Ridgeburn Wastewater Treatment Plant Design Report

Project Name:	Queenstown Development Wastewater Options
Project No:	J9024
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Executive Summary

Gibbons Co. Ltd is undertaking a major residential and commercial development named Ridgeburn, located approximately 6 km south of Arrowtown in the Queenstown Lakes District. The development will include 1,200 residential lots, a supermarket, hotel, offices, and community buildings. To support this, BPO Ltd. has been engaged to design a sustainable and efficient on-site wastewater treatment and discharge system.

Wastewater Treatment Strategy

The selected treatment system is a modular hybrid biological nutrient removal process, incorporating:

Sequencing Batch Reactors (SBRs) for biological treatment,

Ultrafiltration membranes for solids and pathogen removal,

UV disinfection for final polishing.

Treated effluent will be discharged to land-based rapid infiltration beds, avoiding direct discharge to surface waters due to environmental and cultural sensitivities.

Design Basis and Flow Estimates

Wastewater flows were estimated to be up to 920 m³/day (with 20% contingency: 1104 m³/day) using the conservative Metcalf & Eddy method. The design accommodates peak flows, with a 1,500 m³ equalisation tank to buffer daily variations and ensure stable operation.

Process Description

The treatment process includes:

- Headworks screening and grit removal,
- Equalisation tank for flow buffering,
- SBRs for biological treatment,
- Membrane filtration for solids and pathogen removal,
- UV disinfection,
- Sludge dewatering via centrifuge,
- Odour control using a bark-based biofilter system.

Level of Treatment

The level of treatment outlaid in Table 1 is achievable, but it does need to be noted that as this is a biological process, maintaining these levels 100% of the time is potentially unrealistic for any process. The other issue that needs consideration is for the methods for determining the likes of Carbonaceous Biochemical Oxygen Demand 5 day (CBOD5) and Total Suspended solids (TSS) the testing is potentially less than the LOR (Limit of reporting) for the standard test meaning the potential error or plus/minus factor is greater than the limit of consent.

The wastewater treatment plant has been designed to achieve the following level of treatment.

Table 1: Modelled waste water treatment performance.

Parameter	Treatment Quality October to April	Treatment Quality May to September
cBOD (mg/L)	2	2
TSS (mg/L)	2	2
TP (mg/L)	8	8
TN (mg/L)	4	10
NH3 (mg/L)	2	8
E Coli (Cfu/100 mL)	10	10

Biowin® modelling was carried out under a number of flow and temperature scenarios. The modelling confirmed sizing was appropriate and that the levels of treatment were attainable.

Odour Management

Odour sources are contained and treated via a biological bark filter system. All critical components (screening, equalisation, sludge handling) are sealed and vented under negative pressure. The system is designed with redundancy and monitoring to ensure continuous, effective operation.

Conclusion and Recommendations

The Ridgeburn WWTP design prioritizes:

- High effluent quality,
- Operational resilience,
- Environmental protection,
- Cultural and social acceptability.

The proposed SBR with membrane filtration and subsurface irrigation system offers a robust, scalable, and sustainable solution for the Ridgeburn development.

BACKGROUND

Gibbons Co. is a privately owned, luxury property development company that specialises in residential and commercial properties. They are currently in the planning stages for a large residential development about 6 km south of Arrowtown. The development known as Ridgeburn includes about 1200 residential lots with a small supermarket, small hotel, offices and community buildings. The development will be serviced with key infrastructure such as road networks, stormwater management, wastewater systems, and water supply, while adhering to sustainable design principles.

The developer Gibbons Co has engaged BPO to provide engineering support for the planning and consenting of private on-site wastewater treatment and discharge infrastructure.

As part of the preliminary design process, various wastewater treatment options were assessed, and the selected system was chosen for its suitability. The chosen treatment process is a modular hybrid biological nutrient removal system, which includes sequencing batch reactors (SBRs), an ultra-filtration membrane filter, and tertiary UV disinfection. This system ensures high-quality treated wastewater production within a compact design. The treated wastewater will be discharged to land treatment rapid infiltration beds.

PROJECT DESCRIPTION

Location

The proposed Ridgeburn development is located approximately 6 km south of Arrowtown in the Queenstown Lakes District area. The location of the development can be seen in Figure 1 below.

Figure 1: Ridgeburn location

The Ridgeburn development site is bound by the Kawarau River to the south with rural properties to the north, east and west. Apart from the residential properties within the Ridgeburn development, the nearest residential properties are 1.6 km away to the north-east on Morven Ferry Road, and 825 m to the south-east on Chard Road.

The proposed site for the wastewater treatment plant is on the south east corner of the Ridgeburn development at the edge of the top terrace. It is bound on the north and west sides by future residential lots, with river reserve to the south and rural farmland to the east.

Figure 2: Location of WWTP (in red) at Southern end of Ridgeburn.

WASTEWATER CHARACTERISATION

Loading and Flows

Information provided by Gibbons Co. for the Ridgeburn development indicate the following wastewater sources.

Table 2: Sources of Wastewater.

Facility Type	Number of Units /size	Occupants
Housing		
House and Land	*1030*	*3090*
Affordable housing	180	*540*
Commercial Buildings:		
Commercial Area –	3620 m²	10
Supermarket –	3650 m²	30
Hotel –	202 rooms	114
Community Buildings:		
Farmhouse	265m²	4
Shearing Shed	298m²	4
Community Shed	290m²	10

Based on this information a profile of the likely wastewater volumes and characteristics was built up. There are a number of methods available for estimating wastewater flows. The Ministry of Works method estimates flows based on population equivalents assuming 250L per person per day. The Auckland City Council method uses 180 L per day. To align with Queenstown Lakes Land Development requirements, a peak flow of 250 litres per person per day has been used.

The more conservative method using Metcalf and Eddy was selected as being the most appropriate due to its conservative approach. This resulted in a maximum 1004 m^3 per day wastewater flow to which a 20% contingency was added. The results of the wastewater characterisation for both methods are shown below.

Table 3: Wastewater Characteristic using Metcalf & Eddy method.

	Properties	Population	Volume		BOD$_5$		COD		Nitrogen		Phosphorous		Solids		Fat oil and grease	
Housing			M3 min	M3 Max	min kgs	max Kgs	min kgs	max Kgs	min kgs	max Kgs	min kgs	max Kgs	min kgs	max Kgs	min kgs	max Kgs
House and Land	1030	3090	599	773	270	322	629	752	80	98	10	11	278	340	93	105
Affordable housing	180	540	105	135	47	56	104	124	6	15	2	2	49	59	16	18
Commercial Buildings:																
Commercial		10	13.7	19.7	6.2	7.4	14.4	17.3	0.7	1.6	0.17	0..19	5	6	1.65	1.87
Supermarket		88	21.9	31.3	10	12	23	27.5	1.1	2.5	.26	0.31	8	10	2.63	2.98
Hotel		114	28.6	40.9	13	15	30.1	35.9	1.4	3.3	0.34	0.4	10	13	3.44	3.90
Community Buildings:																
Farmhouse		4	0.45	0.9	0.4	0.5	0.9	1.1	0.04	0.1	0.01	0.01	0.4	0.4	0.11	0.12
Shearing Shed		4	0.45	0.9	0.4	0.5	0.9	1.1	0.04	0.1	0.01	0.01	0.9	1.1	0.11	0.12
Community Shed		10	2	2	0.9	1.1	2.1	2.5	0.1	0.3	0.03	0.04	0.9	1.1	0.24	0.27
	Total	3878	**772**	1004	**348**	415	**805**	962	**90**	112	**12**	14	**352**	430	**117**	132
Design Basis	Including 20% contingency	**4622**		**1204**		**495**		**1149**		**133**		**16**		**512**		**159**

Using 2 years of data between 30 Sep 2023 and 01 Oct 2025, a volumetric model as developed to better understand the variations in volume and load. What was surprising was that the level of seasonal variation was less than expected with about a 30% drop from peak load and volume to out of season load and volume

Figure 3 Modelled flow data using Queenstown daily flow variation period 30 Sep 2023 to 01 Oct 2025

