Porirua WWTP
Odour Management Upgrade
Best Practicable Option Assessment

PREPARED FOR WELLINGTON WATER LTD | OCTOBER 2023

Stantec

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Quality statement

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Executive Summary

The purpose of this project is to recommend the Best Practicable Option for the odour impacts currently present at the Porirua Wastewater Treatment Plant. The intent is to achieve less than 2 odour units (ou) at the nearest sensitive receptor as recommended by the NZ Ministry for the Environment's Good Practice Guide for Assessing and Managing Odour. These nearest sensitive receptors would be the houses on the properties adjacent to the treatment plant.

The Porirua Wastewater Treatment Plant (WWTP) is fed from an inlet sewer tunnel that services the city of Porirua and north of Tawa. This inlet sewer tunnel receives flows from the Tangere Drive Pumping Station and Rukutane Point pumping station. This sewer tunnel is currently ventilated. Up to approximately 2018, the ventilation fan pushed fresh air into the tunnel, which had the effect of pressurising the tunnel and forcing foul air into the plant building at the Porirua WWTP. The ventilation was reversed in approximately 2018 to draw fresh air into the sewer from upstream and discharge foul air into the atmosphere.

The Porirua WWTP inlet works includes milliscreens and associated flow channels. The headspaces of these channels are ventilated with a dedicated fan and stack. The plant building also contains screening bins, loadout areas, centrifuges and dewatered sludge bins for the centrifuges. The centrifuges have a passive ventilation system that discharges to the outside of the plant building; the centrifuges are tentatively planned to be decommissioned by late 2026 as a new solids handling upgrade facility with new ventilation and odour treatment is constructed in the northwest of the site. The remainder of the building is ventilated via a fan discharging building air directly to the atmosphere.

A property bordering the Porirua WWTP has recently been subdivided for life-style residential development. The landowner has raised complaints relating to odour from the WWTP. In response to odour complaints from the site, and taking into consideration expert witness testimony, Wellington Water Limited (WWL) were issued with an Air Discharge Permit (WGN200229 [36727]) with associated consent conditions. The consent conditions include, amongst other items, the requirement to engage a suitably qualified professional to develop a best practicable option assessment for odour control at the site.

Stantec personnel visited the site in September 2023. The findings from the site visit included the identification that the milliscreens building ventilation fan was not operating. Some covers also had gaps that were allowing foul air to escape.

Monitoring of hydrogen sulphide (H_2S) was undertaken in July and August of 2023, however most of the data was collected in low winter temperatures and during times where rain impacted the results. The pattern of hydrogen sulphide was used, temperature corrected to summer conditions, and cross checked against summer spot samples taken in 2020. This was used as the basis for design of the load to any future odour control unit.

The odour control options investigated by Stantec were as follows:

- Option 1 – A single odour control unit (OCU) treating flow from all extraction points on site.
- Option 2 – Separate treatment systems being:
  - Option 2a – One OCU treating flow from the Inlet Tunnel only. This foul air stream has a high flow but a low load.
  - Option 2b – One OCU treating flow from the rest of the extraction points. This foul air stream has a low flow but a high load.

Process flow diagrams and duct routes were developed for each option based on the available space on site.

The following OCU treatment technology options were investigated for each flow option:

- Activated Carbon (AC)
- Biofilter
- Biological Trickling Filter (BTF)
- BTF + AC in series.

Each technology for each option was assessed in a multi-criteria assessment that evaluated the following criteria:

- Operational complexity
- Odour performance – i.e., ability to remove odorous compounds.
- Impact on workplace health and safety (WHS). This was split into the following areas:
  - H_2S gas exposure performance - in particular referencing the upcoming changes to the workplace exposure standards for hydrogen sulphide
  - Non-H_2S WHS performance – relating to all other health and safety risks associated with the option.
- Future flexibility to service additional loads.

- Construction / Commissioning requirements.

The assessment concluded that the options with a stack, which provided added dispersion for treated air, were more beneficial from an odour impact and a work health and safety aspect than biofilters, which dispersed treated air at ground level. The biofilter options also required a large footprint (except for in Option 2a where the loads were relatively low), and given the space constraints on site, these biofilters were more expensive at Porirua WWTP than they would be at other sites.

Activated carbon options were identified as having low relative capital costs and good operating properties, however, the electricity costs associated with the heater and the amount of activated carbon needed for replacement on an annual basis made this technology financially unfeasible.

The assessment concluded that, given the stable loads expected to the OCU, a BTF alone would be sufficient for treatment and the value from a secondary activated carbon stage would be unlikely to offset the cost of providing it.

Whilst all options and technologies were investigated, including costing for combinations of different technologies for Option 2, the overall cost for Option 2 (splitting flows to two separate OCUs) was greater than for Option 1 (single OCU) with no added benefit.

A summary of the sizing and costs for Option 1 technologies are shown in Table 1-1.

Table 1-1: Summary of Option 1

OPTION 1							
	Units	Dimensions (m)	Footprint (m)	Costs Note 1			Recommendation
				Capex	**Opex**	**NPV (25 years)**	
Activated Carbon	3	3.4 x 4.68 (dia x H)	15.2 x 8.8 (L x W)	**Low**	**Very High**	**Medium**	**Not recommended**
Biofilter (soil bed)	4	25 x 16 x 1.2 (L x W x H)	103 x 16 (L x W)	**Very High**	**Medium**	**Very High**	**Not recommended**
Biological Trickling Filter	2 (+1)	3 x 7.6 (dia x H)	18.6 x 8.4 (L x W)	**Medium**	**Low**	**Very Low**	**Recommended**
Biological Trickling Filter + Activated carbon	3	BTF: 3 x 4.9 AC: 4 x 3.2 (dia x H)	19.6 x 9.4 (L x W)	**Medium**	**Medium**	**Medium**	**Not recommended**

Note 1: The colour code range for the costs are detailed in Section 4.

Based on the multi-criteria analysis discussed above, Stantec's conclusions and recommendations are as follows.

- Provide ducting as proposed for Option 1
- Provide a single odour control unit based on a biological trickling filter (BTF) technology in the existing car park.

During the next phase of design, the following activities are recommended:

- Confirm cover arrangements with site operations to ensure a custom-built cover can be provided for the existing screenings bins. If a custom built cover cannot be designed, new enclosed bins may be required
- Confirm design of OCU with more up to date H_2S data from the newly installed H_2S monitors (installed in October 2023)
- Confirm if any electrical components are located within the sewer tunnel, the hazardous rating of which could be affected by the reduction in ventilation proposed.
- Confirm duct routes.
- Confirm suitable reclaimed effluent sources. Site wide reclaimed effluent system should be considered.
- Confirm likely offsite odour impacts of preferred solution using dispersion modelling.
- Confirm following potential optimization of preferred design:

- Redundancy – provide no in-built redundancy for the preferred BTF option (i.e., 2 duty towers instead of 2 duty + 1 assist). Instead, redundancy would be to bypass the BTF and vent to atmosphere, as is currently occurring, yet would be discharged, and dispersed via a stack.
- Staging – If using the above redundancy provisions, allow space for a potential AC system downstream of the BTF if load becomes too variable to be able to be treated through a BTF alone.
- Confirm whether the existing water tank can be reused. This may require a standby centrifuge feed water pump be installed to increase redundancy for the duration after the OCU has been built and before the centrifuge has been decommissioned.

A high-level schedule for implementation of the preferred option was also developed, with completion expected in October 2025. The full schedule is shown in Figure 5-1.

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Abbreviations

Enter Abbreviation	Enter Full Name
AC	Activated Carbon
ACPH	Air Changes Per Hour
AQCNZ	Air Quality Consultants New Zealand
BPO	Best Practicable Option
BTF	Biotrickling Filter
DMS	Dimethyl Sulphide
OCU	Odour Control Unit
ou	Odour units
PS	Pump Station
R-SH	Mercaptans
STNZ	Source Testing New Zealand
TWAS	Thickened Waste Activated Sludge
VOC	Volatile Organic Compounds
WHS	Workplace Health and Safety
WWL	Wellington Water Limited
WWTP	Wastewater Treatment Plant

1 Introduction

The Porirua Wastewater Treatment Plant (WWTP) is fed from an inlet sewer tunnel that services the city of Porirua and parts of Tawa. This inlet sewer tunnel receives flows from the Tangere Drive Pumping Station (PS) and Rukutane Point PS.

This sewer tunnel is currently ventilated. Up to approximately 2018 the ventilation fan pushed fresh air into the tunnel, which had the effect of pressurising the tunnel and forcing foul air into the plant building at the Porirua WWTP. The ventilation was reversed in approximately 2018 to draw fresh air into the sewer from upstream and discharge foul air to the atmosphere.

The Porirua WWTP Inlet Works includes milliscreens and associated flow channels. The headspaces of these channels are ventilated with a dedicated fan and stack. The plant building also contains screening bins, loadout areas, centrifuges and dewatered sludge bins for the centrifuges. The centrifuges have a passive ventilation system that discharges to the outside of the plant building; the centrifuges are tentatively planned to be decommissioned by late 2026 as a new solids handling upgrade facility with new ventilation and odour treatment constructed in the northwest of the site. The remainder of the building is ventilated via a fan discharging building air directly to the atmosphere. There is currently a redundant duct running the length of the building which used to discharge generator exhaust to outside the building. When the generator was replaced with an outdoors generator, this ventilation line became redundant.

There are currently no odour control units on site.

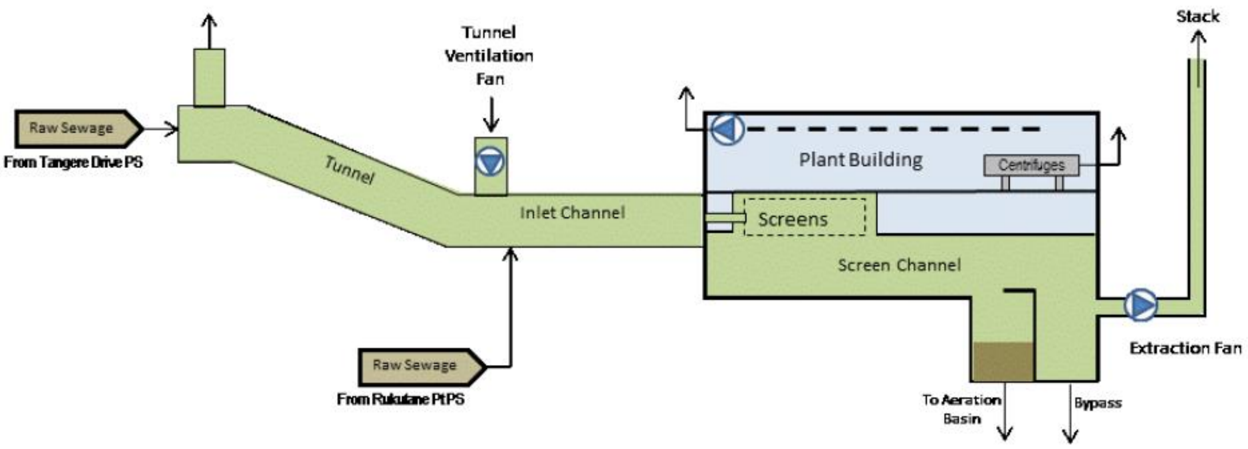

Figure 1-1: Ventilation schematic at the Porirua WWTP

A property bordering the Porirua WWTP has recently been subdivided for life-style residential development. The landowner has raised complaints relating to odour from the WWTP. In 2019, Wellington Water Limited (WWL) requested Veolia, the operations and maintenance contractor, to investigate odour control options. In Feb 2020, Veolia commissioned Armatec Environmental to review the site and provide estimates for different control options (Odour Control Issue Investigation and Options Site Visit Report 28 February 2020, Wellington Water Report E6987). WWL also obtained a similar report from Cardno in 2016 (Porirua WWTP Ventilation System, Ventilation Improvements Concept Design NZ100487).

