Appendix Q19.0 Risk Assessment

As part of Aquacell's standard design process for all recycled water systems, a comprehensive risk analysis is carried out to identify potential risks associated and determine the necessary controls for their mitigation. The Aquacell S150 system is based on proven blackwater treatment designs, which have been successfully installed and operated by Aquacell on multiple sites and risk-assessed in accordance with the Australian Guidelines for Water Recycling. Given the system's compliance history and standardized configuration, Aquacell has carried out an internal site-specific risk assessment workshop for this project. The details of the risk assessment can be found in Appendix Q19.1.

Following the workshop, a HAZOP (Hazard and Operability Study) and a HACCP (Hazard Analysis and Critical Control Point) matrix of the Alspec Industrial Business Park (AIBP) On Site Sewage Management Scheme are prepared and included in Appendix Q19.1 and Appendix Q19.2 respectively. It outlines the risks related to human health, operational, environmental and climate change. It also identifies critical and quality control points with corresponding preventative measures to mitigate or minimize these risks (section 6 of Appendix Q19.3).

In addition to the internal assessment, environmental impacts associated with water quality and quantity, air quality, odour, noise, and land capability during both construction and operation phases have been thoroughly evaluated by external consultants. The findings of this assessment are presented in response to Question 24 (What environmental impact assessments have been undertaken?) of this application are available in Appendix Q24.0. The environmental assessments have not identified any significant adverse environmental impacts associated with the proposed scheme.

Appendix Q19.1

INITIAL DESIGN STAGE HAZOP												ISSUED FOR CONSTRUCTION STAGE HAZOP				COMMISSIONING / HANDOVER STAGE HAZOP			
Item	**Deviation**	**Consequence**	**Causes**	**Safeguards**	**Actions**	**Who**	**Due Date**	**Status**	**Action Checked**	**By**	**Date**	**New Actions Identified/ Outstanding**	**Who**	**Due Date**	**Status**	**Action Checked**	**By**	**Date**	**Closed Out**
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
Section 1 - Inlet works (inclusive of Source water, Wet Well, Emergency Tank, Macerator, Prescreen and Buffer Tank)																			
1a - Source water (Volume, Composition only)	No or low flow	No immediate impact other than limited food for bioreactor	Periods of low population on site, eg, weekends, Christmas	Remote monitoring of plant allows adjustments to be made if required. Do not start plant until sufficient occupancy to supply minimum bio-reactor feed.								Minimum feed volume has been established by design team							
	High influent flow	Wet well and buffer tank fill. No overflow to sewer	Periods of high user demand, rainwater ingress.	Wet well and buffer tanks sized to cope with peak demands. Site is industrial so less prone to diurnal peaks you would see in residential. Wet well and buffer tank have level transducers which allow logged data to be analysed to identify unusual flows during rain events. Pump out connection to buffer tank to allow removal of water off site.								Wet well can now overflow to 300kL emergency tank							
	Reverse Flow	N/A																	
	Low Level	N/A																	
	High level	N/A																	
	High pressure	N/A																	
	Low pressure	N/A																	
	Composition or changing concentration	Plant gets feed which is not designed for and it upsets biological process, foam overs, damage to membranes from FOG's or other chemicals	Occupants dispose of chemicals or other	pH probe warns if pH out of spec, stopping transfer to bio tank. Buffer is mixed to dilute spikes. Pump out point can remove feed if severe contamination. Manual pH correction.	All occupants should be educated to ensure they understand the impacts of diposing of trade waste or other liquid waste streams to the sewer	Client						Rainwater ingress has been considered in the water balance, although impact has been considered insignificant due to smaller collection network and mostly contained.							
	Start up/ shutdown	N/A																	
	Isolation	N/A																	
	Testing	N/A																	
	Maintenance	N/A																	
	Installation	N/A																	
	Cleaning	Spill or overflow of untreated sewage	Uncontrolled flow form process unit failure.	Overflows and drains all feed back to wet well. Control measures specified on process units below such as level switches and transducers.	Ensure floor grading is suitable to direct spills and clean back to floor wastes.	Client						Hose reels included throughout the plant							
1b - Wet Well, Emergency Tank & Macerator	No or low flow	Low inflow to system	No feed from site Blockage at macerator Blockage upstream	Low Level Switch & transmitter to protect pumps. Load sensor in macerator that reverses direction, as well as overload in panel. Bypass line around macerator															
	No or low flow	Low/no flow leaving wet well	Failure of wet well pumps or blockage in line out of	High level switch and transmitter Duty/Standby pump arrangement Overflow to emergency tank -own level instrumentation in emergency tank Macerator reduces likelihood of blockage downstream Emergency tank sized to allow at least 1 day of storage in the event of pump failure. Further allowance for pump out if this is exceeded. Mixing line allowed for to prevent solids build up Valves have been selected appropriately to avoid blockages. Knife gate valves for control, full bore NRVs															
	High influent flow	Receiving more influent than we can treat	More water being received from the network than anticipated. Overflow from treatment plant contributing to level within emergency tank.	High level switch and transmitter Duty/Standby pump arrangement Overflow to emergency tank -own level instrumentation in emergency tank High flow is unlikely to be over a sustained period of time. Short term high flows that exceed capacity will overflow to emergency tank, before being processed by prescreen as capacity allows. Emergency tank sized to allow at least 1 day of storage in the event of pump failure. Further allowance for pump out if this is exceeded. Pumps sized to allow for 3x peak flow															
	Reverse Flow	Gravity flow network, not an issue																	
	Low Level	Pumps run dry and fail to operate	Failure of level transmitter AND level switch	Allowed for both level switch and transmitter															
	High level	Wet well overflows to emergency tank If it persists, emergency tank becomes full	Influent flow exceeds pump rate. Pump failure	Allowed for both level switch and transmitter Duty/stand by pump arrangement Sufficient storage capacity. Allowance for pump outs if ever required.															
	High pressure	Pressure build up in tank Pressure build up in transfer line.	Incorrect closure of valves Blockage	Flowmeter on prescreen inlet will trigger alarm in event of low flow. Gravity flow to macerator Odour scrubber cannot pull enough pressure to impact integrity of concrete storage tank.	Consider adding pressure transducer for on vent line to monitor inlet suction	Aquacell design team	14-Jul-25												
	Low pressure	Low pressure in tank	Vacuum created by odour scrubber	Vent to odour scrubber appropriately sized. Odour scrubber cannot pull enough pressure to impact integrity of concrete storage tank.															
	Composition or changing concentration	Low wastewater strength High wastewater strength High Solids	Foreign object in sewer. Oil/grease creates fat berg Innapropriate disposal of chemicals to sewer	Macerator in line to reduce likelihood of solids build up causing issues. pH sensors incorporated in design. Large volumes in storage tanks should be able to dilute periods of high chemical concentration. Bypass line to allow for maintenance of macerator	All occupants should be educated to ensure they understand the impacts of diposing of trade waste or other liquid waste streams to the sewer Tradewaste agreementrs in place with all occupants.	Aquacell/Client	14-Jul-25												
	Start up/ shutdown	Wet well shutdown	Fault with wet well pumps or routine maintenance	Bypass line allows feed to be diverted from macerator to emergency tank.															
	Isolation	Isolation of macerator. Isolation of wet well.	Routine maintenance or failure of equipment	Isolation and bypasses available. Cutter pumps will assist with reducing solids build up in event of macerator isolation															
	Testing	Requirement to sample influent	Troubleshooting/verification testing	Sample point between wet well and pre screen.															
	Maintenance	equipment offline	Routine servicing or unplanned maintenance	Duty/standby. Able to remove pump by guide rails & level instrumentation from above, means requiring tank access is unlikely. Inlet pit is accesible for maintenance and not deep enough to require confined space permits. Readily accessible for access by lifting equipment	Ensure that sufficent openings are allowed, for both visual inspections, and flushing when required.	Aquacell design team, tank supplier													
	Installation	Issues around Installation of tanks (leak of collapse)	Incorrect design or installation of tank or any process equipment	Engaged third party specialists for design and installation. Inlet works is accessible by crane. Confined space operatives used for initial installation.															
	Cleaning	Build up of solids or grit causing premature pump failure or blokage	Solids passing into wet well, either through macerator or during bypass	Both macerator and cutter pumps incorporated into the design. Mixing line to resuspend any solids. Sloped floors to divert to single point															
1c - Pre Screens	No or Low Flow (into screen)	No impact																	
	High Flow (inflow faster than outflow)	Spill or overflow of untreated sewage. Excess use of process water	Screen is partially or completely blocked which reduces throughput. Failure of solenoid valve on proces water lines.	Screens overflow back to buffer tank so there are no spills. Spray water to screen to assist cleaning. Screen run on time can be tuned to ensure proper cleaning and minimise use of process water. Level transducer will alarm and lock out feed pumps if screen is high. Process water recycles to buffer tank.	Current design shows 3x screens. Design team to investigate **alternative screens** (2x 100%). We can potentially consider "open channel" design. **Details of pump station** (by others) to be confirmed by client.	CF SA JJ			Currently working through alternative options. Expecting proposal by 21/03 (Hydroflux)	Design	19-Mar-25	Design calcs that 2x prescreens can keep up with design flow, though space for a third prescreen has been allowed for if required in future.		14-Jul-25					
	Reverse Flow	Screens back up because it can't empty. Screen syphons buffer tank to wet well. Outlet or overflow from one screen allows flow to the other screen	Blockage in outlet, wet well lower than screens so gravity flow possible	Wet well pumps have NRV's. Inlet to buffer tank is high level with air gap so syphon through screen to wet well is not possble. Screens gravity flow to buffer tank so not possible to pump back to screen. Screen outlets are 150mm with influent screened to < 2mm so blockage unlikely. Level transmitters in screens meaning they shut down if blocked. Duty/standby screen arrangement.	Confirm levels and pipework design are such that flow from one screen to the other through outlets or overflows is not possible				Cannot be closed out until unit is specified.	Design	19-Mar-25	Design finalised, confirm that prescreens both flow to buffer tank and cannot flow from one to another		14-Jul-25					
	Low Level	No Impact																	
	High Level	As for high flow																	
	Low Pressure	No Impact																	
	High Pressure	Damage to screen or risk of odour escaping	Damper to vent system closed. Vent line blocked	Vent line sized to ensure adequate flow in normal operation. Screens can depressurise through overflow line to wet well. During no flow screens can depressurise through buffer tank															
	Low Temperature	No Impact																	
	High temperature	No Impact																	
	Composition or changing concentration	Screen can block	Foreign objects like wet wipes can bind up screen bruch	Correct selection of wet well pumps. Spray bars and screen run on times to ensure screen clears. Routine maintenance and inspection to clear screen	All occupants should be educated to ensure they understand the impacts of diposing of inappropriate objects to the sewer system	Client						Macerator reduces likelihood of large solids entering prescreen. We now have mixed liquir entering the screens - meaning that when we run at higher MLSS concentration, we need to run at lower flow - Plan is to run mixed liquor processing during night time, or blending it with influent.	AQ design team	14-Jul-25	Closed				

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Cleaning	Screens doesn't function due to lack of cleaning. Screenings difficult to dispose of	Screens are difficult to access or clean	Screens are readily accessible. Hose point in treatment plant to allow screen to be cleaned	Ensure bin and system of disposal for screenings is suitable	AQ Design Team			Cannot be closed out until unit is specified.	Design	19-Mar-25	Confirming that disposal system is suitable. Additional roller shutter door added for direct access to prescreens.			Closed				
	Testing	No way of easily testing or getting a representative sample of influent.	No place to take a representative sample.	Sample point on screen inlet															
	Maintenance	Screens can't be maintained	Maintainable parts not accessible	Each screen can be indpendantly isolated	Ensure ready access to screen to remove screen with lifting device if required	AQ Design Tesm			Space will be maintained, once final unit is determined.	Design	19-Mar-25	Confirming that disposal system is suitable. Additional roller shutter door added for direct access to prescreens.			Closed				
	Installation	Screens cant be installed	Insufficient access									Sufficient access from new side road through roller shutter door for installation			Closed				
	Isolation	Screen can't be isolated. Outlet from one screen flows up other screen outlet if the screen is removed for maintenance.	No Isolation points on outlet or overflow	Inlet, process water inlet and vent all have isolation valves. Screens installed at the same level with gravity flow to buffer.	Confirm flow is not possible from one screen to the other via the joined outlets if one screen is removed for maintenance. Similarly for overflows.	AQ Design Team			Since the level for duty & standby is the same, overflow should not be possible. There is no valve between prescreen and buffer to interrupt flow.	Design	19-Mar-25								
1d - Buffer Tank	No or low Flow	No immediate impact other than limited food for bioreactor.	Screen or line blockage. Screen maintenance or failure Pipe failure. Diversion valve failure	Low level in buffer tank is visible on HMI/remote monitoring.															
	High flow	Overflow tank.	Operators running pumps or other equipment in manual. Issue in the plant that prevents processing	Level transducer in buffer tank to generate alarm. Email alarming can be configured. There is a pump out point if waste needs to be removed from site. Buffer tank appropriately sized to take short term interruptions to production.								Buffer tank can overflow to emergency tank if full		14-Jul-25	Closed				
	Reverse flow	Buffer tank drains Anoxic tank.	NRV's on pumped line fail	Feed line to anoxic tank comes in above overflow level so syphoning not possible even if NRV fails.								Feed line now comes in below overflow level. Raise level in anoxic tank to flag warning of reverse flow from anoxic tank to buffer. Alarm to be added to FDS. Consider flow circulation within anoxic tank and best location for mixers		14-Jul-25	Closed				
	High pressure	Tank damage; leakage of wastewater outside tank.	Tank is sealed (odour) with no overflow. Operators run pumps manually. Vent line is blocked at the same time as trying pump waste to the tank.	Gravity flow into tank so pressure is limited to head height of feed liquid. Unlikely to damage undergroundtank. Vent line does not have a damper which could be inadvertantly closed. High level transducer with high level switch backup to stop feeds in automatic.	Confirm if level on out of spec tank would push liquid through vent line to odour scrubber.	AQ Design Team			Vent to odour scrubber is sufficiently sized	Design	19-Mar-25								
	Low pressure	Tank collapse.	Pumping out of tank with no way of drawing air in.	Air can be drawn in through the screens if the vent is blocked.															
	Low level	Pump damage. Loss of containment. LTX / LSL failure	Running pumps in manual	Level transmitter for low level protection with level switch as back up.LTX / LSL if one fails, the other device should still read correctly. Buffer transfer pump is interlocked with low level.															
	High level	Overflow tank.	Failed level transmitter. Leaking or manually open valve on off spec tank	Level transmitter has level switch back up in case of failure.	Consider if the tank should have a trapped outlet that diverts tank contents to a specific area if there is ever an overflow event	AQ Design Team			Overflow from buffer tank to emergency tank is to be incorporated	Design	19-Mar-25	Emergency tank has now been allowed for	AQ Design team	14-Jul-25	Closed				
	High temperature	N/A																	
	Low temperature	N/A																	
	Composition or changing concentration	Poor quality water to MBR. Onset of UF fouling and more CIPs than normal	Different activities by client. Surge in alkali cleaners. Anaerobic and pH drops. Chemical dumping.	Buffer tank smooths out peaks. DO monitoringpH alarms on buffer tank. Program PLC to stop/reduce transfer if buffer tank pH high/low.															
	Start up/ shutdown	Low pH Flammable gases.	Could go anaerobic if shutdown for a long time	pH probe. Ventilation to allow gases to be removed. Pump out tank if waste is not appropriate to start plant with.								We have now established that plant cannot be run until 30kL/day is achieved.	AQ Design team	14/07/2025	closed				
	Cleaning	Hose down needed	Build up of scum, foam and waste inside buffer tank	Sealed tank. Not an aerated tank so foam overs not likely.	Consider sepeciying more than one hose point in the plant	AQ Design Team			Current proposal is that 3x hose points should be allowed. 1x in the main treatment plant, 1x in the sludge room, 1x outside (facing the biotanks)	Design	19-Mar-25								
	Testing	N/A										Add sample line to anoxic feed piping - potentially in valve pit	AQ Design team	14-Jul-25	Closed				
	Maintenance	Pumps and probes in tank need to be serviced	Routine maintenance or failure	Probes/transducers/switches mounted into the top of the tank via flange or similar which allow easy removal. Sumbersible pumps and mixers on rails or similar that allow them to be removed easiy for maintenance.															
	Installation	Incorrectly installed and tank leaks. Pump installation involves a confined space entry.	Inexperienced tank builders Inadequate or undefined quality assurance	Manufacturer to install the tank. Hydrostatic test as part of commissioning. Confined space qualified personel to be used to install the pumps. Consider using the tank manufacturers to install the pumps.															
	Isolation	Can't shut down tank for confined space entry if ever required	Insufficient isolation points	Manual isolation valves upstream of screens and on the transfer line from the out of spec tank.								Consider additional spectacle plate from treated water storage for isolation. We can isolate inlet to off spec.	AQ Design team	14-Jul-25	Closed				
Section 2 - MBR (inclusive of Anoxic, Aerobic, MOS and Filtrate)																			
2a - Bioreactors - Anoxic (including mixer)	No or low Flow	No or limited food for bioreactor.	Buffer tank pumps failed, empty buffer, or MBR overflow stopped, Bio pumps failed, aerobic tank low level (stops bio pumps), blocked line. Closed valve after maintenance.	Regular monitoring and maintenance by service staff.															
	High flow	Overfill and over pressurise tank causing tank damage or flooding.	Overfeeding from buffer (both pumps on manual).	Piping and overflow is within design capacity for two pumps in parallel. High level switch in Aerobic tank															
	Reverse flow	Overfilling	Foaming in aerobic tank. Anoxic overflow pipe blocked.	Check valves in buffer pumps to stop flow back to buffer tank. Anoxic to MBR tank hydraulically not possible other than foam. Foam from aerobic to tank to anoxic is possible but there are spray bars in the aerobic tank to control foaming.								Check valves on anoxic recirc pumps will also prevent reverse flow							
	High pressure	Tank damage. Leakage of wastewater outside tank.	Overflow blocked.	Overflow sits above inlet level of aerobic tank, so not possible to hydraulically block the line.															
	Low pressure	Tank damage	Blocked vents and bio pumps running	Multiple vent paths - overflow from from aerobic, overflow line from MBR, DN80 vent on tank.								Even if vents were blocked, the pumps would not create sufficent vacuum to damage the underground concrete tanks. Vent dia. increased to 100mm							
	Low level	Mixer gets damaged because water level is low	Tank leaking	Low level switch to protect the mixer. No drain valve on tank. No pumps in tank to empty it in normal operation.															
	High level	Spill from tank	Overflow blocked.	Not possible to hydraulically block the overflow.Spray line in aerobic tank to control foaming. Liquid flow will likely unblock any foaming that may carry over into the overflow line.															
	High temperature	Biology effected	Prolonged exposure to hot climate or high temperature feed	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Low temperature	Biology effected	Prolonged exposure to cold climate or low temperature feed.	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Composition or changing concentration	Explosion from gases Corrosion of tank Under performance of mixed liquor.	Anaerobic and may produce odour or explosive gases. Improper disposal of CIP waste. Chemicals in wastewater.	DO probe in the aerobic tank. Mixing and aeration in anoxic tank. Design is inherently anoxic. Safeguards for buffer tank. Buffer tank serves to lower peak concentration in w/water.								Explosive gases will be vented through the OCU stack. pH probe in buffer tank to monitor influent characteristics.							
	Start up / shutdown	No issues with start up Mixed liquor turning septic during prolonged shutdown	Lack of aeration during shutdown	During extended shutdown, manually operate pulse burst aerators to supply oxygen from the aerobic tank. If a long period of time then drain the tank.															
	Cleaning	Accumulation of biomass on floor of tank.	Biomass settles over time	Mixer installed. Upstream screening to remove large items.	Consider access for pump out of tank if ever required.	AQ Design Team			Access hatches are to be provided in all tanks. Vehicle access is possible direct to aerobic tanks.	Design	19-Mar-25								

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Testing	Underperformance of mixed liquor. Design intent is to remove some nitrogen.	DO of anoxic zone is too high such that anoxic conditions do not exist		Consider access point near the weir to insert DO probe (or visually inspect aeration).	AQ Design Team			Visual inspection is possible through access hatches. Instrument probes can be deployed.	Design	19-Mar-25								
	Maintenance	Can't maintian mixer. Can't inspect tank.	No drain valve on tank.	Mixer and level switch accessible without needing to pumps down tank. Tank inspection rare and it's practical to pump down a 40kL tank if required.								Mixers to be installed on guide rail to allow removal without draining tank.							
	Installation	Leakage	Sub-standard installation leading to a leak	Hydrostatic testing at clean water commissioning.															
	Isolation	High risk if confined space entry of anoxic tank with aerobic tank contains unaerated mixed liquor	Unable to isolate headspace of anoxic tank from aerobic tank. Unable to isolate headspace of MBR tank from anoxic tank.	Able to isolate against inundation at other points.															
2b - Bioreactors - Aerobic (including blower skid)	No or low Flow	Underperformance of biological system. Failure to achieve required DO and MLSS levels	Buffer tank pumps failed, empty buffer, or MBR overflow stopped, Bio pumps failed, blocked overflow from anoxic tank, strainer on bio pump outlet blocks.	Alarms and faults allow service staff to monitor pumps remotely. In line flow meter between bio tank and MBR tank monitors flow. Flow switch on instrumentation side stream alarms if flow is inadequate.															
	High flow	Overfill and/or over pressurise tank causing tank damage or flooding.	Excess flow into anoxic tank	MBR tank can only overflow at the rate the bio pumps remove liquid so no net gain from these pumps, even in manual. Overflow DN150 sized correctly.															
	Reverse flow	MBR and bio tank levels equilibrate and part of membrane exposed.	Loss of power NRV for bio pumps stays open	Bio pumps have NRVs. Bio pumps run almost all of the time. MBR tank has level transducer which will alarm if the level drops.															
	High pressure	Tank damage. Leaks	Blocked overflows. Blocked ventilation for foaming.	Tank can vent through anoxic tank, if aerobic tank vent was blocked. Spray bars keep foaming down.	As per anoxic tank. Confirm with installers that vents for bio and buffer tanks have an uphill gradient, which will avoid water accumulting in the vent system.	AQ Design Team			Confirming an uphill gradient will be applied to the vent from the biotank to odour scrubber.	Design	19-Mar-25								
	Low pressure	Tank damage	Pumps running with vent blocked	Multiple vent paths - vent through anoxic, vent through MBR overflow since overflow is not full bore flow.	As per anoxic tank				Risk of blockage considered to be minimal. No valves or other inline equipment in odour scrubber vent lines.	Design	19-Mar-25								
	Low level	Damage to pumps or aerator	Transducer failure	Level transducer is backed up by level switch															
	High level	Spills	Pumps running manually. Foam "fills" tank above liquid level. Transducer failure. Tanks fills goes high from excess spray water	High level transducer is backed up by level switch. Tank overflows to wet well. Tank sealed for odours so foams will likely go down overflow or back to anoxic tank. Spray bars to reduce foam. Control system allows for sprays to run intermittently to operator settings rather than continuously. System is closed loop - spray water doesn't add to volume in plant since it is process water rather than potable.															
	High temperature	Biology effected	Prolonged exposure to hot climate or high temperature feed	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Low temperature	Biology effected	Prolonged exposure to cold climate or low temperature feed.	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Composition or changing concentration	Explosion from gases. Corrosion of tank. Under performance of mixed liquor.	Inadequate DO control leading to anaerobic conditions. Improper disposal of CIP waste. Chemicals in wastewater. Aerator inlet blocked reducing aerator efficiency	DO and MLSS probe in bio pump sidestream to monitor MLSS. Buffer tank smooths concentration changes up stream. CIP chemcials appropriately neutralised before being introduced into the system.	Ensure aerator pipe is easy to inspect and maintain.				Submersible aerator is considered, which should be easy to raise and inspect.	Design	19-Mar-25	Explosive gases will be vented through the OCU stack. pH probe in buffer tank to monitor influent characteristics. Magnesium hydroxide will be dosed to control pH.								
	Start up / shutdown	No issues with start up Mixed liquor turning septic during prolonged shutdown Pump and/or aerator damage due to operation at low level.	Aerator not submerged. Manual operation overrides level switch Inadequate aeration during prolonged shutdown.	Plant has several stages of shutdown which ensures aerators and pumps run for appropriate periods depending on down time. Level switches and transducers protect pump and aerator	Consider replacing AV-331A & AV-332A with a 3-way valve (waste to sludge settling tank)	AS			Addition of 3 way valve considered in design.	Design	19-Mar-25	Sludge settling tank has been removed from the design, so the three way valve is no longer required.							
	Cleaning	Accumulation of biomass on floor of tank.	Biomass settles over time	Mixer installed. Upstream screening to remove large items.	Consider access for pump out of tank if ever required.	AQ Design Team			Camlock and required isolation valves to be incoporated to allow tank to be drained	Design	19-Mar-25	Access for pump outs confirmed. Design now features an emergency tank transfer system from biotank							
	Testing	Underperformance of mixed liquor	DO, pH, MLSS,	External DO and MLSS on bio pump side stream. Can do grab sample from tank.	Consider inspection points in the aerobic tank (to inspect aeration pattern)	AQ Design Team			Inspection hatch to be included in tank. Submersible aerators to be utilised, no aeration grid.	Design	19-Mar-25	Confirmed inspection hatch included in design							
	Maintenance	Biological system underperformance. Pump or aerator failure.	DO/MLSS probe malfunction	Maintenance of DO and pH probes is easy as it is external. Aerator and pumps can be removed from tank without requirement for confined space entry. Access hatch in tank allows for aerator performance to be assessed.															
	Installation	Leakage	Sub-standard installation leading to a leak	Tank manufacturer to install															
	Isolation	High risk if confined space entry of aerobic tank with anoxic tank containing unaerated mixed liquor	Unable to isolate headspace of anoxic tank from aerobic tank.	Able to isolate against inundation.															
2c - MOS System (Including Magnesium Hydroxide dosing)	No or low Flow	Low inflow to MBR tank leads to biomass concentration increases and blocks membranes. Low flow of air causes fouled membranes. Low backwash flow for maintenance clean causing ineffective membrane cleaning. Low alkalinity chemical flow. Low venturi flow leading to not priming the line. Low flow in instrumentation loop giving false reading. No/Low magnesium hydroxide dosing on overflow line	Blocked recirc pump or pump isolated manually. Blower failure or pipe failure. Loss of pump prime. Low alkalinity caused by loss of pump flow or chemical Blocked dosing line or pump failure	Level transducer in MBR tank that would identify when insufficient mixed liquor feed. MBR overflow is adequately sized. Permeability alarm. Air pressure indicator and alarm. Flowmeter on inlet from biology and after outlet of MBR pump. Level switch on line to confirm priming. Flow switch on instrumentation loop. Selected DN20 magnesium hydroxide dosing line to avoid pipe blockages. Incorporated dosing tank mixer to avoid magnesium hydroxide settling in the system. Selected peristaltic pumps for magnesium hydroxide dosing.															
	High flow	High ML flow has no significant consequence. High air flow could cause membrane damage. High filtrate flow causing rapid fouling. High BW flow damaging membrane. High overflow rate causing high level. High vent flow.	High air flow - both blowers running. Incorrect flow setting on filtrate/BW. High vent flow caused by excessive air.	High flow alarm on filtrate flowmeter. TMP alarm. Air flow limited by aeration rate / size of membrane blower. Overflow rate limited by biology pump flow.								Overflow adequately sized							
	Reverse flow	Reverse flow of MLSS to blowers. Reverse flow of MBR tank to aerobic tank.	MLSS damages blowers. System off for an extended period and slow leak through NRV on ML line, leading to membranes partially exposed.	Non-return valve on blower. Blower pipe line installed so it is higher than the filtrate tank overflow. Non-return valves on all pumps. Level transducer alarms prior to the membrane being exposed.															
	High pressure	High air pressure causes blower failure or low air flow High TMP causes rapid fouling and increases energy consumption High BW pressure for maintenance clean.	Blower isolated or line blocked. Poor mixed liquor quality	Pressure relief valve on blowers. Air pressure monitored and alarmed for high pressure. TMP monitored and alarmed. BW pressure monitored and alarmed. Dead head pressure for backwash pump is less than the design rating for the membranes.	Consider actuated valve on MBR filtrate air relief line for priming	AS			Additonal valve to be added onto the line	Design	19-Mar-25	Confrimed actuated valve added on MBR filtrate priming line							
	Low pressure	Low air pressure leading to low air flow and membranes foul faster. Low process water pressure on venturi leading to insufficient vacuum, lead to loss of prime of filtrate pump	Air line or blower line failed.	Blower pressure monitored and alarmed. Level switch on header will detect inadequate venturi operation.								Duty/stand by MOS blower incorporated into the design.							
	Low level	Membranes exposed and may dry out. Could allow air to damage membrane by excessive movement. Air in filtrate line	No inflow or tank drained or valve left open.	Level transducer on MBR tank to monitor level. Low level interlocks blowers and filtrate pump. Low flow through membrane pump detected and alarmedvia flowmeter after MBR pump.															
	High level	Tank is designed to overflow to biology tank. If blocked, then level will rise up the vent line.	Blockage in overflow to aerobic tank.	No manual valves on overflow to aerobic tank. DN150 overflow.															
	High temperature	High temperature can damage the membranes	Exothermic chemical reaction diluting or neutralising chemical	Temperature monitored, although only during filtration. Procedure for CIP to prevent mixing of incompatible chemicals. Membrane tanks indoors so not exposed to direct sunlight.															
	Low temperature	Membrane damage	Exposure to low temperature	Temperature monitored. Membrane tanks are indoors and not exposed to prolonged cold temperature. Membranes submerged with tank contents always moving - no risk of freezing.															
	Composition or changing concentration	Damage to membranes by chemicals or other impurities. Damage caused by high MLSS. Damage caused by excessive fibrous materials blocking the membrane modules. Membrane integrity failure leading to poor quality treated water.	Wrong recipe for CIP or inadvertant overdosing of chemicals during CIP. Fibrous material caused by screen failure.	Automated CIP sequence set up at commissioning. See screen failure safeguards. pH probe in buffer tank to detect some impurities. Turbidity monitor and alarm to detect integrity failure.TMP monitoring to detect fouling. MLSS probe to monitor solids concentration. In line strainer between biology pumps and MBR tank.	Consider selection and suitability of MBR recirc strainer. Ali to investigate rescreening of MLSS from MBRs.	AS			Considering a "pre-pump strainer", which is hydraulically cleaned. Also looking into other options/getting advice from MBR experts.	Design	19-Mar-25	Mixed liquor rescreening has been incorporated to protect membrane failutre caused by fibrous material. Basket strainer also added upstream of MBR tank to protect membrane from fibrous material.							
	Start up/ shutdown	Membranes exposed and may dry out. High flow of filtrate due to incorrect VFD setting.	Passing check valve and level equalisation with bio tank. Leaking drain valve. Membrane damage or bio fouling. Position of manual valve on filtrate pump discharge	Non-return valve in biology supply line. Level transducer on membrane tank and a low level alarm. Established procedures for proper storage of membranes (SMBS). Safeguards as per low and high flow scenarios.															
	Cleaning	Membrane fouling/damage	Wrong chemicals and/or concentration or procedure.	Chemical cleaning to be performed only by trained personnel following appropriate procedures.								Sample points added to CIP line to test chemical if required.							

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Testing	Non-representative samples, or spurious results (e.g. coliforms due to contamination).	Contamination of sample points	Sample points on filtrate and MLSS provided Stainless steel sampling point for ease of disinfection by ethanol (or flamed).								Sampling to be performed only by trained personnel following appropriate procedures.							
	Maintenance	Membranes dry out/fouling/damage	Visual inspection for aeration pattern, hose down for CIP. Removal of membranes	Use trained service personnel. Access for visual inspection is available. Pull out rack for maintenance and change out of membranes is part of design.								Platform ladder has been incorporated for visual inspection. Filtrate turbidity continuously monitored to change filtrate quality due to membrane damage.							
	Installation and environment (sun, noise, odour)	Injury due to inadequate access to equipment. Odour in the room.	Poor layout and design and insufficient isolation.	Tank has lifting lugs fitted to allow it to me craned into position. Local isolators provided on all motors. Manual isolation valves on tanks. Vents for odour control.															
	Isolation	Inability to achieve effective isolation for confined space entry (if required)	Improper isolation.	Manual isolation valves provided. Tank only opens from the side so cannot be inundated.															
2d - Filtrate Tank	No or low Flow (filtrate)	No disinfection = no treated water production Low level in filtrate resulting in disinfection pump runnings dry	Valve failure Filtrate pump failure Pipe leak or blockage	Level transducer and level switch on filtrate tank.															
	No or low Flow (potable)	Unable to prepare CIP/MC solution	Potable top up valve failure. Potable water outage	Level transducer and level switch on filtrate tank. Flowmeter on potable inlet to treatment plant.															
	High flow	Overflow the tank. Inflow upsets instrumentation due to turbulent flow	MOS flow set point too high	Overflow on the tank. High flow alarm on MOS system. Instruments installed as per other Aquacell sites ensures they are not effected by high flow.															
	Reverse flow	Contaminated potable water top up line Air flow from floor drain causes odour	Backflow up line Connection between overflow and floor sink	Air gap for both the filtrate flow and potable water flow into the tank, prevents backflow. Floor drain specified with trap. RPZ valve on potable line.															
	High pressure	Tank damage	Not feasible due to air gap and overflow are vented and DN100 overflow	Since odour risks are unlikely, tank is normally not fully sealed.															
	Low pressure	Tank damage	Not feasible due to air gap and overflow are vented and DN100 overflow	Since odour risks are unlikely, tank is normally not fully sealed.															
	Low level	Damage to disinfection and filtrate pumps	Level TX failure. Break in pipework	Low level switch as backup to level transmitters. Flowmeters will detect low flow from pump to prevent damage.															
	High level	Tank overflows	Level transmitter failure. Blockage in overflow.	Level transmitter is backed up by high level switch. Overflow to floor drain is appropriately sized.															
	High temperature	N/A																	
	Low temperature	N/A																	
	Composition or changing concentration	Uncompliant treated water. Damage to equipment from CIP chemicals	Residual CIP chemical. Membrane integrity issue.	MOS CIP is automated to ensure flushing after CIP. Operating instructions to ensure filtrate tank is drained following CIP. pH is monitored and will pick up some level of incomplete CIP rinse. Turbidity monitored to ensure membrane integrity.															
	Start up/ shutdown	No specific issues																	
	Cleaning	Poor ability to clean any biofilm	Inadequate access	Access hatch on top of tank to add chemicals if required.															
	Testing	Biofilm growing inside the tank without knowing it	Filtrate quality monitoring is on the pipe at the inlet to the filtrate tank	Sample point post disinfection pump to take sample. Opening in top of tank to visually check.															
	Maintenance	Poor ability to clean any biofilm	Inadequate access	Access hatch on top of tank to add chemicals if required.															
	Installation and environment (sun, noise, odour)	Plant is indoors, so no issues.	Filtrate tank larger than available building access.	2 x Filtrate tanks and delivered to site via doorway access.								Confirmed doors are appropriately sized.							
	Isolation	Unsafe working for maintenance	Lack of manual isolation	Isolation valves provided to prevent accidental filling of tank.															
Section 3 - Disinfection (Inclusive of Ozone, BAC, UV and Chlorination)																			
3a - Ozone Treatment including OCT Piping	No or low Flow	Low flow compressed air to ozone skids. No or low filtrate flow. Ozone not generated at suitable rate.	Compressor failure. Upstream pump or valve failure	Ozone levels checked pre OCT pipework. Alarm levels can be set. Ozone skid has alarms that go back to the PLC.								Flowmeter after disinfection pump. Regular maintenance schedule for compressor.							
	High flow	Incomplete treatment or insufficient residual ozone	Flow through ozone OCT pipework too high to get required contact time. Ozone flow into treated water too high leading to over ozonated water	High flow through contact pipe mointored by flowmeter upstream of ozone skid. Ozone levels checked pre OCT pipework. Alarm levels can be set. Ozone skid has alarms that go back to the PLC															
	Reverse flow	Reverse flow through eductor	Line blockage	Check valve on ozone inlet of eductor.															
	High pressure	Damage to equipment	Damage to seals or pipework.	Ozone system has an independent control system and sensors to monitor pressures and alarm. Pipework designed to accommodate pump dead head pressures.								Regular maintenance schedule for compressor. Pressure switch on compressed air receiver							
	Low pressure	Compressed air pressure too low to generate sufficient oxygen	Malfunctioning compressor, air leaks	Ozone system has an independent control system and sensors to monitor pressures and alarm								Regular maintenance schedule for compressor. Pressure switch on compressed air receiver							
	Low level	Low ozone concentration	Increase ozone demand, malfunction ozone unit	Ozone system has independent control system to monitor production. Ozone probes to measure residual ozone and alarm															
	High level	High ozone concentration	Decrease ozone demand	Ozone system has independent control system to monitor production. Ozone probes to measure residual ozone and alarm															
	High temperature	Inadequate colour removal	Ozone half life reduces as temperature rises, temperature affects solubillity	Temperature probe in cell where residual ozone is measured								Upstream and downstream temperature can be monitored from MOS and CCT temperature probe.							
	Low temperature	Inadequate colour removal	Temperature affects solubillity	Temperature probe in cell where residual ozone is measured								Upstream and downstream temperature can be monitored from MOS and CCT temperature probe.							
	Composition or changing concentration	Inadequate colour removal, Ozone begins to concentrate in the air	Ozone demand is not consistent, leaks in ozone system	Ozone concentration meansured at start at outlet of ozone contact tank, ozone destruct unit vented to roof to ensure excess ozone is safely removed.	Confirm there is an ozone sensor and alarm which would detect leaks	Aquacell Design Team			Confirming ozone leak sensor is incorporated into ozone offer	Design	19-Mar-25								
	Start up/ shutdown	Inadequate colour removal	Ozone system requires time to produce ozone on startup		Confirm if there is any stored ozone on shutdown. If so, confirm the system sends it through the destruction unit	Aquacell Design Team			Ozone destruction unit is to be incorporated into ozone system. Current quote does not include this. Ali to get revised quote.	Design	19-Mar-25	Confirming that ozone destruction unit is incorporated into design. Ozone sensor fed back to PLC.							
	Cleaning	No specific cleaning requirements																	
	Testing	Samples required	Ad-hoc sampling for troubleshooting, instrumen verification	Sample points upstream and downstream of ozone unit and OCT pipework	Consider also adding sample point after each OCT leg to monitor ozone decay	AS			Additional sample points to be incorporated into the design.	Design	19-Mar-25	Sample points added after each OCT pipe leg.							
	Maintenance	Break downs	Inappropriate servicing	Service and maintain compressors and Ozone unit as per manufacturer's recommendations															
	Installation and environment (sun, noise, odour)	Noise. Difficult to install OCT pipework skid	Compressor supply compressed air to ozone unit and run at high duty	Units installed indoors away from direct sunlight. Building doors should be large enough. Option to construct in situ if final building design presents a problem	Confirm selection on compressor type considered noise levels. Confirm compressor has an acoustic hood.				Alternative unit to atlas copco to be approached	Design	19-Mar-25	OCT pipe length has been selected to ensure that it can be manufactured off site. Rotary screw compressor has been selected to reduce noise.							
	Isolation	No ability to isolate	Valves and electrical isolators not installed	Ozone units have a main switch on the unit. Isolation valves upstream and downstream.															
3b - BAC Filters	No or Low Flow	Ineffective backwash. System is airlocked.	Insufficient flow from process water pump	Process pump sized correctly. Air relief valves at high points in the system.															
	High Flow	Insufficient contact time for correct treatent. Carbon flushed out of filter housing. Spillage from backwash going to floor waste	Pump incorrect size or running too fast of a VSD	Pump sized correctly for forward flow. Flow controller installed in drain line to control backwash flow. Each pair of filters are in series so not possible to divert twice the flow through one filter	Review backwash pipe connections to floor drain at commissioning. Re-engineer if appropriate. Consider using besser block bund.	AQ Commissioning team			To be considered at commissioning if required. Could consider fabricated flow diverters if required, rather than besser blocks.	Design	19-Mar-25	Appropriately sized drainage pit included in the design to avoid spillage from high backwash flow.							
	Reverse Flow	Forward flow diverts to drain.	Problem with filter valve not locating properly or other internal problem	Limit switches provide feedback to PLC on filter valve status. Flowmeters upstream															
	Low Level	N/A																	
	High Level	N/A																	
	Low Pressure	Filter does not backwash correctly	Process water feed issue (Pump/valve)									Pressure transducer added to process water pump outlet							
	High Pressure	Damage to filter housings. Reduced throughput	Incorrect valve sequencing. High backwash pressure.	Position feedback to be incorporated.								Pressure transducer added to process water pump outlet							
	Low Temperature	N/A																	
	High temperature	N/A																	

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Composition or changing concentration	Residual ozone upsets BAC conditions.	Overdosing ozone upstream. Bio-growth or other contaminant coming from filtrate tank.	Residual ozone measured at the outlet of ozone contact tank. Refer to Filtrate tank maintenance controls.															
	Cleaning	No specific external cleaning requirements. Replacing carbon as per Maintenance controls																	
	Testing	Filters not performing as expected	Carbon exhausted. Upstream process issues	Sample points located updtream and immediately downstream prior to UV units															
	Maintenance	Insufficient colour removal. High HCC count	Filters not backwashed properly	Filters set to backwash on time, differential pressure or manually initiated by operator. High DP is an alarm condition. Unions allow control valve to be disconnected for easy access. "Slurpy" or wet vac's to extract used media.	Ensure adequate height and access for platform ladder when finalising layout	Aquacell Design Team			Mohammad to review access for platform in 3D model	Design	19-Mar-25	Access for platform has been considered.							
	Installation and environment (sun, noise, odour)	Damage to filters from handling or UV	Difficult to handle	Leave vessels on pallet for as long as practically possible. Maintian forklift access to final location if practical. Use at least two people to move filters. Ensure final piping does not impede ability to do initial fill of filter. Filters installed in shed so problem with UV degredation.	Ensure adequate height and access for platform ladder when finalising layout	Aquacell Design Team			as above	Design	19-Mar-25								
	Isolation	Need to replace filter media	Carbon at end of useful life	Each vessel can be isolated to allow the filter to be maintained.															
3c - UV systems	No or low Flow	Overheat the UV	Disinfection pump is off (auto or manual). Downstream valve closed. Air trapped in unit.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time. Valves in the high part of the line allow air to be vented															
	High flow	Inadequate disinfection due to short contact time.	High flow from UV pump	Flow from pump is monitored and alarms on high flow.															
	Reverse flow	Not feasible			Add NRV from diversion line to off spec water tank				Confirmed valve added in P&ID	Design	19-Mar-25								
	High pressure	Damage UV by exceeding design pressure	Downstream valve is closed	UV and pipework rated pressure higher than dead head pressure of pump.															
	Low pressure	UV fouling due to lack of wiper functionality.	Low permeate pressure Manual valve closed Drain valve opened	UV controller monitors wiper action and will alarm if it doesn't wipe. Procedures for maintenance of UV.															
	Low level	Damage to unit due to over temperature	Leak, unit drained and left isolated after service.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time.															
	High level	N/A																	
	High temperature	Damage to unit. Damage to pipework surrounding the UV	Running with no water or low flow.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time. Pipework within line of sight of UV lamp is stainless steel.															
	Low temperature	N/A																	
	Composition or changing concentration	Poor disinfection	Low UVT. Fouled lamps or failed lamps causing low UVI. Pipe material selection incorrect and allows UV light to damage pipework. Valve arrangement used for CIP.	UVT monitor is integral to UV and alarm warns of low UVT. UV dose alarm to warn of low intensity and low dose. Lamp failure alarm. Use stainless steel upstream and downstream of the UV and where there is risk of UV light. CIP solutions not strong enough to damage quartz sleeves.															
	Start up/ shutdown	Inadequate disinfection during start-up. Fouling during extended shutdown	Insufficient lamp warm up time.	Water can be diverted to the off spec tank post CCT contact. UV can be remote started without water flowing if required. UV system has wipers to assist with removing fouling. Manual cleaning of sleeves after prolonged shutdown.															
	Cleaning	Unable to remove lamps for cleaning	Not enough access space provided	Sufficient space around UV unit to open door and perform cleaning. Sufficient space around 130 um and 5 um filters.								Duty/stand by UV arrangement							
	Testing	Need to sample pre or post UV	Troubleshooting, process analysis	Sample points pre and post UV															
	Maintenance	Unable to remove components of UV system, and 130 um and 5 um strainer for cleaning	Not enough access space provided	Sufficient space either side of UV, strainer and cartridge filter.															
	Installation and environment (sun, noise, odour)	No specific issues as unit is indoors																	
	Isolation	Unsafe to work on	No isolation points	Manual valves and electrical isolation provided. UV door cannot be opened without unplugging electrical plug.	Install local isolator on UV (similar to GPO installed at Bankstown). Note in I/O list	AQ Design Team			To be added once IO list is prepared.	Design	19-Mar-25								
3d - Chlorination System (CCT)	No or low Flow	False instrumentation readings, instrument damage if flow cell drains. Inadequate mixing. Overdose of hypochlorite.	UV pump failure. Flow restriction with one or more valves. Flow cell blockage. Flow cell drains. Low level in filtrate tank. Strainer blockage in analysis stream	Flow switch in flow cell. Pump fault alarm. Flow meter upstream of injection point. Flow control using diaphragm valve. Fine adjustment via needle valve in flow cell. Static mixer.															
	High flow	Damage instruments or inaccurate readings. Insufficient contact time.	Valves not set correctly	Flow cell acts as a flow restrictor and has flow indicator with needle valve to control. Adequate volume in CCT to ensure sufficient contact time. Flowmeter in line to monitor flow rates															
	Reverse flow	Backflow to cell causes damage by overpressure	Upstream valves isolated with pump running	NRV after off spec diversion valve to prevent backflow to cell. NRV at disinfection pump prevents backflow through system															
	High pressure	Damage to chlorine probe (max 1bar) or flow cell	Accidently closing a manual valve downstream of cell or closed manual valve at outlet CCT	Pressure regulating valve prevents over pressure for instrument flow. NRV in sidestream prevents overpressure from reverse flow. Pressure gauges for service technicians to set and monitor pressue.								Sufficiently trained operators will maintain the plant. Correct sequences to be outlined in O&M manual.							
	Low pressure	N/a																	
	Low level	Damage to probes by cell draining.	UV Pump stops and line drains.	Treated water tank and off spec holding tank entry points are higher than the remiander of the system. Enter above overflow level so syphon not possible.	Confirm safeguard cited is correct	AQ Design Team			Air gap between pump entry point and overflow to be maintained to avoid siphoning	Design	19-Mar-25	Confirmed air gap has been added.							
	High level	Not an issue - designed to be full																	
	High temperature	Not considered a risk in this installation																	
	Low temperature	Improper disinfection	Lower temperature requires higher chlorine CT									Temperature sensor installed in flow cell. CCT defined. Water diverts below set temperature.							
	Composition or changing concentration	Excessive chlorine level could be a hazard to reuse and irrigation. Inadequate chlorine doesn't ensure adequate disinfection	Chlorine demand is not constant. Dosing failure or incorrect setting. Instrument drift. Inadequate maintenance of chlorine probe. Chlorination affected by pH. Chlorine supplied can vary in strength.	Free chlorine analyser monitors chlorine level. Alarms if too high or too low. Monthly calibration & service checks of probe. Periodic microbial test results. Chlorine dosing rates can be monitored and adjusted remotely. Chlorine dosing control can be made sophisticated if required (eg PID loop). Store chlorine away from direct sunlight. Monitor chlorine inventory to ensure minimum practical time on shelf. Chlorine probe reading is compensated using pH measurement from the same flow cell.								Confirmed PID loop incorporated into chlorine dose control. Chlorine stored under a roof to protect from direct sunlight.							
	Start up / shutdown	Start up -unstable dose control. Shutdown - probe issues over time, fail to calibrate. Chlorine residual drops during shutdown	Incorrect PID loop tuning during commissioning Probe drifts off-spec during storage. Natural decay of chlorine	Free chlorine is a CCP and water will be diverted to off spec tank until chlorine is in target range. Operators service and calibrate probe after extended shutdown.															
	Cleaning	Fouling of piping and equipment	Low residual free chlorine or fault online instrument.	Routine servicing and cleaning of strainer. Strainer union ended.															
	Testing	Can't monitor water quality properly	Inadequate number/location of sample points	Sample point adjacent to instrument sidestream to get representative sample.								Confirmed sample points located before and after CCT							
	Maintenance	Unable to safely remove probes for calibration, or remove strainer for cleaning	Poor access and no isolation	Isolation valves on sidestream, and either side of static mixer (union ended).															
	Installation and environment (sun, noise, odour)	CCT pipe skid doesn't fit though room doors	Skid bigger than opening	Doors on building should be large enough. Could be constructed in situ if it is problematic after final building design is determined. Indoor settting so no issues for probes or pipework,								Skid mounted - fabricated off site. Confirmed door sized adequately to allow for installation							
	Isolation	Can't service easily	No isolation points.	Provision for isolation of CCT, sidestream and static mixer.															
Section 4 - Storage (Inclusive of Treated Water and Off-Spec)																			
4a - Treated Water Storage Tank (including process water pumps and recirc loop)	No or low Flow	No issues for tank. Low potable makeup flow causes tank to run dry. Flow is too low for effective mixing. Flow is too low for process water to service equipment. Low flow doesn't let instrumentation get representative readings. Inadequate chloramine dosing.	Makeup water valve failure. Manual valve closed. Failure of recirc or process water pumps. Multiple process units require water simultaneously. Strainer in instrumentation loop blocked. Dosing pumps under sized	Low level switch and transducer indicate low level. Manual override for auto valve (potable). Physical bypass of automatic valve is possible. Flow switch in instrumentation cell to detect no or low flow. Process units don't use water for extended periods so unlikely to occur concurrently. Pump sized appropriately. Process water pump is duty/standby. Strainer readily accessible and maintainable. Tank needs to maintain minimum volume to protect pumps. Radar level transducer not likely to be affected by swirling motion. Level switches are back ups so minor disturbance acceptable. Mount level switches out of direct line of eductor flow. Dosing pumps adequately sized	Consider limit switches for automatic valve, or alarm in PLC if valve is open and flowmeter doesn't indicate flow. This would allow early detection of valve failure. Depending on end use, refil rate etc. this may not be necessary.	Aquacell Design Team			Potable top up valve to be client scope. We can still request position feedback of valve.	Project delivery	19-Mar-25	Position feedback to be specified.							
	High flow	Process water flow too high at point of intended use. High flow through eductors causes "stirring". Exessive chloramine dosing	Process water pump oversized. High supply water pressure combined with requirement for air gap. Dosing pumps over sized	All points of use for process water have a valve that could be used to throttle flow if required. Dosing pumps adequately sized								Both disinfection pumps and process pumps are adequately sized. Disinfection pumps run on VFD to control flow.							
	Reverse flow	Contamination of potable by recycled water. Contamination of Treated Water tank from sewer (or drain line).	Backup in line Sewer line backs up Drain valve left open and drain line backs up and flows into tank	Air gap between tank and potable top up line. RPZ valve on potable line at plant inlet. Check valves on pumps.	Consider the risk of process water contamination from process s - eg, reverse flow from screen. Need to maintain air gaps. Should there be a RPZ?	Aquacell Design Team			Overflow line is lower than tw entry point to avoid siphoning. Air gap from potable top up maintained. RPZ incorporated (client supply).	Design	19-Mar-25	Confirmed.							
	High pressure	Tank damage and/or rupture. Damage to instrumentation or flow cell. Damage to process units using process water.	Overfilling tank and continuing to pump water into tank faster than it leaves.	Air gap provides a vent pipe when tank filling. Pressure regulators on instrumentation side stream. Presure regulators on process units.	Confirm BAC backwash supply line does not need a pressure regulator on it. Should there be a pressure transducer to alarm low and high pressure on the process pumps?	Aquacell Design Team			Pressure transducer to be incorporated into BAC backwash supply to monitor high & low pressure	Design	19-Mar-25	Overflow line adequately sized. Pressure transducer added to BAC backwash supply line.							

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Low pressure	Tank collapse	Pump out faster than air or water can come into tank.	Air gap for makeup provides a vent point.	Confirm the air gap is sufficient venting.	Aquacell Design Team			Confirmed air gap will be sufficient	Design	19-Mar-25								
	Low level	Pump damage. Instrumentation damage. Insufficient supply for process water. Eductors above water line.	Pumping out faster than makeup or incoming treated water.	Low level switch and low level warning on level transmitter. Level set at commissioning to ensure eductors remain covered even at low level.	Confim with manufacturer is there is a minimum level required to be maintained.	Aquacell Design Team			Low level switch & transducer incorporated to protect equipment.	Design	19-Mar-25	Minimum 100mm of water level to be maintained.							
	High level	Tank backs up and overflows at airgap and/or vent.	Failed level switch and transducer. Potable makeup valves fails open.	Peak flows considered at design stage when sizing overflow and vent lines. Some buffering capacity in buffer tank.	Ensure potable makeup valve fails closed. Limit switches on valve. Manual override on valve. Manual isolation on makeup line. Ensure the overflow line is the first point it overflows from.	Aquacell Design Team			As above, position feedback to be provided on top up valve, manual isolation & a bypasss.	Design	19-Mar-25								
	High temperature	Not considered a risk in this location																	
	Low temperature	Not considered a risk in this location.																	
	Composition or changing concentration	Water is out of specification for delivery. Chlorine concentration can vary. Inadequate or exessive total chlorine in treated water	Chlorine out of range . pH out of range. Failure of control system for diversion. Override of CCP. Dosing pump incorrectly sized. Incorrect selection of static mixer.	Upstream diversion to out of spec tank to prevent water reaching tank in first place. Chlorine, Ammonium sulphate to correct chemistry if required. Free chlorine analyser monitors chlorine level. Alarms if too high or too low. Monthly calibration & service checks of probe. Periodic microbial test results. Chlorine dosing rates can be monitored and adjusted remotely. Chlorine dosing control can be made sophisticated if required (eg PID loop). Store chlorine away from direct sunlight. Monitor chlorine inventory to ensure minimum practical time on shelf. Chlorine probe reading is compensated using pH measurement from the same flow cell. Dosing pump correctly sized. Static mixer appropriately selected.														
	Start up / shutdown	Start up -unstable dose control. Pump damage upon start up. Off-spec water	Pumps not primed (air lock). Restoring pump after maintenance and isolations removed.	Treated water tank to be filled with sufficient potable during commissioning to ensure process water pumps can run the plant.															
	Cleaning	Biogrowth over long term	Insufficient free chlorine	Total chlorine residual maintained through QCP's. Periodic inspection to identify bio growth.															
	Testing	Inadequate total chlorine in the treated water.	Failure of some part of treatment process	Critical control points. Monthly microbacterial lab analysis. Sample point prior to treated water entering tank. Sample point on recirc loop.								Water would be diverted to off spec tank in event of any treatment process failure.							
	Maintenance	Pump can't be removed. Instruments can't be repaired or checked.	Not easily accessible	Pumps are external to tank for easy access. Instrumentation readily accessible	Are eductors installed from the top of the tank so they can be removed?	Aquacell Design Team			Select eductor material as SS316 to minimise the possibility of failure & need for replacement.	Design	19-Mar-25								
	Installation	Tank or liner blows away	Wind		Fill tank with water post installation if required.	Aquacell Installation Team			Filling of tank responsibility of tank supplier	Design	19-Mar-25	100mm of water must be available at time of tank commissioning							
	Isolation	Can't isolate	Lack of isolation valves	Every stream can be isolated															
4b - Off Spec Holding Tank	No or Low Flow	Tank could go stagnant. Algal bloom	Contents of tank not aerated and may not be introduced back into the system	Water in tank has been through biological treatment, and likely at least one other process step, eg, UV, Ozone, chlorination. Water quality is likely to be good.	Confirm tank is covered.	Aquacell Design Team			Confirmed	Design	19-Mar-25								
	High Flow	Out of spec inflow tank overflows faster than buffer tank pups can pump out	UV pump running with water out of spec and bio tank at high level.	High level transducer and switch to stop UV pumps. Buffer tank will have some buffering ability.															
	Reverse Flow	Contamination, odour	Reverse flow from off spec tank to treated water tank. Air from bio tank aeration escapes and enters off spec tank via overflow	Air gap at top of tank where out of spec water drops in. Out of spec tank higher than buffer tank so reverse liquid flow not possble. Out of spec water is being returned to the head of the plant for retreatment anyway.	Confirm P-trap in line between buffer tank and off spec tank to prevent odour	Aquacell Design Team			To be added to P&ID	Design	19-Mar-25	NRV added after CCT							
	Low Level	Tank or liner could blow away.	Drain valve leaking. Large surface area, low weight.	Maintain manufactuers minimum water level. Roof on tank. Low level switch to close drain valve	Confirm with manufactuer if there is a minimum water level that must be maintained after installation. Consider loop or standpipe so the tank cannot drain below minimum level.	Aquacell Design Team			Confirm with supplier minimum required water level	Project delivery	19-Mar-25	100mm of water must be available at time of tank commissioning							
	High Level	Overflow	Tank outlet valve failure, UV pumps running	High level transducer and switch in tank. Some buffering capacity in buffer tank.															
	Low Pressure	Tank collapse	Empty tank faster than air can enter	Tank is emptied via gravity rather than being pumped - slower rate.	Confirm the final tank spec has sufficient venting				Confirmed	Design	19-Mar-25								
	High Pressure	Tank damage	Tank is filled faster than air can escape		Confirm the final tank spec has sufficient venting				Confirmed	Design	19-Mar-25								
	Low Temperature	Not considered a risk in this location																	
	High temperature	Not considered a risk in this location																	
	Composition or changing concentration	Algae develops	UV exposure of nutrient rich water.	Roof on tank to avoid UV exposure. The only incoming stream comes from within the plant which can't be more contaminated than plant feed.															
	Cleaning	Tank requires cleaning	Build up of material over time	Water in tank has already been screened and treated. Unlikely to contain foreign materials. Biological growth can be treated with chlorine.	Confirm access hatches available to enter tank if requireced.				Confirmed	Design	19-Mar-25								
	Testing				Is there a reason we may need to test water quality in this tank?	Aquacell Design Team			Sample point to be added.	Design	19-Mar-25								
	Maintenance	Maintaining probes	Difficult to access installed in the top of the tank	Level transducer and switches rarely require service. Tank unlikely to need servicing during service life.	Confirm final mechancial design allows for access for probe replacement	Aquacell Design Team			Access ladder to be provided. Level instruments to be positioned close to ladder	Design	19-Mar-25								
	Installation	Tank is large mechanical construction	Not installed correctly	Engage tank manufacturer to install as they have the correct equipment and competencies								Confirm sufficient access around all tank locations for installation							
	Isolation	Isolatoin to enable confined space entry.	Breakdown or cleaning	Tank feed can be isolated on both treatment trains post CCT piping. No equipment in tank that would require entry for routine servicing.															
Section 5 - Waste (Inclusive of Sludge Dewatering, Overflow and Drains)																			
5a - Sludge Dewatering	No or Low Flow	No or low flow from polymer dosing system. No or low flow from spray water. Poor dewatering from ineffective mixing of polymer.	Faulty Dosing pump. Issue with potable feed	run/alarm signals present in polymer dosing system. Flow switch present on potable make up to polymer dosing system.								Add flow switch to dewatering unit flush line.	AQ Design team	14-Jul-25	Closed				
	High Flow	Flow too high for polymer to dose properly Exceed capacity of dewatering system	Operator error Faulty VFD	VFD to control flow Flowmeter on WAS pump skid															
	Reverse Flow	Reverse flow through process water		NRVs present on all process water lines.															
	Low Level	Low level in polymer dosing	level instrument failure	Flow switch on make up water Level switch on dosing tank.															
	High Level	Skip overflows	Inadequate warning system									Add camera into sludge handling room	AQ design team	14-Jul-25	Closed				
	Low Pressure	Low pressure from compressed air system	Fault with compressed air system									Pressure switch is provided within pneumatic panel by Hydroflux. Show on P&ID	AQ design team	15-Jul-25	Closed				
	High Pressure	High pressure from mono pump	Valve closed	Pressure relief valve on each mono pump															
	Low Temperature	N/A																	
	High temperature	N/A																	
	Composition or changing concentration	Incorrect sludge concentration may impact dewatering Polymer concentration not appropriate.	Wasting frequency not optimal.	Fully automated process. Flowmeter on dewatering line allows us to run for a set period of time to deliver a set SRT. Until process is optimised, periodic pump out of mixed liquir may be required to ensure that MLSS concentration is maintained.															
	Cleaning	Build up of sludge in sludge recirc line	Infrequent operation of process	Potable line to WAS pump skid to flush line after running sludge rescreening. Spray bar included on dewatering unit Doors included on screen to allow for additional manual cleaning if required.															
	Testing	Samples required	Monitor	Sample point included within sludge dewatering unit								Add additional sample point to sample sludge prior to polymer make up. Check whether there is an additional sample line on the dewatering unit subnatant.	AQ design team	14-Jul-25	Closed				
	Maintenance	Maintaining screw prew presss.	Unable to maintain due to access	Sufficient access to maintain screw press in situ. Also sufficient space to lift complete unit outside if required.															
	Installation	Installation of screw press	Unable to install due to limited access	see above															
	Isolation	Unable to isolate any piece of the dewatering process	Inadequate valving	sufficient valves on all equipment to isolate if required. Duty/stand by pump arrangement															
5b - Plumbing Collecting Overflows and Drains	No or low Flow	Odour. Debris build up in screenings pipe	P-traps dry out	Service team discharge periodically to recharge traps	Ensure suitable fall on screenings overflow and other overflows to ensure debris has best chance of being flushed to wet well.	Aquacell Design Team			Ensure sufficient periodic flushing through overflow to avoid drying of debris is incorporated into the program.	Design	19-Mar-25								
	High flow	Fills up wet well which is then transferred into plant	Ingress from rainwater or other upstream source	All floor wastes are internal so no rainwater ingress. Monintoring or logs during rain events to identify possible ingress of storm Water.	Ensure all below ground tanks are correctly sealed and installed in a manner that prevents rain or groundwater access. Similarly, ensure customer is aware the sewerage system should not allow storm water ingressm	Aquacell installation Team. Aquacell Service Team			Emergency overflow tank to be incorporated into the design	Design	19-Mar-25								

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Reverse flow	Flow up through floor wastes	Wet well does not have an overflow	High level indication on wet well would warn of impending situation.	Consider pump out point on wet well for emergency pump out (similar to Llandilo installation)	Aquacell Design Team			Emergency overflow tank to be incorporated into the design. Emergency pump out preocedure to be captured within the RWMP.	Design	19-Mar-25								
	High pressure	Pressurise pipe	Line blocked	No pumped lines so pressure is limited to static head.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Low pressure	Not considered a risk in this installation.																	
	Low level	Not considered a risk in this installation.																	
	High level	Overflow in floor wastes	Blocked line	Screen overflow pipe is 150mm which will allow debris to flow back to wet well. Correct selection of pumps means screen line unlikely to block.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	High temperature	Not considered a risk in this installation.																	
	Low temperature	Not considered a risk in this installation.																	
	Composition or changing concentration	Blocked lines	Unscreened overflow from pre-screeens	Screen overflows 150mm pipe so anything that makes it through the pump should pass down the pipework															
	Start up / shutdown	Odours	Traps dry out if extended shutdown	Manually charge P-traps in the unlikely event there is an extedned shutwdwon.															
	Cleaning	Blockage	Debris in pipes	Pipes practically sized. Scren overflow is the only line likely to have significant debris.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Testing	N/A																	
	Maintenance	Need to clean pipes	Blockage		Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Installation	Outside of scope																	
	Isolation	N/A																	
Section 6 - Chemical dosing																			
17. Chemical Dosing Systems (including storage and handling)	No or low Flow	Water out of specification leading to inadequate treatment, disinfection or cleaning.	Tank empty. Pump is non-operational (lost prime or failed). Crystallisation (caustic in cold weather) in the dosing line causing blockage. Blocked dosing point. Incorrect pump setting. Ruptured line or fitting.	Chlorine and alkalinity dosing has instruments to monitor water quality and alarms for out of spec. water. Level transmitter and low level switches in all dosing tanks. Citric acid is manually dosed and a visual check plus hand held meter checks is sufficient. Peristaltic pumps have provision to add leak detection (cabling and programming) at a later date if needed. Peristaltic pumps being used to where appropriate to reduce the risk of loss of prime.	Run dosing lines with minimum number of joints. Where possible, mount diaphragm pumps with flooded suction. If available use leak detection feature on pump. Consider double contained dosing tube to prevent major leaks.	Aquacell Design Team			Provide dual contained hose where practical. Consider implication of a leak & where chemical would spill in this event.	Design	19-Mar-25								
	High flow	Water out of specification. Damage to membranes during CIP Bunds fill up with rainfall	Venturi effect of injection point is open if NRV fails. Incorrect pump setting (manual) or false instrument reading (auto). Heavy rainfall	Chlorine and alkalinity dosing has instruments to monitor water quality that have alarms for out of spec. water. Transducer values logged which allows chemical consumption rate to be monitored, even remotely. Chemical area covered, so unlikley to impact individual bunds. Ability to safely remove rainwater from concrete bund by manually draining.																
	Reverse flow	Overflow chemical dosing tanks.	Failed check valve or injection point.	Flow through peristatic pump unlikely. Diaphragm pumps have internal check valves. Line sizes are small so backflow, if it could occur, is very low flow. Bund to catch some overflow. Tank level transducer will show high level.	Consider dosing tank high high alarm off transmitter to warn that tank is overfilling.	Aquacell Design Team			Minimal risk as check valves are incorporated high high LS not required.	Design	19-Mar-25								
	High pressure	Dosing tube ruptures. Overpressurised storage tanks	Blocked dosing point or dosing point manually isolated. Vent blocked during filling	PRVs for metering pumps. Dosing tube suitably pressure rated and of correct material. Peristaltic pumps are inherently limited in discharge pressure. Vents cannot be isolated and are adequately sized															
	Low pressure	No chemicals delivered Could create syphon if line pressure is low. Also see "low flow". Vaccum created in storage tanks	Low line pressure or gravity flow arrangement. Peristaltic pump hose clamps insufficiently fastened. Vent blocked during pumping of chemicals	NRVs on injection quills. Vents cannot be isolated and are adequately sized															
	Low level	Dosing pump runs dry and chemistry is affected.	Tank not refilled or leaking tank/fittings.	Low level warning and low low level alarm on each tank. Level transducers and remote monitor. Bunds around tank to prevent spills getting into drains.															
	High level	Overflow tank	Adding too much chemical. Reverse flow from NRV failure	Sight glass on all tanks except for Magnesium Hydroxide. Magnesium Hydroxide is delivered on IBCs and manually filled. Bunds adequately sized for each chemical storage tank	Consider dosing tank high high alarm off transmitter to warn that tank is overfilling.	Aquacell Design Team			Minimal risk as check valves are incorporated high high LS not required.	Design	19-Mar-25								
	High temperature	Eruption of chemical from tank. Chemical degradation during long term storage.	Adding chemical to the wrong tank causing exothermic reaction (hypo + acid) Chemical storage not adequately protected from sunlight	Clear labelling of chemical tanks. Appropriately trained personnel and PPE. Vents cannot be isolated and are adequately sized. Chemical area covered to avoid direct sunlight. Black tanks used to protect from sunlight.															
	Low temperature	Crystallisation of chemical (particularly caustic) can occur at low temperatures.	Outside temperature drops below chemical freezing point	Caustic tank and dosing lines are indoors. 30% concentration to be used to ensure that crystalisation is not an issue. Dual contained hoses adds additional layer of insulation to dosing lines.	Consider if lines need to be insulated. Would double contained dosing line provide better insulation	Aquacell Design Team			Insulation not considered necessary	Design	19-Mar-25								
	Composition or changing concentration	Potential chemical degradation Magnesium hydroxide solidifies Water out of specification.	Chemical degrades with time and is less effective. Settling in the tank (for slurry)	Clear operating instructions. and trained personnel. Inventory control. Proper storage to minimise chemical degredation. PID or other appropriate control loops to control to a setpoint. Mixer for magnesium hydroxide. Stabilised Magnesium Hydroxide formula to be utilised															
	Start up / shutdown	Chemical degradation during long term storage. Crystallisation in lines or loss of pump prime during long periods not running.	Crystallisation of NaOH. Chlorine degrades with time	Check and/or remix chemical after long storage. Flush and check pump operation (e.g. tubing, pump and line primed). Where chemical doses to a setpoint, control system will accommodate to some extent for the change in concentration.															
	Cleaning	Chemical spill during fill	Operator error dosing line splits	All dosing units are in bunds allowing for safe washdown when required. Dual contained hose utilised to ensure that any break in dosing line is returned to bunded area.	Consider rationalisation of dosing pumps to reduce the possibilities of spilllage	AS			Discussions ongoing	Design	19-Mar-25	Reduced the number of pumps by selecting one pump for two trains for CIP, MW, and alkalinity addition.							
	Testing		No access for flow tests.	Level transducers on tank to verify dose rate. Use handheld measuring cylinder (but would require disconnection of pump suction tubing from tank outlet). Instrumentation - pH, Total Cl2 provide feedback. Handheld checks to confirm pH and concentration during MBR CIP can be taken from existing sample valve.	Consider addign additional sample point	AQ Design Team			Sample point added to CIP recirc line	Design	19-Mar-25								
	Maintenance	Pipe blockage Leakage from fittings. Bunds are not kept clean and empty resulting insufficient bund volume	Insufficient preventative maintenance Bunds allowed to fill with water or rubbish, or chemical overspill	Regular planned maintenance as defined in O&M manual Good housekeeping - requires hand pump to flush and pump out bund, or mop up small spills.															
	Installation	Restricted access for maintenance and leak resolution.	Fittings and connections at front are easier to access, but greater risk of exposure from leaks.	Skids assembled off site as much as possible for easy installation Sufficient access has been provided around all equipment to safely install Chemical storage can be easily offloaded due to being located outside of main treatment building.								Try to keep safety shower line underground where practical. Failing that, piping		14-Jul-25					
	Isolation	Inability to isolate for maintenance / Uncontrolled chemical release	Inadequate isolation in design	Sufficient valving arrangements included for mechanical isolation of all pumps Each pump has a separate circuit breaker to allow the pump to be electrically isolated without affecting other pumps															
Section 7 - Pneumatics																			
7a - Pneumatic System	No or Low Flow	Valves slow to actuate. Ozone can't generate fast enough	Condensation limits reciever capacities. Compressor breakdown. Filters blocked. Air lines undersized.	Compressors sized correctly. Duty standby compressors. Dual filter trains allow cleaning without interrupting air supply. Air recievers to smooth peak damand while compressors recover. Autodrain on receiver and compressor. Air lines sized correctly.															
	High Flow	Valves operate to quickly causing damage	Presssure to components is restricted, but flow is not	Typically not a problem, but inline flow controllers can be installed if required.															
	Reverse Flow	Instrument air receiver flow backwards to process air receivers during high process air demand, starving instruments of air.	High process air demand from ozone.	Appropriately sized air receivers and compressors NRV at instrument air receiver.															
	Low Level	N/A																	
	High Level	N/A																	
	Low Pressure	Valves don't actuate, ozone won't generate	Leaks, air line blows off, compressor breakdown Valve incorrectly isolated.	Duty standby compressors. Compressor has pressure switch to cut in at low pressure. Pressure transmitter and pressure switch on receivers to alarm before low supply pressure drops below operating pressures. System has regulators to set specific pressures for different types or equipment. Recievers installed to buffer pressure drop during peak demand	Confirm what controls Ozone system has for low pressure	Aquacell Design Team			D/S compressors. Compressor designed for peak flow. Pressure switches on all pneumatic boxes to detect low pressure. Ozone system has low pressure cut off function which will stop ozone generation.	Design	19-Mar-25								
	High Pressure	Equipment damage. High pressure explosion	Uncontrollled production of compressed air. Compressor pressure too high for equipment	Pressure vessels from reputable supplier. Pressure vessel certificates to confirm appropriate contruction. Relief valves on compressors and receivers. Regulators so pressure can be custom set for each type of equipment	Ensure pressure vessel certificates and relief valve certificates are obtsined during procurement	Aquacell Procurement Team			To be obtained from supplier	Project delivery	19-Mar-25								
	Low Temperature	n/a																	
	High temperature	n/a																	

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Composition or changing concentration	Humidity/Moisture. Oil or other contaminant in air which causes equipment damage	Inherrent in compressed air systems	Each compressor has an air dryer and air goes thorugh a dual filter system prior to distribution. Compressors and receivers have automatic condensate drains.															
	Cleaning	Water on floor from autodrains	Autodrain discharges condensate	Condensate directed to floor drains															
	Testing	Pressure vessel inspection/test	Statutory requirement		If Aquacell service plant, allow for service of compressor and inspection of pressure vessels.	Aquacell Service Team Aquacell Design Team			Adequate service time to be allowed for compressors. Annual inspection to be organised for pressure vessels.	Aquacell Service Team	19/03/2025								
	Maintenance	Breakdown.	Inadequate servicing.	Compressors and dryers to be maintained as per manufacturers recommendation	If Aquacell service plant, allow for service of compressor and inspectino of pressure vessels. Confirm packaged compressor unit has autodrrain to drain reciever	Aquacell Service Team Aquacell Design Team			Confirmed packaged compressor unit will have autodrrain to drain reciever	Design	19/03/2025								
	Installation	Vibration damage Noise	Improper isolation.		Confirm packaged compressor unit has acoutic hood. Confirm if compressor mounted on vibration mounts. Ensure flexible connection from compressor to fixed pipework. Consider adding flexible hose between compressor and rigid piping	Aquacell Design Team			Compressor selection ongoing. Consider rotary screw compressor.	Design	19/03/2025	Rotary screw compressor has been selected. Flexible hose has been added between compressor and rigid piping	Design	14/07/2025	Closed				
	Isolation	Requirement to isolate and discharge stored energy	Service requirement	Isolation points and drain points	Confirm packaged compressor unit has a drain valve to drain receiver	Aquacell Design Team			Confirmed packaged compressor unit will have autodrrain to drain reciever	Design	19/03/2025								
Section 8 - Odour																			
8a. Odour Scrubber	No or Low Flow	Air doesn't move through scrubber. Air not ejected into atmosphere to disipate. Odour complaints.	Carbon compacted or fouled. Blower on scrubber has failed. Upstream valves are closed.	Odour scrubber blower and upstream aerators all have monitored O/L's. Pre-screens are the only vent lines with dampers that can be closed.	Add valve to allow balancing of flow between tanks	Aquacell Design Team						Magnehelic pressure gauge is allowed for with skid mounted odour control unit. Service item to regularly monitor this locally on site.	AQ service team	14/07/2025					
	High Flow	Insufficient contact time with carbon. Odour complaints.	Low level or no carbon	Routine maintenance. Carbon sampling points	Add valve to allow balancing of flow between tanks.	Aquacell Design Team						Valves have been added to allow balancing between tanks.	Aquacell design team	14/07/2025					
	Reverse Flow	Odours escape	Incorrectly commissioned	Commissioning checks to ensure odour control system is installed correctly.															
	Low Level	Insufficient carbon to scrub odours	System not correctly filled	Carbon sampling points. O&M manual to teach operators correct fill level. Routine Maintenance							`								
	High Level	Carbon exhausts to atmosphere	System not correctly filled	Form of carbon used unlikely to be picked up by fan. Carbon sampling points. O&M manual to teach operators correct fill level. Routine Maintenance															
	Low Pressure	Odour scrubber collapses	Upstream valve closed causing blower to suck in scrubber housing.	Fan cannot generate sufficient pressure to collapse housing															
	High Pressure	High pressure is not possible as system is on suction side of blower and system is open to atmosphere. High differential pressure is possible, causing inefficiencies and odours.	Blocked carbon bed or inlet filters	Differential pressure indicator installed. Routine maintenance. Operator training.															
	Low Temperature	Not considered a risk in this location																	
	High temperature	Not considered a risk in this location																	
	Composition or changing concentration	Condensation can develop in vent lines. H2S concentrations exceeds design limits	Atmospheric conditions. Influent characteristics outside of range. Holding times exceeded. Ineffective mixing.	Sample points located on skid for monitoring H2S levels	Ensure all vent lines move uphill from a tank, or drainpoint where condensate can collect and be drained.	Aqaucell Design Team. Aquacell installation team			Confirmed	Design	19/03/2025								
	Cleaning	No specific cleaning requirements																	
	Testing	Test air or carbon quality	Mointor or check performance of unit	Carbon sampling points. Air sampling point.															
	Maintenance	Carbon exhausted and needs to be replaced. Breakdown or service on scrubber's blower.	Carbon is consumable.	Filter is accessible for cleaning.	Can entire system still run if the blower fails?							System will run passively in event of blower failure	AQ design team	14/07/2025	closed				
	Installation	System is difficult to install	Poor design	Skid mounted system located outside of main treatment plant.															
	Isolation	Can't isolate unit	No upstream or down stream valves	Mechanical and electrical isolation provided Minimum maintainable components means thie requirement will be rare.								Consider if bypass to stack is required during maintenance of carbon beds	AQ design team	14/07/2025	Closed (not required)				
9a - Climate change - Physical and Environmental Risks	Increased Rainfall and Flooding	Overflow of sewers Process inefficiencies Risk recycled water ingress into the stormwater network	Climate impacts not considered in tank sizing Climate impacts not considered in process design Climate impacts not considered in irrigation design/sizing	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. Buffer tank (1ML), Off spec holding tank (1ML), Emergency overflow tank (300kL). The combined plant storage capacity will minimise the risk of sewer overflow during periods of increased rainfall. Any change in sewer composition will be monitored and equalised with the buffer tank to minimise the risk of process inefficiency. The plant's peak flow is 3x higher than average flow, in line with Sydney Water's "*Wastewater Treatment Planning Guidelines*". There is sufficient holding time within the treated water tank to store in extreme rainfall events when the the irrigation area is saturated. A comprehensive wet weather management strategy will be implemented. Further information can be found in the Land Capability Assessment and Irrigation Management Plan.																
	Drought and Reduced Water Availability	Insufficient water available for irrigation during drought and reduced water availability	Increased irrigation requirement	Influent generated from within the industrial develepmont rather than relying on rainfall. Treated water storage system is sufficiently sized.															
	Rising Temperatures	Activated sludge process inefficiencies	High aerobic and anoxic temperature reduces the microbial activities	Tank is a large volume, constructed underground from concrete. Influent temperature will remain unaffected. Temperature is monitored at various stages throughout the process, from influent to effluent.															
	Sea Level Rise and Saltwater Intrusion	N/A - plant is approximately 106m above the sea level and so considered not to be an issue when compared with estimated seawater level rises																	
	Extreme Weather Events (Cyclones, Storms, Bushfires)	Damage to OSSM facility	Inadequate design with regard to extreme weather events.	The development is more than 100 m from forest hazards and more than 50 m from grassland hazards. Safe access and egress between the development and the public road system has been allowed for fire-fighters. A defendable space between structures and the bushfire hazard/boundaries has been provided to allow fire-fighters to gain access to all sides of the structures and the bushfire hazard at the boundary. Access to a reticulated water supply (e.g. hydrants) has been incorporated into the design. The building has been designed by structural engineers with consideration of wind loadings as per accepted Australian standards.																
9b - Climate change - Operational and Process Risks	Process Upsets	Uncompliant treated water.	Plant design has not considered variation in influent as a result of climate change.	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. The plant has remote monitoring and control capability to ensure that any deviations in influent can be appropriately managed. Any change in sewer composition will be mointored and equalised with the buffer tank to minimise the risk of process inefficiency. The plant's peak flow is 3x higher than average flow, in line with Sydney Water's "*Wastewater Treatment Planning Guidelines*".																
	Increased Energy Demand	Greenhouse effect Higher operational cost	Higher energy consumption from pumps to deal with high flow during rainfall.	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. Large buffer capacity will allow the process to operate at normal flow even during periods of wet weather. Recycling water at the source mitigates the need for pumping water large distances to the building from the public water supply, and mitigates the need to pump or transfer wastewater large distances for treatment.															
	Biosolids Management Challenges	Odour Higher waste sludge transportation and treatment cost	Open sludge area resulting in rainwater ingress leading to higher sludge volume	Sludge handling is located inside the shed. Advanced sludge dewatering unit to minimise sludge volumes															
9c - Climate change - Financial and Economic Risks	Higher O&M Costs	Financial viability of scheme becomes questionable.	Increased operating costs due to climate change	Robust financial planning assessment has been completed to ensure that maintenance costs remain viable. 10 year cashflow forecast has been provided allowing for CPI increases. Specific fees and usage rates can be adjusted if required.															
	Capital Investment Needs	Upgrades required to treatment plant	Insufficient redundency in design to accommodate changes	Sufficient storage and process capacity has been considered within the treatment plant. Both CAPEX and OPEX costs have been considered															
9d - Climate change - Social and Reputational Risks	Public Health Risks	Disease Transmission via Pathogens	Inadequate controls of recycled water quality	A comprehensive RWQMP has been developed to implement critical and quality control points to ensure adequate pathogen reduction. Any uncompliant water will be diverted to off spec tank for furter treatment.															

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Community Complaints	Odour Noise Vibration	Increased plant loaded resulting in poor plant performance.	Plant has been sufficiently sized to handle varying load to climate change Environmental impact studies have been conducted and found that no significant risks will be present.															

Appendix Q19.2

HACCP Checklist

Project Name:	A0144 Luddenham Rd Orchard Hills
Completed by:	Justin Taylor
Date of Assessment:	11-Jun-24
Revision:	IFC
Approved By and Date:	

To be approved by the Technical Manager

HACCP Workshop Attendees			Revision 1 Attendees	Revision 2 Attendees
WJ				
JT				
JJ				

DESIGN /			Before Mitigation				After Mitigation					Decision Tree				CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**												**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
1. Source water (sewage influent, collection lines, pump stations)	Biological Hazard: Contact with raw sewage	Plant designed so that contact with sewage in normal operation is not required. Plant room locked so people cannot readily enter. Covers on tanks and locks where appropriate. Trained operators to servicing plant.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Health Hazard: Source water is different to design specification and treatment plant cannot treat correctly.	Plant design conservative with some ability to remove short periods of our of specification sewage. Continuous online monitoring does not allow out of specification water to be delivered. Trade waste cannot be connected directly to the sewer. pH measurement in buffer tank may detect poor feed. Buffer tank will dilute short volumes of out of specification feed.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Biological Hazard: Blockage upsteam of plant causes overflow	Upstream plumbing (by others) designed to comply with AS3500. Upsstream plumbing to have I/O points and gullies to facilitate contolled overflows and easy cleanout.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
2. Inlet Works - Macerator, Wet Well, Prescreen and Buffer Tank	Physical Hazard: Screen mesh blocks and causes the screen to overflow	Level transducer on screen detects prolonged high level and alarms. Screen overflows to buffer tank so there are no uncontained spills.	4	1	5	Low	1	1	2	Low	± 1	Y	N	N		No							Note change to screen overflow. Now overflows to wet well rather than buffer tank. Confirmined no change to risk matrix						
	Physical Hazard: Screen mesh fails and allows oversize material into system.	Routine weekly and monthly maintenance inspections. Heavy particles will settle in buffer tank and not make it into the rest of the treatment plant	2	3	5	Moderate	1	1	2	Low	± 1	Y	N	N		No													
	Health Hazard: Screenings need to be remove from site	Ensure appropriately experienced and licensed contractors are used for maintenance of systems. Contractors use adequate PPE to mitigate against ingestion, skin contact and inhalation. Remediate spills immediately and exclude public from the spill point until rectified.	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No													
	Health Hazard: Prescreen needs to be cleaned manually	Automatic sprays on pre-screen keep it clean reducing manual cleaning to once per month. Cleaning by trained operator wearing appropriate PPE.	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No													
	Physical Hazard: Screenings are typically heavy and need to be disposed of periodically by the operator	Appropriate screening bin selected with the ability to use manual handling aids where required. Change screenings bags frequently so the mass of each changeout is lower	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No							Manual handling requirement qurther reduced by incorporation of vehicle accessway directly to presscreen area. Confirmined no change to risk matrix						
	Environment Hazard: Odour	Screen and buffer tank are sealed and vented through the odour scrubber. Screenings are contained in an endless bag which contains odour. The endless bag can be changed without creating an odour path.	4	1	5	Low	1	1	2	Low	± 1	Y	N	N		No							Wet well is now added as an inlet works item and will be vented through the odour control system. Confirmined no change to risk matrix.						
3. Biological Treatment Process (Anoxic tank and Aerobic bioreactor)	Chemical hazard: Presence of chemicals in the wastewater that disrupt the proper biological treatment.	pH monitoring of the influent may detect chemicals early. Each tennant is required to treat their trade waste separately before discharge from their premises.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													
	Chemical Hazard: Alkaline material is added to control pH in bioreactors, requiring operators to use chemicals	Adding chemicals is an automated process. Chemicals are dosed into the system automatically reducing which almost eliminates the requirement for the operator to handle chemcials. Chemicals are common in water treatement plants and can readily be handled with appropriate PPE. Chemical storage area has been moved outside of shed for improved handling and reduced risks associated with degassing.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No							Note this hazard has been added at IFC stage.						
	Biological hazards: Biology tank foams over due to an event which upsets the biomass	Tanks are sealed and foam will be contained within the biology tank.	3	3	6	High	3	1	4	Low	± 1	Y	N	N		No							Spray nozzles are added to suppress the foam in the aerobic reactors						
	Biological Hazard: Potential aerosols from aeration of bioreactor leading to exposure of workers in the plant room or contamination of surfaces.	All aerated tanks are airtight and vented through an odour scrubber.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													
	Environment Hazard: Odour	Biologiy tank is aerated and less likely to cause odour than buffer tank. All tanks are sealed and vented externally through an odour scrubber.	4	1	5	Low	1	2	4	Low	± 1	Y	N	N		No													
	Physical Hazard: Confined space.	Tanks designed so that maintenance and calibration can be undertaken without the requirement to enter the tanks. Trained personnel only to enter confined space after completing appropriate confined space entry procedure.	2	3	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													

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Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**												**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
	Physical Hazard: Aerated liquid reduces ability to float in tank if person falls in	All lids and hatches secured by bolts or locks to prevent accidently falling in. Plant room only accessible to authorised personnel.	3	5	7	Very High	1	5	6	High	± 1	Y	N	N		No												
	Physical Hazard: Electrocution from terminal box.	IP rating of terminal box is appropriate selected.	4	5	9	Very High	1	5	6	High	± 1	Y	N	N		No							Note this hazard has been added at IFC stage.						
4. UF Membrane Filtration (membrane tank, skid and filtrate tank)	Health Hazard: Membrane integrity is compromised leading to reduced disinfection	Turbidity constantly monitored to detmine membrane integrity.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	Alert level t > 0.15 NTU Critical Level t > 0.2 NTU	Operator alarm is alert level triggered. If critical level is exceeded, the MOS system recirculates for a period to see if the turbidity reduces. If turbidity does not come back within range, the MOS system generates an alarm and goes into standby state.	Continous online monitoring of turbidity during filtration and reciculation by PLC and actuated valve when required.	MOS goes into standby if turbidity does not reduce during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: Turbidity measurement does not reflect the current state of the water because there is no flow through the instrument	Flow switch installed in the instrument loop upstream of the trubidity meter	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	No Flow	If no flow is detected, the MOS system recirculates for a period to see if the flow returns. If flow does not retuen, the MOS system generates an alarm and goes into standby state.	Continous online monitoring of turbidity during filtration and reciculation by PLC and actuated valve when required.	MOS goes into standby if flow does not return during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: Turbidity instrument faults	The turbidity instrument has a built in fault relay which is wired to the PLC	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	Instrument fault	If fault is detected, the MOS system immediately goes into standby state the MOS system generates an alarm.	Continous online monitoring of turbidity fault relay during filtration.	MOS goes into standby if fault does rectify during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Chemical Hazard: CIP requires operators to use chemicals	CIP process is automated. Chemicals are dosed into the system automatically reducing which almost eliminates the requirement for the operator to handle chemcials. Chemicals can be neutralised within the system in a similar manner before they are sent back to the head of the works. Chemicals are common in water treatement plants and can readily be handled with appropriate PPE.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No							Chemical storage area has been moved outside of shed for improved handling and reduced risks associated with degassing.						
	Physical Hazard: Membrane installation requires manual handling	Membranes have a life expectency of >5 years so the activity is rare. The plant room has been designed to leave space to make installation and replacement safe. Two people are used to replace or install membranes.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No												
5. Ozone System	Chemical and Health Hazard: Ozone exposure and inhalation of ozone if leakage occurred	Ozone generator equipped with failure / leak detection system that automatcally shuts down oxone production of gas is detected. Plant room designed with ventilation system, so a small leak will not casue an issue before the detection system acts to shut down generation	1	3	4	Low	1	2	3	Low	± 1	Y	N	Y	Y	No							Confirming that an ozone destruction unit will be incorporated into the design, meaning that any residual ozone vented from the system will be destroyed before it enters the atmosphere						
	Health Hazard: Noise exposure from compressors high duty	If practical, enclose compressor in acoustic hood, PPE to be worn by operators if compressors are not enclosed.	3	3	6	High	1	3	4	Low	± 1	Y	N	Y	Y	No							Selected rotory screw compressor as it has a lower noise level						
6. Biological activated Carbon (BAC) Filter	Physical Hazard: Presence of carbon fines during loading of the carbon vessel.	Operator training and use of dust mask.	3	1	4	Low	1	1	2	Low	± 1	Y	N	N		No							Confirming that appropriate, task specific PPE (gloves, mask, eye protection) will be used and specified within the O&M manual						
	Physical Hazard: Loading bags of carbon into GAC	Use vacuum or "slurpee" to remove used carbon. Assign two people to the task if necessary. Use a funnel to make filling the vessel easier.	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No							Confirming that a special loading procedure including hopper to be incroporated						
7. UV disinfection	Health Hazard: Excessive suspended solids material interfering with the efficiency of the UV disinfection system	UV is downstream of UF process. See UF membrane filtration section for control measures to ensure membrane integrity etc.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No												
	Health Hazard: Low UV dose leading to poor UV disinfection	UV dose constantly monitored by UV unit using flow rate, measured UVI and measured UVT. UV unit outputs dose to the PLC so it can be monitored and acted upon	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Alert level dose < 60mJ/cm2 Critical Level dose < 58mJ/cm2	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: UVT is too low meaning the unit is operating ourside its validated range.	UV has inbuild UVT instrument which is used withing the device, but also ourput to the PLC.	4	4	8	Very High	1	4	5	Moderate	± 2	Y	Y			CCP2	Alert level UVT < 45% Critical Level UVT < 35%	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: UV disinfection not effective due to excessive lamp age,	UV unit monitors lamp age based on actual run time. Other indicators such as UV dose offer a secondary way to monitor poor lamp performance.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Alert level hours > 10,000 Critical Level hours > 12,000	Operator alarm is alert level triggered. Disinfection system goes into shutdown	Continous online monitoring and diversion by PLC and actuated valve when required.	Disinfection system goes into shutdown. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						

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Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**												**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
	Health Hazard: UV unit malfunctions or faults	UV has inbuilt monitoring that identifies warnings and faults. These outputs are monitored by the PLC so the status of the UV unit is knonwn at all times	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Instrument Fault	Operator alarm is alert level triggered. Disinfection system goes into shutdown	Continous online montitoring and diversion by PLC and actuated valve when required.	Disinfection system geos into shutdown. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Flow rate through UV unit takes the unit outside validated range, or doesn't provide sufficient UV dose	UV feed pump's rated capacity is selected well below the maximum validate flow (385 L/min) If the flowrate falls below 23.5 L/min (validated minimum flowrate), the UV dose calculation defaults to the minimum validated flowrate of 23.5 L/min. Flowmeter downstream of the UV monitors flow.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No													
	Physical Hazard: UV lamps are harmful to humans if viewed directly	UV unit is completely sealed so that no light is visible during operation. UV is designed so that the power cable must be removed to access the lamps. This prevents accidentally accessing the lamps while that are lit.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No													
	Environmental Hazard: UV lamps are harmful if not disposed correctly	Dispose of used UV lamps at an appropriate disposal site.	2	2	4	Low	1	1	1	Low	± 1	Y	Y	N		No													
8. Chlorine disinfection (chlorine, dosing pump)	Health Hazard: Insufficient chlorine or chlorine is too high and may cause harm.	System designed to meet minimum Ct in relevant legislation Contact tank designed so that minimum Ct is always achieved Free residual chlorine monitoring	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert Level: FRC > 0.55 mg/L, or FRC > 4.5 mg/L Critical Level: FRC > 0.5 mg/L, or FRC > 5.0 mg/L	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online montitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Biological Hazard: Treated Water outside of target pH range	On-line treated water pH monitoring. pH correction installed as part of the plant.	1	3	4	Low	1	2	3	Low	± 1	Y	Y			CCP3	Alert Level: pH < 6.5, or pH > 8.5 Critical Level: pH < 6.0, or FRC > 8	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online montitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Equipment failure in the chlorine loop means current reported reading of pH or chlorine is not accurate	Monitor the flow through the instrumentation loop to ensure it is continuous. Monitor the instrument status	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	CCP3	Flow through recirc loop must be continuous. Instrument must always be healthy.	Plant diverts to off spec if critical level triggered.	PLC monitors flow switch mounted in instrument cell and fault signal from the field instrument	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Insufficient disinfection because due to variations in temperature.	On-line temperature monitoring, calculate CT for ambient temperature around storage tanks.	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert level T < 16 deg C Critical Level T < 15 deg C	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continuous online Tepmerature probe.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Required Ct is not met because flows are too high, chlorine is too low	Chlorine contact is in a pipe of fixed volume which fixes one variable in the calculation. Flowmeter upstream of the contact tank and chlorine levels allow Ct to be calculated constantly in the PLC	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert level C-T < 12.6 mg.min/L Critical Level C-T < 12.0 mg.min/L	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continuous online calculation from flowmeter and chlorine probe.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
9. Distribution System and Storage Tanks (lines, end use, Off-spec tank)	Health Hazard: Improper use of recycled water.	Education program for occupants. Lilac coloured pipes and fittings. Signage indicating recycled water usage. No taps accessible to the public.	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y	N		No													
	Health Hazard: Long period until use and all residual chlorine consumed	Chlorine is monitored in the treated water recirculation loop. Plant diverts to off spec tank if chlorine out of range.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Alert Level: TC < 0.5 mg/L, or TC > 5.0 mg/L	Operator alarm is alert level triggered.	Continous online montitoring	Warning alarm only to alert operator for TC < 0.5 mg/L Warning alarm and dosing pump stops for TC > 5.0 mg/L	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.	Minor amendments to TC alert level (in line with RWMP). Eductors incorporated into the design to homogenise the TC level within the tank						
	Health Hazard: pH drifts out of specification	pHis monitored in the treated water recirculation loop. Plant diverts to off spec tank if chlorine out of range.	1	3	4	Low	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Alert Level: pH < 6.5, or pH >9	Operator alarm is alert level triggered.	Continous online montitoring	Warning alarm only to alert operator	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.	Minor amendments to pH alert level (in line with RWMP)						
	Health Hazard: Equipment failure in the chlorine loop means current reported reading of pH or chlorine is not accurate	Monitor the flow through the loop to ensure it is continuous. Monitor the instrument status	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Flow through recirc loop must be continuous. Instrument must always be healthy.	Warning alarm and stop chloramine dosing pumps	PLC monitors flow switch mounted in instrument cell and fault signal from the field instrument	Dosing pump stopped. Dosing resumed once cause is determined and issue is resolved.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Biological Hazard: Delivery pipes and fittings leaking or burst leading to uncontained spill	Plumbing installed according to AS/NZS 3500:200. Any leaks reported to Buliding management according to tennant information brochure.	2	3	5	Moderate	1	3	5	Low	± 1	Y	N	N		No													
10. Sludge Handling including WAS Tank	Biological Hazard: Handling of sludge	System is fully automatic and does not require the operator to come into direct contact with sludge. Disposal bins will be designed so they can be handled with appropriate manual handling device.	2	3	5	Moderate	1	2	3	Low	± 1	Y	N	N		No							Dewatered sludge collection process has been designed to avoid manual handling completely. Vehicle can drive directly in and collect the bin for disposal						
	Environmental Hazard: Odour	Waste activate sludge does not typically have a strong odour. Dewatering system is vented through the odour scrubber.	2	2	4	Low	1	2	3	Low	± 1	Y	N	N		No													
	Chemical Hazard: Chemical handling	Chemicals stored and bunded appropriately to prevent spills. PPE as per SDS to be used by operators.	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No													
11. Potable Backup Supply	Health Hazard: Contamination from cross connections	Coloured pipe to differentiate recycled water network. Education of plumbers through site inductions. Cross connection audit by installation plumbers.	3	5	8	Very High	1	5	6	High	± 1	Y	N	N		No													
	Biological Hazard: Reverse flow	RPZ installed on potable top up supply Airgap between fill point and highest water level in treated water storage tank.	3	4	7	Very High	1	4	5	Moderate	± 1	Y	N	N		No													

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Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
12. Climate change	Biological Hazard: Extreme weather (flooding) causing sewage to mix with stormwater runoff	Site not near known water sources that flood. New development would have consdidered forseeable rain events and designed drainage for them.	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	N		No							Climate change impacts on influent flow are negligible due to the short, contained collection network. However, the inlet infrastructure is conservatively sized to handle peak flows up to 900 kL/day—three times the average flow—for robustness.						
	Biological Hazard: Earthquake causing damage to tanks or equipment that results in uncontained spill	Site not kown to be prone to siesmic activity	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	Y		No													
	Environmental Hazard: Fire causing toxic fumes, eg, plastic tanksor pipework burning.	No flammable goods or chemicals are used in the process which reduces the risk of fire starting. System is in an industrial state that will have appropriate fire services and hydrants should a fire break out.	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	N		No							Appropriate fire safety equipment will be installed within the treatment plant.						
13.General	Environmental Hazard: Noise polution disrupting users and residents.	Select equipment to be below 80dB(A) where possible; Louder equipment to be installed in plant room; Use of acoustic hoods to attenuate noise if required eg compressors; Maintain all levels below those specified in DA	2	2	4	Low	1	1	2	Low	± 1	Y	N	N		No							Confirming that all equipment will be below 80dB(A)						
	Environmental Hazard: Odour	All sanitary waste venting from the upstream collection systems are in accordance with AS3500.2 plumbing code requirements to ensure odour is properly handled and vented. The treatment plant prescreen, process and storage tanks are located inside a mechanically ventilated room, so any odours that do occur are unlikely to be a problem for those using the facility. The wet well, prescreen, emergency tank, buffer tanks and sludge dewatering unit which are the potential odour sources, are all sealed and vented through an odour scrubber. The bioreactor uses aerobic conditions which do not generate odour, however as a precaution, these are also vented The plant room is mechanically ventilated.	3	2	5	Moderate	1	1	2	Low	± 1	Y	N	N		No							Odour sources updated in "Preventative Measures" column						
	Environmental Hazard: Runoff off recycled water from irrigation could come into contact with people	Landscape irrigation has controlled irrigation to prevent excessive watering. Land capability study undertaken at design to determine soils irrigation capacity.	1	2	3	Low	1	2	3	Low	± 1	Y	N	N		No							Additional wet weather management strategy will be incorporated to further reduce likelihood of irrigation runoff.						
	Environmental Hazard: Recycled water from irrigation that could introduce contamination into the environment	No industrial waste is sent to the plant which mitigates disolved contaminants passing through the plant. Instrumentation such as pH man indicate the presence of contaminants	1	2	3	Low	1	2	3	Low	± 1	Y	N	N		No							Recycled water reuse has been optimised to maintained effluent water quality (ensuring TDS is suitable for irrigation)						
	Environmental Hazard: Increase of soil sodicity due to sodium based bio alkalinity addition	Replace Sodium Hydroxide with Magnesium Hydroxide as a bioalkalinity adjusting chemical	3	4	7	Very High	1	1	2	Low	± 1	Y	N	N		No							Note this column have been added at IFC stage						
	Environmental Hazard: Overflows or spills exposing people to partially treated sewage or chemicals.	Tank sizes are designed to buffer inflows and outflows from the plant. All tanks have appropriately sized overflows directed back to the wet well. Facilities to pump out system in the event of breakdown causes high tank levels. All chemical tanks bunded with bunds compliant with Australian Standards.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Biological Hazard: Operators exposed to sewage	Plant is designed so the operator has minimal contact with Operators must be experienced with sewage treatment plants prior to servicing the plant. Plant operators are vaccinated.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No							Confirming that appropriate, task specific PPE (gloves, mask, eye protection) will be used and specified within the O&M manual						
	Biological Hazard: Power outages leading to the plant stopping in a state that could lead to uncontrolled discharges	Equipment designed to be fail safe where possible on power down. Plant could be configured to run off a generator if required. In the event of a wide spread outage, the premises feeding the plant are unlikely to be operational which means no feed. Wet well has some capacity for short outages.	3	4	3	Very High	1	4	5	Moderate	± 1	Y	N	N		No							300kL emergency tank now incorporated into the inlet works design. Together with buffer (1ML) tank, treated water tank (1ML) and off-spec (1ML) will provide additional ~6 days storage at full capacity.						
	Physical Hazard: Servicing heavy equipment	Heavy submersible pumps installed on rails with the provision to remove them using mechanical aids	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No							Appropriate vehicular access has been fully considered throughout the design to keep manual handling to a minimum.						
	Physical Hazard: Plant has multiple confined spaces	Confined spaces identfied. Only trained and authorised personnel to enter spaces after completing appropriate confined space entry procedures. Plant has been designed so that maintenance can be conducted without the requirement to enter tanks.	3	5	8	Very High	1	5	6	High	± 1	Y	N	N		No													

Appendix Q20.0 Safety, Reliability, Public Health and Environmental Risks

1.1 Introduction

The proposed scheme is designed to treat wastewater generated across the Alspec Industrial Business Park (AIBP) and supply up to 300 kL per day of high-quality recycled water via a dual-reticulation network to meet non-potable water demands. The onsite sewage management and recycled water production system has been designed to ensure safe and reliable operation in full compliance with national safety guidelines governing the management of public health risks. In addition, the system has been engineered with a strong emphasis on environmental protection, minimising the potential for adverse impacts on surrounding ecosystems.

1.2 Safety

The system prioritises operational safety through resilient design and comprehensive risk mitigation strategies. Key safety features include a 300 kL emergency overflow tank which will provide at least 24 hours of operational response time at average inflow rates in the event of inlet works failure (e.g., screen malfunction). In case of a malfunction in any downstream disinfection process—such as membrane filtration, ultraviolet disinfection, or chlorination—the Off-Spec Water Holding Tank (1 ML) will retain non-compliant water for at least three days. Should the issue extend beyond this timeframe, an additional three days of storage is available in the buffer tank, resulting in a total of six days of holding capacity. This extended buffer capacity significantly reduces the risk of uncontrolled overflow and mitigates environmental risks. If prolonged downtime occurs, sewage stored in the buffer tank will be transported off-site until the system is restored. During such periods, the site's non-potable water needs will be met via a potable water backup supply, ensuring operational continuity. Furthermore, an odour control system has been integrated into the design to effectively manage and mitigate potential odour emissions from the facility, minimising any adverse impacts. A detailed internal HAZOP and HACCP assessment has been carried out to identify the risks related to human health, operational, environmental and climate change. It also defines critical and quality control points and outlines preventative measures to mitigate or minimize these risks. Please refer to Appendix 4 of the Appendix Q20.1 for the HZAOP and HACCP analysis.

1.3 Reliability

The proposed wastewater treatment system is engineered for high operational reliability through a combination of robust process design, equipment redundancies, real-time monitoring, and professional maintenance support. The OSSM plant includes multiple treatment technologies for pollutant removal (biological treatment, ozonation, BAC filters) and pathogen reduction (membrane filtration, UV and chlorination) without relying on single technologies. Additionally, although no disinfection credit is claimed for the ozonation process, it provides significant additional pathogen reduction, further enhancing system redundancy. Critical process components, such as wet well transfer pumps, buffer tank transfer pumps, anoxic and aerobic tank transfer pumps, waste activated sludge (WAS) pumps, and biologically activated carbon (BAC) filter backwash pumps, are configured with duty/standby redundancy to ensure continuous operation in the event of equipment failure. Similarly, the ultraviolet (UV) disinfection system and compressed air supply are designed with full redundancy, maintaining required treatment without disruption. To further enhance resilience and operational flexibility, the treatment system features two parallel process trains of equal capacity. This configuration allows one train to remain in operation while the other undergoes maintenance or is taken offline during periods of low flow.

Reliability is also ensured through a structured servicing and asset management approach. Aquacell's dedicated in-house servicing team is fully trained and experienced in the operation and maintenance of the specific equipment used in the proposed treatment plant. The plant will be supported by a comprehensive Operation and Maintenance (O&M) Manual, including detailed standard operating procedures, preventive maintenance schedules, emergency response protocols, and troubleshooting guides—ensuring the system operates safely and consistently over its service life.

Performance monitoring is managed via Aquacell's Supervisory Control and Data Acquisition (SCADA) system, which enables continuous data acquisition and remote system control. This system captures key performance indicators such as uptime, flow rates, water quality metrics, and alarm notifications, facilitating proactive maintenance and immediate response to any deviations from desired operation. Aquacell's operational history strengthens this reliability, with more than one million hours of operation since commissioning its first recycled water system in 2004.

Aquacell's organisational capability is further supported by its Integrated Management System (IMS), which encompasses safety, quality, and environmental procedures. The IMS has undergone multiple external audits by regulatory authorities including IPART, local councils, and the EPA in Victoria, demonstrating consistent compliance with legislative obligations. A summary of the IMS scope and coverage is provided in Appendix Q20.2. Additional information confirming Aquacell's technical capacity to reliably operate and maintain the proposed scheme is available in Appendix Q20.3.

1.4 Public Health

Public health protection is a key objective of the OSSM scheme. The system is designed and operated in accordance with the Australian Guidelines for Water Recycling (AGWR) to ensure the production of safe, high-quality recycled water.

Further details on the scheme's approach to ensuring that the recycled water is safe for use is provided in Appendix Q20.1, with the following key components:

i. Section 2 of the Appendix outlines the assessment of public health risks and the establishment of product water quality criteria based on the outcomes of that assessment.

ii. Section 4 and 6 describe the response protocols for managing any identified risks in accordance with the Australian Guidelines for Water Recycling (AGWR) and Aquacell's documented risk management procedures.

The OSSM scheme includes multiple pollutant removal and disinfection technologies, with ongoing monitoring and compliance reporting to verify that recycled water consistently meets the required quality standards for non-potable use.

1.5 Environmental Risk

Environmental and ecological risk assessments have been carried out as part of this application and are documented in the accompanying Statement of Environmental Effects, Noise and Vibration Impact Assessment, Odour Impact Assessment, and Land Capability Assessment. These assessments have not identified any significant environmental impacts rising from the proposed scheme. These reports are addressed comprehensively in response to Question 24 ("What environmental impact assessments have been undertaken?"). Furthermore, arrangements for the disposal of waste products generated by the infrastructure are discussed in response to Question 21 ("What waste products will be generated and disposed of?"). The HAZOP and HACCP assessment identified risks related to climate change and incorporated mitigation strategies. Please refer to Appendix 4 of Appendix Q20.1 for the climate change-related risk assessment and control measures.

1.6 Conclusion

The proposed OSSM scheme at Alspec Industrial Business Park is a safe, reliable, and sustainable solution for onsite wastewater treatment and recycled water reuse. Designed to meet the requirements of the Australian Guidelines for Water Recycling (AGWR), it incorporates comprehensive risk controls, redundancies, and monitoring systems. Supported by Aquacell's proven track record and audited management systems, the scheme ensures protection of public health and the environment, with no significant residual risks identified.

Appendix Q20.1

Recycled Water Quality Management Plan

Aquacell Pty Ltd

Alspec Industrial Business Park Blackwater Treatment Plant
Luddenham Rd, Orchard Hills

June 2025, Revision 4

Revision	Date	By	Checked	Document Status	Amendments
1	14/06/2024	AE/WJ	WTJ	Initial Issue	
2	30/07/2024	JJ	WTJ	For Review	Minor amendments throughout
3	4/12/2024	JJ	WTJ	For Review	Minor amendments in line with council RFI.
4	13/06/2025	SMA		For Review	Minor amendments in QCP1, PFD and layout, updated for WICA application

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1. Introduction

1.1 Purpose of the RWQMP

This Recycled Water Management Plan (RWQMP) has been prepared by Aquacell Pty Ltd in relation to the operation of the Blackwater Water Treatment Plant (BWTP) that will be located at the Alspec Industrial Business Park (AIBP) on Luddenham Road, Orchard Hills.

It states the microbial quality objectives for the scheme and describes how implementation of the management plan will ensure those objectives are achieved and maintained. The document contains:

- Responsibilities of the recycled water supplier;
- Description of the recycled water process, including composition of the source and end use applications for which the treated water is fit-for-purpose;
- Detailed validation of the treatment processes; and
- A detailed process control and monitoring program to ensure the treated water meets the required quality for end use.

1.2 Description of the scheme

1.2.1 Site Description

The Alspec Industrial Business Park will be located at 221-227 and 289-317 Luddenham Road, Orchard Hills. The proposed location of the BWTP is shown in Figure 1 below.

The blackwater to be used for recycle will be sourced from onsite toilets, showers, basins and drains (other than stormwater drains).

Recycled water will be supplied to the site for:

- Cooling tower make-up water
- Toilet flushing
- Irrigation

Additional demand beyond the available recycled water will be met using potable water.

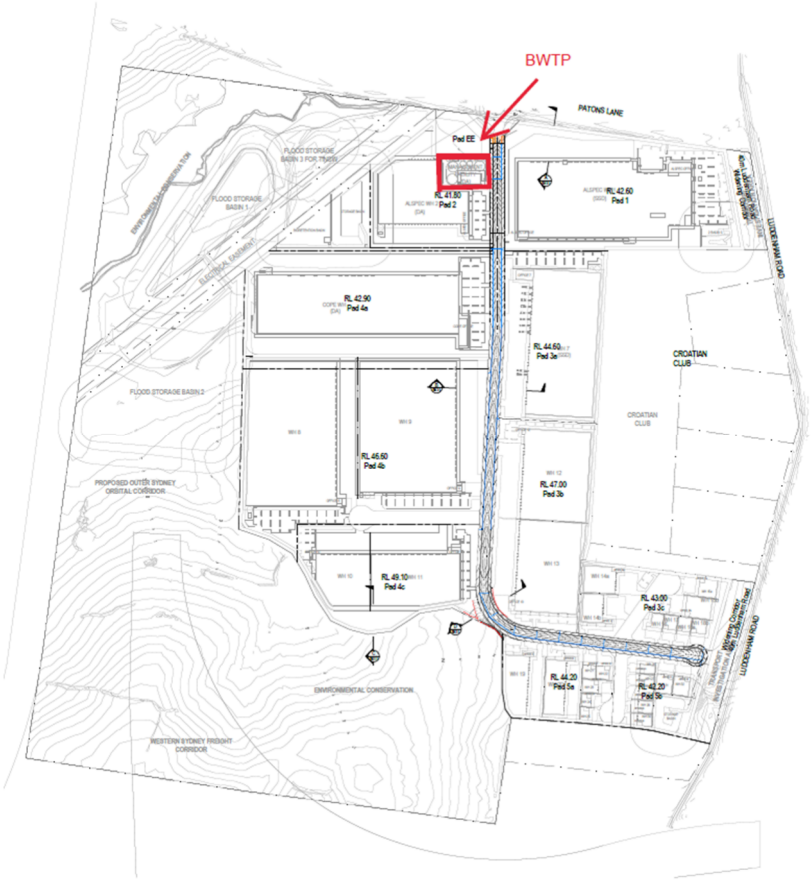


Figure 1: Proposed location of Blackwater Treatment Plant

1.2.2 System Process Design

A flow diagram of the plant showing the key unit operations is provided in Appendix 1, and a general arrangement drawing showing the physical layout of equipment is provided in Appendix 2.

Blackwater from the site is directed to a wet well adjacent to the treatment plant. Effluent from the wet well is pumped to a prescreen and the directed to 1000 kL buffer tank. The BWTP draws water from the buffer tank based on treated water demand, storing the final treated water in a 1000 kL treated water storage tank.

Referring to the flow diagram located in Appendix 1, the system consists of the following units:

- Wet Well (30 kL)
- Emergency Tank (300 kL)
- Prescreen
- Buffer tank for collection of blackwater (1000 kL)
- Two identical process trains with the following process units:
    - Anoxic Tank

- Aerobic Tank
- Membrane bioreactor treatment system (MBR)
- Filtrate tank
- Ozonation
- Biological activated carbon filter (BAC)
- Ultraviolet light disinfection (UV)
- Chlorine disinfection

- Off-spec water holding tank (1000 kL)
- Treated water storage tank (1000 kL)
- Treated water chlorination
- Screw press
- Vents connected to an odour scrubber for odour control
- Overflows and drains to wet well
- Chemical dosing systems

1.3 Management commitment

The scheme manager of the on-site recycling scheme at the AIBP is yet to be determined. They will be committed to ensuring the system is maintained and operated in compliance with relevant guidelines, regulations and standards at all times.

The scheme manager will engage Aquacell Pty Ltd (Aquacell), as the contracted provider of maintenance and operation services for the blackwater treatment plant. Both Aquacell and the scheme manager will provide the same commitment to maintain and operate the system in compliance with relevant guidelines, regulations, and standards at all times.

Under the agreement, the scheme manager will have maintenance personnel on site to undertake all daily, weekly and emergency response tasks associated with the running of the plant. Aquacell will provide initial training and ongoing technical support. Aquacell will be responsible for the majority of the technical and operational activities including on-site servicing, calibrations, regulatory reporting and remote operation as will be detailed in the service contract.

It should be noted that recycled water is treated to a high quality and suitable for human contact. As such, the water is suitable for the purpose of irrigating in the landscaped areas on each of the warehouse lots. Further information can be found within Whitehead & Associates' Land Capability Assessment.

A copy of the Aquacell Recycled Water Policy is provided in Appendix 3.

Comprehensive site management systems for the facility form part of this management plan. These describe the processes and procedures that will be in place to ensure the responsible use and management of recycled water.

1.4 Roles and responsibilities

The scheme manager will be responsible for both the recycled network for the collection and supply of blackwater to the BWTP, and the BWTP itself, which produces recycled water for the scheme. The scheme manager (or designated sub-contractor) will be responsible for the treated water storage and the delivery systems in which the recycled blackwater will be used.

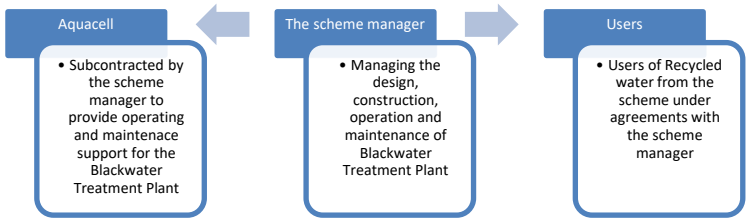
Aquacell provides operation and maintenance support for the BWTP.

In general terms, the scheme manager is responsible for:

- the production and supply of recycled water that is fit for purpose, ensuring that water quality complies with regulated standards and supply agreements up to designated transfer points defined in the RWQMP and supply agreements
- implementation of communication and reporting protocols if water quality does not meet required standards
- operation and maintenance of infrastructure for the production and supply of recycled water up to designated transfer points
- compliance with relevant regulatory requirements for recycled water
- using recycled water only in the manner and for the purposes for which it has been supplied, in accordance with supply agreements
- operation and maintenance of recycled water infrastructure after the designated transfer point
- implementation of control measures and compliance with usage restrictions defined in supply agreements.

The responsibilities and relationships between key roles are outlined in the figure below.

Figure 2. Blackwater Treatment Plant Responsibilities and Relationships



1.5 Scheme Owner

The owner of the development where the BWTP will be installed is to be confirmed.

Business Entity: TBA

Address: TBA

Phone (Business): TBA

Email: TBA

1.6 Responsible entity and scheme manager

The scheme manager is to be confirmed.

Business Entity: TBA

ABN: TBA

Address: TBA

Phone (Business): TBA

Email: TBA

1.7 Scheme operator and recycled water supplier

The scheme operator and supplier of recycled water is Aquacell Pty Ltd (Aquacell).

Business Entity: Aquacell Pty Ltd.

ABN: 79 072 487 015

Address: Suite 6.02, 6A Glen Street,
Milsons Point NSW 2061

Phone (Business): (02) 4721 0545

Email: info@aquacell.com.au

1.8 Users

The users of the recycled water are the staff, tenants and visitors at the AIBP.

2. Water quality objectives

2.1 Microbial

The proposed recycled water quality objectives have been derived based on the application of the principles described in the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks Phase 1 (AGWR) (NRMMC, 2006).

2.1.1 Assumptions

In order to arrive at pathogen log reduction values for the treatment process, assessments must be made of the potential risk of ingestion and frequency of these events for the different exposure routes present in the reuse scheme. The following outlines the assessments made in order to calculate the required treated water quality and hence the associated Log Removal Value (LRV) for the treatment process.

The possible exposure to treated water at this site are:

- Ingestion from cross connections between the drinking and recycled water systems
- Aerosol ingestion from toilets
- Ingestion from cooling towers
- Ingestion of water used for irrigation

2.1.2 Ingestion from cross connections between the drinking and recycled water systems.

Guidance on typical exposure rates and ingestion volumes for cross connection of dual reticulation systems are provided in Table 3.3 of the AGWR. These figures have been adopted for the purposes of calculating performance targets.

There are a number of steps that have been taken to ensure that the risk of cross-connection is low. These include:

- The dual reticulation system will be installed according to AS/NZ 3500 and NSW Health Guidelines for recycled water, including lilac pipe and/or markings.
- Testable reduced pressure zone devices will be provided at all interconnection points between the treated water and the potable water supply.

- Signage to warn of the use of recycled water will be installed.
- The dual pipe system will undergo a full cross connection audit prior to commercial operation. If any cross connections are detected, these will be repaired prior to commercial operation. Cross-connection audits will be carried out at a frequency to be determined by Scheme Owner, in consultation with Aquacell and other stakeholders under the pending recycled water scheme approval to operate under WICA Act. The detailed plan for carrying out cross-connection tests will be documented in the maintenance plan.
- Any maintenance or modification to the reticulation system will occur under strict supervision of the responsible entity and Scheme Manager and in accordance with the site management processes.
- All maintenance workers and plumbing contractors will be fully inducted to the site and made aware of the dual reticulation system and the consequences of cross connections.

2.1.3 Aerosol ingestion from toilets

Table 3.3 of the AGWR provide a guidance on typical exposure rates and ingestion volumes for toilet flushing. These figures have been used for calculating performance targets.

2.1.4 Ingestion from cooling towers

The exposure for those operating the cooling towers (occupational) is considered to be higher than those for the general public. Both of these risks have been considered in the analysis provided in section 2.1.6.

Occupational exposure is mitigated by various means:

- Access to cooling towers restricted to authorised staff only
- The normal practises for maintenance and servicing cooling towers to minimise risk to legionella are applied (e.g., as detailed in the NSW Health document *Legionella control in cooling water systems* (August 2018).
- New construction with modern, low drift design.

2.1.5 Ingestion of water used for irrigation

The proposed irrigation includes drip and spray irrigation for landscaped areas. Table 3.3 of the AGWR provide a guidance on typical ingestion volumes for garden irrigation which have been used for calculating performance targets.

2.1.6 Performance target calculations

The project specific ingestion risks have been considered in order to determine the pathogen removal targets (using sewage as source) required to meet the minimum tolerable health risk of 10^{-6} DALY as recommended by the AGWR. The exposure risks considered, along with associated assumptions, are summarised in Table 1.

Based on the dose equivalent to a DALY of 10^{-6} for each organism (DALYd), the LRV required can be calculated as described in Appendix 2 of the AGWR and shown below as:

LRV = log (raw water concentration x exposure (L) x N / DALYd)

Where "exposure (L) x N" is the weighted total calculated in Table 1 below:

Table 1: Exposure risks for determining health based LRV targets based on AGWR

Use	Ingestion (L)	Frequency (/person/year)	Prop. of population affected (%)	Weighted total (L/yr)	Assumptions
Toilet flushing	0.00001	1100	100	0.011	Tenants and visitors - 3 uses per day
X-connect	1	365	0.1	0.365	1 L/day per person; Assume 1 in 1000
Cooling towers – general public	0.00001	728	100	0.00728	2 exposures per visit (coming and going); 7 visits per week for each week of the year
Cooling towers – occupational	0.0001	728	100	0.0728	2 staff per visit each day, one visit per day, 7 days per week
Irrigation – Municipal + Dual Reticulation	0.001	52	100	0.052	Assumes most people use these areas sparingly and not during irrigation. Assume 1/week.
		Total		**0.503**	

Using the AGWR recommended blackwater microbial concentrations (from AGWR Table A2.1) and the DALYd data for Cryptosporidium, Rotavirus, and Campylobacter (from AGWR Box A2.2), the minimum required and target LRV's (rounded up to the nearest 0.5-log) are determined and presented in Table 2. These values are consistent with the recommended log reduction targets for blackwater as shown in Table 3.8 of the AGWS (for dual reticulation, toilet flushing, washing machine and garden use).

Table 2: Minimum and target LRV's for protozoa, bacteria, and viruses (Blackwater Source)

	Representative family	Concentration in source (organisms/L)	Weighted total (L/yr)	DALYd for DALY of 10^6 (organisms/yr)	LRV required	LRV target
Rotavirus	Viruses	8000	0.503	2.5×10^{-3}	6.2	6.5
Cryptosporidium	Protozoa	2000	0.503	1.6×10^{-2}	4.8	5
Campylobacter	Bacteria	7000	0.503	3.8×10^{-2}	5.0	5

Treatment plant performance objectives are summarised in Table 3. The validation basis for these credits is discussed in section 0.

Table 3: Treatment plant performance objectives for blackwater

	MBR[1]	UV	Chlorination	Total LRV Achieved	Target LRV
Virus	1.5	1	4	6.5	6.5
Protozoa	2	4	0	6	5
Bacteria	4	4	4	12	5

1. *Based on WaterVal Tier 1 default for MBR (See section 5.1)*

2.2 Chemical

No major industry is conducted on site as it is mostly warehousing and offices, so this risk is considered low. However, there is some aluminium processing (extrusion), along with milling, product painting and washing in one of the warehouse facilities (Alspec 1). The wastewater from this these processes will be managed as trade waste to ensure that it does not contain adverse qualities of oil and grease or solvents.

3. System assessment

A Hazard Analysis and Critical Control Point (HACCP) analysis of the AIBP BWTP is conducted and included in Appendix 4. The methodology used will be in accordance with the AGWR and Aquacell's documented risk procedures.

4. Compliance with Australian Guidelines for Water Recycling

The table below lists the 12 elements of the framework for managing recycled water quality and use (as per the AGWR) and shows how the scheme will meet the various elements.

Table 4: AGWR framework elements

Framework element	Activity	Reference Document
Element 1: Commitment to responsible use and management of recycled water quality		
Components: Responsible use of recycled water	Aquacell will operate and maintain the treatment process and provide support. There is a commitment to ensure correct design installation and management. Aquacell WICA retailer (25_009R) and operator licence (25_008) WICA Scheme approval pending to install and operate the system.	WICA scheme approval (Appendix 5) WICA retailer licence (Appendix 7) WICA operator licence (Appendix 8)
Regulatory and formal requirements	There is a WICA scheme approval application pending to install and operate the system.	WICA scheme approval pending (Appendix 5) WICA retailer licence (Appendix 7) WICA operator licence (Appendix 8)
Engaging stakeholders	Stakeholder engagement is pending and will include the development of an information package to create awareness of the various stakeholders' obligations to achieve high water efficiency. This will include marketing material, contractual obligations and site induction information.	
Recycled water policy	The implementation of a recycled water policy is recommended.	Aquacell Recycled Water Policy exists (IMS Document EM010)
Element 2: Assessment of the recycled water system		
Components:	Uses are for toilet flushing, cooling tower makeup and irrigation.	This RWQMP

Identify intended uses and source of recycled water	The water source is blackwater from the AIBP business park development.	
Recycled water system	The plant receives blackwater from the building. Water is subjected to treatment through a membrane bioreactor, ozone, carbon filter, ultraviolet (UV) disinfection and chlorine disinfection. The treated water is piped to a dedicated storage tank and distributed for use.	Operations and Maintenance Manual pending (Appendix 11)
Assessment of water quality data	Raw wastewater is characterised based on typical values for this application, in addition to adopting the values for pathogen content outlined in the AGWR. Treated water quality from the wastewater treatment plant will be tested in accordance with a specified testing regime.	This RWQMP section 7 and AGWR
Hazard identification and risk assessment	A Hazard Analysis and Critical Control Point (HACCP) analysis of the AIBP scheme have been conducted. The methodology used is in accordance with the AGWR and Aquacell's documented risk procedures.	Aquacell HACCP (Appendix 4)
Element 3: Preventative measures for recycled water management		
Components: Preventative measures and multiple barriers	**Human health** Preventative measures to manage risks to human health include: Membrane filtration, UV disinfection and chlorine disinfection; Pipework (purple and/or with text) and signage at site of use indicating that recycled water is being used; Educational material to tenants and site managers about avoidance of inappropriate disposal of wastes; Signage at site to alert plumbers to recycled water system and co-ordination of plumbers through site management; Backflow prevention and cross-connection control; **Environmental performance** Preventative measures to manage risks to the environment include: Education programme for tenants and site managers promoting use of environmentally friendly detergents in the toilets and hand basins and avoidance of disposal of chemicals; A list of detergents considered appropriate for use in the building made available to cleaning staff and updated annually;	This RWQMP AS/NZS 3500:2003 Community page on Aquacell website Employer and contractor induction procedures and records Community page on Aquacell website
Critical control points	Multiple critical control points are confirmed through the HACCP analysis. These are detailed further in section 6.1.	Aquacell HACCP (Appendix 4) This RWQMP section 6.1
Element 4: Operational procedures and process control		
Components: Operational procedures	Operational procedures will be identified for all processes and activities associated with the system, including operation of treatment processes and auditing procedures for cross-connections. Documented procedures must be available to operations personnel and for inspection at any time. Operators are proficient and are able to recognize the significance of changes in the recycled water treatment plant and water quality. They are able to respond appropriately according to established procedures.	Operations and Maintenance Manual pending (Appendix 11) Aquacell Work instructions
Operational monitoring	A number of online monitoring instruments are used to ensure that we always meet the requirements of the Critical Control Points (CCP).	This RWQMP section 6 and 7
Corrective action	Corrective actions include the following: Noncompliance with the CCP's results in the system being stopped or treated water diverted to the Off-spec water holding tank. If cross-connections detected, flow to property stopped until repairs completed. Site switches to potable water backup until cross connection is eliminated.	This RWQMP section 6
Equipment capability and maintenance	Treatment plant and disinfection systems of standard and reliable design. Maintained by qualified supplier.	A service agreement will exist between the scheme manager

		and Aquacell for the maintenance and service of the recycled water treatment plant.
Materials and Chemicals	All plumbing and drainage work is conducted in a manner conforming to AS/NZS standard 3500. All chemical used in the plant are obtained from credible suppliers.	MSDS are supplied for each chemical. Purchasing is in accordance with Aquacell Purchasing and Inventory Procedure (IMS Document PI030)
Element 5: Verification of recycled water quality		
Components: Recycled water quality monitoring (specifically designed for individual systems, taking into account source of water, end uses and receiving environments)	**Human health** Monitoring of defined parameters is undertaken. Building occupant/customer satisfaction, monitored by the operator; complaints are investigated particularly when clusters of complaints are received.	This RWQMP section 6 and 7 Aquacell "Complaints Handling and Dispute Resolution Policy" (IMS Document CS030) Aquacell website "Community" page
Application and discharge site monitoring	**Environmental performance** Out of specification water will be recirculated to the start of the treatment process. Screenings and dewatered biosolids will be disposed of in landfill.	
Documentation and reliability	The sampling plan (location, parameters and frequency) will be determined and agreed to by the relevant authorities. The sampling and testing will be performed by an independent, NATA accredited laboratory.	Laboratory NATA certification Chains of Custody Records of results.
Satisfaction of users of recycled water	In this application, comments regarding end user satisfaction are likely to be directed to the site management. Any complaints will be handled as described in the Human Health section of Element 5 above.	Aquacell "Complaints Handling and Dispute Resolution Policy" (IMS Document CS030)
Short-term evaluation of results	The customer is supplied with a monthly report regarding the performance of the plant. The Aquacell recycled water engineer and service technician are in regular verbal and e-mail correspondence with the building management. Results will be provided to the regulator.	Monthly Service Report to the scheme manager regarding plant operation and performance indicators derived from onsite activities, data trending and analysis and water quality results.
Corrective responses	Corrective action depends on the incident. Most corrective actions occur automatically through appropriate PLC logic. As a minimum, it involves investigation of plant performance records to confirm normal operation, and additional testing to confirm the result and identify the source of any issue which arises. If target criteria for environmental parameters are exceeded, preventative measures need to be reassessed and corrective action taken to ensure environmental performance is improved.	Corrective actions are addressed in section 6.2 this RWQMP
Element 6: Management of incidents and emergencies		

Components: Communication	Noncompliance with approval conditions to be reported immediately to regulator. Noncompliance with approval conditions that that affect public health to also be reported immediately to Sydney Local Health District Public Health Unit (NSW Health) In the case of an incident or emergency that requires a media response, only the CEO is authorized to make any public comment.	Notification procedures as described in section 11.3 of this report. Reporting as required to relevant authorities.
Incident and emergency response protocols	Employees are trained in emergency response and incident protocols. Training records are kept. In the event where the water treatment plant is unable to supply treated water, potable water backup is available.	Aquacell "Incident and Emergency Management Procedure" (IMS Document IE010) Training records
Element 7: Operator, contractor and end user awareness and training		
Components: Operator, contractor and end user awareness and involvement	Operator of treatment plant to be sufficiently skilled to run the plant and investigate any faults; End users are made aware of the restrictions on the use of recycled water and any practice that could threaten human health. Contractors inducted to site are told of the presence of dual pipe systems and the precautions required.	Technician induction on commencement of employment, operating manuals, supervision from experienced engineers. End user awareness via signage, inductions and tenancy agreements. Induction records for the coming on site to work.
Operator, contractor and end user training	Operator to be aware of approval conditions and instructed on occupational health and safety requirements Aquacell has an induction program for new employees and written procedures for all areas of responsibility. Training needs for individual employees are identified and adequate resources made available during the induction phase. Annual performance reviews identify additional training requirements and set performance targets. Training records are kept. Any contractors used on site are accredited, qualified and have the appropriate level of training. A site induction includes familiarization with Aquacell's Safe Work Method Statements (SWMS's), which are site specific. Aquacell maintains a partnership with several contractors to ensure continuity of knowledge and technical expertise.	Induction program Annual reviews Contractor induction records. Aquacell document "Hourly Rate Contractor Requirements" Aquacell terms of purchase to contractors and suppliers. Aquacell SWMS's
Element 8: Community involvement and awareness		
Components: Community consultation	The existence of water recycling will be a feature of advertising and promotion for the development.	
Communication and education	The site management will have an information package regarding recycled water use and hazards which it will make available to all new tenants or upon request.	Information supplied from the site managers for the tenants Undesirable chemical discharges to the recycled water system are listed on

		Aquacell' s website community page
Element 9: Validation research and development		
Components: Validation of processes	Ongoing investigations into recycled water quality and treatment plant performance to refine assessments. This may enable less conservative critical control points to be adopted or treatment requirements reduced.	Validation according to section 5 of this RWQMP
Design of equipment	The design of the plant is based on well-documented and validated technologies.	This RWQMP section 5
Investigative studies and research monitoring	As the depth of operational knowledge regarding this and similar water treatment technologies increases, so the understanding of the weaknesses increases. This results in better opportunity to be proactive regarding operational control and maintenance of the plant, thereby improving operating costs and sustainability of the scheme.	This RWQMP will be reviewed in 12 monthly intervals as part of the process of continual improvement.
Element 10: Documentation and reporting		
Components: Management of documentation and records	Design of treatment plant and reticulation system documented; Operating procedures documented; All results to be recorded and stored; Aquacell has developed an in-house Integrated Management System (IMS) that is based on the ISO 9000 system. Included in this RWQMP and the Operations and Maintenance Manual is information pertaining to preventative measures employed, target and critical limits, critical control points, operating and corrective action procedures. These documents, along with the incident and emergency response plans, training programs and reporting protocols ensure that the plant is operating within set limits at all times. The document control system, ensures that only the most current version of any document is available for use. All documents are reviewed on an annual basis.	RWQMP Operations and Maintenance Manual pending (Appendix 11) Incident and Emergency Management Procedure, (IMS document IE010), Performance reviews, Risk Management Procedure (IMS document RM030)
Reporting	Internal reporting consists of verbal communication between the Aquacell engineer and the site service technician and written reports from the technician to the engineer. The owners of this treatment plant receive a monthly report detailing all operational and performance parameters and the maintenance performed during that month. Reports will also be prepared and submitted to the appropriate regulatory authority as required. Non-compliance breaches are reported immediately	Monthly reporting to the building managers regarding the plant performance. Reports as required by regulators
Element 11: Evaluation and audit		
Components: Long-term evaluation of results	Report as required by appropriate regulatory authority on compliance with approval conditions, including test results audited by regulator. This report will be reviewed by senior management prior to distribution and a copy sent to the regulatory authority and the owners of the treated water plant.	Aquacell will generate a report as required by regulators
Audit of recycled water quality management	Internal audits typically occur on an annual basis or as required by regulator and include a review of the management system, operational procedures and monitoring programs. An Independent audit in compliance with an approved third-party auditor occurs at a frequency yet to be determined.	Aquacell will conduct internal audits as required by regulators. Compliance audits by an independent auditor will be conducted. The frequency of these audits is yet to be determined
Element 12: Review and continual improvement		

Components: Review by senior managers	Performance of treatment plant, customer complaints/satisfaction	A senior review of this plant will be conducted as required in combination with the compliance reporting
Recycled water quality management improvement plan	An improvement plan, based upon the results of the internal and external audits and monthly reports which addresses the performance of the plant and end user expectations is prepared as part of the annual review.	In combination with the compliance reporting, an improvement plan will be developed for this treatment plant, based on the monthly reports and any audits performed.

5. Validation of treatment processes

The validation program for the Alspec Industrial Business Park BWTP is outlined within this section of the RWQMP. The validation program has been designed to evaluate the BWTP's ability to achieve the water quality objectives outlined in section 2 of this RWQMP, which acts as a feasibility study of the BWTP design.

5.1 Membrane Bioreactor Validation

The Membrane Bioreactor (MBR) system is used to achieve a 1.5-log virus, 2-log protozoa and 4-log bacteria removal, as specified in Table 3.

The validation for the membrane bioreactor is based on the WaterVal™ Validation Protocol for Membrane Bioreactors (WaterSecure, 2017) (MBR Protocol). Default credits for the MBR can be claimed if the system operates under the WaterVal Tier 1 operating envelope. The table below shows that the AIBP's BWTP MBR system is designed to operate within this envelope.

Table 5: Operating Envelope for Tier 1 Log Reduction Credits for MBR

Parameter	WaterVal Protocol Tier 1 Operating Envelope		Design conditions	Tier-1 condition met
	Minimum	Maximum		
Bioreactor pH	6	8	6 – 8	✓
Bioreactor dissolved oxygen (mg/L)	1	7	1-2	✓
Bioreactor Temperature (°C)	16	30	16	✓
Solids Retention Time (d)	11	-	20	✓
Hydraulic detention time (h)	6	-	32	✓
Mixed liquor suspended solids (g/L)	3	-	7.5	✓
Transmembrane pressure (kPa)	3	-	3-20	✓
Flux (LMH)	-	30	12.2	✓
Turbidity (NTU)	-	0.2	≤ 0.2 Measured continuously online	✓

The default Tier 1 credits proposed by WaterVal and the claimed credits for this project are shown in Table 6 below.

Table 6: Tier 1 Default LRVs and Claimed LRVs

Pathogen type	Tier 1 Default LRV	Claimed LRV
Viruses	1.5	1.5
Protozoa	2	2
Bacteria	4	4

To ensure the MBR filtrate turbidity continuously meets the Tier 1 condition, it will be monitored and controlled via the critical control points as discussed in section 6.2.1.

5.2 UV Validation

Based on the analysis in section 0 and summarised in Table 3, the UV system is required to achieve a minimum pathogen reduction of 4-log for both protozoa and bacteria, and 1-log for viruses.

The selected UV model, a Hallett 1000P, is validated in accordance with the requirements of the US EPA Ultraviolet Disinfection guidance manual for the final long term 2 enhanced surface water treatment rule (UVDGM) (US EPA, 2006).

Table 1.4 of the UVDGM provides the UV dose requirements for pathogens, and is reproduced below in Table 7.

Table 7: Reproduction of the UVDGM UV dose requirements

Target pathogens	Log inactivation							
	0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**
Cryptosporidium	1.6	2.5	3.9	5.8	8.5	12	15	22
Giardia	1.5	2.1	3.0	5.2	7.7	11	15	22
Virus	39	58	79	100	121	143	163	186

A validated dose of 58 mJ/cm^2 is required for 1-log virus inactivation, and 22 mJ/cm^2 for 4-log protozoa. Bacteria are more UV sensitive than protozoa and will therefore be reduced by an amount at least equal to protozoa (e.g., E. coli up to 10 mJ/cm^2 for 4-log inactivation (AwwaRF, 2004)).

The UV reactor must be validated in accordance with the UVDGM at the required operating conditions for the AIBP BWTP.

Aquacell confirms that the UV system was validated in accordance with the UVDGM, and will achieve the required validated dose for virus and protozoa under the conditions shown in Table 8.

Table 8: UV system operating parameters

Operating Parameter	Operating Conditions
Operating Mode	Calculated dose monitoring
Validated UV Dose	≥ 58 mJ/cm^2 (virus); ≥ 22 mJ/cm^2 (protozoa)
Flowrate	Design: 123 L/min (peak per train)
UVT	≥ 75% (validated min. 34.3%) at 254 nm

An analysis of the proposed UV system and validation of the ability to provide the required dose follows.

5.2.1 UV dose equation

The method of operation chosen for this project to ensure the required UV dose is the calculated dose monitoring approach.

The manufacturer of the UV system has had a validation study carried out by a third party in order to establish the UV performance in accordance with the requirements of the UVDGM. This document is confidential to the UV supplier and has been provided to Aquacell under a non-disclosure agreement for the purpose of validating the suitability of the UV and the required operating parameters.

The design assumptions and associated operating UV reactor design output is summarised in Table 10 below:

Table 9: UV system design assumptions

Parameter	Value	Comment
UVT (%)	75	UV Transmissivity (measured online)
UVA	0.125	UV absorbance (calculated from UVT)
S/S_0	0.85	Combined sleeve and lamp fouling factor (ratio of actual intensity to the intensity with new lamps and sleeves)
Reflection Aging Factors	0.95	Condition of UV light reflectors (a feature of the reactor design)
Flowrate (L/min)	123	Design flowrate per train
Validated UV Dose - Virus (mJ/cm^2)	64	Per US EPA UVDGM
Validated UV Dose - Protozoa (mJ/cm^2)	58	Per US EPA UVDGM

The data from Table 9 shows the UV will generate a validated UV dose of 64 mJ/cm^2 for viruses under the conditions shown This is greater than 58 mJ/cm^2 and therefore the UV reactor is capable of achieving a 1-log virus reduction (per USEPA).

Similarly, Table 9 shows a validated dose 58 mJ/cm^2 is obtained for protozoa under the design conditions. This is greater than 22 mJ/cm^2 and therefore the UV reactor is capable of achieving at least a 4-log reduction in protozoa (per USEPA).

5.2.2 UV validation envelope

The UV validation study indicates a validation envelope extending to a UVT of 34.3% and a minimum flow of 23.5 L/min (1.408 m^3/h), and up to a maximum flow of 386.9 L/min (23.05 m^3/h) and a UVT of 98.9%. The design peak flowrate of 123 L/min (7.4 m^3/h) is within the validated flow range.

UVT and validated UV dose are continuously measured and calculated by the UV controller. This in combination with the UV unit status and lamp age is read to the PLC which monitors the UV operational status. If the flowrate falls below 23.5 L/min, the UV dose calculation defaults to the minimum validated flowrate of 23.5 L/min. Furthermore, the rated capacity of the UV feed pump (PF-DIS-01) is 167 L/min, which is well below the maximum validated flow of 384.2 L/min, thereby mitigating the risk of flow rates exceeding the validated operating envelope.

5.3 Free Chlorine System Validation

The chlorine disinfection system is designed to achieve a 4-log virus and bacteria inactivation, as specified in Table 3. The critical C-T required to achieve this is determined by reference to two separate regulations. Error! Reference source not found. Table 10 is an extract from the *Guidance Manual for Compliance with Filtration and Disinfection Requirements for Public Water Systems using Surface Water Sources* (USEPA 1991). According to US EPA guidelines, at a temperature of 15 degC and pH range of 6 – 9, the C-T requirement for 4.0-log virus inactivation is 4 mg.min/L.

Table 10: Copied from USEPA 1991 Table E-7 – CT values for Inactivation of viruses by free chlorine

Temperature (°C)	Log inactivation – virus					
	2.0		3.0		4.0	
	6-9 pH	10 pH	6-9 pH	10 pH	6-9 pH	10 pH
0.5	6	45	9	66	12	90
5	4	30	6	44	8	60
10	3	22	4	33	6	45
15	2	15	3	22	4	30
20	1	11	2	16	3	22
25	1	7	1	11	2	15

By comparison, the WaterVal™ Validation Protocol for Chlorine Disinfection (WaterSecure, 2017) — underpinned by the US EPA guidance in the Disinfection Profiling and Benchmarking Guidance Manual (US EPA, 1999a) — prescribes specific C–T values based on recent studies using Coxsackievirus B5, which is recognised as the most chlorine-resistant virus within the pH 6–10 range. These values differ from the original US EPA C–T values and are detailed in Table 11, which presents C–T requirements for 1- to 4-log virus reduction across a range of turbidity, pH, and temperature conditions.

Table 11 CT values for 1 to 4 log reduction values of viruses at a range of turbidity, pH and temperature (WaterVal protocol)

pH	LRV	$\leq 0.2NTU$					$\leq 2NTU$					$\leq 5NTU$				
		$5°C$	$10°C$	$15°C$	$20°C$	$25°C$	$5°C$	$10°C$	$15°C$	$20°C$	$25°C$	$5°C$	$10°C$	$15°C$	$20°C$	$25°C$
≤ 7	1	4	3	2	2	1	4	3	2	2	1	4	3	2	2	1
	2	5	4	3	2	2	5	4	3	2	2	6	4	3	2	2
	3	7	5	4	3	2	7	5	4	3	2	7	5	4	3	2
	4	8	6	4	3	2	9	6	4	3	2	9	7	5	3	3
≤ 7.5	1	7	5	4	3	2	7	5	4	3	2	8	6	4	3	2
	2	10	7	5	4	3	10	7	5	4	3	13	9	6	5	4
	3	13	9	7	5	4	13	9	7	5	4	16	12	9	6	5
	4	16	11	8	6	4	16	11	8	6	4	21	15	11	7	6
≤ 8	1	9	7	5	3	3	10	7	5	4	3	12	9	6	4	3
	2	14	10	7	5	4	15	10	7	5	4	19	13	9	7	5
	3	18	13	9	7	5	19	13	10	7	5	25	18	13	9	7
	4	23	16	12	8	6	23	16	12	8	6	32	23	16	11	8
≤ 8.5	1	11	8	6	4	3	12	9	6	5	4	14	10	7	5	4
	2	17	12	9	6	5	19	13	10	7	5	21	15	11	8	6
	3	23	16	12	9	6	25	17	13	9	7	29	21	15	10	8
	4	29	21	15	10	8	31	22	16	11	8	37	26	18	13	9
≤ 9	1	13	9	6	5	3	14	10	7	5	4	15	10	7	5	4
	2	20	14	10	7	5	22	16	11	8	6	23	16	12	8	6
	3	28	19	14	10	7	30	21	15	11	8	32	23	16	11	8
	4	35	25	17	12	9	38	27	19	13	10	41	29	20	14	10

According to this protocol, for ultrafiltered water (essentially particle-free), a C–T value of 12 mg·min/L is required to achieve a 4.0-log virus reduction at pH ≤ 8 and 15 degC. Applying a conservative design approach, the chlorine contact tank has been sized for a 12 mg·min/L C–T. As bacteria are more susceptible to chlorine than viruses, achieving a 4.0-log virus inactivation will also ensure at least a 4.0-log bacteria inactivation.

5.3.1 Chlorine contact tank design

The Theoretical Detention Time (TDT) required is given as follows:

TDT = V/Q

Where:

TDT = Theoretical Detention Time (min)

V = minimum volume of chlorinate contact system (L)

Q = flow rate (L/min)

Actual detention time (T) is determined by correcting for the impact of potential bypass by the use of a baffling factor (BF):

T = TDT x BF

Where:

T = time that water is contact with chlorine (min)

BF = baffling factor (usually between 0.1 – 1.0)

The design for the contact tank uses a long length of pipe to achieve the chlorine contact time. It is generally considered that a L/D of > 40 approximates plug flow (e.g., *Guidelines for validating treatment processes for pathogen removal (DH, 2013), section 8.1.3*), and that under these conditions contact time (T) is equal to theoretical detention time (TDT). That is, the baffling factor (BF) equals one under these conditions.

The design uses a total pipe length (L) of 36 m at a diameter (d) of 246 mm which gives L/d = 146.3, which is greater than the minimum of 40. The calculated volume for the contact pipe is determined as follows:

*Volume (V) = π * (246/1000) ^2 /4 * 36*

= 1.711 m^3 = 1711 L

5.3.2 Chlorine residual calculation

The C-T is defined as:

*C-T (mg·min/L) = C (mg/L) * T (min)*

*= C (mg/L) * TDT*BF*

*= C (mg/L) *V (L)/Q (L/min)*BF*

As BF =1 for plug flow, V= 1711 L, this equation becomes:

***C-T (mg·min/L)** = C (mg/L) *1711/Q (L/min)* 5.1

Equation 5.1 is programmed into the PLC and used to continuously monitor the instantaneous C-T value. At any flow rate, the free chlorine concentration is automatically adjusted to ensure that the C-T is > 12 mg·min/L, while maintaining the chlorine concentration within the operational range of 0.5 – 5 mg/L.

6. Operational monitoring and process control

A Hazard Analysis and Critical Control Point (HACCP) analysis of the Alspec Industrial Business Park BWTP is conducted after the risk management workshop and is included in Appendix 4. The methodology used will be in accordance with the AGWR and Aquacell's documented risk procedures.

6.1 Operational control

A flow diagram summarising the Quality Control Points (QCP) and Critical Control Points (CCP) is shown in Figure 3. Two identical trains with the same process units and QCP's and CCP's will be installed (each producing 150 kL/day). Detailed monitoring and corrective actions for the QCP's and CCP's are described in the following sections.

6.1.1 Critical control points

If water quality parameters for either train A or train B are exceeded at the CCP's, treated water from that train will either be recirculated (MBR CCP's) or diverted to the Off-spec water holding tank. If the CCP limits continue to be exceeded for an extended period of time, the corresponding train will shutdown.

6.1.2 Process Description

Pre-screen:

The prescreen removes non-degradable solids such as fibers, or rags that can block or damage downstream processes and equipment. It also removes some of the degradable waste which help to lower the organic load to the biological treatment process.

Emergency Tank:

A 300 kL emergency storage tank is integrated at the plant's inlet to provide one day of raw sewage holding capacity in the event of a prescreen failure or shutdown, eliminating the need for immediate pump-out.

Buffer Tank:

A 1 ML buffer tank is provided to capture peak flows from the site. This maximizes the amount of water that can be recovered and enables the plant to operate at an efficient and steady flow. A submersible mixer is employed in these tanks to keep solids suspended and to prevent anaerobic conditions occurring.

Bioreactor:

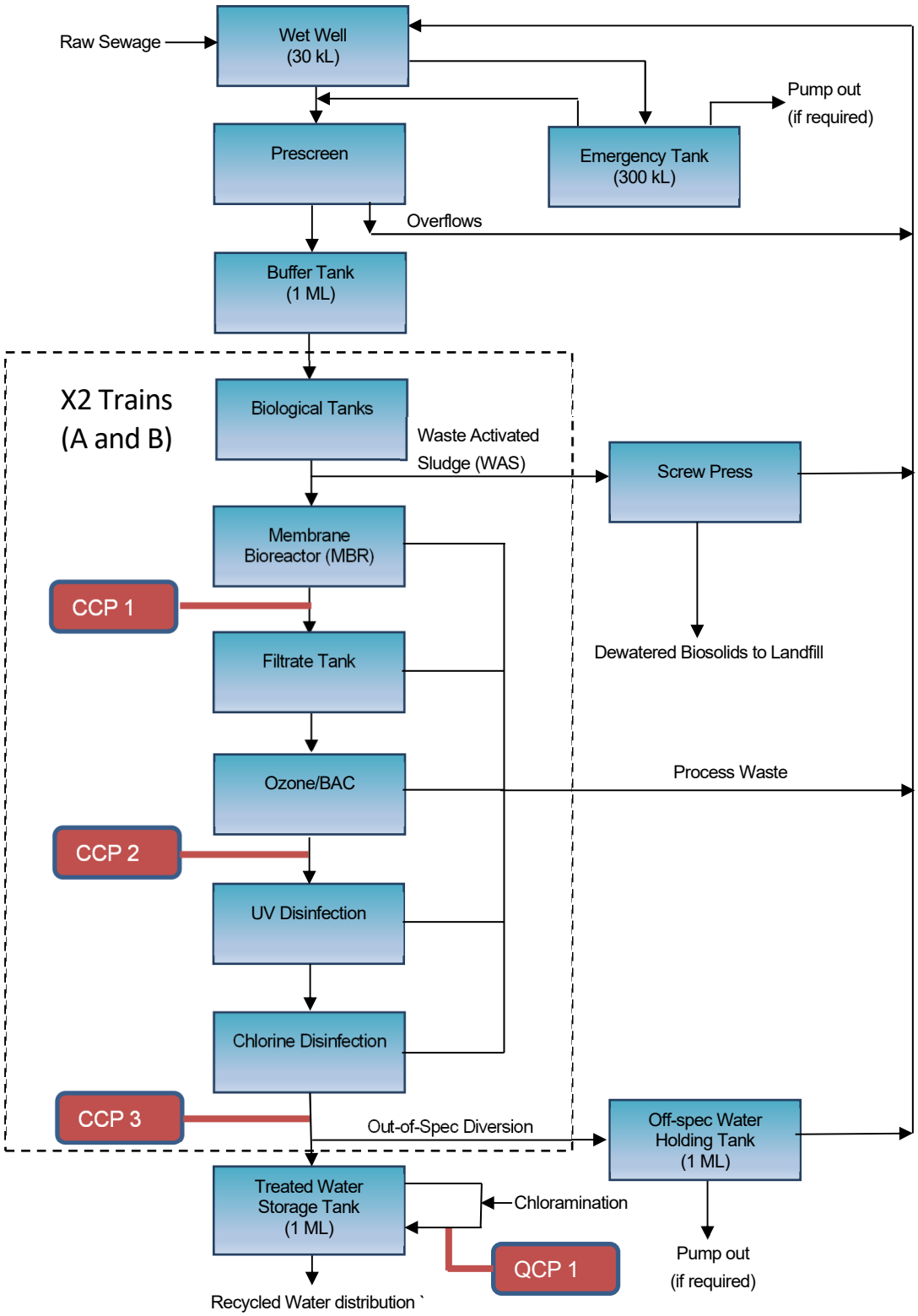
The biological system consists of both anoxic and aerobic stages.

The Anoxic Tank converts nitrate generated by the treatment process to nitrogen gas in order to reduce the nitrogen content of the treated water. Continuous mixing in the anoxic tank ensures that mixed liquor remains homogenous.

The Aerobic Tank carries out further biological treatment of the wastewater to reduce the organic content and convert ammonia nitrogen to nitrate and nitrite. Blowers aerate these tanks to ensure the required air for oxygen transfer is provided.

Mixed liquor suspended solids (MLSS) concentration is monitored continuously and waste activated sludge (WAS) is periodically discharged to maintain the required MLSS level.

Figure 3: Recycled water process flow and critical control points



Screw Press:

The screw press receives sludge from the WAS tank and separates the solid and liquid phases. The liquid is sent back to the start of the process train and the dewatered biosolids are collected for transportation to landfill.

Ultrafiltration membranes:

The combination of ultrafiltration and bioreactor is referred to as a membrane bioreactor (MBR). The biomass suspension from the bioreactor is recirculated past hollow fibre membranes, housed in the MBR tank, and returned to the bioreactor. A portion of the recirculated flow is withdrawn through the membranes as filtrate and collected in the filtrate tank for downstream disinfection.

The membranes are polymeric hollow fibres with a nominal pore size of 0.04 µm. The membranes effectively remove essentially all suspended solids and the bulk of any pathogens, including virus, bacteria and protozoa.

Ozone/BAC:

Filtered water then dosed with ozone and passed through an ozone contact pipe followed by Biological Activated Carbon (BAC) filters. This combination is used to remove colour from the feed water. The BAC employs periodic backwashing to control bacteria levels present in the filter and to ensure the filter bed is well distributed.

Ultraviolet light Disinfection (UV):

The UV system consists of two UV units in parallel. It provides the required dose to ensure the required inactivation of virus, bacteria and protozoa.

Chlorine Disinfection:

Following the UV, the water is dosed with sodium hypochlorite before entering a pipe contactor to provide the necessary chlorine contact time for disinfection. The free chlorine residual and pH of the recycled water are monitored at the end of the chlorine contact pipework.

Treated Water Storage Tank and Distribution:

The treated water is stored in a 1ML Treated Water Storage Tank (TWST) which allows the system to account for peak flows. Water in the TWST is recirculated and dosed with chlorine to maintain a free chlorine residual for storage and distribution.

Off-Spec Storage Tank:

Any treated water that cannot be used for distribution will be diverted to the Off-Spec Storage Tank. This water will then be recirculated back through the treatment process.

Odour Scrubber:

The odour scrubber captures and treats emissions from key odour sources within the facility, including the wet well, prescreen, buffer tank, and screw press, to minimise any adverse impacts on the surrounding environment.

6.2 Monitoring and corrective actions

6.2.1 MBR System

Table 12: MBR critical control point

CCP 1	MBR		
	Turbidity	**Sample Flow Switch**	**Instrument Status**
Critical limits/alert limits			
Alert	≥ 0.15 NTU		
Critical	> 0.2 NTU	No Flow	Instrument Critical Fault
Monitoring procedures			
What	Turbidity	Flow Switch	Transmitter
How	AIT-MBR-01 (HACH TU5300sc)	FS-MBR-01	AIT-MBR-01 (HACH TU5300sc)
When	Continuous, during MOS FILTRATION		
Where	MBR filtrate line		
Who	Aquacell/Automatic		
Corrective actions			
What	MOS recirculation mode entered, returning filtrate to the MBR tank.		MOS goes to standby
How	Open recirculation valve (AV-306A/B) and close filtrate to filtrate tank valve (AV-302A/B)		Filtration stopped
When	If critical limit is exceeded for > 120 s	No flow for > 120 s	Immediate
Where	PLC		
Who	Automatic		

Turbidity:

If during MOS filtration, the turbidity exceeds the alert level for 120 seconds a warning alarm is generated to warn the operator. If the turbidity exceeds the critical level for more than 120 seconds, an alarm is triggered and the filtrate flow is diverted from the filtrate tank and recirculated back to the MBR tank. During recirculation, if the turbidity drops below the critical level for at least 120 seconds, filtrate is sent to disinfection. However, if after 3 filtration/relaxation cycles, the filtrate turbidity has not fallen below the critical limit for at least 120 seconds, the MOS (Membrane Operating System) will go to standby and a standby alarm will be generated.

Production resumes when the operator resets the turbidity alarm after the cause has been identified and addressed.

