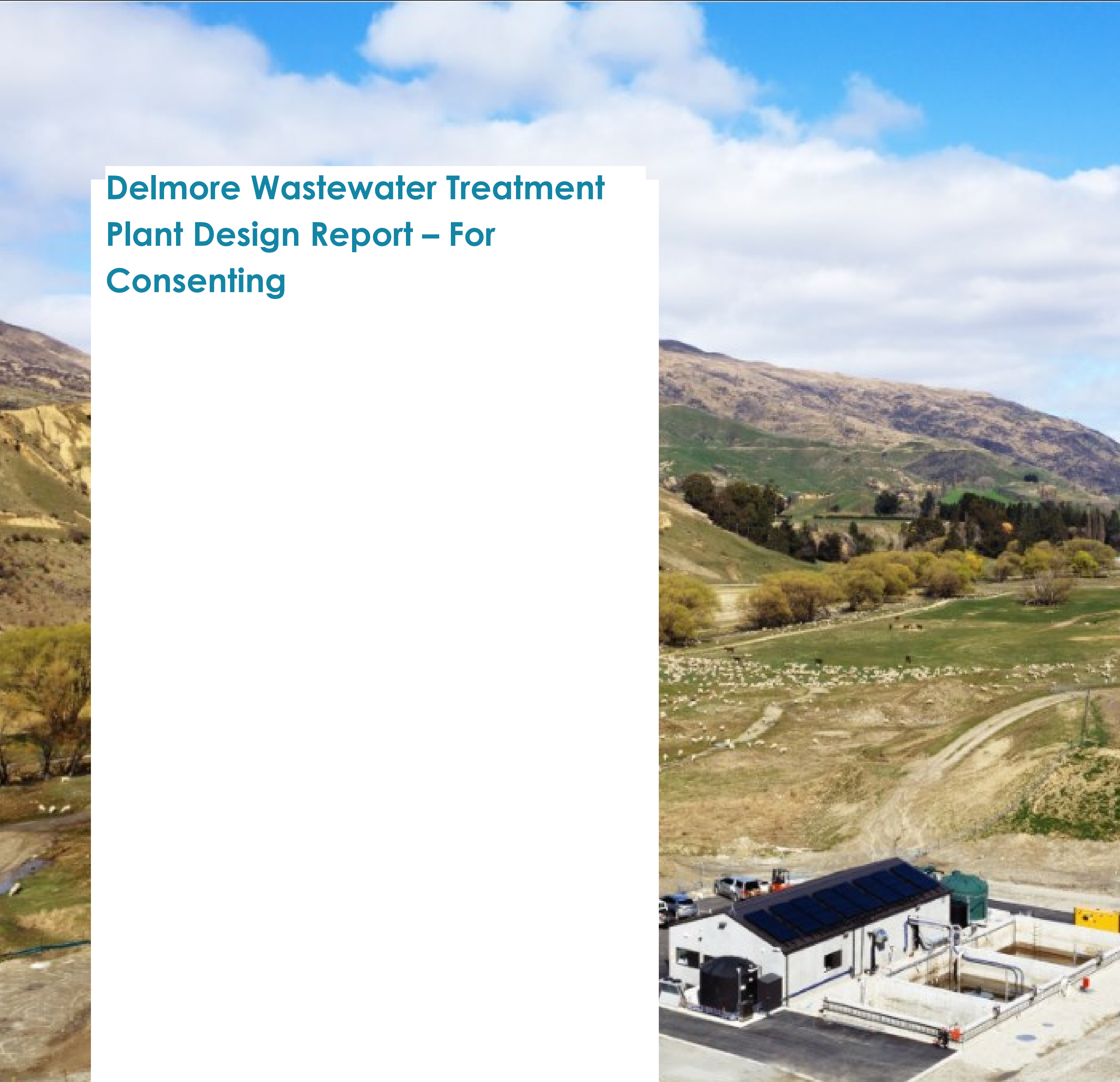

Delmore Wastewater Treatment Plant Design Report – For Consenting

11th February 2025

Apex Water

Apex Water

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Contents

Executive Summary

The Delmore land development project spans 109-hectares and upon completion shall provide approximately 1250 new residential lots and dwellings in the Wainui-Ōrewa region. Apex Water have been engaged to provide wastewater design services for private on-site wastewater treatment and discharge infrastructure, to support the planning and consenting stages of the proposed Delmore development.

The proposed treatment plant will employ a hybrid biological nutrient removal system, featuring a 4-stage Bardenpho activated sludge treatment process, a Membrane Aerated Biofilm Reactor, Hollow Fibre Ultra-filtration membranes and Reverse Osmosis membranes to produce exceptionally high-quality permeate. This system is designed to treat wastewater to such an extent that there are various applications for beneficial re-use.

The overall timeline for the design and construction phases is estimated to be 18 months. This includes the stages from contract award through detailed design, procurement, construction, commissioning, training, and project handover. This timeline is contingent on various assumptions (such as the NZS 3916 D&B contract) and potential project risks.

The treatment process itself encompasses several stages: raw sewage screening, feed and flow balancing, an anoxic stage with the membrane aerated biofilm reactor, an aerobic stage, a second anoxic stage, hollow fibre membrane filtration, and UV disinfection. The system also includes recycle loops (for nitrate and activated sludge) and chemical dosing to provide a supplementary carbon source, adjust pH, and remove phosphorus. This treated wastewater stream is further polished by Reverse Osmosis membranes, providing a resultant water quality that has a nutrient profile an order of magnitude lower than both typical drinking water and a literature derived representation of typical stormwater runoff as obtained from the Urban Runoff Data Book (Williamson, 1993). The resulting treated wastewater discharged from this system would be amongst the highest quality found in New Zealand, utilising a similar treatment train that is used in other countries for drinking water re-use of sewage, however this is not proposed by this report due to the aesthetic and cultural concerns around this type of re-use in New Zealand. The system has two main waste streams, sludge and Reverse Osmosis reject. Sludge shall be held in storage tanks, where it is dewatered using a centrifuge before being removed from the site in skips. There are various potential applications for the reject stream from the reverse osmosis plant including municipal irrigation, or discharge to trade waste via a commercial agreement with Watercare.

The plant shall be initially sized to accommodate stage-1 of the Delmore project which encompasses some 470 residential lots/dwellings. There shall also be consideration during this design process to ensure the treatment infrastructure is modular and it can be scaled to accommodate the future stages of the development should no public wastewater connection become available. The design basis for the plant and the selection of equipment and materials of construction has considered the ability to decommission and remove the treatment plant infrastructure if a public connection becomes available.

This report outlines the design of the treatment process, including the disposal system, and discusses its potential effects on the receiving environment due to the discharge.

Introduction

The Delmore development is an approximately 1250 lot residential land development project located in the Wainui area of the Hibiscus coast. Over the past 15-years the Hibiscus coast has received significant investment for residential land development projects, as a result it has become one of Auckland's fastest growing areas. From the years 2013 to 2018 the Hibiscus and Bays Area observed a population growth of 15.8%, and while slowing since 2018, the region has still grown by 9.6% to 2024, outpacing Auckland's overall rate of 5.4% during the same period (Hibiscus Coast App, 2024). As a result of this increased growth and infrastructure deficits, Watercare has made public notification that wastewater treatment infrastructure is able to connect up to 4000 new homes (as at 14 November 2024) before it reaches capacity, and the area is forecasted to reach its capacity by 2027, with more residential lots in planning or having received resource consent than the existing Army Bay Wastewater Treatment Plant can service (Watercare, 2024). With upgrades to the treatment infrastructure planned for completion in 2031, Watercare has stated they will be actively managing new connections to its network in the area (Watercare, 2024).

To allow for the continued supply of land for residential development in the event that either or both Stage 1 and Stage 2 are unable to connect to Watercare's network when first developed, the developer Vineway has engaged Apex Water (Apex) to provide engineering support for the planning and consenting of private on-site wastewater treatment and discharge infrastructure. It is envisaged that if on-site treatment is required, it will only be temporary, and the plant will be decommissioned when a connection to Watercare's infrastructure becomes available.

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 a 4-stage Bardenpho activated sludge process, a Membrane Aerated Biofilm Reactor, and Hollow Fiber Ultra-filtration membranes with tertiary disinfection. This treated wastewater stream is further polished by Reverse Osmosis membranes, providing a resultant water quality that has a nutrient profile orders of magnitude lower than both typical drinking water and a literature derived representation of typical stormwater runoff as obtained from the Urban Runoff Data Book **(Williamson, 1993)**. This system ensures high-quality permeate production within a compact design. The treated wastewater will be discharged both to land when available, utilising available reserve land alongside a constructed land contact bed designed by the principal in collaboration with local stakeholders.

LIMITATIONS

The opinions, conclusions and recommendations in this report are based on conditions encountered and information provided at the date of preparation of the report. Apex has no responsibility or obligation to update this report to account for events or changes occurring after the date the report was prepared. The opinions, conclusions and recommendations in this report are based on assumptions made by Apex noted in this report.

Overview

SITE LOCATION

The proposed Delmore development is located approximately 35km to the north of central Auckland in the Wainui area. The location of the development can be seen in Figure 1 below.

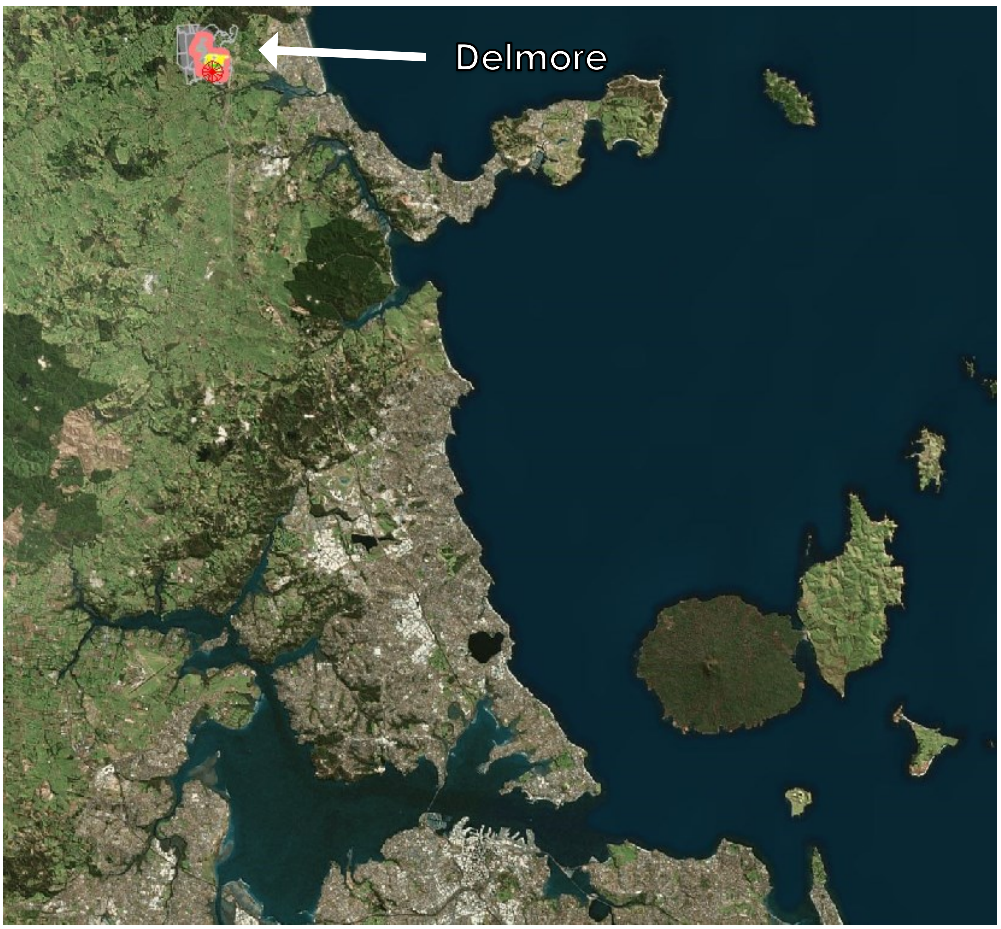


Figure 1 - Delmore Site Location

The Delmore project site is bound by a mixture of developed, future urban zoned, Department of Conservation reserve and rural land. The surrounding sites include residential developments under construction such as Ara Hills to the north-east and Milldale to the south. The broader setting of the Delmore project site in relation to these other extensive residential developments can be seen in Figure 2 below.

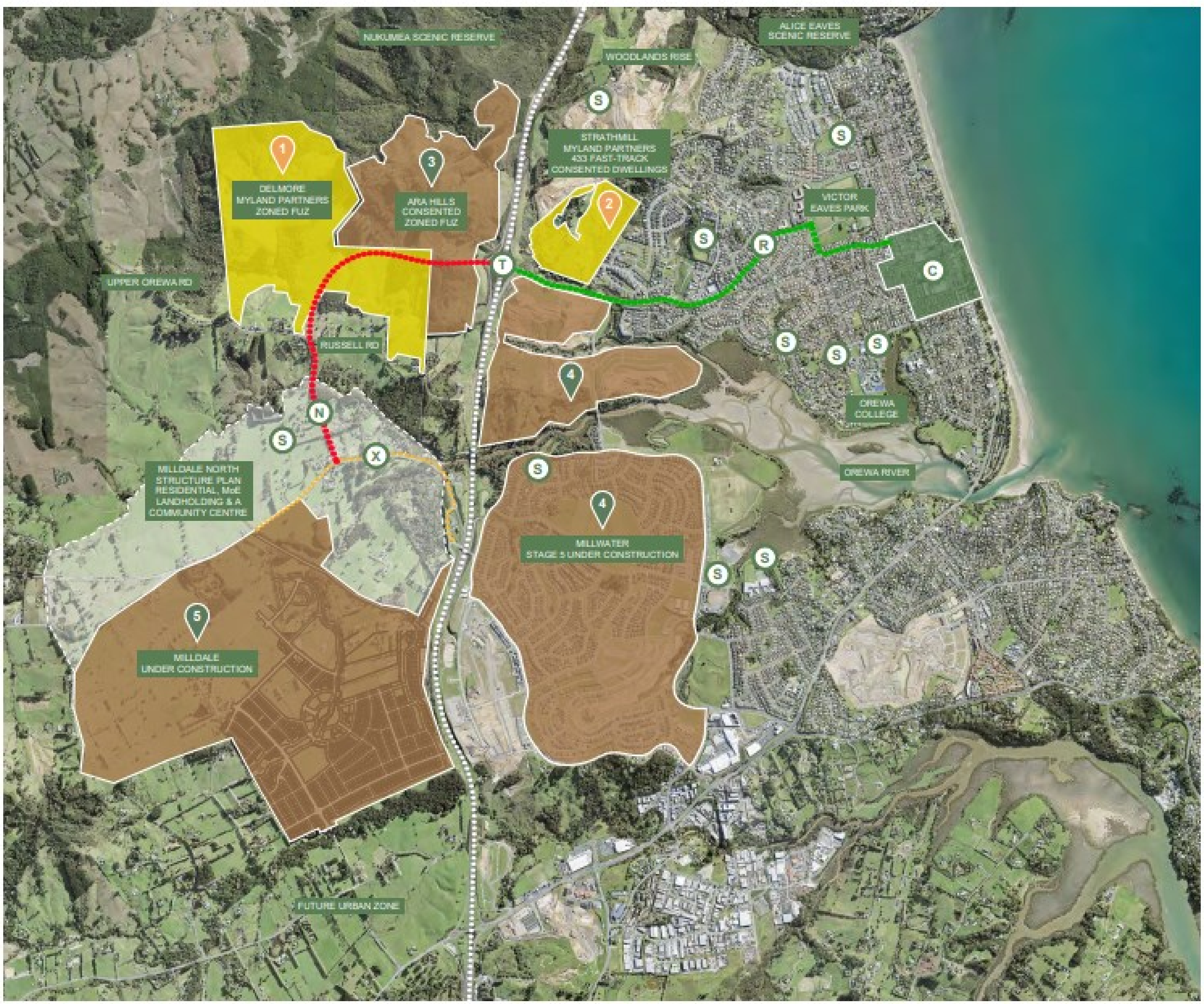


Figure 2 - The proposed Delmore project site and surrounds

The proposed lot for the wastewater treatment plant is bound on all sides by future residential lots. The extent of the proposed lots can be seen in Figure 3 below.

