow and prevents short-circuiting. Influent is received continuously during all phases of the cycle, including settle and decant. This allows the ICEAS process to be controlled on a time, rather than flow basis and ensures equal loading and flow to all basins. The total cycle time designed for the A'Seeb STP is 4.8 hours (288 minutes) in case normal flow. Use of a time-based control system in the ABJ ICEAS process facilitates simple changes to the process control program.

The blowers and aeration system are designed to ensure sufficient supply of oxygen as required for the process. After the aeration/anoxic phase, the system enters a settling phase where liquid/solids separation occurs. The system then enters the decant phase, where treated effluent is decanted from the basin.

<u>SBR Compartment Configuration</u>

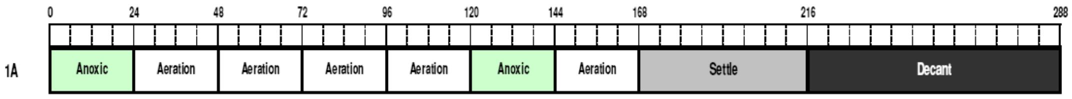
SBR system consists of four basins each having four compartments. The twelve compartment SBR is scheduled to be increased to a sixteen compartment SBR system in 2030. The numbering for compartments is as follows:-



Compartment Numbering

<u>React: Aeration-Anoxic Cycles</u>

React phase are defined in the process as either Aeration or Anoxic (air on-air off). Biological nutrient removal is accomplished in the ICEAS process by incorporating alternating phases Aeration-Anoxic conditions in the React phase as shown in the following Figure. The first period is always anoxic and the last period is always aerated. Two SBR mixers are installed in each SBR compartment, SBR mixers run at all times during air-off period, i.e. during the anoxic phase. The mixers stop when aeration restarts.



Standard Sequence

The above sequence provides the standard sequence for the react, settle and decant periods. In the event that the treatment process requires adjusting to provide differing treatment operations the 2nd to 6th segments in the react phase can be switched between anoxic and aeration.

Operation Modes

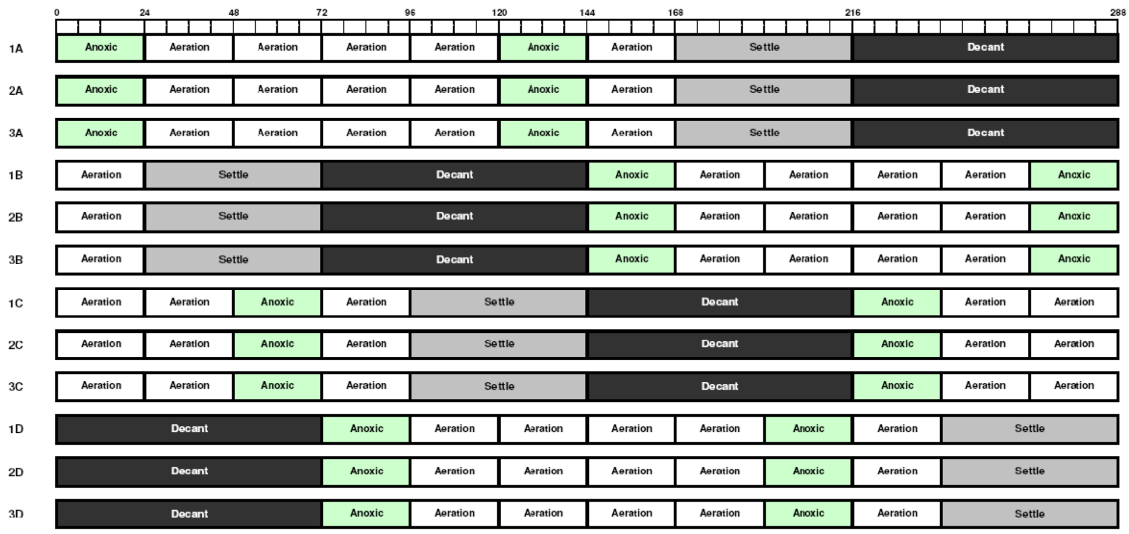
There are two discrete operational modes for SBR system, these are:

Normal flow mode (when high flow mode is not initiated)

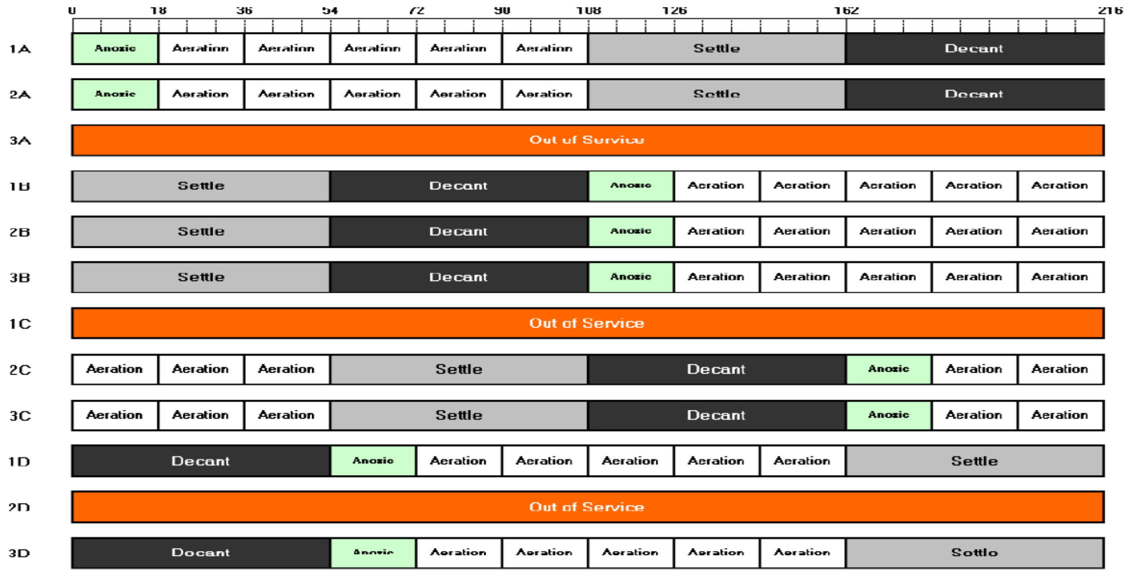
High flow mode (when high flow mode is initiated from radar level)

The cycles for 12 compartments are staggered to ensure that only 3 SBRs decant at any one time and to prevent partner SBRs aerating together.

Operation cycles for normal and high flow modes are detailed as followings:-



Normal Flow Cycle



Storm Flow Cycle

Bower Operations and DO Control

During the aeration period for a compartment, the DCS adjusts the vane position of the blower supplying air in order to maintain the dissolved oxygen around a setpoint. There are two DO setpoints: DO setpoint for the first aeration period and the last aeration period of the react phase. For the first five minutes of both aeration periods the blower will run at a fixed 50% of flow to ensure that the compartment is mixed prior to start DO control.

In the event that the measured DO exceeds the operator defined set point by more than 0.5 mg/l for a continuous period of 5 minutes, the blower will be stopped in automatic mode and mixers start, aeration will not resume until the DO falls to 0.5 mg/l below the setpoint.

Maintenance Condition

If a compartment is out of service through failure or manual selection all flows will continue through the remaining in service compartments. With a compartment out of service the system initially continues to operate in normal mode. In the event that flows increase, the high flow cycle is initiated.

The system prevents more than three compartments (for year 2020) being selected out of service at any one time in automatic. The system also prevents more than one A, B, C or D from being out of service at any one time, for example 1A and 2A.

Ferric Chloride for Phosphorus removal

During six winter months when excess TE is expected to be discharged to sea, phosphorus removal is required and ferric chloride is dosed into the main react chamber of each compartment. Ferric dosing is added to the last 24 min of Air-on Segment to allow sufficient time for flash mixing before the start of the settling phase. The pumps stop at the end of the aeration phase when the compartment enters the settle phase.

1.5 Ultra-filtration (U/F)

The treated water from the decanter of the SBR then goes for tertiary treatment facility, Ultra-Filtration. CS Ultra-Filtration units developed by Siemens are installed for this purpose.