Flow switch:

There is a flow switch in turbidity meter sample line to ensure sample flow is present during MOS filtration. If sample flow is lost, the turbidity readings are unreliable. If during MOS filtration, the flow switch turns off for more than 60 seconds an alarm is triggered to warn the operator. If the flow switch is off more than 120 seconds, an alarm is generated and the filtrate flow is diverted from the filtrate tank and recirculated back to the MBR tank. During recirculation, if the sample flow switch turns on for at least 120 seconds, treated water is redirected to storage. However, if after 3 filtration cycles, the sample flow switch has not turned on for at least 120 seconds, the MOS (Membrane Operating System) will go to standby and a standby alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Instrument Status:

If a critical turbidity instrument fault occurs during MOS filtration or recirculation, the MOS (Membrane Operating System) will immediately go to standby and a standby alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Maintenance:

Turbidity tested by handheld turbidity meter monthly, and recalibrated as required.

6.2.2 UV system

Table 13: UV disinfection critical control point

CCP 2	UV disinfection			
	Validated UV Dose – Virus	**UVT**	**Lamp age**	**UV status**
Critical limits/alert limits				
Alert	< 60 mJ/cm^2	< 45%	> 10,000 hours	
Critical	< 58 mJ/cm^2	< 35%	> 12,000 hours	UV Fault
Monitoring procedures				
What	UV Dose	UVT Monitor	Hour monitor	Lamp monitor
How	UV Controller (Hallett 1000P)	UV Controller (Hallett 1000P)	PLC recorded and UV controller (Hallett 1000P)	UV Controller (Hallett 1000P)
When	Continuous, online			
Where	UV Unit	UV Unit	UV Unit and PLC	UV Unit Output
Who	Aquacell/Automatic			
Corrective actions				
What	Flow diverted to Off-spec Water Holding Tank		Disinfection System goes to shutdown	
How	Close AV-461A/B and open AV-462A/B		Flow stopped	
When	If critical limit is exceeded for > 120 s		Immediate	
Where	PLC			
Who	Automatic			

Validated UV Dose – Virus:

The validated UV dose for virus is calculated by the UV controller using the flow rate, measured UVI and measured UVT. The dose is output from the controller to the PLC for monitoring.

If the UV dose drops below the alert level for more than 120 seconds an alarm is triggered to warn the operator that the UV system is approaching the low UV dose limit. The operator can then check the unit operation and rectify before the UV dose reaches the critical level. If the UV dose drops below the critical level for 120 seconds, an alarm is generated and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the UV dose increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the UV dose does not return above the critical limit for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

UVT:

The UVT is continuously monitored to ensure it remains in the validated range. If the UVT drops below the alert level for more than 120 seconds an alarm is triggered to warn the operator that the UVT is approaching the low limit. If the UVT drops below the critical level for 120 seconds, an alarm is generated and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the UVT increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the UVT does not return above the critical limit for a minimum of 120 seconds, the disinfection system will go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

If the UVT exceeds the maximum validated UVT (98.7%) then the calculated UV dose will use the maximum validated UVT to determine the applied UV dose.

Lamp age:

Lamp age is monitored continuously by the UV control module. If the lamp hour alert level is reached, a warning alarm is generated to warn the operator. If the critical hours are exceeded, the disinfection system will immediately go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the UV lamps have been replaced.

UV Status:

The UV Status is monitored continuously by the PLC and UV control module. If a critical UV fault occurs, the disinfection system will immediately go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause of the fault has been rectified.

Maintenance:

UVT is tested by handheld UVT meter monthly, and recalibrated as required.

6.2.3 Chlorine Disinfection

Table 14: Chlorine disinfection critical control point

CCP 3	Chlorine disinfection					
	Free Chlorine Residual (C)	**pH**	**Flow Switch**	**Temperature**	**Instrument Status**	**Chlorine Contact Time (C-T)**
	Critical limits/alert limits					
Alert	C < 0.55 mg/L or C > 4.5 mg/L	pH > 8.5 or pH < 6.5	No Flow	< 16 deg C		C-T < 12.6 mg.min/L
Critical	C < 0.5 mg/L or C > 5.0 mg/L	pH > 8 or pH < 6.0	No Flow	< 15 deg C	Instrument Fault	C-T < 12 mg.min/L
	Monitoring procedures					
What	Free chlorine residual	pH	Flow switch	Temperature	Transmitter	PLC
How	AE-CCT-3A/B (E&H CCS51E)	AE-CCT-2A/B (E&H CPS11E)	FS-CCT-1A/B (E&H CYA27)	AE-CCT-1A/B (E&H CCS58D)	AIT-CCT-1A/B (E&H Liquiline CM442)	Calculated in PLC
When	Continuous, online					
Where	End of chlorine contact pipe (CCT)		Disinfection Skid	End of chlorine contact pipe (CCT)	UV-Chlorination Skid	End of chlorine contact pipe (CCT)
Who	Aquacell/Automatic					
	Corrective actions					
What	Flow diverted to Off-spec Water Holding Tank				Disinfection System goes to shutdown	Flow diverted to Off-spec Water Holding Tank
How	Close AV-461A/B and open AV-462A/B				Flow stopped	Close AV-461A/B and open AV-462A/B
When	If critical limit is exceeded for > 120 s				Immediate	If critical limit is exceeded for > 120 s
Where	PLC					
Who	Automatic					

Free chlorine residual:

The free chlorine residual at the end of the chlorine contact pipe is continuously monitored. If the free chlorine concentration goes outside the alert range for more than 120 seconds an alarm is triggered to warn the operator. The operator can then check the unit operation and rectify before the it reaches the critical level. If the free chlorine concentration goes outside the critical range for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the free chlorine concentration goes back within the critical range for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the free chlorine concentration does not return within the critical range for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

pH:

The pH measurement at the end of the chlorine contact pipe is continuously monitored. If the pH goes outside the alert range for more than 120 seconds an alarm is triggered to warn the operator. The operator can then check the unit operation and rectify before the it reaches the critical level. If the pH goes outside the critical range for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the pH goes back within the critical range for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the pH does not return within the critical range for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

Flow switch:

There is a flow switch in the temperature and free chlorine sample line to ensure sample flow is present. If sample flow is lost the readings are unreliable.

If the flow switch turns off for more than 60 seconds an alarm is triggered to warn the operator. If the flow switch is off more than 120 seconds, an alarm is generated and the treated water is diverted to the Off-spec Water Holding Tank. During diversion to the Off-spec Water Holding Tank, if the flow switch turns back on for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the flow switch has not turned on for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Water temperature:

The chlorine contact system has been designed based on chlorine contact time (C-T) values for a minimum temperature of 15 deg C.

If the temperature drops below the alert level for more than 120 seconds an alarm is triggered to warn the operator. If the temperature drops below the critical level for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the temperature increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the temperature does not return above the critical limit for a minimum of 120 seconds, the disinfection system will go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed. An increased chlorine residual may be required to allow continued operation at a lower temperature.

Instrument Status:

If there is a CCT instrument critical fault, the disinfection system will immediately go to shutdown and a shutdown alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Chlorine Contact Time:

The chlorine contact time (C-T) is calculated in the PLC using the free chlorine concentration and the flowrate. If the chlorine contact time (C-T) decreases below the critical level for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the C-T increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the C-T does not return above the critical limit for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

Maintenance:

The pH probe is checked against buffer solutions monthly and recalibrated if required.

The free chlorine probe is checked against a DPD photometric free chlorine test monthly and recalibrated as required.

Temperature tested by handheld temperature probe monthly, and recalibrated as required.

6.2.4 Treated Water Storage Chlorination System

Table 15: Treated Water Storage Chlorination quality control point

QCP 1	Total Chlorine Residual (TC)	pH	Sample Flow Switch	Instrument Status
Alert	TC < 0.5 mg/L or TC > 5.0 mg/L	pH < 6.5 mg/L or pH > 9.0 mg/L	No Flow	Instrument Fault
Monitoring procedures				
What	Total chlorine residual	pH	Flow Switch	Transmitter
How	AE-STO-02 (E&H CCS53E)	AE-STO-01 (E&H CPS11E)	FS-STO-01 (E&H CYA27)	AIT-STO-01 (E&H Liquiline CM442)
When	Continuous, when Treated Water Storage Tank recirculation pump is running			
Where	Treated Water Storage Tank recirculation			
Who	Aquacell/Automatic			
Corrective actions				
What	Warning alarm only for < 0.5 mg/L. Stops chloramine dosing pumps if > 5 mg/L		Warning alarm and stop chloramine dosing pumps	
How	PLC triggers alarm		PLC triggers alarm and stops the dosing pumps.	
When	If alert limit is exceeded for > 120 s			Immediate
Where	PLC/HMI			
Who	Automatic			

Total chlorine residual:

When the Treated Water Storage Tank recirculation pump is running, the total chlorine level is continuously monitored to ensure that there is a residual in the treated water distribution system. If the total chlorine level is below the alert limits for more than 120 seconds, an alarm in generated to warn the operator. If the total chlorine level is above the alert limit for more than 120 seconds, an alarm in generated to warn the operator and the chloramination dosing pumps are stopped.

The alert is reset after the total chlorine level is within the range for 120 seconds.

Treated water pH:

The pH in the treated water tank is continuously monitored to ensure it is with the range. If the pH is not within the limits for 120 seconds a warning alarm is generated.

Flow switch:

There is a flow switch in the pH and total chlorine sample line to ensure sample flow is present when the Treated Water Storage Tank recirculation pump is running. If sample flow is lost, the pH and total chlorine readings are unreliable. If the flow switch turns off for more than 60 seconds an alarm is triggered to warn the operator. If the flow switch is off more than 120 seconds, an alarm in generated and the chloramine dosing pumps are stopped.

Chemical dosing resumes after the cause has been identified and addressed.

Instrument Status:

If a treated water storage tank instrument fault occurs when the Treated Water Storage Tank recirculation pump is running, chemical dosing pumps will be shutdown and an alarm will be triggered.

Chemical dosing resumes after the cause has been identified and addressed.

Maintenance:

The pH probe is checked against buffer solutions monthly and recalibrated if required.

The total chlorine probe is checked against a DPD photometric total chlorine test monthly and recalibrated as required.

6.3 Standard operating procedures

An operations and maintenance manual will be supplied with the system to explain detailed operation. This includes a description of the CCP's and QCP's and required operator actions.

A summary of the CCP's is provided in Table 16 along with the control response and operator actions. Further details are provided in the operating and maintenance manual.

During shutdown, wastewater is collected in the buffer tank which has been sized to hold a three-day supply of blackwater. If during shutdown the buffer tank reaches full capacity, it will be pumped out.

Table 16: CCP Summary of control system response and operator actions

CCP	Control System Response	Operator Actions
CCP 1 – MBR	The MBR filtrate turbidity, instrument status and flow switch status are continuously monitored. The MBR will go into recirculation mode if the turbidity conditions are not met.	The system will automatically reset when CCP parameters are in spec. However, if this does not occur, the MBR will go into standby and operator intervention will be required. The operator should contact Aquacell for a detailed investigation. The most likely causes are membrane system leaks (seals or membrane integrity), faulty turbidity readings (due to air bubbles), or biogrowth shedding from pipework.
CCP 2 – UV Disinfection	The validated UV dose is continuously calculated and monitored along with UVT, lamp age and UV status. The plant diverts water to the Off-spec water holding tank after the CCT if the UV conditions are not all met.	The system will automatically reset when CCP parameters are in spec. However, if this does not occur, the disinfection system will shutdown and operator intervention will be required. The relevant parameters that affect UV dose are individually monitored and alarmed to guide the operator response. If further troubleshooting is required, contact Aquacell.
CCP 3 - Chlorination	The free chlorine concentration is continuously monitored along with the pH, temperature, flowrate, instrument status and flow switch status. The plant diverts water to the Off-spec water holding tank after the CCT if the chlorine disinfection conditions are not all met.	The system will automatically reset when CCP parameters are in spec. However, if this does not occur, the disinfection system will shutdown and operator intervention will be required. The most likely issues will be around chlorine dose or chlorine demand. If no obvious faults are present, contact Aquacell.

7. Verification and Ongoing monitoring

To provide evidence that the overall system can deliver water of the specified quality, the verification monitoring plan detailed in Table 17 will be used. This will provide a total of 12 samples over 6 weeks.

Influent and treated water samples will be taken as defined below using Aquacell's sampling procedure (Appendix 6). Sample analysis is undertaken at a NATA accredited laboratory.

Table 17: Treated water verification monitoring program

Parameter	Units	Sampling Frequency (per week)	Duration of monitoring program (weeks)	Compliance Value
Influent				
E.coli	cfu/100ml	2	6	NA
FrNA Coliphage	pfu/100mL	2	6	NA
Clostridium perfringens	cfu/100mL	2	6	NA
Biochemical oxygen demand (BOD)	mg/L	2	6	NA
Total suspended solids (TSS)	mg/L	2	6	NA
pH		2	6	NA
Treated Water				
E.coli	cfu/100ml	2	6	< 1
FrNA Coliphage	pfu/100mL	2	6	< 1
Clostridium perfringens	cfu/100mL	2	6	<1
Crypto-sporidium oocysts	oocysts/L	1 sample during monitoring period	6	<1
Biochemical oxygen demand (BOD)	mg/L	2	6	< 10
Total suspended solids (TSS)	mg/L	2	6	< 10
Turbidity (MBR filtrate) (NTU)	NTU	Continuous online	6	≤ 0.2
Validated UV Dose (virus)	mJ/cm2	Continuous online	6	≥ 58
Free Chlorine (FRC – post CCT)	mg/L	Continuous online	6	Target between 0.5 and 5.0
Chlorine Contact Time (C-T)	mg.min/L	Continuous online	6	C-T ≥ 12
pH (CCT)		Continuous online	6	pH ≤ 8
Total Chlorine (Treated Water Storage)	mg/L	Continuous online	6	TC ≥ 0.5 and TC ≤ 5.0

To provide evidence that the overall system can deliver water of the specified quality on an on-going basis, the following on-going monitoring plan is proposed (Table 18).

Table 18: Treated water ongoing monitoring program

Parameter	Units	Monitoring frequency	Compliance Value
Treated Water			
E.coli	cfu/100ml	Monthly	< 1
Turbidity (MBR filtrate) (NTU)	NTU	Continuous online	≤ 0.2
Validated UV Dose (virus)	mJ/cm2	Continuous online	≥ 58
Chlorine Contact Time (C-T)	mg.min/L	Continuous online	C-T ≥ 12
pH (CCT)		Continuous online	pH ≤ 8
Total Chlorine (Treated Water Storage)	mg/L	Continuous online	TC ≥ 0.5 and TC ≤ 5.0

8. Prerequisite programs

For the effective operation of this RWQMP, prerequisite programs that outline detailed procedures and protocols will be provided.

Operations and Maintenance Procedures:

An operations and maintenance manual in accordance with the AGWR will apply to the scheme and will be attached in Appendix 11. Included in the manual are the Standard Operating Procedures, Maintenance Procedures, Calibration Procedures and Chemical Safety Procedures.

Calibration of Monitoring Instruments:

The calibration of all on-line monitoring instruments will be conducted in accordance with the manufactures' recommendations. The calibration of each instrument is logged and maintained on a standard maintenance record.

Chemical Quality Assurance:

All chemicals required for cleaning, maintenance and water treatment will be supplied by an ISO9001 accredited supplier.

Organisational Quality Management:

Aquacell has developed an in-house management system, IMS (Integrated Management System), which is regularly audited. This system documents Aquacell's regulatory, risk and organisational procedures and protocols.

Inspections:

The plant is under continuous remote supervision by Aquacell as the contracted operator. Data logging of key parameters is a part of this supervision. Weekly inspections are conducted and a checklist is completed by the scheme manager according to the service agreement between the scheme manager and Aquacell. The responsibilities will be clearly delineated in the service agreement. Also, in accordance with the service agreement, monthly maintenance including instrument calibration checks are carried out by Aquacell and records maintained. Quarterly servicing is also carried out by Aquacell and records maintained.

Aquacell will provide the necessary training for the scheme manager's staff to perform the work required. Records of this training will be kept by Aquacell.

9. Incidents and emergencies

Aquacell maintains a community contact and FAQ section of its website with procedures relating to the management of emergencies. This will be updated to include the Alspec Industrial Business Park BWTP.

In addition, a meeting attended between Aquacell, the scheme manager and its relevant contractors will be held to review emergency procedures that are specific to the recycled water scheme and the precinct.

Table 19 describes emergency response incidents and procedures.

Table 19: Incidents and emergencies

Hazards and events that may lead to emergencies	Immediate Response		Corrective Action		Authorities	
	What	Who	What	Who	What	Who
Non-conformance of water with critical limits	If detected by online instrument, plant automatically shuts off supply	Aquacell	Aquacell diagnose and rectify.	Aquacell	Has non-compliant water been delivered? If yes, Aquacell notify the scheme manager. The scheme manager to notify NSW Health.	The scheme manager
Response to exceedances of water quality targets	If there are any occurrences of positive results for the ongoing water quality monitoring as described in Table 18, supply of recycled water should be stopped, and the cause investigated. Aquacell to notify the scheme manager. The scheme manager to immediately notify NSW Health.	Aquacell/ The scheme manager	Aquacell to investigate cause and rectify. Re-test and achieve compliance before resuming delivery of recycled water.	Aquacell	Aquacell to notify the scheme manager. The scheme manager notify NSW Health.	The scheme manager
Accidents that increase level of contamination in source water	Feed water continuously monitored for pH.	Aquacell	Pause production investigate cause. Production resumed once pH returned to specification (may need manual adjustment)	Aquacell	NA	NA
Equipment breakdown and mechanical failure	Critical equipment alarmed for malfunction. Alarm received by operator. Operator to log in and inspect operation of plant. Disable plant if required.	Aquacell	Repair	Aquacell	NA	NA
Cross-connections	If a cross connection is detected, immediately stop use of treated water, and switch to potable water backup.	The scheme manager	Conduct audit to identify location of cross-connection. Rectify. Preventative measures include signage, labelling, colour-coding,	The scheme manager	Should a cross-connection be identified, notify the scheme manager and Aquacell. The scheme	The scheme manager

			information brochures for plumbers and public. Do not reinstate delivery of treated water until cross connect audit has been completed.		manager in turn notify NSW Health.	
Prolonged power outages	Plant shuts down in a safe state on power failure. Notify Aquacell so that restart procedures and checks can be made and the plant monitored during start-up. Potable water backup will provide water needs automatically.	The scheme manager	Remote operator log-in. Restart operation on return of power.	Aquacell	NA	NA
Leakage, spillage, or runoff of recycled water or greywater on site.	For minor contained spills, notify the scheme manager for repair. If treatment plant is responsible contact Aquacell.	The scheme manager	The scheme manager or site management to respond. Aquacell to action if treatment plant is responsible. Incident report to be prepared and corrective actions implemented.	Aquacell/ The scheme manager	If major spill that contaminates or potentially contaminates the environment also contact NSW Health, Department of Planning and Environment, IPART and the City of Penrith Council.	The scheme manager

10. Employee awareness and training

The scheme manager and Aquacell are responsible for ensuring their respective employees and contractors are familiar with the operation of the scheme and aware of the potential consequences of system failures, and of how their decisions can affect the safety of the scheme.

Aquacell will provide an experienced water recycling engineer to monitor the plant. Any contractors used on site must be accredited, qualified and have the appropriate level of training.

A site induction will be required for anyone doing work related to this scheme. This will be carried out and recorded by the scheme manager for work on the dual pipe system, and by Aquacell for work on the treatment plant. For plant work this includes familiarization with Aquacell's Safe Work Method Statements (SWMS's) which are site specific. Aquacell maintains a partnership with several contractors to ensure continuity of knowledge and technical expertise.

Aquacell has an induction program for new employees and written procedures for all areas of responsibility.

Training needs for Aquacell employees are identified and adequate resources made available during the induction phase. Annual performance reviews identify additional training requirements and set performance targets. Training records are kept.

11. Documentation and reporting

11.1 Documentation

The following records and documents will be maintained by Aquacell as the water recycling plant operator.

- Verification and on-going monitoring results
- CCP monitoring results and analysis
- Plant operation data
- Laboratory testing results and analysis
- Breaches of critical limits and corrective actions taken
- Incidents and emergencies and corrective actions taken
- Inspection and maintenance activities relevant to water quality

CCP results and operation data will be collected by an online data acquisition system and kept as an electronic copy by Aquacell.

Verification results will be collected by Aquacell from a NATA accredited testing laboratory and stored electronically by Aquacell.

A record of any maintenance to the treatment plant will be kept. Any equipment adjusted, repaired, replaced or calibrated will be recorded. Monthly maintenance checks and calibrations are recorded on a monthly maintenance checklist (See Operations and Maintenance Manual (Appendix 11), and stored according to Aquacell's document management procedures.

11.2 Reporting

Aquacell will provide a monthly report to the scheme manager in relation to the operation and maintenance of the water recycling plant.

Separate reports, as required by the relevant authorities will also be prepared. These reports will be signed by the designated Aquacell person and includes:

- a summary of the review and improvement processes, and whether the RWQMP has been complied with,
- a summary of priority areas for improvement and actions to address any non-compliances with the RWQMP,
- an analysis of the monitoring data collected for the management of environmental risks,
- an analysis of the monitoring data collected under the RWQMP,
- a summary of incidents and emergencies, including corrective actions,
- a listing or register of supplied recycling schemes, including quality, quantity and type of use, and
- a summary of audit outcomes.

The reports will also be signed by a person authorised as a representative of the organisation/s receiving the report.

11.3 Notifications

Aquacell, as the operator of the recycled water plant, must immediately notify the scheme manager of any incidents that occur with the treatment process or plant that could affect health. This includes:

- Incidents where recycled water has been supplied that does not comply with the three CCP conditions described in Section 0,
- Any other incident or emergency that could directly or indirectly impact on the health of the end users.

Notification should include details of corrective and future preventive action.

Contact details for various key entities in the project are listed in the table below. These will be updated from time to time as appropriate.

Table 20: Contact details

Entity	Contact	Details
Sydney Local Health District Public Health Unit (NSW Health)	Public Health officer	Phone: 02 9515 9420 Phone (after hours): 02 9515 6111 (to speak with the Public Health Officer on call for environmental health) Email: SLHD-PHUEHO@health.nsw.gov.au
IPART	TBA	TBA
Scheme Manager	TBA	TBA
Aquacell	Colin Fisher, Managing Director	Address: Suite 602, 6A Glen Street, Milsons Point, NSW 2061. Phone: 02 4721 0545 Mobile: 0409 393 389 Email: colinf@aquacell.com.au

12. Review and improvement

The plant operation and RWQMP will be reviewed annually and updated as needed. This is an internal review process with appropriate operating staff. The review and improvement process will include:

- Critical analysis of current improvement procedures
- Identify all known deficiencies that require improvement
- Make comparisons with targets and current practices
- Identification of new and continuous improvement opportunities
- Document success of improvements made
- Overall verification of current improvement practices

Any changes to CCP limits must be endorsed by NSW Health or approved by IPART before being implemented.

13. Commissioning the RWQMP

All operational monitoring, critical alarms and corrective actions within the RWQMP will be tested and verified as part of commissioning. A verification report and cross connection audit will be conducted and submitted to IPART for review and approval before any treated water is delivered for use in the precinct.

14. Plumbing

The Building plumbing and drainage system has been designed in accordance with the Water Supply Code of Australia and in accordance with AS/NZS 3500.1 & AS/NZS3500.2.

15. Appendices

Appendix 1 – Process Flow Diagram

Appendix 2 – General Arrangement

Appendix 3 – Aquacell Recycled Water Policy

Appendix 4 – HAZOP and HACCP Analysis

Appendix 5 – WICA Scheme Approval to Install - pending

Appendix 6 - Aquacell Sampling Procedure

Appendix 7 – WICA Retailer Licence

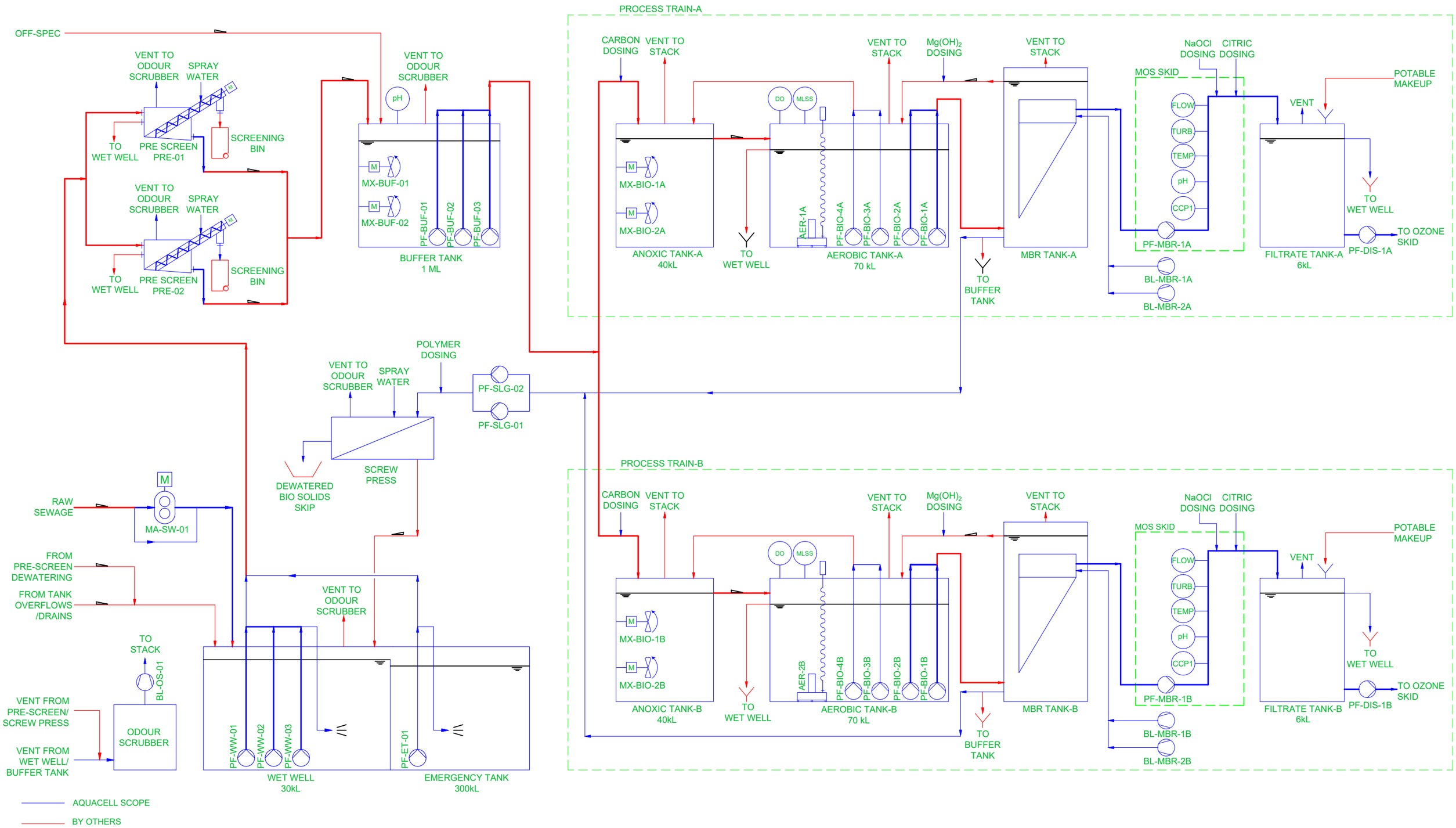
Appendix 8 – WICA Operator Licence

Appendix 9 – Plumbing Audit (Cross Connection Audit) - pending

Appendix 10 – Verification Report - pending

Appendix 11 – Operation and Maintenance Manual - pending

Appendix 1 – Process Flow Diagram



REVISION TABLE

REV	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED	REV	DATE	DESCRIPTION	DRAWN	CHECKED	APPROVED
A	15-Sep-2023	INTIAL ISSUE	S.B	E.B	J.J						
B	14-Jun-2024	UPDATED	S.B	W.J	W.J						
C	27-Jun-2025	UPDATED	S.B	S.A	W.J						
D	28-Aug-2025	UPDATED	S.B	S.A	W.J						

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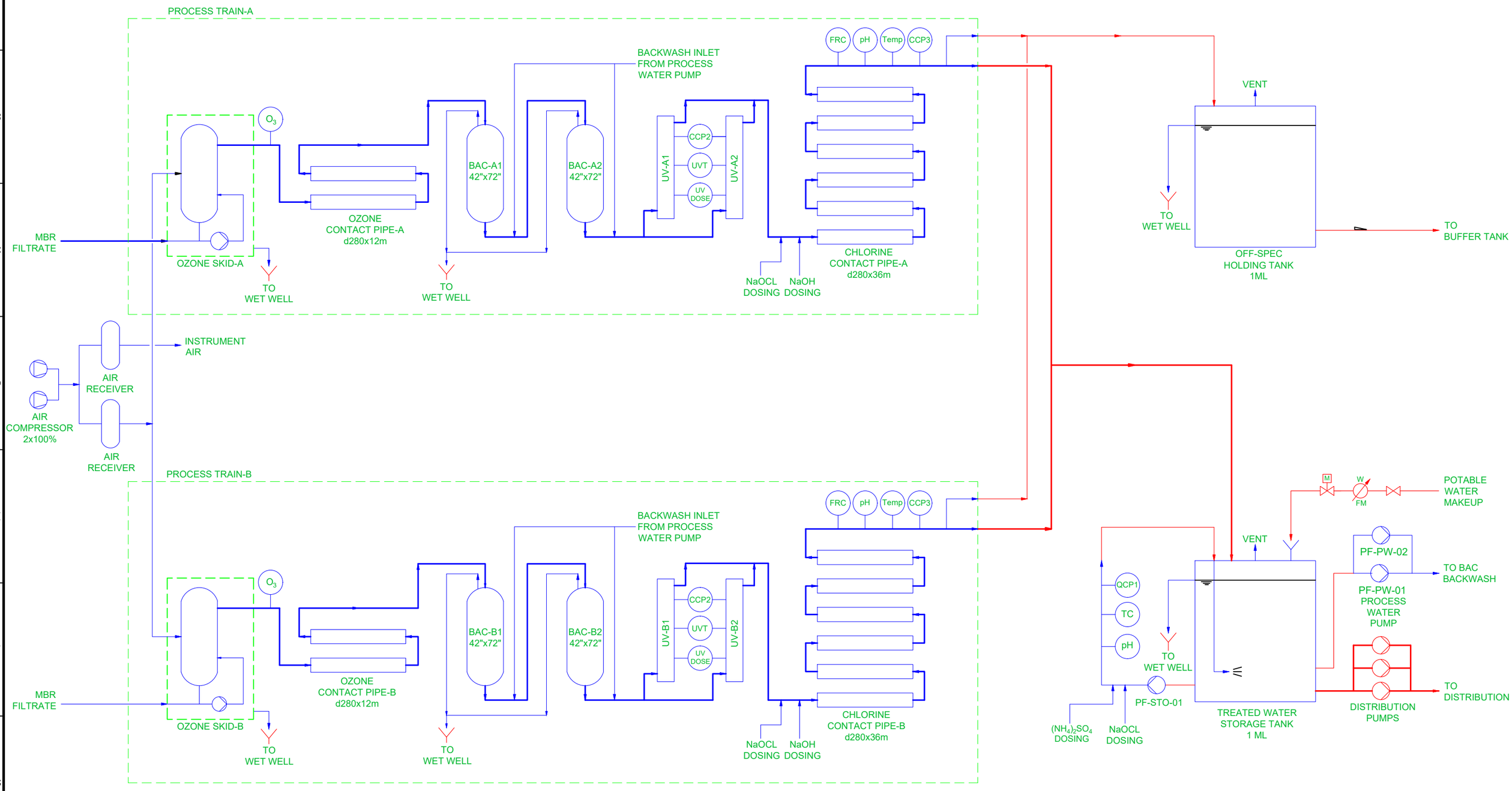
DRAWN	S.B	DATE	15-Sep-2023
CHECKED	A.E	DATE	15-Sep-2023
APPROVED	J.J	DATE	15-Sep-2023

TITLE: PROCESS FLOW DIAGRAM
BLACKWATER TREATMENT PLANT

JOB No: A0144
DRAWING No: A0144-002
PROJECT: LUDDENHAM RD ORCHARD HILLS

DRAWING STANDARD AS1100 | DO NOT SCALE | Rev: D | SHEET No:01 OFF 02 | A1



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DRAWN	S.B	DATE	15-Sep-2023
CHECKED	A.E	DATE	15-Sep-2023
APPROVED	J.J	DATE	15-Sep-2023

TITLE: PROCESS FLOW DIAGRAM
BLACKWATER TREATMENT PLANT

JOB No: A0144
DRAWING No: A0144-002
PROJECT: LUDDENHAM RD ORCHARD HILLS

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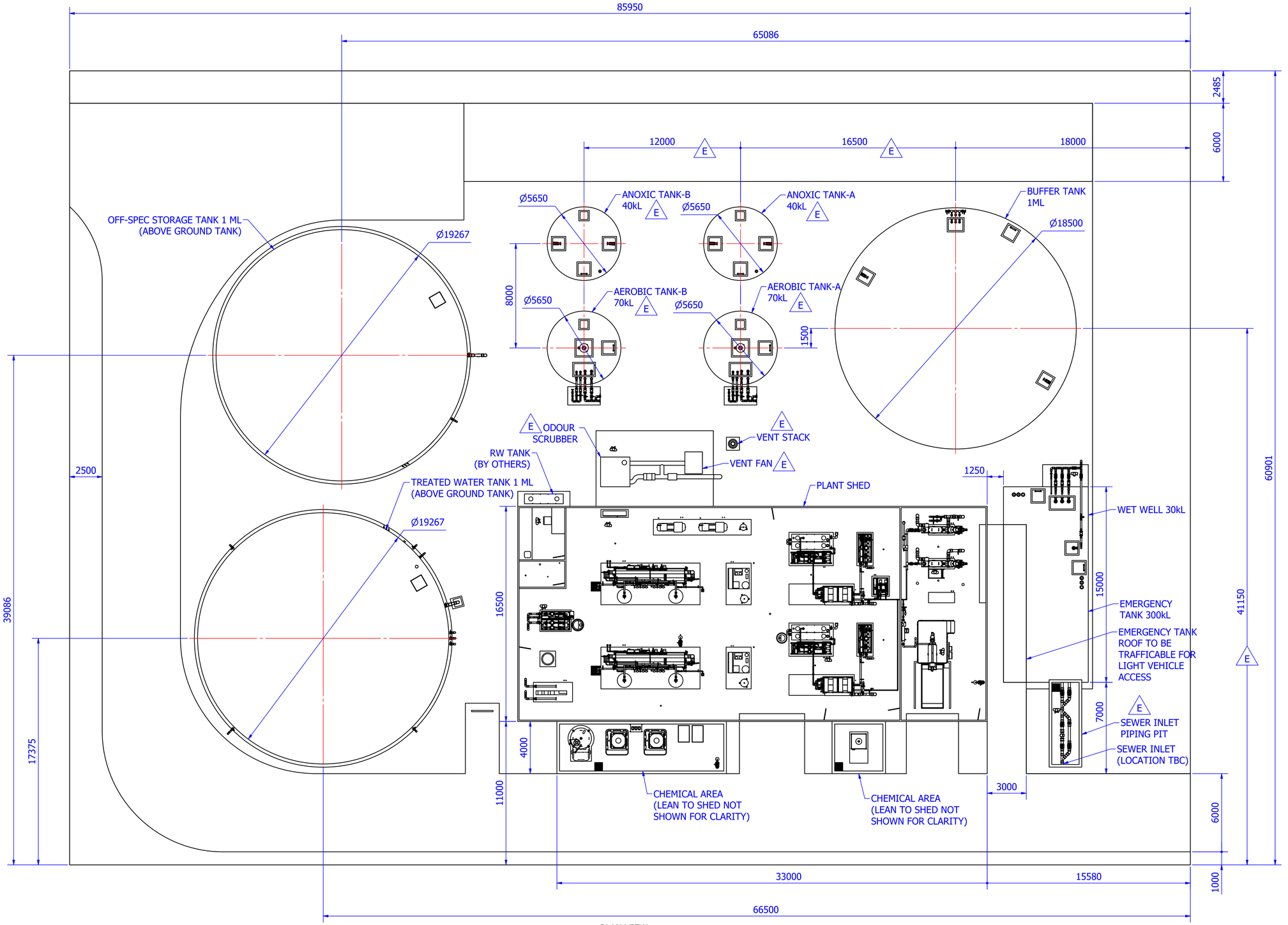
Appendix 2 – General Arrangement



PLAN VIEW
SCALE (1 : 150)

REV	DATE	DESCRIPTION	DRAWN	CHECKED
E	27-Jun-2025	UPDATED	S.BIABANI	J.JENNINGS
D	17-Jun-2025	UPDATED	S.BIABANI	J.JENNINGS
C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
B	14-Jun-2024	UPDATED	S.BIABANI	W.JOHNSON
A	15-Sep-2023	INITIAL ISSUE	S.BIABANI	A.EISSENHAMMER

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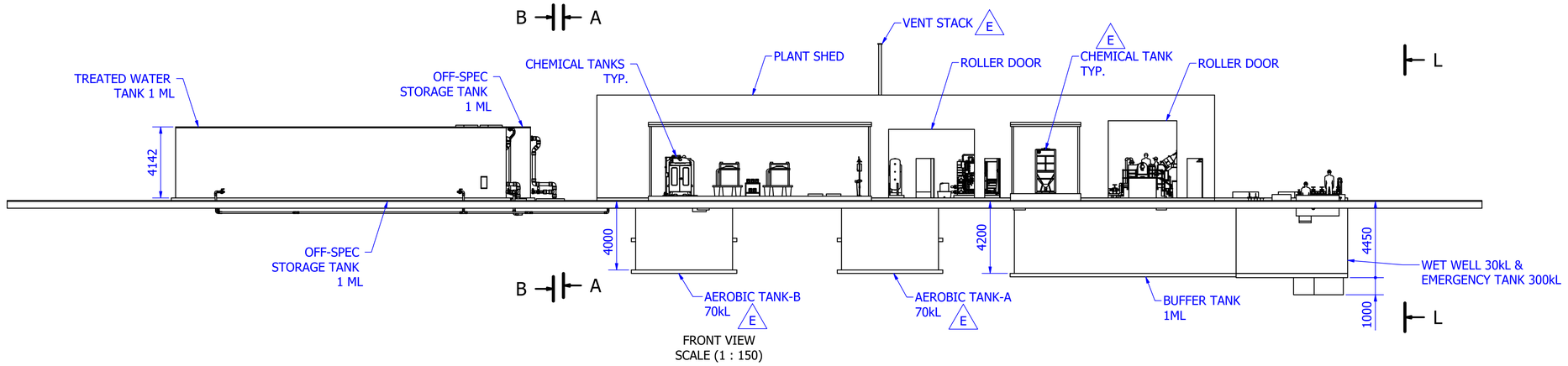
DRAWN	S.BIABANI	DATE	15/09/2023	TITLE: LAYOUT BLACKWATER TREATMENT PLANT
CHECKED	A.EISENHAMMER	DATE	15/09/2023	
APPROVED	J.JENNINGS	DATE	15/09/2023	
JOB No: A0144	DRAWING No: A0144-302			PROJECT: LUDDENHAM RD ORCHARD HILLS

DRAWING STANDARD : AS1100 | DO NOT SCALE | Rev: E | SHEET No: 1 OFF 8 | A1



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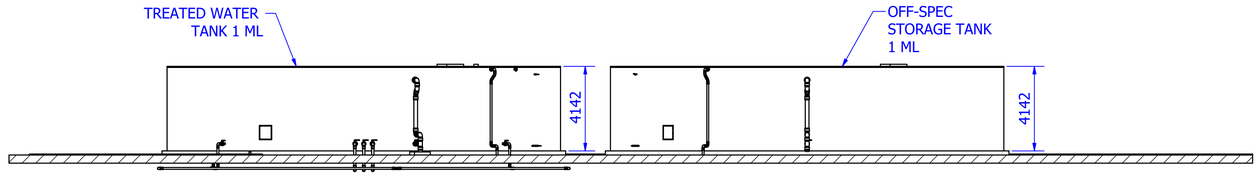

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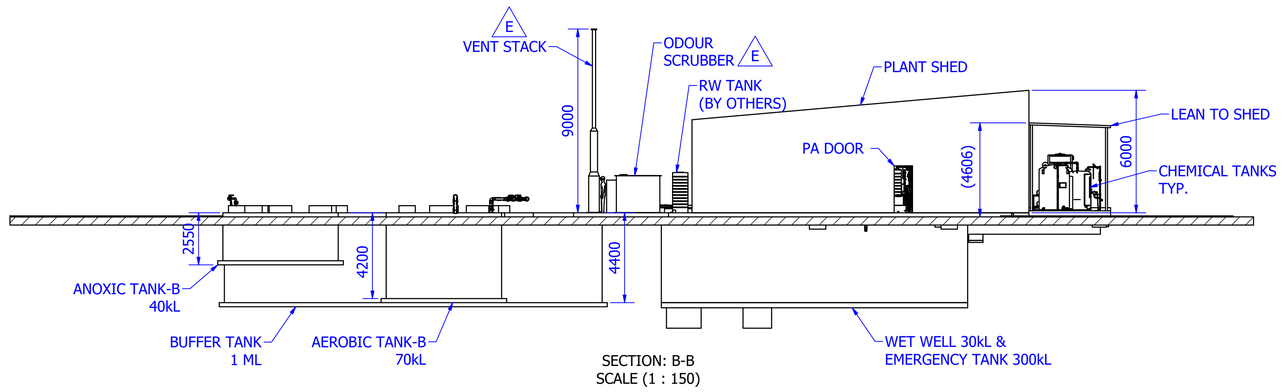

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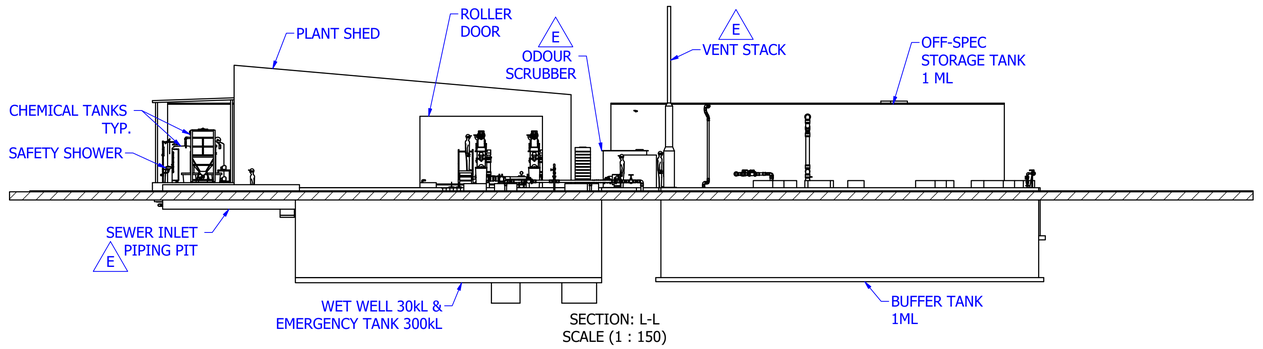

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D	17-Jun-2025	UPDATED	S.BIABANI	J.JENNINGS
C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
B	14-Jun-2024	UPDATED	S.BIABANI	W.JOHNSON
A	15-Sep-2023	INITIAL ISSUE	S.BIABANI	A.EISSENHAMMER

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ANGULAR : ± 0.5 deg
ALL DIMENSIONS IN mm U.N.O

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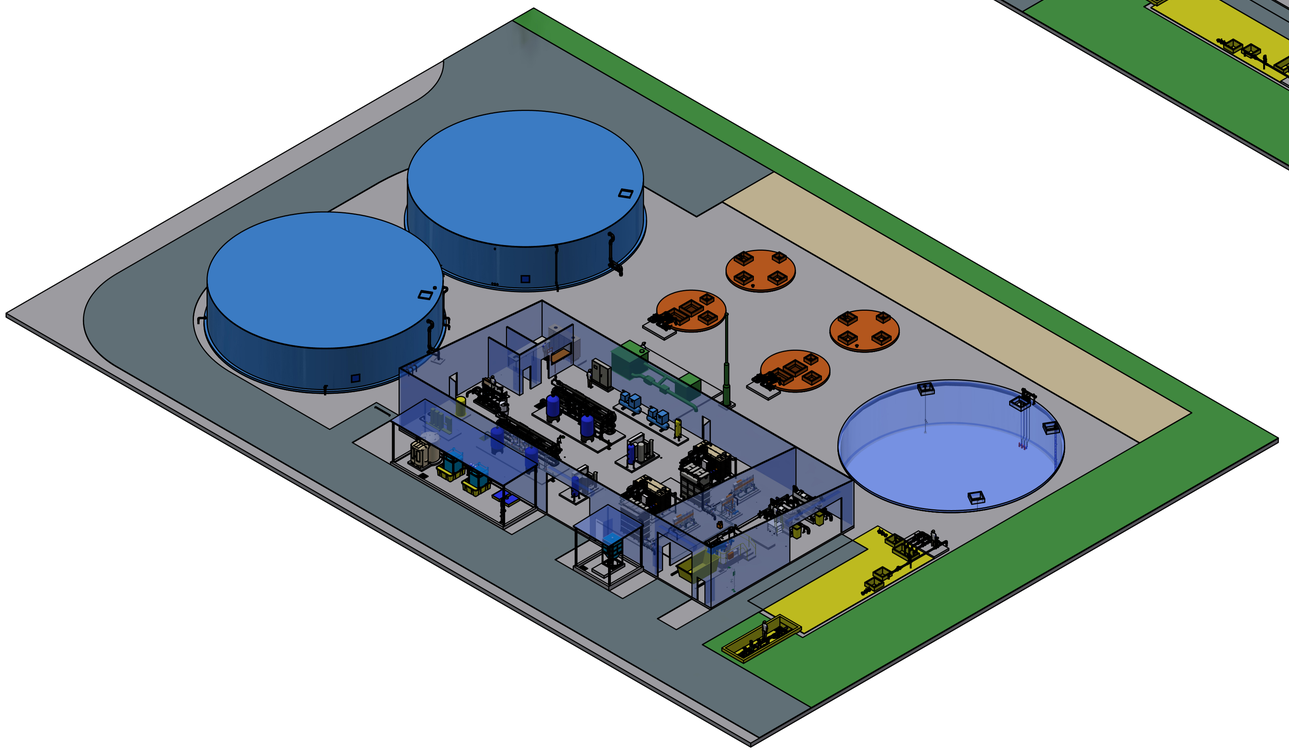
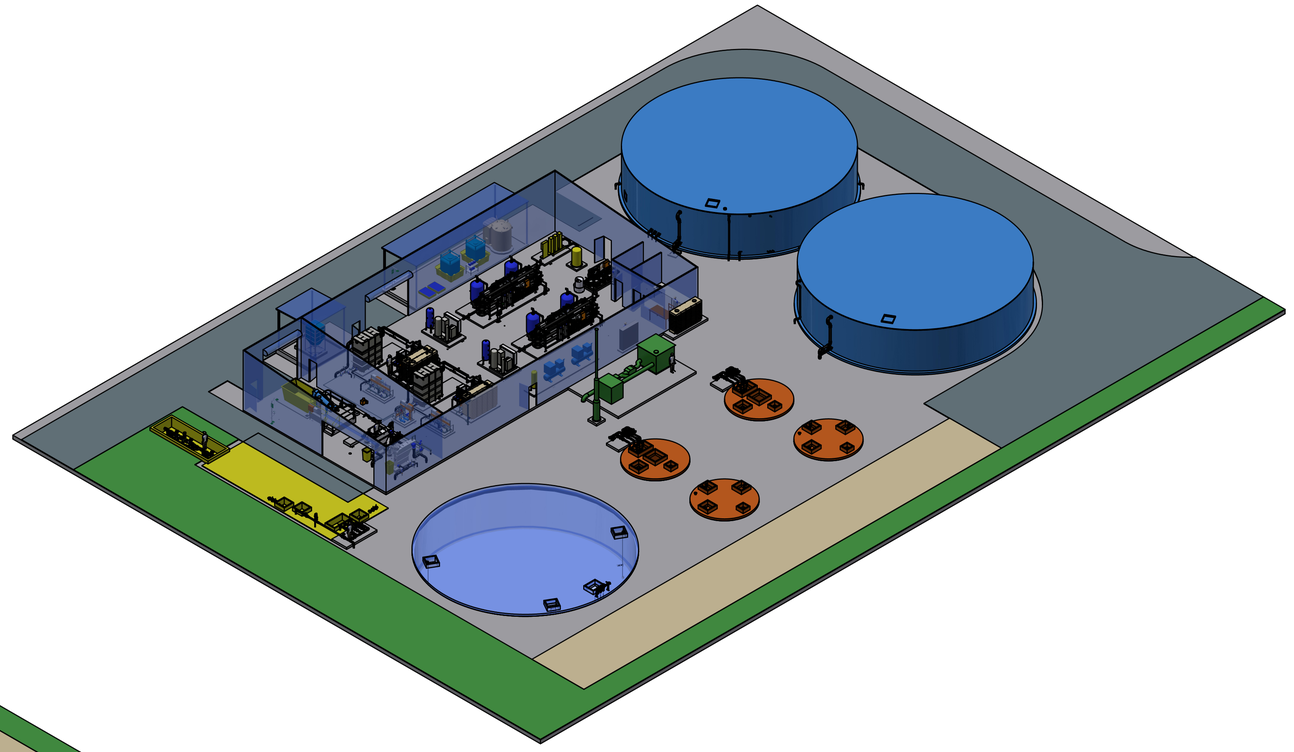
email:info@aquacell.com.au

DRAWN	S.BIABANI	DATE	15/09/2023	TITLE	LAYOUT
CHECKED	A.EISENHAMMER	DATE	15/09/2023		BLACKWATER TREATMENT PLANT
APPROVED	J.JENNINGS	DATE	15/09/2023		
JOB No	A0144	DRAWING No	A0144-302	PROJECT	LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE		Rev: E	SHEET No: 2 OFF 8 — A1





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C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
B	14-Jun-2024	UPDATED	S.BIABANI	W.JOHNSON
A	15-Sep-2023	INITIAL ISSUE	S.BIABANI	A.EISSENHAMMER

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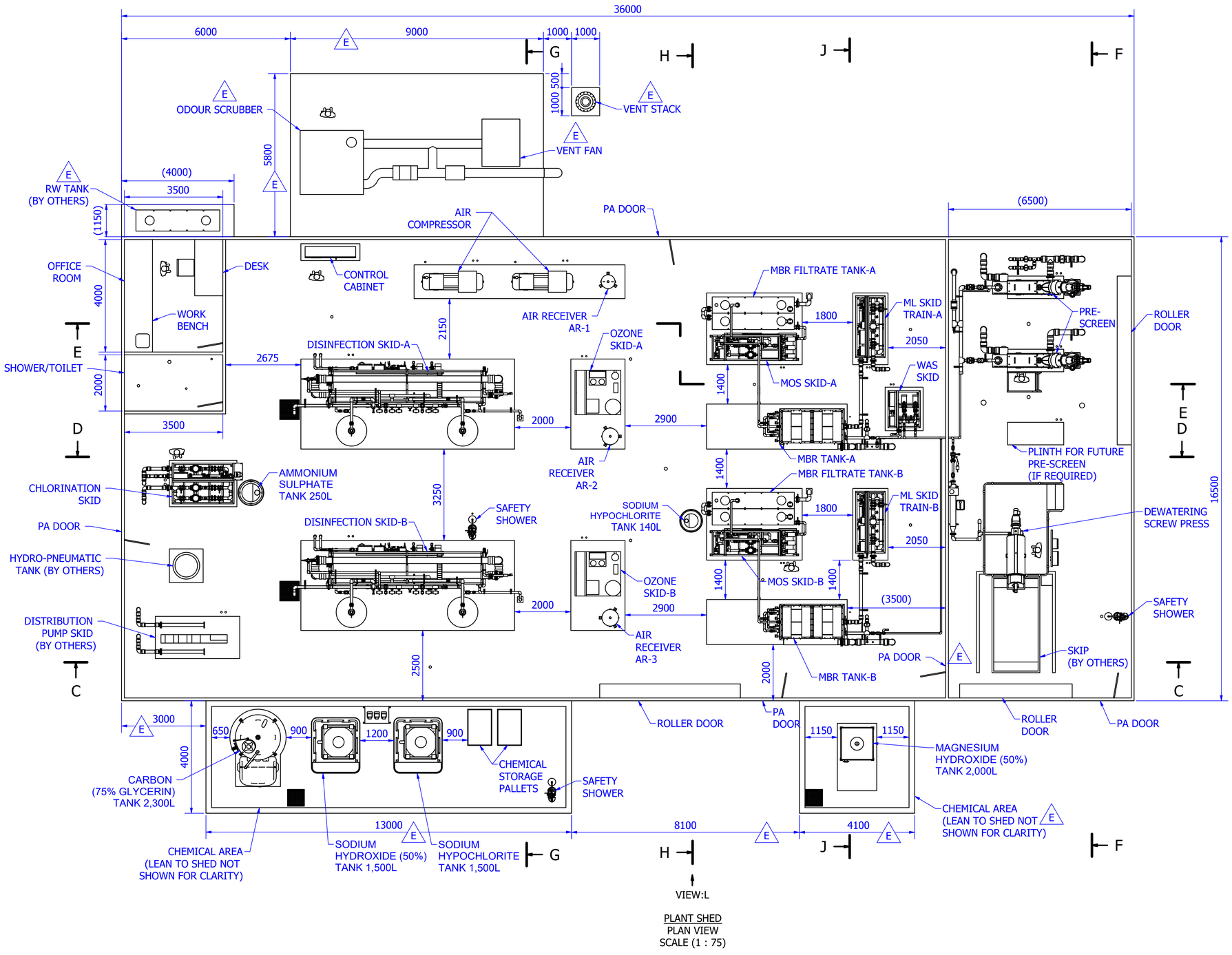
DRAWN	S.BIABANI	DATE	15/09/2023	TITLE: LAYOUT BLACKWATER TREATMENT PLANT
CHECKED	A.EISENHAMMER	DATE	15/09/2023	
APPROVED	J.JENNINGS	DATE	15/09/2023	
JOB No: A0144	DRAWING No: A0144-302			PROJECT: LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE	Rev: E	SHEET No: 3 OFF 8 — A1



PLANT SHED
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SCALE (1 : 75)

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REVISION HISTORY				
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C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
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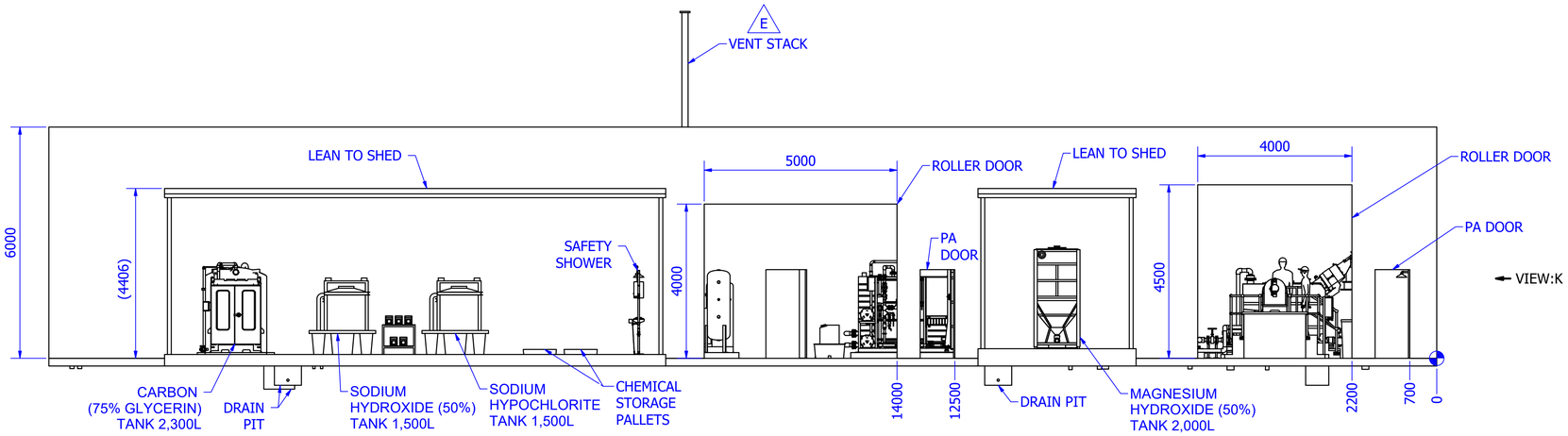
CHECKED	A.EISENHAMMER	DATE	15/09/2023		
APPROVED	J.JENNINGS	DATE	15/09/2023		
JOB No	A0144	DRAWING No	A0144-302	PROJECT	LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE		Rev: E	SHEET No: 4 OFF 8 — A1



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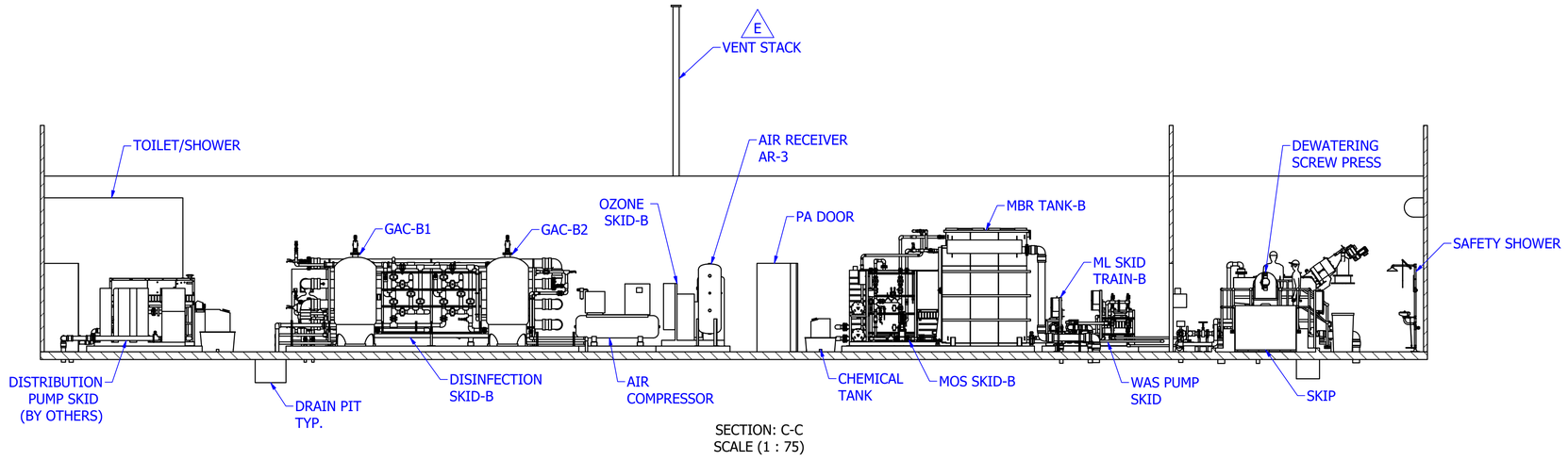

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C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
B	14-Jun-2024	UPDATED	S.BIABANI	W.JOHNSON
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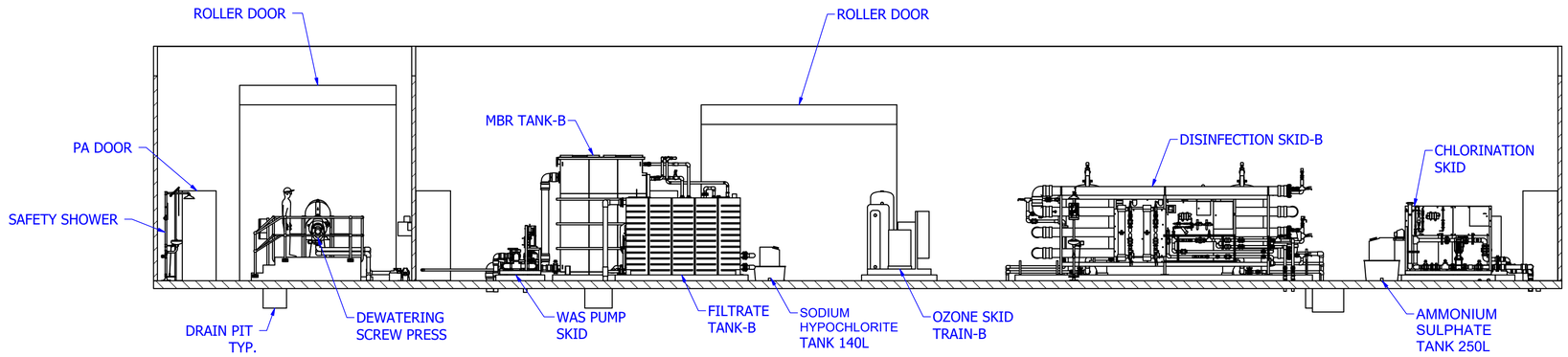
DRAWN	S.BIABANI	DATE	15/09/2023	TITLE	LAYOUT BLACKWATER TREATMENT PLANT
CHECKED	A.EISENHAMMER	DATE	15/09/2023		
APPROVED	J.JENNINGS	DATE	15/09/2023		
JOB No	A0144	DRAWING No	A0144-302	PROJECT	LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE		Rev: E	SHEET No: 5 OFF 8 — A1



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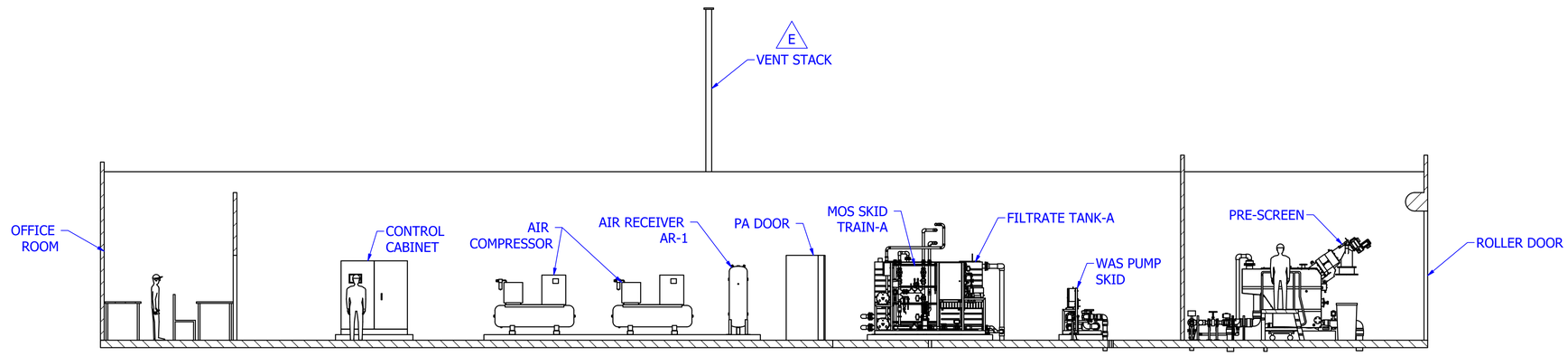

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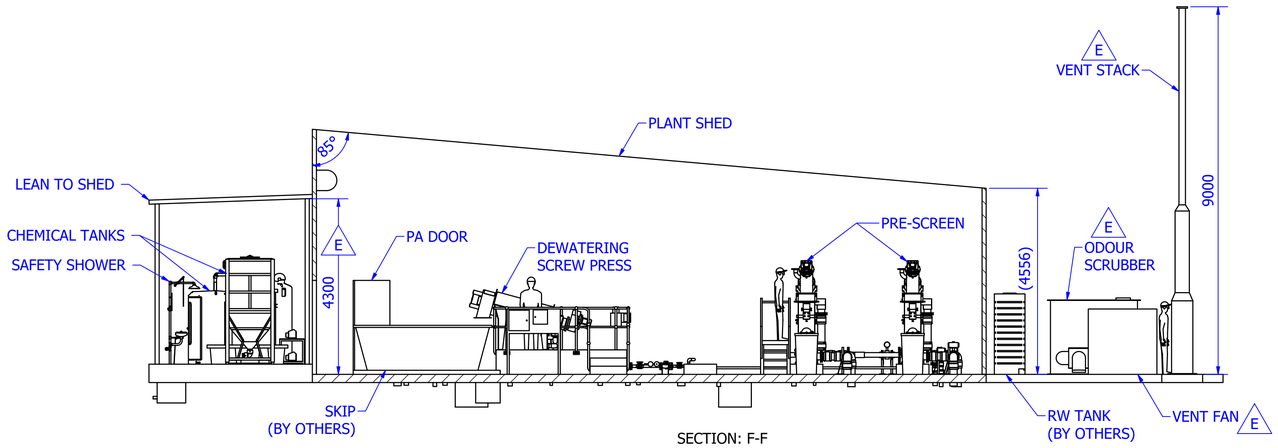
CHECKED	A.EISENHAMMER	DATE	15/09/2023	
APPROVED	J.JENNINGS	DATE	15/09/2023	
JOB No: A0144	DRAWING No: A0144-302			PROJECT: LUDDENHAM RD ORCHARD HILLS

DRAWING STANDARD : AS1100 | DO NOT SCALE | Rev: E | SHEET No: 6 OFF 8 | A1



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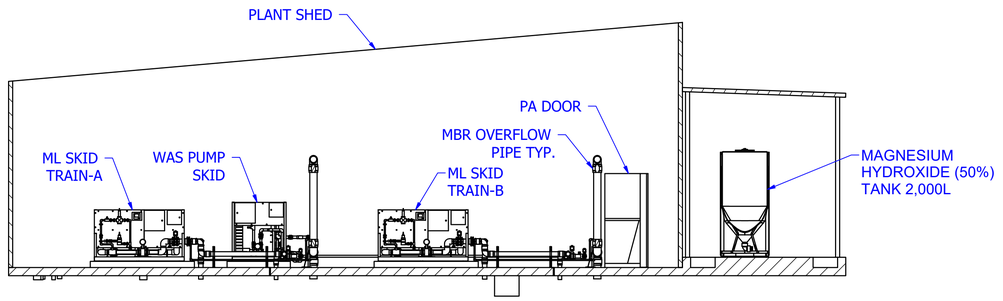

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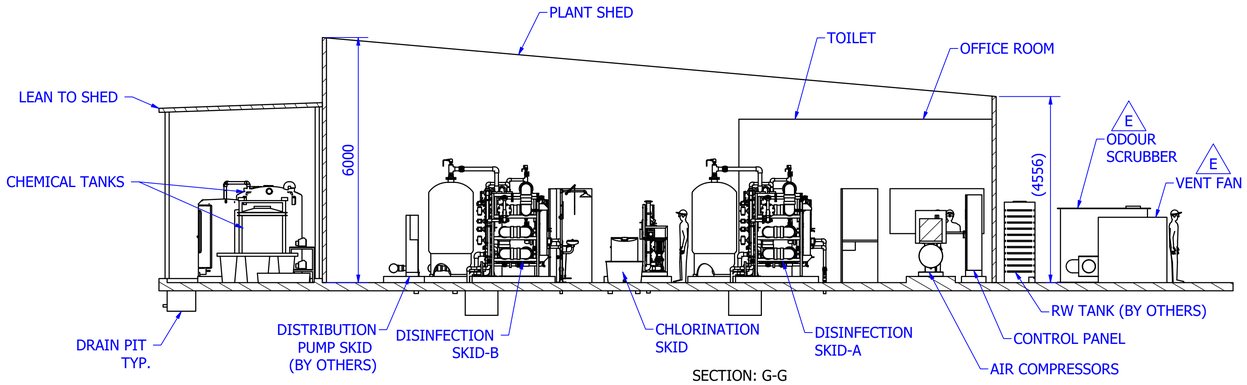

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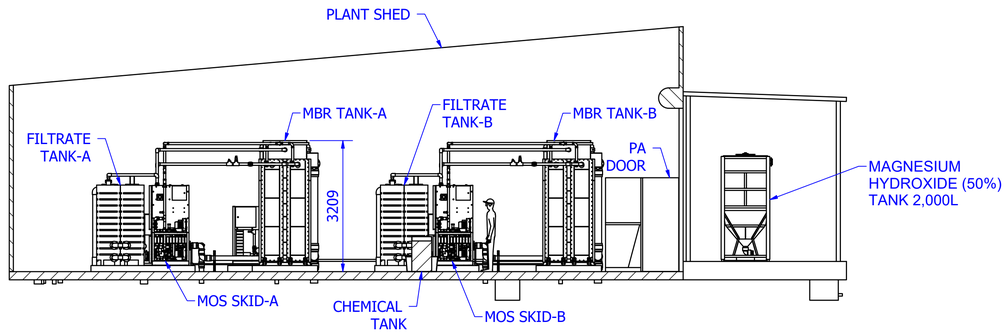

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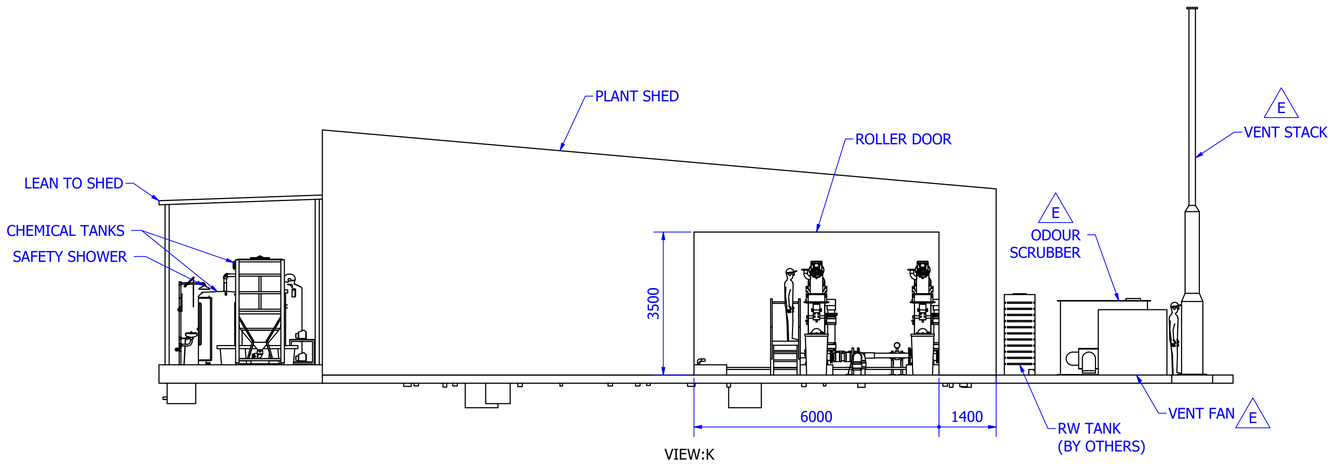

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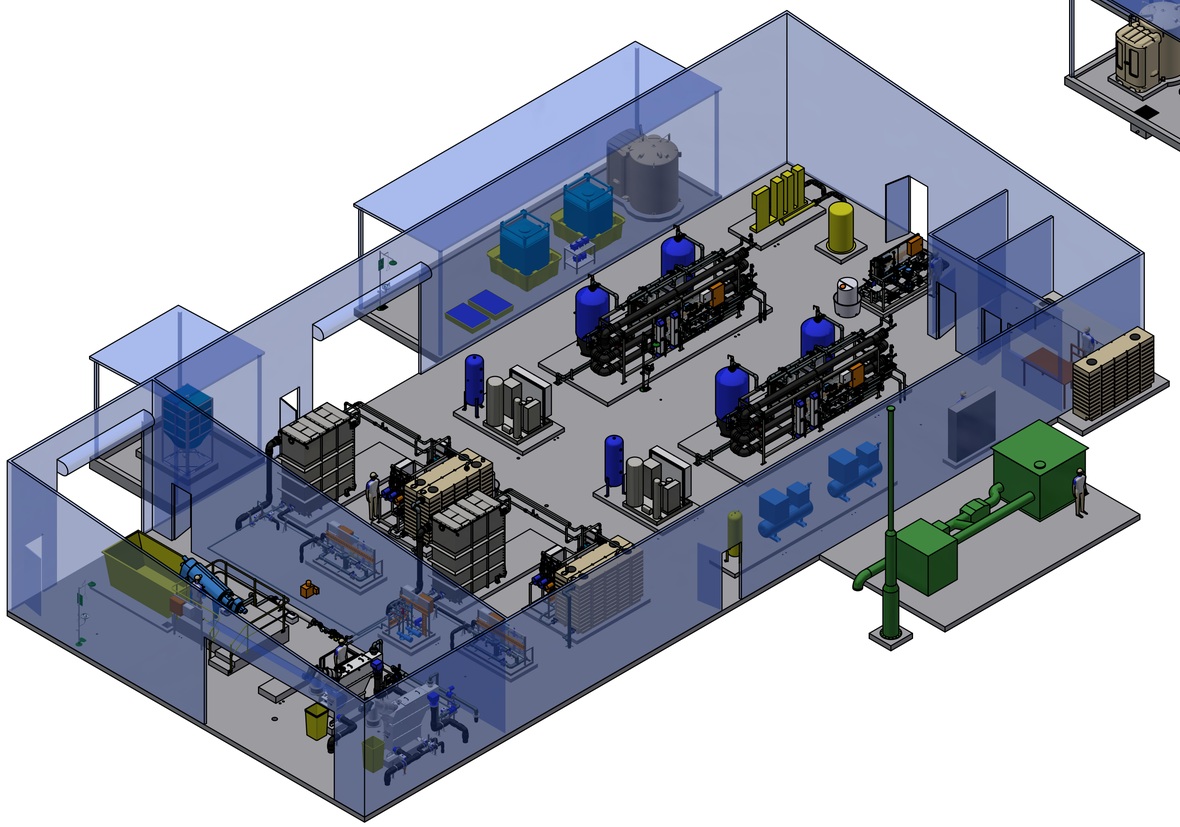

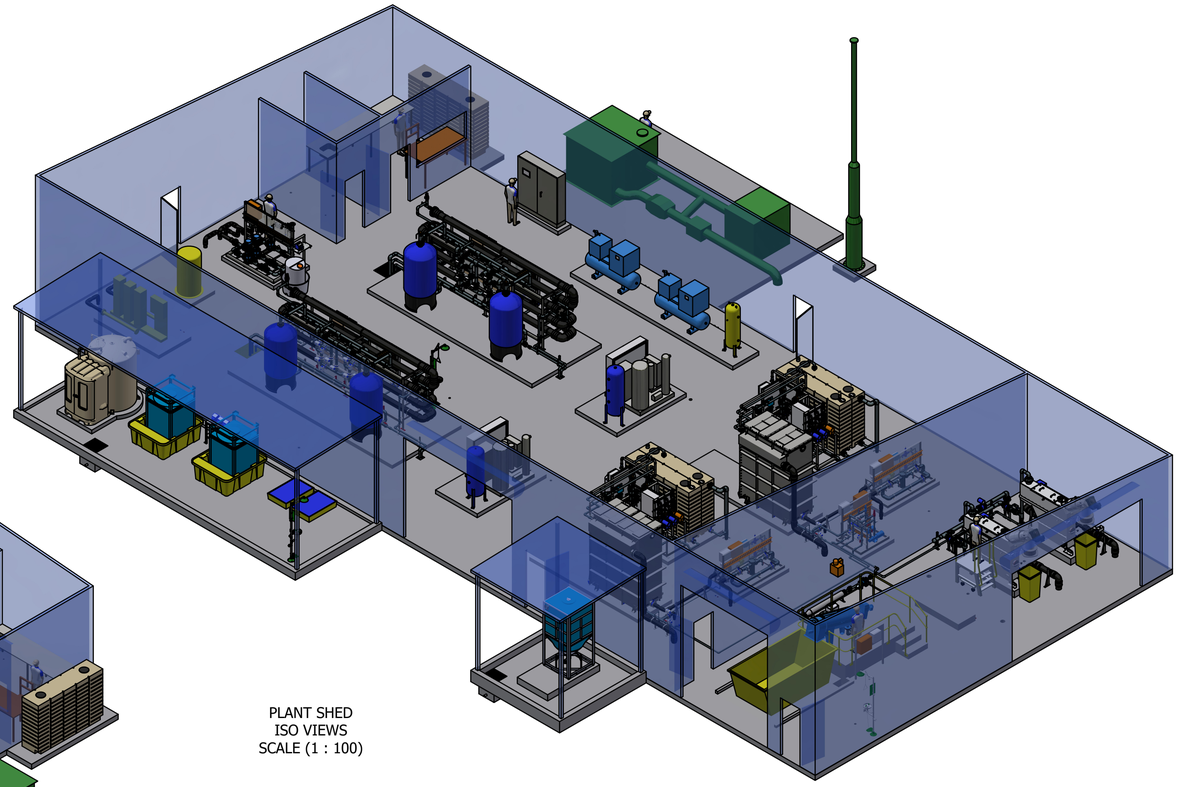

PLANT SHED
ISO VIEWS
SCALE (1 : 100)

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DRAWING STANDARD : AS1100		DO NOT SCALE	Rev: E	SHEET No: 8 OFF 8	A1

Appendix 3 – Aquacell Recycled Water Policy

Aquacell Recycled Water Policy

Aquacell Pty Ltd | Head Office: 602 / 6A Glen St, Milsons Point NSW 2061 Australia | ABN 79 072 487 015
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Document Creation and Review

Revision No	Author	Reviewed By	Approved By	Date
Draft (EM 010-01)	P. Coulton	C. Fisher	C. Fisher	22 July 2011
EM010-2		Annabelle Caspersz		5 December 2011
EM010-3	Edited A. Hidalgo	Colin Fisher		15 July 2025

Document Control

Revision No	Status	Issued To		Date
		Name	Organisation	

RECYCLED WATER POLICY

Aquacell supports and promotes the responsible use of recycled water and the application of a management approach that consistently meets the *Australian Guidelines for Water Recycling*, as well as recycled water user and regulatory requirements.

To achieve this we will:

- Ensure that the protection of public and environmental health is recognised as being of paramount importance.
- Maintain communication and partnerships with all relevant agencies involved in management of water resources, including waters that can be recycled.
- Engage appropriate scientific expertise in developing recycled water schemes.
- Recognise the importance of community participation in decision making processes and the need to ensure the community expectations are met.
- Manage recycled water quality at all points along the delivery chain from source to the recycled water user.
- Use a risk based approach in which potential threats to water quality are identified and controlled.
- Integrate the needs and expectations of our users of recycled water, communities and other stakeholders, regulators and employees into planning processes.
- Establish regular monitoring of control measures and recycled water quality and establish effective reporting mechanisms to provide relevant and timely information and promote confidence in the recycled water supply and its management.
- Develop appropriate contingency planning and incident response capability.
- Participate in appropriate research and development activities to ensure continuous improvement and continued understanding of recycled water issues and performance.
- Contribute to the development of industry regulations and guidelines and other standards relevant to public health and the water cycle.
- Continually improve our practices by assessing performance against corporate commitments and stakeholder expectations.

Aquacell will implement and maintain recycled water management systems consistent with the *Australian Guidelines for Water Recycling* to effectively manage the risks to public and environmental health.

All managers and employees involved in the supply of recycled water are responsible for understanding, implementing, and continuously improving the recycled water management system. Membership and participation in professional associations dealing with management and use of recycled water is encouraged.

Colin Fisher

Managing Director 22nd July 2011

Appendix 4 – HAZOP and HACCP Analysis

HACCP Checklist

Project Name:	A0144 Luddenham Rd Orchard Hills
Completed by:	Justin Taylor
Date of Assessment:	20-Aug-25
Revision:	IFC
Approved By and Date:	WJ 20/08/25

To be approved by the Technical Manager

HACCP Workshop Attendees			Revision 1 Attendees	Revision 2 Attendees
WJ				
JT				
JJ				

DESIGN /			Before Mitigation				After Mitigation					Decision Tree				CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**												**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
1. Source water (sewage influent, collection lines, pump stations)	Biological Hazard: Contact with raw sewage	Plant designed so that contact with sewage in normal operation is not required. Plant room locked so people cannot readily enter. Covers on tanks and locks where appropriate. Trained operators to servicing plant.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Health Hazard: Source water is different to design specification and treatment plant cannot treat correctly.	Plant design conservative with some ability to remove short periods of our of specification sewage. Continuous online monitoring does not allow out of specification water to be delivered. Trade waste cannot be connected directly to the sewer. pH measurement in buffer tank may detect poor feed. Buffer tank will dilute short volumes of out of specification feed.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Biological Hazard: Blockage upsteam of plant causes overflow	Upstream plumbing (by others) designed to comply with AS3500. Upstream plumbing to have I/O points and gullies to facilitate controlled overflows and easy cleanout.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
2. Inlet Works - Macerator, Wet Well, Prescreen and Buffer Tank	Physical Hazard: Screen mesh blocks and causes the screen to overflow	Level transducer on screen detects prolonged high level and alarms. Screen overflows to buffer tank so there are no uncontained spills.	4	1	5	Low	1	1	2	Low	± 1	Y	N	N		No							Note change to screen overflow. Now overflows to wet well rather than buffer tank. Confirmined no change to risk matrix	AQ design team	20-August-2025					
	Physical Hazard: Screen mesh fails and allows oversize material into system.	Routine weekly and monthly maintenance inspections. Heavy particles will settle in buffer tank and not make it into the rest of the treatment plant	2	3	5	Moderate	1	1	2	Low	± 1	Y	N	N		No													
	Health Hazard: Screenings need to be remove from site	Ensure appropriately experienced and licensed contractors are used for maintenance of systems. Contractors use adequate PPE to mitigate against ingestion, skin contact and inhalation. Remediate spills immediately and exclude public from the spill point until rectified.	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No													
	Health Hazard: Prescreen needs to be cleaned manually	Automatic sprays on pre-screen keep it clean reducing manual cleaning to once per month. Cleaning by trained operator wearing appropriate PPE.	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No													
	Physical Hazard: Screenings are typically heavy and need to be disposed of periodically by the operator	Appropriate screening bin selected with the ability to use manual handling aids where required. Change screenings bags frequently so the mass of each changeout is lower	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No							Manual handling requirement further reduced by incorporation of vehicle accessway directly to prescreen area. Confirmined no change to risk matrix. Mechnical bin lifting device included to minimise requirement for manual handling	AQ design team	20-August-2025					
	Environment Hazard: Odour	Screen and buffer tank are sealed and vented through the odour scrubber. Screenings are contained in an endless bag which contains odour. The endless bag can be changed without creating an odour path.	4	1	5	Low	1	1	2	Low	± 1	Y	N	N		No							Wet well is now added as an inlet works item and will be vented through the odour control system. Confirmined no change to risk matrix.	AQ design team	20-August-2025					
3. Biological Treatment Process (Anoxic tank and Aerobic bioreactor)	Chemical hazard: Presence of chemicals in the wastewater that disrupt the proper biological treatment.	pH monitoring of the influent may detect chemicals early. Each tennant is required to treat their trade waste separately before discharge from their premises.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													
	Chemical Hazard: Alkaline material is added to control pH in bioreactors, requiring operators to use chemicals	Adding chemicals is an automated process. Chemicals are dosed into the system automatically reducing which almost eliminates the requirement for the operator to handle chemicals. Chemicals are common in water treatement plants and can readily be handled with appropriate PPE. Chemical storage area has been moved outside of shed for improved handling and reduced risks associated with degassing.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No							Note this hazard has been added at IFC stage.	AQ design team	20-August-2025					
	Biological hazards: Biology tank foams over due to an event which upsets the biomass	Tanks are sealed and foam will be contained within the biology tank.	3	3	6	High	3	1	4	Low	± 1	Y	N	N		No							Spray nozzles are added to suppress the foam in the aerobic reactors	AQ design team	20-August-2025					
	Biological Hazard: Potential aerosols from aeration of bioreactor leading to exposure of workers in the plant room or contamination of surfaces.	All aerated tanks are airtight and vented through an odour scrubber.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													
	Environment Hazard: Odour	Biology tank is aerated and less likely to cause odour than buffer tank. All tanks are sealed and vented externally through an odour scrubber.	4	1	5	Low	1	2	4	Low	± 1	Y	N	N		No													
	Physical Hazard: Confined space.	Tanks designed so that maintenance and calibration can be undertaken without the requirement to enter the tanks. Trained personnel only to enter confined space after completing appropriate confined space entry procedure.	2	3	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													

DESIGN /			Before Mitigation				After Mitigation					Decision Tree				CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Risk Rating	Likelihood	Consequence	Resid. Risk	Risk Rating	Uncertainty												Action Checked	By	Date	Action Checked	By	Date	Closed Out
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
	Physical Hazard: Aerated liquid reduces ability to float in tank if person falls in	All lids and hatches secured by bolts or locks to prevent accidently falling in. Plant room only accessible to authorised personnel.	3	5	7	Very High	1	5	6	High	± 1	Y	N	N		No													
	Physical Hazard: Electrocution from terminal box.	IP rating of terminal box is appropriate selected.	4	5	9	Very High	1	5	6	High	± 1	Y	N	N		No							Note this hazard has been added at IFC stage.	AQ design team	20-August-2025					
4. UF Membrane Filtration (membrane tank, skid and filtrate tank)	Health Hazard: Membrane integrity is compromised leading to reduced disinfection	Turbidity constantly monitored to detmine membrane integrity.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	Alert level t > 0.15 NTU Critical Level t > 0.2 NTU	Operator alarm is alert level triggered. If critical level is exceeded, the MOS system recirculates for a period to see if the turbidity reduces. If turbidity does not come back within range, the MOS system generates an alarm and goes into standby state.	Continous online monitoring of turbidity during filtration and recirculation by PLC and actuated valve when required.	MOS goes into standby if turbidity does not reduce during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: Turbidity measurement does not reflect the current state of the water because there is no flow through the instrument	Flow switch installed in the instrument loop upstream of the trubidity meter	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	No Flow	If no flow is detected, the MOS system recirculates for a period to see if the flow returns. If flow does not retuen, the MOS system generates an alarm and goes into standby state.	Continous online monitoring of turbidity during filtration and recirculation by PLC and actuated valve when required.	MOS goes into standby if flow does not return during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: Turbidity instrument faults	The turbidity instrument has a built in fault relay which is wired to the PLC	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	Instrument fault	If fault is detected, the MOS system immediately goes into standby state the MOS system generates an alarm.	Continous online monitoring of turbidity fault relay during filtration.	MOS goes into standby if fault does rectify during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Chemical Hazard: CIP requires operators to use chemicals	CIP process is automated. Chemicals are dosed into the system automatically reducing which almost eliminates the requirement for the operator to handle chemicals. Chemicals can be neutralised within the system in a similar manner before they are sent back to the head of the works. Chemicals are common in water treatement plants and can readily be handled with appropriate PPE.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No													
	Physical Hazard: Membrane installation requires manual handling	Membranes have a life expectency of >5 years so the activity is rare. The plant room has been designed to leave space to make installation and replacement safe. Two people are used to replace or install membranes.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No													
5. Ozone System	Chemical and Health Hazard: Ozone exposure and inhalation of ozone if leakage occurred	Ozone generator equipped with failure / leak detection system that automatically shuts down ozone production of gas is detected. Plant room designed with ventilation system, so a small leak will not cause an issue before the detection system acts to shut down generation	1	3	4	Low	1	2	3	Low	± 1	Y	N	Y	Y	No							Confirming that an ozone destruction unit will be incorporated into the design, meaning that any residual ozone vented from the system will be destroyed before it enters the atmosphere	AQ design team	20-August-2025					
	Health Hazard: Noise exposure from compressors high duty	If practical, enclose compressor in acoustic hood, PPE to be worn by operators if compressors are not enclosed.	3	3	6	High	1	3	4	Low	± 1	Y	N	Y	Y	No							Selected rotory screw compressor as it has a lower noise level	AQ design team	20-August-2025					
6. Biological activated Carbon (BAC) Filter	Physical Hazard: Presence of carbon fines during loading of the carbon vessel.	Operator training and use of dust mask.	3	1	4	Low	1	1	2	Low	± 1	Y	N	N		No							Confirming that appropriate, task specific PPE (gloves, mask, eye protection) will be used and specified within the O&M manual	AQ design team	20-August-2025					
	Physical Hazard: Loading bags of carbon into GAC	Use vacuum or "slurpee" to remove used carbon. Assign two people to the task if necessary. Use a funnel to make filling the vessel easier.	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No							Confirming that a special loading procedure including hopper to be incroporated	AQ design team	20-August-2025					
7. UV disinfection	Health Hazard: Excessive suspended solids material interfering with the efficiency of the UV disinfection system	UV is downstream of UF process. See UF membrane filtration section for control measures to ensure membrane integrity etc.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No													
	Health Hazard: Low UV dose leading to poor UV disinfection	UV dose constantly monitored by UV unit using flow rate, measured UVI and measured UVT. UV unit outputs dose to the PLC so it can be monitored and acted upon	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Alert level dose < 60mJ/cm2 Critical Level dose < 58mJ/cm2	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: UVT is too low meaning the unit is operating ourside its validated range.	UV has inbuild UVT instrument which is used withing the device, but also ouput to the PLC.	4	4	8	Very High	1	4	5	Moderate	± 2	Y	Y			CCP2	Alert level UVT < 45% Critical Level UVT < 35%	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: UV disinfection not effective due to excesive lamp age,	UV unit monitors lamp age based on actual run time. Other indicators such as UV dose offer a secondary way to monitor poor lamp performance.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Alert level hours > 10,000 Critical Level hours > 12,000	Operator alarm is alert level triggered. Disinfection system goes into shutdown	Continous online monitoring and diversion by PLC and actuated valve when required.	Disinfection system goes into shutdown. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						

DESIGN /			Before Mitigation				After Mitigation												CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**	**Decision Tree**				**CCP/QCP**	**Critical Levels**		**Monitoring**	**Corrective Action**		**Records**	**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
	Health Hazard: UV unit malfunctions or faults	UV has inbuilt monitoring that identifies warnings and faults. These outputs are monitored by the PLC so the status of the UV unit is knonwn at all times	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Instrument Fault	Operator alarm is alert level triggered. Disinfection system goes into shutdown	Continous online monitoring and diversion by PLC and actuated valve when required.	Disinfection system goes into shutdown. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Flow rate through UV unit takes the unit outside validated range, or doesn't provide sufficient UV dose	UV feed pump's rated capacity is selected well below the maximum validated flow (385 L/min) If the flowrate falls below 23.5 L/min (validated minimum flowrate), the UV dose calculation defaults to the minimum validated flowrate of 23.5 L/min. Flowmeter downstream of the UV monitors flow.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No												
	Physical Hazard: UV lamps are harmful to humans if viewed directly	UV unit is completely sealed so that no light is visible during operation. UV is designed so that the power cable must be removed to access the lamps. This prevents accidentally accessing the lamps while that are lit.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No												
	Environmental Hazard: UV lamps are harmful if not disposed correctly	Dispose of used UV lamps at an appropriate disposal site.	2	2	4	Low	1	1	1	Low	± 1	Y	Y	N		No												
8. Chlorine disinfection (chlorine, dosing pump)	Health Hazard: Insufficient chlorine or chlorine is too high and may cause harm.	System designed to meet minimum Ct in relevant legislation Contact tank designed so that minimum Ct is always achieved Free residual chlorine monitoring	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert Level: FRC > 0.55 mg/L, or FRC > 4.5 mg/L Critical Level: FRC > 0.5 mg/L, or FRC > 5.0 mg/L	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Biological Hazard: Treated Water outside of target pH range	On-line treated water pH monitoring. pH correction installed as part of the plant.	1	3	4	Low	1	2	3	Low	± 1	Y	Y			CCP3	Alert Level: pH < 8.5, or pH > 8.5 Critical Level: pH < 6.0, or FRC > 8	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Equipment failure in the chlorine loop means current reported reading of pH or chlorine is not accurate	Monitor the flow through the instrumentation loop to ensure it is continuous. Monitor the instrument status	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	CCP3	Flow through recirc loop must be continuous. Instrument must always be healthy.	Plant diverts to off spec if critical level triggered.	PLC monitors flow switch mounted in instrument cell and fault signal from the field instrument	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Insufficient disinfection because due to variations in temparature.	On-line temperature monitoring, calculate CT for ambient temperature around storage tanks.	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert level T < 16 deg C Critical Level T < 15 deg C	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continuous online Tepmerature probe.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Required Ct is not met because flows are too high, chlorine is too low	Chlorine contact is in a pipe of fixed volume which fixes one variable in the calculation. Flowmeter upstream of the contact tank and chlorine levels allow Ct to be calculated constantly in the PLC	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert level C-T < 12.6 mg.min/L Critical Level C-T < 12.0 mg.min/L	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continuous online calculation from flowmeter and chlorine probe.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
9. Distribution System and Storage Tanks (lines, end use, Off-spec tank)	Health Hazard: Improper use of recycled water.	Education program for occupants. Lilac coloured pipes and fittings. Signage indicating recycled water usage. No taps accessible to the public.	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y	N		No												
	Health Hazard: Long period until use and all residual chlorine consumed	Chlorine is monitored in the treated water recirculation loop. Plant diverts to off spec tank if chlorine out of range.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Alert Level: TC < 0.5 mg/L, or TC > 5.0 mg/L	Operator alarm is alert level triggered.	Continous online monitoring	Warning alarm only to alert operator for TC < 0.5 mg/L Warning alarm and dosing pump stops for TC > 5.0 mg/L	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.	Minor amendments to TC alert level (in line with RWMP). Eductors incorporated into the design to homogenise the TC level within the tank	AQ design team	20-August-2025				
	Health Hazard: pH drifts out of specification	pHis monitored in the treated water recirculation loop. Plant diverts to off spec tank if chlorine out of range.	1	3	4	Low	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Alert Level: pH < 6.5, or pH >9	Operator alarm is alert level triggered.	Continous online monitoring	Warning alarm only to alert operator	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.	Minor amendments to pH alert level (in line with RWMP)	AQ design team	20-August-2025				
	Health Hazard: Equipment failure in the chlorine loop means current reported reading of pH or chlorine is not accurate	Monitor the flow through the loop to ensure it is continuous. Monitor the instrument status	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Flow through recirc loop must be continuous. Instrument must always be healthy.	Warning alarm and stop chloramine dosing pumps	PLC monitors flow switch mounted in instrument cell and fault signal from the field instrument	Dosing pump stopped. Dosing resumed once cause is determined and issue is resolved.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Biological Hazard: Delivery pipes and fittings leaking or burst leading to contaminated soil	Plumbing installed according to AS/NZS 3500:200. Any leaks reported to Building management according to tennant information brochure.	2	3	5	Moderate	1	3	5	Low	± 1	Y	N	N		No												
10. Sludge Handling including WAS Tank	Biological Hazard: Handling of sludge	System is fully automatic and does not require the operator to come into direct contact with sludge. Disposal bins will be designed so they can be handled with appropriate manual handling device.	2	3	5	Moderate	1	2	3	Low	± 1	Y	N	N		No							Dewatered sludge collection process has been designed to avoid manual handling completely. Vehicle can drive directly in and collect the bin for disposal	AQ design team	20-August-2025				
	Environmental Hazard: Odour	Waste activate sludge does not typically have a strong odour. Dewatering system is vented through the odour scrubber.	2	2	4	Low	1	2	3	Low	± 1	Y	N	N		No												
	Chemical Hazard: Chemical handling	Chemicals stored and bunded appropriately to prevent spills. PPE as per SDS to be used by operators.	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No												
11. Potable Backup Supply	Health Hazard: Contamination from cross connections	Coloured pipe to differentiate recycled water network. Education of plumbers through site inductions. Cross connection audit by installation plumbers.	3	5	8	Very High	1	5	6	High	± 1	Y	N	N		No												
	Biological Hazard: Reverse flow	RPZ installed on potable top up supply Airgap between fill point and highest water level in treated water storage tank.	3	4	7	Very High	1	4	5	Moderate	± 1	Y	N	N		No												
12. Climate change	Biological Hazard: Extreme weather (flooding) causing sewage to mix with stormwater runoff	Site not near known water sources that flood. New development would have conbsidered forseeable rain events and designed drainage for them.	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	N		No							Climate change impacts on influent flow are negligible due to the short, contained collection network. However, the inlet infrastructure is conservatively sized to handle peak flows up to 900 kL/day—three times the average flow—for robustness.	AQ design team	20-August-2025				

DESIGN /			Before Mitigation				After Mitigation														CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Risk Rating	Likelihood	Consequence	Resid. Risk	Risk Rating	Uncertainty	Decision Tree			CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	Action Checked	By	Date	Action Checked	By	Date	Closed Out
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*				*Target*	*Action*	*How*	*What*	*How*	*Where*						
	Biological Hazard: Earthquake causing damage to tanks or equipment that results in uncontained spill	Site not kown to be prone to siesmic activity	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	Y	No												
	Environmental Hazard: Fire causing toxic fumes, eg, plastic tanksor pipework burning.	No flammable goods or chemicals are used in the process which reduces the risk of fire starting. System is in an industrial state that will have appropriate fire services and hydrants should a fire break out.	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	N	No							Appropriate fire safety equipment will be installed within the treatment plant.	AQ design team	20-August-2025				
13.General	Environmental Hazard: Noise polution disrupting users and residents.	Select equipment to be below 80dB(A) where possible; Louder equipment to be installed in plant room; Use of acoustic hoods to attenuate noise if required eg compressors; Maintain all levels below those specified in DA	2	2	4	Low	1	1	2	Low	± 1	Y	N	N	No							Confirming that all equipment will be below 80dB(A)	AQ design team	20-August-2025				
	Environmental Hazard: Odour	All sanitary waste venting from the upstream collection systems are in accordance with AS3500.2 plumbing code requirements to ensure odour is properly handled and vented. The treatment plant prescreen, process and storage tanks are located inside a mechanically ventilated room, so any odours that do occur are unlikely to be a problem for those using the facility. The wet well, prescreen, emergency tank, buffer tanks and sludge dewatering unit which are the potential odour sources, are all sealed and vented through an odour scrubber. The bioreactor uses aerobic conditions which do not generate odour, however as a precaution, these are also vented The plant room is mechanically ventilated.	3	2	5	Moderate	1	1	2	Low	± 1	Y	N	N	No							Odour sources updated in "Preventative Measures" column	AQ design team	20-August-2025				
	Environmental Hazard: Runoff off recycled water from irrigation could come into contact with people	Landscape irrigation has controlled irrigation to prevent excesive watering Land capability study undertaken at design to determine soils irrigation capacity.	1	2	3	Low	1	2	3	Low	± 1	Y	N	N	No							Additional wet weather management strategy will be incorporated to further reduce likelihood of irrigation runoff.	AQ design team	20-August-2025				
	Environmental Hazard: Recycled water from irrigation that could introduce contamination into the environment	No industrial waste is sent to the plant which mitigates disolved contaminants passing through the plant. Instrumentation such as pH man indicate the presence of contaminants	1	2	3	Low	1	2	3	Low	± 1	Y	N	N	No							Recycled water reuse has been optimised to maintained effluent water quality (ensuring TDS is suitable for irrigation)						
	Environmental Hazard: Increase of soil sodicity due to sodium based bio alkalinity addition	Replace Sodium Hydroxide with Magnesium Hydroxide as a bioalkalinity adjusting chemical	3	4	7	Very High	1	1	2	Low	± 1	Y	N	N	No							Note this column have been added at IFC stage	AQ design team	20-August-2025				
	Environmental Hazard: Overflows or spills exposing people to partially treated sewage or chemicals.	Tank sizes are designed to buffer inflows and outflows from the plant. All tanks have appropriately sized overflows directed back to the wet well. Facilities to pump out system in the event of breakdown causes high tank levels. All chemical tanks bunded with bunds compliant with Australian Standards.	3	3	6	High	1	2	3	Low	± 1	Y	N	N	No												
	Biological Hazard: Operators exposed to sewage	Plant is designed so the operator has minimal contact with Operators must be experienced with sewage treatment plants prior to servicing the plant. Plant operators are vaccinated.	3	3	6	High	1	2	3	Low	± 1	Y	N	N	No							Confirming that appropriate, task specific PPE (gloves, mask, eye protection) will be used and specified within the O&M manual	AQ design team	20-August-2025				
	Biological Hazard: Power outages leading to the plant stopping in a state that could lead to uncontrolled discharges	Equipment designed to be fail safe where possible on power down. Plant could be configured to run off a generator if required. In the event of a wide spread outage, the premises feeding the plant are unlikely to be operational which means no feed. Wet well has some capacity for short outages.	3	4	3	Very High	1	4	5	Moderate	± 1	Y	N	N	No							300kL emergency tank now incorporated into the inlet works design. Together with buffer (1ML) tank, treated water tank (1ML) and off-spec (1ML) will provide additional ~6 days storage at full capacity.	AQ design team	20-August-2025				
	Physical Hazard: Servicing heavy equipment	Heavy submersible pumps installed on rails with the provision to remove them using mechanical aids	3	3	6	High	1	3	4	Low	± 1	Y	N	N	No							Appropriate vehicular access has been fully considered throughout the design to keep manual handling to a minimum.	AQ design team	20-August-2025				
	Physical Hazard: Plant has multiple confined spaces	Confined spaces identfied. Only trained and authorised personnel to enter spaces after completing appropriate confined space entry procedures. Plant has been designed so that maintenance can be conducted without the requirement to enter tanks.	3	5	8	Very High	1	5	6	High	± 1	Y	N	N	No												

INITIAL DESIGN STAGE HAZOP												ISSUED FOR CONSTRUCTION STAGE HAZOP				COMMISSIONING / HANDOVER STAGE HAZOP			
Item	**Deviation**	**Consequence**	**Causes**	**Safeguards**	**Actions**	**Who**	**Due Date**	**Status**	**Action Checked**	**By**	**Date**	**New Actions Identified/ Outstanding**	**Who**	**Due Date**	**Status**	**Action Checked**	**By**	**Date**	**Closed Out**
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
Section 1 - Inlet works (inclusive of Source water, Wet Well, Emergency Tank, Macerator, Prescreen and Buffer Tank)																			
1a - Source water (Volume, Composition only)	No or low flow	No immediate impact other than limited food for bioreactor	Periods of low population on site, eg, weekends, Christmas	Remote monitoring of plant allows adjustments to be made if required. Do not start plant until sufficient occupancy to supply minimum bio-reactor feed.								Minimum feed volume has been established by design team							
	High influent flow	Wet well and buffer tank fill. No overflow to sewer	Periods of high user demand, rainwater ingress.	Wet well and buffer tanks sized to cope with peak demands. Site is industrial so less prone to diurnal peaks you would see in residential. Wet well and buffer tank have level transducers which allow logged data to be analysed to identify unusual flows during rain events. Pump out connection to buffer tank to allow removal of water off site.								Wet well can now overflow to 300kL emergency tank							
	Reverse Flow	N/A																	
	Low Level	N/A																	
	High level	N/A																	
	High pressure	N/A																	
	Low pressure	N/A																	
	Composition or changing concentration	Plant gets feed which is not designed for and it upsets biological process, foam overs, damage to membranes from FOG's or other chemicals	Occupants dispose of chemicals or other	pH probe warns if pH out of spec, stopping transfer to bio tank. Buffer is mixed to dilute spikes. Pump out point can remove feed if severe contamination. Manual pH correction.	All occupants should be educated to ensure they understand the impacts of diposing of trade waste or other liquid waste streams to the sewer	Client						Rainwater ingress has been considered in the water balance, although impact has been considered insignificant due to smaller collection network and mostly contained.							
	Start up/ shutdown	N/A																	
	Isolation	N/A																	
	Testing	N/A																	
	Maintenance	N/A																	
	Installation	N/A																	
	Cleaning	Spill or overflow of untreated sewage	Uncontrolled flow form process unit failure.	Overflows and drains all feed back to wet well. Control measures specified on process units below such as level switches and transducers.	Ensure floor grading is suitable to direct spills and clean back to floor wastes.	Client						Hose reels included throughout the plant							
1b - Wet Well, Emergency Tank & Macerator	No or low flow	Low inflow to system	No feed from site Blockage at macerator Blockage upstream	Low Level Switch & transmitter to protect pumps. Load sensor in macerator that reverses direction, as well as overload in panel. Bypass line around macerator															
	No or low flow	Low/no flow leaving wet well	Failure of wet well pumps or blockage in line out of	High level switch and transmitter Duty/Standby pump arrangement Overflow to emergency tank -own level instrumentation in emergency tank Macerator reduces likelihood of blockage downstream Emergency tank sized to allow at least 1 day of storage in the event of pump failure. Further allowance for pump out if this is exceeded. Mixing line allowed for to prevent solids build up Valves have been selected appropriately to avoid blockages. Knife gate valves for control, full bore NRVs															
	High influent flow	Receiving more influent than we can treat	More water being received from the network than anticipated. Overflow from treatment plant contributing to level within emergency tank.	High level switch and transmitter Duty/Standby pump arrangement Overflow to emergency tank -own level instrumentation in emergency tank High flow is unlikely to be over a sustained period of time. Short term high flows that exceed capacity will overflow to emergency tank, before being processed by prescreen as capacity allows. Emergency tank sized to allow at least 1 day of storage in the event of pump failure. Further allowance for pump out if this is exceeded. Pumps sized to allow for 3x peak flow															
	Reverse Flow	Gravity flow network, not an issue																	
	Low Level	Pumps run dry and fail to operate	Failure of level transmitter AND level switch	Allowed for both level switch and transmitter															
	High level	Wet well overflows to emergency tank If it persists, emergency tank becomes full	Influent flow exceeds pump rate. Pump failure	Allowed for both level switch and transmitter Duty/stand by pump arrangement Sufficient storage capacity. Allowance for pump outs if ever required.															
	High pressure	Pressure build up in tank Pressure build up in transfer line.	Incorrect closure of valves Blockage	Flowmeter on prescreen inlet will trigger alarm in event of low flow. Gravity flow to macerator Odour scrubber cannot pull enough pressure to impact integrity of concrete storage tank.	Consider adding pressure transducer for on vent line to monitor inlet suction	Aquacell design team	14-Jul-25												
	Low pressure	Low pressure in tank	Vacuum created by odour scrubber	Vent to odour scrubber appropriately sized. Odour scrubber cannot pull enough pressure to impact integrity of concrete storage tank.															
	Composition or changing concentration	Low wastewater strength High wastewater strength High Solids	Foreign object in sewer. Oil/grease creates fat berg Innapropriate disposal of chemicals to sewer	Macerator in line to reduce likelihood of solids build up causing issues. pH sensors incorporated in design. Large volumes in storage tanks should be able to dilute periods of high chemical concentration. Bypass line to allow for maintenance of macerator	All occupants should be educated to ensure they understand the impacts of diposing of trade waste or other liquid waste streams to the sewer Tradewaste agreementrs in place with all occupants.	Aquacell/Client	14-Jul-25												
	Start up/ shutdown	Wet well shutdown	Fault with wet well pumps or routine maintenance	Bypass line allows feed to be diverted from macerator to emergency tank.															
	Isolation	Isolation of macerator. Isolation of wet well.	Routine maintenance or failure of equipment	Isolation and bypasses available. Cutter pumps will assist with reducing solids build up in event of macerator isolation															
	Testing	Requirement to sample influent	Troubleshooting/verification testing	Sample point between wet well and pre screen.															
	Maintenance	equipment offline	Routine servicing or unplanned maintenance	Duty/standby. Able to remove pump by guide rails & level instrumentation from above, means requiring tank access is unlikely. Inlet pit is accesible for maintenance and not deep enough to require confined space permits. Readily accessible for access by lifting equipment	Ensure that sufficent openings are allowed, for both visual inspections, and flushing when required.	Aquacell design team, tank supplier													
	Installation	Issues around Installation of tanks (leak of collapse)	Incorrect design or installation of tank or any process equipment	Engaged third party specialists for design and installation. Inlet works is accessible by crane. Confined space operatives used for initial installation.															
	Cleaning	Build up of solids or grit causing premature pump failure or blokage	Solids passing into wet well, either through macerator or during bypass	Both macerator and cutter pumps incorporated into the design. Mixing line to resuspend any solids. Sloped floors to divert to single point															
1c - Pre Screens	No or Low Flow (into screen)	No impact																	
	High Flow (inflow faster than outflow)	Spill or overflow of untreated sewage. Excess use of process water	Screen is partially or completely blocked which reduces throughput. Failure of solenoid valve on proces water lines.	Screens overflow back to buffer tank so there are no spills. Spray water to screen to assist cleaning. Screen run on time can be tuned to ensure proper cleaning and minimise use of process water. Level transducer will alarm and lock out feed pumps if screen is high. Process water recycles to buffer tank.	Current design shows 3x screens. Design team to investigate **alternative screens** (2x 100%). We can potentially consider "open channel" design. **Details of pump station** (by others) to be confirmed by client.	CF SA JJ			Currently working through alternative options. Expecting proposal by 21/03 (Hydroflux)	Design	19-Mar-25	Design calcs that 2x prescreens can keep up with design flow, though space for a third prescreen has been allowed for if required in future.		14-Jul-25					
	Reverse Flow	Screens back up because it can't empty. Screen syphons buffer tank to wet well. Outlet or overflow from one screen allows flow to the other screen	Blockage in outlet, wet well lower than screens so gravity flow possible	Wet well pumps have NRV's. Inlet to buffer tank is high level with air gap so syphon through screen to wet well is not possble. Screens gravity flow to buffer tank so not possible to pump back to screen. Screen outlets are 150mm with influent screened to < 2mm so blockage unlikely. Level transmitters in screens meaning they shut down if blocked. Duty/standby screen arrangement.	Confirm levels and pipework design are such that flow from one screen to the other through outlets or overflows is not possible				Cannot be closed out until unit is specified.	Design	19-Mar-25	Design finalised, confirm that prescreens both flow to buffer tank and cannot flow from one to another		14-Jul-25					
	Low Level	No Impact																	
	High Level	As for high flow																	
	Low Pressure	No Impact																	
	High Pressure	Damage to screen or risk of odour escaping	Damper to vent system closed. Vent line blocked	Vent line sized to ensure adequate flow in normal operation. Screens can depressurise through overflow line to wet well. During no flow screens can depressurise through buffer tank															
	Low Temperature	No Impact																	
	High temperature	No Impact																	
	Composition or changing concentration	Screen can block	Foreign objects like wet wipes can bind up screen bruch	Correct selection of wet well pumps. Spray bars and screen run on times to ensure screen clears. Routine maintenance and inspection to clear screen	All occupants should be educated to ensure they understand the impacts of diposing of inappropriate objects to the sewer system	Client						Macerator reduces likelihood of large solids entering prescreen. We now have mixed liquir entering the screens - meaning that when we run at higher MLSS concentration, we need to run at lower flow - Plan is to run mixed liquor processing during night time, or blending it with influent.	AQ design team	14-Jul-25	Closed				

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Cleaning	Screens doesn't function due to lack of cleaning. Screenings difficult to dispose of	Screens are difficult to access or clean	Screens are readily accessible. Hose point in treatment plant to allow screen to be cleaned	Ensure bin and system of disposal for screenings is suitable	AQ Design Team			Cannot be closed out until unit is specified.	Design	19-Mar-25	Confirming that disposal system is suitable. Additional roller shutter door added for direct access to prescreens.			Closed				
	Testing	No way of easily testing or getting a representative sample of influent.	No place to take a representative sample.	Sample point on screen inlet															
	Maintenance	Screens can't be maintained	Maintainable parts not accessible	Each screen can be indpendantly isolated	Ensure ready access to screen to remove screen with lifting device if required	AQ Design Tesm			Space will be maintained, once final unit is determined.	Design	19-Mar-25	Confirming that disposal system is suitable. Additional roller shutter door added for direct access to prescreens.			Closed				
	Installation	Screens cant be installed	Insufficient access									Sufficient access from new side road through roller shutter door for installation			Closed				
	Isolation	Screen can't be isolated. Outlet from one screen flows up other screen outlet if the screen is removed for maintenance.	No Isolation points on outlet or overflow	Inlet, process water inlet and vent all have isolation valves. Screens installed at the same level with gravity flow to buffer.	Confirm flow is not possible from one screen to the other via the joined outlets if one screen is removed for maintenance. Similarly for overflows.	AQ Design Team			Since the level for duty & standby is the same, overflow should not be possible. There is no valve between prescreen and buffer to interrupt flow.	Design	19-Mar-25								
1d - Buffer Tank	No or low Flow	No immediate impact other than limited food for bioreactor.	Screen or line blockage. Screen maintenance or failure Pipe failure. Diversion valve failure	Low level in buffer tank is visible on HMI/remote monitoring.															
	High flow	Overflow tank.	Operators running pumps or other equipment in manual. Issue in the plant that prevents processing	Level transducer in buffer tank to generate alarm. Email alarming can be configured. There is a pump out point if waste needs to be removed from site. Buffer tank appropriately sized to take short term interruptions to production.								Buffer tank can overflow to emergency tank if full		14-Jul-25	Closed				
	Reverse flow	Buffer tank drains Anoxic tank.	NRV's on pumped line fail	Feed line to anoxic tank comes in above overflow level so syphoning not possible even if NRV fails.								Feed line now comes in below overflow level. Raise level in anoxic tank to flag warning of reverse flow from anoxic tank to buffer. Alarm to be added to FDS. Consider flow circulation within anoxic tank and best location for mixers		14-Jul-25	Closed				
	High pressure	Tank damage; leakage of wastewater outside tank.	Tank is sealed (odour) with no overflow. Operators run pumps manually. Vent line is blocked at the same time as trying pump waste to the tank.	Gravity flow into tank so pressure is limited to head height of feed liquid. Unlikely to damage undergroundtank. Vent line does not have a damper which could be inadvertantly closed. High level transducer with high level switch backup to stop feeds in automatic.	Confirm if level on out of spec tank would push liquid through vent line to odour scrubber.	AQ Design Team			Vent to odour scrubber is sufficiently sized	Design	19-Mar-25								
	Low pressure	Tank collapse.	Pumping out of tank with no way of drawing air in.	Air can be drawn in through the screens if the vent is blocked.															
	Low level	Pump damage. Loss of containment. LTX / LSL failure	Running pumps in manual	Level transmitter for low level protection with level switch as back up.LTX / LSL if one fails, the other device should still read correctly. Buffer transfer pump is interlocked with low level.															
	High level	Overflow tank.	Failed level transmitter. Leaking or manually open valve on off spec tank	Level transmitter has level switch back up in case of failure.	Consider if the tank should have a trapped outlet that diverts tank contents to a specific area if there is ever an overflow event	AQ Design Team			Overflow from buffer tank to emergency tank is to be incorporated	Design	19-Mar-25	Emergency tank has now been allowed for	AQ Design team	14-Jul-25	Closed				
	High temperature	N/A																	
	Low temperature	N/A																	
	Composition or changing concentration	Poor quality water to MBR. Onset of UF fouling and more CIPs than normal	Different activities by client. Surge in alkali cleaners. Anaerobic and pH drops. Chemical dumping.	Buffer tank smooths out peaks. DO monitoringpH alarms on buffer tank. Program PLC to stop/reduce transfer if buffer tank pH high/low.															
	Start up/ shutdown	Low pH Flammable gases.	Could go anaerobic if shutdown for a long time	pH probe. Ventilation to allow gases to be removed. Pump out tank if waste is not appropriate to start plant with.								We have now established that plant cannot be run until 30kL/day is achieved.	AQ Design team	14/07/2025	closed				
	Cleaning	Hose down needed	Build up of scum, foam and waste inside buffer tank	Sealed tank. Not an aerated tank so foam overs not likely.	Consider sepeciying more than one hose point in the plant	AQ Design Team			Current proposal is that 3x hose points should be allowed. 1x in the main treatment plant, 1x in the sludge room, 1x outside (facing the biotanks)	Design	19-Mar-25								
	Testing	N/A										Add sample line to anoxic feed piping - potentially in valve pit	AQ Design team	14-Jul-25	Closed				
	Maintenance	Pumps and probes in tank need to be serviced	Routine maintenance or failure	Probes/transducers/switches mounted into the top of the tank via flange or similar which allow easy removal. Sumbersible pumps and mixers on rails or similar that allow them to be removed easiy for maintenance.															
	Installation	Incorrectly installed and tank leaks. Pump installation involves a confined space entry.	Inexperienced tank builders Inadequate or undefined quality assurance	Manufacturer to install the tank. Hydrostatic test as part of commissioning. Confined space qualified personel to be used to install the pumps. Consider using the tank manufacturers to install the pumps.															
	Isolation	Can't shut down tank for confined space entry if ever required	Insufficient isolation points	Manual isolation valves upstream of screens and on the transfer line from the out of spec tank.								Consider additional spectacle plate from treated water storage for isolation. We can isolate inlet to off spec.	AQ Design team	14-Jul-25	Closed				
Section 2 - MBR (inclusive of Anoxic, Aerobic, MOS and Filtrate)																			
2a - Bioreactors - Anoxic (including mixer)	No or low Flow	No or limited food for bioreactor.	Buffer tank pumps failed, empty buffer, or MBR overflow stopped, Bio pumps failed, aerobic tank low level (stops bio pumps), blocked line. Closed valve after maintenance.	Regular monitoring and maintenance by service staff.															
	High flow	Overfill and over pressurise tank causing tank damage or flooding.	Overfeeding from buffer (both pumps on manual).	Piping and overflow is within design capacity for two pumps in parallel. High level switch in Aerobic tank															
	Reverse flow	Overfilling	Foaming in aerobic tank. Anoxic overflow pipe blocked.	Check valves in buffer pumps to stop flow back to buffer tank. Anoxic to MBR tank hydraulically not possible other than foam. Foam from aerobic to tank to anoxic is possible but there are spray bars in the aerobic tank to control foaming.								Check valves on anoxic recirc pumps will also prevent reverse flow							
	High pressure	Tank damage. Leakage of wastewater outside tank.	Overflow blocked.	Overflow sits above inlet level of aerobic tank, so not possible to hydraulically block the line.															
	Low pressure	Tank damage	Blocked vents and bio pumps running	Multiple vent paths - overflow from from aerobic, overflow line from MBR, DN80 vent on tank.								Even if vents were blocked, the pumps would not create sufficent vacuum to damage the underground concrete tanks. Vent dia. increased to 100mm							
	Low level	Mixer gets damaged because water level is low	Tank leaking	Low level switch to protect the mixer. No drain valve on tank. No pumps in tank to empty it in normal operation.															
	High level	Spill from tank	Overflow blocked.	Not possible to hydraulically block the overflow.Spray line in aerobic tank to control foaming. Liquid flow will likely unblock any foaming that may carry over into the overflow line.															
	High temperature	Biology effected	Prolonged exposure to hot climate or high temperature feed	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Low temperature	Biology effected	Prolonged exposure to cold climate or low temperature feed.	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Composition or changing concentration	Explosion from gases Corrosion of tank Under performance of mixed liquor.	Anaerobic and may produce odour or explosive gases. Improper disposal of CIP waste. Chemicals in wastewater.	DO probe in the aerobic tank. Mixing and aeration in anoxic tank. Design is inherently anoxic. Safeguards for buffer tank. Buffer tank serves to lower peak concentration in w/water.								Explosive gases will be vented through the OCU stack. pH probe in buffer tank to monitor influent characteristics.							
	Start up / shutdown	No issues with start up Mixed liquor turning septic during prolonged shutdown	Lack of aeration during shutdown	During extended shutdown, manually operate pulse burst aerators to supply oxygen from the aerobic tank. If a long period of time then drain the tank.															
	Cleaning	Accumulation of biomass on floor of tank.	Biomass settles over time	Mixer installed. Upstream screening to remove large items.	Consider access for pump out of tank if ever required.	AQ Design Team			Access hatches are to be provided in all tanks. Vehicle access is possible direct to aerobic tanks.	Design	19-Mar-25								

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Testing	Underperformance of mixed liquor. Design intent is to remove some nitrogen.	DO of anoxic zone is too high such that anoxic conditions do not exist		Consider access point near the weir to insert DO probe (or visually inspect aeration).	AQ Design Team			Visual inspection is possible through access hatches. Instrument probes can be deployed.	Design	19-Mar-25								
	Maintenance	Can't maintian mixer. Can't inspect tank.	No drain valve on tank.	Mixer and level switch accessible without needing to pumps down tank. Tank inspection rare and it's practical to pump down a 40kL tank if required.								Mixers to be installed on guide rail to allow removal without draining tank.							
	Installation	Leakage	Sub-standard installation leading to a leak	Hydrostatic testing at clean water commissioning.															
	Isolation	High risk if confined space entry of anoxic tank with aerobic tank contains unaerated mixed liquor	Unable to isolate headspace of anoxic tank from aerobic tank. Unable to isolate headspace of MBR tank from anoxic tank.	Able to isolate against inundation at other points.															
2b - Bioreactors - Aerobic (including blower skid)	No or low Flow	Underperformance of biological system. Failure to achieve required DO and MLSS levels	Buffer tank pumps failed, empty buffer, or MBR overflow stopped, Bio pumps failed, blocked overflow from anoxic tank, strainer on bio pump outlet blocks.	Alarms and faults allow service staff to monitor pumps remotely. In line flow meter between bio tank and MBR tank monitors flow. Flow switch on instrumentation side stream alarms if flow is inadequate.															
	High flow	Overfill and/or over pressurise tank causing tank damage or flooding.	Excess flow into anoxic tank	MBR tank can only overflow at the rate the bio pumps remove liquid so no net gain from these pumps, even in manual. Overflow DN150 sized correctly.															
	Reverse flow	MBR and bio tank levels equilibrate and part of membrane exposed.	Loss of power NRV for bio pumps stays open	Bio pumps have NRVs. Bio pumps run almost all of the time. MBR tank has level transducer which will alarm if the level drops.															
	High pressure	Tank damage. Leaks	Blocked overflows. Blocked ventilation for foaming.	Tank can vent through anoxic tank, if aerobic tank vent was blocked. Spray bars keep foaming down.	As per anoxic tank. Confirm with installers that vents for bio and buffer tanks have an uphill gradient, which will avoid water accumulting in the vent system.	AQ Design Team			Confirming an uphill gradient will be applied to the vent from the biotank to odour scrubber.	Design	19-Mar-25								
	Low pressure	Tank damage	Pumps running with vent blocked	Multiple vent paths - vent through anoxic, vent through MBR overflow since overflow is not full bore flow.	As per anoxic tank				Risk of blockage considered to be minimal. No valves or other inline equipment in odour scrubber vent lines.	Design	19-Mar-25								
	Low level	Damage to pumps or aerator	Transducer failure	Level transducer is backed up by level switch															
	High level	Spills	Pumps running manually. Foam "fills" tank above liquid level. Transducer failure. Tanks fills goes high from excess spray water	High level transducer is backed up by level switch. Tank overflows to wet well. Tank sealed for odours so foams will likely go down overflow or back to anoxic tank. Spray bars to reduce foam. Control system allows for sprays to run intermittently to operator settings rather than continuously. System is closed loop - spray water doesn't add to volume in plant since it is process water rather than potable.															
	High temperature	Biology effected	Prolonged exposure to hot climate or high temperature feed	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Low temperature	Biology effected	Prolonged exposure to cold climate or low temperature feed.	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Composition or changing concentration	Explosion from gases. Corrosion of tank. Under performance of mixed liquor.	Inadequate DO control leading to anaerobic conditions. Improper disposal of CIP waste. Chemicals in wastewater. Aerator inlet blocked reducing aerator efficiency	DO and MLSS probe in bio pump sidestream to monitor MLSS. Buffer tank smooths concentration changes up stream. CIP chemcials appropriately neutralised before being introduced into the system.	Ensure aerator pipe is easy to inspect and maintain.				Submersible aerator is considered, which should be easy to raise and inspect.	Design	19-Mar-25	Explosive gases will be vented through the OCU stack. pH probe in buffer tank to monitor influent characteristics. Magnesium hydroxide will be dosed to control pH.								
	Start up / shutdown	No issues with start up Mixed liquor turning septic during prolonged shutdown Pump and/or aerator damage due to operation at low level.	Aerator not submerged. Manual operation overrides level switch Inadequate aeration during prolonged shutdown.	Plant has several stages of shutdown which ensures aerators and pumps run for appropriate periods depending on down time. Level switches and transducers protect pump and aerator	Consider replacing AV-331A & AV-332A with a 3-way valve (waste to sludge settling tank)	AS			Addition of 3 way valve considered in design.	Design	19-Mar-25	Sludge settling tank has been removed from the design, so the three way valve is no longer required.							
	Cleaning	Accumulation of biomass on floor of tank.	Biomass settles over time	Mixer installed. Upstream screening to remove large items.	Consider access for pump out of tank if ever required.	AQ Design Team			Camlock and required isolation valves to be incoporated to allow tank to be drained	Design	19-Mar-25	Access for pump outs confirmed. Design now features an emergency tank transfer system from biotank							
	Testing	Underperformance of mixed liquor	DO, pH, MLSS,	External DO and MLSS on bio pump side stream. Can do grab sample from tank.	Consider inspection points in the aerobic tank (to inspect aeration pattern)	AQ Design Team			Inspection hatch to be included in tank. Submersible aerators to be utilised, no aeration grid.	Design	19-Mar-25	Confirmed inspection hatch included in design							
	Maintenance	Biological system underperformance. Pump or aerator failure.	DO/MLSS probe malfunction	Maintenance of DO and pH probes is easy as it is external. Aerator and pumps can be removed from tank without requirement for confined space entry. Access hatch in tank allows for aerator performance to be assessed.															
	Installation	Leakage	Sub-standard installation leading to a leak	Tank manufacturer to install															
	Isolation	High risk if confined space entry of aerobic tank with anoxic tank containing unaerated mixed liquor	Unable to isolate headspace of anoxic tank from aerobic tank.	Able to isolate against inundation.															
2c - MOS System (Including Magnesium Hydroxide dosing)	No or low Flow	Low inflow to MBR tank leads to biomass concentration increases and blocks membranes. Low flow of air causes fouled membranes. Low backwash flow for maintenance clean causing ineffective membrane cleaning. Low alkalinity chemical flow. Low venturi flow leading to not priming the line. Low flow in instrumentation loop giving false reading. No/Low magnesium hydroxide dosing on overflow line	Blocked recirc pump or pump isolated manually. Blower failure or pipe failure. Loss of pump prime. Low alkalinity caused by loss of pump flow or chemical Blocked dosing line or pump failure	Level transducer in MBR tank that would identify when insufficient mixed liquor feed. MBR overflow is adequately sized. Permeability alarm. Air pressure indicator and alarm. Flowmeter on inlet from biology and after outlet of MBR pump. Level switch on line to confirm priming. Flow switch on instrumentation loop. Selected DN20 magnesium hydroxide dosing line to avoid pipe blockages. Incorporated dosing tank mixer to avoid magnesium hydroxide settling in the system. Selected peristaltic pumps for magnesium hydroxide dosing.															
	High flow	High ML flow has no significant consequence. High air flow could cause membrane damage. High filtrate flow causing rapid fouling. High BW flow damaging membrane. High overflow rate causing high level. High vent flow.	High air flow - both blowers running. Incorrect flow setting on filtrate/BW. High vent flow caused by excessive air.	High flow alarm on filtrate flowmeter. TMP alarm. Air flow limited by aeration rate / size of membrane blower. Overflow rate limited by biology pump flow.								Overflow adequately sized							
	Reverse flow	Reverse flow of MLSS to blowers. Reverse flow of MBR tank to aerobic tank.	MLSS damages blowers. System off for an extended period and slow leak through NRV on ML line, leading to membranes partially exposed.	Non-return valve on blower. Blower pipe line installed so it is higher than the filtrate tank overflow. Non-return valves on all pumps. Level transducer alarms prior to the membrane being exposed.															
	High pressure	High air pressure causes blower failure or low air flow High TMP causes rapid fouling and increases energy consumption High BW pressure for maintenance clean.	Blower isolated or line blocked. Poor mixed liquor quality	Pressure relief valve on blowers. Air pressure monitored and alarmed for high pressure. TMP monitored and alarmed. BW pressure monitored and alarmed. Dead head pressure for backwash pump is less than the design rating for the membranes.	Consider actuated valve on MBR filtrate air relief line for priming	AS			Additonal valve to be added onto the line	Design	19-Mar-25	Confrimed actuated valve added on MBR filtrate priming line							
	Low pressure	Low air pressure leading to low air flow and membranes foul faster. Low process water pressure on venturi leading to insufficient vacuum, lead to loss of prime of filtrate pump	Air line or blower line failed.	Blower pressure monitored and alarmed. Level switch on header will detect inadequate venturi operation.								Duty/stand by MOS blower incorporated into the design.							
	Low level	Membranes exposed and may dry out. Could allow air to damage membrane by excessive movement. Air in filtrate line	No inflow or tank drained or valve left open.	Level transducer on MBR tank to monitor level. Low level interlocks blowers and filtrate pump. Low flow through membrane pump detected and alarmedvia flowmeter after MBR pump.															
	High level	Tank is designed to overflow to biology tank. If blocked, then level will rise up the vent line.	Blockage in overflow to aerobic tank.	No manual valves on overflow to aerobic tank. DN150 overflow.															
	High temperature	High temperature can damage the membranes	Exothermic chemical reaction diluting or neutralising chemical	Temperature monitored, although only during filtration. Procedure for CIP to prevent mixing of incompatible chemicals. Membrane tanks indoors so not exposed to direct sunlight.															
	Low temperature	Membrane damage	Exposure to low temperature	Temperature monitored. Membrane tanks are indoors and not exposed to prolonged cold temperature. Membranes submerged with tank contents always moving - no risk of freezing.															
	Composition or changing concentration	Damage to membranes by chemicals or other impurities. Damage caused by high MLSS. Damage caused by excessive fibrous materials blocking the membrane modules. Membrane integrity failure leading to poor quality treated water.	Wrong recipe for CIP or inadvertant overdosing of chemicals during CIP. Fibrous material caused by screen failure.	Automated CIP sequence set up at commissioning. See screen failure safeguards. pH probe in buffer tank to detect some impurities. Turbidity monitor and alarm to detect integrity failure.TMP monitoring to detect fouling. MLSS probe to monitor solids concentration. In line strainer between biology pumps and MBR tank.	Consider selection and suitability of MBR recirc strainer. Ali to investigate rescreening of MLSS from MBRs.	AS			Considering a "pre-pump strainer", which is hydraulically cleaned. Also looking into other options/getting advice from MBR experts.	Design	19-Mar-25	Mixed liquor rescreening has been incorporated to protect membrane failutre caused by fibrous material. Basket strainer also added upstream of MBR tank to protect membrane from fibrous material.							
	Start up/ shutdown	Membranes exposed and may dry out. High flow of filtrate due to incorrect VFD setting.	Passing check valve and level equalisation with bio tank. Leaking drain valve. Membrane damage or bio fouling. Position of manual valve on filtrate pump discharge	Non-return valve in biology supply line. Level transducer on membrane tank and a low level alarm. Established procedures for proper storage of membranes (SMBS). Safeguards as per low and high flow scenarios.															
	Cleaning	Membrane fouling/damage	Wrong chemicals and/or concentration or procedure.	Chemical cleaning to be performed only by trained personnel following appropriate procedures.								Sample points added to CIP line to test chemical if required.							

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Testing	Non-representative samples, or spurious results (e.g. coliforms due to contamination).	Contamination of sample points	Sample points on filtrate and MLSS provided Stainless steel sampling point for ease of disinfection by ethanol (or flamed).								Sampling to be performed only by trained personnel following appropriate procedures.							
	Maintenance	Membranes dry out/fouling/damage	Visual inspection for aeration pattern, hose down for CIP. Removal of membranes	Use trained service personnel. Access for visual inspection is available. Pull out rack for maintenance and change out of membranes is part of design.								Platform ladder has been incorporated for visual inspection. Filtrate turbidity continuously monitored to change filtrate quality due to membrane damage.							
	Installation and environment (sun, noise, odour)	Injury due to inadequate access to equipment. Odour in the room.	Poor layout and design and insufficient isolation.	Tank has lifting lugs fitted to allow it to me craned into position. Local isolators provided on all motors. Manual isolation valves on tanks. Vents for odour control.															
	Isolation	Inability to achieve effective isolation for confined space entry (if required)	Improper isolation.	Manual isolation valves provided. Tank only opens from the side so cannot be inundated.															
2d - Filtrate Tank	No or low Flow (filtrate)	No disinfection = no treated water production Low level in filtrate resulting in disinfection pump runnings dry	Valve failure Filtrate pump failure Pipe leak or blockage	Level transducer and level switch on filtrate tank.															
	No or low Flow (potable)	Unable to prepare CIP/MC solution	Potable top up valve failure. Potable water outage	Level transducer and level switch on filtrate tank. Flowmeter on potable inlet to treatment plant.															
	High flow	Overflow the tank. Inflow upsets instrumentation due to turbulent flow	MOS flow set point too high	Overflow on the tank. High flow alarm on MOS system. Instruments installed as per other Aquacell sites ensures they are not effected by high flow.															
	Reverse flow	Contaminated potable water top up line Air flow from floor drain causes odour	Backflow up line Connection between overflow and floor sink	Air gap for both the filtrate flow and potable water flow into the tank, prevents backflow. Floor drain specified with trap. RPZ valve on potable line.															
	High pressure	Tank damage	Not feasible due to air gap and overflow are vented and DN100 overflow	Since odour risks are unlikely, tank is normally not fully sealed.															
	Low pressure	Tank damage	Not feasible due to air gap and overflow are vented and DN100 overflow	Since odour risks are unlikely, tank is normally not fully sealed.															
	Low level	Damage to disinfection and filtrate pumps	Level TX failure. Break in pipework	Low level switch as backup to level transmitters. Flowmeters will detect low flow from pump to prevent damage.															
	High level	Tank overflows	Level transmitter failure. Blockage in overflow.	Level transmitter is backed up by high level switch. Overflow to floor drain is appropriately sized.															
	High temperature	N/A																	
	Low temperature	N/A																	
	Composition or changing concentration	Uncompliant treated water. Damage to equipment from CIP chemicals	Residual CIP chemical. Membrane integrity issue.	MOS CIP is automated to ensure flushing after CIP. Operating instructions to ensure filtrate tank is drained following CIP. pH is monitored and will pick up some level of incomplete CIP rinse. Turbidity monitored to ensure membrane integrity.															
	Start up/ shutdown	No specific issues																	
	Cleaning	Poor ability to clean any biofilm	Inadequate access	Access hatch on top of tank to add chemicals if required.															
	Testing	Biofilm growing inside the tank without knowing it	Filtrate quality monitoring is on the pipe at the inlet to the filtrate tank	Sample point post disinfection pump to take sample. Opening in top of tank to visually check.															
	Maintenance	Poor ability to clean any biofilm	Inadequate access	Access hatch on top of tank to add chemicals if required.															
	Installation and environment (sun, noise, odour)	Plant is indoors, so no issues.	Filtrate tank larger than available building access.	2 x Filtrate tanks and delivered to site via doorway access.								Confirmed doors are appropriately sized.							
	Isolation	Unsafe working for maintenance	Lack of manual isolation	Isolation valves provided to prevent accidental filling of tank.															
Section 3 - Disinfection (Inclusive of Ozone, BAC, UV and Chlorination)																			
3a - Ozone Treatment including OCT Piping	No or low Flow	Low flow compressed air to ozone skids. No or low filtrate flow. Ozone not generated at suitable rate.	Compressor failure. Upstream pump or valve failure	Ozone levels checked pre OCT pipework. Alarm levels can be set. Ozone skid has alarms that go back to the PLC.								Flowmeter after disinfection pump. Regular maintenance schedule for compressor.							
	High flow	Incomplete treatment or insufficient residual ozone	Flow through ozone OCT pipework too high to get required contact time. Ozone flow into treated water too high leading to over ozonated water	High flow through contact pipe mointored by flowmeter upstream of ozone skid. Ozone levels checked pre OCT pipework. Alarm levels can be set. Ozone skid has alarms that go back to the PLC															
	Reverse flow	Reverse flow through eductor	Line blockage	Check valve on ozone inlet of eductor.															
	High pressure	Damage to equipment	Damage to seals or pipework.	Ozone system has an independent control system and sensors to monitor pressures and alarm. Pipework designed to accommodate pump dead head pressures.								Regular maintenance schedule for compressor. Pressure switch on compressed air receiver							
	Low pressure	Compressed air pressure too low to generate sufficient oxygen	Malfunctioning compressor, air leaks	Ozone system has an independent control system and sensors to monitor pressures and alarm								Regular maintenance schedule for compressor. Pressure switch on compressed air receiver							
	Low level	Low ozone concentration	Increase ozone demand, malfunction ozone unit	Ozone system has independent control system to monitor production. Ozone probes to measure residual ozone and alarm															
	High level	High ozone concentration	Decrease ozone demand	Ozone system has independent control system to monitor production. Ozone probes to measure residual ozone and alarm															
	High temperature	Inadequate colour removal	Ozone half life reduces as temperature rises, temperature affects solubillity	Temperature probe in cell where residual ozone is measured								Upstream and downstream temperature can be monitored from MOS and CCT temperature probe.							
	Low temperature	Inadequate colour removal	Temperature affects solubillity	Temperature probe in cell where residual ozone is measured								Upstream and downstream temperature can be monitored from MOS and CCT temperature probe.							
	Composition or changing concentration	Inadequate colour removal, Ozone begins to concentrate in the air	Ozone demand is not consistent, leaks in ozone system	Ozone concentration meansured at start at outlet of ozone contact tank, ozone destruct unit vented to roof to ensure excess ozone is safely removed.	Confirm there is an ozone sensor and alarm which would detect leaks	Aquacell Design Team			Confirming ozone leak sensor is incorporated into ozone offer	Design	19-Mar-25								
	Start up/ shutdown	Inadequate colour removal	Ozone system requires time to produce ozone on startup		Confirm if there is any stored ozone on shutdown. If so, confirm the system sends it through the destruction unit	Aquacell Design Team			Ozone destruction unit is to be incorporated into ozone system. Current quote does not include this. Ali to get revised quote.	Design	19-Mar-25	Confirming that ozone destruction unit is incorporated into design. Ozone sensor fed back to PLC.							
	Cleaning	No specific cleaning requirements																	
	Testing	Samples required	Ad-hoc sampling for troubleshooting, instrumen verification	Sample points upstream and downstream of ozone unit and OCT pipework	Consider also adding sample point after each OCT leg to monitor ozone decay	AS			Additional sample points to be incorporated into the design.	Design	19-Mar-25	Sample points added after each OCT pipe leg.							
	Maintenance	Break downs	Inappropriate servicing	Service and maintain compressors and Ozone unit as per manufacturer's recommendations															
	Installation and environment (sun, noise, odour)	Noise. Difficult to install OCT pipework skid	Compressor supply compressed air to ozone unit and run at high duty	Units installed indoors away from direct sunlight. Building doors should be large enough. Option to construct in situ if final building design presents a problem	Confirm selection on compressor type considered noise levels. Confirm compressor has an acoustic hood.				Alternative unit to atlas copco to be approached	Design	19-Mar-25	OCT pipe length has been selected to ensure that it can be manufactured off site. Rotary screw compressor has been selected to reduce noise.							
	Isolation	No ability to isolate	Valves and electrical isolators not installed	Ozone units have a main switch on the unit. Isolation valves upstream and downstream.															
3b - BAC Filters	No or Low Flow	Ineffective backwash. System is airlocked.	Insufficient flow from process water pump	Process pump sized correctly. Air relief valves at high points in the system.															
	High Flow	Insufficient contact time for correct treatent. Carbon flushed out of filter housing. Spillage from backwash going to floor waste	Pump incorrect size or running too fast of a VSD	Pump sized correctly for forward flow. Flow controller installed in drain line to control backwash flow. Each pair of filters are in series so not possible to divert twice the flow through one filter	Review backwash pipe connections to floor drain at commissioning. Re-engineer if appropriate. Consider using besser block bund.	AQ Commissioning team			To be considered at commissioning if required. Could consider fabricated flow diverters if required, rather than besser blocks.	Design	19-Mar-25	Appropriately sized drainage pit included in the design to avoid spillage from high backwash flow.							
	Reverse Flow	Forward flow diverts to drain.	Problem with filter valve not locating properly or other internal problem	Limit switches provide feedback to PLC on filter valve status. Flowmeters upstream															
	Low Level	N/A																	
	High Level	N/A																	
	Low Pressure	Filter does not backwash correctly	Process water feed issue (Pump/valve)									Pressure transducer added to process water pump outlet							
	High Pressure	Damage to filter housings. Reduced throughput	Incorrect valve sequencing. High backwash pressure.	Position feedback to be incorporated.								Pressure transducer added to process water pump outlet							
	Low Temperature	N/A																	
	High temperature	N/A																	

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Composition or changing concentration	Residual ozone upsets BAC conditions.	Overdosing ozone upstream. Bio-growth or other contaminant coming from filtrate tank.	Residual ozone measured at the outlet of ozone contact tank. Refer to Filtrate tank maintenance controls.															
	Cleaning	No specific external cleaning requirements. Replacing carbon as per Maintenance controls																	
	Testing	Filters not performing as expected	Carbon exhausted. Upstream process issues	Sample points located updtream and immediately downstream prior to UV units															
	Maintenance	Insufficient colour removal. High HCC count	Filters not backwashed properly	Filters set to backwash on time, differential pressure or manually initiated by operator. High DP is an alarm condition. Unions allow control valve to be disconnected for easy access. "Slurpy" or wet vac's to extract used media.	Ensure adequate height and access for platform ladder when finalising layout	Aquacell Design Team			Mohammad to review access for platform in 3D model	Design	19-Mar-25	Access for platform has been considered.							
	Installation and environment (sun, noise, odour)	Damage to filters from handling or UV	Difficult to handle	Leave vessels on pallet for as long as practically possible. Maintian forklift access to final location if practical. Use at least two people to move filters. Ensure final piping does not impede ability to do initial fill of filter. Filters installed in shed so problem with UV degredation.	Ensure adequate height and access for platform ladder when finalising layout	Aquacell Design Team			as above	Design	19-Mar-25								
	Isolation	Need to replace filter media	Carbon at end of useful life	Each vessel can be isolated to allow the filter to be maintained.															
3c - UV systems	No or low Flow	Overheat the UV	Disinfection pump is off (auto or manual). Downstream valve closed. Air trapped in unit.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time. Valves in the high part of the line allow air to be vented															
	High flow	Inadequate disinfection due to short contact time.	High flow from UV pump	Flow from pump is monitored and alarms on high flow.															
	Reverse flow	Not feasible			Add NRV from diversion line to off spec water tank				Confirmed valve added in P&ID	Design	19-Mar-25								
	High pressure	Damage UV by exceeding design pressure	Downstream valve is closed	UV and pipework rated pressure higher than dead head pressure of pump.															
	Low pressure	UV fouling due to lack of wiper functionality.	Low permeate pressure Manual valve closed Drain valve opened	UV controller monitors wiper action and will alarm if it doesn't wipe. Procedures for maintenance of UV.															
	Low level	Damage to unit due to over temperature	Leak, unit drained and left isolated after service.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time.															
	High level	N/A																	
	High temperature	Damage to unit. Damage to pipework surrounding the UV	Running with no water or low flow.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time. Pipework within line of sight of UV lamp is stainless steel.															
	Low temperature	N/A																	
	Composition or changing concentration	Poor disinfection	Low UVT. Fouled lamps or failed lamps causing low UVI. Pipe material selection incorrect and allows UV light to damage pipework. Valve arrangement used for CIP.	UVT monitor is integral to UV and alarm warns of low UVT. UV dose alarm to warn of low intensity and low dose. Lamp failure alarm. Use stainless steel upstream and downstream of the UV and where there is risk of UV light. CIP solutions not strong enough to damage quartz sleeves.															
	Start up/ shutdown	Inadequate disinfection during start-up. Fouling during extended shutdown	Insufficient lamp warm up time.	Water can be diverted to the off spec tank post CCT contact. UV can be remote started without water flowing if required. UV system has wipers to assist with removing fouling. Manual cleaning of sleeves after prolonged shutdown.															
	Cleaning	Unable to remove lamps for cleaning	Not enough access space provided	Sufficient space around UV unit to open door and perform cleaning. Sufficient space around 130 um and 5 um filters.								Duty/stand by UV arrangement							
	Testing	Need to sample pre or post UV	Troubleshooting, process analysis	Sample points pre and post UV															
	Maintenance	Unable to remove components of UV system, and 130 um and 5 um strainer for cleaning	Not enough access space provided	Sufficient space either side of UV, strainer and cartridge filter.															
	Installation and environment (sun, noise, odour)	No specific issues as unit is indoors																	
	Isolation	Unsafe to work on	No isolation points	Manual valves and electrical isolation provided. UV door cannot be opened without unplugging electrical plug.	Install local isolator on UV (similar to GPO installed at Bankstown). Note in I/O list	AQ Design Team			To be added once IO list is prepared.	Design	19-Mar-25								
3d - Chlorination System (CCT)	No or low Flow	False instrumentation readings, instrument damage if flow cell drains. Inadequate mixing. Overdose of hypochlorite.	UV pump failure. Flow restriction with one or more valves. Flow cell blockage. Flow cell drains. Low level in filtrate tank. Strainer blockage in analysis stream	Flow switch in flow cell. Pump fault alarm. Flow meter upstream of injection point. Flow control using diaphragm valve. Fine adjustment via needle valve in flow cell. Static mixer.															
	High flow	Damage instruments or inaccurate readings. Insufficient contact time.	Valves not set correctly	Flow cell acts as a flow restrictor and has flow indicator with needle valve to control. Adequate volume in CCT to ensure sufficient contact time. Flowmeter in line to monitor flow rates															
	Reverse flow	Backflow to cell causes damage by overpressure	Upstream valves isolated with pump running	NRV after off spec diversion valve to prevent backflow to cell. NRV at disinfection pump prevents backflow through system															
	High pressure	Damage to chlorine probe (max 1bar) or flow cell	Accidently closing a manual valve downstream of cell or closed manual valve at outlet CCT	Pressure regulating valve prevents over pressure for instrument flow. NRV in sidestream prevents overpressure from reverse flow. Pressure gauges for service technicians to set and monitor pressue.								Sufficiently trained operators will maintain the plant. Correct sequences to be outlined in O&M manual.							
	Low pressure	N/a																	
	Low level	Damage to probes by cell draining.	UV Pump stops and line drains.	Treated water tank and off spec holding tank entry points are higher than the remiander of the system. Enter above overflow level so syphon not possible.	Confirm safeguard cited is correct	AQ Design Team			Air gap between pump entry point and overflow to be maintained to avoid siphoning	Design	19-Mar-25	Confirmed air gap has been added.							
	High level	Not an issue - designed to be full																	
	High temperature	Not considered a risk in this installation																	
	Low temperature	Improper disinfection	Lower temperature requires higher chlorine CT									Temperature sensor installed in flow cell. CCT defined. Water diverts below set temperature.							
	Composition or changing concentration	Excessive chlorine level could be a hazard to reuse and irrigation. Inadequate chlorine doesn't ensure adequate disinfection	Chlorine demand is not constant. Dosing failure or incorrect setting. Instrument drift. Inadequate maintenance of chlorine probe. Chlorination affected by pH. Chlorine supplied can vary in strength.	Free chlorine analyser monitors chlorine level. Alarms if too high or too low. Monthly calibration & service checks of probe. Periodic microbial test results. Chlorine dosing rates can be monitored and adjusted remotely. Chlorine dosing control can be made sophisticated if required (eg PID loop). Store chlorine away from direct sunlight. Monitor chlorine inventory to ensure minimum practical time on shelf. Chlorine probe reading is compensated using pH measurement from the same flow cell.								Confirmed PID loop incorporated into chlorine dose control. Chlorine stored under a roof to protect from direct sunlight.							
	Start up / shutdown	Start up -unstable dose control. Shutdown - probe issues over time, fail to calibrate. Chlorine residual drops during shutdown	Incorrect PID loop tuning during commissioning Probe drifts off-spec during storage. Natural decay of chlorine	Free chlorine is a CCP and water will be diverted to off spec tank until chlorine is in target range. Operators service and calibrate probe after extended shutdown.															
	Cleaning	Fouling of piping and equipment	Low residual free chlorine or fault online instrument.	Routine servicing and cleaning of strainer. Strainer union ended.															
	Testing	Can't monitor water quality properly	Inadequate number/location of sample points	Sample point adjacent to instrument sidestream to get representative sample.								Confirmed sample points located before and after CCT							
	Maintenance	Unable to safely remove probes for calibration, or remove strainer for cleaning	Poor access and no isolation	Isolation valves on sidestream, and either side of static mixer (union ended).															
	Installation and environment (sun, noise, odour)	CCT pipe skid doesn't fit though room doors	Skid bigger than opening	Doors on building should be large enough. Could be constructed in situ if it is problematic after final building design is determined. Indoor settting so no issues for probes or pipework,								Skid mounted - fabricated off site. Confirmed door sized adequately to allow for installation							
	Isolation	Can't service easily	No isolation points.	Provision for isolation of CCT, sidestream and static mixer.															
Section 4 - Storage (Inclusive of Treated Water and Off-Spec)																			
4a - Treated Water Storage Tank (including process water pumps and recirc loop)	No or low Flow	No issues for tank. Low potable makeup flow causes tank to run dry. Flow is too low for effective mixing. Flow is too low for process water to service equipment. Low flow doesn't let instrumentation get representative readings. Inadequate chloramine dosing.	Makeup water valve failure. Manual valve closed. Failure of recirc or process water pumps. Multiple process units require water simultaneously. Strainer in instrumentation loop blocked. Dosing pumps under sized	Low level switch and transducer indicate low level. Manual override for auto valve (potable). Physical bypass of automatic valve is possible. Flow switch in instrumentation cell to detect no or low flow. Process units don't use water for extended periods so unlikely to occur concurrently. Pump sized appropriately. Process water pump is duty/standby. Strainer readily accessible and maintainable. Tank needs to maintain minimum volume to protect pumps. Radar level transducer not likely to be affected by swirling motion. Level switches are back ups so minor disturbance acceptable. Mount level switches out of direct line of eductor flow. Dosing pumps adequately sized	Consider limit switches for automatic valve, or alarm in PLC if valve is open and flowmeter doesn't indicate flow. This would allow early detection of valve failure. Depending on end use, refil rate etc. this may not be necessary.	Aquacell Design Team			Potable top up valve to be client scope. We can still request position feedback of valve.	Project delivery	19-Mar-25	Position feedback to be specified.							
	High flow	Process water flow too high at point of intended use. High flow through eductors causes "stirring". Exessive chloramine dosing	Process water pump oversized. High supply water pressure combined with requirement for air gap. Dosing pumps over sized	All points of use for process water have a valve that could be used to throttle flow if required. Dosing pumps adequately sized								Both disinfection pumps and process pumps are adequately sized. Disinfection pumps run on VFD to control flow.							
	Reverse flow	Contamination of potable by recycled water. Contamination of Treated Water tank from sewer (or drain line).	Backup in line Sewer line backs up Drain valve left open and drain line backs up and flows into tank	Air gap between tank and potable top up line. RPZ valve on potable line at plant inlet. Check valves on pumps.	Consider the risk of process water contamination from process s - eg, reverse flow from screen. Need to maintain air gaps. Should there be a RPZ?	Aquacell Design Team			Overflow line is lower than tw entry point to avoid siphoning. Air gap from potable top up maintained. RPZ incorporated (client supply).	Design	19-Mar-25	Confirmed.							
	High pressure	Tank damage and/or rupture. Damage to instrumentation or flow cell. Damage to process units using process water.	Overfilling tank and continuing to pump water into tank faster than it leaves.	Air gap provides a vent pipe when tank filling. Pressure regulators on instrumentation side stream. Presure regulators on process units.	Confirm BAC backwash supply line does not need a pressure regulator on it. Should there be a pressure transducer to alarm low and high pressure on the process pumps?	Aquacell Design Team			Pressure transducer to be incorporated into BAC backwash supply to monitor high & low pressure	Design	19-Mar-25	Overflow line adequately sized. Pressure transducer added to BAC backwash supply line.							