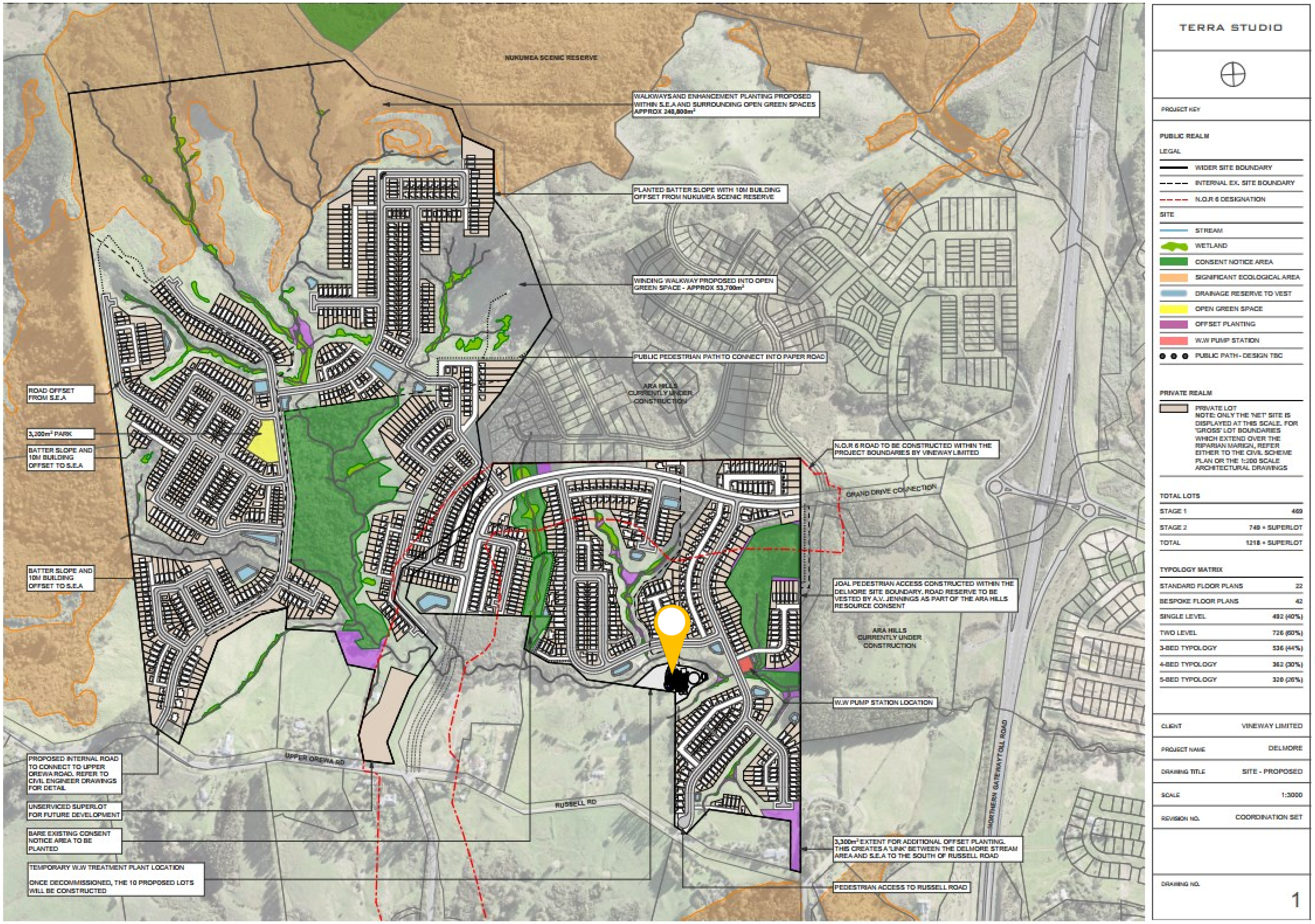


Figure 3 - Proposed Location of the Wastewater Treatment Plant on the Delmore Project Site

Wastewater Treatment

LOADING

The anticipated wastewater loading has been established in consultation with the client's civil engineer, Mckenzie & Co with reference to the Auckland Council Code of Practice for Land Development and Subdivision – Chapter 5: Wastewater. This document details what allowances should be made per dwelling when determining wastewater flows generated from different sized dwellings within new housing developments. Using the information provided within the *Auckland Code of Practice for Land Development and Subdivision - Chapter 5 Wastewater* and the development growth projections provided by Mckenzie & Co., a wastewater model has been developed. Table 1 below outlines information related to the wastewater loading on the proposed treatment plant.

Recommended Design Wastewater Flows

Table 1 - Recommended Design Wastewater Flows

Description	**Number**	**Comment**
Occupancy for Design (Persons)	3	Watercare CoP
Design Wastewater Flow Allowance (L/person.day)	180	Watercare CoP
Design Wastewater Flow Allowance (L/house.day)	540	
Number of Houses	1250	Provided by Client
Peaking Factor	5	
Average Dry Weather Flow (m3/day	648	Provided by Client
Peak Flow (m3/day)	3240	No commercial flows included

Wastewater Conveyance – Infiltration, Inflow and Peak Flows

The Delmore community shall be serviced by a conventional gravity sewer network. In the event that a connection to the broader Watercare network for Stage 1 and/or Stage 2 is delayed because of Army Bay capacity issues, the Delmore network shall be directed into a common pump station which shall feed the treatment plant via a pressurised rising main.

While easy to construct and maintain, when it comes to waste treatment and conveyancing infrastructure, conventional gravity sewers have the disadvantage that they are susceptible to increased hydraulic loading during wet weather events resulting from infiltration and inflow. These periods of increased hydraulic loading are referred to as peaking events.

In wastewater treatment design, peaking factors are used to characterize the maximum hydraulic loading relative to average dry-weather flowrate that the treatment plant and conveyance infrastructure must be designed to accommodate. While dry-weather peak flows are caused by diurnal cycles (morning and evening peak usage), peak flows observed during wet weather events are typically caused by Infiltration and Inflow into the network originating from stormwater and groundwater sources. Infiltration sources are typically caused by damaged or misaligned pipework underground allowing groundwater to enter from saturated soils. Inflow sources are those which enter directly into a wastewater system via illegally or misconnected stormwater drains or damaged wastewater infrastructure at or near ground level.

The Auckland Code of Practice for Land Development and Subdivision provides a peaking factor of 6.7 for conventional gravity sewers, requiring treatment and conveyance infrastructure to accommodate up-to 6.7x the average instantaneous dry-weather flowrates. Without mitigations to decouple peak flows from the treatment process, the entire treatment process must accommodate and be able to process incoming instantaneous flows of up to 6.7x the average dry-weather flow rate. While primary conveyancing systems must be designed to accommodate peak flows, such as those that may occur in 1 in 10-year rainfall events, the sizing of treatment infrastructure to accommodate 1 in 10 frequency events lead to oversizing of the treatment train to accommodate a scenario that by definition should only happen on 1 occasion in a 10-year period, this adds significant cost and complexity. Common sources of infiltration and inflow are shown in Figure 4, below.

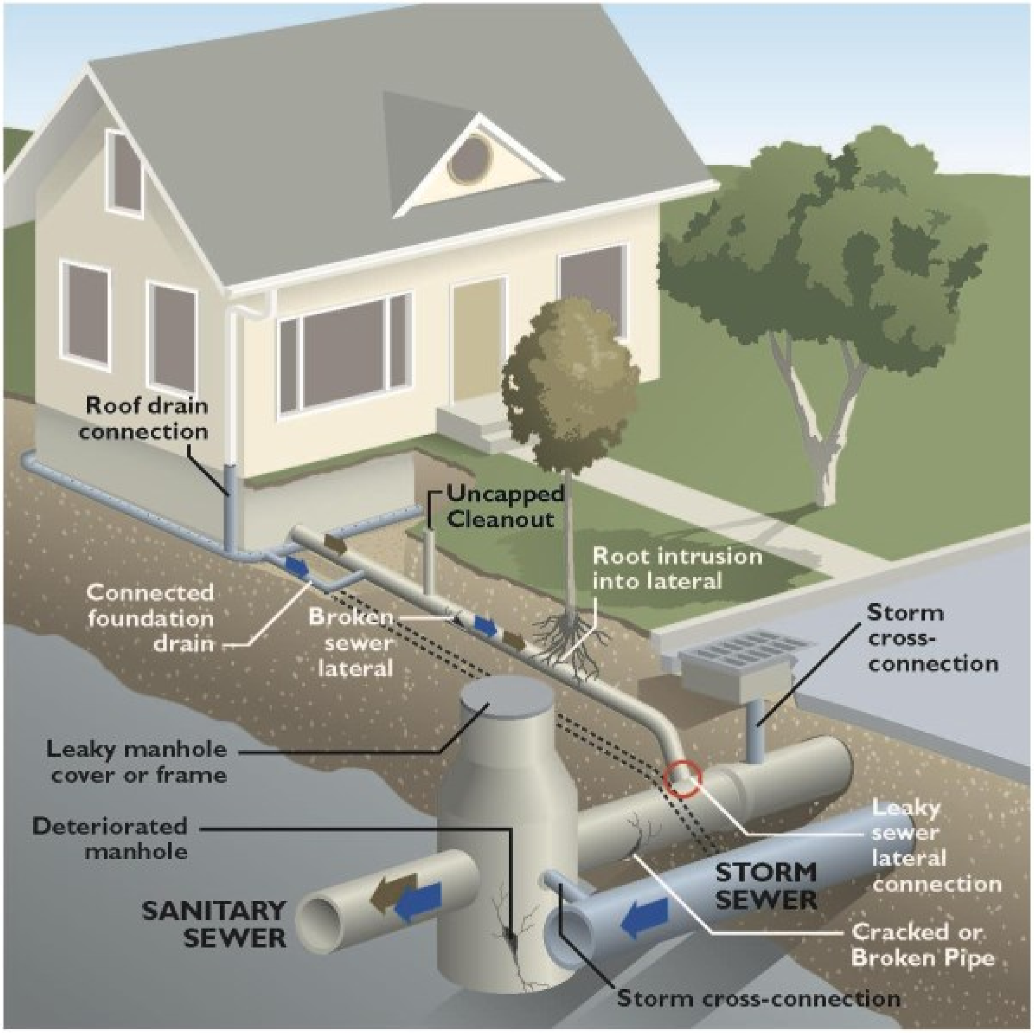


Figure 4 - Sources of Infiltration and Inflow (GHD Limited, 2015)

Taking the client's selection for the use of a conventional gravity sewer network into consideration and the wastewater loading provided by Mckenzie & Co the following wastewater model has been produced.

While equipment such as feed pump stations and headworks screens that are exposed to the direct flow rated from the network will be sized to meet this 6.7 x peaking factor. The actual treatment plant, which inherently buffers out some of this flow can be designed to a lower peaking factor, e.g. around 5 x the ADF.

Flow Buffering

Even with this slightly lower peaking factor used in treatment plant design, to ensure the most cost-effective treatment infrastructure is designed, the main biological and membrane filtration processes should still be decoupled from peaking events. The simplest approach utilised to decouple the treatment train from peak flows is via flow buffering in the form of a large balance tank at the start of the process. When utilising a balance tank, the treatment train is effectively de-coupled from peak flows and can be sized to accommodate the instantaneous average flowrate observed by the plant, with any instantaneous peak flows in excess of the average accumulating in the balance tank for future processing. A balance tank provides not only hydraulic buffering for the process but also allows for process and operational flexibility if downstream equipment or processes require attendance. An example of a wastewater treatment plant designed and built by Apex Water with a flow balancing tank is shown in Figure 5 below.

Figure 5 - A MBR WwTP with Flow Balancing

RAW WASTE QUALITY

The Delmore development primarily consists of a residential area with permanent occupancy. In staged developments, it is common for the strength of sewage to be higher when there are fewer connections, gradually reaching a more typical sewage strength as the development expands. A summary of the expected wastewater strength is provided in Table 2 below, following the Auckland Regional Council Guidance Document GD06 alongside real world test results obtained from the Clarks Beach community.

Table 2 Raw waste quality comparison (Auckland Regional Council Guidance Document GD06 and a similar community)

		GD06	**Clarks Beach**	
		Raw Wastewater	Median	95th Percentile
Flow (m^3/day)		-	250	250
COD (mg/L)		-	550	1,100
COD-filtered(mg/L)		-	200	332
BOD (mg/L)		250 - 350	270	420
TSS (mg/L)		300 - 400	-	-
TKN (mg/L)		-	65	94
NH_4-N(mg/L)		-	48	65
NH_3(mg/L)		Varies	-	-
NO_3(mg/L)		<1	-	-
TN (mg/L)		Varies	-	-
PO_4(mg/L)		10 - 30	-	-
TP (mg/L)		-	10	13
Faecal coliforms (cfu/100mL)		10^8 - 10^{10}		

The Guidance Document GD06 specifies raw wastewater strength limits that can serve as a basis for design; however, the design basis for the Delmore community focuses on ensuring compliance with treated wastewater standards under conditions of inflows at the 95th percentile values, in line with those values reflected within the Clarks Beach results provided above. These values are considered more conservative than the equivalents outlined in GD06 and are also more applicable, as they represent real-world data from a similarly sized small community.

While it is generally considered conservative to design all aspects of the wastewater treatment process around 95th percentile strengths, this approach does not apply to the ratio of nitrogen to carbon in the raw sewage. Nitrogen and phosphorus are the two most critical parameters to manage in the treated wastewater discharge, as these contaminants can contribute to the degradation of any receiving environment. The performance of the treatment plant in removing these contaminants must be carefully considered, particularly when the typical carbon to nitrogen ratio is not present. This situation, though uncommon in standard, mature residential catchments, may arise in areas with numerous bars or restaurants contributing to the flow, or in the early stages of development, where residence times in the sewer network are prolonged due to low flows, leading to BOD degradation within the network.

Although the plant is anticipated to operate with nutrient ratios similar to those presented in the table above, the design must incorporate sufficient flexibility to accommodate the upper range of nitrogen and phosphorus concentrations, even when receiving wastewater with median BOD and COD strength.

SURFACE WATER QUALITY

An assessment of the ecological and environmental condition at the proposed locations of discharge has been carried out by Viridis. Understanding the condition of the receiving environment is critical to the selection of suitable technology to ensure a discharge quality that retains the environmental and ecological features of the site, minimising any potential impact.

The full report provided by Viridis can be found in the documentation supporting this application in which an assessment of the current in stream physiochemical and ecological quality. Table 3 below outlines the baseline physiochemical properties of the stream adjacent the treatment plant site which will ultimately receive flows from the land contact infiltration trench.

Table 3 - Stream Baseline Quality Monitoring Results

Parameter	Existing Quality	Comment
Total Suspended Solids (g/m3)	3	Compliant with ANZG DGV
cBOD5 (g/m3)	<2	Complaint with MfE Guidance for preventing fungus growth
E. Coli (MPN/100mL)	435	Attribute D
Ammoniacal nitrogen (g/m3)	<0.01	Attribute A
Nitrate nitrogen (g/m3)	<0.002	Attribute A
Total nitrogen (g/m3)	0.30	Exceeds ANZG DGV
DRP (g/m3)	<0.004	Attribute A and compliant with ANZG DGV

Total Phosphorus (g/m3)	0.015	Attribute A and compliant with ANZG DGV

While it is common to find waterways on pastoral land to be showing signs of degradation and ecological stress due to the introduction of external sources of nutrients and pathogens from the grazing of livestock, the findings from the Viridis assessment are reflective of a site that is in a good condition considering the current land use. The findings of the Viridis report have been taken into consideration in the following sections when assessing the suitability of the wastewater treatment processes for the Delmore project.

WASTEWATER TREATMENT OPTIONS ASSESSMENT

Treatment systems currently in use throughout New Zealand, which have been considered for suitability at the Delmore site include:

- Membrane Aerated Biofilm Reactor (MABR)
- Membrane Bioreactor (MBR).
- Activated Sludge
- Sequence Batch Reactors (SBRs).
- Submerged Aerated System (SAF).
- Trickling Filters; and,
- Recirculating Textile Packed Bed Reactors (rtPBR).
- Hybrid Membrane Bioreactor / Membrane Aerated Biofilm Reactor

The quality of the receiving environment has driven the options assessment for the wastewater treatment plant and has resulted in the addition of Reverse Osmosis membranes for the polishing of the treated wastewater prior to discharge. Taking this into consideration, as well as through consultation with the Principal and respect of the desired flow ranges, operator inputs, constructability, project life and the lot allocated to the plant, this list has been further reduced to the following processes:

- Membrane Bioreactor (MBR) Nutrient Reduction Process with supplementary Reverse Osmosis polishing membranes.
- Membrane Aerated Biofilm Reactor (MABR) Nutrient Reduction Process with supplementary Reverse Osmosis polishing membranes.
- Hybrid Membrane Bioreactor / Membrane Aerated Biofilm Reactor Nutrient Reduction Process with supplementary Reverse Osmosis polishing membranes.

A review of the selected technologies is outlined below providing a summary of the suitability of these processes for the Delmore site. As each of the processes assessed make use of supplementary Reverse Osmosis for polishing of the treated wastewater, a separate section on the use of these membranes has been included below. Apex Water has recent track record in the design and build of most common treatment processes, Figure 6 below shows a Sequenced Batch Reactor servicing a private land development in Cardrona.

Figure 6 - A Sequenced Batch Reactor designed and built by Apex Water

Membrane Bioreactor (MBR)

An MBR system is a combination of the activated sludge process detailed above with a micro or ultra-filtration system that rejects particles above 0.1 – 0.4micron in size as one of the last stages of the treatment plant. By excluding particles of such a small size, the treated wastewater produced by a MBR plant can reject the majority of pathogens, with samples of permeate from MBR plants designed by Apex often demonstrating E. coli concentrations of less than 1cfu/100mL. MBRs have two basic configurations: (1) an integrated configuration that uses membranes immersed in the bioreactor, and (2) a recirculating configuration where the mixed liquor circulates through a membrane module situated outside the bioreactor.