1.5.1 Screen and Pre-chlorination

The effluent from the decanter is screened with 0.5 mm drum screen and pre-chlorinated by addition of sodium hypochlorite to prevent biofouling of membranes. To comply with the sea discharge regulation (Organic Halogen), the pre-chlorination during the winter season (6 months) is not carried out.

1.5.2 Filtration

The MEMCOR® Submerged Continuous Membrane Filtration - Submerged, (CS), process utilises hollow fibre membranes to provide a self-cleaning system. This system can maintain high flow rates by use of combined air scour and liquid backwash, Maintenance Wash and Chemical Clean In Place sequences.

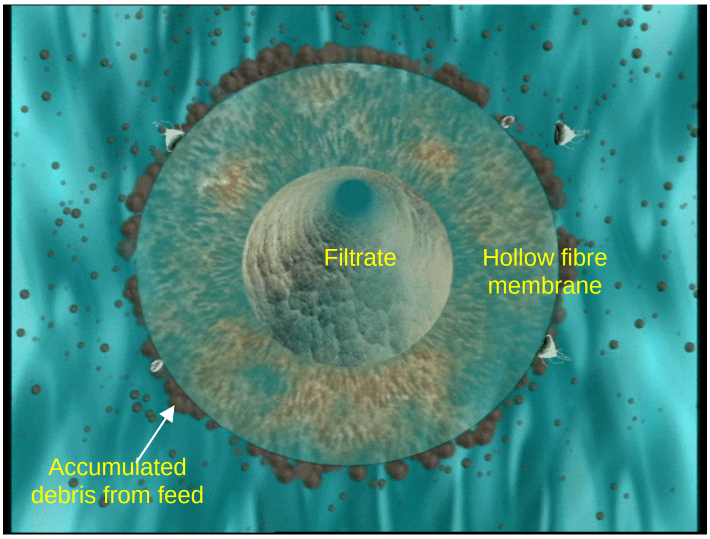
The membranes are submerged in feed water within the cell. The cell water level is automatically maintained above the membranes by the cell inlet valve which maintains the water level to ensure the membranes are submerged at all times.

In filtration, the filtrate pump creates suction on the inside of the hollow fibre membranes, drawing water through the fibre walls leaving solids on the membrane surface.

Important Note!

The unit cell is fitted with a low level switch which raises a category 2 Cell Low Level alarm if uncovered. The low level alarm is a warning alarm only and will not shutdown the unit. The switch is positioned at a point near the tops of the sub modules not at the cell bottom. This is to ensure the sub modules will not be exposed to the risk of drying out.

Flow through the unit is achieved by varying the speed of the Filtrate Pump to maintain the target flow rate. This filtration process removes solids larger than approximately 0.04 microns, (the nominal pore size for the PVDF membranes). As a guide bacteria are typically larger than about 1 micron.



Filtration

During filtration the following calculations are performed to monitor the build up of foulants on the membranes:

Transmembrane Pressure, (TMP) The effective differential pressure (driving force) between the shell and the filtrate side of the membrane. Used to initiate CIP Required alarm and membrane protection trip.

Resistance The resistance to flow of a membrane. Calculated from pressure, flow, temperature values. Used to initiate CIP Required alarm and membrane protection trip.

1.5.3 Start Up

In order for a unit to operate efficiently it must be prepared for filtration by undergoing a Start Up sequence. Once a unit has been selected In Service the cell is filled to the correct working level to ensure the tops of the sub modules are fully sub merged in feed water.

The filtrate side of the unit will then be primed by subjecting the filtrate side of the sub modules to a partial vacuum using the unit Priming Ejector. The priming ejector consists of a number of venturi across which compressed air at approximately 6 bar is passed. This action causes a partial vacuum to be formed at the suction connection of the venturi which “pulls” water through the membranes and into the filtrate header.

A level switch in the ejector suction line detects when the filtrate side of the unit is primed. Once the priming is complete the unit will enter Standby to await a filtration demand from the DCS.

Note!

Priming is also used following sequences which drain the filtrate side of the membranes.