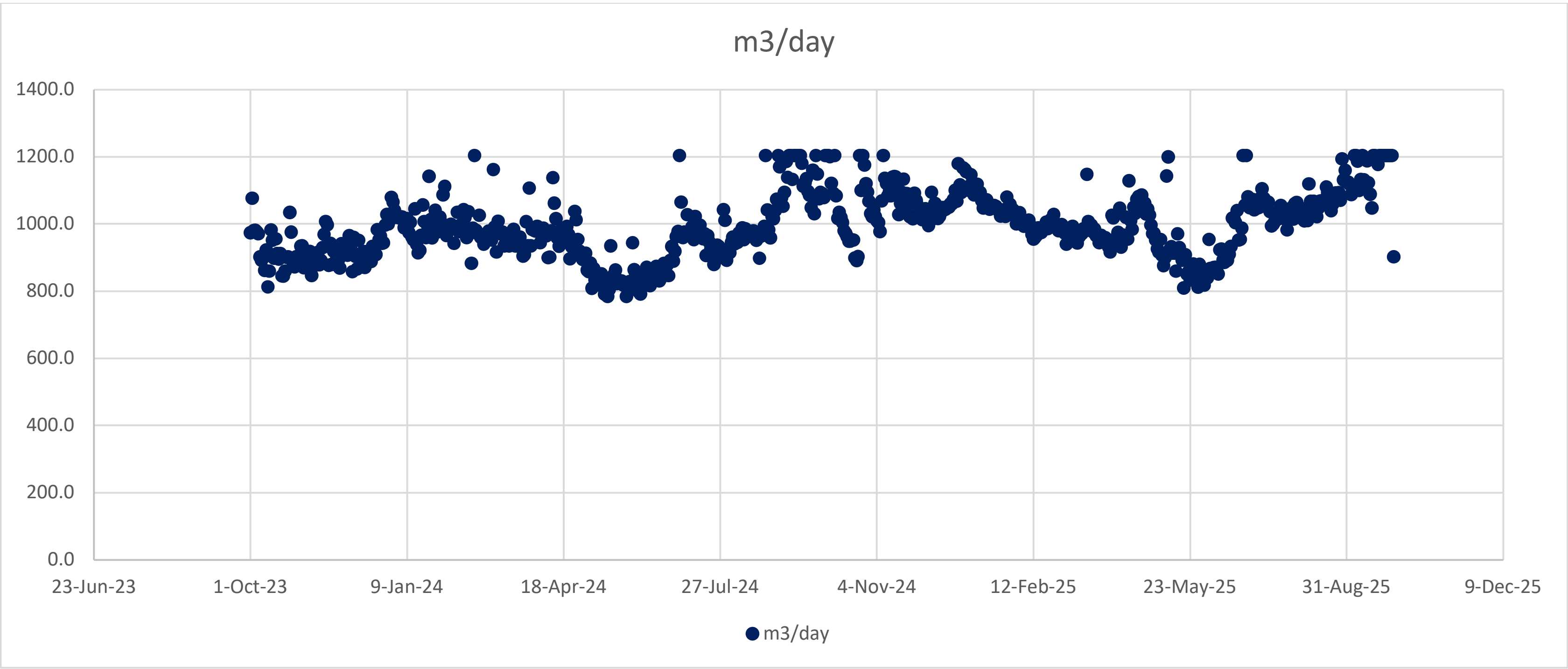


Table 4 Statistical model of volume and load variation, various parameters.

	Flow m3 Annual Volume	Flow m3 Daily Average	Flow m3/day Minimum	Flow m3/day Maximum	BOD5 Kgs/day Annual Kgs	BOD5 Kgs/day Daily Average	BOD5 Kgs/day Minimum	BOD5 Kgs/day Maximum
01 Oct 2023 to 30 Sep 2024	350478	958	784	1204	120888	330	271	415
01 Oct 2024 to 30 Sep 2025	376287	1031	810	1204	129790	356	279	415
	COD Kgs Annual Kgs	**COD Kgs Daily Average**	**COD Kgs Minimum**	**COD Kgs Maximum**	**Nitrogen Kgs Annual Kgs**	**Nitrogen Kgs Daily Average**	**Nitrogen Kgs Minimum**	**Nitrogen Kgs Maximum**
01 Oct 2023 to 30 Sep 2024	279886	765	626	961	32518	89	73	112
01 Oct 2024 to 30 Sep 2025	327262	823	647	961	34913	96	75	112
	Phos Kgs Annual Kgs	**Phos Kgs Daily Average**	**Phos Kgs Minimum**	**Phos Kgs Maximum**	**Solids Kgs/day Annual Kgs**	**BOD5 Kgs/day Daily Average**	**BOD5 Kgs/day Minimum**	**BOD5 Kgs/day Maximum**
01 Oct 2023 to 30 Sep 2024	3978	11	9	14	125205	342	280	430
01 Oct 2024 to 30 Sep 2025	4271	12	9	14	134426	368	289	430
	FOG Kgs Annual Kgs	**FOG Kgs Daily Average**	**FOG Kgs Minimum**	**FOG Kgs Maximum**				
01 Oct 2023 to 30 Sep 2024	38497	105	86	132				
01 Oct 2024 to 30 Sep 2025	41332	113	89	132				

Reticulation

Wastewater collection and reticulation has traditionally been via gravity sewers to centralised pumping stations with pressure mains to transfer to the wastewater treatment plant.

An alternative option of a pressure system or MBBS is also being considered.

The pressure reticulation system is a Macerating Pump Pressure Sewer (MPPS) system. With a MPPS system, each property is provided with a small tank with a pump unit installed which receives the household wastewater. The tank fills and when a certain level is reached the pump starts, pumping waste out of the property, and the level in the tank reduces to a point where the pump stops. The MPPS system is an option due to reduced flow to the treatment plant as a result of reduced wet weather infiltration and ingress (I&I). As the system is under pressure and constructed with HDPE welded pipes additional I&I is expected to be negligible and is accounted for in the daily flow contingency.

Pressure pipes are generally smaller than gravity pipes and usually run full. This could potentially make them more susceptible to freezing and bursting. However, the temperature of the wastewater, the insulating properties of HDPE pipe, and the fact the wastewater is under pressure should reduce this risk. Also, the freezing depth of soils rarely goes down further than 50 cm, even in high alpine areas, so provided pipes are buried lower than this there should be minimal risk of pipes freezing or bursting.

Flow Buffering

Daily wastewater flows are expected to vary significantly, with higher volumes during peak usage times. To account for this, the treatment plant has been designed using a peak flow factor of 5, meaning it can handle short-term surges up to five times the average flow.

However, to ensure the long-term cost-effectiveness and efficiency of the treatment infrastructure, the core biological and membrane filtration processes are designed to operate independently of these peak events. This approach helps avoid oversizing critical treatment components, which would otherwise increase capital and operational costs.

The most straightforward and proven method to manage these flow variations is through the use of a balance tank at the front end of the treatment process. This tank temporarily stores excess flow during peak periods and releases it gradually, allowing the main treatment processes to operate at a steady, average rate.

In addition to managing hydraulic loads, the balance tank also provides operational flexibility. For example, if maintenance is required on downstream equipment, the system can continue to function without interruption.

This design approach supports both regulatory compliance and sustainable infrastructure investment by ensuring reliable performance under variable flow conditions while minimizing unnecessary overbuilding.

Basis of Design

Using the Metcalf and Eddy estimations, with 20% contingency, the following basis of design for the wastewater treatment system was produced for use in sizing of process units. This has been a conservative approach to ensure the system is not undersized and has capacity for peak flows and the ability to cope with full occupancy.

Table 5: Design wastewater constituents as mass and concentration,

	Flow	BOD_5	COD	TN	TP	TSS	FOG
Concentration mg/L	-	315	730	85	10	325	1001
Mass Kg/d	1204	498	1154	134	16	516	159

Treatment Requirements

The level of treatment required is dependent on the discharge method. For water reuse such as on tree plantations typically only a moderate level of treatment is required involving BOD and TSS removal. Discharge for irrigation onto pastural or agricultural lands would require a higher level of BOD and TSS removal along with some form of disinfection. Discharge to rapid infiltration beds typically require a higher level of nutrient removal along with disinfection due to potential connection with subsurface river flows. Discharge to wetlands and surface waters would require a very high level of BOD, TSS, nutrient and pathogen removal close to the standard of the receiving waters. We have not considered direct discharge to surface waters due to the pristine nature of the Kawarau River and the offensiveness of discharging of what is perceived to be human waste to rivers and waterways. Reuse for use as supply water would require the highest standard of treatment but the lack of acceptance of this practice in New Zealand means this is probably not an option. Treated waste water is transferred to the land treatment system. (refer to WGA report on Land Treatment for further discussion on this).

Due to the biological nature of the nitrification/denitrification it is temperature sensitive. For this reason nitrogen removal is more complete during the warmer months. During very cold temperature periods the wastewater could drop to 7 degrees °C entering the plant. This typically results in a decrease in ammonia removal.

Due to the proximity of the proposed land treatment to the Kawarau River the flowing treatment standards will be met:

Table 6: Targeted Treatment Quality

Parameter	Treatment Quality October to April	Treatment Quality May to September
cBOD (mg/L)	2	2
TSS (mg/L)	2	2
TP (mg/L)	8	8
TN (mg/L)	4	10
NH3 (mg/L)	2	8
E Coli (Cfu/100 mL)	10	10

Important:
The targeted treatment quality should not be confused with maximum allowable values from a consent perspective. For a biological process, some variability is inevitable meaning that it wont always be possible to achieve the very high standards proposed for the design targets.

Annual flow data

Seasonality of the location is going to impact on the overall the daily waste-water flows.

To predict this seasonality, two years of data from the inlet to the Shotover waste-water treatment plant was obtained, outliers removed and used as a template for the Ridgeburn data scaling down to reflect the population.

Table 7: Seasonal model for Ridgeburn wastewater flow.