The MBR represents the best available technology for the application proposed for the Delmore development. The key benefits of MBR technology for this application include:

- Reliably high level of treatment achieved.
- Compact process.
- Good at handling seasonal loads.
- Good at treating high strength wastewater.

- Physical barrier prevents bacteria entering the treated water.
- Physical barrier provides exceptionally clear, low turbidity permeate suitable for further disinfection via UV irradiation or chlorine disinfection.

While an MBR is considered one of the best available technologies in the area of wastewater treatment, to achieve the levels of nutrient reduction indicated as required by the Viridis report, a supplementary reverse osmosis treatment step would also be required to further reduce level of nutrients in the resulting wastewater. An example of above ground concrete membrane tanks at a membrane bioreactor treatment plant that has been designed and built by Apex Water for an industrial client can be seen in Figure 7 below.

Figure 7 - An MBR Membrane Tank on an Apex Water designed and built dairy site

Membrane Aerated Bioreactor (MABR)

A Membrane Aerated Bioreactor is a modified activated sludge process, where through the addition of gas transfer membranes, process monitoring and control, the conversion of ammonia in raw wastewater to nitrate (one of the key process steps in the removal of nutrients in the wastewater), known as nitrification is carried out in a very quick and efficient manner.

Characterized by the addition of submerged gas transfer membranes, the MABR process provides aeration for the conversion of ammonia to nitrate directly to the bacteria carrying out the biological processes. The gas transfer membranes provide a large surface area on which the biofilm can grow and allows for efficient oxygen transfer rates. The result of this is that for the same nitrification rate, an MABR treatment process requires a smaller footprint (i.e., smaller tanks) and uses less aeration energy which often comprises one of the largest operational expenses.

An MABR process is generally used as a modification to the activated sludge process, that improves the performance of treatment plants such as a traditional activated sludge or membrane bioreactors (MBR). Improved performance, a smaller plant footprint, and improved OPEX costs can be gained through the addition of MABR treatment to these processes.

The MABR process, in its standalone form, does not utilize filtration membranes and therefore lacks the ability to separate and remove bulk solids from the treated wastewater. Consequently, the treated wastewater may still contain solids unless an additional removal step is implemented. While nutrient removal is achieved efficiently through the MABR process, the presence of residual bulk solids makes the effluent unsuitable for discharge into sensitive receiving environments. However, by incorporating MABR gas transfer membranes along with the appropriate process control features into the MBR treatment process results in a highly effective nutrient removal system that occupies a small footprint and produces treated wastewater of superior quality

Other major benefits of MABR treatment processes include:

- They are easily scalable and can be designed to be modular
- They typically produce much less waste biological matter (sludge) due to the high efficiency of the biofilm requiring less biology to achieve the same rate of nitrification compared to other conventional treatment systems.
- Lower sludge production means lower operational, and disposal costs associated with sludge handling.
- Can be operated to accommodate fluctuating wastewater organic loads without significant performance losses
- By virtue of their energy efficient design, they offer better environmental performance when measured against other conventional treatment options

Hybrid Membrane Bioreactor / Membrane Aerated Bioreactor (MABR)

Through the integration of MABR gas transfer membranes into the MBR treatment process an efficient treatment process producing exceptionally high treated wastewater quality can be achieved on a small footprint. This process combines the advantages of both treatment processes providing a robust treatment process that can handle variable nutrient loads which can be designed and constructed with modularity in mind for future expansion.

A photograph of an MBR/MABR hybrid treatment plant being constructed by Apex Water for Watercare Services can be seen in Figure 8 below.


Figure 8 - An under construction MABR/MBR hybrid treatment plant designed and under construction by Apex Water for Watercare

While this hybrid treatment process would be considered the best available technology for sewage treatment in New Zealand, to achieve the levels of nutrient reduction required for discharge to surface water at this site, a supplementary reverse osmosis treatment step should also be carried out to achieve trace level of nutrients required in the resulting discharge.

Reverse Osmosis (RO) Polishing Membranes

While the Membrane Bioreactor detailed above makes use of membranes for the separation of bulk solids and the removal of pathogens from the treated wastewater stream, these membranes themselves do not provide the level of nutrient reduction required to discharge into the unnamed waterways adjacent the site. To achieve the required level of treatment, Reverse Osmosis Membranes have been included in each of the treatment processes considered above. Unlike conventional dead head filtration processes, a Reverse Osmosis membrane filter operates by being subjected to a constant flow of pressurised water across its surface. While moving across the membrane surface, the water permeates across the membrane while the contaminants as small as salts and nutrient molecules are excluded. The result is an extremely high quality permeate and a concentrated reject stream containing the removed contaminants. While the membranes used by the Membrane Bioreactor have pores small enough to exclude solids down to the size of an individual bacteria, the Reverse Osmosis membranes have pores small enough to also exclude a high level of salts and nutrient molecules such as ammonium, nitrate, and phosphate ions. This allows for the removal of salts, bacteria and other impurities.

While it is uncommon for conventional wastewater treatment application to require the addition of reverse osmosis membranes as a part of the treatment train, these are widely utilised in countries which treat and re-use wastewater in drinking water applications.

It should be noted that the use of Reverse Osmosis essentially produces drinkable water from the treated sewage, and if employed here, as is proposed, it would almost certainly make this water discharged from the Delmore development the cleanest of any treated sewage in New Zealand.

PROCESS SELECTION

Hybrid Membrane Aerated Bioreactor with Ultrafiltration Membranes (MABR + MBR) with Supplementary Reverse Osmosis Membranes.

A multi-criteria assessment (MCA) has been carried out on the processes considered to evaluate each of these on Performance, Future Proofing, Operability, Constructability, Social and Environmental Impact and Resilience and Process Resilience. Each of these has been baselined next to what Apex considers as the more robust treatment solution which consists of a 4-stage Bardenpho activated sludge treatment process, a Membrane Aerated Biofilm Reactor and Hollow Fiber Ultra filtration membranes with Reverse Osmosis membranes for polishing of the resulting treated wastewater.

Table 4 - Multi-Criteria Assessment Carried out on the Treatment Processes Considered

Category	**Criteria**	**Weighting**	**Base Option 1 MABR + MBR**		**Option 2 Bardenpho MBR**		**Option 3 MABR Alone**	
			Score	Weighted Score	Score	Weighted Score	Score	Weighted Score
Performance	Treated Effluent Quality (suitable for Surface Water)	20%	0	0	0	0	-1	-0.2
	Reliability & Robustness	10%	0	0	-1	-0.1	-2	-0.2
Future Proofing	Phased Construction & Future Upgradability	10%	0	0	-1	-0.1	-1	-0.1
	Relocatable / Suitability for Interim plant	10%	0	0	-1	-0.1	-1	-0.1
Operability	Ease of operation	7.5%	0	0	-1	-0.075	-1	-.075
	Process safety	7.5%	0	0	0	0	0	0
Constructability	Ease of implementation	5%	0	0	0.5	0.025	0.5	.025
Social and Environmental Impact	Amenity impacts (noise, odour etc)	5%	0	0	0	0	0	0
	GHG emissions	5%	0	0	-0.50	-0.025	-1	-0.05
Resilience	Process stability under peak flow	5%	0	0	-0.5	-0.025	0	0
	Process stability under future load conditions	5%	0	0	1	0.05	0	0

Financial	Indicative capital cost Relative operating cost	5% 5%	0 0	0 0	1 -1	0.05 -0.05	1 -1	0.05 -0.05
Total Option Score				0		-0.35		-0.7
Rank				1		2		3=

Score	**Description**
-2	Much Worse
-1	Moderately Worse
0	Same as Base Option 1
1	Moderately Better
2	Much Better

Note: the RO system has been excluded from this assessment as it would be required for each of the options

Disadvantages of an MBR – MABR Hybrid Process

Whilst the MBR-MABR Hybrid Process is considered the most suitable for the Delmore application, it does have some limitations. The limitations of this process are well defined and through process design can be mitigated. The disadvantages of MBR – MABR hybrid process systems include:

- Limitations to total flows that the plant can handle

While the membranes provide a physical barrier to solids and bacteria entering the discharge, they also provide a physical limit as to the total flow that the plant can handle. The surface area available for filtration, the level of fouling blocking liquid flow and the physical pressure limitations of membranes all contribute to providing a hydraulic upper limit to a membrane-based treatment process. Where systems exhibit large peak flows mitigation measures need to be employed to handle peak flows. Whilst this is considered a disadvantage of the selected process, it is common to all treatment processes containing membranes. Membranes are considered a necessary process step for the Delmore WwTP due to the required treated wastewater quality and use of tertiary UV disinfection. Through the addition of flow balancing and detailed design this limitation can be mitigated.

- Membrane Organic and Inorganic Fouling

The blocking of the membrane pores over a period of operation due to the accumulation of organic fouling or deposition of inorganic scaling restricts flow through the membrane. Any restriction of flow requires an increase in pressure differential to provide the same flowrate up to the physical pressure limitations of the membranes. The cleaning of the membranes to remove these blockages adds an additional layer of operational complexity that must be managed through a clean in place (CIP) processes. Processes for cleaning both MBR and MABR membranes are well described and commonplace but must be managed and controlled according to good operational practices to ensure the process performance is maintained, the integrity of the membranes is maintained and operator safety in not compromised. While membrane fouling is a disadvantage of the process it is common to all membrane treatment processes which would be required in an application such as that proposed for the Delmore residential land development. An example of hollow fibre membranes with organic and inorganic fouling on the surface of each fibre can be seen in Figure 9 below.

Figure 9 - Hollow Fibre Membranes with visible fouling

- Reverse Osmosis Reject Waste Stream

Reverse Osmosis membrane filtration is considered a form of cross flow filtration, where water is passed across the surface of a membrane which allows the passage of water molecules while blocking most other contaminants, significantly reducing their concentration in the filtered water. This process results in two liquid streams, one of exceptionally high quality that can be discharged into even the most sensitive environments or re-used and the other containing the rejected contaminants that cannot pass through the membrane. The reject stream which makes up approximately 30% of the total volume of the treated wastewater must be discharged or handled appropriately. While this represents an operational constraint, there are various options for disposing of the reject stream of the quality that will result from the proposed Delmore wastewater treatment plant which are discussed in further detail below.

Prevalence of MBR – MABR Systems in the Auckland Region

The adoption of MABR treatment processes and other modified activated sludge systems in New Zealand has been gradual. Potential factors contributing to this include limited technical expertise, the size of the industry, and established design standards. However, in recent years, the uptake of MABRs and other modified activated sludge technologies, such as Moving Bed Biofilm Reactors (MBBR), has gained momentum. Notable new treatment plants utilizing these technologies have been implemented in Te Kauwhata, Waikato (MABR-MBR hybrid), Lake Hawea, Otago (MBBR), and Raglan, Waikato (MABR-MBR hybrid). Both the Lake Hawea and Raglan plants were designed and constructed by Apex Water.

Over the past decade, many new sewage treatment plants in the Auckland region and surrounding areas, including those discharging directly to surface water bodies, have adopted MBR systems. These include facilities in Pukekohe, Warkworth, Clarks Beach, Waiheke Island, Karaka North, and Meremere. Apex Water has been responsible for designing and constructing five of the aforementioned plants. Notably, the wastewater treatment system on Waiheke Island handles unusually strong wastewater, with peak concentrations up to ten times higher than typical sewage. Despite these challenges, the system consistently produces treated water meeting stringent standards, with <10 mg/L total nitrogen (TN), <2 mg/L BOD, <1 mg/L total suspended solids (TSS), and <1 CFU/100mL E. coli.

Expected Wastewater Quality from an MABR -MBR with Reverse Osmosis Membranes

An MABR-MBR treatment plant, such as that proposed for the Delmore development is a best practice wastewater treatment solution. The resulting treated water quality is of such a high quality that by the World Health Organization Standards it meets the requirements for bathing quality water and Australian guidelines for Grade A recycled water without further treatment. For similar treatment processes it is not uncommon for an MBR to have undetectable levels of bacteria in the discharge (e.g., <1 CFU per 100mL).

The addition of reverse osmosis membrane filtration as a processing step provides a significantly more robust physical barrier to the discharge of solids and nutrients ensuring that the treated water has close to zero solids and that virtually all bacteria are removed from the discharge. By utilising Reverse Osmosis membranes to further polish the MBR discharge the resulting water discharged by the treatment plant shall be of a quality that exceeds drinking water nutrient concentrations and far exceeds literature derived stormwater runoff quality (Williamson, 1993) . From a practical perspective and to allow for any minor leaks or damage to membranes, MBRs are often designed to achieve a treated water quality of <4 E. coli/100mL. Following this with UV and Reverse Osmosis would also remove almost all viruses from the wastewater. Table 5 below provides a summary of the expected water quality.:

Table 5 - Expected Treated Effluent Concentration

Parameter		**Proposed Treated Water Quality Median**	**Literature Derived Stormwater Runoff Quality (Williamson, 1993)**	**Proposed Treated Water Quality Median without Reverse Osmosis**	**Consent Discharge Limits for Karaka North (1250 Lots)**	**Watercare Consent Limits for Direct Discharge to Ocean from Clark's Beach**
$cBOD_5$	mg/L	0.5	8	5	5	5
TSS	mg/L	4	170	4	4	5
TN	mg/L	1	2.5	5	5	5
TP	mg/L	0.07	42	2	2	Not limited
AMM-N	mg/L	0.3	0.1	2	2	2
E. Coli	MPN/ 100mL	<4	<1	<4	<4	UV treatment required but no E. *Coli* limit specified

Figure 10 below shows a Membrane Bioreactor designed and built by Apex Water for Watercare in Meremere in the Waikato.

Figure 10 - A MBR treatment plant designed and built by Apex Water for Watercare

TREATMENT TRAIN

A simplified process flow diagram of the MABR-MBR hybrid treatment train is illustrated in Figure 11 below.

This process is characterized by the following unit processes on the main flow path,

1. Raw sewage pump station – This feeds raw sewage to the treatment plant
2. Headwork Screening – These screen bulk solids out of the raw sewage to protect the downstream process.
3. Flow Balancing – A tank which receives the screen sewage buffering peak flows.
4. Pre-Anoxic Tank – The first stage and heart of the biological process housing the MABR modules
5. Aeration Tank – Dissolved oxygen is pumped into this tank to feed the biological process
6. Post Anoxic Tank – The second stage and polishing step of the biological process.
7. Membrane Tank – The filtration step of the process, where bulk 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. Reverse Osmosis Filtration – Permeate from the MBR is pumped across the surface of the RO membranes producing two liquid streams, the permeate for discharge locally and the reject for beneficial re-use or discharge.
10. Permeate Storage – Where permeate (fully treated wastewater) is stored prior to discharge
11. Discharge System – Treated wastewater is discharge via land irrigation or into a land contact infiltration bed for land contact prior to entering the adjacent waterway

Ancillary or other unit processes on minor flow paths may not be shown on the simplified process flow diagram below, but include:

1. Activated Sludge is periodically wasted and stored in the Waste Activated Sludge (WAS) tanks to maintain the required levels of biological activity
2. WAS is dewatered and thickened typically using a centrifuge for discharge and removal as a dry cake. Polymer is dosed to improve the dewatering performance.
3. RO Reject is stored on site prior to being discharged to the Watercare network via a Trade Waste agreement (TBC), or on site for beneficial re-use throughout the development.
4. Aeration blowers feed high volume and medium pressure air to the MABR gas transfer membranes and the aeration tank.
5. Acetic Acid is dosed as a supplementary carbon source to provide food to the biological process
6. Sodium hydroxide is dosed to manage the pH of the treatment process. The biological process consumes alkalinity, decreasing the pH of the wastewater which if not managed negatively impacts biological activity.
7. Aluminium Sulphate is dosed to sequester phosphorous out of solution for removal
8. Citric Acid is used to remove inorganic scaling from the membrane surfaces through a Clean-in-Place (CIP) process.
9. Sodium hypochlorite is used to remove organic fouling from the membrane surfaces through a CIP process.
10. Headworks screenings are collected in a skip for removal to landfill
11. Dewatered sludge is collected in a skip for removal to landfill.