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Low pressure	Tank collapse	Pump out faster than air or water can come into tank.	Air gap for makeup provides a vent point.	Confirm the air gap is sufficient venting.	Aquacell Design Team			Confirmed air gap will be sufficient	Design	19-Mar-25								
	Low level	Pump damage. Instrumentation damage. Insufficient supply for process water. Eductors above water line.	Pumping out faster than makeup or incoming treated water.	Low level switch and low level warning on level transmitter. Level set at commissioning to ensure eductors remain covered even at low level.	Confim with manufacturer is there is a minimum level required to be maintained.	Aquacell Design Team			Low level switch & transducer incorporated to protect equipment.	Design	19-Mar-25	Minimum 100mm of water level to be maintained.							
	High level	Tank backs up and overflows at airgap and/or vent.	Failed level switch and transducer. Potable makeup valves fails open.	Peak flows considered at design stage when sizing overflow and vent lines. Some buffering capacity in buffer tank.	Ensure potable makeup valve fails closed. Limit switches on valve. Manual override on valve. Manual isolation on makeup line. Ensure the overflow line is the first point it overflows from.	Aquacell Design Team			As above, position feedback to be provided on top up valve, manual isolation & a bypasss.	Design	19-Mar-25								
	High temperature	Not considered a risk in this location																	
	Low temperature	Not considered a risk in this location.																	
	Composition or changing concentration	Water is out of specification for delivery. Chlorine concentration can vary. Inadequate or exessive total chlorine in treated water	Chlorine out of range . pH out of range. Failure of control system for diversion. Override of CCP. Dosing pump incorrectly sized. Incorrect selection of static mixer.	Upstream diversion to out of spec tank to prevent water reaching tank in first place. Chlorine, Ammonium sulphate to correct chemistry if required. Free chlorine analyser monitors chlorine level. Alarms if too high or too low. Monthly calibration & service checks of probe. Periodic microbial test results. Chlorine dosing rates can be monitored and adjusted remotely. Chlorine dosing control can be made sophisticated if required (eg PID loop). Store chlorine away from direct sunlight. Monitor chlorine inventory to ensure minimum practical time on shelf. Chlorine probe reading is compensated using pH measurement from the same flow cell. Dosing pump correctly sized. Static mixer appropriately selected.														
	Start up / shutdown	Start up -unstable dose control. Pump damage upon start up. Off-spec water	Pumps not primed (air lock). Restoring pump after maintenance and isolations removed.	Treated water tank to be filled with sufficient potable during commissioning to ensure process water pumps can run the plant.															
	Cleaning	Biogrowth over long term	Insufficient free chlorine	Total chlorine residual maintained through QCP's. Periodic inspection to identify bio growth.															
	Testing	Inadequate total chlorine in the treated water.	Failure of some part of treatment process	Critical control points. Monthly microbacterial lab analysis. Sample point prior to treated water entering tank. Sample point on recirc loop.								Water would be diverted to off spec tank in event of any treatment process failure.							
	Maintenance	Pump can't be removed. Instruments can't be repaired or checked.	Not easily accessible	Pumps are external to tank for easy access. Instrumentation readily accessible	Are eductors installed from the top of the tank so they can be removed?	Aquacell Design Team			Select eductor material as SS316 to minimise the possibility of failure & need for replacement.	Design	19-Mar-25								
	Installation	Tank or liner blows away	Wind		Fill tank with water post installation if required.	Aquacell Installation Team			Filling of tank responsibility of tank supplier	Design	19-Mar-25	100mm of water must be available at time of tank commissioning							
	Isolation	Can't isolate	Lack of isolation valves	Every stream can be isolated															
4b - Off Spec Holding Tank	No or Low Flow	Tank could go stagnant. Algal bloom	Contents of tank not aerated and may not be introduced back into the system	Water in tank has been through biological treatment, and likely at least one other process step, eg, UV, Ozone, chlorination. Water quality is likely to be good.	Confirm tank is covered.	Aquacell Design Team			Confirmed	Design	19-Mar-25								
	High Flow	Out of spec inflow tank overflows faster than buffer tank pups can pump out	UV pump running with water out of spec and bio tank at high level.	High level transducer and switch to stop UV pumps. Buffer tank will have some buffering ability.															
	Reverse Flow	Contamination, odour	Reverse flow from off spec tank to treated water tank. Air from bio tank aeration escapes and enters off spec tank via overflow	Air gap at top of tank where out of spec water drops in. Out of spec tank higher than buffer tank so reverse liquid flow not possble. Out of spec water is being returned to the head of the plant for retreatment anyway.	Confirm P-trap in line between buffer tank and off spec tank to prevent odour	Aquacell Design Team			To be added to P&ID	Design	19-Mar-25	NRV added after CCT							
	Low Level	Tank or liner could blow away.	Drain valve leaking. Large surface area, low weight.	Maintain manufactuers minimum water level. Roof on tank. Low level switch to close drain valve	Confirm with manufactuer if there is a minimum water level that must be maintained after installation. Consider loop or standpipe so the tank cannot drain below minimum level.	Aquacell Design Team			Confirm with supplier minimum required water level	Project delivery	19-Mar-25	100mm of water must be available at time of tank commissioning							
	High Level	Overflow	Tank outlet valve failure, UV pumps running	High level transducer and switch in tank. Some buffering capacity in buffer tank.															
	Low Pressure	Tank collapse	Empty tank faster than air can enter	Tank is emptied via gravity rather than being pumped - slower rate.	Confirm the final tank spec has sufficient venting				Confirmed	Design	19-Mar-25								
	High Pressure	Tank damage	Tank is filled faster than air can escape		Confirm the final tank spec has sufficient venting				Confirmed	Design	19-Mar-25								
	Low Temperature	Not considered a risk in this location																	
	High temperature	Not considered a risk in this location																	
	Composition or changing concentration	Algae develops	UV exposure of nutrient rich water.	Roof on tank to avoid UV exposure. The only incoming stream comes from within the plant which can't be more contaminated than plant feed.															
	Cleaning	Tank requires cleaning	Build up of material over time	Water in tank has already been screened and treated. Unlikely to contain foreign materials. Biological growth can be treated with chlorine.	Confirm access hatches available to enter tank if requireced.				Confirmed	Design	19-Mar-25								
	Testing				Is there a reason we may need to test water quality in this tank?	Aquacell Design Team			Sample point to be added.	Design	19-Mar-25								
	Maintenance	Maintaining probes	Difficult to access installed in the top of the tank	Level transducer and switches rarely require service. Tank unlikely to need servicing during service life.	Confirm final mechancial design allows for access for probe replacement	Aquacell Design Team			Access ladder to be provided. Level instruments to be positioned close to ladder	Design	19-Mar-25								
	Installation	Tank is large mechanical construction	Not installed correctly	Engage tank manufacturer to install as they have the correct equipment and competencies								Confirm sufficient access around all tank locations for installation							
	Isolation	Isolatoin to enable confined space entry.	Breakdown or cleaning	Tank feed can be isolated on both treatment trains post CCT piping. No equipment in tank that would require entry for routine servicing.															
Section 5 - Waste (Inclusive of Sludge Dewatering, Overflow and Drains)																			
5a - Sludge Dewatering	No or Low Flow	No or low flow from polymer dosing system. No or low flow from spray water. Poor dewatering from ineffective mixing of polymer.	Faulty Dosing pump. Issue with potable feed	run/alarm signals present in polymer dosing system. Flow switch present on potable make up to polymer dosing system.								Add flow switch to dewatering unit flush line.	AQ Design team	14-Jul-25	Closed				
	High Flow	Flow too high for polymer to dose properly Exceed capacity of dewatering system	Operator error Faulty VFD	VFD to control flow Flowmeter on WAS pump skid															
	Reverse Flow	Reverse flow through process water		NRVs present on all process water lines.															
	Low Level	Low level in polymer dosing	level instrument failure	Flow switch on make up water Level switch on dosing tank.															
	High Level	Skip overflows	Inadequate warning system									Add camera into sludge handling room	AQ design team	14-Jul-25	Closed				
	Low Pressure	Low pressure from compressed air system	Fault with compressed air system									Pressure switch is provided within pneumatic panel by Hydroflux. Show on P&ID	AQ design team	15-Jul-25	Closed				
	High Pressure	High pressure from mono pump	Valve closed	Pressure relief valve on each mono pump															
	Low Temperature	N/A																	
	High temperature	N/A																	
	Composition or changing concentration	Incorrect sludge concentration may impact dewatering Polymer concentration not appropriate.	Wasting frequency not optimal.	Fully automated process. Flowmeter on dewatering line allows us to run for a set period of time to deliver a set SRT. Until process is optimised, periodic pump out of mixed liquir may be required to ensure that MLSS concentration is maintained.															
	Cleaning	Build up of sludge in sludge recirc line	Infrequent operation of process	Potable line to WAS pump skid to flush line after running sludge rescreening. Spray bar included on dewatering unit Doors included on screen to allow for additional manual cleaning if required.															
	Testing	Samples required	Monitor	Sample point included within sludge dewatering unit								Add additional sample point to sample sludge prior to polymer make up. Check whether there is an additional sample line on the dewatering unit subnatant.	AQ design team	14-Jul-25	Closed				
	Maintenance	Maintaining screw prew presss.	Unable to maintain due to access	Sufficient access to maintain screw press in situ. Also sufficient space to lift complete unit outside if required.															
	Installation	Installation of screw press	Unable to install due to limited access	see above															
	Isolation	Unable to isolate any piece of the dewatering process	Inadequate valving	sufficient valves on all equipment to isolate if required. Duty/stand by pump arrangement															
5b - Plumbing Collecting Overflows and Drains	No or low Flow	Odour. Debris build up in screenings pipe	P-traps dry out	Service team discharge periodically to recharge traps	Ensure suitable fall on screenings overflow and other overflows to ensure debris has best chance of being flushed to wet well.	Aquacell Design Team			Ensure sufficient periodic flushing through overflow to avoid drying of debris is incorporated into the program.	Design	19-Mar-25								
	High flow	Fills up wet well which is then transferred into plant	Ingress from rainwater or other upstream source	All floor wastes are internal so no rainwater ingress. Monintoring or logs during rain events to identify possible ingress of storm Water.	Ensure all below ground tanks are correctly sealed and installed in a manner that prevents rain or groundwater access. Similarly, ensure customer is aware the sewerage system should not allow storm water ingressm	Aquacell installation Team. Aquacell Service Team			Emergency overflow tank to be incorporated into the design	Design	19-Mar-25								

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Reverse flow	Flow up through floor wastes	Wet well does not have an overflow	High level indication on wet well would warn of impending situation.	Consider pump out point on wet well for emergency pump out (similar to Llandilo installation)	Aquacell Design Team			Emergency overflow tank to be incorporated into the design. Emergency pump out preocedure to be captured within the RWMP.	Design	19-Mar-25								
	High pressure	Pressurise pipe	Line blocked	No pumped lines so pressure is limited to static head.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Low pressure	Not considered a risk in this installation.																	
	Low level	Not considered a risk in this installation.																	
	High level	Overflow in floor wastes	Blocked line	Screen overflow pipe is 150mm which will allow debris to flow back to wet well. Correct selection of pumps means screen line unlikely to block.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	High temperature	Not considered a risk in this installation.																	
	Low temperature	Not considered a risk in this installation.																	
	Composition or changing concentration	Blocked lines	Unscreened overflow from pre-screeens	Screen overflows 150mm pipe so anything that makes it through the pump should pass down the pipework															
	Start up / shutdown	Odours	Traps dry out if extended shutdown	Manually charge P-traps in the unlikely event there is an extedned shutwdwon.															
	Cleaning	Blockage	Debris in pipes	Pipes practically sized. Scren overflow is the only line likely to have significant debris.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Testing	N/A																	
	Maintenance	Need to clean pipes	Blockage		Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Installation	Outside of scope																	
	Isolation	N/A																	
Section 6 - Chemical dosing																			
17. Chemical Dosing Systems (including storage and handling)	No or low Flow	Water out of specification leading to inadequate treatment, disinfection or cleaning.	Tank empty. Pump is non-operational (lost prime or failed). Crystallisation (caustic in cold weather) in the dosing line causing blockage. Blocked dosing point. Incorrect pump setting. Ruptured line or fitting.	Chlorine and alkalinity dosing has instruments to monitor water quality and alarms for out of spec. water. Level transmitter and low level switches in all dosing tanks. Citric acid is manually dosed and a visual check plus hand held meter checks is sufficient. Peristaltic pumps have provision to add leak detection (cabling and programming) at a later date if needed. Peristaltic pumps being used to where appropriate to reduce the risk of loss of prime.	Run dosing lines with minimum number of joints. Where possible, mount diaphragm pumps with flooded suction. If available use leak detection feature on pump. Consider double contained dosing tube to prevent major leaks.	Aquacell Design Team			Provide dual contained hose where practical. Consider implication of a leak & where chemical would spill in this event.	Design	19-Mar-25								
	High flow	Water out of specification. Damage to membranes during CIP Bunds fill up with rainfall	Venturi effect of injection point is open if NRV fails. Incorrect pump setting (manual) or false instrument reading (auto). Heavy rainfall	Chlorine and alkalinity dosing has instruments to monitor water quality that have alarms for out of spec. water. Transducer values logged which allows chemical consumption rate to be monitored, even remotely. Chemical area covered, so unlikley to impact individual bunds. Ability to safely remove rainwater from concrete bund by manually draining.																
	Reverse flow	Overflow chemical dosing tanks.	Failed check valve or injection point.	Flow through peristatic pump unlikely. Diaphragm pumps have internal check valves. Line sizes are small so backflow, if it could occur, is very low flow. Bund to catch some overflow. Tank level transducer will show high level.	Consider dosing tank high high alarm off transmitter to warn that tank is overfilling.	Aquacell Design Team			Minimal risk as check valves are incorporated high high LS not required.	Design	19-Mar-25								
	High pressure	Dosing tube ruptures. Overpressurised storage tanks	Blocked dosing point or dosing point manually isolated. Vent blocked during filling	PRVs for metering pumps. Dosing tube suitably pressure rated and of correct material. Peristaltic pumps are inherently limited in discharge pressure. Vents cannot be isolated and are adequately sized															
	Low pressure	No chemicals delivered Could create syphon if line pressure is low. Also see "low flow". Vaccum created in storage tanks	Low line pressure or gravity flow arrangement. Peristaltic pump hose clamps insufficiently fastened. Vent blocked during pumping of chemicals	NRVs on injection quills. Vents cannot be isolated and are adequately sized															
	Low level	Dosing pump runs dry and chemistry is affected.	Tank not refilled or leaking tank/fittings.	Low level warning and low low level alarm on each tank. Level transducers and remote monitor. Bunds around tank to prevent spills getting into drains.															
	High level	Overflow tank	Adding too much chemical. Reverse flow from NRV failure	Sight glass on all tanks except for Magnesium Hydroxide. Magnesium Hydroxide is delivered on IBCs and manually filled. Bunds adequately sized for each chemical storage tank	Consider dosing tank high high alarm off transmitter to warn that tank is overfilling.	Aquacell Design Team			Minimal risk as check valves are incorporated high high LS not required.	Design	19-Mar-25								
	High temperature	Eruption of chemical from tank. Chemical degradation during long term storage.	Adding chemical to the wrong tank causing exothermic reaction (hypo + acid) Chemical storage not adequately protected from sunlight	Clear labelling of chemical tanks. Appropriately trained personnel and PPE. Vents cannot be isolated and are adequately sized. Chemical area covered to avoid direct sunlight. Black tanks used to protect from sunlight.															
	Low temperature	Crystallisation of chemical (particularly caustic) can occur at low temperatures.	Outside temperature drops below chemical freezing point	Caustic tank and dosing lines are indoors. 30% concentration to be used to ensure that crystalisation is not an issue. Dual contained hoses adds additional layer of insulation to dosing lines.	Consider if lines need to be insulated. Would double contained dosing line provide better insulation	Aquacell Design Team			Insulation not considered necessary	Design	19-Mar-25								
	Composition or changing concentration	Potential chemical degradation Magnesium hydroxide solidifies Water out of specification.	Chemical degrades with time and is less effective. Settling in the tank (for slurry)	Clear operating instructions. and trained personnel. Inventory control. Proper storage to minimise chemical degredation. PID or other appropriate control loops to control to a setpoint. Mixer for magnesium hydroxide. Stabilised Magnesium Hydroxide formula to be utilised															
	Start up / shutdown	Chemical degradation during long term storage. Crystallisation in lines or loss of pump prime during long periods not running.	Crystallisation of NaOH. Chlorine degrades with time	Check and/or remix chemical after long storage. Flush and check pump operation (e.g. tubing, pump and line primed). Where chemical doses to a setpoint, control system will accommodate to some extent for the change in concentration.															
	Cleaning	Chemical spill during fill	Operator error dosing line splits	All dosing units are in bunds allowing for safe washdown when required. Dual contained hose utilised to ensure that any break in dosing line is returned to bunded area.	Consider rationalisation of dosing pumps to reduce the possibilities of spilllage	AS			Discussions ongoing	Design	19-Mar-25	Reduced the number of pumps by selecting one pump for two trains for CIP, MW, and alkalinity addition.							
	Testing		No access for flow tests.	Level transducers on tank to verify dose rate. Use handheld measuring cylinder (but would require disconnection of pump suction tubing from tank outlet). Instrumentation - pH, Total Cl2 provide feedback. Handheld checks to confirm pH and concentration during MBR CIP can be taken from existing sample valve.	Consider addign additional sample point	AQ Design Team			Sample point added to CIP recirc line	Design	19-Mar-25								
	Maintenance	Pipe blockage Leakage from fittings. Bunds are not kept clean and empty resulting insufficient bund volume	Insufficient preventative maintenance Bunds allowed to fill with water or rubbish, or chemical overspill	Regular planned maintenance as defined in O&M manual Good housekeeping - requires hand pump to flush and pump out bund, or mop up small spills.															
	Installation	Restricted access for maintenance and leak resolution.	Fittings and connections at front are easier to access, but greater risk of exposure from leaks.	Skids assembled off site as much as possible for easy installation Sufficient access has been provided around all equipment to safely install Chemical storage can be easily offloaded due to being located outside of main treatment building.								Try to keep safety shower line underground where practical. Failing that, piping		14-Jul-25					
	Isolation	Inability to isolate for maintenance / Uncontrolled chemical release	Inadequate isolation in design	Sufficient valving arrangements included for mechanical isolation of all pumps Each pump has a separate circuit breaker to allow the pump to be electrically isolated without affecting other pumps															
Section 7 - Pneumatics																			
7a - Pneumatic System	No or Low Flow	Valves slow to actuate. Ozone can't generate fast enough	Condensation limits reciever capacities. Compressor breakdown. Filters blocked. Air lines undersized.	Compressors sized correctly. Duty standby compressors. Dual filter trains allow cleaning without interrupting air supply. Air recievers to smooth peak damand while compressors recover. Autodrain on receiver and compressor. Air lines sized correctly.															
	High Flow	Valves operate to quickly causing damage	Presssure to components is restricted, but flow is not	Typically not a problem, but inline flow controllers can be installed if required.															
	Reverse Flow	Instrument air receiver flow backwards to process air receivers during high process air demand, starving instruments of air.	High process air demand from ozone.	Appropriately sized air receivers and compressors NRV at instrument air receiver.															
	Low Level	N/A																	
	High Level	N/A																	
	Low Pressure	Valves don't actuate, ozone won't generate	Leaks, air line blows off, compressor breakdown Valve incorrectly isolated.	Duty standby compressors. Compressor has pressure switch to cut in at low pressure. Pressure transmitter and pressure switch on receivers to alarm before low supply pressure drops below operating pressures. System has regulators to set specific pressures for different types or equipment. Recievers installed to buffer pressure drop during peak demand	Confirm what controls Ozone system has for low pressure	Aquacell Design Team			D/S compressors. Compressor designed for peak flow. Pressure switches on all pneumatic boxes to detect low pressure. Ozone system has low pressure cut off function which will stop ozone generation.	Design	19-Mar-25								
	High Pressure	Equipment damage. High pressure explosion	Uncontrollled production of compressed air. Compressor pressure too high for equipment	Pressure vessels from reputable supplier. Pressure vessel certificates to confirm appropriate contruction. Relief valves on compressors and receivers. Regulators so pressure can be custom set for each type of equipment	Ensure pressure vessel certificates and relief valve certificates are obtsined during procurement	Aquacell Procurement Team			To be obtained from supplier	Project delivery	19-Mar-25								
	Low Temperature	n/a																	
	High temperature	n/a																	

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Composition or changing concentration	Humidity/Moisture. Oil or other contaminant in air which causes equipment damage	Inherrent in compressed air systems	Each compressor has an air dryer and air goes thorugh a dual filter system prior to distribution. Compressors and receivers have automatic condensate drains.															
	Cleaning	Water on floor from autodrains	Autodrain discharges condensate	Condensate directed to floor drains															
	Testing	Pressure vessel inspection/test	Statutory requirement		If Aquacell service plant, allow for service of compressor and inspection of pressure vessels.	Aquacell Service Team Aquacell Design Team			Adequate service time to be allowed for compressors. Annual inspection to be organised for pressure vessels.	Aquacell Service Team	19/03/2025								
	Maintenance	Breakdown.	Inadequate servicing.	Compressors and dryers to be maintained as per manufacturers recommendation	If Aquacell service plant, allow for service of compressor and inspectino of pressure vessels. Confirm packaged compressor unit has autodrrain to drain reciever	Aquacell Service Team Aquacell Design Team			Confirmed packaged compressor unit will have autodrrain to drain reciever	Design	19/03/2025								
	Installation	Vibration damage Noise	Improper isolation.		Confirm packaged compressor unit has acoutic hood. Confirm if compressor mounted on vibration mounts. Ensure flexible connection from compressor to fixed pipework. Consider adding flexible hose between compressor and rigid piping	Aquacell Design Team			Compressor selection ongoing. Consider rotary screw compressor.	Design	19/03/2025	Rotary screw compressor has been selected. Flexible hose has been added between compressor and rigid piping	Design	14/07/2025	Closed				
	Isolation	Requirement to isolate and discharge stored energy	Service requirement	Isolation points and drain points	Confirm packaged compressor unit has a drain valve to drain receiver	Aquacell Design Team			Confirmed packaged compressor unit will have autodrrain to drain reciever	Design	19/03/2025								
Section 8 - Odour																			
8a. Odour Scrubber	No or Low Flow	Air doesn't move through scrubber. Air not ejected into atmosphere to disipate. Odour complaints.	Carbon compacted or fouled. Blower on scrubber has failed. Upstream valves are closed.	Odour scrubber blower and upstream aerators all have monitored O/L's. Pre-screens are the only vent lines with dampers that can be closed.	Add valve to allow balancing of flow between tanks	Aquacell Design Team						Magnehelic pressure gauge is allowed for with skid mounted odour control unit. Service item to regularly monitor this locally on site.	AQ service team	14/07/2025					
	High Flow	Insufficient contact time with carbon. Odour complaints.	Low level or no carbon	Routine maintenance. Carbon sampling points	Add valve to allow balancing of flow between tanks.	Aquacell Design Team						Valves have been added to allow balancing between tanks.	Aquacell design team	14/07/2025					
	Reverse Flow	Odours escape	Incorrectly commissioned	Commissioning checks to ensure odour control system is installed correctly.															
	Low Level	Insufficient carbon to scrub odours	System not correctly filled	Carbon sampling points. O&M manual to teach operators correct fill level. Routine Maintenance							`								
	High Level	Carbon exhausts to atmosphere	System not correctly filled	Form of carbon used unlikely to be picked up by fan. Carbon sampling points. O&M manual to teach operators correct fill level. Routine Maintenance															
	Low Pressure	Odour scrubber collapses	Upstream valve closed causing blower to suck in scrubber housing.	Fan cannot generate sufficient pressure to collapse housing															
	High Pressure	High pressure is not possible as system is on suction side of blower and system is open to atmosphere. High differential pressure is possible, causing inefficiencies and odours.	Blocked carbon bed or inlet filters	Differential pressure indicator installed. Routine maintenance. Operator training.															
	Low Temperature	Not considered a risk in this location																	
	High temperature	Not considered a risk in this location																	
	Composition or changing concentration	Condensation can develop in vent lines. H2S concentrations exceeds design limits	Atmospheric conditions. Influent characteristics outside of range. Holding times exceeded. Ineffective mixing.	Sample points located on skid for monitoring H2S levels	Ensure all vent lines move uphill from a tank, or drainpoint where condensate can collect and be drained.	Aqaucell Design Team. Aquacell installation team			Confirmed	Design	19/03/2025								
	Cleaning	No specific cleaning requirements																	
	Testing	Test air or carbon quality	Mointor or check performance of unit	Carbon sampling points. Air sampling point.															
	Maintenance	Carbon exhausted and needs to be replaced. Breakdown or service on scrubber's blower.	Carbon is consumable.	Filter is accessible for cleaning.	Can entire system still run if the blower fails?							System will run passively in event of blower failure	AQ design team	14/07/2025	closed				
	Installation	System is difficult to install	Poor design	Skid mounted system located outside of main treatment plant.															
	Isolation	Can't isolate unit	No upstream or down stream valves	Mechanical and electrical isolation provided Minimum maintainable components means thie requirement will be rare.								Consider if bypass to stack is required during maintenance of carbon beds	AQ design team	14/07/2025	Closed (not required)				
9a - Climate change - Physical and Environmental Risks	Increased Rainfall and Flooding	Overflow of sewers Process inefficiencies Risk recycled water ingress into the stormwater network	Climate impacts not considered in tank sizing Climate impacts not considered in process design Climate impacts not considered in irrigation design/sizing	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. Buffer tank (1ML), Off spec holding tank (1ML), Emergency overflow tank (300kL). The combined plant storage capacity will minimise the risk of sewer overflow during periods of increased rainfall. Any change in sewer composition will be monitored and equalised with the buffer tank to minimise the risk of process inefficiency. The plant's peak flow is 3x higher than average flow, in line with Sydney Water's "*Wastewater Treatment Planning Guidelines*". There is sufficient holding time within the treated water tank to store in extreme rainfall events when the the irrigation area is saturated. A comprehensive wet weather management strategy will be implemented. Further information can be found in the Land Capability Assessment and Irrigation Management Plan.																
	Drought and Reduced Water Availability	Insufficient water available for irrigation during drought and reduced water availability	Increased irrigation requirement	Influent generated from within the industrial develepmont rather than relying on rainfall. Treated water storage system is sufficiently sized.															
	Rising Temperatures	Activated sludge process inefficiencies	High aerobic and anoxic temperature reduces the microbial activities	Tank is a large volume, constructed underground from concrete. Influent temperature will remain unaffected. Temperature is monitored at various stages throughout the process, from influent to effluent.															
	Sea Level Rise and Saltwater Intrusion	N/A - plant is approximately 106m above the sea level and so considered not to be an issue when compared with estimated seawater level rises																	
	Extreme Weather Events (Cyclones, Storms, Bushfires)	Damage to OSSM facility	Inadequate design with regard to extreme weather events.	The development is more than 100 m from forest hazards and more than 50 m from grassland hazards. Safe access and egress between the development and the public road system has been allowed for fire-fighters. A defendable space between structures and the bushfire hazard/boundaries has been provided to allow fire-fighters to gain access to all sides of the structures and the bushfire hazard at the boundary. Access to a reticulated water supply (e.g. hydrants) has been incorporated into the design. The building has been designed by structural engineers with consideration of wind loadings as per accepted Australian standards.																
9b - Climate change - Operational and Process Risks	Process Upsets	Uncompliant treated water.	Plant design has not considered variation in influent as a result of climate change.	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. The plant has remote monitoring and control capability to ensure that any deviations in influent can be appropriately managed. Any change in sewer composition will be mointored and equalised with the buffer tank to minimise the risk of process inefficiency. The plant's peak flow is 3x higher than average flow, in line with Sydney Water's "*Wastewater Treatment Planning Guidelines*".																
	Increased Energy Demand	Greenhouse effect Higher operational cost	Higher energy consumption from pumps to deal with high flow during rainfall.	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. Large buffer capacity will allow the process to operate at normal flow even during periods of wet weather. Recycling water at the source mitigates the need for pumping water large distances to the building from the public water supply, and mitigates the need to pump or transfer wastewater large distances for treatment.															
	Biosolids Management Challenges	Odour Higher waste sludge transportation and treatment cost	Open sludge area resulting in rainwater ingress leading to higher sludge volume	Sludge handling is located inside the shed. Advanced sludge dewatering unit to minimise sludge volumes															
9c - Climate change - Financial and Economic Risks	Higher O&M Costs	Financial viability of scheme becomes questionable.	Increased operating costs due to climate change	Robust financial planning assessment has been completed to ensure that maintenance costs remain viable. 10 year cashflow forecast has been provided allowing for CPI increases. Specific fees and usage rates can be adjusted if required.															
	Capital Investment Needs	Upgrades required to treatment plant	Insufficient redundency in design to accommodate changes	Sufficient storage and process capacity has been considered within the treatment plant. Both CAPEX and OPEX costs have been considered															
9d - Climate change - Social and Reputational Risks	Public Health Risks	Disease Transmission via Pathogens	Inadequate controls of recycled water quality	A comprehensive RWQMP has been developed to implement critical and quality control points to ensure adequate pathogen reduction. Any uncompliant water will be diverted to off spec tank for furter treatment.															

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Community Complaints	Odour Noise Vibration	Increased plant loaded resulting in poor plant performance.	Plant has been sufficiently sized to handle varying load to climate change Environmental impact studies have been conducted and found that no significant risks will be present.															

Appendix 5 – WICA Scheme Approval to Install - pending

Appendix 6 – Aquacell Sampling Procedure

Sampling Work Instructions

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Revision	Date	Author	Amendments
2	11/05/21	Tass Meli	Full update to include new sample preparation requirements and better specify sample point disinfection process

MR160-2
Revision 2, 11 May 2021
Sampling Work Instructions

Process Step	Onsite Sampling
Objectives	The following procedure will be followed when sampling process or recycled waters from Aquacell wastewater treatment facilities that will undergo analytical quality testing including microbiological tests (typically E.coli or Faecal Coliforms). • To collect samples for physical, chemical or microbiological analysis by an external laboratory • Ensure proper sampling techniques are followed
Management Strategy	Aquacell greywater/blackwater treatment and water recycling plants are verified for effective performance on commissioning as required by the local regulator (eg: NSW Health) and/or to validate design performance. Ongoing monitoring via regular sampling is generally required in order to comply with regulations and ensure no health risks are present in recycled water reuse applications The ongoing operational performance of the system is monitored to ensure efficient operation and to protect human health and the environment. When out of specification results occur, they are addressed via the corrective action specified under the appropriate site management plan.
Health and Safety requirements	Biological hazards may be present in process waters. Use gloves safety glasses and protective clothing when sampling. Safely store the alcohol & lighter used for sample point disinfection. Make sure that you have conducted the site hazard assessment before commencing.

Process Step	Onsite Sampling
Actions – off-site preparation	Prior to the commencement of sampling; 1. Obtain sufficient sealed and unused sample bottles as provided by the testing laboratory (eg; Envirolab, ALS). Note: Microbiological sampling bottles are usually 250mL. They are supplied prestrerilised and will contain a tiny amount of Sodium Thiosulphate solution as a preservative so it is normal for moisture to be present in the sample bottle and it must be unopened until sampling. Other sample bottles vary in size (up to 1000mL) and material according to the requirements of the analysis but will be plastic in almost all applications. Larger 15L or 20L carboys may be required for Cryptosporidium of Giardia testing in infrequent test 2. Place the sample bottles in a suitable clean cool storage or esky. Carry additional sample bottles in case resampling or extra samples become necessary. 3. Place frozen freezer blocks in the esky or obtain ice or other cooling medium for the esky once samples are taken - in order to keep samples cool during transport to the laboratory. Larger or carboy sample containers are to be kept out of the sun 4. Prepare a standard chain of custody (COC) form for each sampling site. These are printed from files stored on the Aquacell server at *S:\Aquacell Service\01 Admin\Sampling results - consolidated (use S folder for ongoing monitoring)\COC* 5. Ensure you have alcohol (spray or disinfectant wipes) for cleaning the sample point 6. Ensure you have gloves, safety glasses and any other required site PPE

Actions – On-site sampling	Sampling should be done at the end of site service visits to minimise the holding time prior to sample delivery. 7. Locate the correct sampling point(s). Greywater/blackwater influent sample will be collected from the appropriate sample points. For treated water, the sample point will be a dedicated valve and open line on the recirculation loop. (Note: If no sampling point is available, treated water may be sampled directly from the filtrate discharge to the filtrate pit (eg: Kurrajong) If no direct sampling point is available and a secondary sample container is to be used to dip in tanks or other sampling method, ensure it is clean and disinfected prior to use. If applicable sample collection devices will be rinsed with ethanol then water then dried (sample container for effluent and sample bailer or peristaltic pump for influent). 8. Check that the sample point is visually clean. If not, dismantle and clean the sample point and reassemble before sampling. 9. Complete the sample bottle label including the date and time. The sample description should state the site name. 10. Wear disposable gloves and safety glasses when sampling. 11. If any micro samples are to be taken, these should be taken first. Sample via the installed sample point after disinfecting as follows; - Fully open the sample tap and allow water to flow for 10-20 seconds. This purges the sample line with fresh sample - Close the sample tap - Spray or soak the sample pipe with alcohol. Ensure the open pipe tip is well covered with alcohol. If the sample pipe is metal flame off the alcohol by quickly striking a lighter near the alcohol-soaked sample pipe. Otherwise allow alcohol to evaporate. 12. Open the sample tap and set to flow at a flowrate suitable for sample collection. Flow should be fast enough to ensure quick sample bottle filling in 3-5 seconds but not too fast such that sample splashes out of the sample bottle. 13. Hold the unopened sample bottle close to the sample flow and carefully and quickly open the lid. Keep hold of the lid without touching the inside surface. Keep the lid face down while sampling. 14. Quickly place the sample bottle under the sample stream and fill to approximately 10-20mm from the top rim. Do not rinse out or overfill the sample bottle as this will reduce or remove the preservative in the bottle. 15. Quickly place the lid back on the bottle and tighten securely ensuring the lid is not cross-threaded. 16. If you suspect sampling has not been carried out correctly, discard the sample and retake the sample in a new unused sample bottle.

Process Step	Onsite Sampling
	17. If other sample bottles are required to be filled for non-microbiological testing (such as BOD, TSS, TN, TP) these should now be taken. Micro samples should be taken first. 18. Place all sample bottles into the esky with ice bricks or ice as planned to keep samples cool. 19. Promptly deliver samples to the laboratory on the day of sampling. The chain of custody form(s) will be kept with the sample esky and final notes completed when samples are delivered to laboratory receival point staff.
Corrective action	Depending on the analysis, test results will be available in 2-8days following sampling. BOD or micro tests such as E.coli and Coliforms will generally require 5 – 8 days before sample results are available. If treated water test results do not comply with site critical specifications once received, immediately divert the treated water supply and take other response actions and notifications as required in the site management plan. Arrange for resampling and analysis as soon as possible. Investigate the cause of out of specification samples and implement remedial action as required.
Equipment	PPE; gloves, safety glasses, alcohol solution, lighter Sample bottles as specified by the laboratory. (Note that laboratories will generally accept each other's micro sample bottles if necessary.)
Reporting	Laboratories will provide sample results by email. Details of results of analytical testing must be maintained. Save sample certificates of analysis (COA) in the site service "Monitoring" folder when received. Record routine site service results in the results file stored on the Aquacell server at *S:\Aquacell Service\01 Admin\Sampling results - consolidated (use S folder for ongoing monitoring)* .

Appendix 7 – WICA Retailer Licence

Water Industry Competition Act 2006

Schedule 4, clause 10

Notice of decision – Grant of retailer licence

Licence No. 25_009R

The Independent Pricing and Regulatory Tribunal (**IPART**) grants Aquacell Pty Ltd (ACN 072 487 015) a retailer licence under Schedule 4, clause 10(1) of the *Water Industry Competition Act 2006* (**Act**).

The retailer licence takes effect on 1 March 2025.

In considering whether to grant the retailer licence and what conditions to impose on the licence, IPART had regard to the objects in sections 2A and 5A of the Act.

The retailer licence is attached.

23/01/2025

X

Signed by: carmel.donnelly@ipart.nsw.gov.au

Carmel Donnelly PSM
Chair
On behalf of the Independent Pricing and Regulatory Tribunal

IPART acknowledges the Traditional Custodians of the lands where we work and live. We pay respect to Elders both past and present. We recognise the unique cultural and spiritual relationship and celebrate the contributions of First Nations peoples.

New South Wales Government

Water Industry Competition Act 2006 (NSW)

Retailer Licence no. 25_009R

Aquacell Pty Ltd

(ACN 072 487 015)

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RETAILER LICENCE

Water Industry Competition Act 2006

Licence Authorisation Table

Licensee	Aquacell Pty Ltd ACN 072 487 015
Licence number	25_009R
Version history	Current licence in force since: 1 March 2025. Details about grant, variation, replacement, cancellation or surrender of this licence are set out in Schedule A.
Authorised activities (the Act, s 8F(a))	Sale of water and/or sewerage services.
Authorised maximum scale (the Act, s 8F(b))	249 customer premises per scheme (Category R1)

LICENCE TERMS

1. Grant and authorisation

1.1 The Independent Pricing and Regulatory Tribunal grants this licence under the Act, Schedule 4, clause 10(1).

Note: This licence is deemed to be a licence granted under section 8C of the Act.

1.2 The licensee is authorised to carry out the authorised activities in connection with the schemes for which the licensee is the registered retailer that do not exceed the authorised maximum scale.

Note: This clause authorises the licensee to carry out certain activities that would otherwise be prohibited under section 6B of the Act. This authorisation does not exempt the licensee from obligations under other laws unless expressly provided by those laws.

2. Licence conditions

The licensee must comply with the standard licence conditions specified in Schedule B, Item B2 and the special licence conditions specified in Schedule B, Item B3.

Note: The licensee must also comply with conditions specified in the Act and Regulations.

3. Interpretation

3.1 Expressions used in this licence that are defined in the Act or Regulations have the meanings set out in the Act or the Regulations unless the context otherwise requires.

3.2 In this licence, unless the context otherwise requires:

a. the singular includes the plural and vice versa,
b. a reference to this licence includes any schedule to this licence,
c. a reference to a schedule is to a schedule to this licence, and
d. explanatory notes and headings do not form part of this licence, but in the case of uncertainty may be relied on for interpretation purposes.

3.3 In this licence:

Act means the *Water Industry Competition Act 2006*.

authorised activities mean the activities specified in the licence authorisation table.

authorised maximum scale means the maximum scale of schemes specified in the licence authorisation table.

licensee means the person specified in the licence authorisation table.

Regulations means any regulations made under the Act.

Schedule A Version History

Current licence in force since	1 March 2025
Original grant date	2 February 2010
Transition date	Transitioned licence granted under the Act, Schedule 4, cl. 10(1) on: 1 March 2025
Variation history	Varied under the Act, s. 10 or s. 15 (now repealed) on: • 21 July 2014, • 26 July 2015, • 31 January 2018, • 1 November 2020. Varied under the Act, s. 8M on: Not applicable
Replacement history	Not applicable
Cancellation or surrender	Not applicable

Schedule B Licence Conditions

Item B1 Interpretation

1.1.1 In this schedule:

reporting manual means a document published on IPART's website from time to time setting out notification, information, consultation and reporting requirements for licensed retailers.

1.1.2 If any condition, or part of any condition, is unlawful, that condition, or part of the condition, is severable and does not affect the validity of the licence or the balance of the conditions or condition.

Item B2 Standard licence conditions

B2.1 Maintaining appropriate insurance

2.1.1 The licensee must hold insurance of an appropriate type, scope and limit for the activities it carries out under this licence.

2.1.2 The licensee must provide a copy of each certificate of currency of the insurance held by the licensee to IPART in accordance with the reporting manual.

2.1.3 The licensee must notify IPART in accordance with the reporting manual of a change to:

(a) the insurer or underwriters for an insurance policy held by the licensee; or

(b) the type, scope or limit of insurance held by the licensee.

2.1.4 The licensee must provide a report to IPART in accordance with the reporting manual from an insurance expert certifying that in the insurance expert's opinion the type, scope and limit of the insurance held by the licensee is appropriate for the activities the licensee carries out under this licence:

(a) before commencing to supply water or sewerage services to a scheme; or

(b) when requested by IPART.

2.1.5 In this condition B2.1, **insurance expert** means an insurance broker that holds an Australian financial services licence under Part 7.6 of the *Corporations Act 2001* (Cth) that authorises the broker to provide financial product advice for, and deal in, contracts of insurance within the meaning of Chapter 7 of that Act.

Note: The circumstances in which IPART may request the licensee provide a report under condition 2.1.4 include (but are not limited to) the following:

- where IPART considers that there may have been or may be a change in the type, scope or limit of the insurance held by the licensee; or
- where IPART considers that there may have been or may be a change in the activities the licensee carries out under this licence; or
- where IPART or an approved auditor considers that the type, scope or limit of the insurance held by the licensee may not be appropriate for the activities the licensee carries out under this licence.

B2.2 Complying with audit guidelines

2.2.1 The licensee must undertake audits of its authorised activities in accordance with any audit guidelines issued by IPART and published on IPART's website.

B2.3 Reporting in accordance with the reporting manual

2.3.1 The licensee must prepare and submit the following reports in accordance with the reporting manual:

(a) an annual compliance report, including:

(i) the extent to which the licensee has or has not complied with the Act, the Regulations, this licence and approvals;

(ii) for each failure to comply with the Act, Regulations, this licence or an approval:

a. the particulars of the non-compliance;

b. the reasons for the non-compliance;

c. the actions taken, or to be taken, to mitigate the effects of the non-compliance or to prevent a recurrence of the non-compliance;

(b) reports on performance indicators and other data specified in the reporting manual; and

(c) any other report required by the Act, the Regulations, this licence or an approval.

2.3.2 The licensee must give notices and provide information required by the Act, the Regulations, this licence or an approval in accordance with the reporting manual.

B2.4 Infrastructure to be used

2.4.1 The licensee must only source and supply water by means of water industry infrastructure if that water industry infrastructure is maintained and operated by a licensed operator under the authority of its operator licence or a public water utility.

2.4.2 The licensee must only provide sewerage services by means of water industry infrastructure if that water industry infrastructure is maintained and operated by a licensed operator under the authority of its operator licence or a public water utility.

B2.5 Delineating responsibilities under a code of conduct

2.5.1 The licensee must establish, and provide to IPART, a code of conduct for each scheme for which it is the registered retailer:

(a) before commencing to supply water or sewerage services to a scheme; or

(b) by another date nominated by the licensee and approved by IPART.

2.5.2 Subject to condition 2.5.3, the licensee must obtain agreement to the code of conduct from:

(a) the registered operator for the scheme; and

(b) each licensed operator, licensed retailer and public water utility that:

(i) supplies water or provides sewerage services in the same area of operations as the scheme (unless advised otherwise by IPART in writing); or

(ii) constructs, maintains or operates any water industry infrastructure that is connected to the licensee's water industry infrastructure.

2.5.3 The code of conduct must set out the roles and responsibilities of the entities specified in condition 2.5.2, including by specifying as relevant:

(a) who is responsible for repairing, replacing or maintaining the water industry infrastructure;

(b) who is liable in the event of the unavailability of water;

(c) who is liable in the event of failure of the water industry infrastructure;

(d) who is responsible for sharing information and data and in what circumstances;

(e) who is responsible for communicating with customers or dealing with customer complaints and how complaints will be handled;

(f) who is responsible for managing incidents and how incidents will be managed;

(g) who is responsible for managing water quality and preventing cross-connections; and

(h) who is liable for the fees and charges payable in respect of the use of the water industry infrastructure.

2.5.4 The licensee must comply with its obligations and responsibilities under the code of conduct.

2.5.5 Where the licensee has established a code of conduct in accordance with clause 7 of Schedule B to Licence No. 09_004R granted under section 10 of the Act (now repealed), that code of conduct is deemed to:

(a) have been established in accordance with condition 2.5.1; and

(b) comply with conditions 2.5.2 and 2.5.3, until it is first amended or replaced following the grant of this licence.

2.5.6 In this condition B2.5, code of conduct means a utility service agreement or other agreement or document, however described, that includes a protocol for dealing with the matters set out in condition 2.5.3, as relevant.

Note: The objective of a code of conduct is to minimise risks to public health, safety and customers through the establishment of a protocol of efficient and effective day-to-day working arrangements between the licensee and a public water utility, licensed operator or licensed retailer in relation to the matters covered by the code, which include information sharing and handling customers, incidents or other events.

B2.6 Notification of supply of water or provision of sewerage services

2.6.1 Within 10 days after commencing to supply water to a scheme under this licence, the licensee must notify IPART in accordance with the reporting manual that it has commenced supplying water to customers of the scheme.

2.6.2 Within 10 days after commencing to provide sewerage services to a scheme under this licence, the licensee must notify IPART in accordance with the reporting manual that it has commenced supplying sewerage services to customers of the scheme.

Item B3 Special licence conditions

B3.1 [Not applicable]

Appendix 8 – WICA Operator Licence

New South Wales Government

Water Industry Competition Act 2006 (NSW)

Operator Licence no. 25_008

Aquacell Pty Ltd

(ACN 072 487 015)

Contents

Schedule A Version History

Schedule B Authorised Classes and Authorised Maximum Scales

Schedule C Licence Conditions

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OPERATOR LICENCE

Water Industry Competition Act 2006

Licence Authorisation Table

Licensee	Aquacell Pty Ltd ACN 072 487 015
Licence number	25_008
Version history	Current licence in force since: 17 July 2025 Details about grant, variation, replacement, cancellation or surrender of this licence are set out in Schedule A.
Authorised activities (the Act, s 8E(a))	Construction and operation of water industry infrastructure.
Authorised classes (the Act, s 8E(b))	The classes specified in Schedule B.
Authorised maximum schemes (the Act, s 8E(c))	10 schemes.
Authorised maximum scale (the Act, s 8E(d))	The scale specified for each class in Schedule B.

LICENCE TERMS

1. Grant and authorisation

1.1 The Independent Pricing and Regulatory Tribunal granted this licence under the Act, Schedule 4, clause 10(1).

Note: This licence is deemed to be a licence granted under section 8C of the Act.

1.2 The licensee is authorised to carry out the authorised activities in connection with water industry infrastructure for which the licensee is the registered operator that:

a. is of an authorised class,
b. has a design capacity that does not exceed the authorised maximum scale, and
c. does not exceed the authorised maximum schemes.

Note: This clause authorises the licensee to carry out certain activities that would otherwise be prohibited under sections 6 and 6A of the Act. This authorisation does not exempt the licensee from obligations under other laws unless expressly provided by those laws.

2. Licence conditions

2.1 The licensee must comply with the standard licence conditions specified in Schedule C, Item C2 and the special licence conditions specified in Schedule C, Item C3.

Note: The licensee must also comply with conditions specified in the Act and Regulations.

3. Interpretation

3.1 Expressions used in this licence that are defined in the Act or Regulations have the meanings set out in the Act or the Regulations unless the context otherwise requires.

3.2 In this licence, unless the context otherwise requires:

a. the singular includes the plural and vice versa,
b. a reference to this licence includes any schedule to this licence,
c. a reference to a schedule is to a schedule to this licence, and
d. explanatory notes and headings do not form part of this licence, but in the case of uncertainty may be relied on for interpretation purposes.

3.3 In this licence:

Act means the *Water Industry Competition Act 2006*.

authorised activities mean the activities specified in the licence authorisation table.

authorised class means the class specified in the licence authorisation table.

authorised maximum scale means the maximum scale of schemes specified in the licence authorisation table.

authorised maximum schemes means the maximum number of schemes specified in the licence authorisation table.

design capacity means the capacity of the class of infrastructure as determined in accordance with the document as in force from time to time entitled *Design Capacity Guidelines*, issued by IPART and published in the Gazette and on IPART's website.

licensee means the person specified in the licence authorisation table.

Regulations means any regulations made under the Act.

Schedule A Version History

Current licence in force since	17 July 2025
Original grant date	26 July 2015
Transition date	Transitioned licence granted under the Act, Schedule 4, cl.10(1) on: 1 March 2025
Variation history	Varied under the Act, s. 10 or s. 15 (now repealed) on: • 1 November 2020 • 26 July 2021 Varied under the Act, s. 8M on: • 17 July 2025
Replacement history	Not applicable
Cancellation or surrender	Not applicable

Schedule B Authorised Classes and Authorised Maximum Scales

Authorised classes of water industry infrastructure	Scale category	Parameter	Maximum Scale
Infrastructure for the purpose of the collection and treatment of sewage for disposal and the disposal of the treated sewage.	H3	Sewage processing capacity (kL/day)	900
Infrastructure for the purpose of the collection and treatment of sewage for the production, supply and use of recycled water.	D3	Sewage processing capacity (kL/day)	900

Schedule C Licence Conditions

Item C1 Interpretation

1.1.1 In this schedule:

NSW Health means the Department of the Public Service responsible to the Minister administering the *Public Health Act 2010*.

reporting manual means a document published on IPART's website from time to time setting out notification, information, consultation and reporting requirements for licensed operators.

1.1.2 If any condition, or part of any condition, is unlawful, that condition, or part of the condition, is severable and does not affect the validity of the licence or the balance of the conditions or condition.

Item C2 Standard licence conditions

C2.1 Maintaining appropriate insurance

2.1.1 The licensee must hold insurance of an appropriate type, scope and limit for the activities it carries out under this licence.

2.1.2 The licensee must provide a copy of each certificate of currency of the insurance held by the licensee to IPART in accordance with the reporting manual.

2.1.3 The licensee must notify IPART in accordance with the reporting manual of a change to:

(a) the insurer or underwriters for an insurance policy held by the licensee; or

(b) the type, scope or limit of insurance held by the licensee.

2.1.4 The licensee must provide a report to IPART in accordance with the reporting manual from an insurance expert certifying that in the insurance expert's opinion the type, scope and limit of the insurance held by the licensee is appropriate for the activities the licensee carries out under this licence:

(a) before commencing to operate water industry infrastructure for a scheme under an operational approval; or

(b) when requested by IPART.

2.1.5 In this condition C2.1, **insurance expert** means an insurance broker that holds an Australian financial services licence under Part 7.6 of the *Corporations Act 2001* (Cth) that authorises the broker to provide financial product advice for, and deal in, contracts of insurance within the meaning of Chapter 7 of that Act.

Note: The circumstances in which IPART may request the licensee provide a report under condition 2.1.4 include (but are not limited to) the following:

- where IPART considers that there may have been or may be a change in the type, scope or limit of the insurance held by the licensee; or
- where IPART considers that there may have been or may be a change in the activities the licensee carries out under this licence; or
- where IPART or an approved auditor considers that the type, scope or limit of the insurance held by the licensee may not be appropriate for the activities the licensee carries out under this licence.

C2.2 NSW Health requirements

2.2.1 The licensee must consult with NSW Health each time it develops or proposes to make a material change to any of the following:

(a) a water quality management system for water industry infrastructure constructed or operated by the licensee for drinking water or recycled water, including:

(i) a detailed risk assessment; or

(ii) a technology assessment;

(b) a sewage management plan or system for water industry infrastructure constructed or operated by the licensee for the disposal of treated effluent, including a detailed risk assessment;

(c) a protocol to notify NSW Health of health-related incidents or complaints relating to drinking water, recycled water, non-potable water or treated effluent, as applicable.

2.2.2 The licensee must provide NSW Health with a copy of any report on an operational approval application audit under section 7E(2) of the Act at the same time it provides the report to IPART.

2.2.3 The licensee must provide documents to and consult with NSW Health in accordance with the reporting manual.

Note: Condition C2.7 requires the licensee to notify NSW Health when it commences operating water industry infrastructure.

C2.3 Complying with audit guidelines

2.3.1 The licensee must undertake audits of its authorised activities in accordance with any audit guidelines issued by IPART and published on IPART's website.

C2.4 Reporting in accordance with the reporting manual

2.4.1 The licensee must prepare and submit the following reports in accordance with the reporting manual:

(a) an annual compliance report, including:

(i) the extent to which the licensee has or has not complied with the Act, the Regulations, this licence and approvals;

(ii) for each failure to comply with the Act, Regulations, this licence or an approval:

a. the particulars of the non-compliance;

b. the reasons for the non-compliance;

c. the actions taken, or to be taken, to mitigate the effects of the non-compliance or to prevent a recurrence of the non-compliance;

(b) reports on performance indicators and other data specified in the reporting manual; and

(c) any other report required by the Act, the Regulations, this licence or an approval.

2.4.2 The licensee must give notices, undertake consultation, and provide information required by the Act, the Regulations, this licence or an approval in accordance with the reporting manual.

C2.5 Monitoring

2.5.1 The licensee must undertake any monitoring that is required for the purposes of any of the following plans or systems, as applicable to the licensee's schemes, in accordance with this condition C2.5:

(a) water quality management system;

(b) sewage management plan or system.

2.5.2 The licensee must keep the following records of any samples taken for monitoring purposes:

(a) the date on which the sample was taken;

(b) the time at which the sample was collected;

(c) the point or location at which the sample was taken; and

(d) the chain of custody of the sample (if applicable under the relevant plan or system).

2.5.3 The licensee must ensure that analyses of all samples taken for the purposes of verification monitoring are carried out by a laboratory accredited for the specified tests by the National Association of Testing Authorities or an equivalent body that is acceptable to NSW Health.

2.5.4 In this condition C2.5, **verification monitoring** means verification monitoring as described in the national safety guidelines, as applicable.

C2.6 Delineating responsibilities under a code of conduct

2.6.1 The licensee must establish, and provide to IPART, a code of conduct for each scheme for which it is the registered operator:

(a) before commencing to operate the scheme's water industry infrastructure under an operational approval; or

(b) by another date nominated by the licensee and approved by IPART.

2.6.2 Subject to condition 2.6.3, the licensee must obtain agreement to the code of conduct from:

(a) the registered retailer for the scheme; and

(b) each licensed operator, licensed retailer and public water utility that:

(i) supplies water or provides sewerage services in the same area of operations as the scheme (unless advised otherwise by IPART in writing); or

(ii) constructs, maintains or operates any water industry infrastructure that is connected to the licensee's water industry infrastructure.

2.6.3 The code of conduct must set out the roles and responsibilities of the entities specified in condition 2.6.2, including by specifying as relevant:

(a) who is responsible for repairing, replacing or maintaining the water industry infrastructure;

(b) who is liable in the event of the unavailability of water;

(c) who is liable in the event of failure of the water industry infrastructure;

(d) who is responsible for sharing information and data and in what circumstances;

(e) who is responsible for communicating with customers or dealing with customer complaints and how complaints will be handled;

(f) who is responsible for managing incidents and how incidents will be managed;

(g) who is responsible for managing water quality and preventing cross-connections; and

(h) who is liable for the fees and charges payable in respect of the use of the water industry infrastructure.

2.6.4 The licensee must comply with its obligations and responsibilities under the code of conduct.

2.6.5 Where the licensee has established a code of conduct in accordance with condition 8 of Schedule B to Licence No. 15_032 granted under section 10 of the Act (now repealed), that code of conduct is deemed to:

(a) have been established in accordance with condition 2.6.1; and

(b) comply with conditions 2.6.2 and 2.6.3, until it is first amended or replaced following the grant of this licence.

2.6.6 In this condition C2.6, **code of conduct** means a utility service agreement or other agreement or document, however described, that includes a protocol for dealing with the matters set out in condition 2.6.3, as relevant.

Note: The objective of a code of conduct is to minimise risks to public health, safety and customers through the establishment of a protocol of efficient and effective day-to-day working arrangements between the licensee and a public water utility, licensed operator or licensed retailer in relation to the matters covered by the code, which include information sharing and handling customers, incidents or other events.

C2.7 Notification of commencing operation of water industry infrastructure

2.7.1 Within 10 days after commencing to operate water industry infrastructure for a scheme under an operational approval or variation to an operational approval, the licensee must notify the following entities that it has commenced operating the infrastructure in accordance with the reporting manual:

(a) IPART;

(b) NSW Health;

(c) any public water utility operating in the area of operations of the scheme; and

(d) the local council in which the scheme is located.

C2.8 Notification of material change to plans or systems

2.8.1 If a material change is made to the licensee's asset management plan or system, water quality management system, or sewage management plan or system, the licensee must notify IPART within 10 days in accordance with the reporting manual.

C2.9 Notification of non-compliant plumbing

2.9.1 If the licensee becomes aware that a customer's plumbing is not code compliant, the licensee must within 10 days:

(a) notify the customer of that fact; and

(b) where the plumbing that is not code compliant threatens, or could threaten, water quality, public health or safety, also notify the plumbing regulator of that fact.

2.9.2 In this condition C2.9:

(a) **code compliant** has the meaning given to that term under the *Plumbing and Drainage Act 2011*;

(b) **plumbing** means any pipe, fitting or apparatus that is located:

(i) downstream of a customer's connection point to a water main that is part of the licensee's water infrastructure;

(ii) upstream of a customer's connection point to a sewer main that is part of the licensee's sewerage infrastructure; or

(iii) upstream of a customer's connection point to a stormwater drain that is part of the licensee's water infrastructure; and

(c) **plumbing regulator** has the meaning given to that term under the *Plumbing and Drainage Act 2011*.

Note: Without limiting condition 2.9.1(b), an example of plumbing that is not code compliant which must be notified to the plumbing regulator, is plumbing through which non-potable water can come into contact with drinking water.

Item C3 Special licence conditions

C3.1 [Not applicable]

C3.2 [Not applicable]

Appendix 9 – Plumbing Audit (Cross Connection Audit) - pending

Appendix 10 – Verification Report - pending

Appendix 11 – Operation and Maintenance Manual - pending

Appendix Q20.2 Aquacell Integrated Management System

Aquacell operates under an Integrated Management System (IMS) that governs all aspects of its business operations. The IMS has undergone multiple external audits by regulatory bodies including IPART, local councils, EPA Victoria and other relevant authorities. The scope of the IMS demonstrates Aquacell's ongoing commitment to regulatory compliance, quality assurance, environmental stewardship, and occupational health and safety. The table of contents below showing the areas of the business covered by the IMS.

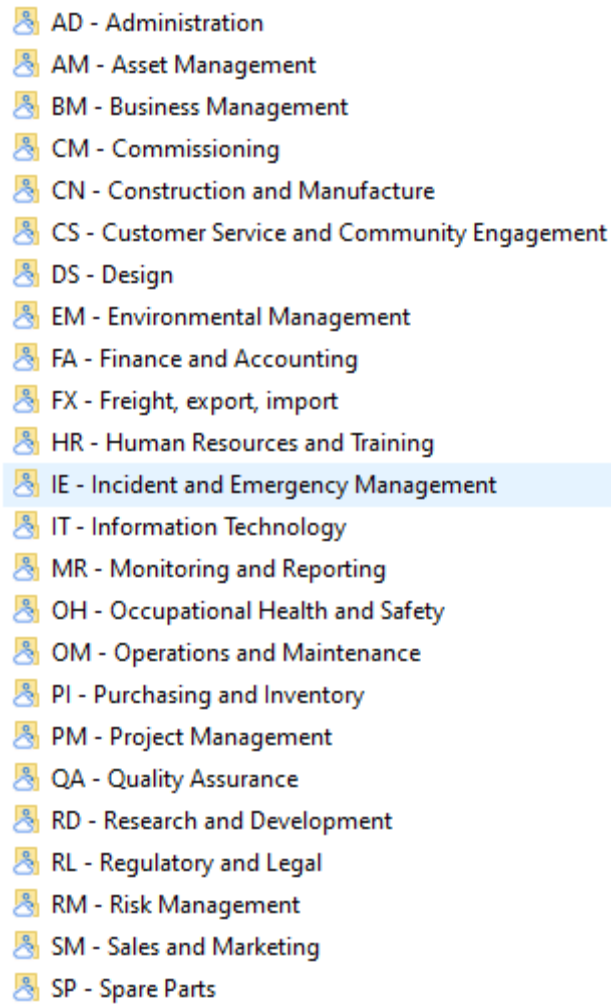


Figure 1 – IMS Table of Contents

Aquacell has implemented a set of Occupational Health and Safety (OHS) policies, which have been effectively applied in the field for over two decades. These policies support a proactive safety culture and ensure the wellbeing of personnel across all operational activities. The structure and contents of the OHS documentation, as maintained within Aquacell's IMS, are presented in Figure 2.

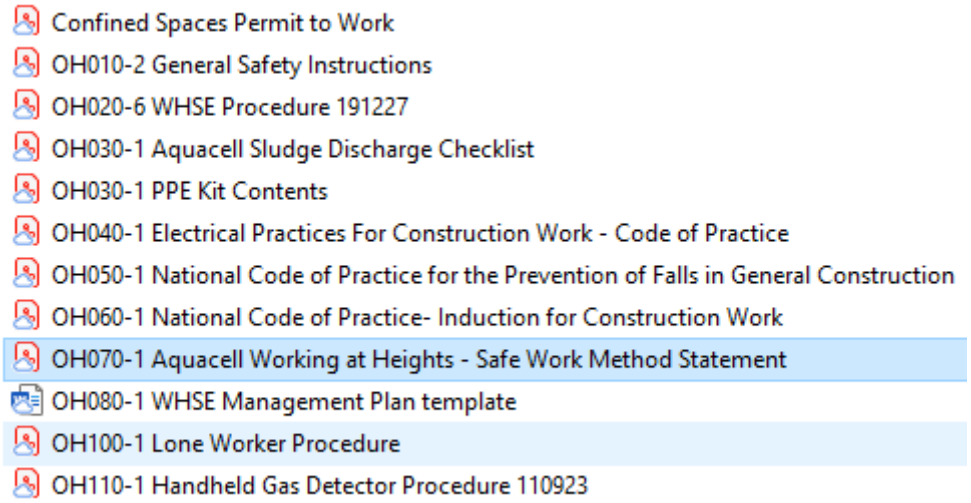


Figure 2 – IMS Safety subfolder document register

Appendix Q20.3

aquacell water recycling

CAPABILITY STATEMENT

Mother nature *accelerated*

Water has recycled naturally for billions of years. But in the last few decades, Aquacell has accelerated and perfected the process for private and public entities across the world. We're proven innovators of water recycling technology, experts in global water recycling regulations and passionate designers of integrated water recycling systems.

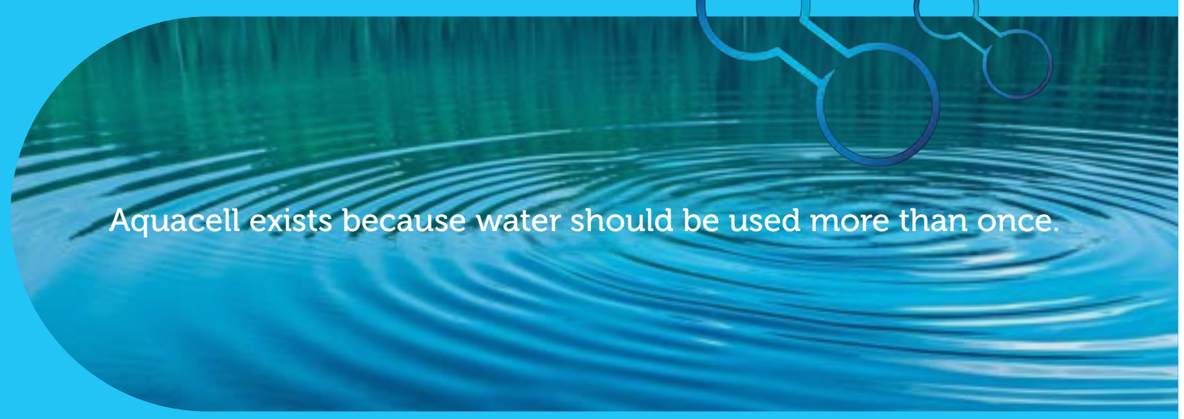
When we began nearly three decades ago, there were no genuine solutions out there. No workable systems. No emerging technologies. What was obvious to us then, and has become plainly evident to all now, was that the world's exponential population growth would soon place enormous pressure on finite water resources and the centralised systems to manage them. Smart solutions to make water re-usable fast were going to be needed in the future, so at Aquacell, we stepped up to deliver.

From humble, but passionate beginnings, Aquacell has evolved into the pre-eminent authority in water recycling around the world with state-of-the art systems being designed and built by our team in our own factories for a spectrum of public and private projects. Our sharp commercial focus and collaborative working approach are non-negotiables within every project we undertake.

That we manage and operate our own systems gives us a vital feedback loop to continually improve and innovate. That we are front and centre with regulatory requirements gives us the expertise to advise, represent and advocate.

To use the water we have more than once at least doubles our water supply. That part is obvious and simple. What isn't obvious and simple is the complex technology, know-how and sophisticated systems required to achieve it.

That's where Aquacell stands tall.



Our History

1996 Aquacell is founded.

1999 Recycled water project completed for Sydney Olympic Games.

First Aquacell in-home system developed after Aquacell was granted the first in-home greywater reuse system approval in Australia.

2003

2005 First private blackwater recycling system completed in Sydney (Blacktown Workers Club).

2007 First large-scale residential Aquacell greywater system at the Prince Henry urban renewal project in Sydney.

2009 Aquacell opens the United States office in partnership with Phoenix Process Equipment Co.

2010 Aquacell becomes one of the first licensed Private Water Utilities under the Water Industry Competition Act.

2014 Aquacell supplies its first Californian in-building greywater recycling system in a high-rise development (181 Fremont).

2017 Aquacell wins the largest private blackwater recycling project in California (Facebook Campus).

2018 Aquacell wins San Francisco's first high-rise blackwater recycling system (Salesforce Tower).

2022 Collaboration with QLD government to amend Plumbing and Drainage Act to permit recycled water use in cooling towers.

2023 Aquacell exceeds 50 contracts in the USA.

2024 Aquacell's end-to-end water re-use service is tapped for the San Francisco Giants' Mission Rock development.

Our Management Team

Our team is a dynamic group of experts from diverse backgrounds, bringing together a wealth of experience, skills, and perspectives. From engineering and design to project management and customer support, each member contributes unique expertise to ensure we deliver the best possible outcome for every project.

Colin Fisher
Managing Director

Alex Sommer
Business Development Manager
(Australia) & Sustainability Lead

Ben Arnold
Business Development
& Product Manager (USA)

Hugh Fisher
Business Development
Manager (UK/Europe)

Peter Hagan
Operations Manager

Michael Kottmyer
Operations Manager (USA)

Warren Johnson
Technical Manager

Justin Taylor
Production Manager

Jordan Jennings
Project Manager

Our Clients

For more details on our extensive client list, please speak to our Business Development team.

MISSION ROCK
dexus
FRASERS PROPERTY
mirvac
MULTIPLEX
gpt
CHASE
GIANTS
CALSTRS
salesforce
Sydney WATER
TISHMAN SPEYER
Emirates
PARRAMATTA CITY COUNCIL
South East Water
Australian National University
VICTORIA State Government | Families, Fairness and Housing
SA Water
LONGWOOD GARDENS

Our Solutions

It's the spectrum of water re-use solutions that sets Aquacell apart.

From sophisticated in-building solutions that improve the sustainability and climate change resilience objectives of commercial projects and emerging applications that can fast-track development in off-grid areas, to streamlined solutions for Private Water Utility Schemes, solving industrial wastewater re-use and providing the capacity to upgrade existing public sector systems, Aquacell has all bases covered. Our team will work closely with you from the outset to pinpoint the specific requirements of your project and provide high-level guidance to both smooth the path for a successful outcome.

In-Building

Aquacell's in-building solutions have contributed significantly to the sustainability and resilience initiatives of commercial projects around the world. Blackwater and greywater recycling converts the vast majority of consumed water within a building into water that can be reused for toilet flushing, garden use, water-based cooling systems and more.

Private Water Utility Schemes

While most developers approach their local water authority to explore solutions for their water and sewerage requirements, that's not the only option. Aquacell is able to provide solutions that are delivered significantly faster than a public utility and invariably considerably less expensive, giving you control of your sewer and water re-use.

Industrial Wastewater Re-use

Traditionally, water treatment on an industrial scale is about reducing toxicity so that used water can re-enter the public utility system at acceptable levels. With Aquacell's focus on re-use, we'll not only reduce toxicity, but also provide the systems to be able to reuse the water many times over.

Off-Grid

Projects beyond public sewer systems are brought to life with Aquacell technology. Our off-grid solutions unlock developable land and provide certainty around water resources. Aquacell designs the treatment plant to suit the project, manufactures all the components, then installs and maintains the system on site.

Our Services

Aquacell has evolved into a total end-to-end water recycling solution for private and public clients requiring guidance and support through the entire process. From initial concept development, management of regulatory requirements and system design to manufacturing, installation and ongoing support, Aquacell is with you all the way.

PLANNING & REGULATORY SUPPORT

Concept Development
Engineering & Design
License Planning
Regulatory Approvals

Over the last few decades, we've become adept at providing comprehensive planning and regulatory support for clients around the world. Our expertise in dissecting intricate regulatory requirements and tailoring strategic responses is complemented by our capacity to professionally represent our clients to relevant authorities during the submission process.

DESIGN

Detailed Design for Construction

Because we've been involved from the outset, we'll design your system to match both your needs and those of the authorities. Our Project Team will work closely with you during the design process, taking input from our Manufacturing and O&M teams to ensure all designed elements are time and cost effective.

MANUFACTURE & INSTALLATION

Manufacturing
Site Works
Installation
Commissioning

All Aquacell systems are built in our own factories. Being both designer and manufacturer ensures time and cost efficiencies and our manufacturing standardisation means key components are integrated and optimised for your project. We understand what works best and our teams mesh together to streamline delivery timelines.

OPERATIONS & MAINTENANCE

Performance Proving
Remote Monitoring
System Maintenance
Compliance & Reporting

Aquacell support doesn't end at the end of the project - there's a whole future ahead of successful operations of the plants we design, manufacture and install. From regulatory compliance, asset replacement to remote monitoring and servicing support, Aquacell provides holistic operational management for the life of the asset.

aquacell.com.au

AUSTRALIA

Sales, Service, Head Office
Milsons Point NSW 2061 Australia

Engineering and Projects
Kingswood NSW 2747 Australia

Aquacell Factory
North Rocks NSW 2151 Australia

1300 278 235

USA

Aquacell by Phoenix
Louisville KY 40299 USA
+1 502 499 6198

UK

London WC2R 0LT
United Kingdom
+44 7 940 701 963

All email enquiries: info@aquacell.com.au

Appendix Q21.0 Waste Products Generated

The Onsite Sewage Management (OSSM) plant has only two waste streams. These are dewatered screenings from the prescreen and dewatered waste activate sludge. Both are solid wastes. Liquid waste from the CIP process is neutralised and returned to the plant inlet. The estimated quantity of screenings is 64 L/day, and there will be an average of 227 L/day of dewater activated sludge.

The following calculations and assumptions were used to determine the daily waste generated by the OSSM under normal condition.

Dewatered screenings from prescreens

Plant capacity: 300 kL/day

Feed solid concentration: 600 mg/L

Solid removal by prescreen: 10%

Removal by screen: 600 x 10% = 60 mg/L

Total solids in screenings: $300 \times 1000 \left(\frac{L}{day}\right) \times \frac{60}{1000 \times 1000} \left(\frac{kg}{L}\right)$

: 18 kg/day

Solid concentration in screening: 20%

Dewatered screening: 18/0.20 = 90 kg/day

Bulk density of dewatered screening: 1.4 tonnes/m^3

Volume of the dewatered screening: 90/1.4 = 64 L/day

Dewatered waste activated sludge

Number of trains: 2

Bioreactor volume per train: 110 kL

Solids retention time (SRT): 30 days

Mixed liquor suspended solid (MLSS) Concentration: 6,500 mg/L

Daily WAS flow per train: 110 kL / 30 days = 3.67 kL/day

Total solids in WAS per train: $3.67 \times 1000 \left(\frac{L}{day}\right) \times \frac{6500}{1000 \times 1000} \left(\frac{kg}{L}\right)$

: 23.83 kg/day

Dewatered sludge concentration: 15% solids

Mass of dewatered solid per train: 23.83/0.15 = 159 kg/day

Bulk density of the solid: 1.4 tonnes/m^3

Volume of dewatered solid per train: 159/1.4 = 114 L/day

Total volume of Waste product of the plant: 227 L/day

The dewatered screenings and the waste sludge will be disposed from the site weekly. It is important to note that, as with all elements of the design, waste volumes have been calculated conservatively, based on full plant capacity. As demonstrated in Appendix Q14.0, the development is not expected to reach full occupancy until Q1 2029. During Stage 1, the biosolids will be transported to a landfill facility for disposal at the required frequency based on incoming flow. This is likely to be every 5 to 6 weeks.

In the event of a prescreen failure, incoming blackwater will be temporarily diverted to a 300 kL emergency storage tank, which provides approximately one day of holding capacity. For extended outages, raw sewage will be transported off-site to a sewage treatment facility. Similarly, in the event of a failure in downstream treatment processes—such as membrane filtration, ozonation, ultraviolet disinfection, or chlorination—the offspec water holding tank (1 ML) and buffer tank (1 ML) is capable of storing for a period of approximately 6 days. If the system cannot be restored within this period, the stored sewage will be transported off-site until normal operations can resume.

The table below summarises the waste generation under different operating conditions (at full plant capacity):

Condition	**Waste Volume Produced**	**Waste Type**	**On site Storage capacity**	**Transport To**
Normal operation	64 L/day	Screenings	Up to 4,000 L	Landfill
	227 L/day	Dewatered sludge		
Prescreen failure	300 kL/day	Raw sewage	300 kL (Emergency tank)	Sewage treatment facility
Disinfection process failure	300 kL/day	Raw sewage	2 ML (Offspec + Buffer tank)	Sewage treatment facility

Appendix Q23.0: Other Regulatory Approvals

List of all the regulatory approvals that have been obtained for the proposed activities:

1. Development Application (DA24/0654) submitted on 12 April 2024 and approved on 6 August 2025. Refer to Appendix Q23.1 for further details about the approval.

Please refer to Appendix Q23.2 for details of where the regulatory approvals apply in relation to the proposed area of operations.

Appendix Q23.1

PENRITH
CITY COUNCIL

NOTICE OF DETERMINATION

DESCRIPTION OF DEVELOPMENT

SWCPP Ref. No.:	PPSSWC-446
Application number:	DA24/0654
Description of development:	Construction and Use of a Sewage Management System Comprising Underground Tanks, Above Ground Tanks, Plant Shed Area and Irrigation Areas to Serve the Alspec Industrial Estate. Works Include Associated Civil Works, Landscaping and Tree Planting.
Classification of development:	N/A

DETAILS OF THE LAND TO BE DEVELOPED

Legal description:	Lot 2 DP 1293805 Lot 1 DP 1293805
Property address:	211 - 227 Luddenham Road, ORCHARD HILLS NSW 2748 289 - 317 Luddenham Road, ORCHARD HILLS NSW 2748

DETAILS OF THE APPLICANT

Name & Address:	HB & B Property Pty Ltd 55-59 Regent Street CHIPPENDALE NSW 2008

DECISION OF CONSENT AUTHORITY

In accordance with Section 2.12 and 4.18(1) (a) of the Environmental Planning and Assessment Act 1979 (as amended), consent is granted subject to the conditions implementation in attachment 1.

Please note that this consent will lapse on the expiry date unless the development has commenced in that time.

Decision:	Approve
Date from which consent operates	6 August 2025
Date the consent expires	6 August 2030
Date of this decision	1 August 2025

POINT OF CONTACT

If you have any questions regarding this determination you should contact:

Assessing Officer:	Jake Bentley
Contact telephone number:	+61247328087

NOTES

Reasons
The conditions in the attached schedule have been imposed in accordance with Section 4.17 of the Environmental Planning and Assessment Act 1979 as amended.

Conditions
Your attention is drawn to the attached conditions of consent in attachment 1.

Certification and advisory notes
You should also check if this type of development requires a construction certificate in addition to this development consent.

It is recommended that you read any Advisory Note enclosed with this notice of determination.

Review of determination
The applicant may request Council to review its determination pursuant to Division 8.2 of the Environmental Planning and Assessment Act 1979 within six months of receiving this Notice of Determination.

These provisions do not apply to designated development, complying development or crown development pursuant to Section 8.2(2) of the Environmental Planning and Assessment Act 1979.

Appeals in the Land and Environment Court
The applicant can appeal against this decision in the Land and Environment Court within six months of receiving this Notice of Determination.

There is no right of appeal to a decision of the Independent Planning Commission or matters relating to a complying development certificate pursuant to clause 8.6(3) of the Environmental Planning and Assessment Act 1979.

Designated development
If the application was for designated development and a written objection was made in respect to the application, the objector can appeal against this decision to the Land and Environment Court within 56 days after the date of this notice.

If the applicant appeals against this decision, objector(s) will be given a notice of the appeal and the objector(s) can apply to the Land and Environment Court within 56 days after the date of this appeal notice to attend the appeal and make submissions at that appeal.

Sydney Western City Planning Panels
If the application was decided by the Sydney Western City Planning Panel, please refer to Section 2.16 of the Environmental Planning and Assessment Act, 1979 (as amended) for any further regulations.

ATTACHMENT 1: CONDITIONS OF CONSENT

General

1 The development must be implemented substantially in accordance the following stamped approved plans and supporting information received with the application, except as may be amended in red or by the following conditions within this consent:

Plan No.	Plan Title	Prepared By	Revision	Date
DA201	OSSM Facility - Masterplan	Nettletontribe	B	18/07/2024
DA205	OSSM Facility - Site Plan Roof Plan	Nettletontribe	D	14/01/2025
DA210	OSSM Facility - General Arrangement Plan	Nettletontribe	D	14/01/2025
DA220	OSSM Facility - Elevation Sheet 1	Nettletontribe	C	14/01/2025
DA221	OSSM Facility - Elevation Sheet 2	Nettletontribe	B	18/07/2024
DA230	OSSM Facility - Section	Nettletontribe	B	18/07/2024
DA240	OSSM Facility - Fence	Nettletontribe	D	14/01/2025
C000	Cover Sheet, Drawing Schedule, Notes and Locality Sketch	Henry & Hymas	02	5/07/2024
C100	General Arrangement Plan	Henry & Hymas	04	10/02/2025
C101	Detail Plan Sheet 1 of 2	Henry & Hymas	07	10/02/2025
C102	Detail Plan Sheet 2 of 2	Henry & Hymas	04	10/02/2025
C110	Site Sections	Henry& Hymas	02	28/01/2025
C200	Stormwater Miscellaneous Details and Pit Lid Schedule	Henry & Hymas	02	05/07/2024
C201	OSD Tank and Sections	Henry & Hymas	04	28/01/2025
C202	Stormwater Typical Details	Henry & Hymas	02	05/07/2024
C203	Stormwater Longitudinal Sections	Henry & Hymas	03	28/01/2025
C251	Post Development Catchment Plan	Henry & Hymas	05	11/02/2025
SE01	Sediment and Erosion Control Plan	Henry & Hymas	05	10/02/2025
SE02	Sediment and Erosion Control Details	Henry & Hymas	03	31/10/2024
BE01	Bulk Earthworks Cut and Fill Plan	Henry & Hymas	03	28/01/2025

00	Landscape Cover Sheet	Geoscapes	D	04/02/2025
01	Landscape Master Plan	Geoscapes	D	04/02/2025
02	Landscape Section A-A	Geoscapes	D	04/02/2025
03	Typical Frontage Landscape Section	Geoscapes	D	04/02/2025
04	Specification, Details & Planting Schedule	Geoscapes	D	04/02/2025
Indicative Irrigation Plans prepared by Nettletontribe Sheets 280-286.				

Report / Document Title	Prepared By	Date
Soil Science Advice Recycled Water Irrigation Areas	SESL Australia	03/02/2024
ESD Report	Arcadis	28/10/2024
Wildlife Hazards Letter	Ecoplanning	27/09/2024
Odour Impact Assessment	EMM	22/08/2024
Noise Impact Assessment	EMM	21/08/2024

2 **Prior to the issue of an Occupation Certificate**, a lighting system shall be installed for the development to provide uniform lighting across common areas and driveways. Exterior lighting shall be located and directed in such a manner so as not to create a nuisance to surrounding landuses. The lighting shall be the minimum level of illumination necessary for safe operation. The lighting shall be in accordance with AS 4282 “Control of the obtrusive effects of outdoor lighting” (1997).

3 **Prior to the issue of a Construction Certificate**, the Certifying Authority is required to ensure approval has been granted through Sydney Water’s online ‘Tap In’ program to determine whether the development will affect Sydney Water’s sewer and water mains, stormwater drains and/or easements, and if further requirements need to be met.

Note: Please refer to the web site http://www.sydneywater.com.au/tapin/index.htm for details on the process or telephone 13 20 92

4 **Prior to the issue of a Construction Certificate,** a Water Industry Competition Act Scheme Approval to Construct the On-site Wastewater Management System must be obtained and held. Evidence of such is to be provided to Council.

5 **Prior to operation of the On-site Wastewater Management System,** all required Water Industry Competition Act approvals must be obtained and held. Evidence of such is to be provided to Council.

6 Should any IPART Water Industry Competition Act 2006 approvals provide inconsistencies with the Development Consent, that are deemed to be more than minor, the Development Consent may require modification to ensure consistency between the Development Consent and IPART approvals.

7 **Prior to the issue of an Occupation Certificate,** the subdivision endorsed under Development Consent DA24/0294 shall be finalised with the plan of subdivision created via Land Registry Services.

8 The stamped approved recycled wastewater irrigation area plans are indicative only.

9 **Prior to the issue of a Construction Certificate,** retaining wall details in relation to finish and colour shall be provided to Penrith City Council's Development Services Team for review and approval.

The retaining wall shall be constructed to the approved finish and colour.

10 The Development shall adhere to the conditions provided by TransGrid in their conditional approval dated 29 November 2024.

Environmental Matters

11 No fill material shall be imported to the site unless expressly approved as part of this consent, and not until such time as a certificate demonstrating that the material is suitable has been submitted to, considered and approved by Council. This certificate may be in the form of a validation certificate, waste classification, or appropriate resource recovery order/exemption. A copy of a report forming the basis for the validation is also to be provided. The certification shall:

- be prepared by an appropriately qualified person with consideration of all relevant guidelines, standards, planning instruments and legislation (e.g. EPA, NEPM, ANZECC, NH&MRC),
- clearly state the legal property description of the fill material source site and the total amount of fill tested,
- provide details of the volume of fill material to be used in the filling operations,
- provide a classification of the fill material to be imported to the site in accordance with the NSW Environment Protection Authority's "Waste Classification Guidelines" 2014, and
- (based on the fill classification) determine whether the fill material is suitable for its intended purpose and land use and whether the fill material will or will not pose an unacceptable risk to human health or the environment

If the Principal Certifying Authority or Penrith City Council is not satisfied that suitable fill materials have been used on the site, further site investigations or remediation work may be requested. In these circumstances the works shall be carried out prior to any further approved works.

Note: An appropriately qualified person is defined as "a person who, in the opinion of Council, has a demonstrated experience, or access to experience in hydrology, environmental chemistry, soil science, eco-toxicology, sampling and analytical procedures, risk evaluation and remediation technologies. In addition, the person will be required to have appropriate professional indemnity and public risk insurance."

12 Where a building is to take place on any land that is to be filled, such filling is to be compacted in accordance with AS3798-1996. Certification is to be submitted to the Principal Certifying Authority by a Geotechnical Engineer verifying that the work has been undertaken prior to the commencement of the construction of any building.

If Penrith City Council is not the Principal Certifying Authority, a copy of the certification is to be submitted to Council for their reference.

13 All resulting waste materials stored on-site are to be contained within a designated area such as a waste bay or bin to ensure that no waste materials are allowed to enter the stormwater system or neighbouring properties. The designated waste storage areas are to be fully enclosed when the site is unattended.

14 Waste materials associated with the development are to be classified and disposed of at a lawful waste

facility, or, if suitable, re-used / recycled. Such works are to be undertaken in accordance with the approved Waste Management Plan, where applicable.

Where the disposal location or waste materials have not been identified in an approved waste management plan, details shall be provided to the Certifier prior to those works commencing.

All receipts and supporting documentation must be retained in order to verify lawful disposal of materials and are to be made available to Penrith City Council on request.

15 The operating noise level of plant and equipment shall not exceed 5dB(A) above the background noise level when measured at the boundaries of the premises. The provisions of the Protection of the Environment Operations Act 1997 apply to the development, in terms of regulating offensive noise.

16 All works and storage areas where spillages are likely to occur shall be bunded. Where Australian Standards apply, bunding construction and capacity must comply with those standards. Where Australian Standards do not apply, the size of the area to be bunded shall be calculated as being equal to 10% of the total volume of containers stored, or 110% of the largest container stored, whichever is the greater.

17 Offensive odours are not to be emitted from the site. Vapours, fumes, gases, particles or any other substance that are considered to be harmful to human health or the environment or impact unreasonably on a person outside of the premises are not to be emitted from the site.

18 Should any "unexpected finds" occur during site excavation and earthworks including, but not limited to, the identification/finding of contaminated soils, buried building materials, asbestos, odour and/or staining, works are to cease immediately and Penrith City Council is to be notified. Any such "unexpected finds" shall be addressed by an appropriately qualified environmental consultant.

19 Dust suppression techniques are to be employed during all works to reduce any potential nuisances to surrounding properties.

20 Mud and soil from vehicular movements to and from the site must not be deposited on the road.

21 All works that involve the use of heavy vehicles, heavy machinery and other equipment likely to cause offence to adjoining properties, are restricted to the following hours in accordance with the NSW Department of Environment and Climate Change's "Interim Construction Noise Guideline" 2009:

- Mondays to Fridays, 7am to 6pm
- Saturdays, 7am to 1pm (if inaudible on neighbouring residential premises), otherwise 8am to 1pm
- No work is permitted on Sundays and Public Holidays.

In the event that the work relates to activities inside the building and does not involve external walls or the roof, and does not involve the interim use of equipment that emits offensive noise, then the works are not restricted to the hours stated above. The provisions of the Protection of the Environment Operations Act, 1997 in regulating offensive noise also apply to all works.

BCA Issues

22 All aspects of the building design shall comply with the applicable performance requirements of the Building Code of Australia so as to achieve and maintain acceptable standards of structural sufficiency, safety (including fire safety), health and amenity for the on-going benefit of the community. Compliance with the performance requirements can only be achieved by:

(a) complying with the deemed to satisfy provisions, or

(b) formulating an alternative solution which:

- complies with the performance requirements, or
- is shown to be at least equivalent to the deemed to satisfy provision, or

(c) a combination of (a) and (b).

Utility Services

23 A Section 73 Compliance Certificate under the Sydney Water Act 1994 shall be obtained from Sydney Water, which verifies that water infrastructure is available to the development. The application must be made through an authorised Water Servicing Coordinator. Please refer to “Your Business” section of Sydney Water’s website at www.sydneywater.com.au then the “e-developer” icon, or telephone 13 20 92.

The Section 73 Compliance Certificate must be submitted to the Principal Certifying Authority **before an Occupation Certificate is issued for the development.**

24 **Prior to the issue of a Construction Certificate,** a written clearance is to be obtained from Endeavour Energy stating that electrical services have been made available to the development or that arrangements have been entered into for the provision of services to the development.

Construction

25 Stamped plans, specifications, a copy of the development consent, the Construction Certificate and any other Certificates to be relied upon shall be available on site at all times during construction.

The following details are to be displayed in a maximum of 2 signs to be erected on the site:

- the name of the Principal Certifying Authority, their address and telephone number,
- the name of the person in charge of the work site and telephone number at which that person may be contacted during work hours,
- that unauthorised entry to the work site is prohibited,
- the designated waste storage area must be covered when the site is unattended, and
- all sediment and erosion control measures shall be fully maintained until completion of the construction phase.

Signage but no more than 2 signs stating the above details is to be erected:

- at the commencement of, and for the full length of the, construction works onsite, and
- in a prominent position on the work site and in a manner that can be easily read by pedestrian traffic.

All construction signage is to be removed when the Occupation Certificate has been issued for the development.

26 Prior to the commencement of construction works:

(a) Toilet facilities at or in the vicinity of the work site shall be provided at the rate of one toilet for every 20 persons or part of 20 persons employed at the site. Each toilet provided must be:

- a standard flushing toilet connected to a public sewer, or
- if that is not practicable, an accredited sewage management facility approved by Council, or
- alternatively, any other sewage management facility approved by Council.

(b) All excavations and backfilling associated with the erection or demolition of a building must be executed safely and in accordance with the appropriate professional standards. All excavations associated with the erection or demolition of a building must be properly guarded and protected to prevent them from being dangerous to life or property.

(c) If an excavation associated with the erection or demolition of a building extends below the level of the base of the footings of a building on an adjoining allotment of land, the person causing the excavation to be made:

- must preserve and protect the building from damage, and
- if necessary, must underpin and support the building in an approved manner, and
- must, at least 7 days before excavating below the level of the base of the footings of a building on an adjoining allotment of land, give notice of intention to do so to the owner of the adjoining allotment of land and furnish particulars of the excavation to the owner of the building being erected or demolished. The owner of the adjoining allotment of land is not liable for any part of the cost of work carried out for the purposes of this condition, whether carried out on the allotment of land being excavated or on the adjoining allotment of land, (includes a public road and any other public place).

(d) If the work involved in the erection or demolition of a building is likely to cause pedestrian or vehicular traffic in a public place to be obstructed or rendered inconvenient, or involves the enclosure of a public place, a hoarding or fence must be erected between the work site and the public place:

- if necessary, an awning is to be erected, sufficient to prevent any substance from, or in connection with, the work falling into the public place,
- the work site must be kept lit between sunset and sunrise if it is likely to be hazardous to persons in the public place, and
- any such hoarding, fence or awning is to be removed when the work has been completed.

Engineering

27 An Infrastructure Restoration Bond is to be lodged with Penrith City Council for development involving works around Penrith City Council's Public Infrastructure Assets **(should the Collector Road be dedicated to Council at the time of works)**. The bond is to be lodged with Penrith City Council **prior to commencement of any works on site** or prior to the issue of any Construction Certificate, whichever occurs first. The bond and applicable fees are in accordance with Council's adopted Fees and Charges.

An application form together with an information sheet and conditions are available on Council's website.

Contact Penrith City Council's Asset Management Department on 4732 7777 or visit Penrith City Council's website for more information.

28 Lodgment of relevant Section 138 Roads Act applications, including payment of application and Council fees together with any applicable bonds, shall be lodged with and approved by Penrith City Council (being the Roads Authority for any works required in a public road). **This condition applies pending timing of Collector Road dedication.**

You are required to lodge the applicable Section 138 Roads Act application for the below works that apply to your specific development prior to that work activity commencing. Please liaise with your builder to determine what applications are required for your development.

These works may include but are not limited to the following:

a) Construction of driveways (including kerb reinstatement of redundant driveway crossings and reconstruction of any affected footpaths and/or cycleways)
b) Temporary road reserve occupancies
c) Road reserve openings for the installation of:
i. Utilities (water, sewer, power, telecommunications)
ii. Private stormwater connections to the kerb (including stormwater connection to Penrith City Council owned drainage)
iii. Reconstruction of concrete footpath and/or cycleways across the frontage
d) Establishment of a construction work zone
e) Establishment of road reserve hoardings and temporary structures/fencing etc.
f) Operation of a tower crane over the road reserve

All works shall be carried out in accordance with the Roads Act Approval and the conditions outlined in the Roads Act Applications, the development consent, including the stamped approved plans, and Penrith City Council's Driveway and Road Reserve Restoration Works Specification, guidelines and engineering best practice.

Contact Penrith City Council's Asset Management Department on 4732 7777 or visit Penrith City Council's website for more information.

Note:
- All works associated with the Roads Act approval(s) must be completed **prior to the issue of any Occupation Certificate.**

29 The stormwater management system shall be consistent with the plan/s lodged for development approval, prepared by Henry & Hymas, reference number 231664_DA_C000 to 231664_DA_BE01.

Prior to the issue of any Construction Certificate, the Certifier shall ensure that the stormwater management system has been designed in accordance with Penrith City Council's Stormwater Drainage Specification for Building Developments and Water Sensitive Urban Design (WSUD) Policy.

Engineering plans and supporting calculations for the stormwater management system are to be prepared by a suitably qualified person and shall accompany the application for a Construction Certificate.

30 **Prior to the issue of any Construction Certificate**, the Certifier shall ensure that vehicular access, circulation, manoeuvring, pedestrian and parking areas associated with the subject development are in accordance with Penrith Development Control Plan 2014, AS2890.1, AS2890.2 and AS2890.6.

31 **Prior to the commencement of any works on-site (including demolition works)**, a Construction Traffic Management Plan (CTMP) shall be submitted to Penrith City Council's Asset

Management Department for endorsement. The CTMP shall be prepared by a suitably qualified consultant with appropriate training and certification from Transport for NSW. The CTMP shall include details of any required road closures, work zones, loading zones and the like. Approval of the CTMP may require approval of the Local Traffic Committee. Please contact Council's Asset Management Department on 4732 7777 and refer to Council's website for a copy of the Temporary Road Reserve Occupancy Application Form.

32 **Prior to commencement of any works** associated with the development, sediment and erosion control measures shall be installed in accordance with the approved Construction Certificate and to ensure compliance with the Protection of the Environment Operations Act 1997 and Managing Urban Stormwater series from the Office of Environment and Heritage.

The erosion and sediment control measures shall remain in place and be maintained until all disturbed areas have been rehabilitated and stabilised.

33 **Prior to the issue of any Occupation Certificate**, Works As Executed drawings, final operation and maintenance management plans and any other compliance documentation for the stormwater management system shall be submitted to the Principal Certifier in accordance with Penrith City Council's Engineering Construction Specification for Civil Works, Stormwater Drainage Specification for Building Developments and Water Sensitive Urban Design Technical Guidelines.

An original set of Works As Executed drawings and copies of the final operation and maintenance management plans and compliance documentation shall also be submitted to Penrith City Council with notification of the issue of the Occupation Certificate where Penrith City Council is not the Principal Certifier.

34 **Prior to the issue of any Occupation Certificate**, the Principal Certifier shall ensure that the stormwater management systems (including on-site detention and water sensitive urban design)

- have been satisfactorily completed in accordance with the approved Construction Certificate and the requirements of this consent;
- have met the design intent with regard to any construction variations to the approved design, and;
- Any remedial works required to be undertaken have been satisfactorily completed.

Details of the approved and constructed system/s shall be provided as part of the Works As Executed drawings.

35 **Prior to the issue of any Occupation Certificate,** a restriction on the use of land and positive covenant relating to the stormwater management systems (including on-site detention and water sensitive urban design) shall be registered on the title of the property. The restriction on the use of land and positive covenant shall be in Penrith City Council's standard wording as detailed in Council's Stormwater Specification for Building Developments - Appendix F.

36 The stormwater management system shall continue to be operated and maintained in perpetuity for the life of the development in accordance with the final operation and maintenance management plan.

Regular inspection records are required to be maintained and made available to Penrith City Council on request. All necessary improvements are required to be made immediately upon awareness of any deficiencies in the stormwater management systems.

37 Works cannot commence until an updated Sediment and Erosion Control Report and Plans are prepared and submitted to the Certifier for approval. The following plans must be updated to include use of Type A or B sediment basins with an automated system of flocculant dosing, and as per the requirements of the Technical guidance for achieving Wianamatta–South Creek stormwater management targets (DPE 2002).

- Civil Plans, prepared by Henry and Hymas, project number 231664, Drawing numbers C000 – BE01,
- Integrated Water Cycle Management Report Sewer Treatment Facility prepared by Henry and Hymas, Issue 2, dated July 2024

The Applicant must ensure the delivery and operation of all construction phase erosion and sediment controls on the site is supervised and certified by a Certified Professional Erosion Sediment Control (CPESC). Monthly audits are to be completed by CPESC and kept on record for the duration of the works and an additional 12 months following completion of works.

38 The Applicant must ensure any stormwater that is harvested for reuse during the interim stormwater management phases is first treated and disinfected in accordance with Australian Guidelines for Water Recycling: Managing Health and Environmental Risks: Stormwater harvesting and reuse (NRMC, EPHC and NHMRC 2009).

39 **Prior to the issue of an Occupation Certificate,** it shall be ensured that any private pipe infrastructure that is required to cross a public road to service properties is subject to an accepted formal maintenance agreement entered into with Council.

Landscaping

40 All landscape works are to be constructed in accordance with the stamped approved plans and Chapter C6 Landscape Design of Penrith Development Control Plan 2014.

Landscaping shall be maintained:

- in accordance with the approved plan, and
- in a healthy state, and
- in perpetuity by the existing or future owners and occupiers of the property.

If any of the vegetation comprising that landscaping dies or is removed, it is to be replaced with vegetation of the same species and, to the greatest extent practicable, the same maturity, as the vegetation which died or was removed.

41 Upon completion of the landscape works associated with the development and **prior to the issue of an Occupation Certificate for the development**, an Implementation Report must be submitted to the Principal Certifying Authority attesting to the satisfactory completion of the landscaping works for the development.

An Occupation Certificate should not be issued until such time as a satisfactory Implementation Report has been received and endorsed. If Penrith City Council is not the Principal Certifying Authority, a copy of the satisfactory Implementation Report is to be submitted to Council together with the Occupation Certificate for the development.

42 No trees are to be removed, ring barked, cut, topped, or lopped or wilfully destroyed (other than those within the proposed building footprint or as shown on the approved plans) without the prior consent of Penrith City Council and in accordance with Chapter C2 – Vegetation Management of Penrith Development Control Plan 2014.

Section 94

43 This condition is imposed in accordance with **Penrith City Council's Section 7.12 Contributions Plan for Non-Residential Development**. Based on the current rates applicable to contributions payable under this plan, **$113,300.44** is to be paid to Council **prior to issue of a Construction Certificate** being issued for this development (the rates are subject to quarterly reviews). If not paid within the current quarterly period, this contribution will be reviewed at the time of payment in accordance with the adopted Section 7.12 Contributions plan.

Council should be contacted prior to payment to ascertain the rate for the current quarterly period. The Section 7.12 Contributions Plan for Non-Residential Development is available on Council's website.

44 **Prior to the issue of an Occupation Certificate,** a compliance matrix / statement is to be submitted to and endorsed by Councils City Planning – Contributions Officers that outlines the relevant infrastructure, contributions payable or commitments to be delivered in accordance with the registered or applicable Planning Agreement. It must be demonstrated that the applicable commitments have been satisfied **prior to the issue of an Occupation Certificate.**

Certification

45 Prior to the commencement of any earthworks or construction works on site, the proponent is to:

(a) employ a Principal Certifying Authority to oversee that the said works carried out on the site are in accordance with the development consent and related Construction Certificate issued for the approved development, and with the relevant provisions of the Environmental Planning and Assessment Act 1979, and accompanying Regulation, and

(b) submit a Notice of Commencement to Penrith City Council.

The Principal Certifying Authority shall submit to Council an "Appointment of Principal Certifying Authority" in accordance with Section 6.6 of the Environmental Planning and Assessment Act 1979.

Information to accompany the Notice of Commencement

Two (2) days before any earthworks or construction/demolition works are to commence on site (including the clearing of site vegetation), the proponent shall submit a "Notice of Commencement" to Council in accordance with Section 6.6 of the Environmental Planning and Assessment Act 1979.

46 An Occupation Certificate is to be obtained from the Principal Certifying Authority on completion of all works and prior to the occupation/use of the development.

The Certificate shall not be issued if any conditions of this consent, but not the conditions relating to the operation of the development, are outstanding.

A copy of the Occupation Certificate and all necessary documentation supporting the issue of the Certificate is to be submitted to Penrith City Council, if Council is not the Principal Certifying Authority.

Operation of OSSM

47 There shall be no effluent runoff from the subject site to adjoining premises, public places or waterways including stormwater drains.

SIGNATURE

Name:	Jake Bentley
Signature:	

For the Development Services Manager

Appendix Q23.2

Appendix Q24.0 Environmental Impact Assessment

Environmental impacts related to water quality and quantity, air quality, odour, noise, and land capability associated with the construction and operation of the infrastructure have been thoroughly investigated. A Statement of Environmental Effects (SEE) has been prepared in support of a development application (DA) for the onsite sewer management system at 221-235 Luddenham Road. It assessed the environmental impacts associates with the development. Section 4.3 of this document outlines the potential environmental impacts from the development. No significant environmental impacts were identified in relation to the onsite sewage management (OSSM) system as detailed in Appendix Q24.1.

An odour impact assessment has also been carried out which concluded that the odour concentrations from the facility are below the applicable NSW EPA odour impact assessment criteria for urbanised areas across all assessment locations (see Appendix Q24.2).

Additionally, a noise and vibration impact study has been conducted. The findings indicate that the noise levels are are compliant with the project noise trigger levels and cumulative impact assessment criteria. Although during construction phase noise management level (NML) exceedances of up to 2 dB were identified, no exceedances of the "highly noise affected" management threshold are anticipated for any receptor. Vibration impacts from both construction and operational activities are not expected to be significant at any assessed location (refer to Appendix Q24.3).

Furthermore, a Land Capability Assessment (LCA) was undertaken (Appendix Q24.4) to evaluate the suitability of the proposed recycled water irrigation areas and an Irrigation Management Plan (IMP) was prepared (Appendix Q24.5). The LCA concluded that the application of recycled water is generally appropriate across the proposed Recycled Water Irrigation Zone (RWIZ) locations throughout the site. In summary, the environmental assessments have not identified any significant adverse environmental impacts associated with the proposed scheme.

Appendix Q24.1

URBIS

Statement of Environmental Effects

On-Site Sewer Management System

Prepared for
HB+B Property
23 August 2024

URBIS STAFF RESPONSIBLE FOR THIS REPORT WERE:

Director	Bruce Colman
Associate Director	Anthony Kong
Consultant	Taylah Brito
Project Code	Natalia Grodek
Report Number	P0007737

Urbis acknowledges the important contribution that Aboriginal and Torres Strait Islander people make in creating a strong and vibrant Australian society.

We acknowledge, in each of our offices, the Traditional Owners on whose land we stand.

All information supplied to Urbis in order to conduct this research has been treated in the strictest confidence. It shall only be used in this context and shall not be made available to third parties without client authorisation. Confidential information has been stored securely and data provided by respondents, as well as their identity, has been treated in the strictest confidence and all assurance given to respondents have been and shall be fulfilled.

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1. Introduction

This Statement of Environmental Effects (SEE) has been prepared by Urbis Ltd on behalf of HB+B Property (the Applicant/Proponent) in support of a Development Application (DA) for an on-site sewer management system at 221-235 Luddenham Road, Orchard Hills (the **site**).

The DA seeks consent from Penrith City Council for:

- Plant Shed Building
- Sewer Treatment Tanks
- Associated irrigation area

The proposed works have an estimated development cost of $10,302,609 and development consent is sought in accordance with Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

The SEE:

- describes the site and proposed development,
- provides an assessment of the proposal against the relevant matters for consideration under section 4.15 of the EP&A Act 1979,
- explains the likely impacts of the proposed development on the natural and built environment, and
- outlines how these impacts are proposed to be reduced or mitigated.

The SEE should be read together with the architectural plans and supporting documentation submitted with the DA under separate cover as follows.

Table 1 Supporting Documentation

Title	Prepared By
Architectural Plans	Nettleton Tribe
Irrigation Area Plans	Nettleton Tribe
Landscape Documentation	Geoscapes
Sewer Treatment Plant Documentation	Aquacell
Process Flow Diagrams	Aquacell
Recycled Water Quality Management Plan	Aquacell
Wastewater Flow Assessment	Aquacell
Land Capability Assessment	Whitehead
Irrigation Plans	Nettleton Tribe
Irrigation Management Plan	Whitehead
Irrigation Detailed Plans	Total Irrigation Designers
Sewer & Treated Water Reticulation Plans	Arcadis
Civil & Stormwater Documentation	Henry & Hymas
Flood Letter	Arcadis

Title	Prepared By
Traffic & Parking Letter	Arcadis
Bushfire Letter	Peterson Bushfire
Acoustic Assessment	EMM
Air Quality Assessment	EMM
Waste Management Plan	HBB Property
QS Report	Napier & Blakeley

2. Site Analysis

2.1. Site Location

The site is located within the Alspec Industrial Business Park (AIBP) estate at 221-227 Luddenham Road, Orchard Hills and is legally described as Lot 1 in DP DP1293805. Orchard Hills is a Suburb within the Penrith Local Government Area (LGA), located at the heart of Western Sydney. The broader Business Park Boundary is defined by Patons Lane to the north, Luddenham Road to the east, Stockdale Road to the west, and a residential property to the south.

The subject site is located at the north western corner of the AIBP site with a direct interface to a warehouse development on proposed Lot 2 and the internal estate road to the east.

Figure 1 Site Location Map

Source: Geoscapes

2.2. Site Description

The key features of the site are summarised in the following table.

Table 2 Site Description

Site Characteristic	Description
Legal Description (Title Particulars)	Lot 1 in DP1293805
Site Ownership	Atilol Holdings Pty Ltd

Site Characteristic	Description
Title Encumbrances (Easements etc.)	An existing easement for batter which benefits the EE Lot is located along the northern boundary of the site. The easement for batter is proposed to be relinquished as part of the bulk earthworks DA.
Zoning	E4 General Industrial
Existing Use / Structures	The site is currently undeveloped and characterised by former rural residential land.
Site Area	5,242m^2
Existing GFA	N/A
Site Frontage	60.9m
Vegetation	The site comprises of grassed land with some scattered trees.
Hydrology	No watercourses traverse the site.
Heritage	The site does not contain a heritage item of local or state significance, nor is it within a heritage conservation area.
Bushfire	The site is identified as being affected by Vegetation Category 2 for Bushfire hazard.
Biodiversity	The site is not identified as containing biodiversity values.
Vehicular/Site Access	The proposed development has a direct interface with the north-south internal local road, which provides access to Patons Lane and Luddenham Road.
Adjacent land uses North	The surroundings north of the site are predominantly rural residential and agricultural facilities. The Erskine Park Fire Service and Dogs NSW are also located to the north-east. The Western Motorway (M4) is located further north of the site accessed via the Luddenham Road and Mamre Road connection. South Creek flows north-south, with an unnamed tributary connection beginning north of the site and breaking away to the west.
Adjacent land uses East	The eastern boundary divides its interface with Luddenham Road (northern half) and several properties (southern half). These include agricultural, community and cultural uses pertaining to the Bosna Croatian Club, a plant nursery and Luddenham Oval. Further east across Luddenham Road are several rural residential dwellings and South Creek, a major creek line.
Adjacent land uses South	Immediately south of the site are future development applications for the AIBP for industrial land uses. Further south is the Northern Gateway Precinct of the Western Sydney Aerotropolis
Adjacent land uses West	To the west is another property proposed for industrial land uses as part of the AIBP. Further west is an environmental conservation zone which is adjacent to a tributary of South Creek. To the north west of the site is a waste management service relating to a recycling and landfill centre
Public Transport	The surrounding public transport network indicates the area is currently underserviced by public transport. It can be assumed the level of service provision reflects the low travel demands of the locality. The level of public transport

Site Characteristic	Description
	servicing Luddenham Road will increase as the Aerotropolis develops.
Roads	The site is in proximity to existing road networks and planned infrastructure corridors. Luddenham Road provides direct access to the Western Sydney Aerotropolis and the Airport. It also provides connections to Mamre Road with access to the M4 Western Motorway towards the north, and connections to Elizabeth Drive to the south.

Photographs of the existing development and surrounding context are provided below.

Picture 1 View from the junction of Patons Lane and Luddenham Road at the north eastern corner of the AIBP.

Source: Google Maps

Picture 2 View looking north along Luddenham Road.

Source: Google Maps

Picture 3 Picture 4 View looking north towards the undeveloped lot across Patons Lane.

Source: Google Maps

Picture 5 View looking east towards residential properties across Luddenham Road.

Source: Google Maps

3. Development Description

The Development Application seeks development consent for the construction and operation of an On-site sewer management (OSSM) system that will service the Alspec Industrial Business Park (AIBP).

3.1. Key Elements

The key elements of the proposed development are summarised in the table below. Reference should be made to the accompanying architectural plans and supporting documentation for further detail.

Table 3 Summary of Proposal

Key Element	Proposal
Development Types (Land Use)	Waste water infrastructure
Description of Development	The proposal seeks to develop an on-site waste disposal system comprising of 492m^2 of underground tanks, 567m^2 of above ground tanks and 648m^2 of plant shed area. Together a total of 9 tanks are proposed onsite. A service lane is proposed through the site connecting to the AIBP north south road. Landscaped setbacks are proposed comprising of vegetation and tree planting to achieve a total landscape area of 892m^2.
Site Preparation	Earthworks and lot pad design will be approved under a separate DA (DA24/0294). Accordingly, site preparation works can be assumed to have been assessed under DA24/0294. The construction of a retaining wall at the northern boundary is proposed.
Stormwater / drainage	An underground OSD and rainwater tank is proposed to be constructed at the northwest site corner.
Built Form & Design	No buildings are proposed to be constructed. A plant shed is proposed at the south-east corner of the site.
Front setback	The proposed plant shed aligns with the 15m front building setback from the proposed AIBP internal road. This includes a 7.5m landscape setback.
Side setbacks/separation	5m building setback for the north and south boundaries. This includes landscape setbacks as follows: ▪ 2.5m northern side boundary. ▪ 1m southern side boundary. ▪ 2.5m western rear boundary.
Waste	Screenings from the prescreen and biosolids from the screw press will be processed and stored within the sludge handling room for removal by a specialised waste contractor and disposed of at an appropriately licenced facility.
Access and Parking	
Vehicle access	Maintenance vehicles will be able to enter and exit the site in a forward direction from the proposed AIBP local road at the south east corner of the site. There is also a turnaround facility providing space for larger vehicles up to 8.8m in length to turn around within the site.
Pedestrian access	No pedestrian access is provided to the site.

Key Element	Proposal
Car parking	One formal parking space is provided along the southern boundary adjacent to the plant shed. This is sufficient to accommodate the maintenance activities required for the facility.
Proposed new road/lane/access	A 6m wide service lane is proposed to traverse the site from the south eastern corner at the AIBP local road, to the site's north western corner to the adjacent industrial property.
Landscaping and Public Domain	Landscaping is proposed in the form of landscape setbacks and tree planting. 14 trees are proposed to be planted along the setbacks, in addition to shrub and groundcover planting.
Landscape area	892m^2 (17.02%) of landscape area is proposed. Permeable gravel is also proposed for 1,538m^2.
Number of trees to be impacted by the proposed works	No trees are proposed to be removed as part of this application. This has been addressed as part of the AIBP local DA (DA24/0294).
Fencing	A 2.1m high black palisade fence is proposed for the eastern (front) and southern boundaries. The boundaries to the north and west propose a 1.8m high black powder coated chain link fence with barbed wire over.
Staging and Infrastructure Delivery	
Development Staging	The proposal will be constructed in the second stage of the development, once the bulk earthworks are complete.
Operational Details	
Number of Employees	No staff are proposed to be permanently based onsite.
Plans of Management	A Recycled Water Quality Management Plan (RWQMP) has been prepared by Aquacell to identify the microbial objectives for the facility and describes how the implementation of the management plan will ensure the objectives are achieved. Refer to **Section 4.3.2**.
Subdivision	Subdivision is not proposed as part of the application.

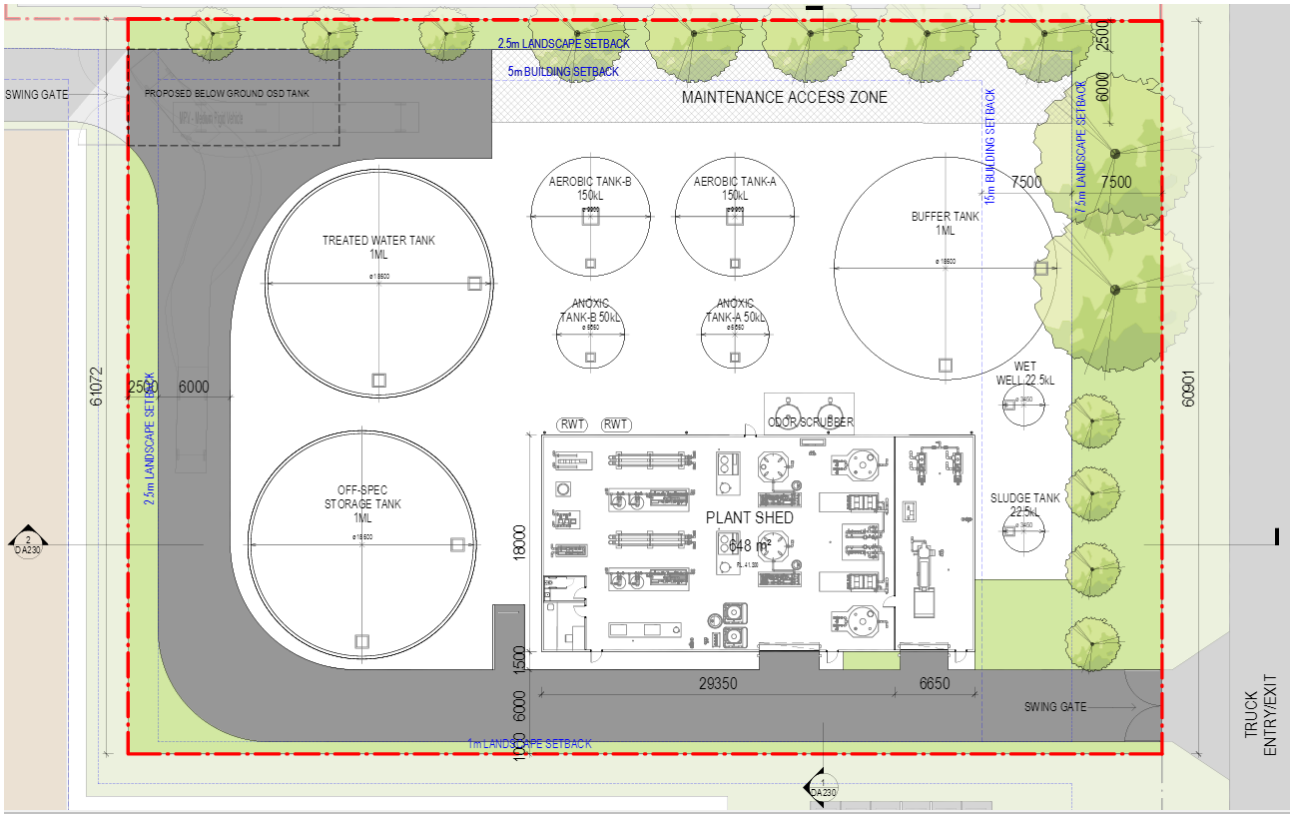
3.2. Site Layout

The proposed OSSM facility comprises the construction of several tanks which will be located above and below ground. Most central to the site is the proposed plant shed which is an enclosed structure adjacent to the tanks and will house the plant and equipment for the sewer treatment process. Most of the tanks will be underground, with two 1ML tanks designed to be aboveground and located to the rear of the site.

Below ground tanks relate to the storage and treatment of sewage and above ground holding tanks are for the storage of treated water. The location and size of each tank is illustrated in Figure 3. An isometric plan is provided to demonstrate the 3D views of the proposed structures, refer Figure 4. The scale of depth of each tank to be constructed is highlighted at Figure 5.

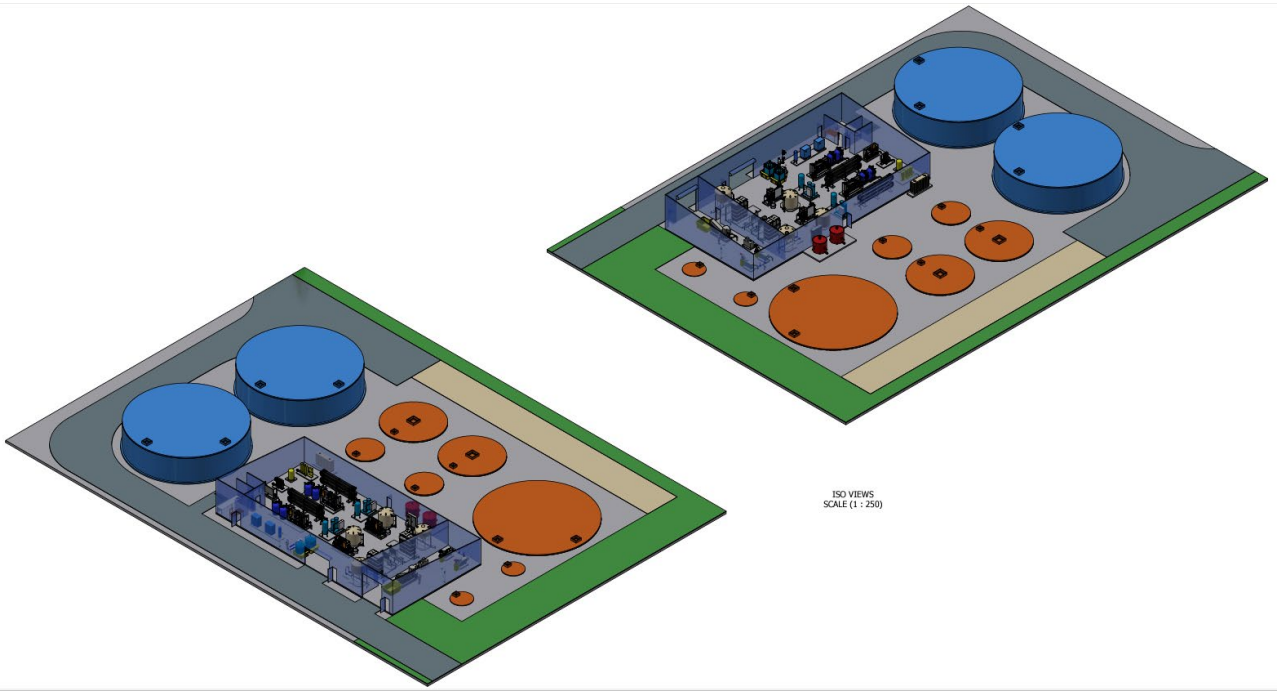
North of the tank components and plant shed is a maintenance access zone which links to the proposed service lane to provide operational and maintenance access.

Figure 2 General Arrangement Plan



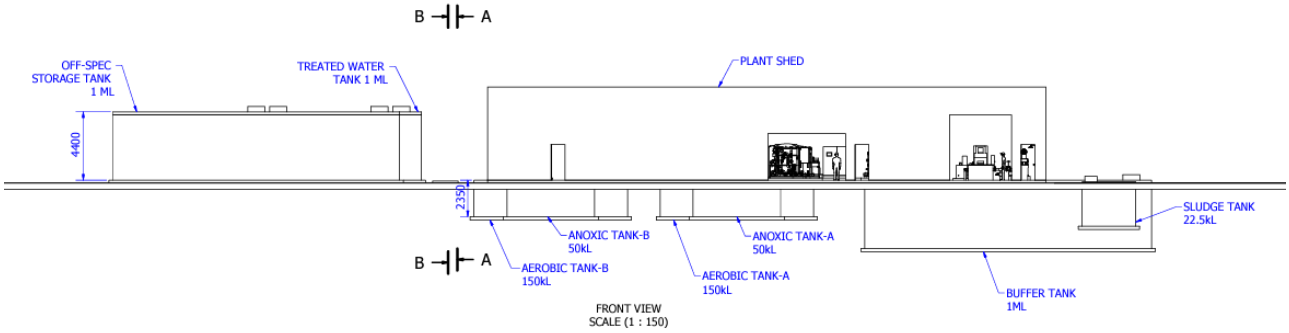
Source: Nettleton Tribe

Figure 3 Site Layout - Isometric Views



Source: Aquacell Water Recycling

Figure 4 Section - Front View



Source: Aquacell Water Recycling

3.3. Proposed Operations

The proposed OSSM facility seeks to deliver a Blackwater Water Treatment Plant (BWTP). The proposed operations of the BWTP is described within the Recycled Water Quality Management Plan (RWQMP) attached to this SEE.

The blackwater will be sourced from onsite toilets, showers, basins and drains (other than stormwater drains). Once treated, the water will be redistributed to the warehouses via a recycled water main located in the road reserve of the main estate road. Recycled water will be supplied to the site for:

- Cooling tower make-up water
- Toilet flushing
- Irrigation

Additional demand beyond the available recycled water will be met using potable water. Refer to the following figure which outlines the Irrigation Masterplan Strategy attached to this SEE. The locations marked in purple outline the areas to be irrigated by the OSSM, which include:

- AIBP local road streetscape setbacks (except for the streetscape areas in proximity to the Luddenham Road and AIPB local road intersection to the south).
- Landscape areas within the OSSM site.
- Patons Lane setback which interfaces the proposed Alspec Warehouse.

Figure 5 Irrigation Masterplan Strategy

TOTAL IRRIGATION AREA ACHIEVED (ha)		21.50
	Other Site Stormwater Catchments Via Bioretention And Storage Ponds (ha)	13.80
	Collector Road and Patons Lane landscape strips (ha)	0.78
	OSSM Treated Water Irrigation Area (ha)	3.65
	Harvested Rainwater and Stormwater Irrigation Area (ha)	3.27
TOTAL IRRIGATION AREA REQUIRED (ha)		18.44
NW and SE catchments (ha)		11.44
NE catchment on Lot 1 (ha)		0.47
Rainwater tanks on lots (ha)		2.88
Treated water from OSSM Facility (ha)		3.65
IRRIGATION AREA SURPLUS (ha)		3.06

Source: Nettleton Tribe

3.4. System Process

A flow diagram of the plant showing the key unit operations is provided in the Sewer Treatment Plant Process Flow Diagrams attached to this SEE.

The process involves directing the Blackwater from the site to a wet well adjacent to the treatment plant. Effluent from the wet well is pumped to a pre-screen and then directed to 1000kL buffer tank. The BWTP draws water from the buffer tank based on treated water demand, storing the final treated water in a 1000 kL treated water storage tank.

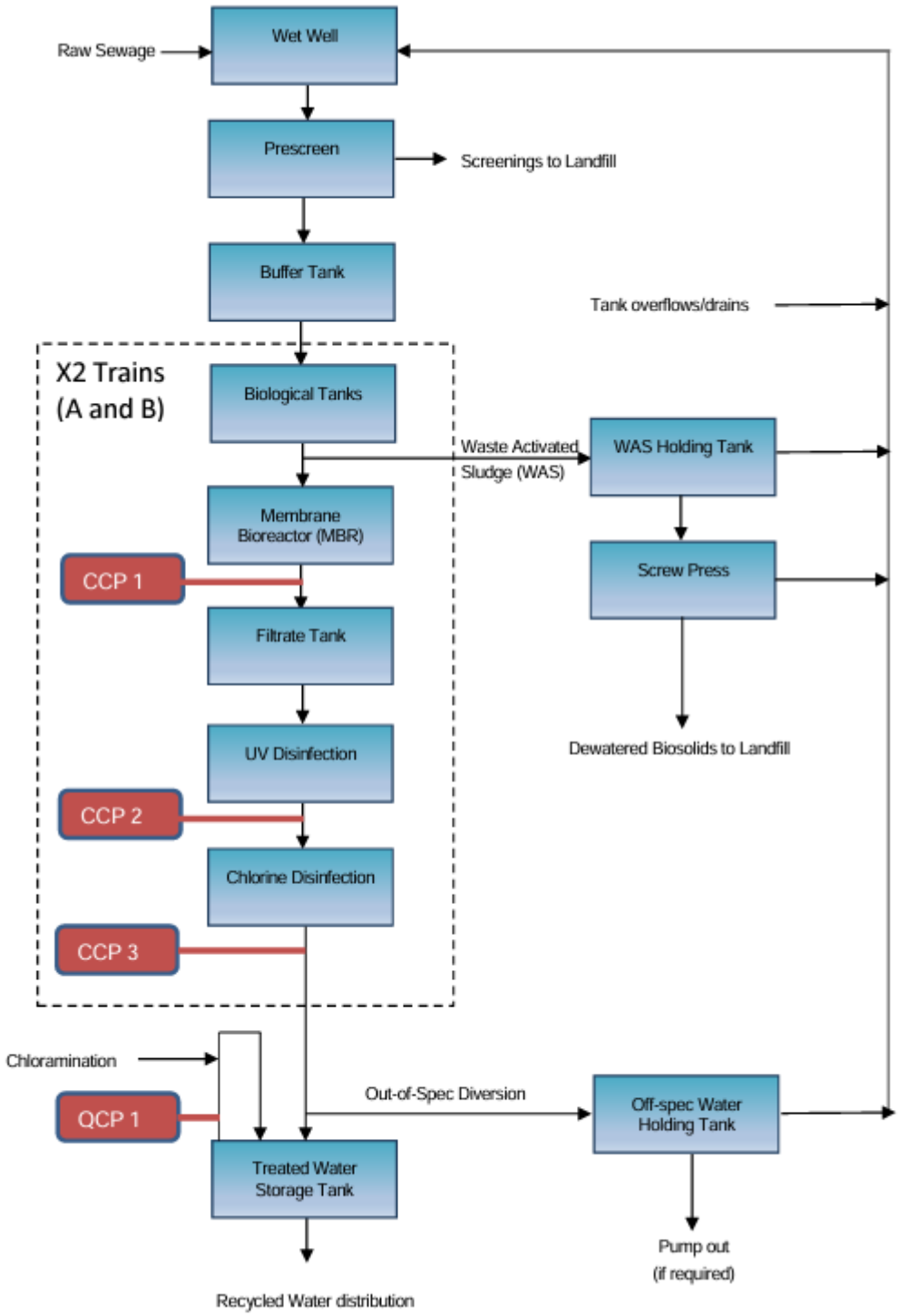
A process diagram is contained at **Figure 6**, sourced from the Recyced Water Quality Management Plan attached to this SEE. A brief description of each component of the process is summarised in the following table.

Table 4 Process Description

Component	Description
Pre-screen	Removes non-degradable solids such as fibres, or rags that can block or damage downstream processes and equipment. It also removes some of the degradable waste which help to lower the organic load to the biological treatment process.
Buffer Tank	A 1 ML buffer tank is provided to capture peak flows from the site. This maximizes the amount of water than can be recovered and enables the plant to operate at an efficient and steady flow.
Bioreactor	The biological system consists of both anoxic and aerobic stages. The Anoxic Tank converts nitrate generated by the treatment process to nitrogen gas in order to reduce the nitrogen content of the treated water. Continuous mixing in the anoxic tank ensures that mixed liquor remains homogenous. The Aerobic Tank carries out further biological treatment of the wastewater to reduce the organic content and convert ammonia nitrogen to nitrate and nitrite. Blowers aerate these tanks to ensure the required air for oxygen transfer is provided.
Screw Press	The screw press receives sludge from the WAS tank and separates the solid and liquid phases. The liquid is sent back to the start of the process train and the dewatered biosolids are collected for transportation to landfill.
Ultrafiltration Membranes	The combination of ultrafiltration and bioreactor is referred to as a membrane bioreactor (MBR). The biomass suspension from the bioreactor is recirculated past hollow fibre membranes, housed in the MBR tank, and returned to the bioreactor. A portion of the recirculated flow is withdrawn through the membranes as filtrate and collected in the filtrate tank for downstream disinfection.
Ozone/BAC	Filtered water is then dosed with ozone and passed through an ozone contact pipe followed by Biological Activated Carbon (BAC) filters. This combination is used to remove colour from the feed water. The BAC employs periodic backwashing to control bacteria levels present in the filter and to ensure the filter bed is well distributed.
Ultraviolet Light Disinfection (UV)	The UV system consists of two UV units in parallel. It provides the required dose to ensure the required inactivation of virus, bacteria and protozoa.
Chlorine Disinfection	Following the UV, the water is dosed with sodium hypochlorite before entering a pipe contactor to provide the necessary chlorine contact time for disinfection. The free chlorine residual and pH of the recycled water are monitored at the end of the chlorine contact pipework.
Treated Water Storage Tank and Distribution	The treated water is stored in a 1ML Treated Water Storage Tank (TWST) which allows the system to account for peak flows. Water in the TWST is recirculated and dosed with chlorine to maintain a free chlorine residual for storage and distribution.

Off-Spec Storage Tank	Any treated water that cannot be used for distribution will be diverted to the Off-Spec Storage Tank. This water will then be recirculated back through the treatment process.

Figure 6 Recycled Water Process Flow and Critical Control Points



Source: Aquacell Water Recycling

4. Planning Assessment

4.1. Approvals Under Other Acts

Table 5 Approvals under other Acts

Act		Assessment
Environmental Protection Biodiversity and Conservation Act 1998 (Commonwealth)		Not required.
Local Government Act 1993	*S68*	A person may carry out an activity specified within this section only with prior approval of Council. Part C applies to the proposal and requires consent from Council: ***Part C – Management of waste*** *6 Operate a system of sewage management.* *(1) In this Part,* ***operate a system of sewage management*** *means hold or process, or re-use or discharge, sewage or by-products of sewage (whether or not the sewage is generated on the premises on which the system of sewage management is operated).*
EP&A Div 4.8 Integrated Development		Refer to the following sections.
Coal Mine Subsidence Compensation Act 2017	*s 22*	Not required.
Fisheries Management Act 1994	*s 144* *s 201* *s205* *s219*	Not required.
Heritage Act	*s58*	Not required.
Mining Act 1992	*ss 63, 64*	Not required.
National Parks and Willdlife Act 1974	*S90*	Not required, dealt with as part of the Bulk Earthworks DA 24/0294
Petroleum (Onshore) Act 1991	*s16*	Not required.
Protection of the Environment Operations Act	*ss43(a, 47 and 55* *ss43(b), 48 and 55* *ss43(d), %% and 122*	Not required.
Roads Act 1993	*s138*	Not required.
Rural Fires Act 1997	*s100B*	Not required.
Water Management Act 2000	*89, 90, 91*	Not required.

4.2. S4.15 Evaluation

The following tables address the relevant matters for consideration under section 4.15(1)(a) of the EP&A Act 1979.

4.2.1. Applicable Environmental Planning Instruments

Table 6 Applicable Environmental Planning Instruments

Matter for Consideration - s4.15(1)(a)(i)	Consistency
State Environmental Planning Policies	
State Environmental Planning Policy (Resilience and Hazards) 2021	This SEPP provides a state-wide planning approach for the remediation of land and aims to promote the remediation of contaminated land to reduce the risk of harm to human health or the environment. Chapter 4 of the Resilience and Hazards SEPP requires the consent authority to consider whether land is contaminated prior to the issuance of consent to a development application. The site will undergo site preparation works under a separate local DA (DA24/0924) for Bulk Earthworks which will ensure the site will be made suitable from a contamination perspective.
State Environmental Planning Policy (Transport and Infrastructure) 2021	The aim of State Environmental Planning Policy (Transport and Infrastructure) 2021 is to facilitate the effective delivery of infrastructure across NSW. This is achieved by identifying matters to be considered in the assessment of development adjacent to particular types of infrastructure, including classified roads, rail corridors and prescribing consultation requirements for certain development. The OSSM facility does not require any staff to operate onsite. Therefore it is not considered traffic generating development under Schedule 3 of the Transport and Infrastructure SEPP and does not require referral to TfNSW.
Clause 2.126 Development Permitted with or without consent	Under *Chapter 2 Infrastructure - Division 18 Sewerage Systems*, development for the purpose of sewage treatment plants may be carried out with consent on land in a prescribed zone. A *Prescribed Zone* under this clause includes E4 General Industrial. The proposal is therefore permissible with consent under the Transport and Infrastructure SEPP.
Clause 2.119 Development with frontage to classified road.	The development is not proposed on a classified road. Therefore, this is not applicable to the proposal.
Penrith Local Environmental Plan 2010	
2.1 Land Use Zones	Whist *Sewerage Systems* are prohibited in the E4 zone under the Penrith LEP, it is permitted with consent under the Transport and Infrastructure SEPP as discussed in the above section. Notwithstanding, the proposed development is consistent with the relevant objectives of the E4 zone given the proposal will support the industrial land uses to achieve water conservation through recycled water re-use.
2.6 Subdivision	Not sought for subdivision
4.1 Minimum lot size	Complies
4.3 Height of Buildings	Complies The proposed building height of the Plant Shed is 6m and complies with the maximum building height in the LEP of 24m.
4.4 Floor Space Ratio	Complies

Matter for Consideration - s4.15(1)(a)(i)	Consistency
4.6 Exceptions to development standards	Complies
5.21 Flood Planning	The site is not identified as being affected by the flood planning area. However, identified flood levels at Unnamed Creek north-west of the site. The proposed design and elevation of the OSSM facility adequately positions the development out of flood risk, aligning with council requirements. This is further discussed in **Section 4.3.4**.

4.2.2. Development Control Plan Considerations

Table 7 Applicable Development Control Plans

Matter for Consideration - s4.15(1)(a)(iii)	Consistency
Penrith Development Control Plan 2010	
2.3 Bushfire Management	A Bushfire Assessment has been prepared to assess the proposals compliance with 'Planning for Bushfire Protection 2019' (PBP) guidelines. Whilst the site is identified as bushfire prone land, the development employs the relevant measures and design controls to achieve compliance with the PBP. Further assessment is contained at **Section 4.3.5**.
3.1 The Water Cycle/Water Conservation	The proposal ensures the minimisation of impacts on the water cycle and natural ecosystems. **Section 4.3.7** demonstrates the site's stormwater management aligns with best practice principles. It is designed to safely convey flow through the site and within the capacity of the downstream system. It also confirms water conservations targets achieve a minimum 80% non potable water demand to be provided through rainwater or stormwater harvesting storages.
3.2 Catchment Management and Water Quality	To manage the impact on downstream water quality, water quality measures at source and end of line treatments will be provided. **Section 4.3.7** details how the water quality reductions have been met by the proposed development.
3.5 Flood Planning	A flood Letter has been prepared and discussed at **Section 4.3.4**. It highlights the site's elevation is at RL 41.2m AHD which exceeds the Probable Maximum Flood (PMF) levels identified in the report. This indicates the development is positioned out of flood risk and is complying with council requirements.
3.6 Stormwater Management and Drainage	An Integrated Water Cycle Management Report has been prepared and contained at **Section 4.3.7**. It confirms the facility is designed to safely convey flow through the site and within the capacity of the downstream system. In addition, a below ground OSD tank is proposed at the north west corner of the site to ensure runoff from the development is appropriately managed in accordance with Council's requirements.
5.1 Waste Management Plans	A Waste Management Plan has been prepared for the proposal and discussed in **Section 4.3.8**.
5.5 On-Site Sewage Management	Council have been engaged to discuss the proposal. Further discussion against Council controls is provided below at control 13.3 On-site Sewage Management.
6.1 Landscape Design Controls	The proposed development includes landscape treatment in the form of vegetation and tree planting. Landscape plans have been prepared to demonstrate the appropriate landscape setbacks have been achieved and there is sufficient planting of native species to provide shade and visual amenity.

Matter for Consideration - s4.15(1)(a)(iii)	Consistency
	In addition, recycled water collected from the site will be used for irrigation of landscape areas.
10.2 Traffic Management and Safety	A Traffic Letter has been prepared to supplement the existing Traffic Impact Assessment prepared for the broader AIBP (refer **Section 4.3.6**). It highlights that the proposal is not considered traffic generating development. It demonstrates that the layout and design of the OSSM facility provides safe entry and egress from the site, and adequate parking to support the future operations.
10.4 Roads	The proposed service lane is designed to comply with the design requirements for a local road. The appropriate widths are achieved to align with the requirements set out in this section.
10.5 Parking, Access and Driveways	As demonstrated above, the Traffic Letter confirms there is a sufficient amount of parking to support the facility as there are no staff proposed to be permanently based onsite. The parking associated with maintenance activities can be completely accommodated for onsite. Refer **Section 4.2.6**. It also demonstrates the proposed driveway provides safe access to and from the site.
12.4 Industrial and Commercial Development	The proposed development will not adversely impact on the amenity of neighbouring residential development. The proposed OSSM facility will not generate any exceedances during the operation or construction stage of the development. Refer **Section 4.3.10** for further details.
12.7 Vibration and Blasting	As detailed above, the Noise and Vibration Assessment described in **Section 4.3.10** confirms their will be no vibration impacts that will affect the amenity of the surrounding area.
13.3 On-Site Sewage Management	The proposed construction and operations of the OSSM facility has been designed in accordance with Council's On-Site Sewage Management and Greywater Reuse Policy. A Wastewater Flow Assessment has been prepared to verify the expected wastewater flows to be handled by the OSSM facility. Refer **Section 4.3.1**.
14.2 Cooling with Landscaping	The design employs landscape elements to provide amenity and shade. Green infrastructure is delivered onsite through vegetation and tree planting to reduce the proposals contribution to the urban heat island effect. Consideration to reducing demand on non potable water resources is achieved through the employment of water conservation targets to passively irrigate the site with collected stormwater and rainwater.
14.3 Cool Colours and Materials	The proposed materials and colours selected ensure the minimisation of impacts on urban heat. The Plant Shed uses a translucent wall sheeting to address the east and west elevations which receive direct sunlight. Darker colours are employed on the north and south elevation which do not receive significant sunlight in order to reduce urban heat.
E18 Luddenham Road Industrial Business Park	
18.2.1 Building Setbacks	The following building setbacks are required: ▪ Collector Road – north south Boulevard: 15m ▪ Estate roads: 7.5m ▪ Rear and side boundaries: 5m The proposal aligns with the specified building setbacks and therefore complies.
18.2.2 Landscaping	The following landscaping setbacks are required: ▪ All other roads: 50% of building setback ▪ Rear boundaries: 2.5m The proposal aligns with the specified landscape setbacks and therefore complies. Tree planting is proposed along the front setback and side

Matter for Consideration - s4.15(1)(a)(iii)	Consistency
	setback to enhance landscape treatment and provide visual amenity at these interfaces.
18.2.3 Building and Urban Design	The proposal does not seek to construct a building which requires assessment under this control. Notwithstanding, the proposed plant shed and tanks are appropriately designed and sited to ensure functionality of the OSSM operations. They are minor structures which do not represent significant bulk or scale. They employ high quality colours and materials that are sympathetic to the future industrial character and ensure structures are not visually obtrusive from the public domain. Landscaping is provided in the form of vegetation and tree planting to soften the look of the facility and filter views from the streetscape. Overall, it achieves a high quality look commensurate of an OSSM facility within the Industrial setting of the AIBP.
18.3.2 Noise Pollution	The proposed OSSM facility will not generate any exceedances during the operation or construction stage of the development. Refer to **Section 4.3.10** which demonstrates how the assessment results comply with the relevant requirements.
18.3.3 Air Pollution	The proposed development has been assessed for its potential impact on air quality. **Section 4.3.9** of this SEE demonstrates the development does not adversely impact on air quality.
18.3.4 Trading/Operating Hours of Premises	The operation of the development will not impact on the amenity of adjoining residential and rural areas.
18.3.5 Storage, Transport and/or processing of chemical substances	Storage, transport and processing of chemical substances is to be undertaken by trained operatives only, in accordance with Aquacell RWQMP and O&M Manual.
18.4 Road network and site access	The proposal aligns with the Road hierarchy map. A 6m wide Service Road is proposed to travel through the site, in accordance with the Road Hierarchy Map. It provides a single lane, and permits large vehicle turnaround movements. Refer to **Section 4.3.6** which further discusses the traffic and access assessment.
18.5 Access and Parking	The development is not classified as traffic generating and therefore does not require many parking spots. The provision of parking aligns with the generation rates from operation. Refer to **Section 4.3.6** which further discusses the parking and access assessment.
18.6 Integrated Water Cycle Management	The proposal demonstrate compliance with the stormwater quality targets during construction and operations. Refer to **Section 4.3.7** for the IWCM Report confirming the proposal compliance with water quality and stormwater quantity requirements.
18.7 Flood Prone Land	The proposed development ensures it does not impact on flood behaviour and ensures the development is compatible with flood risk. **Section 4.3.2** outlines the assessment of the proposal against relevant flood controls. In summary, it confirms the proposal aligns with the requirements for flood management and no adverse impacts arise.

4.2.3. Any Planning Agreement

The applicant has entered into an agreement with Penrith City Council for a Voluntary Planning Agreement (VPA) which seeks to deliver the Luddenham Road widening, upgrading of Patons Lane and a signalised intersection to Luddenham Road. The VPA has been executed and is now registered on title.

4.3. Impact Statement

The table below assesses the likely environmental, social and economic impacts of the OSSM facility in accordance with section 4.15(1)(b) of the EP&A Act 1979.

4.3.1. Wastewater Flow Assessment

The Wastewater Flow Assessment, conducted by Aquacell verifies the anticipated wastewater flows that the proposed OSSM plant will need to manage. The assessment used several sources to generate a potential wastewater flow information tailored to the Alspec Industrial Estate. The sources used included the following:

- **Survey of tenants** – information on water usage, staffing, and any on-site process that could generate wastewater
- **Development warehouse and office areas** – the site masterplan was used to identify number of lots and the warehouse area of each lot
- **Specific information on key water users** – information on layout of the warehouse, staffing levels and water bills from the other Alspec sites in Australia.

The information was combined to develop the expected wastewater generation in litres per square metre of combined office and warehouse areas. The estimated total wastewater generation for the full development is approximately 290 kL/day. This aligns closely with the calculations made by Arcadis, which estimated a maximum wastewater generation of 298 kL/day.

4.3.2. Recycled Water Quality Management Plan

A Recycled Water Quality Management Plan (RWQMP) has been prepared by Aquacell to identify the microbial objectives for the facility and describes how the implementation of the management plan will ensure the objectives are achieved. The RWQMP describes:

- The responsibility of the recycled water supplier
- Description of the recycled water process
- Detailed validation of the treatment processes
- A detailed process control and monitoring program to ensure the treated water meets the required quality for end use.

Roles and Responsibilities

There will be a scheme manager for the OSSM. They will be committed to ensuring the system is maintained and operated in compliance with relevant guidelines, regulations and standards at all times. Both Aquacell and the scheme manager will provide the same commitment to maintain and operate the system in compliance with relevant guidelines, regulations, and standards at all times. Under the agreement, the scheme manager will have maintenance personnel on site to undertake all daily, weekly and emergency response tasks associated with the running of the plant. Aquacell will provide initial training and ongoing technical support. Aquacell will be responsible for the majority of the technical and operational activities including on-site servicing, calibrations, regulatory reporting and remote operation as will be detailed in the service contract.

In general terms, the scheme manager is responsible for:

- the production and supply of recycled water that is fit for purpose, ensuring that water quality complies with regulated standards and supply agreements up to designated transfer points defined in the RWQMP and supply agreements.
- implementation of communication and reporting protocols if water quality does not meet required standards.
- operation and maintenance of infrastructure for the production and supply of recycled water up to designated transfer points.
- compliance with relevant regulatory requirements for recycled water.
- using recycled water only in the manner and for the purposes for which it has been supplied, in accordance with supply agreements.
- operation and maintenance of recycled water infrastructure after the designated transfer point.

- implementation of control measures and compliance with usage restrictions defined in supply agreements.

Water Quality Objectives

The proposed recycled water quality objectives have been derived based on the application of the principles described in the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks Phase 1 (AGWR) (NRMMC, 2006).

The possible exposure to treated water at this site are:

- Ingestion from cross connections between the drinking and recycled water systems
- Aerosol ingestion from toilets
- Ingestion from cooling towers
- Ingestion of water used for irrigation

Table 8 Possible Exposure to Treated Water

Possible Exposure	Description
Ingestion from cross connections between the drinking and recycled water systems	There are a number of steps that have been taken to ensure that the risk of cross-connection is low. These include: ▪ The dual reticulation system will be installed according to AS/NZ 3500 and NSW Health Guidelines for recycled water, including lilac pipe and/or markings. ▪ Testable reduced pressure zone devices will be provided at all interconnection points between the treated water and the potable water supply. ▪ Signage to warn of the use of recycled water will be installed. ▪ The dual pipe system will undergo a full cross connection audit prior to commercial operation. If any cross connections are detected, these will be repaired prior to commercial operation. Cross-connection audits will be carried out at a frequency to be determined by Scheme Owner, in consultation with Aquacell and other stakeholders under the pending recycled water scheme approval to operate under Section 68 of the Local Government Act (1993). The detailed plan for carrying out cross-connection tests will be documented in the maintenance plan. ▪ Any maintenance or modification to the reticulation system will occur under strict supervision of the responsible entity and Scheme Manager and in accordance with the site management processes. ▪ All maintenance workers and plumbing contractors will be fully inducted to the site and made aware of the dual reticulation system and the consequences of cross connections.
Aerosol ingestion from toilets	Table 3.3 of the AGWR provide a guidance on typical exposure rates and ingestion volumes for toilet flushing. These figures have been used for calculating performance targets.
Ingestion from cooling towers	The exposure for those operating the cooling towers (occupational) is considered to be higher than those for the general public. Occupational exposure is mitigated by various means: ▪ Access to cooling towers restricted to authorised staff only ▪ The normal practises for maintenance and servicing cooling towers to minimise risk to legionella are applied (e.g., as detailed in the NSW Health document Legionella control in cooling water systems (August 2018). ▪ New construction with modern, low drift design.

Ingestion of water used for irrigation	The proposed irrigation includes drip and spray irrigation for landscaped areas. Table 3.3 of the AGWR provide a guidance on typical ingestion volumes for garden irrigation which have been used for calculating performance targets.
Performance target calculations	The project specific ingestion risks have been considered to determine the pathogen removal targets (using sewage as source) required to meet the minimum tolerable health risk of 10^{-6} DALY as recommended by the AGWR.

Validation of Treatment Process

The validation program has been designed to evaluate the BWTP's ability to achieve the water quality objectives, which acts as a feasibility study of the BWTP design. This includes membrane bioreactor validation, UV validation, and free chlorine system validation.

Monitoring

Verification and ongoing monitoring will be achieved by providing evidence that the overall system can deliver water of the specified quality. A verification monitoring plan is provided which will create a total of 12 samples over 6 weeks. Sample analysis is undertaken at a NATA accredited laboratory. To provide evidence that the overall system can deliver water of the specified quality on an on-going basis, the following on-going monitoring plan is proposed.

Figure 7 Treated Water Ongoing Monitoring Program

Parameter	Units	Monitoring frequency	Compliance Value
Treated Water			
E.coli	cfu/100ml	Monthly	< 1
Turbidity (MBR filtrate) (NTU)	NTU	Continuous online	≤ 0.2
Validated UV Dose (virus)	mJ/cm2	Continuous online	≥ 58
Chlorine Contact Time (C-T)	mg.min/L	Continuous online	C-T ≥ 4
pH (CCT)		Continuous online	pH ≤ 9.0 and pH ≥ 6.0
Total Chlorine (Treated Water Storage)	mg/L	Continuous online	TC ≥ 0.5 and TC ≤ 5.0

Source: Aquacell

Employee Awareness and Training

Aquacell will provide an experienced water recycling engineer to monitor the plant. Any contractors used on site must be accredited, qualified and have the appropriate level of training. A site induction is also required for those completing work related to the facility.

4.3.3. Land Capability Assessment and Irrigation Management Plan

A Land Capability Assessment (LCA) and Irrigation Management Plan (IMP) has been prepared by Whitehead and Associates for the application of 'excess' recycled water generated by the AIBP. Recycled water land application and associated infrastructure is referred to as the Alspec Industrial Business Park recycled water scheme (RWS). The proposed LCA and IMP have been prepared for a proposed recycled water irrigation zone (RWIZ). The analysis involves modelling a dedicated RWIZ to demonstrate sufficient capacity to manage expected recycled water in a sustainable and reliable manner over the expected lifespan of the RWS.

The proposed RWIZ will entirely consist of landscaped areas which are distributed across the AIBP as irregular shaped zones. For irrigation efficiency and installation feasibility, small; non-contiguous and intricately-shaped areas are excluded. However, HB+B has indicated that these areas may be considered in the future following detailed hydraulic analysis for serviceability. Only the largest, relatively uniform portions of proposed landscaped gardens throughout the AIBP are delineated as part of the RWIZ.

Modelling was completed to simulate irrigation of recycled water over the AIBP. The results demonstrate minor irrigation runoff occurs in a typical year during May, June and July. The proposed 3.65ha irrigation RWIZ is limited by the hydraulic factor of irrigation runoff. This limiting criteria as well as all other metrics under the proposed RWIZ scenarios pose low risk to the surrounding environment and exhibit sustainable recycled water land irrigation as well as improving deficiencies occurring at background conditions such as nitrogen leaching and plant water stress.

The modelling assumptions and results assume the adoption of appropriate irrigation scheduling and management protocols, as well as use of automated controls to ensure that recycled water irrigation within the RWIZ remains both 'effective' and 'sustainable'. This is summarised in the following table.

Table 9 Irrigation Scheduling and Environmental Monitoring

Component	Description	Recommendation
Irrigation Timing	Irrigation is assumed to occur one - two discrete intervals during each available day. Final details of the proposed irrigation schedule depend on the capabilities of the hydraulic distribution design, pump assembly and zoning requirements to service the RWIZ.	It is recommended that irrigation is limited to daylight hours (7am-5pm) to ensure that any issues can be easily identified by visual observation.
Irrigation Controls	It is anticipated that irrigation (pump) control timers will be installed to ensure the maximum sustainable irrigation rates are not exceeded.	Flow meters are to be installed on the RWI discharge line to measure the volume of irrigation water applied during each interval, with the total volumes recorded daily. After 1st year of data collection, the MEDLI water balance should be reviewed and the irrigation schedule amended if required.
Soil Moisture Management	Irrigation operations should ensure that all recycled water is assimilated within the area of application, avoiding both surface runoff and excessive deep infiltration. RWI should be undertaken on a suitable soil moisture deficit basis, i.e. the soil is always allowed to partially dry before applying a controlled amount of recycled water to increase soil moisture levels to field capacity.	To avoid over irrigation of poorly drained areas, soil moisture monitoring is recommended using soil moisture probes and regular operator inspection of the RWIZ. Additionally, regular visual inspections of the irrigation supply infrastructure and the RWIZ for signs of soil structural problems, over-irrigation, vegetation stress and equipment failure or damage (e.g. leaks).
Soil Monitoring	Routine soil monitoring is important to detect early signs of (physical or chemical) changes within the RWIZ as a result of recycled water irrigation.	It is recommended soil sampling be undertaken in at least one location within the RWIZ at 6-monthly intervals for the first 2 years of scheme operation, then annually thereafter. Samples should be collected from topsoil (200mm) and subsoil (500mm) locations at each monitoring site.

Groundwater Monitoring	Soil groundwater monitoring should be maintained throughout the year especially during winter months. Groundwater monitoring is used to determine whether to irrigate that day. Groundwater Monitoring should be conducted on an as monthly basis during January- April, and September - December. Monitoring should be conducted on an as weekly basis during May - August and along with any day(s) after a rain event.	To ensure operation of the RWI scheme is not contributing to increases in the shallow groundwater table beneath the RWIZ, it is recommended to install two-three (2-3) observation wells within the RWIZ at selected low points. Based on observed soil conditions, the minimum installed depth of each well should be 1.8m or at refusal (bedrock). Standing water level (SWL) within each well should be recorded monthly.

4.3.4. Flood

Arcadis were engaged to prepare a Flood Letter which investigates the proposal's compliance with Council requirements in the On-site Sewage Management and Greywater Reuse Policy (EH002) and the DCP.

It is a Council Policy to ensure OSSM systems be situated outside flood affected areas and comply with specified buffer distances. Additionally, all electrical and mechanical components are to be above the 1% Annual Exceedance Probability (AEP) flood levels. These requirements highlight the importance of the OSSM system installation appropriately mitigating and managing flood impacts.

The Flood Assessment Arcadis previously completed for the AIBP local DA (DA24/0294) identified flood levels at the Unnamed Creek west of the site. The OSSM site's elevation at RL 41.2m AHD exceeds the Probable Maximum Flood (PMF) levels identified in the report. This indicates the development is positioned out of flood risk and is complying with council requirements.

The plans demonstrate that the proposed development generally meets the regulations and standards set by council. The proposed development meets the offset requirements by being 100m away from the Unnamed creek and is not adjacent to any mapped or significant overland flow path.

As a result, the proposed OSSM system meets the stipulated requirements for flood management and presents a well-considered approach to environmental sustainability and infrastructure resilience.

4.3.5. Bushfire

The Bushfire Assessment, conducted by Peterson Bushfire, has been designed to ensure that the necessary bushfire protection measures are in place, in accordance with the 'Planning for Bushfire Protection 2019' (PBP) guidelines as the site has been identified as bushfire prone land.

The assessment has identified potential bushfire hazards in the vicinity of the site. These include a possible grassland hazard along the north-western and western boundaries of Lot 2, as well as a forest corridor beyond Patons Lane to the north. The effective slope of the site was also measured during the assessment to understand its potential influence on fire behaviour. The effective slope class underneath the hazards is 'downslope 0-5 degrees'.

Furthermore, the site was evaluated against the Bushfire Attack Level (BAL), which confirmed that the proposed facility is located beyond any BAL. This demonstrates that the development is more than 100 m from forest hazards and more than 50 m from grassland hazards.

As a result, the assessment makes the following recommendations:

- Safe access and egress between the development and the public road system for fire-fighters
- defendable space between structures and the bushfire hazard/boundaries to allow fire-fighters to gain access to all sides of the structures and the bushfire hazard at the boundary; and
- Access to a reticulated water supply (e.g. hydrants) for firefighting.

These measures are available and provided by the proposed development location and layout. Additional bushfire protection measures are not required as the proposed development complies with the PBP.

4.3.6. Traffic

The Traffic Letter conducted by Arcadis has been prepared to review the likely traffic impacts associated with the proposed development. This letter supplements the Traffic Impact Assessment prepared for the AIBP local DA (DA24/0294) to review the likely construction and operation traffic impacts generated by the OSSM facility.

Construction

During construction of the proposed development it is estimated to involve up to 25 workers during peak construction activity onsite. The peak period for construction traffic is expected to occur in the AM peak hour when up to 30 vehicles will enter and exit the site, however the values represented during the peak hour are expected to be lower for most of the construction phase. A summary of the peak construction traffic generation is summarised below.

Figure 8 Summary of peak construction traffic generation

Vehicle type	Peak Hour	Inbound movements	Outbound movements
Light vehicles	AM peak	25	0
	PM peak	0	25
Heavy vehicles	AM peak	5	2
	PM peak	1	1

Source: Arcadis

The projected traffic demand during the construction phase is assessed to have minimal impact on traffic and the broader road network with an additional 25 light vehicle movements and 4 heavy vehicle movements during both AM and PM peak hour.

If the proposed development construction occurs during the same time as the peak of the broader AIBP bulk earthworks activity, any impacts to Patons Lane can be managed through the implementation of a Construction Traffic Management Plan.

Operational Traffic

Typical operational traffic is expected to involve a single maintenance vehicle on an adhoc basis, and no staff are proposed to be permanently based onsite. Parking associated with maintenance facility can be wholly accommodated on site. As such the proposed facility is anticipated to have negligible impact on the surrounding road network.

Design

A review of the proposed design was undertaken to confirm the layout of the proposed development generally aligns with the DCP. Maintenance vehicles will be able to enter and exit the site in a forward direction. With a turnaround facility providing space for larger vehicles up to 8.8m in length to turn around within the site.

To conclude, the traffic assessment supports the construction and operation of the proposed OSSM facility. It demonstrates any traffic impacts during construction can be effectively managed in conjunction with activity occurring across the AIBP through the implementation of a Construction Traffic Management Plan.

4.3.7. Integrated Water Cycle Management Plan

An Integrated Water Cycle Management (IWCM) Report has been prepared by Henry & Hymas to demonstrate the proposed design and stormwater management aligns with best practice principles and Councils DCP.

Stormwater Quantity

Key issues related to stormwater quality are the increase of impervious surfaces which will increase the peak stormwater flows from the site during storm events. On-site Stormwater Detention (OSD) is proposed for the

development to ensure that runoff from the development is appropriately managed in accordance with Council's requirements. Flows from the site will be reduced via an underground tank with 245m^3 of detention storage and one orifice plate.

Pre and post developed flows were calculated for the relevant storm events. It demonstrates the proposed development meets Council's stormwater detention requirements, as illustrated in the following Table.

Table 10 Catchment Flows

Storm event	Pre-developed Flows (m3/s)	Post – Developed Flows (m3/s)
20year ARI storm	0.041	0.041
100year ARI storm	0.065	0.053

Source: Henry & Hymas

In summary, the site stormwater system has been designed to safely convey the flows through the site and within the capacity of the downstream system. The proposal aligns with the findings and assumptions outlined in the IWCM Report prepared for the AIBP local DA (DA24/0294).

Water Quality

The development may potentially increase gross pollutants, sediments, hydrocarbons and nutrient concentrations in stormwater runoff. To manage this impact on downstream water quality, water quality measures at source and end of line treatments will be provided. Council requires post developed pollutants to be reduced to specified targets.

The water quality reductions have been met by the proposed development. They have been satisfied through the usage of 11 x 690 mm Psorb Cartridges and Oceanguard pit baskets in each grated inlet pit. In addition, a 10kL rainwater tank is proposed to irrigate into 201m^2 of landscaped area. The remainder of the landscaping area on site will be irrigated via recycled water from the OSSM facility. Stormwater is proposed to discharge to the storage basin in the north west corner of the site, which ensures that the MARV requirements are met.

Furthermore, water conservation targets are specified by Council to achieve a minimum of 80% non-potable demand to be provided through rainwater or stormwater harvesting storages. Two 5kL Rainwater Tanks are proposed, which will achieve a 89.3% reuse rate and comply with Council's requirement.

4.3.8. Waste

A Waste Management Plan has been prepared by HB+B Property to demonstrate the appropriate waste disposal activities relating to the proposal during demolition, construction and operational phases.

Demolition

No structures currently exist on site. These structures were demolished in early 2023 under a separate Complying Development Application. Therefore, no waste will be generated from this phase.

Construction

Rubbish skips and bins will be used during the construction stage for the collection of general construction waste and material packaging. All rubbish placed in skips will be removed from site by a designated waste removal contractor and taken to an approved and licensed waste disposal and recycling facility. At no time will rubbish skips or bins be stored on the footpath or roadway during the course of the works.

All waste will be dealt with and disposed of in accordance with Penrith City Council's requirements.

Operation

Screenings from the prescreen and biosolids from the screw press will be processed and stored within the sludge handling room for removal by a specialised waste contractor and disposed of at an appropriately licenced facility.

One operational maintenance contractor will visit the site weekly on an ad hoc basis. No staff are proposed to be to be permanently based on site, therefore general waste is expected to be low. Any general waste will

be disposed of by the maintenance contractor. Green waste will be managed by a separate landscape maintenance contractor.

Maintenance and waste vehicles will enter and leave the site in a forward direction at all times.

4.3.9. Air Quality

An Air Quality Impact Assessment (AQIA) has been prepared by EMM Consulting to assess any air or odour impacts generated by the site. Modelling and assessment studies were completed to predict any adverse impacts to the surrounding amenity.

Several residential properties and future industrial properties surrounding and within the AIBP were selected as assessment locations for the AQIA modelling (Refer following Figure). In addition, existing sources of odour was reviewed for neighbouring sources of industrial air pollutant emissions. It identified the Bingo Industries' Patons Lane Resource Recovery Facility which is approximately 0.8km from the site. Previous modelling for this site was completed, and confirms it is unlikely that cumulative odour impacts with the facility would occur. Therefore, no further consideration of odour emissions from the facility is undertaken.

Figure 9 Assessment Locations

Source: EMM Consulting

Aquacell advised the potential odour emission generating processes at the project include the following:

- Three external in-ground storage tanks, specifically the buffer tank, the wet well tank and sludge storage tank.
- Two waste activated sludge (WAS) holding tanks within the main shed.
- Two pre-screens and one dewatering screen, and associated screenings storage bins, within the main shed.

The following odour mitigation methods apply to the above processes:

- The external tanks will be enclosed and fitted with passive carbon filters to treat potential fugitive odour emissions.
- The two WAS holding tanks within the main building will be vented to passive carbon filters.
- The area of the pre-screens and dewatering screen will be ducted, with collected air diverted to two scrubber devices to be located on the northern wall of the main shed.

Aquacell have advised that the following odour emission reductions apply to the above mitigation methods:

- Passive carbon filters – 99% reduction.
- Scrubber device – greater than 95% reduction.

Aquacell highlight all other components of the project will be sealed or have negligible odour generation potential. Therefore, there are no other odour emission sources identified in the assessment.

Odour emissions were estimated using conservative odour monitoring sample from the Sydney Water odour emissions database. The results demonstrate that the predicted odour concentrations from the facility were below the applicable NSW EPA odour impact assessment criteria for urbanised areas at all assessment locations.

The results of the dispersion modelling convey that the operation of the facility is unlikely to generate adverse odour impacts in the surrounding environment. The proposed odour emission mitigation measures advised by Aquacell are likely to be effective at limiting the potential odour emission generation from the facility.