In May 2020 Veolia commissioned Source Testing New Zealand Limited (STNZ) to conduct a brief site assessment of the current ventilation system and review the Armatec and Cardno proposals to determine the best options to mitigate potential odour emissions from the site. The Cardno report focussed on controlling the odour within the building, while the Armatec report focused on controlling odour emissions from the milliscreens ventilation system.

Air Quality Consultants New Zealand (AQCNZ) have also been engaged both historically and currently to support Wellington Water Ltd (WWL) with odour surveys.

In response to odour complaints from the site, Wellington Water were issued with an Air Discharge Permit (WGN200229 [36727]) with associated consent conditions. The consent conditions are summarised as follows:

- An odour management plan (OMP) be developed for the site to minimise odour impact. This OMP, along with any modifications, must be approved by the Environment Regulation department of Wellington Regional Council.
- Interim odour control measures must be implemented including:
    - Installation of hydrogen sulphide (H_2S) monitors on the inlet tunnel vent and milliscreens building vent

    - Installation of new meteorological station
    - Interlock the inlet tunnel vent fan to switch off when winds below 3 m/s are identified coming from the north (between 315° and 45°) between the hours of 0500 and 2300. This interlock should cease in the event the building H_2S levels increase above workplace exposure standard limits.
    - Engage an independent suitably qualified and experienced professional to undertake an odour survey.
        - If the survey does not identify noxious, dangerous, offensive, or objectionable odours to the extent that is causes an adverse effect at or beyond the site boundary, the odour survey should be repeated after 12 months.
        - If the survey identifies noxious, dangerous, offensive, or objectionable odours to the extent that is causes an adverse effect at or beyond the site boundary, the wind speed trigger should be reviewed, amended and an odour survey repeated.
            - If the repeated survey does not identify noxious, dangerous, offensive, or objectionable odours to the extent that is causes an adverse effect at or beyond the site boundary, the odour survey should be repeated after 12 months.
            - If the repeated odour survey identifies noxious, dangerous, offensive, or objectionable odours to the extent that is causes an adverse effect at or beyond the site boundary, odour neutralising sprays located at the milliscreens vent, and the tunnel vent should be employed and operate whenever the associated fans are operating. An odour survey should then be repeated.
- Develop a Best Practicable Option (BPO) investigation **(this investigation)** to mitigate odour effects associated with the site. The investigation shall:
    - Be undertaken by an independent suitably qualified and experienced professional.
    - Involve consultation with the members of the Odour Community Liaison Group (OCLG).
    - Assess all potential odour sources at the WWTP including but not limited to, the tunnel vent stack, the milliscreen extraction stack, sludge centrifuges and the milliscreen building ventilation.
    - Identify options to minimise the odour from the WWTP, including via a stand-alone system on each single source, a combined odour control system for all sources, or options in between.
    - Identify the Best Practicable Option, which may include a combination of odour control measures, to minimise odour from the WWTP. The report shall set out a programme for the installation and operationalisation of the Best Practicable Option by 31 July 2025, or an agreed alternative date.
    - After the BPO recommendations have been implemented, engage an independent suitably qualified and experienced professional to undertake an odour survey.
        - If the survey does not identify noxious, dangerous, offensive, or objectionable odours to the extent that is causes an adverse effect at or beyond the site boundary, the odour survey should be repeated after 12 months.
        - If the survey identifies noxious, dangerous, offensive, or objectionable odours to the extent that is causes an adverse effect at or beyond the site boundary, the BPO recommendations should be reviewed.
- Establish and maintain an Odour Liaison and Community Group (OCLG) to act as a forum to consult and inform the community on odour works and impacts associated with the site.
- Develop a communications plan to communicate with the residents of the affected area.
- Develop and maintain a webpage to provide the community with information relevant to the consent.

1.1 Scope of Work

The purpose of this work is to develop the BPO to resolve the odour impacts that are present at the site.

The following tasks have been outlined as part of this scope of works:

- Task 1 – Document Review
- Task 2 – Project kick-off and site visit
- Task 3 – Options assessment methodology
- Task 4 – Options development and assessment
- Task 5 – Reporting
- Task 6 – Option Selection Workshop

This report addresses Task 5 of the above tasks.

1.2 Information Inputs

The following information inputs were used as part of this BPO) assessment for the Porirua WWTP Odour Management Upgrade:

- Previous odour assessment reports by Cardno (2016), Armatec (2020), and Veolia (2020).
- As-built drawings
- 3D models of the plant in Truview and Naviswork

- H_2S data from the online analyser
- Wellington Regional Council consent conditions WGN200229
- Ministry for the Environment. 2016. Good Practice Guide for Assessing and Managing Odour. Wellington: Ministry for the Environment.
- Workplace exposure standards and biological exposure indices, Worksafe NZ.

1.3 Assumptions

The key assumptions that were necessary for the purposes of completing this BPO assessment are listed below.

- The aeration basin and subsequent processes have low odour emissions and have not been included in this study. This was validated through the site visit.
- Condition assessments of the covers, ductwork, and odour control systems were limited to visual inspections only. No material testing or analysis was completed.
- Non-financial criteria will be assessed on a qualitative basis rather than a quantitative basis.
- Financial criteria will be assessed on a comparative basis. Items that are common to all options were not costed.
- Ventilation rates will be based on industry best practice which generally includes the following:
  - 12 air changes per hour from covered inlet channels, or 120% of the maximum headspace reduction rate (e.g., from pumping)
  - 12 air changes per hour from screenings bins
  - 6 air changes per hour from pumping stations
  - 25 air changes per hour from conveyors
  - 1 m/s velocity assuming a mostly empty inlet sewer tunnel. This is in line with the Sydney Water Technical Specification for Odour Control Units and was set to overcome the drag of foul air from wastewater coming down a sewer. Note that this normally results in less than 12 air changes per hour which is the National Fire Protection Association (NFPA) of America’s recommended extraction rate to allow for a less stringent flammable protection to occur within the sewer.
- The basis of design for the contaminant load is provided below:
  - H_2S – provided by WWL from on-site measurements. Note that this was assessed by Stantec and modified as detailed in Section 2.2
  - Mercaptans – Assumed as being 1% of H_2S concentration measurements.
  - Dimethyl sulphide – estimated from Stantec’s experience at similar sites as 0.1% of H_2S concentration.
  - Volatile organic compounds (VOCs) – estimated from Stantec’s experience at similar domestic sewer sites as 1ppm average and peak of 5ppm.
- High-level sketches, layout drawings and electrical load requirements have been produced for all the options.
- Costs for mechanical and electrical odour control equipment were estimated from Stantec’s database of odour control unit costs with a single supplier (Armatec) providing high level cost estimates for some options.
- Costing (Level zero estimate) was conducted to the Wellington Water Cost Estimation Manual.
- The level of accuracy of the cost estimates that have been developed are suitable of options level design. Not all pricing information that was used was provided by an equipment supplier.
- Sizing was based on standard Stantec sizing calculations (nominated as pre-existing IP).

1.4 Existing Site

1.4.1 Site Layout

The Porirua WWTP consists of the following process units as shown in Figure 1-2.

- Inlet tunnel complete with vent.
- Site building, separated into two parts being:
  - Inlet works
    - Milliscreens – Removes screenings.
    - Discharge chamber – Directs screened wastewater to the ventilation chamber.
    - Screenings conveyors – Conveyors collected screenings to the processing facility.
    - Screenings press – Washes screenings and removes excess water.
    - Screenings bins – Stores washed screenings.
    - Vent and fans – Ventilate from the discharge chamber with the intent to provide sufficient ventilation to keep the milliscreens under negative pressure.
    - Associated channels and distribution chambers
  - Solids handling
    - Centrifuges – Dewaters thickened sludge.
    - Biosolids bins – Stores dewatered sludge.

This building also contains storerooms, workshops, meetings rooms, blower rooms, switch rooms and control rooms.
At the front of the building there is also a car park, a generator and diesel storage for the generator.

- Gravity thickeners – These thicken waste activated sludge (TWAS) from the oxidation ditch.
- Ventilation Chamber – This chamber provides space for entrained air to be removed from the process to prevent accumulation and blockage of pipework.
- Oxidation ditch – This provides a mix of anoxic and aerobic treatment in a carousel arrangement to biologically treat wastewater.
- Clarifiers – These separate treated effluent from the biological mixed liquor
- Return activated sludge pumping system – This system returns activated sludge from the clarifiers to the oxidation ditch.
- UV treatment – These disinfect treated effluent prior to discharge.

An upgrade to the solids handling facilities is currently planned to be commissioned by late 2026. The solids handling upgrade will consist of new biosolids storage and treatment facilities, including a new, standalone, odour control facility for these covered processes.