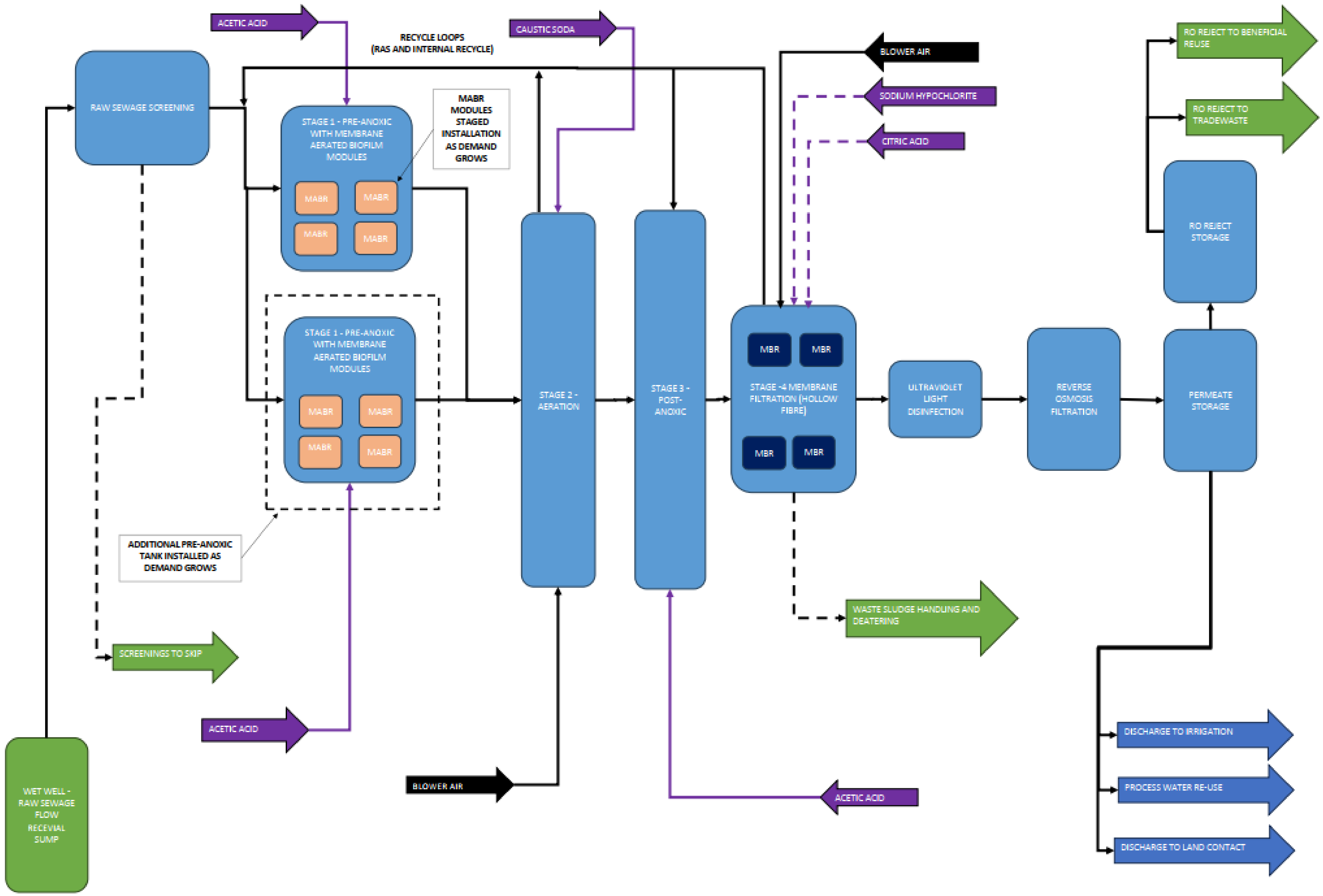


Figure 11 - Simplified Process Flow Diagram

Modelling of the Biological Process

Biological modelling of the treatment process has been carried out making use of Biological Modelling software. This design step is critical to both confirming the technology selection is appropriate for the wastewater volumetric and nutrient loading expected, but also in providing input to the planning and consenting of the overall project site.

The biological modelling process is carried out on Biowin software which is a tool that tied together the biological, chemical and physical process models. Through the production and optimisation of t the Biowin model, the discharge quality can be determined for a range of flow scenarios. These scenarios allow a sensitivity analysis to be carried out on the proposed design to determine its suitability and stability under a range of influent flows and strengths.

One of the other key outputs of this stage of the design process includes bulk sizing of the unit processes which allows for a preliminary layout of the site including:

- Bulk dimensions of the treatment plant building – Planning and land use considerations
- Bulk dimensions of the treatment plant biological reactor tanks – Planning and land use considerations
- Volumetric consumption of the ancillary chemicals – Planning, land-use and hazardous substance considerations
- Site layout, permeable and impermeable surface make-up –Planning, land use, hazardous substances and industrial and trade related activities considerations
- Site layout – Noise generation, attenuation, vehicle movements, air discharges and operational ergonomics of the site – Planning, land-use, traffic and discharge to air considerations.

Further details related to planning and consenting is covered later in this document.

An overview of the BioWin model as visualised from the computer is illustrated in Figure 12 below. The following subsections provide further details of the plant design.

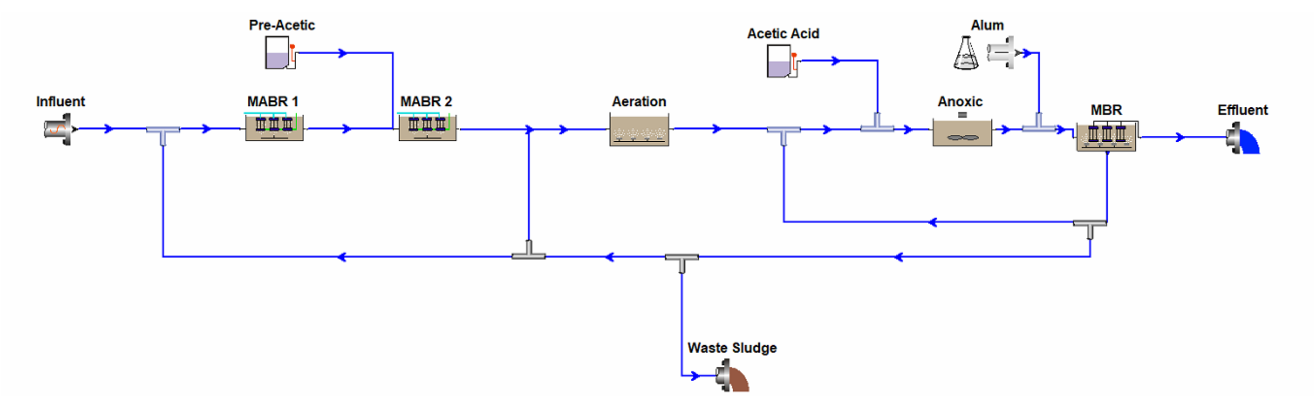


Figure 12 - Biowin Modelling Overview

MAIN UNIT PROCESSES

Headworks Screening

The incoming wastewater is directed through a wastewater receival pump station and delivered directly into the headworks system, where the screens are sized to handle the full hydraulic capacity of the development, including instantaneous peak flow conditions.

The wastewater enters a tank containing a screw compactor, which is fitted with a fine screen element. As the effluent flows through the screen, solids larger than 2mm are removed. Over time, these solids accumulate on the screen, which can cause a decrease in flow. This blockage results in a rise in water level, which is monitored by a level sensor inside the tank. When the water level reaches a predetermined point, a signal is triggered to automatically initiate the cleaning of the screen filter.

The screenings are then transported from the screening area to the dewatering or pressing section, where they are washed to remove organic matter. The collected solids are placed into sealed wheelie bins for removal from the site. Under full production, these bins will typically require emptying every one to two weeks.

Following screening, the effluent flows into a grit sedimentation tank (hopper), where grit particles are separated from the wastewater. The grit settles at the bottom of the hopper, and a horizontal screw conveyor at the base directs it to an extraction chamber. In this chamber, an extraction screw lifts, dewaters, and washes the grit, which is then discharged through a chute into a collection bin. Air diffusers inside the sedimentation hopper help enhance the separation of organic material from the grit. The removed grit is collected in a second sealed wheelie bin, which is also emptied periodically. Under full production, this bin will need to be replaced once or twice a month.

To ensure that all screenings are effectively captured, the wheelie bins are modified with a chute that passes through the lid, creating a tight seal. This system helps contain any odour and ensures that all screenings are directed into the bin. The headworks screens are installed on a sealed concrete surface, which drains to a sump that pumps the wastewater directly into the treatment plant. Typically, a heavy-duty plastic liner is used in the wheelie bins, and a duty-standby arrangement is employed to ensure an empty bin is always available for replacement. When a bin is full, it is replaced, the liner is removed, and the contents are disposed of in the dewatered sludge skip.

The headworks screening process performs the following functions:

- Removal of solids from the incoming wastewater.
- Washing, conveying, and dewatering of the screenings prior to disposal in the screenings bin.
- Separation of sand and grit.
- Lifting, dewatering, and washing of separated grit, which can be discharged to the screenings bin or a separate bin.
- Reduction in the volume of screenings by 40–60%, depending on the quality of the screenings.
- Dry solids content ranging from 25–35%, depending on the quality of the screenings.

Figure 13 below shows both the coarse and fine inlet screens.

Figure 13 - Fine and Coarse Inlet Screens at a treatment plant designed and built by Apex Water

To reduce operational complexity the screens often sit on a raised platform hydraulically upgradient of the biologically process. While raw sewage is pumped into the screen, the screened sewage flows under gravity through the screens and into the rest of the process.

Balance Tank

The balance tank acts as a buffer protecting or decoupling the treatment processes from peak flows. Screened sewage passes directly into the balance tank under gravity where it is accumulated prior to treatment.

This balance tank consists of a large sealed, bolted steel panel tank where screened sewage is able to accumulate if it is received by the treatment plant at a rate higher than it can be processed by the downstream treatment process. The principle of decoupling the treatment process from peak flows allows the treatment plant to be sized for a lower flowrate, as opposed to the peak instantaneous flowrate which has the benefit of considerably reducing the size and cost of the process equipment required.

Pre-Anoxic Tank -

The Pre-Anoxic tank is an open-top stainless-steel vessel. The screened wastewater is pumped from the balance tank, where it is mixed and maintained at a fixed level, before passing into the subsequent stage of the treatment process: the aeration tank.

This tank functions as a biological treatment unit where nitrogen compounds and organic materials are removed through biological processes, converting them into carbon dioxide, water, and nitrogen gas.

By incorporating MABR membranes into the Pre-Anoxic tank, the system achieves highly efficient simultaneous nitrification-denitrification. The MABR membranes provide a surface for biofilm development, hosting large populations of nitrifying and denitrifying bacteria. In the Pre-Anoxic environment, oxygen diffuses across the MABR membranes, creating a gradient that decreases as it moves through the biofilm. This gradient enables both aerobic and anoxic bacteria to thrive in close proximity, optimizing the biological treatment process.

The Pre-Anoxic tank is equipped with the following components:

- MABR membrane modules
- Mixers to maintain effective suspension and mixing of bacteria with incoming contaminants
- A recirculation pump(s) to circulate wastewater between the anoxic and aeration tanks, with the wastewater flowing back into the Pre-Anoxic tank via a penetration in the dividing wall.

Aeration Tanks

From the pre-anoxic tank, the flow enters the bolted steel panel aeration tank, in which naturally occurring bacteria grow and eat the organic contaminants in the wastewater. Ammonia is the main form of nitrogen present in the feed to this tank. The aerobic tank converts this to nitrate for removal by the anoxic tanks.

The aeration tank is fitted with fine bubble diffusers to efficiently transfer oxygen delivered by the blowers into the water. By keeping a positive level of dissolved oxygen in the aeration tank, aerobic conditions are retained, and the discharge of offensive odour is prevented. An aeration tank in operation can be seen in Figure 14 below.

Figure 14 - An Aeration Tank in Action (Large Blue Tank)

Air is provided to the process through blowers which are to be housed in a soundproof plant room. As failure of the aeration system is one of the main odour risks of the site, a spare blower is included. In addition to this, a back-up generator is installed on site which will automatically switch on should power supply to the site fail.

The blowers operate based on continuous measurement of dissolved oxygen. Alarms will be raised if the dissolved oxygen drops below a threshold value (e.g. 0.1ppm) for long enough to potentially develop anaerobic conditions (e.g. 4 hours). Under this scenario, a text message alarm is raised that alerts both the operators and maintenance staff that the plant requires urgent attention before conditions can develop that may result in a release of offensive odours.

Post Anoxic Tank

The nitrate-rich effluent from the aerobic tanks, is directed into the Post-Anoxic tank. Here, it is mixed with highly concentrated biomass recycled from the MBR tanks, allowing for the removal of any remaining nitrate, thus significantly improving the quality of the discharge.

The continuous supply of nitrate to the Post-Anoxic tank, combined with its very short hydraulic residence time (typically only one to two hours, depending on the incoming flow rate), ensures that anaerobic conditions—along with the associated risk of odours—are avoided.

When extremely low nitrogen concentrations are required in the discharge, as in this case, the wastewater may deplete its carbon-based contaminants, which are essential for the bacteria to process nitrogen. To address this, a supplemental carbon source is introduced to the Post-Anoxic tank to support the bacteria in removing additional nitrogen.
The recommended carbon source is 49% acetic acid, a cost-effective, safe, and natural chemical (essentially distilled vinegar).

For phosphorus removal, Aluminium Sulphate (Alum), a commonly used water treatment chemical, is dosed into the Post-Anoxic tank. This precipitates phosphorus from the solution. The precipitated phosphorus is then removed by the MBR membranes and is ultimately removed from the system along with the waste sludge.

MBR

A Membrane Bioreactor (MBR) is defined by the integration of a membrane filtration system that separates suspended solids and microorganisms from the treated effluent. The membranes used in this process have a pore size smaller than that of individual bacteria, thus providing a physical barrier that effectively prevents bacterial contamination in the final effluent.

This physical separation mechanism is what enables MBRs to consistently deliver some of the highest quality treated effluent available from commercially proven wastewater treatment technologies. An example of a modular and containerised MBR treatment plant designed and built by Apex Water for Watercare Meremere is shown in Figure 15 below.

Figure 15 - A modular and containerised MBR treatment plant designed and built by Apex Water for Watercare

Conventional sewage treatment plants typically produce effluent containing between 1,000 and 1,000,000 Colony Forming Units (CFU/100mL) of *E. coli*. In contrast, MBR systems commonly achieve effluent quality of less than 5 CFU/100mL, with several MBR plants managed by Apex Water routinely achieving undetectable bacterial levels (<1 CFU/100mL) without the need for additional disinfection processes.

It is proposed that this treatment plant will utilise submerged hollow fibre membranes. These membranes are air-scoured continuously during operation to prevent fouling and maintain performance. Additionally, the membrane tanks operate under high dissolved oxygen conditions to minimise the risk of odour generation.

In applications where significant nitrogen removal is required, such as in this proposal, the biological processes within the treatment plant can deplete the alkalinity present in the incoming wastewater. Without proper management through supplemental alkalinity dosing, a reduction in pH could occur, potentially harming the bacterial population and compromising the entire treatment process.

Biological modelling of the proposed plant indicates that, at the higher end of expected influent nitrogen concentrations, dosing of supplemental alkalinity is essential to maintain stable operational conditions.

The system design therefore incorporates automated dosing of caustic soda into the aeration tank, with the dosing adjusted according to real-time pH measurements to ensure that alkalinity levels are maintained within the optimal range for biological activity.

Phosphorus removal is also a key consideration, and the system is designed to actively reduce phosphorus to very low concentrations, which is particularly important in protecting the receiving environment. Phosphorus typically originates from domestic cleaning products and is more easily managed compared to other contaminants. A small dose of Aluminium Sulphate (Alum) is added to the Post-Anoxic tank to precipitate dissolved phosphorus, facilitating its removal via the MBR membrane system.

It should be noted that the addition of Alum increases the cleaning frequency of the membranes, as it leads to the formation of insoluble compounds that can contribute to membrane fouling.

UV Disinfection

The water that passes through the membranes is subjected to ultraviolet (UV) disinfection prior to entering RO system. High-intensity UV light is employed to deactivate microorganisms in the MBR permeate, rendering them incapable of reproduction. During passage through the UV reactor, over 99.9% of residual bacteria and viruses are effectively neutralised in addition to those already removed by the membrane filters.

The UV disinfection system is equipped with multiple individual lamps, failure monitoring capabilities, continuous online UV intensity (UVI) monitoring, and an automatic wiper system for maintaining the cleanliness of the lamps. Adequate clear space is provided around the UV unit to facilitate the easy removal and replacement of lamps and quartz sleeves.

The UV system is programmed to activate 3 minutes prior to the commencement of discharge flow, allowing for an appropriate warm-up period, and deactivates once the flow ceases. A notable advantage of MBR treatment is the typically consistent flow of treated effluent, which ensures the UV reactor operates optimally under continuous conditions.

By sing the UV before the RO system, any potential biofouling of the RO is also reduced.

Reverse Osmosis (RO)

The treated wastewater that has passed through the membranes of the Membrane Bioreactor and UV is of sufficient quality that is suitable for unrestricted municipal irrigation and other forms of beneficial re-use. However, for discharge via the land contact infiltration system, the Viridis report indicates that an even higher level of treatment than this is required to mitigate effects on the receiving environment. The treated wastewater is therefore passed through an RO membrane filter which will reduce the concentration of any remaining contaminants to trace levels.