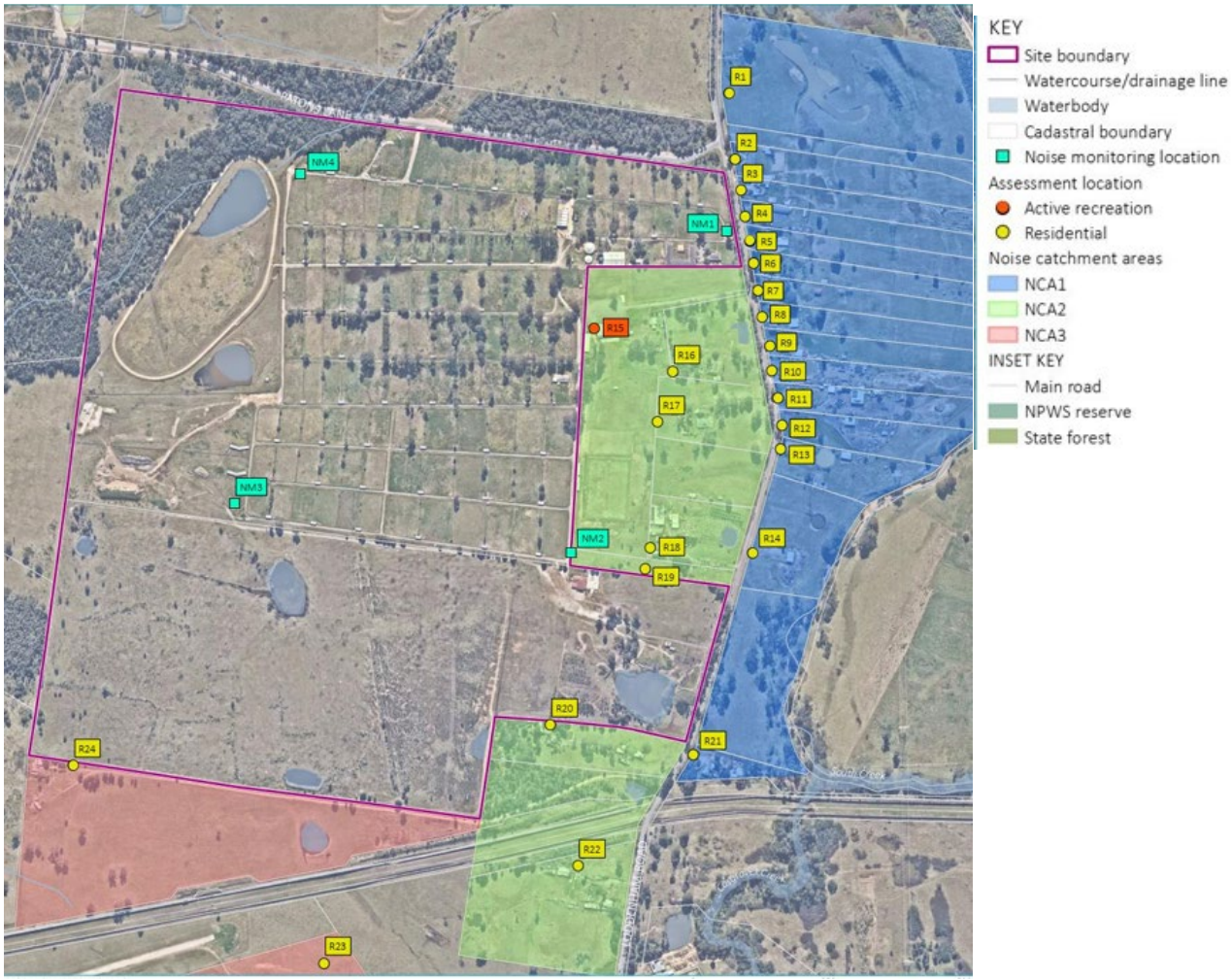
4.3.10. Noise

A Noise and Vibration Impact Assessment has been prepared by EMM Consulting to predict the noise emissions generated by the site construction and operations, which will also be assessed against the relevant objectives. EMM have undertaken previous assessments for the broader AIBP site, which will be used to help inform the projects modelling and assessment.

Noise locations were selected as part of the broader AIBP masterplan. They have been separated into three noise catchment areas (NCAs) as described below:

- NCA1 represents residential assessment locations on the eastern side of Luddenham Road. The dwelling façades face Luddenham Road and are exposed to road traffic noise.
- NCA2 represents residential assessment locations on the western side of Luddenham Road. These properties are all set back from Luddenham Road and would be expected to experience lower noise from existing road traffic which is consistent with noise monitoring conducted at the site. It is noted that these properties have been included in the precinct structure plan and rezoned to E4 General Industrial.
- NCA3 represents remote assessment locations which are removed from Luddenham Road.

Figure 10 Noise Monitoring and Assessment Locations



Source: EMM Consulting

Construction Noise

Construction equipment sound power levels (Lw) have been sourced from an EMM database of similar equipment based on measurements at other construction sites. Earthworks and site-preparation are expected to be the most significant noise impact.

Construction noise levels are predicted to comply with the construction noise management levels (NML) at NCA1 and NCA3. Minor exceedances of NML of up to 2 dB are predicted for some receivers in NCA2. No exceedances of the highly noise affected level are predicted.

Table 11 Predicted Construction Noise Levels

Noise catchment area	Predicted noise level	Construction NML	Highly noise affected level	Exceedance of construction NML	Exceedance of highly noise affected level
NCA1	41-50	50	75	Nil	Nil
NCA2	38-47	45	75	Up to 2 dB	Nil
NCA3	36-41	45	75	Nil	Nil
Receiver R15 (non-residential)	53	65	N/A	Nil	N/A

Source: EMM Consulting

Construction vibration was assessed, noting that the nearest assessment location to the project is over 500m from the lot boundary, well beyond the recommended minimum working distance for cosmetic damage or human response. Therefore, no vibration impact is predicted from construction activities associated with the OSSM facility.

Operational Noise

Modelling for operational noise included the future warehouse and office buildings as barriers as it is assumed they will be constructed prior to the full operation of the OSSM facility.

Operational noise sources were assessed, noting all significant noise sources will be located within the plant shed. All equipment has been assumed to operate concurrently and have 100% utilisation for the purpose of the assessment. Maintenance activities were also reviewed, highlighting that emptying of the sludge pan is expected to be the only significant noise generating regular maintenance activity.

Operational scenarios have been developed to assess a worst-case 15 minutes for regular operation and maintenance activities. This includes:

- OSSM continuous operation
  - continuous operation of all equipment within plant shed.
  - continuous operation of the odour scrubber fan.
  - This scenario will be assessed for day, evening and night periods.
- OSSM maintenance
  - continuous operation of all equipment within plant shed.
  - continuous operation of the odour scrubber fan.
  - continuous operation of the vacuum pump truck.
  - This scenario will be assessed for day period only.

Predicted operational levels are provided in the following Table. Results for each noise catchment area are provided for day, evening and night periods. The highest result for a receiver within each noise catchment area has been provided. It confirms no exceedance of predicted noise trigger level is predicted.

Table 12 Predicted Operational Noise Levels

Assessment period	Noise catchment area	Predicted noise level		Project noise trigger level (PNTL)	Exceedance of Project noise trigger level (PNTL)
		OSSM continuous operation	OSSM maintenance[1]		
Day	NCA1	28	36	45	Nil
	NCA2	22	39	40	Nil
	NCA3	<20	33	40	Nil
	R15	21	35	53	Nil
Evening	NCA1	28	NA	43	Nil
	NCA2	22	NA	40	Nil
	NCA3	<20	NA	39	Nil
	R15	21	NA	53	Nil
Night	NCA1	28	NA	38	Nil
	NCA2	22	NA	35	Nil
	NCA3	<20	NA	35	Nil
	R15	21	NA	53	Nil

1. OSSM maintenance activities will occur during the day period only and predictions are combined with normal operations as relevant.

Source: EMM Consulting

Sleep disturbance assessment was completed, and found no exceedance of the sleep disturbance screening target.

In addition, the cumulative operational noise from the AIBP has been previously assessed by comparing operational noise predictions against project amenity noise level. The results demonstrate there are no predicted exceedances of amenity noise levels.

Overall, the proposed OSSM facility will not generate any exceedances during the operation or construction stage of the development.

4.4. The Suitability of the Site for the Development

In accordance with s4.15(1)(c) of the EP&A Act the site is considered highly suitable for the proposed development for these reasons:

- The proposed works are permissible within the zone. The proposed OSSM facility will facilitate development consistent with the intent of the zone objectives.
- The Project aligns and has been designed in respect to the emerging local character of the AIBP and broader locality with adequate consideration is given to the site-specific constraints and opportunities.
- The detailed impact assessment undertaken for the Project demonstrates that the proposed development can occur without any unacceptable environmental impacts to the nearby residential land and the surrounding transport network.

4.5. Any Submissions Made In Accordance With The Act Or Regulations

In accordance with s4.15(1)(d) of the EP&A Act, it is acknowledged that submissions arising from the public notification of this application will need to be considered by the Consent Authority in its assessment. The proponent will undertake to formally respond and attempt to resolve to any relevant issues relating to the proposed development.

4.6. The Public Interest

In accordance with s4.15(1)(e) of the EP&A Act the proposed development is considered in the public interest for these reasons:

- The proposal is consistent with relevant State and local strategic plans and demonstrates a high level of consistency with the relevant planning controls.
- No adverse environmental, social or economic impacts will result from the proposal.

5. Conclusion

The SEE demonstrates the proposed development is appropriate for the site and the locality for these reasons:

- The proposal satisfies the applicable local and state planning controls.
- Responds positively to the surrounding site context. The proposal seeks consent to erect a plant shed and storage tanks of minor scale. They employ colours and materials that are similar to the selection employed for the broader AIBP in order to uphold a similar character. Adequate landscaping is employed to create green buffers along the site's interface and visually filter views to the site. The simple, high quality design of the site ensures it respects and is compatible with the future character of the AIBP.
- The proposal will provide a positive environmental impact as it will enable the AIBP to use recycled water to meet its non-potable water demand. Recycled water will be used for irrigation and toilet flushing in order to conserve water and make a positive environmental impact. Any unacceptable environmental impacts have been appropriately managed to avoid any adverse impacts.
- The proposal is in the public interest as the OSSM facility will support the broader AIBP to be sustainable and reduce its water demand.

Accordingly, it is submitted that the proposal is in the public interest and should be approved subject to appropriate consent conditions.

Disclaimer

This report is dated 23 August 2024 and incorporates information and events up to that date only and excludes any information arising, or event occurring, after that date which may affect the validity of Urbis Ltd **(Urbis)** opinion in this report. Urbis prepared this report on the instructions, and for the benefit only, of HB+B Property **(Instructing Party)** for the purpose of Statement of Environmental Effects **(Purpose)** and not for any other purpose or use. To the extent permitted by applicable law, Urbis expressly disclaims all liability, whether direct or indirect, to the Instructing Party which relies or purports to rely on this report for any purpose other than the Purpose, and to any other person which relies or purports to rely on this report for any purpose whatsoever (including the Purpose).

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URBIS

Appendix Q24.2

Alspec Industrial Business Park On-site Sewer Management Facility

Odour impact assessment

Prepared for HBB Property Pty Ltd

August 2024

Alspec Industrial Business Park On-site Sewer Management Facility

Odour impact assessment

HBB Property Pty Ltd

E240557 RP1

August 2024

Version	Date	Prepared by	Reviewed by	Comments
V0.1	19 August 2024	A. Gilbert S. Fishwick	S. Fishwick	Draft
V1	22 August 2024	A. Gilbert S. Fishwick	S. Fishwick	Final

Approved by

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20 August 2024

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1 Introduction

1.1 Background/overview

HB+B Property Pty Ltd (HBB) is seeking development approval from Penrith City Council (Council) for a proposed on-site sewer management facility (the facility) at the Alspec Industrial Business Park (AIBP) at 221–235 Luddenham Road, Orchard Hills. The proposed development will be located at the northern end of the AIBP adjacent to the warehouse lot 2.

It is understood that collected blackwater to be treated by the facility will be sourced from toilets, showers, basins and drains (other than stormwater drains) across the AIBP. The treated water will be held in holding tanks and reused at the AIBP for cooling tower make-up water, for toilet flushing in each of the warehouses and for irrigation of landscaping on each of the lots.

The regional setting and local setting of the facility are shown in Figure 1.1 and Figure 1.2 respectively.

HBB has engaged EMM Consulting Pty Ltd (EMM) to undertake an odour impact assessment in support of the development application for the facility to be submitted to Council.

Figure 1.1 Regional setting

Figure 1.2 Local setting

1.2 Proposed development

Blackwater from the AIBP is directed to a wet well adjacent to the treatment plant. Effluent from the wet well is pumped to a pre-screen and the directed to 1,000 kilolitre (kL) buffer tank. The treatment plant draws water from the buffer tank based on treated water demand, storing the final treated water in a 1,000 kL treated water storage tank.

The proposed treatment system consists of the following units:

- Wet Well
- Pre-screen
- Buffer tank for collection of blackwater
- Two identical process trains with the following process units
    - Anoxic Tank
    - Aerobic Tank
    - Membrane bioreactor treatment system (MBR)
    - Filtrate tank
    - Ozonation
    - Biological activated carbon filter (BAC)
    - Ultraviolet light disinfection (UV)
    - Chlorine disinfection
- Off-spec water holding tank
- Treated water storage tank
- Treated water chlorination
- Waste activated sludge (WAS) holding tank
- Screw press
- Vents connected to an odour scrubber for odour control
- Overflows and drains to wet well
- Chemical dosing systems

The layout of the proposed facility is illustrated in Figure 1.3.

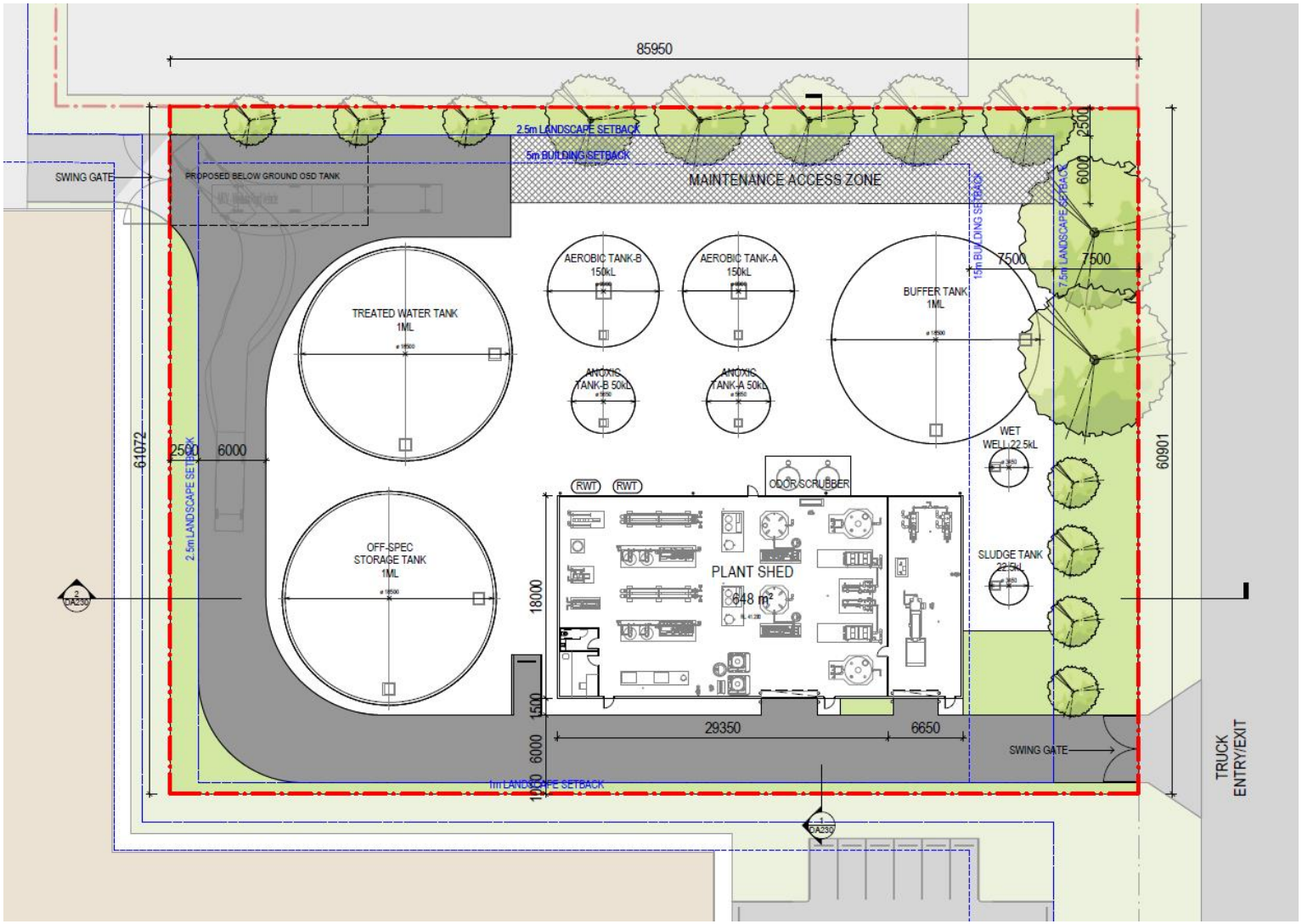


Figure 1.3 Proposed facility layout

Source: Nettleton Tribe 2024

2 Site setting and sensitive receptors

2.1 Site and surrounding area

The AIBP is located at 221–235 Luddenham Road, Orchard Hills, approximately 41 kilometres (km) west of the Sydney CBD in the Greater Western Sydney region. The AIBP has recently been rezoned from RU2 Rural landscape to E4 General Industrial, with land classifications in the surrounding area including C2 Environmental Conservation and RU2 Rural landscape. The nearest residential zone is an area of R2 Low Density Residential within the suburb of St Clair, approximately 1.6 km north-east of the AIBP and an area of C4 Environmental Living within the Twin Creeks residential neighbourhood, approximately 1.0 km south of the AIBP.

2.2 Assessment locations

A selection of representative residential properties and future industrial properties surrounding and within the AIBP have been chosen as assessment locations for this modelling study, these are presented in Table 2.1 and shown in Figure 2.1.

Table 2.1 Assessment locations

Location ID	Classification	Coordinate (MGA, 56)	
		Easting	Northing
R1	Residential	292749	6255740
R2	Residential	292736	6255687
R3	Residential	292758	6255639
R4	Residential	292763	6255603
R5	Residential	292762	6255547
R6	Residential	292772	6255509
R7	Residential	292780	6255456
R8	Residential	292793	6255410
R9	Residential	292797	6255354
R10	Residential	292825	6255304
R11	Residential	292824	6255246
R12	Residential	292823	6255209
R13	Residential	293251	6255198
R14	Residential	293264	6255156
R15	Residential	293248	6255109
R16	Residential	292662	6254625
R17	Residential	292537	6254646
R18	Residential	292378	6254671
R19	Residential	292502	6254384

Location ID	Classification	Coordinate (MGA, 56)	
		Easting	Northing
R20	Residential	292568	6254244
R21	Residential	292559	6254199
R22	Residential	292560	6254162
R23	Residential	292589	6254136
R24	Residential	292618	6254105
R25	Residential	291970	6254195
R26	Residential	292724	6255925
R27	Residential	292676	6255360
R28	Residential	292647	6255254
R29	Residential	292597	6255025
R30	Residential	292646	6254976
R31	Residential	291436	6254625
R32	Recreational	292498	6255414
R33	Industrial*	292342	6255519
R34	Industrial*	292179	6255490
R35	Industrial*	292193	6255617
R36	Industrial*	292550	6255695

*Location of future industrial development within ABIP

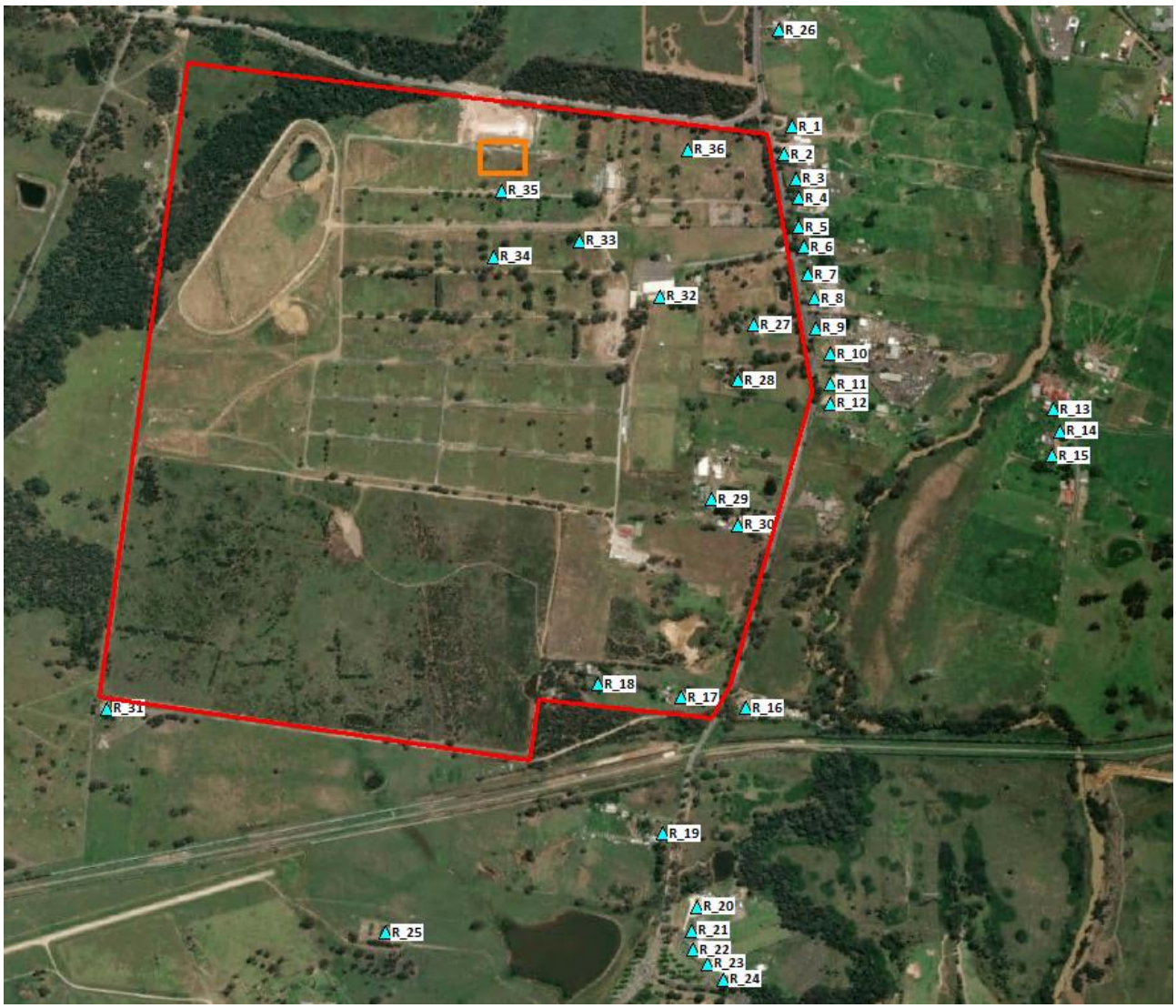


Figure 2.1 Assessment locations

3 Assessment criteria

No instrument-based method can measure an odour response in the same way as the human nose. Therefore "dynamic olfactometry" is typically used as the basis of odour quantification by regulatory authorities. Dynamic olfactometry is the measure of odour by presenting a sample of odorous air to a panel of people with decreasing quantities of clean odour-free air. The panellists then note when the smell becomes detectable. The correlations between the known dilution rations and the panellists' responses are then used to calculate the number of dilutions of the original sample required to achieve the odour detection threshold. The units for odour measurement in dynamic olfactometry are "odour units" (ou), which are dimensionless and are effectively "dilutions to threshold".

The odour nuisance level can be as low as 2 ou and as high as 10 ou (for less offensive odours), whereas an odour assessment criterion of 7 ou is likely to represent the level below which 'offensive' odours should not occur. The *Technical Framework: Assessment and Management of Odour from Stationary Sources in NSW* (NSW DECC 2006a) recommends that, as a design criterion, no individual should be exposed to ambient odour levels greater than 7 ou.

The EPA (2022) prescribes odour goals which take into account the population density for a particular area. A summary of the EPA's population-based odour assessment criteria is presented in Table 3.1.

Table 3.1 Impact assessment criteria for complex mixtures of odorous air pollutants

Population of affected community	Odour units (ou), 1-second nose response time average*(99th percentile)
~ 2	7
~ 10	6
~ 30	5
~ 125	4
~ 500	3
Urban (2,000) and/or schools and hospitals	2

Note:*a nose response average refers to the instantaneous perception of odours by the human nose and is derived using peak-to-mean ratios, described in Section 5.2.

In the interests of conservatism, the most stringent odour goal of 2 ou has been adopted in this assessment for all surrounding assessment locations.

4 Existing environment

4.1 Existing sources of odour

The proposed development is located in western Sydney, predominantly surrounded by rural landscapes and residential properties. Regarding neighbouring sources of industrial air pollutant emissions, the facility is approximately 0.8 km south-east of Bingo Industries' Patons Lane Resource Recovery Facility.

An odour impact assessment was completed for the Patons Lane Resource Recovery Facility by RWDI Australia Limited [1] in 2022. The results of the dispersion modelling undertaken in that report show predicted odour concentrations across the AIBP and adjacent existing residential receptors of less than 0.3 ou. On the basis of these predicted odour concentrations, it is unlikely that cumulative odour impacts with the facility would occur. No further consideration of odour emissions from the Patons Lane Resource Recovery Facility is made in this report.

4.2 Dispersion meteorology

4.2.1 Monitoring data resources

Meteorological mechanisms govern the generation, dispersion, transformation, and eventual removal of pollutants from the atmosphere. To adequately characterise the dispersion meteorology of a region, information is needed on the prevailing wind regime, ambient temperature, rainfall, relative humidity, mixing depth and atmospheric stability.

There are no meteorological measurements taken at the AIBP. In reviewing the meteorological environment of the local area, the following publicly available data sources were analysed:

- Bureau of Meteorology (BoM) Automatic weather station (AWS) at Badgerys Creek (station 067108), located approximately 9.0 km south-west of the AIBP. One-hour average measurements of wind speed, wind direction, standard deviation of wind direction, temperature, station-level barometric pressure and relative humidity were sourced from this AWS
- BoM Bankstown Airport AWS (station 066137) located approximately 23.4 km east of the AIBP. One-hour average measurements of cloud observations were sourced from this AWS.

Data from these stations were analysed for use in this assessment and are documented in the proceeding sections.

4.2.2 Prevailing winds and selection of a representative year

The meteorological data recorded by the BoM Badgerys Creek AWS were analysed for the five-year period between 2019 and 2023 (see Appendix A). The analysis demonstrated a similarity across years in the most important parameters for dispersion, such as wind speed and wind direction winds. The inter-annual profiles for air temperature and relative humidity were also generally comparable between 2019 and 2023 (Appendix A). The 2019 dataset showed higher daytime temperatures and lower relative humidity, which are indicative of the strong drought conditions experienced in 2019.

A summary of the annual average wind speed, percentage of calms (wind speeds less than 0.5 metres per second (m/s)), and data recovery for each year is presented in Table 4.1.

[1] https://majorprojects.planningportal.nsw.gov.au/prweb/PRRestService/mp/01/getContent?AttachRef=MP09_0074-MOD-2%2120230110T054030.327%20GMT

The statistics in Table 4.1 show that there was a general inter-annual consistency in the recorded annual average wind speed and annual percentage of calms for each year.

Table 4.1 Summary of average wind speed, percentage of calms and data recovery for BoM Badgerys Creek AWS

Year	Average wind speed (m/s)	Calms (%)	Data recovery (%)*
2019	2.6	8.2%	95
2020	2.4	11.8%	100
2021	2.4	7.9%	99
2022	2.5	7.8%	99
2023	2.4	8.6%	85

*Note: based on availability of wind speed data.

On the basis of similarities in inter-annual trends with wind speed and direction for the years between 2019 and 2023, the 2021 calendar year was adopted as the 12-month modelling period for the purpose of this odour impact assessment and is considered suitably representative of meteorological conditions recorded at the BoM Badgerys Creek AWS.

It is noted that 2022 was affected by the La Niña phenomenon which resulted in significantly higher than average rainfall across the region and was therefore excluded. While the 2023 calendar year is the most recent at the time of reporting, the meteorological dataset was below the data completeness threshold of 90% required for dispersion modelling, as set out in the Approved Methods for Modelling.

Annual, seasonal and diurnal wind roses created from wind speed and direction data collected at the BoM Badgerys Creek AWS are presented in Figure 4.1 to Figure 4.3, respectively.

Annually the wind rose shows a prevailing wind alignment from the north-east and the south to south-west. On a seasonal basis, the autumn and winter months show prevailing south-westerly winds, while winds from the north-east through to the south-east are more dominant in the summer months. Diurnally, the wind direction patterns during the night hours are dominant from the south-west, while a notable north-east and south-west is experienced during the day. Average wind speeds were higher during the day and the percentage of calms was higher at night-time.

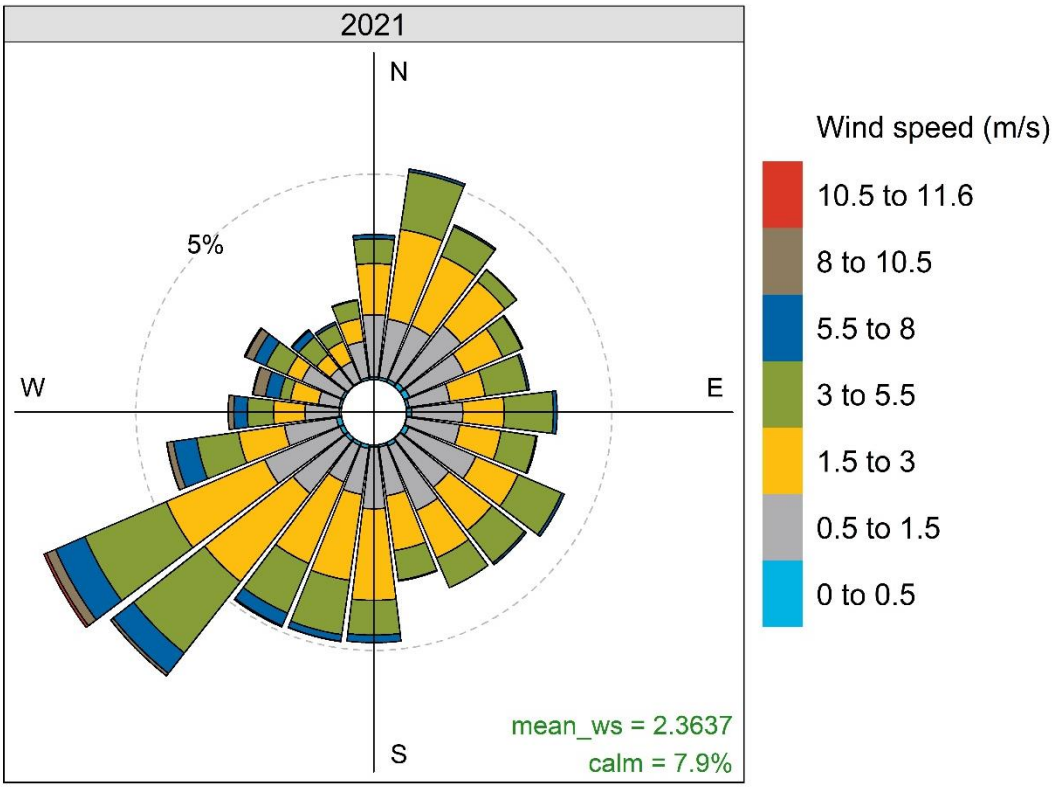


Figure 4.1 **Annual wind speed and direction – Badgerys Creek AWS – 2021**

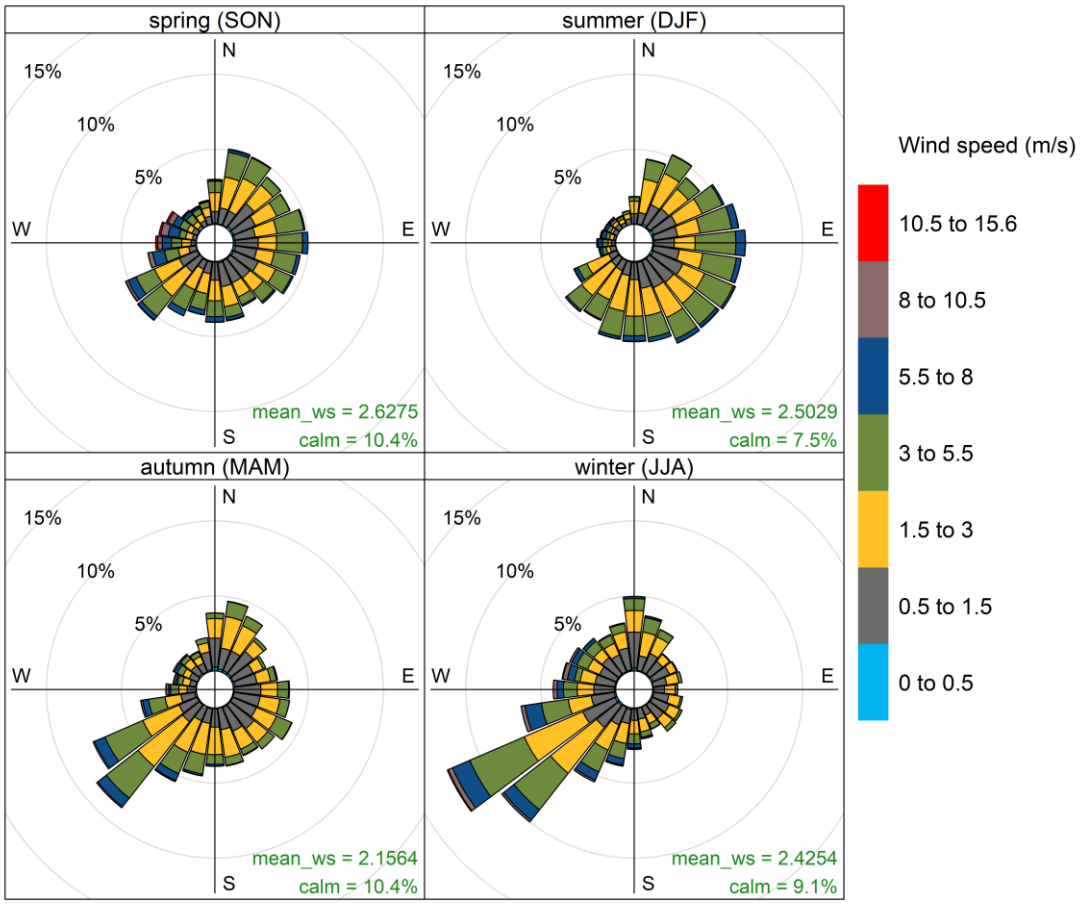


Figure 4.2 Seasonal wind speed and direction – BoM Badgerys Creek – 2019 to 2023

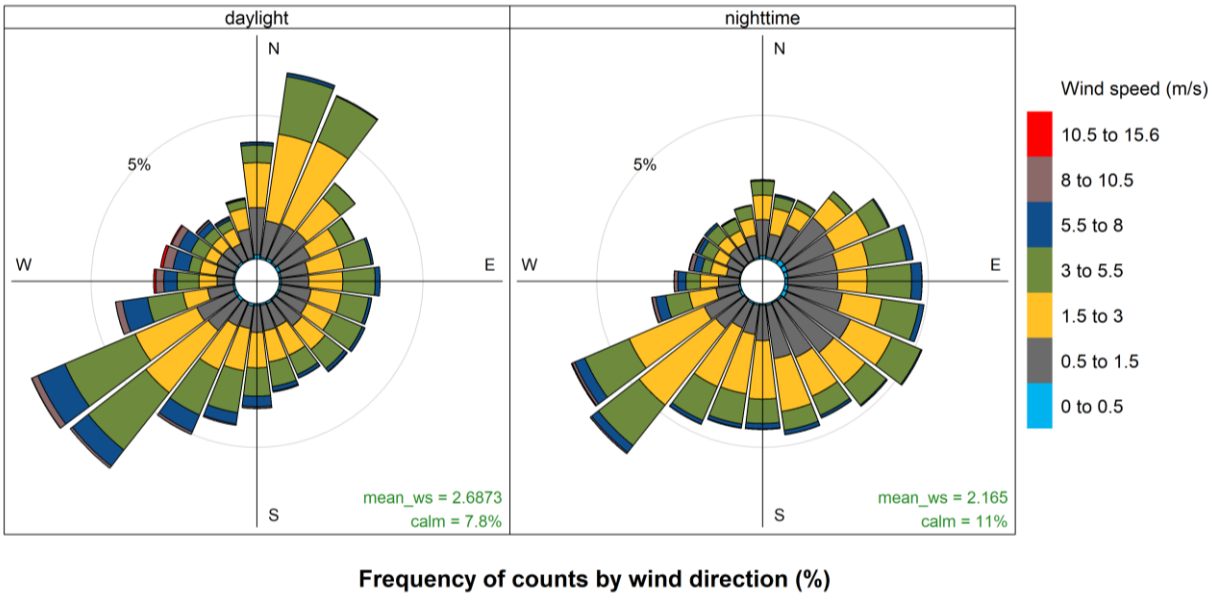


Figure 4.3 Diurnal wind speed and direction – BoM Badgerys Creek -2019 to 2023

4.2.3 Meteorological modelling

Atmospheric dispersion modelling for this assessment has been completed using the AMS[2]/USEPA[3] regulatory model (AERMOD) (model version v23132). The meteorological inputs for AERMOD were generated using the AERMET meteorological processor (model version v23132), using local surface observations from the BoM Badgerys Creek AWS and upper air profiles generated by the Commonwealth Scientific and Industrial Research Organisation (CSIRO) TAPM meteorological modelling module.

Further details of the TAPM meteorological modelling and AERMET data processing completed to prepare the inputs for AERMOD are documented in Appendix A.

4.2.4 Atmospheric stability and mixing depth

Atmospheric stability refers to the degree of turbulence or mixing that occurs within the atmosphere and is a controlling factor in the rate of atmospheric dispersion of pollutants.

The Monin-Obukhov length (L) provides a measure of the stability of the surface layer (i.e. the layer above the ground in which vertical variation of heat and momentum flux is negligible; typically about 10% of the mixing height). Negative L values correspond to unstable atmospheric conditions, while positive L values correspond to stable atmospheric conditions. Very large positive or negative L values correspond to neutral atmospheric conditions.

Figure 4.4 illustrates the diurnal variation of atmospheric stability, derived from the Monin-Obukhov length calculated by AERMET based on observation data collected from the BoM Badgerys Creek AWS in 2021.

The diurnal profile presented illustrates that atmospheric instability increases during daylight hours as convective energy increases, whereas stable atmospheric conditions prevail during the night-time. This profile indicates that the potential for atmospheric dispersion of emissions would be greatest during daytime hours and lowest during evening through to early morning hours.

[2] AMS – American Meteorological Society

[3] USEPA – United States Environmental Protection Agency

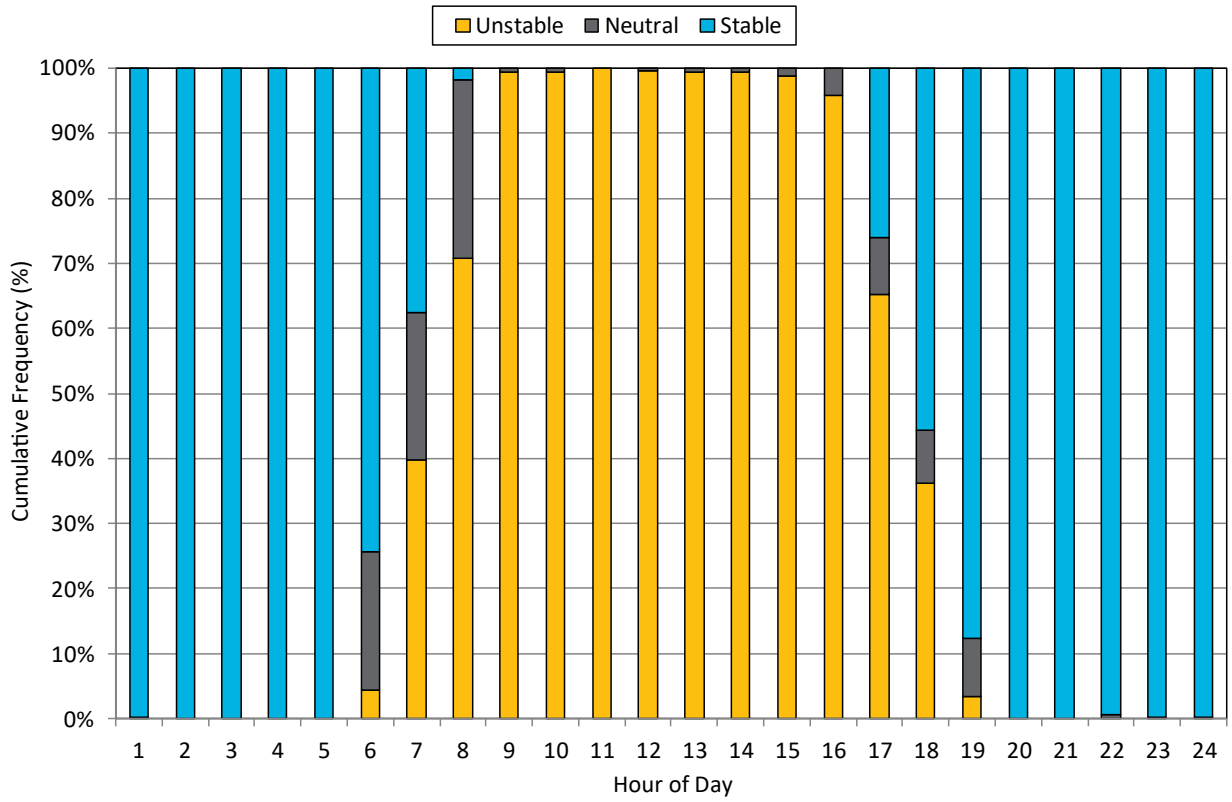
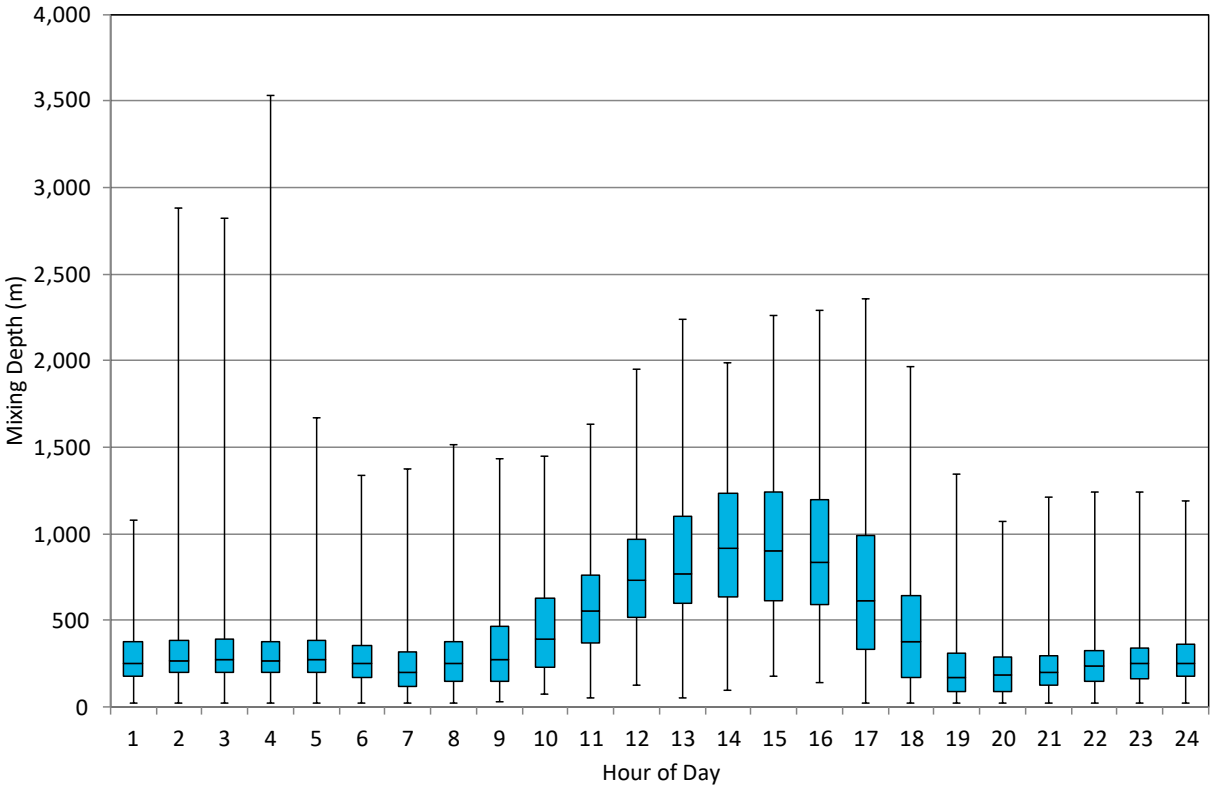


Figure 4.4 **AERMET-generated diurnal variation in atmospheric stability – BoM Badgerys Creek AWS - 2021**

Hourly-varying atmospheric boundary layer depths were calculated by AERMET and refers to the height of the atmosphere above ground level within which the dispersion of air pollution occurs. The variation in boundary layer depth by hour of the day is illustrated in Figure 4.5. The profile presented Figure 4.5 shows that greater boundary layer depths are experienced during the daytime hours between mid-morning and late afternoon. Higher day-time wind velocities and the onset of incoming solar radiation increases the amount of mechanical and convective turbulence in the atmosphere. As turbulence increases so too does the depth of the boundary layer, generally contributing to higher mixing depths and greater potential for atmospheric dispersion of pollutants.



Note: blue bars indicate the interquartile range (IQR), or middle 50% of the data, while the whiskers indicate highest and lowest values.

Figure 4.5 **AERMET-generated diurnal variation in atmospheric boundary layer depth – BoM Badgerys Creek AWS - 2021**

5 Emissions inventory

5.1 Odour emission calculations

Details of the project have been provided by the design engineer firm, Aquacell Pty Ltd (Aquacell).

Based on advice from Aquacell, the potentially odour emission generating processes at the project are the following:

- Three external in-ground storage tanks, specifically the buffer tank, the wet well tank and sludge storage tank.
- Two waste activated sludge (WAS) holding tanks within the main shed.
- Two pre-screens and one dewatering screen, and associated screenings storage bins, within the main shed.

The following odour mitigation methods apply to the above processes:

- The external tanks will be enclosed and fitted with passive carbon filters to treat potential fugitive odour emissions.
- The two WAS holding tanks within the main building will be vented to passive carbon filters.
- The area of the pre-screens and dewatering screen will be ducted, with collected air diverted to two scrubber devices to be located on the northern wall of the main shed.

Aquacell have advised that the following odour emission reductions apply to the above mitigation methods:

- Passive carbon filters – 99% reduction.
- Scrubber device – greater than 95% reduction.

Aquacell have advised that all other components of the project will be sealed or have negligible odour generation potential. Therefore, no other odour emission sources are characterised in this report.

In order to estimate odour emissions from the project, EMM have reviewed the Sydney Water Corporation (SWC) odour emissions database, which is based on historical odour emissions sampling data from operational wastewater treatment facilities in the SWC network.

The following odour emission source resources were adopted:

- External storage tanks (buffer tank, wet well tank, sludge storage tank) – average normalised odour emission rate from “Sludge Storage” samples.
- WAS holding tanks – average normalised odour emission rate from “Sludge Storage” samples.
- Pre-screens - – average normalised odour emission rate from “Screenings Bins” samples.
- Dewatering screen - – average normalised odour emission rate from “Sludge Dewatering Building” samples.

Details of the odour emissions calculations are presented in Table 5.1.

Table 5.1 Odour emission calculations

Emission source	Diameter (m)	Area (m^2)	Air flow (m^3/hr)	Exit diameter (m)	Velocity (m/s)	Specific Odour Emission Rate ($ou.m^3/m^2/s$)	Emission reduction	Odour emission rate ($ou.m^3/s$)
Wet well	3.5	9.3	-	-	-	12.336	99%	1.153
Sludge tank	3.5	9.3	-	-	-	12.336	99%	1.153
Buffer tank	18.5	268.8	-	-	-	12.336	99%	33.159
Pre-screen 1 + bin		2.5				0.0694	-	-
Pre-screen 2 + bin		2.5				0.0694	-	-
Dewatering screen		10				0.3631	-	-
Scrubber #1 and #2			18	0.15	0.3	-	95%	0.0995
WAS holding tank #1 and #2	2.4	4.5	-	-	-	12.336	99%	0.558

Note: Emissions from Pre-screen 1 + bin, Pre-screen 2 + bin and Dewatering screen are captured by Scrubber #1 and #2

5.2 Peak-to-mean

The calculated hourly odour emission rates were paired with the appropriate near field peak-to-mean ratios from Table 6.1 of the NSW EPA Approved Methods for Modelling. The EPA-recommended peak-to-mean ratios are designed to convert the predicted one-hour average odour concentrations to a 1-second nose response concentration for comparison with the appropriate impact assessment criterion for odour. For the type of emission source adopted in the modelling (wake affected point source or volume source) a peak-to-mean ratio of 2.3 has been applied.

6 Dispersion modelling

6.1 Dispersion model selection and configuration

The atmospheric dispersion modelling completed for this assessment used the AERMOD dispersion model (version v23132). AERMOD is designed to handle a variety of pollutant source types, including surface and buoyant elevated sources, in a wide variety of settings such as rural and urban as well as flat and complex terrain.

In addition to the 36 individual assessment locations (documented in Section 2.2), odour concentrations were predicted over a nested grid domain of 10 km by 10 km with spacing ranging from 50 to 500 decreasing with proximity to the AIBP (totalling 5,770 receptor points).

The BPIP PRIME model in AERMOD was used for future proposed buildings within 100 m of the proposed scrubber stacks. These were implemented to account for building wake effects from the proposed development and surrounding building structures.

Modelling was undertaken using a combination of area sources (for external tanks), point sources (scrubbers) and volume sources (for WAS holding tank carbon filters). The location of model emission sources are aligned with the site layout shown in Figure 1.3.

Simulations were undertaken for the 12-month period for January to December 2021 using the AERMET-generated meteorological domain file (see Section 4.2 for a description of input meteorology).

6.2 Predicted odour concentrations

Predicted 99th percentile 1-second odour concentrations from the facility are presented in Table 6.1 for each of the adopted assessment locations. A contour plot illustrating the spatial variation in predicted odour concentrations is presented in Figure 6.1.

It is noted that the isopleth plots of the 1-second average odour concentrations do not represent the dispersion pattern for any individual time period, but rather illustrate the highest concentration that was predicted to occur at each model calculation point given the range of meteorological conditions occurring over the 2021 modelling period.

The results of the dispersion modelling show that the operation of the facility is unlikely to generate adverse odour impacts in the surrounding environment. The proposed odour emission mitigation measures (discussed in Section 5.1) are therefore likely to be effective at limiting the potential odour emission generation from the facility.

Table 6.1 Predicted 99th percentile 1-second odour concentration (ou)

Assessment location ID	Predicted 99th percentile 1-second odour concentration (ou)
Criterion	**2**
R1	<1
R2	<1
R3	<1
R4	<1
R5	<1
R6	<1
R7	<1
R8	<1
R9	<1
R10	<1
R11	<1
R12	<1
R13	<1
R14	<1
R15	<1
R16	<1
R17	<1
R18	<1
R19	<1
R20	<1
R21	<1
R22	<1
R23	<1
R24	<1
R25	<1
R26	<1
R27	<1
R28	<1
R29	<1
R30	<1
R31	<1

Assessment location ID	Predicted 99th percentile 1-second odour concentration (ou)
Criterion	**2**
R32	<1
R33	<1
R34	<1
R35	<1

Figure 6.1 Predicted 99th percentile 1-second odour concentration (ou) contours

7 Conclusion

This odour impact assessment presents a quantitative modelling assessment of potential odour emissions and impacts from the proposed facility.

Meteorological modelling was completed using AERMET, with observations incorporated primarily from the BoM Badgerys Creek AWS recorded during 2021.

Odour emissions were estimated using conservative odour monitoring sample from the SWC odour emissions database. Atmospheric dispersion modelling of odour emissions was undertaken using the AERMOD dispersion model.

The results of the modelling showed that the predicted odour concentrations from the facility were below the applicable NSW EPA odour impact assessment criteria for urbanised areas at all assessment locations.

The results of the dispersion modelling show that the operation of the facility is unlikely to generate adverse odour impacts in the surrounding environment. The proposed odour emission mitigation measures (discussed in Section 5.1) are therefore likely to be effective at limiting the potential odour emission generation from the facility.

References

Aquacell 2024, *Recycled Water Quality Management Plan Alspec Industrial Business Park Blackwater Treatment Plant Luddenham Rd, Orchard Hills*, June 2024.

Department of Environment and Climate Change:

- 2006a, Technical Framework: Assessment and management of odour from stationary sources in NSW

- 2006b, Technical Notes: Assessment and management of odour from stationary sources in NSW.

NSW EPA 2022, *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales*. New South Wales Environment Protection Authority, Sydney.

RWDI 2022, *Patons Lane Resource Recovery Facility – Integrated Water and Leachate Plant Modifications Air Quality Impact Assessment* December 2022

Abbreviations

AERMOD	AMS /USEPA regulatory model
AIBP	Alspec industrial business park
AWS	Automatic weather station
BAC	Biological activated carbon filter
BoM	Bureau of Meteorology
Council	Penrith City Council
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DA	development application
DCCEEW	NSW Department of Climate Change, Energy, the Environment and Water
EMM	EMM Consulting Pty Limited
Facility	Proposed on-site sewer management facility
km	kilometres
kL	kilolitre
LGA	local government area
MBR	Membrane bioreactor
NSW EPA	NSW Environment Protection Authority
ou	odour units
SWC	Sydney Water Corporation
UV	Ultraviolet light
WAS	waste activated sludge

Appendix A
Meteorological analysis

EMM
creating opportunities

A.1 Meteorological data analysis for the Badgerys Creek AWS – 2019 to 2023

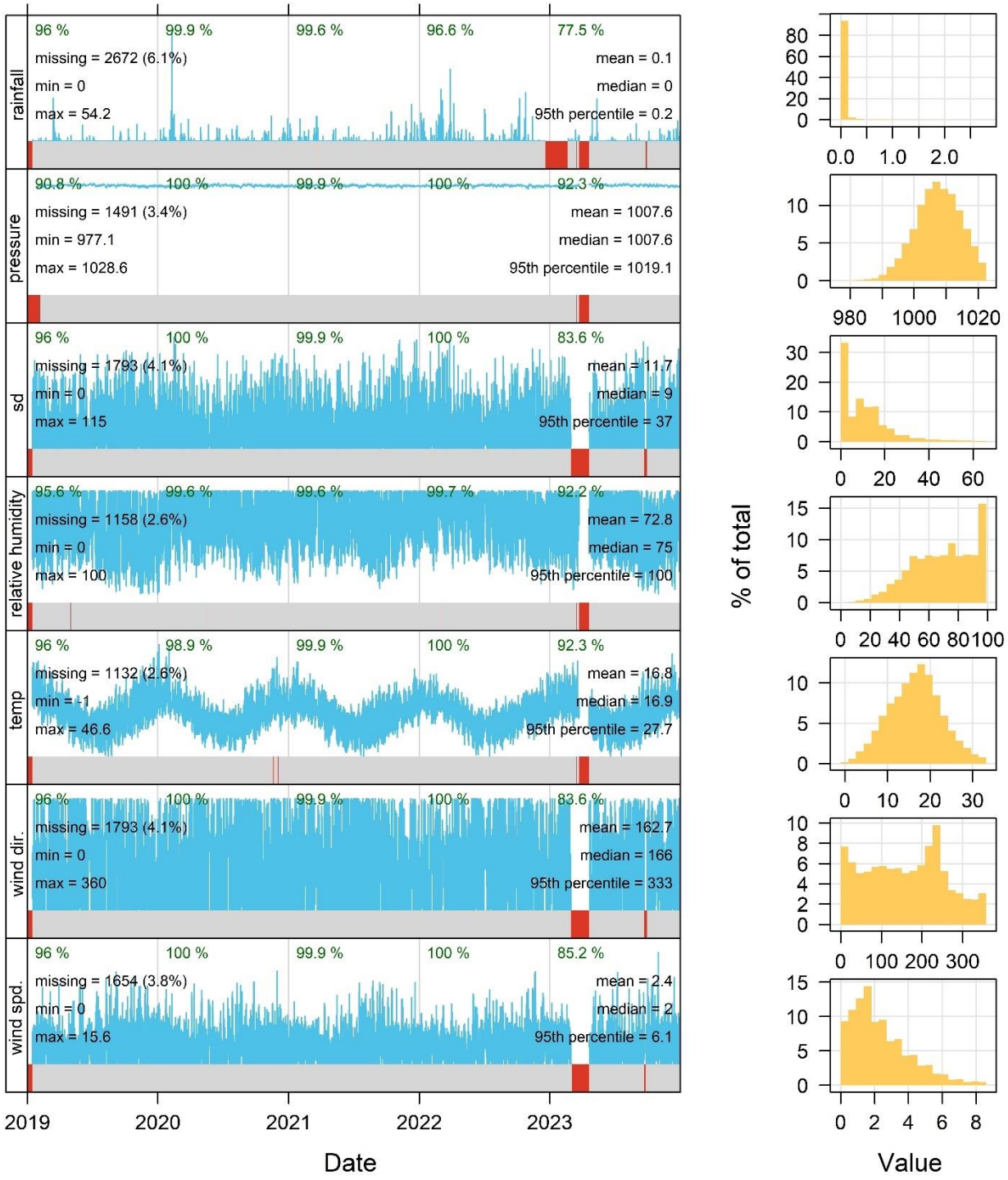


Figure A.1 Data completeness analysis plot – BoM Badgerys Creek AWS – 2019 to 2023

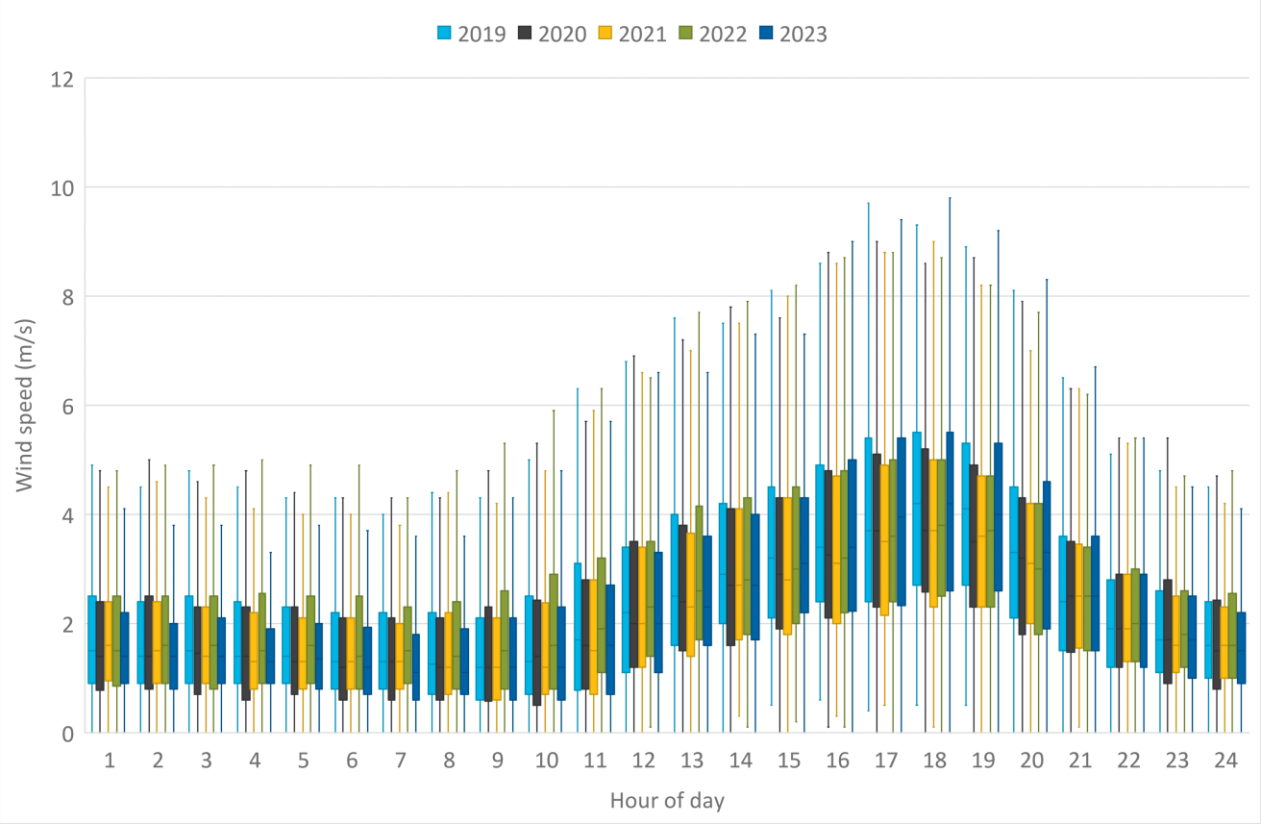


Figure A.2 **Inter-annual variability in diurnal wind speed – Badgerys Creek– 2019 to 2023**

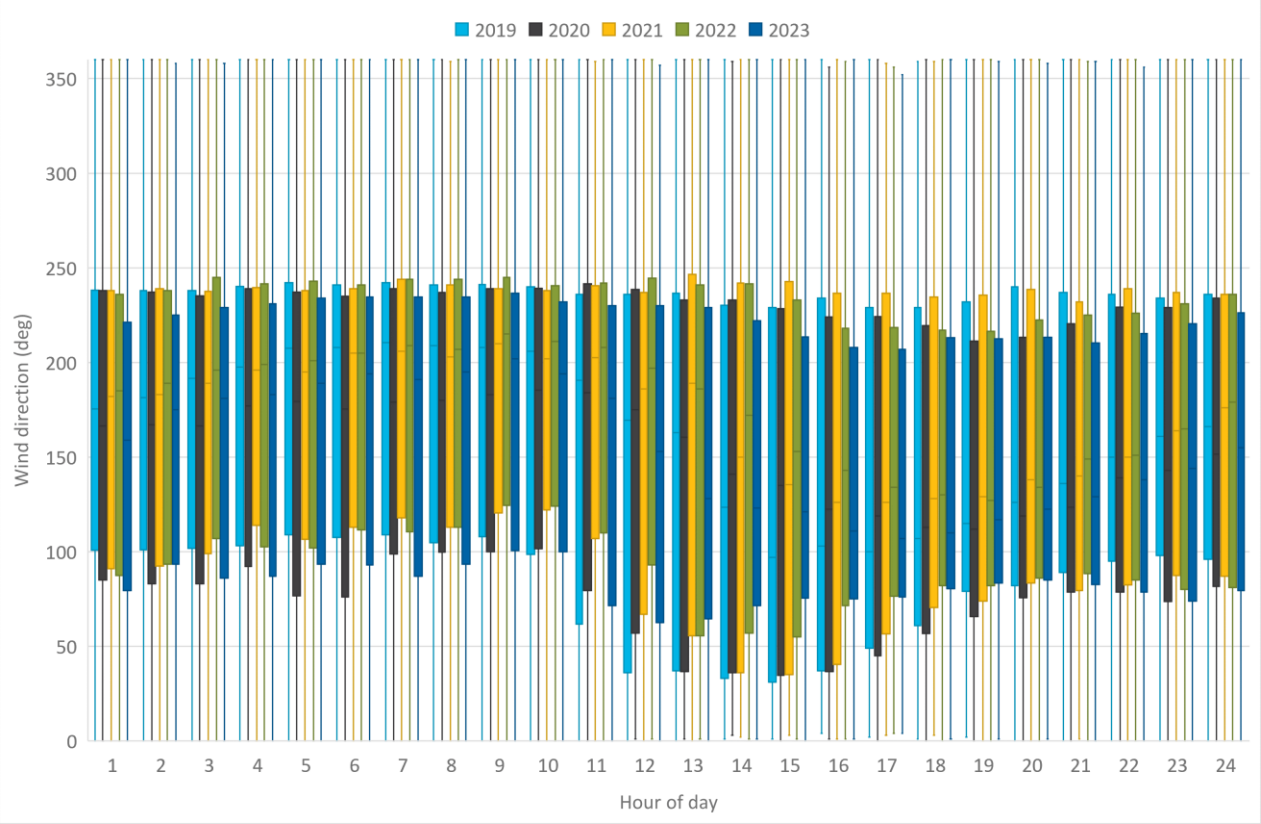


Figure A.3 **Inter-annual variability in diurnal wind direction – Badgerys Creek– 2019 to 2023**

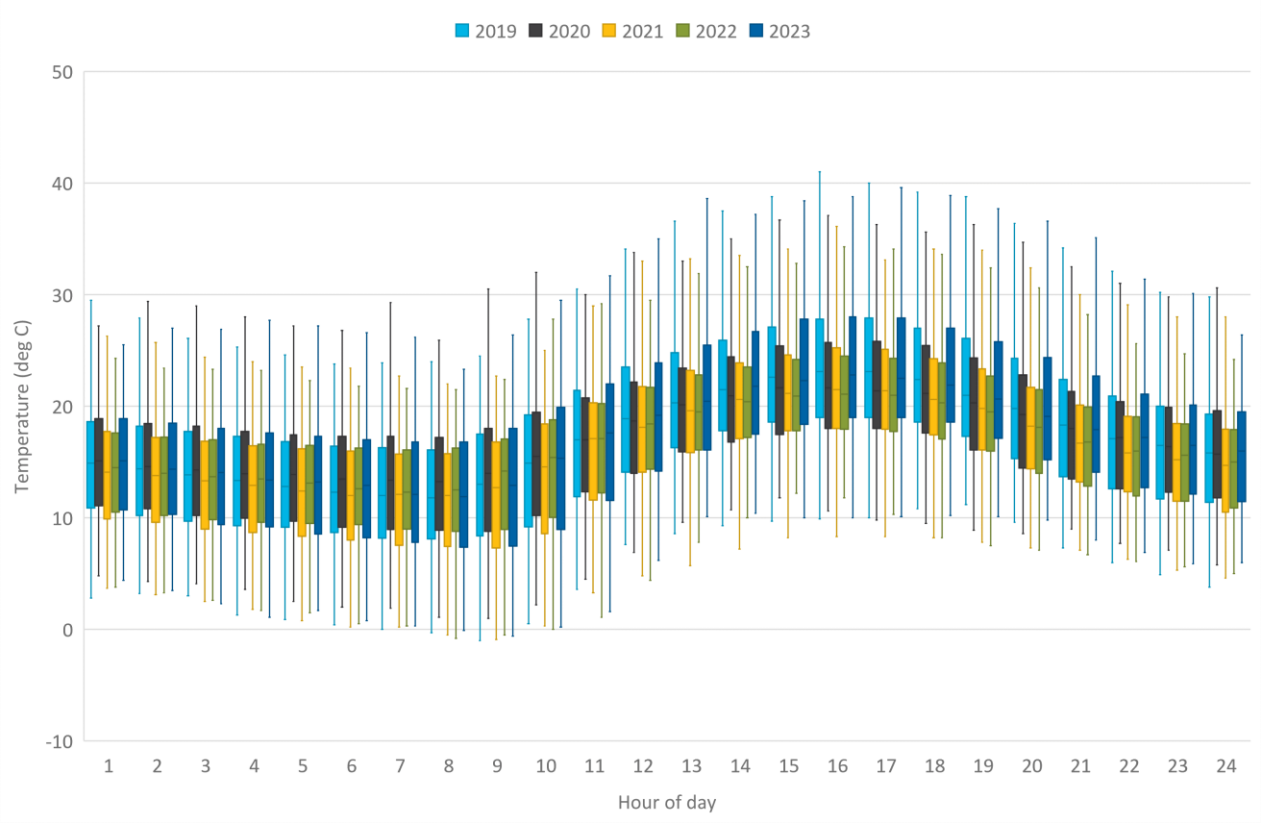


Figure A.4 **Inter-annual variability in diurnal air temperature – Badgerys Creek– 2019 to 2023**

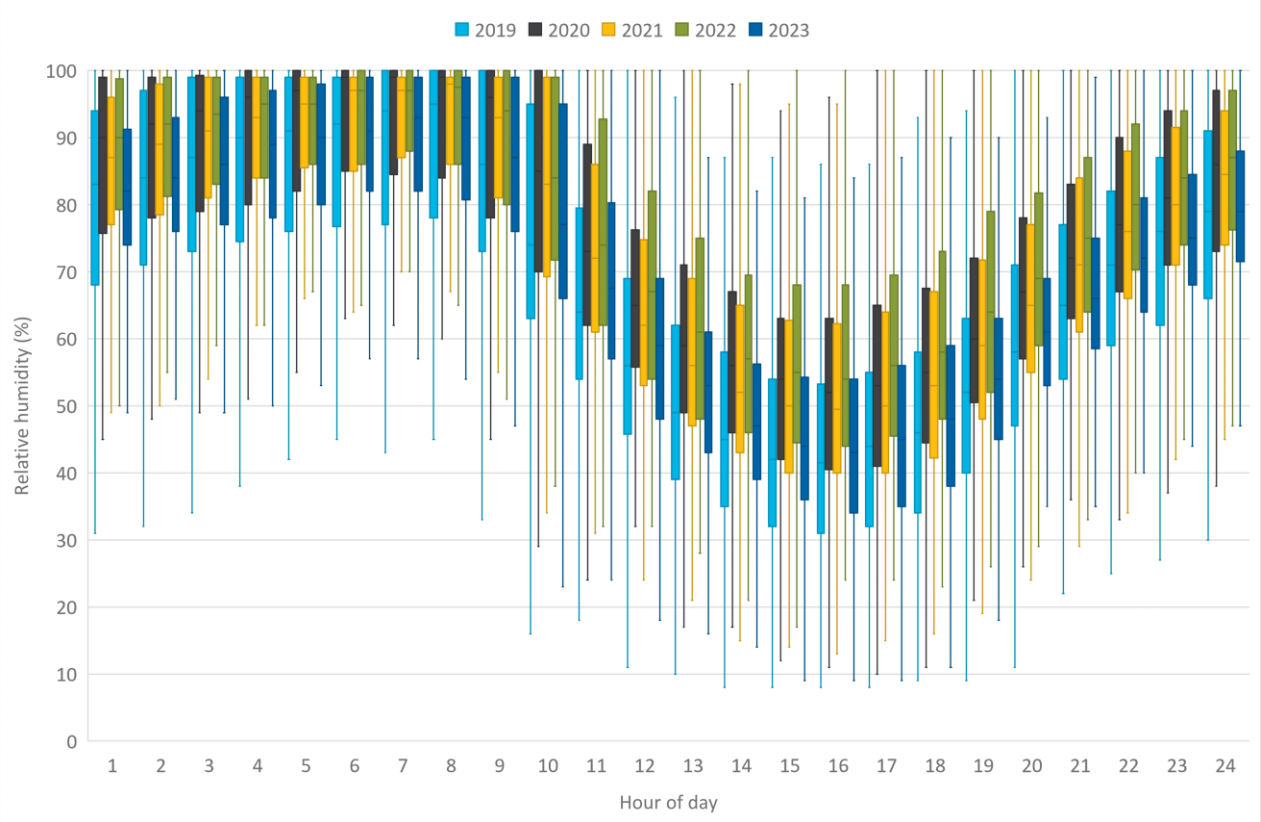


Figure A.5 **Inter-annual variability in diurnal relative humidity – Badgerys Creek– 2019 to 2023**

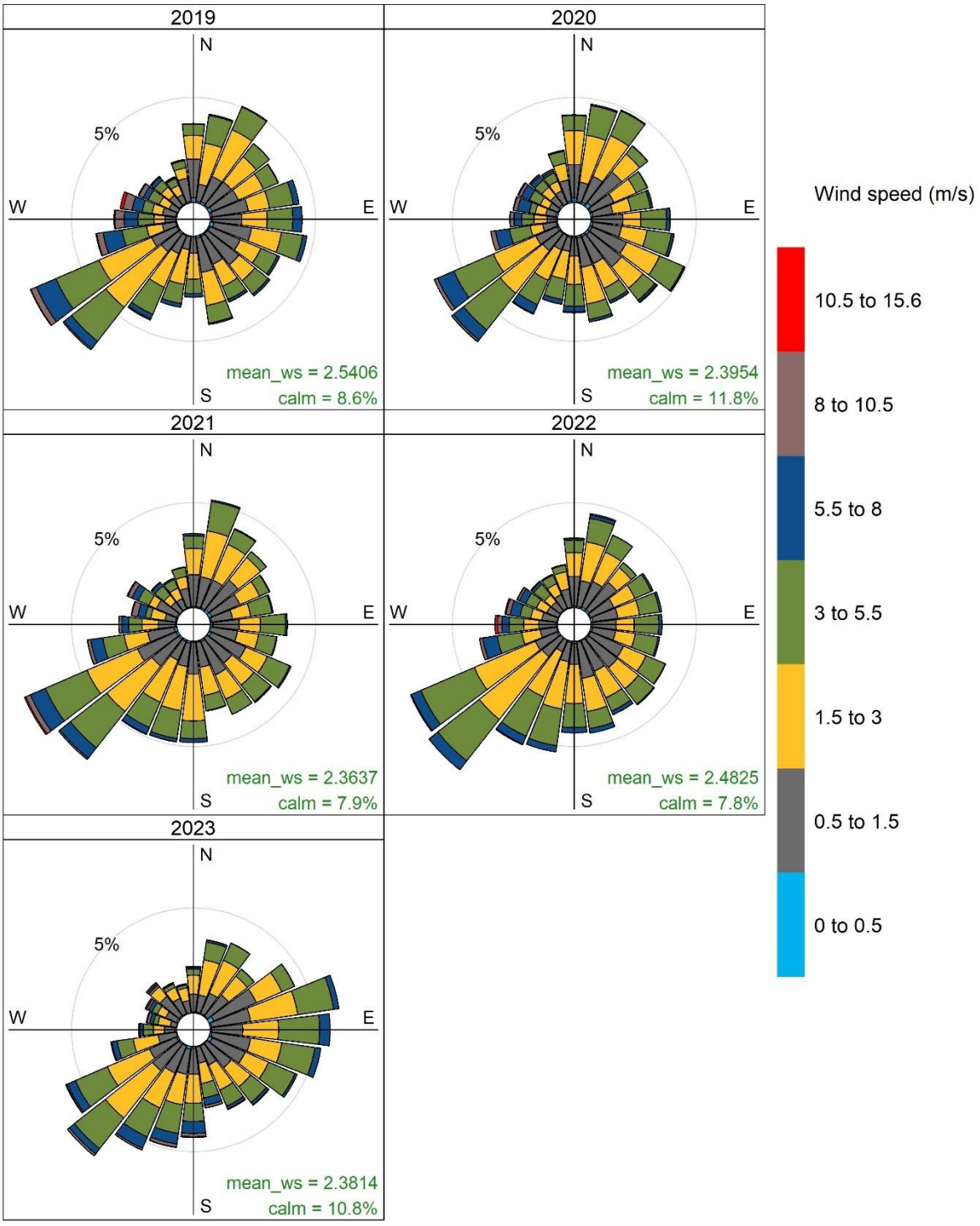


Figure A.6 **Inter-annual comparison of recorded wind speed and direction – Badgerys Creek AWS – 2019 to 2023**

A.2 Meteorological modelling

A.2.1 TAPM modelling

The CSIRO prognostic meteorological model TAPM was used to generate the required upper air prognostic dataset required for AERMET modelling.

TAPM was configured and run as follows:

- TAPM version 4.0.4
- inclusion of high resolution (90 m) regional topography (improvement over default 250 m resolution data)
- grid domains with cell resolutions of 30 km, 10 km, 3 km, 1 km and 0.3 km. Each grid domain features 25 x 25 horizontal grid points and 25 vertical levels
- TAPM default databases for land use, synoptic analyses and sea surface temperature;
- TAPM defaults for advanced meteorological inputs
- surface meteorological data from the BoM Badgerys Creek AWS location were incorporated into the modelling
- two 'spin-up' days allowed at the beginning and end of the run.

A.2.2 AERMET meteorological processing

The meteorological inputs for AERMOD were generated using the AERMET meteorological processor. The following sections provide an overview of meteorological processing completed for this assessment.

A.2.3 Surface characteristics

Prior to processing meteorological data, the surface characteristics of the area surrounding the adopted monitoring station require parameterisation. The following surface parameters are required by AERMET:

- surface roughness length
- albedo
- Bowen ratio.

As detailed by USEPA (2013), the surface roughness length is related to the height of obstacles to the wind flow (e.g. vegetation, built environment) and is, in principle, the height at which the mean horizontal wind speed is zero based on a logarithmic profile. The surface roughness length influences the surface shear stress and is an important factor in determining the magnitude of mechanical turbulence and the stability of the boundary layer. The albedo is the fraction of total incident solar radiation reflected by the surface back to space without absorption. The daytime Bowen ratio, an indicator of surface moisture, is the ratio of sensible heat flux to latent heat flux and is used for determining planetary boundary layer parameters for convective conditions driven by the surface sensible heat flux.

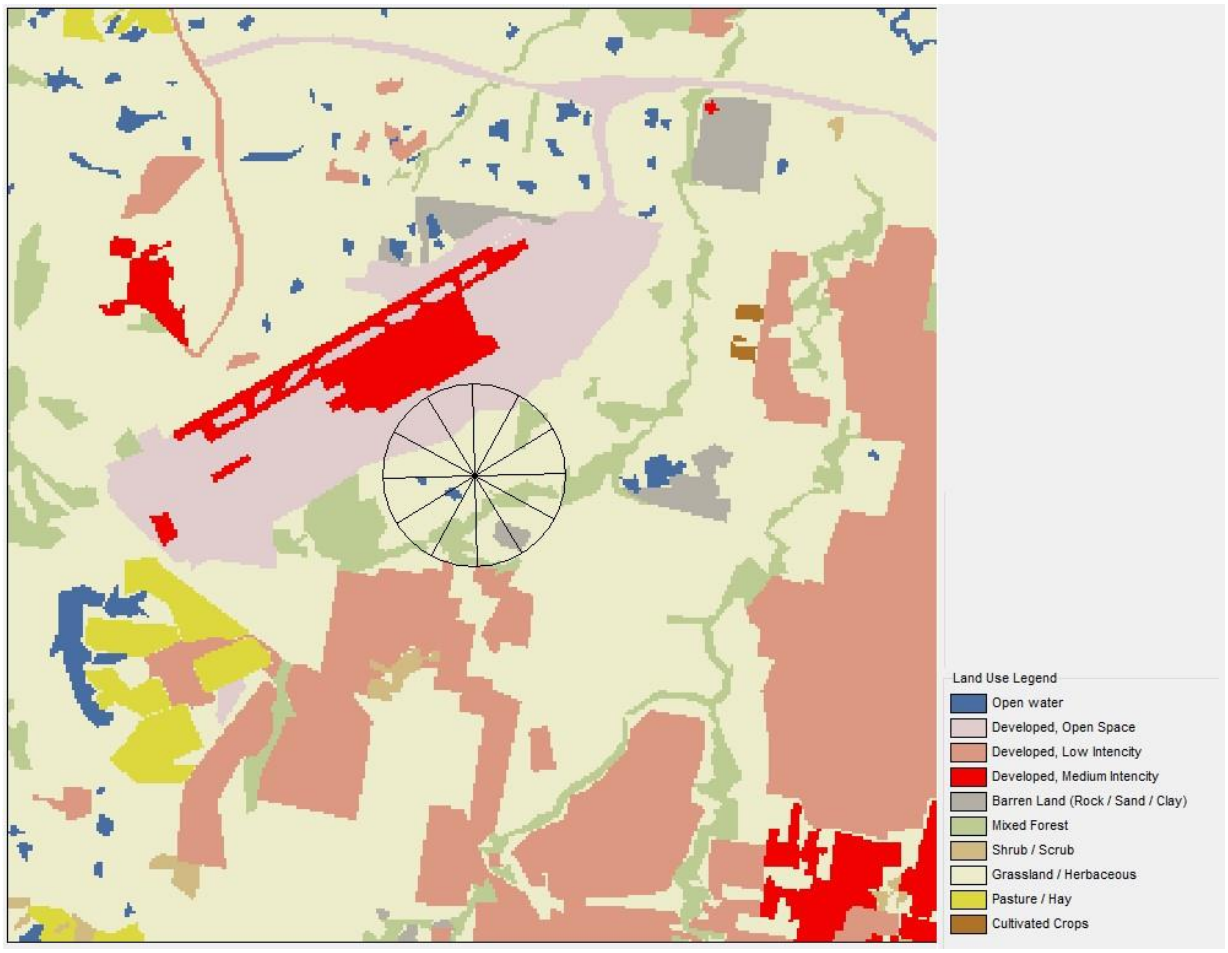
The land cover of the 10 km by 10 km area surrounding the BoM Badgerys Creek AWS was mapped (see Figure A.7). Using the AERSURFACE tool and following the associated guidance of USEPA (2013), surface roughness was determined for 12 (30 degree) sectors grouped by similar land use types within a 1 km radius around the BoM Badgerys Creek AWS, while the Bowen ratio and albedo were determined for the total area. Monthly-varying

values for surface roughness, Bowen ratio and albedo were allocated to each sector based on the values prescribed by USEPA (2013).

Surface moisture characteristics for the 2021 modelling period was determined by comparing the period rainfall total to the previous 30-year rainfall records from the following BoM long term rainfall stations:

- Badgerys Creek AWS (067108)
- Bringelly (Maryland) (067015)
- Orchard Hills Treatment Works (067084).

Annual rainfall modelling was 1,064 mm, which places the 12-month period wetter than average with the 70th percentile rainfall totals for the previous 30 years. A 'wet' surface moisture classification was allocated. It is noted that the rainfall records are not incorporated into dispersion model predictions (i.e. no wet deposition is modelled).



Note: Marked in figure are the 1 km radius for surface roughness (12 sectors defined) and 10 km x 10 km for albedo/Bowen ratio (total image shown)

Figure A.7 Land use map for AERSURFACE processing

Table A.1 Monthly surface roughness length values by sector

Month	Surface roughness length (m) by sector (degrees)											
	0-30	30-60	60-90	90-120	120-150	150-180	180-210	210-240	240-270	270-300	300-330	330-0
Jan	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Feb	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Mar	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Apr	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
May	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271
Jun	0.119	0.060	0.032	0.057	0.049	0.016	0.145	0.134	0.163	0.076	0.023	0.219
Jul	0.119	0.060	0.032	0.057	0.049	0.016	0.145	0.134	0.163	0.076	0.023	0.219
Aug	0.119	0.060	0.032	0.057	0.049	0.016	0.145	0.134	0.163	0.076	0.023	0.219
Sep	0.185	0.129	0.092	0.125	0.116	0.039	0.169	0.167	0.190	0.114	0.057	0.254
Oct	0.185	0.129	0.092	0.125	0.116	0.039	0.169	0.167	0.190	0.114	0.057	0.254
Nov	0.185	0.129	0.092	0.125	0.116	0.039	0.169	0.167	0.190	0.114	0.057	0.254
Dec	0.223	0.179	0.145	0.175	0.168	0.056	0.181	0.185	0.202	0.136	0.084	0.271

Table A.2 Monthly Bowen ratio and albedo values (all sectors)

Month	Monthly value (all sectors)	
	Bowen ratio	Albedo
January	1.03	0.18
February	1.03	0.18
March	1.13	0.18
April	1.13	0.18
May	1.13	0.18
June	1.13	0.18
July	1.13	0.18
August	1.13	0.18
September	0.98	0.18
October	0.98	0.18
November	0.98	0.18
December	1.03	0.18

A.2.4 Meteorological inputs

Monitoring data from the Canterbury Racecourse AWS were combined with TAPM meteorological modelling outputs for input to AERMET. The following parameters were input as input data to AERMET:

- wind speed and directions – Badgerys Creek AWS
- temperature (heights of 10 m and 50 m) – Badgerys Creek AWS (10 m) and TAPM (50 m)
- relative humidity – Badgerys Creek AWS
- station level pressure – Badgerys Creek AWS
- cloud cover – Bankstown Airport AWS (in absence of measurements at Badgerys Creek)
- solar insolation – TAPM
- mixing depth – TAPM.

The period of meteorological data input to AERMET was 1 January 2021 to 31 December 2021.

A.2.5 Upper air profile

Due to the absence of necessary local upper air meteorological measurements, the hourly profile generated by TAPM at the Badgerys Creek AWS location was adopted. Using the temperature difference between levels, the TAPM-generated vertical temperature profile for each hour was adjusted relative to the hourly surface (10 m) temperature observations from the Badgerys Creek AWS.

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Appendix Q24.3

Alspec Industrial Business Park

On-Site Sewer Management facility Noise and Vibration Impact Assessment

Prepared for HBB Property

August 2024

Alspec Industrial Business Park

On-Site Sewer Management facility Noise and Vibration Impact Assessment

HBB Property

E240588 RP1

August 2024

Version	Date	Prepared by	Reviewed by	Comments
1	16 August 2024	R. Bruniges	N. Ishac	Draft
2	21 August 2024	R. Bruniges	N. Ishac	Final

Approved by

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20 August 2024

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1 Introduction

1.1 Project context and overview

EMM Consulting Pty Limited (EMM) has been engaged by HB+B Property (HBB) to undertake a noise and vibration Impact Assessment (NVIA) for the Alspec Industrial Business Park (AIBP) On-Site Sewer Management (OSSM) facility.

The proposed AIBP is to be located at 211-227 and 289-317 Luddenham Road, Orchard Hills NSW. An OSSM facility is included as part of the development and will collect blackwater from offices and warehouses and recycle for further use on site.

This construction and operational noise and vibration impact assessment (NVIA) will support the development application for the AIBP OSSM facility.

1.2 Purpose of this report

This NVIA documents the existing acoustical environment; applicable noise and vibration objectives; noise modelling methodology and assumptions; and predicted noise emissions from site operations assessed against relevant objectives.

The NVIA report has been prepared in general accordance with the following relevant guidelines and policies:

- Noise Policy for Industry (NPfI) (EPA 2017)
- Interim Construction Noise Guideline (ICNG) (DECC 2009)
- Road Noise Policy (RNP) (DECCW 2011)
- Assessing Vibration: a technical guideline (the vibration guideline) (DEC 2006).

2 Project and site description

2.1 Site location

The site is located at 221-235 Luddenham Road, Orchard Hills, NSW within the AIBP. The OSSM is located near the northwest boundary of the AIBP, between proposed Warehouse 1 and 2. The indicative AIBP layout and location of the OSSM are shown in Figure 2.1.

The proposed site and adjacent allotments are located within the Penrith City Council local government area (LGA). The site is zoned E4 General Industrial.

2.2 Previous assessments

EMM has undertaken the following assessments for the AIBP based on an indicative site masterplan:

- Masterplan operational and traffic noise impact assessment (EMM report J200388 RP1_V6) - March 2022
- Construction Noise and Vibration Impact Assessment (EMM report E230636 RP2) - July 2023.
- Masterplan operational and traffic noise impact assessment (EMM report *E230918_RP2_AlspecMasterplanNIA_V2)*- August 2024

The assessment completed in August 2024 was an update to the operational noise impact assessment completed in March 2022 based on an updated masterplan and final ground contours from the site bulk earthworks plan.

2.3 On-Site Sewer Management Design

The OSSM facility for the AIBP will collect and treat blackwater from offices and warehouses within the development. The treated water will be held in holding tanks and reused on site for toilet flushing in each of the warehouses and irrigation of landscaping on each of the lots. A site plan for the OSSM facility is shown in Figure 2.2.

A list of plant items proposed for the OSSM facility has been provided by Acquacell Pty limited. Where relevant to this noise impact assessment, sound pressure levels for each plant item are shown in Table 2.1. With the exception of the odour scrubber fans all noise generating plant will be contained within the plant shed shown in Figure 2.2.

Table 2.1 OSSM plant sound pressure levels dB(A)

Description	No. Installed	No. Operating	Type	Sound pressure level at 1m
Wet Well Transfer Pumps	2	1	Submersible, Grinder	N/A (submerged)
Buffer Transfer Pumps	3	2	Submersible, Vortex	N/A (submerged)
Process Water Pump	2	1	End suction centrifugal	55
Storage Tank Recirc. Pump	1	1	End suction centrifugal	55
Sludge Dewatering Pump	2	1	Progressive cavity	50
Buffer Tank Mixer	1	1	Submersible	N/A (submerged)
Pre-screen	2	1	Motor + gearbox	75
Air Compressor	2	1	Screw Drive with noise encl.	68

Description	No. Installed	No. Operating	Type	Sound pressure level at 1m
Wet Well Transfer Pumps	2	1	Submersible, Grinder	N/A (submerged)
Sludge Dewatering System	1	1	Peristaltic pumps + mixers	65
Odour Scrubber Fans	2	1	Carbon Filter	82
Hypo Dosing Pump (TWS)	1	1	Peristaltic pump	65
Distribution Pumps - Recycled Water	3	2	Vertical Multistage centrifugal	52
WAS Transfer Pumps	2	1	Progressive cavity	50
Bio to MBR Transfer	4	2	Submersible, Vortex	N/A (submerged)
PF-MBR-01 MBR Filtrate Pump	4	2	Centrifugal, in-line, multistage	55
BL-MBR-01/02 MBR Blower	4	2	Centrifugal blower	65
AER-01 Bio Aerator	2	2	Submersible Aerator	N/A (submerged)
Ozone and UV feed	2	2	Centrifugal, in-line, multistage	55
MX-BIO-01 Anoxic tank mixer	2	2	Submersible	N/A (submerged)
Ozone System	2	2	Refrigerated drier/oxygen conc.	70
PD-MBR-01 Hypochlorite Dosing (MC)	2	2	Electronic dosing pump	70
PD-MBR-02 Hypochlorite Dosing (CIP)	2	2	Electronic dosing pump	70
PD-MBR-03 Chemical Transfer - MBR CIP	2	2	Electronic dosing pump	70
PD-CCT-01 Hypochlorite Dosing (CCT)	2	2	Peristaltic pump	65
PD-MBR-04 Dilute Sodium hydroxide	2	2	Peristaltic pump	65
PD-CCT-02 Sodium Hydroxide	2	2	Peristaltic pump	65

2.4 Maintenance activities

The OSSM will be maintained by one maintenance contractor who may need to be on site a few days a week and will typically travel to and from site in a light vehicle. Outside of emergency repairs, general maintenance activities will only occur during daylight hours and are unlikely to be audible or noticeable above vehicle movements within the industrial area.

A vacuum pump truck will be required to come to site once a month to clear out the sludge tank, located to the east of the plant shed. It is assumed this activity will occur only during the day period.

2.5 Traffic generation

The OSSM is expected to generate a few light vehicle movements per week for maintenance activities. Occasional heavy vehicle movements will be required for delivery of materials and clearing of the sludge tank but would be expected to be less than one heavy vehicle per week in total. Traffic generated by the OSSM is insignificant compared to existing traffic on Luddenham Road and traffic generated by the AIBP and therefore has not been assessed further.

Traffic generated by the AIBP has been assessed as part of the masterplan assessment (refer to EMM report *E230918_RP2_AlspecMasterplanNIA_V2*).

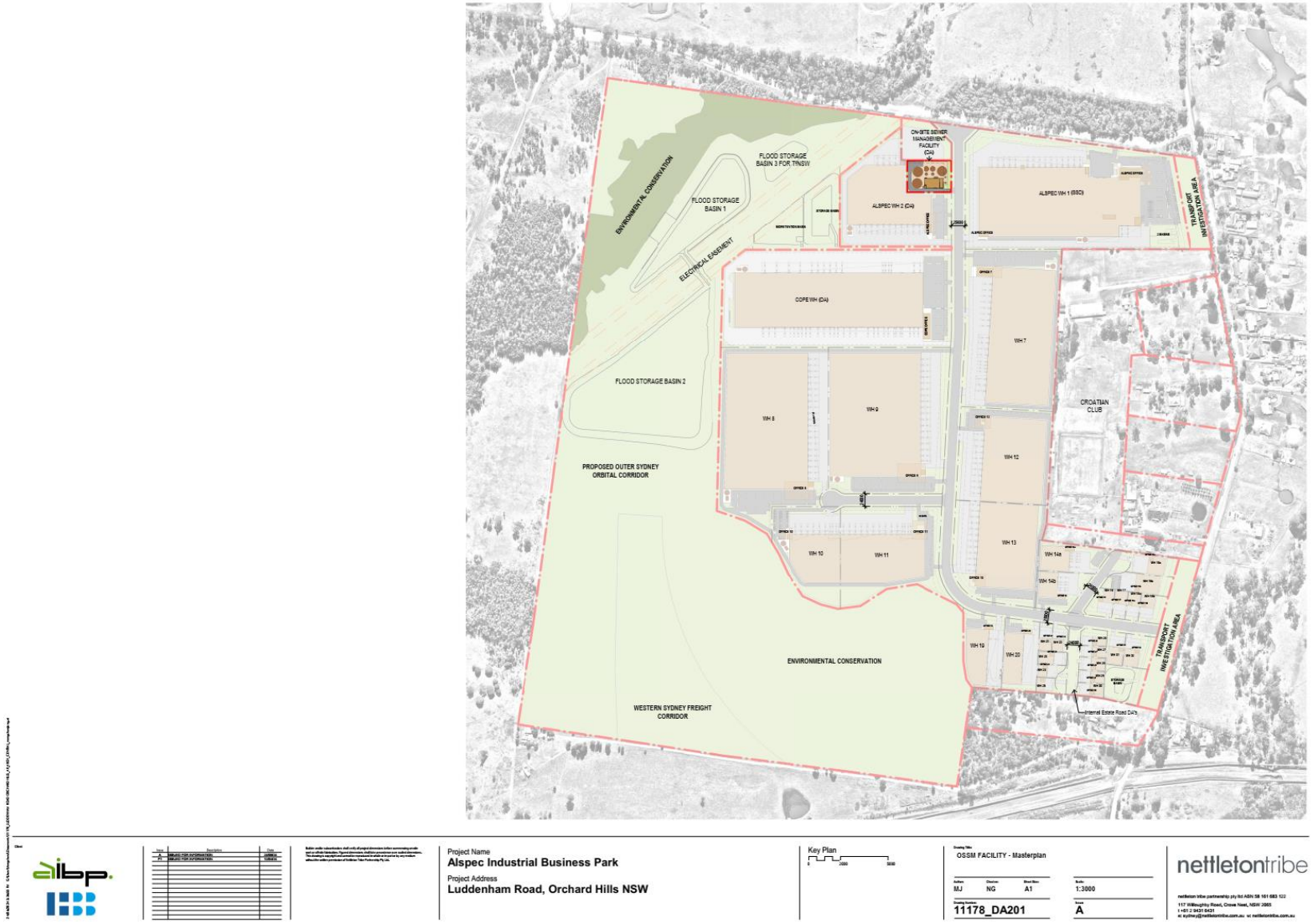


Figure 2.1 AIBP layout and OSSM location

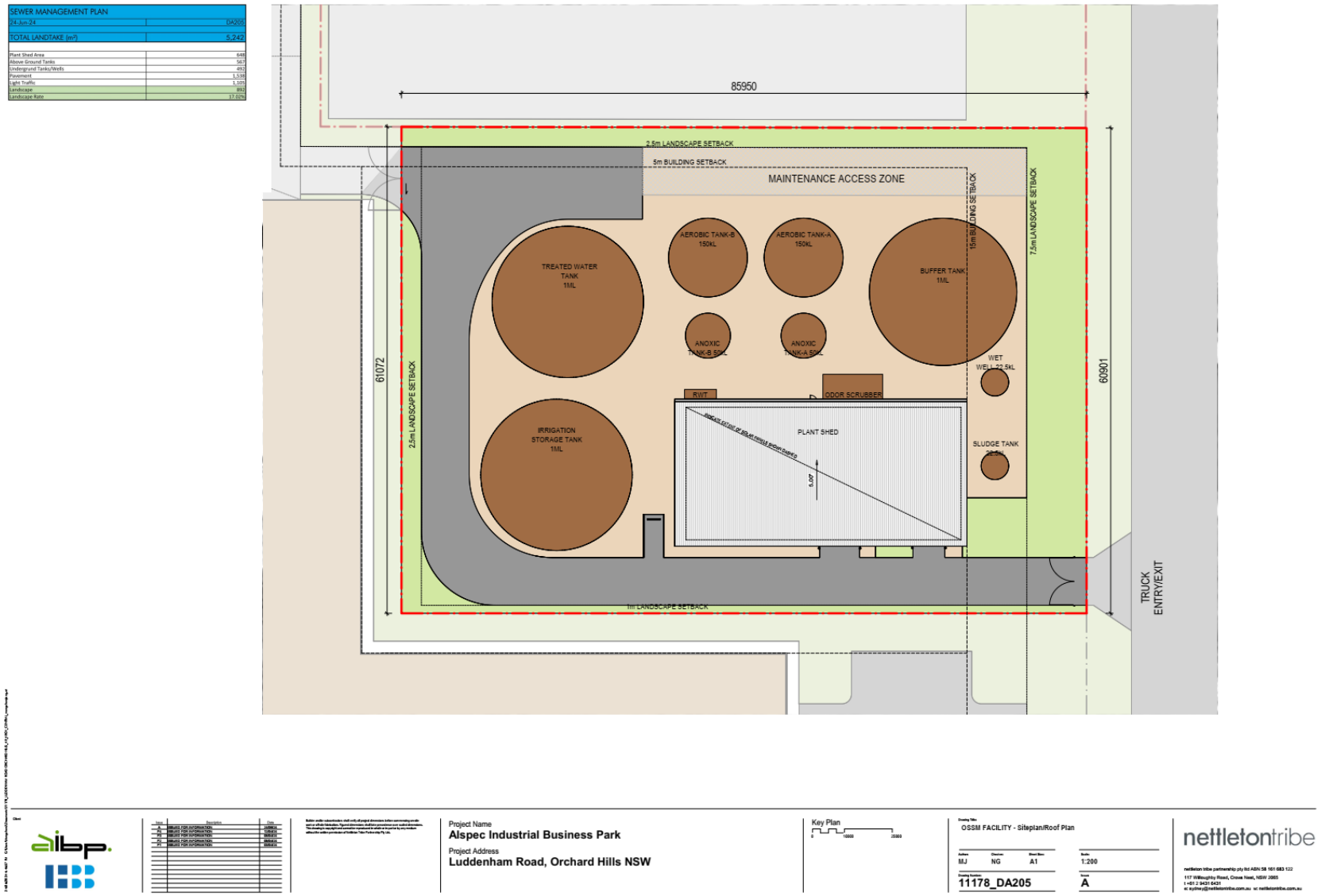


Figure 2.2 Proposed site plan

2.6 Assessment locations

Noise assessment locations were considered as part of the AIBP masterplan. These locations are considered suitable for assessment of noise impacts from this project. Off site assessment locations that could potentially experience noise from the development have been separated into three noise catchment areas (NCAs) which have been derived based on noise environments and are discussed as follows:

- NCA1 represents residential assessment locations on the eastern side of Luddenham Road. The dwelling façades face Luddenham Road and are exposed to road traffic noise.
- NCA2 represents residential assessment locations on the western side of Luddenham Road. These properties are all set back from Luddenham Road and would be expected to experience lower noise from existing road traffic which is consistent with noise monitoring conducted at the site. It is noted that these residential properties have been included in the precinct structure plan and rezoned to E4 General Industrial.

Assessment locations are provided in Table 2.2 and shown on Figure 3.1.

Table 2.2 Assessment locations

Noise catchment area	Assessment location ID	Address	Coordinates (MGA56)		Land use
			Easting	Northing	
NCA1	R1	182 Luddenham Road, Orchard Hills	292707	6255864	Residential
NCA1	R2	202 Luddenham Road, Orchard Hills	292718	6255742	Residential
NCA1	R3	212 Luddenham Road, Orchard Hills	292729	6255685	Residential
NCA1	R4	216 Luddenham Road, Orchard Hills	292737	6255636	Residential
NCA1	R5	222 Luddenham Road, Orchard Hills	292745	6255592	Residential
NCA1	R6	226 Luddenham Road, Orchard Hills	292752	6255550	Residential
NCA1	R7	230 Luddenham Road, Orchard Hills	292760	6255500	Residential
NCA1	R8	236 Luddenham Road, Orchard Hills	292768	6255452	Residential
NCA1	R9	240 Luddenham Road, Orchard Hills	292782	6255398	Residential
NCA1	R10	246 Luddenham Road, Orchard Hills	292786	6255352	Residential
NCA1	R11	250 Luddenham Road, Orchard Hills	292797	6255301	Residential
NCA1	R12	256 Luddenham Road, Orchard Hills	292804	6255252	Residential
NCA1	R13	262 Luddenham Road, Orchard Hills	292802	6255208	Residential
NCA1	R14	268 Luddenham Road, Orchard Hills	292750	6255017	Residential
NCA1	R21	320 Luddenham Road, Orchard Hills	292641	6254644	Residential
NCA2	R15	229 Luddenham Road, Orchard Hills	292458	6255431	Commercial/Active recreation
NCA2	R16	233 Luddenham Road, Orchard Hills	292603	6255351	Residential
NCA2	R17	251 Luddenham Road, Orchard Hills	292575	6255258	Residential
NCA2	R18	275 Luddenham Road, Orchard Hills	292561	6255025	Residential

Noise catchment area	Assessment location ID	Address	Coordinates (MGA56)		Land use
			Easting	Northing	
NCA2	R19	287 Luddenham Road Orchard Hills	292552	6254987	Residential
NCA2	R20	319 Luddenham Road, Orchard Hills	292377	6254700	Residential
NCA2	R22	339 Luddenham Road, Orchard Hills	292428	6254440	Residential
NCA3	R23	405 Luddenham Road, Orchard Hills	291959	6254260	Residential
NCA3	R24	327 Luddenham Road, Orchard Hills	291497	6254625	Residential

HBB Property entered into a sales agreement for the residential dwelling at R19 (287 Luddenham Road). They have advised the property will be vacated prior to commencement of any construction works. This is significant as this dwelling is the closest receiver to the project and adjoins a future driveway to the AIBP development.

3 Existing environment

Noise monitoring was done to quantify the existing noise environment around the proposed development site. Four unattended noise loggers were deployed at locations representative of the acoustic environment at the nearest assessment locations close to Luddenham Road and at locations representative of receivers further removed from it.

3.1 Measurement equipment and locations

Noise monitoring was carried out using three Acoustic Research Labs (ARL) NGARA environmental noise loggers and one Svantek 979 environmental noise logger. The details of each noise monitoring locations are provided in Table 3.1 and shown on Figure 3.1.

Table 3.1 Monitoring locations

Monitor ID	Equipment type and serial number	Period of measurement (2020)	Monitoring location		
			Address	Easting (MGA56)	Northing (MGA56)
NM1	Svantek 979, 21095	24 July to 4 August	221-227 Luddenham Road, Orchard Hills	292703	6255625
NM2	ARL NGARA, 878125	1 to 13 July	221-227 Luddenham Road, Orchard Hills	292376	6254999
NM3	ARL NGARA, 878123	1 to 13 July	221-227 Luddenham Road, Orchard Hills	291825	6255085
NM4	ARL NGARA, 878138	1 to 13 July	221-227 Luddenham Road, Orchard Hills	291902	6255708

Loggers were programmed to record statistical noise level indices continuously in 15 minute intervals in accordance with the requirements of the NPfI, including the L_{Amax}, L_{A1}, L_{A10}, L_{A50}, L_{A90}, L_{A99}, L_{Amin} and the L_{Aeq}. Calibration of all instrumentation was checked prior to and following measurements. All equipment had current NATA (or manufacturer) calibration status.

3.2 Weather affected noise data

Weather data for the survey period was obtained from the BOM weather station at Badgerys Creek (ID 067108). Wind speed and the rainfall data were used to exclude noise data during periods of any rainfall and/or wind speed in excess of 5 metres per second (m/s) in accordance with NPfI requirements.

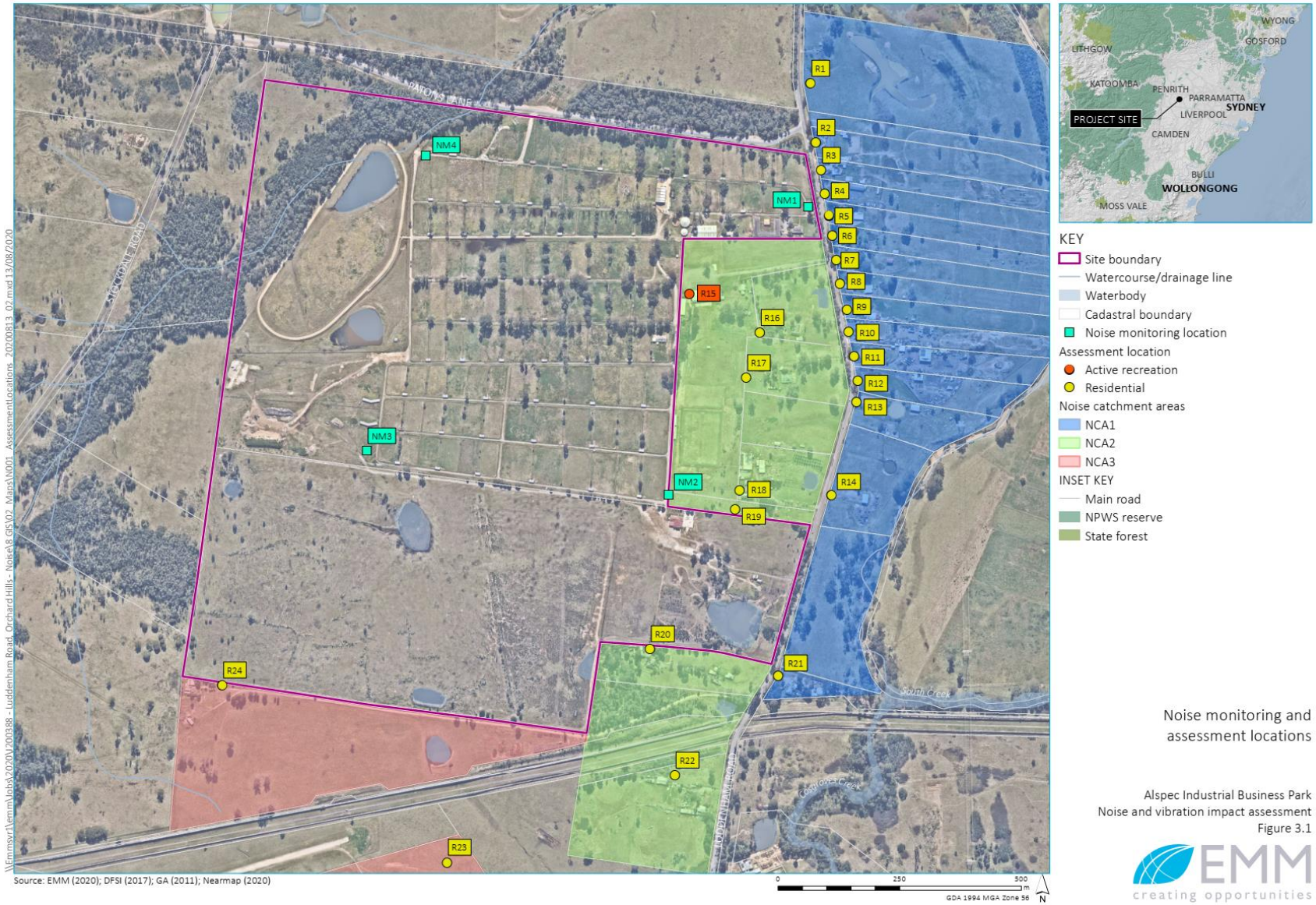


Figure 3.1 Site survey and assessment locations

3.3 Measured noise levels

A summary of the existing background and ambient noise levels is provided in Table 3.2.

Table 3.2 Summary of unattended ambient noise monitoring

Noise monitoring location	Time period[1]	Existing noise levels, dB	
		$L_{Aeq,period}$	Rating background level (RBL)
NM1	Day	58	40
	Evening	56	39
	Night	54	34
NM2	Day	53	34
	Evening	43	36
	Night	41	30
NM3	Day	48	30
	Evening	41	34
	Night	39	30
NM4	Day	51	29
	Evening	41	36
	Night	40	33

1. Day is 7 am to 6 pm; evening 6 pm to 10 pm; night 10 pm to 7 am. On Sundays and Public Holidays, day is 8 am to 6 pm; evening 6 pm to 10 pm; night 10 pm to 8 am.

Noise levels measured at NM2, NM3 and NM4 indicate that the evening RBL is consistently higher than the day RBL. Monitoring was done during the colder winter months which would typically negate insect noise which more commonly contributes to higher evening noise levels. Monitoring locations were also far removed from each other and thus removed from a possible singular extraneous noise source which may impact the data. As such it can only be concluded that this is characteristic of the area.

The acoustic environment in some locations can have RBLs which would result in noise criteria that are impractical for the reasonable assessment of noise from a site. Section 2.3 of the NPfI provides guidance where the recorded RBL is below the minimum assumed background noise level and is reproduced in Table 3.3. In these cases the minimum assumed background noise level is adopted for assessment purposes in accordance with the NPfI.

Table 3.3 Minimum assumed RBLs (NPfI)

Time of day	Minimum assumed rating background noise level, dBA
Day	35
Evening	30
Night	30

4 Assessment criteria

4.1 Construction noise

The ICNG promotes a clear understanding of ways to identify and minimise noise from construction and to identify 'feasible' and 'reasonable' work practices. It recommends standard construction hours where noise from construction activities is audible at residential premises (i.e. assessment locations), as follows:

- Monday to Friday - 7 am to 6 pm
- Saturday - 8 am to 1 pm
- Sundays or public holidays - no construction work.

The ICNG acknowledges that works outside standard hours may be necessary, with justification provided to the relevant authorities.

The ICNG provides two methodologies to assess construction noise emissions. The first is a quantitative approach that is suited to major construction projects with typical durations of more than three weeks. This method requires noise emission predictions from construction activities at the nearest assessment locations and assessment against ICNG recommended noise levels.

The second is a qualitative approach, which is a simplified assessment process that relies more on noise management strategies. This method is suited to short-term infrastructure and maintenance projects of less than three weeks.

This assessment has adopted the quantitative approach. The qualitative aspects of the assessment include identification of assessment locations, description of works involved, including predicted noise levels and proposed management measures that include a complaints handling procedure.

4.1.1 Construction noise management levels

Table 4.1 provides ICNG noise management levels (NML) which apply to residential assessment locations.

Table 4.1 ICNG construction noise management levels for residences

Time of day	NML $L_{Aeq,15min}$	Application
Recommended standard hours: Monday to Friday 7 am to 6 pm, Saturday 8 am to 1 pm, no work on Sundays or public holidays	Noise-affected rated background level (RBL) RBL + 10 dB	The noise-affected level represents the point above which there may be some community reaction to noise. Where the predicted or measured Leq(15-min) is greater than the noise-affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level. The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.

Time of day	NML $L_{Aeq,15min}$	Application
	Highly noise affected 75 dBA	The highly noise-affected level represents the point above which there may be strong community reaction to noise. Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: • times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences), and • if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.
Outside recommended standard hours	Noise-affected RBL + 5 dB	A strong justification would typically be required for works outside the recommended standard hours. The proponent should apply all feasible and reasonable work practices to meet the noise affected level. Where all feasible and reasonable practices have been applied and noise is more than 5 dBA above the noise-affected level, the proponent should negotiate with the community. For guidance on negotiating agreements see Section 7.2.2 of the ICNG.

Source: ICNG (EPA, 2009).

The only non-residential use near the site is the Bosna Croatian Club at 229 Luddenham Road (Receiver 15). This receiver is considered both active recreation (soccer oval) and commercial premises (club) in accordance with the ICNG. For this assessment construction noise will be assessed against the more conservative noise management level for active recreation areas of $L_{Aeq,15minute}$ 65 dB.

Table 4.2 Construction noise management levels – all assessment locations

Assessment location	Adopted RBL[1]	NML, $L_{Aeq,15minute}$ dB	HNML, $L_{Aeq,15minute}$ dB
R1-R14 & R21 (NM1)	40	50	75
R15	n/a	65	n/a
R16-R20 & R22 (NM2)	35	45	75
R23, R24 (NM3)	35	45	75

Notes: 1. Based on the day period RBL established in Table 3.2 and Table 3.3

2. NML – Noise management Level, HNML – highly noise affected management level

4.2 Construction vibration

4.2.1 Human perception of vibration

Humans can detect vibration levels that are well below those causing any risk of damage to a building or its contents.

The actual perception of motion or vibration may not in itself be disturbing or annoying. An individual's response to that perception, and whether the vibration is "normal" or "abnormal", depends very strongly on previous experience and expectations, and on other connotations associated with the perceived vibration source. For example, the vibration that a person responds to as "normal" in a car, bus or train is considerably higher than what is perceived as "normal" in a shop, office or dwelling.

Human tactile perception of random motion, as distinct from human comfort considerations, was investigated by Diekmann and subsequently updated in German Standard DIN 4150 Part 2 1999. On this basis, the resulting degrees of perception for humans are suggested by the vibration level categories given in Table 4.3.

Table 4.3 suggests that people will just be able to feel floor vibration at peak levels of approximately 0.15 millimetres per second (mm/s) and that the motion becomes "noticeable" at a level of approximately 1 mm/s.

Table 4.3 Peak vibration levels and human perception of motion

Approximate vibration level	Degree of perception
0.10 mm/s	Not felt
0.15 mm/s	Threshold of perception
0.35 mm/s	Barely noticeable
1 mm/s	Noticeable
2.2 mm/s	Easily noticeable
6 mm/s	Strongly noticeable
14 mm/s	Very strongly noticeable

Note: These approximate vibration levels (in floors of building) are for vibration having a frequency content in the range of 8 Hertz (Hz) to 80 Hz.

4.2.2 Assessing vibration - a technical guideline

The vibration guideline is based on BS 6472 – 2008, Evaluation of human exposure to vibration in buildings (1–80 Hz) (British Standards Institution 2008). It presents preferred and maximum vibration values for the use in assessing human responses to vibration and provides recommendations for measurement and evaluation.

For vibration levels below preferred values, there is a low probability of adverse comment or disturbance to building occupants. Where all feasible and reasonable mitigation measures have been applied and vibration values are beyond the relevant maximum value, it is recommended that the operator negotiate directly with the affected community.

The vibration guideline defines three vibration types and provides direction for assessing and evaluating against applicable criteria. Table 2.2 of the guideline provides examples of the three vibration types and has been reproduced in Table 4.4.

Table 4.4 Examples of types of vibration

Continuous vibration	Impulsive vibration	Intermittent vibration
Machinery, steady road traffic, continuous construction activity (such as tunnel boring machinery).	Infrequent: Activities that create up to three distinct vibration events in an assessment period, e.g. occasional dropping of heavy equipment, occasional loading and unloading. Blasting is assessed using ANZEC (1990).	Trains, intermittent nearby construction activity, passing heavy vehicles, forging machines, impact pile driving, jack hammers. Where the number of vibration events in an assessment period is three or fewer these would be assessed against impulsive vibration criteria.

Source: DEC (2006).

Continuous vibration associated with compaction of road base and fill is most relevant to the construction of this project.

Intermittent vibration (as defined in Section 2.1 of the guideline) is assessed using the vibration dose concept which relates to vibration magnitude and exposure time. Intermittent vibration is representative of heavy vehicle pass-bys and construction activities such as impact hammering, rolling or general excavation work.

Section 2.4 of the guideline provides acceptable values for intermittent vibration in terms of vibration dose values (VDV) which requires the measurement of the overall weighted rms (root mean square) acceleration levels over the frequency range 1 Hz to 80 Hz.

To calculate VDV the following formula is used (refer to Section 2.4.1 of the guideline):

$$VDV = \left[\int_0^T a^4(t)dt\right]^{0.25}$$

Where VDV is the vibration dose value in $m/s^{1.75}$, *a (t)* is the frequency-weighted rms of acceleration in m/s^2 and *T* is the total period of the day (in seconds) during which vibration may occur.

The acceptable VDV for intermittent vibration are reproduced in Table 4.5.

Table 4.5 Acceptable vibration dose values for intermittent vibration

Location	Daytime		Night-time	
	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$	Preferred value, $m/s^{1.75}$	Maximum value, $m/s^{1.75}$
Critical areas	0.10	0.20	0.10	0.20
Residences	0.20	0.40	0.13	0.26
Offices, schools, educational institutions and places of worship	0.40	0.80	0.40	0.80
Workshops	0.80	1.60	0.80	1.60

Notes: Day time is 7.00 am to 10.00 pm and night-time is 10.00 pm to 7.00 am.

These criteria are indicative only, and there may be a need to assess intermittent values against continuous or impulsive criteria for critical areas.

There is a low probability of adverse comment or disturbance to building occupants at vibration values below the preferred values. Adverse comment or complaints may be expected if vibration values approach the maximum values. The guideline recommends that activities should be designed to meet the preferred values where an area is not already exposed to vibration.

4.2.3 Structural vibration

i Australian Standard AS 2187.2 – 2006

In terms of the most recent relevant vibration damage criteria, Australian Standard AS 2187.2 - 2006 *Explosives - Storage and Use - Use of Explosives* recommends that the frequency dependent guideline values and assessment methods given in BS 7385 Part 2-1993 *Evaluation and measurement for vibration in buildings Part 2* be used as they are "applicable to Australian conditions".

The standard sets guide values for building vibration based on the lowest levels above which damage has been credibly demonstrated. These levels are judged to give a minimum risk of vibration induced damage, where minimal risk for a named effect is usually taken as a 95% probability of no effect.

Sources of vibration that are considered in the standard include demolition, blasting (carried out during mineral extraction or construction excavation), piling, ground treatments (e.g. compaction), construction equipment, tunnelling, road and rail traffic and industrial machinery.

The recommended limits (guide values) for transient vibration to manage minimal risk of cosmetic damage to residential and industrial buildings are presented numerically in Table 4.6 and graphically in Figure 4.1.

Table 4.6 Transient vibration guide values - minimal risk of cosmetic damage

Line[1]	Type of building	Peak component particle velocity in frequency range of predominant pulse	
		4 Hz to 15 Hz	15 Hz and above
1	Reinforced or framed structures Industrial and heavy commercial buildings	50 mm/s	50 mm/s
2	Unreinforced or light framed structures Residential or light commercial type buildings	15 mm/s at 4 Hz increasing to 20 mm/s at 15 Hz	20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above

Notes: 1. Refers to the "Line" in Figure 4.1.

The standard notes that the guide values in Table 4.6 relate predominantly to transient vibration which does not give rise to resonant responses in structures and low-rise buildings.

Where the dynamic loading caused by continuous vibration is such as to give rise to dynamic magnification due to resonance, especially at the lower frequencies where lower guide values apply, then the guide values in Table 4.6 may need to be reduced by up to 50%.

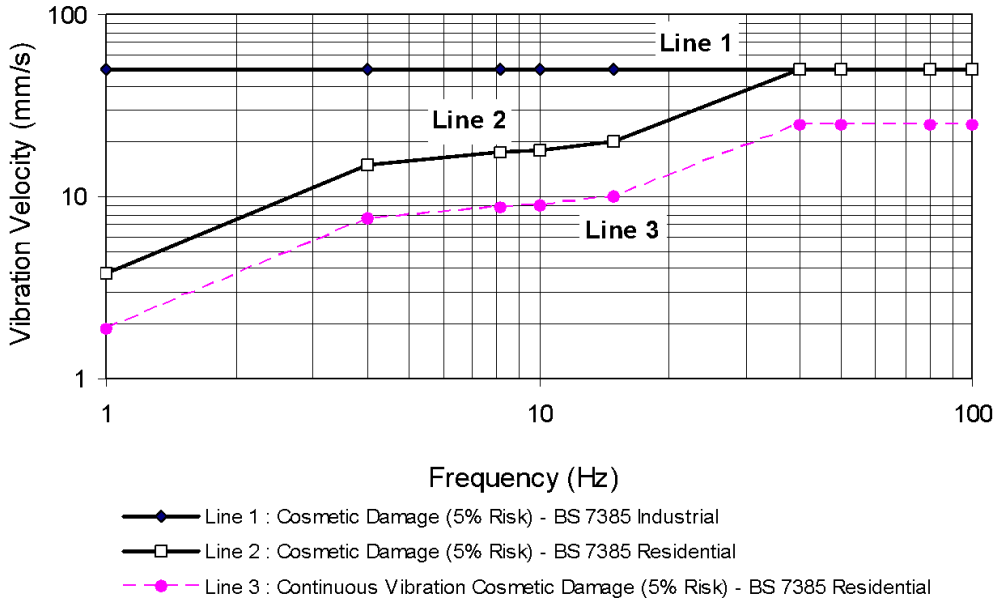


Figure 4.1 Graph of transient vibration guide values for cosmetic damage

In the lower frequency region where strains associated with a given vibration velocity magnitude are higher, the guide values for building types corresponding to Line 2 are reduced. Below a frequency of 4 Hz where a high displacement is associated with the relatively low peak component particle velocity value, a maximum displacement of 0.6 mm (zero to peak) is recommended. This displacement is equivalent to a vibration velocity of 3.7 mm/s at 1 Hz (as shown in Figure 4.1).

Fatigue considerations are also addressed in the standard, and it is concluded that unless calculation indicates that the magnitude and number of load reversals is significant (in respect of the fatigue life of building materials) then the guide values in Table 4.6 should not be reduced for fatigue considerations.

To assess the likelihood of cosmetic damage due to vibration, AS2187 specifies that vibration measurements should be made at the base of the building and the highest of the orthogonal vibration components (transverse, longitudinal and vertical directions) should be compared with the criteria curves presented in Table 4.6.

It is noteworthy that in addition to the guide values nominated in Table 4.6 the standard states that:

> Some data suggests that the probability of damage tends towards zero at 12.5 mm/s peak component particle velocity. This is not inconsistent with an extensive review of the case history information available in the UK.

4.3 Operational noise

Noise from development in NSW is regulated by the local council, DPHI and/or the EPA, and sites generally have environmental protection licence and/or development consent conditions stipulating noise limits. These limits are typically derived from project specific trigger or operational noise levels predicted at assessment locations. They are based on EPA guidelines (e.g. NPfI) or noise levels that can be achieved by a specific site following the application of all feasible and reasonable noise mitigation.

The objectives of noise trigger levels for industry established in accordance with the NPfI are to protect the community from excessive intrusive noise and preserve amenity for specific land uses. It should be noted that the audibility of a noise source does not necessarily equate to non-compliance at an assessment location.

4.3.1 Intrusiveness noise levels

The intrusiveness noise level is expressed as:

$L_{Aeq,15minute}$ = Rating Background Level + 5 dB

Where:

- $L_{Aeq,15minute}$ represents the equivalent continuous (energy average) A-weighted sound pressure level of the source over 15 minutes
- RBL represents the background level to be used for assessment purposes.

Intrusive noise levels are only applied to residential receptors (residences). For other receptor categories, recommended amenity noise levels apply.

Table 4.7 presents the site intrusiveness noise levels based on adopted RBLs.

Table 4.7 Project intrusiveness noise levels (dB)

Assessment location	Representative NM[1]	Measured background noise level, RBL			Project Intrusiveness noise level, $L_{Aeq,15min}$		
		Day	Evening	Night	Day	Evening	Night
NCA1	NM1	40	39	34	45	44	39
NCA2	NM2	35(34)	35(36)	30	40	40	35
NCA3	NM3	35(30)	34	30	40	39	35
N/A	NM4	35(29)	35(36)	30	40	40	35

4.3.2 Amenity noise levels

The assessment of amenity is based on noise levels specific to the land use. These noise levels relate only to industrial noise and exclude road or rail traffic noise. Where measured existing industrial noise approaches recommended amenity noise levels (RANL), it needs to be demonstrated that levels from new developments will not contribute to existing such that amenity levels are exceeded.

To ensure that industrial noise levels (existing plus new) remain within RANL for an area, the project amenity noise level (PANL) for a new industrial development is the RANL (see Table 2.2 of the NPfI) minus 5 dB. Although likely conservative, this approach was adopted together with a whole of precinct assessment part of the masterplan study to ensure amenity targets are satisfied (refer to EMM report *E230918_RP2_AlspecMasterplanNIA_V2*).

Amenity for various assessment locations is presented in Table 4.8 as per the NPfI.

It is commonly acknowledged and accepted amongst regulators and industry that average noise levels are typically 3 dB higher over a 15-minute worst case assessment period when compared to an entire day (11 hour) assessment period. This is outlined in the NPfI and has been used in this assessment to standardise the time period to 15 minutes for both intrusive and amenity criteria.

Table 4.8 Amenity noise levels dB

Assessment location	Indicative area	Time period[1]	RANL $L_{Aeq,period}$	PANL $L_{Aeq,period}$	PANL $L_{Aeq,15min}$
Residential	Rural	Day	50	45	48
		Evening	45	40	43
		Night	40	35	38
	Suburban	Day	55	50	53
		Evening	45	40	43
		Night	40	35	38
Active recreation	All	When in use	55	50	53
Commercial	All	When in use	65	60	63

Source: NPfI (EPA 2017).

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: remaining periods.

The only non-residential use near the site is the Bosna Croatian Club at 229 Luddenham Road (Receiver 15). This receiver is considered both active recreation (soccer oval) and commercial premises (club) in accordance with the

NPfI. For this assessment operational noise will be assessed against the more conservative project amenity noise level for active recreation areas of $L_{Aeq,15minute}$ 53 dB.

4.3.3 Project noise trigger level

The project noise trigger level (PNTL) is the lower of the calculated intrusiveness or amenity noise levels. A summary of the PNTL for the assessment of operational noise from the project is presented in Table 4.9.

Table 4.9 Project noise trigger levels – LAeq,15minute dB

Assessment location	Assessment period[1]	Intrusiveness noise level	PANL[2]	PNTL[3]
R1-R14 & R21 (NCA1, Suburban)	Day	45	53	45
	Evening	44	43	43
	Night	39	38	38
R16-R20 & R22 (NCA2, Rural)	Day	40	48	40
	Evening	40	43	40
	Night	35	38	35
R23, R24 (NCA3, Rural)	Day	40	48	40
	Evening	39	43	39
	Night	35	38	35
Active recreation	When in use	NA	53	53

Notes: 1. Day: 7 am to 6 pm Monday to Saturday; 8 am to 6 pm Sundays and public holidays; Evening: 6 pm to 10 pm; Night: remaining periods.

2. Project amenity $L_{Aeq,15min}$ noise level is the RANL $L_{Aeq,period}$ +3 dB as per the NPfI.

3. PNTL is the lower of the calculated intrusiveness or amenity noise levels.

4.4 Sleep disturbance

The NPfI suggests that a detailed maximum noise level event assessment should be undertaken where operation or construction night period noise at a residential location exceed screening levels of:

- $L_{Aeq,15minute}$ 40 dB or the prevailing RBL plus 5 dB (whichever is the greater), and/or
- L_{Amax} 52 dB or the prevailing RBL plus 15 dB (whichever is the greater).

As all maintenance activities are expected to occur during the day period, and operational noise sources from the OSSM are continuous, sleep disturbance impact has been assessed against a criterion of $L_{Aeq,15minute}$ 40 dB.

4.5 Cumulative operational noise

Cumulative operational noise is typically assessed against RANL listed in Table 4.8, however where a standalone project can meet the stricter project amenity PANL, cumulative impact due to the project is not expected as that criterion allows for industrial noise contributions from multiple sites/projects.

PANL listed in Table 4.9 have conservatively been used to assess cumulative operational noise.

5 Assessment

5.1 Noise modelling methodology

Operational and construction noise levels were predicted using DGMR Software proprietary modelling software, iNoise, implementing international standard ISO 9613-2:1996 'Acoustics – Attenuation of sound during propagation outdoors' algorithms. As per Section 1 of the Standard:

> The method predicts the equivalent continuous A-weighted sound pressure level (as described in parts 1 to 3 of ISO 1996) under meteorological conditions favourable to propagation from sources of known sound emission.
>
> These conditions are for downwind propagation, as specified in 5.4.3.3 of ISO 1996-2:1987 or, equivalently, propagation under a well-developed moderate ground-based temperature inversion, such as commonly occurs at night.

The model calculates total noise levels at assessment locations from concurrent operation of multiple noise sources. It considers factors that influence noise propagation such as the lateral and vertical location of plant, source-to-receptor distances, ground effects, atmospheric absorption, topography of the site and surrounding area and applicable meteorological conditions.

The model was populated with 3-D topography of the project and surrounding area, extending out past all assessment locations. Plant and equipment representing the range of proposed construction and operation scenarios were placed at locations that would represent worst case noise levels throughout the construction and operational scenarios.

Table 5.1 Modelling standard parameters

Modelling Parameter	Input/s
Model	ISO 9613-2:1996
Environmental conditions	Humidity 70% Temperature 10°C Air pressure [mbar] 1013.3
Elevation contours	Contours adopted from NSW Elevation Data Services Site contours were taken as final ground heights from the AIBP bulk earthworks plan.
Receiver height	1.5m above ground for single storey
Ground absorption factor	0.7 over open grass 0.0 for concrete and paved industrial area
Warehouse height	14.6m for larger warehouses 10m for small and medium warehouses

5.2 Construction noise

Construction equipment sound power levels (L_W) have been sourced from an EMM database of similar equipment based on measurements at other construction sites. Earthworks and site-preparation are expected to be the most significant noise impact.

The model included cumulative operation of all construction plant and equipment as an area source across the project site providing a potential worst-case scenario.

Table 5.2 Construction equipment sound power levels $L_{Aeq,15minute}$ dB

Equipment/activity	Number of items (per 15 minutes)	L_{WA} per item	Total L_{WA}	Cumulative L_{WA}
Initial site preparation works/bulk earthworks				
Excavator	1	104	104	118
Dozer	1	112	112	
Dump truck	1	108	108	
Light vehicle	4	75	81	
FEL	1	105	105	
Road truck (deliveries)	1	105	105	
Grader	1	108	108	
Roller	1	114	114	
Crane	1	106	106	
Generator	1	97	97	

Works associated with commissioning and landscaping will generate significantly lower noise levels than the site preparation works identified in Table 5.2 and have not been considered further in this assessment. Worst case predictions for construction noise impact are shown in Table 5.3. The range of predicted noise levels represent the predicted worst case impact for the range of receptors in the noise catchment area.

Table 5.3 Predicted construction noise levels, $L_{Aeq,15minute}$ dB

Noise catchment area	Predicted noise level	Construction NML	Highly noise affected level	Exceedance of construction NML	Exceedance of highly noise affected level
NCA1	41-50	50	75	Nil	Nil
NCA2	38-47	45	75	Up to 2 dB	Nil
NCA3	36-41	45	75	Nil	Nil
Receiver R15 (non-residential)	53	65	N/A	Nil	N/A

Construction noise levels are predicted to comply with the construction NML at NCA1 and NCA3. Minor exceedances of NML of up to 2 dB are predicted for some receivers in NCA2. No exceedances of the highly noise affected level are predicted.

5.3 Construction vibration

Safe working distances for typical items of vibration intensive plant are listed in Table 5.4. The safe working distances are quoted for both “Cosmetic Damage” (refer British Standard BS 7385) and “Human Comfort” (refer British Standard BS 6472-1).

Table 5.4 Recommended minimum working distances for vibration intensive plant

Equipment	Approx. Size/weight/model	Minimum distance	
		Cosmetic damage (BS 7385)	Human response (OE&H vibration guideline)
Vibratory roller	1-2 tonne	5 m	15 m to 20 m
	2-4 tonne	6 m	20 m
	4-6 tonne	12 m	40 m
	7-13 tonne	15 m	100 m
	13-18 tonne	20 m	100 m
	>18 tonne	25 m	100 m
Small hydraulic hammer	300 kg (5 to 12t excavator)	2 m	7 m
Medium hydraulic hammer	900 kg (12 to 18t excavator)	7 m	23 m
Large hydraulic hammer	1600 kg (18 to 34t excavator)	22 m	73 m
Pile driver – vibratory	Sheet piles	2 m to 20 m	20 m
Pile rig– bored	<800 mm	2 m (nominal)	N/A
Pile rig – hammer	12 t down force	15 m	50 m
Jackhammer	handheld	1 m (nominal)	Avoid contact with structure

Source: From Transport for NSW Construction Noise and Vibration Guideline, September 2023 – based on residential building.

Minimum work distances relate to continuous vibration. For most construction activity, vibration emissions are intermittent in nature. The safe working distances are therefore conservative.

The minimum working distances presented in Table 5.4 are indicative and will vary depending on the particular item of plant and local geotechnical conditions. They apply to cosmetic damage of typical buildings under typical geotechnical conditions.

The nearest assessment location to the project is over 500m from the lot boundary which is well beyond the recommended minimum working distance for cosmetic damage or human response. No vibration impact is predicted from construction activities associated with the OSSM facility.

5.4 Operational noise

5.4.1 Noise barriers

Operational noise impact from the development has been modelled using the site plans provided. As the OSSM will service all the warehouses within the AIBP, it has been assumed the warehouse and office buildings will be constructed prior to full operation of the OSSM and hence they have been included as barriers in the noise model.

5.4.2 OSSM facility noise sources

Significant noise generating plant for the OSSM facility are detailed in Table 2.1. All significant noise sources, with the exception of the odour scrubber fan, will be located within the plant shed. Table 5.5 provides sound power data for the OSSM facility which has been calculated based on sound pressure data provided by the client. All

equipment has been assumed to operate concurrently and have 100% utilisation for the purpose of this assessment.

5.4.3 Maintenance activities

Emptying of the sludge tank is expected to be the only significant noise generating regular maintenance activity required on site. A vacuum pump truck will require to come to site to empty the sludge tank, which is located to the east of the plant shed. While this activity will not occur for a significant period of time, and will only be required once a month, a vacuum truck operating continuously from a 15 minute assessment period has been assessed as a worst case maintenance impact.

5.4.4 Sound power data

Sound power data for the OSSM facility has been calculated based on the equipment list shown in Table 2.1. Sound power data for the vacuum pump truck has been sourced from EMM's library. All sources considered in the noise model and sound power used are presented in Table 5.5.

Table 5.5 Equipment sound power levels $L_{Aeq,15minute}$ dB

Plant Item	Quantity	L_{WA}	Note
OSSM facility noise sources			
Plant shed	1	89	Continuous operation
Odour scrubber fan	1	90	Continuous operation, external to plant room
Maintenance noise sources			
Vacuum pump truck	1	116[1]	Continuous operation for 15 minutes

1. Sound power level is inclusive of a 5dB tonal penalty and is based on EMM data which ranged from 105 to 111dB.

5.4.5 Operational scenarios

Operational scenarios have been developed to assess a worst-case 15 minutes for regular operation and maintenance activities.

i OSSM continuous operation

This scenario includes:

- continuous operation of all equipment within plant shed
- continuous operation of the odour scrubber fan

This scenario will be assessed for day, evening and night periods.

ii OSSM maintenance

This scenario includes:

- continuous operation of all equipment within plant shed

- continuous operation of the odour scrubber fan
- continuous operation of the vacuum pump truck.

This scenario will be assessed for day period only.

5.4.6 Sleep disturbance

With the exception of maintenance activities, which will occur during the day period only, all noise sources associated with the OSSM are expected to operate continuously. As there are no emergent noise sources, sleep disturbance impact will be assessed comparing continuous OSSM operations against the sleep disturbance screening criterion of $L_{Aeq,15minute}$ 40 dB.

5.4.7 Predicted operational noise levels

Predicted operational levels are provided in Table 5.6. Results for each noise catchment area are provided for day, evening and night periods. The highest result for a receiver within each noise catchment area has been provided.

Table 5.6 Predicted operational noise levels, $L_{Aeq,15minute}$ dB

Assessment period	Noise catchment area	Predicted noise level		Project noise trigger level (PNTL)	Exceedance of Project noise trigger level (PNTL)
		OSSM continuous operation	OSSM maintenance[1]		
Day	NCA1	28	36	45	Nil
	NCA2	22	39	40	Nil
	NCA3	<20	33	40	Nil
	R15	21	35	53	Nil
Evening	NCA1	28	NA	43	Nil
	NCA2	22	NA	40	Nil
	NCA3	<20	NA	39	Nil
	R15	21	NA	53	Nil
Night	NCA1	28	NA	38	Nil
	NCA2	22	NA	35	Nil
	NCA3	<20	NA	35	Nil
	R15	21	NA	53	Nil

1. OSSM maintenance activities will occur during the day period only and predictions are combined with normal operations as relevant.

No exceedance of PNTL is predicted.

5.4.8 Sleep disturbance assessment

Predicted maximum noise levels are provided in Table 5.7. The highest result for a receiver within each noise catchment area has been provided.

Table 5.7 Predicted maximum noise levels at residential assessment locations, L_{Aeq} dB

Noise catchment area	Predicted noise level	Sleep disturbance criterion	Exceedance
NCA1	28	40	Nil
NCA2	22	40	Nil
NCA3	<20	40	Nil

No exceedance of the sleep disturbance screening target is predicted.

5.4.9 Cumulative operational noise

Cumulative noise from the AIBP has been assessed in the masterplan noise impact assessment (EMM July 2024) with total noise levels predicted to comply with recommended amenity noise levels (RANL) at all assessment locations with the exception of R18-R20. These assessment locations, while still privately owned are zoned E4 and part of proposed future industrial expansion. For these residences the NPfI states "for isolated residences within an industrial zone the industrial amenity level would usually apply". Operational noise from the OSSM facility is not a significant contributor to cumulative noise at these assessment locations.

Cumulative operational impact from the OSSM facility has been assessed by comparing operational noise predictions against project amenity noise levels (PANL) as shown in Table 5.8.

Table 5.8 Predicted operational noise levels, $L_{Aeq,15minute}$ dB against PANL

Assessment period	Noise catchment area	Predicted noise level		PANL	Exceedance
		OSSM continuous operation	OSSM maintenance[1]		
Day	NCA1	28	36	53	Nil
	NCA2	22	39	48	Nil
	NCA3	<20	33	48	Nil
	R15	21	35	53	Nil
Evening	NCA1	28	NA	43	Nil
	NCA2	22	NA	43	Nil
	NCA3	<20	NA	43	Nil
	R15	21	NA	53	Nil
Night	NCA1	28	NA	38	Nil
	NCA2	22	NA	38	Nil
	NCA3	<20	NA	38	Nil
	R15	21	NA	53	Nil

1. OSSM maintenance activities will occur during the day period only.

No exceedance of amenity noise levels is predicted.

6 Noise mitigation and management

6.1 Construction noise

The ICNG requires that construction noise is assessed against NMLs. Where it is predicted to exceed NMLs, feasible and reasonable noise mitigation strategies should be adopted to minimise impacts as practicable. Predictions confirm construction NMLs will be satisfied at most receptors most of the time. Nonetheless, the following is provided for application where appropriate.

6.1.1 Work practices

Work practice methods include:

- regular reinforcement (such as at toolbox talks) of the need to minimise noise and vibration
- regular identification of noisy activities and adoption of improvement techniques
- avoiding the use of portable radios, public address systems or other methods of site communication that may unnecessarily impact upon nearby residents
- develop routes for the delivery of materials and parking of vehicles to minimise noise
- where possible, avoid the use of equipment that generates impulsive noise
- minimise the movement of materials and plant and unnecessary metal-on-metal contact
- minimise truck movements
- schedule respite periods for intensive works as determined through consultation with potentially affected neighbours (e.g. a daily respite period for a minimum of one hour at midday).

6.1.2 Plant and equipment

Additional measures for plant and equipment include:

- where possible, choose quieter plant and equipment based on the optimal power and size to most efficiently perform the required tasks
- movement alarms and beepers to be replaced with non-tonal level varying quackers or equivalent
- operate plant and equipment in the quietest and most efficient manner
- regularly inspect and maintain plant and equipment to minimise noise and vibration level increases, to ensure that all noise and vibration reduction devices are operating effectively.

6.1.3 Quantifying noise reductions

Approximate noise reductions provided by some of these measures are provided in Table 6.1.

Table 6.1 Relative effectiveness of various forms of noise control

Noise control	Nominal noise reduction possible, in total A-weighted sound pressure level
Increase source to receiver distance[1]	approximately 6 dB for each doubling of distance
Reduce equipment operating times or turn off idling machinery[2]	approximately 3 dB per halving of operating time
Operating training on quiet operation[2]	up to 3 to 5 dB
Screening (e.g. noise barrier)[1]	normally 5dB to 10 dB, maximum 15 dB
Enclosure (e.g. shed/building)[1]	normally 15 dB to 25 dB, maximum 50 dB
Silencing (e.g. exhaust mufflers)[1]	normally 5 dB to 10 dB, maximum 20 dB

1. Sourced from AS2436-2010.
2. Based on EMM's measurement experience at construction and mining sites.

7 Conclusion

EMM has completed an assessment of potential noise impacts associated with the proposed On-Site Sewer Management facility (OSSM) for the Alspec Industrial Business Park (AIBP) located at 221-235 Luddenham Road, Orchard Hills, NSW. The assessment considered the potential for operational, construction and road traffic noise and vibration impacts of the project and has been prepared in accordance with the methodologies outlined in the ICNG, NPfI and RNP, as well as other relevant guidelines and standards.

Construction noise management levels and operational project noise trigger levels for the project have been established based on the results of ambient noise monitoring and methodologies provided in the ICNG and NPfI.

Noise modelling has been done to predict likely levels generated during the site establishment construction period, and operations combined with typical worst-case maintenance activities. Findings of the assessment are summarised as follows:

- Construction noise predictions confirm levels satisfy NMLs at most receptors most of the time. NML exceedances of up to 2 dB for some receivers in NCA2 are however indicated. No exceedances of the highly noise affected management level are predicted for any receptor. Mitigation measures are provided herein.
- Operational noise levels are predicted to satisfy project noise trigger levels and cumulative impact assessment criteria.
- Sleep disturbance is not expected as predictions satisfy screening criteria.
- Traffic generated by the OSSM will be insignificant relative to existing traffic on Luddenham Road and traffic generated by AIBP.
- Construction and operation at the site are not anticipated to generate significant vibration impacts at any assessment location.

References

NSW Noise Policy for Industry (NPfI) (EPA 2017).

Road Noise Policy (RNP) (DECCW 2011).

Interim Construction Noise Guideline (ICNG) (EPA 2009).

Construction Noise and Vibration Guideline (TfNSW 2023)

Assessing Vibration: a technical guide (EPA 2006)

Glossary

Project and technical terms

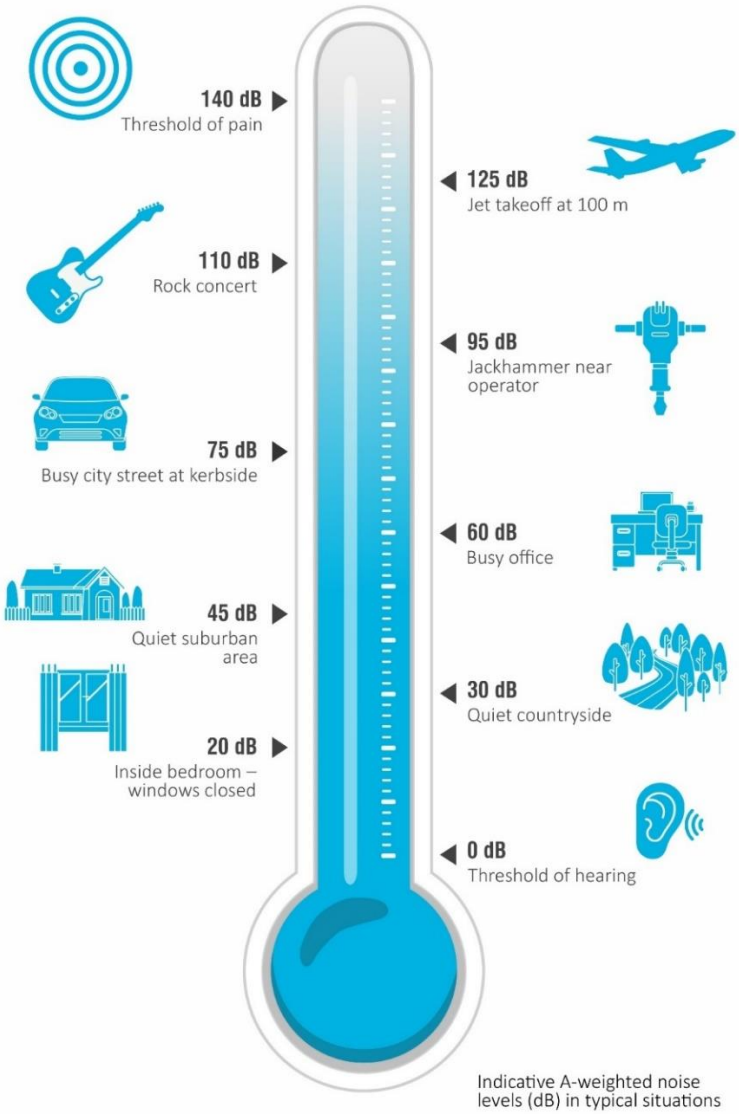
Term	Meaning
dB(A)	Noise level measurement units are decibels (dB). The “A” weighting scale is used to approximate how humans hear noise.
L_{Amax}	The maximum root mean squared A-weighted noise level over a time period.
L_{A1}	The A-weighted noise level which is exceeded for 1% of the time.
$L_{A1,1minute}$	The A-weighted noise level which is exceeded for 1% of the specified time period of 1 minute.
L_{A10}	The A-weighted noise level which is exceeded for 10% of the time.
L_{Aeq}	The energy average A-weighted noise level.
L_{A50}	The A-weighted noise level which is exceeded for 50% of the time, also the median noise level during a measurement period.
L_{A90}	The A-weighted noise level exceeded for 90% of the time, also referred to as the “background” noise level and commonly used to derive noise limits.
L_{Amin}	The minimum A-weighted noise level over a time period.
L_{Ceq}	The energy average C-weighted noise energy during a measurement period. The “C” weighting scale is used to take into account low-frequency components of noise within the audibility range of humans.
SPL	Sound pressure level. Fluctuations in pressure measured as 10 times a logarithmic scale, with the reference pressure being 20 micropascals.
Hertz (Hz)	The frequency of fluctuations in pressure, measured in cycles per second. Most sounds are a combination of many frequencies together.
Day	Monday – Saturday: 7 am to 6 pm, on Sundays and Public Holidays: 8 am to 6 pm.
Evening	Monday – Saturday: 6 pm to 10 pm, on Sundays and Public Holidays: 6 pm to 10 pm.
Night	Monday – Saturday: 10 pm to 7 am, on Sundays and Public Holidays: 10 pm to 8 am.
ABL	The assessment background level (ABL) is defined in the INP as a single figure background level for each assessment period (day, evening and night). It is the tenth percentile of the measured L90 statistical noise levels.
RBL	The rating background level (RBL) is an overall single value background level representing each assessment period over the whole monitoring period. The RBL is used to determine the intrusiveness criteria for noise assessment purposes and is the median of the average background levels.
Sound power level (Lw)	A measure of the total power radiated by a source. The sound power of a source is a fundamental property of the source and is independent of the surrounding environment.

Common noise levels

The table below gives an indication as to how an average person perceives changes in noise levels. Examples of common noise levels encountered on a daily basis are provided in the figure below.

Perceived change in noise

Change in sound level (dB)	Perceived change in noise
up to 2	typically indiscernible
3	just perceptible
5	noticeable difference
10	twice (or half) as loud
15	large change
20	four times as loud (or quarter) as loud



Indicative A-weighted noise levels (dB) in typical situations

Australia

SYDNEY
Ground floor 20 Chandos Street
St Leonards NSW 2065
T 02 9493 9500

NEWCASTLE
Level 3 175 Scott Street
Newcastle NSW 2300
T 02 4907 4800

BRISBANE
Level 1 87 Wickham Terrace
Spring Hill QLD 4000
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CANBERRA
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Canberra City ACT 2601

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Melbourne VIC 3000
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Appendix Q24.4

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LCA for RWMS at 221-227 & 289-317 Luddenham Rd, Orchard Hills NSW

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Document Control Sheet

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Job Reference:	3578_LCA _005
Synopsis:	This report presents the results of a land capability assessment (LCA) to support sustainable and compliant irrigation of (surplus) recycled water (RW) generated from the recycled water management scheme (RWMS) servicing the 'Alspec Industrial Business Park' development at 221-227 & 289-317 Luddenham Rd, Orchard Hills NSW.
Client Details	
Client:	Aquacell P/L
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Mark Saunders	Ben Colautti

Disclaimer

The information contained in this report is based on independent research undertaken by Ben Colautti of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review and limited soil sample analysis only, and the conclusions made in this report are based on the information gained and the assumptions as outlined. Under no circumstances, can it be considered that these results represent the actual state of the site at all points, as subsurface conditions are inherently variable. Concentrations of contaminants may also change with time, and the conclusions in this report have a limited lifespan.

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Introduction

Whitehead and Associates Environmental Consultants Pty Ltd ("W&A") were engaged by Aquacell Pty Ltd (the "Client") to prepare a Land Capability Assessment (LCA) for the land application of 'surplus' recycled water (RW) generated from the proposed 'Alspec Business Park' development at 221-227 & 289-317 Luddenham Rd, Orchard Hills (the "Site"). The Site encompasses 10 existing lots: Lot 99 of DP1282927; Lot 1 and Lot 2 of DP1293805; Lot 1 of DP396972; Lot 24 of DP331426; Lot 2 of DP219794 as well as Lot 1, Lot 2, Lot 3 and Lot 4 of DP520117. The Site is approximately 146.05ha in area and is zoned E4 (general industrial), C2 (environmental conservation) and RU2 (rural landscape) under the Penrith Local Environmental Plan 2010.

The Site is bound by private rural properties to the north, west and south and Luddenham Road to the east. The Site, is wholly within the South Creek catchment and is dissected by a tributary of South Creek through the north-west. It is moderately bushfire prone (Vegetation Category 1 and 2) and contains multiple dams and associated drainage channels, with surface water draining to either South Creek to the east or a South Creek tributary to the north-west.

The proposed development, 'Alspec Industrial Business Park' ("AIBP" or "Business Park"), includes the construction of a warehousing, office, and distribution facility over ~63ha of developable land at the Site. A large portion of the Site has been defined as undevelopable area due to the presence of an environmental conservation zone (ECZ); area defined for a future Transport for NSW project (Outer Sydney Orbital), and stormwater collection areas associated with the proposal.

A decentralised wastewater treatment plant (WWTP) is proposed to treat sanitary wastewater generated from the AIBP. A substantial portion of RW will return to the Business Park via dual-reticulation ('third pipe') to service non-potable demand (toilet flushing and cooling tower water), with remaining (surplus) RW to be irrigated to land within a dedicated recycled water irrigation zone (RWIZ). The proposed registered operator (PRO) of the recycled water management scheme (RWMS) will be Aquacell Pty Ltd.

Once the development is complete, the WWTP will provide sewerage services to over 30 small retail customer premises. As such, the scheme is being assessed by the Independent Pricing and Regulatory Tribunal (IPART) under the Water Industry Competition Act 2006 (WICA). This LCA has been undertaken in reference to the assessment and design principles of:

- Independent Pricing and Regulatory Tribunal, Water Industry Competition Act 2006 Scheme Approval Application Guide, Mar 2024 (IPART, 2024);
- Penrith City Council, On-Site Sewage Management and Greywater Reuse Policy, April 2014 (PSC, 2014);
- NSW DEC (2004), Environmental Guidelines for the Use of Effluent by Irrigation (DEC, 2004);
- NSW DPI, Recycled Water Management Systems, May 2015 (NSW DPI, 2015);
- State Environmental Planning Policy (Precincts - Western Sydney Parkland City), 2021-728 (SEPP, 2021);
- National Water Quality Management Strategy (2006), Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (AGWR, 2006); and
- AS/NZS 1547:2012 On-site Domestic Wastewater Management (Standards Australia / Standards New Zealand, 2012).

1 Scope of Works

This document presents a detailed LCA to support the RWIZ design at the Site. The analysis involves investigation of available area for a dedicated RWIZ for surplus RW application in a sustainable and reliable manner over the expected lifespan of the RWMS. The scope of works include:

- preparing a detailed LCA, including soil investigations and in-situ permeability testing;
- identifying appropriate setbacks (buffers) for RWIZ management; and
- identifying any land improvement works or mitigation measures required to address particular site constraints (e.g. soil importation, vegetation improvement, landscaping, and stormwater diversion).

2 Development

It is understood, a DA has been submitted to Penrith City Council ("Council") for the enabling works which include the demolition of existing infrastructure, clearing of vegetation, storm water and civil works (earthworks) to create level pads, as per the proposed industrial subdivision. Changes to landform are sourced from 'Henry and Hymas P/L, GENERAL ARRANGEMENT PLAN, DWG No. 19221_D2_C100, Rev 3, May 25' (ref: '2025 Earthworks Plan').

It is understood future building development will be assessed under separate DAs for each proposed lot. However, the general lot layout is delineated as per the Plan: 'nettletontribe P/L, INDICATIVE CONCEPT MASTERPLAN FOR AIBP, DWG No. 11178_DA109, Issue C, 29 May 2025' (ref: '2025 Masterplan') which shows 32 'sites'.

Each site will include one (1) warehouse and at least one (1) attached office. The warehouses range from 238m^2 to 46,314m^2 GFA. Also proposed are extensive hardstand including roads, loading zones and carparks, and ~9.2ha of landscaping area.

3 Land Capability Assessment

A site and soil assessment was undertaken by W&A on 20 June 2024. As per our investigation, a description of Site physical constraints and the degree of limitation they pose to recycled water irrigation is provided in the following table.

Reference is made to the rating scale in Table 2.1 and 2.2 of DEC, 2004.

<table>
<tr><th colspan="5">SITE ASSESSMENT</th></tr>
<tr><th>Parameter</th><th colspan="2">Data/ Observation</th><th>Reference</th><th>Classification/ Outcome</th></tr>
<tr><td>Climate</td><td colspan="2">The Site experiences a temperate climate typical of south eastern Australia.
Median annual rainfall for the Site is 793mm and mean annual pan evaporation is 1,473.4mm.</td><td>SILO weather station - 067084</td><td>Nil limitation</td></tr>
<tr><td colspan="2">Flooding
Land Application Area above 1:20 AEP flood level:
Land Application Area above 1:100 AEP flood level:
Electrical components above 1:100 AEP flood level:</td><td>Yes
Yes
Yes</td><td>Council Mapping</td><td>Nil limitation</td></tr>
<tr><td></td><td colspan="2">The Site has high wind and sun exposure.</td><td>Slight limitation</td><td></td></tr>
</table>

SITE ASSESSMENT			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Exposure and Vegetation	Existing overlying crop at the Site comprises 'cleared' agricultural pasture as well as areas of native scrubland. Proposed overlying crop within the RWIZ consists of complex landscape planting, for further detail see Section 4.4. Proposed vegetation must be trimmed, weeded and maintained regularly, see Section 6.2 of 3578_IMP _005 for further detail.		
Slope	Existing landform within the development area is relatively gentle 1-3%. The final landform within the proposed RWIZ is expected to comprise variable slopes between 3-33%. Landscape areas will include a 33% batter transition between levelled building pads, as well as intermittently integrated retaining walls. The majority of landscaped area is expected to comprise <10% slope, particularly adjacent to the central roadways where gentle grades of ~3% are proposed (2025 Earthworks Plan).	Moderate limitation	
Aspect and Landform	The landform in the proposed RWIZ will be linear planar, with a predominantly north-west aspect.	Nil limitation	
Run-on and Seepage	Low run-on onto the RWIZ is expected. Due to the elevated location of the development area, upslope seepage is not expected.	Nil limitation	
Erosion Potential	Localised soil surface cracking identified during Site investigation. Potential erosion will be mitigated using erosion and sediment controls during construction and revegetation of the proposed RWIZ (see Section 6.2 of 3578_IMP _005).	Slight limitation	
Site Drainage	Poorly drained in northern section of proposed RWIZ. Remaining areas are moderately to poorly drained. Hydrophytic (water-adapted) vegetation was recorded throughout the RWIZ, becoming more abundant in the north. Natural GW seepage is to the north towards a tributary of South Creek. Moderate mottling was present in subsoils, indicating inhibited seasonal drainage.	Moderate limitation	
Fill	None observed or present.	Nil limitation	
Groundwater	No shallow water table present; however, groundwater (GW) seepage was observed into BH5 and BH6 during W&A soil investigations. NSW Office of Water GW bore registry indicates no domestic bores are located within proximity to the Site. An industrial bore (GW105382) is located within the north-west corner of the Site and a monitoring	Slight limitation	

SITE ASSESSMENT				
Parameter	**Data/ Observation**		**Reference**	**Classification/ Outcome**
	bore (GW113238) is located ~190m north-west of the Site boundary. *See Figure 1, Appendix A for GW bore locations and see Appendix B for GW bore reports.*			
Buffers Applicable Permanent rivers and creeks (50m):		Yes	Achievable	
Intermittent waterways, dams and retention basins (15m):		Yes	Achievable	
Domestic groundwater bores (100m):		Yes	Achievable	
Lot boundaries (0.5m):		Yes	Achievable, with reduced buffers Risk assessment provided (see Section 5)	
Buildings and Roads (0.5m):		Yes		
Stormwater Pit (0.5m)		Yes		
Upslope from retaining walls (3m)		Yes	Achievable	
In-ground/above ground Rainwater Tank (9m/0.5m)		Yes	Achievable	
Limiting horizon (GW, bedrock etc.) (>0.6m):		Yes	Achievable	
Surface Rock/ Outcrop	None observed or present.		Nil limitation	
Available Land for RWIZ	DEC (2004) provides guidance regarding the application of suitable setbacks from Site features. Based on the applied setback distances (see Section 4.3), as well as the removal of non-developable land (see Figure 2, Appendix A), approximately 7.6ha of landscape area is identified as 'available' for irrigation at the Site. The Client has indicated that irrigation of stormwater is also required in these areas to meet OSD goals; therefore, the total irrigable landscape RWIZ is 3.65ha. Land identified as 'available' for irrigation within landscaped areas of the proposal are shown at Figure 1, Appendix A of 3578_IMP_005.		Moderate limitation	
Concluding Remarks Slope, drainage and available land area pose moderate limitations to RW irrigation and management at the Site. The slope constraint can be managed by appropriate application method selection (see Section 4.2). The restriction on available land area restrictions can be managed by optimising efficient RW application in suitable landscape areas (RWIZ) and through the effective use of available RW storage. See Section 4.4 of 3578_IMP _005 for further detail. Identified drainage and GW limitations will be mitigated or avoided through conservative RWIZ design.				