	Month Total	Daily flow Average	Daily flow Minimum	Daily Flow Maximum
Oct-23	28363	915	807	1070
Nov-23	27145	905	842	1001
Dec-23	29004	936	852	1072
Jan-24	30807	994	908	1134
Feb-24	28734	991	878	1196
Mar-24	29863	963	899	1154
Apr-24	28871	962	889	1131
May-24	25766	831	779	929
Jun-24	25733	858	787	971
Jul-24	29859	963	874	1196
Aug-24	30080	970	892	1196
Sep-24	33923	1131	1024	1196
Oct-24	32664	1054	885	1196
Nov-24	31997	1067	971	1196
Dec-24	32719	1055	989	1172
Jan-25	32772	1057	1016	1139
Feb-25	27640	987	949	1027
Mar-25	30105	971	934	1140
Apr-25	30143	1005	911	1122
May-25	27945	901	804	1192
Jun-25	28292	943	812	1196
Jul-25	32039	1034	976	1098
Aug-25	33001	1065	1003	1186
Sep-25	34471	1149	897	1196
Year 1 annual flow	348149	951	779	1196
Year 2 annual flow	373787	1024	804	1196

Summary of Secondary Treatment Technologies

The table below provides a summary of potential technologies and their suitability.

Table 8: Technology summary and evaluation.

Technology	Suitability	Reason
Flow through Activated Sludge	No	• High capital cost • Fixed volumes not suitable for variable flows • Complexity
SBR	Yes	• Provides nutrient removal, • Resistant to variable loads, • Suitable for cold temperatures • Integrated clarification • Can be used in tanks or basins
Ponds	No	• Variable performance during cold periods. • Potential for flipping during Spring
MBR	Potentially	Has possible application as an add on but is high risk due to low flux during cold periods
Trickling filters	No	High risk during cold periods
MBBR	Yes	• Provides nutrient removal, • Resistant to variable loads, • Suitable for cold temperatures • Can be used in tanks or basins • Requires primary treatment
RBC	Yes	• Provides nutrient removal, • Resistant to variable loads, • Suitable for cold temperatures • Requires primary treatment
IFAS	Potentially	Could be integrated into an SBR system
AGS	No	Requires specialised operation and biomass development
Annamox	No	Requires specialised operation and biomass development
MABRs	Potentially	Has possible application as an add on but is high risk due to low flux during cold periods

Based on these investigations a short list of three technologies, SBR, MBBR and RBC, were identified as being suitable for this application. These options were then rated for footprint, effluent quality and ease of operation. A tank based SBR system achieved the highest score so has been selected for this project.

Table 9: Comparison scoring for WWTP options.

	Footprint (m2)	Effluent BOD/TSS/TN	Ease of Operation	Total Score
MBBR	1300	20/20/10	Medium	
Score	3/5	13/20	7/10	**23**
SBR (tank)	1500	10/15/8	Skilled	
Score	3/5	16/20	6/10	**25**
SBR (basin)	2400	10/15/8	Skilled	
Score	2/5	16/20	6/10	**24**
RBC	1400	20/30/20	Medium	
Score	3/5	12/20	8/10	**23**

In order to achieve a higher level of treatment SBR, filtration is required to remove residual solids. Ultra-filtration membranes are the most effective way of achieving this. Using the membranes for polishing maintains the flexibility of the SBR system which a standard MBR could not achieve. Reduced solids loading on the membranes compared to that in a conventional MBR system result in a higher achievable flux (membrane throughput) and reduced risk of membrane fouling.

PROCESS MODELLING

Overview

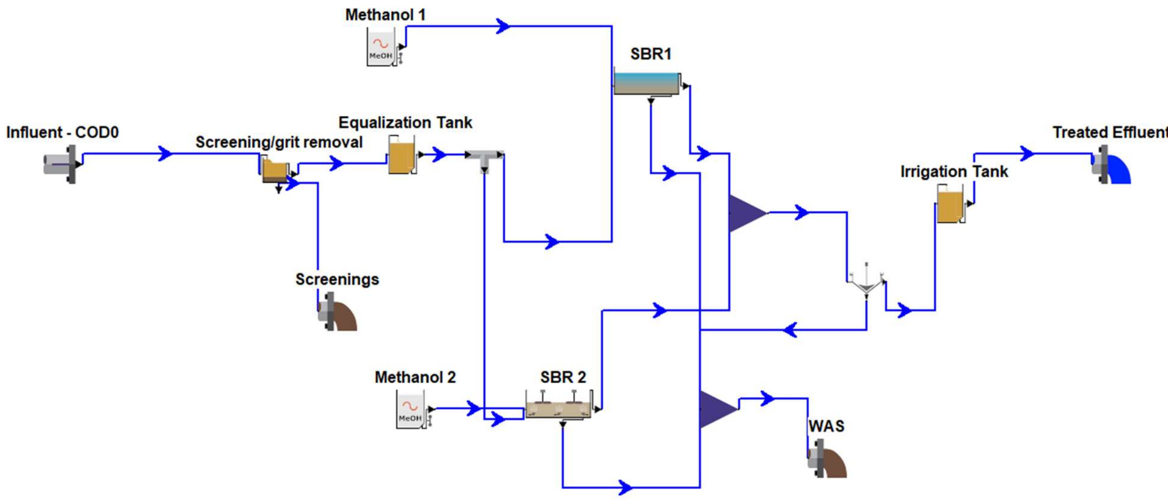
Modelling of the proposed SBR with membrane filtration was carried out using Biowin®. BioWin® is a wastewater treatment modelling software used to simulate biological, chemical, and physical processes within treatment plants. It enables whole-plant analysis, supporting design, optimization, and performance evaluation of systems such as activated sludge, nutrient removal, and anaerobic digestion. A number of scenarios were modelled over different flow and temperature conditions. The variable flow and temperature condition scenarios were modelled under two different configurations. The summer optimised configuration had an 8 hour cycle and reduced aeration, while the winter configuration had a 10 hour cycle with longer aeration. These are shown in the table below.

Table 10: Scenarios modelled.

Scenario	Flow m3/d	Temperature	Set up
1	1500	15	Optimised for summer
2	1500	7	Optimised for Winter
3	970 to 1500	7 - 22	Optimised for summer
4	970 to 1500	7 - 22	Optimised for Winter

Please note, the Biowin® modelling work was undertaken with a maximum flow of 1500m3 per day. This value has been downsized to 1200m3 per day to align with regional expectations of per person peak waste water generation. There is no anticipated impact of this on the reduction of the identified analytical parameters. Making rerunning the Biowin® model unnecessary.

Figure 4: configuration of the Biowin® model.



Scenario 1 has maximum flows, but a more typical temperature of 15 degrees. This resulted in total nitrogen (TN) being under 4 mg/L.

The highest stress scenario (2) was based on constant maximum flow and a wastewater temperature of 7 ºC. Modelling for this scenario indicated that there was a reduction in nitrification and denitrification resulting in 10 mg/L TN in the treated wastewater. It is likely that these extreme conditions would only occur occasionally in the winter months of May through to September.

Scenarios 3 and 4 used optimised operation for winter and summer conditions. This, along with more realistic flow conditions, resulted in improved treatment results for both winter and summer.

The table below indicates the effluent quality for all six scenarios for total nitrogen, ammonia and nitrates. All scenarios indicated less than 1 mg/L for both BOD and TSS.

Table 11: Effluent quality from modelling scenarios.

Scenario	Flow m3/d	Temperature	Total Nitrogen	Ammonia
1	1500	15	4	2
2	1500	7	10	8
3 (summer)	970 to 1200	12 - 22	4	1
4 (winter)	970 to 1200	7 - 12	4	2

The two figures below indicate the difference in performance using winter and summer configurations. Winter configuration has a longer cycle time and more time dedicated to nitrification (ammonia removal). Configuration for winter (figure 4) results in total nitrogen under 4 mg/L in winter but poor performance in the warmer months. Configuration for summer (Figure 5) resulted in better performance in summer, autumn and spring but poor winter performance. Through adjusting operation between cold and warmer periods optimal treatment should be achieved.

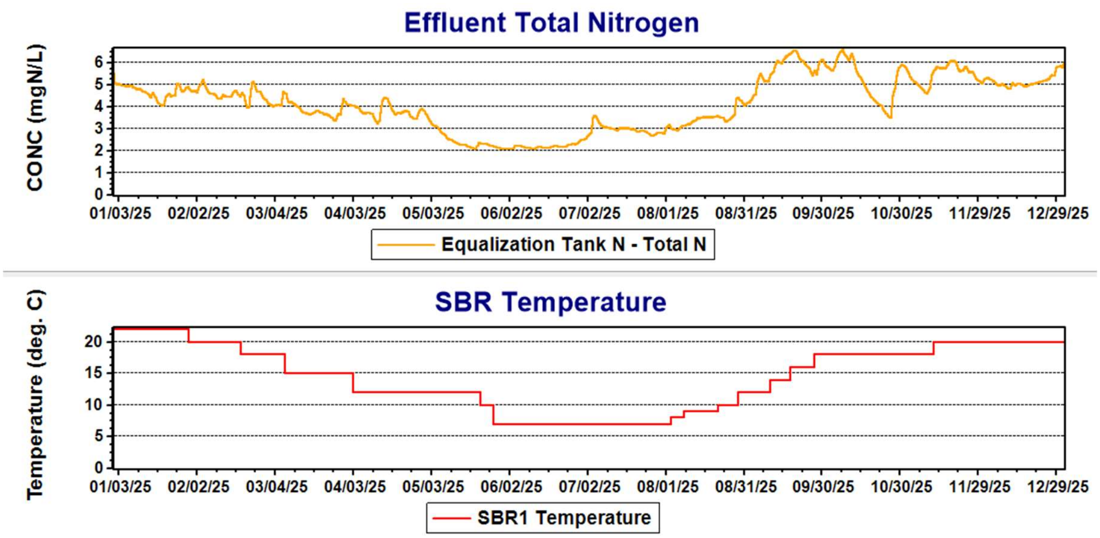


Figure 5: Nitrogen in the effluent with winter configuration.