The high-quality treated wastewater discharged from the MBR process is pressurised and passed across the surface of a RO membrane. The RO membrane allows the passage of water molecules across the surface of the membrane while excluding contaminants such as nutrients, bacteria and other dissolved solids. During the process of passing over the surface of the membrane, the concentration of contaminants in the membrane feed increases due to water passing through the membrane while contaminants are rejected. At the end of the RO treatment step, the wastewater is separated into two streams, a RO reject stream which contains the concentrated nutrients that have been removed (about 30% of the overall wastewater) and the permeate stream which has passed through the RO membrane.

While the permeate stream is suitable for tertiary disinfection prior to discharge into the local environment, the reject stream must be handled and discharged separately. This is discussed in detail below.

Permeate Storage

The water produced by the plant is of such a high quality that it can be beneficially re-used at the treatment plant as process water or unrestricted municipal irrigation. The inlet screens run through an automated cleaning process requiring high pressure water to be sprayed internally to dislodge and clear accumulated solids.

Solids Management

Sludge production is a by-product of the treatment process. The activated sludge contains the bacteria used to facilitate the nutrient reduction processes and is recycled throughout the tanks as required to continuously seed the biological process. The overall process uses naturally occurring bacteria to convert pollution in the wastewater to water, carbon dioxide, nitrogen gas, and more bacteria. As the membranes are continuously concentrating and recycling the solids as they separate them from the treated water, the bacteria if not removed accumulates in the process, eventually having a negative impact on the biological process. All that is required to manage this is to divert a portion of this bacteria in the form of a solids rich waste stream to sludge storage tanks in order to remove it from the process. While simple to achieve, solids management is a very important aspect in the management of the plants operation to ensure optimal performance.

This Waste Activated Sludge (WAS) is pumped and stored in two storage tanks with a combined volume of 60 m3. The sludge settles and thickens in the WAS storage tanks ahead of dewatering and removal. WAS collected in these tanks will be dewatered to a concentration of approximately 18% solids in a decanter centrifuge in order minimise the volume of waste sludge requiring disposal off-site. The decanter centrifuge is located inside a building to contain odour and noise.

The dewatered sludge is conveyed by the dewatering unit to a covered skip where it is collected. The cover of the skip is connected to the site's odour extraction and treatment system to ensure no odours are released from this area of the plant.

Dewatered sludge will be collected by a specialist waste collection company who will dispose of it at a suitably licensed landfill capable of receiving and disposing of biosolids generated at wastewater treatment facilities, such as that located in Hampton Downs.

Reject Waste Stream Management

This liquid reject stream is a by-product of all RO filtration processes and in the Delmore application shall result in approximately 30% of the wastewater fed to the process being produced as RO Reject. While this liquid waste stream contains contaminants that are blocked from passage through the RO membrane, it is still of sufficient quality to meet Grade A+ recycled water standards for unrestricted municipal reuse for all purposes other than as drinking water.

There are several proposed re-use applications for the RO reject stream on the development, as well as the option to discharge it to sewer via a trade waste agreement yet to be negotiated with Watercare. The proposed discharge and re-use options include:

- Dual reticulation – In this application, the RO reject stream is reticulated around the development for outdoor use by residents. Each property would have a single outdoor tap appropriately labelled that can be used for irrigation or outdoor washing purposes.
- Landscape irrigation within the development for reserves, parks and verges.

- Dust Control and Suppression –The RO reject is collected by non-potable water tankers and is used for dust suppression on Stage-2 of the development during the summer months while bulk earthworks are underway.
- Trade Waste Discharge – Subject to agreement with Watercare, any RO retentate that cannot be beneficially re-used could be discharged to Watercare via trade waste agreement. This is considered feasible due to the quality of the RO reject stream which is treated to a higher standard than is likely to be achieved by the Army Bay sewage treatment plant. Apex have been involved in various projects within the Auckland region which discharge trade waste to the Watercare network via bespoke commercial trade waste agreements.

For each of these scenarios, the RO Reject shall be stored within a tank located on site for re-use or discharge to the Watercare network.

Chemical Systems

The plant will incorporate the chemical systems detailed in Table 6 below.

Table 6 Chemical Systems

Chemical	**Purpose / Details**	**Dose Point**	**Approx. Consumption**
Acetic acid (49%)	Provides a carbon source for nitrogen removal.	Post Anoxic	150L/day
Caustic soda (30%)	Provides pH adjustment as required. The biological reactions can consume all alkalinity available, dropping the pH into a range that is harmful to the bacteria.	Aeration tanks	50L/day
Aluminium sulphate	Precipitates out phosphorus as it can be filtered out by the MBR system. Note, the addition of aluminium sulphate does increase the MBR cleaning requirements.	Anoxic tank 2	40L/day
Sodium hypochlorite (13%)	Utilised for membrane CIP to remove organic fouling on the membranes	MBR tanks	100L/month
Citric acid	Utilised for membrane CIP to remove inorganic scaling from the membranes	MBR tanks	100L/month

Treated Effluent Discharge

Options for Dealing with the Treated Wastewater

The wastewater treated by the MABR-MBR plant is of such high quality that it meets World Health Organisation guidelines for bathing water and can therefore be reused for landscape irrigation and similar uses around the development.

While there are few standards in New Zealand for recycled water systems, the proposed system can meet the requirements in the Queensland Public Health Regulations 2005 for its highest grade: Class A+ Recycled water suitable for dual reticulation. Table 7 provides details of the minimum log reductions of pathogens and indicator organisms required for class A+ recycled water systems from the Department of Energy and Waste Supply, Queensland Government.

Table 7 - Recycled Water Classifications (Department of Energy and Water Supply Queensland, 2008)

Indicative Log Removal Required to Achieve Class A+)[2]	**Microbiological Pathogen**[1]
5	Bacteria – Indicator E. coli
6.5	Viruses – Indicator F-RNA bacteriophages, Somatic coliphages
5	Protozoa – Clostridium perfringens
5	Helminths - Clostridium perfringens

Discharge Options the Delmore Site

Due to the nature and quality of the receiving environment the proposed treatment plant, the Delmore project is proposing a tiered approach to the management of treated wastewater discharges from the site. This tiered approach proposes various discharge or re-use options including, land irrigation, beneficial re-use (watering and/or dust suppression), discharge to a land contact infiltration trench or discharge of **treated** wastewater to Army

Bay. The plant control system would be configured to automatically select the discharge path based on real time meteorological monitoring and other factors such as time of year. Site investigation works carried out by Viridis highlighted low in stream nutrient concentrations, requiring the exceptionally high level of treatment proposed. It is known that during periods of low flow that the in-stream concentrations of nutrients will be more sensitive to discharges from the wastewater treatment plant and as such mitigations have been included to ensure the discharge to the stream is minimised during the summer months of December through the end of February when flows may be low in the stream adjacent the land contact infiltration trench.

A summary of the proposed discharge paths is detailed below with further information presented in the following sections:

Scenario	**Proposed Discharge Paths**	**Comment**
1. Low Instream Flowrates (Summer Conditions / In-stream Mean Average Low Flow Conditions (MALF)	1. Preferential Discharge to Land via irrigation. 2. Beneficial Re-use – Watering of Greenspaces on-site and Dust Suppression 3. Discharge to Land Contact Bed up to the agreed limit 4. Discharge of Permeate off site to an different discharge location this could be: a. Trucked away b. Discharged to the Army Bay WwTP (subject to commercial agreement)	1. Refer to the section below detailing discharge to land for further information – Preferential discharge to land would occur in this scenario. During this period of the year, the irrigation deficit in the irrigation field is maximised due to warmer weather and lower rain fall, maximising the irrigation potential. 2. Beneficial Re-Use – MALF conditions occur during warmer months when consents allow bulk earthworks. The requirement for dust suppression water will be maximised, as will the watering of berms and greenspaces in the development. 3. Discharge of a maximum consented limit to the Land Contact bed during the period. 4. *Subject to agreement with Watercare*. The balance of

		treated wastewater flows, if any would be directed to Army Bay. It is understood that capacity constraints at Army Bay are hydraulic and biological during peak events. Any discharges in this case would occur during dry weather and would be of a quality higher than the Arny Bay treatment plant could achieve.
2. Median In Stream Flowrates (Average Condition)	1. Preferential Discharge to Land via Irrigation 2. Back-up discharge of Permeate to land infiltration trench	During median conditions there is little impact to the ecology of the stream.
3. Peak In Stream Flowrates (Peak Wet Weather)	1. Preferential Discharge to Land via Irrigation 2. Back-up discharge of Permeate to land infiltration trench	During peak conditions there is little impact to the ecology of the stream.

Discharge to Land Contact Bed

Whilst utilising this discharge pathway the treated wastewater shall be discharged to a constructed land contact bed. The proposed land contact bed will consist of a rock filled infiltration trench and drainage blanket following the contours along and extending up to the riparian edge of the waterways adjacent the wastewater treatment plant compound. Whilst discharging to the land contact bed. The treated wastewater shall flow through the discharge pipework into the rock filled trench. Assimilation of this discharge shall occur through the soils surrounding this trench, however if the surrounding soils become saturated to the extent that they can no longer assimilate water at the rate of discharge, the trench shall accumulate water until it overfills (under the surface of the ground) and permeates through the drainage blanket below ground level towards the edge of the adjacent waterway into which it shall discharge. The drainage blanket shall be heavily planted making any nutrients within the treated wastewater permeating through this zone available for uptake by plants growing in the contact area.

The addition of planting along the drainage blanket and along the riparian edge may provide some additional polishing of the discharge, however it has not been considered in this report.

Discharge to Land, or Land irrigation

Description of the Irrigation Field

The proposal to irrigate discharges from the wastewater treatment plant allows for the beneficial re-use some of the treated wastewater through uptake by vegetation and minimise, as best as possible discharges to more sensitive receiving environments.

Treated wastewater is conveyed to the irrigation area via a pressurised polyethylene rising main running between the treatment plant site and the irrigation field where it is then distributed onto the irrigation field.

Prioritising the discharge to land, when available has many advantages over the land contact bed due to the ability of microbes in soil and plant life to assimilate residual nutrients within the treated wastewater. Due to the extremely high level of treatment proposed by the treatment plant, the nutrient concentration of the discharged water when passed through the Reverse Osmosis filter will be significantly lower than the sustainable rate at which the plant life in the irrigation field can uptake and beneficially re-use. As such, it is proposed that the discharge to the irrigation field allows for a higher discharge concentration limit.

When considered in the context of the existing pastoral land use and the extremely high level of treatment, it is highly probable that resulting nutrient loading from the wastewater discharge may be lower than is currently observed from the working farm.

Discharge to Beneficial Re-use

There are various applications throughout the completed and under construction development for the re-use of the treated wastewater or Reverse Osmosis reject stream. These sources of water can be utilised for the watering of gardens, berms and other greenspaces throughout the development, as well as for dust suppression for areas undertaking bulk earthworks. As the discharge philosophy for the site is to minimise discharges to the stream at times of low flow, this will align with the maximum capacity for beneficial re-use due, both via land irrigation or other locations as these will occur during dry summer months. The design of the proposed wastewater treatment plant includes the addition of a

1,000m3, the inclusion of this tank will maximise both the irrigation and beneficial re-use of the treated permeate by allowing it to be stored for times when demand is higher. The buffering of discharges in the balance tank to maximise beneficial re-use, or irrigation hasn't been considered in the modelling carried out below and hence the results determine should represent a conservative assessment.

Discharge Offsite

During the summer period from December through the end of February when the in-stream flowrates are likely to be low, the discharge into this receiving environment shall be managed. This involves discharging only up to 20% of the resulting flows into the land contact trench. As the preferred discharge path is to land, any discharges to the infiltration trench will be limited to times where the irrigation field is experiencing run-off conditions and hence cannot receive flows. In this case, where there is a balance of treated wastewater that cannot be discharged to irrigation, beneficially re-used or sent to the infiltration trench this would then be discharged offsite to a separate location. As the treated water quality is exceptionally high there are numerous possible locations where the permeate produced could be discharged. Subject to commercial agreement, this balance of volume could be directed offsite via tanker discharged to the Army Bay wastewater treatment plant as treated permeate. It is worth noting that the permeate discharged by the treatment plant, if directed to the Army Bay facility would likely be cleaner going into the network than the Army Bay plant can produce providing dilution.

The scenario in which these discharges would be required include:

- Summer Months – As the tiered approach to managing discharges proposes to minimise discharges to the stream at periods of low flow, any discharges would only occur during the summers months when the in-stream flowrates were at Mean Average Low Flow (MALF) conditions. During Median and Peak flow conditions, the stream can take the full consented discharge flowrate, if required (noting the plant will preferentially discharge to land irrigation)

- Not Raining – Through review of the past 10-years of rainfall data, it has been assumed that rainfall events greater than 3mm would result in in stream flows above the MALF conditions on site allowing for discharge into the stream. As such, it is unlikely that the plant would need to discharge off-site if there was a peaking wet weather event occurring, as flows can be managed on-site to land or to the land contact bed.

- Irrigation Field Capacity Constrained – Discharges offsite would only occur if the generation of treated wastewater was greater than the irrigation field could sustainably assimilate hydraulically and in terms of nutrient application.

- Land Contact Infiltration Trench Capacity Constrained – It is proposed that during MALF conditions that only 20% of treated wastewater flows be directed to the land contact infiltration trench, if the irrigation field is unable to accommodate further flows. The balance of the irrigation field and land contact irrigation trench would then accumulate in the permeate tank for discharge on a different day or removed from site, if the prevailing meteorological conditions required this.

Discharge Scenarios

To model the proposed discharge split between the irrigation field, the land contact infiltration trench and any remaining volume to beneficial re-use (berm watering, dust suppression etc.) or (subject to commercial agreement) offsite discharge (Army Bay, trucked offsite etc.), a water balance has been carried out using 10-years of meteorological data and Penman Evapotranspiration records. A summary of the scenarios modelled is detailed below providing the percentage split of treated water discharged to each of the modelled locations over a 10-year period onto a 5-hectare irrigation field located in a separate location. This split of flows resulting from this modelling is considered conservative as it does not account for the effect of the proposed 1,000m3 permeate tank that has been allowed for in the design. In operation, this tank would hold back treated permeate if the weather conditions did not make it suitable for irrigation on any specific day. The benefit of this is that there is often greater irrigation potential in the irrigation field than there is treated wastewater produced during a single day, meaning that during dry weather the irrigation field is operating at under capacity. By holding back permeate for later irrigation when the conditions are not suitable, the maximum capacity of the irrigation field can be utilised, significantly reducing the amount of treated water sent either to the infiltration trench or to an alternate discharge path.

Scenario	Period of Year	Description of Conditions for Discharge Path	Volume Discharged to Land Irrigation (%)	Volume Discharged to Land Contact Bed (%)	Volume Discharged to Alternative Beneficial Re-Use or Alternate discharge location (%)
Scenario 1	Dry Month Discharges – Conservatively assuming that all discharges between December through February are occurring into a MALF condition, unless there has been 3mm/d of rain on the day in question.	Preferential Discharge to Land up to Irrigation Deficit, when not encountering Run-Off Conditions Capacity to discharge 20% of treated water to land contact trench during MALF (if irrigation field can't take it) Capacity to discharge 100% of treated water to land contact trench if rainfall is greater than 3mm/day and if the irrigation field is experiencing Run-Off Conditions Balance to Alternate Beneficial Re-use of Discharge Location	80%	14%	6%
Scenario 2	All other time periods	Preferential Discharge to Land up to Irrigation Deficit, when not	36%	53%	10%

	encountering Run-Off Conditions Capacity to discharge 100% of treated water to land contact trench Balance to Alternate Beneficial Re-use of Discharge Location			
	Total	31%	59%	10%

Irrigation Rates and Volumes

The modelling carried out above has made use of soil analysis testing completed on the proposed irrigation field to determine the sustainable application rate of treated wastewater onto the site. This testing, carried out by Riley Consultants has determined the following:

…'the soils and its ability to transfer treated effluent into the groundwater via the underlying soils formations is between 2-3mm/day."

This is based on site investigation works carried out by Riley Consultants and information provided within the Guidance Document-06 for On-site Wastewater Management in the Auckland Region for the soil types encountered on the Delmore site.'

In addition to the infiltration rate, the uptake and evapotranspiration rate by the plant life in the irrigation zone has been considered when determining the amount of water that can be sustainably discharged. Ten years of Penman evapotranspiration rates and soil moisture deficit records from the nearest weather station with suitable records has been applied. These show that during the summer there is an average of 4-5mm/day of irrigation deficit based on evapotranspiration potential, and this drops to 0-1mm mid-winter. The maximum possible application rate utilising 10-years of meteorological data and Penman Evapotranspiration records is 8.5mm/day. A variety of irrigation scenarios were evaluated to establish the water balance on full final design flow of wastewater and the past ten years of weather data in order to determine how to maximise the amount of water reused via the irrigation system.

