Venus Bay Community Sewage Scheme Concept and Options Assessment Report – Rev A

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June 2022

Job Number: 15112

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Quality Approved ISO 9001 Environmental Approved AS/NZS ISO 14001 Safety Approved AS/NZS 4801

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1. CONTEXT

Venus Bay is located on a headland on the south-east coast of Victoria, in the South Gippsland Shire, with Bass Strait to the south and Anderson Inlet to the north. Historically the town was a holiday destination with primarily transitory population peaking in the summer months. Residences were largely holiday homes with few permanent residents. More recently with changes to working conditions, retirees and many people opting for a "sea change", the proportion of permanent residents and tourism has increased along with demands for local commercial services.

For potable water the town is primarily serviced through individual rainwater collection in tanks and in some cases supplementation from groundwater. For wastewater management the lots are individually serviced primarily with septic systems and drain fields with around 50% operating secondary aerated treatment systems. It has been identified that there are potential public health and environmental health risks with potential groundwater contamination through infiltration of primary treated wastewater in the town, particularly when the groundwater is also used to supplement drinking water supplies. In addition, the groundwater could potentially impact the ecological values of Anderson Inlet which is a nursery area for many fish species and highly valued recreational area for swimming, windsurfing and fishing.

Commercial offerings currently consist of a general store, real estate, pharmacy, cafes, restaurant, pizza shop, fish and chip vendor and other small retail (including hairdresser).

Due to the ongoing increase in population and demands on these services, the wastewater treatment and disposal systems of these commercial allotments are potentially at or over their treatment limits and they have no opportunity to expand their businesses or accommodate new business offerings due to the limited area for drain fields and effluent disposal area.

An offsite treatment and disposal system is considered preferable to allow for the expected continued growth in community and tourism in the town. Due to climatic conditions, disposal may be constrained with winter storage requirements and options may include reuse for irrigation and Aquifer recharge.

This area is also rich in cultural heritage which must be protected and therefore low impact implementation of any proposed infrastructure is preferable. In this case, a low bore pressure sewer system which can be bored or drilled has significant advantages and a precedent has been implemented in similar conditions on the Mornington Peninsula. Assuming the timing is suitable these works can be aligned with the proposed Council streetscape works and the Surf Life Saving Club upgrades to minimise disruptions to traffic and the community.

Initially, the SGSC are looking to service the primary commercial zone, community house, the surf lifesaving club (SLC) and public toilets located in Jupiter Street and at the SLC.

We understand the primary stakeholders in project will be:

- South Gippsland Shire Council
- South Gippsland Water
- DELWP
- Venus Bay Surf Lifesaving Club
- EPA Victoria
- Parks Victoria
- First Peoples Relations
- Venus Bay community
- Venus Bay business owners
- Adjacent landholders

Relevant regulations and guidelines include (but not limited to):

- Environment Protection Act 2017
- Environment Protection Regulations 2021, S.R. No. 47/2021
- Environment Reference Standard (ERS) (Victorian Government Gazette, No. S 245 26 May 2021) – (replaces State Environmental Protection Policies (SEPP))
- EPA Publication 500, Code of practice for small wastewater treatment plants, June 1997
- Environment Protection (Scheduled Premises) Regulation 2017
- EPA Publication 168, Guidelines for Wastewater Irrigation, revised April 1991
- EPA Publication 464.2, Use of Reclaimed Water, June 2003

Purpose of this report

This report was commissioned to establish the feasibility of a low-bore smart pressure sewer network and reedbed treatment system to provide a community sewerage scheme for Venus Bay. The primary objective of the scheme is to relieve pressure on the commercial zone of Venus Bay which is restricted in development and expansion by the limited treatment capacity of onsite wastewater systems and to allow increased services and development of other community assets including the Lifesaving Club and Community House and provision of public toilet facilities. It is envisaged that into the future the scheme will also provide opportunity for residential connections to allow the phase out of ageing and outdated septic tank infrastructure.

The low-bore smart pressure sewer network consists of small (approximately 1000 L capacity) individual storage and pump systems on each serviced lot. These pump systems are controlled individually through the use of a Onebox controller linked to a central server. The advantages of this sewer network system include reduced impacts and disruption during installation as pipes are easily bored, it is not reliant on gravity, infiltration of stormwater is largely eliminated (reducing wet weather flows) and the storage on each site and the ability to control the pumps individually allows peak flows to be evened out across the day or a number of days. This system has previously been installed by SEW on the Mornington Peninsula in very similar topographical and ground conditions to Venus Bay.

New style (hybrid) reedbed treatment systems were considered appropriate as they are a natural passive (low energy) treatment alternative that offer considerably reduced treatment footprint (over lagoon systems) but without the higher levels of energy required by more compact mechanical-based systems. Other advantages include low and simple maintenance requirements, reduced risk of odour, reduced noise, extremely high resilience to variations in daily flows and pollutant loads, long life span and their vegetated character presents a visually pleasing image. The modular nature of reedbed systems also allows for incremental expansion of treatment capacity with increasing number of connections without the requirements for large capital outlays in one go. The proposed reedbed system was successfully trialled on wastewater from the Mornington Peninsula small bore sewer network and treated the water to equivalent of Class C.

Larger scale treatment systems have previously been considered in a sewer feasibility report prepared by Earth Tech in 2006, however, we understand that these systems were not considered feasible at that point in time. We note that this report has not considered other treatment systems.

2. ESTIMATION OF DESIGN FLOWS

To determine the appropriate design flow for the commercial lots to be serviced in the absence of metered flow data for most properties we have looked in detail at the flow patterns based on OneBox controller runtime data for commercial connections in Poowong, Loch, Nyora (PLN) and elsewhere.

A sample of weekly runtime data for commercial connections in PLN is included in Appendix.

The largest potential flow will come from the toilet blocks, surf lifesaving club the Restaurant and Cavity Bar. The Cavity Bar metered flow data provided by South Gippsland Shire with peak at 1500 L/d compares to Feb data for Poowong Hotel at 600 L/d and the Olive Café in Loch at 900 L/d. This is reflective of the scale and catchment size in Venus Bay. Reasonable to consider peak flow at Cavity Bar at 1750 L/d. For the toilet blocks the Loch toilet block had a peak flow of 1,100 L/d in Feb data set. We also looked at data for Merricks Beach in the South East Water network which is considered similar activity to Venus Bay beach one with peak of 210 L/d. On this basis the peak is estimated to be 1000L/d is reasonable with significant seasonal variability. The surf club design estimate takes into consideration the potential 126 seat restaurant redevelopment therefore based on VicEPA the design should accommodate 126 seats by 30L/seat or 3,780L/d and accommodation of 34 beds. Both toilet blocks and Surf Lifesaving Club flows will be significantly reduced outside peak summer season.

The fish & chip shop in Poowong peak for Feb data period was 385L/d and the Nyora Pizza shop peak for same period was 1070 L/d. Expected flows relatively low with no sit in or wash up requirements. Peak of 1000L/d deemed appropriate. Based on this capacity it will accommodate 100 meals based on VicEPA estimate of 10L per meal

For the other commercial properties including Retail and Real Estate flows will be minimal and standard retail 400 L/d will be appropriate.

The current commercial sector peak flow is therefore estimated as follows:

Table 1: Current Commercial Design Flow Assessment Summary

Commercial Lot	Design Peak Flow (L/d)	Summer Avr (L/d)	Winter Avr (L/d)	Comment
Beach 1 Toilet	1000	500	200	Based on comparison Loch 1,100 (L/d)& Merrick Beach (210 L/s)
Surf Club	7180	2000	250	126 seat development based on 30L/seat. 34 Beds at 100L/bed
Take Away 121 Jupiter Bvd	1000	600	300	Comparison Feb peak data, Nyora Pizza 1,077 (L/d), Loch Café 971 (L/d), Poowong Take Away 375 (L/d)
General Store 135 Jupiter Bvd	800	400	400	General Store recent transferred ownership, proprietor looking at increasing the food offering
Real Estate 133 Jupiter Bvd	400	250	250	Assume average domestic flows
Pharmacy 131 Jupiter Bvd	400	250	250	Assume average domestic flows
Restaurant 127-129 Jupiter Bvd	4000	2000	500	The Bay Gourmet, liquor licence 80 person assume 50L/head. Ex. Grease trap, septic and treatment in series
Bar and restaurant 1-2/114-116 Jupiter Bvd	2000	1000	500	Cavity Bar - Based on flow meter data, assume 25% growth
Real Estate 3/114-116 Jupiter Bvd	400	250	250	Estimate dry commercial, kitchenette installed.
Retail shops at / 114-116 Jupiter Bvd	0	0	0	No water fixtures installed at present.
Fish and Chip / Ice Creamery 112 Jupiter Bvd	1000	600	300	Comparison Feb peak data, Nyora Pizza 1,077 (L/d), Loch Café 971 (L/d), Poowong Take Away 375 (L/d)
Public Toilet 126A Jupiter Bvd	1000	500	250	Comparison to Loch toilet Feb data peak 1,100 L/d. Noting unlimited bore water available.
Community Centre 27 Canterbury Road	1000	500	100	Potential location on pipe route to be confirmed
Sub-Total (L/d)	20180	8850	3550	

Future Additional Flows

It is anticipated that once a sewer connection is available it is likely that there will be an expansion of businesses in the commercial zone, including development of currently vacant lots, which will increase wastewater flows. We estimate that this will be an additional 10,000 L/day peak flows (i.e. 50% increase on current estimated commercial flows).

There is also a Caravan Park, not included in the current design flow assessment, which may benefit from connection to the sewer. If the camping site was to connect to the network at some stage in the future, the expected peak flow would add an estimated 20,000 L/d, based on approx. 80 cabins.

In addition, there are priority residential connections (currently serviced with septic tank and drainfields only – not including properties with AWTS or other secondary treatment systems) as outlined in the below schematic prepared by South Gippsland Shire Council. This diagram indicates 70-80 priority residential connections (depending on the treatment location and sewer servicing route). Based on typical residential flows on existing networks in Victoria the peak daily flow is 400 L/p/d, so 80 residential connections in total would generate an additional 32,000 L/d. This increase in connections is likely to occur over a period of years as residential systems fail.

In summary the design flows are as follows:

Table 2: Design Flows

Design Flows	Peak Day Flow (L/d)	Summer Avg (L/d)	Winter Avg (L/d)
Existing Commercial	20,180	8,850	3,550
Future Commercial Flows	10,000	5,000	2,500
Initial Phase Subtotal	**30,180**	**13,850**	**6,050**
Caravan Park	20,000	16,000	5,500
Priority Residential	32,000	24,000	8,000
Ultimate Design Flow Total, L/day	**82,180**	**53,850**	**19,550**

Note: "Existing Commercial" includes public toilets, Surf Lifesaving Club and Community Hall

Smart Pressure Sewer Network Design Flows

In determining the sewer network flows consideration must be given to allowing for future flow scenarios to ensure that the installation of the pipe only occurs once.

The highest total peak design flow is 82,180 L/d (refer table above) which is equivalent to an average equivalent instantaneous flow of 0.95 L/s and diurnal peak of 2.85 L/s (based on 3 times average flow).

The available capacity for the network with mainly OD90 mains is approximately 4.2 L/s.

On the basis of the estimate peak flow with full commercial and residential connections on pipe route an OD90 main will have sufficient capacity to service the additional priority connections and also allow for additional connection of non-priority residences if required, and potentially, into the future, connection of additional residences from an extended network. The use of smart pressure sewer with OneBox can offer reduced peak flow utilising Advanced Peak Shifting mode which limits the number of concurrent pumps within the network there increasing the potential connections numbers even further.

The available capacity for the network with mainly OD125 mains is approximately 10.2 L/s.

Reedbed Treatment System Design Flows

For the purposes of this report, the wastewater treatment and disposal options must consider the "Initial Phase Subtotal" volumes as a priority for treatment to address the limitations of commercial development in Venus Bay.

We understand that ultimately, the "Caravan Park" and the "Priority Residential" customers may connect to the system in the future, however Table 2 clearly shows that these potential additional flows will have a significant impact on the overall feasibility if considered in the initial phase. Therefore they have been addressed as a future expansion option to consider.

As noted previously, with the smart pressure sewer, each property has it's own storage and pump system creating an overall network storage volume. The Onebox is able to control the individual pumps and buffer flows within the network storage on a daily basis allowing optimal flows to the treatment reedbeds. As the larger peak daily flows are likely to occur predominantly on the weekend we would recommend incorporation of a buffer tank to buffer the flows over the week, reducing peak daily flows and thereby reducing the required treatment plant size accordingly.

Ultimate Design Flows

We have assumed that during peak summer season there will be 2 peak days (over the weekend) and 5 average summer flow days which gives a weekly flow of (2 x 82,180 L/day + 5 x 53,850 L/day) = 433,610 L/week. This weekly volume is equivalent to a daily volume of (433,610 / 7) = 61,944 L/day. This is the daily design flow for the treatment system.