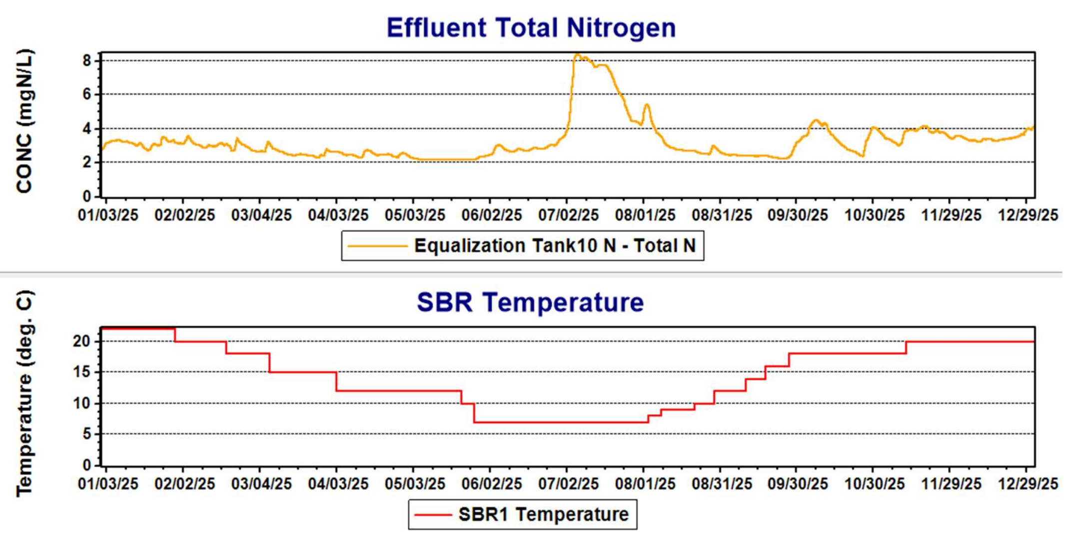


Figure 6: Nitrogen in the effluent with summer winter configuration.

PROCESS DESCRIPTION

A simplified process flow diagram of the SBR and membrane treatment train is illustrated in the figure below.

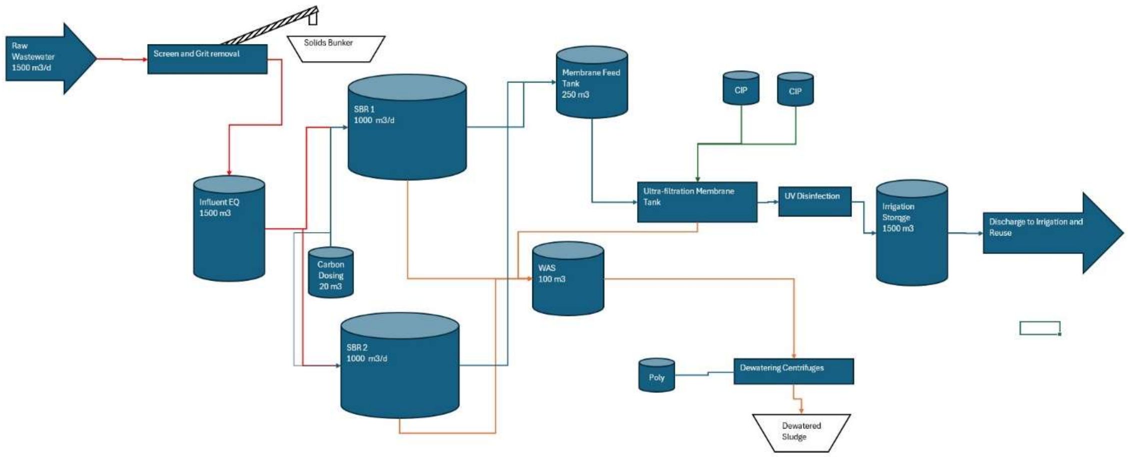


Figure 7: Process Flow Diagram.

This process includes the following components

1. Raw unscreened sewage arrives at the plant via the pressurised rising main.
2. Headwork Screening - These screen bulk solids out of the raw sewage to protect the downstream process.
3. Equalisation Tank - A tank which receives the screened sewage buffering peak flows.
4. SBR tanks 1 and 2
5. Waste Activated Sludge (WAS) Tank – this holds WAS taken from the SBRs and solids removed by the membrane filtration system.
6. Dewatering System – Takes sludge from the WAS tank and dewaters using centrifuges and polymer
7. Membrane Filtration- The filtration step of the process, where remaining solids, bacteria and viruses are filtered out of the wastewater
8. UV Disinfection -- The UV disinfection step where any remaining bacteria or viruses are deactivated through exposure to ultraviolet light.
9. Treated Wastewater Storage - Where fully treated wastewater is stored prior to discharge.
10. Discharge System - Treated wastewater is discharged to the Land treatment site at the rate that it can be received

Additional processes include:

1. Aeration blowers feed high volume and medium pressure air to SBR to maintain biological activity. Aeration is via venturi aerators.
2. Methanol or similar is dosed as a supplementary carbon source to provide food to the biological process. The source of dosed carbon for this has not been confirmed but this could also be Ethanol, Acetic acid, Liquid Sugar or Sodium Acetate. This will be defined in the next design phase. The current design enables bulk handling of different chemicals that can be used.
3. Citric Acid is used to remove inorganic scaling from the membrane surfaces through a Clean-in-Place (CIP) process.
4. Sodium hypochlorite is used to remove organic fouling from the membrane surfaces through a CIP process.
5. Headworks screenings are collected in a skip for removal to landfill
6. Dewatered sludge is collected in a skip for removal to landfill.
7. The irrigation tank has automatic aeration to minimise odour both at the plant and during irrigation.
8. The odour removal system draws potentially foul air from the screens, Equalisation tank, SBR Reactors, Irrigation tank and the dewatering system. The foul air passes through a biological bark filter which effectively removes offensive odours.

Headworks Screening and Grit removal

Wastewater entering the facility is directed to the headworks system, where screening equipment is designed to accommodate the full hydraulic load of the site, including peak flow events.

Once inside the system, the wastewater passes through a tank equipped with a screw compactor and a fine screen. This screen filters out solids larger than 2mm. As these solids build up on the screen, they can impede flow, causing the water level in the tank to rise. A level sensor monitors this change, and when a set threshold is reached, it activates an automated cleaning cycle for the screen.

The collected screenings are compacted and dewatered within the screw mechanism, then discharged into sealed wheelie bins for off-site disposal. During full operational periods, these bins typically require emptying every one to two weeks.

After screening, the effluent moves into a grit sedimentation channel, where heavier grit particles settle at the bottom. A horizontal screw conveyor transports the grit to an extraction chamber, where it is lifted, washed, and dewatered before being deposited into a second sealed bin. This bin is generally emptied once or twice per month under full production.

To ensure effective containment and odour control, the wheelie bins are fitted with sealed chutes through their lids. The headworks screens are mounted on a sealed concrete base that drains into a sump, which then pumps the wastewater to the treatment plant. Heavy-duty plastic liners are used in the bins, and a duty-standby setup ensures that a replacement bin is always available. Once a bin is full it can be removed for disposal

Equalisation Tank

The 1500 m³ equalisation tank serves as a critical buffer between the incoming screened wastewater and the downstream Sequencing Batch Reactors (SBRs). Its primary function is to smooth out fluctuations in flow and load, ensuring a consistent feed to the biological treatment process. During peak inflow periods, excess wastewater is temporarily stored in the tank and gradually released during low-flow periods. This flow equalisation helps maintain optimal operating conditions in the SBRs, preventing hydraulic overload and enhancing biological performance. The tank is equipped with mixers to prevent solids settling and odour generation.

SBRs

The plant includes two 1000 m³ Sequencing Batch Reactors (SBRs), which operate in alternating cycles to treat the wastewater biologically. Each SBR follows a sequence of phases:

- Mixed Fill/Anoxic Phase: Wastewater is introduced and mixed without aeration, promoting denitrification by encouraging facultative bacteria to reduce nitrates to nitrogen gas.
- Aerated Phase: Air is supplied via blowers to maintain aerobic conditions, supporting the breakdown of organic matter and nitrification (conversion of ammonia to nitrate). Some alkalinity addition may be required as this step consumes alkalinity.
- Anoxic Phase: Aeration stops and mixing continues, allowing denitrification to occur. Carbon dosing is typically required to drive this process.
- Settle Phase: Mixing stops, allowing solids to settle and form a sludge blanket.
- Decant Phase: The clarified supernatant is decanted and transferred to the membrane tank for further treatment.