Due to the highly seasonal soil moisture of the proposed irrigation field, the modelling has assumed the full maximum application rate of 8.5mm/day could be applied to the irrigation field, except when experiencing run-off conditions. By including continuous moisture monitoring into the irrigation field and automatically stopping the irrigation system from starting irrigation of saturated soils, this will also mitigate the risk of applying excessive water to the irrigation field if the capacity of the soil to receive and permeate or evapotranspire this quantity of water applied is exceeded by detecting this and stopping irrigation.

While the provision of a necessary area of land to be made available for land irrigation shall be made, the modelling carried out above has been based on a parcel of land of 5 hectares in size. A summary of the parameters used to model to discharge split are presented in Table 8 below.

Table 8 - Discharge Scenario Parameters

Parameter	**No.**	**Comment**
Irrigation Field Area (Ha)	5Ha	
Soil Sustainable Permeability (mm/d)	3mm/d	Without evapotranspiration
Maximum Application Rate (mm/d)	8.5mm/d	Including evapotranspiration when not encountering runoff conditions

Reverse Osmosis Reject %	30%	All RO Reject has been modelled as going to Army Bay or other beneficial re-use path. This stream has various re-use options on site and can be irrigated.

Maintaining Soil Health

Although the treated wastewater is of exceptionally high quality, consideration must be made to the nutrients it is providing to the soil in the irrigation field. The sustainable limits for application of nutrients to soil are as per the following table.

Table 9 - Sustainable land application nutrient loading limits

Nutrient	**Application Limit**
Total nitrogen (TN)	220 kg/Ha.year
Total phosphorous (TP)	80 kg/Ha.year
Biochemical oxygen demand (BOD_5)	600 kg/Ha.year

To model to application rates of nutrients into the irrigation field it has been conservatively assumed that the treatment process would be operating without the use of the Reverse Osmosis membranes. This has been assumed as the sustainable application rates of nutrients to land are significantly higher than surface water bodies, due to their ability to assimilate and make use of available nutrients. The summary of the nutrient loading into the irrigation field is detailed in Table 12 below.

Table 10 - Total nutrient loading limits for irrigation options at the discharge strength permitted by the proposed conditions

Description of the Scenario	Average Annual Reuse by Irrigation (m^3)	Nitrate Loading Rate (kg/ha/yr)	P Loading Rate (kg/ha/yr)	BOD_5 Loading Rate (kg/ha/day)
Application of up to 8.5mm/day except when encountering run-off conditions	66,800m3	67	27	67

The irrigation volumes in **Error! Reference source not found.** and the irrigation field areas have b een used to calculate the annual nutrient loading rates under the different irrigation scenarios. **Error! Reference source not found.** provides the nitrogen, phosphorous and BOD5 loading rates at the proposed median discharge strength for each of the scenarios considered.

Based on a total irrigation area of 5.0 Ha, a sensitivity analysis has been completed for each of the forementioned nutrients with the two irrigation options evaluated. A summary of the sensitivity analysis for discharge scenario 2 can be seen below in **Error! Reference source not f ound.** below for nitrogen, phosphorous and BOD5.

Table 11 - Discharge Scenario 3 Nutrient Loading Sensitivity Analysis

Median Discharge Nitrogen Concentration (g/m^3)	Nitrogen Loading Rate (kg/ha/yr)	Discharge Phosphorus Concentration (g/m^3)	Phosphorous Loading Rate (kg/ha/yr)	Discharge BOD_5 Concentration (g/m^3)	BOD_5 Loading Rate (kg/ha/yr)
1	13.4	0.1	1.34	1	13.4
5	66.8	1	13.56	10	133.6
7.5	100.2	2.5	33.4	20	267.2
15	200.4	5	66.8	45	601

Due to the relatively small loading of nutrients into the irrigation field relative to its capacity to sustainably assimilate nutrients, the application of nutrients are not considered limiting factors to the discharge. For nutrients such as nitrogen and phosphorous which soils are typically less able to sustainably assimilate, the discharge would need to be approximately 3x worse than the figures used within the modelling, of the treatment plant operating without the RO filter for the application to be considered unsustainable. This reflects the extremely high level of treatment carried out by the treatment plant even before the RO filtration system polishing is considered. On this basis, it is considered acceptable to discharge permeate prior to final RO treatment step, if the discharge location is to land irrigation.

EFFECTS OF THE DISCHARGE ON SURFACE WATER QUALITY

A technical assessment of the discharge on the surface water quality has been carried out by Viridis and is presented in documentation supporting this application. This assessment has assumed that treated wastewater that has either been discharged to land via irrigation or through the rapid infiltration trenches and will permeate through the drainage bed and after land contact will ultimately end up in unnamed stream adjacent the treatment plant compound. The assessment has considered how this discharge would impact the quality of these receiving environments under three different scenarios. These scenarios, prior to receiving any discharge from the wastewater treatment plant are described briefly below:

Scenario 1 – A dry weather low flow discharge.

Scenario 2 – A representation of average conditions.

Scenario 3 - A peak wet weather discharge.

A summary of these scenarios and a description of the effects are outlined in Table 12 below.

Table 12 - A Summary of the Assessment of the Effects detailed by Viridis

Scenario	Description of Effect
1	*Under Scenario 1, which is representative of summer conditions, the discharge was projected to increase concentrations of total ammoniacal nitrogen and dissolved reactive phosphorus (DRP) in the tributary, shifting water quality from NPS-FM Attribute Band A to Band B. This shift indicates nutrient levels that may begin to affect the most sensitive aquatic species (MfE 2024). However,*

	macroinvertebrate survey results (Viridis 2025) indicate that the stream's invertebrate community is dominated by taxa tolerant of inorganic pollution and nutrient enrichment. All monitored sites had Macroinvertebrate Community Index (MCI-sb) and Quantitative MCI (QMCI-sb) scores within Attribute Band D, below the national bottom line (NBL). Given the existing degraded condition of the macroinvertebrate community, the predicted increase in ammoniacal nitrogen and DRP is not expected to have a significant ecological impact. Other key water quality parameters, including total suspended solids (TSS), carbonaceous biological oxygen demand ($cBOD_5$), nitrate nitrogen, total nitrogen, and total phosphorus, remained comparable to baseline conditions. While E. coli counts were slightly reduced due to dilution from the discharge, they remained within the NPS-FM 'Poor' quality band
2	*Under Scenario 2, which represents average conditions, the discharge would be expected to have minimal impact on the receiving water quality. In cases where baseline monitoring showed ammoniacal nitrogen and nitrate nitrogen concentrations within Attribute Band A, water quality remained within the same band post-discharge. DRP concentrations shifted from Attribute Band A to B. While total nitrogen concentrations increased slightly compared to baseline conditions, they were already elevated above the ANZG DGV in the stream. The discharge was not predicted to elevate other contaminants beyond relevant guideline values. Similar to Scenario 1, TSS and BOD5 remained comparable with baseline conditions, and E. coli counts remained within the NPS-FM Attribute Band for 'Poor' quality.*
3	*Under peak wet weather conditions (Scenario 3), discharges from the WWTP are expected to have minimal impact on receiving water quality. The primary effect is a slight increase in contaminant concentrations compared to baseline conditions; however, these changes do not result in a shift in Attribute Bands or exceed ANZG DGV. Overall, water quality is expected to remain stable*

Odour Management

ODOUR SOURCES

The mitigation of odour forming conditions, or the treatment of sources which cannot be mitigated is paramount due to the location of the treatment plant within the residential subdivision.

The following table identifies the potential sources of offensive odours and the mitigations, or treatment proposed to ensure the emission of the these to the surrounding environment is avoided.

Table 13 - Odour Sources and Mitigations

Treatment Process	**Potential Odour Source**	**Mitigation Measure**
Headworks screens	Raw Sewage and Screenings	System (including screening bins) is fully enclosed and connected to the odour extraction network under negative pressure.
Balance tank	Raw screened sewage	The tank is to be sealed and connected to the odour extraction network under negative pressure. In routine operation this tank will be operated at near 0% level and shall be designed with an internal sump.
Pre-Anoxic Tank	Raw Screened Sewage	Continuously recycle flow from the aeration tank, providing large quantities of nitrate rich water, and preventing anaerobic

		conditions from developing. The Oxidation-Reduction potential of the contents of this tank are continuously monitored which allows the contents to be monitored for generation of anaerobic conditions.
Aeration tank	Anaerobic conditions from overloading or aeration equipment failure can generate offensive odour	The aeration tanks are fitted with fine bubble diffusers to efficiently transfer oxygen from the air into the water. By maintaining a positive level of dissolved oxygen in the aeration tank, odour emissions are minimised meaning that this tank does not need to be covered.
Anoxic tank 2	Anaerobic conditions from overloading or aeration equipment failure can generate offensive odour	Continuous supply of nitrate to this anoxic tank, combined with its very short hydraulic residence times prevents anaerobic conditions from developing.
MBR tanks	Anaerobic conditions from overloading or aeration equipment failure can generate offensive odour	The membranes in these tanks are continuously cleaned by scouring with air. The contents of this tank have already had almost all dissolved contaminants (e.g. organic load and nutrients) removed by previous steps in the process. Therefore, the membrane tanks have a very high concentration of dissolved oxygen in them. These factors combine to

		mitigate the risk of the membrane tanks generating offensive odours.
WAS tanks	Contains sludge which has a high risk of releasing offensive odour.	The WAS tanks are fully enclosed and connected to the odour extraction and treatment network. The WAS is aerated to maintain conditions which mitigate the formation of offensive odours.
Sludge dewatering and dewatered sludge storage	Processes sludge which has a high risk of releasing offensive odour.	The sludge dewatering plant is fully enclosed and connected directly to the odour removal and treatment system. It is also housed in a building separately connected to the odour extraction and treatment network.
Site wastewater sump	Fully enclosed underground collection tank that receives discharges from any sludge dewatering/settling, any spillages of wastewater around the site and black water from the site's own amenities and toilets.	Sump is fully enclosed and connected to the odour extraction and treatment network.

ODOUR CONTROL UNITS

The formation of offensive odours cannot be controlled in the network that feeds the wastewater treatment plant, and as such the inclusion of infrastructure to capture and treat offensive odours is required. An odour control system is used to remove or destroy odours or other contaminants from sources extracted from a facility. The air the is sent to an odour control system is generally collected from enclosed spaces which house equipment or liquids which have the potential to generate offensive odour. These enclosed spaces are maintained under negative pressure, meaning any fugitive odours are extracted and transported to the odour control device. A summary of common odour control devices found in industrial applications and their advantages and disadvantages are shown below in Table 14.

Table 14 - Common Odour Control Devices found in Industrial Processes

Technology	**Operation**	**Advantages**	**Disadvantages**
Biofilter	Uses aerobic bacteria growing on a bed of bark chips to oxidise contaminants such as hydrogen sulphide (the primary offensive odour compound from sewage). Air is extracted from plant odour sources by fan and passed through the bed of bark prior to being discharged to air.	• Well-established technology. • Low capital and operating cost.	• Treatment can fail if the moisture and pH of the bark bed is not kept within the optimum range. • Larger biofilters can be prone to short-circuiting. • Larger biofilters can produce a plume of 'bark' scented air from passing high volumes of air (generally considered inoffensive but can be quite noticeable on neighbouring properties).
Carbon scrubber	Uses an activated carbon pallet bed. Odour causing compounds are adsorbed onto the activated carbon pallets and thereby removed from the air stream. The carbon pallets can also be doped with sodium hydroxide, which significantly increases the ability of the	• System relies on physical adsorption, so is more robust and reliable than biological oxidation.	• Higher capital and operating costs than a biofilter. • Carbon requires replacing every one to three years.

	carbon to remove and neutralise acidic gasses, such as hydrogen sulphide from sewage and sludge.		
Multistage chemical scrubber	Uses product specific bed(s) to remove contaminants.	• Able to tailor removal to specific pollutants.	• Complex system. • High capital and operating costs. • More suitable for industrial sites where specific gaseous pollutants are targeted in conjunction with dust or other particulate matter.

SELECTION OF ODOUR CONTROL DEVICE T

Through an assessment of the advantages and disadvantages of each common odour control system detailed in Table 14 above, the preferred odour control system is the carbon scrubber. The carbon scrubber offers reliability and well demonstrated performance without onerous operational requirements in a simple treatment process. A review of odour sources has been carried out by Air Matters and can be found in documentation supporting this application.

Operation into Service

The commissioning of biological nutrient reduction processes can be complex and requires technical oversight by persons experienced in both their design and operation. As the core nutrient reduction process is biologically driven, a sufficient concentration of biomass (bacteria) must be available to consume available contaminants within the raw water.
The proposed wastewater treatment plant will need to be made available to receive waste upon the connection and completion of the first properties within the development site. The generation of sufficient biomass to sustain the treatment process during the early stages of the development when few houses are complete and occupied will require a significant amount of operation oversight by Apex Water. Apex's experience indicates that for a seeded and supplementary fed biological treatment process, the time required to develop sufficient biomass is typically up-to, and at times greater than 2 months post the receipt of wastewater, contingent on a number of conditions.

Biomass within wastewater treatment processes thrives and grows when subjected to optimal conditions, when these are upset the biology can underperform, become stressed and ultimately fail at removing nutrients from the wastewater. During the early stages of the development when there are few connections to the sewer network it is common for wastewater strengths to be lower in concentration. Low concentration waste and variable influent volumes can make the removal of contaminants more difficult due to there being sub-optimal conditions to support the bacteria required for nutrient reduction. During commissioning, operational intervention will be carried out to ensure the correct conditions are maintained to support healthy biomass and promote further growth. Some of the factors which can influence the health of the biomass are outlined below:

- Insufficient food (carbon-based contaminants in wastewater) available in the raw wastewater to sustain existing biomass and allow for growth
- Too much food available in the raw wastewater for the concentration of biomass available
- Insufficient alkalinity to support the required nutrient reduction levels
- Insufficient concentration of dissolved oxygen to support biological processes
- Biomass average residence time within the system is too high
- Biomass average residence time within the system is too low

As biomass growth and nutrient removal is dependent on wastewater being fed as a food source to the bacteria in the plant, the wastewater treatment plant cannot be fully biologically commissioned prior to receipt of first waste. To facilitate the completion and final sign-off of dwellings within the development, the treatment facility will be physically complete and able to receive wastewater with functionality testing sufficiently advanced to render to plant suitable to receive waste and begin developing biomass. Once sufficient waste is received, the automation sequences will be commissioned followed by tuning of the treatment parameters to optimize the treatment process. As the plant is sized to receive the wastewater from the stage-1 portion of the development, it is noteworthy that during the early stages the physical capacity of the plant will be grossly decoupled from the volume of waste produced. This allows for a large capacity for flow buffering. The Balance Tank proposed has sufficient capacity to buffer wastewater inflows for an extended period. This large volume allows for a large contingency in the time required to ensure biological commissioning and biomass growth processes are complete while the plant is receiving some incoming wastewater.

Although Apex's experience indicates that this may not be an issue, maintaining a suitable dissolved oxygen concentration within the raw accumulated wastewater will be required to ensure the development of anaerobic conditions and possible generation of foul odour is mitigated. To support this, the aeration system and odour control system will be key systems that will be functionality tested online prior to biological commissioning commences. Provision will also be available for removal of raw waste for disposal at a third-party treatment facility during the commissioning period.

Proposed Site Layout

The wastewater treatment facilities are to be located within a compound surrounded by security fencing to exclude non-operational personnel. The site shall allow provision for all access requirements from operational vehicles and personnel for servicing the facility. The following sections of the report cover the visual aspects of the site, make-up of the compound and details on the main structures to be located on the site.

TREATMENT PLANT LOCATION AND LAYOUT

The proposed wastewater treatment plant compound is shown in Figure 16 below, which identifies key structures and equipment.