SOIL ASSESSMENT (physical)			
Parameter	**Data/ Observation**	**Reference**	**Classification/ Outcome**
Soil Depth	>1,200mm	Nil limitation	
Soil Profile	BH1: A: 0mm - 200mm, weakly structured, dark yellowish brown loam (Cat 3). B_1: 200mm - 800mm, strongly structured, strong brown light clay (Cat 5). B_2: 800mm – 1,200mm, weakly structured, yellowish brown medium clay (Cat 6). BH2: A: 0mm - 200mm, weakly structured, very dark brown clay loam (Cat 4). B: 200mm – 1,200mm, weakly structured, brownish yellow heavy clay (Cat 6). BH3: A: 0mm - 200mm, moderately structured, very dark brown clay loam (Cat 4). B_1: 200mm - 500mm, weakly structured, yellowish red heavy clay (Cat 6). B_2: 500mm – 1,200mm, weakly structured, red heavy clay (Cat 6). BH4: A: 0mm - 200mm, weakly structured, strong brown clay loam (Cat 4). B_1: 200mm – 1,100mm, weakly structured, yellowish brown medium clay (Cat 6). B_2: 1,100mm – 1,200mm, weakly structured, strong brown medium clay (Cat 6). BH5: A: 0mm - 250mm, moderately structured, dark greyish brown loam (Cat 3). B: 250mm – 1,200mm, weakly structured, yellowish brown heavy clay (Cat 6). BH6: A: 0mm - 200mm, weakly structured, very dark grey medium clay (Cat 6). B_1: 200mm - 700mm, weakly structured, brown heavy clay (Cat 6). B_2: 700mm – 1,200mm, weakly structured, pale brown heavy clay (Cat 6). *Borehole locations are shown in Figure 2, Appendix A. Soil borelogs are presented in Appendix B*.	Severe limitation	
Depth to Water Table	No shallow water table encountered during W&A soil survey. Interflow (lateral subsurface seepage) was observed in BH5 and BH6.	Nil limitation	

SOIL ASSESSMENT (physical)				
Coarse Fragments (%)	<2%		Nil limitation	
Soil Permeability	PH1 subsoil: inconclusive PH2 subsoil: 0.216 mm/hr PH3 subsoil: 0.012 mm/hr		Based on in-situ permeability testing.	Severe limitation
	Proposed topsoil import will consist >20mm/hr See Section 4.5 for further detail.		Landscape Contractor	Minor limitation
Emerson Aggregate Class (EAT)	Topsoil: 7 - 3(3) Subsoil: 7 - 2(2)	Stable to moderately dispersive	Slight limitation	
Soil Landscape	The site sits on Blacktown (bt) and South Creek (sc) soil landscapes. More than 99% of the proposed RWIZ location occurs on Blacktown (bt), as described below. Topography includes gently undulating rises on Wianamatta Group shales. Local relief to 30 m, slopes usually >5%. Broad rounded crests and ridges with gently inclined slopes. Cleared Eucalypt woodland and tall open-forest (dry sclerophyll forest). Soils consist shallow to moderately deep (>100 cm) hard setting mottled texture contrast soils, Red and Brown Podzolic Soils on crests grading to Yellow Podzolic Soils on lower slopes and in drainage lines. Limitations include localised seasonal waterlogging, localised water erosion hazard, moderately reactive highly plastic subsoil, and localised surface movement potential.		Soil Landscapes of the Penrith 1:100,000 sheet (Bannerman S.M. and Hazelton P.A., 2011)	
Concluding Remarks Natural Site soils are generally characterised as loam to clay loam (Cat 3-4) topsoils to 200-250mm, underlain by medium to heavy clay (Cat 6) subsoil to >1,200mm. Soil structure is moderate to weak in the topsoil and weak in the subsoil. Soil permeability poses a severe limitation to RW irrigation at the Site. Identified limitations will be mitigated through engineered RWIZ design (refer Section 4.5) and conservative soil loading rates. Minor soil stability limitations can be managed through soil improvement recommendations (Section 6.1 of 3578_IMP _005).				

SOIL ASSESSMENT (chemical)				
Parameter	**Data / Observation**		**Reference**	**Classification / Outcome**
pH	Existing Topsoil: 4.54 - 5.13 Existing Subsoil: 4.5 - 5.28	Strongly to very strongly acid	Nil limitation	
	Proposed Topsoil: 5.4 - 6.8	Moderately acid to neutral	Minor limitation	

EC (dS/m)	Existing Topsoil: 0.28 - 1.01 Existing Subsoil: 0.44 - 5.02	Non-saline to moderately saline	Slight limitation	
	Proposed Topsoil: <0.5	Non-saline	Minor limitation	
ESP (%)	13.6	Sodic	From previous job on the same soil landscape (bt) See Appendix B	Moderate limitation
CEC (me/100g)	12.5	Moderate fertility		Nil limitation
P-sorption (mg/kg)	452	High		Nil limitation
Concluding Remarks Soil sodicity (ESP) poses moderate limitation to RW irrigation; however, potential negative consequences will be mitigated through soil improvement recommendations (Section 6.1 of 3578_IMP _005) Salinity (EC) will be managed by irrigation design, with appropriate use of flushing within the soil rootzone (refer Section 4.3 of 3578_IMP _005).				

4 Recycled Water Management Scheme

The following section outlines relevant information on the proposed RWMS.

4.1 Wastewater Treatment Plant

Individual development lots are expected to generate sanitary wastewater (or equivalent) which will be treated in a dedicated 300kL/day WWTP installed at the Site. The centralised WWTP will be manufactured, constructed and operated by the Client and will include three (3) 1ML storage tanks (buffer tank, treated water tank and 'off-spec' tank).

Treated water (RW) will be supplied back to development lots via dual-reticulation (third pipe) to service non-potable demand such as toilet flushing and cooling tower water. While efforts will be made to ensure that the volume of RW matches non-potable demand from AIBP, surplus RW is expected at times throughout the operating year, and will be land applied in the dedicated RWIZ.

See Figure 1, Appendix A of 3578_IMP_005 for proposed WWTP location.

4.2 RWIZ Positioning

The works layout plan (2025 Masterplan) provides guidance on available areas for RW irrigation. The adopted RWIZ is proposed to be wholly located within delineated landscaped garden areas of the Business Park. The following summarises the key information available on the proposed RWIZ:

- Approximately 9.27ha of managed landscape area is proposed along building frontages, property boundaries, and adjacent to internal roadways, paths and car parking areas.
- A proportion (~4ha) of the landscape area is required to meet OSD goals.

The final RWIZ location will be determined in consultation with a licensed irrigation specialist and the Consent authority, complying with the following conditions:

- The RWIZ must only be located within proposed landscape areas outside of adopted setbacks as outlined in this LCA;
- RW application within the RWIZ will comprise a combination of surface irrigation (SI) and sub-surface irrigation (SSI), installed as follows:

  - SI methods will be applied on slopes ≤6%; and
  - SSI methods will be applied on slopes >6% and less than 33%; and
- The RWIZ must be located outside of sag locations (low points) in the stormwater drainage network (collection pits).

Other RWIZ management recommendations are outlined in Section 5.2 of 3578_IMP _005.

4.3 Buffer Controls

Table 3 of PSC (2014) provides recommended buffer distances for domestic effluent management systems. However, due to the high quality of the RW produced by the WWTP, regulatory classification as 'recycled water' or 'reclaimed water' is considered appropriate.

As such, the NSW DEC (2004) guidelines are considered appropriate to delineate the applied buffer distances for RW irrigation, with the final determination based on a risk assessment of the scheme and dependent on the final quality of the recycled water.

Based on this, the following (nominal) buffers have been defined to assist in maintaining appropriate environmental and public health offsets from the proposed RWIZ:

- 50m from permanent waterways;
- 15m setback from surface waters (dams and storage basins);
- 15m setback from intermittent drainage channels and stormwater swales;
- 100m from GW bore wells;
- 3.0m setback from retaining walls (upslope);
- 1.0m from open stormwater pits; and
- 0m setback from transmission line easements.

To optimise the available land area within the RWIZ, and to make use of extensive lawn areas requiring irrigation, reduced buffers to property boundaries, buildings and hardstand areas (roads, carparks and pathways) are recommended.

A risk analysis is provided to support the proposed reduction in applied buffer from the features (see Section 5.1).

4.4 RWIZ Planting

A planting strategy is proposed for landscape areas of the Site by Geoscapes P/L. The strategy 'Geoscapes PL, Planting Schedule & Imagery - COPE Sensitive Freight, DWG No. LDA-10, Rev G, Mar 2024' (ref: 'COPE Planting Scheme') nominates a mix of 40 separate species, ranging from trees to shrubs and grasses. Proposed species are taxonomically distributed across 32 genera and 24 families, with all but one being native. It is understood the COPE Planting Scheme will be applied across all landscaped areas of the Site (Client).

The COPE Planting Scheme comprises an overstorey of mid-size trees and a mixed understorey of shrubs, groundcover and grasses. The family Myrtaceae encompasses ~56% of the overstorey horizontal planting area. The family Asparagaceae (32%) and Myrtaceae (~9%) dominate the understorey horizontal planting area. Overall, the family Myrtaceae represents the most abundant family at approximately one third (33%) of the combined landscaping regime.

MEDLI plant parameters (as outlined in Section 9.8 of MEDLI Technical Manual) are defined for a range of 'default' plant covers within the MEDLI model package. These default plant covers are

sourced from published and unpublished data and range from sown crops to 'mown' pasture and forest trees.

As per Client, via the landscaping contractor, planting methods may vary and include direct seeding, tube and potted specimens up to 45L.

A modified plant cover, based on the Myrtaceae family (default), was selected as the model crop for MEDLI modelling, as described in Section 3.6 of 3578_IMP_005.

4.5 RWIZ Engineered Soil

Due to the presence of shallow natural topsoils (<250mm), as well as the limiting hydraulic characteristics of Site subsoils, it is proposed to import good quality topsoil across parts of the RWIZ prior to the installation of the RW irrigation system.

The Client, via a landscaping contractor, has provided specification of the soil import. It will be virgin excavated natural material ('VENM') certified (Cat 2-4) soil. Organic matter is expected to be 2-5%, permeability of >20mm/hr and non-sodic at <7%Na of ECEC. There will no more than 20%w/w particles of 2.0 – 20mm and no more than 10%w/w particles of >20mm.

Soil importation will improve RWIZ performance by increasing the separation distance between the point of effluent application (surface and shallow subsurface) and the most-limiting subsurface constraint (medium/heavy clay subsoil) as well as providing additional soil-water storage. The final imported soil profile across the RWIZ will be determined by the landscape designer.

The following installation procedure is recommended:

- Remove natural soil within the RWIZ to a specified depth (as per landscaper);
- Scarify (lightly till) the proposed RWIZ footprint;
- Add good quality (Cat 2) topsoil in 100mm-200mm lifts, rolled to approximate field density, until the set required topsoil profile is achieved;
- Install the irrigation system on the imported topsoil material;
- Cover with an additional 100mm of good quality imported (Cat 2) topsoil material; and
- Revegetate with proposed plant regime (Section 4.4).

The topsoil import and the scarified subsoil will be amended with a calcium ameliorant during installation see Section 6.1 of 3578_IMP_005. MEDLI inputs of the constructed soil profile is presented in Section 3.7 of 3578_IMP_005.

5 Risk Analysis

To determine the minimum acceptable buffer distance from the proposed RWIZ to property boundaries, buildings and hardstand areas of the development, a risk analysis has been undertaken. The analysis comprises a semi-quantitative risk assessment and viral die-off modelling. The procedures used are guided by Section 3 of AGWR (2006) and Appendix 1 of DEC (2004) for the safe reuse of recycled water.

5.1 Buffer Risk Assessment

A buffer risk assessment was completed in accordance with the procedure outlined in Appendix R of *AS/NZS1547:*2012 and was further informed by Appendix 6 of AGWR (2006) and Section 4.10 of DEC (2004).

AS/NZS 1547:2012 recommends that if a high level of constraint is identified for any Site feature, the maximum setback values should be considered. However, in practice the overall setback distance should be "based on an evaluation of the [relevant] constraint items and corresponding sensitive features and how these interact to provide a pathway or barrier for wastewater movement" to the Site feature.

The development layout is heavily vehicle oriented, designed to cater for both private cars as well as rigid trucks and semi-trailer movements. While pedestrian movements will occur, they are unlikely in RWIZ areas. Therefore, any contact with the RW irrigation system can be significantly reduced by design and control measures.

The proposed RWIZ design supports a reduction in the applied buffer to property boundaries, buildings and hardstand areas, based on the following assumptions:

- Improved (vertical) drainage in the engineered topsoil profile to optimise RW infiltration;
- Advanced secondary effluent quality (low strength - DEC,2004);
- RWIZ slope predominantly <10%; minor areas of 33% (3:1 batter);
- Application method of low-risk SI and SSI.

  Low risk SI includes large droplet, low-throw sprinklers and 180° inward-throwing sprinklers. SSI will be located adjacent to foot traffic areas and on all slopes greater than 6%; and
- signage to minimise accidental exposure.

Based on the assessment, a reduction in the applied buffer to identified buildings, hardstand areas and property boundaries to 0.5m is supported. A copy of the risk-based buffer assessment matrix is presented in Appendix B.

5.2 Viral Die-Off

To assess risk of subsoil seepage of pathogens away from the RWIZ, pathogen transport modelling was undertaken. The model considers the movement of viruses away from the RWIZ using an established 1-dimensional viral die-off model developed by Beavers and Gardner (1993) and refined by Cromer *et al.* (2001). Details of the methodology can be found in Cromer *et al*. (2001).

The model generally applies to water moving in saturated soils, i.e. in shallow GW beneath a RWIZ. These conditions are considered most conducive to pathogen transport. In unsaturated (vadose zone) soils, the travel distances will be substantially less. As such, the method is considered very conservative when applied to sites with drained topsoils and deep water tables. Some key assumptions used in the modelling are provided below:

- Bacteria have lesser die-off times than viruses and can therefore be assumed to be eliminated within a shorter distance than viruses (Cromer *et al.* 2001);
- Viral reduction has been set at four (4) orders of magnitude for advanced secondary treatment (Cromer *et al.* 2001); and
- Cooler temperatures allow viruses to reside longer in the soil and hence provide potentially greater travel distances. Groundwater temperatures are based on the mean minimum temperature at the Site of 11.6°C (BOM Station 067084 ORCHARD HILLS WWTP).

Modelling inputs and predicted maximum viral transport distances are summarised in the following table. Appendix B provides additional information on the modelling methodology and full results.

Parameter	Value
Groundwater temperature (ºC)	11.6
Days for Viral Die-off	60
Porosity of soil (decimal)	0.53
K_{sat} (m/day)	0.01
Groundwater gradient (%)	33
Depth to groundwater (m)	1
Horizontal distance travelled in groundwater (m)	**0.08**

Viral die-off modelling demonstrates that with advanced secondary treatment, 100% pathogen reduction within the soil is expected to occur ~0.1m from the RWIZ boundary.

5.3 Risk Summary

The results of the buffer risk assessment and viral die-off modelling show that residual contaminants will be reduced to background levels well within the available buffers and before reaching the surrounding sensitive receptors.

Based on the assessment, the applied buffer of **0.5m** to identified buildings, hardstand areas and property boundaries is justified.

Appendix A

Figures

Figure 1 - Site Locality Plan

3578: LCA and IMP for Proposed Water Recycling Scheme for Alspec Business Park: Luddenham Rd, Orchard Hills

N

Whitehead & Associates
Environmental Consultants

(Approx Scale)

0 1 2 3 4 5 6 7 km

Revision	001
Drawn	BC
Approved	MS

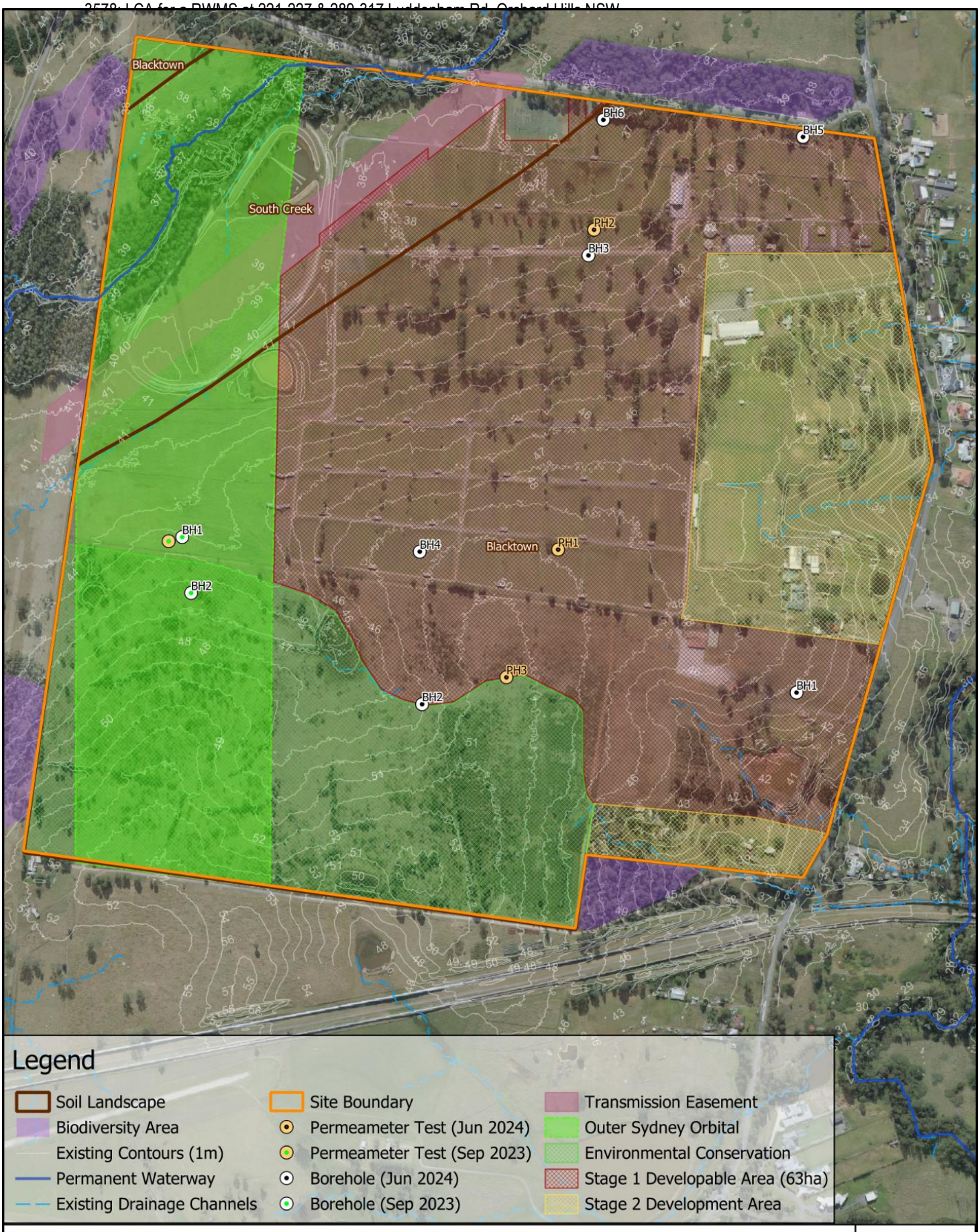


Figure 2 - Site Plan Showing Natural Features

3578: LCA for Proposed Water Recycling Scheme at Luddenham Rd, Orchard Hills

N

Revision	001
Drawn	BC
Approved	MS

Whitehead & Associates
Environmental Consultants

(Approx Scale) 0 150 300 450 600 m

Appendix B

Soil Borelogs and Laboratory Results

Soil Permeameter Results

GW Bore Reports

Buffer Reduction Matrix

Viral Die-Off Modelling

Whitehead & Associates
Environmental Consultants

Key to Soil Borelogs

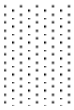
Symbols

W	Watertable depth	●	Sample collected
X	Depth of refusal		

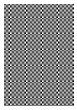
Moisture condition

D	Dry
SM	Slightly moist
M	Moist
VM	Very moist
W	Wet / saturated

Graphic Log and Textures

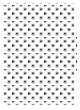


S - Sand
LS - Loamy sand
CS - Clayey sand



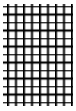
CL - Clay loam
SCL - Sandy clay loam
SiCL - Silty clay loam

Gravel (G)

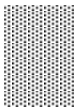


SL - Sandy loam

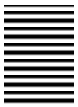
LC - Light clay
SC - Sandy clay



Parent material (stiff)



L - Loam
LFS - Loam fine sandy
SiL - Silty loam



MC - Medium clay
HC - Heavy clay

Parent material (weathered)

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Jordan Jennings - AquaCell P/L	**Borehole No:**	**BH1**
Site:	221-227 Luddenham Rd, Orchard Hills	Excavated/logged by:	B.C, B.M
Date:	20th June 2024	Excavation type:	Auger, crowbar & shovel
Notes:	- refer to site plan for position of borehole		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles/ Gley	Coarse Fragments	Moisture Condition	Comments
0.1 0.2		BH1/1	A	L	weak	dark yellowish brown	N/A	<2%	M	
0.3 0.4 0.5 0.6 0.7 0.8		BH1/2	B_1	LC	strong	strong brown	N/A	<2%	SM	
0.9 1 1.1 1.2		BH1/3	B_2	MC	weak	yellowish brown	N/A	<2%	SM	

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Jordan Jennings - AquaCell P/L	**Borehole No:**	**BH2**
Site:	221-227 Luddenham Rd, Orchard Hills	Excavated/logged by:	B.C, B.M
Date:	20th June 2024	Excavation type:	Auger, crowbar & shovel
Notes:	- refer to site plan for position of borehole		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles/ Gley	Coarse Fragments	Moisture Condition	Comments
0.1		BH2/1	A	CL	weak	very dark brown	N/A	<2%	M	
0.2										
0.3		BH2/2	B	HC	weak	brownish yellow	10% red	<2%	M	
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1										
1.1										
1.2										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Jordan Jennings - AquaCell P/L	**Borehole No:**	**BH3**
Site:	221-227 Luddenham Rd, Orchard Hills	Excavated/logged by:	B.C, B.M
Date:	20th June 2024	Excavation type:	Auger, crowbar & shovel
Notes:	- refer to site plan for position of borehole		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles/ Gley	Coarse Fragments	Moisture Condition	Comments
0.1		BH3/1	A	CL	moderate	very dark brown	N/A	<2%	SM	
0.2										
0.3		BH3/2	B_1	HC	weak	yellowish red	N/A	<2%	M	
0.4										
0.5										
0.6		BH3/3	B_2	HC	weak	red	N/A	<2%	M	
0.7										
0.8										
0.9										
1										
1.1										
1.2										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Jordan Jennings - AquaCell P/L	**Borehole No:**	**BH4**
Site:	221-227 Luddenham Rd, Orchard Hills	Excavated/logged by:	B.C, B.M
Date:	20th June 2024	Excavation type:	Auger, crowbar & shovel
Notes:	- refer to site plan for position of borehole		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles/ Gley	Coarse Fragments	Moisture Condition	Comments
0.1		BH4/1	A	CL	weak	strong brown	N/A	<2%	M	
0.2										
0.3		BH4/2	B_1	MC	weak	yellowish brown	N/A	<2%	M	
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1										
1.1										
1.2		BH4/3	B_2	MC	weak	strong brown	N/A	<2%	M	

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Jordan Jennings - AquaCell P/L	**Borehole No:**	**BH5**
Site:	221-227 Luddenham Rd, Orchard Hills	Excavated/logged by:	B.C, B.M
Date:	20th June 2024	Excavation type:	Auger, crowbar & shovel
Notes:	- refer to site plan for position of borehole		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles/ Gley	Coarse Fragments	Moisture Condition	Comments
0.1		BH5/1	A	L	moderate	dark greyish brown	N/A	<2%	M	
0.2										
0.3		BH5/2	B	HC	weak	yellowish brown	N/A	<2%	M	
0.4										
0.5										
0.6										
0.7										
0.8										
0.9										
1										
1.1										
1.2										

SOIL BORE LOG

Whitehead & Associates
Environmental Consultants

Client:	Jordan Jennings - AquaCell P/L	**Borehole No:**	**BH6**
Site:	221-227 Luddenham Rd, Orchard Hills	Excavated/logged by:	B.C, B.M
Date:	20th June 2024	Excavation type:	Auger, crowbar & shovel
Notes:	- refer to site plan for position of borehole		

PROFILE DESCRIPTION

Depth (m)	Graphic Log	Sampling depth/name	Horizon	Texture	Structure	Colour	Mottles/ Gley	Coarse Fragments	Moisture Condition	Comments
0.1		BH6/1	A	MC	weak	very dark grey	N/A	<2%	M	
0.2										
0.3		BH6/2	B_1	HC	weak	brown	10% red	<2%	M	
0.4										
0.5										
0.6										
0.7										
0.8		BH6/3	B_2	HC	weak	pale brown	10% red	<2%	M	
0.9										
1										
1.1										
1.2										

Project 3578: 221-227 Luddenham Rd, Orchard Hills

Sheet 1 - Soil Sampling Schedule and Results of pH, EC and Emerson Aggregate Test Analysis

Site	Sample Name	Sample Depth (mm)	Texture Class	EAT [1]	Rating [2]	pH_f [3]	$pH_{1:5}$ [4]	Rating	$EC_{1:5}$ (µS/cm)	ECe (dS/m) [5]	Rating	Other analysis [6]
BH1	1/1	200	L	3(2)	Slight	n/a	4.94	very strongly acid	29	0.28	non-saline	
	1/2	800	LC	3(1)	Slight	n/a	4.78	very strongly acid	51	0.44	non-saline	
	1/3	1200	MC	3(2)	Slight	n/a	4.50	very strongly acid	64	0.48	non-saline	
BH2	2/1	200	CL	3(2)	Slight	n/a	4.54	very strongly acid	118	1.01	non-saline	
	2/2	1200	HC	3(3)	Moderate	n/a	4.55	very strongly acid	421	2.44	slightly saline	
BH3	3/1	200	CL	3(2)	Slight	n/a	4.89	very strongly acid	50	0.43	non-saline	
	3/2	500	HC	3(2)	Slight	n/a	4.9	very strongly acid	137	0.79	non-saline	
	3/3	1200	HC	7	Negligible	n/a	4.7	very strongly acid	453	2.63	slightly saline	
BH4	4/1	200	CL	3(3)	Moderate	n/a	4.7	very strongly acid	89	0.77	non-saline	
	4/2	1100	MC	3(3)	Moderate	n/a	4.9	very strongly acid	142	1.07	non-saline	
	4/3	1200	MC	3(2)	Slight	n/a	5.1	strongly acid	344	2.58	slightly saline	
BH5	5/1	250	L	3(1)	Slight	n/a	4.9	very strongly acid	106	1.01	non-saline	
	5/2	1200	LC	3(1)	Slight	n/a	5.3	strongly acid	500	4.30	moderately saline	
BH6	6/1	200	MC	7	Negligible	n/a	5.1	strongly acid	76	0.57	non-saline	
	6/2	700	HC	2(2)	High	n/a	5.1	strongly acid	203	1.18	non-saline	
	6/3	1200	HC	3(2)	Slight	n/a	5.0	very strongly acid	866	5.02	moderately saline	

Notes:- (also refer Interpretation Sheet 1)

n/a not available
n/t not tested
[1] The modified Emerson Aggregate Test (EAT) provides an indication of soil susceptibility to dispersion.
[2] Ratings describe the likely hazard associated with land application of treated wastewater.
[3] pH measured in the field using Raupac Indicator.
[4] pH measured on 1:5 soil:water suspensions using a *Hanna Combo* hand-held pH/EC/temp meter.
[5] Electrical conductivity of the saturated extract (Ece) = $EC_{1:5}$(µS/cm) x MF / 1000. Units are dS/m. MF is a soil texture multiplication factor.
[6] External laboratories used for the following analyses, if indicated:

- CEC (Cation exchange capacity)
- Psorb (Phosphorus sorption capacity)
- Bray Phosphorus
- Organic carbon
- Total nitrogen

Job No. 3251, Box Hill NSW

Sheet 2 - Results of External Laboratory Analysis

Comp 1	Depth (m)	CEC (me/100g)	Rating	Ca (mg/kg)	Rating	Mg (mg/kg)	Rating	Na (mg/kg)	Rating	K (mg/kg)	Rating	ESP (%)	Rating	P-sorp. (mg/kg)	Rating
	1m	12.5	M	751	L	586	H	393	H	103	L	13.6	S	452	H

Notes:- (also refer Interpretation Sheet 2)

Converting mg kg-1 to cmol (+) kg-1 from: Table D3–2, Vegetable SOILpak. D3. Chemical tests
n/t

Phone Office/Lab (02) 6775 1157

email: lanfaxlabs@bigpond.com.au
Website: http://www.lanfaxlabs.com.au
Lab address: 493 Old Inverell Road
Postal address: PO Box 4690 Armidale NSW 2350
Director: Dr Robert Patterson FIEAust, CPSS, CPAg
Soil Scientists and Environmental Engineers

Lanfax Laboratories
ABN 72 212 385 096
Quality Assurance and Quality Control by Approved Methods

14th June 2022

Whitehead & Associates
197 Main Road
Cardiff NSW 2285

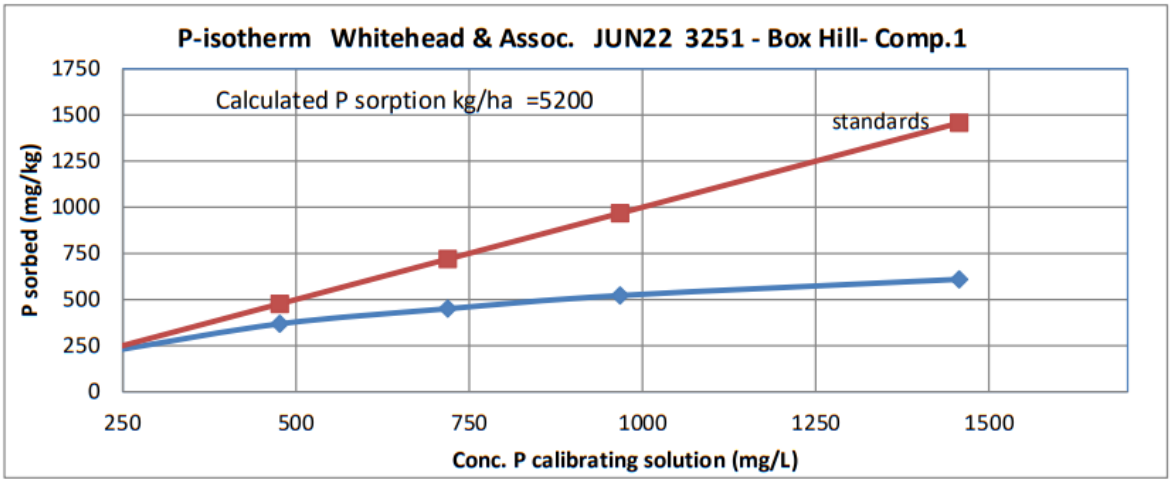
Sample 3251, Bore holes Composite 1 & 2
Received 10th June 2022, sample date 2nd June 2022
Samples dried to 50°C, crushed and sieved to minus 2 mm prior to analysis

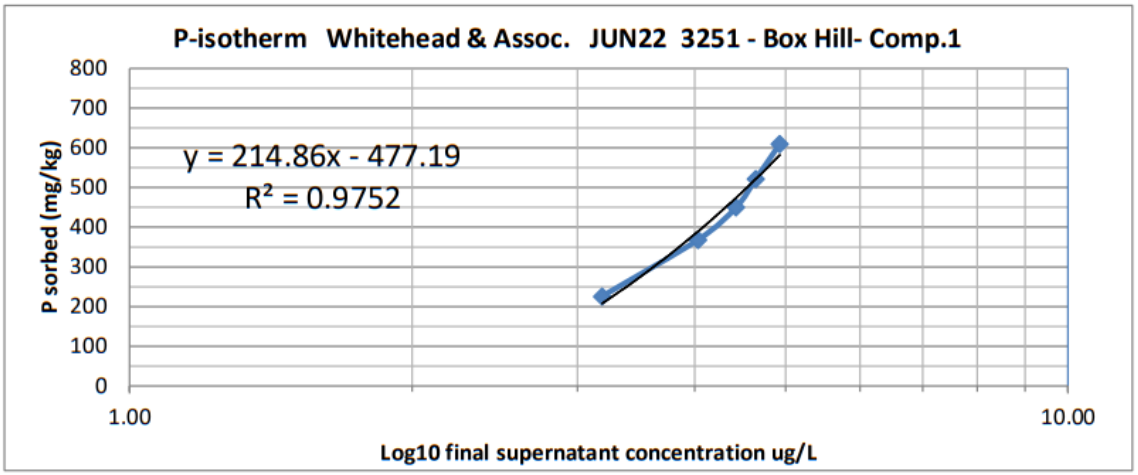
	Whitehead & Assoc. - JUN22												
Site Location	Exc.Al+H	Ca		K		Mg		Na		Base Sat.	ESP	CEC	Ca/Mg
Sample ID	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	mg/kg	cmol+/kg	%	%	cmol+/kg	ratio
Whitehead&Assoc-3251-Box Hill-Comp 1	2.0	751	3.75	103	0.26	586	4.82	393	1.71	84.1	13.6	12.5	0.8
Whitehead&Assoc-3251-Box Hill-Comp 2	2.1	650	3.24	79	0.20	499	4.11	321	1.40	81.1	12.7	11.0	0.8

Methods: Rayment & Lyons 2011
P sorption modified method 9J1 - elevated equilibrating solutions, ICP determination of P
Cations: Method 15D3, no pretreatment
Exchangeable Acidity: Method 15G1

Yours faithfully,

Dr Robert Patterson FIEAust, CPSS(3), CPAg
Soil Scientist and Environmental Engineer





Percent sorbed is the proportion of the initial P sorbed during equilibration						P-isotherm Whitehead & Assoc. JUN22 3			
Initial P	filtrate	sorbed P	Sample	Percent		Std line	filtrate	X-axis	Y-axis
mgP/L	P	mg/kg	I.D.	sorbed			C	Log C	
	mg/L			(%)			ugP/L		
24.1	1.54	225.8	Whitehead & Assoc. JUN22	93.6		241	1543	3.19	225.8
47.7	10.83	368.3	3251 - Box Hill- Comp.1	77.3		477	10833	4.03	368.3
71.9	26.87	450.3		62.6		719	26867	4.43	450.3
96.8	44.59	521.6		53.9		968	44590	4.65	521.6
145.7	84.74	609.4		41.8		1457	84741	4.93	609.4
Calculated P sorption kg/ha =			5200						

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Test # 3578_June2024 PH1

Time (hr:min:sec)	Time after start (min)	Level in Tube (cm)	Drop of Level (cm)	Rate of Water Level Drop (cm/min)
10:58am	0	130.0		
	13	130.0	0.0	0.0
	26	130.3	-0.3	0.0
	39	130.2	0.1	0.0
	52	130.0	0.2	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.0
Rate of Loss of Water from Reservoir			(cm^3/min)	0.0

Enter data in green cells

Select Steady Rate of Water Level Drop from Rate of Water Level Drop Column (Column E) and enter in pink cell (E34). This value should be the average of three consecutive values with no more than 10% variation

Disclaimer: CET does not warrant data produced by use of this spreadsheet or any interpretation based on that data

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Parameter	Symbol	Value
Depth of Water in Test Hole (cm)	H	30
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.0
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	0.00
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.0000
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.00

Confirm data in green cells and adjust if necessary

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Test # 3578_June2024 PH2

Time (hr:min:sec)	Time after start (min)	Level in Tube (cm)	Drop of Level (cm)	Rate of Water Level Drop (cm/min)
11:04pm	0	134.6		
	13	134.6	0.0	0.0
	26	134.1	0.5	0.0
	39	132.8	1.3	0.1
	52	129.2	3.6	0.3
	65	129.0	0.2	0.0
	78	128.5	0.5	0.0
	91	125.0	3.5	0.3
	104	124.8	0.2	0.0
	117	124.8	0.0	0.0
	130	121.7	3.1	0.2
	143	121.7	0.0	0.0
	156	118.5	3.2	0.2
	169	118.5	0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.1
Rate of Loss of Water from Reservoir			(cm^3/min)	0.7

Enter data in green cells

Select Steady Rate of Water Level Drop from Rate of Water Level Drop Column (Column E) and enter in pink cell (E34). This value should be the average of three consecutive values with no more than 10% variation

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Parameter	Symbol	Value
Depth of Water in Test Hole (cm)	H	30
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.1
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	0.71
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.0004
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.01

Confirm data in green cells and adjust if necessary

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Test # 3578_June2024 PH3

Time (hr:min:sec)	Time after start (min)	Level in Tube (cm)	Drop of Level (cm)	Rate of Water Level Drop (cm/min)
12:20pm	0	129.6		
	13	129.6	0.0	0.0
	26	129.5	0.1	0.0
	39	129.5	0.0	0.0
	52	129.1	0.4	0.0
	65	129.1	0.0	0.0
	78	129.1	0.0	0.0
	91	129.1	0.0	0.0
	104	129.0	0.1	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
			0.0	0.0
Selected Steady Rate of Water Level Drop			(cm/min)	0.0
Rate of Loss of Water from Reservoir			(cm^3/min)	0.0

Enter data in green cells

Select Steady Rate of Water Level Drop from Rate of Water Level Drop Column (Column E) and enter in pink cell (E34). This value should be the average of three consecutive values with no more than 10% variation

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Parameter	Symbol	Value
Depth of Water in Test Hole (cm)	H	33
Radius of Test Hole (cm)	r	3.75
Inner Tube External Diameter (cm)	D_i	0.9
Outer Tube Internal Diameter (cm)	D_o	3.2
Rate of Water Level Drop (cm/min)	L	0.0
Inner Tube Cross Sectional Area (cm^2)	A_i	0.64
Outer Tube Cross Sectional Area (cm^2)	A_o	8.04
Flowrate (cm^3/min)	Q	0.04
Saturated Hydraulic Conductivity (cm/min)	K_{sat}	0.0000
Saturated Hydraulic Conductivity (m/day)	K_{sat}	0.00

Confirm data in green cells and adjust if necessary

Disclaimer: CET does not warrant data produced by use of this spreadsheet or any interpretation based on that data

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Construction Sciences

TEST PIT LOG SHEET

Hole No: TP30

Client: HB+B Property
Project: Geotechnical Assessment, Proposed Industrial Land Development
Location: 221-227 and 289-317 Luddenham Road
Job No: 5017200153
Sheet: 1 of 1

Position: -33.82592, 150.75363 | Angle from Horizontal: 90° | Surface Elevation:
Machine Type: 5 tonne Excavator | Excavation Method: EX
Excavation Dimensions: 1.50m LONG AND 0.30m WIDE | Contractor: Platinum Excavation
Date Excavated: 4/5/20 | Logged By: NL | Checked By: VDS

Excavation: Method	Excavation: Resistance	Excavation: Stability	Water	Sampling & Testing: Sample or Field Test	Depth (m)	Material Description: Graphic Log	Classification	SOIL TYPE, plasticity or particle characteristic, colour, secondary and minor components ROCK TYPE, grain size and type, colour, fabric & texture, strength, weathering, defects and structure	Moisture Condition	Consistency Relative Density	STRUCTURE & Other Observations
EX	F	Stable	Not Encountered					Clayey SILT: high plasticity, dark brown	M (≈PL)		TOPSOIL
								0.20m			
				D 0.40 - 0.50 m	0.5		CH	CLAY: high plasticity, grey mottled brown and red, trace gravel	M (≈PL)	St	RESIDUAL SOIL 0.30 m: with tree root 0.30m to 0.50m
				D 1.40 - 1.50 m	1.0						
					1.5			1.50m			
								SHALE, pale brown and grey, with clay, very low strength	D		WEATHERED ROCK
								1.80m			
					2.0			TERMINATED AT 1.80 m Target depth			
					2.5						

METHOD
EX Excavator bucket
R Ripper
HA Hand auger
PT Push tube
SON Sonic drilling
AH Air hammer
PS Percussion sampler
AS Short spiral auger
AD/V Solid flight auger: V-Bit
AD/T Solid flight auger: TC-Bit
HFA Hollow flight auger
WB Washbore drilling
DT Diatube

PENETRATION
VE Very Easy (No Resistance)
E Easy
F Firm
H Hard
VH Very Hard (Refusal)

WATER
Water Level on Date shown
water inflow
water outflow

FIELD TESTS
SPT - Standard Penetration Test
HP - Hand/Pocket Penetrometer
DCP - Dynamic Cone Penetrometer
PSP - Perth Sand Penetrometer
MC - Moisture Content
PBT - Plate Bearing Test
IMP - Borehole Impression Test
PID - Photoionisation Detector
VS - Vane Shear; P=Peak, R=Resdual (uncorrected kPa)

SAMPLES
B - Bulk disturbed sample
D - Disturbed sample
ES - Environmental sample
U - Thin wall tube 'undisturbed'

MOISTURE
D - Dry
M - Moist
W - Wet
PL - Plastic limit
LL - Liquid limit
w - Moisture content

SOIL CONSISTENCY
VS - Very Soft
S - Soft
F - Firm
St - Stiff
VSt - Very Stiff
H - Hard

RELATIVE DENSITY
VL - Very Loose
L - Loose
MD - Medium Dense
D - Dense
VD - Very Dense

Refer to explanatory notes for details of abbreviations and basis of descriptions

CONSTRUCTION SCIENCES

CS 2.01.7.GLB Log CARDINO NON-CORED 5017200153 LOGS.GPJ <<DrawingFile>> 01/06/2020 15:36 10.0.000 Datgel AGS RTA, Photo, Monitoring Tools

WaterNSW
Work Summary

GW105382

Licence: 10WA109455 **Licence Status:** CURRENT

Authorised Purpose(s): INDUSTRIAL
Intended Purpose(s): INDUSTRIAL

Work Type: Bore
Work Status:
Construct.Method: Rotary
Owner Type:

Commenced Date:
Completion Date: 19/04/2004

Final Depth: 252.00 m
Drilled Depth: 252.00 m

Contractor Name: Ultra Drilling
Driller: Bradley Alan Dodd
Assistant Driller:

Property: OSBOURNE PARK 227 Luddenham Rd ORCHARD HILLS 2748 NSW
GWMA: -
GW Zone: -

Standing Water Level (m): 24.000
Salinity Description:
Yield (L/s): 1.100

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	CLAREMONT	1 1099147
Licensed:	CUMBERLAND	CLAREMONT	Whole Lot 1//1099147

Region: 10 - Sydney South Coast
River Basin: - Unknown
Area/District:

CMA Map:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: Unknown

Northing: 6255672.000
Easting: 291651.000

Latitude: 33°49'07.2"S
Longitude: 150°44'55.9"E

GS Map: -
MGA Zone: 56
Coordinate Source: Unknown

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	90.00	171			Down Hole Hammer
1		Hole	Hole	90.00	252.00	140			Down Hole Hammer
1	1	Casing	Pvc Class 9	0.30	90.00	140			Driven into Hole, Riveted and Glued
1	1	Casing	Steel	0.30	1.00	168			Driven into Hole, Riveted and Glued

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
144.00	145.00	1.00	Unknown		146.00	0.60	146.00	01:00:00	3760.00
180.00	181.00	1.00	Unknown		182.00	0.90	243.00	01:00:00	2760.00
240.00	241.00	1.00	Unknown	24.00	243.00	1.10	243.00	01:00:00	2490.00

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	5.00	5.00	CLAY	Clay	
5.00	80.00	75.00	SHALE	Shale	
80.00	119.00	39.00	SANDSTONE	Sandstone	
119.00	125.00	6.00	SHALE	Shale	
125.00	222.00	97.00	SANDSTONE	Sandstone	
222.00	226.00	4.00	SHALE	Shale	
226.00	240.00	14.00	SANDSTONE	Sandstone	
240.00	252.00	12.00	SANDSTONE	Sandstone	

Remarks

09/11/2005: Previous Lic No: 10BL163876

WaterNSW
Work Summary

GW113238

Licence:		**Licence Status:**	
		Authorised Purpose(s):	
		Intended Purpose(s):	MONITORING BORE
Work Type:	Bore		
Work Status:	Equipped		
Construct.Method:			
Owner Type:	Private		
Commenced Date:		**Final Depth:**	18.50 m
Completion Date:	15/02/2012	**Drilled Depth:**	18.50 m
Contractor Name:	(None)		
Driller:	Unkown Unknown		
Assistant Driller:			
Property:		**Standing Water Level (m):**	
GWMA:		**Salinity Description:**	
GW Zone:		**Yield (L/s):**	

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	CUMBERLAND	CLAREMONT	40//738126
Licensed:			

Region:	10 - Sydney South Coast	**CMA Map:**			
River Basin:	- Unknown	**Grid Zone:**		**Scale:**	
Area/District:					
Elevation:	0.00 m (A.H.D.)	**Northing:**	6256011.000	**Latitude:**	33°48'56.0"S
Elevation Source:	Unknown	**Easting:**	291462.000	**Longitude:**	150°44'48.8"E
GS Map:	-	**MGA Zone:**	56	**Coordinate Source:**	Unknown

Remarks

29/07/2014: Nat Carling, 29-July-2014; Added status, drill method, depth.

*** End of GW113238 ***

Warning To Clients: This raw data has been supplied to the WaterN 8W by drillers, licencees and other sources. WaterN 8W does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

Project: Allpec Business Park Recycled Water Irrigation Scheme

AS1547:2012 Table R1 and R2 Buffer Distance Justification

Site Feature	Site Constraint Items of Concern	Constraint Scale: Low Constraint	Constraint Scale: High Constraint	Applicable Constraint	Risk Assessment	Risk Assessment: Low (1)	Risk Assessment: Moderate (2)	Risk Assessment: High (3)	Mitigation Measures	Revised Risk Assessment: Low (1)	Revised Risk Assessment: Moderate (2)	Revised Risk Assessment: High (3)	Revised Risk Rating	Distance: Minimum Acceptable Buffer (m)
Property Boundary	RW Quality	Secondary treated effluent with disinfection	Primary treated effluent	Secondary to tertiary treatment with membrane filtration and UV disinfection (low strength - DEC, 2004)	Low	✓	1	0	The Client has confirmed RW quality will be improved for P and N from 10mg/L to 2.5mg/L (P) and from 20mg/L to 10mg/L (N). This ensures limit only increases the quantity of P and N leaving the Site by <5%.	✓	1	0	0	0.5
	Slope	0-6% (surface effluent application), 0 - 10% (subsurface effluent application)	>10% (surface effluent application) >30% subsurface effluent application	RWNZ adjacent to property boundaries see flat (0 %) to steep (33%) slopes	Moderate	0	✓	2	SSI should be applied on slopes greater than 6% (DECC, 2014). SSI on slopes ≤6% should be large droplet and minimise aerosol spray.	✓	1	0	0	
	Access / Contact	high foot traffic	low foot traffic	moderate foot traffic areas adjacent to RWNZ	Moderate	0	✓	2	Fencing combined with warning signs will be used to restrict or control access to RWNZ adjacent to foot traffic areas. As well as implementation of night-time irrigation to minimise contact risk.	✓	1	0	0	
	Application Method	Drip irrigation or subsurface application of effluent	Surface/above ground application of effluent	A combination of SSI and SI	Moderate	0	✓	2	SSI should be applied in RWNZ in areas adjacent to foot traffic and on slopes >6%. to ensure infiltration. SSI on slopes ≤6% must be low risk and suitably away from foot traffic.	✓	1	0	0	
	Application Rate	zero irrigation surcharge and/or tank overflow	high volume of irrigation surcharge and/or tank overflow	relatively low quantity of irrigation surcharge and/or tank overflow	Moderate	0	✓	2	Constructed dilution drains will divert expected limit to storage basins on site. Nutrients leaving the Site via limit are known to be less than 5% of natural stormwater for a worst case year, suitably showing the risk of eutrophication of natural waterways via limit is very low.	✓	1	0	0	
Buildings	RW Quality	Secondary treated effluent with disinfection	Primary treated effluent	Secondary to tertiary treatment with membrane filtration and UV disinfection (low strength - DEC, 2004)	Low	✓	1	0	The Client has confirmed RW quality will be improved for P and N from 10mg/L to 2.5mg/L (P) and from 20mg/L to 10mg/L (N). This ensures limit only increases the quantity of P and N leaving the Site by <5%.	✓	1	0	0	0.5
	Slope	0-6% (surface effluent application), 0 - 10% (subsurface effluent application)	>10% (surface effluent application) >30% subsurface effluent application	RWNZ adjacent to buildings are flat (0%) to gentle (6%) slopes	Low	✓	1	0	Utilisation of low-risk spray irrigations. SI on slopes ≤6% should be large droplet, with low throw height and radius and minimise aerosol spray.	✓	1	0	0	
	Access / Contact	high foot traffic	low foot traffic	moderate foot traffic areas adjacent to RWNZ	Moderate	0	✓	2	Fencing combined with warning signs will be used to restrict or control access to RWNZ adjacent to foot traffic areas. As well as implementation of night-time irrigation to minimise contact risk.	✓	1	0	Low	
	Application Method	Drip irrigation or subsurface application of effluent	Surface/above ground application of effluent	A combination of SSI and SI	Moderate	0	✓	2	SSI should be applied in RWNZ in areas adjacent to foot traffic and on slopes >6%. to ensure infiltration. SSI on slopes ≤6% must be low risk and suitably away from foot traffic.	✓	1	0	0	
	Application Rate	zero irrigation surcharge and/or tank overflow	high volume of irrigation surcharge and/or tank overflow	relatively low quantity of irrigation surcharge and/or tank overflow	Moderate	0	✓	2	Constructed dilution drains will divert expected limit to storage basins on site. Nutrients leaving the Site via limit are known to be less than 5% of natural stormwater for a worst case year, suitably showing the risk of eutrophication of natural waterways via limit is very low.	✓	1	0	0	
Mandaland	RW Quality	Secondary treated effluent with disinfection	Primary treated effluent	Secondary to tertiary treatment with membrane filtration and UV disinfection (low strength - DEC, 2004)	Low	✓	1	0	The Client has confirmed RW quality will be improved for P and N from 10mg/L to 2.5mg/L (P) and from 20mg/L to 10mg/L (N). This ensures limit only increases the quantity of P and N leaving the Site by <5%.	✓	1	0	0	0.5
	Slope	0-6% (surface effluent application), 0 - 10% (subsurface effluent application)	>10% (surface effluent application) >30% subsurface effluent application	RWNZ adjacent to hardstand are flat (0%) to steep (33%) slopes	Moderate	0	✓	2	SSI should be applied on slopes greater than 6% (DECC, 2014). SSI on slopes ≤6% should be large droplet and minimise aerosol spray.	✓	1	0	0	
	Access / Contact	high foot traffic	low foot traffic	moderate foot traffic areas adjacent to RWNZ	Moderate	0	✓	2	Fencing combined with warning signs will be used to restrict or control access to RWNZ adjacent to foot traffic areas. As well as implementation of night-time irrigation to minimise contact risk.	✓	1	0	Low	
	Application Method	Drip irrigation or subsurface application of effluent	Surface/above ground application of effluent	A combination of SSI and SI	Moderate	0	✓	2	SSI should be applied in RWNZ in areas adjacent to foot traffic and on slopes >6%. to ensure infiltration. SSI on slopes ≤6% must be low risk and suitably away from foot traffic.	✓	1	0	0	
	Application Rate	zero irrigation surcharge and/or tank overflow	high volume of irrigation surcharge and/or tank overflow	relatively low quantity of irrigation surcharge and/or tank overflow	Moderate	0	✓	2	Constructed dilution drains will divert expected limit to storage basins on site. Nutrients leaving the Site via limit are known to be less than 5% of natural stormwater for a worst case year, suitably showing the risk of eutrophication of natural waterways via limit is very low.	✓	1	0	0	

Beavers, Cromer, Gardner Viral Dieoff Model (refer Cromer *et al.*, 2001)

Project 3578 - Alspec Business Park NSW Recycled Water Irrigation Scheme

Step 1	Use Figure 1 in Cromer *et al.* (2001) (reproduced below) to determine days travel time using groundwater temperature* and a selected order of magnitude reduction.

* If mean groundwater temperature is unavailable, mean daily air temperature can be used in most cases.

Groundwater Temperature (°C)	11.6	mean min temp. BOM: 067084 ORCHARD HILLS WWTP
Order of magnitude reduction	4	secondary treatment to tertiary
Days required for viral reduction	**60**	(from Figure 1, below)

Step 2	Calculate the predicted travel distance using Equation 4 from Cromer *et al.* (2001). $Dg = (t-d_v.P/K)/(P/K.I)$

Time in days	t =	60	days	See notes below for description of values
Effective porosity of soil (fraction)	P =	0.53		
Saturated hydraulic conductivity	K =	0.01	m/day	
Groundwater gradient (fraction)	I =	0.33		
Vertical drainage before entering groundwater	d_v =	0.9	m	

Setback Distance	Distance travelled in groundwater			
		d_g =	**0.08**	**m**

Notes:

Porosity (P):	Assume weak medium clay 53% (Hazelton & Murphy 2007)
Ksat (K):	weak medium clay, inferred Ksat of 0.000114m/day (*in-situ testing*).
Groundwater gradient (I):	Assume max groundwater gradient of 33%
Vertical drainage (d_v):	Assume 1.0m of unsaturated flow before reaching groundwater

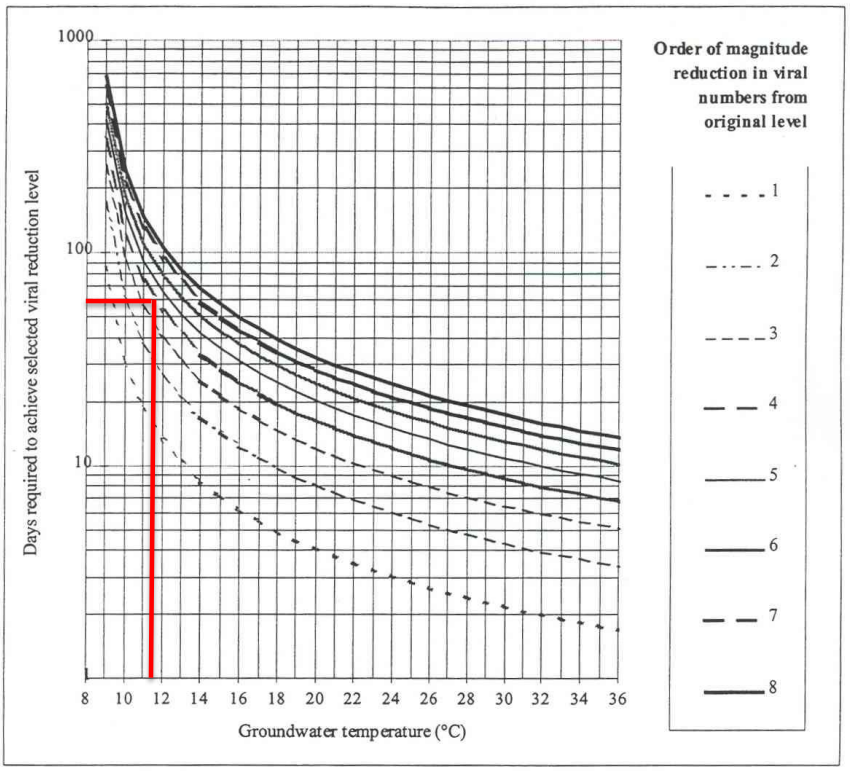

Figure 1. Relationship between Groundwater Temperature and Viral Die-Off Time for Various Order-of-Magnitude Reductions in Viral Numbers

(Figure 1 taken from Cromer et al., 2001)

Appendix Q24.5

Whitehead & Associates
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IMP for RWMS at 221-227 & 289-317 Luddenham Rd, Orchard Hills NSW

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Document Control Sheet

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Author:	Ben Colautti
Project Manager:	Mark Saunders
Date of Issue:	22/08/25
Job Reference:	3578_IMP _005
Synopsis:	This report presents the results of an irrigation management plan (IMP) which outlines sustainable and compliant irrigation of (surplus) recycled water (RW) generated via a recycled water management scheme (RWMS) as part of a proposed development named 'Alspec Industrial Business Park' at 221-227 & 289-317 Luddenham Rd, Orchard Hills NSW.
Client Details	
Client:	Aquacell P/L
Primary Contact:	Jordan Jennings

Document Distribution

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Document Verification

Checked by:	***Issued by:***
Mark Saunders	Ben Colautti

Disclaimer

The information contained in this report is based on independent research undertaken by Ben Colautti of Whitehead & Associates Environmental Consultants Pty Ltd (W&A). To our knowledge, it does not contain any false, misleading or incomplete information. Recommendations are based on an appraisal of the site conditions subject to the limited scope and resources available for this project, and follow relevant industry standards. The work performed by W&A included a desktop review and limited soil sample analysis only, and the conclusions made in this report are based on the information gained and the assumptions as outlined. Under no circumstances, can it be considered that these results represent the actual state of the site at all points, as subsurface conditions are inherently variable. Concentrations of contaminants may also change with time, and the conclusions in this report have a limited lifespan.

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Introduction

Whitehead and Associates Environmental Consultants Pty Ltd ("W&A") were engaged by Aquacell Pty Ltd (the "Client") to prepare an Irrigation Management Plan (IMP) for the land application of 'surplus' recycled water (RW) generated from the proposed 'Alspec Business Park' development at 221-227 & 289-317 Luddenham Rd, Orchard Hills ("the Site"). The Site, encompasses 10 existing lots: Lot 99 of DP1282927; Lot 1 and Lot 2 of DP1293805; Lot 1 of DP396972; Lot 24 of DP331426; Lot 2 of DP219794 as well as Lot 1, Lot 2, Lot 3 and Lot 4 of DP520117. The Site is approximately 146.05ha in area and is zoned E4 (general industrial), C2 (environmental conservation) and RU2 (rural landscape) under the Penrith Local Environmental Plan 2010.

The proposed development, 'Alspec Industrial Business Park' ("AIBP" or "Business Park"), includes the construction of a warehousing, office, and distribution facility over ~63ha of developable land at the Site. A large portion of the Site has been defined as undevelopable area due to the presence of an environmental conservation zone (ECZ); area defined for a future Transport for NSW project (Outer Sydney Orbital), and stormwater collection areas associated with the proposal.

A decentralised wastewater treatment plant (WWTP) is proposed to treat sanitary wastewater generated from the AIBP. A substantial portion of RW will return to the Business Park via dual-reticulation ('third pipe') to service non-potable demand (toilet flushing and cooling tower water), with remaining (surplus) RW to be irrigated to land within a dedicated recycled water irrigation zone (RWIZ). The proposed registered operator (PRO) of the recycled water management scheme (RWMS) will be Aquacell Pty Ltd.

Once the development is complete, the WWTP will provide sewerage services to over 30 small retail customer premises. As such, the scheme is being assessed by the Independent Pricing and Regulatory Tribunal (IPART) under the Water Industry Competition Act 2006 (WICA). This IMP continues on from a Land Capability Assessment (LCA) prepared for the Site (3578_LCA_005) and provides guidance and recommendations for surplus RW irrigation undertaken in reference to the assessment and design principles of:

- Independent Pricing and Regulatory Tribunal, Water Industry Competition Act 2006 Scheme Approval Application Guide, March 2024 (IPART, 2024a);
- Penrith City Council, On-Site Sewage Management and Greywater Reuse Policy, April 2014 (PSC, 2014);
- NSW DEC (2004), Environmental Guidelines for the Use of Effluent by Irrigation (DEC, 2004);
- NSW DPI, Recycled Water Management Systems, May 2015 (NSW DPI, 2015);
- State Environmental Planning Policy (Precincts - Western Sydney Parkland City), 2021-728 (SEPP, 2021);
- National Water Quality Management Strategy (2006), Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 1) (AGWR, 2006); and
- AS/NZS 1547:2012 On-site Domestic Wastewater Management (Standards Australia / Standards New Zealand, 2012).

1 Scope of Works

This document presents a detailed IMP to support the RW irrigation scheme at the Site. The analysis includes modelling of a dedicated RWIZ to demonstrate sufficient capacity to manage expected surplus RW application in a sustainable and reliable manner over the expected lifespan of the RWMS. The scope of works includes:

- daily soil-water modelling to determine the sustainability of typical and maximum RW application rates;
- optimising the use of available RW storage;
- examining the impact of seasonal variability and (potential) climate-change on the RWIZ design; and
- providing advice and guidance regarding RW reuse in the proposed RWIZ.

2 Development

It is understood future building development will be assessed under separate DAs for each proposed lot. However, the general lot layout is delineated as per the Plan: 'nettletontribe P/L, INDICATIVE CONCEPT MASTERPLAN FOR AIBP, DWG No. 11178_DA109, Issue C, 29 May 2025' (ref: '2025 Masterplan') which shows 32 'sites'.

Each site will include one (1) warehouse and at least one (1) attached office. The warehouses range from 238m^2 to 46,314m^2 GFA. The development will be supported by new internal roadways and hardstand (loading zones, carparks etc.). Approximately 9.2ha of landscaping area is proposed throughout the Site.

3 Recycled Water Reuse

The proposed irrigation strategy is based on 100% reuse of surplus RW, with provision of wet-weather storage and mitigation to prevent overflow in a 100-year climate period. This will ensure the scheme can operate without the requirements for controlled (precautionary) discharge to the environment.

Long-term daily water, nutrient and salinity modelling has been undertaken to support the design, based on site and soil characteristics as described in the LCA (3578_LCA_005).

3.1 Nominated Recycled Water Irrigation Zone

The proposed RWIZ is to be wholly located within delineated landscape areas of the AIBP, comprising approximately 3.65ha along building frontages, property boundaries and adjacent to internal roadways, paths and car parking areas. A combination of spray irrigation (SI) and shallow subsurface irrigation (SSI) methods are proposed.

The proposed RWIZ is shown in Figure 1 of Appendix A.

3.2 Irrigation Modelling

Water, nutrient and salinity modelling was undertaken using the Model for Effluent Disposal using Land Irrigation (MEDLI). MEDLI was developed by the Queensland Department of Natural Resources (DNR). It is a mathematical computer model that is designed to simulate irrigation of RW over a parcel of land over an extended time frame. MEDLI balances water and nutrients by simulating daily inputs and outputs against each other. It is capable of simulating storage dynamics, different irrigation operations, rainfall, transpiration, plant growth and nutrient, salinity

and soil-water dynamics over long time periods. MEDLI was updated in 2023, with the current version (V2.5.02) used for this project.

The project-specific inputs to the MEDLI model prepared are described further here.

3.2.1 Climate

Daily rainfall, evaporation, solar radiation and the maximum and minimum temperature for the Site are required for the simulation. Climate data was obtained from the SILO (Data Drill) database produced by the Queensland Government's Department of Science, Information Technology and Innovation (DSITI) division. SILO data is constructed from the Bureau of Meteorology (BoM) records and interpolated across a national grid.

A SILO dataset for ORCHARD HILLS TREATMENT WORKS (067084) was generated for the period 1965-2024 (60 years) and utilised for the model.

3.2.2 RW Quantity

As per a wastewater flow assessment by the Client (Aquacell PL), the (ultimate) AIBP development is expected to generate a peak RW hydraulic load of 245,000L/day (245kL/day).

Client advice indicates a minimum 50% (conservative) of treated RW will be returned to the development sites for on-lot reuse via third-pipe reticulation, resulting in an expected (maximum) surplus RW irrigation volume of **122.5kL/day** (230.4kL/day x 50%). Peak daily flow is assumed to occur during weekday periods, reducing to approximately 10% of that volume on weekend days.

As such, weekday flows of 122.5kL/day and weekend day flows of 12.25kL/day are used in the MEDLI modelling. This calculates to a typical RW surplus of 33,277kL/yr (91.11kL/avg day) requiring irrigation.

3.2.3 RW Quality

Based on Client advice, the RW quality or specification (spec) will achieve the following performance criteria (90th percentile to maximum):

- Total Nitrogen: ≤20mg/L;
- Total Phosphorus: ≤10mg/L;
- BOD_5: <5mg/L;
- Suspended Solids: ≤10mg/L; and
- Total Dissolved Salts: 1,500mg/L (EC ~2.3dS/m).

This is considered Low Strength (Table 3.1 DEC, 2004) and suitable for unrestricted open space re-use.

3.2.3.1 RW Quality Compliance

In the event that RW produced by the WWTP does not meet required standards, it will be diverted to an 'off-spec' storage tank for reprocessing through the treatment system (Client advice).

3.2.4 RW Storage

Available storage is described as a 'pond' in the MEDLI model. This volume can be used to withhold irrigation during extended periods of wet-weather or to manage seasonal fluctuations in RW surplus.

The proposed WWTP will include 3ML of 'closed' storage tanks, comprising:

- a 1ML (influent) buffer tank;

- a 1ML treated water tank to service instantaneous on-lot (third-pipe) demand; and
- a 1ML 'off-spec' storage tank.

Based off Client advice, on a business as usual (BAU) day storage utilisation of the tanks will comprise:

- >700kL of available volume in the influent tank - the WWTP has a 300kL/day capacity and a peak day of 245kL, as such, no flow balancing is expected.
- ~1ML of available volume in the off-spec tank - off-spec generation is not expected as a common occurrence.
- >700kL of available volume in the treated water tank - 245kL of volume will be maintained as available for re-use.

This suggests ~2.4ML (0.7ML + 1ML + 0.7ML) of storage will be available for irrigation storage on a typical day. However, (rare) occurrences such as WWTP failure or poor WWTP performance will utilise a portion of this volume, as such, for model purposes, a conservative 'pond' storage volume of 1ML is chosen.

3.2.5 Soil

Based on the RWIZ location, a combination of soil data from boreholes (BH1- BH6) was used to build the MEDLI soil input data. Natural RWIZ soils are characterised as weakly structured loam (Cat 3) to clay loam (Cat 4) topsoil to ~200mm, underlain by weakly structured heavy clay (Cat 6) subsoil to 1,200mm.

The proposed RWIZ will be improved by increasing the topsoil depth through the placement of sandy loam (Cat 2) to loam (Cat 3) fill material, upon which the landscaping and RW irrigation will be applied.

Based on the proposed soil profile (3578_LCA_005, Section 4.5), RWIZ soils are defined as weakly structured sandy loam (Cat 2) to loam (Cat 3) topsoil to minimum 1,000mm, underlain by a weakly structured heavy clay (Cat 6) subsoil to 1,200mm.

3.2.5.1 Soil Permeability

During the LCA, three (3) in-situ permeameter tests were conducted within the subsoil of the proposed RWIZ. The saturated hydraulic conductivity (K_{sat}) results for each test were as follows: PH1 – inconclusive; PH2 -0.216mm/hr and PH3 - 0.012mm/hr. An averaged value of **0.114** (0.216 + 0.0112 / 2) was used to define subsoil K_{sat}.

Topsoil K_{sat} values were inferred from the MEDLI User Manual, based on the (design) weakly structured sandy loam (Cat 2) engineered soil profile.

Modelled topsoil thickness was reduced to 900mm to account for the most-limiting RWIZ application method (SSI) which will be installed a minimum 100mm below the finished surface. The modelled RWIZ soil profile is summarised as follows.

Layer	Depth	Texture	Structure	Saturated Hydraulic Conductivity (mm/hr)
1	100	SL	weak	120
2	350	SL	weak	120
2	450	SL	weak	120
3	500	HC	weak	0.114

3.2.5.2 Soil Hydraulics

The MEDLI model algorithm partitions water applied to the RWIZ (rainfall or irrigation) into either infiltration or runoff using the USDA-SCS (1972) 'curve number' technique. Runoff (rainfall and irrigation) is modelled using four (4) characteristics: daily rainfall; runoff coefficient; soil moisture status and plant cover effects. Daily rainfall is fixed, based on the selected climate dataset. The remaining characteristics are user-defined (modified Curve Number) and model-derived (soil-water deficit and total plant cover).

The primary characteristic is the runoff Curve Number (CN). This empirical value describes the capacity of the soil to retain applied water based principally on the dominant hydrologic soil group. CN values are provided as ranges to allow for user selection based on land use. A CN value of 100 = all applied water will runoff.

A conservative representation of the 'design' soil profile is used (hydrologic soil group B; CN = 81-85) where "soils are moderately-deep to deep and have a moderate rate of water transmission".

W&A have used an average value (CN = 83) for the model.

3.2.5.3 Soil Chemistry

Phosphorus adsorption data was taken from an analogous soil sample on the same (Blacktown) soil landscape. See Appendix B of 3578_LCA_005. Colwell P is inferred as 44mg/kg, based on Table 5.20 of Hazelton and Murphy (2007).

Natural nitrate nitrogen (NO_3) in the topsoil is estimated as 4.3mg/kg and organic nitrogen estimated as 601mg/kg for 'farmland'[a].

Other soil inputs were sourced as default values from the MEDLI User manual.

3.2.6 Crop

MEDLI provides a range of crop cover types for model use. These 'default' library items provide a baseline case for crop behaviour under irrigation and can be modified using site-specific or species-specific information.

To determine the most appropriate crop cover for the Site from the MEDLI library, W&A undertook a taxonomical analysis of the proposed landscape planting regime (3578_LCA_005, Section 4.4). Performance alterations of crop parameters were also undertaken to more-accurately simulate a layered, mixed-cover landscape planting array.

As per Section 4.4 of the LCA, Myrtaceae is the most abundant taxonomical plant family in the COPE planting scheme. As such, a 'non-rotation' MEDLI default crop of Tea Tree (*Melaleuca alternifolia*) was selected as the preferred baseline crop input.

Further, to account for the proposed understorey and, to a lesser extent, an 'emergent' tree layer (e.g. Forest Red Gum), some 'default' plant parameters were adjusted. With guidance from the MEDLI V2.5.02 User Manual (Jun 2023), nine (9) default Tea Tree plant parameters were modified, as follows:

- Growth was 'kickstarted' based on the use of saplings for landscape planting (Client);
- Maximum crop coefficient was increased from 0.9mm/mm to 1.1mm/mm (~22% increase);
- Radiation use efficiency was increased from 7 to 9 kg/ha/MJ/m² (~29% increase);
- Maximum shoot nitrogen was increased from 0.01 to 0.03 (fraction dwt) (200% increase);
- Maximum shoot phosphorus was increased from 0.0012 to 0.0024 (100% increase);

[a]Zhijing et al, Ecological Engineering, Soil nitrogen distributions for different land uses, Nov 2013

- Maximum shoot nitrogen concentration at which leaf area growth occurs was increased from 0.002 to 0.006 (200% increase);
- Maximum shoot nitrogen concentration at which leaf area growth occurs optimally was increased from 0.008 to 0.024 (200% increase);
- Maximum shoot nitrogen concentration at which dry matter growth occurs was increased from 0.002 to 0.006 (200% increase); and
- Maximum shoot nitrogen concentration at which dry matter growth occurs optimally was increased from 0.008 to 0.024 (200% increase).

This enhanced Tea Tree crop was utilised as the 'model' crop representing the COPE Planting Scheme in the RWIZ.

3.3 Irrigation Application

Traditional 'deficit' irrigation is not practical at the Site, given the variable water requirements for the landscape plantings, modified soil profile and highly distributed RWIZ; therefore, the proposed irrigation design is based on 'fixed' daily application, supported by direct rainfall override and active monitoring of soil-water conditions within the RWIZ to maintain applications rates; optimise drainage and ensure crop water availability.

The proposal assumes fixed daily RW application to a depth of 2.54mm. An override control is proposed whereby 'no irrigation' will occur where there has been more than 30mm of rainfall to the RWIZ in the previous 24-hour period and active monitoring measures will be used to ensure that RW irrigation remains sustainable. The available 1ML of RW storage will be used to manage RW volumes when irrigation is being withheld from the RWIZ.

The Client has advised the preferred irrigation window will be overnight (6pm – 6am). This approach is preferred to ensure that the risk of unintended 'primary' contact is minimised. In all likelihood, the irrigation window may be extended on weekend days or during the warmer (spring / summer) months of the year in response to landscape (crop) requirements.

3.3.1 Irrigation Operations

Irrigation is modelled to occur under the following conditions:

- A non-rotation cropping regime of (enhanced) Tea Tree crop;
- Irrigation is available during all days of the year (i.e. 1/1 – 31/12);
- Irrigation is triggered at a 'specified fixed frequency' of every day;
- A rainfall override of 30mm/day is applied;
- When triggered, irrigation is applied to a fixed depth of 2.54mm/day;
- Irrigation will occur overnight (6pm – 6am); and
- Application assumes pressure compensating sub-surface irrigation (or equivalent).

4 Addressing Climate Change

The WICA Scheme Approval Application Guide (Question 25) requires consideration of climate change risk in the sustainable (long-term) sizing and operation of the RWIZ. This can be achieved by a range of approaches, including risk management, adaptation strategies, mitigation measures or design integration.

4.1.1 Climate Risk

W&A elected to use a modified climate data forecast to examine the potential impact of possible 'future' climate change on the proposed RWIZ design. Climate data (Section 3.2.1) was altered to account for future projections through the use of the SILO Biophysical Modelling (CCS)[b] toolset.

Climate projections are available as daily time-series and provide a total of six climate elements (rainfall, evaporation, minimum and maximum temperature, solar radiation and vapour pressure deficit) in P51 data format, which are compatible with MEDLI. The CCS offers 32 global climate models (GCMs) which are based on results of the Fifth Assessment Report (AR5) completed by the Intergovernmental Panel on Climate Change (IPCC).

The global climate model 'CNRM-CM5' was selected, based on relative centricity for both indexes in the Waterson *et al.* (2011) matrix (see Figure 3, Appendix B). Forecast climate data sets were generated based on the following inputs (see 'sample' screenshot Figure 1, Appendix B):

- Climate perturbation method = Change Factor;
- Climate projection year = 2050;
- Global warming sensitivity = Medium; and
- Representative Concentration Pathway (RCP) = 4.5, which represents the current 'stabilised'[c] emission scenario.

A graphical summary of the original (067084) and projected rainfall and evaporation data sets is provided as Figure 4 in Appendix B. As shown, the soil-moisture balance is predicted to remain nett negative (rainfall<<evaporation) across all modelling scenarios. The average annual decrease in available soil moisture compared to the current (standard) climate datasets are 25% (RCP 4.5); 22% (RCP 6) and 31% (RCP 8.5).

W&A consider the RCP 4.5 scenario to be appropriately conservative for the project, particularly given the larger increases in evaporation forecast under the more aggressive projections.

5 Model Results

5.1 MEDLI Run Set up

Model simulations were completed under both the business as usual (BAU) and future climate (FC) frameworks. Two (2) scenarios were run for each as part of the assessment, as follows:

- Run001 – BAU: Dryland (no irrigation) scenario; 1.2m (engineered) soil profile and enhanced Tea Tree crop;
- Run002d – BAU: RW irrigation (12.25 - 122.5kL/day); 1ML pond; 3.65ha RWIZ; fixed daily irrigation depth of 2.54mm; 30mm rainfall override; 1.2m (engineered) soil profile and enhanced Tea Tree crop;
- Run001a – FC: Dryland (no irrigation) scenario; 1.2m (engineered) soil profile and enhanced Tea Tree crop;
- Run002e – FC: RW irrigation (12.25 - 122.5kL/day); 1ML pond; 3.65ha RWIZ, fixed daily irrigation depth of 2.54mm; 30mm rainfall override; 1.2m (engineered) soil profile and enhanced Tea Tree crop.

[b] https://www.longpaddock.qld.gov.au/seasonal-climate-outlook/CCS/

[c] https://www.usgs.gov/news/data-spotlight-downscaled-climate-projections-inform-climate-research-south-central-us-region#:~:text=RCP%204.5%20Scenario%20%2D%20This%20can%20be,in%20a%20moderate%20overall%20increase%20in%20temperature.

5.2 Background Condition

A 'no irrigation' or 'dryland' simulation was completed for both climate scenarios to establish 'background' for comparison to the RW irrigation runs.

Background deep drainage ("DD") for Run001 is 220mm/year or 27.1% of total water (rainfall only), while rainfall runoff is estimated as ~55mm/year or 6.8% of total water. Remaining rainfall (66.1% total water) is lost to plant uptake and evaporation. The predicted soil-water balance remains negative (ΔSW = -0.6mm) on an annual basis and plant yields are moderately impacted by water stress, with ~83 days/yr without crop.

Background DD for Run001a is 204mm/year or 26.4% of total water (rainfall only), while rainfall runoff is estimated as ~50mm/year or 6.5% of total water. Remaining rainfall (67.1% total water) is lost to plant uptake and evaporation. The predicted soil-water balance remains negative (ΔSW = -0.8mm) on an annual basis and plant yields remain impacted by water stress, with ~97 days/yr without crop.

5.3 MEDLI Outcomes

MEDLI outcomes for irrigation runs are shown in the following table. Full model simulation results and MEDLI diagnostic reports are presented in Appendix E.

MEDLI Outcomes		Run002d	Run002e
Hydraulics	Assumed storage volume (kL)	1000	1000
	Average 'recycled water' generation (kL/day)	91.11	91.11
	Average outflow (Irrigation) (kL/day)	91.0	91.1
	Overflow Frequency (% of days)	0.3	0.1
	RW reuse (%)	99.9	100
	Probability of at least 90% effluent reuse (%)	100	100
	Number of days without irrigation (days/year)	5.27	4.97
	Effective Irrigation Depth (average) (mm/day)	2.49	2.49
	Annual Deep Drainage Total Water (mm/year)	270.6	243.6
	Annual Deep Drainage (total inputs) (%)	15.7	14.5
	Annual Soil evaporation (total inputs) (%)	20.4	27
	Annual Transpiration (total inputs) (%)	60.5	54.9
	Annual Rainfall Runoff (total inputs) (%)	3.4	3.7
	Annual Irrigation Runoff (total inputs) (%)	0	0
	Change in soil-water balance (ΔSW) (+/-)	-0.1	-0.2
Nutrients and Plant	Annual Nitrogen load from Irrigation (kg/ha/year)	182.17	182.26
	Nitrogen Removed by Crop (kg/ha/year)	246.63	236.65
	Annual Nitrogen Leaching (kg/ha/year)	3.03	12.97
	Average nitrate-N concentration of deep drainage (mg/L)	1.12	5.32
	Annual Phosphorus load from Irrigation (kg/ha/year)	91.08	91.13
	Phosphorus Removed by Crop (kg/ha/year)	51.28	43.29
	Annual Phosphorus Leaching (kg/ha/year)	0.01	0.01
	Average (annual) P concentration of deep drainage (mg/L)	0.00246	0.00336
	Design soil profile storage life based on average infiltrated water phosphorus concn. of (~5.47) mg/L (years)	130.16	109.09
	Average monthly green crop cover (%)	0.71	0.6
	Average monthly water stress coefficient (0 = no stress, 1 = full stress)	0.06	0.06
	Average monthly waterlogging coefficient (0 = no stress, 1 = full stress)	0.02	0.02
	No. days without crop/year (days)	0	5.05
	Salinity of Infiltrated Water (dS/m)	2.34	2.34

	Relative Plant Yield Reduction due to Salinity (decimal)	1.666	1.344
	Salinity of the soil solution (at DUL) at base of rootzone (dS/m)	1	1

5.4 Discussion of Results

The MEDLI outcomes under current (BAU) conditions for a 'typical' climate year (Run002d) are discussed here, including comparison with (accepted) good irrigation practice, as defined in relevant guidelines. The modelled annual RW irrigation was 910.8mm/yr.

Pond Performance: In a typical year 100% of surplus RW is re-used. Pond overflow events (where the volume of RW requiring storage exceeds 1ML) are sufficiently mitigated, with ~2.2 events per 10 years exceeding 50m^3 expected. The average recurrence interval for overflow events is 2.1 years, with an average duration of 2.14 days. The expected overflow frequency achieves the safest DEC (2004) target that controlled discharges of stored effluent will only occur in <10% of years (90th percentile containment).

Management of storage overflow is discussed further in Section 5.5.

Hydraulic Performance: Good irrigation practice is considered where crop transpiration is >50% of total water (TW) applied (rainfall + irrigation); DD is <50% and irrigation-induced runoff is effectively 0% of hydraulic export annually. Hydraulic export results are expanded upon further here:

- Transpiration: is increased from 93mm/yr (dryland) to 1,041mm/yr (60.5% of TW) under irrigated conditions. RW irrigation improves plant water stress from 83 days/yr without crop (dryland) to 0 days/yr.
- Deep Drainage: DD increased from 220mm/yr (dryland) to 270.6mm/yr (15.7% of TW) under irrigated conditions. This represents a minor increase and is considered acceptable to allow for accumulated salts from RW to be flushed from the upper soil profile in the RWIZ.

  Irrigation Supplied Percolation (ISP) is the difference between irrigated and dryland DD. ISP should have a maximum (common) rate of 180mm/yr (15mm/month) for an inland Site (IPART, 2024a). ISP is 50.7mm/yr (270.7mm/year - 220mm/year) under the proposed scenario.
- Irrigation Runoff: does not occur (0% of TW) under irrigated conditions. RW runoff should be zero (IPART, 2024a).

Nutrients: Good irrigation practice demonstrates that the majority of RW nutrients are up taken by the RWIZ crop. To maintain higher nutrient uptake rates, plants should be kept in a growth phase via periodic trimming (see Section 7.2). Nutrient outcomes are expanded upon further here:

- Nitrogen: Total Nitrogen (TN) loading to the RWIZ is manageable, with outputs exceeding inputs. The average annual nitrogen stress index (0 = no stress, 1 = full stress) increased from 0.29 (dryland) to 0.38 under irrigated conditions.

  Minor TN leaching is modelled to occur (3.03 kg/ha/yr), although most is expected to be captured or transformed via in-soil processes and storage (less than dryland leaching). The average TN concentration in DD is estimated as ~1.12mg/L.
- Phosphorus: Total Phosphorus (TP) is expected to be sustainably utilised and stored within the RWIZ. Negligible TP leaching is modelled, with an average TP concentration in DD of <0.003mg/L.

  The P storage life in the RWIZ soil profile is expected to exceed 130 years (greater than 50 years – a standard metric).

Salinity: The salinity of the soil solution at the base of the rootzone (at DUL) is 8.2dS/m; however, this is closely matched to the selected crop in the RWIZ with the average water-uptake-weighted rootzone salinity ~1.67dS/m (crop threshold 20dS/m[d]). The percentage of years that crop yields are expected to fall below 90% of potential due to salinity is zero (0%).

Organic Load Rate: The expected organic loading rate to RWIZ soil (43kg/ha/yr) falls well under the maximum threshold of 18,000kg/ha/yr (DEC, 2004).

Waterlogging: The average monthly waterlogging index (0 = no stress, 1 = full stress) shows irrigation does not pose a risk to RWIZ performance (0.02), ranging from 0.00 to 0.07 annually. The dominant Melaleuca spp. crop assemblage is water-tolerant and can achieve high relative growth in damp soils[e].

Crop Maintenance: Modelling shows crop health is very good with an average monthly green cover of 79% under irrigated conditions (increasing from 8% under dryland conditions).

5.4.1 Future Climate Scenario

Under the 2050 climate projections (Run002e), RWIZ performance is expected to adjust based on the drying conditions, with associated changes in some performance criteria. The MEDLI outcomes for Run002e, and how they compare to Run002d, are summarised here:

- Pond Performance: 100% reuse of surplus RW is maintained. The frequency and magnitude of pond overflow events is reduced, with ~1.2 events per 10 years exceeding 50m^3 expected. The average recurrence interval for overflow events is 3.8 years, with an average duration of 1.94 days.

  The DEC (2004) 90th percentile containment requirement is achievable.

- Hydraulic Performance: Crop transpiration is expected to decrease marginally to 924mm/yr (54.9% of TW) and DD will reduce to 243.6mm/yr (14.5% of TW) in response to the dryer conditions. ISP is expected to remain low at 40.1mm/yr (243.6mm/year – 203.5mm/year) and irrigation runoff will not occur.

  All hydraulic performance outcomes are expected to remain within acceptable limits.

- Nutrients: Crop nitrogen stress is expected to improve (0.31); however, TN leaching may increase by >400% (12.97 kg/ha/yr) (Still below dryland) in response to reduced crop cover reliability (57% average monthly green cover). Similarly, the P storage life in RWIZ soils is expected to reduce (~109 years) due to lower crop uptake.

  Measures are proposed (refer Section 6.4.2) to monitor the long-term nutrient performance of the RWIZ to identify and prevent potential future environmental impacts.

- Others: Salinity, organic loading and waterlogging performance criteria largely remained stable and within acceptable limits.

5.5 Storage vs RW Application

Daily summaries for rainfall, evaporation, pond overflow, pond storage volume and RW irrigation were generated for the modelled scenarios across the 60yr modelling period. From these, the Hydraulic Performance of the RWIZ and the relationship between RW Storage and RW Application rates can be displayed graphically (see Figures 5-8, Appendix C).

[d]Lowe et al, Australian Forestry, Salt Tolerance of Tea Tree (Melaleuca alternifolia), Vol 63, Iss 4, Jul 2000

[e]Moezal et al. UWA, Screening for Salt and Waterlogging Tolerance in Eucalyptus and Melaleuca Species, Sep 1989

Under the proposed RW irrigation scenario (Run002d), it is demonstrated that active irrigation of the RWIZ can be reliably maintained for the majority of the year, with controlled override used to prevent irrigation under threshold rainfall conditions (>30mm/day), which occur an average of 5.3 days per year. During these periods, surplus RW is safely retained within the assigned 1ML RW storage for subsequent irrigation when conditions improve.

As shown, the RW storage is well utilised (~97% of days) across the model period, with the stored volume comprising a combination of intra-week surplus (above irrigation demand) and retained override volumes during non-irrigation days. The average 'active' RW storage volume across the model period is ~282kL.

The modelling identifies 60 days of overflow in the form of 28 discrete events (days of sequential overflow) across the 60-year simulation. The size of these events range between 0.5m^3 and 242.7m^3, with a cumulative average of 30.6m^3 per year. Smaller events (<50m^3/day) are expected to occur ~2.5 times per 10 years and are expected to be safely manageable using existing (additional) RW storage volumes.

Larger overflow events (>50m^3/day) occur as a result of isolated extreme rainfall events or following extended periods of wet-weather. Approximately 13 such events are identifiable in the dataset, with 2022 contributing the majority (3). The largest cumulative overflow volume recorded was 242.7m^3, following an extended (3-day) rainfall period when storage was well utilised.

Whilst uncommon (~2.2 times per 10 years), these larger events will require 'additional' management measures.

5.5.1 Overflow Management

In reviewing the daily summaries for the 60-year model period, some consistent circumstances are noted where RW storage 'overflow' probability is increased. Of the 13 large (>50m^3/day) overflow events, the following characteristics are common:

- They exclusively occur in March, May, June and July;
- the average duration is 2.84 days;
- all events occur where the following conditions are met:
    - the cumulative rainfall total in the previous 14 days preceding event commencement was >60mm;
    - the quantity of no irrigation days in the previous 21 days preceding event commencement was two (2) or more; and
    - the maximum available capacity in storage in the previous 14 days preceding event commencement was ~500kL.

From this, it is possible to establish a set of threshold criteria by which the probability of 'potential' RW storage overflow conditions may be predicted and appropriately managed.

By monitoring long-term cumulative rainfall and storage conditions, an established 'trigger' can be used to instigate (precautionary) storage.

Further detail on this approach is provided in Section 6.2.1.

5.6 Summary

Long-term water, nutrient and salinity modelling demonstrate that the proposed RWMS can be sustainably implemented to manage surplus RW generation from the Alspec Industrial Business Park under current (BAU) and future (FC) environmental conditions.

An average 91.1 kL of 'low strength' RW will be applied to the proposed **3.65ha** irrigation RWIZ daily, with active management, monitoring and controls to prevent adverse environmental and public health outcomes.

A minimum 1ML of RW storage will remain available to withhold irrigation from the RWIZ during periods when application is not appropriate.

6 Irrigation Scheduling, Management and Monitoring

For RW irrigation schemes of this scale there should be established procedures and controls to prevent irrigation when conditions do not suit. Modelling assumptions and results assume the adoption of appropriate irrigation scheduling and management protocols, as well as the use of automated controls to ensure that RW irrigation within the RWIZ remains both 'effective' and 'sustainable'.

6.1 RWIZ Installation

A key component of the irrigation system design will be control automation. Pressure and flow rate requirements will differ between surface irrigation (spray) and subsurface irrigation (dripper) applications. These areas will require appropriate zoning to ensure that effective irrigation loading rates to the RWIZ are not exceeded and that even distribution is maintained. This will require an automatic irrigation controller (e.g. programmable logic) to be fitted.

RWIZ infrastructure set-up is described below; however, a detailed irrigation system design will be required before installation of the system. The final irrigation system design should be submitted to the approval authority by the nominated supplier.

6.1.1 Spray Irrigation

Spray irrigation (SI) is considered low-risk when used away from foot traffic and on slopes ≤6%. General details for the proposed SI zones of the RWIZ are as follows:

- In zones where irrigation will be installed within 0.5m of the property boundary, hardstand and buildings (Section 5.1 of 3578_LCA_005), application will be achieved using 'adjustable throw arc' sprinkler heads appropriate to the location (corners 90°, edges 180° and centres 360°);
- The proposed sprinkler heads are 'MP rotator nozzles', manufactured by Hunter Industries Inc., and are recognised as a responsible water-saving tool (Smart WaterMark Approved). See model specification details in Appendix D;
- The sprinkler heads utilise a rotating nozzle and produce large droplet size ensuring even coverage and reduced spray drift (misting);
- Screens of trees or shrubs are recommended in and around SI areas to limit the risk of accidental contact; and
- Anemometer switching systems should be incorporated.

6.1.2 Subsurface Irrigation

Shallow subsurface irrigation (SSI) methods should be used in areas near expected foot traffic and on slopes >6%. General details for the proposed SSI zones of the RWIZ are as follows:

- Pressure-compensating subsurface drip (PCSD) line specifically designed for effluent irrigation (e.g. Toro Drip-in, Netafim Bioline or Wasteflow) should be used, with emitter flow rates of 1.6 – 2.3 L/hr;
- The SSI should be split into separate zones to proportionally distribute RW between each zone via a hydraulic sequencing valve (or similar);
- In sloping areas, line leakage controls (dripline non-leakage or DNL valves) will be necessary to prevent drain-down of each zone;
- Roots can interfere with the functioning of plumbing pipework and subsurface irrigation systems; the installer must guarantee installed hardware be resilient to root intrusion;

- In-line filters (minimum 120µm or to manufacturer's specifications) should be included to minimise solids entering the pipelines and emitters. Filters must be removed and cleaned regularly (at least at 3-monthly intervals);
- A flush main must be installed to periodically clean-out the irrigation lines to provide effective long-term performance. Either manual or automatic flush valves may be installed, with flush water directed back to the treatment system or to a dedicated ground-flush pit; and
- Air release valves will be installed at the high points in individual irrigation areas to prevent soil particles being sucked into the lines at the end of pump cycles as pipelines depressurise.

6.2 RWIZ Management

The following measures are proposed to optimise the sustainability of the RWIZ design.

6.2.1 RW Storage

To ensure sufficient RW storage is available to prevent 'uncontrolled' discharges from the RWMS under normal operating conditions (excluding failure or damage), it is recommended the system operator monitors long-term storage and climate conditions throughout the year and establishes critical triggers for actively managing RW storage volumes.

Specifically, we recommend the following actions as appropriate:

- The volume of RW storage shall be confirmed and recorded at 8-9am daily. This may be achieved via a fixed (external) indicator or calibrated sensor on the 1ML RW storage.
- The 14-day cumulative rainfall total for BOM station 067084 (Orchard Hills WWTP) shall also be calculated and recorded at the same time daily.
- If less than 500m^3 of volume is available in storage and two (2) or more 'no-irrigation' days have occurred in the preceding 3 weeks, a 'precautionary' storage trigger shall apply.

Storage Volume Management

During the period the precautionary storage trigger is active (attention period). The operator shall:

- Take the necessary actions to ensure a minimum 0.5ML (500m^3) of free RW storage volume remains available for duration of the attention period. Response actions include:
  - active volume management (e.g. cross-tank transfer); and if not achievable
  - off-site removal by a licensed contractor (pump-out).

As per Section 3.2.4 a total of 2.4ML of available storage is expected on a typical operation day, as such, preliminary assessment suggests cross tank transfer will manage modelled overflow.

The Client shall incorporate the requirements for RW storage management into associated approvals documentation for the RWMS, including (but not limited to) Risk Assessments, Operational Plans, Monitoring Plans and Contingency Plans.

6.3 On-site RWIZ Controls

On-site controls should be applied in association with end-use controls to reduce both human exposure to hazards and the impact on receiving environments. Such restrictions include signage; control of application methods, rates and times; use of buffer zones; control of access and control of plumbing and distribution systems.

6.3.1 Irrigation Timing

Irrigation is expected to occur during (1-2) discrete intervals during each available day. The final details of the proposed irrigation schedule will depend on the capabilities of the pump assembly, hydraulic distribution design and zoning requirements to service the entire RWIZ.

Potential exposure to RW can be reduced by limiting the time of application.

The Client has proposed irrigation will occur overnight between the hours of 6pm and 6am. Access to the RWIZ and the potential for inadvertent primary contact is significantly reduced during this period.

Overnight irrigation will replenish the soil-water volume lost through crop transpiration the previous day.

6.3.2 Controlling RWIZ Public Access

Controlling public access to the RWIZ is largely managed by appropriate positioning of the RWIZ in areas away from foot traffic. However, in zones adjacent to public-use (e.g. car parking), low-moderate foot traffic is expected. As such, prominent signage should be installed wherever recycled water is being used (e.g. 'recycled water being irrigated in this area'). The incorporation of symbols should be considered, and warning signs should be designed with reference to AS1319 (Safety signs for the occupational environment 2004) and AS2416 (Design and application of water safety signs 2002).

6.3.3 Controlling Application Rates

Safe and low-risk application rates are incorporated into the RWIZ design to minimise the potential for (RW) runoff to occur. This approach is predicated on strict control of appropriate application rates.

Final 'dose' volumes to each dedicated zone will be determined as part of the final irrigation system design. The design must ensure that the volume of RW directed to each zone does not exceed the design irrigation depth (2.7mm/d) determined by comprehensive daily (MEDLI) modelling.

Flow meters are to be installed on the RW irrigation discharge line to record the volume of irrigation water applied during each interval, with the total volumes recorded (i.e. manually or data logger) on a daily basis.

After the 1st year of data collection, the MEDLI water balance should be reviewed and the irrigation schedule amended (if required).

6.4 Monitoring

6.4.1 Surface Management

Irrigation operations should ensure that all RW is assimilated within the area of application, avoiding both surface runoff and excessive deep infiltration. RW irrigation should ensure the RWIZ soil is always allowed to partially dry before applying a controlled amount of RW to increase soil moisture levels.

To avoid over irrigation, regular inspection of the RWIZ by the system operator is required. As a guide, some simple rules for sustainable RW irrigation are provided below:

- Do not irrigate if ponding water is observed in the irrigation area/s or if runoff is evident;
- Do not irrigate if soils are waterlogged;
- Ensure regular, intermittent dosing of the RWIZ zones at application rates sufficient to wet the ground but not cause ponding or runoff;
- Ensure that soil moisture conditions are kept within a range that is suitable for plant growth;
- For effective utilisation of water on hot days only irrigate early in the morning or late in the afternoon; and
- Ensure groundcover health is maintained within the RWIZ through appropriate land management practices.

W&A recommend that regular visual inspections of the irrigation supply infrastructure and the RWIZ for signs of soil structural issues, poor drainage, vegetation stress and equipment failure or damage (e.g. leaks). Identified issues should be addressed or rectified as soon as practical.

6.4.2 Soil Monitoring

Routine soil monitoring is important to detect early signs of (physical or chemical) changes within the RWIZ as a result of RW irrigation. Samples should be collected from topsoil (200mm) and subsoil (500-700mm composite) at three (3) monitoring locations within the RWIZ. Soil monitoring data should be recorded on Site for later comparison.

Proposed soil monitoring locations should reflect the range of application methods and crop covers proposed.

All samples should be analysed for the following parameters:

- Major cations (Exchangeable Al, Ca, K, Mg, Na);
- Base saturation (%);
- Exchangeable sodium percentage (ESP);
- Cation exchange capacity (CEC);
- Ca/Mg ratio;
- Total organic carbon;
- Total Nitrogen (mg/kg);
- Organic Nitrogen (mg/kg);
- Total Phosphorus (mg/kg); and
- P-sorption capacity (mg/kg).

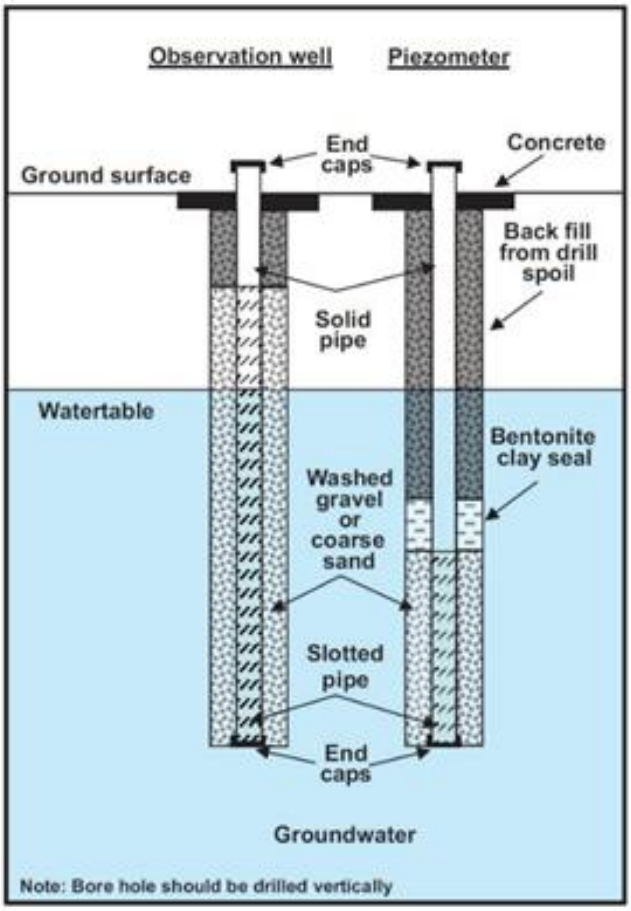
W&A recommend that soil sampling is undertaken at 6-monthly intervals for the first 2 years of scheme operation, then annually thereafter.

6.4.3 Groundwater Monitoring

While MEDLI modelling has been used to demonstrate that 'DD' rates beneath the RWIZ are not excessive, field investigations completed for the LCA (3578_LCA_005) identify slowly permeable (natural) subsoils which are prone to waterlogging.

To ensure that operation of the RW irrigation scheme is not contributing to increases in the shallow groundwater table beneath the RWIZ, W&A recommend the installation of three (3) shallow groundwater observation wells within the RWIZ (nominal locations shown on Figure 1, Appendix A). Based on observed soil conditions, the minimum installed depth of each well should be 1.8m or at refusal.

A schematic of a 'typical' monitoring well installation is provided here.



Monitoring should be conducted on a monthly basis, with the standing water level (SWL) below ground level recorded. If standing water is recorded in the observation bores, a water sample should be collected and analysed for pH and EC (dS/m).

To monitor the quality of shallow GW beneath the RWIZ, a composite sample should be collected from the observation bores quarterly and analysed for the following:

- Major cations (Exchangeable Al, Ca, K, Mg, Na);
- EC (dS/m);
- Total Nitrogen (mg/L);
- Nitrate-N (mg/L);
- Total Phosphorus (mg/L); and
- Ortho-phosphate (mg/L).

7 Mitigation Measures

7.1 Soil Improvement

Given that Site subsoils are identified as moderately sodic and slightly dispersive (3578_LCA_005), drainage and fertility may be impacted within the RWIZ. These properties can combine to reduce the soils' capacity for sustainable irrigation.

Prolonged application of recycled water can exacerbate the situation. Application of a calcium mineral is a recognised way of reducing the effects of poor soil fertility and instability. It does this by supplying calcium to the affected soil and thereby elevating calcium concentrations with respect to sodium. Added calcium will improve the soil CEC and Ca/Mg ratio, improving fertility, while reducing the potential for soil structural degradation. Gypsum (calcium sulphate) is the preferred soil amendment for improving soil fertility and drainage.

Gypsum is only slowly soluble in water, so simply broadcasting at the surface can be of limited benefit as it can take a long time for the calcium to penetrate the soil and reach the deeper soil layers. Therefore, it is necessary to mix the amendment into the topsoil import during RWIZ construction.

A gypsum application rate of 2kg/m^2 is recommended.

7.2 Vegetation

The RWIZ crop provides a sink for hydraulic losses from the water balance by transpiration to the atmosphere. Harvested shoot biomass also provides a sink for nutrient losses (nitrogen and phosphorus) as the plant grows and takes up these nutrients from the soil. The (MEDLI) modelling assumes groundcover that is actively managed (mown) with harvested material transported away from the RWIZ. The kickstart component assumes the groundcover retains ≥20% biomass following each harvest (mowing) cycle.

W&A acknowledge that 'mowing' 100% of the proposed landscape areas is unlikely; however, equivalent vegetation management (cropping) is expected to be achieved through cutting of lawn and groundcover; trimming of (tree/shrub) overgrowth and weeding.

Vegetation should be harvested and removed from the site under a programmed maintenance scheme.

8 Conclusions and Recommendations

This completes the Irrigation Management Plan (IMP) for the Alspec Industrial Business Park at 221-227 & 289-317 Luddenham Rd, Orchard Hills NSW.

Specifically, W&A recommend the following:

- A minimum RWIZ area of **3.65ha** will be provided;
- The established RWIZ must comply with adopted setbacks;
- The RWIZ will be constructed using an engineered soil profile of **Cat 2-3** soil;
- The proposed RWIZ comprises a combination of (low-throw) surface and shallow subsurface irrigation methods and must be installed as per the requirements of this IMP;
- A (minimum) **1ML** of RW storage capacity will be available;
- RW shall be applied at a fixed daily irrigation depth of **2.54mm**;
- No irrigation will proceed when **>30mm of rainfall** has occurred in the previous 24-hours;
- RWIZ soil will be amended with gypsum (**2kg/m²**) prior to system operation; and
- RW application rates will be monitored using flow meters.

Appendix A

Site Plan

Figure 1 - Site Plan Showing Stage 1 Development and Proposed RWMS

3578: LCA and IMP for Proposed Water Recycling Scheme at Luddenham Rd, Orchard Hills

Whitehead & Associates
Environmental Consultants

(Approx Scale)

Revision	001
Drawn	BC
Approved	MS

Appendix B

Climate Change Modelling Information

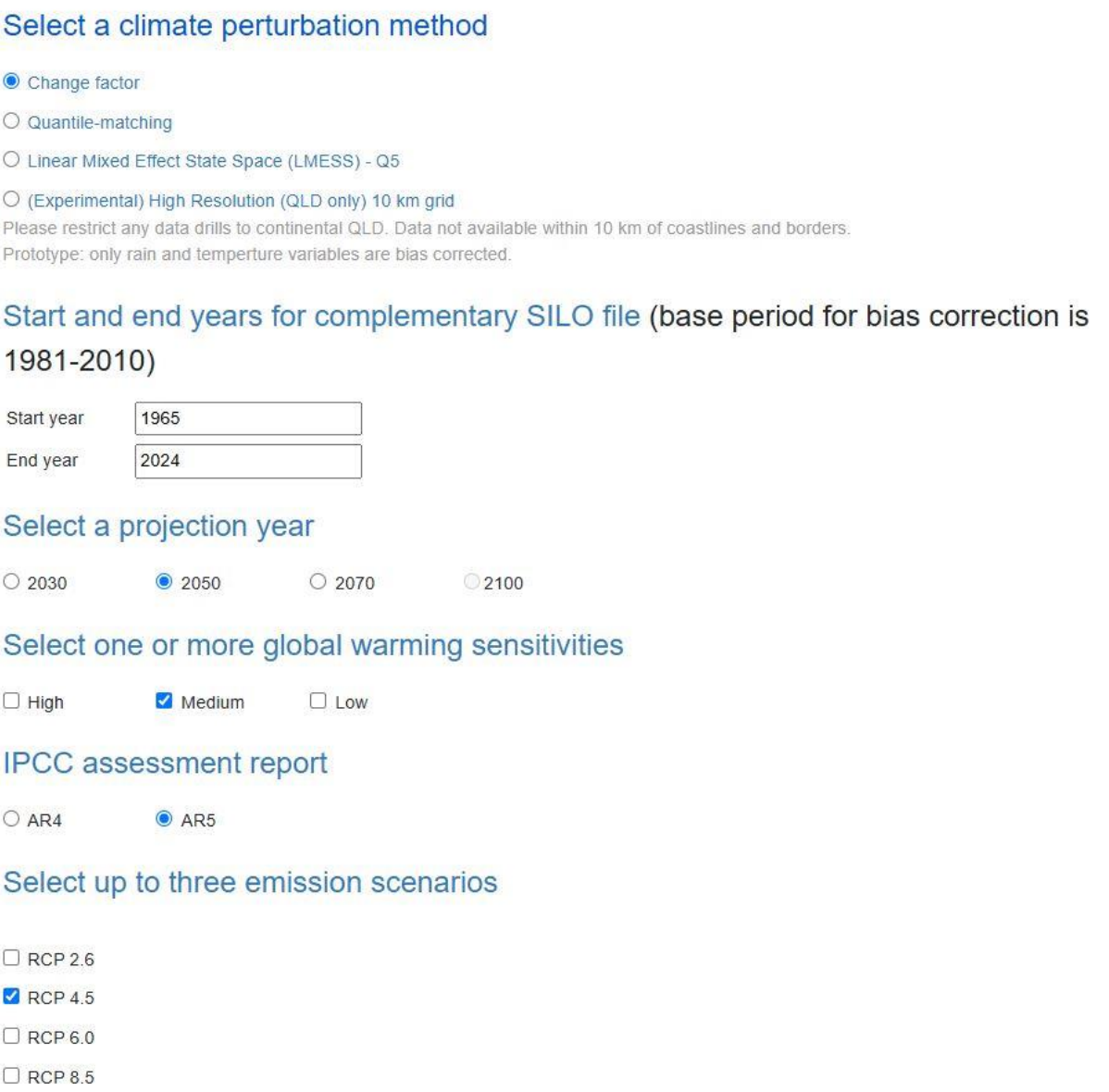
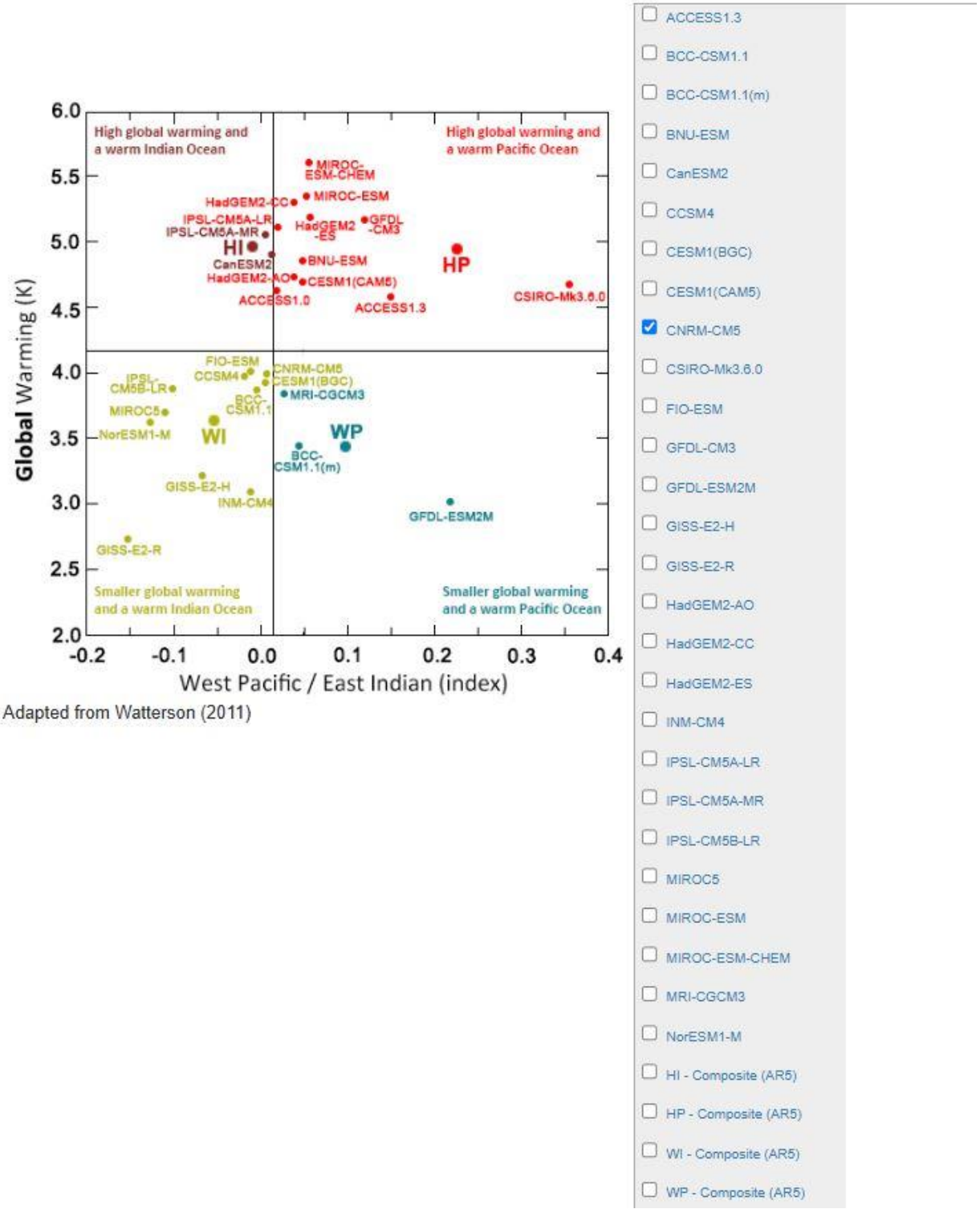


Figure 2 - Summary of the CCS run

Climate models

Models HI, HP, WI and WP are composites of the four mean climate response patterns below.



Adapted from Watterson (2011)

Figure 3 - Global Warming (K) vs West Pacific/East Indian index scale

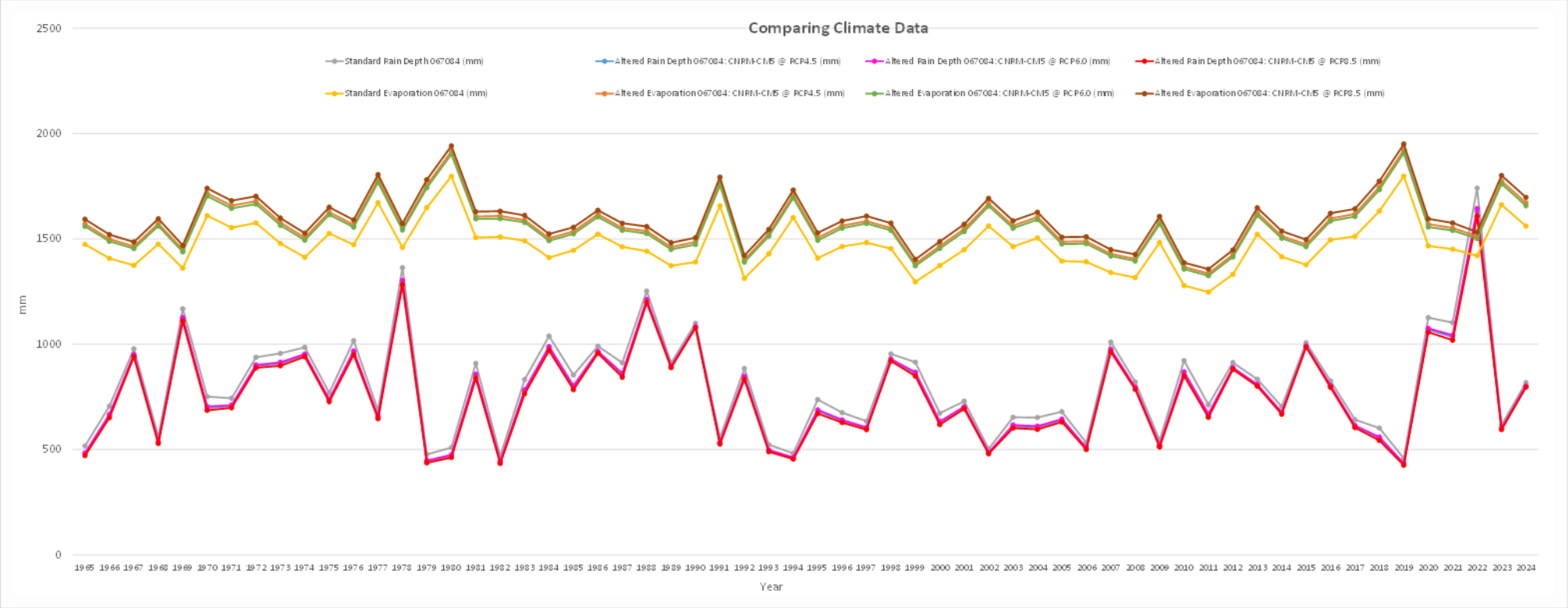


Figure 4 - Climate Altered Data Plot

Appendix C

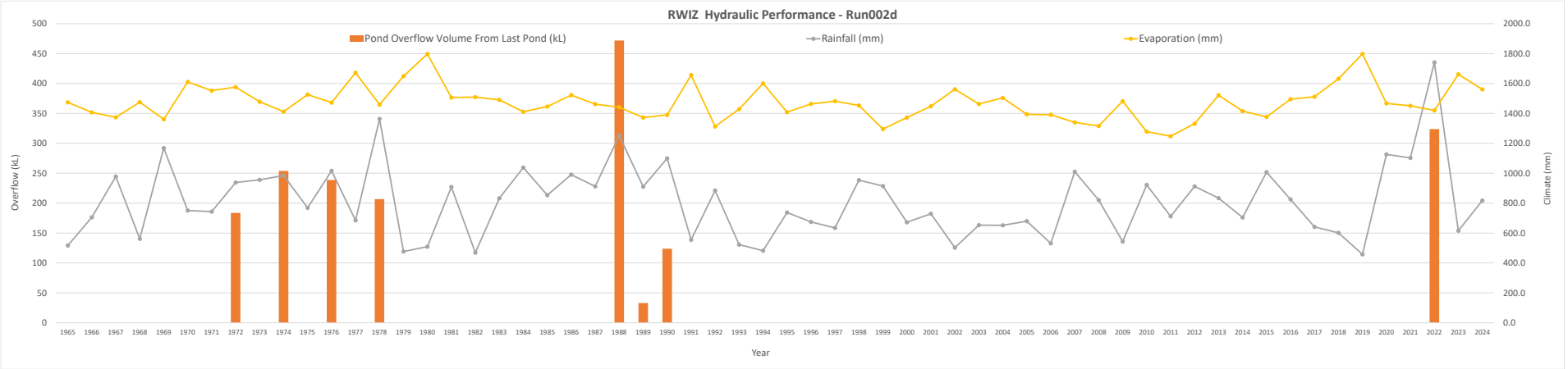


Figure 5 - Run002d RWIZ Hydraulic Performance Graph

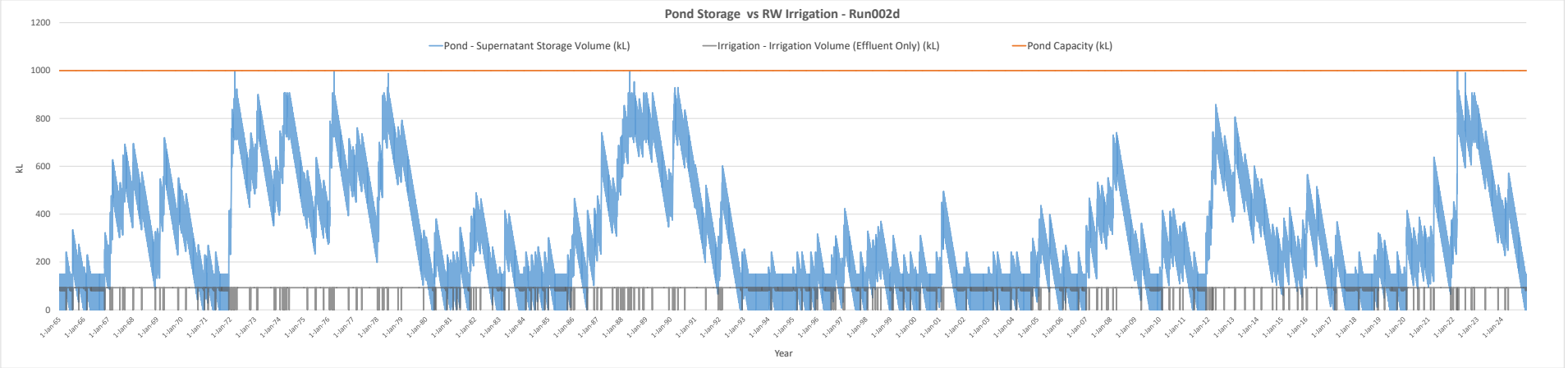


Figure 6 - Run002d Pond Storage vs RW Irrigation Graph

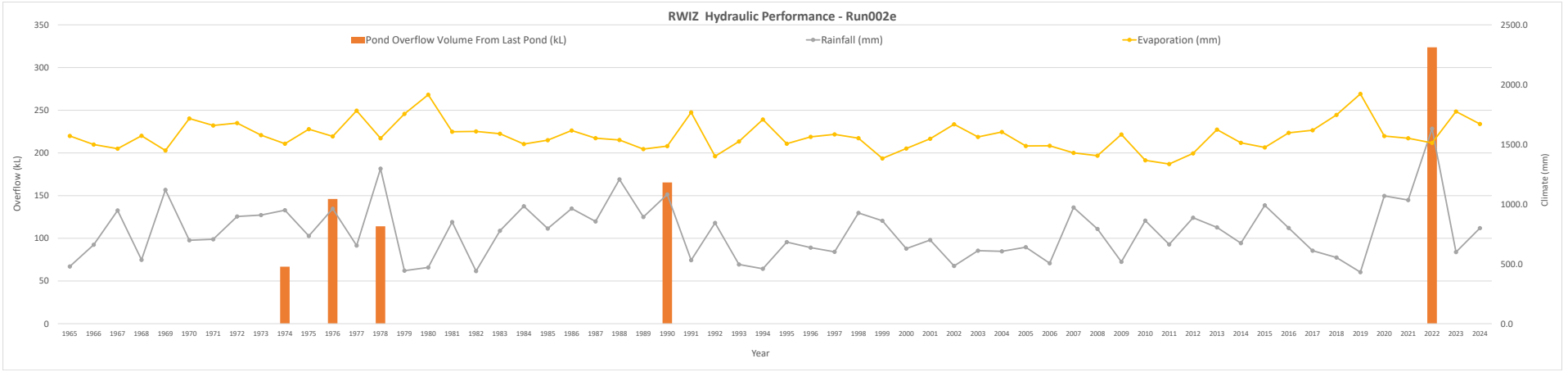


Figure 7 - Run002e RWIZ Hydraulic Performance Graph

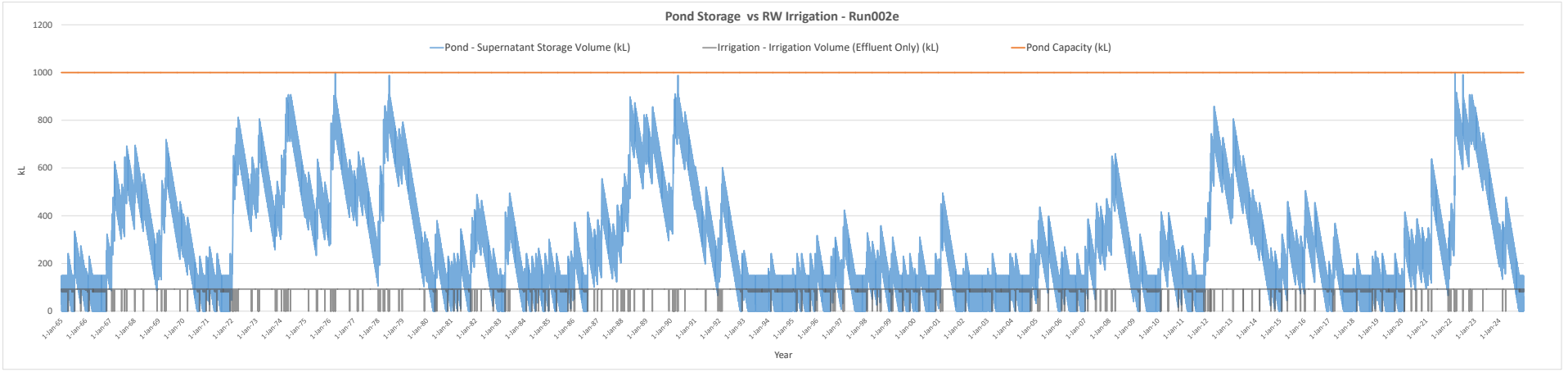


Figure 8 - Run002e Pond Storage vs RW Irrigation Graph

Appendix D

SI Specification

Hunter® | Built on Innovation®

Standard MP Rotator Nozzle

With the lowest precipitation rate on the market and multi-stream technology, the Standard MP Rotator Nozzle is the most trusted high-efficiency nozzle solution, offering up to 30% water savings over traditional spray nozzles.

KEY BENEFITS

- Lowest precipitation rate in the industry of approximately 10 mm/hr
- Matched precipitation for simplified irrigation design and flexibility
- Double-pop feature protects the nozzle from external debris
- High distribution uniformity for a healthy landscape with maximum water efficiency
- Wind-resistant, multi-stream technology prevents misting
- Adjustable arc only when running for vandal resistance
- Removable filter screen prevents nozzle from clogging
- Colour-coded for easy identification

Operating Specifications

- Radius reduction up to approximately 25% on all models
- Recommended operating pressure: 2.8 bar; 280 kPa
- Minimum radius setting achieved at 2.1 bar; 210 kPa
- Warranty period: 3 years

Options

- Pair with Pro-Spray™ PRS40 pop-up for pressure regulation to 2.8 bar; 280 kPa for nominal radius settings
- Pair with Pro-Spray PRS30 pop-up for pressure regulation to 2.1 bar; 210 kPa for minimum radius settings

MP ROTATOR PERFORMANCE DATA

MP1000

Radius: 2.5 to 4.5 m
Adjustable Arc & Full Circle

Maroon: 90° to 210°
Lt. Blue: 210° to 270°
Olive: 360°

Arc	Pressure			Radius	Flow		Precip mm/hr	
	bar	kPa		m	m³/hr	l/min	■	▲
90°	2.0	200		3.7	0.04	0.64	11	13
	2.5	250		4	0.04	0.72	11	13
	2.8	280		4.1	0.05	0.8	11	13
	3.0	300		4.3	0.05	0.87	11	13
	3.5	350		4.5	0.06	0.95	11	13
	3.8	380		4.5	0.06	1.02	12	14
180°	2.0	200		3.7	0.08	1.29	11	13
	2.5	250		4	0.09	1.44	11	13
	2.8	280		4.1	0.1	1.59	11	13
	3.0	300		4.3	0.1	1.67	11	13
	3.5	350		4.5	0.12	1.9	11	13
	3.8	380		4.5	0.12	1.93	12	13
210°	2.0	200		3.7	0.09	1.52	12	13
	2.5	250		4	0.1	1.71	11	13
	2.8	280		4.1	0.11	1.86	11	13
	3.0	300		4.3	0.12	1.93	11	13
	3.5	350		4.5	0.13	2.16	11	13
	3.8	380		4.5	0.14	2.24	11	13
270°	2.0	200		3.7	0.11	1.82	11	12
	2.5	250		4	0.12	2.01	10	12
	2.8	280		4.1	0.14	2.39	11	13
	3.0	300		4.3	0.15	2.54	11	13
	3.5	350		4.5	0.17	2.73	11	13
	3.8	380		4.5	0.17	2.84	11	13
360°	2.0	200		3.7	0.16	2.62	12	13
	2.5	250		4	0.18	2.92	11	13
	2.8	280		4.1	0.19	3.18	11	13
	3.0	300		4.3	0.2	3.34	11	13
	3.5	350		4.5	0.23	3.71	11	13
	3.8	380		4.5	0.23	3.83	11	13

MP2000

Radius:4.0 to 6.4 m
Adjustable Arc & Full Circle
Black: 90° to 210°
Green: 210° to 270°
Red: 360°

Arc	Pressure			Radius	Flow		Precip mm/hr	
	bar	kPa		m	m³/hr	l/min	■	▲
90°	2.0	200		5.5	0.09	1.44	12	13
	2.5	250		5.8	0.09	1.52	11	13
	2.8	280		6.1	0.1	1.63	11	12
	3.0	300		6.4	0.11	1.74	10	12
	3.5	350		6.4	0.11	1.78	11	12
	3.8	380		6.4	0.11	1.82	11	12
180°	2.0	200		5.2	0.15	2.43	11	13
	2.5	250		5.5	0.16	2.69	11	12
	2.8	280		5.8	0.18	2.92	11	12
	3.0	300		6.1	0.2	3.22	11	12
	3.5	350		6.4	0.21	3.45	10	12
	3.8	380		6.4	0.22	3.6	11	12
210°	2.0	200		5.2	0.17	2.84	11	13
	2.5	250		5.5	0.19	3.07	11	12
	2.8	280		5.8	0.2	3.26	10	12
	3.0	300		6.1	0.21	3.45	10	11
	3.5	350		6.4	0.23	3.71	9	11
	3.8	380		6.4	0.23	3.83	10	11
270°	2.0	200		5.2	0.22	3.6	11	12
	2.5	250		5.5	0.24	3.9	10	12
	2.8	280		5.8	0.25	4.17	10	12
	3.0	300		6.1	0.27	4.43	10	11
	3.5	350		6.4	0.28	4.66	9	11
	3.8	380		6.4	0.3	4.93	10	11
360°	2.0	200		5.2	0.29	4.85	11	13
	2.5	250		5.5	0.32	5.19	10	12
	2.8	280		5.8	0.34	5.61	10	12
	3.0	300		6.1	0.36	5.95	10	11
	3.5	350		6.4	0.39	6.37	9	11
	3.8	380		6.4	0.4	6.59	10	11

MP3000

Radius:6.7 to 9.1 m
Adjustable Arc & Full Circle
Blue: 90° to 210°
Yellow: 210° to 270°
Grey: 360°

Arc	Pressure			Radius	Flow		Precip mm/hr	
	bar	kPa		m	m³/hr	l/min	■	▲
90°	2.0	200		8.2	0.17	2.88	10	12
	2.5	250		8.5	0.19	3.11	10	12
	2.8	280		9.1	0.2	3.26	10	11
	3.0	300		9.1	0.21	3.41	10	12
	3.5	350		9.1	0.22	3.6	11	12
	3.8	380		9.1	0.23	3.83	11	13
180°	2.0	200		8.2	0.36	5.99	11	12
	2.5	250		8.5	0.39	6.44	11	12
	2.8	280		9.1	0.42	6.9	10	12
	3.0	300		9.1	0.44	7.31	11	12
	3.5	350		9.1	0.47	7.73	11	13
	3.8	380		9.1	0.49	8.07	12	14
210°	2.0	200		8.2	0.42	6.97	11	12
	2.5	250		8.5	0.46	7.54	11	13
	2.8	280		9.1	0.49	8.03	10	12
	3.0	300		9.1	0.52	8.53	11	12
	3.5	350		9.1	0.55	8.98	11	13
	3.8	380		9.1	0.57	9.44	12	14
270°	2.0	200		8.2	0.55	8.98	11	12
	2.5	250		8.5	0.59	9.66	11	12
	2.8	280		9.1	0.63	10.35	10	12
	3.0	300		9.1	0.66	10.95	11	12
	3.5	350		9.1	0.7	11.6	11	13
	3.8	380		9.1	0.74	12.2	12	14
360°	2.0	200		8.2	0.72	11.94	11	12
	2.5	250		8.5	0.78	12.89	11	12
	2.8	280		9.1	0.84	13.8	10	12
	3.0	300		9.1	0.89	14.63	11	12
	3.5	350		9.1	0.94	15.43	11	13
	3.8	380		9.1	0.98	16.18	12	14

MP3500

Radius:9.4 to 10.7 m

Adjustable Arc & Full Circle

Lt. Brown: 90° to 210°

Arc	Pressure			Radius	Flow		Precip mm/hr	
	bar	kPa		m	m³/hr	l/min	■	▲
90°	2.0	200		10.4	0.26	4.28	10	11
	2.5	250		10.4	0.28	4.58	10	12
	2.8	280		10.7	0.29	4.84	10	12
	3.0	300		10.7	0.31	5.22	11	13
	3.5	350		10.7	0.33	5.41	11	13
	3.8	380		10.7	0.34	5.68	12	14
180°	2.0	200		10.4	0.51	8.48	9	11
	2.5	250		10.4	0.60	10.03	11	13
	2.8	280		10.7	0.65	10.83	11	13
	3.0	300		10.7	0.70	11.73	12	14
	3.5	350		10.7	0.73	12.15	13	15
	3.8	380		10.7	0.75	12.41	13	15
210°	2.0	200		10.4	0.65	10.75	10	12
	2.5	250		10.4	0.70	11.66	11	13
	2.8	280		10.7	0.75	12.45	11	13
	3.0	300		10.7	0.80	13.40	12	14
	3.5	350		10.7	0.85	14.23	13	15
	3.8	380		10.7	0.90	14.91	13	16

Bold = Recommended pressure

MP CORNER

Radius: 2.5 to 4.5 m
Adjustable Arc: 45° to 105°
Color Code: Turquoise

Arc	Pressure			Radius	Flow	
	bar	kPa		m	m³/hr	l/min
45°	2.0	200		3.5	0.04	0.61
	2.5	250		4.0	0.04	0.68
	2.8	280		4.1	0.04	0.70
	3.0	300		4.3	0.04	0.73
	3.5	350		4.4	0.05	0.78
	3.8	380		4.5	0.05	0.81
90°	2.0	200		3.5	0.08	1.27
	2.5	250		4.0	0.08	1.40
	2.8	280		4.1	0.09	1.44
	3.0	300		4.3	0.09	1.57
	3.5	350		4.4	0.10	1.67
	3.8	380		4.5	0.10	1.73
105°	2.0	200		3.5	0.09	1.48
	2.5	250		4.0	0.10	1.63
	2.8	280		4.1	0.10	1.70
	3.0	300		4.3	0.11	1.83
	3.5	350		4.4	0.12	1.94
	3.8	380		4.5	0.12	2.00

Bold = Recommended pressure

MP ROTATOR PERFORMANCE DATA MP CORNER

MPCorner
Radius: 2.5 to 4.5 m
Adjustable Arc: 45° to 105°
Color Code: Turquoise

Arc	Pressure		Radius	Flow	
	bar	kPa	m	m³/hr	l/min
45°	1.7	170	...	...	...
	2.0	200	3.5	0.04	0.61
	2.5	250	4.0	0.04	0.68
	2.8	**280**	**4.1**	**0.04**	**0.70**
	3.0	300	4.3	0.04	0.73
	3.5	350	4.4	0.05	0.78
	3.8	380	4.5	0.05	0.81
90°	1.7	170	3.2	0.07	1.15
	2.0	200	3.5	0.08	1.27
	2.5	250	4.0	0.08	1.40
	2.8	**280**	**4.1**	**0.09**	**1.44**
	3.0	300	4.3	0.09	1.57
	3.5	350	4.4	0.10	1.67
	3.8	380	4.5	0.10	1.73
105°	1.7	170	3.2	0.08	1.34
	2.0	200	3.5	0.09	1.48
	2.5	250	4.0	0.10	1.63
	2.8	**280**	**4.1**	**0.10**	**1.70**
	3.0	300	4.3	0.11	1.83
	3.5	350	4.4	0.12	1.94
	3.8	380	4.5	0.12	2.00

Bold = Recommended pressure

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https://www.hunterindustries.com/en-metric/irrigation-product/mp-rotator/standard-mp-rotator-nozzle
080224

Appendix E

Daily Modelling Inputs and Results

General Information

SCENARIO REPORT: Full run

General information

Enterprise: 3578_IMP Orchard Hills
Client: Jordan Jennings - AquaCell P/L
MEDLI user: WHITEHEAD2012\marksaunders

Description:

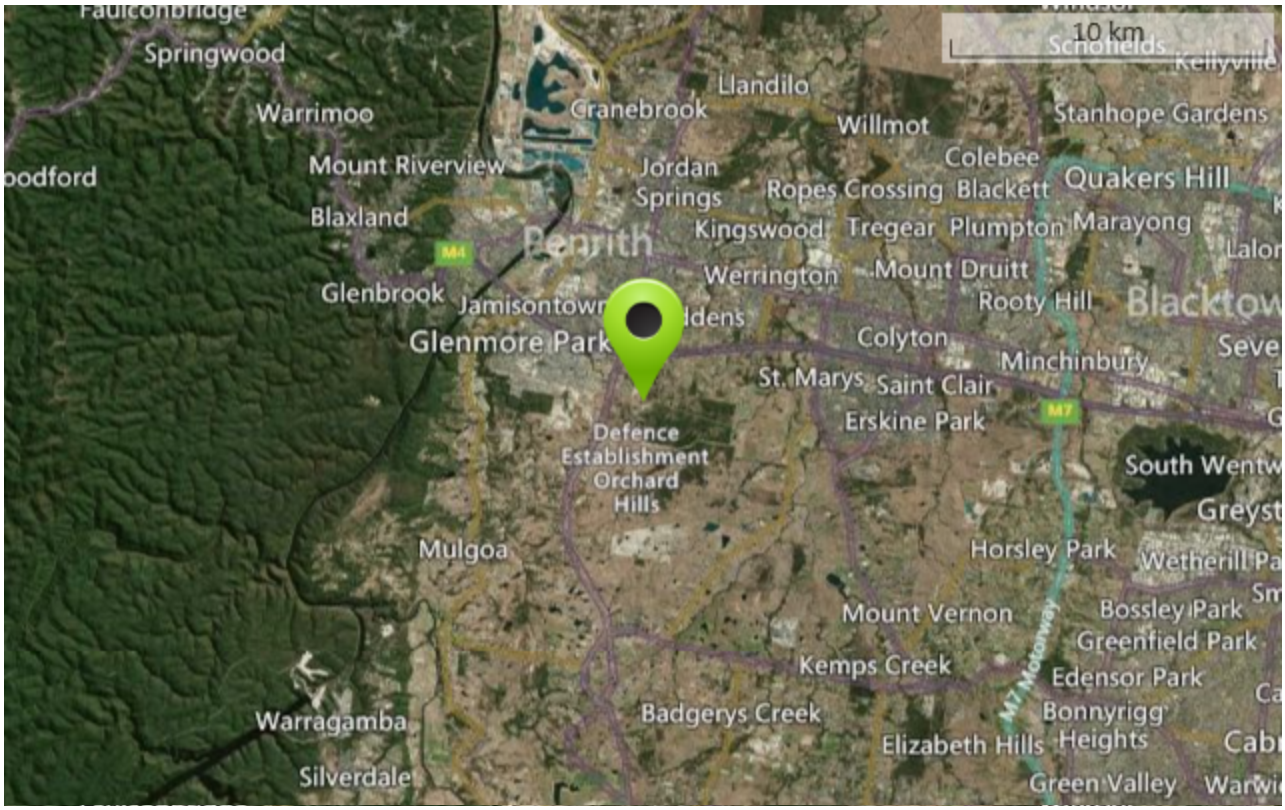
RWIZ design for Alspec Business Park; Luddenham Rd, Orchard Hills

Scenario details:

3578 - RWMS for Alspec Business Park, Original Climate Data, Dryland Melaleuca alternifolia pasture altered as per COPE Landscaping; Kickstarted MCC to 1.1 RUE to 10 MSN to 0.03 MSP to 0.0024 MSNCLGO to 0.006 MSNCLGOO to 0.024 MSNCDMGO to 0.06 MSNCDMGOO to 0.024, constructed 900mm Cat 2 topsoil.

Map of location:

Note: If the map above appears as a dark box, check that the network is accessible and that the coordinates are not for a location in the ocean.



Description

Climate information

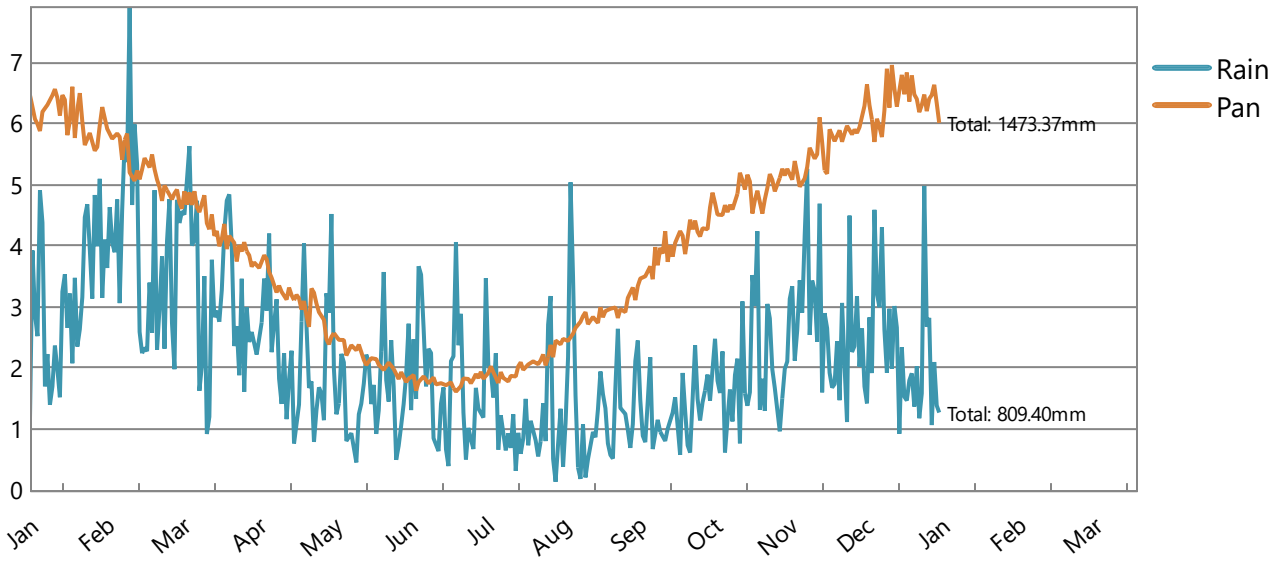
Climate Data Location: 67084, 1965 - 2024, -33.8°, 150.71°
Run Period: 01/01/1965 to 31/12/2024 (60 years)

Climate statistics

	5th Percentile		50th Percentile		95th Percentile	
Rainfall (mm/year)	(Year 1979)	479.3	(Year 1975)	793.0	(Year 1988)	1210.2
Pan evaporation (mm/year)	(Year 1999)	1304.3	(Year 2003)	1463.8	(Year 1977)	1667.0

Climate data

Daily average across run period:



Description

Wastestream information

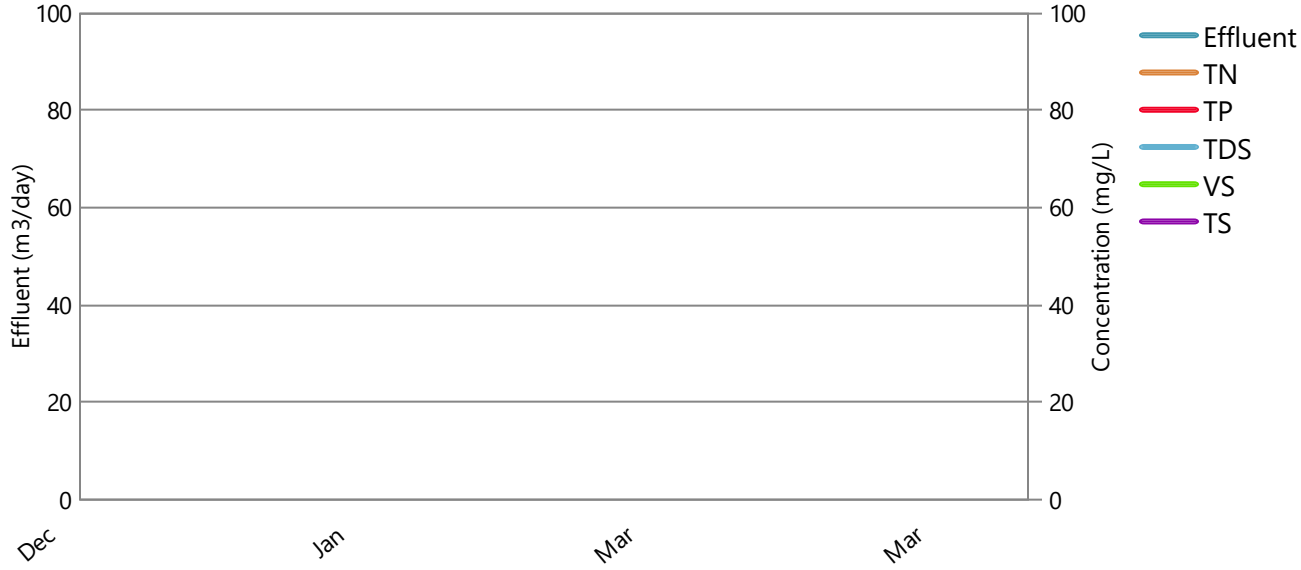
Wastestream Name: - New generic system

Wastestream production description

Daily New generic system data supplied for a representative year. This wastestream is not separately pretreated.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream

Effluent Quantity: 0.00 m3/year or 0.00 m3/day (Min-Max 0.00 - 0.00)

Flow-Weighted Average (Min - Max) Daily Effluent Quality Entering the Pond System:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total phosphorus	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total dissolved salts	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

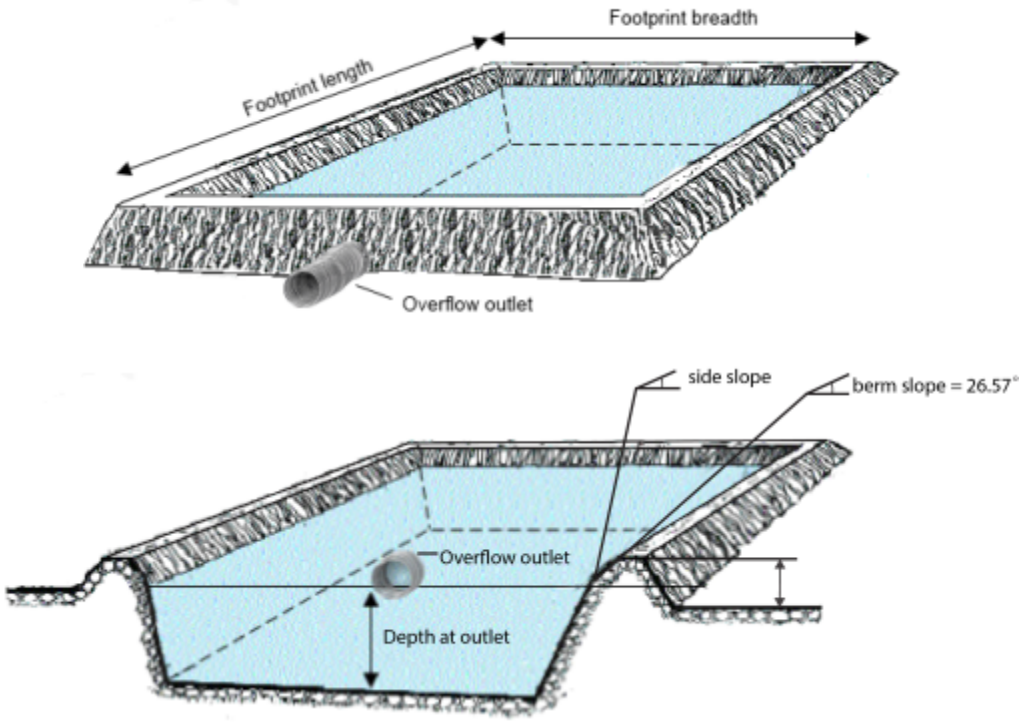
Description

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system details

	Pond 1
Maximum pond volume (m3)	1000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	4.00
Maximum water surface area (m2)	250.10
Pond footprint length (m)	15.81
Pond footprint width (m)	15.81
Pond catchment area (m2)	250.10
Average active volume (m3)	0.00



Irrigation pump limits

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump rate per area limit (ML/day/ha)	1.00

Shandying water

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	No

Description

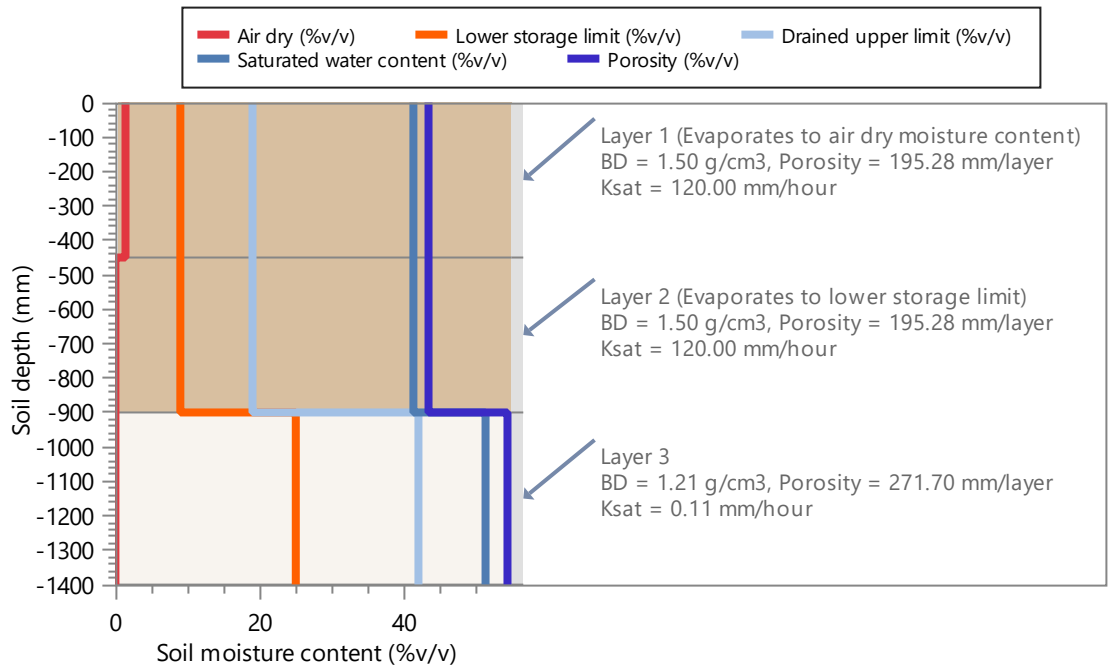
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Soil type: 3578_Orchard Hills_imported tops, 1400.00 mm defined profile depth

Profile porosity (mm)	662.26
Profile saturation water content (mm)	628.20
Profile drained upper limit (or field capacity) (mm)	381.00
Profile lower storage limit (or permanent wilting point) (mm)	206.00
Profile available water capacity (mm)	175.00
Profile limiting saturated hydraulic conductivity (mm/hour)	0.11
Surface saturated hydraulic conductivity (mm/hour)	120.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	7.75
Soil evaporation Cona (mm/sqrt day)	3.50

Profile



Planting regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average monthly cover (fraction) (minimum - maximum)	0.07 (0.06 - 0.08)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 1.1 x Pan coefficient 1)	1.10
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Potential rooting depth in defined soil profile (mm)	1200.00
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05

Irrigation rules: Pressure-compensating SSI

Rule 1. Irrigation triggered every 1 days and rainfall is less than or equal to 2000.00 mm
Rule 2. Irrigate up to a soil water content of drained upper limit plus 2.28 mm
Rule 3. Irrigation window from 1/1 to 31/12 including the days specified
Rule 4. A minimum of 0 days must be skipped between irrigation events

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank (wet weather storage pond: 1000 m3)

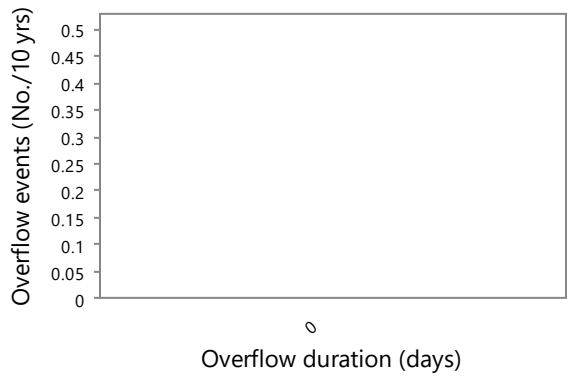
Pond system water balance (m3/year)

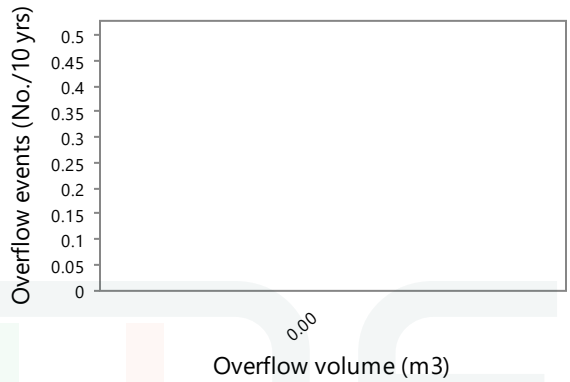
(no data available)

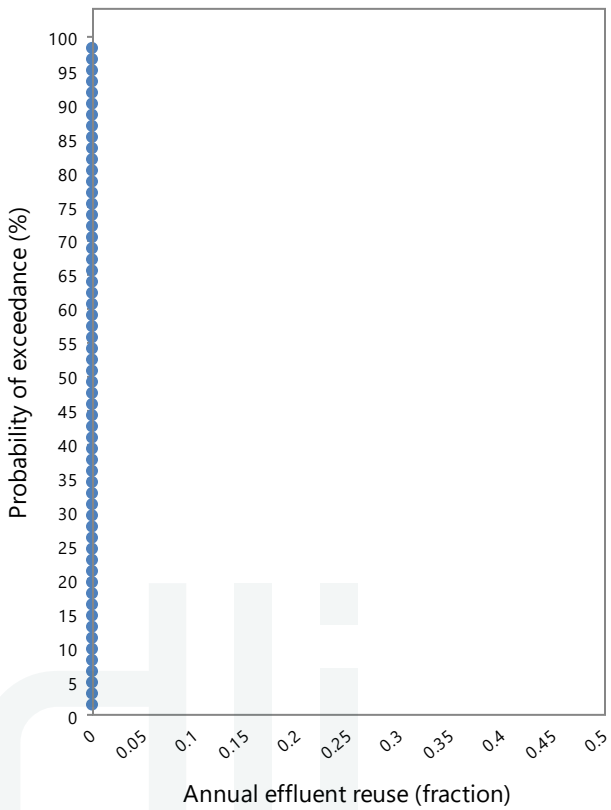
Name	Value
Rain	0.00
Inflow	0.00
Recycling	0.00
Evaporation	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Removed in sludge	0.00
Delta storage	0.00

Overflow and reuse diagnostics

Metric	Value
Total volume of overflow (m3/10 years)	0.00
Total number of overflow events (events/10 years)	0.00
Total number of pond overflow days (days/10 years)	0.00
Probability of at least 90% effluent reuse (%)	0.00
Effluent reuse (Proportion of inflow + net gain in rain that is irrigated) (fraction)	0.00







Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system nitrogen balance (kg/year)

(no data available)

Name	Value
Inflow	0.00
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Delta storage	0.00

Pond system phosphorus balance (kg/year)

(no data available)

Name	Value
Inflow	0.00
Recycling	0.00
Sludge	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Delta storage	0.00

Pond system salt balance (kg/year)

(no data available)

Name	Value
Inflow	0.00
Recycling	0.00
Sludge*	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Delta storage	0.00

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond system sludge accumulation: 0.00 kg dwt/year

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond nutrient concentrations and salinity

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	0.00
Average phosphorus concentration of pond liquid (mg/L)	0.00
Average salinity of pond liquid (dS/m)	0.00

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	N.D.*
Final phosphorus concentration of pond liquid (mg/L)	N.D.*
Final salinity of pond liquid (dS/m)	N.D.*

* Not determined. Pond is empty.

Performance

Water use (assumes 100% irrigation efficiency)

Metric	Value
Pond water irrigated (m3/year)	0.00
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	0.00
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation quality

Metric	Value
Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	0.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	0.00
Average phosphorus concentration of irrigation water (mg/L)	0.00
Average salinity of irrigation water (dS/m)	0.00

Irrigation diagnostics (No effluent irrigation occurred!)