Cycle durations can be adjusted based on influent characteristics and flow rates. During high flow periods, shorter cycles with increased aeration may be used to maintain treatment efficiency. During low flow periods, extended anoxic phases can improve nitrogen removal. This flexibility allows the system to achieve reliable nitrification and denitrification under varying conditions.

The SBRs will have a roof and an exhaust lines under negative pressure feeding the bio filter.

Membrane Ultra Filtration

Effluent from the SBRs is polished using tubular, pressure-driven ultrafiltration membrane modules. These membranes provide a physical barrier that removes suspended solids, bacteria, and viruses, producing high-quality permeate. The modules operate under low fouling conditions and are periodically cleaned using Clean-in-Place (CIP) procedures. The membranes offer excellent pathogen removal, typically achieving log reductions of 4–6 for bacteria and viruses, making the effluent suitable for reuse or safe discharge.

UV Disinfection

Following membrane filtration, the treated wastewater undergoes ultraviolet (UV) disinfection. The UV system uses high-intensity lamps emitting light at 254 nm, which penetrates microbial cells and disrupts their DNA, rendering them inactive. This step provides an additional barrier against pathogens, ensuring that any remaining bacteria or viruses are effectively neutralised. The UV system is designed to handle peak flow rates and includes sensors to monitor lamp intensity and water clarity, ensuring consistent disinfection performance.

Sludge Dewatering

Waste sludge (WAS) from the SBRs and membrane system is pumped to the dewatering shed, where it is processed using a high-speed centrifuge. Polymer is dosed to enhance solids separation, resulting in a dewatered sludge cake with approximately 18% solids content. This cake is collected in skips and sent to landfill for final disposal. The dewatering system is housed in a purpose-built shed to contain noise and odour, and includes ventilation and drainage systems to maintain a clean working environment.

Calculated Sludge Volumes

LIne	Daily Kgs of BOD5	Daily Kgs of WAS (dry)	Daily Kgs of WAS at 18% Solids
1	**415**	**415**	**2307**

Table 12: Calculated daily sludge volumes for off site disposal

Without exhaustive research, it appears the closest and most convenient landfill to receive the dewatered sludge will likely be Kings Bend Winton.

Typically, we would look at other options but these are limited in this location

	Option	Location	Distance Kms	Comment
1	Landfill	Kings Bend Winton	160	
2	Anaerobic Digestion	Green Island Dunedin	258	
3	Incineration	Tahuna Dunedin	264	See below
4	Cut and carry Biomass	N/A	N/A	See below.
5	Composting or Vermiculture	Unknown	N/A	See below

Table 13: Sludge disposal options

There is no doubt that landfill is far from an ideal solution for the disposal of this material however, geographically, there are understood to be very limited options in proximity to the site for this disposal other than landfill. Dunedin City Council (DCC) certainly operates both

Anaerobic Digestion facilities and Incineration facilities but it is unlikely that DCC will accept material from outside their geographical territory for these facilities and the transportation would be prohibitive.

The is no evidence of any interest in establishing Cut and carry operations in the lower South island. This technology has strong interest in the North Island currently however working operations are at Pilot or research scale. Likewise with composting and vermiculture. The use of WAS material in either composting or Vermiculture needs significant dilution with other substrates, once processed, there are also limited markets for reuse of this material with the human waste content.

Odour Removal

Odorous air from the screenings area, equalisation tank, SBR reactors, irrigation tank and sludge dewatering shed is extracted and treated using a bark-filled biological filter. This filter uses natural microbial communities living in the bark media to biologically degrade odorous compounds such as hydrogen sulphide and ammonia. Compared to activated carbon or chemical scrubbers, biological filters offer lower operating costs, reduced chemical use, and sustainable performance. The bark media is periodically replaced to maintain efficiency, and the system is designed to handle variable airflows without compromising treatment. The Biofilter is sectioned to enable rotation of duty and also accommodate maintenance and media replacement.

Irrigation Tank

The 1500 m^3 irrigation holding tank stores fully treated wastewater prior to land application. It acts as a buffer between the treatment plant and the land treatment system, allowing for controlled discharge based on irrigation schedules and soil absorption capacity. The tank is equipped with level sensors and automated valves to regulate flow, ensuring that the land treatment system receives consistent volumes without overloading. This helps protect groundwater and maintain compliance with environmental discharge limits. The Irrigation tank is covered with a exhaust line under negative pressure to the bio filter for Odour Control.

There are also two additional 1500m3 tanks which have been designed to operate as backup irrigations storage but they can also be converted to SBR reactors at a later date to accommodate capacity expansion.

Irrigation Pumps

The location of the irrigation land is approximately 2 kilometres from the plant. At the highest point, the elevation of the rising main to the irrigation network is 360 metres. A target flow rate of 60m3/h has been used to establish the required infrastructure enabling some excess capacity to provide contingency.

Three pumps each capable of 30m3 per hour with a pressure capability of 380 metres has been allowed for to feed into two 104mm rising mains (duty standby) or alternatively 3 x 80mm rising mains requiring two lines to be available to meet peak flow at any time.

The 3 pumps each sized at 50Kwatts will rotate duty so that there are 2 on duty with the third either in maintenance or in standby mode.

Backup Generator

A generator has been sized to cover peak electrical demand

LIne	Description	Installed Duty kW
1	Inlet works	4
2	Feed pumps	10
3	Internal Pumping	4
4	Aeration	55
5	Mixing	20
6	Decant Pumps	22
7	Membranes	22
8	Dewatering	15
9	Odour Control	4
10	UV	1
11	Discharge to Irrigation	110
12	Miscellaneous	5
	Total	**272**

Table 14: Power demand table

Terra Power Systems (Caterpillar) have provided a recommendation and specifications for a suitable standby Generator.

Terra Power Systems have recommended a 400KVA Diesel fired unit which comes as a containerised unit with on board Diesel storage. An Additional external tank will be required to meet the targeted 24 hours of operational capacity.

ODOUR MANAGEMENT

There are a number of potential odour sources within the WWTP. The table below lists the potential sources and appropriate mitigation measures to ensure that no offensive odours are detectable beyond the boundary of the WWTP.

Source	Odour Potential	Mitigation Measure
Screening and grit Removal	Raw sewage and screenings which have high potential for odour generation	The screen and grit channel are covered and connected to the odour removal system. This operates under negative pressure prevent odour from escaping. Bins receiving screenings and grit are fully enclosed.
Equalisation Tank	Raw screened sewage has a high potential for odour generation	The Equalisation Tank is covered and connected to the odour removal system. This operates under negative pressure prevent odour from escaping.
SBRs	There is a limited potential for odour generation under anaerobic conditions.	Wastewater within the SBRs is highly oxygenated during the aerobic phases preventing offensive odour generation. Anoxic phases are cycled for short duration to prevent the formation of true anaerobic conditions which could give rise to offensive odours. However given the sensitivities of the nearby proposed urban development and the need to minimise temperature loss, the reactors will be covered and exhaust passed through the Bio filter.
WAS Tank	There is a high potential for odour generation under anaerobic conditions.	The WAS Tank is covered and connected to the odour removal system. This operates under negative pressure prevent odour from escaping. The sludge is aerated within the tank to prevent it turning anaerobic.
Membrane Feed Tank	Treated wastewater with low TSS and residual BOD has a low potential for odour generation	This is fully enclosed limiting the escape of any potential odour
Membrane filters	Minimal risk	Membranes are fully enclosed and sealed

Source	Odour Potential	Mitigation Measure
Dewatering Building	Thickened sludges have high potential for odour generation.	Centrifuges and bins are enclosed and directly connected to the odour removal and treatment system. This operates under negative pressure prevent odour from escaping. The building itself is also connected to the odour removal and treatment system.
Irrigation tank	Low Risk	The irrigation tank contains wastewater treated to a high standard with minimal solids and organic content meaning the risk of odour generation is very low. However, it has been recommended that some odour mitigation be considered so automatic aeration triggered by ORP measurement and exhaust capture and treatment by the Biofilter has been added.

Table 15: Potential odour sources and proposed mitigation

The odour containment and treatment system draws of air and foul odours from a number of sources:

- Screening and Grit Removal
- Equalisation Tank
- WAS Tank
- SBR reactors
- Irrigation tank/s
- Dewatering Centrifuge
- Dewatering Building

The air is pulled through ducting by centrifugal fans and delivered to a biological odour scrubber. The scrubber uses bark chips is a passive biofiltration system that treats odorous air by passing it through a bed of organic media—typically bark or wood chips. Microorganisms naturally colonize the media and biologically degrade odorous compounds such as hydrogen sulphide, mercaptans and ammonia. These systems are low-maintenance, cost-effective, and well-suited for treating odour loads from wastewater treatment processes.