Ultimate daily design flow for treatment system = 62,000 L/day (refer to previous paragraph for assumptions and calculations).

Note that the reedbed system has the ability to cope with large fluctuations in flows and water quality. A system designed for 62,000 L/day can treat over 80,000 L/day for a day or two, however, the preference is to buffer the flows where possible – as noted above.

Initial Phase Design Flows

Using a similar methodology as described in the Ultimate Design Flows (above) the Daily Design flows for the initial phase treatment system are 18,500 L/day.

3. TREATMENT PLANT SITE OPTIONS

The preferred location of the treatment plant is a key decision which will inform the network requirements and efficient effluent disposal route.

Two potential wastewater sites have been identified by South Gippsland Shire Council. These sites are identified as Site A and Site B in Fig 1 below.

- Site A is located on crown owned land and adjacent to the existing Council Waste Transfer Station (crown land leased by Council) off Canterbury Road.
- Site B is located at the entrance to Venus Bay from Tarwin Lower off Jupiter Blvd on what is currently privately owned agricultural land.

This document is not intended to provide a recommendation on the preferred treatment site, however, we have made a list of observations for each site based on the information we have at hand and which should be considered when this decision is to be made (refer Table 3).

Figure 1 Waste Water Treatment Plant locations

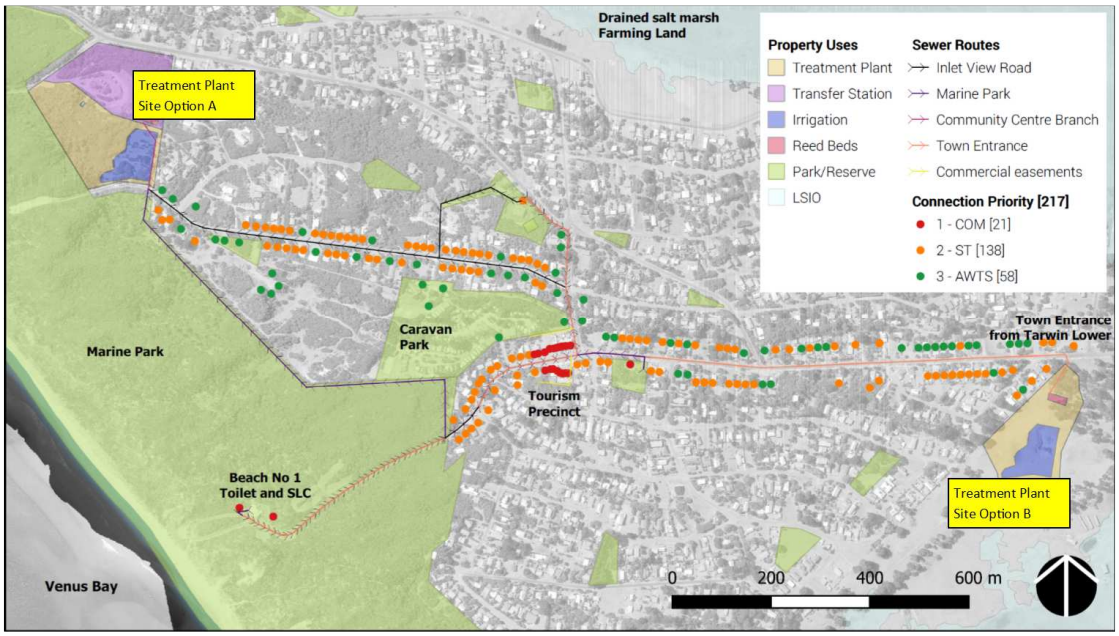


Table 3: Wastewater Treatment Plant Site Observations

Item	SITE A (Transfer Stations Access)	SITE B (Agricultural Land off Juniper Rd)
1. Neighbour Proximity	No nearby neighbours, no visibility from public road, adjacent to low density residential (LDRZ).	Located to the rear of higher density residential properties (Township zone – TZ) on Satellite Crescent.
2. Land Ownership	Crown owned Land to be leased by council (as occurs now for the waste transfer station).	Privately owned agricultural land which would require property purchase (compulsory acquisition).
3. Zoning	PUZ1 (Public Use Zone – Service and Utility) – does not require rezoning for construction and operation of a wastewater treatment utility	FZ – Farming. This land would require rezoning to allow construction and operation of a wastewater treatment utility
4. Depth to Groundwater	Surface elevation approx.. 8m – 20m AHD, Water table elevation varies from 3m - 7m AHD. (based on Bore Depths, Visualising Victoria's Groundwater website)	Surface elevation approx. 3m-12m AHD, Water table elevation varies from 2m - 4m AHD. (based on Bore Depths, Visualising Victoria's Groundwater website)
5. Vegetation	Heavily vegetated in parts that may require clearing for expansion of treatment plant or implementation of drainfield (subject to DEWLP approval).	Primarily cleared pasture with some trees.
6. Ground Conditions	Proximity to historic buried landfill requires risk mitigation at detailed design stage.	Not known
7. Proximity to connections	Network length 2,486m on Inlet View Rd including connections to Community Centre and Public Toilet Block.	Network length 2,410m on Jupiter Blvd including connection to Community Centre

Recommendation is to perform a detailed analysis of both sites, preferably a multi-criteria analysis (MCA), to decide on a suitable treatment site location. This analysis should include:

- Geotechnical investigation of soil type, depth to ground water, presence of absence of acid sulphate soil and a land capability assessment
- Cultural and heritage assessment,
- Ecological and Environmental study including flora and fauna assessment
- Access and ease of construction
- Potential for future expansion
- Overall site cost analysis
- Stakeholder engagement (social implications)

For the purposes of this feasibility study, we have assumed locating the treatment system on site A as an example. We expect the costs for the pressure sewer network system and the treatment system will be similar (within 20%) for both locations, excluding specific site costs such as access roads, fencing and site security, land procurement, land clearing, leasing costs, servicing costs (power, water, comms), site investigation costs, authority approvals, site remediation, community engagement etc.

4. COLLECTION NETWORK OPTIONS

The previous sewer feasibility report prepared by Earth Tech in 2006 considered multiple collection options and costed 2 potential preferred solutions being modified gravity sewer and pressure sewer. It determined that pressure sewer is the lowest network cost and modified gravity sewer is the lowest connection cost. The modified gravity sewer was based on providing shallower pipe grades and fewer manholes than WSAA standards require to reduce costs.

The required pipe route from connection to the Surf Lifesaving Club at Beach 1 to the treatment plant at SITE A will overcome a high point 150m downstream of the Surf Lifesaving Club, fall to the Commercial centre and rise to the treatment plant site with three interim high points on route. To accommodate this design with a gravity sewer solution will require pumping from the Surf Lifesaving Club to the high point 150m downstream and gravity pipework to a low point at the commercial centre and a main transfer pumping station and rising main to SITE A. The transfer pump station would be located at the low point close to the junction of Centre Rd and Jupiter Blvd. Connection of the Community Centre on Canterbury Rd would also require pumping as the interim high point to connect to the transfer pump station would require gravity pipe in excess of 4m depth. To accommodate future residential connections on Inlet View Road pumping stations would also be required between interim high points to avoid gravity mains in excess of 4m deep. Deep excavations in sandy soils would require additional shoring measures to prevent collapse of the side walls during construction. On this basis a gravity sewer based solution would be prohibitively expense requiring deep sewers due to undulating terrain and multiple transfer pump stations.

Considering that the pipe route from the Beach 1 toilet block to treatment plant SITE A includes four separate intermediate high points and potential for future residential connections along its route the pressure sewer solution is optimal for the network. The pressure sewer network will follow land contour with approx. 900mm cover. With discharge to SITE A being higher elevation than the bulk of the network the network will remain fully primed with the possible exception of the high point downstream of the Surf Lifesaving Club and therefore air valves will be limited to this high point. An elevated discharge pipe at the treatment plant site should facilitate avoiding any air valves and associated odour management and should be fully assessed at detailed design.

Despite the relatively high connection cost, the relatively small number of commercial connections in the initial phase ensures the pressure sewer network option remains the lowest cost overall.

The fully pressured network also removes the network side stormwater / groundwater infiltration risk (i.e. increased wet weather flows are avoided) and use of the OneBox controller will facilitate identification of any infiltration at connections and control of peak flows to benefit treatment plant operation. The OneBox flushing mode will also facilitate self-cleansing velocity through the winter months when flows will be well below design flow to avoid any potential network issues.

Recommendation to utilise pressure sewer network as the most feasible and lowest cost option for connection of commercial properties.

5. COLLECTION NETWORK ALIGNMENT OPTIONS

Three network layouts have been considered based on connection of the Priority 1 Commercial sites as detailed in Figure 2 below. Inclusion of a network to SITE B is included for comparisons purposes only.

FIGURE 2 CONNECTION PRIORITY

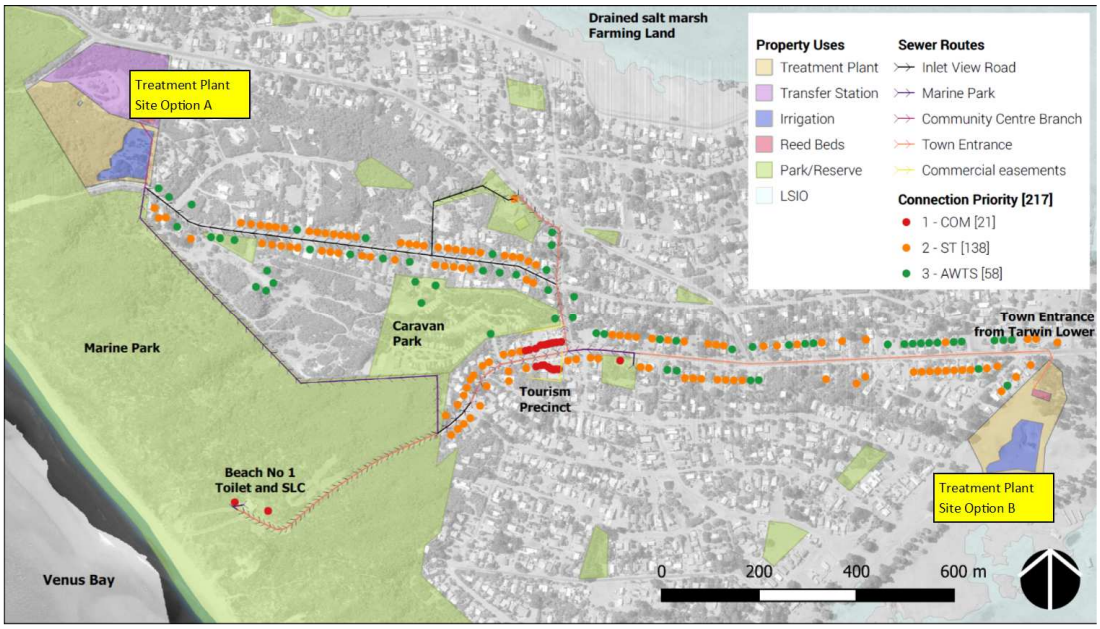
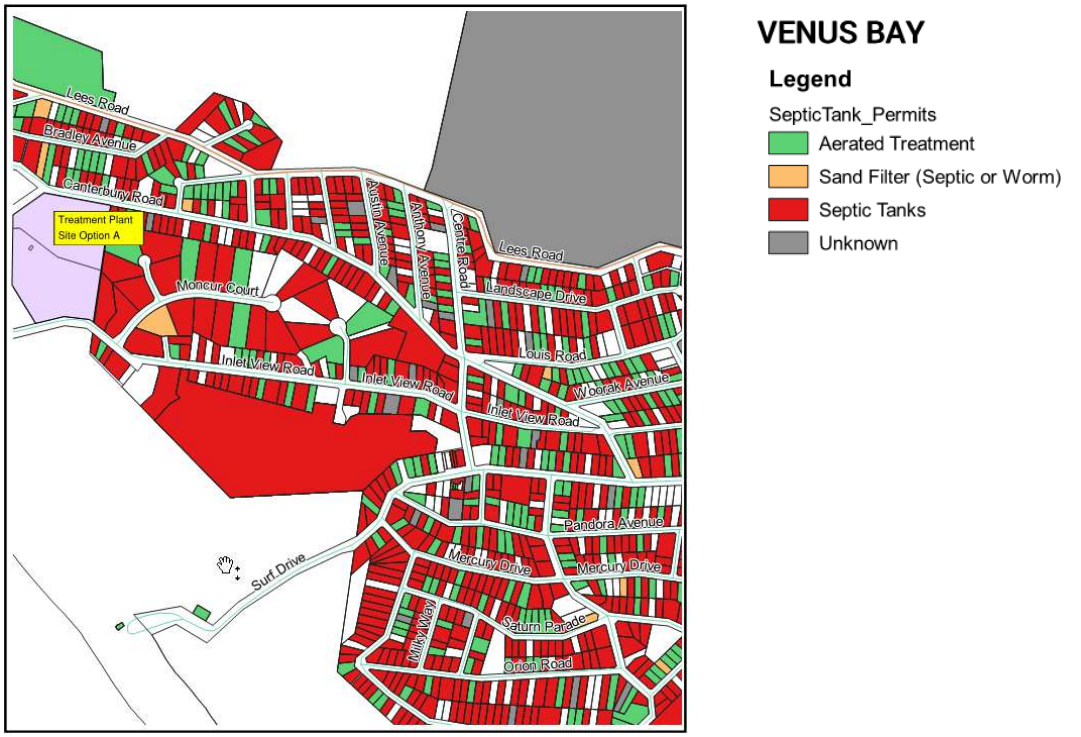


FIGURE 3 CONNECTION PRIORITY – CANTERBURY RD OPTION



Alignment Option A – Inlet View Rd.