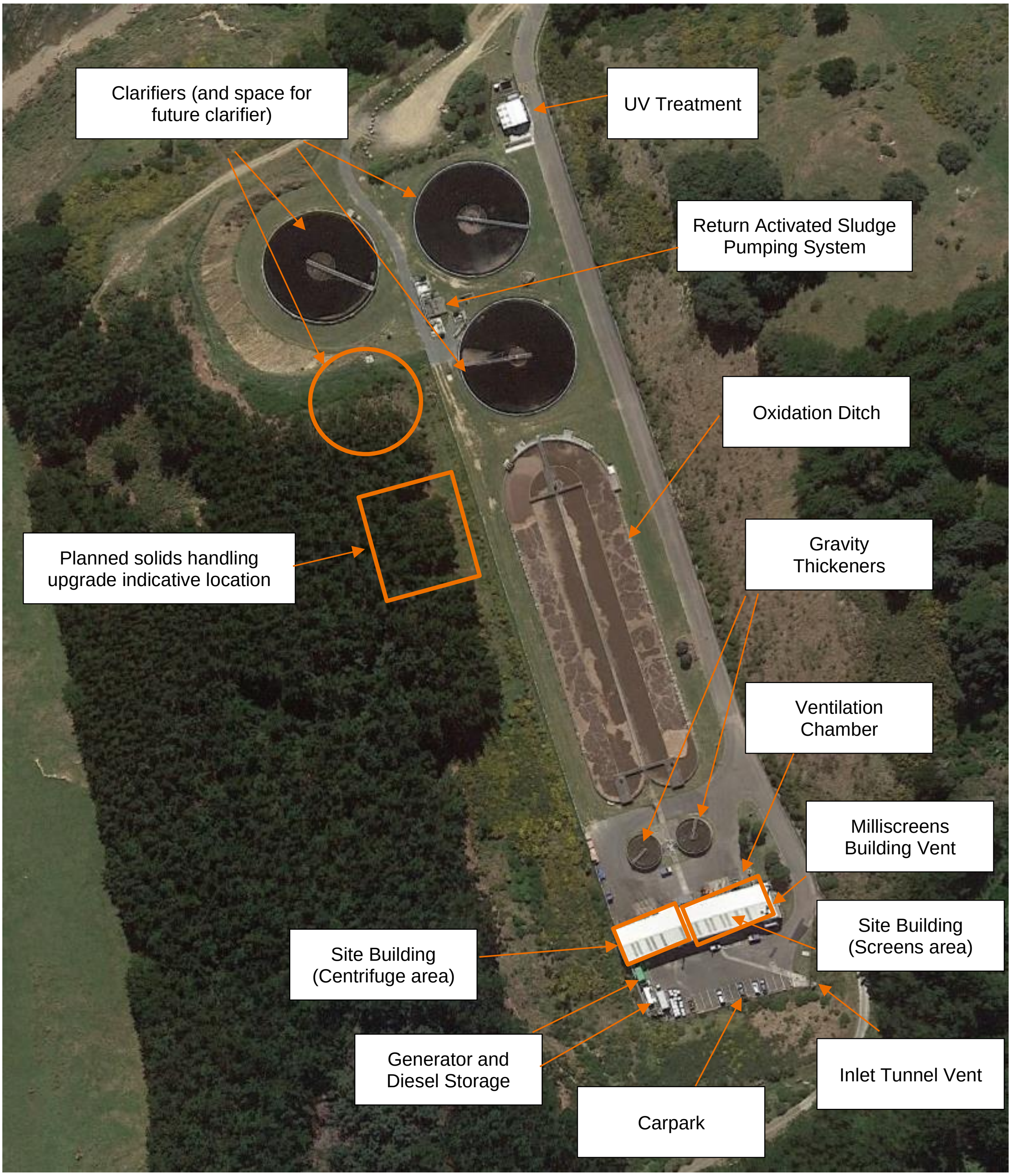

Figure 1-2: Site Layout

1.4.2 Site Visit Findings

A site visit was conducted on 27 September 2023 and attended by WWL, Veolia, and Stantec staff. The key findings from the site visit are listed below.

- The weather was inclement with intermittent rain and cold (approximately 10°C) temperatures.
- Vacuum pressure measurements were taken inside the Tunnel Vent Stack and inside the downstream Inlet Channel. The vacuum pressure decreased from -68 Pa in close proximity to the Tunnel Vent stack to -15 Pa over a short distance from the Tunnel Vent Stack to the Inlet Channel. This suggests that there are gaps in the Inlet Channel cover and the zone of influence of this vent stack was up to, approximately, the milliscreens.

- The pressure was also measured at the Milliscreens and Milliscreens Effluent Channel/Distribution Chamber. A positive pressure was measured at Milliscreen 1 (0.7 Pa) and effluent channel/distribution chamber (2.6 Pa); a vacuum pressure was not being maintained at those extraction points.
- The air flow rate in the tunnel vent stack was determined with an anemometer and the instrument indicated a flow rate of 22,000 m^3/h when positioned at 1 m from the edge of the vent stack; this equates to a velocity of approximately 7.8 m/s.
- The air flow rate and pressure measured at the building vent stack was 0.9 m/s -0.2 Pa, respectively. This indicated that the fan was not working properly during the site visit. It is likely that if this fan was operating correctly, significantly more negative pressure would have been occurring at the milliscreens.
- The Screenings Room (that housing the screenings processing and bins) was noted to be very odorous during the site visit. The odour was primarily from the Screening Bins, which were not covered.
- The gravity thickeners were not odorous during the site visit.
- Increased odour was identified from the ventilation chamber.
- No discernible offensive odour was identified from the oxidation ditch.
- No discernible offensive odour was identified from the return activated sludge pumping station.
- No discernible offensive odour was identified from the clarifiers.
- No discernible offensive odour was identified from the generator and diesel storage area.
- No discernible offensive odour was identified from the UV treatment area.
- Suitable locations to site the odour control units (OCUs) and odour duct routes were identified.
- It was noted that the screenings press system has been replaced by the Noggerath® Wash Press which is used most of the time.
- The Milliscreens covers achieve a good seal, however there are areas in some corners that are open. These gaps would need to be sealed to ensure a sufficient differential pressure is attained to improve capture of gases.

1.5 Previous Work

1.5.1 Cardno

In March 2016, Cardno evaluated the design and operation of the existing ventilation system. The following issues were identified:

- The Inlet Works headspace ventilation system operated under positive pressure forcing foul air into the carpark.
- Gaps were identified in various covers (e.g., Inlet Channel, Screens, Screen Effluent Channel, screenings conveyors)
- The building ventilation system was not providing the required 12 air changes per hour.

Improvements to the Inlet Works ventilation was identified as highest priority, and three options were proposed:

- Reverse the direction of the Tunnel ventilation fan to extract foul air instead of forcing fresh air into the Inlet Channel
- Single direction ventilation from Tunnel, through Inlet Works to a discharge stack
- Separate the headspaces of the Tunnel and Inlet Works space using a flap valve, actuated slide gate (more robust solution) or inverted siphon structure.

Additional improvements for the building ventilation and centrifuges were identified to meet the recommended ventilation rate of 12 air changes per hour.

1.5.2 Armatec Environment

In February 2020, Armatec identified major sources of odour and corrosion coming from the Building Main Stack, Distribution Chamber, and solids/screenings bins. Additionally, large gaps in the covers of the Inlet Channel were noted. These gaps result in a large amount of fresh air being drawn into the Inlet Channel, which reduces the ability to maintain a negative pressure.

Armatec recommended better sealing of all covers on the Inlet Channel and screens. They also recommended increasing the extraction rates of the building and to odour control system to treat the odour prior to discharge.

1.5.3 Veolia

In May 2020, Veolia commissioned Source Testing New Zealand Limited (STNZ) to assess the Porirua WWTP ventilation system and review Cardo and Armatec reports. STNZ's findings agreed with the conclusions outlined by Cardno and Armatec. STNZ found that the main sources of odour were from the inlet tunnel and the milliscreens. STNZ recommended the installation of an odour control unit for treatment and the separation the Tunnel and Inlet Channel headspaces to improve the extraction rates from the respective.

STNZ recommended the following next steps:

- Separate the headspace of the Inlet Channel from the Tunnel
- Measure the extraction flow rates for the Tunnel, Inlet Channel and Milliscreens
- Implement continuous H_2S monitoring to determine load and level of treatment required.
- After gathering this information, design an odour control system.

1.6 Exclusions

The following exclusions apply to this scope of work.

- Consultation with nearby residents has not been included as part of this scope of works, however findings are intended to be presented to the OCLG.
- Chemical dosing as a form odour treatment within the sewer network or at the WWTP were not considered, only gas phase treatment mechanisms have been assessed.
- Stantec has not allowed for corrosion remediation works or the provision of protective linings on concrete to prevent further corrosion.
- Olfactory sampling has not been included as part of this scope of works.
- Dispersion modelling has not been included as part of this scope of works.
  - As dispersion modelling has been excluded, it is implicitly assumed that designing odour control units to standard criteria outlined in Section 1.3 will be sufficient to bring the odour impact to below 2 odour units at the nearest sensitive receptors. An odour control unit that is activated carbon-based generally produces a discharge of 500 odour units. Biologically based odour control units generally produce a discharge of 1,000 – 2,000 odour units, relying on dispersion to bring this level to below 2 odour units by the time the treated air plume reaches sensitive receptors.
- The existing centrifuges, gravity thickeners and solids handing area has been excluded as odour source extraction points. It is understood that this solids handing equipment will be demolished and relocated as part of the solids handling upgrade. Therefore, it has been assumed that the new solids handling equipment will have its own dedicated odour control system. It should be noted that bringing the foul air from the solids handling upgrade facilities to any new odour control system was identified as being more costly, and having unacceptable limitations on site growth, compared to providing a standalone system local to the new upgrade facility.

1.7 Options Investigated

The odour control options investigated by Stantec were as follows:

- Option 1 – A single odour control unit (OCU) treating flow from all extraction points on site. These extraction points were only from those that were identified as being odour sources from site. The following OCU treatment options were investigated:
  - Activated Carbon (AC)
  - Biofilter
  - Biological Trickling Filter (BTF)
  - BTF + AC in series
- Option 2 – Separate treatment systems being:
  - Option 2a - One OCU treating flow from the Inlet Tunnel only and
  - Option 2b - One OCU treating flow from the rest of the extraction points.

  The following OCU treatment options were investigated for Option 2:
  - Two AC OCUs
  - Two Biofilter OCUs
  - Two BTF OCUs
  - Two BTF + AC in series OCUs

  It should be noted that whilst a mix of different technology types between the two OCUs was not investigated in detail, a discussion on doing so is included in this report.

2 Design Inputs

2.1 Flow

To determine the air extraction flow rate for each option, the volume to be ventilated at each extraction point was estimated using as-built drawings, 3D laser scans and estimates/measurements from the site visit. As outlined in Section 1.3, the proposed ventilation rates based on industry best practices are summarised below:

- Inlet tunnel – velocity of 1 m/s in a mostly empty Inlet Tunnel, or a ventilation rate 120% of the maximum fill rate, whichever is larger. This is in line with the Sydney Water's Technical Specification for Odour Control Units (ACP0004). It should be noted that this particular source has a large volume and the sizing approach for this source can greatly change the size of the OCU. Targeting a velocity of 1 m/s is considered sufficient to overcome natural drag of foul air whilst ensuring the OCU is not overly large. Note that this normally results in less than 12 air changes per hour which is the National Fire Protection Association (NFPA) of America's recommended extraction rate to allow for a less stringent flammable protection to occur within the sewer.
- Inlet Channel, Milliscreens, Milliscreen Effluent Channel, Distribution Chamber, Ventilation Chamber, Screenings Press, Screenings Bins – ventilated at a rate of 12 air changes per hour (ACPH). This is in line with industry standards for ventilation of screens and screenings processing and assumes the covers are sufficiently tight fitting such that a differential pressure of 15 Pa is achieved.
- Screenings Conveyor – ventilated at a rate of 25 ACPH. This is in line with industry standards for ventilation of conveyors.