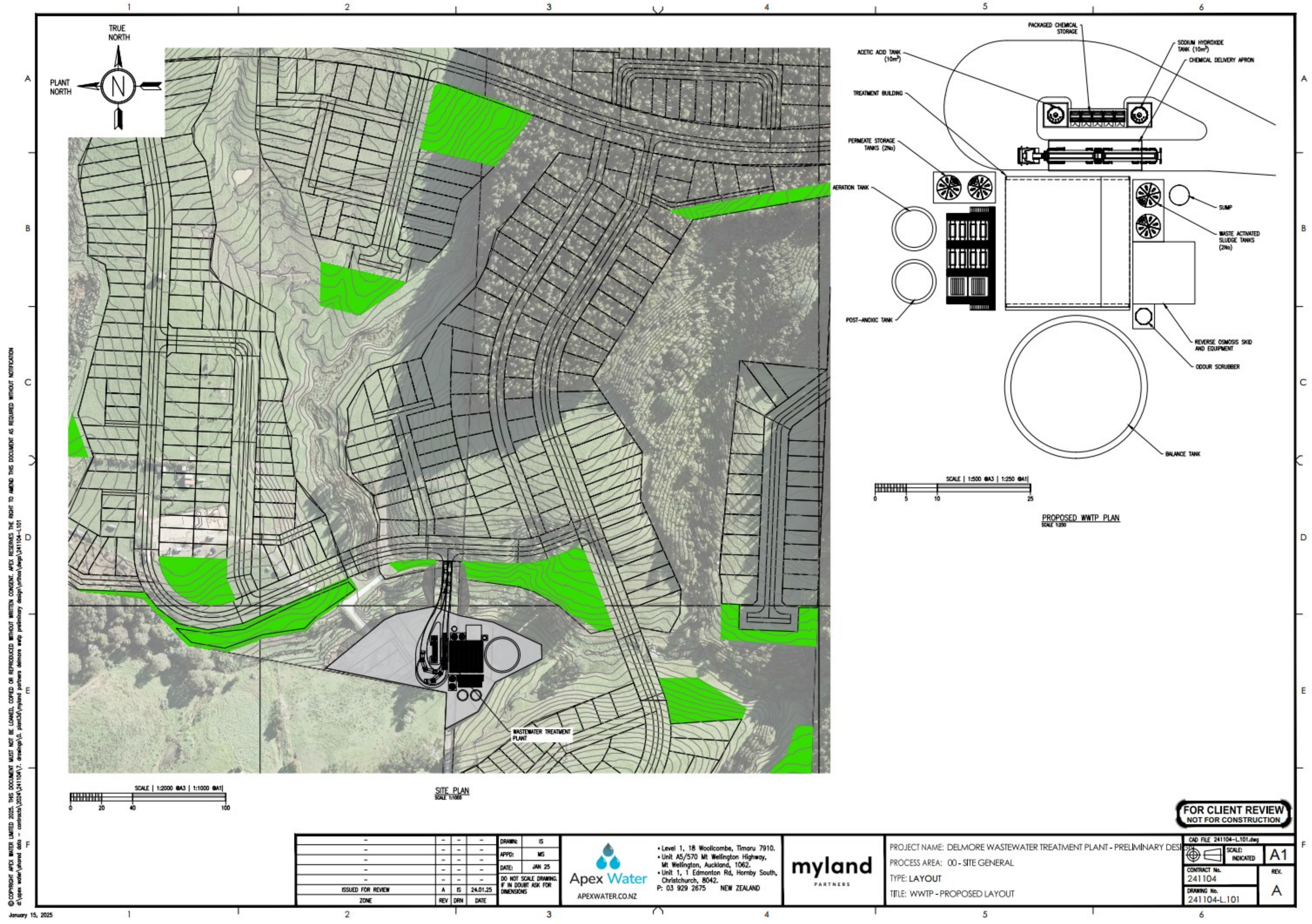


Figure 16 - Proposed Delmore WwTP Layout

VISUAL RENDERS

Renders of the proposed wastewater treatment plant and the associated structures can be seen in Figures 22 through 23 below.

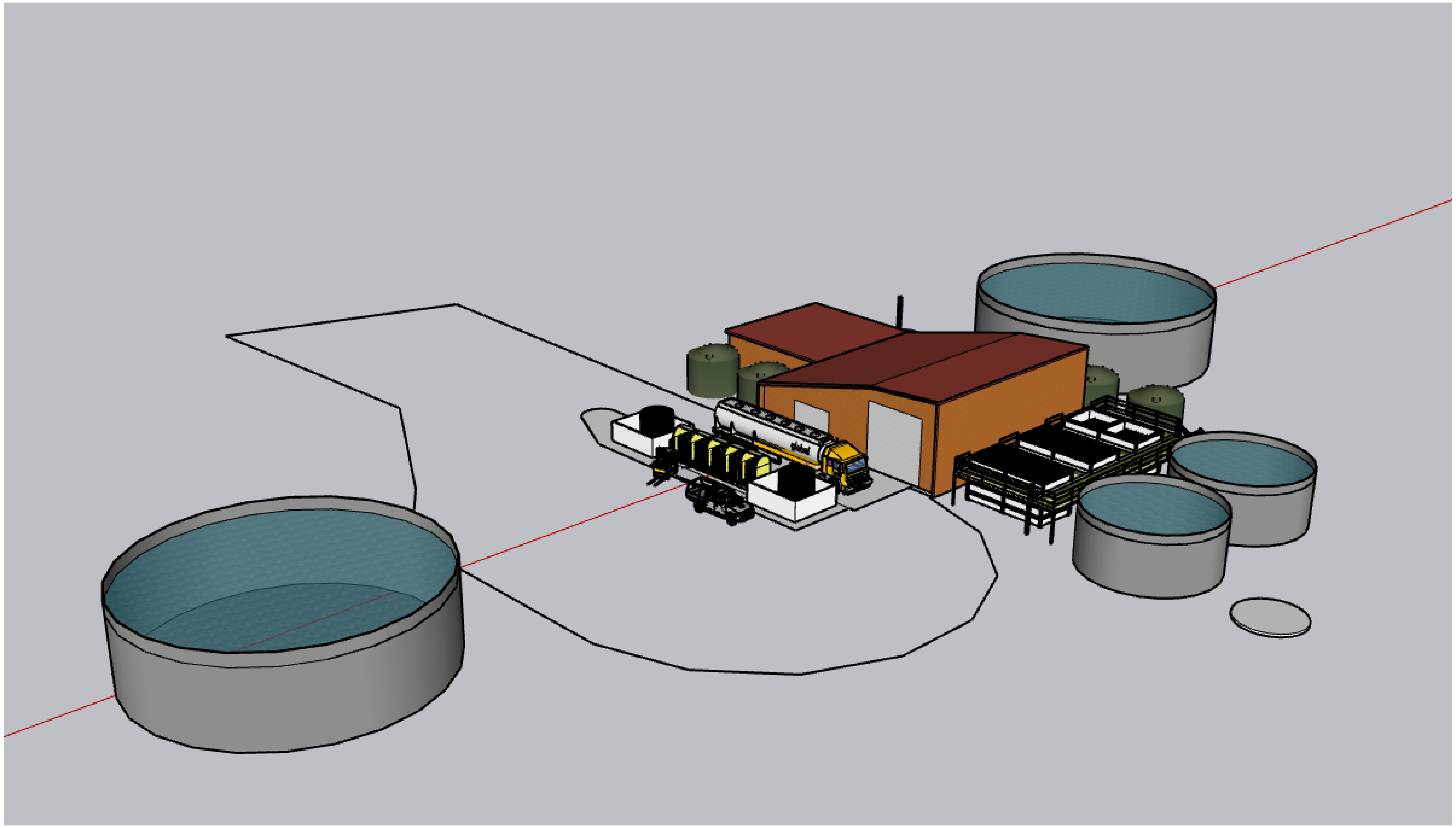
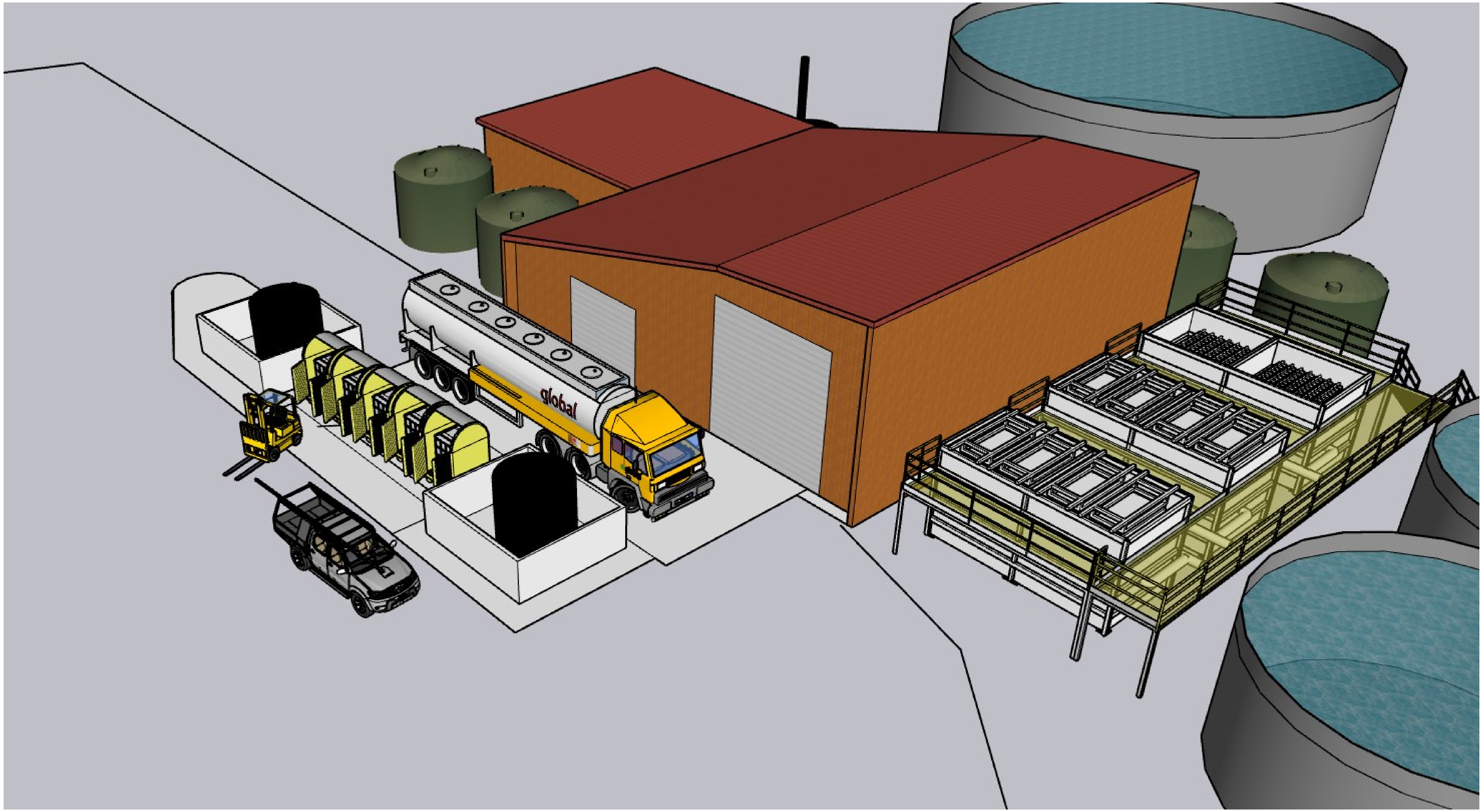


Figure 17 - Visual Render of the Proposed Delmore WwTP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SURFACE MAKE UP

A parcel of land of approximately 5850m2 has been allocated to the treatment plant and associated infrastructure. Based on the proposed site layout, the approximate breakdown of the site coverage between structures, impermeable surfaces and permeable or landscaped areas is shown in Table 15 below. A further breakdown of the site allocated to the wastewater treatment plant can be found in the architectural and landscape plans supporting the consent application.

Table 15 - Surface Make-up

Type of Surface	**Area (m2)**
Hard surfaces (Impermeable including structure)	3200
Landscaped (Permeable)	2650
Total	5850

PLANT STRUCTURES

Wastewater Treatment Plant Building

In the context of the broader development, and the proximity of the proposed treatment plant to residential lots, noisy equipment shall be located within the treatment plant building which shall be constructed of material appropriate to the required level of noise attenuation. Alongside the key items of process equipment located within the treatment plant building, general site facilities such as the control room, toilets, and other site amenities shall be housed with separate partitions within the building. The general configuration of the proposed wastewater treatment plant building can be seen below in Figure 18.

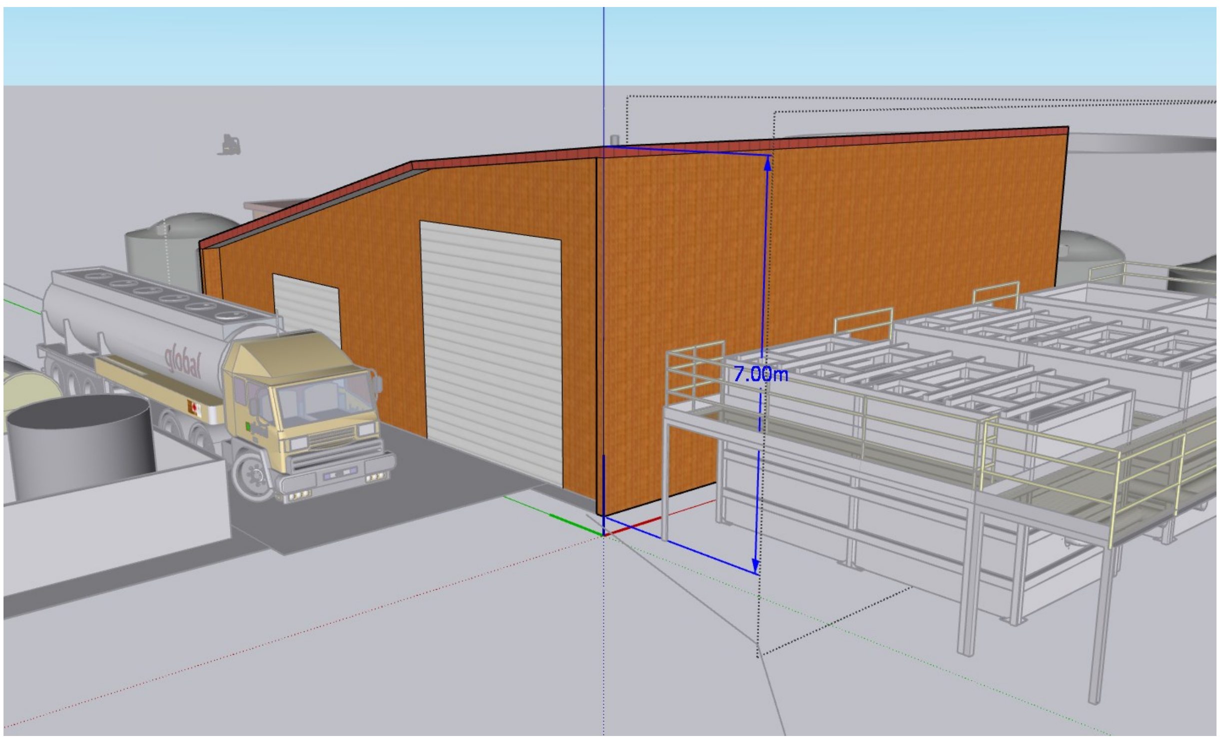

Figure 18 - Wastewater Treatment Plant Building

Balance Tank and Permeate Tank

The balance tank and permeate tank shall consist of a sealed and bolted steel panel tank up to a height of 7m. This type of tank has been selected as the material is suitable to the proposed life of the treatment plant, it is easy to construct and decommission once the plant is to be removed. The balance tank shall be sealed and vented to the odour scrubber system and shall be operated at a low level. The purpose of the balance tank is to buffer peak flows. The proposed balance tank can be seen in Figure 19 below. The Permeate tank is used to buffer permeate discharges to maximise the beneficial re-use of treated water.

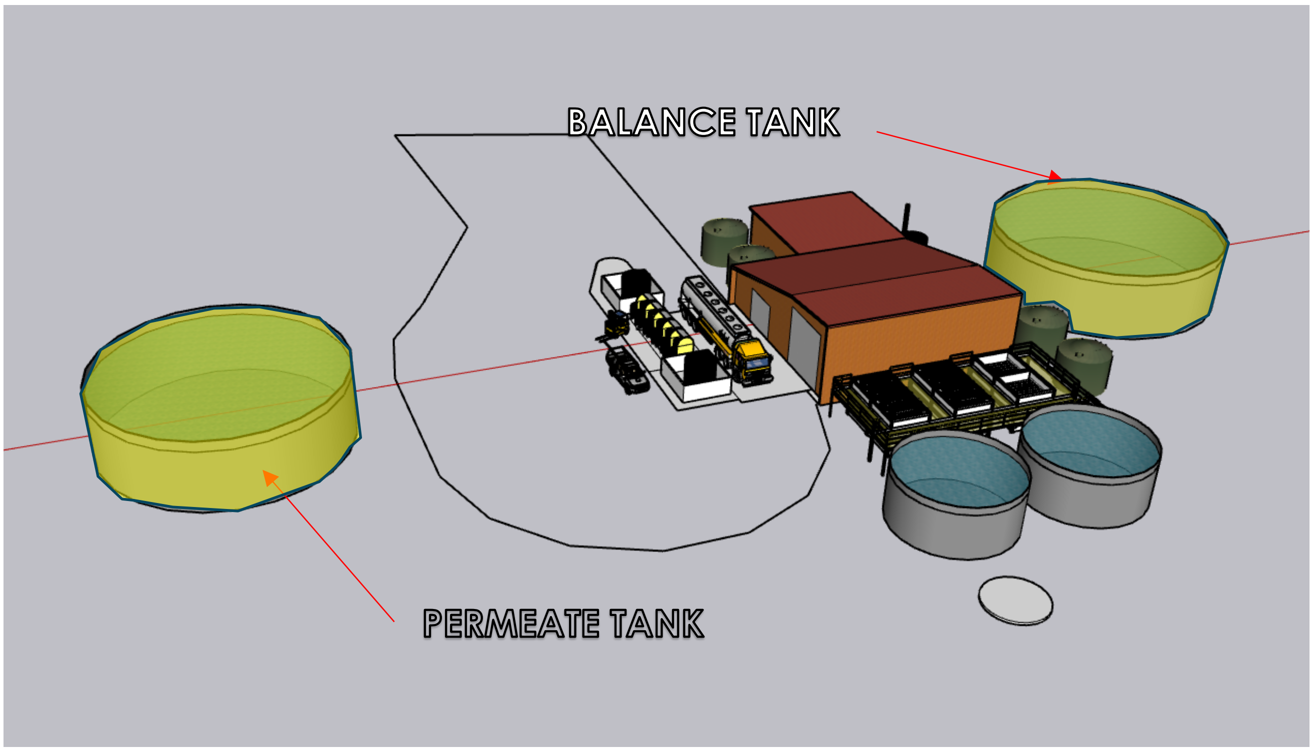

Figure 19 - The proposed balance tank for the Delmore development

Pre-Anoxic Tank - Membrane Aerated Biofilm Reactor Tanks

The Pre-Anoxic tank is located within the modular portion of the process The MABR membrane modules are also located within these tanks. Figure 20 below shows the Pre-Anoxic tanks, as required to treat Stage-1 volumes with an indication of where the future additional tanks can be placed should additional treatment capacity be required.