Metric	Value
No. periods/year without any irrigable effluent in the wet weather storage pond (periods/year)	0.00
Average length of such periods (days)	0.00

Irrigation triggering and application

No. Days without Irrigation Applied per Year: 365.25 (with irrigation too small, <0.0001 mm, to apply)
No. Days without Irrigation Applied per Year: 365.25 (with no supply - no application)
No. Days with Irrigation Applied per Year: 0.00
No. Days with Irrigation Triggered per Year: 365.25

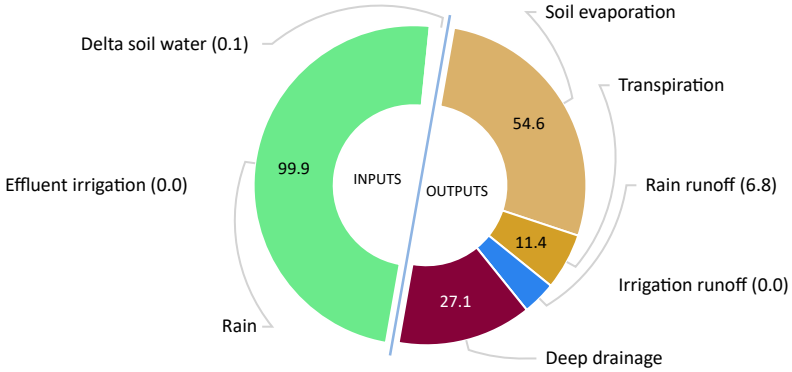
Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

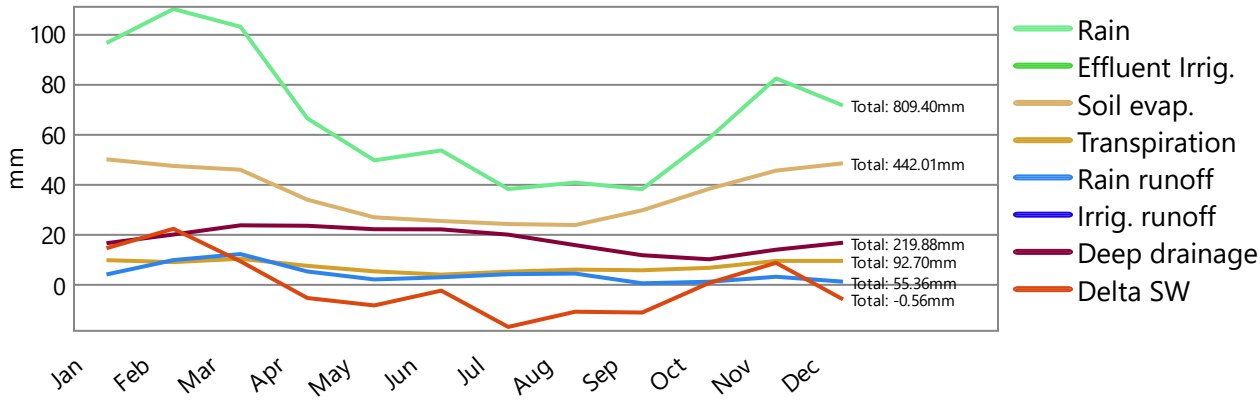
Soil Type: 3578_Orchard Hills_imported tops, 141.00 mm PAWC at maximum root depth

Soil water balance (%)

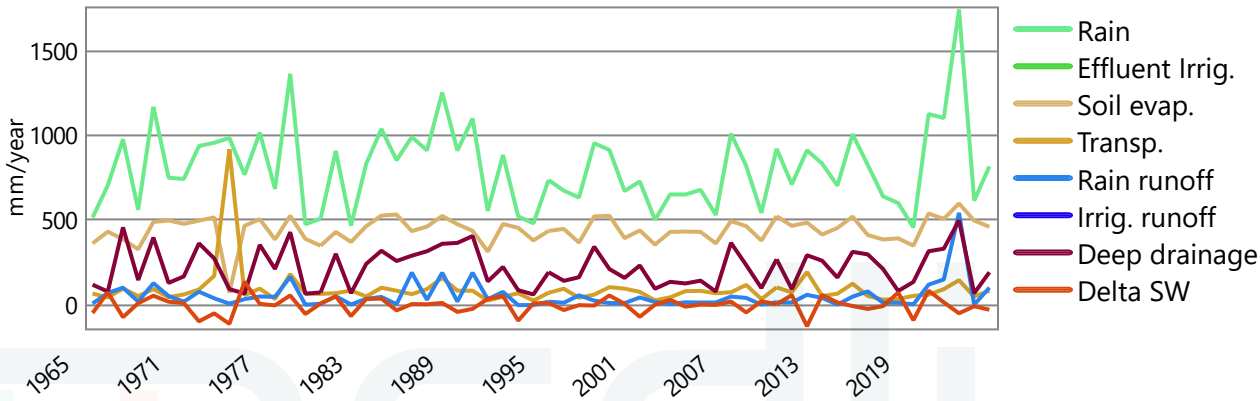


Name	Value
Rain	99.9
Effluent irrigation	0.0
Soil evaporation	54.6
Transpiration	11.4
Rain runoff	6.8
Irrigation runoff	0.0
Deep drainage	27.1
Delta soil water	-0.1

Average monthly totals (mm)



Average annual totals (mm/year)

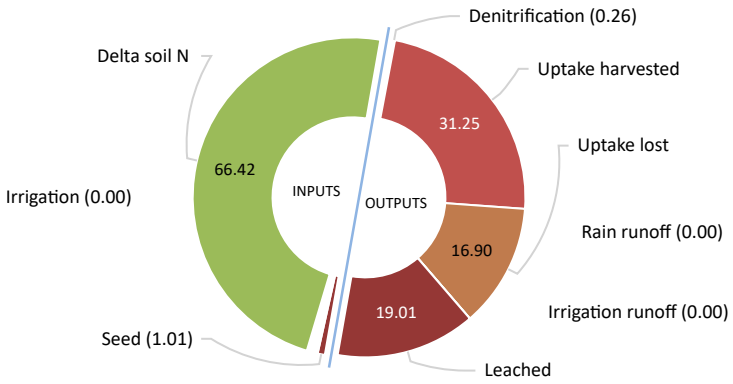


Performance

Paddock information

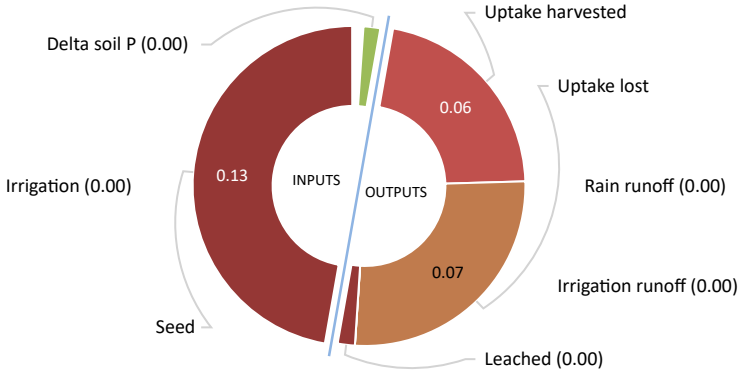
Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Irrigation Ammonia-N Volatilisation Losses (kg/ha/year): 0.00
Proportion of Total Nitrogen in Irrigated Effluent as Ammonium (fraction): 0.30

Soil nitrogen balance (kg/ha/year)



Name	Value
Seed	1.01
Irrigation	0.00
Denitrification	0.26
Uptake harvested	31.25
Uptake lost	16.90
Rain runoff	0.00
Irrigation runoff	0.00
Leached	19.01
Delta soil N	-66.42

Soil phosphorus balance (kg/ha/year)



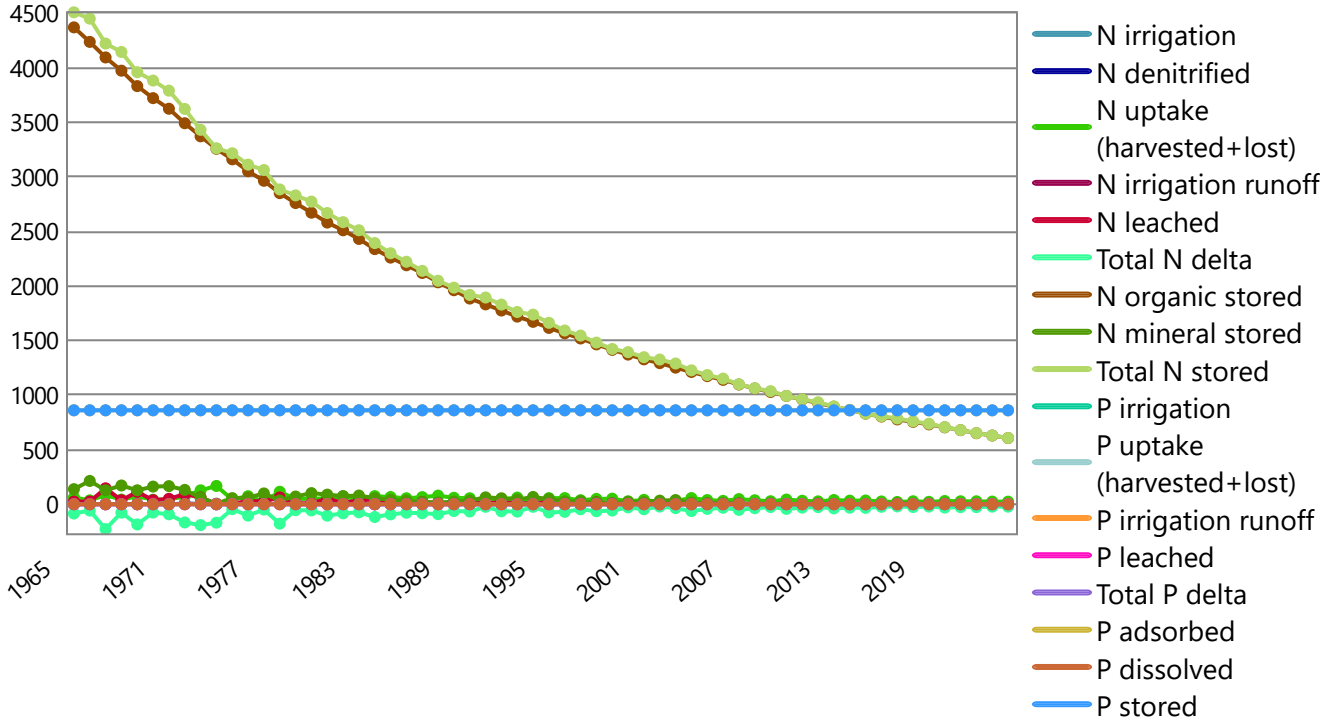
Name	Value
Seed	0.13
Irrigation	0.00
Uptake harvested	0.06
Uptake lost	0.07
Rain runoff	0.00
Irrigation runoff	0.00
Leached	4.51E-03
Delta soil P	-4.51E-03

Performance

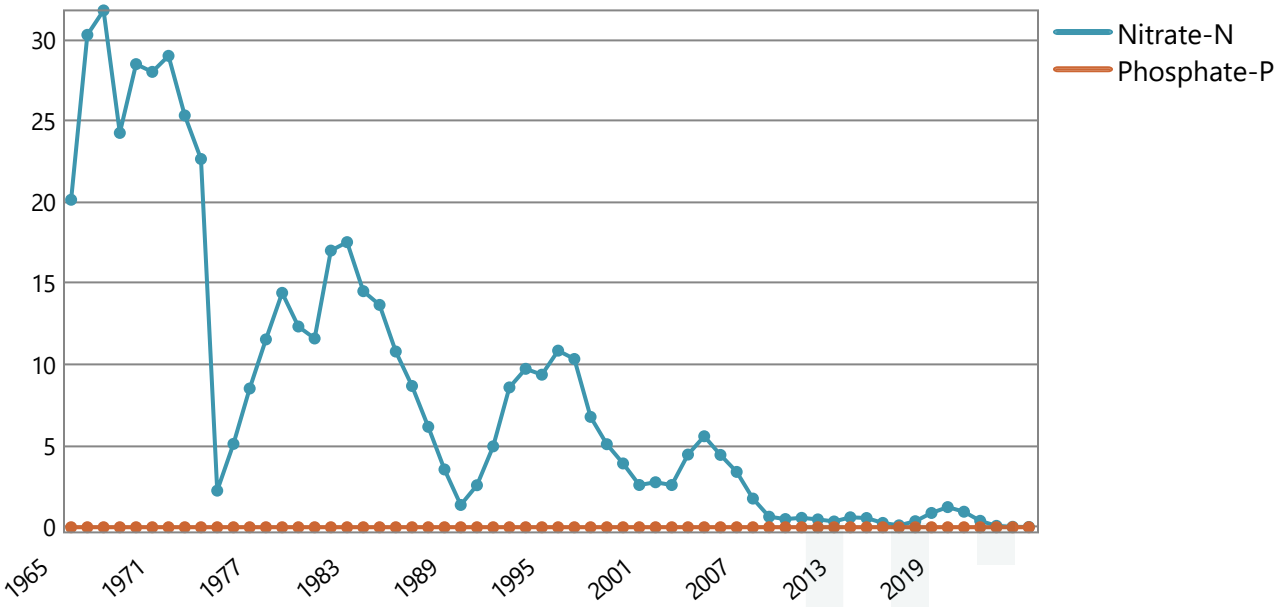
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops

Annual nutrient totals (kg/ha)



Annual nutrient leaching concentration (mg/L)



Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant growth (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield* (kg/ha/year)	1748.02 (-208.81 - 18919.71)
Average annual shoot dry matter lost (kg/ha/year)	781.62 (0.00 - 1569.41)
Average monthly plant (green) cover (fraction)	0.07 (0.06 - 0.08)
Average monthly root depth (mm)	233.92 (193.85 - 268.58)

Plant nutrient uptake (minimum - maximum)

Metric	Value
Average annual shoot nitrogen in harvestable yield* (kg/ha/year)	31.25 (-7.87 - 160.11)
Average annual shoot nitrogen lost (kg/ha/year)	16.90 (0.00 - 32.12)
Average annual shoot phosphorus in harvestable yield* (kg/ha/year)	0.06 (-0.08 - 0.17)
Average annual shoot phosphorus lost (kg/ha/year)	0.07 (0.00 - 0.22)
Average annual shoot nitrogen concentration (fraction dwt)	0.02 (0.01 - 0.03)
Average annual shoot phosphorus concentration (fraction dwt)	0.000 (0.000 - 0.001)

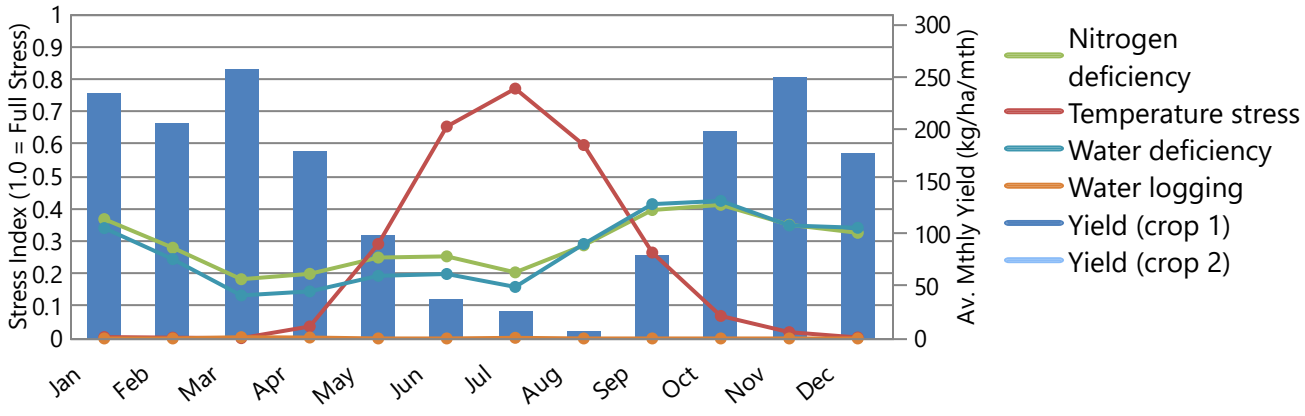
*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Performance

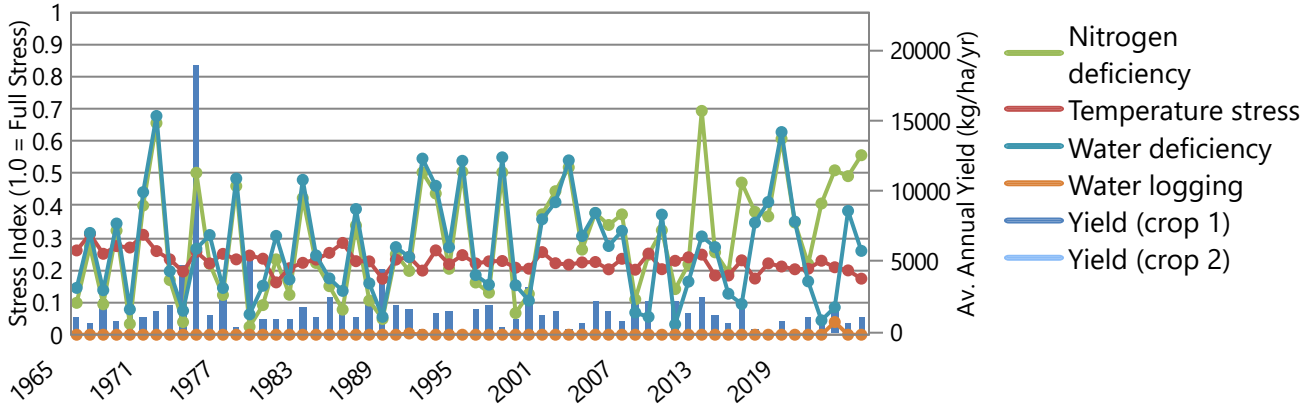
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Av. monthly stresses & harvestable yield* (kg/ha/month)



Av. annual stresses & harvestable yield* (kg/ha/year)



*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Normal and forced harvest information

No. of Harvests per Year: 0.00 (normal), 1.38 (forced by crop death due to water stress).
No. Days without Crop per Year (no./year): 83.13 (due to water stress [79.32], temperature stress - not frost [2.90] and frosting [0.92])

Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant salinity tolerance

Metric	Value
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05
No. years assumed for leaching to reach steady-state (years)	25.00

Soil salinity

Metric	Value
Average Infiltrate Salinity (dS/m)	0.03

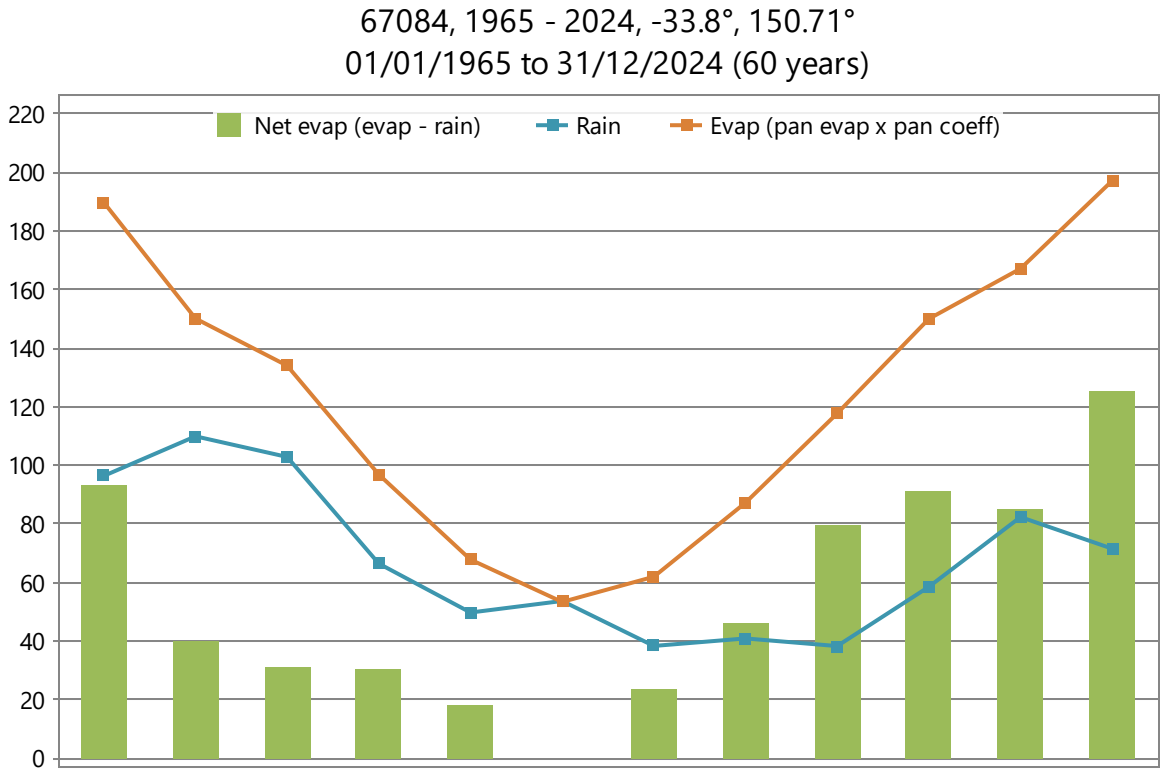
No salinity calculations as no irrigation occurred.

Diagnostics

Scenario information

Enterprise: 3578_IMP Orchard Hills

Climate long-term monthly averages (mm)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.4	109.9	102.9	66.5	49.8	53.7	38.4	40.9	38.3	58.6	82.4	71.6	809.4
Evap	189.8	150.1	134.0	96.9	67.9	53.4	62.0	87.3	117.7	150.0	167.1	197.1	1473.4
Net evap	93.3	40.2	31.2	30.4	18.1	-0.3	23.6	46.3	79.4	91.5	84.8	125.6	664.0
Net evap/day	3.0	1.4	1.0	1.0	0.6	0.0	0.8	1.5	2.6	3.0	2.8	4.1	1.8

Diagnostics

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Effluent Type: - 0.00 m3/year or 0.00 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 0.00 *non-zero flow days/year.*

Constituent	Concentration (mg/L)	Load (kg/year)
Total nitrogen	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total phosphorus	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total dissolved salts	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

Ammonia-N loss from pond system water surface area: 0.00 kg/m2/year

Last pond (wet weather store): 1000.00 m3

Metric	Value
Theoretical hydraulic retention time (days)	0.00
Volume of overflow (m3/year) Average (minimum-maximum)	0.00 (0.00 - 0.00)
Volume of overflow per day (m3/day) Average (minimum-maximum)	0.00 (0.00 - 0.00)
No overflow days - Average per year (Total in run period)	0.00 (0)
No. overflow events per 10 years exceeding threshold of 0.250 m3* (events/10 years)	0.00
Average overflow event recurrence interval (years)	0.00
Average duration of overflow (days)	0.00
Probability of at least 90% effluent reuse (%)	0.00
Effluent reuse (proportion of inflow + net rain gain that is irrigated) (fraction)	0.00
Average salinity (dS/m)	0.00
Salinity on final day of simulation (dS/m)	0.00

* The threshold is the volume equivalent of the top 1 mm depth of water of a full pond

Volume distribution of the overflow events

Overflow volume (m3)	Overflow events (No./10 yrs)
0	0.00

Diagnostics

Scenario information

Area irrigated: 3.65 ha total area

Loading to whole irrigation area: (assuming 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	0.00	0.00
Total nitrogen applied (kg)	0.00	0.00
Total phosphorus applied (kg)	0.00	0.00
Total salts applied (kg)	0.00	0.00

Shandying

Metric	Value
Annual allocation of fresh water for shandying (m3/year)	0.00
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Minimum shandy water is used	No

Irrigation issues

Metric	Value
Number of days without irrigation (days/year)	365.25

Diagnostics

Paddock information

Paddock: - 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Irrigation Rules
Irrigation triggered every 1 days and rainfall is less than or equal to 2000.00 mm
Irrigate up to a soil water content of drained upper limit plus 2.28 mm
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil water balance (mm): 3578_Orchard Hills_imported tops, 141.00 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.4	109.9	102.9	66.5	49.8	53.7	38.4	40.9	38.3	58.6	82.4	71.6	809.4
Efflt. irrg.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil evap	50.2	47.6	46.1	34.1	27.1	25.7	24.5	24.1	29.9	38.5	45.7	48.6	442.0
Transpn.	10.1	9.3	10.7	7.9	5.7	4.4	5.5	6.4	6.1	7.1	9.8	9.8	92.7
Rain runoff	4.4	10.2	12.5	5.6	2.5	3.3	4.5	4.8	0.9	1.5	3.5	1.6	55.4
Irr. runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	16.9	20.3	24.0	23.8	22.4	22.3	20.3	16.1	12.1	10.5	14.3	17.0	219.9
Delta SW	14.9	22.6	9.7	-4.9	-7.9	-2.0	-16.4	-10.4	-10.7	1.0	9.1	-5.5	-0.6

Soil nitrogen balance: (Concentrations are flow-weighted)

Metric	Value
Average annual nitrogen added in seed (kg/ha/year)	1.01
Average annual nitrogen added from irrigation (kg/ha/year)	0.00
Av. annual soil N removed by uptake (harvest + lost) (kg/ha/year)	48.15 (31.25, 16.90)
Av. annual soil nitrogen removed by denitrification (kg/ha/year)	0.26
Average annual soil nitrogen leached (kg/ha/year)	19.01
Average annual nitrate-N loading to groundwater (kg/ha/year)	19.01
Soil organic-N kg/ha (Initial - Final)	4507.50 - 605.79
Soil inorganic-N kg/ha (Initial - Final)	84.07 - 0.62
Average nitrate-N concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	8.65 (31.79)
Excluding first year of data (mg/L)	8.54 (31.79)

Soil phosphorus balance: (Concentrations are flow-weighted)

Metric	Value
Average annual phosphorus added in seed (kg/ha/year)	0.13
Average annual phosphorus added from irrigation (kg/ha/year)	0.00
Av. annual soil P removed by uptake (harvest + lost) (kg/ha/yr)	0.13 (0.06, 0.07)
Average annual soil phosphorus leached (kg/ha/year)	4.51E-03
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	860.20 - 859.93
Average phosphate-P concentration in rootzone (mg/L)	2.04E-03
Average phosphate-P concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	2.05E-03 (2.05E-03)
Last year only (mg/L)	2.05E-03 (N.D.*)
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.00 mg/L (years)	999.00

* Not determined

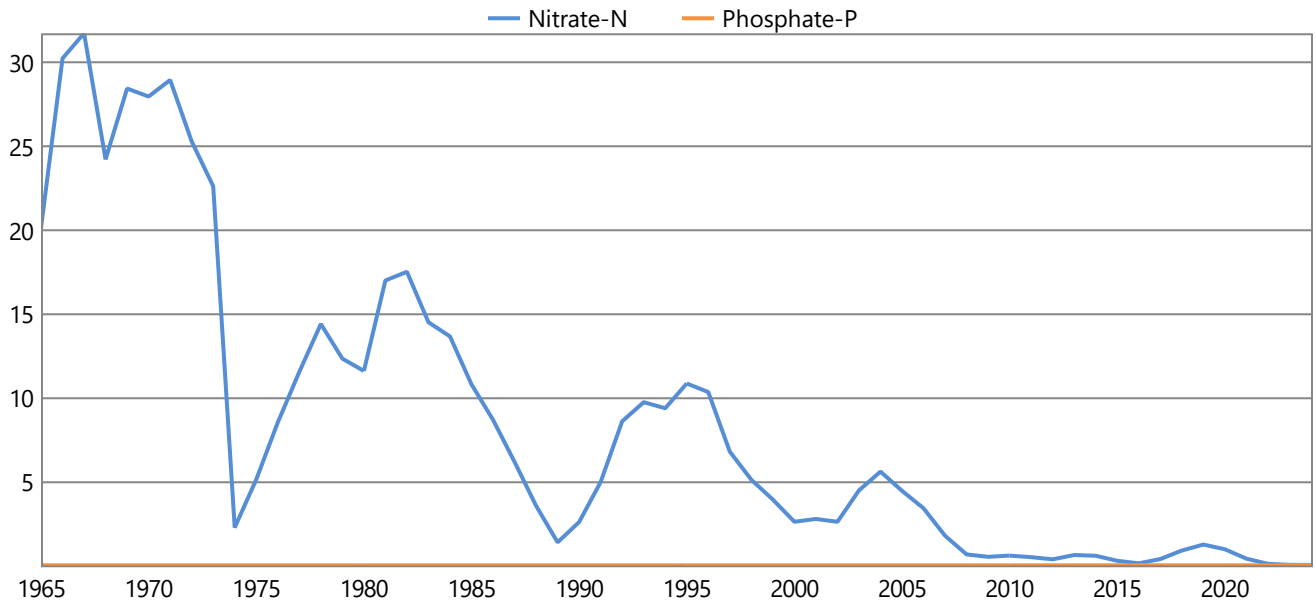
Diagnostics

Paddock information

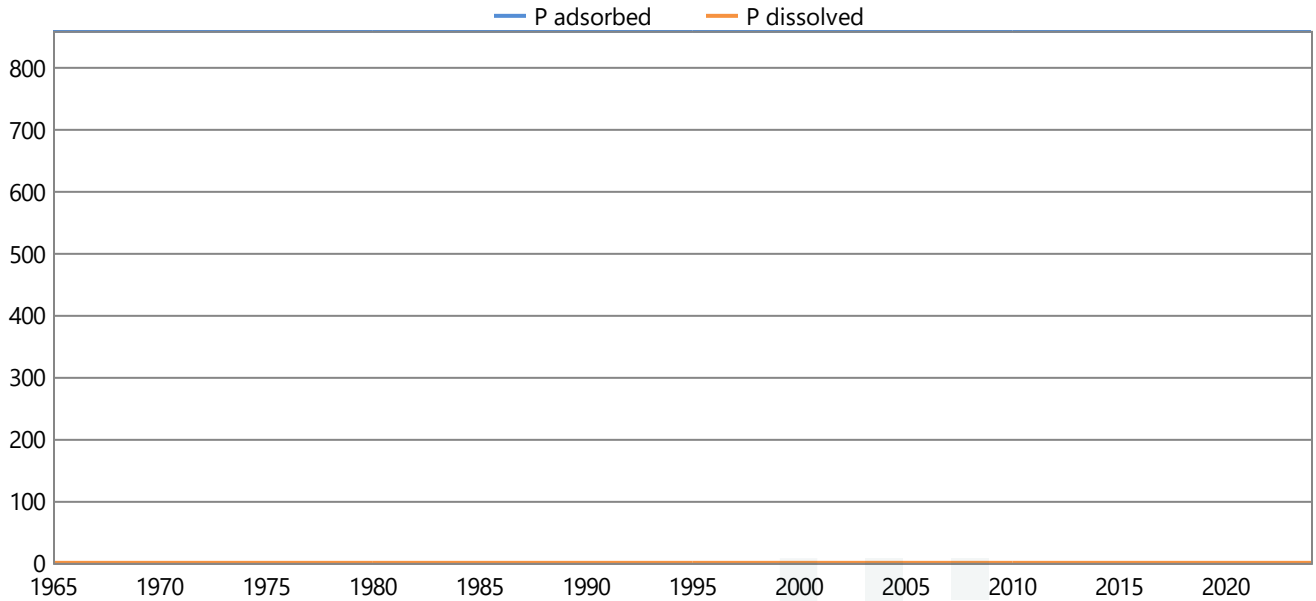
Paddock: 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual phosphate-P in soil (kg/ha)



Diagnostics

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average plant performance (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield (kg/ha/year)	1748.02 (-208.81 - 18919.71)
Average annual shoot dry matter lost (kg/ha/year)	781.62 (0.00 - 1569.41)
Average monthly plant (green) cover (fraction)	0.07 (0.06 - 0.08)
Average monthly crop factor (fraction)	0.08 (0.06 - 0.09)
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Average monthly root depth (mm)	233.92 (193.85 - 268.58)
Average number of normal harvests per year (no./year)	0.00 (0.00 - 0.00)
Average number of normal harvests for last five years only (no./year)	0.00
Average number of forced harvests per year (no./year)	1.38 (0.00 - 3.00)
Average number of forced harvests for last five years only (no./year)	1.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.29 (0.02 - 0.69)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.06)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.77 (0.58 - 0.95)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.27 (0.13 - 0.42)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop per year. Excludes bare fallow days (days)	83.13

Soil salinity - plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 25 -year running averages.

No salinity calculations as no irrigation occurred.

Diagnostics

Run information

Messages generated when the scenario was run
********** WASTESTREAM RESULTS **********
TABLE OF QUANTITY AND QUALITY OF EACH RAINFALL-INDEPENDENT WASTESTREAM (AFTER PRETREATMENT AND BEFORE ENTERING ANY SEDIMENTATION BASIN)
_____
Source Volume_m3/yr N conc_mg/L P conc_mg/L TDS conc_mg/L N load_kg/yr P load_kg/yr TDS load_kg/yr
New generic system 0.0 0.0 0.0 0.0 0.0 0.0 0.0
_____
********** END WASTESTREAM RESULTS **********
No. Days without Irrigation Applied per Year: 365.25 (with irrigation too small, <0.0001 mm, to apply)
This is a Dryland scenario
No effluent irrigation has occurred!
WARNING: Soil phosphorus adsorption capacity was already exhausted at start of run
WARNING: Pasture yield and soil nutrient balances may be INVALID due to the frequent kickstarting of pasture establishment. Try to reduce the number of forced harvests.
WARNING: Plant phosphorus deficiency. No soil phosphorus has been available for plant uptake for 69.37% of days of simulation.
WARNING: Plant phosphorus deficiency. At shoot P concentrations below 0.2% dry weight, many plant species will show reduced yields due to phosphorus deficiency. Please check if this is true for the simulated species, as if so, the predicted plant yield and soil nutrient balances will be INVALID!
WARNING: CONDITIONAL FINISH!

General Information

SCENARIO REPORT: Full run

General information

Enterprise: 3578_IMP Orchard Hills
Client: Jordan Jennings - AquaCell P/L
MEDLI user: WHITEHEAD2012\marksaunders

Description:

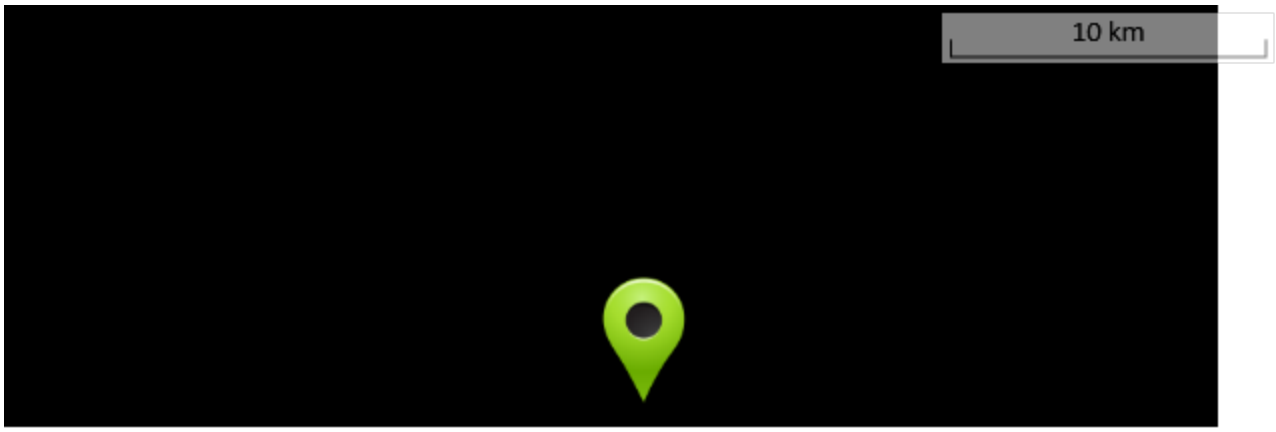
RWIZ design for Alspec Business Park; Luddenham Rd, Orchard Hills

Scenario details:

3578 - Run002d: RW irrigation (12.25 - 122.5kL per day); Original Climate Data; 3.65ha RWIZ; 1ML storage; IT = fixed daily IRR depth 2.54mm; 30mm Rainfall Override; 1.2m (engineered) soil profile and enhanced Tea Tree crop (as per COPE Landscaping Plan).

Map of location:

Note: If the map above appears as a dark box, check that the network is accessible and that the coordinates are not for a location in the ocean.



Description

Climate information

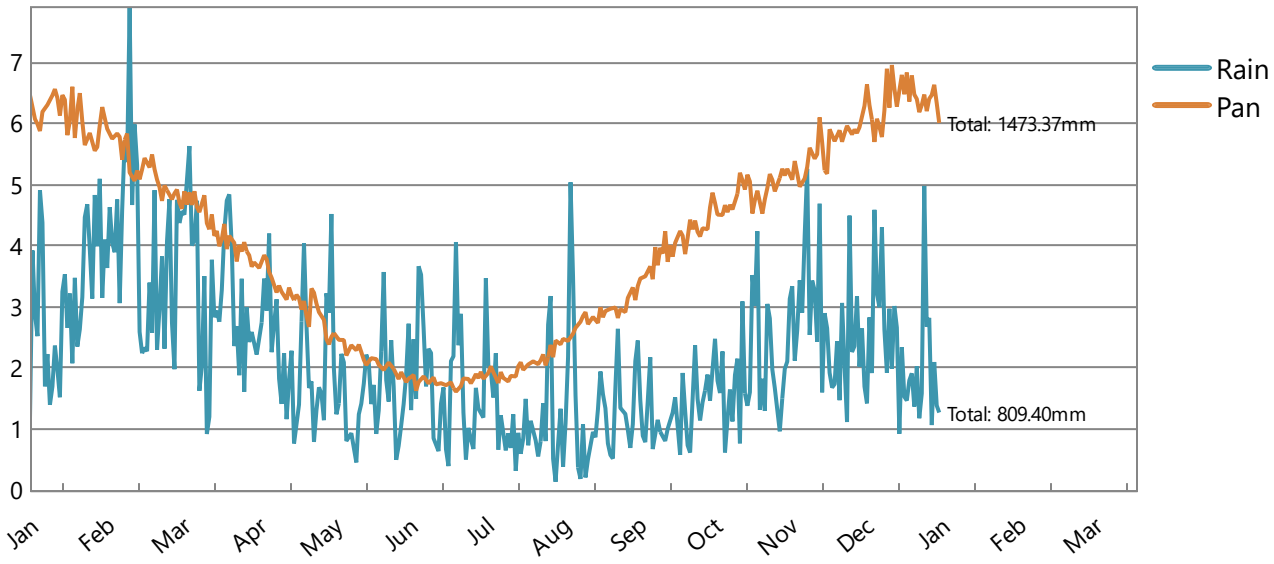
Climate Data Location: 67084, 1965 - 2024, -33.8°, 150.71°
Run Period: 01/01/1965 to 31/12/2024 (60 years)

Climate statistics

	5th Percentile		50th Percentile		95th Percentile	
Rainfall (mm/year)	(Year 1979)	479.3	(Year 1975)	793.0	(Year 1988)	1210.2
Pan evaporation (mm/year)	(Year 1999)	1304.3	(Year 2003)	1463.8	(Year 1977)	1667.0

Climate data

Daily average across run period:



Description

Wastestream information

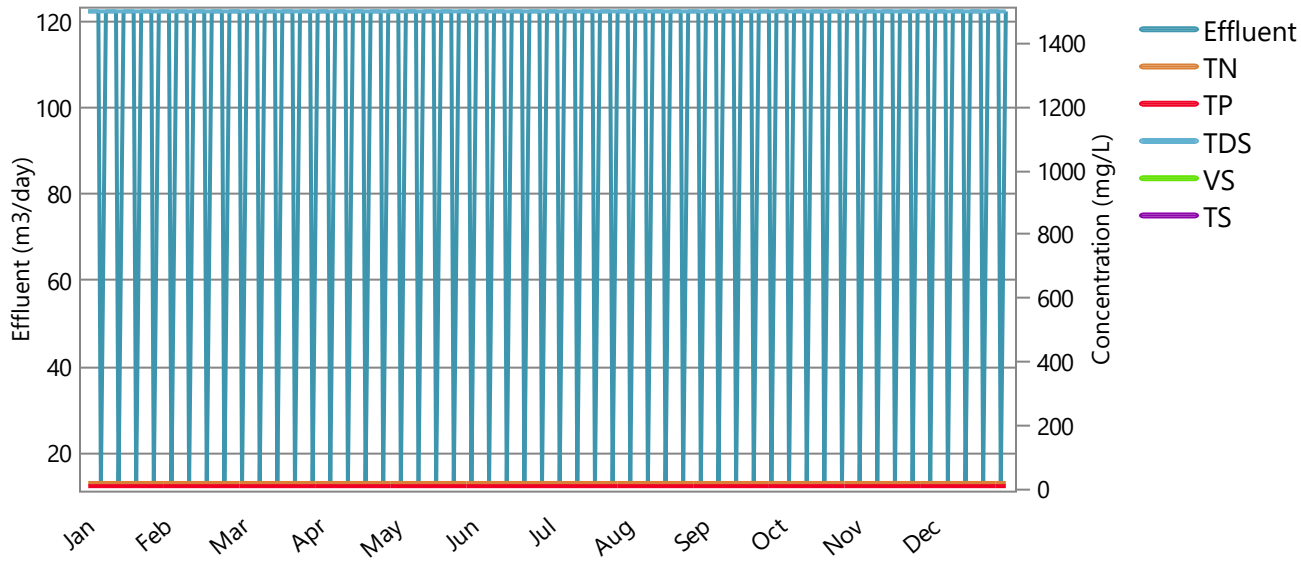
Wastestream Name: - New generic system

Wastestream production description

Daily New generic system data supplied for a representative year. This wastestream is not separately pretreated.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream

Effluent Quantity: 33277.13 m3/year or 91.11 m3/day (Min-Max 12.25 - 122.50)

Flow-Weighted Average (Min - Max) Daily Effluent Quality Entering the Pond System:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	20.00 (20.00 - 20.00)	665.54 (664.93 - 667.38)
Total phosphorus	10.00 (10.00 - 10.00)	332.77 (332.47 - 333.69)
Total dissolved salts	1500.00 (1500.00 - 1500.00)	49915.69 (49869.75 - 50053.50)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

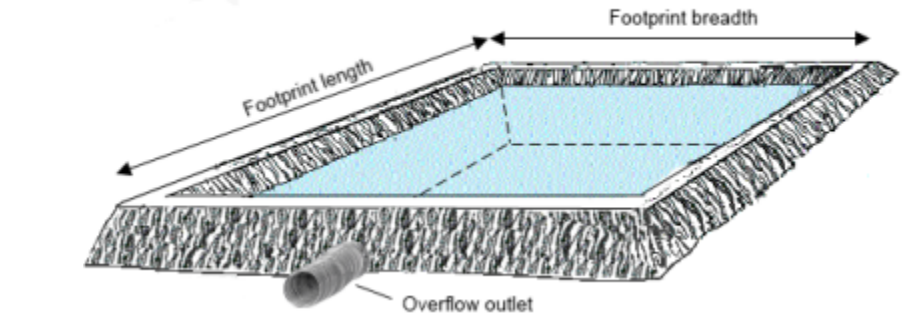
Description

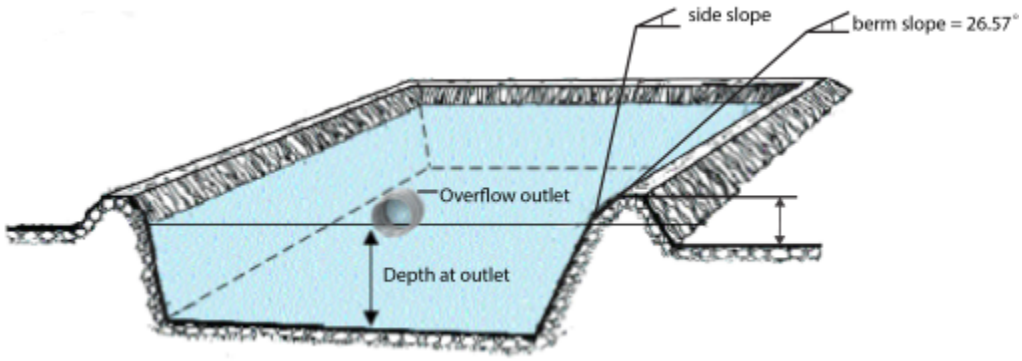
Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system details

	Pond 1
Maximum pond volume (m3)	1000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	4.00
Maximum water surface area (m2)	250.10
Pond footprint length (m)	15.81
Pond footprint width (m)	15.81
Pond catchment area (m2)	250.10
Average active volume (m3)	306.33





Irrigation pump limits

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump rate per area limit (ML/day/ha)	1.00

Shandying water

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	No

Description

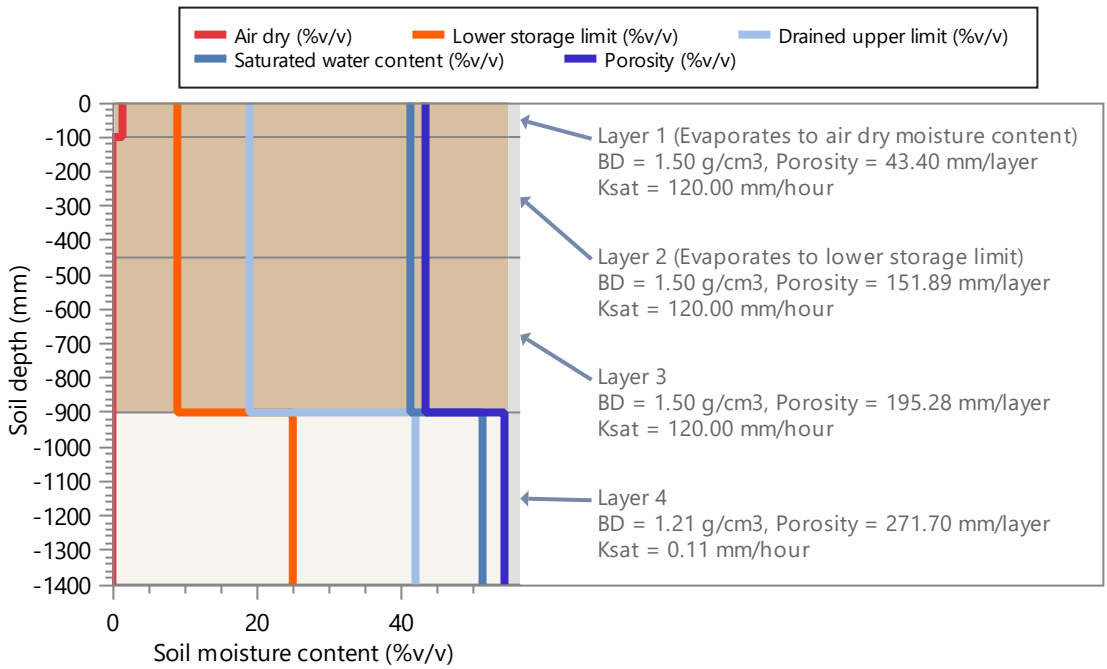
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Soil type: 3578_Orchard Hills_imported tops, 1400.00 mm defined profile depth

Profile porosity (mm)	662.26
Profile saturation water content (mm)	628.20
Profile drained upper limit (or field capacity) (mm)	381.00
Profile lower storage limit (or permanent wilting point) (mm)	206.00
Profile available water capacity (mm)	175.00
Profile limiting saturated hydraulic conductivity (mm/hour)	0.11
Surface saturated hydraulic conductivity (mm/hour)	120.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	7.75
Soil evaporation Cona (mm/sqrt day)	3.50

Profile



Planting regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average monthly cover (fraction) (minimum - maximum)	0.71 (0.67 - 0.75)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 1.1 x Pan coefficient 1)	1.10
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Potential rooting depth in defined soil profile (mm)	1200.00
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05

Irrigation rules: Pressure-compensating SSI

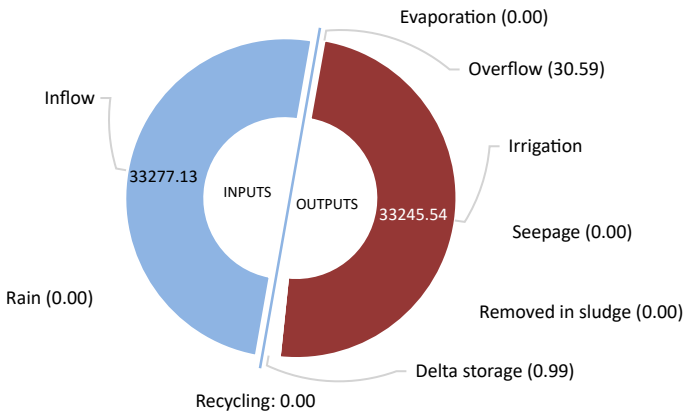
Rule 1. Irrigation triggered every 1 days and rainfall is less than or equal to 30.00 mm
Rule 2. Irrigate a fixed amount of 2.54 mm each day
Rule 3. Irrigation window from 1/1 to 31/12 including the days specified
Rule 4. A minimum of 0 days must be skipped between irrigation events

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank (wet weather storage pond: 1000 m3)

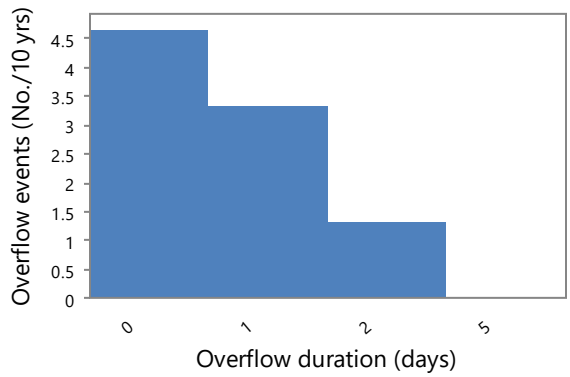
Pond system water balance (m3/year)

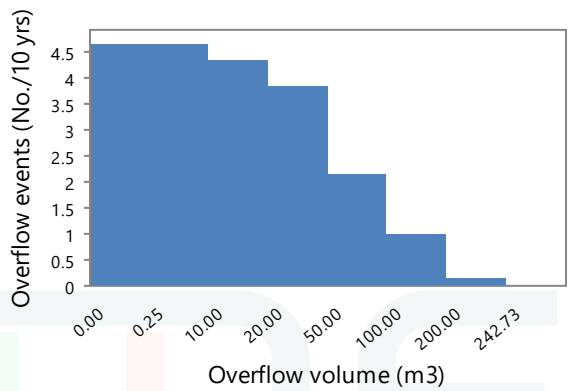


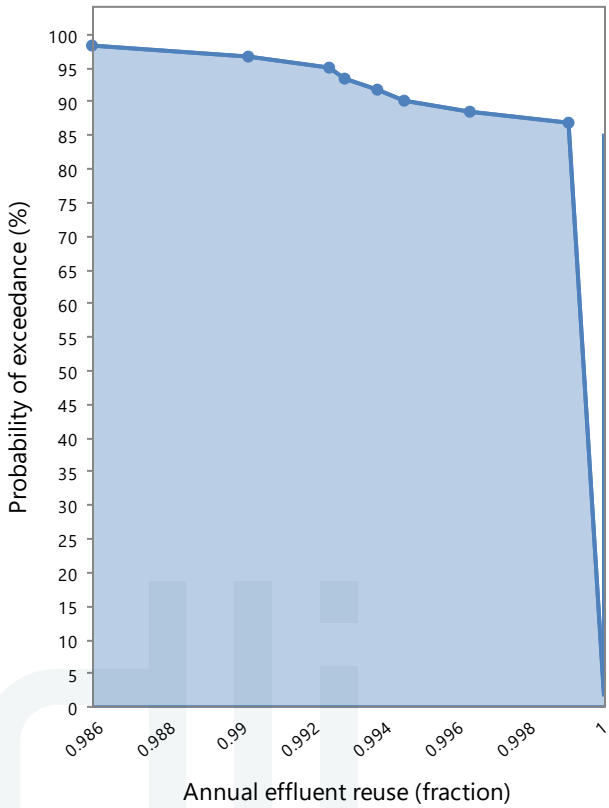
Name	Value
Rain	0.00
Inflow	33277.13
Recycling	0.00
Evaporation	0.00
Overflow	30.59
Irrigation	33245.54
Seepage	0.00
Removed in sludge	0.00
Delta storage	0.99

Overflow and reuse diagnostics

Metric	Value
Total volume of overflow (m3/10 years)	305.94
Total number of overflow events (events/10 years)	4.67
Total number of pond overflow days (days/10 years)	10.00
Probability of at least 90% effluent reuse (%)	100.00
Effluent reuse (Proportion of inflow + net gain in rain that is irrigated) (fraction)	1.00





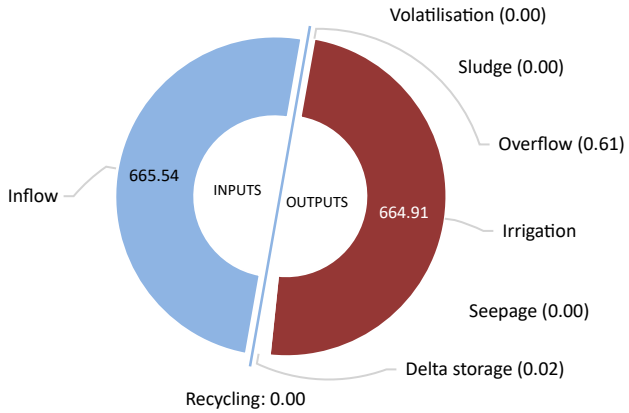


Performance

Pond system information

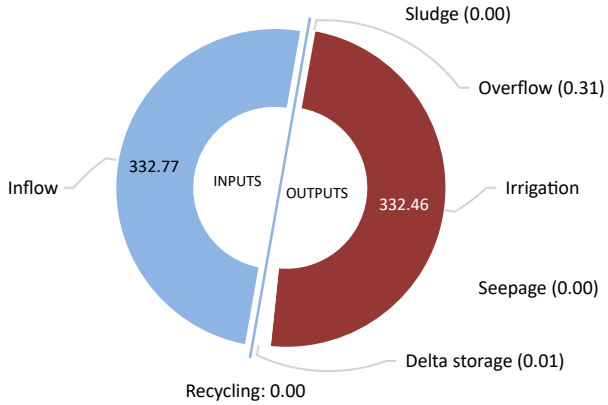
Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system nitrogen balance (kg/year)



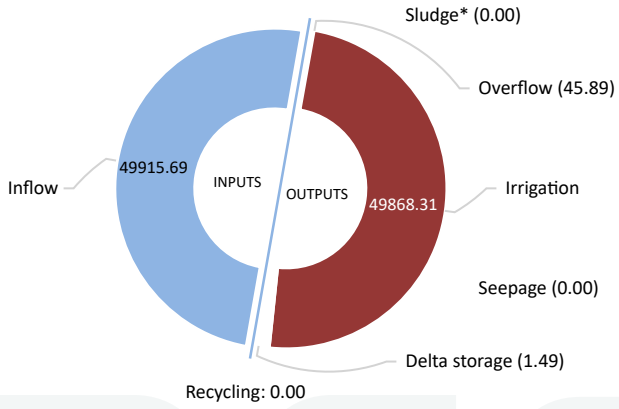
Name	Value
Inflow	665.54
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.61
Irrigation	664.91
Seepage	0.00
Delta storage	0.02

Pond system phosphorus balance (kg/year)



Name	Value
Inflow	332.77
Recycling	0.00
Sludge	0.00
Overflow	0.31
Irrigation	332.46
Seepage	0.00
Delta storage	0.01

Pond system salt balance (kg/year)



Name	Value
Inflow	49915.69
Recycling	0.00
Sludge*	0.00
Overflow	45.89
Irrigation	49868.31
Seepage	0.00
Delta storage	1.49

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond system sludge accumulation: 0.00 kg dwt/year

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond nutrient concentrations and salinity

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	20.00
Average phosphorus concentration of pond liquid (mg/L)	10.00
Average salinity of pond liquid (dS/m)	2.34

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	20.00
Final phosphorus concentration of pond liquid (mg/L)	10.00
Final salinity of pond liquid (dS/m)	2.34

Performance

Water use (assumes 100% irrigation efficiency)

Metric	Value
Pond water irrigated (m3/year)	33245.54
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	33245.54
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation quality

Metric	Value
Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	20.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	20.00
Average phosphorus concentration of irrigation water (mg/L)	10.00
Average salinity of irrigation water (dS/m)	2.34

Irrigation diagnostics

Metric	Value
No. periods/year without any irrigable effluent in the wet weather storage pond (periods/year)	0.00
Average length of such periods (days)	0.00

Irrigation triggering and application

No. Days without Irrigation Applied per Year: 5.27 (with rain exceeding specified rainfall threshold)
No. Days without Irrigation Applied per Year: 5.27 (with not triggered)
No. Days with Irrigation Applied per Year: 359.98 (with full application [349.25] and supply limited - partial application [10.73])
No. Days with Irrigation Triggered per Year: 359.98

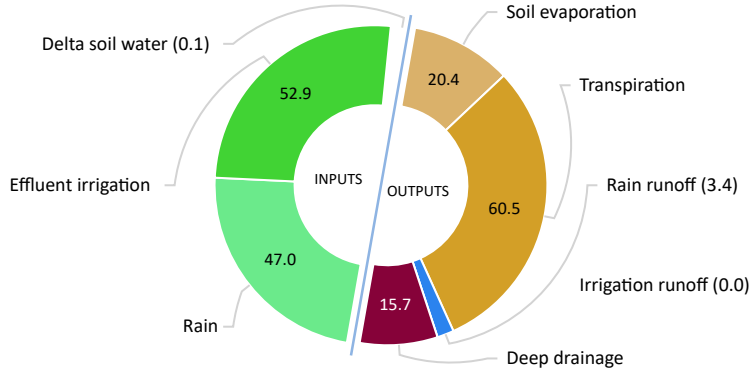
Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

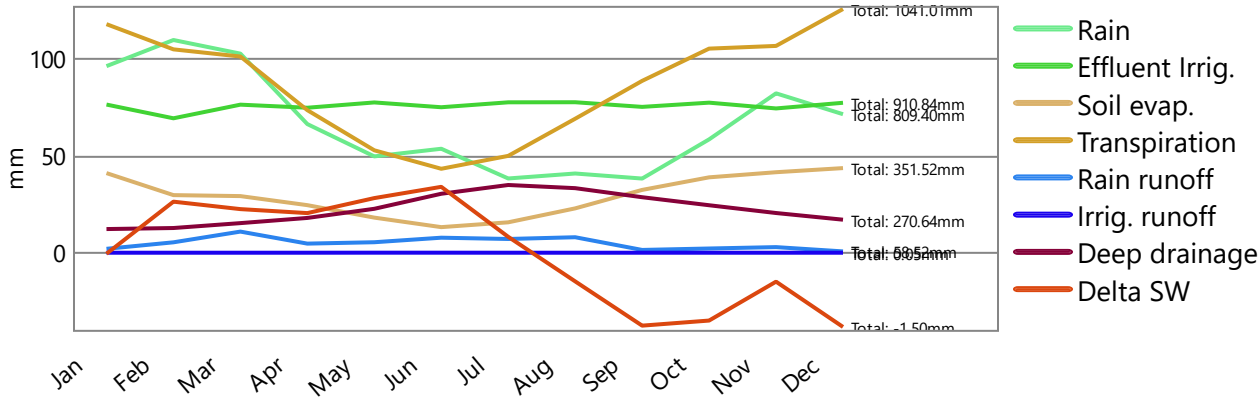
Soil Type: 3578_Orchard Hills_imported tops, 141.00 mm PAWC at maximum root depth

Soil water balance (%)

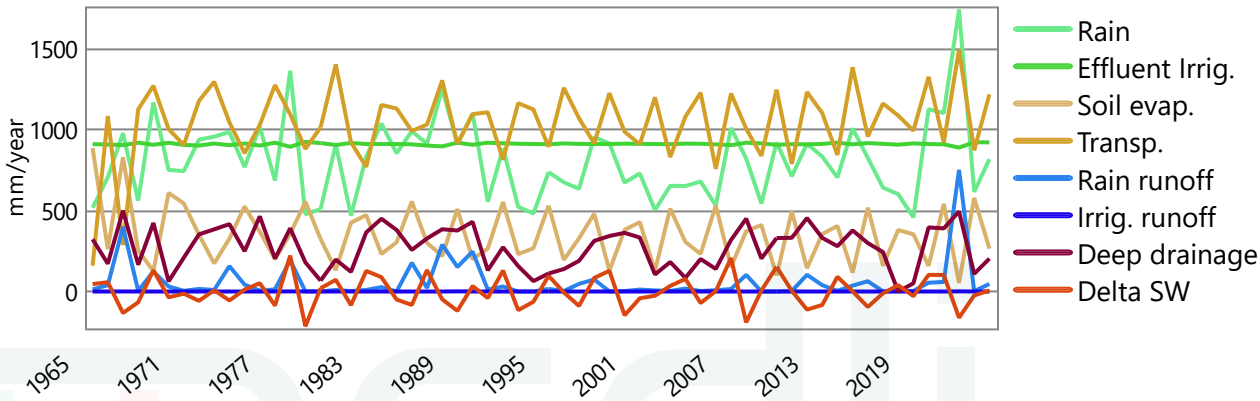


Name	Value
Rain	47.0
Effluent irrigation	52.9
Soil evaporation	20.4
Transpiration	60.5
Rain runoff	3.4
Irrigation runoff	0.0
Deep drainage	15.7
Delta soil water	-0.1

Average monthly totals (mm)



Average annual totals (mm/year)

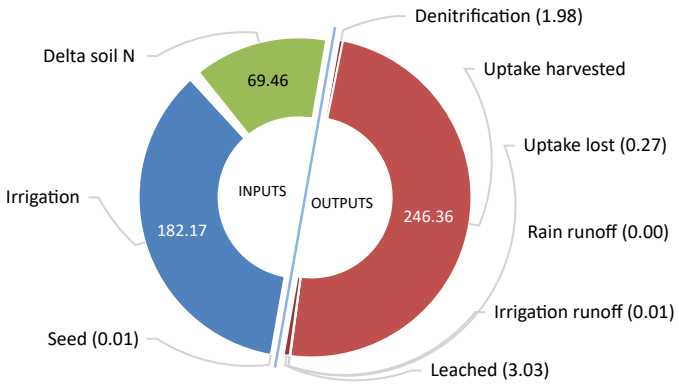


Performance

Paddock information

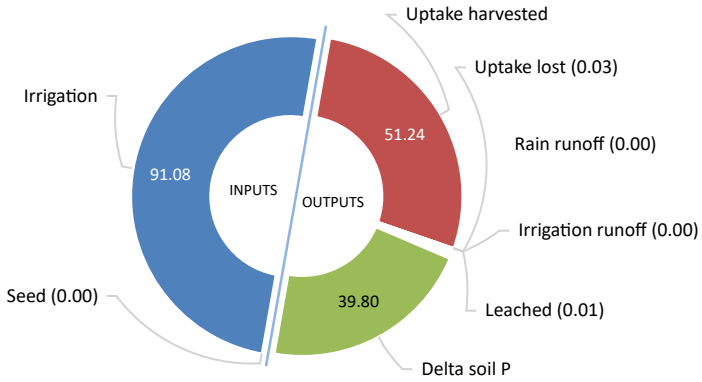
Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Irrigation Ammonia-N Volatilisation Losses (kg/ha/year): 0.00
Proportion of Total Nitrogen in Irrigated Effluent as Ammonium (fraction): 0.30

Soil nitrogen balance (kg/ha/year)



Name	Value
Seed	0.01
Irrigation	182.17
Denitrification	1.98
Uptake harvested	246.36
Uptake lost	0.27
Rain runoff	0.00
Irrigation runoff	0.01
Leached	3.03
Delta soil N	-69.46

Soil phosphorus balance (kg/ha/year)



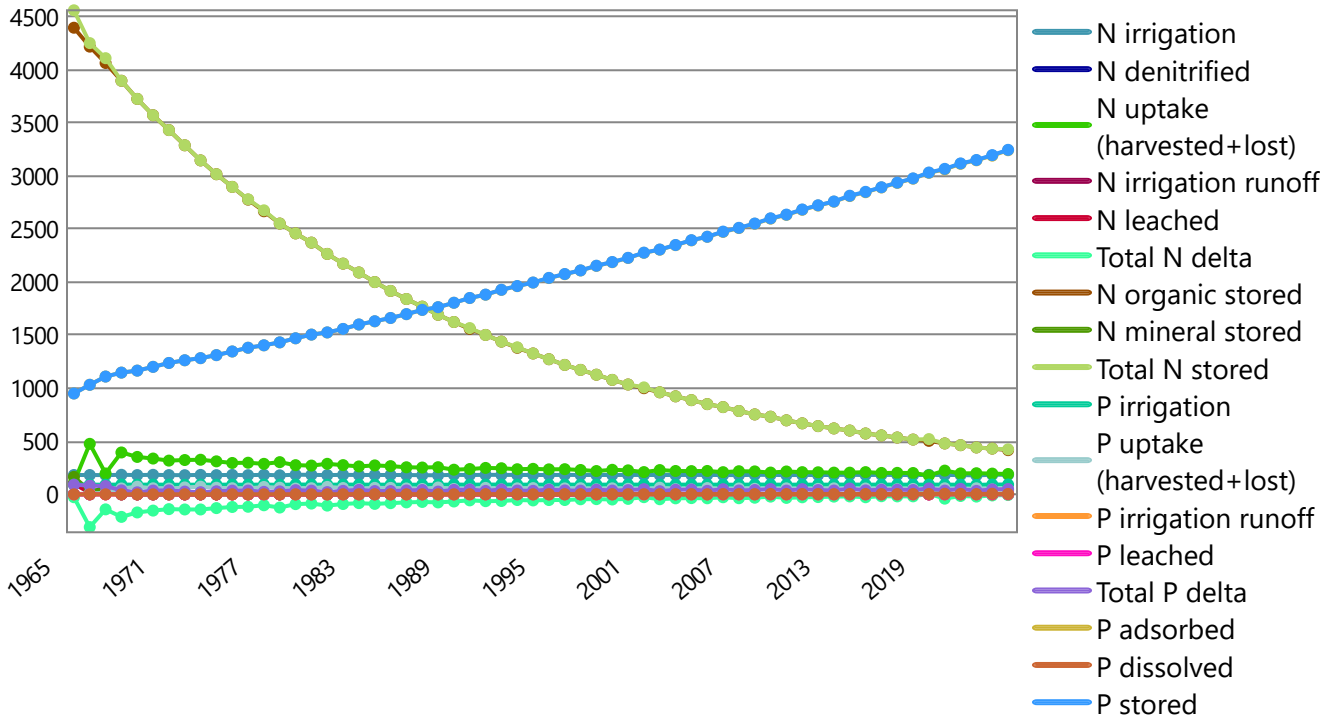
Name	Value
Seed	1.50E-03
Irrigation	91.08
Uptake harvested	51.24
Uptake lost	0.03
Rain runoff	0.00
Irrigation runoff	5.00E-03
Leached	0.01
Delta soil P	39.80

Performance

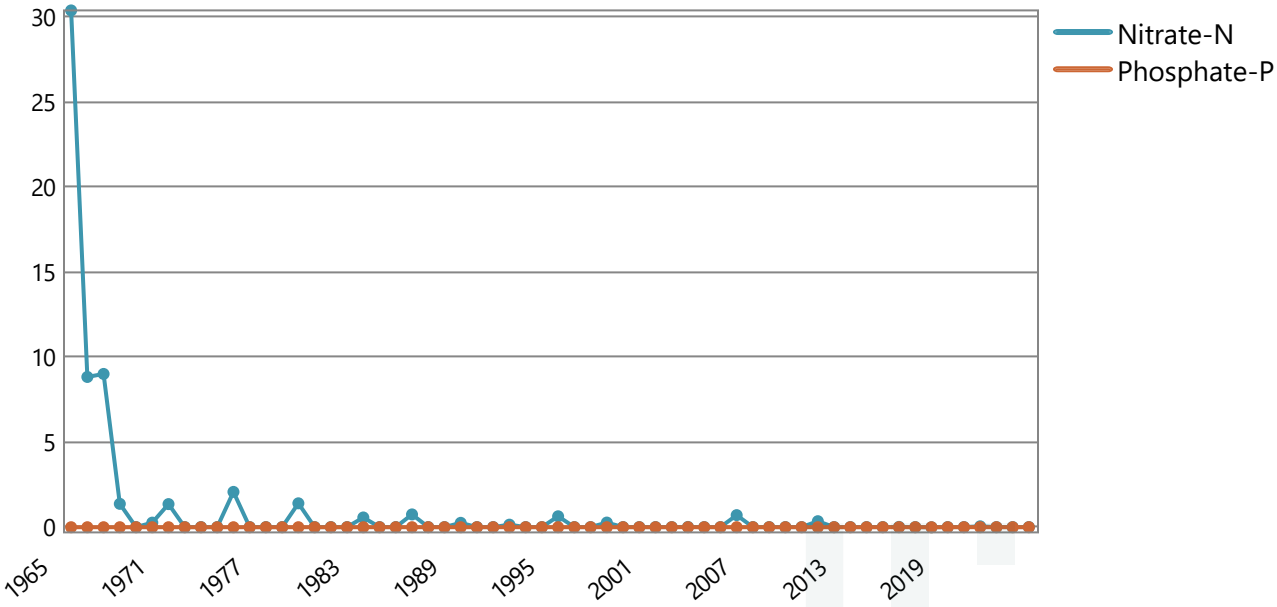
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops

Annual nutrient totals (kg/ha)



Annual nutrient leaching concentration (mg/L)



Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant growth (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield* (kg/ha/year)	17694.27 (4567.37 - 25730.16)
Average annual shoot dry matter lost (kg/ha/year)	11.68 (0.00 - 551.52)
Average monthly plant (green) cover (fraction)	0.71 (0.67 - 0.75)
Average monthly root depth (mm)	1183.99 (1176.93 - 1188.35)

Plant nutrient uptake (minimum - maximum)

Metric	Value
Average annual shoot nitrogen in harvestable yield* (kg/ha/year)	246.36 (109.56 - 475.43)
Average annual shoot nitrogen lost (kg/ha/year)	0.27 (0.00 - 13.20)
Average annual shoot phosphorus in harvestable yield* (kg/ha/year)	51.24 (0.60 - 71.82)
Average annual shoot phosphorus lost (kg/ha/year)	0.03 (0.00 - 1.65)
Average annual shoot nitrogen concentration (fraction dwt)	0.02 (0.01 - 0.03)
Average annual shoot phosphorus concentration (fraction dwt)	0.003 (0.000 - 0.003)

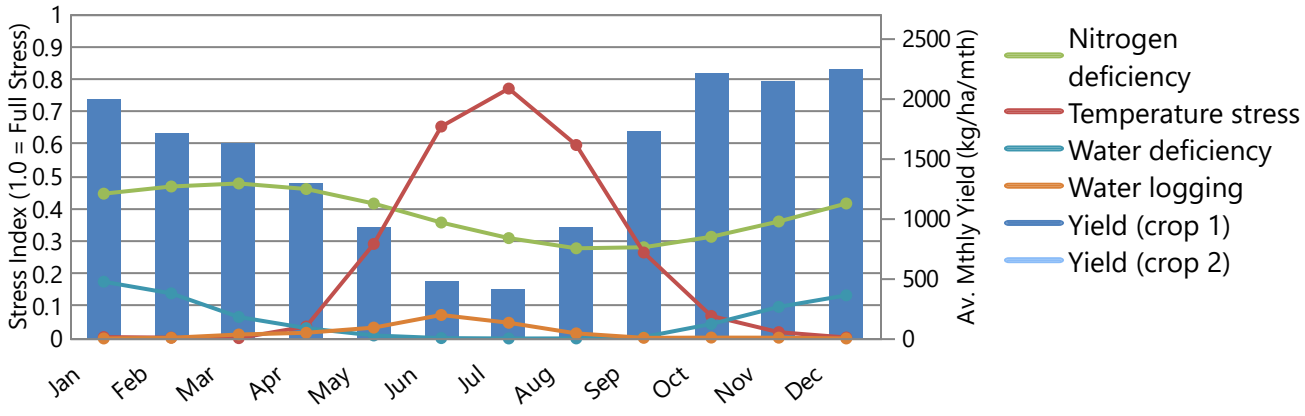
*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Performance

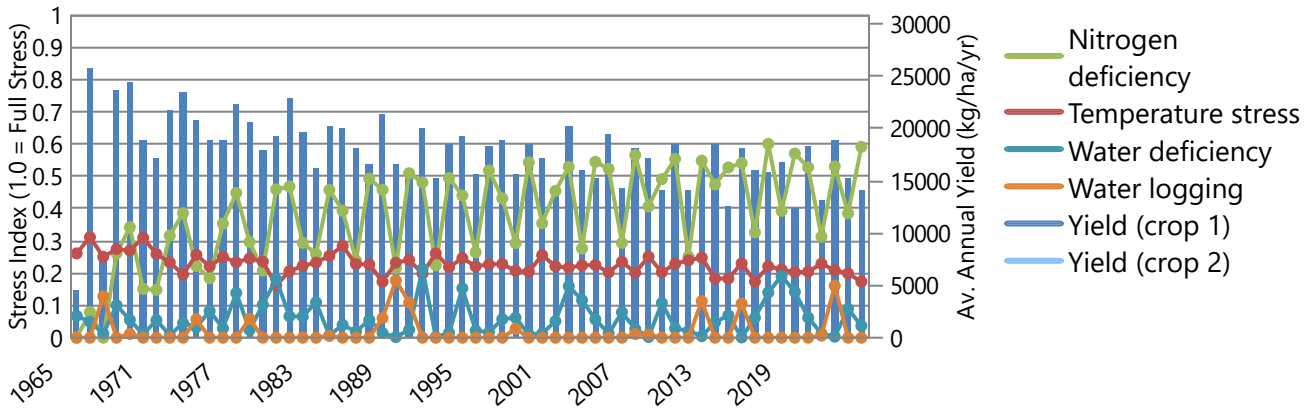
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Av. monthly stresses & harvestable yield* (kg/ha/month)



Av. annual stresses & harvestable yield* (kg/ha/year)



*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Normal and forced harvest information

No. of Harvests per Year: 0.65 (normal).
No. Days without Crop per Year (no./year): 0.00

Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant salinity tolerance

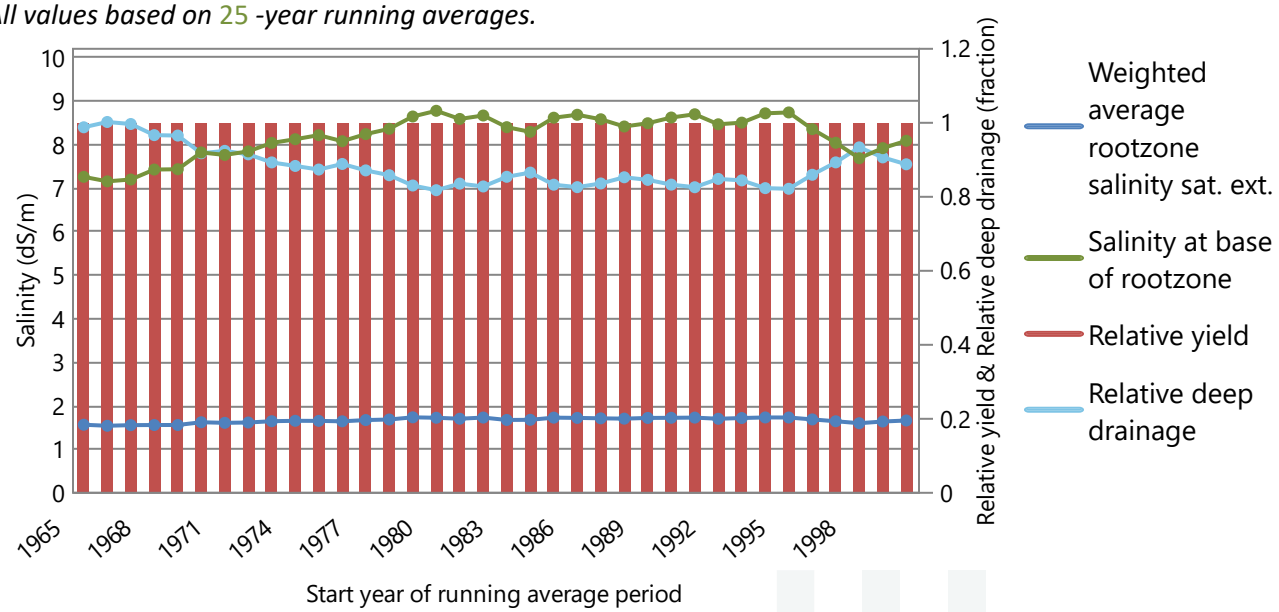
Metric	Value
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05
No. years assumed for leaching to reach steady-state (years)	25.00

Soil salinity

Metric	Value
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	1.30
Salt added by rainfall (kg/ha/year)	144.17
Average annual salt added & leached at steady state (kg/ha/year)	13805.97
Average leaching fraction based on 25 -year running averages (fraction)	0.36
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.67
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	8.20
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average annual rootzone salinity and relative yield

All values based on 25 -year running averages.

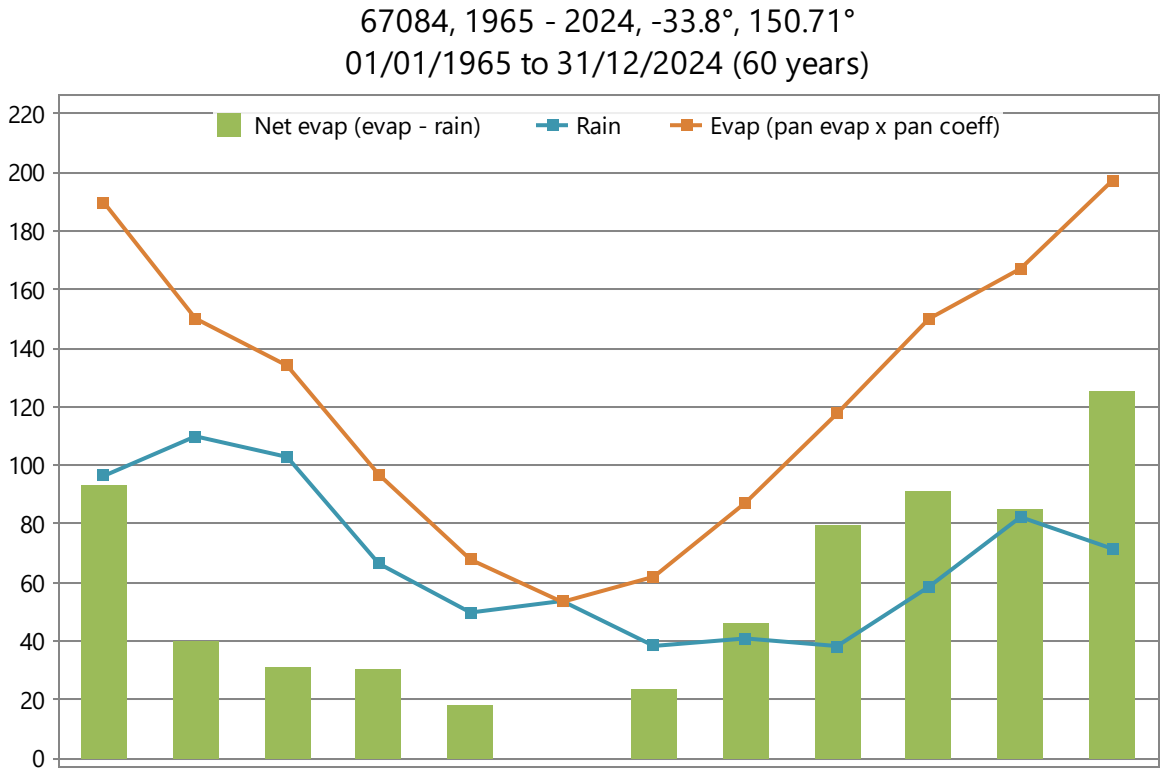


Diagnostics

Scenario information

Enterprise: 3578_IMP Orchard Hills

Climate long-term monthly averages (mm)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.4	109.9	102.9	66.5	49.8	53.7	38.4	40.9	38.3	58.6	82.4	71.6	809.4
Evap	189.8	150.1	134.0	96.9	67.9	53.4	62.0	87.3	117.7	150.0	167.1	197.1	1473.4
Net evap	93.3	40.2	31.2	30.4	18.1	-0.3	23.6	46.3	79.4	91.5	84.8	125.6	664.0
Net evap/day	3.0	1.4	1.0	1.0	0.6	0.0	0.8	1.5	2.6	3.0	2.8	4.1	1.8

Diagnostics

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Effluent Type: - 33277.13 m3/year or 91.11 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.25 *non-zero flow days/year.*

Constituent	Concentration (mg/L)	Load (kg/year)
Total nitrogen	20.00 (20.00 - 20.00)	665.54 (664.93 - 667.38)
Total phosphorus	10.00 (10.00 - 10.00)	332.77 (332.47 - 333.69)
Total dissolved salts	1500.00 (1500.00 - 1500.00)	49915.69 (49869.75 - 50053.50)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

Ammonia-N loss from pond system water surface area: 0.00 kg/m2/year

Last pond (wet weather store): 1000.00 m3

Metric	Value
Theoretical hydraulic retention time (days)	10.98
Volume of overflow (m3/year) Average (minimum-maximum)	30.59 (0.00 - 472.01)
Volume of overflow per day (m3/day) Average (minimum-maximum)	0.08 (0.00 - 122.50)
No overflow days - Average per year (Total in run period)	1.00 (60)
No. overflow events per 10 years exceeding threshold of 0.250 m3* (events/10 years)	4.67
Average overflow event recurrence interval (years)	2.14
Average duration of overflow (days)	2.14
Probability of at least 90% effluent reuse (%)	100.00
Effluent reuse (proportion of inflow + net rain gain that is irrigated) (fraction)	1.00
Average salinity (dS/m)	2.34
Salinity on final day of simulation (dS/m)	2.34

* The threshold is the volume equivalent of the top 1 mm depth of water of a full pond

Volume distribution of the overflow events

Overflow volume (m3)	Overflow events (No./10 yrs)
0	4.67
0.250101	4.67
10	4.33
20	3.83
50	2.17
100	1.00
200	0.17
242.728	0.00

Scenario information

Area irrigated: 3.65 ha total area

Loading to whole irrigation area: (assuming 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	33245.54	9108.37
Total nitrogen applied (kg)	664.91	182.17
Total phosphorus applied (kg)	332.46	91.08
Total salts applied (kg)	49868.31	13662.55

Shandying

Metric	Value
Annual allocation of fresh water for shandying (m3/year)	0.00
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Minimum shandy water is used	No

Irrigation issues

Metric	Value
Number of days without irrigation (days/year)	5.27

Diagnostics

Paddock information

Paddock: - 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Irrigation Rules
Irrigation triggered every 1 days and rainfall is less than or equal to 30.00 mm
Irrigate a fixed amount of 2.54 mm each day
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil water balance (mm): 3578_Orchard Hills_imported tops, 141.00 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.4	109.9	102.9	66.5	49.8	53.7	38.4	40.9	38.3	58.6	82.4	71.6	809.4
Efflt. irrg.	76.6	69.5	76.5	74.9	77.7	75.2	77.7	77.8	75.4	77.6	74.6	77.5	910.8
Soil evap	41.2	29.8	29.3	24.6	18.1	13.2	15.7	22.9	32.5	39.0	41.6	43.7	351.5
Transpn.	118.1	105.1	101.4	73.7	52.9	43.4	50.1	69.2	88.8	105.5	106.9	125.9	1041.0
Rain runoff	2.0	5.4	10.9	4.7	5.4	7.8	7.1	8.0	1.4	2.2	2.9	0.7	58.5
Irr. runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	12.2	12.8	15.3	18.0	22.7	30.5	35.0	33.4	28.7	24.5	20.5	17.1	270.6
Delta SW	-0.5	26.4	22.5	20.5	28.2	34.0	8.2	-14.8	-37.7	-35.1	-15.0	-38.4	-1.5

Soil nitrogen balance: (Concentrations are flow-weighted)

Metric	Value
Average annual nitrogen added in seed (kg/ha/year)	0.01
Average annual nitrogen added from irrigation (kg/ha/year)	182.17
Av. annual soil N removed by uptake (harvest + lost) (kg/ha/year)	246.63 (246.36, 0.27)
Av. annual soil nitrogen removed by denitrification (kg/ha/year)	1.98
Average annual soil nitrogen leached (kg/ha/year)	3.03
Average annual nitrate-N loading to groundwater (kg/ha/year)	3.03
Soil organic-N kg/ha (Initial - Final)	4507.50 - 416.32
Soil inorganic-N kg/ha (Initial - Final)	84.07 - 7.56
Average nitrate-N concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	1.12 (30.38)
Excluding first year of data (mg/L)	0.53 (9.01)

Soil phosphorus balance: (Concentrations are flow-weighted)

Metric	Value
Average annual phosphorus added in seed (kg/ha/year)	1.50E-03
Average annual phosphorus added from irrigation (kg/ha/year)	91.08
Av. annual soil P removed by uptake (harvest + lost) (kg/ha/yr)	51.28 (51.24, 0.03)
Average annual soil phosphorus leached (kg/ha/year)	0.01
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 3.35
Adsorbed phosphorus (kg/ha) (Initial - Final)	860.20 - 3244.76
Average phosphate-P concentration in rootzone (mg/L)	0.60
Average phosphate-P concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	2.46E-03 (4.15E-03)
Last year only (mg/L)	4.15E-03 (N.D.*)
Design soil profile storage life based on average infiltrated water phosphorus concn. of 5.48 mg/L (years)	130.16

* Not determined

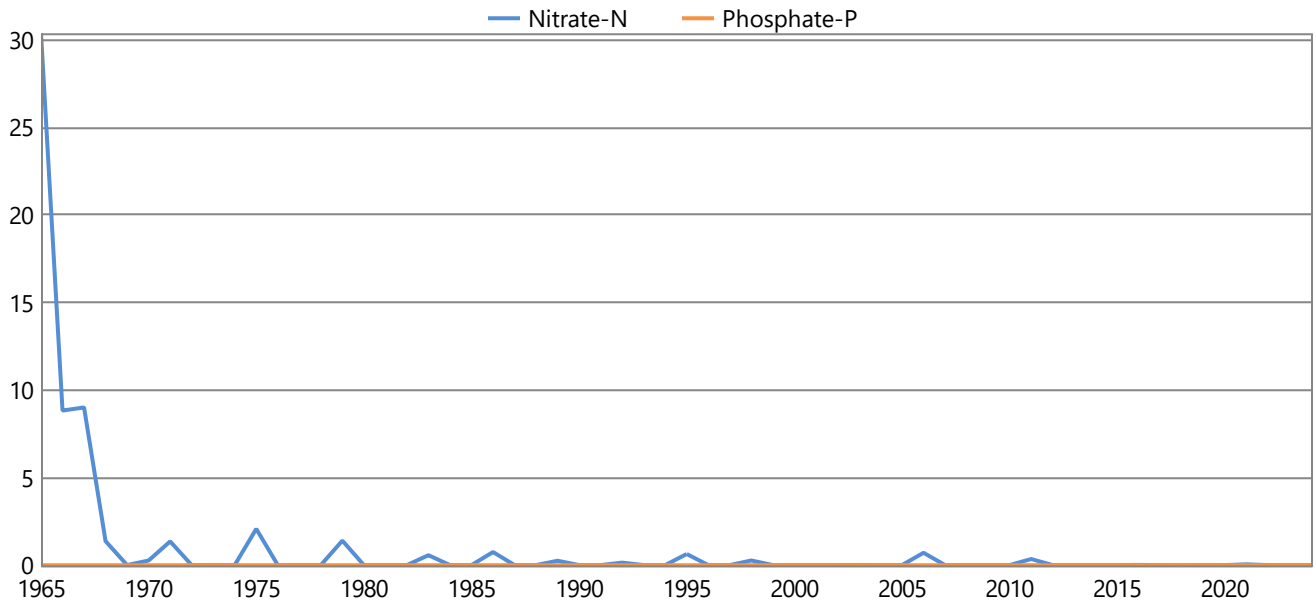
Diagnostics

Paddock information

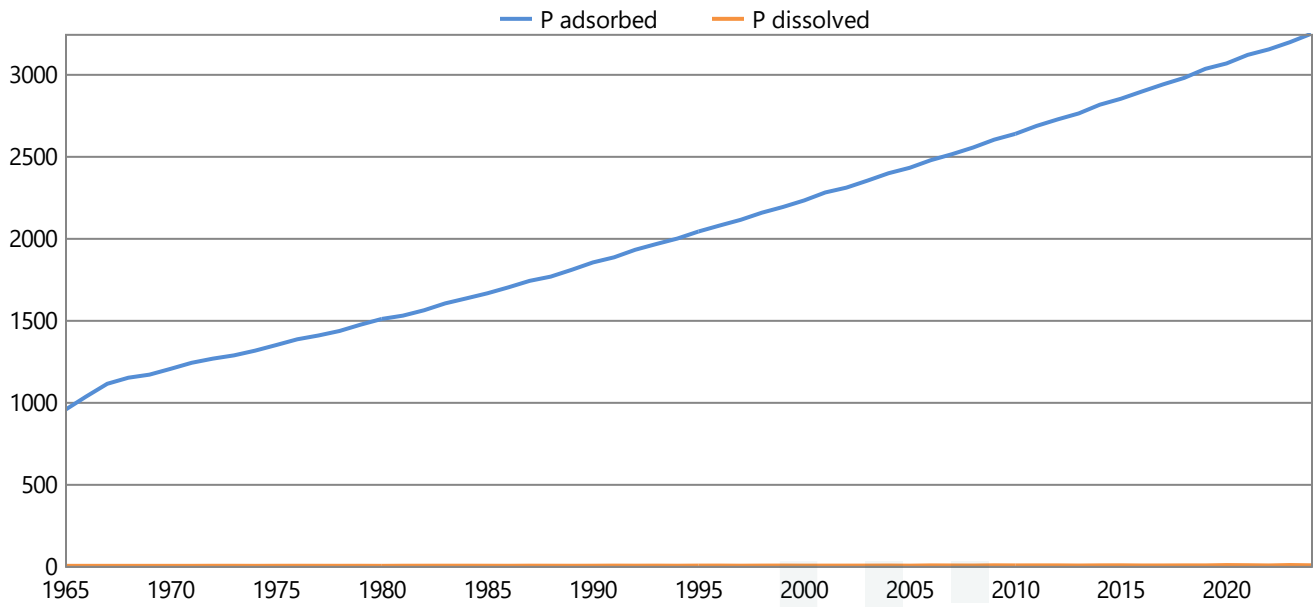
Paddock: 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual phosphate-P in soil (kg/ha)



Diagnostics

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average plant performance (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield (kg/ha/year)	17694.27 (4567.37 - 25730.16)
Average annual shoot dry matter lost (kg/ha/year)	11.68 (0.00 - 551.52)
Average monthly plant (green) cover (fraction)	0.71 (0.67 - 0.75)
Average monthly crop factor (fraction)	0.79 (0.74 - 0.83)
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Average monthly root depth (mm)	1183.99 (1176.93 - 1188.35)
Average number of normal harvests per year (no./year)	0.65 (0.00 - 1.00)
Average number of normal harvests for last five years only (no./year)	0.60
Average number of forced harvests per year (no./year)	0.00 (0.00 - 0.00)
Average number of forced harvests for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.38 (0.00 - 0.60)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.06)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.77 (0.58 - 0.95)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.06 (0.00 - 0.17)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.07)
No. days without crop per year. Excludes bare fallow days (days)	0.00

Soil salinity - plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 25 -year running averages.

Metric	Value
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	1.30
Salt added by rainfall (kg/ha/year)	144.17
Average annual salt added & leached at steady state (kg/ha/year)	13805.97
Average leaching fraction based on 25 -year running averages (fraction)	0.36
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.67
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	8.20
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Diagnostics

Run information

Messages generated when the scenario was run
********** WASTESTREAM RESULTS **********
TABLE OF QUANTITY AND QUALITY OF EACH RAINFALL-INDEPENDENT WASTESTREAM (AFTER PRETREATMENT AND BEFORE ENTERING ANY SEDIMENTATION BASIN)
_____
Source Volume_m3/yr N conc_mg/L P conc_mg/L TDS conc_mg/L N load_kg/yr P load_kg/yr TDS load_kg/yr
New generic system 33277.1 20.0 10.0 1500.0 665.5 332.8 49915.7
_____
********** END WASTESTREAM RESULTS **********
WARNING: Plant phosphorus deficiency. No soil phosphorus has been available for plant uptake for 0.58% of days of simulation.
UNCONDITIONAL FINISH

General Information

SCENARIO REPORT: Full run

General information

Enterprise: 3578_IMP Orchard Hills
Client: Jordan Jennings - AquaCell P/L
MEDLI user: WHITEHEAD2012\marksaunders

Description:

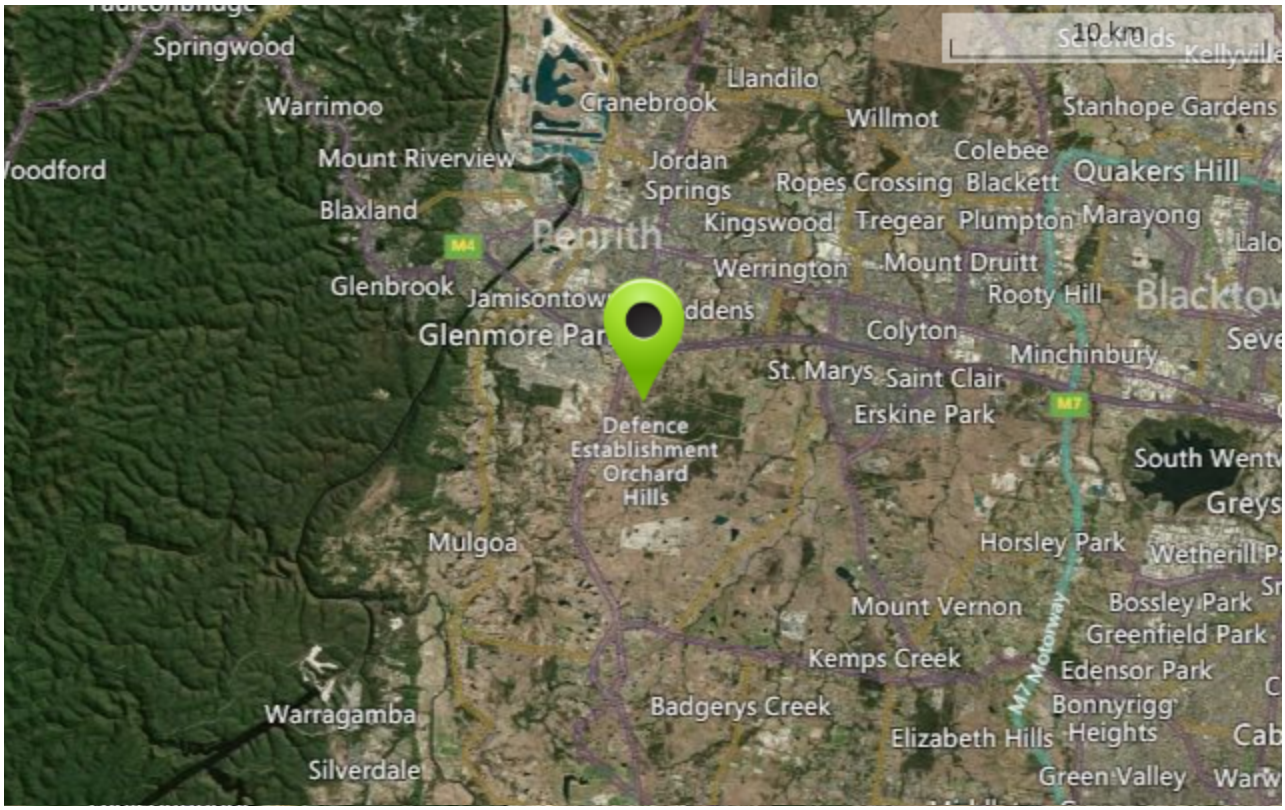
RWIZ design for Alspec Business Park; Luddenham Rd, Orchard Hills

Scenario details:

3578 - RWMS for Alspec Business Park, Original Climate Data, Dryland Melaleuca alternifolia pasture altered as per COPE Landscaping; Kickstarted MCC to 1.1 RUE to 9 MSN to 0.03 MSP to 0.0024 MSNCLGO to 0.006 MSNCLGOO to 0.024 MSNCDMGO to 0.06 MSNCDMGOO to 0.024, constructed 900mm Cat 2 topsoil.

Map of location:

Note: If the map above appears as a dark box, check that the network is accessible and that the coordinates are not for a location in the ocean.



Description

Climate information

Climate Data Location: 067084_RCP45_2050_M_CNRM-CM5_-33.8020_150.7069_CFV2.0, -33.802°, 150.7069°

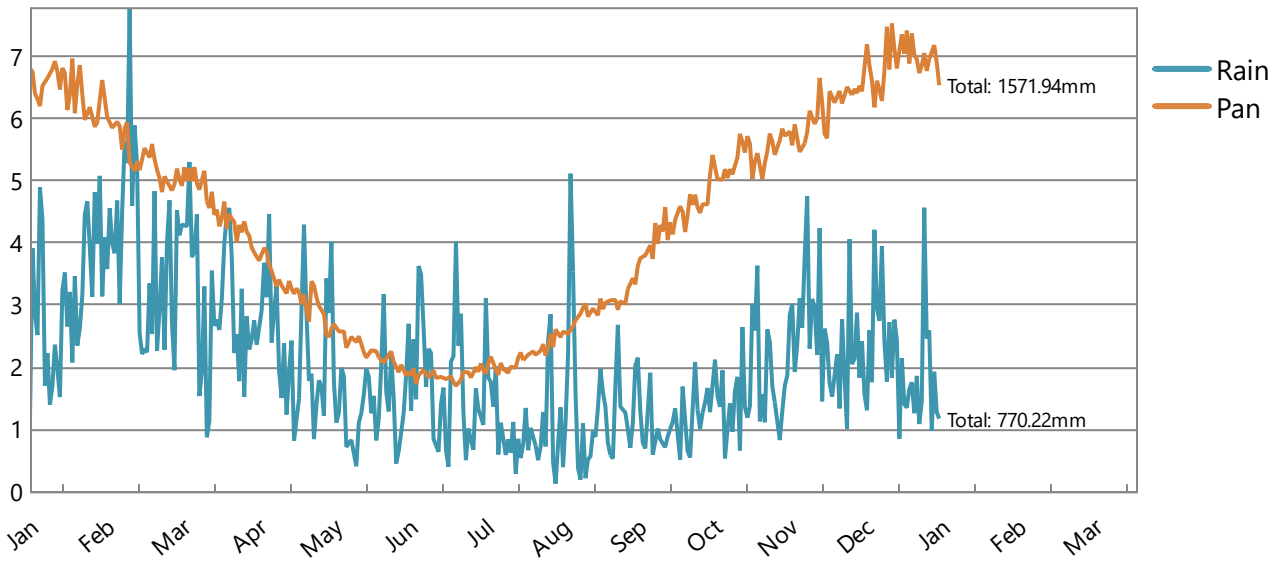
Run Period: 01/01/1965 to 31/12/2024 (60 years)

Climate statistics

	5th Percentile		50th Percentile		95th Percentile	
Rainfall (mm/year)	(Year 1979)	451.6	(Year 1975)	755.6	(Year 1988)	1163.4
Pan evaporation (mm/year)	(Year 1999)	1391.6	(Year 2003)	1562.8	(Year 1977)	1778.7

Climate data

Daily average across run period:



Description

Wastestream information

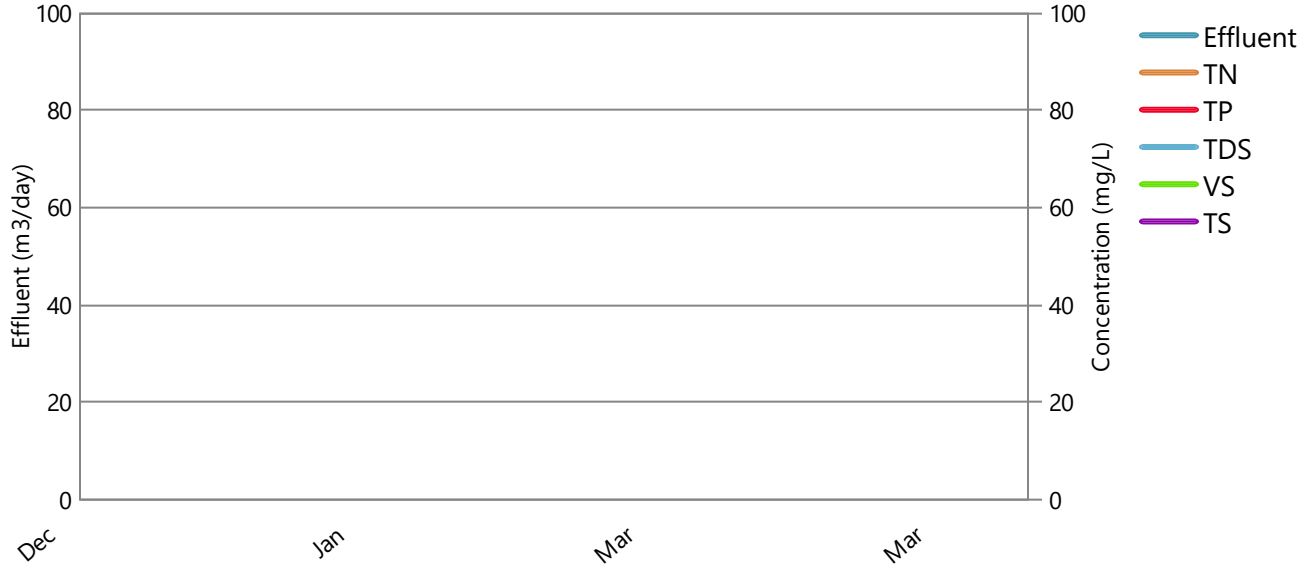
Wastestream Name: - New generic system

Wastestream production description

Daily New generic system data supplied for a representative year. This wastestream is not separately pretreated.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream

Effluent Quantity: 0.00 m3/year or 0.00 m3/day (Min-Max 0.00 - 0.00)

Flow-Weighted Average (Min - Max) Daily Effluent Quality Entering the Pond System:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total phosphorus	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total dissolved salts	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

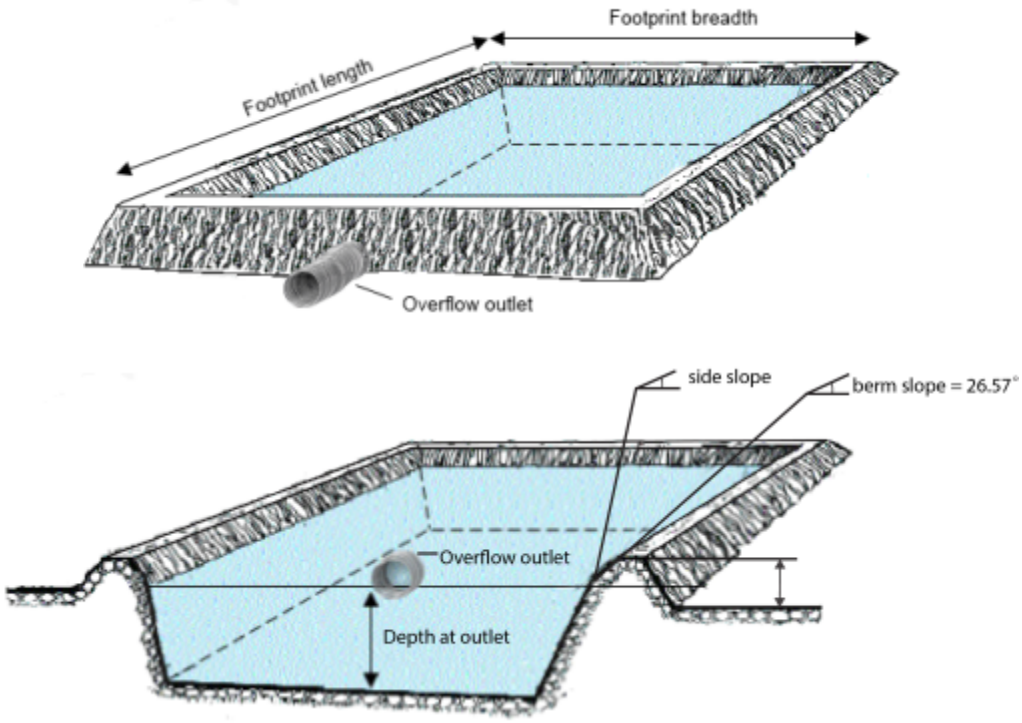
Description

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system details

	Pond 1
Maximum pond volume (m3)	1000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	4.00
Maximum water surface area (m2)	250.10
Pond footprint length (m)	15.81
Pond footprint width (m)	15.81
Pond catchment area (m2)	250.10
Average active volume (m3)	0.00



Irrigation pump limits

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump rate per area limit (ML/day/ha)	1.00

Shandying water

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	No

Description

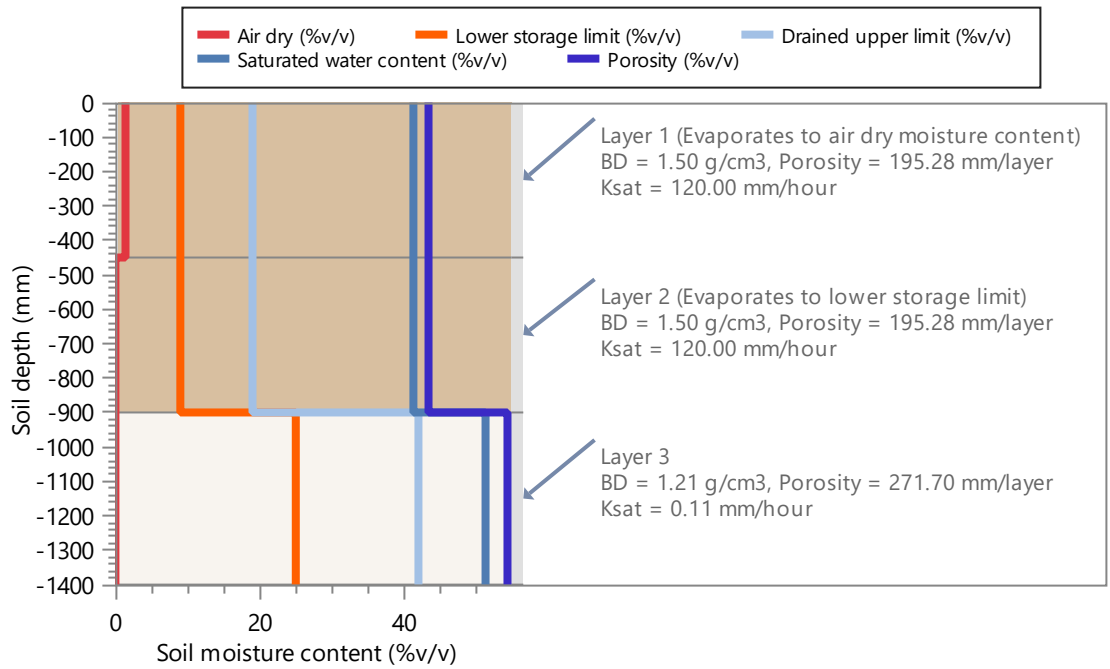
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Soil type: 3578_Orchard Hills_imported tops, 1400.00 mm defined profile depth

Profile porosity (mm)	662.26
Profile saturation water content (mm)	628.20
Profile drained upper limit (or field capacity) (mm)	381.00
Profile lower storage limit (or permanent wilting point) (mm)	206.00
Profile available water capacity (mm)	175.00
Profile limiting saturated hydraulic conductivity (mm/hour)	0.11
Surface saturated hydraulic conductivity (mm/hour)	120.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	7.75
Soil evaporation Cona (mm/sqrt day)	3.50

Profile



Planting regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average monthly cover (fraction) (minimum - maximum)	0.05 (0.04 - 0.06)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 1.1 x Pan coefficient 1)	1.10
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Potential rooting depth in defined soil profile (mm)	861.14
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05

Irrigation rules: Pressure-compensating SSI

Rule 1. Irrigation triggered every 1 days and rainfall is less than or equal to 2000.00 mm
Rule 2. Irrigate up to a soil water content of drained upper limit plus 2.28 mm
Rule 3. Irrigation window from 1/1 to 31/12 including the days specified
Rule 4. A minimum of 0 days must be skipped between irrigation events

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank (wet weather storage pond: 1000 m3)

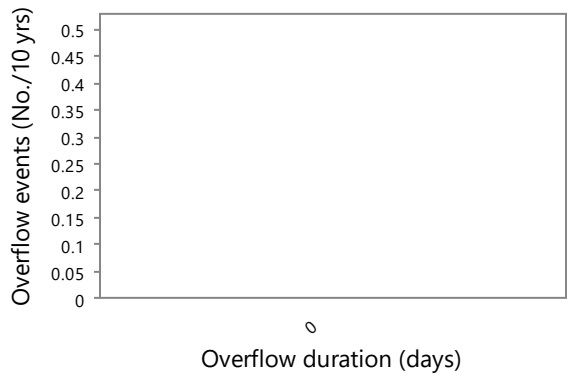
Pond system water balance (m3/year)

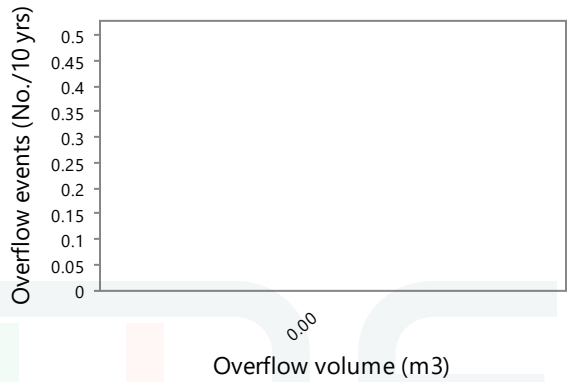
(no data available)

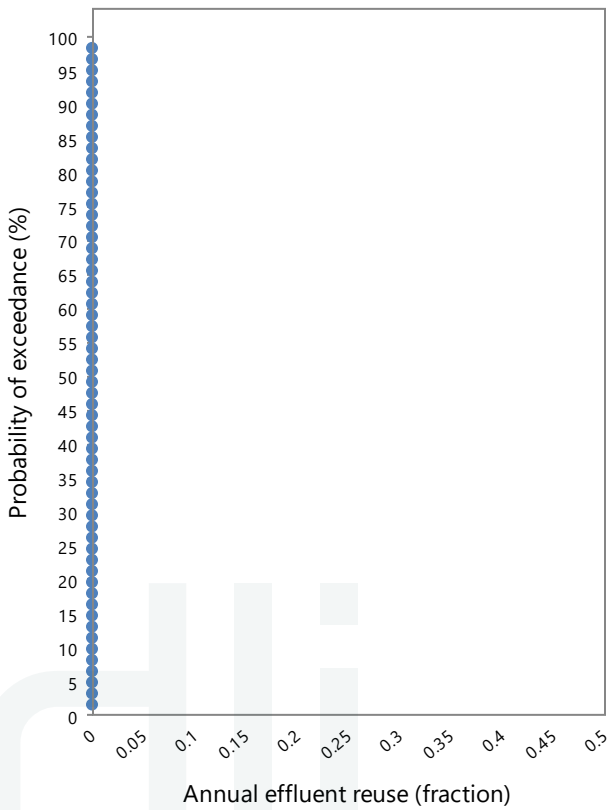
Name	Value
Rain	0.00
Inflow	0.00
Recycling	0.00
Evaporation	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Removed in sludge	0.00
Delta storage	0.00

Overflow and reuse diagnostics

Metric	Value
Total volume of overflow (m3/10 years)	0.00
Total number of overflow events (events/10 years)	0.00
Total number of pond overflow days (days/10 years)	0.00
Probability of at least 90% effluent reuse (%)	0.00
Effluent reuse (Proportion of inflow + net gain in rain that is irrigated) (fraction)	0.00







Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system nitrogen balance (kg/year)

(no data available)

Name	Value
Inflow	0.00
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Delta storage	0.00

Pond system phosphorus balance (kg/year)

(no data available)

Name	Value
Inflow	0.00
Recycling	0.00
Sludge	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Delta storage	0.00

Pond system salt balance (kg/year)

(no data available)

Name	Value
Inflow	0.00
Recycling	0.00
Sludge*	0.00
Overflow	0.00
Irrigation	0.00
Seepage	0.00
Delta storage	0.00

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond system sludge accumulation: 0.00 kg dwt/year

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond nutrient concentrations and salinity

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	0.00
Average phosphorus concentration of pond liquid (mg/L)	0.00
Average salinity of pond liquid (dS/m)	0.00

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	N.D.*
Final phosphorus concentration of pond liquid (mg/L)	N.D.*
Final salinity of pond liquid (dS/m)	N.D.*

* Not determined. Pond is empty.

Performance

Water use (assumes 100% irrigation efficiency)

Metric	Value
Pond water irrigated (m3/year)	0.00
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	0.00
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation quality

Metric	Value
Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	0.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	0.00
Average phosphorus concentration of irrigation water (mg/L)	0.00
Average salinity of irrigation water (dS/m)	0.00

Irrigation diagnostics (No effluent irrigation occurred!)

Metric	Value
No. periods/year without any irrigable effluent in the wet weather storage pond (periods/year)	0.00
Average length of such periods (days)	0.00

Irrigation triggering and application

No. Days without Irrigation Applied per Year: 365.25 (with irrigation too small, <0.0001 mm, to apply)
No. Days without Irrigation Applied per Year: 365.25 (with no supply - no application)
No. Days with Irrigation Applied per Year: 0.00
No. Days with Irrigation Triggered per Year: 365.25

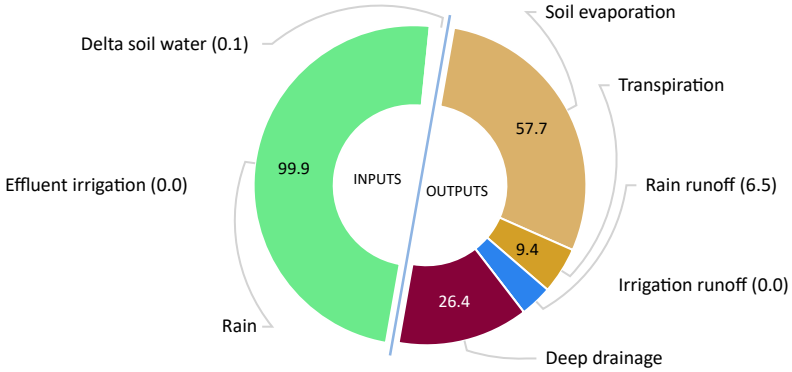
Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

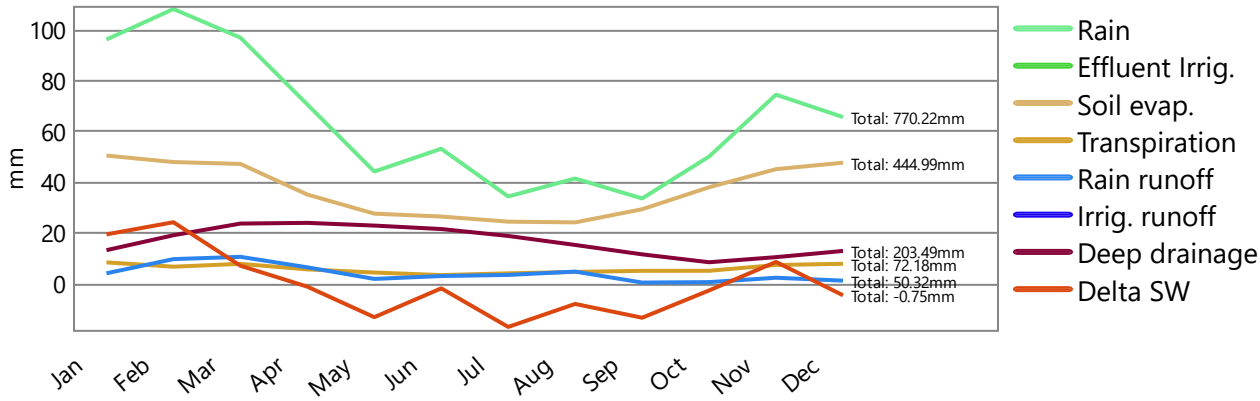
Soil Type: 3578_Orchard Hills_imported tops, 86.11 mm PAWC at maximum root depth

Soil water balance (%)

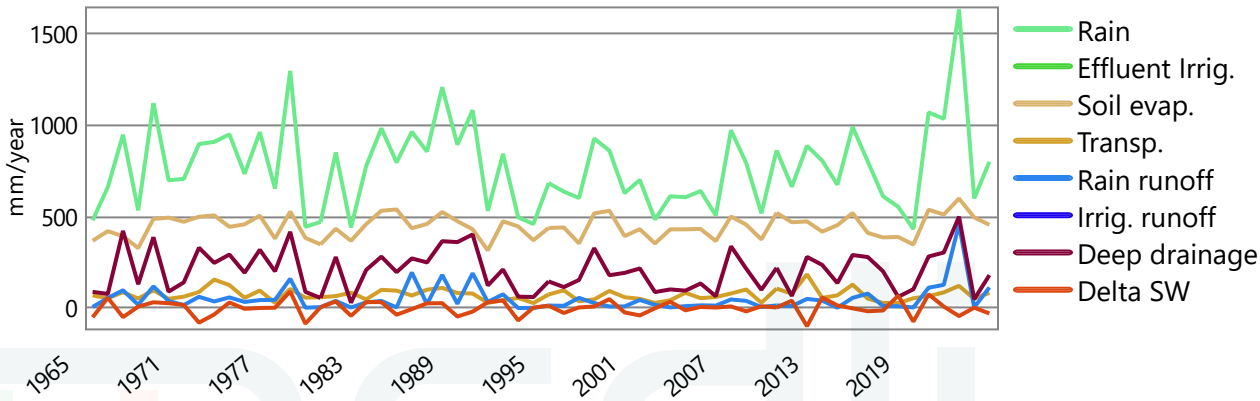


Name	Value
Rain	99.9
Effluent irrigation	0.0
Soil evaporation	57.7
Transpiration	9.4
Rain runoff	6.5
Irrigation runoff	0.0
Deep drainage	26.4
Delta soil water	-0.1

Average monthly totals (mm)



Average annual totals (mm/year)

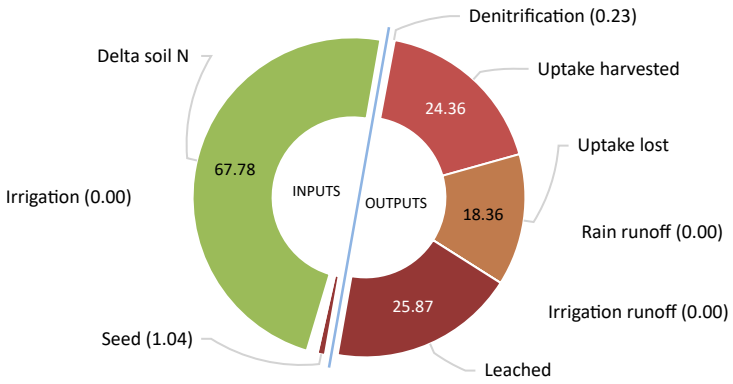


Performance

Paddock information

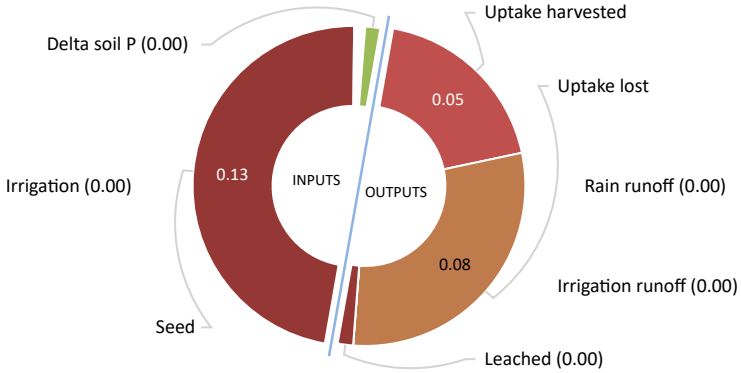
Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Irrigation Ammonia-N Volatilisation Losses (kg/ha/year): 0.00
Proportion of Total Nitrogen in Irrigated Effluent as Ammonium (fraction): 0.30

Soil nitrogen balance (kg/ha/year)



Name	Value
Seed	1.04
Irrigation	0.00
Denitrification	0.23
Uptake harvested	24.36
Uptake lost	18.36
Rain runoff	0.00
Irrigation runoff	0.00
Leached	25.87
Delta soil N	-67.78

Soil phosphorus balance (kg/ha/year)



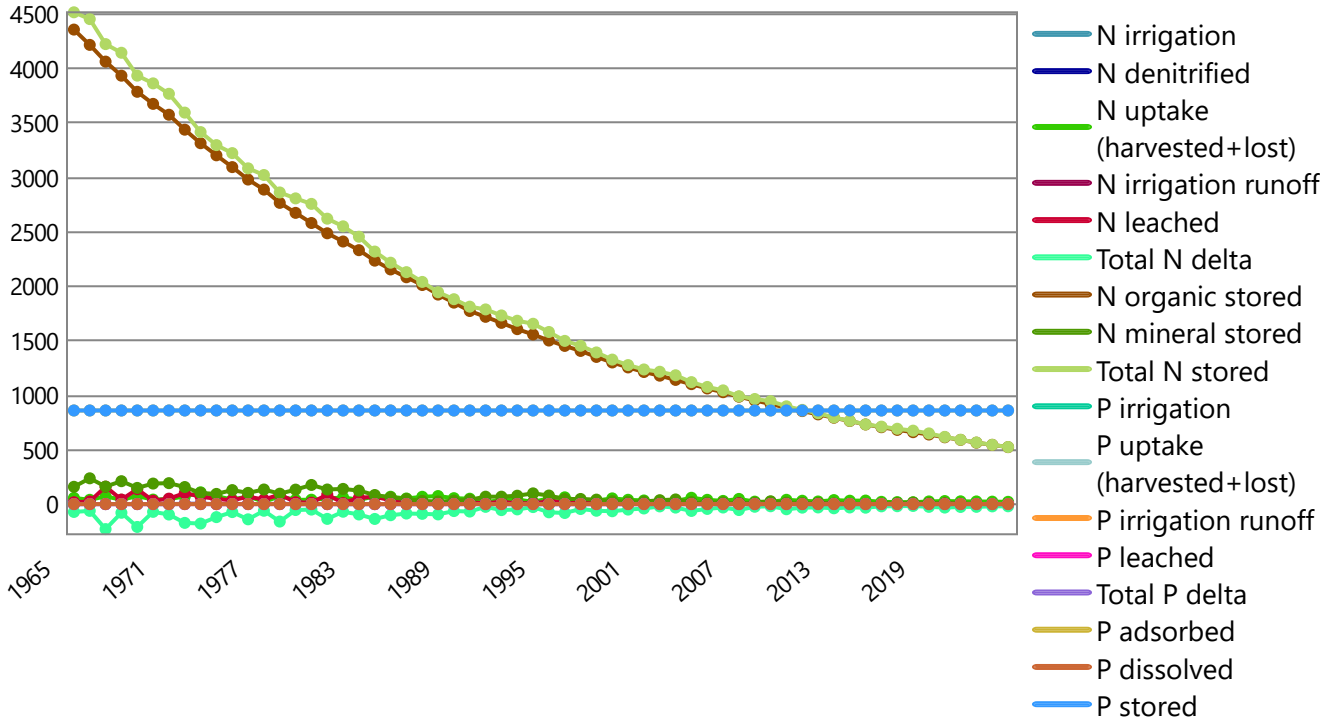
Name	Value
Seed	0.13
Irrigation	0.00
Uptake harvested	0.05
Uptake lost	0.08
Rain runoff	0.00
Irrigation runoff	0.00
Leached	4.17E-03
Delta soil P	-4.17E-03

Performance

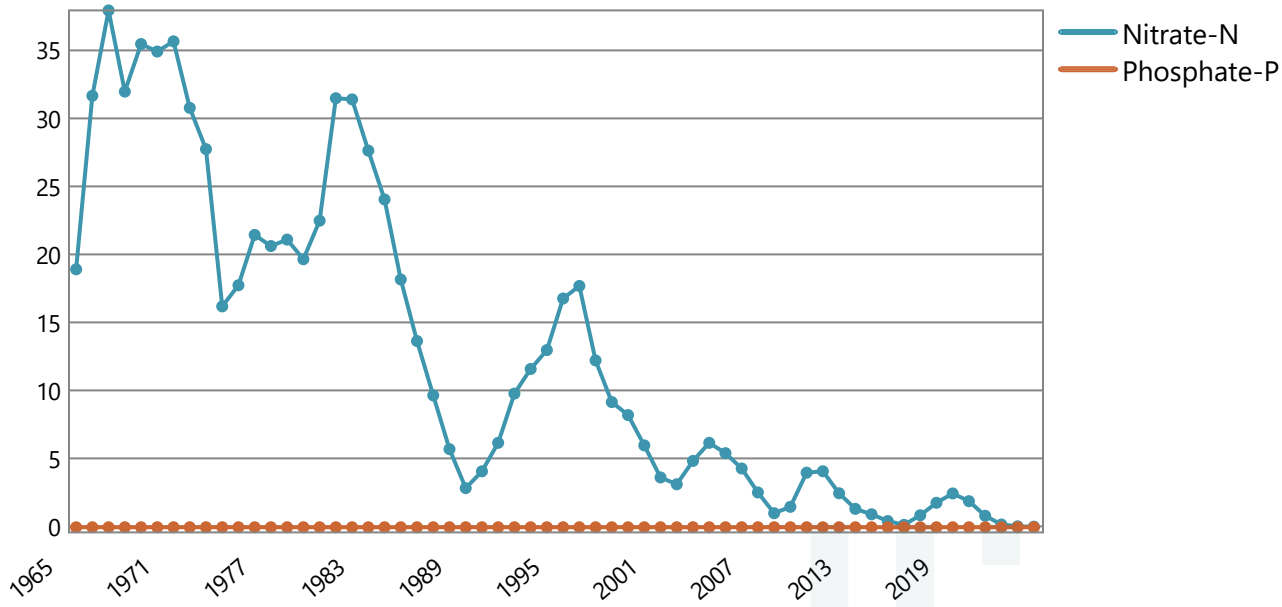
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops

Annual nutrient totals (kg/ha)



Annual nutrient leaching concentration (mg/L)



Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant growth (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield* (kg/ha/year)	1134.20 (-221.26 - 3612.88)
Average annual shoot dry matter lost (kg/ha/year)	798.69 (0.00 - 1507.82)
Average monthly plant (green) cover (fraction)	0.05 (0.04 - 0.06)
Average monthly root depth (mm)	205.24 (152.83 - 241.27)

Plant nutrient uptake (minimum - maximum)

Metric	Value
Average annual shoot nitrogen in harvestable yield* (kg/ha/year)	24.36 (-6.36 - 90.81)
Average annual shoot nitrogen lost (kg/ha/year)	18.36 (0.00 - 32.54)
Average annual shoot phosphorus in harvestable yield* (kg/ha/year)	0.05 (-0.05 - 0.16)
Average annual shoot phosphorus lost (kg/ha/year)	0.08 (0.00 - 0.25)
Average annual shoot nitrogen concentration (fraction dwt)	0.02 (0.01 - 0.03)
Average annual shoot phosphorus concentration (fraction dwt)	0.000 (0.000 - 0.001)

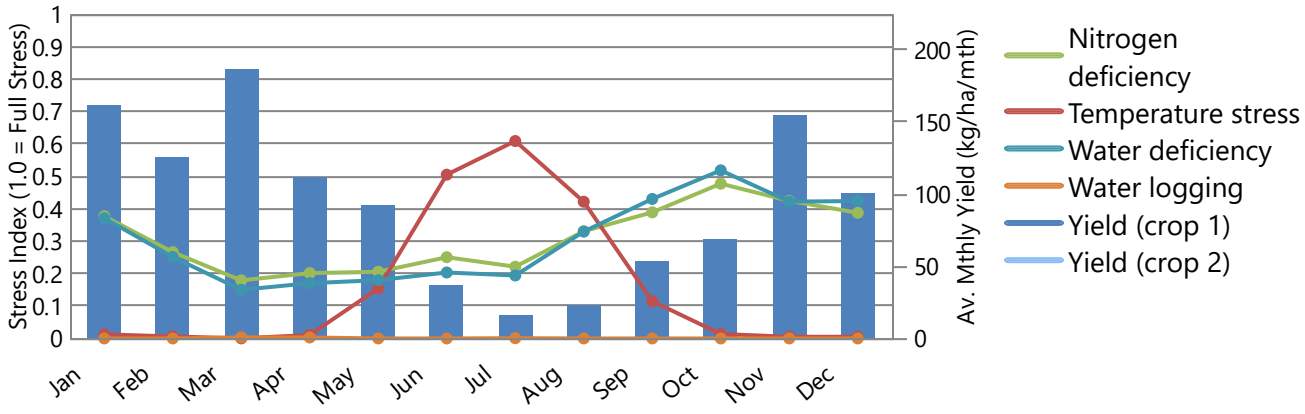
*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Performance

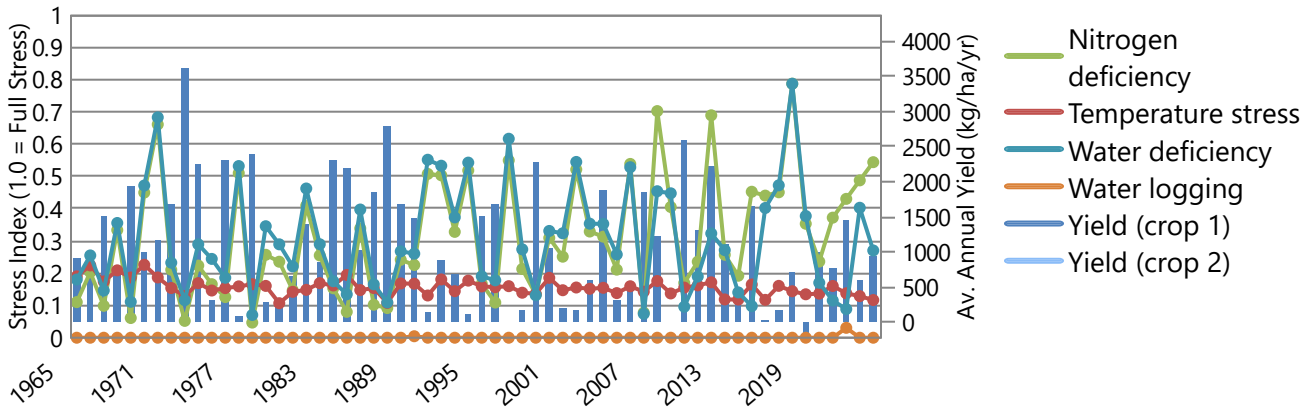
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Av. monthly stresses & harvestable yield* (kg/ha/month)



Av. annual stresses & harvestable yield* (kg/ha/year)



*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Normal and forced harvest information

No. of Harvests per Year: 0.00 (normal), 1.43 (forced by crop death due to water stress).
No. Days without Crop per Year (no./year): 97.10 (due to water stress [95.58], temperature stress - not frost [1.28] and frosting [0.23])

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant salinity tolerance

Metric	Value
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05
No. years assumed for leaching to reach steady-state (years)	25.00

Soil salinity

Metric	Value
Average Infiltrate Salinity (dS/m)	0.03

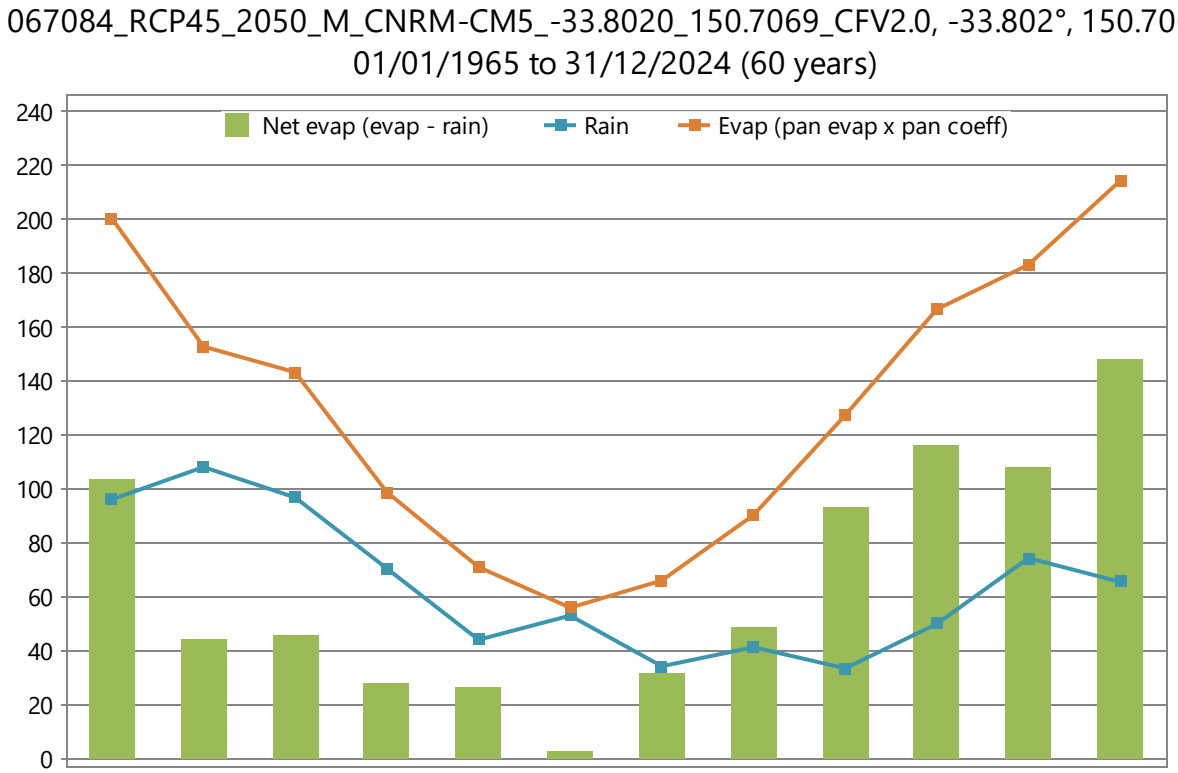
No salinity calculations as no irrigation occurred.

Diagnostics

Scenario information

Enterprise: 3578_IMP Orchard Hills

Climate long-term monthly averages (mm)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.3	108.3	97.0	70.7	44.3	53.3	34.5	41.6	33.7	50.2	74.6	65.8	770.2
Evap	200.5	153.0	143.4	99.0	71.3	56.2	66.3	90.5	127.5	166.7	183.3	214.4	1571.9
Net evap	104.2	44.7	46.4	28.3	26.9	2.9	31.8	48.9	93.8	116.5	108.7	148.6	801.7
Net evap/day	3.4	1.6	1.5	0.9	0.9	0.1	1.0	1.6	3.1	3.8	3.6	4.8	2.2

Diagnostics

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Effluent Type: - 0.00 m3/year or 0.00 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 0.00 *non-zero flow days/year.*

Constituent	Concentration (mg/L)	Load (kg/year)
Total nitrogen	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total phosphorus	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total dissolved salts	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

Ammonia-N loss from pond system water surface area: 0.00 kg/m2/year

Last pond (wet weather store): 1000.00 m3

Metric	Value
Theoretical hydraulic retention time (days)	0.00
Volume of overflow (m3/year) Average (minimum-maximum)	0.00 (0.00 - 0.00)
Volume of overflow per day (m3/day) Average (minimum-maximum)	0.00 (0.00 - 0.00)
No overflow days - Average per year (Total in run period)	0.00 (0)
No. overflow events per 10 years exceeding threshold of 0.250 m3* (events/10 years)	0.00
Average overflow event recurrence interval (years)	0.00
Average duration of overflow (days)	0.00
Probability of at least 90% effluent reuse (%)	0.00
Effluent reuse (proportion of inflow + net rain gain that is irrigated) (fraction)	0.00
Average salinity (dS/m)	0.00
Salinity on final day of simulation (dS/m)	0.00

* The threshold is the volume equivalent of the top 1 mm depth of water of a full pond

Volume distribution of the overflow events

Overflow volume (m3)	Overflow events (No./10 yrs)
0	0.00

Diagnostics

Scenario information

Area irrigated: 3.65 ha total area

Loading to whole irrigation area: (assuming 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	0.00	0.00
Total nitrogen applied (kg)	0.00	0.00
Total phosphorus applied (kg)	0.00	0.00
Total salts applied (kg)	0.00	0.00

Shandying

Metric	Value
Annual allocation of fresh water for shandying (m3/year)	0.00
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Minimum shandy water is used	No

Irrigation issues

Metric	Value
Number of days without irrigation (days/year)	365.25

Diagnostics

Paddock information

Paddock: - 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Irrigation Rules
Irrigation triggered every 1 days and rainfall is less than or equal to 2000.00 mm
Irrigate up to a soil water content of drained upper limit plus 2.28 mm
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil water balance (mm): 3578_Orchard Hills_imported tops, 86.11 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.3	108.3	97.0	70.7	44.3	53.3	34.5	41.6	33.7	50.2	74.6	65.8	770.2
Efflt. irrg.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Soil evap	50.6	48.0	47.3	35.2	27.7	26.6	24.6	24.3	29.5	38.1	45.2	47.8	445.0
Transpn.	8.5	6.8	8.0	5.8	4.5	3.5	4.2	4.8	5.2	5.2	7.5	8.0	72.2
Rain runoff	4.2	9.8	10.7	6.6	2.0	3.2	3.6	4.9	0.6	0.8	2.5	1.4	50.3
Irr. runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	13.3	19.2	23.8	24.1	23.0	21.7	18.9	15.4	11.7	8.6	10.6	13.0	203.5
Delta SW	19.6	24.4	7.2	-1.0	-13.0	-1.7	-16.9	-7.8	-13.3	-2.5	8.7	-4.4	-0.8

Soil nitrogen balance: (Concentrations are flow-weighted)

Metric	Value
Average annual nitrogen added in seed (kg/ha/year)	1.04
Average annual nitrogen added from irrigation (kg/ha/year)	0.00
Av. annual soil N removed by uptake (harvest + lost) (kg/ha/year)	42.72 (24.36, 18.36)
Av. annual soil nitrogen removed by denitrification (kg/ha/year)	0.23
Average annual soil nitrogen leached (kg/ha/year)	25.87
Average annual nitrate-N loading to groundwater (kg/ha/year)	25.87
Soil organic-N kg/ha (Initial - Final)	4507.50 - 523.52
Soil inorganic-N kg/ha (Initial - Final)	84.07 - 0.96
Average nitrate-N concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	12.71 (37.93)
Excluding first year of data (mg/L)	12.67 (37.93)

Soil phosphorus balance: (Concentrations are flow-weighted)

Metric	Value
Average annual phosphorus added in seed (kg/ha/year)	0.13
Average annual phosphorus added from irrigation (kg/ha/year)	0.00
Av. annual soil P removed by uptake (harvest + lost) (kg/ha/yr)	0.13 (0.05, 0.08)
Average annual soil phosphorus leached (kg/ha/year)	4.17E-03
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 0.01
Adsorbed phosphorus (kg/ha) (Initial - Final)	860.20 - 859.95
Average phosphate-P concentration in rootzone (mg/L)	2.04E-03
Average phosphate-P concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	2.05E-03 (2.05E-03)
Last year only (mg/L)	2.05E-03 (N.D.*)
Design soil profile storage life based on average infiltrated water phosphorus concn. of 0.00 mg/L (years)	999.00

* Not determined

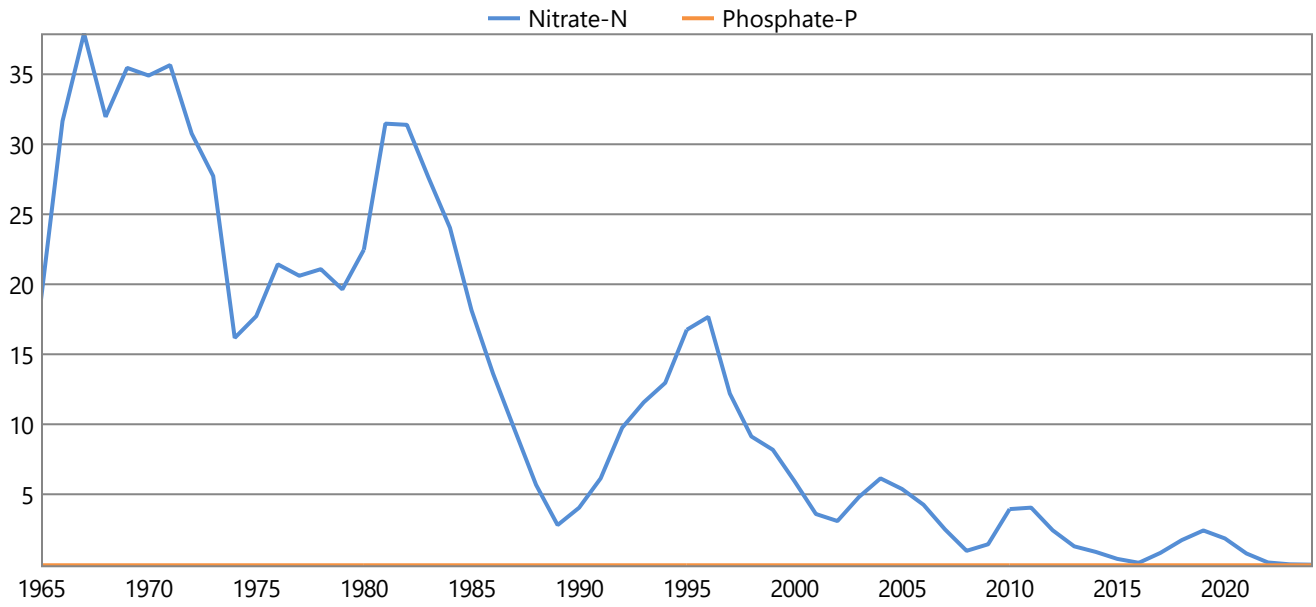
Diagnostics

Paddock information

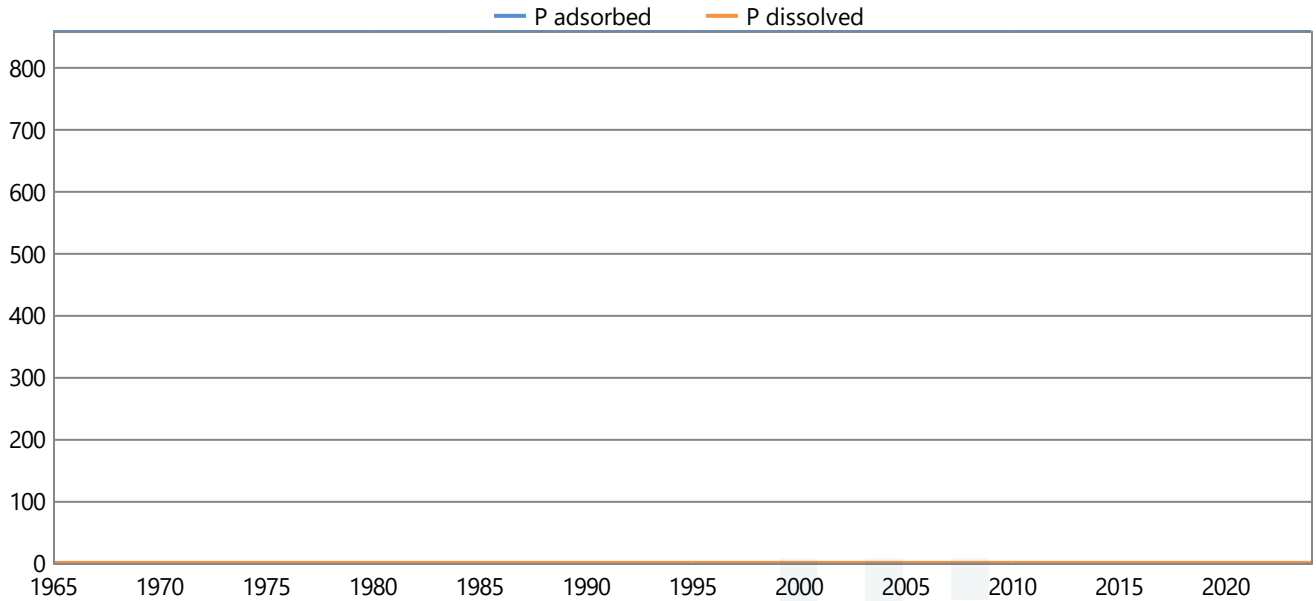
Paddock: 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual phosphate-P in soil (kg/ha)



Diagnostics

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average plant performance (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield (kg/ha/year)	1134.20 (-221.26 - 3612.88)
Average annual shoot dry matter lost (kg/ha/year)	798.69 (0.00 - 1507.82)
Average monthly plant (green) cover (fraction)	0.05 (0.04 - 0.06)
Average monthly crop factor (fraction)	0.06 (0.04 - 0.07)
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Average monthly root depth (mm)	205.24 (152.83 - 241.27)
Average number of normal harvests per year (no./year)	0.00 (0.00 - 0.00)
Average number of normal harvests for last five years only (no./year)	0.00
Average number of forced harvests per year (no./year)	1.43 (0.00 - 3.00)
Average number of forced harvests for last five years only (no./year)	1.20
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.31 (0.05 - 0.79)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.01 (0.00 - 0.11)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.61 (0.40 - 0.85)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.30 (0.15 - 0.52)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.00 (0.00 - 0.00)
No. days without crop per year. Excludes bare fallow days (days)	97.10

Soil salinity - plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 25 -year running averages.

No salinity calculations as no irrigation occurred.

Diagnostics

Run information

Messages generated when the scenario was run
********** WASTESTREAM RESULTS **********
TABLE OF QUANTITY AND QUALITY OF EACH RAINFALL-INDEPENDENT WASTESTREAM (AFTER PRETREATMENT AND BEFORE ENTERING ANY SEDIMENTATION BASIN)
_____
Source Volume_m3/yr N conc_mg/L P conc_mg/L TDS conc_mg/L N load_kg/yr P load_kg/yr TDS load_kg/yr
New generic system 0.0 0.0 0.0 0.0 0.0 0.0 0.0
_____
********** END WASTESTREAM RESULTS **********
No. Days without Irrigation Applied per Year: 365.25 (with irrigation too small, <0.0001 mm, to apply)
This is a Dryland scenario
No effluent irrigation has occurred!
WARNING: Soil phosphorus adsorption capacity was already exhausted at start of run
WARNING: Pasture yield and soil nutrient balances may be INVALID due to the frequent kickstarting of pasture establishment. Try to reduce the number of forced harvests.
WARNING: Plant phosphorus deficiency. No soil phosphorus has been available for plant uptake for 68.47% of days of simulation.
WARNING: Plant phosphorus deficiency. At shoot P concentrations below 0.2% dry weight, many plant species will show reduced yields due to phosphorus deficiency. Please check if this is true for the simulated species, as if so, the predicted plant yield and soil nutrient balances will be INVALID!
WARNING: CONDITIONAL FINISH!

General Information

SCENARIO REPORT: Full run

General information

Enterprise: 3578_IMP Orchard Hills
Client: Jordan Jennings - AquaCell P/L
MEDLI user: WHITEHEAD2012\marksaunders

Description:

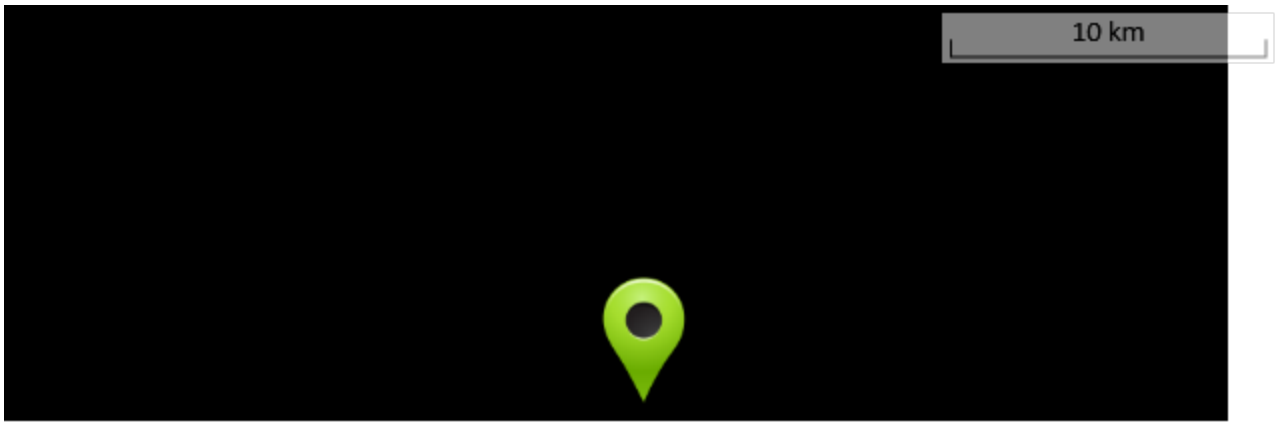
RWIZ design for Alspec Business Park; Luddenham Rd, Orchard Hills

Scenario details:

3578 - Run002e: RW irrigation (12.25 - 122.5kL per day); RCP4.5 projected Climate Data; 3.65ha RWIZ; 1ML storage; IT = fixed daily IRR depth 2.54mm; 30mm Rainfall Override; 1.2m (engineered) soil profile and enhanced Tea Tree crop (as per COPE Landscaping Plan).

Map of location:

Note: If the map above appears as a dark box, check that the network is accessible and that the coordinates are not for a location in the ocean.



Description

Climate information

Climate Data Location: 067084_RCP45_2050_M_CNRM-CM5_-33.8020_150.7069_CFV2.0, -33.802°, 150.7069°

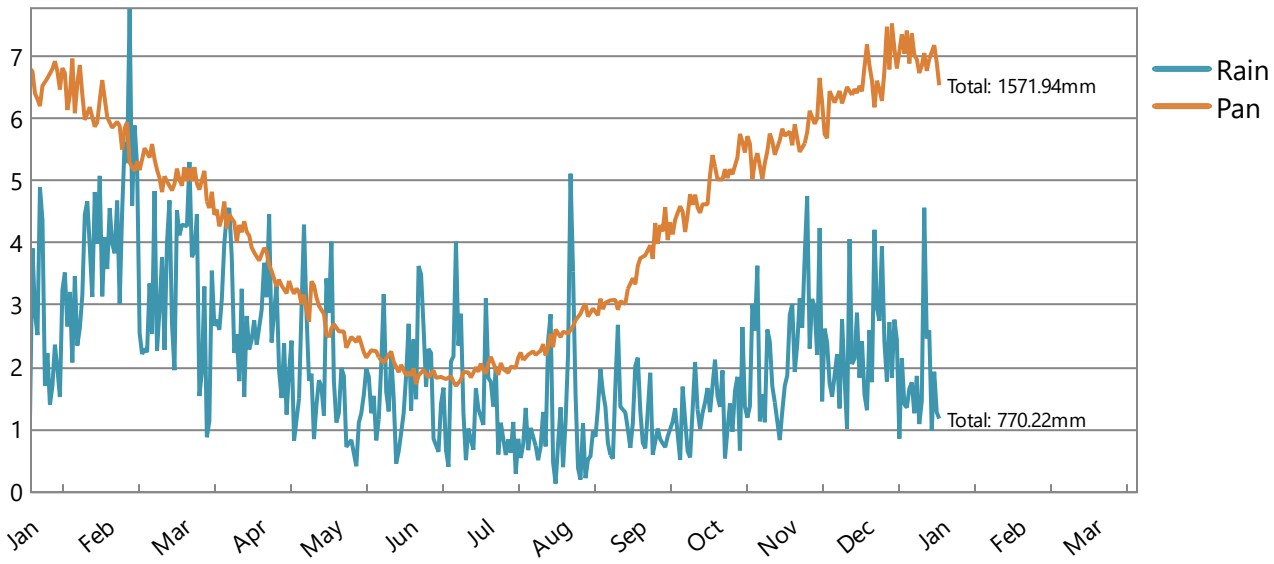
Run Period: 01/01/1965 to 31/12/2024 (60 years)

Climate statistics

	5th Percentile		50th Percentile		95th Percentile	
Rainfall (mm/year)	(Year 1979)	451.6	(Year 1975)	755.6	(Year 1988)	1163.4
Pan evaporation (mm/year)	(Year 1999)	1391.6	(Year 2003)	1562.8	(Year 1977)	1778.7

Climate data

Daily average across run period:



Description

Wastestream information

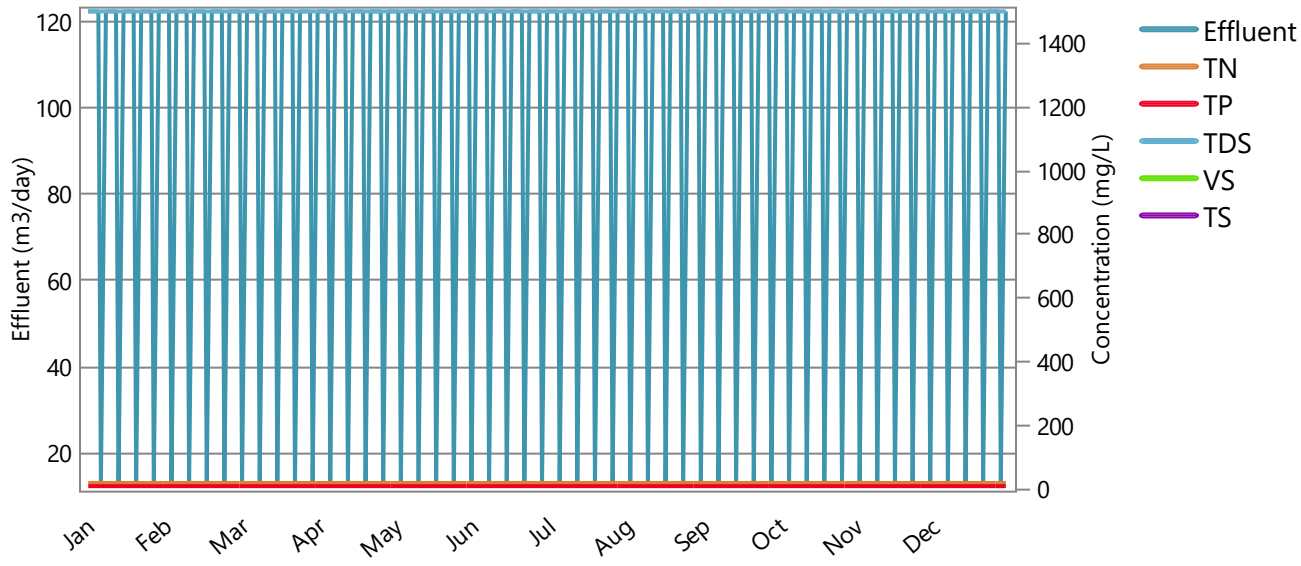
Wastestream Name: - New generic system

Wastestream production description

Daily New generic system data supplied for a representative year. This wastestream is not separately pretreated.