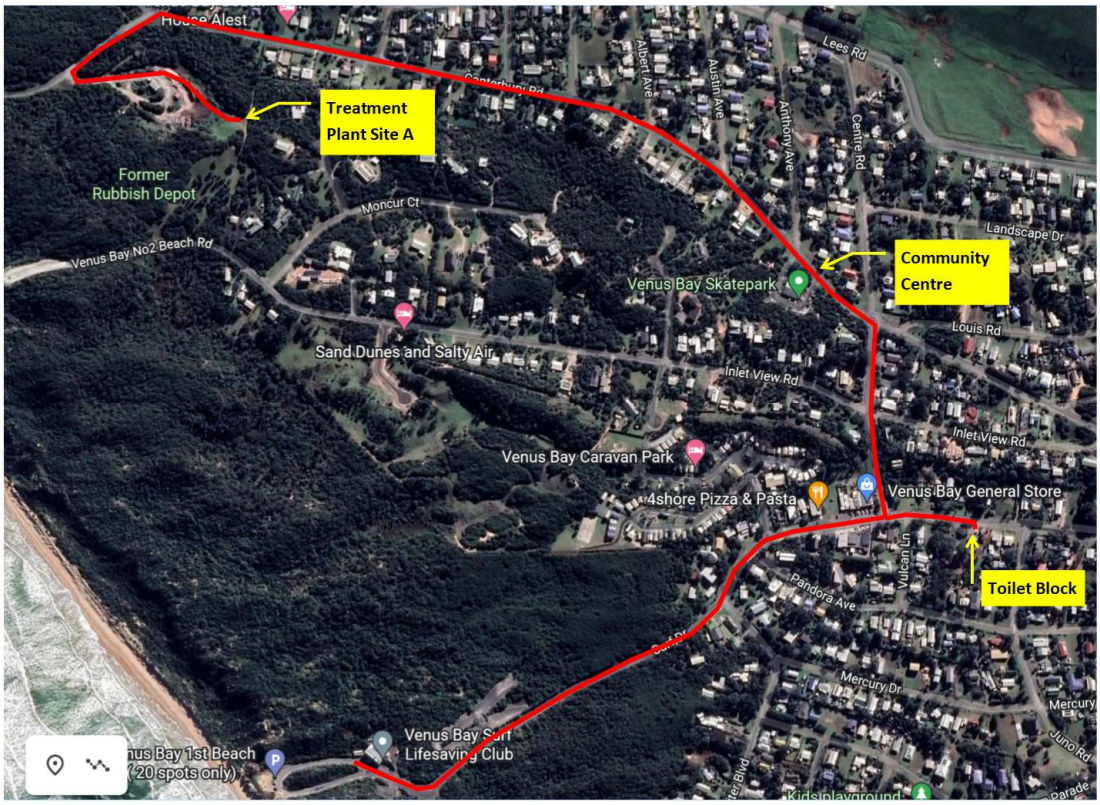
The total pipe length is 2,490m inclusive of 250m off road on council bushland, 280m connection to the Community Centre on Canterbury Rd and 115m connection to the Public Toilet on Jupiter Blvd.

Figure 4: Network Alignment Option A

Alignment Option A1 – Canterbury Rd.

This alignment seeks to avoid off road element associated challenges for future location and maintenance. The total pipe length is 2,640m inclusive of 250m within Transfer Station access road and 115m connection to the Public Toilet on Jupiter Blvd.

FIGURE 5: NETWORK ALIGNMENT OPTION A1



Alignment Option B – Jupiter Blvd.

The total pipe alignment is 2,410m inclusive of 180m off road into agricultural site (Site B) and 415m to connect to the Community Centre on Canterbury Rd.

FIGURE 6: NETWORK ALIGNMENT OPTION B

Recommended Route (based on Treatment Plant site A)

The decision is based on the comparative assessment of shorter pipe length and alignment off road through native vegetation. From a purely financial lens the additional 150m (2,640 – 2,490) of pipework valued at $22,500 (150m x $150/m) can be compared with additional detailed design costs associated with impact assessments for flora & fauna and cultural heritage associated with off road alignment. From a network management perspective location within the road reserve is preferable for ease of future access. With financial impact minimal the potential for reduced environmental impact and preferred road alignment for long term access the Alignment Option A1 – Canterbury Rd is recommended.

Future proposals to connect properties on Inlet View Rd to the network can be easily accommodated with additional pipe length.

Network Capacity and Pipe Sizing

The capacity of the network will be determined by the selection of the pipe size connection to the treatment plant site. For pressure sewer PN16 pipe (pressure rating = 1.6MPa) the size options under consideration are OD90 (Outside Diameter = 90mm) and OD125 (Outside Diameter = 125mm), both of which are available as a roll thereby minimising pipe connections and speeding up directional drill installation.

The capacity of the network will be approx. 4.2L/s if the network is sized at OD90 from the Commercial centre to SITE A treatment plant based on a design pump head of 56m and Option A1 alignment.

If we considered the Priority 1 Commercial design flow estimate of 20,180 L/d or 0.7 L/s peak flow (assuming a peaking factor of 3 times average flow) in isolation. The 3 times average flow to estimate peak flow is a common industry practice based on measured flow data. In practice, with such a small number of connections, the peak flows will be statistically based on concurrent pumps running which will be much higher than nominal 3 times average for large scale network.

To achieve self -cleansing on an OD90 main requires a flow < 2.5L/s or 5 pumps pumping concurrently. This can be easily achieved with OneBox control during flushing mode and is possible during design peak flow. The total capacity of the network with OD90 from the commercial area to treatment plant site A is 4.2L/s or 8 pumps pumping concurrently.

With the benefit of OneBox advanced peak shifting control the OD90 main will have capacity to accommodate 400 residential connections or without advanced peak shifting, approximately 200 residential connections. With commercial design flow equivalent to approximately 75 residential connections this indicated capacity for between 125 and 325 residential housing capacity into the future.

The capacity of the network will be approx. 10.2L/s for an OD125 sized main. This network sizing would accommodate the commercial connection and in excess of 500 residential connections, sufficient for all residential properties in the immediate area. To achieve self-cleansing the OD125 pipe will need to achieve 4.8L/s or approx. 8 pumps pumping.

By comparison the combination of residential properties on Jupiter Rd, Inlet View Rd and direct connections off Canterbury Rd is approx. 240 residential properties. The cost difference between OD90 and OD125 installation is nominal at approx. $25/m. On this basis a sizing of OD90 downstream from the commercial area to the treatment plant site A is recommended.

6. REEDBED WASTEWATER TREATMENT

Wastewater management and water quality objectives

The following extract (Waste Water Management Issues in Gippsland – 2004, pg 8) offers an insight into the aspirations for wastewater management in Venus Bay.

> ***Venus Bay***
>
> - Objectives are to maintain the Bay as a peaceful holiday settlement allowing development to occur in an environmentally and socially sustainable manner that protects the delicate landforms and character of the area.
> - Implementation strategies include ensuring that each site is capable of on-site waste disposal which does not prejudice groundwater quality.

Water quality objectives will primarily depend on disposal method and requirements for mitigation of potential detrimental impacts on water quality and environmental values. There are no surface water bodies (dams, lakes, creeks, rivers) in close proximity to our site. The primary risks are in relation to treated water disposal and groundwater quality.

Groundwater environmental values

Beneficial Use data on Visualising Victoria's Groundwater Map suggests that the groundwater in Venus Bay corresponds to segment A2 (TDS concentration of 501-1,000 mg/L). Note: the new Environment Reference Standard (ERS) (Victorian Government Gazette, No. S 245 26 May 2021) has this segment documented as TDS concentration range of 601-1200 mg/L.

According to Table 5.3 of the ERS 2021 the groundwater segment A2 has a number of environmental values, including potable water supply.

The ERS also notes that these environmental values may not apply where the background water quality levels fall outside the relevant objectives specified in Table 5.4. In a previous study (refer extract below) they found significant faecal bacterial contamination of groundwater in Venus Bay and found that the groundwater is no longer suitable for potable water use (i.e. the water quality falls outside the requirements of the AWDG.)

Extract from Waste Water Management Issues in Gippsland – 2004, pg 24

> It should be noted that Venus Bay was identified as a classic case study in this work "The Venus Bay area had no reticulated water or sewerage. A shallow aquifer receives wastewater from approximately 1300 mainly holiday households and is also heavily used to supplement limited rainwater tank supply. A study found that there was significant faecal bacterial contamination of groundwater that is at its worst after the holiday season. As a consequence (and a precaution), water from the aquifer is no longer suitable for drinking unless it has been treated" (James C Smith & Associates 2002).

We acknowledge that the groundwater in this region is still suitable as a "raw" potable water supply and with appropriate treatment could be used as a potable water supply. Therefore, for the purposes of design of the wastewater treatment and disposal system we believe it's prudent to maintain potable water as an aspirational environmental value to apply to the groundwater.

In terms of water quality objectives, the ERS notes that the background water quality level becomes the objective for an indicator where the objective cannot be attained due to the background water quality. This is the case for Venus Bay, therefore the objective becomes a non-worsening of the existing background water quality. However, as noted previously our aspiration is to improve groundwater quality. Groundwater testing in the vicinity of the disposal area is recommended prior to operation of the treatment system would establish background levels and inform treatment objectives.

Potential threats to groundwater quality

Currently septic wastewater, both primary and secondary treatment, are being discharged to land throughout Venus Bay. This represents a significant risk to groundwater quality, as:

- onsite treatment systems (many with primary septic treatment only) are producing low quality water,
- many existing disposal fields are undersized and overloaded (particularly in summer)
- the typical depth to aquifer in many locations is less than 2m,
- there is no monitoring of treatment performance (until failure of system is obvious through visual inspection or odours),
- there is a high probability of detrimental effect on groundwater quality (as proven in previous groundwater quality studies)

A centralised treatment system treating wastewater from the commercial zone will improve the situation markedly through:

- reduction in volume of wastewater disposal in commercial zone,
- higher level of treatment,
- full monitoring and maintenance of treatment system with regular water quality testing,
- minimum 10m depth to groundwater for disposal allowing additional treatment in soil column, and
- minimum setbacks from existing extraction bores > 50m.

Treated water quality requirements

As noted previously, despite the current state of groundwater not being potable quality (i.e. compliant with ADWG), the objective is to maintain or improve the background water quality of the groundwater so that potential use for drinking water purposes is maintained (albeit with appropriate treatment).

The primary contaminants of concern are:

- BOD (Biological Oxygen Demand)
- Suspended Solids (SS)
- Pathogens – including bacteria, protozoa, viruses and helminths
- Nutrients – primarily nitrogen (N) and phosphorus (P) noting that nitrogen is usually the limiting nutrient in coastal areas.

EPA calls for a 20/30 Standard (20 mg/L BOD and 30 mg/L SS) prior to disposal of wastewater to land. (EPA publication 500), however, in high permeability sandy soils this may not be a suitable standard.

Treatment system options

This report was commissioned to establish the feasibility of a pressure sewer network and reedbed treatment system to provide a community sewerage scheme for Venus Bay. The objective of the scheme is to relieve pressure on the commercial zone of Venus Bay which is restricted in development and expansion by the wastewater treatment capacity of onsite systems and to allow development of other community assets including the lifesaving club and public toilet provision. It is envisaged that the scheme will also provide opportunity for residential connections to allow the phase out of ageing and outdated septic tank infrastructure.

Other larger scale treatment systems have been considered in a previous sewer feasibility report prepared by Earth Tech in 2006, however, these were considered not feasible at that point in time. We note that this report has not considered other alternate treatment systems.

Reedbed treatment system options

There are a number of options and configurations available for natural reedbed systems depending on treated water quality requirements. These can consist of vertical flow, horizontal flow and tidal flow systems or a combination of these, known as hybrid systems and can be configured to achieve a range of specific water treatment requirements.