The odour containment and treatment system will be designed using first principles of biological wastewater treatment:

- As much as possible, odour sources are contained and vented to the odour ducting system. Air inlets into the vented process units have been designed with adequate path lengths to eliminate fugitive emissions from wind gusts.
- Each odour point-source has its own flow control valve to enable efficient balancing of the odour extraction system.
- The odour fans have been designed with 100% redundancy and connected to the back-up generator to ensure uninterrupted operation.
- Online pressure monitoring in the odour ducting system will alarm during out of normal conditions.
- Air humidification upstream of the biofilter will ensure optimum uniform moisture conditions throughout the biofilter bed.

The biofilter will be constructed, operated and maintained to ensure:

- A bed depth of at least 1.4 m (including gravel layer)
- A filter medium that is visibly damp below the surface with a moisture content of generally between 50% and 70% on a dry weight basis; water application will be set manually, however a pre-humidifier will be installed upstream of the biofilter inlet to ensure air reaches the bottom of the bed in a humidified state.
- An inlet temperature of generally less than 35°C;
- A pressure drop of generally less than 200mm water gauge and monitored by a pressure gauge;
- An even distribution of air flow through the filter bed;
- There is no bypass of untreated air around the sides of or through fissures in the filter bed; and
- An operating pH in the range of between 5 and 8 (following an initial weathering period).
- The biofilter will have segregated cells to enable rotation of operation and the ability to take cells off line for maintenance or media replacement

Physical Plant Description

An area of approximately 3000 m^2 has been set aside for the WWTP. This has been offset 50 m away from the boundary of any residential lot and 25 from the boundary with neighbouring farmland. The plant will be surrounded on the north and west by green belt of trees. On the south and east side the plant will be obscured from view by existing shelterbelt trees.

The plant itself will be enclosed in a 2m high chain link fence with a lockable double access gate.

The surface of the whole area, apart from tanks, buildings and equipment slabs, is compacted gravel hardstand.

An area of approximately 750 m^2 has been set aside for potential addition of SBR tanks in order to allow expansion of the plant to accept wastewater from outside development, for example Arrowtown.

A layout showing key components is shown below.

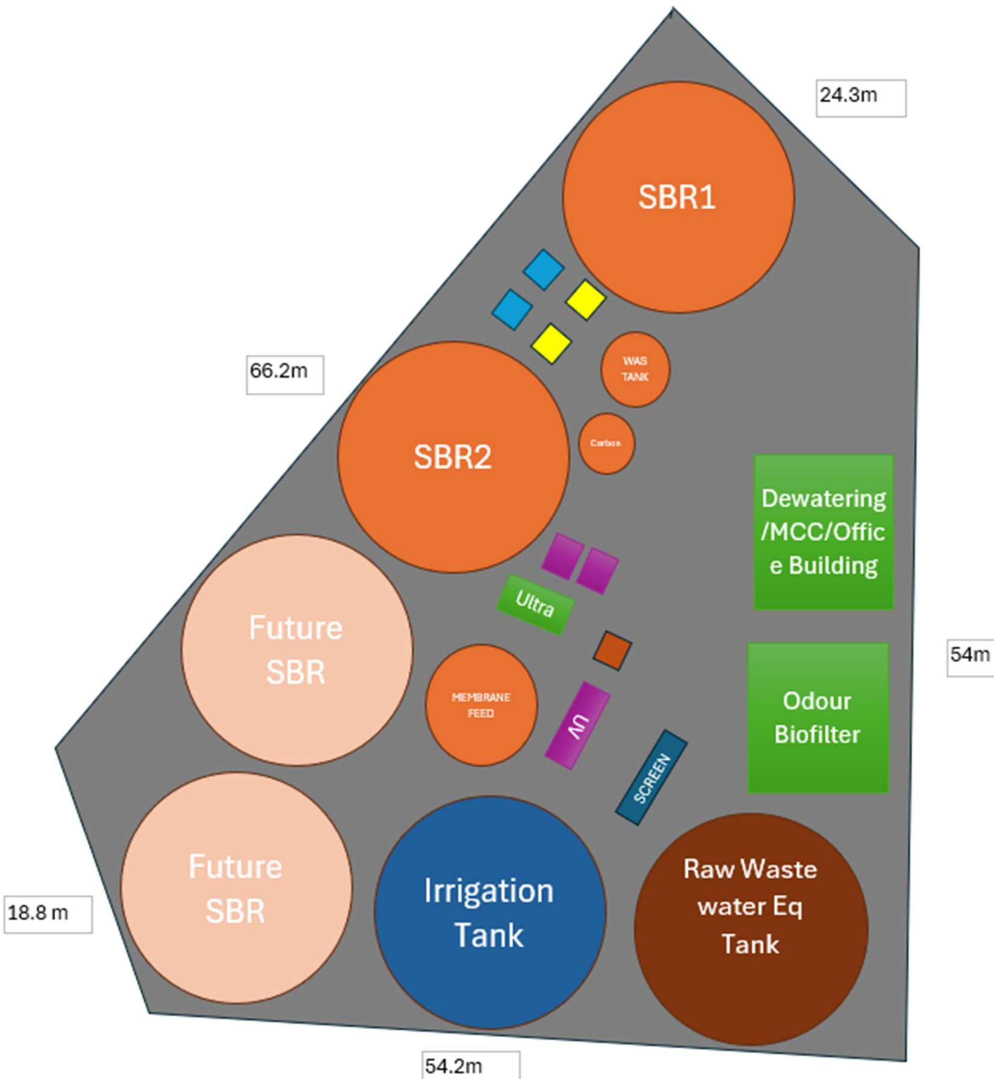


Figure 6: Preliminary Layout of the WWTP.Note: Future SBR tanks to be used as backup irrigation storage initially.

Key Structures

Main Plant Building. The main plant building houses the dewatering equipment, a small workshop, a small office for use as a control room, a small room for the preparation and sometimes analysis of wastewater samples, as well as an MCC room for the housing electrical panels. As the building will be housing centrifuges which can be noisy the building will be suitably lined with noise attenuating liner.

Equalisation Tank. The Equalisation Tank will be a covered, sealed and bolted steel panel tank or Spiral double folded seam tank with a height of 8.5 m. It is sized to hold up to 1500 m^3 of wastewater. The Equalisation Tank will be sealed and vented to the odour treatment system. The purpose of the balance tank is to buffer peak flows and allow even flows to the SBRs.

SBRs. There are two SBRs which received raw wastewater from the Equalisation Tank. They will both be open topped bolted steel tanks or Spiral double folded seam tank with stair access to the top. These are each designed to hold up to 1000 m^3 and will not exceed 6.5 m in height.

Membrane Feed Tank. The Membrane Feed Tank holds treated wastewater prior to being pumped through the membrane filters. will be a covered, sealed and steel or stainless steel tank with a height of 5.5 m. It is sized to hold up to 250 m^3 of wastewater

WAS Tank. The WAS Tank holds waste activated sludge prior to being pumped to the dewatering centrifuge. It will be a covered, sealed and bolted steel panel tank with a height of 5.5 m. It is sized to hold up to 100 m^3 of Sludge. The contents will be aerated and air from this process will be sent to odour treatment system.

Irrigation Tank. The Irrigation Tank will be a covered, sealed and bolted steel panel tank or Spiral double folded seam tank with a height of 8.5 m. It is sized to hold up to 1500 m^3 of treated wastewater. The purpose of the balance tank is to buffer peak flows and allow even flows to the irrigation system.

Future SBRs. The future SBRs will be constructed within the current phases of this development so that they can be utilised as backup storage for treated wastewater awaiting irrigation. This is to provide a volumetric buffer for maintenance windows or interruptions to irrigation triggered by weather. If and when the need develops, these two vessels can be converted to batch reactors to increase the plant capacity.

Odour Biofilter. This is a multi cell rectangular wooden structure approximately 1.6 m high. It is filled with bark and wood chips which act as a media for odour reducing microbes. The various facilities connected to the biofilter operate under negative air pressure maintained by extraction fans

TREATED EFFLUENT CONSENT LIMITS

Overview

This particular application is unique, as this is a greenfield urban development requiring its own water and waste-water infrastructure. Typically, a process like this would be being built for an existing community with allowance for expansion. There would also be historic data of residential occupancy and waste-water volumes and character. In the case of a new development, there is no occupancy data or waste water data. The other issue is that the development doesn't all come on line all at once so waste water volumes build over the lifetime of the development. The actual waste water load to be generated by this development and treated through this process wont be known for sure until the development is completed and all properties are sold and occupied.

To overcome this, models are used to provide a projection of occupancy and the resulting waste water to be generated. The limitations of models need to be recognised. These are theoretical projections, something that needs to be kept front of mind when reviewing.

The next issue this unique situation presents is that the volume and load of waste water builds slowly over the development period. The construction of the waste water plant is designed to process the peak load of the full development and although, one of the features of the SBR technology is the level of turndown that it is capable of, the reality is that performance of this plant will not be optimum with the reduced loads. The plant will still produce a high quality effluent but will fall short of the targeted outputs prescribed in the Executive summary. With this in mind and considering that the treated waste water is being irrigated rather than discharged to water some options for flexibility with consent limits should be considered.