Based on the ventilation rate criteria listed above, a summary of the extraction rates calculated for each extraction point is shown in Table 2-1.

Table 2-1: Extraction flow rates by extraction point

Extraction Point	Volume (m^3)	Number of Units	Air Changes per Hour (ACPH)	Extraction rate (m^3/h) Note 1
Inlet sewer tunnel	Volume - 1,897.5 m^3 Cross sectional surface area – 2.3 m^2	1	-	8,280 Note 2
Inlet channel	44.7	1	12	536
Inlet channel overflow section	9.3	1	12	112
Inlet channel twin pipes 1	8.5	1	12	102
Inlet channel twin pipes 2	5.2	1	12	62
Inlet channel twin chambers 1	4.2	1	12	50
Inlet channel twin chambers 2	4.2	1	12	50
Bifurcation channel	14.5	1	12	174
Screen inlet pipe (4 pipes)	1.9	4	12	91
Milliscreen 1	17.9	1	12	215
Milliscreen 2	17.9	1	12	215
Milliscreen 3	17.9	1	12	215
Milliscreen 4	17.9	1	12	215
Screened effluent channel	65.7	1	12	788
Distribution chamber (overflow chamber)	46.3	1	12	555
Distribution chamber (effluent chamber)	40.6	1	12	487
Ventilation chamber	17.1	1	12	206
Screenings press	7.5	1	12	90
Screenings conveyor	1.1	1	25	27
Screenings bin A	7.1	1	12	85
Screenings bin B	7.1	1	12	85

Note 1 – The existing building ventilation arrangements should be sufficient (even with doors closed) when all milliscreens are covered and the new extraction system is in place. If a Milliscreen cover is removed, the doors should be opened to prevent foul air accumulating within the building.
Note 2 – Maximum wastewater flow of approximately 1,350 L/s. 120% of this would equate to 5,800 m3/h. Taking higher of 120% fill rate and 1.0 m/s velocity.

For Option 1, the flow from all extraction points is conveyed to a single OCU for treatment. For Option 2a, the Inlet Sewer Tunnel will be extracted to its own OCU for treatment. In Option 2b, the remaining extraction points at the plant (Inlet Channel, Milliscreens, Milliscreens Effluent Channel, Distribution Chamber, Ventilation Chamber, Screenings Works) will be ventilated to a separate OCU for treatment. The flow rates for each Option are summarised in Table 2-2.

Table 2-2: OCU flow rates by ventilation option

Ventilation Option	Flow Rate (m^3/h)
Option 1	12,700
Option 2a	8,300
Option 2b	4,400

Full Process Flow Diagrams (PFDs) can be found in Appendix A .

2.2 Load

2.2.1 General

Stantec received the online hydrogen sulphide (H_2S) monitoring data from the Porirua WWTP Building Vent Stack for August 2023 (also known as the Milliscreens Vent) and Inlet Tunnel (June 2023 to August 2023). The data is presented in Figure 2-1 along with the rainfall data for the same period.

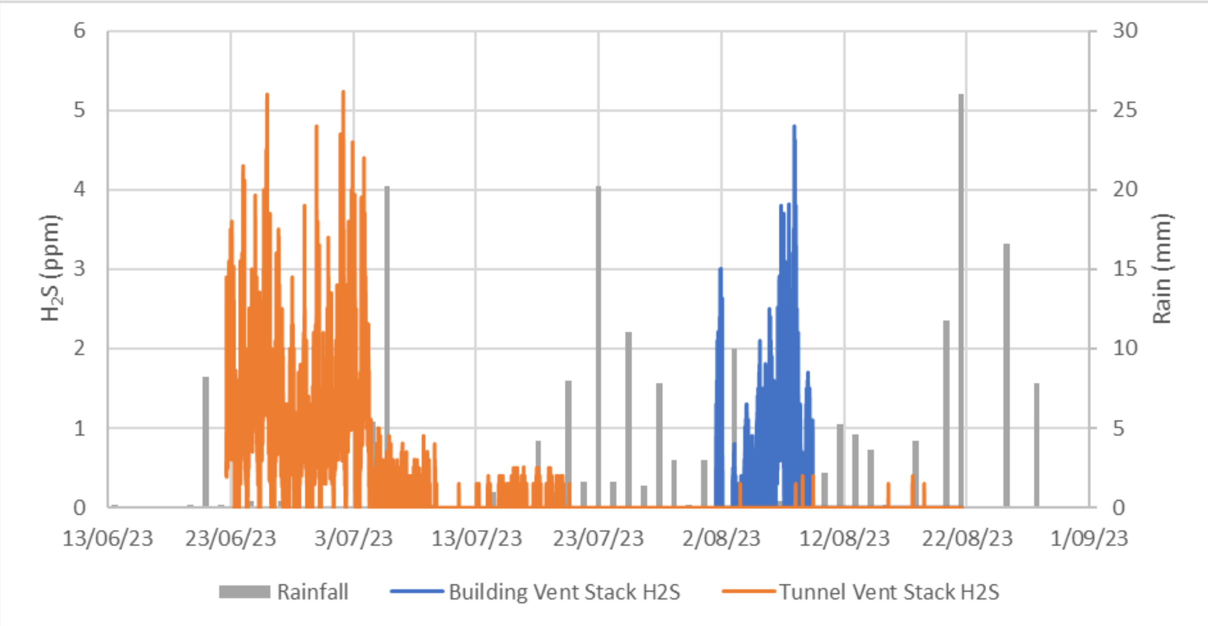

Figure 2-1: H_2S from building and tunnel vent stack online analyser and rainfall from June 2023 to August 2023

Ideally, H_2S monitoring should be completed during dry summer conditions. Due to project schedule constraints, data was collected over a short period during winter, and it was found that H_2S levels were heavily impacted by rainfall over the data collection period. Therefore, the data is not fully representative of the average or peak H_2S concentrations that are expected to occur at the Porirua WWTP. Summertime concentrations of H_2S were estimated for the purposes of completing this BPO assessment by using the data presented in Figure 2-1 which were also supplemented by spot-H_2S results reported by Armatec (not rain affected), and temperature corrections. In general, this means that the pattern of the continuous H_2S monitoring was used and was corrected to a summer average condition based on temperature corrections and cross-checked with the spot samples conducted by Armatec. It is recommended that the design is modified as more data becomes available from the newly installed H_2S sensors.

In February 2020, Armatec measured H_2S concentrations of 40 ppm and 1.5 ppm at the Building Vent Stack and Tunnel Vent Stack, respectively. Therefore, it was concluded that the Building Vent H_2S concentration is 26.6 times greater than the Tunnel Vent Stack during non-rain affected periods. The average H_2S concentration in the Tunnel Vent Stack for the dry winter period (June 2023 to early July 2023) was 1.1 ppm at an average temperature of 16°C. Assuming an average summer temperature of 20°C, the temperature corrected concentration is 1.5 ppm, using Equation 1. This matches the measurement from Armatec. Similarly, the 99th percentile summertime H_2S concentration for this period was calculated to be 5.2 ppm using equation 1; this is considered the peak H_2S concentration for design purposes.

Equation 1 – Temperature correction for H_2S from gas-liquid equilibrium (Henry's Law) and biological activity (Arrhenius' Law)

$$[H_2S]_2 = [H_2S]_1 \frac{1.07^{(T2-293.15)} \times e^{-2100\times\left(\frac{1}{T2}-\frac{1}{298.15}\right)}}{1.07^{(T1-293.15)} \times e^{-2100\times\left(\frac{1}{T1}-\frac{1}{298.15}\right)}}$$

The average H_2S concentration at the building (Milliscreen) Vent Stack was estimated by multiplying the measured average concentration of H_2S by the online instrument (1.1 ppm) by 26.6 and then temperature corrected the value from 13°C to 20°C using Equation 1, resulting in 56 ppm of H_2S. This is similar to the 40 ppm spot-measurement by Armatec. The peak value was calculated similarly and results in a peak H_2S concentration of 177 ppm.

As described in Section 1.3, the other contaminants considered in the concept design of the OCUs were mercaptans, volatile organic compounds, and dimethyl sulphide. The corresponding concentrations of the respective contaminants are shown in Table 2-3. Ammonia was not considered as part of this scope of works as the extraction points did not include biosolids treatment processes.
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Table 2-3: Individual odour loads by extraction point

Extraction Point	H_2S (ppm)		R-SH (ppm)		VOC (ppm)		DMS (ppm)		NH_3 (ppm)	
	Average	Peak	Average	Peak	Average	Peak	Average	Peak	Average	Peak
Inlet sewer tunnel	1.5	5	0.0	0.0	1.0	5.0	0.0	0.0	0.0	0.0
Inlet channel	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Inlet channel overflow section	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Inlet channel twin pipes 1	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Inlet channel twin pipes 2	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Inlet channel twin chambers 1	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Inlet channel twin chambers 2	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Bifurcation channel	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Screen inlet pipe (4 pipes)	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Milliscreen 1	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Milliscreen 2	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Milliscreen 3	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Milliscreen 4	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Screened effluent channel	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Distribution chamber	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0

Extraction Point	H_2S (ppm)		R-SH (ppm)		VOC (ppm)		DMS (ppm)		NH_3 (ppm)	
(overflow chamber)										
Distribution chamber (effluent chamber)	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Ventilation chamber	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Screenings press	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Screenings conveyor	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Screenings bin A	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0
Screenings bin B	56	177	0.6	1.8	1.0	5.0	0.1	0.2	0.0	0.0

2.2.2 Option 1

Contaminant concentrations that require treatment at the OCU were calculated using the data presented in Table 2-1 and Table 2-2. The contaminant concentrations used for the design of the Option 1 OCU is presented in Table 2-4.

Table 2-4: Contaminants load for Option 1

Contaminant	Average (ppm)	Peak (ppm)
Hydrogen sulphide (H_2S)	20.3	64.4
Mercaptans (R-SH)	0.2	0.6
Volatile Organic Compounds (VOC)	1.0	5.0
Dimethyl sulphide (DMS)	0.02	0.1
Ammonia (NH_3)	0.0	0.0

2.2.3 Option 2

2.2.3.1 Option 2a – Inlet sewer tunnel

The contaminant concentrations used for the design of the Option 2a OCU is presented in Table 2-5.

Table 2-5: Contaminants load for Option 2a

Contaminant	Average (ppm)	Peak (ppm)
Hydrogen sulphide (H_2S)	1.55	5.18
Mercaptans (R-SH)	0.0	0.0
Volatile Organic Compounds (VOC)	1.0	5.0
Dimethyl sulphide (DMS)	0.0	0.0
Ammonia (NH_3)	0.0	0.0

2.2.3.2 Option 2b – Other odour-emitting sources

The contaminant concentrations used for the design of the Option 2b OCU is presented in Table 2-6.