The attraction of reedbed systems are:

- they are low in energy use, odour and noise.
- they are well suited to highly varying inflows and can deal well with overloading for short periods of time (weeks) with minimal if any reduction in treatment performance.
- Unsaturated vertical flow systems are popular in Europe, particularly in France, as they are able to deal with the solids in situ and are fully aerobic so avoid odour production.
- Modularity inherent in reedbed systems allow incremental expansion to cater for increasing connections and flows.

For this feasibility study we have considered a 3 stage Reedbed system

- 1st stage vertical flow filtration with aeration removes solids (which aerobically humifies in-situ) and oxidises BOD / COD and ammonia (nitrification).
- 2nd stage – vertical up-flow saturated sub-surface anaerobic denitrification stage – converts nitrate to volatile nitrogen.
- 3rd stage – vegetated vertical flow polishing sand filter – filters solids, oxidises remaining pollutants and reduces pathogens.

The 1st and 3rd stages are fed / dosed intermittently (pulsed) to improve aeration and oxygen transfer. This can easily be achieved with the IOTA One Box control system. All stages are planted with phragmites and result in secondary treated effluent.

Additional treatment will be achieved through land disposal on the sandy soils in the soil column. For sandy soils an unsaturated soil depth to groundwater of greater than 0.6m is deemed suitable to remove pathogens from secondary treated effluent (refer section 3.3 Separation distances, Waste Water Management in Coastal Settlements of Gippsland Project Part 2: Report on Management Strategies for Domestic Wastewater in Gippsland). At Treatment Site A it appears there is >5m of soil depth above water table in the proposed drainage area (refer Visualising Victoria's Groundwater)

A similar 3-stage Reedbed system was trialled at SEW Boneo WWTP (refer poster in appendix for details) and achieved an equivalent of Class C water quality. Class A quality would be achievable with additional disinfection. These water classes are no longer officially recognised by EPA as part of the ADWG risk management approach, however, they are informative in water quality comparisons and suitable uses.

Water Class	Class A	Class C
Biochemical Oxygen Demand (BOD_5), mg/L	<10	<10
Total Suspended Solids, mg/L	<10	<10
E.coli (cfu/100ml)	<10	<1000
Potential uses (based on ADWG risk management)	Non-potable uses – e.g. toilet flushing, laundry, spray irrigation of edible crops and pasture, washdown	Non-potable uses – e.g. spray irrigation of pasture (with controlled public access), sub-surface drip irrigation

Note that historical Water Classes do not include nutrient level requirements.

At this point we do not believe that tertiary treatment (disinfection) is required to meet the objectives. If required other options such as recirculation through the stage 3 polishing sand filter, UV treatment and / or chlorination could be applied prior to disposal, however it should be noted that the use of chlorine may have a detrimental effect on treatment of the effluent in the soil through disturbance of soil microbiology which play a large role in the additional treatment provided by the soil.

Expected water quality from Reedbed System prior to land application (to be confirmed during detailed design):

- Biochemical Oxygen Demands as measured in a 5 day test (BOD5) < 10mg/L
- Suspended Solids (SS) < 10 mg/L
- Total Nitrogen (TN) < 25 mg/L
- Total Phosphorus (TP) < 10 mg/L
- E.coli < 1,000 cfu/100mLs

This level of treatment is far greater than that being achieved by the onsite systems currently used in Venus Bay, and we believe this treated water quality is sufficient to maintain and improve the current groundwater quality, thereby meeting the objectives outlined in the ERS.

Options to improve treatment of nutrients (TN and TP) are also available if deemed necessary for suitable disposal to land. This may include changes to plant operation or additional treatment area (volume) may be required. The treatment requirements and treatment system design will be further refined during the detailed design stage.

Treatment system construction options

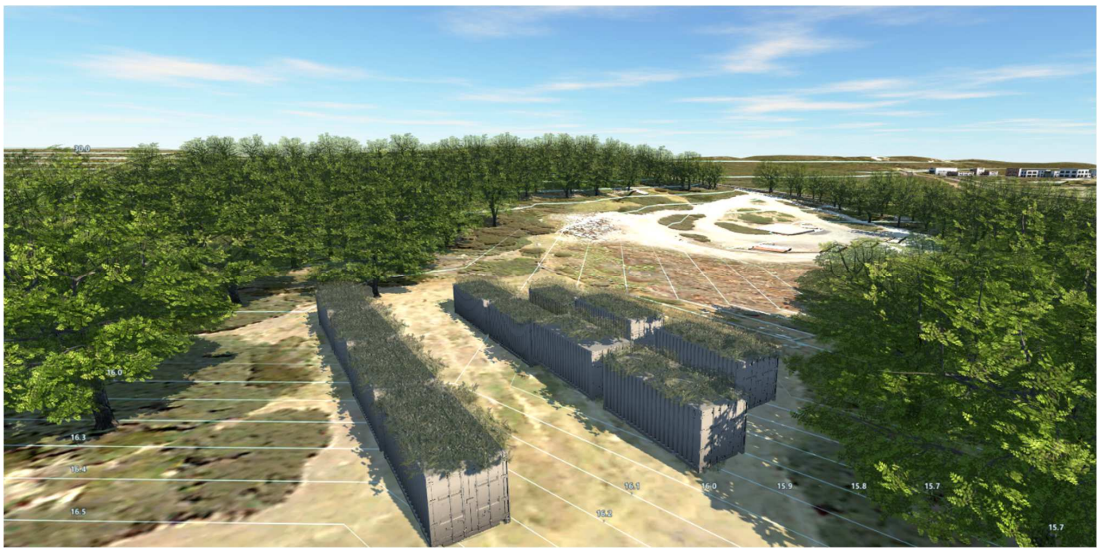
Reedbed treatment systems can be constructed in a number of ways. Most commonly for larger systems this would be done directly in the ground but for smaller installations a containerised option offers system flexibility.

In ground installations consist of excavated cells, lined with clay or HDPE and filled with media. At site A there are a number of risks due to ground conditions and previous landfill history of the site. These include:

- Contamination of soil due to buried landfill in location of treatment system may cause issues with excavation
- The sandy nature of the soil and the previous landfill in this location may present issues with unstable ground
- For inground systems a liner would be required due to the highly permeable nature of the soil. This may be a clay liner (if clay can be sourced nearby) or high-density polyethylene (HDPE)
- Another option is a containerised reedbed system
    - In this option the system is contained within a number of lined shipping containers
    - This configuration minimises ground disturbance and reduces risks from existing ground contamination and instability.
    - It is also modular and a large portion of the construction can occur offsite, minimising disturbance to neighbours
    - Even after installation the system remains easily transportable and can be moved in the future if required.
- Expansion / Staging options
    - The modular nature of the containerised treatment system lends itself to incremental expansion with ability to grow with increasing number of connections. The consequence of this is no significantly large capital expenditure is required as expansion occurs.

Typical lifespan for reedbed system that is well maintained is >25 years.

FIGURE 7: INDICATIVE LAYOUT FOR CONTAINERISED REEDBED SYSTEM ON SITE A (VIEW 1)

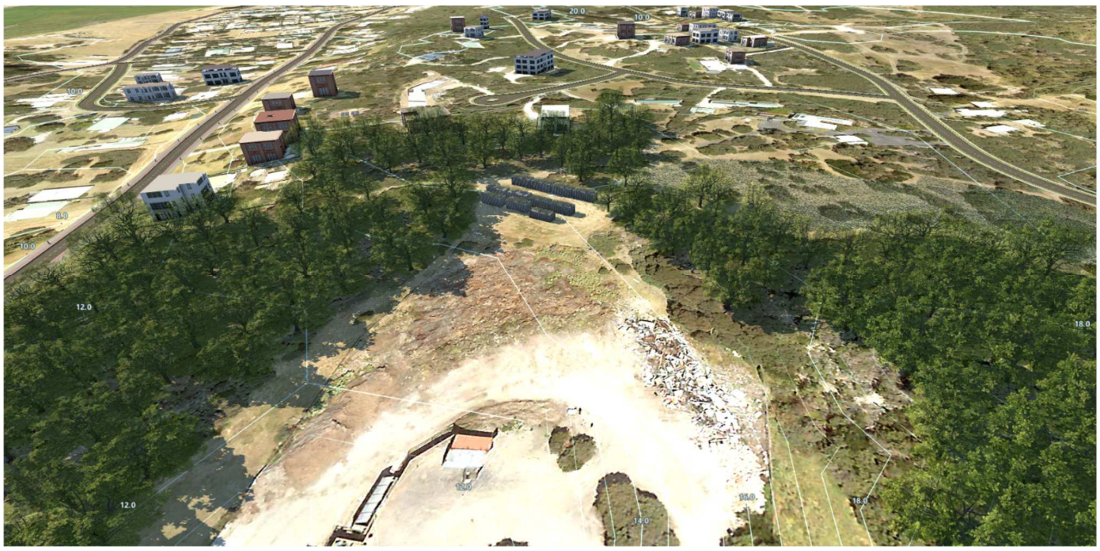


Maintenance Activities

Access will be provided for maintenance and sludge removal via an access track. Maintenance activities will include:

- Regular fortnightly checks of plant health and weeding (primarily during establishment)
- Regular (annual) trimming or harvesting of reeds is not generally required, however, this may be deemed necessary to reduce fire risk (refer fire risk below). Harvesting is best done mid-late autumn when reeds are still green, prior to senescence. The harvested reeds can be used for stockfeed or composted as green waste for beneficial reuse.
- Fortnightly checking for potential blockages and pump operation or response to remote monitoring alarms.
- Sludge management (every 10 years)
    - Solids will build-up slowly on first stage reed beds to a depth of around 30cm over a ten-year period. Most of the solids are composted and mineralised in-situ leaving a dry compost material (typically >50-70% w/w solids), thereby avoiding disposal issues of the wet sludge typical of conventional wastewater treatment systems. After 10 years this material can be removed for further treatment and reuse or disposal.
    - The composted sludge can be removed (along with reeds) using a small excavator towards the end of the summer period. This will require feedpipe removal and reinstallation of the feedpipe after composted sludge removal, which is a quick and easy process.
    - It is likely that EPA will require a 3-year withholding period prior to any application of the composted sludge for soil amendment due to potential presence of pathogens or alternately it can be diverted to a commercial high-temperature composting facility such as that at Dutson Downs to allow reuse as soil amendment.
    - After sludge removal, the system can be put back into service immediately. Plants will grow back from viable rhizomes which remain in the media layer.
- Remote monitoring can be provided to assist with plant monitoring, fault finding and maintenance activities.

FIGURE 8: INDICATIVE LAYOUT FOR CONTAINERISED REEDBED SYSTEM ON SITE A (VIEW 2)



Recommended treatment system

At this stage the recommended water treatment quality target is minimum of class C (plus nutrient reduction). Noting that (as with all treatment systems) class A is achievable with additional tertiary treatment (disinfection) such as UV and chlorination.

To achieve class C level of treatment we recommend a 3 stage reedbed treatment system as outlined above.

The modular nature of a reedbed treatment system, which consists of a number of reed cells, ensures that the system can be expanded as demand increases. This reduces the upfront capital costs and allows a staged incremental approach to the treatment plant.

To inform the feasibility study we have addressed two phases of the development (the "Initial Phase" and "Ultimate Design"). The phases are outlined as per table below:

Phases	Scope	Total Estimated Flows (kL/day)	Treatment System Size
Initial Phase	• existing commercial area • public toilets at the surf life-saving club • public toilets Jupiter Boulevard Park • surf lifesaving club • future potential expansion of commercial zone	Peak Flows = 30.2 Treatment Design = 18.5	10 x 20' containers
Ultimate Design	• addition of caravan park • addition of priority residential houses along sewer route	Peak Flows = 82.2 Treatment Design = 62.0	34 x 20' containers

7. EFFLUENT DISPOSAL OPTIONS

To assess the disposal options for the treated wastewater a Land Capability Assessment (LCA) by a suitably qualified practitioner is required. This would be performed as part of detailed design. However, we know from previous assessments in the area that the soil is classified as sandy and has high permeability.

Options for treated wastewater disposal at Treatment Site A include:

- reticulated domestic reuse of treated effluent for non-potable water use - unlikely to be economically feasible at present but can potentially be implemented in the future.
- Sub-surface pressure-compensated drip irrigation on dedicated grassed area located adjacent to treatment location (crown land zoned PUZ1 to be leased by council)
    - This requires installation of shallow trenches for installation of dripline.
    - water is applied directly to the plant roots
- Sub-mulch pressure-compensated drip irrigation on the bushland area adjacent to treatment location (crown land zoned PUZ1 to be leased by council) without vegetation removal.
    - This requires laying of irrigation drip line through bush disposal area and covering with mulch layer.
    - Existing bush area will have deeper roots, higher carbon levels and greater soil water storage capabilities, and higher microbial biodiversity thereby improving in-soil treatment.
    - Effect of nutrients, particularly phosphorus on native vegetation would need to be carefully considered with this approach.
- Off-site disposal to nearby farmland (yet to be identified and would require land lease or purchase)

Setbacks, Winter Storage and Disposal Area Estimates

We note that the recommended minimum setback distance for wastewater drip irrigation areas is 20m with appropriate fencing and notices (refer Table 1, EPA Publication 168, Guidelines for Wastewater Irrigation, revised April 1991)

For the purposes of feasibility, we have performed some high-level preliminary calculations using the EPA 168 publication guidelines to estimate potential irrigation area and winter storage requirements.