Wastestream

Average Daily Quantity and Flow-Weighted Average Quality:



Wastestream

Effluent Quantity: 33277.13 m3/year or 91.11 m3/day (Min-Max 12.25 - 122.50)

Flow-Weighted Average (Min - Max) Daily Effluent Quality Entering the Pond System:

	Concentration (mg/L)	Load (kg/year)
Total nitrogen	20.00 (20.00 - 20.00)	665.54 (664.93 - 667.38)
Total phosphorus	10.00 (10.00 - 10.00)	332.77 (332.47 - 333.69)
Total dissolved salts	1500.00 (1500.00 - 1500.00)	49915.69 (49869.75 - 50053.50)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

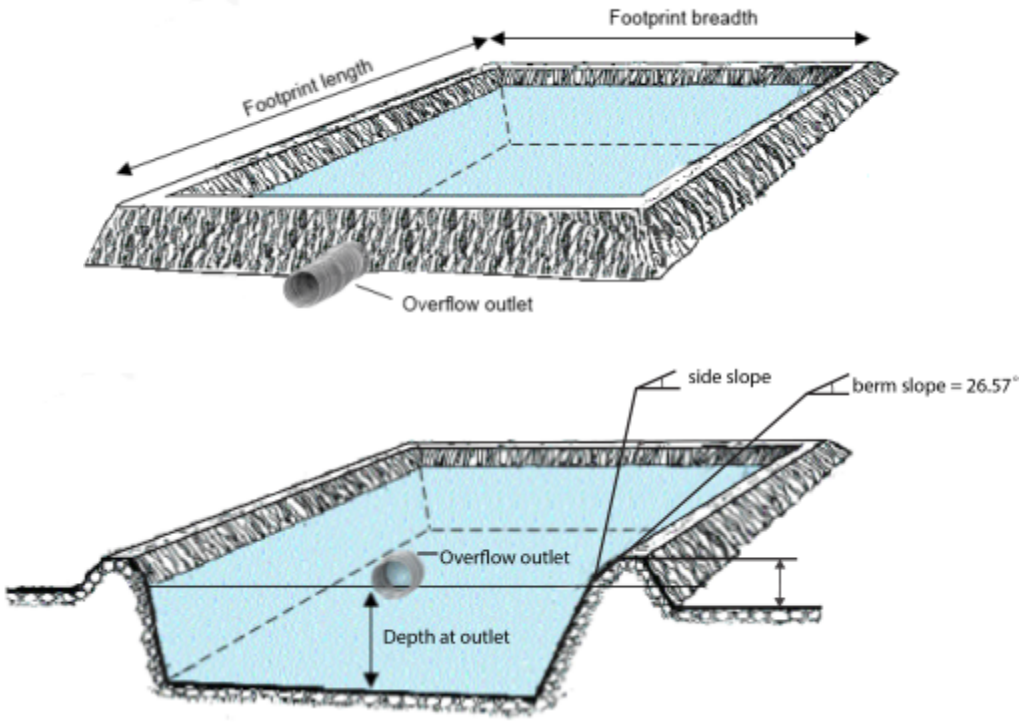
Description

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system details

	Pond 1
Maximum pond volume (m3)	1000.00
Minimum allowable pond volume (m3)	0.00
Pond depth at overflow outlet (m)	4.00
Maximum water surface area (m2)	250.10
Pond footprint length (m)	15.81
Pond footprint width (m)	15.81
Pond catchment area (m2)	250.10
Average active volume (m3)	281.97



Irrigation pump limits

Minimum pump rate per area limit (ML/day/ha)	0.00
Maximum pump rate per area limit (ML/day/ha)	1.00

Shandying water

Annual allocation of fresh water available for shandying (m3/year)	0.00
Maximum rate of application of fresh water (ML/day)	0.00
Nitrogen concentration (mg/L)	0.00
Salinity (dS/m)	0.00
Minimum shandy water is used	No

Description

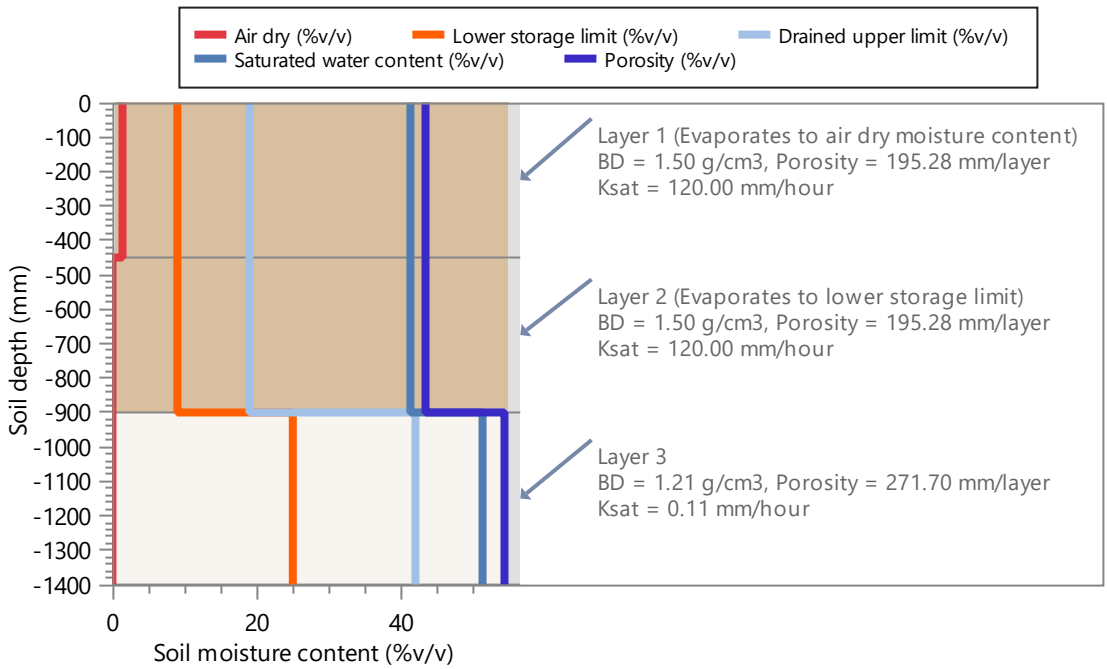
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Soil type: 3578_Orchard Hills_imported tops, 1400.00 mm defined profile depth

Profile porosity (mm)	662.26
Profile saturation water content (mm)	628.20
Profile drained upper limit (or field capacity) (mm)	381.00
Profile lower storage limit (or permanent wilting point) (mm)	206.00
Profile available water capacity (mm)	175.00
Profile limiting saturated hydraulic conductivity (mm/hour)	0.11
Surface saturated hydraulic conductivity (mm/hour)	120.00
Runoff curve number II (coefficient)	83.00
Soil evaporation U (mm)	7.75
Soil evaporation Cona (mm/sqrt day)	3.50

Profile



Planting regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average monthly cover (fraction) (minimum - maximum)	0.60 (0.56 - 0.63)
Maximum crop factor at 100% cover (mm/mm) (Maximum crop coefficient 1.1 x Pan coefficient 1)	1.10
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Potential rooting depth in defined soil profile (mm)	1200.00
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05

Irrigation rules: Pressure-compensating SSI

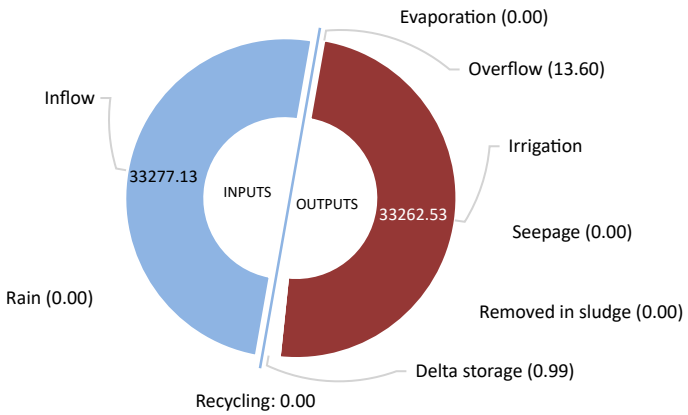
Rule 1. Irrigation triggered every 1 days and rainfall is less than or equal to 30.00 mm
Rule 2. Irrigate a fixed amount of 2.54 mm each day
Rule 3. Irrigation window from 1/1 to 31/12 including the days specified
Rule 4. A minimum of 0 days must be skipped between irrigation events

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank (wet weather storage pond: 1000 m3)

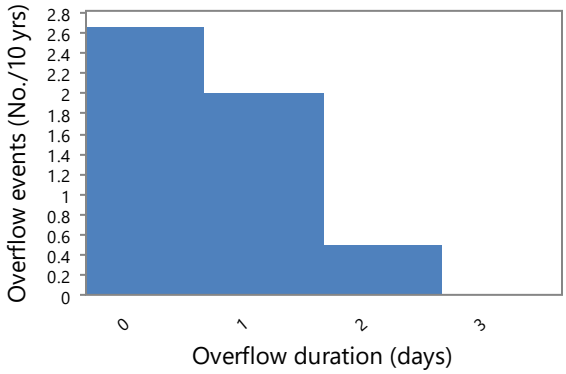
Pond system water balance (m3/year)

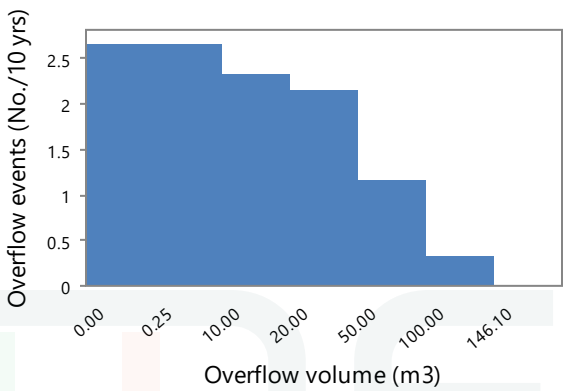


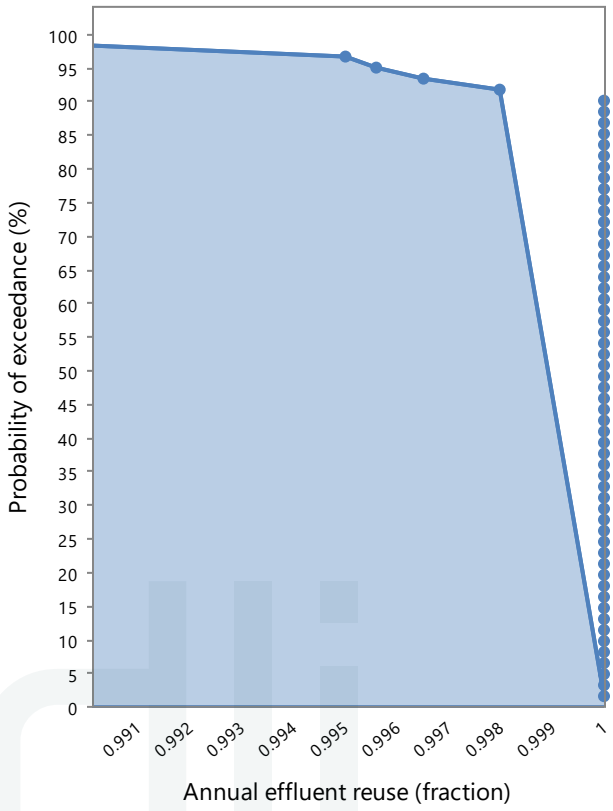
Name	Value
Rain	0.00
Inflow	33277.13
Recycling	0.00
Evaporation	0.00
Overflow	13.60
Irrigation	33262.53
Seepage	0.00
Removed in sludge	0.00
Delta storage	0.99

Overflow and reuse diagnostics

Metric	Value
Total volume of overflow (m3/10 years)	136.02
Total number of overflow events (events/10 years)	2.67
Total number of pond overflow days (days/10 years)	5.17
Probability of at least 90% effluent reuse (%)	100.00
Effluent reuse (Proportion of inflow + net gain in rain that is irrigated) (fraction)	1.00





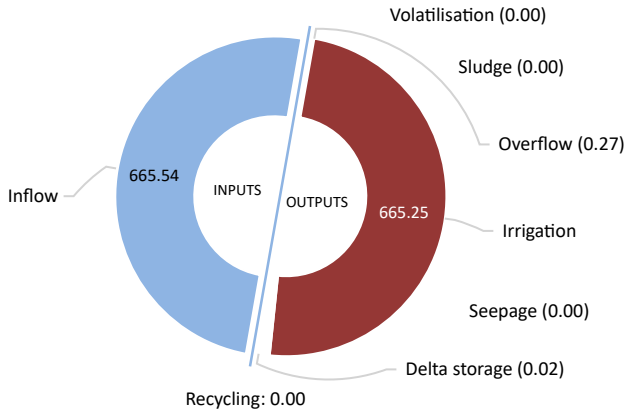


Performance

Pond system information

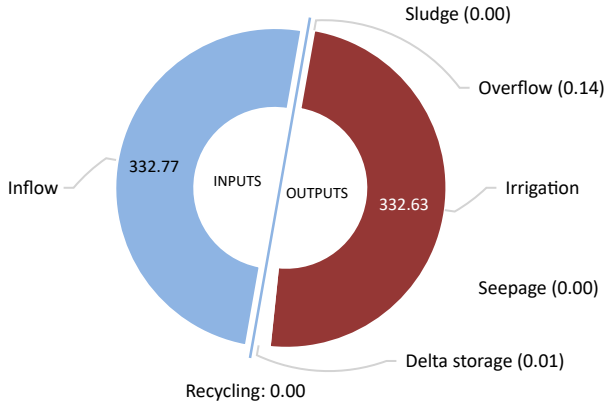
Pond System Configuration: 1 closed (sludge-free) storage tank

Pond system nitrogen balance (kg/year)



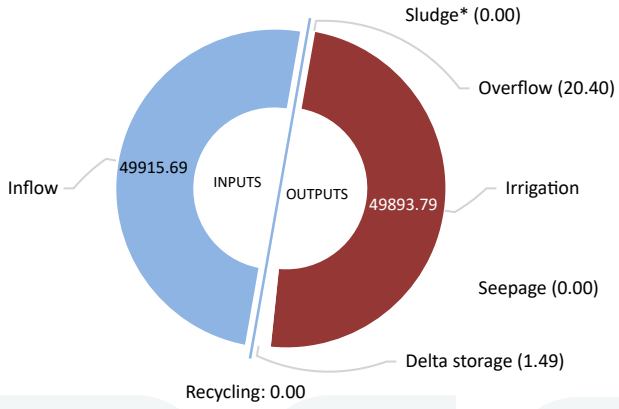
Name	Value
Inflow	665.54
Recycling	0.00
Volatilisation	0.00
Sludge	0.00
Overflow	0.27
Irrigation	665.25
Seepage	0.00
Delta storage	0.02

Pond system phosphorus balance (kg/year)



Name	Value
Inflow	332.77
Recycling	0.00
Sludge	0.00
Overflow	0.14
Irrigation	332.63
Seepage	0.00
Delta storage	0.01

Pond system salt balance (kg/year)



Name	Value
Inflow	49915.69
Recycling	0.00
Sludge*	0.00
Overflow	20.40
Irrigation	49893.79
Seepage	0.00
Delta storage	1.49

* Salt removal in sludge is not calculated from the pond salt balance. However if salt could be assumed to be present in the sludge at the same concentration as in the pond supernatant (up to a maximum of salt added in inflow) - then salt accumulation in the sludge could be 0.00 kg/year

Pond system sludge accumulation: 0.00 kg dwt/year

Performance

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Pond nutrient concentrations and salinity

Average across simulation period	Pond 1
Average nitrogen concentration of pond liquid (mg/L)	20.00
Average phosphorus concentration of pond liquid (mg/L)	10.00
Average salinity of pond liquid (dS/m)	2.34

Value on final day of simulation period	Pond 1
Final nitrogen concentration of pond liquid (mg/L)	20.00
Final phosphorus concentration of pond liquid (mg/L)	10.00
Final salinity of pond liquid (dS/m)	2.34

Performance

Water use (assumes 100% irrigation efficiency)

Metric	Value
Pond water irrigated (m3/year)	33262.53
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Total water irrigated (m3/year)	33262.53
Proportion of irrigation events requiring shandying (fraction of events)	0.00
Proportion of years shandying water allocation of 0 m3/year is exceeded (fraction of years)	0.00
Average exceedance as a proportion of annual shandy water allocation (fraction of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)

Irrigation quality

Metric	Value
Average nitrogen concentration of irrigation water - before ammonia loss during irrigation (mg/L)	20.00
Average nitrogen concentration of irrigation water - after ammonia loss during irrigation (mg/L)	20.00
Average phosphorus concentration of irrigation water (mg/L)	10.00
Average salinity of irrigation water (dS/m)	2.34

Irrigation diagnostics

Metric	Value
No. periods/year without any irrigable effluent in the wet weather storage pond (periods/year)	0.00
Average length of such periods (days)	0.00

Irrigation triggering and application

No. Days without Irrigation Applied per Year: 4.97 (with rain exceeding specified rainfall threshold)
No. Days without Irrigation Applied per Year: 4.97 (with not triggered)
No. Days with Irrigation Applied per Year: 360.28 (with full application [348.58] and supply limited - partial application [11.70])
No. Days with Irrigation Triggered per Year: 360.28

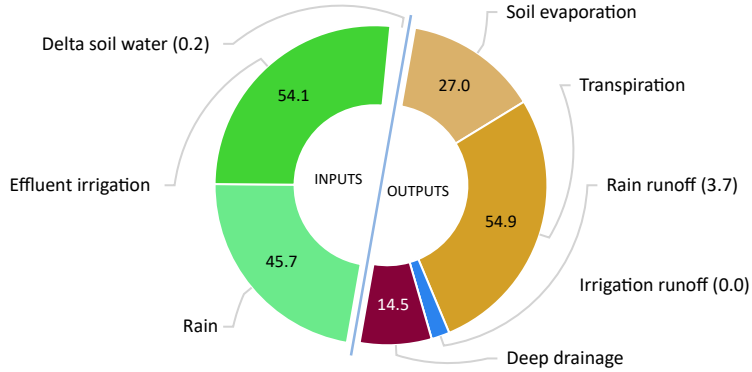
Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

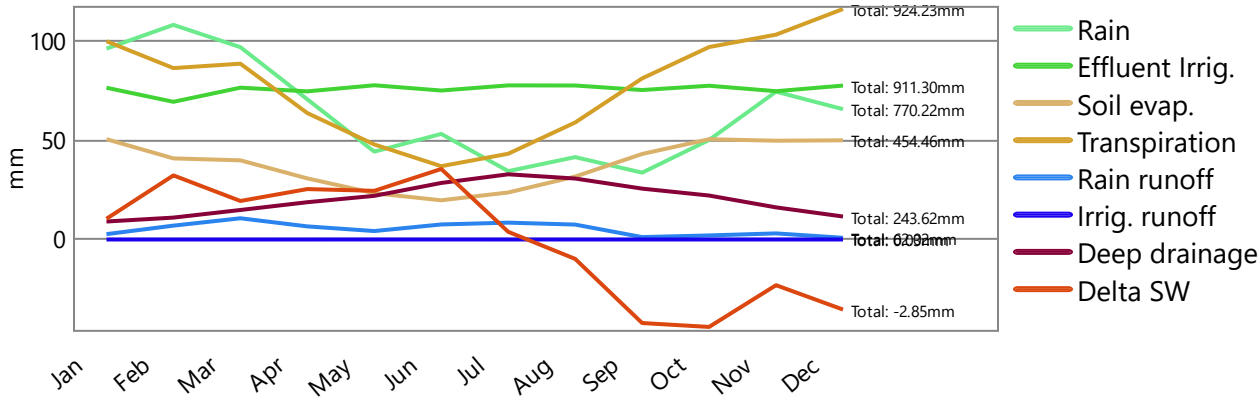
Soil Type: 3578_Orchard Hills_imported tops, 141.00 mm PAWC at maximum root depth

Soil water balance (%)

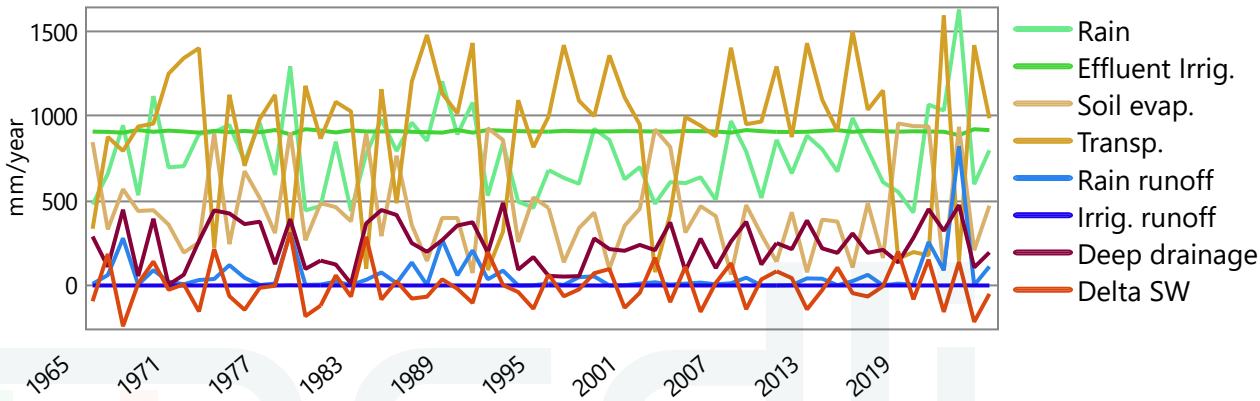


Name	Value
Rain	45.7
Effluent irrigation	54.1
Soil evaporation	27.0
Transpiration	54.9
Rain runoff	3.7
Irrigation runoff	0.0
Deep drainage	14.5
Delta soil water	-0.2

Average monthly totals (mm)



Average annual totals (mm/year)

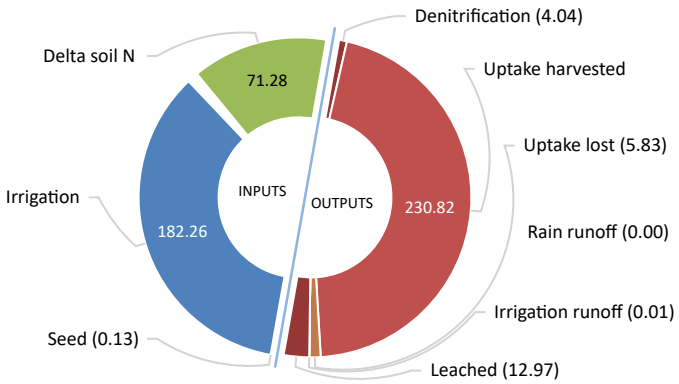


Performance

Paddock information

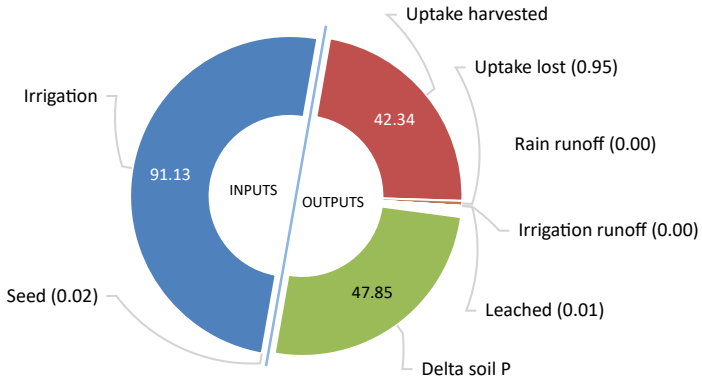
Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Irrigation Ammonia-N Volatilisation Losses (kg/ha/year): 0.00
Proportion of Total Nitrogen in Irrigated Effluent as Ammonium (fraction): 0.30

Soil nitrogen balance (kg/ha/year)



Name	Value
Seed	0.13
Irrigation	182.26
Denitrification	4.04
Uptake harvested	230.82
Uptake lost	5.83
Rain runoff	0.00
Irrigation runoff	0.01
Leached	12.97
Delta soil N	-71.28

Soil phosphorus balance (kg/ha/year)



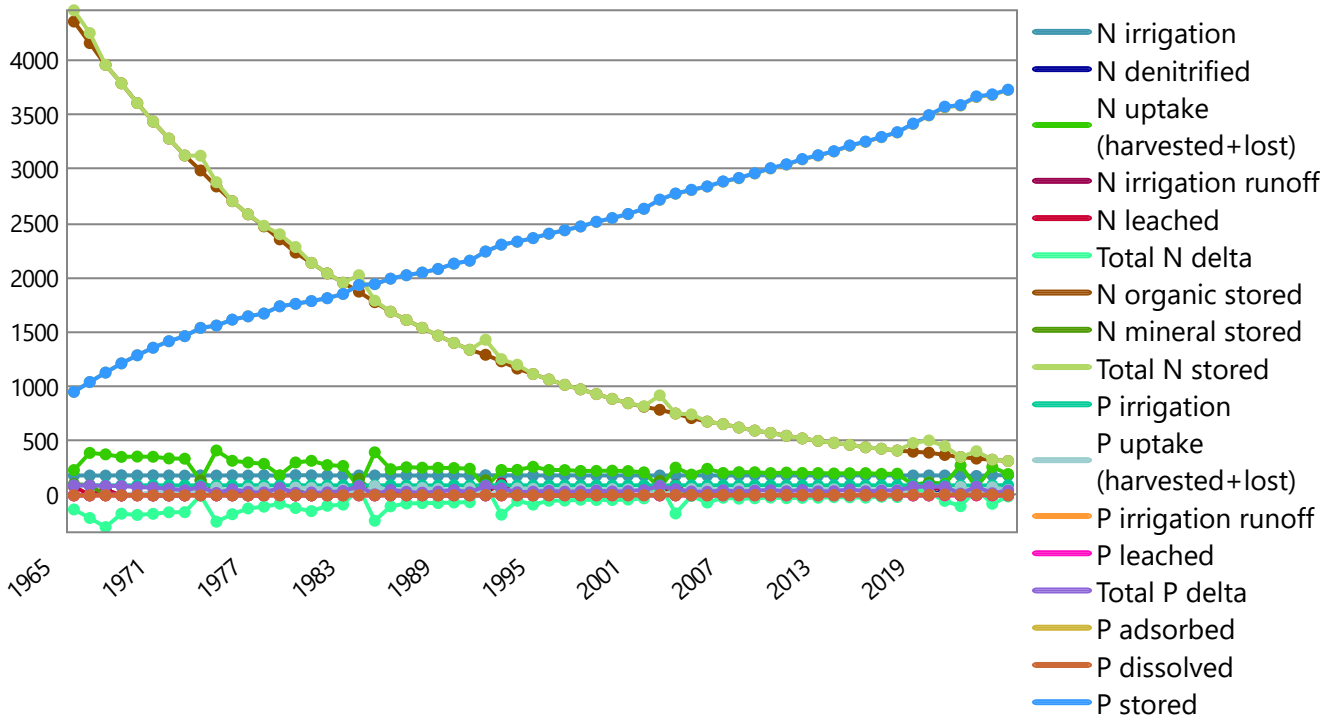
Name	Value
Seed	0.02
Irrigation	91.13
Uptake harvested	42.34
Uptake lost	0.95
Rain runoff	0.00
Irrigation runoff	3.34E-03
Leached	0.01
Delta soil P	47.85

Performance

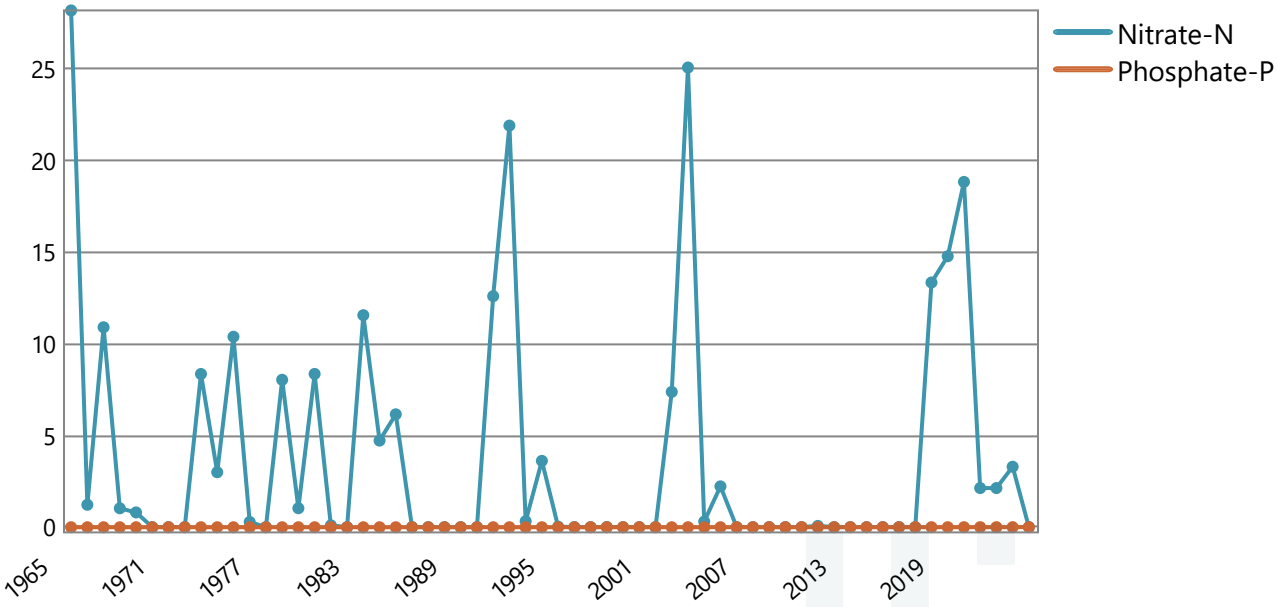
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops

Annual nutrient totals (kg/ha)



Annual nutrient leaching concentration (mg/L)



Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant growth (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield* (kg/ha/year)	16315.60 (-1303.49 - 27602.50)
Average annual shoot dry matter lost (kg/ha/year)	341.01 (0.00 - 3602.54)
Average monthly plant (green) cover (fraction)	0.60 (0.56 - 0.63)
Average monthly root depth (mm)	1035.89 (1011.60 - 1076.67)

Plant nutrient uptake (minimum - maximum)

Metric	Value
Average annual shoot nitrogen in harvestable yield* (kg/ha/year)	230.82 (3.92 - 411.80)
Average annual shoot nitrogen lost (kg/ha/year)	5.83 (0.00 - 63.90)
Average annual shoot phosphorus in harvestable yield* (kg/ha/year)	42.34 (-3.77 - 82.78)
Average annual shoot phosphorus lost (kg/ha/year)	0.95 (0.00 - 10.74)
Average annual shoot nitrogen concentration (fraction dwt)	0.02 (0.01 - 0.03)
Average annual shoot phosphorus concentration (fraction dwt)	0.003 (0.000 - 0.003)

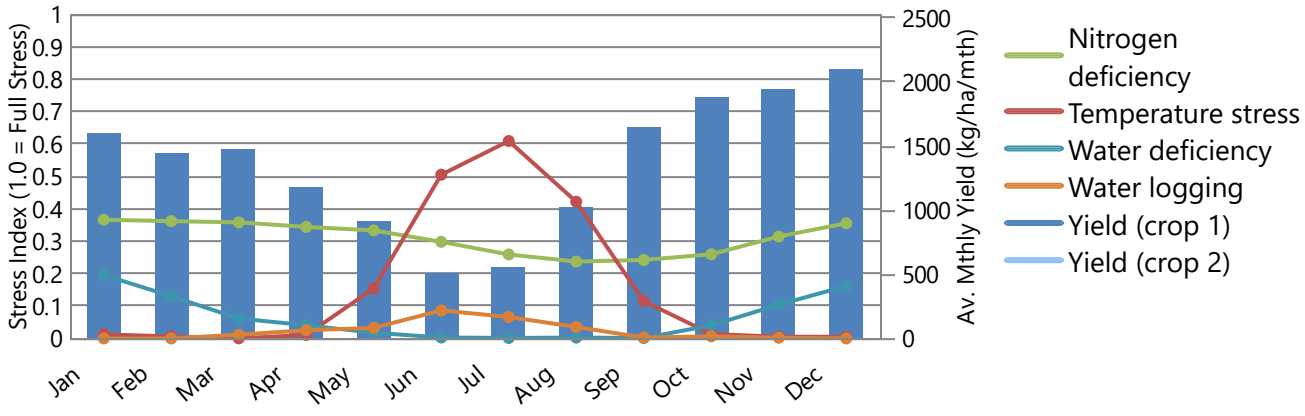
*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Performance

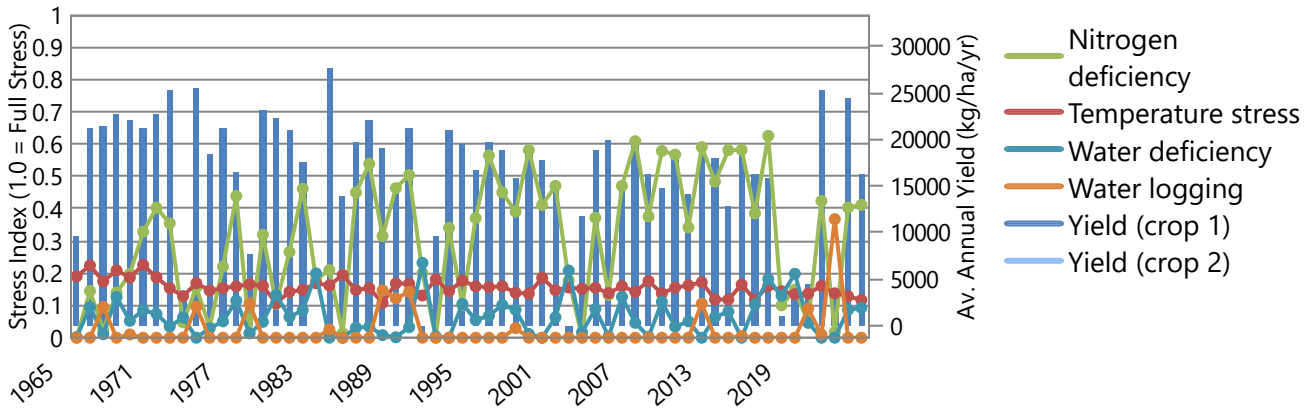
Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Av. monthly stresses & harvestable yield* (kg/ha/month)



Av. annual stresses & harvestable yield* (kg/ha/year)



*Harvestable yield is a measure of *net* gain over a nominated period - say monthly. It is the total shoot-dry-matter gain minus any shot-dry-matter loss within a given period. Hence, just like financial investments, negative harvestable yields may occur when the (episodic) losses exceed the gains made within a particular accounting period.

Normal and forced harvest information

No. of Harvests per Year: 0.57 (normal), 0.17 (forced by crop death due to water stress).
No. Days without Crop per Year (no./year): 5.05 (due to water stress)

Performance

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha
Soil Type: 3578_Orchard Hills_imported tops
Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Plant salinity tolerance

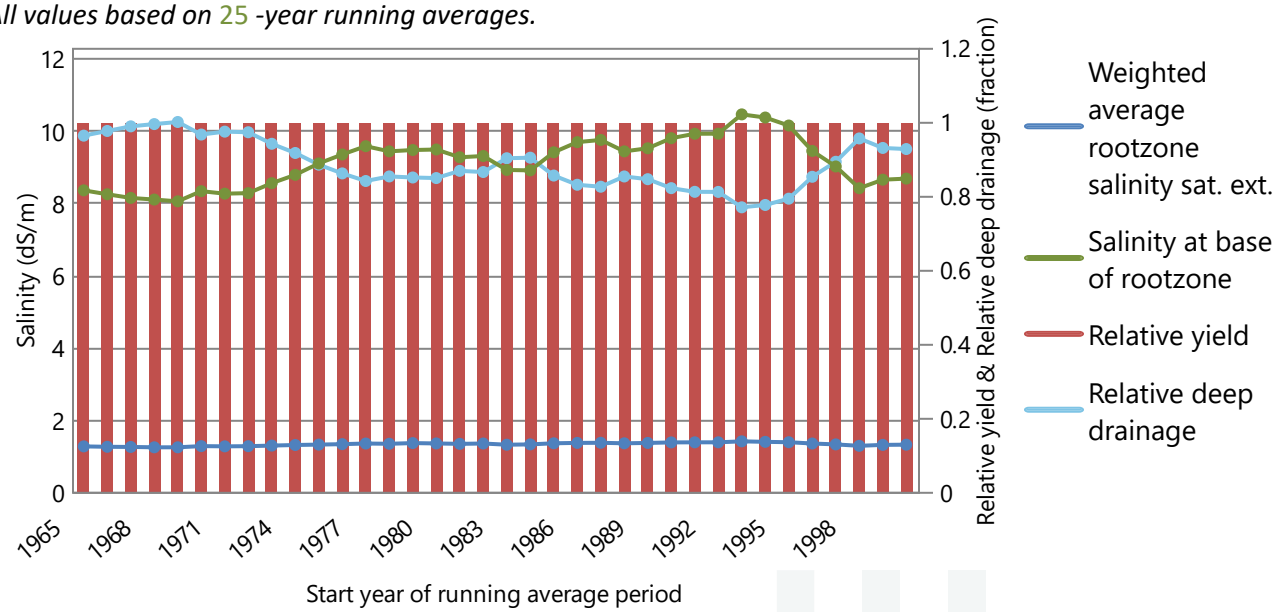
Metric	Value
Salt tolerance	Tolerant
Salinity threshold (dS/m soil saturation extract)	8.00
Proportion of yield decrease per dS/m increase (fraction/dS/m)	0.05
No. years assumed for leaching to reach steady-state (years)	25.00

Soil salinity

Metric	Value
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	1.33
Salt added by rainfall (kg/ha/year)	135.98
Average annual salt added & leached at steady state (kg/ha/year)	13805.01
Average leaching fraction based on 25 -year running averages (fraction)	0.45
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.34
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	9.14
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Average annual rootzone salinity and relative yield

All values based on 25 -year running averages.

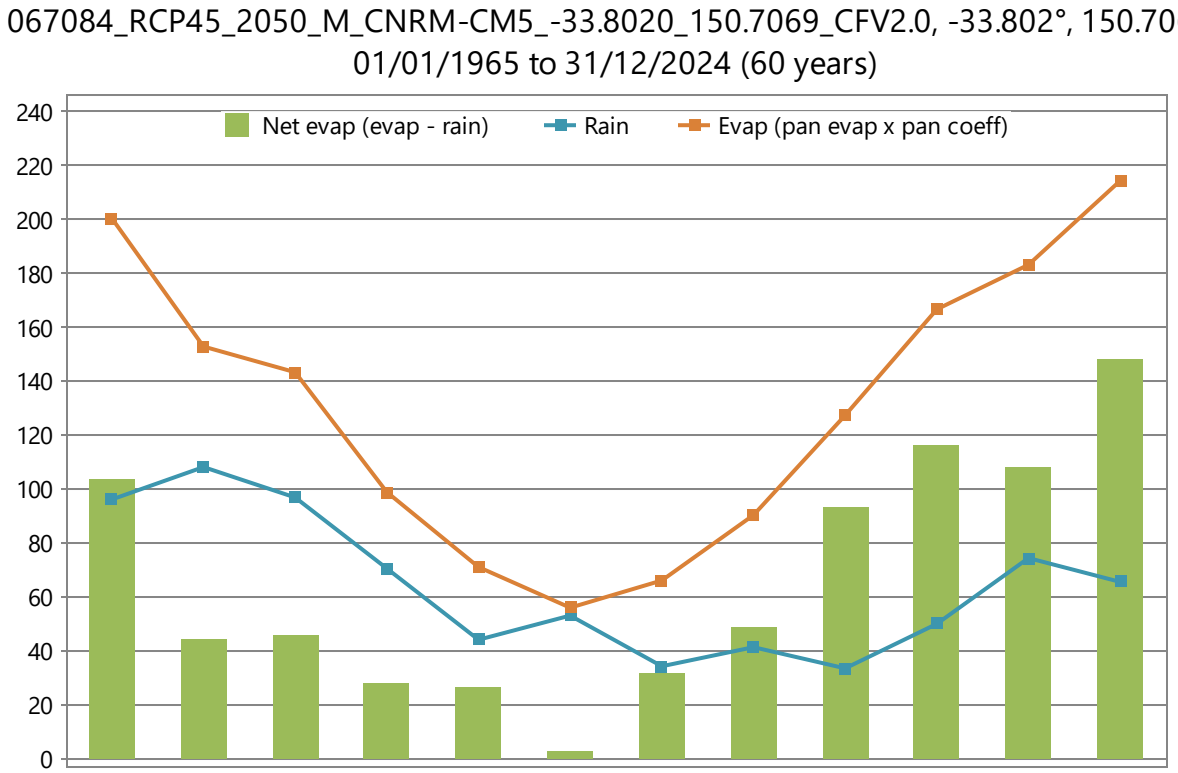


Diagnostics

Scenario information

Enterprise: 3578_IMP Orchard Hills

Climate long-term monthly averages (mm)



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.3	108.3	97.0	70.7	44.3	53.3	34.5	41.6	33.7	50.2	74.6	65.8	770.2
Evap	200.5	153.0	143.4	99.0	71.3	56.2	66.3	90.5	127.5	166.7	183.3	214.4	1571.9
Net evap	104.2	44.7	46.4	28.3	26.9	2.9	31.8	48.9	93.8	116.5	108.7	148.6	801.7
Net evap/day	3.4	1.6	1.5	0.9	0.9	0.1	1.0	1.6	3.1	3.8	3.6	4.8	2.2

Diagnostics

Pond system information

Pond System Configuration: 1 closed (sludge-free) storage tank

Effluent Type: - 33277.13 m3/year or 91.11 m3/day generated on average

Effluent entering pond system after any pretreatment and recycling

Average (Minimum-Maximum) influent quality calculated for 365.25 *non-zero flow days/year.*

Constituent	Concentration (mg/L)	Load (kg/year)
Total nitrogen	20.00 (20.00 - 20.00)	665.54 (664.93 - 667.38)
Total phosphorus	10.00 (10.00 - 10.00)	332.77 (332.47 - 333.69)
Total dissolved salts	1500.00 (1500.00 - 1500.00)	49915.69 (49869.75 - 50053.50)
Volatile solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)
Total solids	0.00 (0.00 - 0.00)	0.00 (0.00 - 0.00)

Ammonia-N loss from pond system water surface area: 0.00 kg/m2/year

Last pond (wet weather store): 1000.00 m3

Metric	Value
Theoretical hydraulic retention time (days)	10.98
Volume of overflow (m3/year) Average (minimum-maximum)	13.60 (0.00 - 323.74)
Volume of overflow per day (m3/day) Average (minimum-maximum)	0.04 (0.00 - 122.50)
No overflow days - Average per year (Total in run period)	0.52 (31)
No. overflow events per 10 years exceeding threshold of 0.250 m3* (events/10 years)	2.67
Average overflow event recurrence interval (years)	3.75
Average duration of overflow (days)	1.94
Probability of at least 90% effluent reuse (%)	100.00
Effluent reuse (proportion of inflow + net rain gain that is irrigated) (fraction)	1.00
Average salinity (dS/m)	2.34
Salinity on final day of simulation (dS/m)	2.34

* The threshold is the volume equivalent of the top 1 mm depth of water of a full pond

Volume distribution of the overflow events

Overflow volume (m3)	Overflow events (No./10 yrs)
0	2.67
0.250101	2.67
10	2.33
20	2.17
50	1.17
100	0.33
146.1	0.00

Diagnostics

Scenario information

Area irrigated: 3.65 ha total area

Loading to whole irrigation area: (assuming 100% irrigation efficiency)

	Quantity/year	Quantity/ha/year
Total irrigation applied (m3)	33262.53	9113.02
Total nitrogen applied (kg)	665.25	182.26
Total phosphorus applied (kg)	332.63	91.13
Total salts applied (kg)	49893.79	13669.53

Shandying

Metric	Value
Annual allocation of fresh water for shandying (m3/year)	0.00
Average shandy water irrigation (m3/year) (minimum - maximum)	0.00 (0.00 - 0.00)
Average exceedance as a proportion of annual shandy water allocation (% of allocation) (minimum - maximum)	0.00 (0.00 - 0.00)
Minimum shandy water is used	No

Irrigation issues

Metric	Value
Number of days without irrigation (days/year)	4.97

Diagnostics

Paddock information

Paddock: - 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Irrigation Rules
Irrigation triggered every 1 days and rainfall is less than or equal to 30.00 mm
Irrigate a fixed amount of 2.54 mm each day
Irrigation window from 1/1 to 31/12 including the days specified
A minimum of 0 days must be skipped between irrigation events

Soil water balance (mm): 3578_Orchard Hills_imported tops, 141.00 mm PAWC at maximum root depth

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Year
Rain	96.3	108.3	97.0	70.7	44.3	53.3	34.5	41.6	33.7	50.2	74.6	65.8	770.2
Efflt. irrg.	76.6	69.5	76.6	74.7	77.8	75.2	77.8	77.7	75.4	77.6	74.8	77.7	911.3
Soil evap	50.6	40.9	39.9	30.8	23.3	19.8	23.7	31.7	43.1	50.6	49.8	50.0	454.5
Transpn.	100.0	86.5	88.7	63.8	47.9	37.0	43.3	59.0	81.3	97.1	103.4	116.3	924.2
Rain runoff	2.7	7.0	10.7	6.6	4.3	7.6	8.5	7.5	1.2	2.0	3.1	0.9	62.0
Irr. runoff	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Drainage	9.1	11.0	14.9	18.8	22.0	28.5	32.9	30.8	25.7	22.2	16.2	11.6	243.6
Delta SW	10.5	32.3	19.4	25.4	24.6	35.6	3.9	-9.8	-42.2	-44.1	-23.1	-35.4	-2.8

Soil nitrogen balance: (Concentrations are flow-weighted)

Metric	Value
Average annual nitrogen added in seed (kg/ha/year)	0.13
Average annual nitrogen added from irrigation (kg/ha/year)	182.26
Av. annual soil N removed by uptake (harvest + lost) (kg/ha/year)	236.65 (230.82, 5.83)
Av. annual soil nitrogen removed by denitrification (kg/ha/year)	4.04
Average annual soil nitrogen leached (kg/ha/year)	12.97
Average annual nitrate-N loading to groundwater (kg/ha/year)	12.97
Soil organic-N kg/ha (Initial - Final)	4507.50 - 315.04
Soil inorganic-N kg/ha (Initial - Final)	84.07 - 0.02
Average nitrate-N concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	5.32 (28.19)
Excluding first year of data (mg/L)	4.86 (25.07)

Soil phosphorus balance: (Concentrations are flow-weighted)

Metric	Value
Average annual phosphorus added in seed (kg/ha/year)	0.02
Average annual phosphorus added from irrigation (kg/ha/year)	91.13
Av. annual soil P removed by uptake (harvest + lost) (kg/ha/yr)	43.29 (42.34, 0.95)
Average annual soil phosphorus leached (kg/ha/year)	0.01
Dissolved phosphorus (kg/ha) (Initial - Final)	0.01 - 3.12
Adsorbed phosphorus (kg/ha) (Initial - Final)	860.20 - 3727.84
Average phosphate-P concentration in rootzone (mg/L)	0.77
Average phosphate-P concentration of deep drainage (Max annual concentration)	
Across all years (mg/L)	3.36E-03 (0.01)
Last year only (mg/L)	0.01 (N.D.*)
Design soil profile storage life based on average infiltrated water phosphorus concn. of 5.63 mg/L (years)	109.09

* Not determined

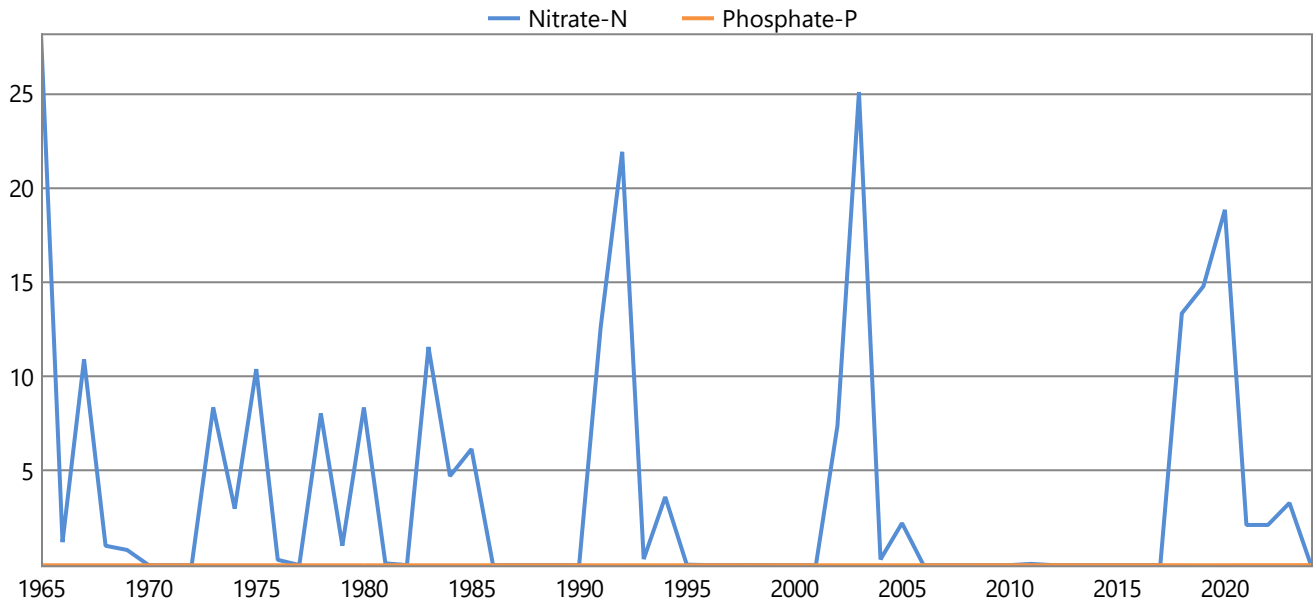
Diagnostics

Paddock information

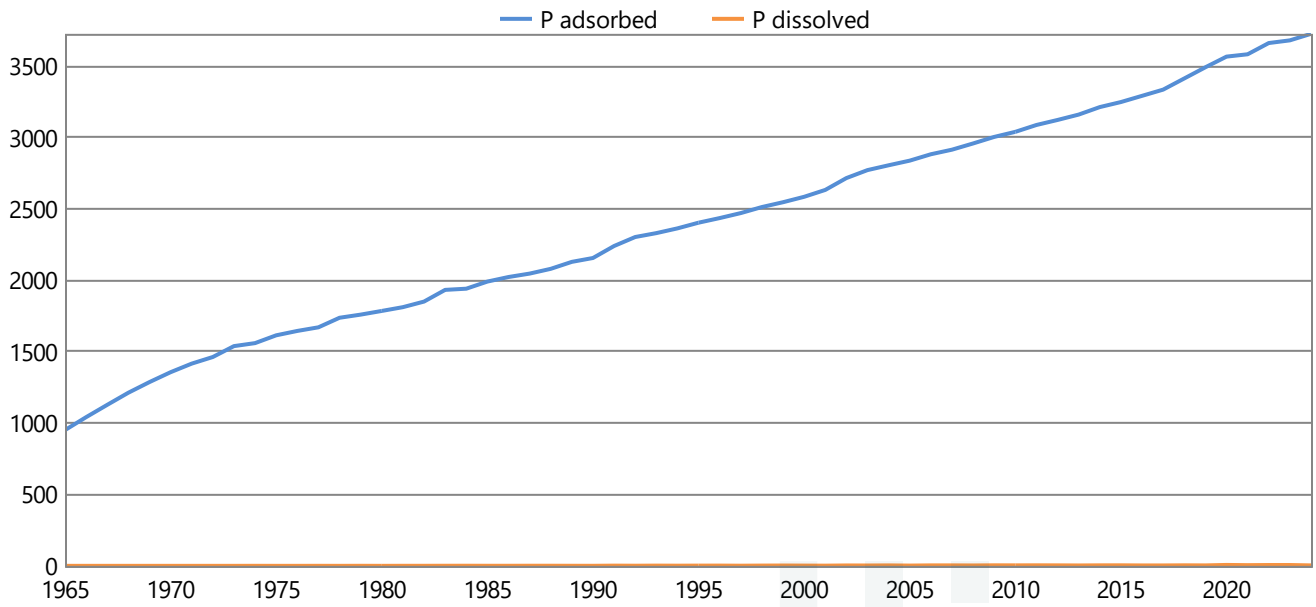
Paddock: 3578_Orchard Hills, 3.65 ha

Irrigation: Pressure-compensating SSI with 0% ammonium loss during irrigation

Annual nutrient leachate concentration (mg/L)



Annual phosphate-P in soil (kg/ha)



Diagnostics

Paddock information

Paddock: 3578_Orchard Hills, 3.65 ha

Planting Regime: Continuous Melaleuca alternifolia pasture COPE_3578, kick started

Average plant performance (minimum - maximum)

Metric	Value
Average annual shoot dry matter harvestable yield (kg/ha/year)	16315.60 (-1303.49 - 27602.50)
Average annual shoot dry matter lost (kg/ha/year)	341.01 (0.00 - 3602.54)
Average monthly plant (green) cover (fraction)	0.60 (0.56 - 0.63)
Average monthly crop factor (fraction)	0.66 (0.61 - 0.70)
Dead cover (if Mthly Covers) or Tot. cover left after harvest (fraction)	0.25
Average monthly root depth (mm)	1035.89 (1011.60 - 1076.67)
Average number of normal harvests per year (no./year)	0.57 (0.00 - 1.00)
Average number of normal harvests for last five years only (no./year)	0.40
Average number of forced harvests per year (no./year)	0.17 (0.00 - 2.00)
Average number of forced harvests for last five years only (no./year)	0.00
Average annual nitrogen deficiency index (0 = no stress, 1 = full stress) (coefficient)	0.31 (0.00 - 0.62)
Average January temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.01 (0.00 - 0.11)
Average July temperature stress index (0 = no stress, 1 = full stress) (coefficient)	0.61 (0.40 - 0.85)
Average monthly water stress index (0 = no stress, 1 = full stress) (coefficient)	0.06 (0.00 - 0.20)
Average monthly waterlogging index (0 = no stress, 1 = full stress) (coefficient)	0.02 (0.00 - 0.09)
No. days without crop per year. Excludes bare fallow days (days)	5.05

Soil salinity - plant salinity tolerance: Tolerant

Assumes 1.0 dS/m Electrical Conductivity = 640 mg/L Total Dissolved Salts

All values based on 25 -year running averages.

Metric	Value
Salinity of infiltrated water (Average salinity of rainwater = 0.03 dS/m) (dS/m)	1.33
Salt added by rainfall (kg/ha/year)	135.98
Average annual salt added & leached at steady state (kg/ha/year)	13805.01
Average leaching fraction based on 25 -year running averages (fraction)	0.45
Average water-uptake-weighted rootzone salinity sat. ext. (dS/m)	1.34
Salinity of the soil solution (at drained upper limit) at base of rootzone (dS/m)	9.14
Relative crop yield expected due to salinity (fraction)	1.00
Proportion of years that crop yields would be expected to fall below 90% of potential due to salinity (fraction)	0.00

Diagnostics

Run information

Messages generated when the scenario was run
********** WASTESTREAM RESULTS **********
TABLE OF QUANTITY AND QUALITY OF EACH RAINFALL-INDEPENDENT WASTESTREAM (AFTER PRETREATMENT AND BEFORE ENTERING ANY SEDIMENTATION BASIN)
_____
Source Volume_m3/yr N conc_mg/L P conc_mg/L TDS conc_mg/L N load_kg/yr P load_kg/yr TDS load_kg/yr
New generic system 33277.1 20.0 10.0 1500.0 665.5 332.8 49915.7
_____
********** END WASTESTREAM RESULTS **********
WARNING: Plant phosphorus deficiency. No soil phosphorus has been available for plant uptake for 2.50% of days of simulation.
UNCONDITIONAL FINISH

Appendix Q25.0

Recycled Water Quality Management Plan

Aquacell Pty Ltd

Alspec Industrial Business Park Blackwater Treatment Plant
Luddenham Rd, Orchard Hills

June 2025, Revision 4

Revision	Date	By	Checked	Document Status	Amendments
1	14/06/2024	AE/WJ	WTJ	Initial Issue	
2	30/07/2024	JJ	WTJ	For Review	Minor amendments throughout
3	4/12/2024	JJ	WTJ	For Review	Minor amendments in line with council RFI.
4	13/06/2025	SMA		For Review	Minor amendments in QCP1, PFD and layout, updated for WICA application

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1. Introduction

1.1 Purpose of the RWQMP

This Recycled Water Management Plan (RWQMP) has been prepared by Aquacell Pty Ltd in relation to the operation of the Blackwater Water Treatment Plant (BWTP) that will be located at the Alspec Industrial Business Park (AIBP) on Luddenham Road, Orchard Hills.

It states the microbial quality objectives for the scheme and describes how implementation of the management plan will ensure those objectives are achieved and maintained. The document contains:

- Responsibilities of the recycled water supplier;
- Description of the recycled water process, including composition of the source and end use applications for which the treated water is fit-for-purpose;
- Detailed validation of the treatment processes; and
- A detailed process control and monitoring program to ensure the treated water meets the required quality for end use.

1.2 Description of the scheme

1.2.1 Site Description

The Alspec Industrial Business Park will be located at 221-227 and 289-317 Luddenham Road, Orchard Hills. The proposed location of the BWTP is shown in Figure 1 below.

The blackwater to be used for recycle will be sourced from onsite toilets, showers, basins and drains (other than stormwater drains).

Recycled water will be supplied to the site for:

- Cooling tower make-up water
- Toilet flushing
- Irrigation

Additional demand beyond the available recycled water will be met using potable water.

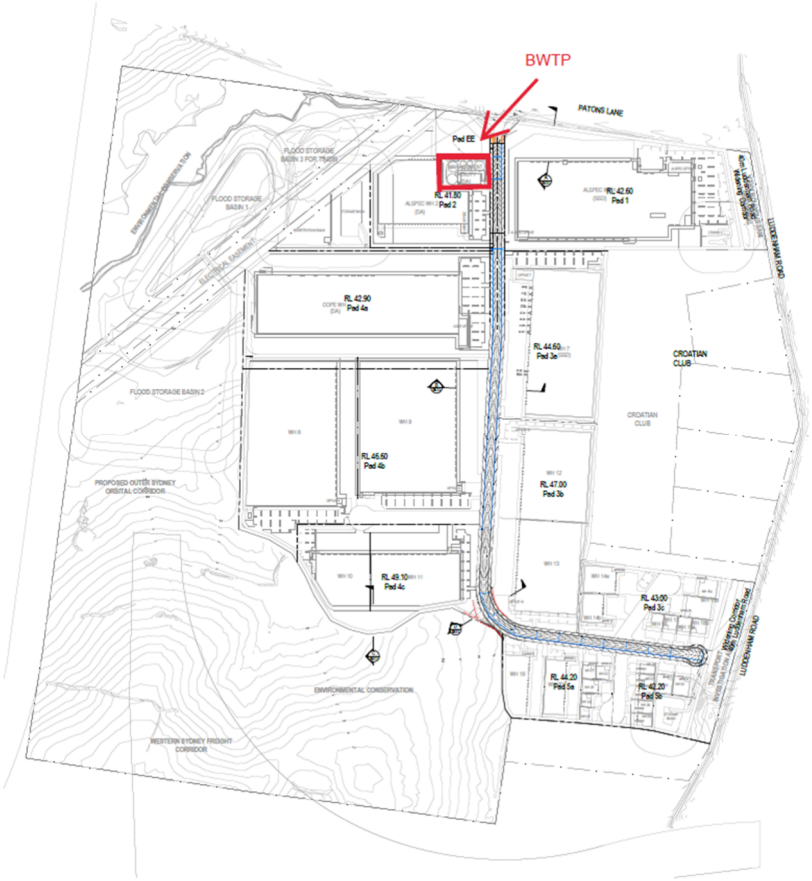


Figure 1: Proposed location of Blackwater Treatment Plant

1.2.2 System Process Design

A flow diagram of the plant showing the key unit operations is provided in Appendix 1, and a general arrangement drawing showing the physical layout of equipment is provided in Appendix 2.

Blackwater from the site is directed to a wet well adjacent to the treatment plant. Effluent from the wet well is pumped to a prescreen and the directed to 1000 kL buffer tank. The BWTP draws water from the buffer tank based on treated water demand, storing the final treated water in a 1000 kL treated water storage tank.

Referring to the flow diagram located in Appendix 1, the system consists of the following units:

- Wet Well (30 kL)
- Emergency Tank (300 kL)
- Prescreen
- Buffer tank for collection of blackwater (1000 kL)
- Two identical process trains with the following process units:
    - Anoxic Tank

- Aerobic Tank
- Membrane bioreactor treatment system (MBR)
- Filtrate tank
- Ozonation
- Biological activated carbon filter (BAC)
- Ultraviolet light disinfection (UV)
- Chlorine disinfection

- Off-spec water holding tank (1000 kL)
- Treated water storage tank (1000 kL)
- Treated water chlorination
- Screw press
- Vents connected to an odour scrubber for odour control
- Overflows and drains to wet well
- Chemical dosing systems

1.3 Management commitment

The scheme manager of the on-site recycling scheme at the AIBP is yet to be determined. They will be committed to ensuring the system is maintained and operated in compliance with relevant guidelines, regulations and standards at all times.

The scheme manager will engage Aquacell Pty Ltd (Aquacell), as the contracted provider of maintenance and operation services for the blackwater treatment plant. Both Aquacell and the scheme manager will provide the same commitment to maintain and operate the system in compliance with relevant guidelines, regulations, and standards at all times.

Under the agreement, the scheme manager will have maintenance personnel on site to undertake all daily, weekly and emergency response tasks associated with the running of the plant. Aquacell will provide initial training and ongoing technical support. Aquacell will be responsible for the majority of the technical and operational activities including on-site servicing, calibrations, regulatory reporting and remote operation as will be detailed in the service contract.

It should be noted that recycled water is treated to a high quality and suitable for human contact. As such, the water is suitable for the purpose of irrigating in the landscaped areas on each of the warehouse lots. Further information can be found within Whitehead & Associates' Land Capability Assessment.

A copy of the Aquacell Recycled Water Policy is provided in Appendix 3.

Comprehensive site management systems for the facility form part of this management plan. These describe the processes and procedures that will be in place to ensure the responsible use and management of recycled water.

1.4 Roles and responsibilities

The scheme manager will be responsible for both the recycled network for the collection and supply of blackwater to the BWTP, and the BWTP itself, which produces recycled water for the scheme. The scheme manager (or designated sub-contractor) will be responsible for the treated water storage and the delivery systems in which the recycled blackwater will be used.

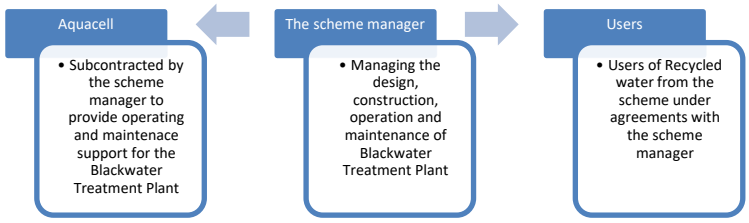
Aquacell provides operation and maintenance support for the BWTP.

In general terms, the scheme manager is responsible for:

- the production and supply of recycled water that is fit for purpose, ensuring that water quality complies with regulated standards and supply agreements up to designated transfer points defined in the RWQMP and supply agreements
- implementation of communication and reporting protocols if water quality does not meet required standards
- operation and maintenance of infrastructure for the production and supply of recycled water up to designated transfer points
- compliance with relevant regulatory requirements for recycled water
- using recycled water only in the manner and for the purposes for which it has been supplied, in accordance with supply agreements
- operation and maintenance of recycled water infrastructure after the designated transfer point
- implementation of control measures and compliance with usage restrictions defined in supply agreements.

The responsibilities and relationships between key roles are outlined in the figure below.

Figure 2. Blackwater Treatment Plant Responsibilities and Relationships



1.5 Scheme Owner

The owner of the development where the BWTP will be installed is to be confirmed.

Business Entity: TBA

Address: TBA

Phone (Business): TBA

Email: TBA

1.6 Responsible entity and scheme manager

The scheme manager is to be confirmed.

Business Entity: TBA

ABN: TBA

Address: TBA

Phone (Business): TBA

Email: TBA

1.7 Scheme operator and recycled water supplier

The scheme operator and supplier of recycled water is Aquacell Pty Ltd (Aquacell).

Business Entity: Aquacell Pty Ltd.

ABN: 79 072 487 015

Address: Suite 6.02, 6A Glen Street,
Milsons Point NSW 2061

Phone (Business): (02) 4721 0545

Email: info@aquacell.com.au

1.8 Users

The users of the recycled water are the staff, tenants and visitors at the AIBP.

2. Water quality objectives

2.1 Microbial

The proposed recycled water quality objectives have been derived based on the application of the principles described in the Australian Guidelines for Water Recycling: Managing Health and Environmental Risks Phase 1 (AGWR) (NRMMC, 2006).

2.1.1 Assumptions

In order to arrive at pathogen log reduction values for the treatment process, assessments must be made of the potential risk of ingestion and frequency of these events for the different exposure routes present in the reuse scheme. The following outlines the assessments made in order to calculate the required treated water quality and hence the associated Log Removal Value (LRV) for the treatment process.

The possible exposure to treated water at this site are:

- Ingestion from cross connections between the drinking and recycled water systems
- Aerosol ingestion from toilets
- Ingestion from cooling towers
- Ingestion of water used for irrigation

2.1.2 Ingestion from cross connections between the drinking and recycled water systems.

Guidance on typical exposure rates and ingestion volumes for cross connection of dual reticulation systems are provided in Table 3.3 of the AGWR. These figures have been adopted for the purposes of calculating performance targets.

There are a number of steps that have been taken to ensure that the risk of cross-connection is low. These include:

- The dual reticulation system will be installed according to AS/NZ 3500 and NSW Health Guidelines for recycled water, including lilac pipe and/or markings.
- Testable reduced pressure zone devices will be provided at all interconnection points between the treated water and the potable water supply.

- Signage to warn of the use of recycled water will be installed.
- The dual pipe system will undergo a full cross connection audit prior to commercial operation. If any cross connections are detected, these will be repaired prior to commercial operation. Cross-connection audits will be carried out at a frequency to be determined by Scheme Owner, in consultation with Aquacell and other stakeholders under the pending recycled water scheme approval to operate under WICA Act. The detailed plan for carrying out cross-connection tests will be documented in the maintenance plan.
- Any maintenance or modification to the reticulation system will occur under strict supervision of the responsible entity and Scheme Manager and in accordance with the site management processes.
- All maintenance workers and plumbing contractors will be fully inducted to the site and made aware of the dual reticulation system and the consequences of cross connections.

2.1.3 Aerosol ingestion from toilets

Table 3.3 of the AGWR provide a guidance on typical exposure rates and ingestion volumes for toilet flushing. These figures have been used for calculating performance targets.

2.1.4 Ingestion from cooling towers

The exposure for those operating the cooling towers (occupational) is considered to be higher than those for the general public. Both of these risks have been considered in the analysis provided in section 2.1.6.

Occupational exposure is mitigated by various means:

- Access to cooling towers restricted to authorised staff only
- The normal practises for maintenance and servicing cooling towers to minimise risk to legionella are applied (e.g., as detailed in the NSW Health document *Legionella control in cooling water systems* (August 2018).
- New construction with modern, low drift design.

2.1.5 Ingestion of water used for irrigation

The proposed irrigation includes drip and spray irrigation for landscaped areas. Table 3.3 of the AGWR provide a guidance on typical ingestion volumes for garden irrigation which have been used for calculating performance targets.

2.1.6 Performance target calculations

The project specific ingestion risks have been considered in order to determine the pathogen removal targets (using sewage as source) required to meet the minimum tolerable health risk of 10^{-6} DALY as recommended by the AGWR. The exposure risks considered, along with associated assumptions, are summarised in Table 1.

Based on the dose equivalent to a DALY of 10^{-6} for each organism (DALYd), the LRV required can be calculated as described in Appendix 2 of the AGWR and shown below as:

LRV = log (raw water concentration x exposure (L) x N / DALYd)

Where "exposure (L) x N" is the weighted total calculated in Table 1 below:

Table 1: Exposure risks for determining health based LRV targets based on AGWR

Use	Ingestion (L)	Frequency (/person/year)	Prop. of population affected (%)	Weighted total (L/yr)	Assumptions
Toilet flushing	0.00001	1100	100	0.011	Tenants and visitors - 3 uses per day
X-connect	1	365	0.1	0.365	1 L/day per person; Assume 1 in 1000
Cooling towers – general public	0.00001	728	100	0.00728	2 exposures per visit (coming and going); 7 visits per week for each week of the year
Cooling towers – occupational	0.0001	728	100	0.0728	2 staff per visit each day, one visit per day, 7 days per week
Irrigation – Municipal + Dual Reticulation	0.001	52	100	0.052	Assumes most people use these areas sparingly and not during irrigation. Assume 1/week.
		Total		**0.503**	

Using the AGWR recommended blackwater microbial concentrations (from AGWR Table A2.1) and the DALYd data for Cryptosporidium, Rotavirus, and Campylobacter (from AGWR Box A2.2), the minimum required and target LRV's (rounded up to the nearest 0.5-log) are determined and presented in Table 2. These values are consistent with the recommended log reduction targets for blackwater as shown in Table 3.8 of the AGWS (for dual reticulation, toilet flushing, washing machine and garden use).

Table 2: Minimum and target LRV's for protozoa, bacteria, and viruses (Blackwater Source)

	Representative family	Concentration in source (organisms/L)	Weighted total (L/yr)	DALYd for DALY of 10^6 (organisms/yr)	LRV required	LRV target
Rotavirus	Viruses	8000	0.503	2.5×10^{-3}	6.2	6.5
Cryptosporidium	Protozoa	2000	0.503	1.6×10^{-2}	4.8	5
Campylobacter	Bacteria	7000	0.503	3.8×10^{-2}	5.0	5

Treatment plant performance objectives are summarised in Table 3. The validation basis for these credits is discussed in section 0.

Table 3: Treatment plant performance objectives for blackwater

	MBR[1]	UV	Chlorination	Total LRV Achieved	Target LRV
Virus	1.5	1	4	6.5	6.5
Protozoa	2	4	0	6	5
Bacteria	4	4	4	12	5

1. *Based on WaterVal Tier 1 default for MBR (See section 5.1)*

2.2 Chemical

No major industry is conducted on site as it is mostly warehousing and offices, so this risk is considered low. However, there is some aluminium processing (extrusion), along with milling, product painting and washing in one of the warehouse facilities (Alspec 1). The wastewater from this these processes will be managed as trade waste to ensure that it does not contain adverse qualities of oil and grease or solvents.

3. System assessment

A Hazard Analysis and Critical Control Point (HACCP) analysis of the AIBP BWTP is conducted and included in Appendix 4. The methodology used will be in accordance with the AGWR and Aquacell's documented risk procedures.

4. Compliance with Australian Guidelines for Water Recycling

The table below lists the 12 elements of the framework for managing recycled water quality and use (as per the AGWR) and shows how the scheme will meet the various elements.

Table 4: AGWR framework elements

Framework element	Activity	Reference Document
Element 1: Commitment to responsible use and management of recycled water quality		
Components: Responsible use of recycled water	Aquacell will operate and maintain the treatment process and provide support. There is a commitment to ensure correct design installation and management. Aquacell WICA retailer (25_009R) and operator licence (25_008) WICA Scheme approval pending to install and operate the system.	WICA scheme approval (Appendix 5) WICA retailer licence (Appendix 7) WICA operator licence (Appendix 8)
Regulatory and formal requirements	There is a WICA scheme approval application pending to install and operate the system.	WICA scheme approval pending (Appendix 5) WICA retailer licence (Appendix 7) WICA operator licence (Appendix 8)
Engaging stakeholders	Stakeholder engagement is pending and will include the development of an information package to create awareness of the various stakeholders' obligations to achieve high water efficiency. This will include marketing material, contractual obligations and site induction information.	
Recycled water policy	The implementation of a recycled water policy is recommended.	Aquacell Recycled Water Policy exists (IMS Document EM010)
Element 2: Assessment of the recycled water system		
Components:	Uses are for toilet flushing, cooling tower makeup and irrigation.	This RWQMP

Identify intended uses and source of recycled water	The water source is blackwater from the AIBP business park development.	
Recycled water system	The plant receives blackwater from the building. Water is subjected to treatment through a membrane bioreactor, ozone, carbon filter, ultraviolet (UV) disinfection and chlorine disinfection. The treated water is piped to a dedicated storage tank and distributed for use.	Operations and Maintenance Manual pending (Appendix 11)
Assessment of water quality data	Raw wastewater is characterised based on typical values for this application, in addition to adopting the values for pathogen content outlined in the AGWR. Treated water quality from the wastewater treatment plant will be tested in accordance with a specified testing regime.	This RWQMP section 7 and AGWR
Hazard identification and risk assessment	A Hazard Analysis and Critical Control Point (HACCP) analysis of the AIBP scheme have been conducted. The methodology used is in accordance with the AGWR and Aquacell's documented risk procedures.	Aquacell HACCP (Appendix 4)
Element 3: Preventative measures for recycled water management		
Components: Preventative measures and multiple barriers	**Human health** Preventative measures to manage risks to human health include: Membrane filtration, UV disinfection and chlorine disinfection; Pipework (purple and/or with text) and signage at site of use indicating that recycled water is being used; Educational material to tenants and site managers about avoidance of inappropriate disposal of wastes; Signage at site to alert plumbers to recycled water system and co-ordination of plumbers through site management; Backflow prevention and cross-connection control; **Environmental performance** Preventative measures to manage risks to the environment include: Education programme for tenants and site managers promoting use of environmentally friendly detergents in the toilets and hand basins and avoidance of disposal of chemicals; A list of detergents considered appropriate for use in the building made available to cleaning staff and updated annually;	This RWQMP AS/NZS 3500:2003 Community page on Aquacell website Employer and contractor induction procedures and records Community page on Aquacell website
Critical control points	Multiple critical control points are confirmed through the HACCP analysis. These are detailed further in section 6.1.	Aquacell HACCP (Appendix 4) This RWQMP section 6.1
Element 4: Operational procedures and process control		
Components: Operational procedures	Operational procedures will be identified for all processes and activities associated with the system, including operation of treatment processes and auditing procedures for cross-connections. Documented procedures must be available to operations personnel and for inspection at any time. Operators are proficient and are able to recognize the significance of changes in the recycled water treatment plant and water quality. They are able to respond appropriately according to established procedures.	Operations and Maintenance Manual pending (Appendix 11) Aquacell Work instructions
Operational monitoring	A number of online monitoring instruments are used to ensure that we always meet the requirements of the Critical Control Points (CCP).	This RWQMP section 6 and 7
Corrective action	Corrective actions include the following: Noncompliance with the CCP's results in the system being stopped or treated water diverted to the Off-spec water holding tank. If cross-connections detected, flow to property stopped until repairs completed. Site switches to potable water backup until cross connection is eliminated.	This RWQMP section 6
Equipment capability and maintenance	Treatment plant and disinfection systems of standard and reliable design. Maintained by qualified supplier.	A service agreement will exist between the scheme manager

		and Aquacell for the maintenance and service of the recycled water treatment plant.
Materials and Chemicals	All plumbing and drainage work is conducted in a manner conforming to AS/NZS standard 3500. All chemical used in the plant are obtained from credible suppliers.	MSDS are supplied for each chemical. Purchasing is in accordance with Aquacell Purchasing and Inventory Procedure (IMS Document PI030)
Element 5: Verification of recycled water quality		
Components: Recycled water quality monitoring (specifically designed for individual systems, taking into account source of water, end uses and receiving environments)	**Human health** Monitoring of defined parameters is undertaken. Building occupant/customer satisfaction, monitored by the operator; complaints are investigated particularly when clusters of complaints are received.	This RWQMP section 6 and 7 Aquacell "Complaints Handling and Dispute Resolution Policy" (IMS Document CS030) Aquacell website "Community" page
Application and discharge site monitoring	**Environmental performance** Out of specification water will be recirculated to the start of the treatment process. Screenings and dewatered biosolids will be disposed of in landfill.	
Documentation and reliability	The sampling plan (location, parameters and frequency) will be determined and agreed to by the relevant authorities. The sampling and testing will be performed by an independent, NATA accredited laboratory.	Laboratory NATA certification Chains of Custody Records of results.
Satisfaction of users of recycled water	In this application, comments regarding end user satisfaction are likely to be directed to the site management. Any complaints will be handled as described in the Human Health section of Element 5 above.	Aquacell "Complaints Handling and Dispute Resolution Policy" (IMS Document CS030)
Short-term evaluation of results	The customer is supplied with a monthly report regarding the performance of the plant. The Aquacell recycled water engineer and service technician are in regular verbal and e-mail correspondence with the building management. Results will be provided to the regulator.	Monthly Service Report to the scheme manager regarding plant operation and performance indicators derived from onsite activities, data trending and analysis and water quality results.
Corrective responses	Corrective action depends on the incident. Most corrective actions occur automatically through appropriate PLC logic. As a minimum, it involves investigation of plant performance records to confirm normal operation, and additional testing to confirm the result and identify the source of any issue which arises. If target criteria for environmental parameters are exceeded, preventative measures need to be reassessed and corrective action taken to ensure environmental performance is improved.	Corrective actions are addressed in section 6.2 this RWQMP
Element 6: Management of incidents and emergencies		

Components: Communication	Noncompliance with approval conditions to be reported immediately to regulator. Noncompliance with approval conditions that that affect public health to also be reported immediately to Sydney Local Health District Public Health Unit (NSW Health) In the case of an incident or emergency that requires a media response, only the CEO is authorized to make any public comment.	Notification procedures as described in section 11.3 of this report. Reporting as required to relevant authorities.
Incident and emergency response protocols	Employees are trained in emergency response and incident protocols. Training records are kept. In the event where the water treatment plant is unable to supply treated water, potable water backup is available.	Aquacell "Incident and Emergency Management Procedure" (IMS Document IE010) Training records
Element 7: Operator, contractor and end user awareness and training		
Components: Operator, contractor and end user awareness and involvement	Operator of treatment plant to be sufficiently skilled to run the plant and investigate any faults; End users are made aware of the restrictions on the use of recycled water and any practice that could threaten human health. Contractors inducted to site are told of the presence of dual pipe systems and the precautions required.	Technician induction on commencement of employment, operating manuals, supervision from experienced engineers. End user awareness via signage, inductions and tenancy agreements. Induction records for the coming on site to work.
Operator, contractor and end user training	Operator to be aware of approval conditions and instructed on occupational health and safety requirements Aquacell has an induction program for new employees and written procedures for all areas of responsibility. Training needs for individual employees are identified and adequate resources made available during the induction phase. Annual performance reviews identify additional training requirements and set performance targets. Training records are kept. Any contractors used on site are accredited, qualified and have the appropriate level of training. A site induction includes familiarization with Aquacell's Safe Work Method Statements (SWMS's), which are site specific. Aquacell maintains a partnership with several contractors to ensure continuity of knowledge and technical expertise.	Induction program Annual reviews Contractor induction records. Aquacell document "Hourly Rate Contractor Requirements" Aquacell terms of purchase to contractors and suppliers. Aquacell SWMS's
Element 8: Community involvement and awareness		
Components: Community consultation	The existence of water recycling will be a feature of advertising and promotion for the development.	
Communication and education	The site management will have an information package regarding recycled water use and hazards which it will make available to all new tenants or upon request.	Information supplied from the site managers for the tenants Undesirable chemical discharges to the recycled water system are listed on

		Aquacell' s website community page
Element 9: Validation research and development		
Components: Validation of processes	Ongoing investigations into recycled water quality and treatment plant performance to refine assessments. This may enable less conservative critical control points to be adopted or treatment requirements reduced.	Validation according to section 5 of this RWQMP
Design of equipment	The design of the plant is based on well-documented and validated technologies.	This RWQMP section 5
Investigative studies and research monitoring	As the depth of operational knowledge regarding this and similar water treatment technologies increases, so the understanding of the weaknesses increases. This results in better opportunity to be proactive regarding operational control and maintenance of the plant, thereby improving operating costs and sustainability of the scheme.	This RWQMP will be reviewed in 12 monthly intervals as part of the process of continual improvement.
Element 10: Documentation and reporting		
Components: Management of documentation and records	Design of treatment plant and reticulation system documented; Operating procedures documented; All results to be recorded and stored; Aquacell has developed an in-house Integrated Management System (IMS) that is based on the ISO 9000 system. Included in this RWQMP and the Operations and Maintenance Manual is information pertaining to preventative measures employed, target and critical limits, critical control points, operating and corrective action procedures. These documents, along with the incident and emergency response plans, training programs and reporting protocols ensure that the plant is operating within set limits at all times. The document control system, ensures that only the most current version of any document is available for use. All documents are reviewed on an annual basis.	RWQMP Operations and Maintenance Manual pending (Appendix 11) Incident and Emergency Management Procedure, (IMS document IE010), Performance reviews, Risk Management Procedure (IMS document RM030)
Reporting	Internal reporting consists of verbal communication between the Aquacell engineer and the site service technician and written reports from the technician to the engineer. The owners of this treatment plant receive a monthly report detailing all operational and performance parameters and the maintenance performed during that month. Reports will also be prepared and submitted to the appropriate regulatory authority as required. Non-compliance breaches are reported immediately	Monthly reporting to the building managers regarding the plant performance. Reports as required by regulators
Element 11: Evaluation and audit		
Components: Long-term evaluation of results	Report as required by appropriate regulatory authority on compliance with approval conditions, including test results audited by regulator. This report will be reviewed by senior management prior to distribution and a copy sent to the regulatory authority and the owners of the treated water plant.	Aquacell will generate a report as required by regulators
Audit of recycled water quality management	Internal audits typically occur on an annual basis or as required by regulator and include a review of the management system, operational procedures and monitoring programs. An Independent audit in compliance with an approved third-party auditor occurs at a frequency yet to be determined.	Aquacell will conduct internal audits as required by regulators. Compliance audits by an independent auditor will be conducted. The frequency of these audits is yet to be determined
Element 12: Review and continual improvement		

Components: Review by senior managers	Performance of treatment plant, customer complaints/satisfaction	A senior review of this plant will be conducted as required in combination with the compliance reporting
Recycled water quality management improvement plan	An improvement plan, based upon the results of the internal and external audits and monthly reports which addresses the performance of the plant and end user expectations is prepared as part of the annual review.	In combination with the compliance reporting, an improvement plan will be developed for this treatment plant, based on the monthly reports and any audits performed.

5. Validation of treatment processes

The validation program for the Alspec Industrial Business Park BWTP is outlined within this section of the RWQMP. The validation program has been designed to evaluate the BWTP's ability to achieve the water quality objectives outlined in section 2 of this RWQMP, which acts as a feasibility study of the BWTP design.

5.1 Membrane Bioreactor Validation

The Membrane Bioreactor (MBR) system is used to achieve a 1.5-log virus, 2-log protozoa and 4-log bacteria removal, as specified in Table 3.

The validation for the membrane bioreactor is based on the WaterVal™ Validation Protocol for Membrane Bioreactors (WaterSecure, 2017) (MBR Protocol). Default credits for the MBR can be claimed if the system operates under the WaterVal Tier 1 operating envelope. The table below shows that the AIBP's BWTP MBR system is designed to operate within this envelope.

Table 5: Operating Envelope for Tier 1 Log Reduction Credits for MBR

Parameter	WaterVal Protocol Tier 1 Operating Envelope		Design conditions	Tier-1 condition met
	Minimum	Maximum		
Bioreactor pH	6	8	6 – 8	✓
Bioreactor dissolved oxygen (mg/L)	1	7	1-2	✓
Bioreactor Temperature (°C)	16	30	16	✓
Solids Retention Time (d)	11	-	20	✓
Hydraulic detention time (h)	6	-	32	✓
Mixed liquor suspended solids (g/L)	3	-	7.5	✓
Transmembrane pressure (kPa)	3	-	3-20	✓
Flux (LMH)	-	30	12.2	✓
Turbidity (NTU)	-	0.2	≤ 0.2 Measured continuously online	✓

The default Tier 1 credits proposed by WaterVal and the claimed credits for this project are shown in Table 6 below.

Table 6: Tier 1 Default LRVs and Claimed LRVs

Pathogen type	Tier 1 Default LRV	Claimed LRV
Viruses	1.5	1.5
Protozoa	2	2
Bacteria	4	4

To ensure the MBR filtrate turbidity continuously meets the Tier 1 condition, it will be monitored and controlled via the critical control points as discussed in section 6.2.1.

5.2 UV Validation

Based on the analysis in section 0 and summarised in Table 3, the UV system is required to achieve a minimum pathogen reduction of 4-log for both protozoa and bacteria, and 1-log for viruses.

The selected UV model, a Hallett 1000P, is validated in accordance with the requirements of the US EPA Ultraviolet Disinfection guidance manual for the final long term 2 enhanced surface water treatment rule (UVDGM) (US EPA, 2006).

Table 1.4 of the UVDGM provides the UV dose requirements for pathogens, and is reproduced below in Table 7.

Table 7: Reproduction of the UVDGM UV dose requirements

Target pathogens	Log inactivation							
	0.5	**1.0**	**1.5**	**2.0**	**2.5**	**3.0**	**3.5**	**4.0**
Cryptosporidium	1.6	2.5	3.9	5.8	8.5	12	15	22
Giardia	1.5	2.1	3.0	5.2	7.7	11	15	22
Virus	39	58	79	100	121	143	163	186

A validated dose of 58 mJ/cm^2 is required for 1-log virus inactivation, and 22 mJ/cm^2 for 4-log protozoa. Bacteria are more UV sensitive than protozoa and will therefore be reduced by an amount at least equal to protozoa (e.g., E. coli up to 10 mJ/cm^2 for 4-log inactivation (AwwaRF, 2004)).

The UV reactor must be validated in accordance with the UVDGM at the required operating conditions for the AIBP BWTP.

Aquacell confirms that the UV system was validated in accordance with the UVDGM, and will achieve the required validated dose for virus and protozoa under the conditions shown in Table 8.

Table 8: UV system operating parameters

Operating Parameter	Operating Conditions
Operating Mode	Calculated dose monitoring
Validated UV Dose	≥ 58 mJ/cm^2 (virus); ≥ 22 mJ/cm^2 (protozoa)
Flowrate	Design: 123 L/min (peak per train)
UVT	≥ 75% (validated min. 34.3%) at 254 nm

An analysis of the proposed UV system and validation of the ability to provide the required dose follows.

5.2.1 UV dose equation

The method of operation chosen for this project to ensure the required UV dose is the calculated dose monitoring approach.

The manufacturer of the UV system has had a validation study carried out by a third party in order to establish the UV performance in accordance with the requirements of the UVDGM. This document is confidential to the UV supplier and has been provided to Aquacell under a non-disclosure agreement for the purpose of validating the suitability of the UV and the required operating parameters.

The design assumptions and associated operating UV reactor design output is summarised in Table 10 below:

Table 9: UV system design assumptions

Parameter	Value	Comment
UVT (%)	75	UV Transmissivity (measured online)
UVA	0.125	UV absorbance (calculated from UVT)
S/S_0	0.85	Combined sleeve and lamp fouling factor (ratio of actual intensity to the intensity with new lamps and sleeves)
Reflection Aging Factors	0.95	Condition of UV light reflectors (a feature of the reactor design)
Flowrate (L/min)	123	Design flowrate per train
Validated UV Dose - Virus (mJ/cm^2)	64	Per US EPA UVDGM
Validated UV Dose - Protozoa (mJ/cm^2)	58	Per US EPA UVDGM

The data from Table 9 shows the UV will generate a validated UV dose of 64 mJ/cm^2 for viruses under the conditions shown This is greater than 58 mJ/cm^2 and therefore the UV reactor is capable of achieving a 1-log virus reduction (per USEPA).

Similarly, Table 9 shows a validated dose 58 mJ/cm^2 is obtained for protozoa under the design conditions. This is greater than 22 mJ/cm^2 and therefore the UV reactor is capable of achieving at least a 4-log reduction in protozoa (per USEPA).

5.2.2 UV validation envelope

The UV validation study indicates a validation envelope extending to a UVT of 34.3% and a minimum flow of 23.5 L/min (1.408 m^3/h), and up to a maximum flow of 386.9 L/min (23.05 m^3/h) and a UVT of 98.9%. The design peak flowrate of 123 L/min (7.4 m^3/h) is within the validated flow range.

UVT and validated UV dose are continuously measured and calculated by the UV controller. This in combination with the UV unit status and lamp age is read to the PLC which monitors the UV operational status. If the flowrate falls below 23.5 L/min, the UV dose calculation defaults to the minimum validated flowrate of 23.5 L/min. Furthermore, the rated capacity of the UV feed pump (PF-DIS-01) is 167 L/min, which is well below the maximum validated flow of 384.2 L/min, thereby mitigating the risk of flow rates exceeding the validated operating envelope.

5.3 Free Chlorine System Validation

The chlorine disinfection system is designed to achieve a 4-log virus and bacteria inactivation, as specified in Table 3. The critical C-T required to achieve this is determined by reference to two separate regulations. Error! Reference source not found. Table 10 is an extract from the *Guidance Manual for Compliance with Filtration and Disinfection Requirements for Public Water Systems using Surface Water Sources* (USEPA 1991). According to US EPA guidelines, at a temperature of 15 degC and pH range of 6 – 9, the C-T requirement for 4.0-log virus inactivation is 4 mg.min/L.

Table 10: Copied from USEPA 1991 Table E-7 – CT values for Inactivation of viruses by free chlorine

Temperature (°C)	Log inactivation – virus					
	2.0		3.0		4.0	
	6-9 pH	10 pH	6-9 pH	10 pH	6-9 pH	10 pH
0.5	6	45	9	66	12	90
5	4	30	6	44	8	60
10	3	22	4	33	6	45
15	2	15	3	22	4	30
20	1	11	2	16	3	22
25	1	7	1	11	2	15

By comparison, the WaterVal™ Validation Protocol for Chlorine Disinfection (WaterSecure, 2017) — underpinned by the US EPA guidance in the Disinfection Profiling and Benchmarking Guidance Manual (US EPA, 1999a) — prescribes specific C–T values based on recent studies using Coxsackievirus B5, which is recognised as the most chlorine-resistant virus within the pH 6–10 range. These values differ from the original US EPA C–T values and are detailed in Table 11, which presents C–T requirements for 1- to 4-log virus reduction across a range of turbidity, pH, and temperature conditions.

Table 11 CT values for 1 to 4 log reduction values of viruses at a range of turbidity, pH and temperature (WaterVal protocol)

pH	LRV	$\leq 0.2NTU$					$\leq 2NTU$					$\leq 5NTU$				
		$5°C$	$10°C$	$15°C$	$20°C$	$25°C$	$5°C$	$10°C$	$15°C$	$20°C$	$25°C$	$5°C$	$10°C$	$15°C$	$20°C$	$25°C$
≤ 7	1	4	3	2	2	1	4	3	2	2	1	4	3	2	2	1
	2	5	4	3	2	2	5	4	3	2	2	6	4	3	2	2
	3	7	5	4	3	2	7	5	4	3	2	7	5	4	3	2
	4	8	6	4	3	2	9	6	4	3	2	9	7	5	3	3
≤ 7.5	1	7	5	4	3	2	7	5	4	3	2	8	6	4	3	2
	2	10	7	5	4	3	10	7	5	4	3	13	9	6	5	4
	3	13	9	7	5	4	13	9	7	5	4	16	12	9	6	5
	4	16	11	8	6	4	16	11	8	6	4	21	15	11	7	6
≤ 8	1	9	7	5	3	3	10	7	5	4	3	12	9	6	4	3
	2	14	10	7	5	4	15	10	7	5	4	19	13	9	7	5
	3	18	13	9	7	5	19	13	10	7	5	25	18	13	9	7
	4	23	16	12	8	6	23	16	12	8	6	32	23	16	11	8
≤ 8.5	1	11	8	6	4	3	12	9	6	5	4	14	10	7	5	4
	2	17	12	9	6	5	19	13	10	7	5	21	15	11	8	6
	3	23	16	12	9	6	25	17	13	9	7	29	21	15	10	8
	4	29	21	15	10	8	31	22	16	11	8	37	26	18	13	9
≤ 9	1	13	9	6	5	3	14	10	7	5	4	15	10	7	5	4
	2	20	14	10	7	5	22	16	11	8	6	23	16	12	8	6
	3	28	19	14	10	7	30	21	15	11	8	32	23	16	11	8
	4	35	25	17	12	9	38	27	19	13	10	41	29	20	14	10

According to this protocol, for ultrafiltered water (essentially particle-free), a C–T value of 12 mg·min/L is required to achieve a 4.0-log virus reduction at pH ≤ 8 and 15 degC. Applying a conservative design approach, the chlorine contact tank has been sized for a 12 mg·min/L C–T. As bacteria are more susceptible to chlorine than viruses, achieving a 4.0-log virus inactivation will also ensure at least a 4.0-log bacteria inactivation.

5.3.1 Chlorine contact tank design

The Theoretical Detention Time (TDT) required is given as follows:

TDT = V/Q

Where:

TDT = Theoretical Detention Time (min)

V = minimum volume of chlorinate contact system (L)

Q = flow rate (L/min)

Actual detention time (T) is determined by correcting for the impact of potential bypass by the use of a baffling factor (BF):

T = TDT x BF

Where:

T = time that water is contact with chlorine (min)

BF = baffling factor (usually between 0.1 – 1.0)

The design for the contact tank uses a long length of pipe to achieve the chlorine contact time. It is generally considered that a L/D of > 40 approximates plug flow (e.g., *Guidelines for validating treatment processes for pathogen removal (DH, 2013), section 8.1.3*), and that under these conditions contact time (T) is equal to theoretical detention time (TDT). That is, the baffling factor (BF) equals one under these conditions.

The design uses a total pipe length (L) of 36 m at a diameter (d) of 246 mm which gives L/d = 146.3, which is greater than the minimum of 40. The calculated volume for the contact pipe is determined as follows:

*Volume (V) = π * (246/1000) ^2 /4 * 36*

= 1.711 m^3 = 1711 L

5.3.2 Chlorine residual calculation

The C-T is defined as:

*C-T (mg·min/L) = C (mg/L) * T (min)*

*= C (mg/L) * TDT*BF*

*= C (mg/L) *V (L)/Q (L/min)*BF*

As BF =1 for plug flow, V= 1711 L, this equation becomes:

***C-T (mg·min/L)** = C (mg/L) *1711/Q (L/min)* 5.1

Equation 5.1 is programmed into the PLC and used to continuously monitor the instantaneous C-T value. At any flow rate, the free chlorine concentration is automatically adjusted to ensure that the C-T is > 12 mg·min/L, while maintaining the chlorine concentration within the operational range of 0.5 – 5 mg/L.

6. Operational monitoring and process control

A Hazard Analysis and Critical Control Point (HACCP) analysis of the Alspec Industrial Business Park BWTP is conducted after the risk management workshop and is included in Appendix 4. The methodology used will be in accordance with the AGWR and Aquacell's documented risk procedures.

6.1 Operational control

A flow diagram summarising the Quality Control Points (QCP) and Critical Control Points (CCP) is shown in Figure 3. Two identical trains with the same process units and QCP's and CCP's will be installed (each producing 150 kL/day). Detailed monitoring and corrective actions for the QCP's and CCP's are described in the following sections.

6.1.1 Critical control points

If water quality parameters for either train A or train B are exceeded at the CCP's, treated water from that train will either be recirculated (MBR CCP's) or diverted to the Off-spec water holding tank. If the CCP limits continue to be exceeded for an extended period of time, the corresponding train will shutdown.

6.1.2 Process Description

Pre-screen:

The prescreen removes non-degradable solids such as fibers, or rags that can block or damage downstream processes and equipment. It also removes some of the degradable waste which help to lower the organic load to the biological treatment process.

Emergency Tank:

A 300 kL emergency storage tank is integrated at the plant's inlet to provide one day of raw sewage holding capacity in the event of a prescreen failure or shutdown, eliminating the need for immediate pump-out.

Buffer Tank:

A 1 ML buffer tank is provided to capture peak flows from the site. This maximizes the amount of water that can be recovered and enables the plant to operate at an efficient and steady flow. A submersible mixer is employed in these tanks to keep solids suspended and to prevent anaerobic conditions occurring.

Bioreactor:

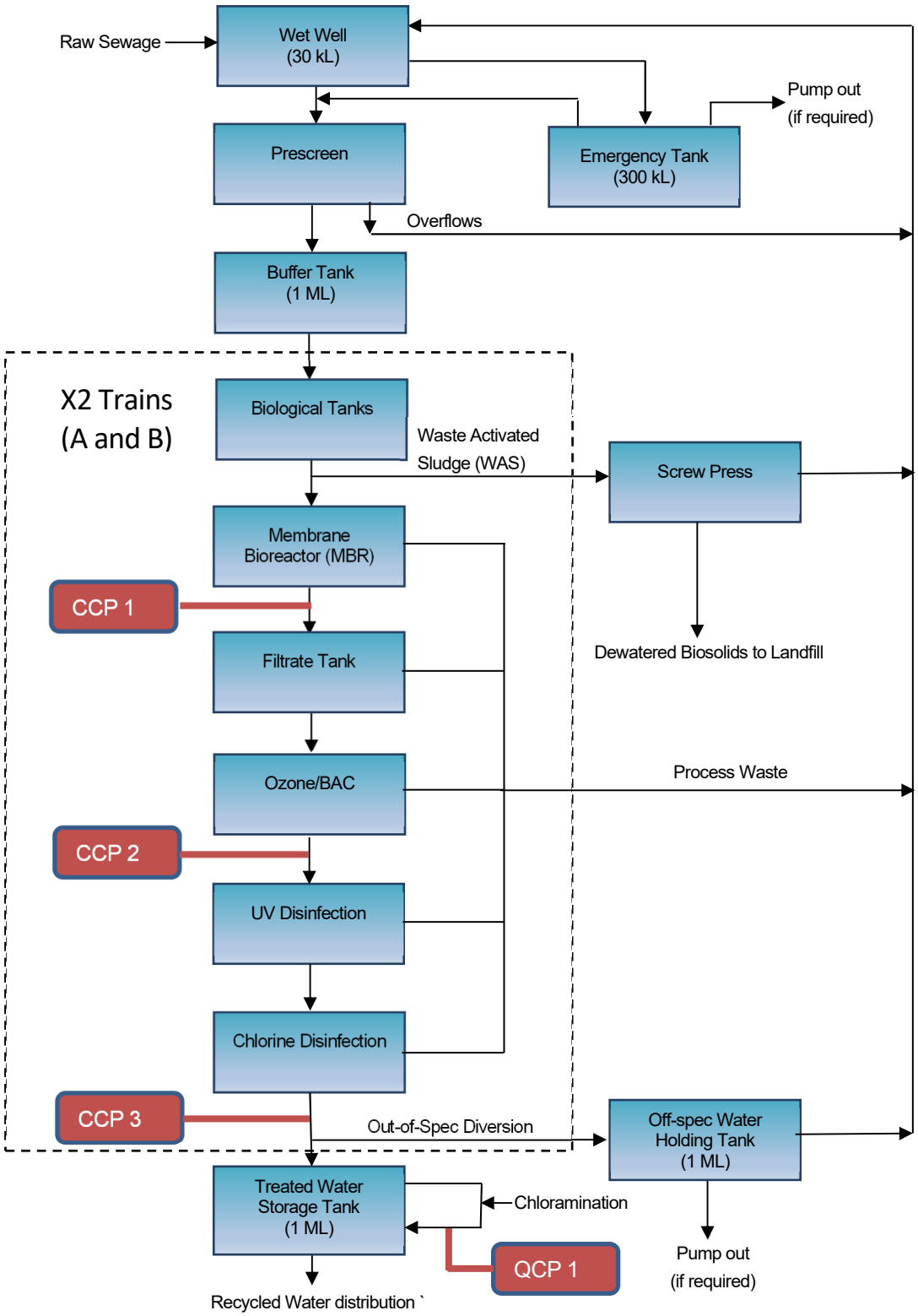
The biological system consists of both anoxic and aerobic stages.

The Anoxic Tank converts nitrate generated by the treatment process to nitrogen gas in order to reduce the nitrogen content of the treated water. Continuous mixing in the anoxic tank ensures that mixed liquor remains homogenous.

The Aerobic Tank carries out further biological treatment of the wastewater to reduce the organic content and convert ammonia nitrogen to nitrate and nitrite. Blowers aerate these tanks to ensure the required air for oxygen transfer is provided.

Mixed liquor suspended solids (MLSS) concentration is monitored continuously and waste activated sludge (WAS) is periodically discharged to maintain the required MLSS level.

Figure 3: Recycled water process flow and critical control points



Screw Press:

The screw press receives sludge from the WAS tank and separates the solid and liquid phases. The liquid is sent back to the start of the process train and the dewatered biosolids are collected for transportation to landfill.

Ultrafiltration membranes:

The combination of ultrafiltration and bioreactor is referred to as a membrane bioreactor (MBR). The biomass suspension from the bioreactor is recirculated past hollow fibre membranes, housed in the MBR tank, and returned to the bioreactor. A portion of the recirculated flow is withdrawn through the membranes as filtrate and collected in the filtrate tank for downstream disinfection.

The membranes are polymeric hollow fibres with a nominal pore size of 0.04 µm. The membranes effectively remove essentially all suspended solids and the bulk of any pathogens, including virus, bacteria and protozoa.

Ozone/BAC:

Filtered water then dosed with ozone and passed through an ozone contact pipe followed by Biological Activated Carbon (BAC) filters. This combination is used to remove colour from the feed water. The BAC employs periodic backwashing to control bacteria levels present in the filter and to ensure the filter bed is well distributed.

Ultraviolet light Disinfection (UV):

The UV system consists of two UV units in parallel. It provides the required dose to ensure the required inactivation of virus, bacteria and protozoa.

Chlorine Disinfection:

Following the UV, the water is dosed with sodium hypochlorite before entering a pipe contactor to provide the necessary chlorine contact time for disinfection. The free chlorine residual and pH of the recycled water are monitored at the end of the chlorine contact pipework.

Treated Water Storage Tank and Distribution:

The treated water is stored in a 1ML Treated Water Storage Tank (TWST) which allows the system to account for peak flows. Water in the TWST is recirculated and dosed with chlorine to maintain a free chlorine residual for storage and distribution.

Off-Spec Storage Tank:

Any treated water that cannot be used for distribution will be diverted to the Off-Spec Storage Tank. This water will then be recirculated back through the treatment process.

Odour Scrubber:

The odour scrubber captures and treats emissions from key odour sources within the facility, including the wet well, prescreen, buffer tank, and screw press, to minimise any adverse impacts on the surrounding environment.

6.2 Monitoring and corrective actions

6.2.1 MBR System

Table 12: MBR critical control point

CCP 1	MBR		
	Turbidity	**Sample Flow Switch**	**Instrument Status**
Critical limits/alert limits			
Alert	≥ 0.15 NTU		
Critical	> 0.2 NTU	No Flow	Instrument Critical Fault
Monitoring procedures			
What	Turbidity	Flow Switch	Transmitter
How	AIT-MBR-01 (HACH TU5300sc)	FS-MBR-01	AIT-MBR-01 (HACH TU5300sc)
When	Continuous, during MOS FILTRATION		
Where	MBR filtrate line		
Who	Aquacell/Automatic		
Corrective actions			
What	MOS recirculation mode entered, returning filtrate to the MBR tank.		MOS goes to standby
How	Open recirculation valve (AV-306A/B) and close filtrate to filtrate tank valve (AV-302A/B)		Filtration stopped
When	If critical limit is exceeded for > 120 s	No flow for > 120 s	Immediate
Where	PLC		
Who	Automatic		

Turbidity:

If during MOS filtration, the turbidity exceeds the alert level for 120 seconds a warning alarm is generated to warn the operator. If the turbidity exceeds the critical level for more than 120 seconds, an alarm is triggered and the filtrate flow is diverted from the filtrate tank and recirculated back to the MBR tank. During recirculation, if the turbidity drops below the critical level for at least 120 seconds, filtrate is sent to disinfection. However, if after 3 filtration/relaxation cycles, the filtrate turbidity has not fallen below the critical limit for at least 120 seconds, the MOS (Membrane Operating System) will go to standby and a standby alarm will be generated.

Production resumes when the operator resets the turbidity alarm after the cause has been identified and addressed.

Flow switch:

There is a flow switch in turbidity meter sample line to ensure sample flow is present during MOS filtration. If sample flow is lost, the turbidity readings are unreliable. If during MOS filtration, the flow switch turns off for more than 60 seconds an alarm is triggered to warn the operator. If the flow switch is off more than 120 seconds, an alarm is generated and the filtrate flow is diverted from the filtrate tank and recirculated back to the MBR tank. During recirculation, if the sample flow switch turns on for at least 120 seconds, treated water is redirected to storage. However, if after 3 filtration cycles, the sample flow switch has not turned on for at least 120 seconds, the MOS (Membrane Operating System) will go to standby and a standby alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Instrument Status:

If a critical turbidity instrument fault occurs during MOS filtration or recirculation, the MOS (Membrane Operating System) will immediately go to standby and a standby alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Maintenance:

Turbidity tested by handheld turbidity meter monthly, and recalibrated as required.

6.2.2 UV system

Table 13: UV disinfection critical control point

CCP 2	UV disinfection			
	Validated UV Dose – Virus	**UVT**	**Lamp age**	**UV status**
Critical limits/alert limits				
Alert	< 60 mJ/cm^2	< 45%	> 10,000 hours	
Critical	< 58 mJ/cm^2	< 35%	> 12,000 hours	UV Fault
Monitoring procedures				
What	UV Dose	UVT Monitor	Hour monitor	Lamp monitor
How	UV Controller (Hallett 1000P)	UV Controller (Hallett 1000P)	PLC recorded and UV controller (Hallett 1000P)	UV Controller (Hallett 1000P)
When	Continuous, online			
Where	UV Unit	UV Unit	UV Unit and PLC	UV Unit Output
Who	Aquacell/Automatic			
Corrective actions				
What	Flow diverted to Off-spec Water Holding Tank		Disinfection System goes to shutdown	
How	Close AV-461A/B and open AV-462A/B		Flow stopped	
When	If critical limit is exceeded for > 120 s		Immediate	
Where	PLC			
Who	Automatic			

Validated UV Dose – Virus:

The validated UV dose for virus is calculated by the UV controller using the flow rate, measured UVI and measured UVT. The dose is output from the controller to the PLC for monitoring.

If the UV dose drops below the alert level for more than 120 seconds an alarm is triggered to warn the operator that the UV system is approaching the low UV dose limit. The operator can then check the unit operation and rectify before the UV dose reaches the critical level. If the UV dose drops below the critical level for 120 seconds, an alarm is generated and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the UV dose increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the UV dose does not return above the critical limit for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

UVT:

The UVT is continuously monitored to ensure it remains in the validated range. If the UVT drops below the alert level for more than 120 seconds an alarm is triggered to warn the operator that the UVT is approaching the low limit. If the UVT drops below the critical level for 120 seconds, an alarm is generated and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the UVT increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the UVT does not return above the critical limit for a minimum of 120 seconds, the disinfection system will go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

If the UVT exceeds the maximum validated UVT (98.7%) then the calculated UV dose will use the maximum validated UVT to determine the applied UV dose.

Lamp age:

Lamp age is monitored continuously by the UV control module. If the lamp hour alert level is reached, a warning alarm is generated to warn the operator. If the critical hours are exceeded, the disinfection system will immediately go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the UV lamps have been replaced.

UV Status:

The UV Status is monitored continuously by the PLC and UV control module. If a critical UV fault occurs, the disinfection system will immediately go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause of the fault has been rectified.

Maintenance:

UVT is tested by handheld UVT meter monthly, and recalibrated as required.

6.2.3 Chlorine Disinfection

Table 14: Chlorine disinfection critical control point

CCP 3	Chlorine disinfection					
	Free Chlorine Residual (C)	**pH**	**Flow Switch**	**Temperature**	**Instrument Status**	**Chlorine Contact Time (C-T)**
	Critical limits/alert limits					
Alert	C < 0.55 mg/L or C > 4.5 mg/L	pH > 8.5 or pH < 6.5	No Flow	< 16 deg C		C-T < 12.6 mg.min/L
Critical	C < 0.5 mg/L or C > 5.0 mg/L	pH > 8 or pH < 6.0	No Flow	< 15 deg C	Instrument Fault	C-T < 12 mg.min/L
	Monitoring procedures					
What	Free chlorine residual	pH	Flow switch	Temperature	Transmitter	PLC
How	AE-CCT-3A/B (E&H CCS51E)	AE-CCT-2A/B (E&H CPS11E)	FS-CCT-1A/B (E&H CYA27)	AE-CCT-1A/B (E&H CCS58D)	AIT-CCT-1A/B (E&H Liquiline CM442)	Calculated in PLC
When	Continuous, online					
Where	End of chlorine contact pipe (CCT)		Disinfection Skid	End of chlorine contact pipe (CCT)	UV-Chlorination Skid	End of chlorine contact pipe (CCT)
Who	Aquacell/Automatic					
	Corrective actions					
What	Flow diverted to Off-spec Water Holding Tank				Disinfection System goes to shutdown	Flow diverted to Off-spec Water Holding Tank
How	Close AV-461A/B and open AV-462A/B				Flow stopped	Close AV-461A/B and open AV-462A/B
When	If critical limit is exceeded for > 120 s				Immediate	If critical limit is exceeded for > 120 s
Where	PLC					
Who	Automatic					

Free chlorine residual:

The free chlorine residual at the end of the chlorine contact pipe is continuously monitored. If the free chlorine concentration goes outside the alert range for more than 120 seconds an alarm is triggered to warn the operator. The operator can then check the unit operation and rectify before the it reaches the critical level. If the free chlorine concentration goes outside the critical range for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the free chlorine concentration goes back within the critical range for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the free chlorine concentration does not return within the critical range for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

pH:

The pH measurement at the end of the chlorine contact pipe is continuously monitored. If the pH goes outside the alert range for more than 120 seconds an alarm is triggered to warn the operator. The operator can then check the unit operation and rectify before the it reaches the critical level. If the pH goes outside the critical range for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the pH goes back within the critical range for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the pH does not return within the critical range for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

Flow switch:

There is a flow switch in the temperature and free chlorine sample line to ensure sample flow is present. If sample flow is lost the readings are unreliable.

If the flow switch turns off for more than 60 seconds an alarm is triggered to warn the operator. If the flow switch is off more than 120 seconds, an alarm is generated and the treated water is diverted to the Off-spec Water Holding Tank. During diversion to the Off-spec Water Holding Tank, if the flow switch turns back on for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the flow switch has not turned on for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Water temperature:

The chlorine contact system has been designed based on chlorine contact time (C-T) values for a minimum temperature of 15 deg C.

If the temperature drops below the alert level for more than 120 seconds an alarm is triggered to warn the operator. If the temperature drops below the critical level for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the temperature increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the temperature does not return above the critical limit for a minimum of 120 seconds, the disinfection system will go to shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed. An increased chlorine residual may be required to allow continued operation at a lower temperature.

Instrument Status:

If there is a CCT instrument critical fault, the disinfection system will immediately go to shutdown and a shutdown alarm will be generated.

Production resumes when the operator resets the alarm after the cause has been identified and addressed.

Chlorine Contact Time:

The chlorine contact time (C-T) is calculated in the PLC using the free chlorine concentration and the flowrate. If the chlorine contact time (C-T) decreases below the critical level for 120 seconds, an alarm is triggered and the treated water is diverted to the Off-spec Water Holding Tank. If during diversion to the Off-spec Water Holding Tank, the C-T increases back above the critical level for 120 seconds, the treated water will be redirected to the Treated Water Storage Tank. However, if after 2 hours the C-T does not return above the critical limit for a minimum of 120 seconds, the disinfection system will shutdown and a shutdown alarm will be generated.

Production can resume when the operator resets the alarm after the cause has been identified and addressed.

Maintenance:

The pH probe is checked against buffer solutions monthly and recalibrated if required.

The free chlorine probe is checked against a DPD photometric free chlorine test monthly and recalibrated as required.

Temperature tested by handheld temperature probe monthly, and recalibrated as required.

6.2.4 Treated Water Storage Chlorination System

Table 15: Treated Water Storage Chlorination quality control point

QCP 1	Total Chlorine Residual (TC)	pH	Sample Flow Switch	Instrument Status
Alert	TC < 0.5 mg/L or TC > 5.0 mg/L	pH < 6.5 mg/L or pH > 9.0 mg/L	No Flow	Instrument Fault
Monitoring procedures				
What	Total chlorine residual	pH	Flow Switch	Transmitter
How	AE-STO-02 (E&H CCS53E)	AE-STO-01 (E&H CPS11E)	FS-STO-01 (E&H CYA27)	AIT-STO-01 (E&H Liquiline CM442)
When	Continuous, when Treated Water Storage Tank recirculation pump is running			
Where	Treated Water Storage Tank recirculation			
Who	Aquacell/Automatic			
Corrective actions				
What	Warning alarm only for < 0.5 mg/L. Stops chloramine dosing pumps if > 5 mg/L		Warning alarm and stop chloramine dosing pumps	
How	PLC triggers alarm		PLC triggers alarm and stops the dosing pumps.	
When	If alert limit is exceeded for > 120 s			Immediate
Where	PLC/HMI			
Who	Automatic			

Total chlorine residual:

When the Treated Water Storage Tank recirculation pump is running, the total chlorine level is continuously monitored to ensure that there is a residual in the treated water distribution system. If the total chlorine level is below the alert limits for more than 120 seconds, an alarm in generated to warn the operator. If the total chlorine level is above the alert limit for more than 120 seconds, an alarm in generated to warn the operator and the chloramination dosing pumps are stopped.

The alert is reset after the total chlorine level is within the range for 120 seconds.

Treated water pH:

The pH in the treated water tank is continuously monitored to ensure it is with the range. If the pH is not within the limits for 120 seconds a warning alarm is generated.

Flow switch:

There is a flow switch in the pH and total chlorine sample line to ensure sample flow is present when the Treated Water Storage Tank recirculation pump is running. If sample flow is lost, the pH and total chlorine readings are unreliable. If the flow switch turns off for more than 60 seconds an alarm is triggered to warn the operator. If the flow switch is off more than 120 seconds, an alarm in generated and the chloramine dosing pumps are stopped.

Chemical dosing resumes after the cause has been identified and addressed.

Instrument Status:

If a treated water storage tank instrument fault occurs when the Treated Water Storage Tank recirculation pump is running, chemical dosing pumps will be shutdown and an alarm will be triggered.

Chemical dosing resumes after the cause has been identified and addressed.

Maintenance:

The pH probe is checked against buffer solutions monthly and recalibrated if required.

The total chlorine probe is checked against a DPD photometric total chlorine test monthly and recalibrated as required.

6.3 Standard operating procedures

An operations and maintenance manual will be supplied with the system to explain detailed operation. This includes a description of the CCP's and QCP's and required operator actions.

A summary of the CCP's is provided in Table 16 along with the control response and operator actions. Further details are provided in the operating and maintenance manual.

During shutdown, wastewater is collected in the buffer tank which has been sized to hold a three-day supply of blackwater. If during shutdown the buffer tank reaches full capacity, it will be pumped out.

Table 16: CCP Summary of control system response and operator actions

CCP	Control System Response	Operator Actions
CCP 1 – MBR	The MBR filtrate turbidity, instrument status and flow switch status are continuously monitored. The MBR will go into recirculation mode if the turbidity conditions are not met.	The system will automatically reset when CCP parameters are in spec. However, if this does not occur, the MBR will go into standby and operator intervention will be required. The operator should contact Aquacell for a detailed investigation. The most likely causes are membrane system leaks (seals or membrane integrity), faulty turbidity readings (due to air bubbles), or biogrowth shedding from pipework.
CCP 2 – UV Disinfection	The validated UV dose is continuously calculated and monitored along with UVT, lamp age and UV status. The plant diverts water to the Off-spec water holding tank after the CCT if the UV conditions are not all met.	The system will automatically reset when CCP parameters are in spec. However, if this does not occur, the disinfection system will shutdown and operator intervention will be required. The relevant parameters that affect UV dose are individually monitored and alarmed to guide the operator response. If further troubleshooting is required, contact Aquacell.
CCP 3 - Chlorination	The free chlorine concentration is continuously monitored along with the pH, temperature, flowrate, instrument status and flow switch status. The plant diverts water to the Off-spec water holding tank after the CCT if the chlorine disinfection conditions are not all met.	The system will automatically reset when CCP parameters are in spec. However, if this does not occur, the disinfection system will shutdown and operator intervention will be required. The most likely issues will be around chlorine dose or chlorine demand. If no obvious faults are present, contact Aquacell.

7. Verification and Ongoing monitoring

To provide evidence that the overall system can deliver water of the specified quality, the verification monitoring plan detailed in Table 17 will be used. This will provide a total of 12 samples over 6 weeks.

Influent and treated water samples will be taken as defined below using Aquacell's sampling procedure (Appendix 6). Sample analysis is undertaken at a NATA accredited laboratory.

Table 17: Treated water verification monitoring program

Parameter	Units	Sampling Frequency (per week)	Duration of monitoring program (weeks)	Compliance Value
Influent				
E.coli	cfu/100ml	2	6	NA
FrNA Coliphage	pfu/100mL	2	6	NA
Clostridium perfringens	cfu/100mL	2	6	NA
Biochemical oxygen demand (BOD)	mg/L	2	6	NA
Total suspended solids (TSS)	mg/L	2	6	NA
pH		2	6	NA
Treated Water				
E.coli	cfu/100ml	2	6	< 1
FrNA Coliphage	pfu/100mL	2	6	< 1
Clostridium perfringens	cfu/100mL	2	6	<1
Crypto-sporidium oocysts	oocysts/L	1 sample during monitoring period	6	<1
Biochemical oxygen demand (BOD)	mg/L	2	6	< 10
Total suspended solids (TSS)	mg/L	2	6	< 10
Turbidity (MBR filtrate) (NTU)	NTU	Continuous online	6	≤ 0.2
Validated UV Dose (virus)	mJ/cm2	Continuous online	6	≥ 58
Free Chlorine (FRC – post CCT)	mg/L	Continuous online	6	Target between 0.5 and 5.0
Chlorine Contact Time (C-T)	mg.min/L	Continuous online	6	C-T ≥ 12
pH (CCT)		Continuous online	6	pH ≤ 8
Total Chlorine (Treated Water Storage)	mg/L	Continuous online	6	TC ≥ 0.5 and TC ≤ 5.0

To provide evidence that the overall system can deliver water of the specified quality on an on-going basis, the following on-going monitoring plan is proposed (Table 18).

Table 18: Treated water ongoing monitoring program

Parameter	Units	Monitoring frequency	Compliance Value
Treated Water			
E.coli	cfu/100ml	Monthly	< 1
Turbidity (MBR filtrate) (NTU)	NTU	Continuous online	≤ 0.2
Validated UV Dose (virus)	mJ/cm2	Continuous online	≥ 58
Chlorine Contact Time (C-T)	mg.min/L	Continuous online	C-T ≥ 12
pH (CCT)		Continuous online	pH ≤ 8
Total Chlorine (Treated Water Storage)	mg/L	Continuous online	TC ≥ 0.5 and TC ≤ 5.0

8. Prerequisite programs

For the effective operation of this RWQMP, prerequisite programs that outline detailed procedures and protocols will be provided.

Operations and Maintenance Procedures:

An operations and maintenance manual in accordance with the AGWR will apply to the scheme and will be attached in Appendix 11. Included in the manual are the Standard Operating Procedures, Maintenance Procedures, Calibration Procedures and Chemical Safety Procedures.

Calibration of Monitoring Instruments:

The calibration of all on-line monitoring instruments will be conducted in accordance with the manufactures' recommendations. The calibration of each instrument is logged and maintained on a standard maintenance record.

Chemical Quality Assurance:

All chemicals required for cleaning, maintenance and water treatment will be supplied by an ISO9001 accredited supplier.

Organisational Quality Management:

Aquacell has developed an in-house management system, IMS (Integrated Management System), which is regularly audited. This system documents Aquacell's regulatory, risk and organisational procedures and protocols.

Inspections:

The plant is under continuous remote supervision by Aquacell as the contracted operator. Data logging of key parameters is a part of this supervision. Weekly inspections are conducted and a checklist is completed by the scheme manager according to the service agreement between the scheme manager and Aquacell. The responsibilities will be clearly delineated in the service agreement. Also, in accordance with the service agreement, monthly maintenance including instrument calibration checks are carried out by Aquacell and records maintained. Quarterly servicing is also carried out by Aquacell and records maintained.

Aquacell will provide the necessary training for the scheme manager's staff to perform the work required. Records of this training will be kept by Aquacell.

9. Incidents and emergencies

Aquacell maintains a community contact and FAQ section of its website with procedures relating to the management of emergencies. This will be updated to include the Alspec Industrial Business Park BWTP.

In addition, a meeting attended between Aquacell, the scheme manager and its relevant contractors will be held to review emergency procedures that are specific to the recycled water scheme and the precinct.

Table 19 describes emergency response incidents and procedures.

Table 19: Incidents and emergencies

Hazards and events that may lead to emergencies	Immediate Response		Corrective Action		Authorities	
	What	Who	What	Who	What	Who
Non-conformance of water with critical limits	If detected by online instrument, plant automatically shuts off supply	Aquacell	Aquacell diagnose and rectify.	Aquacell	Has non-compliant water been delivered? If yes, Aquacell notify the scheme manager. The scheme manager to notify NSW Health.	The scheme manager
Response to exceedances of water quality targets	If there are any occurrences of positive results for the ongoing water quality monitoring as described in Table 18, supply of recycled water should be stopped, and the cause investigated. Aquacell to notify the scheme manager. The scheme manager to immediately notify NSW Health.	Aquacell/ The scheme manager	Aquacell to investigate cause and rectify. Re-test and achieve compliance before resuming delivery of recycled water.	Aquacell	Aquacell to notify the scheme manager. The scheme manager notify NSW Health.	The scheme manager
Accidents that increase level of contamination in source water	Feed water continuously monitored for pH.	Aquacell	Pause production investigate cause. Production resumed once pH returned to specification (may need manual adjustment)	Aquacell	NA	NA
Equipment breakdown and mechanical failure	Critical equipment alarmed for malfunction. Alarm received by operator. Operator to log in and inspect operation of plant. Disable plant if required.	Aquacell	Repair	Aquacell	NA	NA
Cross-connections	If a cross connection is detected, immediately stop use of treated water, and switch to potable water backup.	The scheme manager	Conduct audit to identify location of cross-connection. Rectify. Preventative measures include signage, labelling, colour-coding,	The scheme manager	Should a cross-connection be identified, notify the scheme manager and Aquacell. The scheme	The scheme manager

			information brochures for plumbers and public. Do not reinstate delivery of treated water until cross connect audit has been completed.		manager in turn notify NSW Health.	
Prolonged power outages	Plant shuts down in a safe state on power failure. Notify Aquacell so that restart procedures and checks can be made and the plant monitored during start-up. Potable water backup will provide water needs automatically.	The scheme manager	Remote operator log-in. Restart operation on return of power.	Aquacell	NA	NA
Leakage, spillage, or runoff of recycled water or greywater on site.	For minor contained spills, notify the scheme manager for repair. If treatment plant is responsible contact Aquacell.	The scheme manager	The scheme manager or site management to respond. Aquacell to action if treatment plant is responsible. Incident report to be prepared and corrective actions implemented.	Aquacell/ The scheme manager	If major spill that contaminates or potentially contaminates the environment also contact NSW Health, Department of Planning and Environment, IPART and the City of Penrith Council.	The scheme manager

10. Employee awareness and training

The scheme manager and Aquacell are responsible for ensuring their respective employees and contractors are familiar with the operation of the scheme and aware of the potential consequences of system failures, and of how their decisions can affect the safety of the scheme.

Aquacell will provide an experienced water recycling engineer to monitor the plant. Any contractors used on site must be accredited, qualified and have the appropriate level of training.

A site induction will be required for anyone doing work related to this scheme. This will be carried out and recorded by the scheme manager for work on the dual pipe system, and by Aquacell for work on the treatment plant. For plant work this includes familiarization with Aquacell's Safe Work Method Statements (SWMS's) which are site specific. Aquacell maintains a partnership with several contractors to ensure continuity of knowledge and technical expertise.

Aquacell has an induction program for new employees and written procedures for all areas of responsibility.

Training needs for Aquacell employees are identified and adequate resources made available during the induction phase. Annual performance reviews identify additional training requirements and set performance targets. Training records are kept.

11. Documentation and reporting

11.1 Documentation

The following records and documents will be maintained by Aquacell as the water recycling plant operator.

- Verification and on-going monitoring results
- CCP monitoring results and analysis
- Plant operation data
- Laboratory testing results and analysis
- Breaches of critical limits and corrective actions taken
- Incidents and emergencies and corrective actions taken
- Inspection and maintenance activities relevant to water quality

CCP results and operation data will be collected by an online data acquisition system and kept as an electronic copy by Aquacell.

Verification results will be collected by Aquacell from a NATA accredited testing laboratory and stored electronically by Aquacell.

A record of any maintenance to the treatment plant will be kept. Any equipment adjusted, repaired, replaced or calibrated will be recorded. Monthly maintenance checks and calibrations are recorded on a monthly maintenance checklist (See Operations and Maintenance Manual (Appendix 11), and stored according to Aquacell's document management procedures.

11.2 Reporting

Aquacell will provide a monthly report to the scheme manager in relation to the operation and maintenance of the water recycling plant.

Separate reports, as required by the relevant authorities will also be prepared. These reports will be signed by the designated Aquacell person and includes:

- a summary of the review and improvement processes, and whether the RWQMP has been complied with,
- a summary of priority areas for improvement and actions to address any non-compliances with the RWQMP,
- an analysis of the monitoring data collected for the management of environmental risks,
- an analysis of the monitoring data collected under the RWQMP,
- a summary of incidents and emergencies, including corrective actions,
- a listing or register of supplied recycling schemes, including quality, quantity and type of use, and
- a summary of audit outcomes.

The reports will also be signed by a person authorised as a representative of the organisation/s receiving the report.

11.3 Notifications

Aquacell, as the operator of the recycled water plant, must immediately notify the scheme manager of any incidents that occur with the treatment process or plant that could affect health. This includes:

- Incidents where recycled water has been supplied that does not comply with the three CCP conditions described in Section 0,
- Any other incident or emergency that could directly or indirectly impact on the health of the end users.

Notification should include details of corrective and future preventive action.

Contact details for various key entities in the project are listed in the table below. These will be updated from time to time as appropriate.

Table 20: Contact details

Entity	Contact	Details
Sydney Local Health District Public Health Unit (NSW Health)	Public Health officer	Phone: 02 9515 9420 Phone (after hours): 02 9515 6111 (to speak with the Public Health Officer on call for environmental health) Email: SLHD-PHUEHO@health.nsw.gov.au
IPART	TBA	TBA
Scheme Manager	TBA	TBA
Aquacell	Colin Fisher, Managing Director	Address: Suite 602, 6A Glen Street, Milsons Point, NSW 2061. Phone: 02 4721 0545 Mobile: 0409 393 389 Email: colinf@aquacell.com.au

12. Review and improvement

The plant operation and RWQMP will be reviewed annually and updated as needed. This is an internal review process with appropriate operating staff. The review and improvement process will include:

- Critical analysis of current improvement procedures
- Identify all known deficiencies that require improvement
- Make comparisons with targets and current practices
- Identification of new and continuous improvement opportunities
- Document success of improvements made
- Overall verification of current improvement practices

Any changes to CCP limits must be endorsed by NSW Health or approved by IPART before being implemented.

13. Commissioning the RWQMP

All operational monitoring, critical alarms and corrective actions within the RWQMP will be tested and verified as part of commissioning. A verification report and cross connection audit will be conducted and submitted to IPART for review and approval before any treated water is delivered for use in the precinct.

14. Plumbing

The Building plumbing and drainage system has been designed in accordance with the Water Supply Code of Australia and in accordance with AS/NZS 3500.1 & AS/NZS3500.2.

15. Appendices

Appendix 1 – Process Flow Diagram

Appendix 2 – General Arrangement

Appendix 3 – Aquacell Recycled Water Policy

Appendix 4 – HAZOP and HACCP Analysis

Appendix 5 – WICA Scheme Approval to Install - pending

Appendix 6 - Aquacell Sampling Procedure

Appendix 7 – WICA Retailer Licence

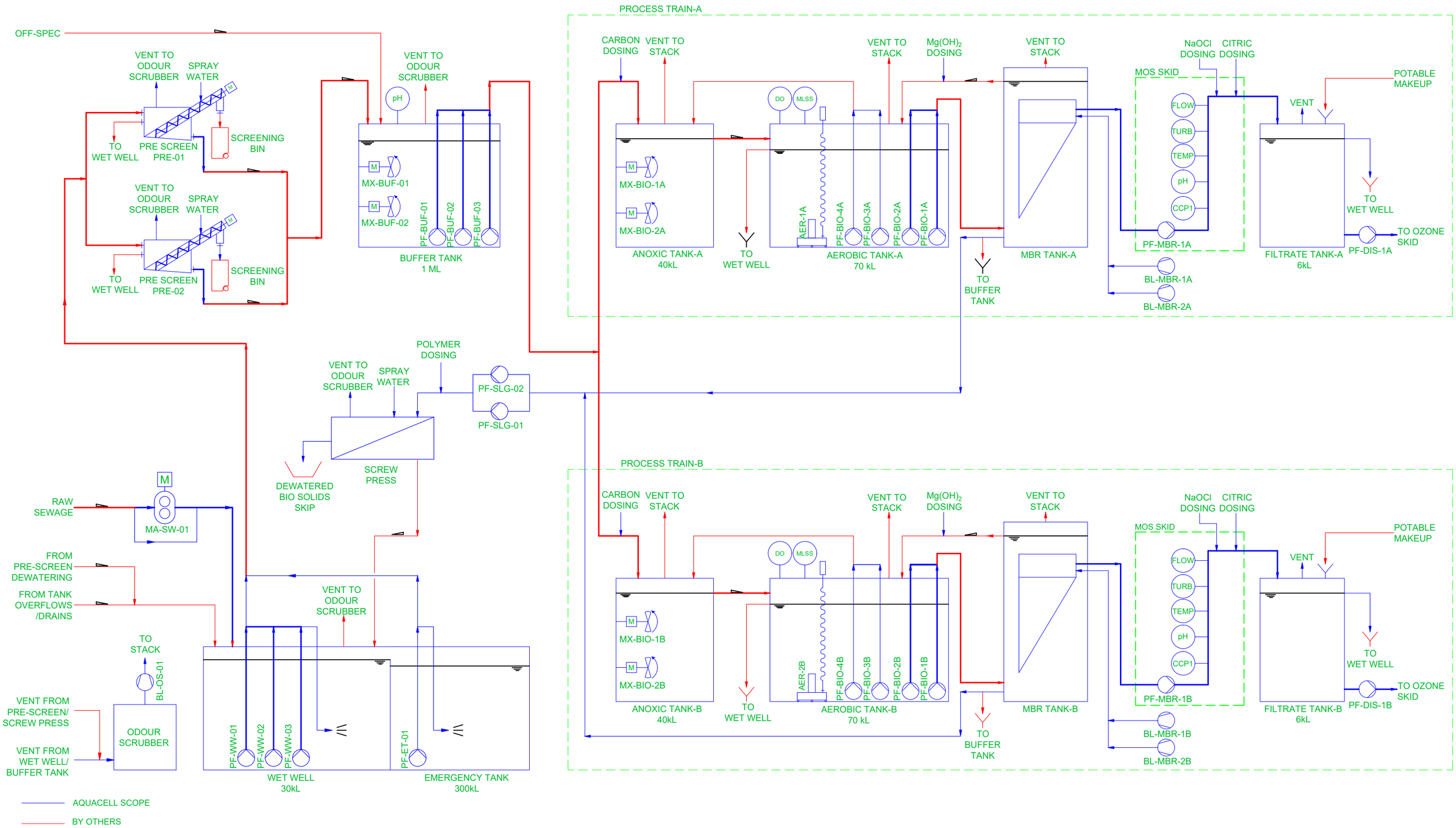
Appendix 8 – WICA Operator Licence

Appendix 9 – Plumbing Audit (Cross Connection Audit) - pending

Appendix 10 – Verification Report - pending

Appendix 11 – Operation and Maintenance Manual - pending

Appendix 1 – Process Flow Diagram



REVISION TABLE

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A	15-Sep-2023	INTIAL ISSUE	S.B	E.B	J.J						
B	14-Jun-2024	UPDATED	S.B	W.J	W.J						
C	27-Jun-2025	UPDATED	S.B	S.A	W.J						
D	28-Aug-2025	UPDATED	S.B	S.A	W.J						

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DRAWN	S.B	DATE	15-Sep-2023
CHECKED	A.E	DATE	15-Sep-2023
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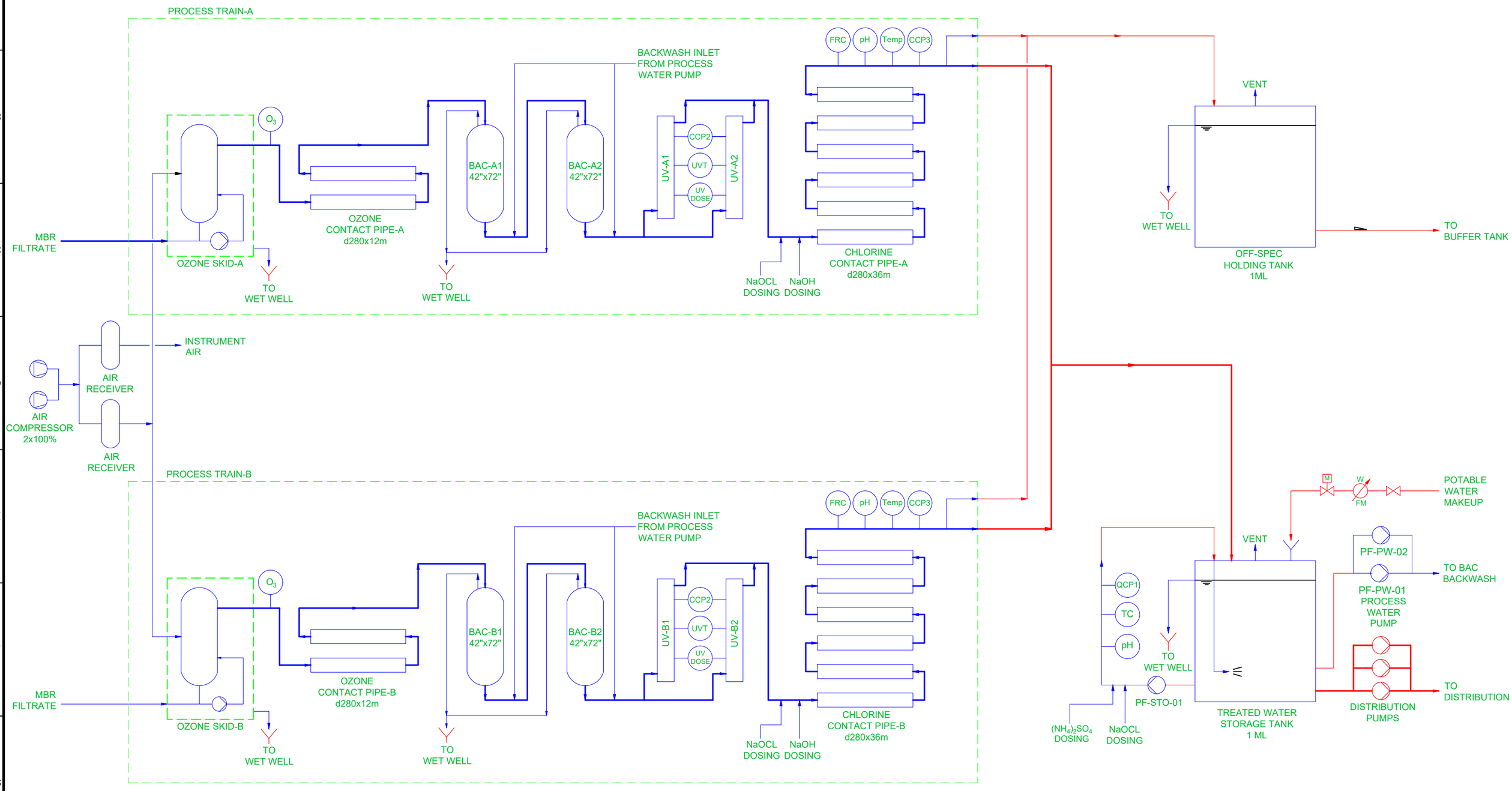
TITLE: PROCESS FLOW DIAGRAM
BLACKWATER TREATMENT PLANT

JOB No: A0144
DRAWING No: A0144-002
PROJECT: LUDDENHAM RD ORCHARD HILLS

DRAWING STANDARD AS1100 | DO NOT SCALE | Rev: D | SHEET No:01 OFF 02 | A1



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PROJECT: LUDDENHAM RD ORCHARD HILLS

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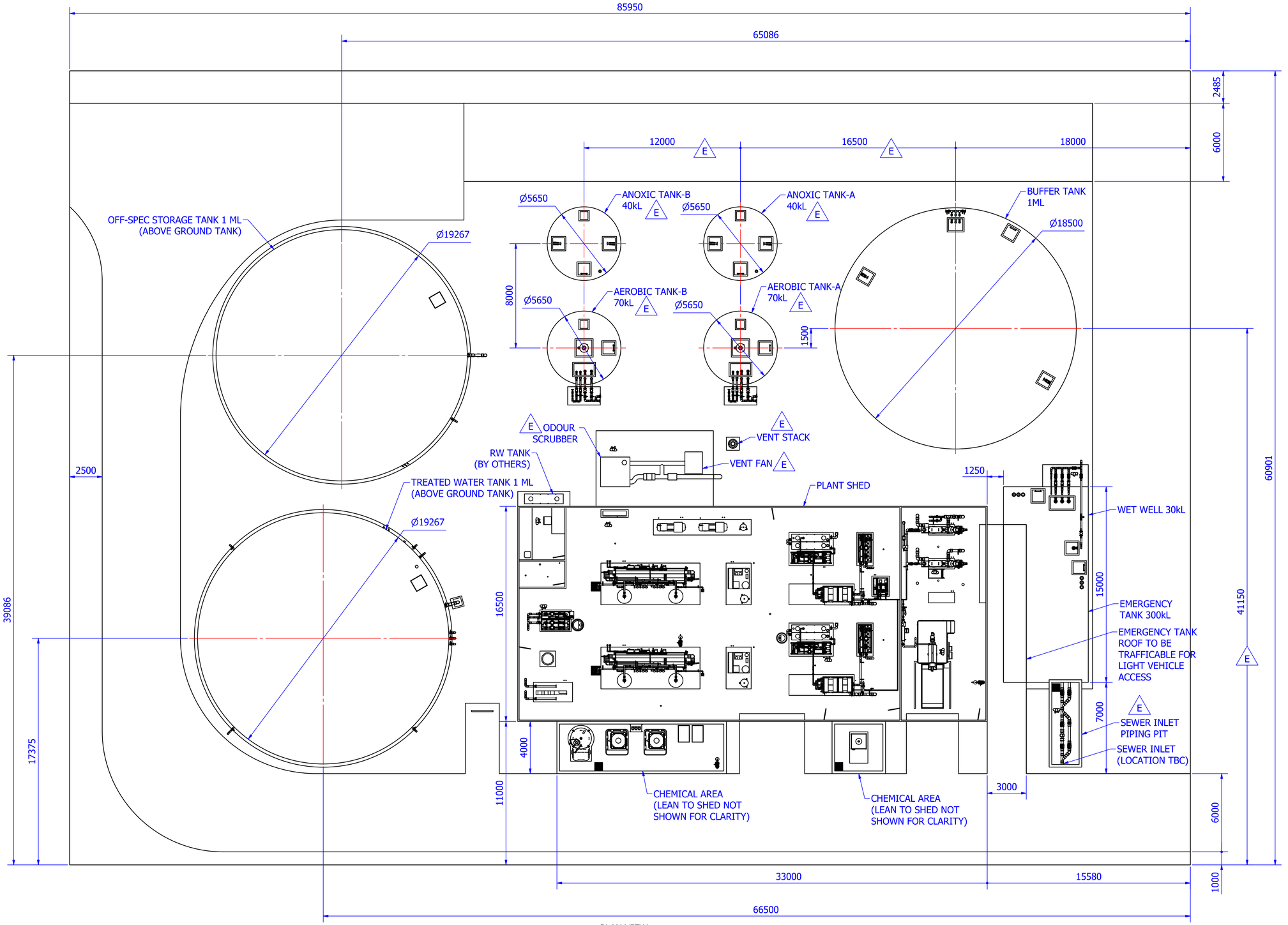
Appendix 2 – General Arrangement



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D	17-Jun-2025	UPDATED	S.BIABANI	J.JENNINGS
C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
B	14-Jun-2024	UPDATED	S.BIABANI	W.JOHNSON
A	15-Sep-2023	INITIAL ISSUE	S.BIABANI	A.EISSENHAMMER

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DRAWN	S.BIABANI	DATE	15/09/2023	TITLE: LAYOUT BLACKWATER TREATMENT PLANT
CHECKED	A.EISENHAMMER	DATE	15/09/2023	
APPROVED	J.JENNINGS	DATE	15/09/2023	
JOB No: A0144	DRAWING No: A0144-302			PROJECT: LUDDENHAM RD ORCHARD HILLS

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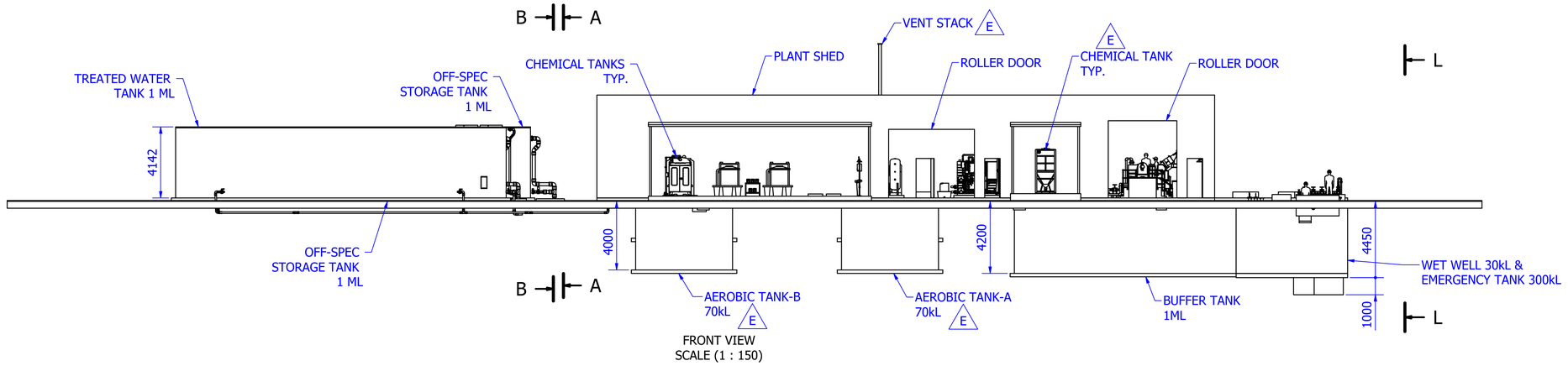

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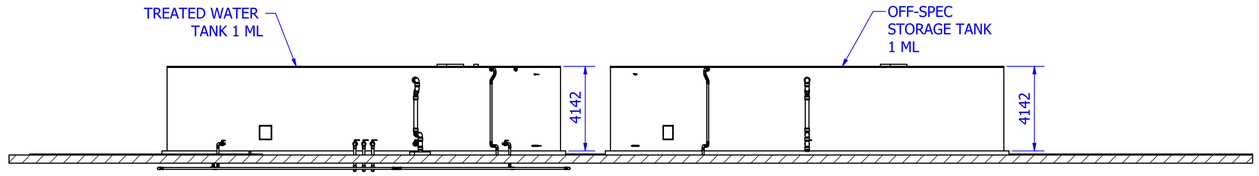

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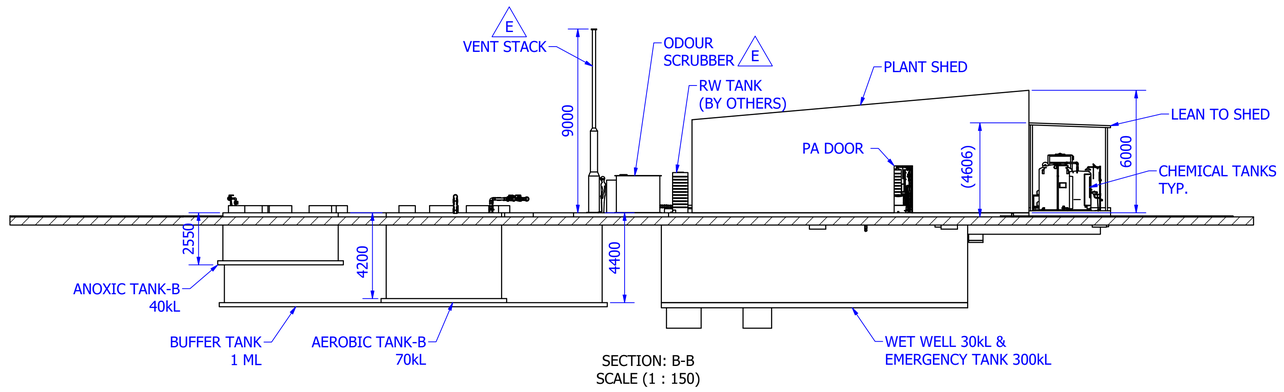

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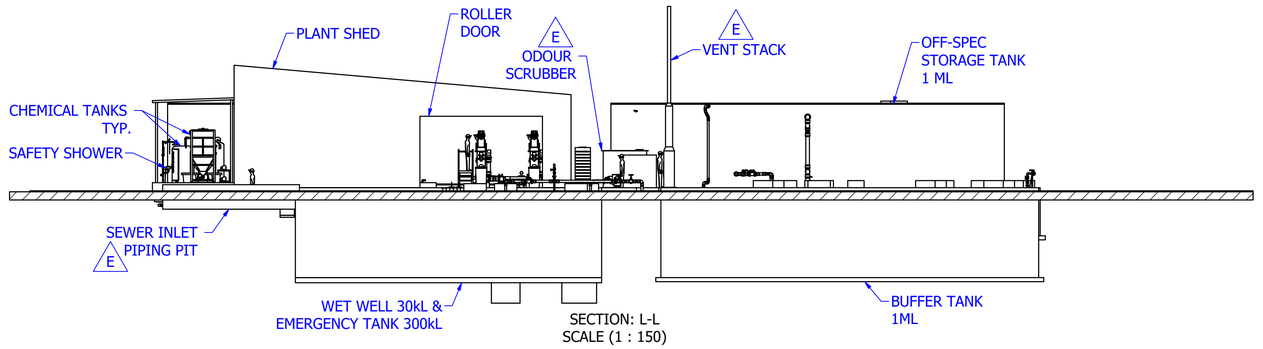

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DRAWN	S.BIABANI	DATE	15/09/2023	TITLE	LAYOUT
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APPROVED	J.JENNINGS	DATE	15/09/2023		
JOB No	A0144	DRAWING No	A0144-302	PROJECT	LUDDENHAM RD ORCHARD HILLS
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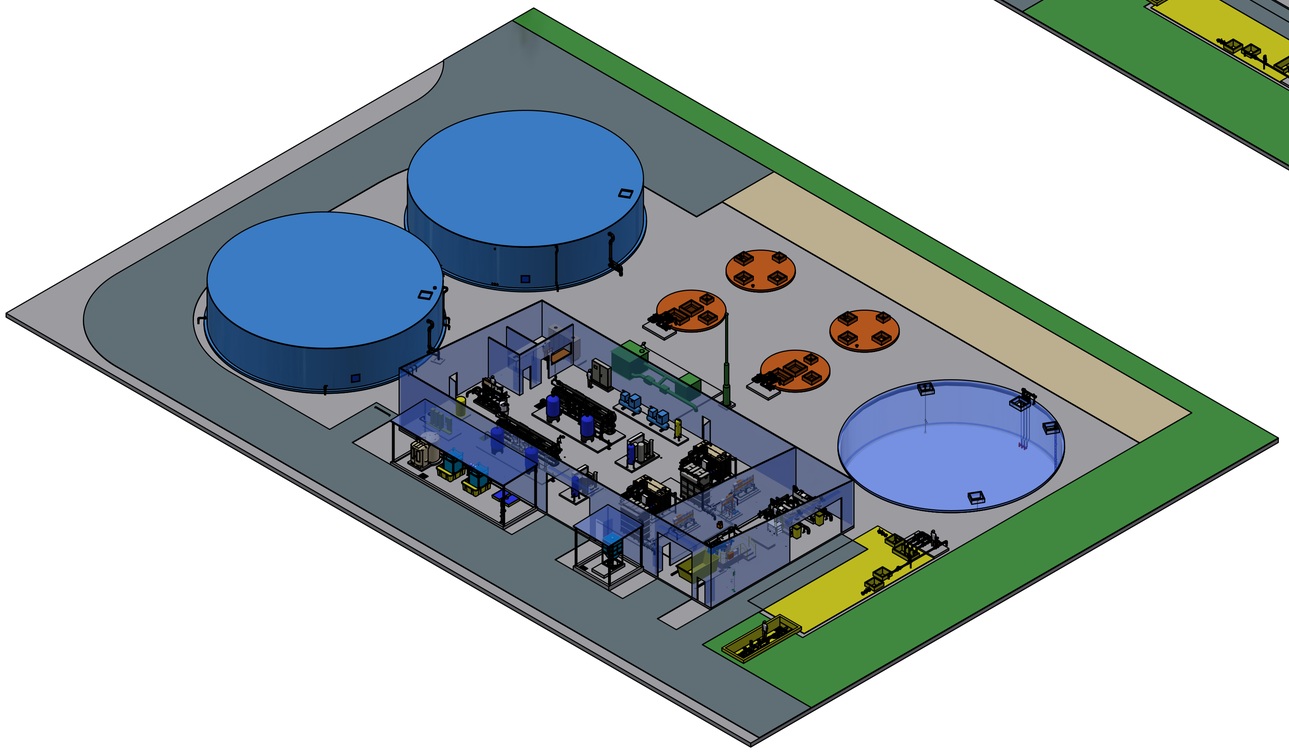

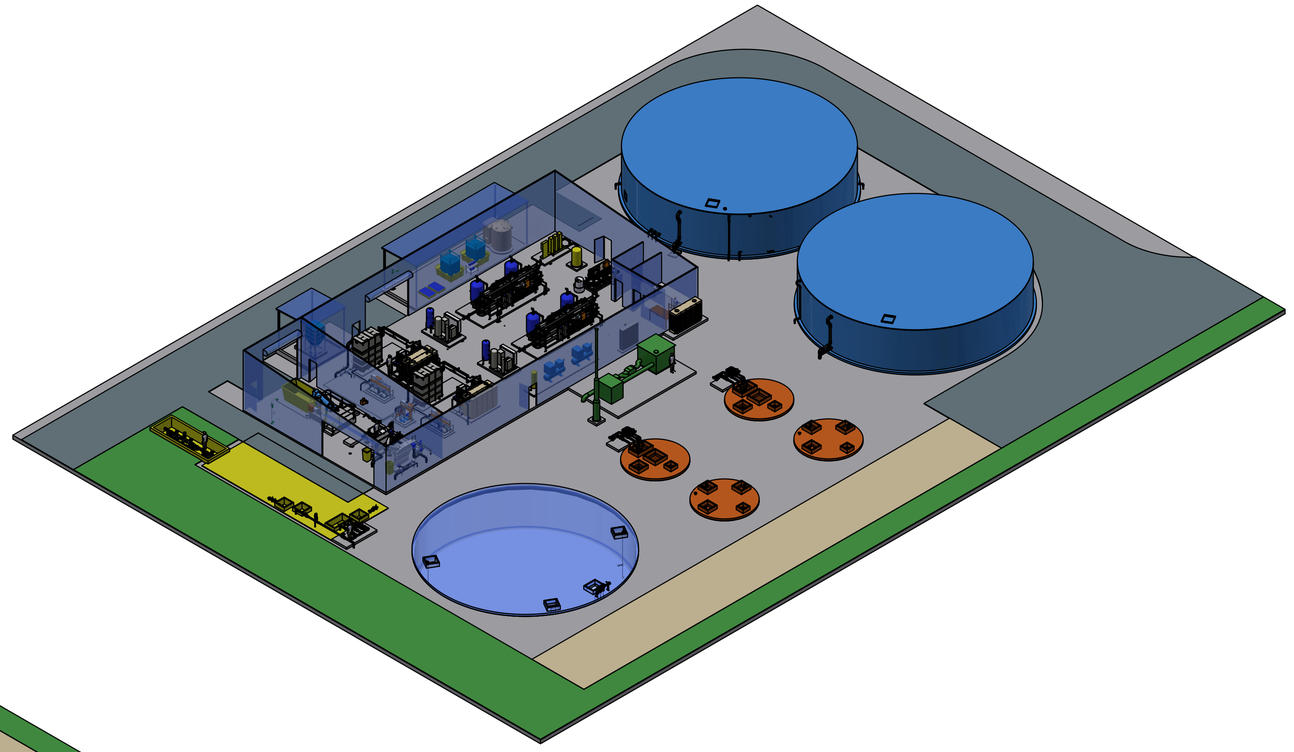

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D	17-Jun-2025	UPDATED	S.BIABANI	J.JENNINGS
C	02-May-2025	UPDATED	S.BIABANI	J.JENNINGS
B	14-Jun-2024	UPDATED	S.BIABANI	W.JOHNSON
A	15-Sep-2023	INITIAL ISSUE	S.BIABANI	A.EISSENHAMMER

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DECIMAL : ± 0.5 mm
ANGULAR : ± 0.5 deg
ALL DIMENSIONS IN mm U.N.O

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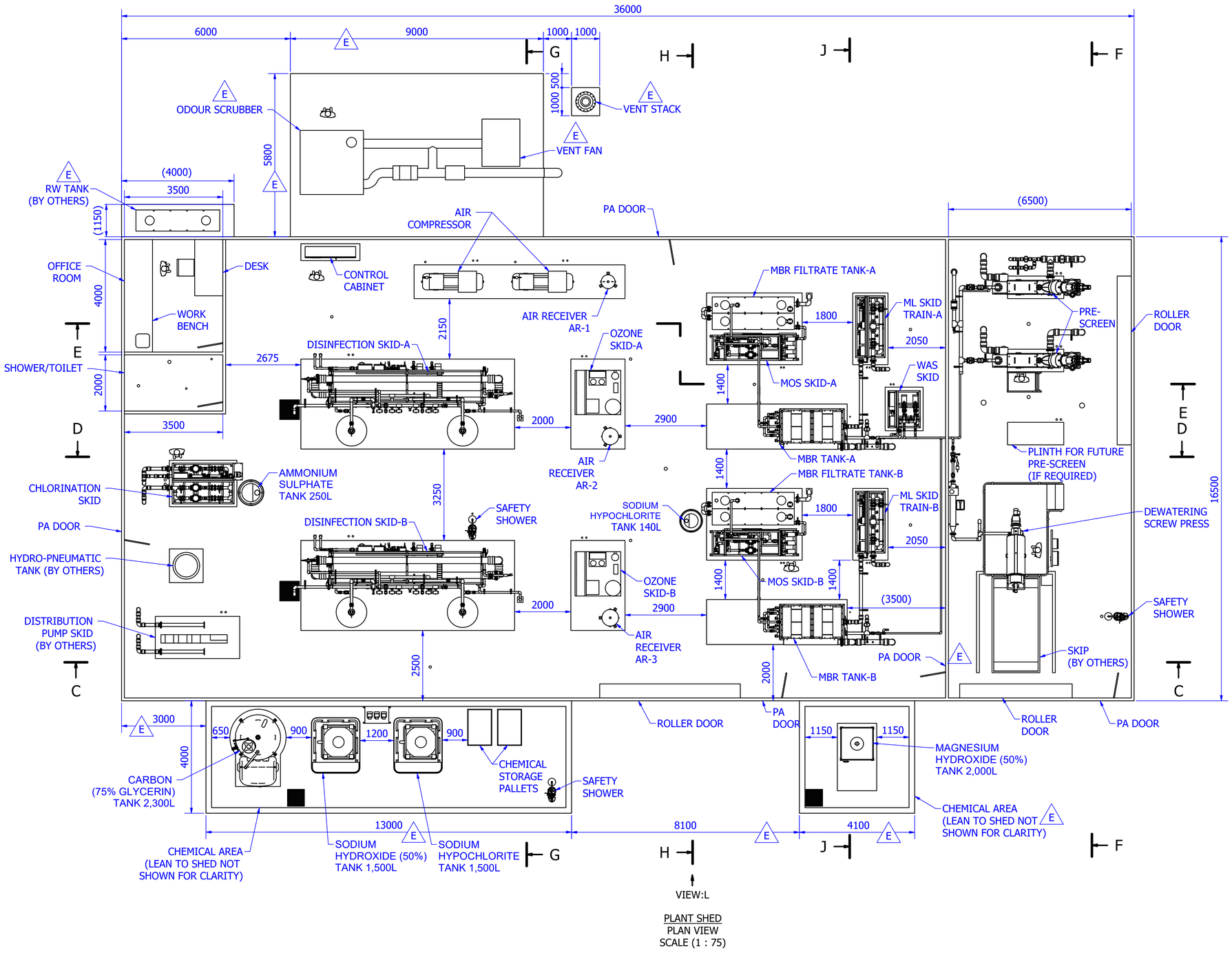
email:info@aquacell.com.au

DRAWN	S.BIABANI	DATE	15/09/2023	TITLE: LAYOUT BLACKWATER TREATMENT PLANT
CHECKED	A.EISENHAMMER	DATE	15/09/2023	
APPROVED	J.JENNINGS	DATE	15/09/2023	
JOB No: A0144	DRAWING No: A0144-302			PROJECT: LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE	Rev: E	SHEET No: 3 OFF 8 — A1



PLANT SHED
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SCALE (1 : 75)

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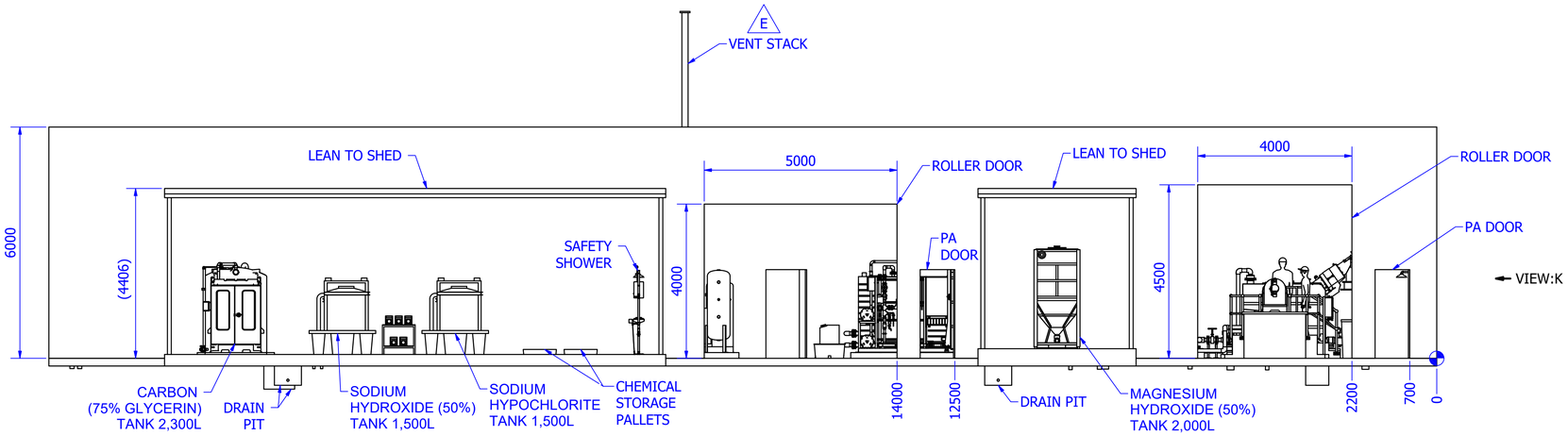
JOB No	A0144	DRAWING No	A0144-302	PROJECT	LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE		Rev: E	SHEET No: 4 OFF 8 — A1



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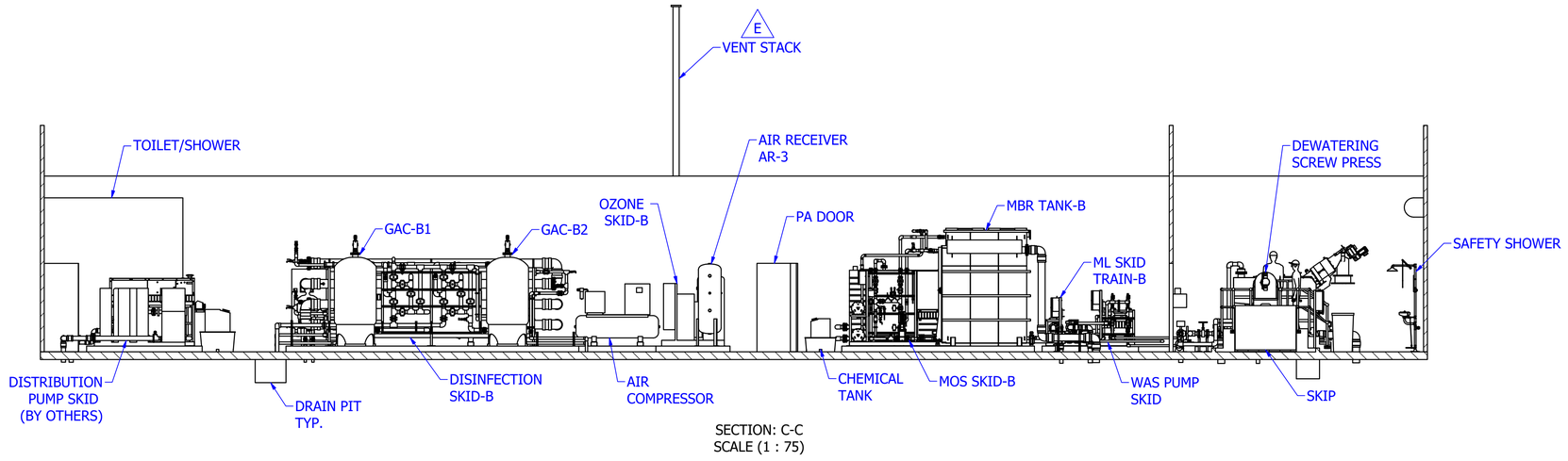

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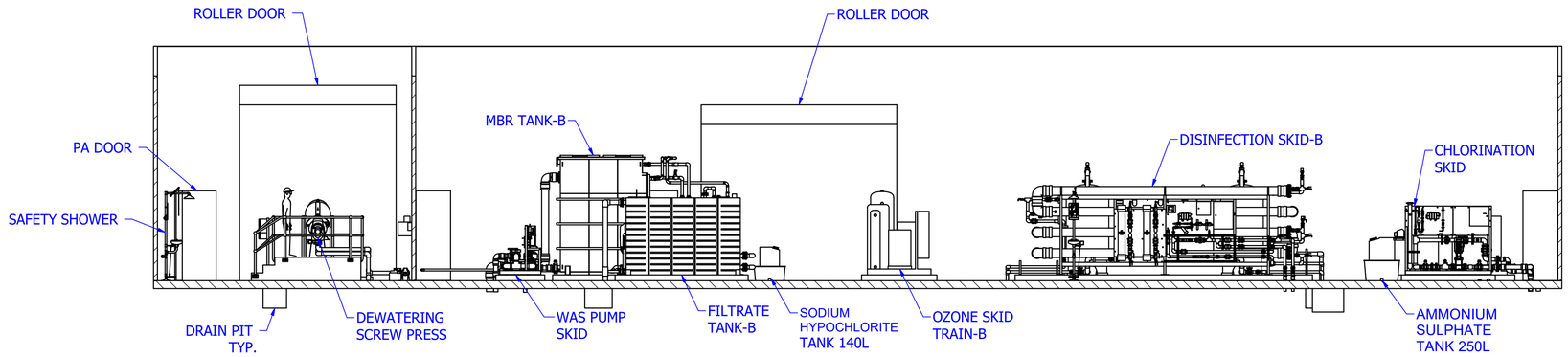
APPROVED	J.JENNINGS	DATE	15/09/2023		
JOB No	A0144	DRAWING No	A0144-302	PROJECT	LUDDENHAM RD ORCHARD HILLS
DRAWING STANDARD : AS1100		DO NOT SCALE		Rev: E	SHEET No: 5 OFF 8 — A1



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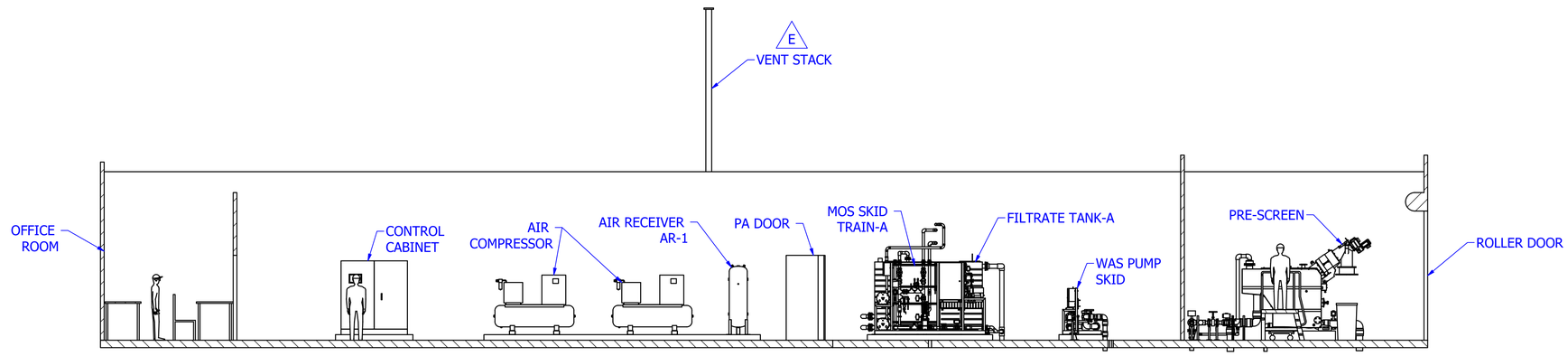

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APPROVED	J.JENNINGS	DATE	15/09/2023	
JOB No: A0144	DRAWING No: A0144-302			PROJECT: LUDDENHAM RD ORCHARD HILLS

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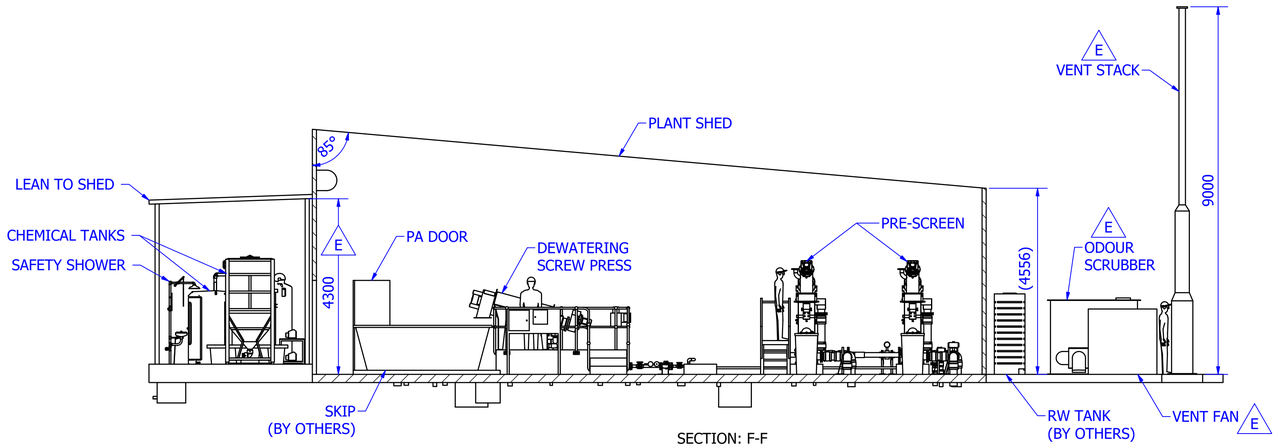

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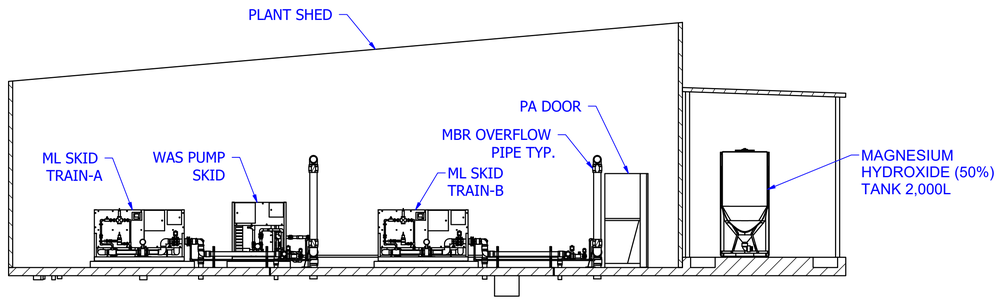

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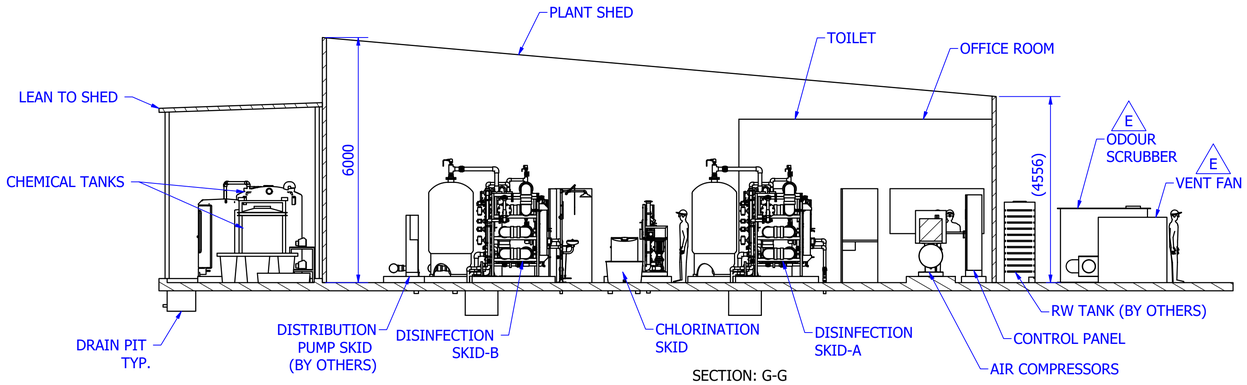

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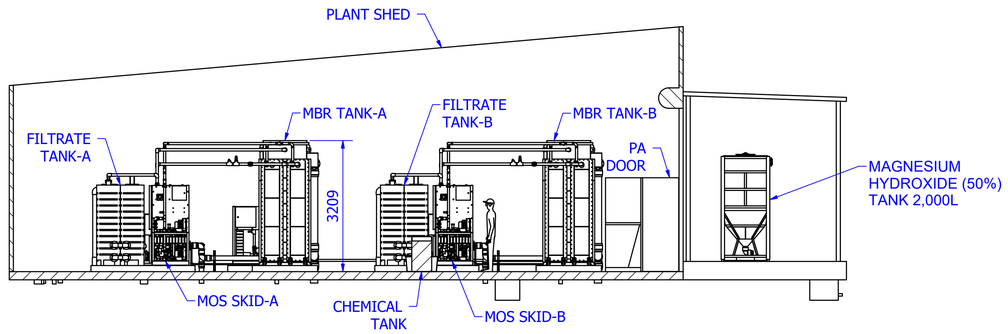

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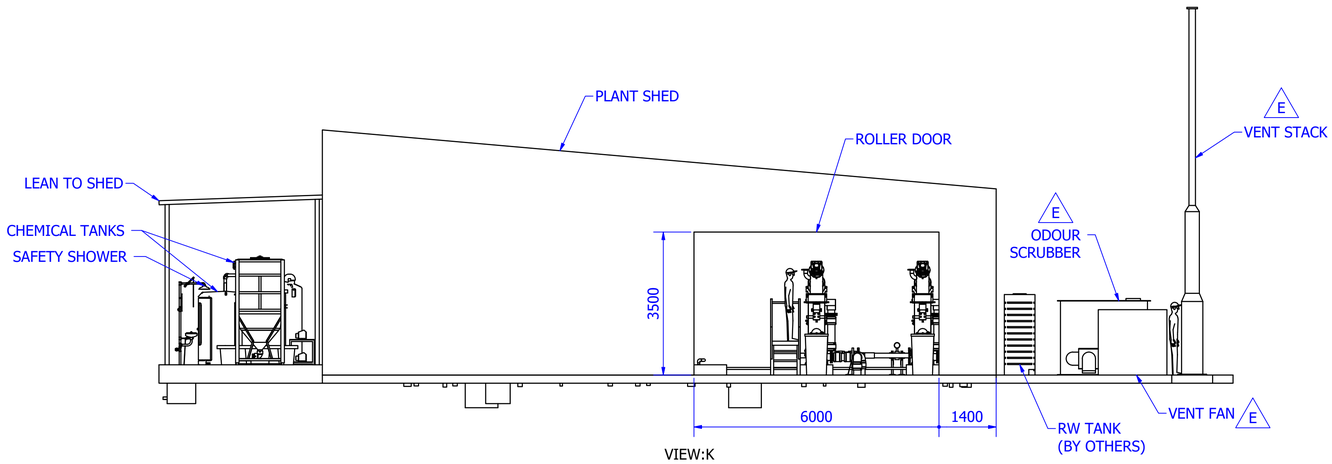

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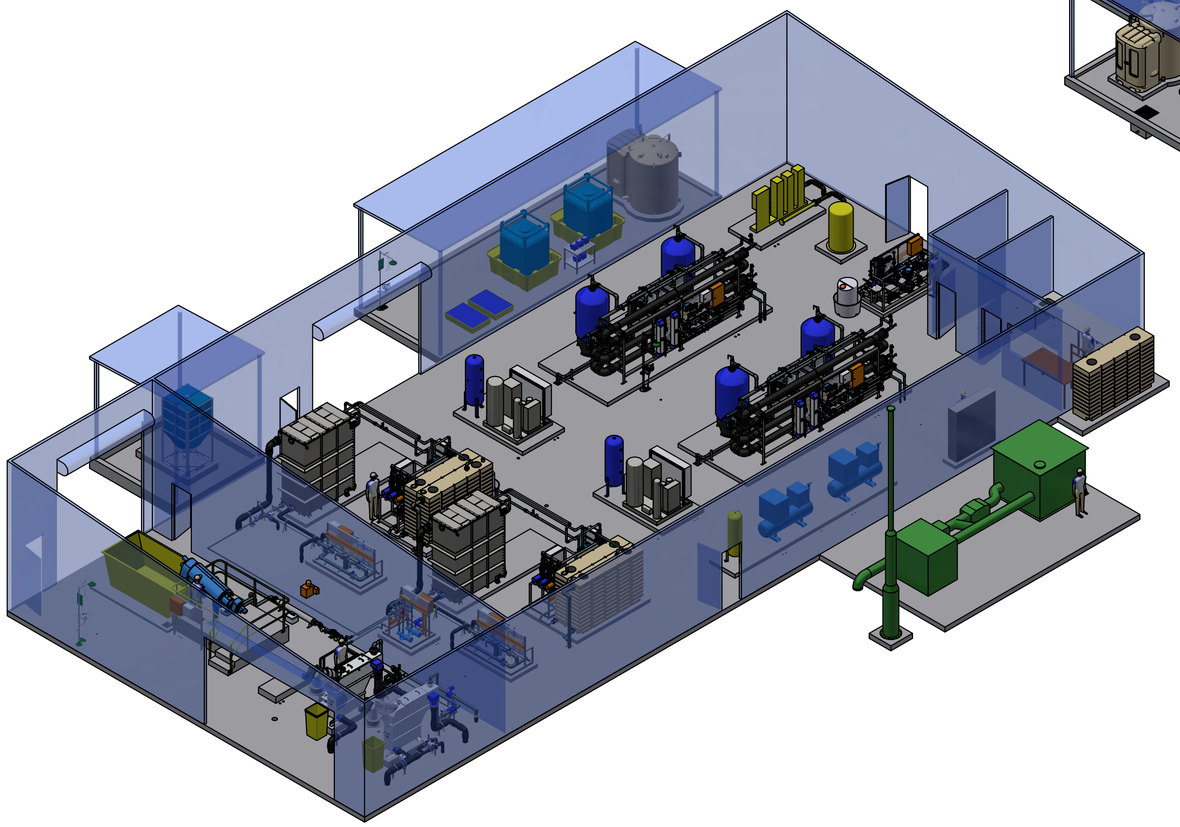

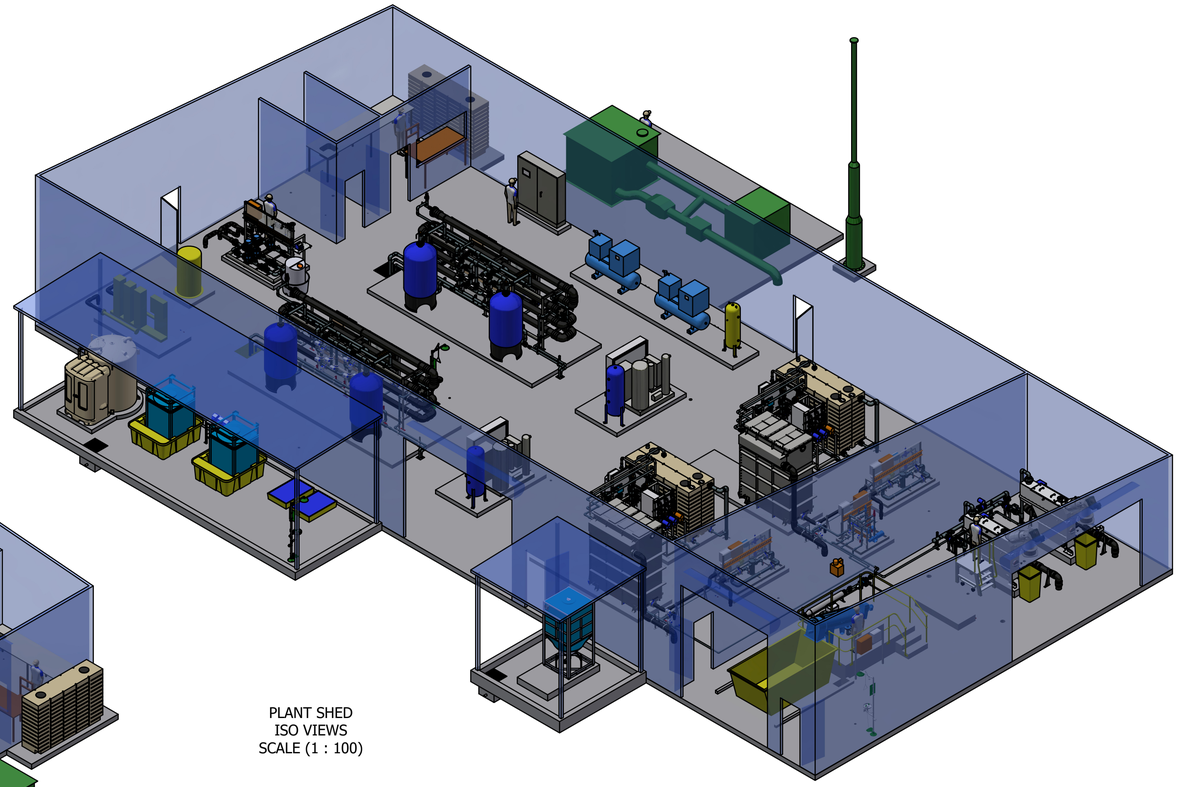

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APPROVED	J.JENNINGS	DATE	15/09/2023		
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DRAWING STANDARD : AS1100		DO NOT SCALE	Rev: E	SHEET No: 8 OFF 8	A1

Appendix 3 – Aquacell Recycled Water Policy

Aquacell Recycled Water Policy

Aquacell Pty Ltd | Head Office: 602 / 6A Glen St, Milsons Point NSW 2061 Australia | ABN 79 072 487 015
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Document Creation and Review

Revision No	Author	Reviewed By	Approved By	Date
Draft (EM 010-01)	P. Coulton	C. Fisher	C. Fisher	22 July 2011
EM010-2		Annabelle Caspersz		5 December 2011
EM010-3	Edited A. Hidalgo	Colin Fisher		15 July 2025

Document Control

Revision No	Status	Issued To		Date
		Name	Organisation	

RECYCLED WATER POLICY

Aquacell supports and promotes the responsible use of recycled water and the application of a management approach that consistently meets the *Australian Guidelines for Water Recycling*, as well as recycled water user and regulatory requirements.