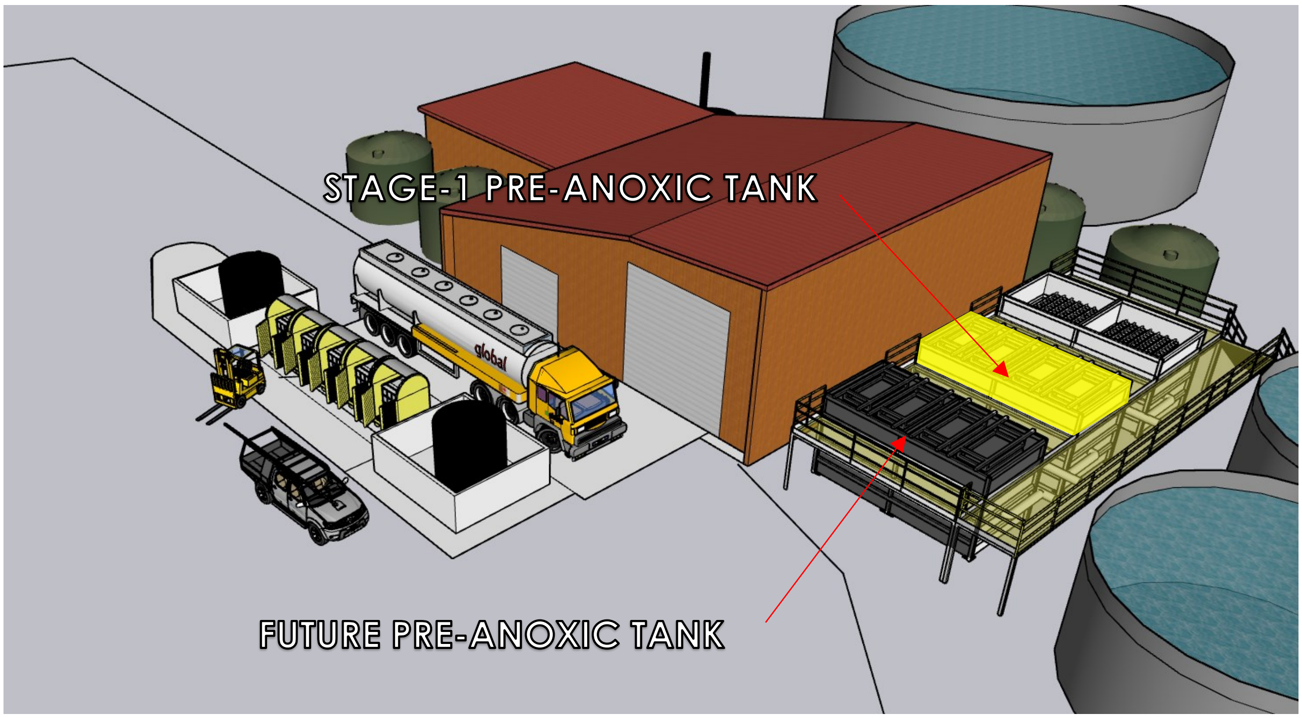

Figure 20 - Pre-Anoxic Treatment Tanks

Aeration Tank

The Aeration tank shall consist of a bolted steel panel tank, like the Balance tank. This style of tank has been selected due to its ease of construction and demolition, simplifying the decommissioning of the plant when it is no longer required. Figure 21 below shows the proposed aeration tank.

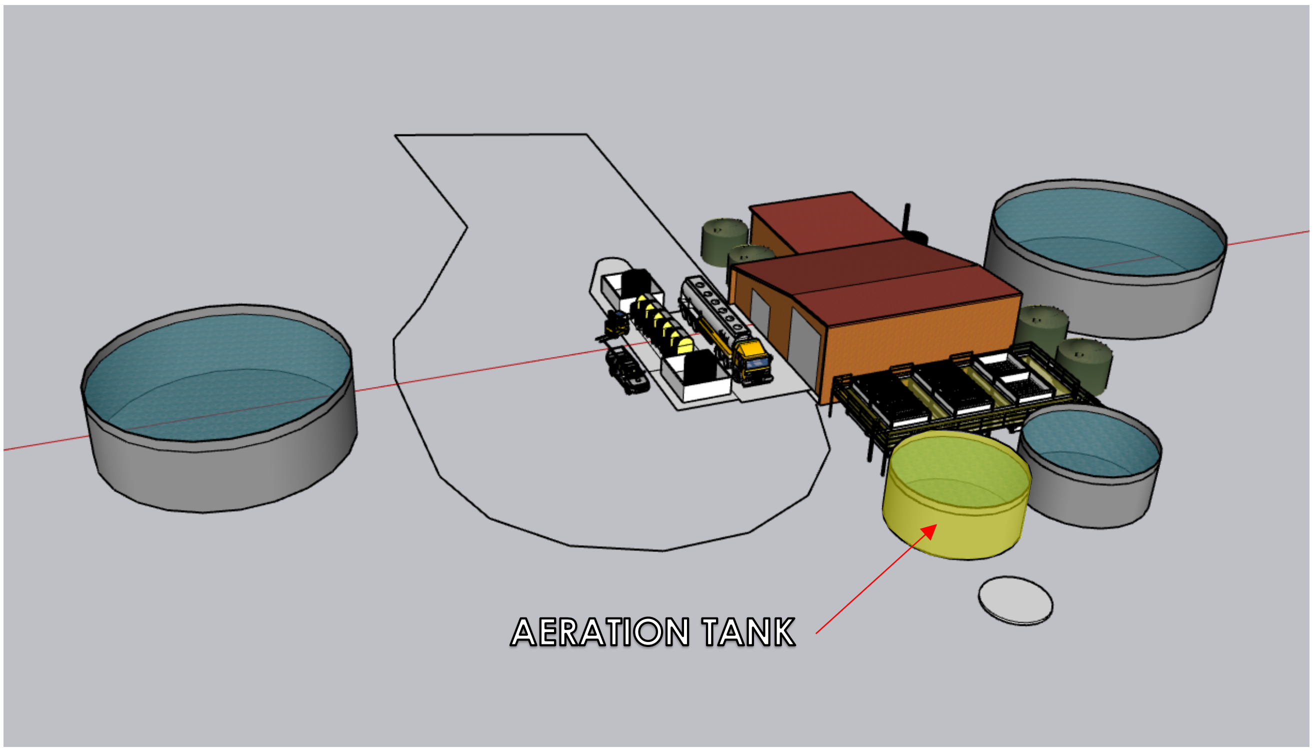

Figure 21 - The Delmore WwTP Aeration Tank

Post Anoxic Tank

The Post-Anoxic tank shall consist of a bolted steel panel tank of the same sizing as the aeration tank. This style of tank has been selected due to its ease of construction and demolition, simplifying the decommissioning of the plant when it is no longer required. Figure 22 below shows the proposed post-anoxic tank location.

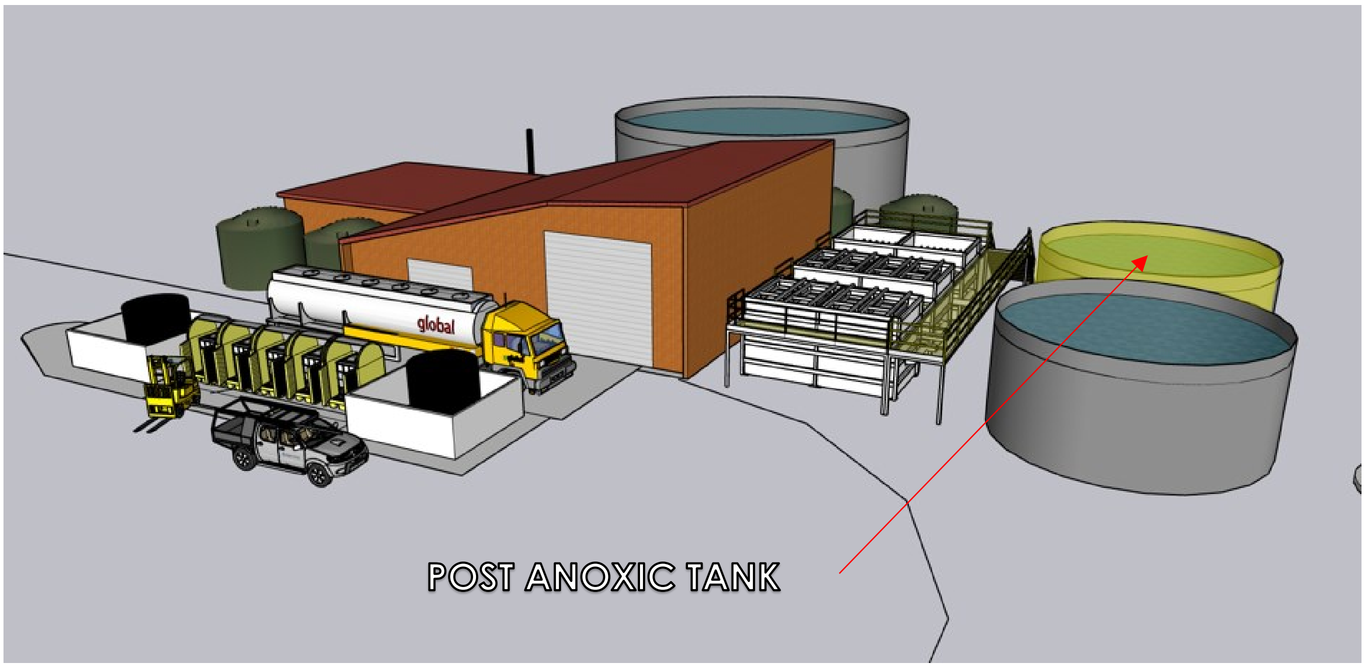

Figure 22 - Delmore Post-Anoxic Tank Location

Membrane Tank

These tanks are constructed of stainless steel and are sized to as closely as possible align with the general dimensions of a 20ft container to make them easily transportable and modular. The MBR membranes cassettes housing the hollow fibre membrane that sit within this tank are modular and can be installed as the wastewater loading increases. The location of the membrane tank can be seen in Figure 23 below.

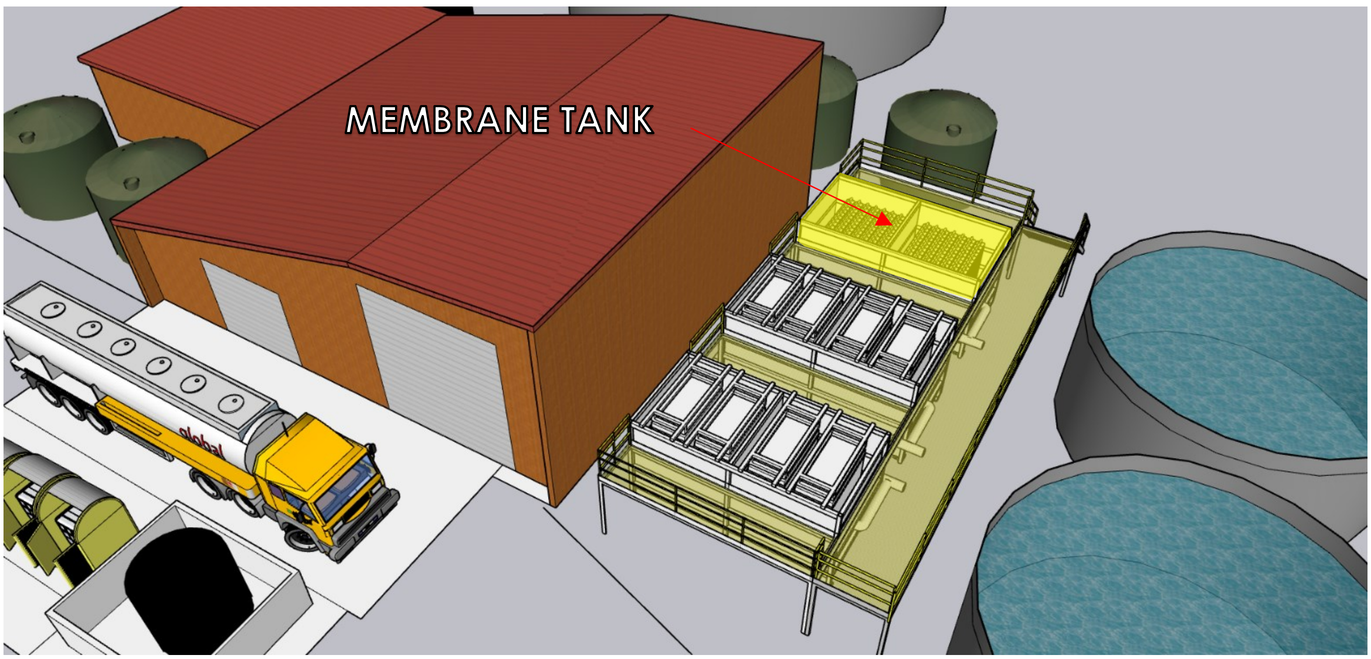

Figure 23 - Membrane tank

Other Structures

The site comprises of a number of other ancillary features which do not make up the treatment process, but service it and the site. These include:

- The overall site apron generally consisting of an impermeable surface providing vehicle access, parking and housing stormwater diversion and handling.
- The chemical load out bay, an area separated from the overall site's stormwater system consisting of an impermeable surface constructed to allow for deliveries of the chemicals used within the treatment process while minimizing any risk to the environment or personnel from spills.
- Waste Activated Sludge (WAS) tanks, consisting of two up-to 30m3 polyethylene tanks used for the settling of WAS which is a biproduct of the treatment process.
- Treated Wastewater (Permeate) storage tanks, consisting of two up-to 30m3 polyethylene tank used for the storage of permeate prior to discharge.
- Chemical storage tanks – consisting of two high density polyethylene storage tanks up-to 10m3 in volume. These two tanks will hold Sodium hydroxide and Acetic acid required in the treatment process.
- Intermediate Bulk Storage Bunds, consisting of 6no. relocatable covered bunds, used for the storage of bulk packaged chemicals which are delivered in 1000L containers. These chemicals include, Aluminium Sulphate, Sodium hypochlorite and Citric acid.
- A permeate tank for the storage and handling of permeate produced from the process for buffering periods where irrigation or re-use demand in low and allowing this stream to be discharged later. This tank has been sized to hold 1,000m3.
- Odour scrubber tanks and equipment typically consisting of a carbon vessel and vent stack used to draw-off and treat air from potentially odour generating areas in the process.

Conclusions and Recommendations

The Delmore land development consists of some 109 hectares of greenfield land in the Wainui-Orewa area and upon completion shall provide approximately 1250 new residential lots and dwellings. To deal with the risk of an infrastructure deficit in the local public wastewater network, Vineway Ltd is seeking that its resource consent approvals provide for private wastewater treatment and discharge facilities to be constructed if the need arises and until such a time that a public wastewater connection is made available to the site.

Apex Water have been engaged by Vineway to carry out design for the purpose of consenting, including an options assessment, biological modelling and the determination of key parameters of a proposed wastewater treatment plant to service the future development.

Through the assessment of different treatment plant options, Apex Water recommends the following:

- The proposed treatment plant consists of a hybrid modular 4-stage Bardenpho activated sludge treatment process, including a Membrane Aerated Biofilm Reactor, and Hollow Fibre Ultra-filtration membranes. The permeate produced can then be further treated via Reverse Osmosis membranes to produce exceptionally high-quality permeate that in many regards is better than drinking water quality.

- The treatment plant is designed such that it is partially modular, and its capacity can be increased as the development grows, with options to serve the full capacity of the development.

- Discharges of treated wastewater from the facility shall take a land first approach, making use of available land to preferentially receive discharges. Where the capacity of the land to receive flows from the plant is exceeded by the plant's capacity, the balance shall be directed to a land contact infiltration trench or (subject to commercial agreement) to the Army Bay treatment plant during off-peak periods.

- The resulting treated wastewater quality is expected to be of the highest quality of any treated sewage in New Zealand.

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