Based on the “Initial Phase” Treatment design flows presented in Table 2, initial estimates indicate a disposal area of approximately 5,000-6,000 m^2 depending on crop and potential 1.0-1.5 ML of winter storage.

In considering the “Ultimate” Treatment design flows presented in Table 2, initial estimates indicate a disposal area of approximately 14,500-19,000 m^2 depending on crop and potential 2.7-3.4 ML of winter storage

Note: These preliminary estimates will need to be confirmed through a full LCA.

FIGURE 9: INDICATIVE EFFLUENT DISPERSAL AREA (CIRCA 5000 m^2)

Recommended effluent disposal options for "Initial Phase"

- Disposal to grassed area on crown land (zoned PUZ1) adjacent to treatment system to be leased by council via pressure-compensated drip irrigation.
- Consideration should be given to pressure-compensated drip irrigation of adjacent bushland (crown land zoned PUZ1 to be leased by council) during detailed design.

Recommended effluent disposal options for "Ultimate" scenario

- Disposal to crown land (zoned PUZ1) adjacent to treatment system to be leased by council via pressure-compensated drip irrigation (land clearing may be required).
- Consideration of off-site disposal options

Winter Storage Options

Winter storage is usually required to prevent excess irrigation during the winter period causing water logging of soils and resulting in infiltration to groundwater. The requirement by the EPA ((refer section 5.1, EPA Publication 168, Guidelines for Wastewater Irrigation, revised April 1991) is that "Facilities for wastewater storage and irrigation should be designed and constructed to contain all the waste in at least the 90 percentile (rainfall) year". It should be noted that a smart pressure sewer network and reedbed system are not as adversely affected by wet weather flows as gravity sewer networks and lagoon treatment systems due to reduced infiltration into the pipe network and reduce rainwater collection area of reedbeds compared to lagoon systems.

- Dam storage
    - Large area – not accommodated in treatment area
    - Heritage impacts from excavation
    - Constructability in unstable ground and additional cost implications
    - Requires additional storage volume winter rainfall falling on the storage dam itself
- Tank storage
    - Can potentially be located in treatment area.
    - Cost-effective option requiring minimal excavation.
    - No rainfall capture so no need to allow extra storage rainfall = reduced winter storage requirement.

- No winter storage
    - Discharge of winter wastewater to land during busier summer period potentially increasing seepage to groundwater during that time, and this along with greater groundwater extraction during summer period potentially increases exposure risks.
    - Continued irrigation through winter should not pose any additional risks to groundwater quality for the following reasons:
        - This is currently what happens with existing onsite systems
        - Winter flow volumes are low which leads to low land application rates and increased treatment,
        - Reedbed offers higher treatment efficiency than existing onsite systems
        - Treatment through sandy soil profile is high (>10m soil depth) in comparison to existing onsite systems,
        - Distance from disposal area to existing extraction bores is high (>50m),
        - Dilution with winter rainfall is high due to higher aquifer recharge in winter
        - Reduced groundwater extraction increases residence time of any treated wastewater which may reach the aquifer and hence offers additional treatment (within the aquifer) prior to extraction.

Recommended Winter Storage

- For the purposes of costing we have allowed for 1,000 kL of tank storage for winter storage for the "Initial Phase". This can be expanded ~3 times to consider the "Ultimate" flow regime.
- Moving forward we would look to work with the EPA to establish a "no winter storage" option

8. TREATMENT, DISPOSAL AND STORAGE SUMMARY

Phases	Scope	Total Estimated Flows (kL/day)	Treatment System, Disposal and Storage
Initial Phase	• existing commercial area • public toilets at the surf life-saving club • public toilets Jupiter Boulevard Park • surf lifesaving club • future potential expansion of commercial zone	Peak = 30.2 Treatment Design = 18.5	• 10 x 20' shipping containers • 5,000-6,000 m^2 irrigation area • 1.0-1.5 ML of winter storage
Ultimate Design	• addition of caravan park • addition of priority residential houses along sewer route	Peak = 82.2 Treatment Design = 62.0	• 34 x 20' shipping containers • 14,500-19,000 m^2 irrigation area • 2.7-3.4 ML of winter storage

9. TREATMENT AND DISPOSAL RISKS

- Buffer distances
  - EPA publication 500, Figure 5: Suggested buffer distances indicates that for a population equivalent of 100 (20,000 L/day @ 200 L/ person) a bio-filter plant would require a buffer distance of around 20m.
  - EPA publication 168, Table 1, recommend minimum setback distance for wastewater drip irrigation areas is 20m with appropriate fencing and notices
- Noise
  - The reedbed system has few sources of noise. Electrical / mechanical items consist of small pumps and small air blowers. These items will be contained within pumpwells or other housing structures and emit low noise levels.
  - Removal of solids from first stage occurs only once per ten years via small excavator.
  - Site A is also located minimum of 40m distance from nearby residences with dense vegetation between which will mitigate any noise produced by the plant.
- Odour Management
  - EPA require no discernible odour at boundary (EPA 500)
  - Aerobic vertical flow reedbeds are extremely low in odour and will present far less risk of odour than a waste activated treatment system or lagoons.
  - Annual wind roses from the BOM (Wonthaggi Station no. 086127) indicate prevailing winds are predominantly north-westerly (9am) and west and north-westerly (3pm). Winds in this direction would aid in dispersal and cast any potential odour over low density residential areas or bushland with no residences. An odour management strategy would need to be prepared during the detailed design phase of the project.
  - Site A is also located minimum of 40m distance from nearby residences allowing dissipation of any odour.
  - An odour management strategy will be required as part of detailed design.
- Flood risk
  - There is minimal risk of flood in either treatment site location.
  - Risk of water ingress into pressure sewer system due to floods in low lying areas is extremely low due to sealed storages and pressurised pipe system.
- Risks from fire
  - The common reed (*Phragmites australis*) is known to go through a period of senescence for a period of 3-4 months during winter at which time the above ground part of the plants “brown off” and potentially become flammable.
  - The risk from fire is low as the senescence occurs during the winter period and fires or other sources of ignition in this cooler period are unlikely.
  - The risk of fire from reedbeds is no greater than surrounding vegetated areas.
  - The above ground containerised installation reduces the fire risk.
  - Harvesting of reeds prior to senescence is possible to help reduce fire risk if required.
- Discussion of risks from wildlife (rabbits, wombats, snakes other)
  - For the containerised system most animals would find it difficult to enter, therefore, we see no additional risks.
  - Failure of irrigation pipework through damage by animals (chewing or other) is a possible risk which can be monitored through pressure sensors in the irrigation network and regular irrigation inspections.

- Security
    - Perimeter fencing to deter theft and vandalism should be considered along with lockable enclosures for key equipment for additional safety.
    - Remote monitoring cameras can be mounted to monitor system and provide a level of security along with ability to monitor plant health.

10. DETAIL DESIGN CONSIDERATIONS AND APPROVALS

Treatment plant and effluent discharge approvals

The construction of a wastewater treatment plant treating more than 5000 L/day requires a Works Approval from VicEPA. In our experience this can take many months and should be considered in project planning.

The disposal of treated effluent to the environment will form part of the VicEPA Works Approval. This will require consideration of treated water quality and any impacts on the environment (including groundwater).

Should vegetation removal be required for construction of the treatment plant or irrigation drain field then approval from DEWLP would be required as part of the works approval process.

Planning Approval (Planning and Environmental Act 1970)

It is anticipated that the impact of construction activities will be minimal based on directional drilling of pipework within the existing road reserve network and avoiding vegetation. The CIZ (Construction Impact Zones) being limited to drill sites (8m * 2m) generally 100m apart and the treatment plant site. The treatment plant will be containerised, above ground and largely fabricated off site minimising disturbance. On this basis planning permission for the network should be exempt based on water infrastructure in road reserve avoiding all native vegetation disturbance. Detail design should seek to avoid damage to native vegetation and pursue planning exemption.

Cultural heritage

Precedence in similar pressure sewer installation work within the Mornington Peninsula suggest cultural heritage disturbance is unlikely with directional drilling of small-bore pipework in the disturbed road reserve.

However, installation of a winter storage dam and or effluent disposal in undisturbed or less disturbed areas will require a cultural heritage investigation to ensure cultural heritage values in proposed areas are protected. A cultural heritage due diligence report is recommended for treatment site selection at detailed design stage.

11. OPINION OF PROBABLE COST

The figures presented herein are our opinion of probable cost and will be affected by detailed design, discussions with EPA, items such as survey, LCA, Geotech investigations and other authority approvals. They have been provided for the purpose of an initial options analysis feasibility study.

The cost estimate table below for the Reticulation Infrastructure System is based on individual pressure sewer connections to each commercial property sized to achieve 24 hours storage. The network costs are based on recommended alignment on Canterbury Rd (Option A1) with directional drilling for pressure sewer network within road reserves. This option caters for both the "Initial" Phase and the "Ultimate" phase.

Capital costs

Reticulation Infrastructure System

Item	Description	Unit	Quantity	Price ($)	Total ($)
1	OD50mm PE100 pipe installed	m	220	110	24,000
2	OD63mm PE100 pipe installed	m	660	120	79,200
3	OD90mm PE100 pipe installed	m	1,860	150	279,000
4	Single pump connection (1000L)	no	3	11,500	34,500
5	Double pump connection (1500L)	no	6	17,500	105,000
6	Double pump connection (3000L)	no	2	21,500	43,000
7	Double pump connection (7000L)	no	1	30,000	30,000
SUBTOTAL			**2,752**	**80,880**	**594,700**

The treatment plant cost estimate is based on containerised reedbed solution to minimum Class C, effluent disposal in grassed area and winter storage tanks. We have provided cost estimates for both the "Initial" Phase and the "Ultimate" phase

Initial Phase Treatment & Disposal System

Item	Description	Unit	Quantity	Price ($)	Total ($)
8a	Containerised Reedbed Treatment Plant	no	1	505,000	505,000
9a	Irrigation System (including pumpwell and pumps)	no	1	127,000	127,000
10a	Winter Storage Tank (if required)	kL	1,000	300,000	300,000
SUBTOTAL				**932,000**	**932,000**

Ultimate Phase Treatment & Disposal System

Item	Description	Unit	Quantity	Price ($)	Total ($)
8b	Containerised Reedbed Treatment Plant	no	3	1,448,000	1,448,000
9b	Irrigation System (including pumpwell and pumps)	no	3	381,000	381,000
10b	Winter Storage Tank (if required)	kL	3,000	900,000	900,000
SUBTOTAL				**2,729,000**	**2,729,000**

Exclusions

Estimated Costs Exclude:

- GST costs
- Contingency & escalation allowances
- Land acquisition costs
- Native vegetation management
- Site preparation, access road / tracks
- Site servicing (water, electricity, etc)
- Fencing / Security (site dependent)
- Professional fees (outside of treatment system)
- Site analysis and reporting (LCA, environmental, ecology, culture and heritage, geotechnical investigations etc.)
- Community consultation
- Groundwater analysis
- Authority approval process including fees (and any water testing required)

Ongoing maintenance costs (typical)

Connection and Sewer Network

The connection and network maintenance costs will include monitoring cost at approx. $40/site/year and likely replacement of components at average 10 to 15 years for the controller and 20 years for pumps. The pressure sewer system with fault alarms is a run to failure system so no routine maintenance required. Anticipate a call out rate of 5% to 7% for faults.

Reedbed Treatment Plant

The maintenance of reedbed treatment systems is relatively simple and well within the abilities of authority water treatment operators. Some basic training will be required in terms of management of the reeds / plants.

We would estimate that during peak season the Initial phase system may require 1 person for 1/2 day per week, however, during the off-season this would be significantly less. Based on this we would estimate costs at around $15k to $20k per annum.

Replacement of mechanical components such as pumps will likely be required every 15 to 20 years.