Table 2-6: Contaminants load for option 2b

Contaminant	Average (ppm)	Peak (ppm)
Hydrogen sulphide (H_2S)	55.91	176.95
Mercaptans (R-SH)	0.56	1.77
Volatile Organic Compounds (VOC)	1.0	5.0
Dimethyl sulphide (DMS)	0.06	0.18
Ammonia (NH_3)	0.0	0.0

2.3 Location

There is very little available area on site. The locations available for OCUs were considered as shown in Figure 2-2 with details of each location given in Table 2-7.

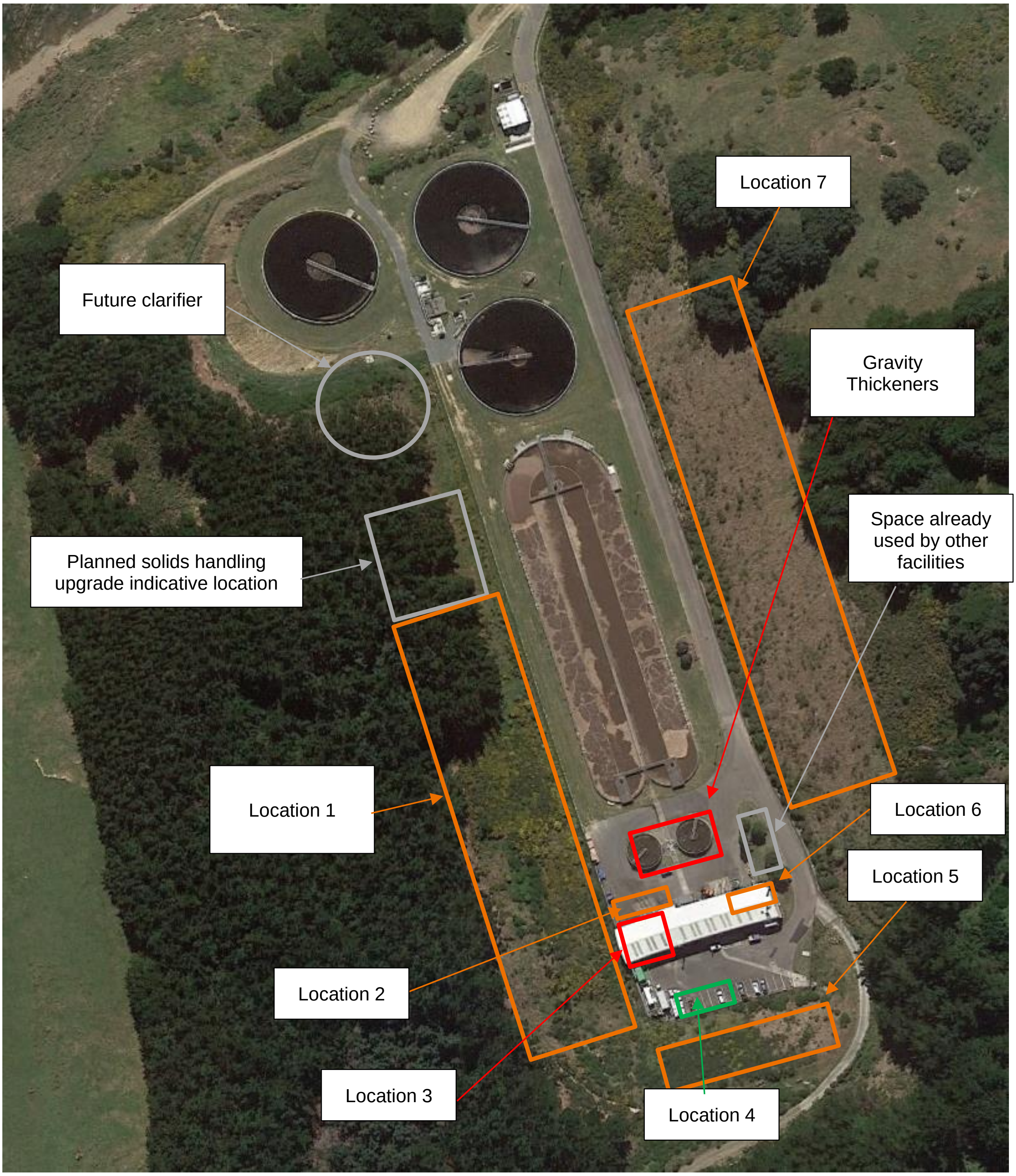


Figure 2-2: Potential OCU Locations

Table 2-7: Description of Potential OCU Locations

Location	Description	Conclusion
Gravity Thickeners	Gravity thickeners will become redundant when the solids handling upgrade occurs. However, this is currently planned for a year after the odour works are due to be completed. Therefore, it will not be available for use by an OCU.	Cannot use
Location 1	West of site - Area currently earmarked for treatment upgrade. Steep slopes meaning significant earthworks would be required to use this area. No access behind existing building.	Undesirable to use
Location 2	North of existing solids handling – Area will become unused and redundant after solids handling upgrade. Building itself will be reused for other works, so access will still be required. Access to building will need to be maintained. Area would need to still allow truck movements (particularly during solids handling upgrade works). Area is limited so would only be able to be used for Option 2b (small flow) and non-biofilter type OCU. As location is lower than process units, a small pump station would be needed for drain returns.	Undesirable to use
Location 3	Existing centrifuge area – This area within the building, where the existing centrifuges are, will become available once the solids handling upgrade works are complete. However, this is currently planned for a year after the odour works are due to be completed. Therefore, it will not be available for use by an OCU.	Cannot use
Location 4	Car park area – Area is limited, yet flat and available. Currently used for storage and car parking which can be relocated or removed.	Available to use
Location 5	Area to the south of car park – Steep slopes meaning significant earthworks would be required to use this area.	Undesirable to use
Location 6	Storage area within building – Poor access and small area. Is fine to use, however it is too small for any OCU under consideration, and the maintenance of equipment would be challenging in this small space.	Undesirable to use
Location 7	Area to east of site - large area available however on a steep slope where significant earthworks are required. Duct bridge would be needed across main site access road if this area is used. Area furthest away from areas needing to be ventilated.	Undesirable to use

3 Options Development

This BPO assessment considers a combined and separated odour duct network and four different treatment technologies as detailed below. Design criteria for each technology is given in Table 3-1.

- Activated carbon (AC) – Activated carbon involves adsorption of contaminants onto the active sites on the activated carbon. This would include a pre-filter to prevent clogging and a heater to prolong the life of the activated carbon. Activated carbon would include a mechanism to determine depletion of carbon such as sniff ports or copper rod insertion. Discharge would be via a stack which would provide additional dispersion. The designs have allowed for 12 months between activated carbon changeover.
- Biofilter (soil beds) – Open topped biofilters allow contaminants to be removed through biological processes. Biomass grows within the media and the media (often bark or similar) is consumed as nutrient as part of the biological process. As biofilters are open topped, there is no ability for treated air to be discharged through a stack for added dispersion. As biofilters become larger, there is a greater risk of short circuiting, increasing the risk of contaminant bypass and operator exposure to high levels of H_2S and other contaminants. Biofilters are well suited to low concentrations and generally are not suitable if the average H_2S load is > 10 ppm. Whilst they can be designed for higher concentrations, they tend to be much larger to achieve a greater removal percentage than for lowly loaded systems. Biological processes, in general, are also only suitable if the load is relatively stable with peaks of 4-5 times the average generally acceptable.
- Biotrickling filter (BTF) only – Like biofilters, BTFs remove contaminants through biological processes. The main differences to biofilters are:
  - That BTFs are provided in towers, meaning treated air can be captured and discharged via a stack for added dispersion, and
  - That BTFs are provided with inorganic media, meaning media is not consumed during the biological process and can last for much longer, however if lowly loaded tend to need an alternate nutrient source either from reclaimed effluent or added nutrient.
  - That BTFs can treat a higher load with treatment still very high for H_2S levels > 100ppm if designed adequately.

  BTFs tend to have a much smaller footprint than biofilters, however tend to be more expensive as they require custom built towers. As with biofilters, biological processes, in general, are also only suitable if the load is relatively stable with peaks of 4-5 times the average generally acceptable.
- Biotrickling filter combined with activated carbon (BTF + AC) – This arrangement is common when the load to the OCU is highly variable or if a BTF is designed to only remove H_2S and no other contaminants. Activated carbon is intended to adsorb any contaminants that bypass or bleed through the BTF. Having two types of technology tends to give a greater overall treatment.

Table 3-1: Design criteria for OCU technologies

Criteria	Activated Carbon	Biofilter	Biotrickling Filter	Biotrickling Filter + Activated Carbon
Media life	12 months between changeout	2-5 years depending on load going to biofilter	10 years for inorganic media	As per BTF and AC
Contact time	Minimum 3 seconds	N/A – dependant on load.	N/A – dependant on load	Minimum 2 seconds
Water supply	Not required for process use	Humidification on the inlet as well as sprays on each bed. Assumed the use of reclaimed effluent.	Humidification of inlet as well as recirculation and fresh water make up. Assumed the use of reclaimed effluent for water make up. New water tank and pump set allowed for	As per BTF
Stack	9 m tall with cone to give 15 m/s	N/A	9 m tall with cone to give 15 m/s discharge velocity	9 m tall with cone to give 15 m/s discharge velocity

Criteria	Activated Carbon	Biofilter	Biotrickling Filter	Biotrickling Filter + Activated Carbon
	discharge velocity			
Heater	For 10°C temperature rise	N/A	N/A	Downstream of BTF. Designed for 10°C temperature rise
Pre-Filter	Required	Required	Not required	Not required
Redundancy	'n+1' to allow full treatment when one AC is offline for media changeout. Fans to be Duty / Standby	Generally 'n+1' to allow media changeout – All units to operate continuously to ensure biomass is available on all units. Fans to be Duty / Standby	Generally 'n' with space for future BTF or AC – All units to operate continuously to ensure biomass is available on all units. Fans to be Duty / Standby	BTF and AC act as redundancy for each other, no additional redundancy. Fans to be Duty / Standby
Return streams[1]	None	Occasional low pH blowdown	Frequent or occasional (depending on design) low pH blowdown	Frequent or occasional (depending on design) low pH blowdown
Achievable discharge odour[2]	500 – 1,000 ou	1,000 – 2,000 ou	1,000 – 2,000 ou	500 – 1,000 ou

The configuration of the options included in this study are as follows:

- Option 1: Single odour unit (OCU) treating all sources of odour.
- Option 2a: Inlet Tunnel ventilated to one OCU.
- Option 2b: Inlet Channel, Milliscreens, Milliscreens Effluent Channel, Distribution and Ventilation Chamber, Screenings Press, Screenings Conveyor, and Screenings Bins ventilated to a separate OCU.

Stantec has developed an options level design of the odour duct network and OCU, general arrangement sketches, and cost for each option which is detailed on the following sections.