To achieve this we will:

- Ensure that the protection of public and environmental health is recognised as being of paramount importance.
- Maintain communication and partnerships with all relevant agencies involved in management of water resources, including waters that can be recycled.
- Engage appropriate scientific expertise in developing recycled water schemes.
- Recognise the importance of community participation in decision making processes and the need to ensure the community expectations are met.
- Manage recycled water quality at all points along the delivery chain from source to the recycled water user.
- Use a risk based approach in which potential threats to water quality are identified and controlled.
- Integrate the needs and expectations of our users of recycled water, communities and other stakeholders, regulators and employees into planning processes.
- Establish regular monitoring of control measures and recycled water quality and establish effective reporting mechanisms to provide relevant and timely information and promote confidence in the recycled water supply and its management.
- Develop appropriate contingency planning and incident response capability.
- Participate in appropriate research and development activities to ensure continuous improvement and continued understanding of recycled water issues and performance.
- Contribute to the development of industry regulations and guidelines and other standards relevant to public health and the water cycle.
- Continually improve our practices by assessing performance against corporate commitments and stakeholder expectations.

Aquacell will implement and maintain recycled water management systems consistent with the *Australian Guidelines for Water Recycling* to effectively manage the risks to public and environmental health.

All managers and employees involved in the supply of recycled water are responsible for understanding, implementing, and continuously improving the recycled water management system. Membership and participation in professional associations dealing with management and use of recycled water is encouraged.

Colin Fisher

Managing Director 22nd July 2011

Appendix 4 – HAZOP and HACCP Analysis

HACCP Checklist

Project Name:	A0144 Luddenham Rd Orchard Hills
Completed by:	Justin Taylor
Date of Assessment:	20-Aug-25
Revision:	IFC
Approved By and Date:	WJ 20/08/25

To be approved by the Technical Manager

HACCP Workshop Attendees			Revision 1 Attendees	Revision 2 Attendees
WJ				
JT				
JJ				

DESIGN /			Before Mitigation				After Mitigation					Decision Tree				CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**												**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
1. Source water (sewage influent, collection lines, pump stations)	Biological Hazard: Contact with raw sewage	Plant designed so that contact with sewage in normal operation is not required. Plant room locked so people cannot readily enter. Covers on tanks and locks where appropriate. Trained operators to servicing plant.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Health Hazard: Source water is different to design specification and treatment plant cannot treat correctly.	Plant design conservative with some ability to remove short periods of our of specification sewage. Continuous online monitoring does not allow out of specification water to be delivered. Trade waste cannot be connected directly to the sewer. pH measurement in buffer tank may detect poor feed. Buffer tank will dilute short volumes of out of specification feed.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
	Biological Hazard: Blockage upsteam of plant causes overflow	Upstream plumbing (by others) designed to comply with AS3500. Upstream plumbing to have I/O points and gullies to facilitate controlled overflows and easy cleanout.	3	3	6	High	1	2	3	Low	± 1	Y	N	N		No													
2. Inlet Works - Macerator, Wet Well, Prescreen and Buffer Tank	Physical Hazard: Screen mesh blocks and causes the screen to overflow	Level transducer on screen detects prolonged high level and alarms. Screen overflows to buffer tank so there are no uncontained spills.	4	1	5	Low	1	1	2	Low	± 1	Y	N	N		No							Note change to screen overflow. Now overflows to wet well rather than buffer tank. Confirmined no change to risk matrix	AQ design team	20-August-2025					
	Physical Hazard: Screen mesh fails and allows oversize material into system.	Routine weekly and monthly maintenance inspections. Heavy particles will settle in buffer tank and not make it into the rest of the treatment plant	2	3	5	Moderate	1	1	2	Low	± 1	Y	N	N		No													
	Health Hazard: Screenings need to be remove from site	Ensure appropriately experienced and licensed contractors are used for maintenance of systems. Contractors use adequate PPE to mitigate against ingestion, skin contact and inhalation. Remediate spills immediately and exclude public from the spill point until rectified.	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No													
	Health Hazard: Prescreen needs to be cleaned manually	Automatic sprays on pre-screen keep it clean reducing manual cleaning to once per month. Cleaning by trained operator wearing appropriate PPE.	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No													
	Physical Hazard: Screenings are typically heavy and need to be disposed of periodically by the operator	Appropriate screening bin selected with the ability to use manual handling aids where required. Change screenings bags frequently so the mass of each changeout is lower	5	3	8	High	1	3	4	Low	± 1	Y	N	N		No							Manual handling requirement further reduced by incorporation of vehicle accessway directly to prescreen area. Confirmined no change to risk matrix. Mechnical bin lifting device included to minimise requirement for manual handling	AQ design team	20-August-2025					
	Environment Hazard: Odour	Screen and buffer tank are sealed and vented through the odour scrubber. Screenings are contained in an endless bag which contains odour. The endless bag can be changed without creating an odour path.	4	1	5	Low	1	1	2	Low	± 1	Y	N	N		No							Wet well is now added as an inlet works item and will be vented through the odour control system. Confirmined no change to risk matrix.	AQ design team	20-August-2025					
3. Biological Treatment Process (Anoxic tank and Aerobic bioreactor)	Chemical hazard: Presence of chemicals in the wastewater that disrupt the proper biological treatment.	pH monitoring of the influent may detect chemicals early. Each tennant is required to treat their trade waste separately before discharge from their premises.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													
	Chemical Hazard: Alkaline material is added to control pH in bioreactors, requiring operators to use chemicals	Adding chemicals is an automated process. Chemicals are dosed into the system automatically reducing which almost eliminates the requirement for the operator to handle chemicals. Chemicals are common in water treatement plants and can readily be handled with appropriate PPE. Chemical storage area has been moved outside of shed for improved handling and reduced risks associated with degassing.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No							Note this hazard has been added at IFC stage.	AQ design team	20-August-2025					
	Biological hazards: Biology tank foams over due to an event which upsets the biomass	Tanks are sealed and foam will be contained within the biology tank.	3	3	6	High	3	1	4	Low	± 1	Y	N	N		No							Spray nozzles are added to suppress the foam in the aerobic reactors	AQ design team	20-August-2025					
	Biological Hazard: Potential aerosols from aeration of bioreactor leading to exposure of workers in the plant room or contamination of surfaces.	All aerated tanks are airtight and vented through an odour scrubber.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													
	Environment Hazard: Odour	Biology tank is aerated and less likely to cause odour than buffer tank. All tanks are sealed and vented externally through an odour scrubber.	4	1	5	Low	1	2	4	Low	± 1	Y	N	N		No													
	Physical Hazard: Confined space.	Tanks designed so that maintenance and calibration can be undertaken without the requirement to enter the tanks. Trained personnel only to enter confined space after completing appropriate confined space entry procedure.	2	3	5	Moderate	1	2	3	Low	± 1	Y	N	N		No													

DESIGN /			Before Mitigation				After Mitigation					Decision Tree				CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Risk Rating	Likelihood	Consequence	Resid. Risk	Risk Rating	Uncertainty												Action Checked	By	Date	Action Checked	By	Date	Closed Out
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
	Physical Hazard: Aerated liquid reduces ability to float in tank if person falls in	All lids and hatches secured by bolts or locks to prevent accidently falling in. Plant room only accessible to authorised personnel.	3	5	7	Very High	1	5	6	High	± 1	Y	N	N		No													
	Physical Hazard: Electrocution from terminal box.	IP rating of terminal box is appropriate selected.	4	5	9	Very High	1	5	6	High	± 1	Y	N	N		No							Note this hazard has been added at IFC stage.	AQ design team	20-August-2025					
4. UF Membrane Filtration (membrane tank, skid and filtrate tank)	Health Hazard: Membrane integrity is compromised leading to reduced disinfection	Turbidity constantly monitored to detmine membrane integrity.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	Alert level t > 0.15 NTU Critical Level t > 0.2 NTU	Operator alarm is alert level triggered. If critical level is exceeded, the MOS system recirculates for a period to see if the turbidity reduces. If turbidity does not come back within range, the MOS system generates an alarm and goes into standby state.	Continous online monitoring of turbidity during filtration and recirculation by PLC and actuated valve when required.	MOS goes into standby if turbidity does not reduce during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: Turbidity measurement does not reflect the current state of the water because there is no flow through the instrument	Flow switch installed in the instrument loop upstream of the trubidity meter	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	No Flow	If no flow is detected, the MOS system recirculates for a period to see if the flow returns. If flow does not retuen, the MOS system generates an alarm and goes into standby state.	Continous online monitoring of turbidity during filtration and recirculation by PLC and actuated valve when required.	MOS goes into standby if flow does not return during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: Turbidity instrument faults	The turbidity instrument has a built in fault relay which is wired to the PLC	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP1	Instrument fault	If fault is detected, the MOS system immediately goes into standby state the MOS system generates an alarm.	Continous online monitoring of turbidity fault relay during filtration.	MOS goes into standby if fault does rectify during recirculation. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Chemical Hazard: CIP requires operators to use chemicals	CIP process is automated. Chemicals are dosed into the system automatically reducing which almost eliminates the requirement for the operator to handle chemicals. Chemicals can be neutralised within the system in a similar manner before they are sent back to the head of the works. Chemicals are common in water treatement plants and can readily be handled with appropriate PPE.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No													
	Physical Hazard: Membrane installation requires manual handling	Membranes have a life expectency of >5 years so the activity is rare. The plant room has been designed to leave space to make installation and replacement safe. Two people are used to replace or install membranes.	3	3	6	High	1	3	4	Low	± 1	Y	Y	N		No													
5. Ozone System	Chemical and Health Hazard: Ozone exposure and inhalation of ozone if leakage occurred	Ozone generator equipped with failure / leak detection system that automatically shuts down ozone production of gas is detected. Plant room designed with ventilation system, so a small leak will not cause an issue before the detection system acts to shut down generation	1	3	4	Low	1	2	3	Low	± 1	Y	N	Y	Y	No							Confirming that an ozone destruction unit will be incorporated into the design, meaning that any residual ozone vented from the system will be destroyed before it enters the atmosphere	AQ design team	20-August-2025					
	Health Hazard: Noise exposure from compressors high duty	If practical, enclose compressor in acoustic hood, PPE to be worn by operators if compressors are not enclosed.	3	3	6	High	1	3	4	Low	± 1	Y	N	Y	Y	No							Selected rotory screw compressor as it has a lower noise level	AQ design team	20-August-2025					
6. Biological activated Carbon (BAC) Filter	Physical Hazard: Presence of carbon fines during loading of the carbon vessel.	Operator training and use of dust mask.	3	1	4	Low	1	1	2	Low	± 1	Y	N	N		No							Confirming that appropriate, task specific PPE (gloves, mask, eye protection) will be used and specified within the O&M manual	AQ design team	20-August-2025					
	Physical Hazard: Loading bags of carbon into GAC	Use vacuum or "slurpee" to remove used carbon. Assign two people to the task if necessary. Use a funnel to make filling the vessel easier.	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No							Confirming that a special loading procedure including hopper to be incroporated	AQ design team	20-August-2025					
7. UV disinfection	Health Hazard: Excessive suspended solids material interfering with the efficiency of the UV disinfection system	UV is downstream of UF process. See UF membrane filtration section for control measures to ensure membrane integrity etc.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No													
	Health Hazard: Low UV dose leading to poor UV disinfection	UV dose constantly monitored by UV unit using flow rate, measured UVI and measured UVT. UV unit outputs dose to the PLC so it can be monitored and acted upon	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Alert level dose < 60mJ/cm2 Critical Level dose < 58mJ/cm2	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: UVT is too low meaning the unit is operating ourside its validated range.	UV has inbuild UVT instrument which is used withing the device, but also ouput to the PLC.	4	4	8	Very High	1	4	5	Moderate	± 2	Y	Y			CCP2	Alert level UVT < 45% Critical Level UVT < 35%	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						
	Health Hazard: UV disinfection not effective due to excesive lamp age,	UV unit monitors lamp age based on actual run time. Other indicators such as UV dose offer a secondary way to monitor poor lamp performance.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Alert level hours > 10,000 Critical Level hours > 12,000	Operator alarm is alert level triggered. Disinfection system goes into shutdown	Continous online monitoring and diversion by PLC and actuated valve when required.	Disinfection system goes into shutdown. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.						

DESIGN /			Before Mitigation				After Mitigation												CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	**Potential Hazard**	**Preventative Measure**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Likelihood**	**Consequence**	**Resid. Risk**	**Risk Rating**	**Uncertainty**	**Decision Tree**				**CCP/QCP**	**Critical Levels**		**Monitoring**	**Corrective Action**		**Records**	**Action Checked**	**By**	**Date**	**Action Checked**	**By**	**Date**	**Closed Out**
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*					*Target*	*Action*	*How*	*What*	*How*	*Where*							
	Health Hazard: UV unit malfunctions or faults	UV has inbuilt monitoring that identifies warnings and faults. These outputs are monitored by the PLC so the status of the UV unit is knonwn at all times	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y			CCP2	Instrument Fault	Operator alarm is alert level triggered. Disinfection system goes into shutdown	Continous online monitoring and diversion by PLC and actuated valve when required.	Disinfection system goes into shutdown. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Flow rate through UV unit takes the unit outside validated range, or doesn't provide sufficient UV dose	UV feed pump's rated capacity is selected well below the maximum validated flow (385 L/min) If the flowrate falls below 23.5 L/min (validated minimum flowrate), the UV dose calculation defaults to the minimum validated flowrate of 23.5 L/min. Flowmeter downstream of the UV monitors flow.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No												
	Physical Hazard: UV lamps are harmful to humans if viewed directly	UV unit is completely sealed so that no light is visible during operation. UV is designed so that the power cable must be removed to access the lamps. This prevents accidentally accessing the lamps while that are lit.	4	4	8	Very High	1	4	5	Moderate	± 1	Y	Y	N		No												
	Environmental Hazard: UV lamps are harmful if not disposed correctly	Dispose of used UV lamps at an appropriate disposal site.	2	2	4	Low	1	1	1	Low	± 1	Y	Y	N		No												
8. Chlorine disinfection (chlorine, dosing pump)	Health Hazard: Insufficient chlorine or chlorine is too high and may cause harm.	System designed to meet minimum Ct in relevant legislation Contact tank designed so that minimum Ct is always achieved Free residual chlorine monitoring	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert Level: FRC > 0.55 mg/L, or FRC > 4.5 mg/L Critical Level: FRC > 0.5 mg/L, or FRC > 5.0 mg/L	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Biological Hazard: Treated Water outside of target pH range	On-line treated water pH monitoring. pH correction installed as part of the plant.	1	3	4	Low	1	2	3	Low	± 1	Y	Y			CCP3	Alert Level: pH < 8.5, or pH > 8.5 Critical Level: pH < 6.0, or FRC > 8	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continous online monitoring and diversion by PLC and actuated valve when required.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Equipment failure in the chlorine loop means current reported reading of pH or chlorine is not accurate	Monitor the flow through the instrumentation loop to ensure it is continuous. Monitor the instrument status	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	CCP3	Flow through recirc loop must be continuous. Instrument must always be healthy.	Plant diverts to off spec if critical level triggered.	PLC monitors flow switch mounted in instrument cell and fault signal from the field instrument	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Insufficient disinfection because due to variations in temparature.	On-line temperature monitoring, calculate CT for ambient temperature around storage tanks.	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert level T < 16 deg C Critical Level T < 15 deg C	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continuous online Tepmerature probe.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Health Hazard: Required Ct is not met because flows are too high, chlorine is too low	Chlorine contact is in a pipe of fixed volume which fixes one variable in the calculation. Flowmeter upstream of the contact tank and chlorine levels allow Ct to be calculated constantly in the PLC	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y			CCP3	Alert level C-T < 12.6 mg.min/L Critical Level C-T < 12.0 mg.min/L	Operator alarm is alert level triggered. Plant diverts to off spec if critical level triggered.	Continuous online calculation from flowmeter and chlorine probe.	Plant automatically diverts to off-spec tank. Production resumed once cause is determined and contents in tank are within specification.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
9. Distribution System and Storage Tanks (lines, end use, Off-spec tank)	Health Hazard: Improper use of recycled water.	Education program for occupants. Lilac coloured pipes and fittings. Signage indicating recycled water usage. No taps accessible to the public.	3	2	5	Moderate	1	2	3	Low	± 1	Y	Y	N		No												
	Health Hazard: Long period until use and all residual chlorine consumed	Chlorine is monitored in the treated water recirculation loop. Plant diverts to off spec tank if chlorine out of range.	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Alert Level: TC < 0.5 mg/L, or TC > 5.0 mg/L	Operator alarm is alert level triggered.	Continous online monitoring	Warning alarm only to alert operator for TC < 0.5 mg/L Warning alarm and dosing pump stops for TC > 5.0 mg/L	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.	Minor amendments to TC alert level (in line with RWMP). Eductors incorporated into the design to homogenise the TC level within the tank	AQ design team	20-August-2025				
	Health Hazard: pH drifts out of specification	pHis monitored in the treated water recirculation loop. Plant diverts to off spec tank if chlorine out of range.	1	3	4	Low	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Alert Level: pH < 6.5, or pH >9	Operator alarm is alert level triggered.	Continous online monitoring	Warning alarm only to alert operator	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.	Minor amendments to pH alert level (in line with RWMP)	AQ design team	20-August-2025				
	Health Hazard: Equipment failure in the chlorine loop means current reported reading of pH or chlorine is not accurate	Monitor the flow through the loop to ensure it is continuous. Monitor the instrument status	3	2	5	Moderate	1	2	3	Low	± 1	Y	N	Y	Y	QCP1	Flow through recirc loop must be continuous. Instrument must always be healthy.	Warning alarm and stop chloramine dosing pumps	PLC monitors flow switch mounted in instrument cell and fault signal from the field instrument	Dosing pump stopped. Dosing resumed once cause is determined and issue is resolved.	Identify cause remotely if possible. Otherwise attend site and investigate using hand held instruments and other tools as appropriate.	Service Records. Online datalogging.							
	Biological Hazard: Delivery pipes and fittings leaking or burst leading to contaminated soil	Plumbing installed according to AS/NZS 3500:200. Any leaks reported to Building management according to tennant information brochure.	2	3	5	Moderate	1	3	5	Low	± 1	Y	N	N		No												
10. Sludge Handling including WAS Tank	Biological Hazard: Handling of sludge	System is fully automatic and does not require the operator to come into direct contact with sludge. Disposal bins will be designed so they can be handled with appropriate manual handling device.	2	3	5	Moderate	1	2	3	Low	± 1	Y	N	N		No							Dewatered sludge collection process has been designed to avoid manual handling completely. Vehicle can drive directly in and collect the bin for disposal	AQ design team	20-August-2025				
	Environmental Hazard: Odour	Waste activate sludge does not typically have a strong odour. Dewatering system is vented through the odour scrubber.	2	2	4	Low	1	2	3	Low	± 1	Y	N	N		No												
	Chemical Hazard: Chemical handling	Chemicals stored and bunded appropriately to prevent spills. PPE as per SDS to be used by operators.	3	3	6	High	1	3	4	Low	± 1	Y	N	N		No												
11. Potable Backup Supply	Health Hazard: Contamination from cross connections	Coloured pipe to differentiate recycled water network. Education of plumbers through site inductions. Cross connection audit by installation plumbers.	3	5	8	Very High	1	5	6	High	± 1	Y	N	N		No												
	Biological Hazard: Reverse flow	RPZ installed on potable top up supply Airgap between fill point and highest water level in treated water storage tank.	3	4	7	Very High	1	4	5	Moderate	± 1	Y	N	N		No												
12. Climate change	Biological Hazard: Extreme weather (flooding) causing sewage to mix with stormwater runoff	Site not near known water sources that flood. New development would have conbsidered forseeable rain events and designed drainage for them.	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	N		No							Climate change impacts on influent flow are negligible due to the short, contained collection network. However, the inlet infrastructure is conservatively sized to handle peak flows up to 900 kL/day—three times the average flow—for robustness.	AQ design team	20-August-2025				

DESIGN /			Before Mitigation				After Mitigation														CONSTRUCTION STAGE HACCP			COMMISSIONING / HANDOVER STAGE HACCP			
Step	Potential Hazard	Preventative Measure	Likelihood	Consequence	Resid. Risk	Risk Rating	Likelihood	Consequence	Resid. Risk	Risk Rating	Uncertainty	Decision Tree			CCP/QCP	Critical Levels		Monitoring	Corrective Action		Records	Action Checked	By	Date	Action Checked	By	Date	Closed Out
Process unit	*Physical, chemical, biological, other*		*1 to 5*	*1 to 5*	*D + E*		*1 to 5*	*1 to 5*	*D + E*			*Y or N*				*Target*	*Action*	*How*	*What*	*How*	*Where*						
	Biological Hazard: Earthquake causing damage to tanks or equipment that results in uncontained spill	Site not kown to be prone to siesmic activity	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	Y	No												
	Environmental Hazard: Fire causing toxic fumes, eg, plastic tanksor pipework burning.	No flammable goods or chemicals are used in the process which reduces the risk of fire starting. System is in an industrial state that will have appropriate fire services and hydrants should a fire break out.	1	4	5	Moderate	1	4	5	Moderate	± 1	Y	N	N	No							Appropriate fire safety equipment will be installed within the treatment plant.	AQ design team	20-August-2025				
13.General	Environmental Hazard: Noise polution disrupting users and residents.	Select equipment to be below 80dB(A) where possible; Louder equipment to be installed in plant room; Use of acoustic hoods to attenuate noise if required eg compressors; Maintain all levels below those specified in DA	2	2	4	Low	1	1	2	Low	± 1	Y	N	N	No							Confirming that all equipment will be below 80dB(A)	AQ design team	20-August-2025				
	Environmental Hazard: Odour	All sanitary waste venting from the upstream collection systems are in accordance with AS3500.2 plumbing code requirements to ensure odour is properly handled and vented. The treatment plant prescreen, process and storage tanks are located inside a mechanically ventilated room, so any odours that do occur are unlikely to be a problem for those using the facility. The wet well, prescreen, emergency tank, buffer tanks and sludge dewatering unit which are the potential odour sources, are all sealed and vented through an odour scrubber. The bioreactor uses aerobic conditions which do not generate odour, however as a precaution, these are also vented The plant room is mechanically ventilated.	3	2	5	Moderate	1	1	2	Low	± 1	Y	N	N	No							Odour sources updated in "Preventative Measures" column	AQ design team	20-August-2025				
	Environmental Hazard: Runoff off recycled water from irrigation could come into contact with people	Landscape irrigation has controlled irrigation to prevent excesive watering Land capability study undertaken at design to determine soils irrigation capacity.	1	2	3	Low	1	2	3	Low	± 1	Y	N	N	No							Additional wet weather management strategy will be incorporated to further reduce likelihood of irrigation runoff.	AQ design team	20-August-2025				
	Environmental Hazard: Recycled water from irrigation that could introduce contamination into the environment	No industrial waste is sent to the plant which mitigates disolved contaminants passing through the plant. Instrumentation such as pH man indicate the presence of contaminants	1	2	3	Low	1	2	3	Low	± 1	Y	N	N	No							Recycled water reuse has been optimised to maintained effluent water quality (ensuring TDS is suitable for irrigation)						
	Environmental Hazard: Increase of soil sodicity due to sodium based bio alkalinity addition	Replace Sodium Hydroxide with Magnesium Hydroxide as a bioalkalinity adjusting chemical	3	4	7	Very High	1	1	2	Low	± 1	Y	N	N	No							Note this column have been added at IFC stage	AQ design team	20-August-2025				
	Environmental Hazard: Overflows or spills exposing people to partially treated sewage or chemicals.	Tank sizes are designed to buffer inflows and outflows from the plant. All tanks have appropriately sized overflows directed back to the wet well. Facilities to pump out system in the event of breakdown causes high tank levels. All chemical tanks bunded with bunds compliant with Australian Standards.	3	3	6	High	1	2	3	Low	± 1	Y	N	N	No												
	Biological Hazard: Operators exposed to sewage	Plant is designed so the operator has minimal contact with Operators must be experienced with sewage treatment plants prior to servicing the plant. Plant operators are vaccinated.	3	3	6	High	1	2	3	Low	± 1	Y	N	N	No							Confirming that appropriate, task specific PPE (gloves, mask, eye protection) will be used and specified within the O&M manual	AQ design team	20-August-2025				
	Biological Hazard: Power outages leading to the plant stopping in a state that could lead to uncontrolled discharges	Equipment designed to be fail safe where possible on power down. Plant could be configured to run off a generator if required. In the event of a wide spread outage, the premises feeding the plant are unlikely to be operational which means no feed. Wet well has some capacity for short outages.	3	4	3	Very High	1	4	5	Moderate	± 1	Y	N	N	No							300kL emergency tank now incorporated into the inlet works design. Together with buffer (1ML) tank, treated water tank (1ML) and off-spec (1ML) will provide additional ~6 days storage at full capacity.	AQ design team	20-August-2025				
	Physical Hazard: Servicing heavy equipment	Heavy submersible pumps installed on rails with the provision to remove them using mechanical aids	3	3	6	High	1	3	4	Low	± 1	Y	N	N	No							Appropriate vehicular access has been fully considered throughout the design to keep manual handling to a minimum.	AQ design team	20-August-2025				
	Physical Hazard: Plant has multiple confined spaces	Confined spaces identfied. Only trained and authorised personnel to enter spaces after completing appropriate confined space entry procedures. Plant has been designed so that maintenance can be conducted without the requirement to enter tanks.	3	5	8	Very High	1	5	6	High	± 1	Y	N	N	No												

INITIAL DESIGN STAGE HAZOP												ISSUED FOR CONSTRUCTION STAGE HAZOP				COMMISSIONING / HANDOVER STAGE HAZOP			
Item	**Deviation**	**Consequence**	**Causes**	**Safeguards**	**Actions**	**Who**	**Due Date**	**Status**	**Action Checked**	**By**	**Date**	**New Actions Identified/ Outstanding**	**Who**	**Due Date**	**Status**	**Action Checked**	**By**	**Date**	**Closed Out**
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
Section 1 - Inlet works (inclusive of Source water, Wet Well, Emergency Tank, Macerator, Prescreen and Buffer Tank)																			
1a - Source water (Volume, Composition only)	No or low flow	No immediate impact other than limited food for bioreactor	Periods of low population on site, eg, weekends, Christmas	Remote monitoring of plant allows adjustments to be made if required. Do not start plant until sufficient occupancy to supply minimum bio-reactor feed.								Minimum feed volume has been established by design team							
	High influent flow	Wet well and buffer tank fill. No overflow to sewer	Periods of high user demand, rainwater ingress.	Wet well and buffer tanks sized to cope with peak demands. Site is industrial so less prone to diurnal peaks you would see in residential. Wet well and buffer tank have level transducers which allow logged data to be analysed to identify unusual flows during rain events. Pump out connection to buffer tank to allow removal of water off site.								Wet well can now overflow to 300kL emergency tank							
	Reverse Flow	N/A																	
	Low Level	N/A																	
	High level	N/A																	
	High pressure	N/A																	
	Low pressure	N/A																	
	Composition or changing concentration	Plant gets feed which is not designed for and it upsets biological process, foam overs, damage to membranes from FOG's or other chemicals	Occupants dispose of chemicals or other	pH probe warns if pH out of spec, stopping transfer to bio tank. Buffer is mixed to dilute spikes. Pump out point can remove feed if severe contamination. Manual pH correction.	All occupants should be educated to ensure they understand the impacts of diposing of trade waste or other liquid waste streams to the sewer	Client						Rainwater ingress has been considered in the water balance, although impact has been considered insignificant due to smaller collection network and mostly contained.							
	Start up/ shutdown	N/A																	
	Isolation	N/A																	
	Testing	N/A																	
	Maintenance	N/A																	
	Installation	N/A																	
	Cleaning	Spill or overflow of untreated sewage	Uncontrolled flow form process unit failure.	Overflows and drains all feed back to wet well. Control measures specified on process units below such as level switches and transducers.	Ensure floor grading is suitable to direct spills and clean back to floor wastes.	Client						Hose reels included throughout the plant							
1b - Wet Well, Emergency Tank & Macerator	No or low flow	Low inflow to system	No feed from site Blockage at macerator Blockage upstream	Low Level Switch & transmitter to protect pumps. Load sensor in macerator that reverses direction, as well as overload in panel. Bypass line around macerator															
	No or low flow	Low/no flow leaving wet well	Failure of wet well pumps or blockage in line out of	High level switch and transmitter Duty/Standby pump arrangement Overflow to emergency tank -own level instrumentation in emergency tank Macerator reduces likelihood of blockage downstream Emergency tank sized to allow at least 1 day of storage in the event of pump failure. Further allowance for pump out if this is exceeded. Mixing line allowed for to prevent solids build up Valves have been selected appropriately to avoid blockages. Knife gate valves for control, full bore NRVs															
	High influent flow	Receiving more influent than we can treat	More water being received from the network than anticipated. Overflow from treatment plant contributing to level within emergency tank.	High level switch and transmitter Duty/Standby pump arrangement Overflow to emergency tank -own level instrumentation in emergency tank High flow is unlikely to be over a sustained period of time. Short term high flows that exceed capacity will overflow to emergency tank, before being processed by prescreen as capacity allows. Emergency tank sized to allow at least 1 day of storage in the event of pump failure. Further allowance for pump out if this is exceeded. Pumps sized to allow for 3x peak flow															
	Reverse Flow	Gravity flow network, not an issue																	
	Low Level	Pumps run dry and fail to operate	Failure of level transmitter AND level switch	Allowed for both level switch and transmitter															
	High level	Wet well overflows to emergency tank If it persists, emergency tank becomes full	Influent flow exceeds pump rate. Pump failure	Allowed for both level switch and transmitter Duty/stand by pump arrangement Sufficient storage capacity. Allowance for pump outs if ever required.															
	High pressure	Pressure build up in tank Pressure build up in transfer line.	Incorrect closure of valves Blockage	Flowmeter on prescreen inlet will trigger alarm in event of low flow. Gravity flow to macerator Odour scrubber cannot pull enough pressure to impact integrity of concrete storage tank.	Consider adding pressure transducer for on vent line to monitor inlet suction	Aquacell design team	14-Jul-25												
	Low pressure	Low pressure in tank	Vacuum created by odour scrubber	Vent to odour scrubber appropriately sized. Odour scrubber cannot pull enough pressure to impact integrity of concrete storage tank.															
	Composition or changing concentration	Low wastewater strength High wastewater strength High Solids	Foreign object in sewer. Oil/grease creates fat berg Innapropriate disposal of chemicals to sewer	Macerator in line to reduce likelihood of solids build up causing issues. pH sensors incorporated in design. Large volumes in storage tanks should be able to dilute periods of high chemical concentration. Bypass line to allow for maintenance of macerator	All occupants should be educated to ensure they understand the impacts of diposing of trade waste or other liquid waste streams to the sewer Tradewaste agreementrs in place with all occupants.	Aquacell/Client	14-Jul-25												
	Start up/ shutdown	Wet well shutdown	Fault with wet well pumps or routine maintenance	Bypass line allows feed to be diverted from macerator to emergency tank.															
	Isolation	Isolation of macerator. Isolation of wet well.	Routine maintenance or failure of equipment	Isolation and bypasses available. Cutter pumps will assist with reducing solids build up in event of macerator isolation															
	Testing	Requirement to sample influent	Troubleshooting/verification testing	Sample point between wet well and pre screen.															
	Maintenance	equipment offline	Routine servicing or unplanned maintenance	Duty/standby. Able to remove pump by guide rails & level instrumentation from above, means requiring tank access is unlikely. Inlet pit is accesible for maintenance and not deep enough to require confined space permits. Readily accessible for access by lifting equipment	Ensure that sufficent openings are allowed, for both visual inspections, and flushing when required.	Aquacell design team, tank supplier													
	Installation	Issues around Installation of tanks (leak of collapse)	Incorrect design or installation of tank or any process equipment	Engaged third party specialists for design and installation. Inlet works is accessible by crane. Confined space operatives used for initial installation.															
	Cleaning	Build up of solids or grit causing premature pump failure or blokage	Solids passing into wet well, either through macerator or during bypass	Both macerator and cutter pumps incorporated into the design. Mixing line to resuspend any solids. Sloped floors to divert to single point															
1c - Pre Screens	No or Low Flow (into screen)	No impact																	
	High Flow (inflow faster than outflow)	Spill or overflow of untreated sewage. Excess use of process water	Screen is partially or completely blocked which reduces throughput. Failure of solenoid valve on proces water lines.	Screens overflow back to buffer tank so there are no spills. Spray water to screen to assist cleaning. Screen run on time can be tuned to ensure proper cleaning and minimise use of process water. Level transducer will alarm and lock out feed pumps if screen is high. Process water recycles to buffer tank.	Current design shows 3x screens. Design team to investigate **alternative screens** (2x 100%). We can potentially consider "open channel" design. **Details of pump station** (by others) to be confirmed by client.	CF SA JJ			Currently working through alternative options. Expecting proposal by 21/03 (Hydroflux)	Design	19-Mar-25	Design calcs that 2x prescreens can keep up with design flow, though space for a third prescreen has been allowed for if required in future.		14-Jul-25					
	Reverse Flow	Screens back up because it can't empty. Screen syphons buffer tank to wet well. Outlet or overflow from one screen allows flow to the other screen	Blockage in outlet, wet well lower than screens so gravity flow possible	Wet well pumps have NRV's. Inlet to buffer tank is high level with air gap so syphon through screen to wet well is not possble. Screens gravity flow to buffer tank so not possible to pump back to screen. Screen outlets are 150mm with influent screened to < 2mm so blockage unlikely. Level transmitters in screens meaning they shut down if blocked. Duty/standby screen arrangement.	Confirm levels and pipework design are such that flow from one screen to the other through outlets or overflows is not possible				Cannot be closed out until unit is specified.	Design	19-Mar-25	Design finalised, confirm that prescreens both flow to buffer tank and cannot flow from one to another		14-Jul-25					
	Low Level	No Impact																	
	High Level	As for high flow																	
	Low Pressure	No Impact																	
	High Pressure	Damage to screen or risk of odour escaping	Damper to vent system closed. Vent line blocked	Vent line sized to ensure adequate flow in normal operation. Screens can depressurise through overflow line to wet well. During no flow screens can depressurise through buffer tank															
	Low Temperature	No Impact																	
	High temperature	No Impact																	
	Composition or changing concentration	Screen can block	Foreign objects like wet wipes can bind up screen bruch	Correct selection of wet well pumps. Spray bars and screen run on times to ensure screen clears. Routine maintenance and inspection to clear screen	All occupants should be educated to ensure they understand the impacts of diposing of inappropriate objects to the sewer system	Client						Macerator reduces likelihood of large solids entering prescreen. We now have mixed liquir entering the screens - meaning that when we run at higher MLSS concentration, we need to run at lower flow - Plan is to run mixed liquor processing during night time, or blending it with influent.	AQ design team	14-Jul-25	Closed				

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Cleaning	Screens doesn't function due to lack of cleaning. Screenings difficult to dispose of	Screens are difficult to access or clean	Screens are readily accessible. Hose point in treatment plant to allow screen to be cleaned	Ensure bin and system of disposal for screenings is suitable	AQ Design Team			Cannot be closed out until unit is specified.	Design	19-Mar-25	Confirming that disposal system is suitable. Additional roller shutter door added for direct access to prescreens.			Closed				
	Testing	No way of easily testing or getting a representative sample of influent.	No place to take a representative sample.	Sample point on screen inlet															
	Maintenance	Screens can't be maintained	Maintainable parts not accessible	Each screen can be indpendantly isolated	Ensure ready access to screen to remove screen with lifting device if required	AQ Design Tesm			Space will be maintained, once final unit is determined.	Design	19-Mar-25	Confirming that disposal system is suitable. Additional roller shutter door added for direct access to prescreens.			Closed				
	Installation	Screens cant be installed	Insufficient access									Sufficient access from new side road through roller shutter door for installation			Closed				
	Isolation	Screen can't be isolated. Outlet from one screen flows up other screen outlet if the screen is removed for maintenance.	No Isolation points on outlet or overflow	Inlet, process water inlet and vent all have isolation valves. Screens installed at the same level with gravity flow to buffer.	Confirm flow is not possible from one screen to the other via the joined outlets if one screen is removed for maintenance. Similarly for overflows.	AQ Design Team			Since the level for duty & standby is the same, overflow should not be possible. There is no valve between prescreen and buffer to interrupt flow.	Design	19-Mar-25								
1d - Buffer Tank	No or low Flow	No immediate impact other than limited food for bioreactor.	Screen or line blockage. Screen maintenance or failure Pipe failure. Diversion valve failure	Low level in buffer tank is visible on HMI/remote monitoring.															
	High flow	Overflow tank.	Operators running pumps or other equipment in manual. Issue in the plant that prevents processing	Level transducer in buffer tank to generate alarm. Email alarming can be configured. There is a pump out point if waste needs to be removed from site. Buffer tank appropriately sized to take short term interruptions to production.								Buffer tank can overflow to emergency tank if full		14-Jul-25	Closed				
	Reverse flow	Buffer tank drains Anoxic tank.	NRV's on pumped line fail	Feed line to anoxic tank comes in above overflow level so syphoning not possible even if NRV fails.								Feed line now comes in below overflow level. Raise level in anoxic tank to flag warning of reverse flow from anoxic tank to buffer. Alarm to be added to FDS. Consider flow circulation within anoxic tank and best location for mixers		14-Jul-25	Closed				
	High pressure	Tank damage; leakage of wastewater outside tank.	Tank is sealed (odour) with no overflow. Operators run pumps manually. Vent line is blocked at the same time as trying pump waste to the tank.	Gravity flow into tank so pressure is limited to head height of feed liquid. Unlikely to damage undergroundtank. Vent line does not have a damper which could be inadvertantly closed. High level transducer with high level switch backup to stop feeds in automatic.	Confirm if level on out of spec tank would push liquid through vent line to odour scrubber.	AQ Design Team			Vent to odour scrubber is sufficiently sized	Design	19-Mar-25								
	Low pressure	Tank collapse.	Pumping out of tank with no way of drawing air in.	Air can be drawn in through the screens if the vent is blocked.															
	Low level	Pump damage. Loss of containment. LTX / LSL failure	Running pumps in manual	Level transmitter for low level protection with level switch as back up.LTX / LSL if one fails, the other device should still read correctly. Buffer transfer pump is interlocked with low level.															
	High level	Overflow tank.	Failed level transmitter. Leaking or manually open valve on off spec tank	Level transmitter has level switch back up in case of failure.	Consider if the tank should have a trapped outlet that diverts tank contents to a specific area if there is ever an overflow event	AQ Design Team			Overflow from buffer tank to emergency tank is to be incorporated	Design	19-Mar-25	Emergency tank has now been allowed for	AQ Design team	14-Jul-25	Closed				
	High temperature	N/A																	
	Low temperature	N/A																	
	Composition or changing concentration	Poor quality water to MBR. Onset of UF fouling and more CIPs than normal	Different activities by client. Surge in alkali cleaners. Anaerobic and pH drops. Chemical dumping.	Buffer tank smooths out peaks. DO monitoringpH alarms on buffer tank. Program PLC to stop/reduce transfer if buffer tank pH high/low.															
	Start up/ shutdown	Low pH Flammable gases.	Could go anaerobic if shutdown for a long time	pH probe. Ventilation to allow gases to be removed. Pump out tank if waste is not appropriate to start plant with.								We have now established that plant cannot be run until 30kL/day is achieved.	AQ Design team	14/07/2025	closed				
	Cleaning	Hose down needed	Build up of scum, foam and waste inside buffer tank	Sealed tank. Not an aerated tank so foam overs not likely.	Consider sepeciying more than one hose point in the plant	AQ Design Team			Current proposal is that 3x hose points should be allowed. 1x in the main treatment plant, 1x in the sludge room, 1x outside (facing the biotanks)	Design	19-Mar-25								
	Testing	N/A										Add sample line to anoxic feed piping - potentially in valve pit	AQ Design team	14-Jul-25	Closed				
	Maintenance	Pumps and probes in tank need to be serviced	Routine maintenance or failure	Probes/transducers/switches mounted into the top of the tank via flange or similar which allow easy removal. Sumbersible pumps and mixers on rails or similar that allow them to be removed easiy for maintenance.															
	Installation	Incorrectly installed and tank leaks. Pump installation involves a confined space entry.	Inexperienced tank builders Inadequate or undefined quality assurance	Manufacturer to install the tank. Hydrostatic test as part of commissioning. Confined space qualified personel to be used to install the pumps. Consider using the tank manufacturers to install the pumps.															
	Isolation	Can't shut down tank for confined space entry if ever required	Insufficient isolation points	Manual isolation valves upstream of screens and on the transfer line from the out of spec tank.								Consider additional spectacle plate from treated water storage for isolation. We can isolate inlet to off spec.	AQ Design team	14-Jul-25	Closed				
Section 2 - MBR (inclusive of Anoxic, Aerobic, MOS and Filtrate)																			
2a - Bioreactors - Anoxic (including mixer)	No or low Flow	No or limited food for bioreactor.	Buffer tank pumps failed, empty buffer, or MBR overflow stopped, Bio pumps failed, aerobic tank low level (stops bio pumps), blocked line. Closed valve after maintenance.	Regular monitoring and maintenance by service staff.															
	High flow	Overfill and over pressurise tank causing tank damage or flooding.	Overfeeding from buffer (both pumps on manual).	Piping and overflow is within design capacity for two pumps in parallel. High level switch in Aerobic tank															
	Reverse flow	Overfilling	Foaming in aerobic tank. Anoxic overflow pipe blocked.	Check valves in buffer pumps to stop flow back to buffer tank. Anoxic to MBR tank hydraulically not possible other than foam. Foam from aerobic to tank to anoxic is possible but there are spray bars in the aerobic tank to control foaming.								Check valves on anoxic recirc pumps will also prevent reverse flow							
	High pressure	Tank damage. Leakage of wastewater outside tank.	Overflow blocked.	Overflow sits above inlet level of aerobic tank, so not possible to hydraulically block the line.															
	Low pressure	Tank damage	Blocked vents and bio pumps running	Multiple vent paths - overflow from from aerobic, overflow line from MBR, DN80 vent on tank.								Even if vents were blocked, the pumps would not create sufficent vacuum to damage the underground concrete tanks. Vent dia. increased to 100mm							
	Low level	Mixer gets damaged because water level is low	Tank leaking	Low level switch to protect the mixer. No drain valve on tank. No pumps in tank to empty it in normal operation.															
	High level	Spill from tank	Overflow blocked.	Not possible to hydraulically block the overflow.Spray line in aerobic tank to control foaming. Liquid flow will likely unblock any foaming that may carry over into the overflow line.															
	High temperature	Biology effected	Prolonged exposure to hot climate or high temperature feed	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Low temperature	Biology effected	Prolonged exposure to cold climate or low temperature feed.	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Composition or changing concentration	Explosion from gases Corrosion of tank Under performance of mixed liquor.	Anaerobic and may produce odour or explosive gases. Improper disposal of CIP waste. Chemicals in wastewater.	DO probe in the aerobic tank. Mixing and aeration in anoxic tank. Design is inherently anoxic. Safeguards for buffer tank. Buffer tank serves to lower peak concentration in w/water.								Explosive gases will be vented through the OCU stack. pH probe in buffer tank to monitor influent characteristics.							
	Start up / shutdown	No issues with start up Mixed liquor turning septic during prolonged shutdown	Lack of aeration during shutdown	During extended shutdown, manually operate pulse burst aerators to supply oxygen from the aerobic tank. If a long period of time then drain the tank.															
	Cleaning	Accumulation of biomass on floor of tank.	Biomass settles over time	Mixer installed. Upstream screening to remove large items.	Consider access for pump out of tank if ever required.	AQ Design Team			Access hatches are to be provided in all tanks. Vehicle access is possible direct to aerobic tanks.	Design	19-Mar-25								

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Testing	Underperformance of mixed liquor. Design intent is to remove some nitrogen.	DO of anoxic zone is too high such that anoxic conditions do not exist		Consider access point near the weir to insert DO probe (or visually inspect aeration).	AQ Design Team			Visual inspection is possible through access hatches. Instrument probes can be deployed.	Design	19-Mar-25								
	Maintenance	Can't maintian mixer. Can't inspect tank.	No drain valve on tank.	Mixer and level switch accessible without needing to pumps down tank. Tank inspection rare and it's practical to pump down a 40kL tank if required.								Mixers to be installed on guide rail to allow removal without draining tank.							
	Installation	Leakage	Sub-standard installation leading to a leak	Hydrostatic testing at clean water commissioning.															
	Isolation	High risk if confined space entry of anoxic tank with aerobic tank contains unaerated mixed liquor	Unable to isolate headspace of anoxic tank from aerobic tank. Unable to isolate headspace of MBR tank from anoxic tank.	Able to isolate against inundation at other points.															
2b - Bioreactors - Aerobic (including blower skid)	No or low Flow	Underperformance of biological system. Failure to achieve required DO and MLSS levels	Buffer tank pumps failed, empty buffer, or MBR overflow stopped, Bio pumps failed, blocked overflow from anoxic tank, strainer on bio pump outlet blocks.	Alarms and faults allow service staff to monitor pumps remotely. In line flow meter between bio tank and MBR tank monitors flow. Flow switch on instrumentation side stream alarms if flow is inadequate.															
	High flow	Overfill and/or over pressurise tank causing tank damage or flooding.	Excess flow into anoxic tank	MBR tank can only overflow at the rate the bio pumps remove liquid so no net gain from these pumps, even in manual. Overflow DN150 sized correctly.															
	Reverse flow	MBR and bio tank levels equilibrate and part of membrane exposed.	Loss of power NRV for bio pumps stays open	Bio pumps have NRVs. Bio pumps run almost all of the time. MBR tank has level transducer which will alarm if the level drops.															
	High pressure	Tank damage. Leaks	Blocked overflows. Blocked ventilation for foaming.	Tank can vent through anoxic tank, if aerobic tank vent was blocked. Spray bars keep foaming down.	As per anoxic tank. Confirm with installers that vents for bio and buffer tanks have an uphill gradient, which will avoid water accumulting in the vent system.	AQ Design Team			Confirming an uphill gradient will be applied to the vent from the biotank to odour scrubber.	Design	19-Mar-25								
	Low pressure	Tank damage	Pumps running with vent blocked	Multiple vent paths - vent through anoxic, vent through MBR overflow since overflow is not full bore flow.	As per anoxic tank				Risk of blockage considered to be minimal. No valves or other inline equipment in odour scrubber vent lines.	Design	19-Mar-25								
	Low level	Damage to pumps or aerator	Transducer failure	Level transducer is backed up by level switch															
	High level	Spills	Pumps running manually. Foam "fills" tank above liquid level. Transducer failure. Tanks fills goes high from excess spray water	High level transducer is backed up by level switch. Tank overflows to wet well. Tank sealed for odours so foams will likely go down overflow or back to anoxic tank. Spray bars to reduce foam. Control system allows for sprays to run intermittently to operator settings rather than continuously. System is closed loop - spray water doesn't add to volume in plant since it is process water rather than potable.															
	High temperature	Biology effected	Prolonged exposure to hot climate or high temperature feed	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Low temperature	Biology effected	Prolonged exposure to cold climate or low temperature feed.	Tank is a large volume. Climate is moderate without prolonged extremes. Influent plant is typical blackwater temperatures.															
	Composition or changing concentration	Explosion from gases. Corrosion of tank. Under performance of mixed liquor.	Inadequate DO control leading to anaerobic conditions. Improper disposal of CIP waste. Chemicals in wastewater. Aerator inlet blocked reducing aerator efficiency	DO and MLSS probe in bio pump sidestream to monitor MLSS. Buffer tank smooths concentration changes up stream. CIP chemcials appropriately neutralised before being introduced into the system.	Ensure aerator pipe is easy to inspect and maintain.				Submersible aerator is considered, which should be easy to raise and inspect.	Design	19-Mar-25	Explosive gases will be vented through the OCU stack. pH probe in buffer tank to monitor influent characteristics. Magnesium hydroxide will be dosed to control pH.								
	Start up / shutdown	No issues with start up Mixed liquor turning septic during prolonged shutdown Pump and/or aerator damage due to operation at low level.	Aerator not submerged. Manual operation overrides level switch Inadequate aeration during prolonged shutdown.	Plant has several stages of shutdown which ensures aerators and pumps run for appropriate periods depending on down time. Level switches and transducers protect pump and aerator	Consider replacing AV-331A & AV-332A with a 3-way valve (waste to sludge settling tank)	AS			Addition of 3 way valve considered in design.	Design	19-Mar-25	Sludge settling tank has been removed from the design, so the three way valve is no longer required.							
	Cleaning	Accumulation of biomass on floor of tank.	Biomass settles over time	Mixer installed. Upstream screening to remove large items.	Consider access for pump out of tank if ever required.	AQ Design Team			Camlock and required isolation valves to be incoporated to allow tank to be drained	Design	19-Mar-25	Access for pump outs confirmed. Design now features an emergency tank transfer system from biotank							
	Testing	Underperformance of mixed liquor	DO, pH, MLSS,	External DO and MLSS on bio pump side stream. Can do grab sample from tank.	Consider inspection points in the aerobic tank (to inspect aeration pattern)	AQ Design Team			Inspection hatch to be included in tank. Submersible aerators to be utilised, no aeration grid.	Design	19-Mar-25	Confirmed inspection hatch included in design							
	Maintenance	Biological system underperformance. Pump or aerator failure.	DO/MLSS probe malfunction	Maintenance of DO and pH probes is easy as it is external. Aerator and pumps can be removed from tank without requirement for confined space entry. Access hatch in tank allows for aerator performance to be assessed.															
	Installation	Leakage	Sub-standard installation leading to a leak	Tank manufacturer to install															
	Isolation	High risk if confined space entry of aerobic tank with anoxic tank containing unaerated mixed liquor	Unable to isolate headspace of anoxic tank from aerobic tank.	Able to isolate against inundation.															
2c - MOS System (Including Magnesium Hydroxide dosing)	No or low Flow	Low inflow to MBR tank leads to biomass concentration increases and blocks membranes. Low flow of air causes fouled membranes. Low backwash flow for maintenance clean causing ineffective membrane cleaning. Low alkalinity chemical flow. Low venturi flow leading to not priming the line. Low flow in instrumentation loop giving false reading. No/Low magnesium hydroxide dosing on overflow line	Blocked recirc pump or pump isolated manually. Blower failure or pipe failure. Loss of pump prime. Low alkalinity caused by loss of pump flow or chemical Blocked dosing line or pump failure	Level transducer in MBR tank that would identify when insufficient mixed liquor feed. MBR overflow is adequately sized. Permeability alarm. Air pressure indicator and alarm. Flowmeter on inlet from biology and after outlet of MBR pump. Level switch on line to confirm priming. Flow switch on instrumentation loop. Selected DN20 magnesium hydroxide dosing line to avoid pipe blockages. Incorporated dosing tank mixer to avoid magnesium hydroxide settling in the system. Selected peristaltic pumps for magnesium hydroxide dosing.															
	High flow	High ML flow has no significant consequence. High air flow could cause membrane damage. High filtrate flow causing rapid fouling. High BW flow damaging membrane. High overflow rate causing high level. High vent flow.	High air flow - both blowers running. Incorrect flow setting on filtrate/BW. High vent flow caused by excessive air.	High flow alarm on filtrate flowmeter. TMP alarm. Air flow limited by aeration rate / size of membrane blower. Overflow rate limited by biology pump flow.								Overflow adequately sized							
	Reverse flow	Reverse flow of MLSS to blowers. Reverse flow of MBR tank to aerobic tank.	MLSS damages blowers. System off for an extended period and slow leak through NRV on ML line, leading to membranes partially exposed.	Non-return valve on blower. Blower pipe line installed so it is higher than the filtrate tank overflow. Non-return valves on all pumps. Level transducer alarms prior to the membrane being exposed.															
	High pressure	High air pressure causes blower failure or low air flow High TMP causes rapid fouling and increases energy consumption High BW pressure for maintenance clean.	Blower isolated or line blocked. Poor mixed liquor quality	Pressure relief valve on blowers. Air pressure monitored and alarmed for high pressure. TMP monitored and alarmed. BW pressure monitored and alarmed. Dead head pressure for backwash pump is less than the design rating for the membranes.	Consider actuated valve on MBR filtrate air relief line for priming	AS			Additonal valve to be added onto the line	Design	19-Mar-25	Confrimed actuated valve added on MBR filtrate priming line							
	Low pressure	Low air pressure leading to low air flow and membranes foul faster. Low process water pressure on venturi leading to insufficient vacuum, lead to loss of prime of filtrate pump	Air line or blower line failed.	Blower pressure monitored and alarmed. Level switch on header will detect inadequate venturi operation.								Duty/stand by MOS blower incorporated into the design.							
	Low level	Membranes exposed and may dry out. Could allow air to damage membrane by excessive movement. Air in filtrate line	No inflow or tank drained or valve left open.	Level transducer on MBR tank to monitor level. Low level interlocks blowers and filtrate pump. Low flow through membrane pump detected and alarmedvia flowmeter after MBR pump.															
	High level	Tank is designed to overflow to biology tank. If blocked, then level will rise up the vent line.	Blockage in overflow to aerobic tank.	No manual valves on overflow to aerobic tank. DN150 overflow.															
	High temperature	High temperature can damage the membranes	Exothermic chemical reaction diluting or neutralising chemical	Temperature monitored, although only during filtration. Procedure for CIP to prevent mixing of incompatible chemicals. Membrane tanks indoors so not exposed to direct sunlight.															
	Low temperature	Membrane damage	Exposure to low temperature	Temperature monitored. Membrane tanks are indoors and not exposed to prolonged cold temperature. Membranes submerged with tank contents always moving - no risk of freezing.															
	Composition or changing concentration	Damage to membranes by chemicals or other impurities. Damage caused by high MLSS. Damage caused by excessive fibrous materials blocking the membrane modules. Membrane integrity failure leading to poor quality treated water.	Wrong recipe for CIP or inadvertant overdosing of chemicals during CIP. Fibrous material caused by screen failure.	Automated CIP sequence set up at commissioning. See screen failure safeguards. pH probe in buffer tank to detect some impurities. Turbidity monitor and alarm to detect integrity failure.TMP monitoring to detect fouling. MLSS probe to monitor solids concentration. In line strainer between biology pumps and MBR tank.	Consider selection and suitability of MBR recirc strainer. Ali to investigate rescreening of MLSS from MBRs.	AS			Considering a "pre-pump strainer", which is hydraulically cleaned. Also looking into other options/getting advice from MBR experts.	Design	19-Mar-25	Mixed liquor rescreening has been incorporated to protect membrane failutre caused by fibrous material. Basket strainer also added upstream of MBR tank to protect membrane from fibrous material.							
	Start up/ shutdown	Membranes exposed and may dry out. High flow of filtrate due to incorrect VFD setting.	Passing check valve and level equalisation with bio tank. Leaking drain valve. Membrane damage or bio fouling. Position of manual valve on filtrate pump discharge	Non-return valve in biology supply line. Level transducer on membrane tank and a low level alarm. Established procedures for proper storage of membranes (SMBS). Safeguards as per low and high flow scenarios.															
	Cleaning	Membrane fouling/damage	Wrong chemicals and/or concentration or procedure.	Chemical cleaning to be performed only by trained personnel following appropriate procedures.								Sample points added to CIP line to test chemical if required.							

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Testing	Non-representative samples, or spurious results (e.g. coliforms due to contamination).	Contamination of sample points	Sample points on filtrate and MLSS provided Stainless steel sampling point for ease of disinfection by ethanol (or flamed).								Sampling to be performed only by trained personnel following appropriate procedures.							
	Maintenance	Membranes dry out/fouling/damage	Visual inspection for aeration pattern, hose down for CIP. Removal of membranes	Use trained service personnel. Access for visual inspection is available. Pull out rack for maintenance and change out of membranes is part of design.								Platform ladder has been incorporated for visual inspection. Filtrate turbidity continuously monitored to change filtrate quality due to membrane damage.							
	Installation and environment (sun, noise, odour)	Injury due to inadequate access to equipment. Odour in the room.	Poor layout and design and insufficient isolation.	Tank has lifting lugs fitted to allow it to me craned into position. Local isolators provided on all motors. Manual isolation valves on tanks. Vents for odour control.															
	Isolation	Inability to achieve effective isolation for confined space entry (if required)	Improper isolation.	Manual isolation valves provided. Tank only opens from the side so cannot be inundated.															
2d - Filtrate Tank	No or low Flow (filtrate)	No disinfection = no treated water production Low level in filtrate resulting in disinfection pump runnings dry	Valve failure Filtrate pump failure Pipe leak or blockage	Level transducer and level switch on filtrate tank.															
	No or low Flow (potable)	Unable to prepare CIP/MC solution	Potable top up valve failure. Potable water outage	Level transducer and level switch on filtrate tank. Flowmeter on potable inlet to treatment plant.															
	High flow	Overflow the tank. Inflow upsets instrumentation due to turbulent flow	MOS flow set point too high	Overflow on the tank. High flow alarm on MOS system. Instruments installed as per other Aquacell sites ensures they are not effected by high flow.															
	Reverse flow	Contaminated potable water top up line Air flow from floor drain causes odour	Backflow up line Connection between overflow and floor sink	Air gap for both the filtrate flow and potable water flow into the tank, prevents backflow. Floor drain specified with trap. RPZ valve on potable line.															
	High pressure	Tank damage	Not feasible due to air gap and overflow are vented and DN100 overflow	Since odour risks are unlikely, tank is normally not fully sealed.															
	Low pressure	Tank damage	Not feasible due to air gap and overflow are vented and DN100 overflow	Since odour risks are unlikely, tank is normally not fully sealed.															
	Low level	Damage to disinfection and filtrate pumps	Level TX failure. Break in pipework	Low level switch as backup to level transmitters. Flowmeters will detect low flow from pump to prevent damage.															
	High level	Tank overflows	Level transmitter failure. Blockage in overflow.	Level transmitter is backed up by high level switch. Overflow to floor drain is appropriately sized.															
	High temperature	N/A																	
	Low temperature	N/A																	
	Composition or changing concentration	Uncompliant treated water. Damage to equipment from CIP chemicals	Residual CIP chemical. Membrane integrity issue.	MOS CIP is automated to ensure flushing after CIP. Operating instructions to ensure filtrate tank is drained following CIP. pH is monitored and will pick up some level of incomplete CIP rinse. Turbidity monitored to ensure membrane integrity.															
	Start up/ shutdown	No specific issues																	
	Cleaning	Poor ability to clean any biofilm	Inadequate access	Access hatch on top of tank to add chemicals if required.															
	Testing	Biofilm growing inside the tank without knowing it	Filtrate quality monitoring is on the pipe at the inlet to the filtrate tank	Sample point post disinfection pump to take sample. Opening in top of tank to visually check.															
	Maintenance	Poor ability to clean any biofilm	Inadequate access	Access hatch on top of tank to add chemicals if required.															
	Installation and environment (sun, noise, odour)	Plant is indoors, so no issues.	Filtrate tank larger than available building access.	2 x Filtrate tanks and delivered to site via doorway access.								Confirmed doors are appropriately sized.							
	Isolation	Unsafe working for maintenance	Lack of manual isolation	Isolation valves provided to prevent accidental filling of tank.															
Section 3 - Disinfection (Inclusive of Ozone, BAC, UV and Chlorination)																			
3a - Ozone Treatment including OCT Piping	No or low Flow	Low flow compressed air to ozone skids. No or low filtrate flow. Ozone not generated at suitable rate.	Compressor failure. Upstream pump or valve failure	Ozone levels checked pre OCT pipework. Alarm levels can be set. Ozone skid has alarms that go back to the PLC.								Flowmeter after disinfection pump. Regular maintenance schedule for compressor.							
	High flow	Incomplete treatment or insufficient residual ozone	Flow through ozone OCT pipework too high to get required contact time. Ozone flow into treated water too high leading to over ozonated water	High flow through contact pipe mointored by flowmeter upstream of ozone skid. Ozone levels checked pre OCT pipework. Alarm levels can be set. Ozone skid has alarms that go back to the PLC															
	Reverse flow	Reverse flow through eductor	Line blockage	Check valve on ozone inlet of eductor.															
	High pressure	Damage to equipment	Damage to seals or pipework.	Ozone system has an independent control system and sensors to monitor pressures and alarm. Pipework designed to accommodate pump dead head pressures.								Regular maintenance schedule for compressor. Pressure switch on compressed air receiver							
	Low pressure	Compressed air pressure too low to generate sufficient oxygen	Malfunctioning compressor, air leaks	Ozone system has an independent control system and sensors to monitor pressures and alarm								Regular maintenance schedule for compressor. Pressure switch on compressed air receiver							
	Low level	Low ozone concentration	Increase ozone demand, malfunction ozone unit	Ozone system has independent control system to monitor production. Ozone probes to measure residual ozone and alarm															
	High level	High ozone concentration	Decrease ozone demand	Ozone system has independent control system to monitor production. Ozone probes to measure residual ozone and alarm															
	High temperature	Inadequate colour removal	Ozone half life reduces as temperature rises, temperature affects solubillity	Temperature probe in cell where residual ozone is measured								Upstream and downstream temperature can be monitored from MOS and CCT temperature probe.							
	Low temperature	Inadequate colour removal	Temperature affects solubillity	Temperature probe in cell where residual ozone is measured								Upstream and downstream temperature can be monitored from MOS and CCT temperature probe.							
	Composition or changing concentration	Inadequate colour removal, Ozone begins to concentrate in the air	Ozone demand is not consistent, leaks in ozone system	Ozone concentration meansured at start at outlet of ozone contact tank, ozone destruct unit vented to roof to ensure excess ozone is safely removed.	Confirm there is an ozone sensor and alarm which would detect leaks	Aquacell Design Team			Confirming ozone leak sensor is incorporated into ozone offer	Design	19-Mar-25								
	Start up/ shutdown	Inadequate colour removal	Ozone system requires time to produce ozone on startup		Confirm if there is any stored ozone on shutdown. If so, confirm the system sends it through the destruction unit	Aquacell Design Team			Ozone destruction unit is to be incorporated into ozone system. Current quote does not include this. Ali to get revised quote.	Design	19-Mar-25	Confirming that ozone destruction unit is incorporated into design. Ozone sensor fed back to PLC.							
	Cleaning	No specific cleaning requirements																	
	Testing	Samples required	Ad-hoc sampling for troubleshooting, instrumen verification	Sample points upstream and downstream of ozone unit and OCT pipework	Consider also adding sample point after each OCT leg to monitor ozone decay	AS			Additional sample points to be incorporated into the design.	Design	19-Mar-25	Sample points added after each OCT pipe leg.							
	Maintenance	Break downs	Inappropriate servicing	Service and maintain compressors and Ozone unit as per manufacturer's recommendations															
	Installation and environment (sun, noise, odour)	Noise. Difficult to install OCT pipework skid	Compressor supply compressed air to ozone unit and run at high duty	Units installed indoors away from direct sunlight. Building doors should be large enough. Option to construct in situ if final building design presents a problem	Confirm selection on compressor type considered noise levels. Confirm compressor has an acoustic hood.				Alternative unit to atlas copco to be approached	Design	19-Mar-25	OCT pipe length has been selected to ensure that it can be manufactured off site. Rotary screw compressor has been selected to reduce noise.							
	Isolation	No ability to isolate	Valves and electrical isolators not installed	Ozone units have a main switch on the unit. Isolation valves upstream and downstream.															
3b - BAC Filters	No or Low Flow	Ineffective backwash. System is airlocked.	Insufficient flow from process water pump	Process pump sized correctly. Air relief valves at high points in the system.															
	High Flow	Insufficient contact time for correct treatent. Carbon flushed out of filter housing. Spillage from backwash going to floor waste	Pump incorrect size or running too fast of a VSD	Pump sized correctly for forward flow. Flow controller installed in drain line to control backwash flow. Each pair of filters are in series so not possible to divert twice the flow through one filter	Review backwash pipe connections to floor drain at commissioning. Re-engineer if appropriate. Consider using besser block bund.	AQ Commissioning team			To be considered at commissioning if required. Could consider fabricated flow diverters if required, rather than besser blocks.	Design	19-Mar-25	Appropriately sized drainage pit included in the design to avoid spillage from high backwash flow.							
	Reverse Flow	Forward flow diverts to drain.	Problem with filter valve not locating properly or other internal problem	Limit switches provide feedback to PLC on filter valve status. Flowmeters upstream															
	Low Level	N/A																	
	High Level	N/A																	
	Low Pressure	Filter does not backwash correctly	Process water feed issue (Pump/valve)									Pressure transducer added to process water pump outlet							
	High Pressure	Damage to filter housings. Reduced throughput	Incorrect valve sequencing. High backwash pressure.	Position feedback to be incorporated.								Pressure transducer added to process water pump outlet							
	Low Temperature	N/A																	
	High temperature	N/A																	

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Composition or changing concentration	Residual ozone upsets BAC conditions.	Overdosing ozone upstream. Bio-growth or other contaminant coming from filtrate tank.	Residual ozone measured at the outlet of ozone contact tank. Refer to Filtrate tank maintenance controls.															
	Cleaning	No specific external cleaning requirements. Replacing carbon as per Maintenance controls																	
	Testing	Filters not performing as expected	Carbon exhausted. Upstream process issues	Sample points located updtream and immediately downstream prior to UV units															
	Maintenance	Insufficient colour removal. High HCC count	Filters not backwashed properly	Filters set to backwash on time, differential pressure or manually initiated by operator. High DP is an alarm condition. Unions allow control valve to be disconnected for easy access. "Slurpy" or wet vac's to extract used media.	Ensure adequate height and access for platform ladder when finalising layout	Aquacell Design Team			Mohammad to review access for platform in 3D model	Design	19-Mar-25	Access for platform has been considered.							
	Installation and environment (sun, noise, odour)	Damage to filters from handling or UV	Difficult to handle	Leave vessels on pallet for as long as practically possible. Maintian forklift access to final location if practical. Use at least two people to move filters. Ensure final piping does not impede ability to do initial fill of filter. Filters installed in shed so problem with UV degredation.	Ensure adequate height and access for platform ladder when finalising layout	Aquacell Design Team			as above	Design	19-Mar-25								
	Isolation	Need to replace filter media	Carbon at end of useful life	Each vessel can be isolated to allow the filter to be maintained.															
3c - UV systems	No or low Flow	Overheat the UV	Disinfection pump is off (auto or manual). Downstream valve closed. Air trapped in unit.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time. Valves in the high part of the line allow air to be vented															
	High flow	Inadequate disinfection due to short contact time.	High flow from UV pump	Flow from pump is monitored and alarms on high flow.															
	Reverse flow	Not feasible			Add NRV from diversion line to off spec water tank				Confirmed valve added in P&ID	Design	19-Mar-25								
	High pressure	Damage UV by exceeding design pressure	Downstream valve is closed	UV and pipework rated pressure higher than dead head pressure of pump.															
	Low pressure	UV fouling due to lack of wiper functionality.	Low permeate pressure Manual valve closed Drain valve opened	UV controller monitors wiper action and will alarm if it doesn't wipe. Procedures for maintenance of UV.															
	Low level	Damage to unit due to over temperature	Leak, unit drained and left isolated after service.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time.															
	High level	N/A																	
	High temperature	Damage to unit. Damage to pipework surrounding the UV	Running with no water or low flow.	Unit has over temperature alarm and shuts down. PLC alarms on low flow for extended period of time. Pipework within line of sight of UV lamp is stainless steel.															
	Low temperature	N/A																	
	Composition or changing concentration	Poor disinfection	Low UVT. Fouled lamps or failed lamps causing low UVI. Pipe material selection incorrect and allows UV light to damage pipework. Valve arrangement used for CIP.	UVT monitor is integral to UV and alarm warns of low UVT. UV dose alarm to warn of low intensity and low dose. Lamp failure alarm. Use stainless steel upstream and downstream of the UV and where there is risk of UV light. CIP solutions not strong enough to damage quartz sleeves.															
	Start up/ shutdown	Inadequate disinfection during start-up. Fouling during extended shutdown	Insufficient lamp warm up time.	Water can be diverted to the off spec tank post CCT contact. UV can be remote started without water flowing if required. UV system has wipers to assist with removing fouling. Manual cleaning of sleeves after prolonged shutdown.															
	Cleaning	Unable to remove lamps for cleaning	Not enough access space provided	Sufficient space around UV unit to open door and perform cleaning. Sufficient space around 130 um and 5 um filters.								Duty/stand by UV arrangement							
	Testing	Need to sample pre or post UV	Troubleshooting, process analysis	Sample points pre and post UV															
	Maintenance	Unable to remove components of UV system, and 130 um and 5 um strainer for cleaning	Not enough access space provided	Sufficient space either side of UV, strainer and cartridge filter.															
	Installation and environment (sun, noise, odour)	No specific issues as unit is indoors																	
	Isolation	Unsafe to work on	No isolation points	Manual valves and electrical isolation provided. UV door cannot be opened without unplugging electrical plug.	Install local isolator on UV (similar to GPO installed at Bankstown). Note in I/O list	AQ Design Team			To be added once IO list is prepared.	Design	19-Mar-25								
3d - Chlorination System (CCT)	No or low Flow	False instrumentation readings, instrument damage if flow cell drains. Inadequate mixing. Overdose of hypochlorite.	UV pump failure. Flow restriction with one or more valves. Flow cell blockage. Flow cell drains. Low level in filtrate tank. Strainer blockage in analysis stream	Flow switch in flow cell. Pump fault alarm. Flow meter upstream of injection point. Flow control using diaphragm valve. Fine adjustment via needle valve in flow cell. Static mixer.															
	High flow	Damage instruments or inaccurate readings. Insufficient contact time.	Valves not set correctly	Flow cell acts as a flow restrictor and has flow indicator with needle valve to control. Adequate volume in CCT to ensure sufficient contact time. Flowmeter in line to monitor flow rates															
	Reverse flow	Backflow to cell causes damage by overpressure	Upstream valves isolated with pump running	NRV after off spec diversion valve to prevent backflow to cell. NRV at disinfection pump prevents backflow through system															
	High pressure	Damage to chlorine probe (max 1bar) or flow cell	Accidently closing a manual valve downstream of cell or closed manual valve at outlet CCT	Pressure regulating valve prevents over pressure for instrument flow. NRV in sidestream prevents overpressure from reverse flow. Pressure gauges for service technicians to set and monitor pressue.								Sufficiently trained operators will maintain the plant. Correct sequences to be outlined in O&M manual.							
	Low pressure	N/a																	
	Low level	Damage to probes by cell draining.	UV Pump stops and line drains.	Treated water tank and off spec holding tank entry points are higher than the remiander of the system. Enter above overflow level so syphon not possible.	Confirm safeguard cited is correct	AQ Design Team			Air gap between pump entry point and overflow to be maintained to avoid siphoning	Design	19-Mar-25	Confirmed air gap has been added.							
	High level	Not an issue - designed to be full																	
	High temperature	Not considered a risk in this installation																	
	Low temperature	Improper disinfection	Lower temperature requires higher chlorine CT									Temperature sensor installed in flow cell. CCT defined. Water diverts below set temperature.							
	Composition or changing concentration	Excessive chlorine level could be a hazard to reuse and irrigation. Inadequate chlorine doesn't ensure adequate disinfection	Chlorine demand is not constant. Dosing failure or incorrect setting. Instrument drift. Inadequate maintenance of chlorine probe. Chlorination affected by pH. Chlorine supplied can vary in strength.	Free chlorine analyser monitors chlorine level. Alarms if too high or too low. Monthly calibration & service checks of probe. Periodic microbial test results. Chlorine dosing rates can be monitored and adjusted remotely. Chlorine dosing control can be made sophisticated if required (eg PID loop). Store chlorine away from direct sunlight. Monitor chlorine inventory to ensure minimum practical time on shelf. Chlorine probe reading is compensated using pH measurement from the same flow cell.								Confirmed PID loop incorporated into chlorine dose control. Chlorine stored under a roof to protect from direct sunlight.							
	Start up / shutdown	Start up -unstable dose control. Shutdown - probe issues over time, fail to calibrate. Chlorine residual drops during shutdown	Incorrect PID loop tuning during commissioning Probe drifts off-spec during storage. Natural decay of chlorine	Free chlorine is a CCP and water will be diverted to off spec tank until chlorine is in target range. Operators service and calibrate probe after extended shutdown.															
	Cleaning	Fouling of piping and equipment	Low residual free chlorine or fault online instrument.	Routine servicing and cleaning of strainer. Strainer union ended.															
	Testing	Can't monitor water quality properly	Inadequate number/location of sample points	Sample point adjacent to instrument sidestream to get representative sample.								Confirmed sample points located before and after CCT							
	Maintenance	Unable to safely remove probes for calibration, or remove strainer for cleaning	Poor access and no isolation	Isolation valves on sidestream, and either side of static mixer (union ended).															
	Installation and environment (sun, noise, odour)	CCT pipe skid doesn't fit though room doors	Skid bigger than opening	Doors on building should be large enough. Could be constructed in situ if it is problematic after final building design is determined. Indoor settting so no issues for probes or pipework,								Skid mounted - fabricated off site. Confirmed door sized adequately to allow for installation							
	Isolation	Can't service easily	No isolation points.	Provision for isolation of CCT, sidestream and static mixer.															
Section 4 - Storage (Inclusive of Treated Water and Off-Spec)																			
4a - Treated Water Storage Tank (including process water pumps and recirc loop)	No or low Flow	No issues for tank. Low potable makeup flow causes tank to run dry. Flow is too low for effective mixing. Flow is too low for process water to service equipment. Low flow doesn't let instrumentation get representative readings. Inadequate chloramine dosing.	Makeup water valve failure. Manual valve closed. Failure of recirc or process water pumps. Multiple process units require water simultaneously. Strainer in instrumentation loop blocked. Dosing pumps under sized	Low level switch and transducer indicate low level. Manual override for auto valve (potable). Physical bypass of automatic valve is possible. Flow switch in instrumentation cell to detect no or low flow. Process units don't use water for extended periods so unlikely to occur concurrently. Pump sized appropriately. Process water pump is duty/standby. Strainer readily accessible and maintainable. Tank needs to maintain minimum volume to protect pumps. Radar level transducer not likely to be affected by swirling motion. Level switches are back ups so minor disturbance acceptable. Mount level switches out of direct line of eductor flow. Dosing pumps adequately sized	Consider limit switches for automatic valve, or alarm in PLC if valve is open and flowmeter doesn't indicate flow. This would allow early detection of valve failure. Depending on end use, refil rate etc. this may not be necessary.	Aquacell Design Team			Potable top up valve to be client scope. We can still request position feedback of valve.	Project delivery	19-Mar-25	Position feedback to be specified.							
	High flow	Process water flow too high at point of intended use. High flow through eductors causes "stirring". Exessive chloramine dosing	Process water pump oversized. High supply water pressure combined with requirement for air gap. Dosing pumps over sized	All points of use for process water have a valve that could be used to throttle flow if required. Dosing pumps adequately sized								Both disinfection pumps and process pumps are adequately sized. Disinfection pumps run on VFD to control flow.							
	Reverse flow	Contamination of potable by recycled water. Contamination of Treated Water tank from sewer (or drain line).	Backup in line Sewer line backs up Drain valve left open and drain line backs up and flows into tank	Air gap between tank and potable top up line. RPZ valve on potable line at plant inlet. Check valves on pumps.	Consider the risk of process water contamination from process s - eg, reverse flow from screen. Need to maintain air gaps. Should there be a RPZ?	Aquacell Design Team			Overflow line is lower than tw entry point to avoid siphoning. Air gap from potable top up maintained. RPZ incorporated (client supply).	Design	19-Mar-25	Confirmed.							
	High pressure	Tank damage and/or rupture. Damage to instrumentation or flow cell. Damage to process units using process water.	Overfilling tank and continuing to pump water into tank faster than it leaves.	Air gap provides a vent pipe when tank filling. Pressure regulators on instrumentation side stream. Presure regulators on process units.	Confirm BAC backwash supply line does not need a pressure regulator on it. Should there be a pressure transducer to alarm low and high pressure on the process pumps?	Aquacell Design Team			Pressure transducer to be incorporated into BAC backwash supply to monitor high & low pressure	Design	19-Mar-25	Overflow line adequately sized. Pressure transducer added to BAC backwash supply line.							

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Low pressure	Tank collapse	Pump out faster than air or water can come into tank.	Air gap for makeup provides a vent point.	Confirm the air gap is sufficient venting.	Aquacell Design Team			Confirmed air gap will be sufficient	Design	19-Mar-25								
	Low level	Pump damage. Instrumentation damage. Insufficient supply for process water. Eductors above water line.	Pumping out faster than makeup or incoming treated water.	Low level switch and low level warning on level transmitter. Level set at commissioning to ensure eductors remain covered even at low level.	Confim with manufacturer is there is a minimum level required to be maintained.	Aquacell Design Team			Low level switch & transducer incorporated to protect equipment.	Design	19-Mar-25	Minimum 100mm of water level to be maintained.							
	High level	Tank backs up and overflows at airgap and/or vent.	Failed level switch and transducer. Potable makeup valves fails open.	Peak flows considered at design stage when sizing overflow and vent lines. Some buffering capacity in buffer tank.	Ensure potable makeup valve fails closed. Limit switches on valve. Manual override on valve. Manual isolation on makeup line. Ensure the overflow line is the first point it overflows from.	Aquacell Design Team			As above, position feedback to be provided on top up valve, manual isolation & a bypasss.	Design	19-Mar-25								
	High temperature	Not considered a risk in this location																	
	Low temperature	Not considered a risk in this location.																	
	Composition or changing concentration	Water is out of specification for delivery. Chlorine concentration can vary. Inadequate or exessive total chlorine in treated water	Chlorine out of range . pH out of range. Failure of control system for diversion. Override of CCP. Dosing pump incorrectly sized. Incorrect selection of static mixer.	Upstream diversion to out of spec tank to prevent water reaching tank in first place. Chlorine, Ammonium sulphate to correct chemistry if required. Free chlorine analyser monitors chlorine level. Alarms if too high or too low. Monthly calibration & service checks of probe. Periodic microbial test results. Chlorine dosing rates can be monitored and adjusted remotely. Chlorine dosing control can be made sophisticated if required (eg PID loop). Store chlorine away from direct sunlight. Monitor chlorine inventory to ensure minimum practical time on shelf. Chlorine probe reading is compensated using pH measurement from the same flow cell. Dosing pump correctly sized. Static mixer appropriately selected.														
	Start up / shutdown	Start up -unstable dose control. Pump damage upon start up. Off-spec water	Pumps not primed (air lock). Restoring pump after maintenance and isolations removed.	Treated water tank to be filled with sufficient potable during commissioning to ensure process water pumps can run the plant.															
	Cleaning	Biogrowth over long term	Insufficient free chlorine	Total chlorine residual maintained through QCP's. Periodic inspection to identify bio growth.															
	Testing	Inadequate total chlorine in the treated water.	Failure of some part of treatment process	Critical control points. Monthly microbacterial lab analysis. Sample point prior to treated water entering tank. Sample point on recirc loop.								Water would be diverted to off spec tank in event of any treatment process failure.							
	Maintenance	Pump can't be removed. Instruments can't be repaired or checked.	Not easily accessible	Pumps are external to tank for easy access. Instrumentation readily accessible	Are eductors installed from the top of the tank so they can be removed?	Aquacell Design Team			Select eductor material as SS316 to minimise the possibility of failure & need for replacement.	Design	19-Mar-25								
	Installation	Tank or liner blows away	Wind		Fill tank with water post installation if required.	Aquacell Installation Team			Filling of tank responsibility of tank supplier	Design	19-Mar-25	100mm of water must be available at time of tank commissioning							
	Isolation	Can't isolate	Lack of isolation valves	Every stream can be isolated															
4b - Off Spec Holding Tank	No or Low Flow	Tank could go stagnant. Algal bloom	Contents of tank not aerated and may not be introduced back into the system	Water in tank has been through biological treatment, and likely at least one other process step, eg, UV, Ozone, chlorination. Water quality is likely to be good.	Confirm tank is covered.	Aquacell Design Team			Confirmed	Design	19-Mar-25								
	High Flow	Out of spec inflow tank overflows faster than buffer tank pups can pump out	UV pump running with water out of spec and bio tank at high level.	High level transducer and switch to stop UV pumps. Buffer tank will have some buffering ability.															
	Reverse Flow	Contamination, odour	Reverse flow from off spec tank to treated water tank. Air from bio tank aeration escapes and enters off spec tank via overflow	Air gap at top of tank where out of spec water drops in. Out of spec tank higher than buffer tank so reverse liquid flow not possble. Out of spec water is being returned to the head of the plant for retreatment anyway.	Confirm P-trap in line between buffer tank and off spec tank to prevent odour	Aquacell Design Team			To be added to P&ID	Design	19-Mar-25	NRV added after CCT							
	Low Level	Tank or liner could blow away.	Drain valve leaking. Large surface area, low weight.	Maintain manufactuers minimum water level. Roof on tank. Low level switch to close drain valve	Confirm with manufactuer if there is a minimum water level that must be maintained after installation. Consider loop or standpipe so the tank cannot drain below minimum level.	Aquacell Design Team			Confirm with supplier minimum required water level	Project delivery	19-Mar-25	100mm of water must be available at time of tank commissioning							
	High Level	Overflow	Tank outlet valve failure, UV pumps running	High level transducer and switch in tank. Some buffering capacity in buffer tank.															
	Low Pressure	Tank collapse	Empty tank faster than air can enter	Tank is emptied via gravity rather than being pumped - slower rate.	Confirm the final tank spec has sufficient venting				Confirmed	Design	19-Mar-25								
	High Pressure	Tank damage	Tank is filled faster than air can escape		Confirm the final tank spec has sufficient venting				Confirmed	Design	19-Mar-25								
	Low Temperature	Not considered a risk in this location																	
	High temperature	Not considered a risk in this location																	
	Composition or changing concentration	Algae develops	UV exposure of nutrient rich water.	Roof on tank to avoid UV exposure. The only incoming stream comes from within the plant which can't be more contaminated than plant feed.															
	Cleaning	Tank requires cleaning	Build up of material over time	Water in tank has already been screened and treated. Unlikely to contain foreign materials. Biological growth can be treated with chlorine.	Confirm access hatches available to enter tank if requireced.				Confirmed	Design	19-Mar-25								
	Testing				Is there a reason we may need to test water quality in this tank?	Aquacell Design Team			Sample point to be added.	Design	19-Mar-25								
	Maintenance	Maintaining probes	Difficult to access installed in the top of the tank	Level transducer and switches rarely require service. Tank unlikely to need servicing during service life.	Confirm final mechancial design allows for access for probe replacement	Aquacell Design Team			Access ladder to be provided. Level instruments to be positioned close to ladder	Design	19-Mar-25								
	Installation	Tank is large mechanical construction	Not installed correctly	Engage tank manufacturer to install as they have the correct equipment and competencies								Confirm sufficient access around all tank locations for installation							
	Isolation	Isolatoin to enable confined space entry.	Breakdown or cleaning	Tank feed can be isolated on both treatment trains post CCT piping. No equipment in tank that would require entry for routine servicing.															
Section 5 - Waste (Inclusive of Sludge Dewatering, Overflow and Drains)																			
5a - Sludge Dewatering	No or Low Flow	No or low flow from polymer dosing system. No or low flow from spray water. Poor dewatering from ineffective mixing of polymer.	Faulty Dosing pump. Issue with potable feed	run/alarm signals present in polymer dosing system. Flow switch present on potable make up to polymer dosing system.								Add flow switch to dewatering unit flush line.	AQ Design team	14-Jul-25	Closed				
	High Flow	Flow too high for polymer to dose properly Exceed capacity of dewatering system	Operator error Faulty VFD	VFD to control flow Flowmeter on WAS pump skid															
	Reverse Flow	Reverse flow through process water		NRVs present on all process water lines.															
	Low Level	Low level in polymer dosing	level instrument failure	Flow switch on make up water Level switch on dosing tank.															
	High Level	Skip overflows	Inadequate warning system									Add camera into sludge handling room	AQ design team	14-Jul-25	Closed				
	Low Pressure	Low pressure from compressed air system	Fault with compressed air system									Pressure switch is provided within pneumatic panel by Hydroflux. Show on P&ID	AQ design team	15-Jul-25	Closed				
	High Pressure	High pressure from mono pump	Valve closed	Pressure relief valve on each mono pump															
	Low Temperature	N/A																	
	High temperature	N/A																	
	Composition or changing concentration	Incorrect sludge concentration may impact dewatering Polymer concentration not appropriate.	Wasting frequency not optimal.	Fully automated process. Flowmeter on dewatering line allows us to run for a set period of time to deliver a set SRT. Until process is optimised, periodic pump out of mixed liquir may be required to ensure that MLSS concentration is maintained.															
	Cleaning	Build up of sludge in sludge recirc line	Infrequent operation of process	Potable line to WAS pump skid to flush line after running sludge rescreening. Spray bar included on dewatering unit Doors included on screen to allow for additional manual cleaning if required.															
	Testing	Samples required	Monitor	Sample point included within sludge dewatering unit								Add additional sample point to sample sludge prior to polymer make up. Check whether there is an additional sample line on the dewatering unit subnatant.	AQ design team	14-Jul-25	Closed				
	Maintenance	Maintaining screw prew presss.	Unable to maintain due to access	Sufficient access to maintain screw press in situ. Also sufficient space to lift complete unit outside if required.															
	Installation	Installation of screw press	Unable to install due to limited access	see above															
	Isolation	Unable to isolate any piece of the dewatering process	Inadequate valving	sufficient valves on all equipment to isolate if required. Duty/stand by pump arrangement															
5b - Plumbing Collecting Overflows and Drains	No or low Flow	Odour. Debris build up in screenings pipe	P-traps dry out	Service team discharge periodically to recharge traps	Ensure suitable fall on screenings overflow and other overflows to ensure debris has best chance of being flushed to wet well.	Aquacell Design Team			Ensure sufficient periodic flushing through overflow to avoid drying of debris is incorporated into the program.	Design	19-Mar-25								
	High flow	Fills up wet well which is then transferred into plant	Ingress from rainwater or other upstream source	All floor wastes are internal so no rainwater ingress. Monintoring or logs during rain events to identify possible ingress of storm Water.	Ensure all below ground tanks are correctly sealed and installed in a manner that prevents rain or groundwater access. Similarly, ensure customer is aware the sewerage system should not allow storm water ingressm	Aquacell installation Team. Aquacell Service Team			Emergency overflow tank to be incorporated into the design	Design	19-Mar-25								

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Reverse flow	Flow up through floor wastes	Wet well does not have an overflow	High level indication on wet well would warn of impending situation.	Consider pump out point on wet well for emergency pump out (similar to Llandilo installation)	Aquacell Design Team			Emergency overflow tank to be incorporated into the design. Emergency pump out preocedure to be captured within the RWMP.	Design	19-Mar-25								
	High pressure	Pressurise pipe	Line blocked	No pumped lines so pressure is limited to static head.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Low pressure	Not considered a risk in this installation.																	
	Low level	Not considered a risk in this installation.																	
	High level	Overflow in floor wastes	Blocked line	Screen overflow pipe is 150mm which will allow debris to flow back to wet well. Correct selection of pumps means screen line unlikely to block.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	High temperature	Not considered a risk in this installation.																	
	Low temperature	Not considered a risk in this installation.																	
	Composition or changing concentration	Blocked lines	Unscreened overflow from pre-screeens	Screen overflows 150mm pipe so anything that makes it through the pump should pass down the pipework															
	Start up / shutdown	Odours	Traps dry out if extended shutdown	Manually charge P-traps in the unlikely event there is an extedned shutwdwon.															
	Cleaning	Blockage	Debris in pipes	Pipes practically sized. Scren overflow is the only line likely to have significant debris.	Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Testing	N/A																	
	Maintenance	Need to clean pipes	Blockage		Ensure adequate I/O points in design to accommodate unblocking lines if required	Aquacell Design Team			Minimal chance of blockage on overflow lines. Drain lines feature local isolation for easy servicing.	Design	19-Mar-25								
	Installation	Outside of scope																	
	Isolation	N/A																	
Section 6 - Chemical dosing																			
17. Chemical Dosing Systems (including storage and handling)	No or low Flow	Water out of specification leading to inadequate treatment, disinfection or cleaning.	Tank empty. Pump is non-operational (lost prime or failed). Crystallisation (caustic in cold weather) in the dosing line causing blockage. Blocked dosing point. Incorrect pump setting. Ruptured line or fitting.	Chlorine and alkalinity dosing has instruments to monitor water quality and alarms for out of spec. water. Level transmitter and low level switches in all dosing tanks. Citric acid is manually dosed and a visual check plus hand held meter checks is sufficient. Peristaltic pumps have provision to add leak detection (cabling and programming) at a later date if needed. Peristaltic pumps being used to where appropriate to reduce the risk of loss of prime.	Run dosing lines with minimum number of joints. Where possible, mount diaphragm pumps with flooded suction. If available use leak detection feature on pump. Consider double contained dosing tube to prevent major leaks.	Aquacell Design Team			Provide dual contained hose where practical. Consider implication of a leak & where chemical would spill in this event.	Design	19-Mar-25								
	High flow	Water out of specification. Damage to membranes during CIP Bunds fill up with rainfall	Venturi effect of injection point is open if NRV fails. Incorrect pump setting (manual) or false instrument reading (auto). Heavy rainfall	Chlorine and alkalinity dosing has instruments to monitor water quality that have alarms for out of spec. water. Transducer values logged which allows chemical consumption rate to be monitored, even remotely. Chemical area covered, so unlikley to impact individual bunds. Ability to safely remove rainwater from concrete bund by manually draining.																
	Reverse flow	Overflow chemical dosing tanks.	Failed check valve or injection point.	Flow through peristatic pump unlikely. Diaphragm pumps have internal check valves. Line sizes are small so backflow, if it could occur, is very low flow. Bund to catch some overflow. Tank level transducer will show high level.	Consider dosing tank high high alarm off transmitter to warn that tank is overfilling.	Aquacell Design Team			Minimal risk as check valves are incorporated high high LS not required.	Design	19-Mar-25								
	High pressure	Dosing tube ruptures. Overpressurised storage tanks	Blocked dosing point or dosing point manually isolated. Vent blocked during filling	PRVs for metering pumps. Dosing tube suitably pressure rated and of correct material. Peristaltic pumps are inherently limited in discharge pressure. Vents cannot be isolated and are adequately sized															
	Low pressure	No chemicals delivered Could create syphon if line pressure is low. Also see "low flow". Vaccum created in storage tanks	Low line pressure or gravity flow arrangement. Peristaltic pump hose clamps insufficiently fastened. Vent blocked during pumping of chemicals	NRVs on injection quills. Vents cannot be isolated and are adequately sized															
	Low level	Dosing pump runs dry and chemistry is affected.	Tank not refilled or leaking tank/fittings.	Low level warning and low low level alarm on each tank. Level transducers and remote monitor. Bunds around tank to prevent spills getting into drains.															
	High level	Overflow tank	Adding too much chemical. Reverse flow from NRV failure	Sight glass on all tanks except for Magnesium Hydroxide. Magnesium Hydroxide is delivered on IBCs and manually filled. Bunds adequately sized for each chemical storage tank	Consider dosing tank high high alarm off transmitter to warn that tank is overfilling.	Aquacell Design Team			Minimal risk as check valves are incorporated high high LS not required.	Design	19-Mar-25								
	High temperature	Eruption of chemical from tank. Chemical degradation during long term storage.	Adding chemical to the wrong tank causing exothermic reaction (hypo + acid) Chemical storage not adequately protected from sunlight	Clear labelling of chemical tanks. Appropriately trained personnel and PPE. Vents cannot be isolated and are adequately sized. Chemical area covered to avoid direct sunlight. Black tanks used to protect from sunlight.															
	Low temperature	Crystallisation of chemical (particularly caustic) can occur at low temperatures.	Outside temperature drops below chemical freezing point	Caustic tank and dosing lines are indoors. 30% concentration to be used to ensure that crystalisation is not an issue. Dual contained hoses adds additional layer of insulation to dosing lines.	Consider if lines need to be insulated. Would double contained dosing line provide better insulation	Aquacell Design Team			Insulation not considered necessary	Design	19-Mar-25								
	Composition or changing concentration	Potential chemical degradation Magnesium hydroxide solidifies Water out of specification.	Chemical degrades with time and is less effective. Settling in the tank (for slurry)	Clear operating instructions. and trained personnel. Inventory control. Proper storage to minimise chemical degredation. PID or other appropriate control loops to control to a setpoint. Mixer for magnesium hydroxide. Stabilised Magnesium Hydroxide formula to be utilised															
	Start up / shutdown	Chemical degradation during long term storage. Crystallisation in lines or loss of pump prime during long periods not running.	Crystallisation of NaOH. Chlorine degrades with time	Check and/or remix chemical after long storage. Flush and check pump operation (e.g. tubing, pump and line primed). Where chemical doses to a setpoint, control system will accommodate to some extent for the change in concentration.															
	Cleaning	Chemical spill during fill	Operator error dosing line splits	All dosing units are in bunds allowing for safe washdown when required. Dual contained hose utilised to ensure that any break in dosing line is returned to bunded area.	Consider rationalisation of dosing pumps to reduce the possibilities of spilllage	AS			Discussions ongoing	Design	19-Mar-25	Reduced the number of pumps by selecting one pump for two trains for CIP, MW, and alkalinity addition.							
	Testing		No access for flow tests.	Level transducers on tank to verify dose rate. Use handheld measuring cylinder (but would require disconnection of pump suction tubing from tank outlet). Instrumentation - pH, Total Cl2 provide feedback. Handheld checks to confirm pH and concentration during MBR CIP can be taken from existing sample valve.	Consider addign additional sample point	AQ Design Team			Sample point added to CIP recirc line	Design	19-Mar-25								
	Maintenance	Pipe blockage Leakage from fittings. Bunds are not kept clean and empty resulting insufficient bund volume	Insufficient preventative maintenance Bunds allowed to fill with water or rubbish, or chemical overspill	Regular planned maintenance as defined in O&M manual Good housekeeping - requires hand pump to flush and pump out bund, or mop up small spills.															
	Installation	Restricted access for maintenance and leak resolution.	Fittings and connections at front are easier to access, but greater risk of exposure from leaks.	Skids assembled off site as much as possible for easy installation Sufficient access has been provided around all equipment to safely install Chemical storage can be easily offloaded due to being located outside of main treatment building.								Try to keep safety shower line underground where practical. Failing that, piping		14-Jul-25					
	Isolation	Inability to isolate for maintenance / Uncontrolled chemical release	Inadequate isolation in design	Sufficient valving arrangements included for mechanical isolation of all pumps Each pump has a separate circuit breaker to allow the pump to be electrically isolated without affecting other pumps															
Section 7 - Pneumatics																			
7a - Pneumatic System	No or Low Flow	Valves slow to actuate. Ozone can't generate fast enough	Condensation limits reciever capacities. Compressor breakdown. Filters blocked. Air lines undersized.	Compressors sized correctly. Duty standby compressors. Dual filter trains allow cleaning without interrupting air supply. Air recievers to smooth peak damand while compressors recover. Autodrain on receiver and compressor. Air lines sized correctly.															
	High Flow	Valves operate to quickly causing damage	Presssure to components is restricted, but flow is not	Typically not a problem, but inline flow controllers can be installed if required.															
	Reverse Flow	Instrument air receiver flow backwards to process air receivers during high process air demand, starving instruments of air.	High process air demand from ozone.	Appropriately sized air receivers and compressors NRV at instrument air receiver.															
	Low Level	N/A																	
	High Level	N/A																	
	Low Pressure	Valves don't actuate, ozone won't generate	Leaks, air line blows off, compressor breakdown Valve incorrectly isolated.	Duty standby compressors. Compressor has pressure switch to cut in at low pressure. Pressure transmitter and pressure switch on receivers to alarm before low supply pressure drops below operating pressures. System has regulators to set specific pressures for different types or equipment. Recievers installed to buffer pressure drop during peak demand	Confirm what controls Ozone system has for low pressure	Aquacell Design Team			D/S compressors. Compressor designed for peak flow. Pressure switches on all pneumatic boxes to detect low pressure. Ozone system has low pressure cut off function which will stop ozone generation.	Design	19-Mar-25								
	High Pressure	Equipment damage. High pressure explosion	Uncontrollled production of compressed air. Compressor pressure too high for equipment	Pressure vessels from reputable supplier. Pressure vessel certificates to confirm appropriate contruction. Relief valves on compressors and receivers. Regulators so pressure can be custom set for each type of equipment	Ensure pressure vessel certificates and relief valve certificates are obtsined during procurement	Aquacell Procurement Team			To be obtained from supplier	Project delivery	19-Mar-25								
	Low Temperature	n/a																	
	High temperature	n/a																	

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Composition or changing concentration	Humidity/Moisture. Oil or other contaminant in air which causes equipment damage	Inherrent in compressed air systems	Each compressor has an air dryer and air goes thorugh a dual filter system prior to distribution. Compressors and receivers have automatic condensate drains.															
	Cleaning	Water on floor from autodrains	Autodrain discharges condensate	Condensate directed to floor drains															
	Testing	Pressure vessel inspection/test	Statutory requirement		If Aquacell service plant, allow for service of compressor and inspection of pressure vessels.	Aquacell Service Team Aquacell Design Team			Adequate service time to be allowed for compressors. Annual inspection to be organised for pressure vessels.	Aquacell Service Team	19/03/2025								
	Maintenance	Breakdown.	Inadequate servicing.	Compressors and dryers to be maintained as per manufacturers recommendation	If Aquacell service plant, allow for service of compressor and inspectino of pressure vessels. Confirm packaged compressor unit has autodrrain to drain reciever	Aquacell Service Team Aquacell Design Team			Confirmed packaged compressor unit will have autodrrain to drain reciever	Design	19/03/2025								
	Installation	Vibration damage Noise	Improper isolation.		Confirm packaged compressor unit has acoutic hood. Confirm if compressor mounted on vibration mounts. Ensure flexible connection from compressor to fixed pipework. Consider adding flexible hose between compressor and rigid piping	Aquacell Design Team			Compressor selection ongoing. Consider rotary screw compressor.	Design	19/03/2025	Rotary screw compressor has been selected. Flexible hose has been added between compressor and rigid piping	Design	14/07/2025	Closed				
	Isolation	Requirement to isolate and discharge stored energy	Service requirement	Isolation points and drain points	Confirm packaged compressor unit has a drain valve to drain receiver	Aquacell Design Team			Confirmed packaged compressor unit will have autodrrain to drain reciever	Design	19/03/2025								
Section 8 - Odour																			
8a. Odour Scrubber	No or Low Flow	Air doesn't move through scrubber. Air not ejected into atmosphere to disipate. Odour complaints.	Carbon compacted or fouled. Blower on scrubber has failed. Upstream valves are closed.	Odour scrubber blower and upstream aerators all have monitored O/L's. Pre-screens are the only vent lines with dampers that can be closed.	Add valve to allow balancing of flow between tanks	Aquacell Design Team						Magnehelic pressure gauge is allowed for with skid mounted odour control unit. Service item to regularly monitor this locally on site.	AQ service team	14/07/2025					
	High Flow	Insufficient contact time with carbon. Odour complaints.	Low level or no carbon	Routine maintenance. Carbon sampling points	Add valve to allow balancing of flow between tanks.	Aquacell Design Team						Valves have been added to allow balancing between tanks.	Aquacell design team	14/07/2025					
	Reverse Flow	Odours escape	Incorrectly commissioned	Commissioning checks to ensure odour control system is installed correctly.															
	Low Level	Insufficient carbon to scrub odours	System not correctly filled	Carbon sampling points. O&M manual to teach operators correct fill level. Routine Maintenance							`								
	High Level	Carbon exhausts to atmosphere	System not correctly filled	Form of carbon used unlikely to be picked up by fan. Carbon sampling points. O&M manual to teach operators correct fill level. Routine Maintenance															
	Low Pressure	Odour scrubber collapses	Upstream valve closed causing blower to suck in scrubber housing.	Fan cannot generate sufficient pressure to collapse housing															
	High Pressure	High pressure is not possible as system is on suction side of blower and system is open to atmosphere. High differential pressure is possible, causing inefficiencies and odours.	Blocked carbon bed or inlet filters	Differential pressure indicator installed. Routine maintenance. Operator training.															
	Low Temperature	Not considered a risk in this location																	
	High temperature	Not considered a risk in this location																	
	Composition or changing concentration	Condensation can develop in vent lines. H2S concentrations exceeds design limits	Atmospheric conditions. Influent characteristics outside of range. Holding times exceeded. Ineffective mixing.	Sample points located on skid for monitoring H2S levels	Ensure all vent lines move uphill from a tank, or drainpoint where condensate can collect and be drained.	Aqaucell Design Team. Aquacell installation team			Confirmed	Design	19/03/2025								
	Cleaning	No specific cleaning requirements																	
	Testing	Test air or carbon quality	Mointor or check performance of unit	Carbon sampling points. Air sampling point.															
	Maintenance	Carbon exhausted and needs to be replaced. Breakdown or service on scrubber's blower.	Carbon is consumable.	Filter is accessible for cleaning.	Can entire system still run if the blower fails?							System will run passively in event of blower failure	AQ design team	14/07/2025	closed				
	Installation	System is difficult to install	Poor design	Skid mounted system located outside of main treatment plant.															
	Isolation	Can't isolate unit	No upstream or down stream valves	Mechanical and electrical isolation provided Minimum maintainable components means thie requirement will be rare.								Consider if bypass to stack is required during maintenance of carbon beds	AQ design team	14/07/2025	Closed (not required)				
9a - Climate change - Physical and Environmental Risks	Increased Rainfall and Flooding	Overflow of sewers Process inefficiencies Risk recycled water ingress into the stormwater network	Climate impacts not considered in tank sizing Climate impacts not considered in process design Climate impacts not considered in irrigation design/sizing	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. Buffer tank (1ML), Off spec holding tank (1ML), Emergency overflow tank (300kL). The combined plant storage capacity will minimise the risk of sewer overflow during periods of increased rainfall. Any change in sewer composition will be monitored and equalised with the buffer tank to minimise the risk of process inefficiency. The plant's peak flow is 3x higher than average flow, in line with Sydney Water's "*Wastewater Treatment Planning Guidelines*". There is sufficient holding time within the treated water tank to store in extreme rainfall events when the the irrigation area is saturated. A comprehensive wet weather management strategy will be implemented. Further information can be found in the Land Capability Assessment and Irrigation Management Plan.																
	Drought and Reduced Water Availability	Insufficient water available for irrigation during drought and reduced water availability	Increased irrigation requirement	Influent generated from within the industrial develepmont rather than relying on rainfall. Treated water storage system is sufficiently sized.															
	Rising Temperatures	Activated sludge process inefficiencies	High aerobic and anoxic temperature reduces the microbial activities	Tank is a large volume, constructed underground from concrete. Influent temperature will remain unaffected. Temperature is monitored at various stages throughout the process, from influent to effluent.															
	Sea Level Rise and Saltwater Intrusion	N/A - plant is approximately 106m above the sea level and so considered not to be an issue when compared with estimated seawater level rises																	
	Extreme Weather Events (Cyclones, Storms, Bushfires)	Damage to OSSM facility	Inadequate design with regard to extreme weather events.	The development is more than 100 m from forest hazards and more than 50 m from grassland hazards. Safe access and egress between the development and the public road system has been allowed for fire-fighters. A defendable space between structures and the bushfire hazard/boundaries has been provided to allow fire-fighters to gain access to all sides of the structures and the bushfire hazard at the boundary. Access to a reticulated water supply (e.g. hydrants) has been incorporated into the design. The building has been designed by structural engineers with consideration of wind loadings as per accepted Australian standards.																
9b - Climate change - Operational and Process Risks	Process Upsets	Uncompliant treated water.	Plant design has not considered variation in influent as a result of climate change.	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. The plant has remote monitoring and control capability to ensure that any deviations in influent can be appropriately managed. Any change in sewer composition will be mointored and equalised with the buffer tank to minimise the risk of process inefficiency. The plant's peak flow is 3x higher than average flow, in line with Sydney Water's "*Wastewater Treatment Planning Guidelines*".																
	Increased Energy Demand	Greenhouse effect Higher operational cost	Higher energy consumption from pumps to deal with high flow during rainfall.	Sewer collection network is significantly smaller and so relatively contained, compared with a typical municipal wastewater network. Large buffer capacity will allow the process to operate at normal flow even during periods of wet weather. Recycling water at the source mitigates the need for pumping water large distances to the building from the public water supply, and mitigates the need to pump or transfer wastewater large distances for treatment.															
	Biosolids Management Challenges	Odour Higher waste sludge transportation and treatment cost	Open sludge area resulting in rainwater ingress leading to higher sludge volume	Sludge handling is located inside the shed. Advanced sludge dewatering unit to minimise sludge volumes															
9c - Climate change - Financial and Economic Risks	Higher O&M Costs	Financial viability of scheme becomes questionable.	Increased operating costs due to climate change	Robust financial planning assessment has been completed to ensure that maintenance costs remain viable. 10 year cashflow forecast has been provided allowing for CPI increases. Specific fees and usage rates can be adjusted if required.															
	Capital Investment Needs	Upgrades required to treatment plant	Insufficient redundency in design to accommodate changes	Sufficient storage and process capacity has been considered within the treatment plant. Both CAPEX and OPEX costs have been considered															
9d - Climate change - Social and Reputational Risks	Public Health Risks	Disease Transmission via Pathogens	Inadequate controls of recycled water quality	A comprehensive RWQMP has been developed to implement critical and quality control points to ensure adequate pathogen reduction. Any uncompliant water will be diverted to off spec tank for furter treatment.															

Item	Deviation	Consequence	Causes	Safeguards	Actions	Who	Due Date	Status	Action Checked	By	Date	New Actions Identified/ Outstanding	Who	Due Date	Status	Action Checked	By	Date	Closed Out
Equipment, tank, process unit	*Condition such as no flow, high flow, pH change*	*What happens*	*Why does it happen*	*Valves, alarms, instrument, design*	*To be done to mitigate*	*By*	*Date*												
	Community Complaints	Odour Noise Vibration	Increased plant loaded resulting in poor plant performance.	Plant has been sufficiently sized to handle varying load to climate change Environmental impact studies have been conducted and found that no significant risks will be present.															

Appendix 5 – WICA Scheme Approval to Install - pending

Appendix 6 – Aquacell Sampling Procedure

Sampling Work Instructions

Aquacell Pty Ltd

Suite 602, 6A Glen Street, Milsons Point NSW, Australia

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Revision	Date	Author	Amendments
2	11/05/21	Tass Meli	Full update to include new sample preparation requirements and better specify sample point disinfection process

MR160-2
Revision 2, 11 May 2021
Sampling Work Instructions

Process Step	Onsite Sampling
Objectives	The following procedure will be followed when sampling process or recycled waters from Aquacell wastewater treatment facilities that will undergo analytical quality testing including microbiological tests (typically E.coli or Faecal Coliforms). • To collect samples for physical, chemical or microbiological analysis by an external laboratory • Ensure proper sampling techniques are followed
Management Strategy	Aquacell greywater/blackwater treatment and water recycling plants are verified for effective performance on commissioning as required by the local regulator (eg: NSW Health) and/or to validate design performance. Ongoing monitoring via regular sampling is generally required in order to comply with regulations and ensure no health risks are present in recycled water reuse applications The ongoing operational performance of the system is monitored to ensure efficient operation and to protect human health and the environment. When out of specification results occur, they are addressed via the corrective action specified under the appropriate site management plan.
Health and Safety requirements	Biological hazards may be present in process waters. Use gloves safety glasses and protective clothing when sampling. Safely store the alcohol & lighter used for sample point disinfection. Make sure that you have conducted the site hazard assessment before commencing.

Process Step	Onsite Sampling
Actions – off-site preparation	Prior to the commencement of sampling; 1. Obtain sufficient sealed and unused sample bottles as provided by the testing laboratory (eg; Envirolab, ALS). Note: Microbiological sampling bottles are usually 250mL. They are supplied prestrerilised and will contain a tiny amount of Sodium Thiosulphate solution as a preservative so it is normal for moisture to be present in the sample bottle and it must be unopened until sampling. Other sample bottles vary in size (up to 1000mL) and material according to the requirements of the analysis but will be plastic in almost all applications. Larger 15L or 20L carboys may be required for Cryptosporidium of Giardia testing in infrequent test 2. Place the sample bottles in a suitable clean cool storage or esky. Carry additional sample bottles in case resampling or extra samples become necessary. 3. Place frozen freezer blocks in the esky or obtain ice or other cooling medium for the esky once samples are taken - in order to keep samples cool during transport to the laboratory. Larger or carboy sample containers are to be kept out of the sun 4. Prepare a standard chain of custody (COC) form for each sampling site. These are printed from files stored on the Aquacell server at *S:\Aquacell Service\01 Admin\Sampling results - consolidated (use S folder for ongoing monitoring)\COC* 5. Ensure you have alcohol (spray or disinfectant wipes) for cleaning the sample point 6. Ensure you have gloves, safety glasses and any other required site PPE

Actions – On-site sampling	Sampling should be done at the end of site service visits to minimise the holding time prior to sample delivery. 7. Locate the correct sampling point(s). Greywater/blackwater influent sample will be collected from the appropriate sample points. For treated water, the sample point will be a dedicated valve and open line on the recirculation loop. (Note: If no sampling point is available, treated water may be sampled directly from the filtrate discharge to the filtrate pit (eg: Kurrajong) If no direct sampling point is available and a secondary sample container is to be used to dip in tanks or other sampling method, ensure it is clean and disinfected prior to use. If applicable sample collection devices will be rinsed with ethanol then water then dried (sample container for effluent and sample bailer or peristaltic pump for influent). 8. Check that the sample point is visually clean. If not, dismantle and clean the sample point and reassemble before sampling. 9. Complete the sample bottle label including the date and time. The sample description should state the site name. 10. Wear disposable gloves and safety glasses when sampling. 11. If any micro samples are to be taken, these should be taken first. Sample via the installed sample point after disinfecting as follows; - Fully open the sample tap and allow water to flow for 10-20 seconds. This purges the sample line with fresh sample - Close the sample tap - Spray or soak the sample pipe with alcohol. Ensure the open pipe tip is well covered with alcohol. If the sample pipe is metal flame off the alcohol by quickly striking a lighter near the alcohol-soaked sample pipe. Otherwise allow alcohol to evaporate. 12. Open the sample tap and set to flow at a flowrate suitable for sample collection. Flow should be fast enough to ensure quick sample bottle filling in 3-5 seconds but not too fast such that sample splashes out of the sample bottle. 13. Hold the unopened sample bottle close to the sample flow and carefully and quickly open the lid. Keep hold of the lid without touching the inside surface. Keep the lid face down while sampling. 14. Quickly place the sample bottle under the sample stream and fill to approximately 10-20mm from the top rim. Do not rinse out or overfill the sample bottle as this will reduce or remove the preservative in the bottle. 15. Quickly place the lid back on the bottle and tighten securely ensuring the lid is not cross-threaded. 16. If you suspect sampling has not been carried out correctly, discard the sample and retake the sample in a new unused sample bottle.

Process Step	Onsite Sampling
	17. If other sample bottles are required to be filled for non-microbiological testing (such as BOD, TSS, TN, TP) these should now be taken. Micro samples should be taken first. 18. Place all sample bottles into the esky with ice bricks or ice as planned to keep samples cool. 19. Promptly deliver samples to the laboratory on the day of sampling. The chain of custody form(s) will be kept with the sample esky and final notes completed when samples are delivered to laboratory receival point staff.
Corrective action	Depending on the analysis, test results will be available in 2-8days following sampling. BOD or micro tests such as E.coli and Coliforms will generally require 5 – 8 days before sample results are available. If treated water test results do not comply with site critical specifications once received, immediately divert the treated water supply and take other response actions and notifications as required in the site management plan. Arrange for resampling and analysis as soon as possible. Investigate the cause of out of specification samples and implement remedial action as required.
Equipment	PPE; gloves, safety glasses, alcohol solution, lighter Sample bottles as specified by the laboratory. (Note that laboratories will generally accept each other's micro sample bottles if necessary.)
Reporting	Laboratories will provide sample results by email. Details of results of analytical testing must be maintained. Save sample certificates of analysis (COA) in the site service "Monitoring" folder when received. Record routine site service results in the results file stored on the Aquacell server at *S:\Aquacell Service\01 Admin\Sampling results - consolidated (use S folder for ongoing monitoring)* .

Appendix 7 – WICA Retailer Licence

Water Industry Competition Act 2006

Schedule 4, clause 10

Notice of decision – Grant of retailer licence

Licence No. 25_009R

The Independent Pricing and Regulatory Tribunal (**IPART**) grants Aquacell Pty Ltd (ACN 072 487 015) a retailer licence under Schedule 4, clause 10(1) of the *Water Industry Competition Act 2006* (**Act**).

The retailer licence takes effect on 1 March 2025.

In considering whether to grant the retailer licence and what conditions to impose on the licence, IPART had regard to the objects in sections 2A and 5A of the Act.

The retailer licence is attached.

23/01/2025

X

Signed by: carmel.donnelly@ipart.nsw.gov.au

Carmel Donnelly PSM
Chair
On behalf of the Independent Pricing and Regulatory Tribunal

IPART acknowledges the Traditional Custodians of the lands where we work and live. We pay respect to Elders both past and present. We recognise the unique cultural and spiritual relationship and celebrate the contributions of First Nations peoples.

New South Wales Government

Water Industry Competition Act 2006 (NSW)

Retailer Licence no. 25_009R

Aquacell Pty Ltd

(ACN 072 487 015)

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RETAILER LICENCE

Water Industry Competition Act 2006

Licence Authorisation Table

Licensee	Aquacell Pty Ltd ACN 072 487 015
Licence number	25_009R
Version history	Current licence in force since: 1 March 2025. Details about grant, variation, replacement, cancellation or surrender of this licence are set out in Schedule A.
Authorised activities (the Act, s 8F(a))	Sale of water and/or sewerage services.
Authorised maximum scale (the Act, s 8F(b))	249 customer premises per scheme (Category R1)

LICENCE TERMS

1. Grant and authorisation

1.1 The Independent Pricing and Regulatory Tribunal grants this licence under the Act, Schedule 4, clause 10(1).

Note: This licence is deemed to be a licence granted under section 8C of the Act.

1.2 The licensee is authorised to carry out the authorised activities in connection with the schemes for which the licensee is the registered retailer that do not exceed the authorised maximum scale.

Note: This clause authorises the licensee to carry out certain activities that would otherwise be prohibited under section 6B of the Act. This authorisation does not exempt the licensee from obligations under other laws unless expressly provided by those laws.

2. Licence conditions

The licensee must comply with the standard licence conditions specified in Schedule B, Item B2 and the special licence conditions specified in Schedule B, Item B3.

Note: The licensee must also comply with conditions specified in the Act and Regulations.

3. Interpretation

3.1 Expressions used in this licence that are defined in the Act or Regulations have the meanings set out in the Act or the Regulations unless the context otherwise requires.

3.2 In this licence, unless the context otherwise requires:

a. the singular includes the plural and vice versa,
b. a reference to this licence includes any schedule to this licence,
c. a reference to a schedule is to a schedule to this licence, and
d. explanatory notes and headings do not form part of this licence, but in the case of uncertainty may be relied on for interpretation purposes.

3.3 In this licence:

Act means the *Water Industry Competition Act 2006*.

authorised activities mean the activities specified in the licence authorisation table.

authorised maximum scale means the maximum scale of schemes specified in the licence authorisation table.

licensee means the person specified in the licence authorisation table.

Regulations means any regulations made under the Act.

Schedule A Version History

Current licence in force since	1 March 2025
Original grant date	2 February 2010
Transition date	Transitioned licence granted under the Act, Schedule 4, cl. 10(1) on: 1 March 2025
Variation history	Varied under the Act, s. 10 or s. 15 (now repealed) on: • 21 July 2014, • 26 July 2015, • 31 January 2018, • 1 November 2020. Varied under the Act, s. 8M on: Not applicable
Replacement history	Not applicable
Cancellation or surrender	Not applicable

Schedule B Licence Conditions

Item B1 Interpretation

1.1.1 In this schedule:

reporting manual means a document published on IPART's website from time to time setting out notification, information, consultation and reporting requirements for licensed retailers.

1.1.2 If any condition, or part of any condition, is unlawful, that condition, or part of the condition, is severable and does not affect the validity of the licence or the balance of the conditions or condition.

Item B2 Standard licence conditions

B2.1 Maintaining appropriate insurance

2.1.1 The licensee must hold insurance of an appropriate type, scope and limit for the activities it carries out under this licence.

2.1.2 The licensee must provide a copy of each certificate of currency of the insurance held by the licensee to IPART in accordance with the reporting manual.

2.1.3 The licensee must notify IPART in accordance with the reporting manual of a change to:

(a) the insurer or underwriters for an insurance policy held by the licensee; or

(b) the type, scope or limit of insurance held by the licensee.

2.1.4 The licensee must provide a report to IPART in accordance with the reporting manual from an insurance expert certifying that in the insurance expert's opinion the type, scope and limit of the insurance held by the licensee is appropriate for the activities the licensee carries out under this licence:

(a) before commencing to supply water or sewerage services to a scheme; or

(b) when requested by IPART.

2.1.5 In this condition B2.1, **insurance expert** means an insurance broker that holds an Australian financial services licence under Part 7.6 of the *Corporations Act 2001* (Cth) that authorises the broker to provide financial product advice for, and deal in, contracts of insurance within the meaning of Chapter 7 of that Act.

Note: The circumstances in which IPART may request the licensee provide a report under condition 2.1.4 include (but are not limited to) the following:

- where IPART considers that there may have been or may be a change in the type, scope or limit of the insurance held by the licensee; or
- where IPART considers that there may have been or may be a change in the activities the licensee carries out under this licence; or
- where IPART or an approved auditor considers that the type, scope or limit of the insurance held by the licensee may not be appropriate for the activities the licensee carries out under this licence.

B2.2 Complying with audit guidelines

2.2.1 The licensee must undertake audits of its authorised activities in accordance with any audit guidelines issued by IPART and published on IPART's website.

B2.3 Reporting in accordance with the reporting manual

2.3.1 The licensee must prepare and submit the following reports in accordance with the reporting manual:

(a) an annual compliance report, including:

(i) the extent to which the licensee has or has not complied with the Act, the Regulations, this licence and approvals;

(ii) for each failure to comply with the Act, Regulations, this licence or an approval:

a. the particulars of the non-compliance;

b. the reasons for the non-compliance;

c. the actions taken, or to be taken, to mitigate the effects of the non-compliance or to prevent a recurrence of the non-compliance;

(b) reports on performance indicators and other data specified in the reporting manual; and

(c) any other report required by the Act, the Regulations, this licence or an approval.

2.3.2 The licensee must give notices and provide information required by the Act, the Regulations, this licence or an approval in accordance with the reporting manual.

B2.4 Infrastructure to be used

2.4.1 The licensee must only source and supply water by means of water industry infrastructure if that water industry infrastructure is maintained and operated by a licensed operator under the authority of its operator licence or a public water utility.

2.4.2 The licensee must only provide sewerage services by means of water industry infrastructure if that water industry infrastructure is maintained and operated by a licensed operator under the authority of its operator licence or a public water utility.

B2.5 Delineating responsibilities under a code of conduct

2.5.1 The licensee must establish, and provide to IPART, a code of conduct for each scheme for which it is the registered retailer:

(a) before commencing to supply water or sewerage services to a scheme; or

(b) by another date nominated by the licensee and approved by IPART.

2.5.2 Subject to condition 2.5.3, the licensee must obtain agreement to the code of conduct from:

(a) the registered operator for the scheme; and

(b) each licensed operator, licensed retailer and public water utility that:

(i) supplies water or provides sewerage services in the same area of operations as the scheme (unless advised otherwise by IPART in writing); or

(ii) constructs, maintains or operates any water industry infrastructure that is connected to the licensee's water industry infrastructure.

2.5.3 The code of conduct must set out the roles and responsibilities of the entities specified in condition 2.5.2, including by specifying as relevant:

(a) who is responsible for repairing, replacing or maintaining the water industry infrastructure;

(b) who is liable in the event of the unavailability of water;

(c) who is liable in the event of failure of the water industry infrastructure;

(d) who is responsible for sharing information and data and in what circumstances;

(e) who is responsible for communicating with customers or dealing with customer complaints and how complaints will be handled;

(f) who is responsible for managing incidents and how incidents will be managed;

(g) who is responsible for managing water quality and preventing cross-connections; and

(h) who is liable for the fees and charges payable in respect of the use of the water industry infrastructure.

2.5.4 The licensee must comply with its obligations and responsibilities under the code of conduct.

2.5.5 Where the licensee has established a code of conduct in accordance with clause 7 of Schedule B to Licence No. 09_004R granted under section 10 of the Act (now repealed), that code of conduct is deemed to:

(a) have been established in accordance with condition 2.5.1; and

(b) comply with conditions 2.5.2 and 2.5.3, until it is first amended or replaced following the grant of this licence.

2.5.6 In this condition B2.5, code of conduct means a utility service agreement or other agreement or document, however described, that includes a protocol for dealing with the matters set out in condition 2.5.3, as relevant.

Note: The objective of a code of conduct is to minimise risks to public health, safety and customers through the establishment of a protocol of efficient and effective day-to-day working arrangements between the licensee and a public water utility, licensed operator or licensed retailer in relation to the matters covered by the code, which include information sharing and handling customers, incidents or other events.

B2.6 Notification of supply of water or provision of sewerage services

2.6.1 Within 10 days after commencing to supply water to a scheme under this licence, the licensee must notify IPART in accordance with the reporting manual that it has commenced supplying water to customers of the scheme.

2.6.2 Within 10 days after commencing to provide sewerage services to a scheme under this licence, the licensee must notify IPART in accordance with the reporting manual that it has commenced supplying sewerage services to customers of the scheme.

Item B3 Special licence conditions

B3.1 [Not applicable]

Appendix 8 – WICA Operator Licence

New South Wales Government

Water Industry Competition Act 2006 (NSW)

Operator Licence no. 25_008

Aquacell Pty Ltd

(ACN 072 487 015)

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OPERATOR LICENCE

Water Industry Competition Act 2006

Licence Authorisation Table

Licensee	Aquacell Pty Ltd ACN 072 487 015
Licence number	25_008
Version history	Current licence in force since: 17 July 2025 Details about grant, variation, replacement, cancellation or surrender of this licence are set out in Schedule A.
Authorised activities (the Act, s 8E(a))	Construction and operation of water industry infrastructure.
Authorised classes (the Act, s 8E(b))	The classes specified in Schedule B.
Authorised maximum schemes (the Act, s 8E(c))	10 schemes.
Authorised maximum scale (the Act, s 8E(d))	The scale specified for each class in Schedule B.

LICENCE TERMS

1. Grant and authorisation

1.1 The Independent Pricing and Regulatory Tribunal granted this licence under the Act, Schedule 4, clause 10(1).

Note: This licence is deemed to be a licence granted under section 8C of the Act.

1.2 The licensee is authorised to carry out the authorised activities in connection with water industry infrastructure for which the licensee is the registered operator that:

a. is of an authorised class,
b. has a design capacity that does not exceed the authorised maximum scale, and
c. does not exceed the authorised maximum schemes.

Note: This clause authorises the licensee to carry out certain activities that would otherwise be prohibited under sections 6 and 6A of the Act. This authorisation does not exempt the licensee from obligations under other laws unless expressly provided by those laws.

2. Licence conditions

2.1 The licensee must comply with the standard licence conditions specified in Schedule C, Item C2 and the special licence conditions specified in Schedule C, Item C3.

Note: The licensee must also comply with conditions specified in the Act and Regulations.

3. Interpretation

3.1 Expressions used in this licence that are defined in the Act or Regulations have the meanings set out in the Act or the Regulations unless the context otherwise requires.

3.2 In this licence, unless the context otherwise requires:

a. the singular includes the plural and vice versa,
b. a reference to this licence includes any schedule to this licence,
c. a reference to a schedule is to a schedule to this licence, and
d. explanatory notes and headings do not form part of this licence, but in the case of uncertainty may be relied on for interpretation purposes.

3.3 In this licence:

Act means the *Water Industry Competition Act 2006*.

authorised activities mean the activities specified in the licence authorisation table.

authorised class means the class specified in the licence authorisation table.

authorised maximum scale means the maximum scale of schemes specified in the licence authorisation table.

authorised maximum schemes means the maximum number of schemes specified in the licence authorisation table.

design capacity means the capacity of the class of infrastructure as determined in accordance with the document as in force from time to time entitled *Design Capacity Guidelines*, issued by IPART and published in the Gazette and on IPART's website.

licensee means the person specified in the licence authorisation table.

Regulations means any regulations made under the Act.

Schedule A Version History

Current licence in force since	17 July 2025
Original grant date	26 July 2015
Transition date	Transitioned licence granted under the Act, Schedule 4, cl.10(1) on: 1 March 2025
Variation history	Varied under the Act, s. 10 or s. 15 (now repealed) on: • 1 November 2020 • 26 July 2021 Varied under the Act, s. 8M on: • 17 July 2025
Replacement history	Not applicable
Cancellation or surrender	Not applicable

Schedule B Authorised Classes and Authorised Maximum Scales

Authorised classes of water industry infrastructure	Scale category	Parameter	Maximum Scale
Infrastructure for the purpose of the collection and treatment of sewage for disposal and the disposal of the treated sewage.	H3	Sewage processing capacity (kL/day)	900
Infrastructure for the purpose of the collection and treatment of sewage for the production, supply and use of recycled water.	D3	Sewage processing capacity (kL/day)	900

Schedule C Licence Conditions

Item C1 Interpretation

1.1.1 In this schedule:

NSW Health means the Department of the Public Service responsible to the Minister administering the *Public Health Act 2010*.

reporting manual means a document published on IPART's website from time to time setting out notification, information, consultation and reporting requirements for licensed operators.

1.1.2 If any condition, or part of any condition, is unlawful, that condition, or part of the condition, is severable and does not affect the validity of the licence or the balance of the conditions or condition.

Item C2 Standard licence conditions

C2.1 Maintaining appropriate insurance

2.1.1 The licensee must hold insurance of an appropriate type, scope and limit for the activities it carries out under this licence.

2.1.2 The licensee must provide a copy of each certificate of currency of the insurance held by the licensee to IPART in accordance with the reporting manual.

2.1.3 The licensee must notify IPART in accordance with the reporting manual of a change to:

(a) the insurer or underwriters for an insurance policy held by the licensee; or

(b) the type, scope or limit of insurance held by the licensee.

2.1.4 The licensee must provide a report to IPART in accordance with the reporting manual from an insurance expert certifying that in the insurance expert's opinion the type, scope and limit of the insurance held by the licensee is appropriate for the activities the licensee carries out under this licence:

(a) before commencing to operate water industry infrastructure for a scheme under an operational approval; or

(b) when requested by IPART.

2.1.5 In this condition C2.1, **insurance expert** means an insurance broker that holds an Australian financial services licence under Part 7.6 of the *Corporations Act 2001* (Cth) that authorises the broker to provide financial product advice for, and deal in, contracts of insurance within the meaning of Chapter 7 of that Act.

Note: The circumstances in which IPART may request the licensee provide a report under condition 2.1.4 include (but are not limited to) the following:

- where IPART considers that there may have been or may be a change in the type, scope or limit of the insurance held by the licensee; or
- where IPART considers that there may have been or may be a change in the activities the licensee carries out under this licence; or
- where IPART or an approved auditor considers that the type, scope or limit of the insurance held by the licensee may not be appropriate for the activities the licensee carries out under this licence.

C2.2 NSW Health requirements

2.2.1 The licensee must consult with NSW Health each time it develops or proposes to make a material change to any of the following:

(a) a water quality management system for water industry infrastructure constructed or operated by the licensee for drinking water or recycled water, including:

(i) a detailed risk assessment; or

(ii) a technology assessment;

(b) a sewage management plan or system for water industry infrastructure constructed or operated by the licensee for the disposal of treated effluent, including a detailed risk assessment;

(c) a protocol to notify NSW Health of health-related incidents or complaints relating to drinking water, recycled water, non-potable water or treated effluent, as applicable.

2.2.2 The licensee must provide NSW Health with a copy of any report on an operational approval application audit under section 7E(2) of the Act at the same time it provides the report to IPART.

2.2.3 The licensee must provide documents to and consult with NSW Health in accordance with the reporting manual.

Note: Condition C2.7 requires the licensee to notify NSW Health when it commences operating water industry infrastructure.

C2.3 Complying with audit guidelines

2.3.1 The licensee must undertake audits of its authorised activities in accordance with any audit guidelines issued by IPART and published on IPART's website.

C2.4 Reporting in accordance with the reporting manual

2.4.1 The licensee must prepare and submit the following reports in accordance with the reporting manual:

(a) an annual compliance report, including:

(i) the extent to which the licensee has or has not complied with the Act, the Regulations, this licence and approvals;

(ii) for each failure to comply with the Act, Regulations, this licence or an approval:

a. the particulars of the non-compliance;

b. the reasons for the non-compliance;

c. the actions taken, or to be taken, to mitigate the effects of the non-compliance or to prevent a recurrence of the non-compliance;

(b) reports on performance indicators and other data specified in the reporting manual; and

(c) any other report required by the Act, the Regulations, this licence or an approval.

2.4.2 The licensee must give notices, undertake consultation, and provide information required by the Act, the Regulations, this licence or an approval in accordance with the reporting manual.

C2.5 Monitoring

2.5.1 The licensee must undertake any monitoring that is required for the purposes of any of the following plans or systems, as applicable to the licensee's schemes, in accordance with this condition C2.5:

(a) water quality management system;

(b) sewage management plan or system.

2.5.2 The licensee must keep the following records of any samples taken for monitoring purposes:

(a) the date on which the sample was taken;

(b) the time at which the sample was collected;

(c) the point or location at which the sample was taken; and

(d) the chain of custody of the sample (if applicable under the relevant plan or system).

2.5.3 The licensee must ensure that analyses of all samples taken for the purposes of verification monitoring are carried out by a laboratory accredited for the specified tests by the National Association of Testing Authorities or an equivalent body that is acceptable to NSW Health.

2.5.4 In this condition C2.5, **verification monitoring** means verification monitoring as described in the national safety guidelines, as applicable.

C2.6 Delineating responsibilities under a code of conduct

2.6.1 The licensee must establish, and provide to IPART, a code of conduct for each scheme for which it is the registered operator:

(a) before commencing to operate the scheme's water industry infrastructure under an operational approval; or

(b) by another date nominated by the licensee and approved by IPART.

2.6.2 Subject to condition 2.6.3, the licensee must obtain agreement to the code of conduct from:

(a) the registered retailer for the scheme; and

(b) each licensed operator, licensed retailer and public water utility that:

(i) supplies water or provides sewerage services in the same area of operations as the scheme (unless advised otherwise by IPART in writing); or

(ii) constructs, maintains or operates any water industry infrastructure that is connected to the licensee's water industry infrastructure.

2.6.3 The code of conduct must set out the roles and responsibilities of the entities specified in condition 2.6.2, including by specifying as relevant:

(a) who is responsible for repairing, replacing or maintaining the water industry infrastructure;

(b) who is liable in the event of the unavailability of water;

(c) who is liable in the event of failure of the water industry infrastructure;

(d) who is responsible for sharing information and data and in what circumstances;

(e) who is responsible for communicating with customers or dealing with customer complaints and how complaints will be handled;

(f) who is responsible for managing incidents and how incidents will be managed;

(g) who is responsible for managing water quality and preventing cross-connections; and

(h) who is liable for the fees and charges payable in respect of the use of the water industry infrastructure.

2.6.4 The licensee must comply with its obligations and responsibilities under the code of conduct.

2.6.5 Where the licensee has established a code of conduct in accordance with condition 8 of Schedule B to Licence No. 15_032 granted under section 10 of the Act (now repealed), that code of conduct is deemed to:

(a) have been established in accordance with condition 2.6.1; and

(b) comply with conditions 2.6.2 and 2.6.3, until it is first amended or replaced following the grant of this licence.

2.6.6 In this condition C2.6, **code of conduct** means a utility service agreement or other agreement or document, however described, that includes a protocol for dealing with the matters set out in condition 2.6.3, as relevant.

Note: The objective of a code of conduct is to minimise risks to public health, safety and customers through the establishment of a protocol of efficient and effective day-to-day working arrangements between the licensee and a public water utility, licensed operator or licensed retailer in relation to the matters covered by the code, which include information sharing and handling customers, incidents or other events.

C2.7 Notification of commencing operation of water industry infrastructure

2.7.1 Within 10 days after commencing to operate water industry infrastructure for a scheme under an operational approval or variation to an operational approval, the licensee must notify the following entities that it has commenced operating the infrastructure in accordance with the reporting manual:

(a) IPART;

(b) NSW Health;

(c) any public water utility operating in the area of operations of the scheme; and

(d) the local council in which the scheme is located.

C2.8 Notification of material change to plans or systems

2.8.1 If a material change is made to the licensee's asset management plan or system, water quality management system, or sewage management plan or system, the licensee must notify IPART within 10 days in accordance with the reporting manual.

C2.9 Notification of non-compliant plumbing

2.9.1 If the licensee becomes aware that a customer's plumbing is not code compliant, the licensee must within 10 days:

(a) notify the customer of that fact; and

(b) where the plumbing that is not code compliant threatens, or could threaten, water quality, public health or safety, also notify the plumbing regulator of that fact.

2.9.2 In this condition C2.9:

(a) **code compliant** has the meaning given to that term under the *Plumbing and Drainage Act 2011*;

(b) **plumbing** means any pipe, fitting or apparatus that is located:

(i) downstream of a customer's connection point to a water main that is part of the licensee's water infrastructure;

(ii) upstream of a customer's connection point to a sewer main that is part of the licensee's sewerage infrastructure; or

(iii) upstream of a customer's connection point to a stormwater drain that is part of the licensee's water infrastructure; and

(c) **plumbing regulator** has the meaning given to that term under the *Plumbing and Drainage Act 2011*.

Note: Without limiting condition 2.9.1(b), an example of plumbing that is not code compliant which must be notified to the plumbing regulator, is plumbing through which non-potable water can come into contact with drinking water.

Item C3 Special licence conditions

C3.1 [Not applicable]

C3.2 [Not applicable]

Appendix 9 – Plumbing Audit (Cross Connection Audit) - pending

Appendix 10 – Verification Report - pending

Appendix 11 – Operation and Maintenance Manual - pending