12. APPENDICES

A. Weekly runtime data for commercial connections in PLN

B. Poster - 3-stage Reedbed system trial at SEW Boneo WWTP

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
PWPSS00019	18687	16470	17462	19479	19629	20644	21724	134095	10,728	Sheds
PWPSS000138	0	0	0	18257	22485	22355	22282	85379	6,830	Dairy
LOCHPSS000108	698	2625	8459	4078	1562	1726	2947	22095	1,768	Hotel
NYORA00052	1157	4740	4037	1920	2126	4131	2683	20794	1,664	Residential
PWPSS00027	437	1565	4205	3369	2911	2962	3272	18721	1,498	Kindergarden
NYORA000176	1892	2697	3697	3687	1642	2707	2180	18502	1,480	Residential
NYORA00077	2120	3645	3183	2114	1951	2119	3024	18156	1,452	Residential
NYORA000137	1725	1498	1766	3736	1814	1930	1963	14431	1,154	Residential
NYORA000115	605	1610	3759	2834	1944	1051	2596	14399	1,152	Residential
NYORA00069	2036	1610	2773	3493	1020	1194	2070	14196	1,136	Residential
NYORA000140	303	162	298	313	1407	10690	364	13537	1,083	Residential
NYORA000198	933	1010	3737	2618	1392	1880	1930	13500	1,080	Residential
NYORA00012	2056	2172	1739	1226	1162	2090	2968	13413	1,073	Residential
NYORA000192	1654	1809	2256	1976	1800	1707	1722	12924	1,034	Residential
NYORA00088	2161	1338	1996	1620	1532	1696	2414	12757	1,021	Residential
NYORA000105	1263	1651	1825	969	945	3129	2654	12436	995	Residential
LOCHPSS0001	1997	1298	1437	1955	1824	1715	1953	12179	974	Brewery & Distillery
NYORA000112	1268	1281	1372	1844	1725	2059	1837	11386	911	
NYORA000108	1398	2117	1579	1559	1559	1024	2087	11323	906	
NYORA000191	1150	1564	1420	2171	1624	2113	1141	11183	895	
NYORA00096	1552	1713	1611	1690	2104	937	1229	10836	867	
NYORA00062	1070	1773	2143	1176	1946	866	1690	10664	853	
NYORA00014	168	2243	3874	1959	302	496	1515	10557	845	
PWPSS000123	601	2278	973	566	3620	778	1268	10084	807	
NYORA00011	1599	1358	642	1794	1092	2480	784	9749	780	
NYORA000196	1304	1121	1189	1107	1816	1306	1489	9332	747	
NYORA00053	2446	2366	901	655	1990	0	961	9319	746	
NYORA-04753	1758	547	1835	1238	1931	357	1440	9106	728	
NYORA000113	2138	839	886	1036	1798	566	1647	8910	713	
PWPSS000112	1369	1172	1045	816	1443	1702	1317	8864	709	
NYORA000125	1655	2838	623	726	661	416	1562	8481	678	
LOCHPSS00037	1762	496	1584	1756	656	550	1401	8205	656	
PWPSS00090	166	397	1863	3239	761	834	795	8055	644	
NYORA000172	877	705	1070	1094	1891	616	1756	8009	641	
NYORA000169	1105	936	1029	1095	967	893	1935	7960	637	Pizza & Takeaway
NYORA000164	1939	592	1448	1209	607	942	1179	7916	633	
LOCHPSS000100	0	423	541	4057	1713	706	376	7816	625	
LOCHPSS00011	1398	1022	1045	1087	991	1545	711	7799	624	
NYORA-04106-2	1074	975	1452	888	764	1360	1103	7616	609	
NYORA000141	250	275	2268	1972	909	643	1174	7491	599	
PWPSS00062	1089	1814	1359	674	806	958	778	7478	598	
PWPSS000101	145	1261	2351	1092	645	813	1093	7400	592	
NYORA00020	604	1078	1500	1005	713	928	1550	7378	590	
PWPSS00036	845	997	996	1215	571	1518	1005	7147	572	
NYORA000148	379	1476	1058	1032	700	308	2128	7081	566	
NYORA-04841	373	1004	1096	938	889	969	1803	7072	566	
NYORA00037	370	1269	2343	1289	551	359	734	6915	553	
PWPSS000115	464	1350	1709	953	379	858	1190	6903	552	
PWPSS00054	921	1090	1057	1331	772	666	1040	6877	550	
NYORA000133	645	881	847	694	953	1553	1275	6848	548	
LOCHPSS00016	479	1266	1858	880	658	605	1091	6837	547	
LOCHPSS00018	1661	847	1162	660	541	615	1292	6778	542	
PWPSS00097	929	704	599	2234	608	573	969	6616	529	
NYORA000194	1401	632	1090	1192	779	577	880	6551	524	
PWPSS00049	793	1422	726	1375	803	600	642	6361	509	
NYORA-06118	912	807	1005	693	1352	1074	511	6354	508	
PWPSS00047	2152	690	789	685	410	1002	591	6319	506	
NYORA000114	848	680	853	852	655	1095	1326	6309	505	
LOCHPSS0003	673	384	1089	514	1116	1474	1033	6283	503	
NYORA000146	1025	475	1016	932	919	843	934	6144	492	

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
NYORA00061	1825	849	454	797	1014	0	1161	6100	488	
NYORA000107	1271	463	1001	631	521	828	1340	6055	484	
NYORA00094	730	656	853	1168	905	1028	704	6044	484	
NYORA00080	839	658	1219	694	811	821	998	6040	483	
LOCHPSS00054	875	268	1105	878	849	833	1129	5937	475	
PWPSS00096	594	952	576	861	1031	970	824	5808	465	
NYORA000135	1484	1111	326	330	0	1659	865	5775	462	
PWPSS000134	518	569	616	760	359	2584	362	5768	461	
NYORA000165	885	727	555	515	750	1234	1002	5668	453	
NYORA000144	921	580	1064	353	645	987	1102	5652	452	
LOCHPSS000101	1201	1184	0	0	1279	964	947	5575	446	Café
NYORA00041	616	298	621	2064	590	305	1066	5560	445	
LOCHPSS00094	533	643	1040	917	839	1182	377	5531	442	
NYORA-05276	335	1047	988	756	505	955	923	5509	441	
LOCHPSS0004	382	606	788	1061	770	910	991	5508	441	
NYORA000162	955	779	987	914	151	480	1194	5460	437	
NYORA000177	559	834	677	1027	923	323	1078	5421	434	
PWPSS00040	425	843	831	884	769	800	774	5326	426	
PWPSS00010	899	797	510	733	578	858	921	5296	424	
NYORA00076	372	788	961	382	762	1207	798	5270	422	
PWPSS00069	897	397	507	1299	363	548	1143	5154	412	
NYORA-07237	355	454	797	1067	913	818	714	5118	409	
PWPSS00077	888	970	905	463	557	369	956	5108	409	
NYORA00030	676	296	608	585	807	857	1203	5032	403	
NYORA00086	558	587	354	573	1404	579	969	5024	402	
NYORA0006	330	916	467	663	762	878	1005	5021	402	
PWPSS00083	550	567	2101	681	374	175	520	4968	397	
NYORA00013	579	809	634	1197	429	895	404	4947	396	
LOCHPSS00089	705	431	876	660	900	640	713	4925	394	
PWPSS00068	392	751	695	849	546	691	990	4914	393	
NYORA0007	273	609	1103	574	273	698	1379	4909	393	
NYORA000170	536	522	626	711	405	1158	949	4907	393	
NYORA-07015	465	1204	469	436	1034	663	612	4883	391	
NYORA000200	505	643	808	710	770	900	541	4877	390	
PWPSS00046	676	566	671	469	689	982	824	4877	390	
NYORA-05376	693	340	1025	560	534	1117	607	4876	390	
NYORA00085	580	649	688	676	1093	405	770	4861	389	
PWPSS0001	574	909	461	1260	967	246	401	4818	385	
NYORA00097	621	635	445	672	499	1204	707	4783	383	
NYORA000106	480	512	768	890	515	889	647	4701	376	
NYORA000190	504	679	360	603	1102	610	833	4691	375	
NYORA-07401	1044	489	590	392	483	753	918	4669	374	
LOCHPSS00017	717	516	233	712	773	764	931	4646	372	
LOCHPSS000112	564	996	770	514	354	932	507	4637	371	
NYORA000128	658	506	1068	590	552	693	555	4622	370	
PWPSS00057	736	336	934	375	1222	541	454	4598	368	
PWPSS000107	454	510	815	439	798	915	643	4574	366	
PWPSS0006	811	526	433	597	577	1130	483	4557	365	
NYORA-06316	796	602	544	485	691	838	595	4551	364	
PWPSS00024	319	1021	716	1082	339	359	708	4544	364	
LOCHPSS00093	749	449	620	764	962	686	275	4505	360	
NYORA000129	563	785	601	912	151	1046	440	4498	360	
NYORA00074	551	1066	680	570	530	546	555	4498	360	General Store
NYORA00045	773	409	839	635	830	393	616	4495	360	
LOCHPSS00062	445	602	753	608	600	610	868	4486	359	
NYORA00058	153	155	904	312	1576	452	932	4484	359	
LOCHPSS000102	732	526	517	762	631	748	546	4462	357	
PWPSS00081	408	951	873	837	162	662	556	4449	356	
NYORA000122	324	206	594	558	492	639	1560	4373	350	
LOCHPSS000107	0	589	1032	722	288	603	1121	4355	348	Wine Bar

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
NYORA00035	643	786	454	361	370	723	991	4328	346	
LOCHPSS00045	500	822	801	668	400	496	636	4323	346	
PWPSS00089	636	830	709	695	544	147	754	4315	345	
PWPSS00038	647	824	606	469	510	651	607	4314	345	
NYORA000111	679	572	743	514	422	852	513	4295	344	
NYORA00084	187	765	841	604	388	820	681	4286	343	
NYORA00049	817	556	841	400	679	403	568	4264	341	
PWPSS00093	814	500	542	403	1012	398	559	4228	338	Café & Takeaway
PWPSS00044	949	438	579	707	746	500	308	4227	338	
NYORA000193	718	334	592	798	344	731	703	4220	338	
NYORA00092	164	1018	901	356	571	520	670	4200	336	
NYORA000104	557	586	865	692	437	580	437	4154	332	
PWPSS00011	550	638	550	1046	596	187	567	4134	331	
NYORA000147	187	706	468	590	631	736	802	4120	330	
PWPSS00032	682	679	470	860	174	539	704	4108	329	
NYORA00067	530	699	839	476	313	440	795	4092	327	
PWPSS00016	786	210	296	457	739	893	666	4047	324	
LOCHPSS00033	784	256	397	743	872	530	425	4007	321	
PWPSS00066	559	575	558	440	429	770	666	3997	320	
LOCHPSS00079	336	530	649	558	630	464	816	3983	319	
NYORA000130	112	640	1473	975	288	57	398	3943	315	Pharmacy
NYORA000167	611	382	683	660	549	490	566	3941	315	
NYORA000110	325	578	464	823	310	631	787	3918	313	
NYORA000204	481	635	335	322	489	952	698	3912	313	
NYORA00063	425	691	662	659	401	330	741	3909	313	
PWPSS00018	322	822	153	649	754	525	684	3909	313	
NYORA000119	551	658	590	217	404	667	799	3886	311	
LOCHPSS00075	0	492	902	539	0	699	1223	3855	308	
NYORA000174	276	1904	336	400	410	268	260	3854	308	
LOCHPSS0006	197	588	1400	456	400	589	220	3850	308	
LOCHPSS00060	384	374	681	664	556	671	519	3849	308	
PWPSS00022	692	894	354	364	318	527	689	3838	307	
NYORA-08544	265	151	247	692	546	1021	909	3831	306	
NYORA00054	659	294	519	456	652	445	802	3827	306	
NYORA-04866	610	426	516	510	556	588	605	3811	305	
PWPSS00023	490	501	475	500	717	501	569	3753	300	
NYORA000171	311	622	632	283	433	691	768	3740	299	
LOCHPSS00026	840	0	1052	960	635	238	0	3725	298	
NYORA00090	633	376	295	271	270	936	915	3696	296	
NYORA000201	599	591	951	485	134	713	160	3633	291	
LOCHPSS00023	375	526	571	379	520	860	400	3631	290	
PWPSS00031	372	186	830	408	147	1074	611	3628	290	
PWPSS00014	460	361	552	577	289	938	421	3598	288	
NYORA-07238	517	370	650	556	402	704	382	3581	286	
NYORA-04820	490	570	478	445	719	283	590	3575	286	
PWPSS000113	443	485	258	232	0	268	1886	3572	286	General Store
LOCHPSS00052	518	303	294	778	536	312	823	3564	285	
NYORA-06884	250	325	483	444	673	533	811	3519	282	
PWPSS00033	422	318	263	465	610	974	453	3505	280	
LOCHPSS00049	0	0	1315	663	124	334	1047	3483	279	
PWPSS00085	525	311	565	539	328	703	509	3480	278	
LOCHPSS000106	423	603	284	366	672	627	485	3460	277	
LOCHPSS00022	546	389	540	433	486	496	562	3452	276	
LOCHPSS00019	129	682	1008	560	399	136	532	3446	276	
PWPSS00028	519	285	695	333	545	553	516	3446	276	
LOCHPSS00041	539	379	564	338	751	527	339	3437	275	
NYORA00017	540	800	446	319	340	321	665	3431	274	
NYORA000117	585	564	439	420	407	717	282	3414	273	
NYORA-04725	571	502	571	536	358	351	520	3409	273	
LOCHPSS00099	0	76	581	753	489	611	895	3405	272	Foodstore & Café