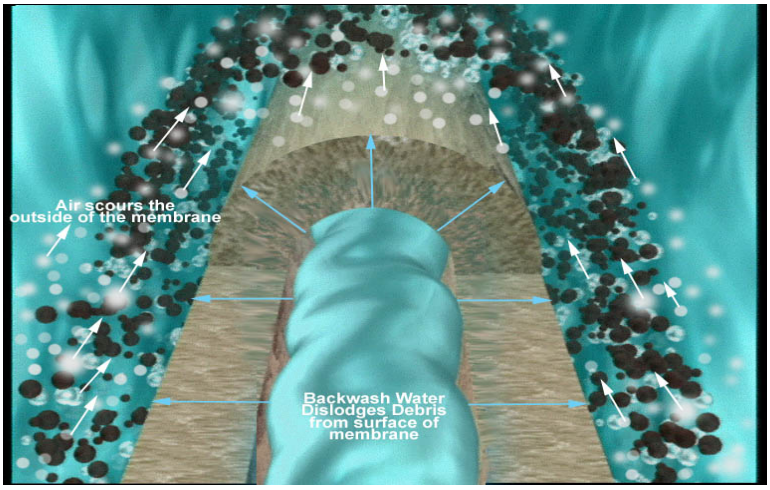
1.5.4 Standby

When the unit has completed a start up as described above it will enter the standby state. In standby the unit will remain primed and filled with all valves closed and the filtrate pump stopped until it receives a demand signal from the DCS. When the demand signal is present the unit will enter filtration.

1.5.5 Backwash

As deposits build up on the membrane fibres, resistance to flow increases, this will result in a drop in filtration flow rate across the membrane and thus a rise in pressure differential, (Trans Membrane Pressure, TMP). To compensate for this flow reduction, the speed of the filtrate pump is raised.

Before the resistance to flow and the TMP across the membrane becomes excessive, the membrane is Backwashed on a time in filtration, (“Filtration Time”), to remove any accumulated deposits, e.g. the unit is backwashed every 22 minutes in filtration.



Backwash

During backwash, filtration is stopped and air is applied to the outside of the fibres to scour the feed side of the membranes. Simultaneously a small amount of filtrate is pushed through the fibres, (from inside to out), to dislodge any deposits from the membranes. The cell is then drained to transport the loose deposits to the backwash drain lines. The cell is refilled with feed prior to returning to standby to await filtrate demand.

1.5.6 Maintenance Wash

A Maintenance Wash is automatically initiated on the unit at regular intervals (in plant normal operation) to maintain the membranes between CIPs with a chemical clean which is not as vigorous as a CIP. Two types of maintenance wash are performed a Sodium Hypochlorite and Sulphuric Acid. Maintenance Wash intervals are set by the DCS. For normal plant operation a Hypochlorite MW will be performed every 24 hours and an Acid MW will be performed every 72 hours. When the plant is in winter operation no maintenance washes will be performed, see 2.3.2 for details.

1.5.7 Clean In Place, (CIP)

A chemical cleaning sequence is automatically initiated to remove any contaminants from the membrane surface not removed by the backwash process. Two types of cleaning regime are carried out, Sodium Hypochlorite or Sulphuric Acid/Citric Acid mix. The cleaning cycles are referred to as Clean In Place because there is no requirement to remove the membranes from the cell to perform the clean. CIP intervals are set by the DCS and will vary between 14 days for normal plant operation and 4.5 days for winter operation, see 2.3.2 for details.

<u>Note!</u>

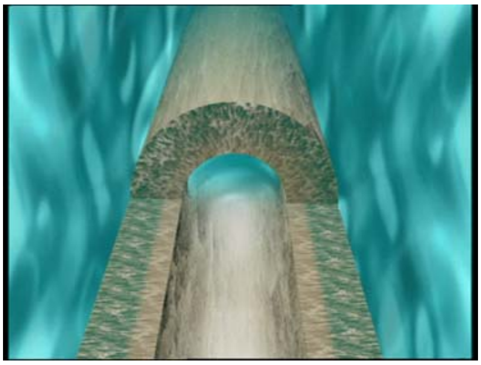
Hold – During CIP and Maintenance Wash sequences, if a fault occurs which raises a category 1 or 2 alarm, the unit will enter the HOLD state. In this state the unit is placed in a safe state with all unit valves closed and drives stopped, the point in the sequence (CIP or MW) that was running at the time of the fault will be retained in memory. Once the fault has been cleared and the alarms reset the unit may be returned to service whereupon the sequence will resume from the point at which the fault occurred.