3.1 Option 1 - Combined OCU

For Option 1, which will ventilate foul air from all extraction points into a single OCU, the flow rate is 12,700 m^3/h. The foul air for this option has a relatively high flow and a relatively high (yet stable) load, which is ideal for biotrickling filters.

[1] Return streams from biological based odour control processes are normally acidic however the flows tend to be minimal and have very limited impact on the wastewater treatment processes. The pipes that deliver these acidic returns, and the location that it is returned, should be protected against acidic corrosion.
[2] Odour units as defined by AS/NZS4323.3 and AS/NZS4323.4 which sets out a method that defines how odour is measured. This is generally through the taking of a sample in a manner that does not become contaminated by the sampling equipment. The sample is then provided in dilutions to a panel of people who have passed an odour sensitivity test. The number of dilutions it takes for half of the panel to detect an odour is given as the 'odour unit' (ou) of the original sample.

Generally a level of 500 ou – 2,000 ou is standard for the discharge of odour control units with the reliance on dispersion (either from a stack or through ground level dispersion) to reduce the odour further such that it is less than 2 to 10 ou by the time the treated air comes into contact with a potential receptor.

3.1.1 Ductwork

Option 1 has the OCU located at Location 4 (east part of the car park) for the AC, BTF and BTF+AC options and in Location 5 (south of the car park) for the biofilter option.

The duct has been designed to ensure independent ductwork connections to each process unit. This arrangement allows negative pressure to be more efficiently provided to all process units, rather than relying on a very high negative pressure at one end of the entire train (as is currently occurring).

There is very limited location on site for ducts from the screenings handling area (and ventilation chamber). There is a DN150 hole through the wall from the screenings handling area to the storeroom where the existing extraction duct and fan is located. The intent is that the duct from the screenings area, after picking up connections from the screening's bins, screenings press, conveyor and ventilation chamber, will travel through this DN150 hole and enter into the existing duct. The existing duct will act as a duct tunnel to feed the screenings area duct into the distribution chamber. This is shown in Figure 3-1 and Figure 3-2.

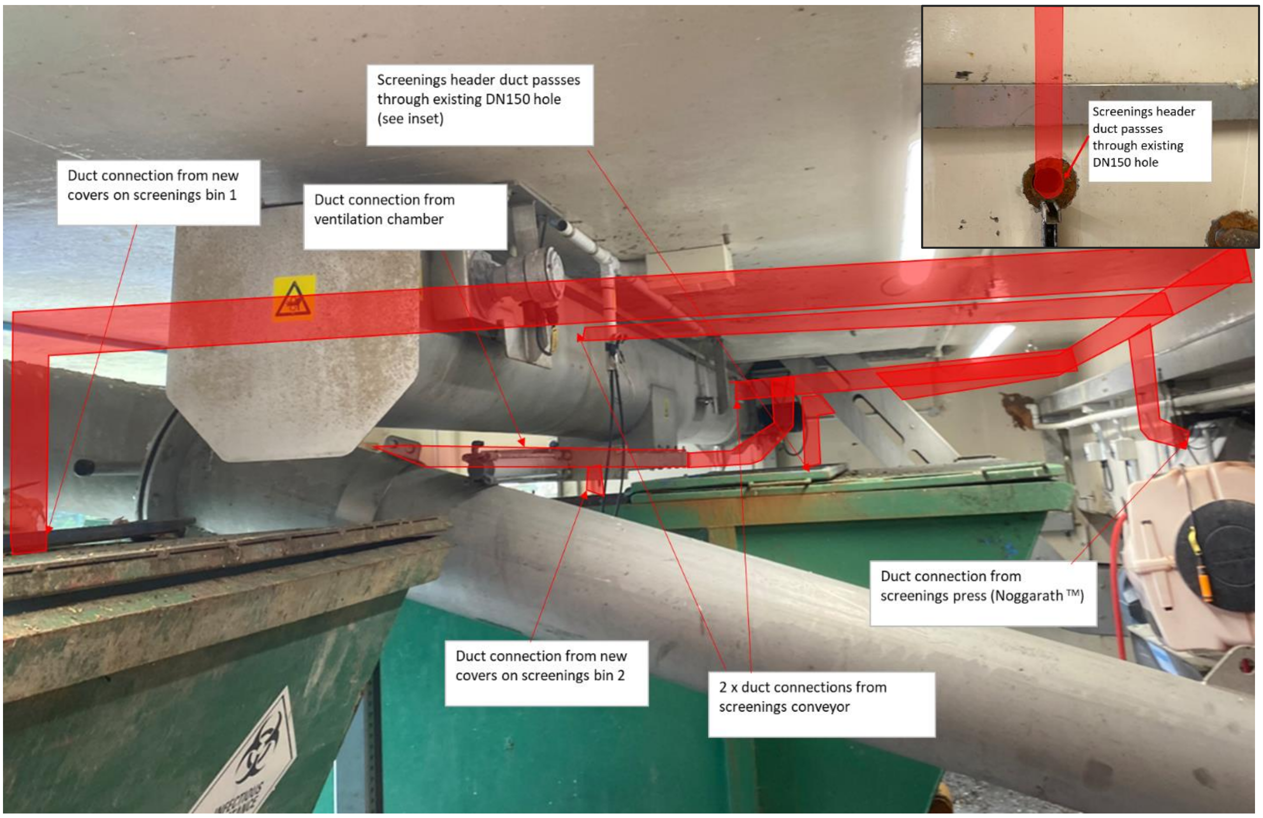


Figure 3-1: Ductwork within screenings area

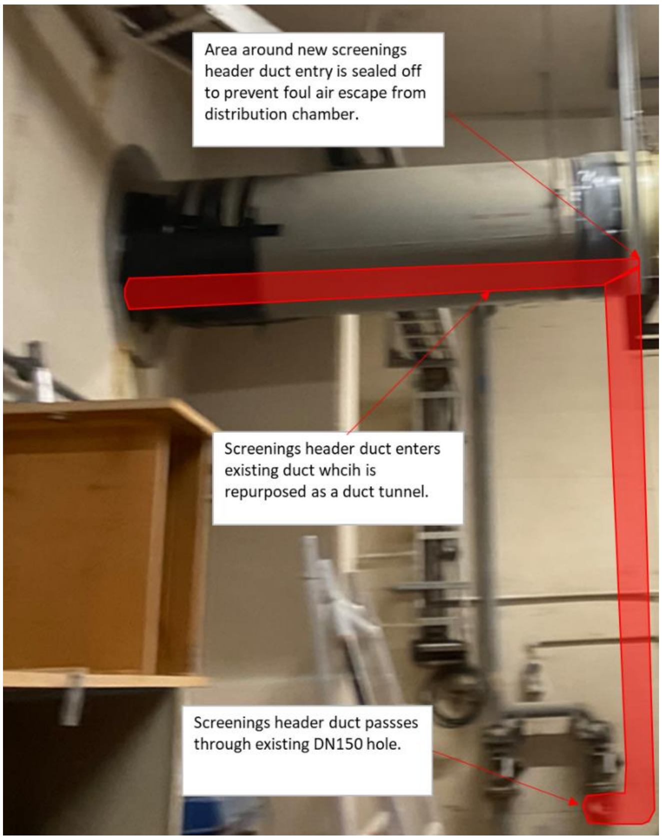


Figure 3-2: Duct header from screenings area travels through existing duct into distribution chamber

It should be noted that Stantec have allowed for new, custom-built covers for the existing screenings bins to aid in the capture of foul air from these sources. These bin covers will need to be designed with heavy input from the operators on site to ensure the bins are still operable even with covers in place. An alternative would be to replace the bins with full enclosed bins and connect ducts from these fully enclosed bins into the screenings header in the manner shown in Figure 3-1.

Ductwork within the building needs to be provided in a manner that allows access for personnel and the gantry crane. The duct header within the building will be hung from the peak of the roof. There is currently an existing redundant DN250 (approx.) duct here which was originally intended to take exhaust from the generator when it was located internally. This duct will be replaced with the main header. The duct header will take ducts from the screenings area and the distribution chamber initially. 2 new penetrations will be made in the existing distribution chamber, one for the screenings area duct and one for the extraction from the discharge chamber as shown in Figure 3-3. Ducts from the Milliscreens will then be added sequentially. Ductwork to the Milliscreens to be provided in sections to allow removal of ductwork if the Milliscreens need to be removed. The duct will leave the Milliscreens, come to the building wall and travel behind the gantry crane guides as shown in Figure 3-4.

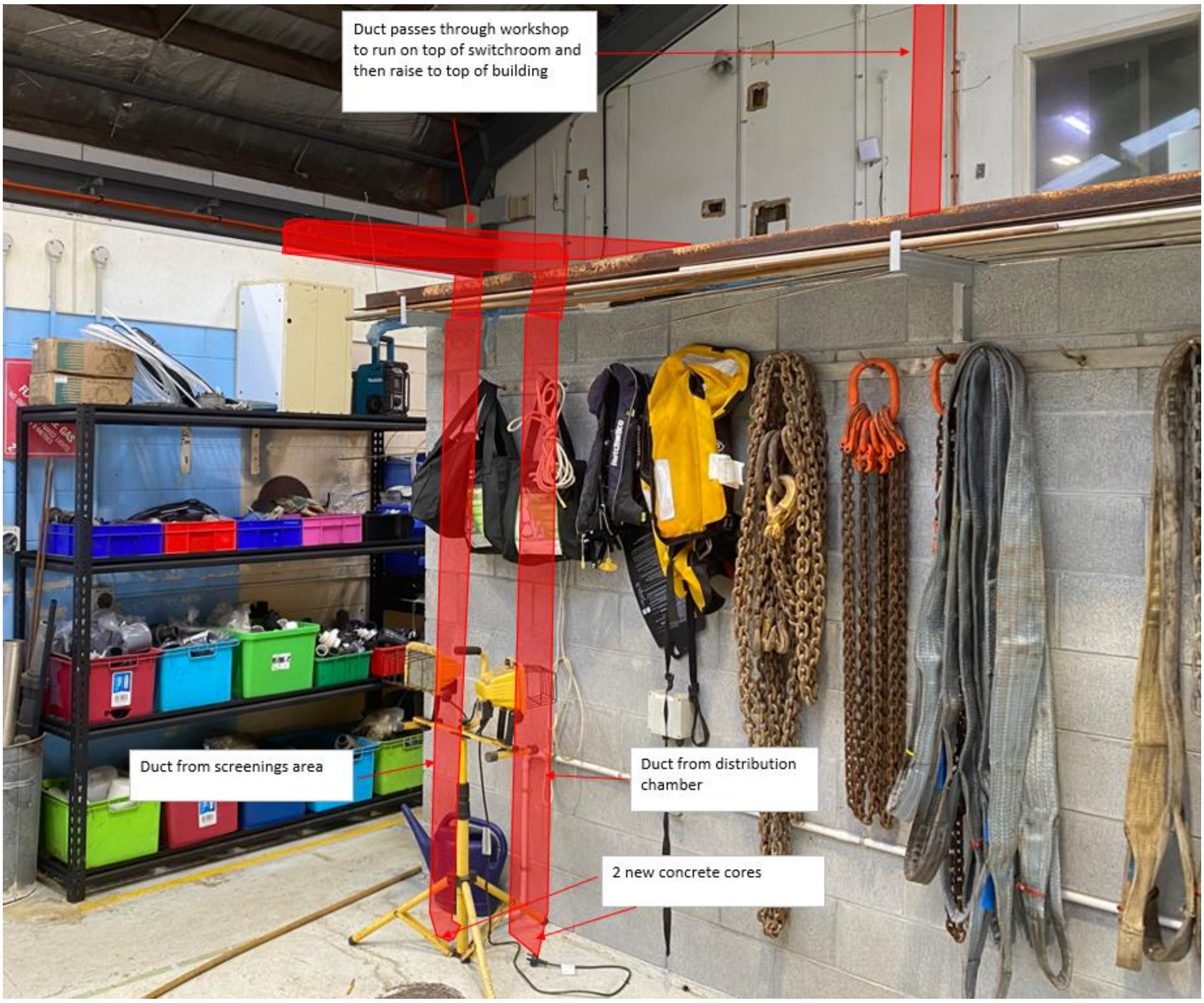


Figure 3-3: Option 1 Screenings header duct, and duct from distribution chamber, combine and travel to top of peaked roof.