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
NYORA00036	390	535	275	840	290	615	455	3400	272	
LOCHPSS00071	601	271	472	496	450	249	860	3399	272	
PWPSS000105	518	585	310	509	353	777	328	3380	270	
NYORA00016	421	610	614	408	435	637	249	3374	270	
NYORA000189	383	548	531	410	526	400	555	3353	268	
LOCHPSS00090	292	642	290	121	733	253	1004	3335	267	
NYORA000142	92	666	560	593	307	373	706	3297	264	
NYORA000149	380	539	760	332	152	595	538	3296	264	
PWPSS00074	0	1884	793	143	137	148	149	3254	260	
LOCHPSS00059	353	515	322	550	303	692	515	3250	260	
PWPSS00064	533	263	484	343	154	660	789	3226	258	
NYORA000143	165	470	482	454	145	771	738	3225	258	
PWPSS00026	397	573	740	558	354	243	338	3203	256	
NYORA00081	302	351	314	145	275	1166	624	3177	254	
NYORA000210	353	241	1299	374	373	167	359	3166	253	
LOCHPSS00067	452	465	445	486	359	434	479	3120	250	
LOCHPSS00048	293	230	430	653	506	521	475	3108	249	
NYORA00029	373	479	305	503	184	772	486	3102	248	
NYORA000134	278	0	124	293	0	368	2024	3087	247	
NYORA00059	132	555	576	532	438	441	404	3078	246	
NYORA00066	444	273	267	605	610	0	869	3068	245	
NYORA000156	135	481	453	295	294	895	492	3045	244	
NYORA00022	505	495	364	480	521	289	366	3020	242	
LOCHPSS00046	490	339	660	324	471	297	403	2984	239	
NYORA00024	339	491	466	664	481	177	354	2972	238	
NYORA00026	293	747	741	708	155	141	150	2935	235	
PWPSS000117	289	484	420	444	729	282	273	2921	234	
PWPSS00034	140	702	325	414	134	136	1005	2856	228	
NYORA00047	284	255	143	565	281	696	625	2849	228	
LOCHPSS00057	631	160	489	349	500	160	557	2846	228	
NYORA00048	541	253	945	254	137	319	383	2832	227	
NYORA000118	296	125	914	509	276	126	558	2804	224	
LOCHPSS00077	484	460	384	473	328	475	177	2781	222	
NYORA000100	326	281	565	395	437	445	316	2765	221	
LOCHPSS00083	306	180	324	815	270	490	346	2731	218	
NYORA000178	257	263	291	125	861	250	652	2699	216	
NYORA-06477	585	269	265	129	660	501	290	2699	216	
LOCHPSS00038	531	374	453	338	342	141	516	2695	216	
NYORA000179	318	202	325	348	557	442	502	2694	216	
NYORA000153	237	448	236	449	283	541	450	2644	212	
NYORA000116	716	263	215	253	286	253	617	2603	208	
NYORA000208	180	154	170	432	175	701	762	2574	206	
NYORA000126	515	335	602	399	185	181	346	2563	205	
LOCHPSS000109	352	177	356	177	357	540	561	2520	202	
PWPSS000133	369	188	373	462	269	271	535	2467	197	
PWPSS000102	283	220	393	291	289	283	631	2390	191	
NYORA00050	369	339	360	238	465	229	366	2366	189	
NYORA000182	284	268	156	131	576	158	779	2352	188	
PWPSS00098	0	846	0	761	0	0	721	2328	186	
LOCHPSS000114	162	313	461	301	308	468	314	2327	186	
LOCHPSS0005	621	436	239	546	421	0	60	2323	186	
PWPSS00043	205	446	456	458	302	310	136	2313	185	
PWPSS00037	365	267	381	181	543	395	180	2312	185	
NYORA-05906	228	242	522	112	258	266	683	2311	185	
NYORA00083	342	128	377	146	267	567	460	2287	183	
PWPSS000122	348	637	469	0	424	376	0	2254	180	
NYORA00057	268	313	0	555	526	250	330	2242	179	
PWPSS00099	228	29	404	651	515	205	210	2242	179	
NYORA00021	300	403	581	157	350	156	284	2231	178	
NYORA00034	249	241	307	375	410	258	387	2227	178	

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
NYORA000152	210	200	290	97	650	414	335	2196	176	
PWPSS00061	312	456	286	142	293	429	276	2194	176	
NYORA000157	0	361	730	360	388	0	341	2180	174	
LOCHPSS00043	281	270	283	478	267	132	464	2175	174	
NYORA0008	262	135	403	149	270	690	261	2170	174	
LOCHPSS00082	397	242	240	409	121	236	495	2140	171	
NYORA000180	105	255	456	405	260	205	451	2137	171	
NYORA000160	406	270	269	458	305	150	270	2128	170	
PWPSS00076	314	252	390	344	342	334	152	2128	170	
PWPSS00020	566	136	452	136	376	164	289	2119	170	
PWPSS00095	563	219	439	151	284	153	307	2116	169	
LOCHPSS00036	0	360	522	354	175	200	431	2042	163	
PWPSS000109	116	394	371	119	423	264	355	2042	163	
PWPSS000121	136	410	1126	228	0	0	132	2032	163	
NYORA000127	412	441	500	137	126	132	273	2021	162	
LOCHPSS00081	294	369	190	401	381	289	95	2019	162	
LOCHPSS00051	373	355	195	200	225	363	290	2001	160	
LOCHPSS0002	0	265	149	160	410	448	540	1972	158	
NYORA000138	132	389	253	259	404	277	258	1972	158	
NYORA000173	144	160	141	295	283	475	465	1963	157	
PWPSS000106	457	211	130	321	436	120	282	1957	157	
LOCHPSS00025	492	430	612	138	276	0	0	1948	156	
NYORA-04735	314	546	583	502	0	0	0	1945	156	
PWPSS000120	131	68	287	167	561	591	136	1941	155	
PWPSS00030	337	77	919	155	148	145	158	1939	155	
PWPSS00053	182	295	544	190	354	175	187	1927	154	
PWPSS0008	199	67	607	205	390	201	255	1924	154	
NYORA-04192-2	371	167	450	281	135	178	305	1887	151	
PWPSS000128	0	474	147	474	162	327	303	1887	151	
PWPSS00087	0	148	0	0	0	1250	476	1874	150	
NYORA00018	0	328	856	335	0	338	0	1857	149	
PWPSS000103	162	305	165	300	309	310	299	1850	148	
LOCHPSS00027	305	446	183	140	145	190	435	1844	148	
PWPSS00052	0	276	419	438	139	148	412	1832	147	
LOCHPSS00024	304	292	140	131	387	424	143	1821	146	
PWPSS00058	150	286	509	334	0	0	530	1809	145	
PWPSS00065	153	359	293	151	269	298	282	1805	144	
NYORA-08545	242	155	257	136	352	363	292	1797	144	
LOCHPSS00010	479	336	326	320	324	0	0	1785	143	
NYORA00082	405	280	398	267	425	0	0	1775	142	
NYORA00070	195	185	170	375	466	165	208	1764	141	
LOCHPSS00039	553	409	399	137	263	0	0	1761	141	
NYORA000150	0	185	20	946	124	458	0	1733	139	
LOCHPSS00013	140	192	340	292	147	309	294	1714	137	
LOCHPSS00074	0	0	380	478	220	295	340	1713	137	
LOCHPSS00030	290	160	407	300	275	149	126	1707	137	
NYORA00064	181	379	369	182	217	176	190	1694	136	
PWPSS000110	0	139	169	328	294	324	440	1694	136	
NYORA-04752	276	177	394	177	197	208	264	1693	135	
NYORA000161	142	266	135	141	281	581	135	1681	134	
NYORA-07712	278	199	366	236	492	108	0	1679	134	
NYORA000136	130	127	282	257	400	161	319	1676	134	
NYORA00071	299	333	433	298	0	306	0	1669	134	
NYORA-05904	145	232	471	140	190	327	162	1667	133	
NYORA0003	220	157	226	295	394	231	143	1666	133	
LOCHPSS00068	0	188	376	187	191	500	212	1654	132	
NYORA00095	155	0	295	161	177	363	501	1652	132	
LOCHPSS00034	170	150	180	325	156	168	502	1651	132	
NYORA00046	127	252	252	132	289	257	313	1622	130	
NYORA-06364	0	338	247	266	250	131	387	1619	130	

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
NYORA00025	403	0	496	0	221	258	216	1594	128	
NYORA00027	125	251	259	261	135	264	275	1570	126	
LOCHPSS00087	285	132	146	320	155	371	160	1569	126	
LOCHPSS00066	187	208	539	207	213	0	197	1551	124	
NYORA-04738	0	0	0	305	399	409	421	1534	123	
NYORA-06117	400	101	205	106	319	103	300	1534	123	
PWPSS00080	233	719	0	0	0	405	170	1527	122	
NYORA-04842	117	136	236	132	415	121	364	1521	122	
NYORA000158	659	0	342	0	0	0	492	1493	119	
NYORA000123	142	151	156	151	334	137	415	1486	119	
PWPSS000124	201	156	197	308	205	101	298	1466	117	
PWPSS00039	221	146	235	387	113	231	133	1466	117	
PWPSS00035	327	495	160	158	325	0	0	1465	117	
PWPSS00021	147	242	137	167	145	485	136	1459	117	
PWPSS00050	220	395	670	160	0	0	0	1445	116	
PWPSS000111	129	221	402	275	134	134	140	1435	115	
LOCHPSS00040	0	516	177	197	156	151	207	1404	112	
LOCHPSS00096	264	0	126	290	0	261	463	1404	112	
LOCHPSS00078	120	236	225	276	115	273	126	1371	110	
PWPSS000135	0	454	0	470	0	444	0	1368	109	
NYORA00098	0	382	342	450	190	0	0	1364	109	
PWPSS00048	201	375	241	180	0	182	180	1359	109	
PWPSS00082	0	152	660	172	178	195	0	1357	109	IGA X-press
NYORA000168	248	225	370	0	234	264	0	1341	107	
LOCHPSS000113	175	192	0	182	207	398	172	1326	106	
LOCHPSS00042	0	0	125	0	390	395	375	1285	103	
PWPSS00060	116	137	236	396	132	122	125	1264	101	
LOCHPSS00088	0	149	159	289	261	123	265	1246	100	
PWPSS00070	193	79	190	210	0	371	170	1213	97	
LOCHPSS00050	0	354	693	0	0	161	0	1208	97	
NYORA000185	127	296	255	129	129	135	129	1200	96	
PWPSS00055	0	132	167	362	0	366	172	1199	96	
LOCHPSS00064	351	0	172	172	344	0	156	1195	96	
NYORA-06713	131	301	266	0	0	374	114	1186	95	
NYORA-06880	199	105	203	120	212	110	213	1162	93	
LOCHPSS00014	150	302	146	146	156	0	248	1148	92	
PWPSS000127	0	154	0	0	0	985	0	1139	91	
NYORA000139	150	0	294	130	146	139	277	1136	91	
NYORA000186	0	0	684	293	0	0	131	1108	89	
LOCHPSS00061	112	110	230	230	0	227	127	1036	83	
PWPSS00051	131	60	0	136	0	575	131	1033	83	
NYORA000212	175	320	180	194	155	0	0	1024	82	
NYORA000120	288	0	277	0	298	157	0	1020	82	
NYORA000175	0	172	167	167	167	167	168	1008	81	
LOCHPSS00029	241	120	121	121	120	120	121	964	77	
NYORA00099	215	0	175	176	230	0	165	961	77	
LOCHPSS000105	182	0	151	138	0	311	163	945	76	
PWPSS000131	0	138	199	262	236	0	106	941	75	
LOCHPSS00085	174	0	0	88	192	98	374	926	74	
NYORA000184	153	329	0	130	144	0	159	915	73	
LOCHPSS00053	135	136	131	126	121	127	131	907	73	
PWPSS00079	0	132	234	0	270	135	120	891	71	
NYORA000101	0	202	202	238	0	192	0	834	67	
NYORA00055	0	0	0	0	0	660	170	830	66	
PWPSS00029	145	90	145	0	146	145	150	821	66	
PWPSS000108	0	468	0	0	154	0	171	793	63	
NYORA00010	145	0	145	160	150	147	0	747	60	
PWPSS000129	0	376	0	0	199	0	150	725	58	
LOCHPSS00072	0	0	364	184	0	0	175	723	58	
NYORA00033	0	146	145	142	0	146	142	721	58	