1.5.8 Draindown

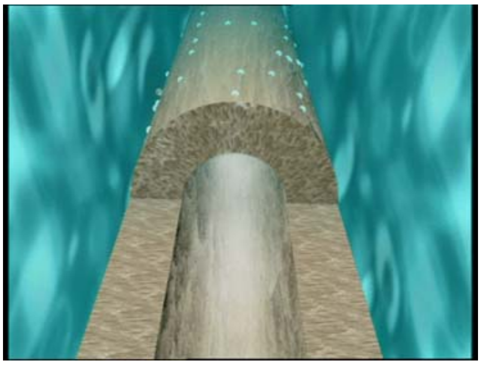
A sequence either automatically called by another sequence or manually by the operator. In Draindown low pressure air (120kPa) is used to force water out of the lumens of the fibres for a preset time. This is followed by the cell drain valve being opened to drain the cell contents. If the Draindown has been called as part of another sequence once the unit is drained the initiating sequence will step on. If the Draindown is manually initiated the unit will shutdown after draining is complete.

1.5.9 Integrity Testing – Pressure Decay Test

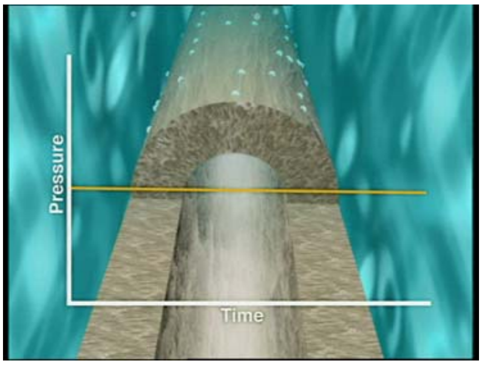
The integrity of the membranes within a unit is tested daily by the automatic initiation of the Pressure Decay Test, (the test may also be initiated manually by the operator). In the test, the unit is removed from filtration and the membrane lumens, (centres), are drained and then pressurised with low pressure air. The air supply is then removed and the trapped air pressure in the membrane is monitored over a time period. The pressure drop during the test provides an indication of the membrane integrity. A high pressure drop is indicative of a broken membrane fibre or a damaged/failed 'O' ring. A unit having a very high decay rate will not be allowed to return to filtration.



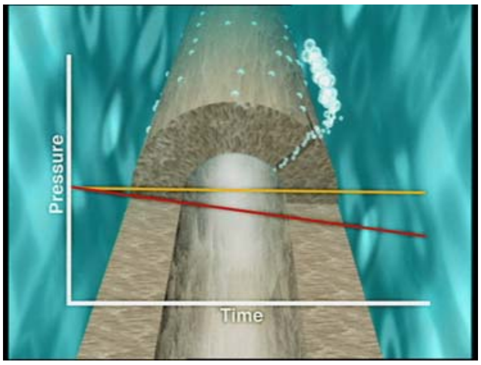
Lumen drain



Pressurise



No Integrity failure. Low pressure drop during test



Membrane damage causing rapid pressure drop during test

1.5.10 Rack Maintenance

If maintenance is required on a unit for sub module repair or any work that requires a rack removing from the cell the unit must be placed in the Rack Maintenance state. This state removes it from service and partially drains the cell to facilitate rack removal. Once work is complete the unit may be selected to refill the cell after which the unit will shutdown.

1.5.11 Wastewater Drain/Discharge

All acid MW waste, Hypochlorite MW Cell Drain and Initial rinse waste and all CIP waste and rinse waters are directed to CIP waste tank and finally discharged to SBR distribution chamber after neutralization process. The neutralization is achieved by re-circulating tank waste during the neutralization process with Sodium Hydroxide/Sodium Bisulphate addition.

Backwash waste generated during CS cell Backwash process is drained by gravity to the site pumping station and finally directed to the head of the works.