Figure 3-4: Milliscreens ductwork (only one shown) and main duct header.

For the AC, BTF and BTF+AC options, the duct header will then travel down the roof pitch and go through the wall to go outside the building where duct from the inlet channel will be picked up. The duct header will then travel underground to the OCU slab. This is shown in Figure 3-5. As the duct will travel underground, there is a high risk of condensate forming and blocking the pipe. The underground section of the duct will need a drain line to be able to drain back to the inlet channel. It should be noted that a duct bridge was considered instead of an underground duct, however, was rejected on the basis that draining of the duct could be provided. During the concept design, an above ground duct, complete with duct bridge across the car park, could be considered.

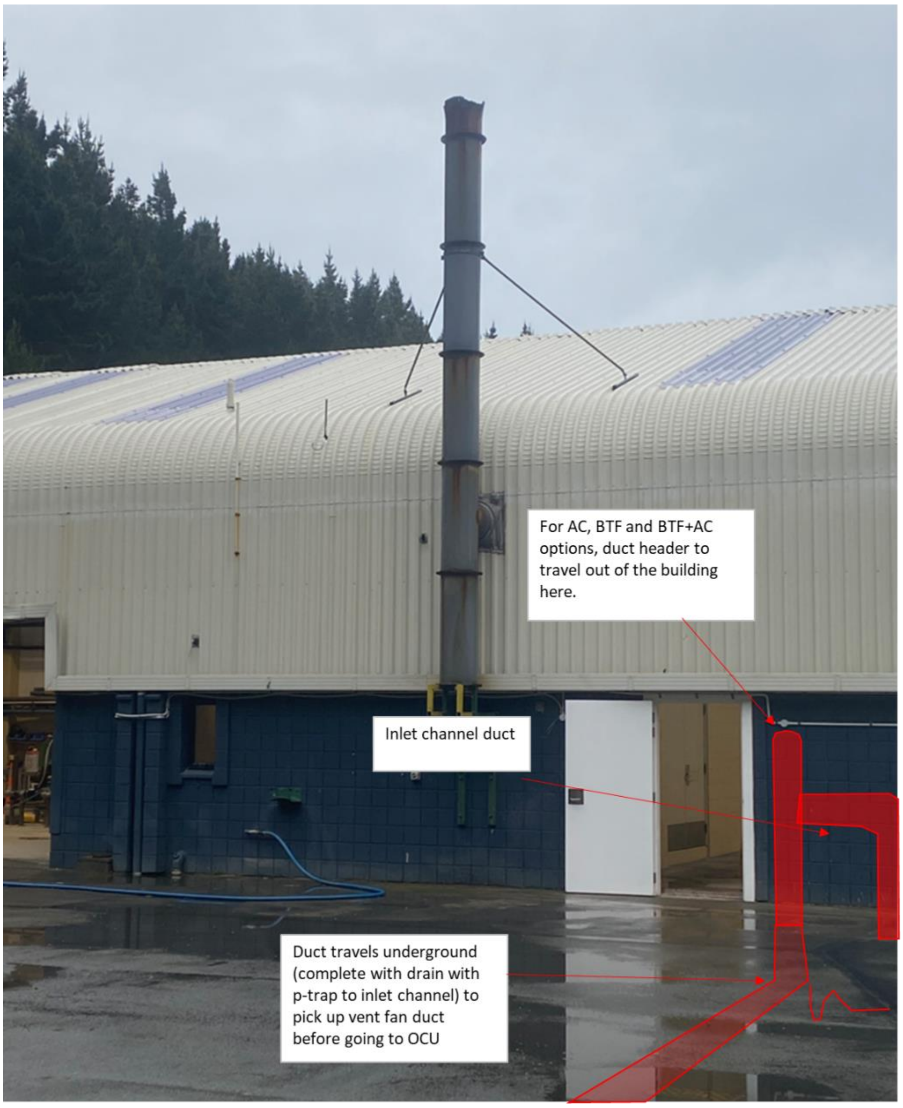


Figure 3-5: Inlet channel connection and underground duct header

After crossing the car park, the duct will travel above ground and connect with the duct from the inlet tunnel. The inlet tunnel duct will travel parallel to the car park (and to the south) before entering the OCU location. The overall duct arrangement is shown in Figure 3-6.

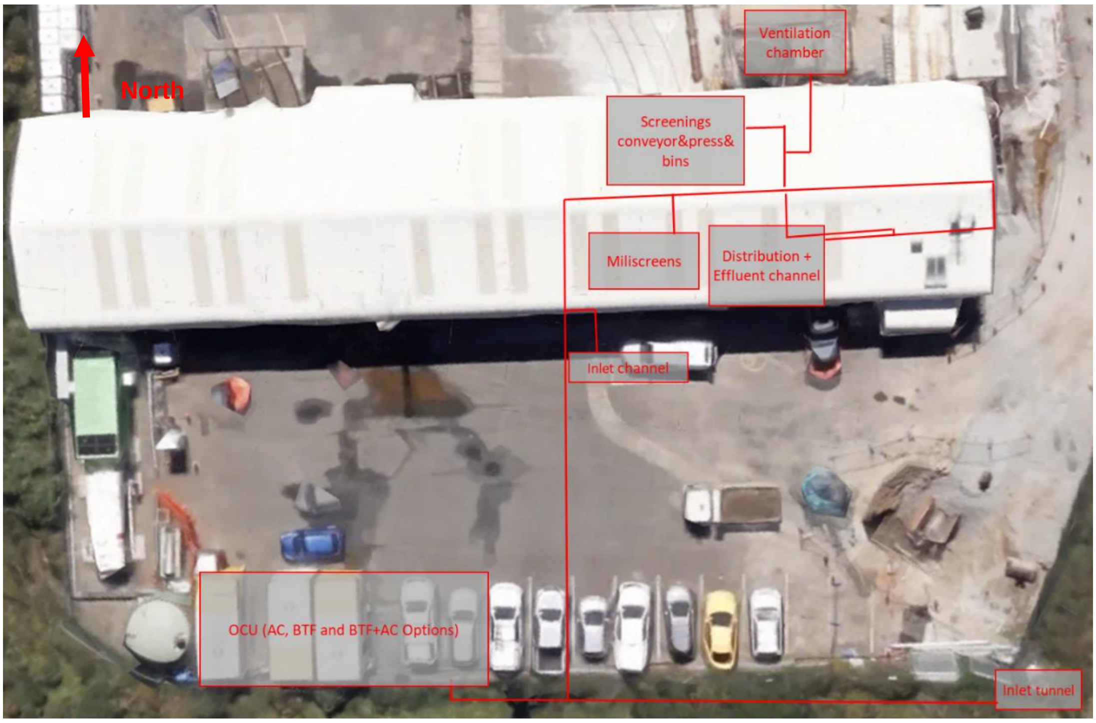


Figure 3-6: Ductwork arrangement for AC, BTF and AC+BTF technologies for Option 1

For the biofilter option, the duct header (after Milliscreens has been added) will travel along the peak of the roof to the western end of the building (as shown in Figure 3-4) where it will come to ground level and meet with the duct from the inlet channel. The duct from the inlet channel will travel along the outside of the building as shown in Figure 3-7. The inlet channel duct does not enter the building earlier as it would add an extra building penetration, and it would make the header too large to be supported at the peak of the building. After combining, the main header will then travel south to join the duct from the inlet tunnel before entering the biofilter. The overall duct arrangement is shown in Figure 3-8.

Figure 3-7: Inlet channel duct travels along outside of building for Biofilter option

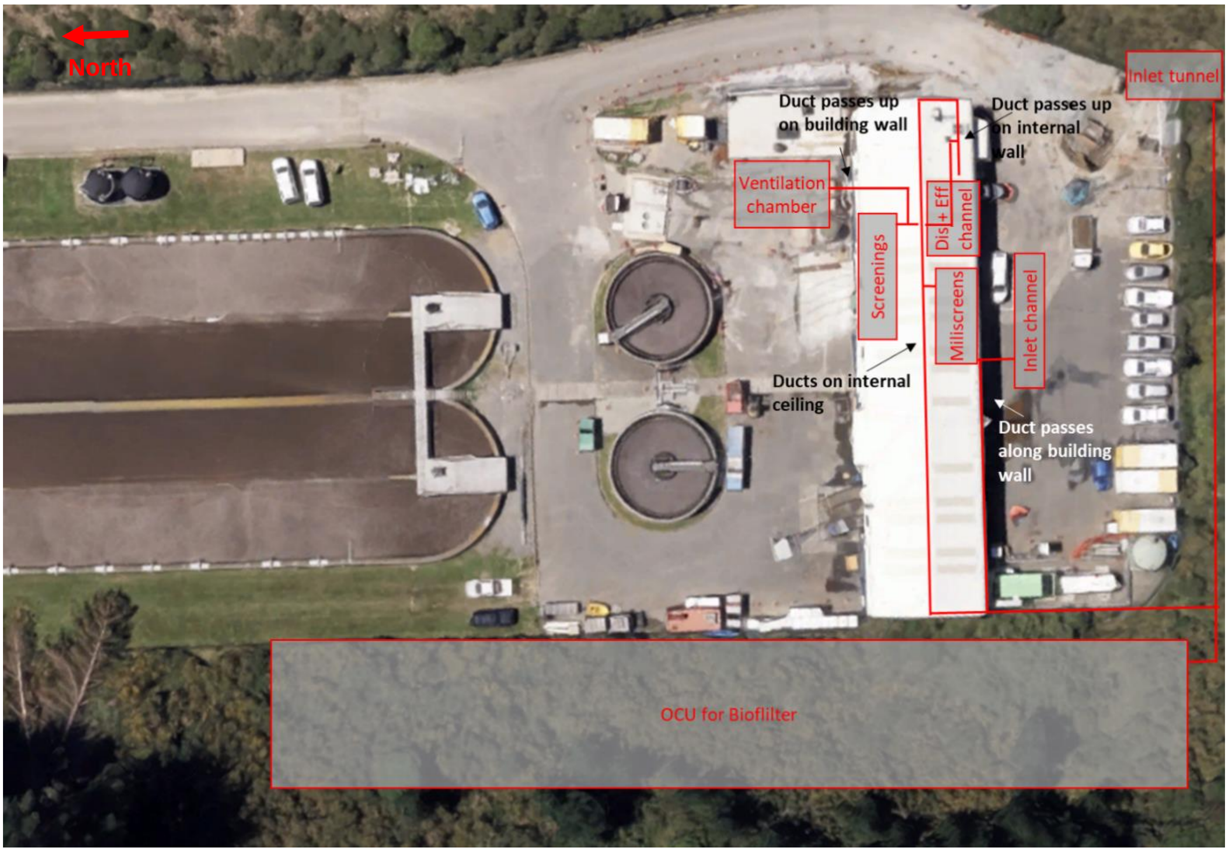


Figure 3-8: Ductwork arrangement for Biofilter OCU for Option 1

It is recommended that each duct to each process unit be provided with a lockable damper complete with manual flow measurement points to allow commissioning and flow adjustment during the lifespan of the odour extraction system.