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
PWPSS0002	0	291	140	148	128	0	0	707	57	
NYORA000131	135	134	0	136	139	153	0	697	56	
LOCHPSS000110	268	0	0	167	0	127	131	693	55	
PWPSS00042	0	135	130	125	0	298	0	688	55	
LOCHPSS00069	134	135	0	159	134	125	0	687	55	
NYORA00087	85	85	170	85	87	83	92	687	55	
NYORA-04066-2	6	0	0	0	0	418	261	685	55	
LOCHPSS000104	0	137	141	0	131	129	131	669	54	
NYORA-06116	162	200	0	100	100	90	0	652	52	
LOCHPSS00058	0	0	149	0	152	322	0	623	50	
LOCHPSS00047	120	245	120	129	0	0	0	614	49	
NYORA00023	89	175	92	86	86	83	0	611	49	
PWPSS00091	172	87	168	167	0	0	0	594	48	
NYORA-08646	0	0	148	154	151	0	138	591	47	
NYORA00042	145	0	146	146	0	146	0	583	47	
PWPSS00075	187	27	0	184	0	176	0	574	46	
LOCHPSS00063	196	0	184	0	0	186	0	566	45	
NYORA00089	156	129	0	127	125	0	0	537	43	
PWPSS0009	0	71	0	159	138	0	146	514	41	
LOCHPSS00084	0	0	0	0	0	235	276	511	41	
NYORA000181	0	0	0	165	170	0	175	510	41	
LOCHPSS00020	0	0	0	122	0	0	379	501	40	
NYORA0004	0	147	0	0	177	0	152	476	38	
LOCHPSS00044	3	0	0	0	165	131	126	425	34	
PWPSS0005	0	143	0	137	0	0	136	416	33	
LOCHPSS0007	0	4	0	0	405	0	0	409	33	
PWPSS00025	373	0	0	0	0	0	0	373	30	
LOCHPSS00091	114	0	137	0	0	114	0	365	29	Bowling Club
LOCHPSS00065	0	125	0	225	0	0	0	350	28	
PWPSS000114	0	350	0	0	0	0	0	350	28	
NYORA-06478	0	0	0	0	4	0	320	324	26	
PWPSS00084	0	37	137	0	0	0	131	305	24	
LOCHPSS00056	0	136	0	0	152	0	0	288	23	
PWPSS000116	0	113	0	0	0	166	0	279	22	
NYORA00078	0	0	129	0	132	0	0	261	21	
PWPSS00063	167	59	0	0	0	0	0	226	18	
PWPSS00041	0	47	0	0	0	0	172	219	18	
PWPSS00059	0	44	0	0	0	0	166	210	17	
LOCHPSS00031	0	0	0	0	0	0	178	178	14	
PWPSS00094	0	147	0	0	0	0	0	147	12	
LOCHPSS00032	0	0	0	0	0	121	0	121	10	
LOCHPSS00035	0	0	0	0	121	0	0	121	10	
PWPSS00073	0	106	0	0	0	0	0	106	8	
LOCHPSS00080	0	0	4	95	0	0	0	99	8	
NYORA-04867	0	5	0	0	0	0	88	93	7	
LOCHPSS00055	0	0	87	0	0	0	0	87	7	
PWPSS00072	0	60	0	0	0	0	0	60	5	
PWPSS00086	0	58	0	0	0	0	0	58	5	
PWPSS00045	0	56	0	0	0	0	0	56	4	
PWPSS00092	0	50	0	0	0	0	0	50	4	
PWPSS000130	0	40	0	0	0	0	0	40	3	
NYORA-07896	0	29	0	0	0	0	0	29	2	
PWPSS000132	4	23	0	0	0	0	0	27	2	
PWPSS00071	0	27	0	0	0	0	0	27	2	
LOCHPSS00028	0	0	0	0	5	0	0	5	0	
NYORA00065	0	0	5	0	0	0	0	5	0	
LOCHPSS00015	0	0	0	0	0	0	4	4	0	
LOCHPSS00076	0	0	0	0	0	0	4	4	0	
LOCHPSS00095	0	0	4	0	0	0	0	4	0	
LOCHPSS00098	0	0	0	0	0	0	4	4	0	

Pump Run Time (secs)	30-May	31-May	1-Jun	2-Jun	3-Jun	4-Jun	5-Jun	Week Total (secs)	Flow estimate (L/d)	Property details
NYORA000145	0	0	0	0	0	0	4	4	0	
NYORA000188	0	0	0	0	0	0	4	4	0	
NYORA00032	0	0	0	0	0	0	4	4	0	
NYORA00068	0	0	0	0	0	0	4	4	0	
NYORA-05019	0	0	4	0	0	0	0	4	0	
PWPSS00056	0	4	0	0	0	0	0	4	0	
LOCHPSS00097	0	0	2	0	0	0	0	2	0	

Low energy waste water collection and treatment system for remote and developing communities

An off-grid solar energy system for pressure sewer has been successfully developed and utilised for remote sites. In conjunction, Reedbed Technology's wastewater treatment system was also trialled and demonstrated to be able to treat the wastewater from pressure sewer systems to equivalent of Class C quality. The OneBox® control system for pressure sewer is an ideal system to ensure consistent and manageable flows to the reed bed treatment maximising efficient treatment. The combination of these technologies provides the opportunity for a community sewer system for remote and developing communities who have suffered from service constraints in the past.

Introduction

Pressure Sewer technology is rapidly being adopted as an alternative for locations traditionally difficult or costly for gravity sewerage networks.

South East Water is currently deploying 16,000 pressure sewer units along the Mornington Peninsula, as part of the Peninsula ECO project replacing ageing, failing and poorly maintained septic tanks. Taking the learnings from this project, South East Water recognised the opportunity to develop a solar powered pressure sewer for remote locations where main electricity is cost prohibitive or unreliable.

CJArms as Reedbed Technology has developed a low-energy treatment technology that can treat both wastewater and sludge solids in the one system with very low OPEX. The aim of this work was to demonstrate that this low-energy treatment solution in combination with the solar powered pressure sewer could provide a complete collection and treatment system that is off-the-grid for both power and sewer.

Highlights

- Off-grid pressure sewer system successfully installed at Parks Victoria sites.
- Ability to deal with low winter UV and high demand periods utilising OneBox®.
- Reedbed Technology treatment system can successfully treat sewage from pressure sewer to equivalent Class C (see Figure 2).
- Sewage sludge is composted in-situ and removed on a 10-year cycle.
- Cost effective collection and treatment system solution for remote and developing communities with minimal operating complexity.

Process

- Developed and tested an integrated solar energy system consisting of solar panels, battery, control system, and communications integrated with a cabinet, and easy-to-install pole and footing system.
- Two Parks Victoria public toilet block sites were identified within the Peninsula Eco pressure sewer network that were still on septic tanks and didn't have electricity connection.
- Parks Victoria were interested in the solar option as the cost for electricity connection was high.
- Installed sites over the 2017–18 summer period and monitored throughout 2018.
- Independently at Boneo, trials were being undertaken by South East Water, Iota and Reedbed Technology to determine the suitability and effectiveness of the reed bed system to treat sewage generated from the pressure sewer network.
- Reedbed Technology's treatment system (see Figure 3) consisted of three stages of vertical flow reed cells with a total area of 6–8 m^2.
- Reed beds were subject to a daily feed of 600-800 L of raw sewage which was fed batch-wise in 50L doses directly onto the reed bed system (no primary treatment or screening) with a portion of the flow recirculated.
- Fortnightly sampling of sewage inflow and outflow from the reed bed system enabled analysis of treatment performance.

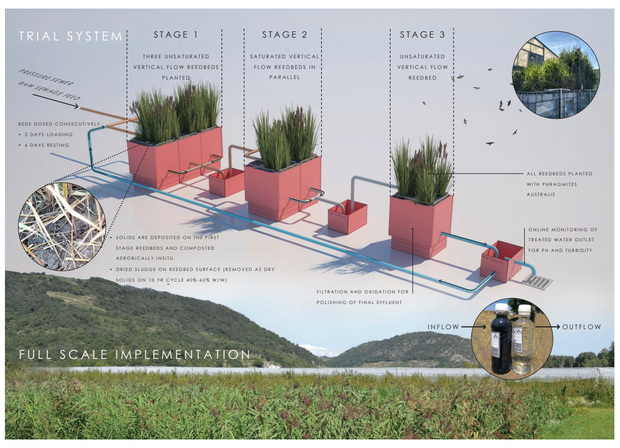


Figure 3
Trial system schematic.

Results/outcomes

The solar pressure systems originally installed for Parks Victoria were designed to meet what we considered to be a typical public toilet usage profile for relatively isolated sites. It was anticipated that it would need to pump a volume of 240–320L/day (3-4 Pump runs/day), and up to 8–10 pump runs on some extreme one-off occasions. It was also anticipated that the system would need be able to continue to operate for at least one (up to three) days with poor solar yield (i.e. UV Index 1 or less), and that the Lithium battery technology could recharge time within 1–2 hours (in UV Index 5 conditions). Under typical conditions the system worked as specified.

However, on a reasonable number of occasions the system has had to deal with conditions of 'continuous flow' cause by leaking (or open) fixtures in the amenity block. These continuous flow conditions now placed demand on the solar energy system well above the original specification and was now required to deal with volumes of 80–100L/hour meaning pump activations every 45–60 minutes. The optimisation to deal with these new performance expectations included both hardware a nd software solutions. Such as the inclusion of a second battery, development of continuous flow algorithms for OneBox® to identify the abnormal conditions and send alerts well in advance of flat batteries and high-level alarms (see Figure 1), and the development of a backup generator connection point.

The Reedbed Technology sewage treatment system achieved consistently good treatment performance over a period of 15 months, despite the highly varied quality of inflow (see Figure 4). The water analysis results shown in Figure 3 demonstrate that the system, with a treatment area of 6m^2 and a daily flow of 800L, was able to achieve equivalent of Class C quality water. Sludge composted in-situ was measured at 57 per cent w/w DS and 2mm depth within six days of the last sewage loading (see Figure 3). Water flow through the system can be achieved by gravity given sufficient fall reducing energy practically to zero. The energy use for recirculation (calculated at 0.125 kWh/kL) can be provided by a solar pump.

Conclusion

The combination of a OneBox®-controlled solar pressure sewer system, together with the Reedbed Technology sewage treatment system has demonstrated the potential to provide an integrated complete collection and treatment system that is off-the-grid for both power and sewer.

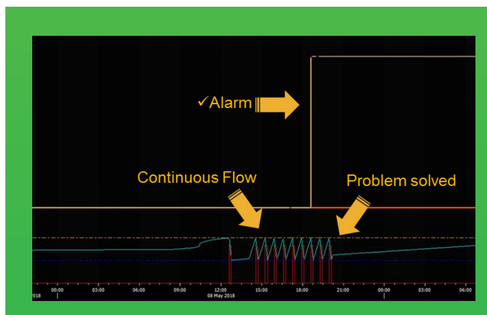
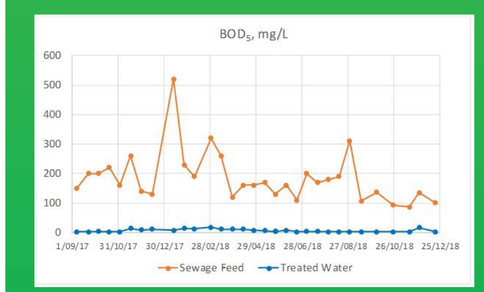


Figure 1
Demonstrates the effectiveness of continuous flow algorithm, highlighting the initial flow, alarm and when the problem was resolved.

Figure 2
Sample of sewage feed and treated water outlet.



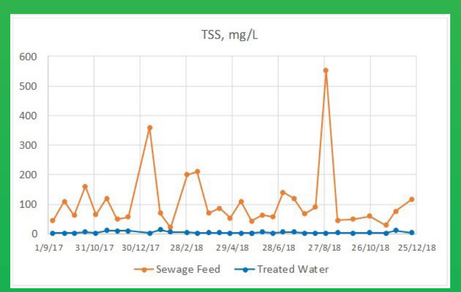


Figure 4
Visual inspection of sewage feed and treated water from reedbed system.

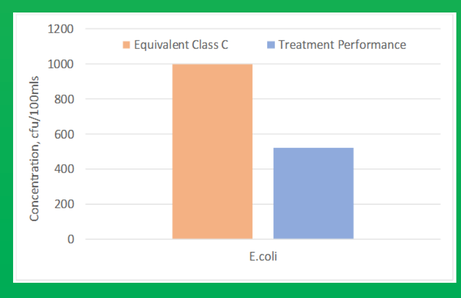


Figure 5
Performance targets and performance for treatment area of 6m2 and sewage feed of 800 L/day.

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