1) Target mass loads as the primary limit with concentrations as an upper limit restriction.
2) Weekly flow proportional sampling for compliance purposes
3) Annual compliance is based on the following:
   Median value of the weekly compliance results below the limit applying to kgs/day of load from each parameter and flow volume per day.
   The concentration limit is a maximum value based on a 95 percentile of the weekly data.
4) Reporting should be a quarterly progress report followed up with an annual compliance report.

The targeted treatment levels in the executive summary are ambitious and it is anticipated that once operating at optimum, the plant will achieve these levels regularly. It does need to be acknowledged that this is a biological process which will at times not behave quite to expectations therefore, it is essential that consent limits are set with this in mind particularly in light of the development program running over a number of years with specific development phases identified . Given that the treated waste water will be applied to land, the requirements for very low CBOD5 and TSS become less significant than if discharged to water as is reflected in the National waste water standards.

Considering this, the limits in tables 16 to 20 reflect a high level of treatment for the application while still being achievable for the process in the majority of circumstances during the phased development.

Note: Phase 1 not only covers the biological startup phase of the wastewater treatment plant, it will also cover a period when there will be minimal volumes from typical residential occupancy, the loads will be small, concentrated to the working hours of the day and dependent on the number of contractors working on site on any given day. Saturdays and Sundays will likely have effectively zero load. As such, concentrations are likely to be highly variable yet still within the limits of the mass load. As phase 1 reaches its conclusion, the background residential load will stabilise this hence concentrations can be applied to phase 2.

Table 16: Phase 1 proposed Consent limits.

Parameter	Kgs/day Median	Mg/l 95 % ile
cBOD	3	
TSS	6	
TP	6	
TN	9	
NH3	3	

Parameter	Count
E Coli (Cfu/100 mL)	10

Table 17: Phase 2 proposed Consent limits.

Parameter	Kgs/day Median	Mg/l 95 % ile
cBOD	3	15
TSS	6	10
TP	6	10
TN	9	25
NH3	3	10

Parameter	Count
E Coli (Cfu/100 mL)	10

Table 18: Phase 3 proposed Consent limits.

Parameter	Kgs/day Median	Mg/l 95 % ile
cBOD	6	15
TSS	10	10
TP	10	10
TN	12	10
NH3	6	8

Parameter	Count
E Coli (Cfu/100 mL)	10

Table 19: Phase 4 and 5 proposed Consent limits.

Parameter	Kgs/day Median	Mg/l 95 % ile
cBOD	6	9
TSS	12	10
TP	12	8
TN	12	10
NH3	6	8

Parameter	Count	
E Coli (Cfu/100 mL)	10	

Table 20: Anticipated peak flow rates across the 5 phases of project development through to completion

Parameter	Flow m3/day Average	Flow m3/day 95%ile
Phase 1	75	178
Phase 2	192	373
Phase 3	330	570
Phase 4	487	766
Phase 5	664	963
Completion	890	1204

Tables 16,17,18 ,19 and 20 layout viable consent limits during the initial start up of the plant and the phasing of the development. This provides sufficient protection to the receiving environment while also providing sufficient flexibility during the initial phases of the development to accommodate both the initial startup of the waste water treatment plant and the light volumes and loads.

Compliance measurement will be undertaken at the discharge from the irrigation tank. Prior to the irrigation transfer pumps. This will be an automated function with flow measurement via mag flow meter and sampler via autosampler. Samplers will be refrigerated during collection to reduce sample deterioration. COD (chemical oxygen demand) analysis will be undertaken on site to initially as a quick check. After a confirmation period of comparison with CBOD5, applicant may pursue the option of COD/CBOD5 ratios to determine CBOD5 with periodic CBOD5 analysis checks to confirm relationship. COD testing will be part of in process testing of plant performance and control and will serve as early warning if concentrations are increasing.

Consent review:

Its is suggested that no review should be required in the first 2 years of operation. There will be very little load getting to the plant until the second half of year one. At the end of year 2, Phase one of the development should be completed, and Phase 2 should be coming on line making the end of year two the ideal time for the first review. Consent reviews should be undertaken at the end of year 4 and year 6. Part of the year 6 review should be a decision regarding frequency of ongoing consent reviews.

TREATED EFFLUENT DISCHARGE

Overview

Refer WGA land treatment and Hydrogeology report.

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Appendix 1

Waste water treatment options review

Treatment Technology Assessment

A wide range of technologies were considered for use in the wastewater treatment plant. These technologies are described and discussed below.

Flow-through Activated Sludge (AS) Processes

The activated sludge (AS) process is a widely used biological wastewater treatment method: the wastewater is aerated to promote the growth of microorganisms that degrade organic matter, followed by clarification to separate and recycle sludge. It can be configured in many ways to achieve removal of BOD (biochemical oxygen demand), nitrification (conversion of ammonia to nitrate), denitrification (removal of nitrate) and phosphorus removal. Variations include plug-flow or completely mixed reactors, aerobic and anoxic zones, and selective recycle of sludge.

Standard systems are typically constructed in rectangular concrete tanks and use diffused-air aeration (though surface aerators can also be used). Common nutrient-removal variants include the Bardenpho and MLE systems, which incorporate both anoxic and aerobic stages for simultaneous nutrient and BOD removal; they require clarifiers to recycle sludge back into earlier treatment zones.

However, because these reactors have fixed volumes, they are not sufficiently flexible when flows or wastewater composition vary significantly over time. For example, low flows can lead to excessive residence time in the clarifier, creating anaerobic zones and causing the clarifier to “flip”. Fixed volumes of anoxic and aerobic zones cannot easily adjust to changes in influent composition or flow.

In addition, bespoke AS systems are often expensive—large square concrete tanks and complex operational arrangements raise capital and operational costs. For these reasons, flow-through AS systems are considered not appropriate for the proposed application.

Sequencing Batch Reactor (SBR)

The SBR is essentially an aerated activated sludge basin in which the reaction and settlement steps occur in the same tank. The cycle proceeds through fill, react (aeration), settle, decant. As with AS, suspension of biomass and aeration drive the process, which means higher energy requirements than simpler pond systems. With retention times under a day, SBRs have a smaller footprint, but they are more susceptible to biomass wash-out if operated improperly.

Advantages are:

- Cost-effective compared to some alternatives
- Robust process
- Small footprint
- Moderate sludge production

- Easily configurable for BOD removal, nitrification, denitrification and enhanced phosphorus removal
- Requires skilled operators for tuning.

Disadvantages:

- A greater degree of automation is required to ensure biomass concentrations respond correctly to hydraulic and organic loads.
- There are higher capital costs due to increased aeration requirements.

An example of a typical SBR cycle for nitrogen removal is shown in the figure below.

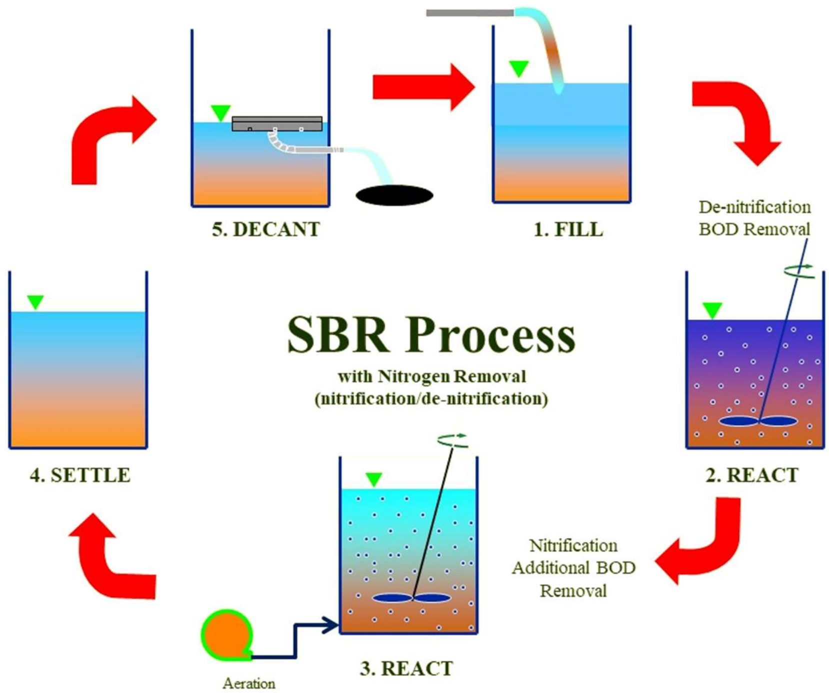

Figure 3: Example SBR Cycle.

Pond Systems

For facultative pond systems, sizing is often based on areal loading rates (e.g., ~120 kg BOD/ha/day in summer, ~80 kg BOD/ha/day in winter), with primary treatment reducing the organic load to the pond.

Features:

- Low energy requirement compared to AS
- Low operator input
- Cost-effective
- Less sludge production than AS systems
- Few mechanical/electrical components
- Low O&M costs
- Large land footprint and land requirement

Disadvantages: ponds are prone to freezing in harsh winters; they may suffer spring turnover—bottom sludge rising and floating, causing odours—and algal blooms in summer. Effluent quality can be very variable. If used for untreated effluent, for this project an area on the order of ~8 ha would be required. For these reasons a pond system is not recommended for the development.