1.6 Onsite-Hypochlorite Generation System (OSHG)

The Treated Effluent (TE) that has been pulled through the membranes will be disinfected before any reuse application.

The TE from the Ultra-Filtration system will be conveyed by the permeate pumps (one pump per train) to the four treated effluent storage tanks. Disinfection of the TE will be accomplished by the addition of sodium hypochlorite which is generated by Onsite-Hypochlorite Generation System (OSGH) from salt. OSHG and the relevant facilities (sodium hypochlorite storage tank and feeding facilities) are housed above the TE storage tanks.

The Onsite-Hypochlorite Generation System (OSHG) has a capacity to cover membrane pre-chlorination and post-chlorination requirements.

1.7 Treated Effluent Storage (TE)

The disinfected TE will be stored in four TE storage reservoirs. Pumps will be deployed at these storage tanks to supply the TE to the TE distribution centres in Al Khoudh and Mobella and to Naseem Gardens/Farms.

1.8 Aerobic Digestion

The SAS from the individual SBR compartment are pumped into the digesters via a single pumping header. In accordance with the SBR operation, three (four for 2030) SBRs discharge SAS simultaneously, and this combined flow is received in a single digester.

The digester starts to operate when a digester inlet valve is opened. Batches of SAS are received until TWL is reached, when the system changes feed to the next available digester. The digester which has achieved TWL, and is now off-line, continues to aerate for a fixed time period between 0-4hrs. On expiry of this time, the digester contents are allowed to settle/consolidate for 1 hour to remove supernatant, thus thickening the sludge.

The decanter is started by timer expiry of settlement. Supernatant liquid will be decanted from each digester maximum two times per day to increase the digester sludge content from an estimated 0.85% to 1.5%. The supernatant liquid will be recycled to site pumping station. The digested sludge at 1.5% concentration is pumped during each cycle to the aerated buffer tanks.

1.9 Centrifuge

Centrifuge feed pumps transfer digested sludge to centrifuge for dewatering. Centrate is taken back to pretreatment facility via site pumping station.

The centrifuges will be located in a second story to provide for discharge of cake solids into cake truck trailers below. These systems (centrifuge dewatering system, polymer dosing facility and cake unloading facility) will be located within the dewatering building.

The centrifuge system will be enclosed in the sludge processing building covered by an odour control system.

1.10 Marine Outfall

Excess Treated Effluent, expected during winter months will be disposed to sea through a marine outfall. And also, in cases of emergency, when the wastewater is partially or untreated due to downstream equipment or STP failure, such wastewater will be discharged to the sea through the marine outfall.

The pipeline with 1.4 m diameter follows an alignment parallel to the proposed access road to the facility until it passes beneath the Muscat Sohar Highway. The location of the discharge will be located 1.8 km into the sea and near Naseem Gardens.

1.11 Odour Control System (OCU)

The OCUs are installed at MPS 3, MPS 2 and the STP to cover the following areas in each location:

MPS 2: wet well and discharge header

MPS 3: wet well and discharge header

STP: MPS 1 wet well, pre-treatment facility, distribution chamber, dewatering room and cake room and AD reactors and buffer tanks.

The OCUSs are constituted with 2 units (dual system). The main equipment of the odour control system is wet scrubber system. The major treatment mechanism is chemical oxidation process using scrubber system. This system consists of each unit have scrubber, exhaust fans and recirculation pumps. The mechanism of odour control is that first, the odorous matters and gases are collected through ducts and transferred to the scrubber by the induced fan. Second, these gases are treated in the scrubber with chemical oxidation. Third, clean gases are emitted to the air through the mist eliminator which is top of the scrubber.

1.12 TE Facilities (Al-Khoudh and Al-Mobellah)

Two Treated Effluent distribution centres will be established in Al Khoudh and Al Mobellah respectively. The TE from the A'Seeb STP at Al Manumah will be transported to the distribution centres through pipelines. The receiving end at the distribution centre will have booster chlorine dosing facilities prior to the TE being stored in the storage tanks. Tanker filling facilities will be available at each distribution centre. TE will also be distributed from each of the facility through a network of pipelines to existing irrigation reservoirs of Muscat Municipality.