Membrane Bioreactor (MBR)

MBRs combine membrane filtration (micro- or ultrafiltration) with an activated sludge process. Two main configurations: submerged (membrane inside reactor) or side-stream (membrane after biological stage).

Advantages:

- High quality effluent: very low TSS (total suspended solids) — often <2 mg/L
- Independent control of solids retention time (SRT) and hydraulic retention time (HRT) because biomass is retained by the membrane
- Small footprint because high biomass can be maintained in a small volume
- Robust to load variations

Disadvantages:

- High capital and operational costs
- At low temperatures, membrane flux (and hydraulic capacity) drops significantly; this can coincide with peak hydraulic loads (e.g., ski-season) so capacity may be compromised
- At low temperatures, activated sludge can break apart to pin flocs, causing membrane fouling and risk of overflow
- Membrane fouling/clogging: requires regular cleaning and maintenance
- High energy consumption (especially if air scouring is used)
- Operational complexity: more sophisticated automation and control required; chemical cleaning often needed.

While MBRs produce excellent effluent quality, the technology is only recommended if final discharge is to surface waters and is not recommended if discharge is to land because of the high cost and operational risk during cold periods.

Moving Bed Biofilm Reactor (MBBR)

An MBBR uses plastic carrier media in an aeration tank to support biofilm growth, combining advantages of both activated sludge and fixed-film technologies.

Advantages:

- High biomass concentration in a smaller tank → reduced footprint, increased removal efficiency
- Process performance is not solely dependent on sludge retention time
- Increased process stability
- Short retention period (often <4 hours)
- Better resilience to shock loading

Disadvantages:

- When nutrient removal is required, multiple tanks may be needed (for BOD removal, nitrification, denitrification) — complexity increases
- Effluent TSS quality is not as good, so clarifiers and possibly filters are typically required as a polishing step

- Because of the short retention times, MBBR is usually only suited to wastewater that has undergone primary treatment.

Given those constraints, MBBR is only suitable if the influent is pre-treated.

Rotating Biological Contactor (RBC)

The RBC is an attached-growth treatment system: slowly rotating discs (around 3 rpm) are partially submerged in the wastewater; as they rotate, biomass grows on the disc surfaces and is alternately immersed and exposed to oxygen, so no forced aeration is required. Modular units allow seasonal variation management.

Advantages:

- Compact, modular, extendable
- Low noise and odour nuisance
- Simple, rapid and economical installation
- Short hydraulic residence times
- Reliable attached-growth process adapted to organic/hydraulic load variation
- Minimal operation and lower energy cost (suppliers claim ~30% of AS system energy cost)

Disadvantages:

- Start-up issues may occur when high flows suddenly arrive (e.g., summer holiday flows) — some capacity may be idle in off-peak months and require management (pre-seeding)
- Not suitable for raw wastewater requires primary treatment
- More prone to flies/insects and odours compared to submerged growth systems Nevertheless, RBC has been used in alpine resorts in North America and Europe and is a potential candidate for this application.

Biological Trickling Filters

In a trickling filter, wastewater is distributed over a bed of media (rocks, high-surface-area plastic media or fabric sheets). A biofilm develops on the media surface; ambient air flows through the reactor, providing oxygen to the biofilm. Denitrification occurs deeper in the media (low oxygen), nitrification nearer the air/water interface.

Advantages:

- Low energy requirement relative to AS
- Low operator input
- Modular and expandable
- Small footprint if plastic media are used
- Less sludge production than AS
- Low mechanical/electrical componentry
- Low O&M cost

Disadvantages:

- Because the filter relies on ambient air, the reactor temperature tends to follow ambient; in harsh cold conditions treatment can drop off (freezing risk, cooling effect of air evaporation)
- Trickling filters can respond slowly after extended low use, since biomass sloughs off and repopulation can take weeks

- Effluent quality is not high in TSS; often clarification is required

Due to the operational uncertainties under variable organic/hydraulic loads and risks during cold periods, trickling filters are not recommended for this application.

Integrated Fixed-Film Activated Sludge (IFAS)

IFAS combines conventional activated sludge and biofilm technologies in one reactor. Media (carriers) are introduced in specific zones within the AS process; IFAS can also be integrated into SBR systems. It supports two biological populations: mixed liquor suspended solids (MLSS) degrade organic matter, while the biofilm supports a strong nitrifying population enabling nitrification of ammonium. Biofilm enables anaerobic, aerobic and anoxic zones to exist together in one stage.

Advantages:

- Improved nitrification and denitrification compared to simple suspended growth systems
- Smaller footprint than comparable AS plants
- Increased process stability
- Reduced sludge production
- More resistant to organic and hydraulic shock loads
- Better resistance to temperature fluctuations (especially in covered installations)

Disadvantages:

- May require more aeration and mixing to ensure free-floating media are well distributed
- Higher capital cost
- Requires specialized knowledge and expertise to operate
- Specialized replacement parts required

Due to the operating complexities of this type of plant, IFAS is not recommended for this application.

Aerobic Granular Sludge (AGS)

AGS is a relatively new technology that uses granular biomass (rather than flocs) to treat wastewater. Usually run in SBR configuration, the granules nicely settle and allow good effluent quality with low TSS. Advantages include simultaneous removal of carbon, nitrogen and phosphorus, fast settling, and smaller footprint compared to conventional AS systems. The idea is similar to IFAS but AGS does not require carrier media. It is already operating in >70 plants worldwide.

However, AGS requires very skilled operators to develop the granules with the correct properties for nutrient removal and settleability. Because of these operational challenges, AGS is not recommended for this application.

Anammox Process

The anaerobic ammonium oxidation (Anammox) process is a biological treatment where ammonium and nitrite are converted directly to nitrogen gas under anaerobic conditions by specialized bacteria. It is highly efficient in nitrogen removal and uses less energy and produces fewer greenhouse gas emissions than conventional nitrification/denitrification routes. It can be integrated into existing activated sludge processes (e.g., IFAS, AGS, SBR). Although around 200 full-scale plants are operating worldwide, the slow growth rate of Anammox bacteria and the high level of operational control required mean this technology is not considered suitable for this development.

Membrane Aerated Biofilm Reactor (MABR)

The MABR uses a membrane (typically gas-permeable) on which a biofilm grows; oxygen diffuses directly through the membrane from the air side to the wastewater side, eliminating the need for bubble aeration (hence potential energy savings). The single-tank, small-footprint design allows modular retrofits and easy integration into existing plants; MABRs are particularly effective for nitrogen removal through simultaneous nitrification and denitrification. Although promising, this technology is newer and has had limited application in cold climates.

Summary of Secondary Treatment Technologies

The table below provides a summary of potential technologies and their suitability.

Table 2: Technology summary and evaluation.

Technology	Suitability	Reason
Flow through Activated Sludge	No	• High capital cost • Fixed volumes not suitable for variable flows • Complexity
SBR	Yes	• Provides nutrient removal, • Resistant to variable loads, • Suitable for cold temperatures • Integrated clarification • Can be used in tanks or basins
Ponds	No	• Variable performance during cold periods. • Potential for flipping during Spring
MBR	Potentially	Has possible application as an add on but is high risk due to low flux during cold periods
Trickling filters	No	High risk during cold periods
MBBR	Yes	• Provides nutrient removal, • Resistant to variable loads, • Suitable for cold temperatures • Can be used in tanks or basins • Requires primary treatment
RBC	Yes	• Provides nutrient removal, • Resistant to variable loads, • Suitable for cold temperatures • Requires primary treatment
IFAS	Potentially	Could be integrated into an SBR system
AGS	No	Requires specialised operation and biomass development
Annamox	No	Requires specialised operation and biomass development
MABRs	Potentially	Has possible application as an add on but is high risk due to low flux during cold periods

Based on these investigations a short list of three technologies, SBR, MBBR and RBC, were identified as being suitable for this application. These options were then rated for footprint, effluent quality and ease of operation. A tank based SBR system achieved the highest score so has been selected for this project.

Table 3: Comparison scoring for WWTP options.

	Footprint (m2)	Effluent BOD/TSS/TN	Ease of Operation	Total Score
MBBR	1300	20/20/10	Medium	
Score	3/5	13/20	7/10	**23**
SBR (tank)	1500	10/15/8	Skilled	
Score	3/5	16/20	6/10	**25**
SBR (basin)	2400	10/15/8	Skilled	
Score	2/5	16/20	6/10	**24**
RBC	1400	20/30/20	Medium	
Score	3/5	12/20	8/10	**23**

In order to achieve a higher level of treatment SBR filtration is required to remove residual solids. Ultra-filtration membranes are considered to be the most effective way of achieving this. Using the membranes for polishing maintains the flexibility of the SBR system which a standard MBR could not achieve. Reduced solids loading on the membranes compared to that in a conventional MBR system result in a higher achievable flux (membrane throughput) and reduced risk of membrane fouling.

Appendix 2

Generator Specification