3.1.2 Activated Carbon Only

Table 3-2 provides a summary of the key design parameters. The with a rough layout shown in Figure 3-9. The general arrangement sketch for this option is shown in Appendix B .

Table 3-2: Design of activated carbon for Option 1

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	12,700	
Configuration	-	2 duty/1 assist	
AC vessels dimensions	m x m (dia x H)	3.4 x 4.6	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	15.2 x 8.8	Dimensions of floor slab
Carbon mass	kg	25,900	Each vessel. Based on the required carbon for 365 days service life. The required carbon to maintain a contact time of 3s is 5,900 kg.
Residual contaminants	-	Below detection limit	
Fan capacity	kW	15	
Heater capacity	kW	45	For 10°C temperature rise

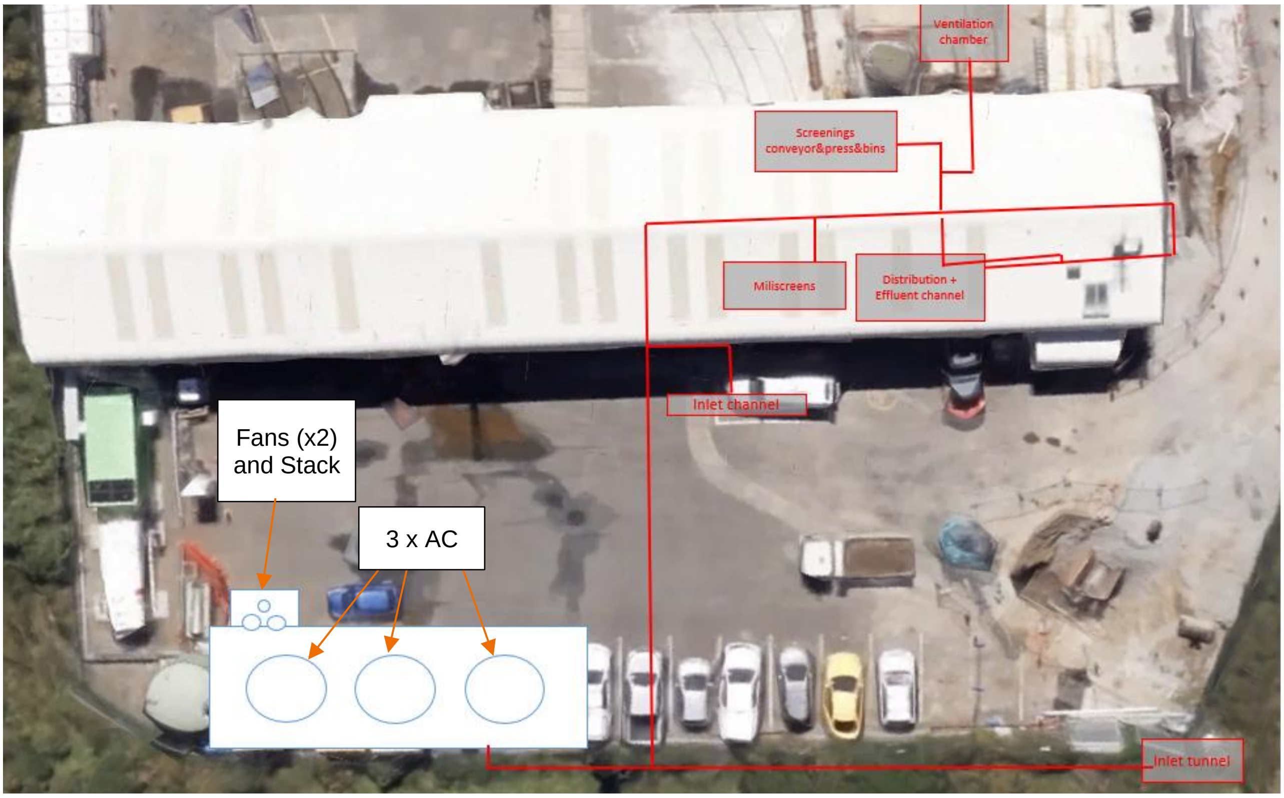


Figure 3-9: Option 1 – AC Layout

3.1.3 Biofilter

The open-topped biofilters were sized to achieve 99.5% of H_2S removal with additional removal for non-H_2S substances. It should be noted that the base of the biofilter will be acidic to promote autotrophic H_2S removing biomass, whilst the upper areas will operate at a neutral pH to promote heterotrophic biomass which remove other contaminants.

Table 3-3 provides a summary of the key design parameters with a rough layout shown in Figure 3-10. general layout for this option is shown in Appendix B .

Table 3-3: Design of open-topped biofilter for Option 1

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	12,700	
Bed configuration	-	3 duty/1 assist	Intent is to allow full treatment in 3 operational units
Dimensions	m x m (L x W)	25 x 16	Estimated for each bed, and media depth of 1.2m.
Footprint	m x m (L x W)	106 x 20	Dimensions of earthworks.
Media volume	m^3	486	Estimated for each bed.
Bed Depth	m	1.2	
Removal rate	%	H_2S: 99.5% R-SH: 80% VOC: 40% DMS: 60%	
Residual contaminants	ppm	H_2S: 0.1 R-SH: 0.04 VOC: 0.6 DMS: 0.008	Average load.
Surface Loading Rate	m^3/m^2h	10.5	Governed by contaminant removal rates
Fan capacity	kW	30	

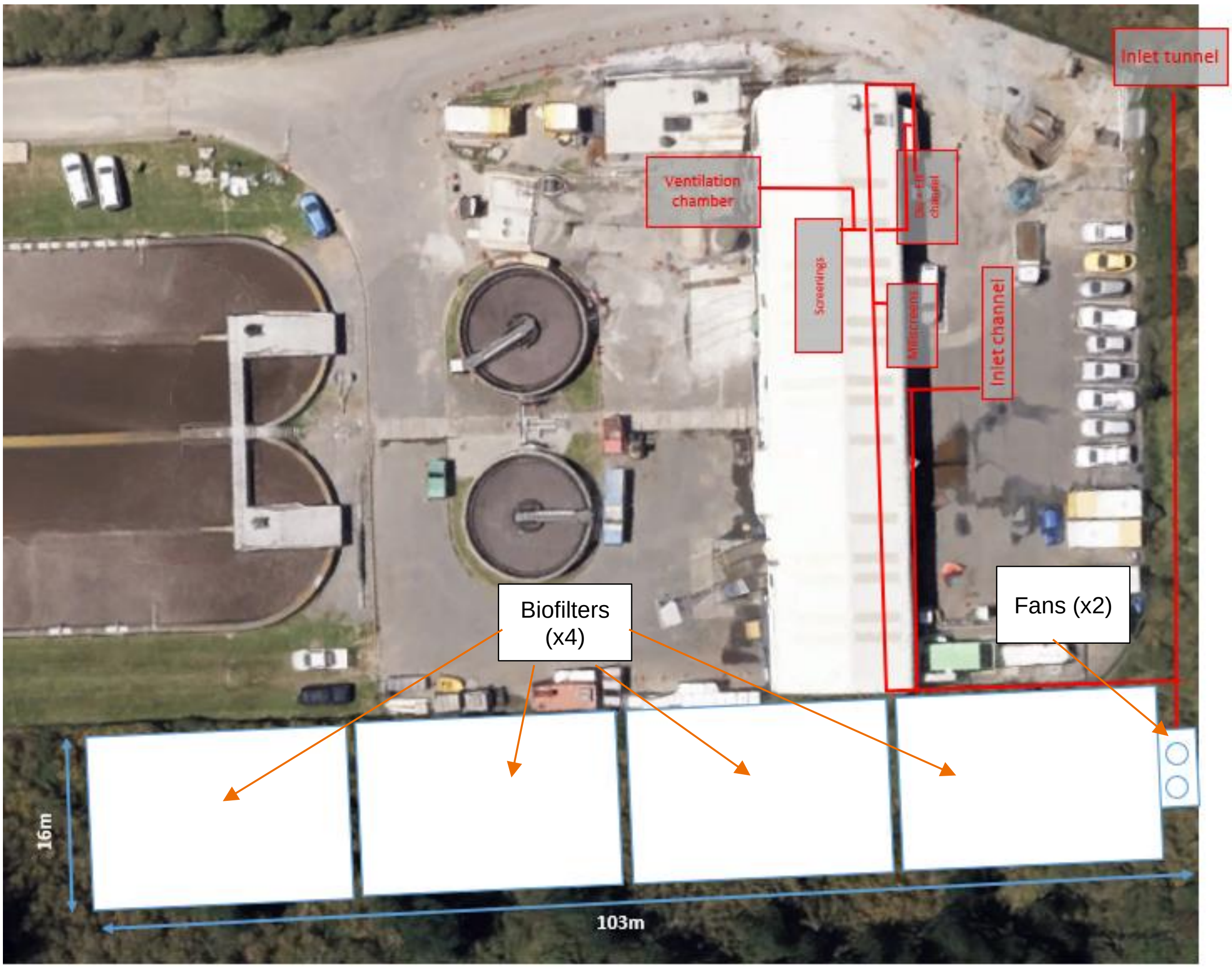


Figure 3-10: Option 1 – Biofilter Layout

3.1.4 Biotrickling Filter Alone

The BTFs were sized to achieve 99.5% of H_2S removal, and, for the average load, this efficiency was enough to reach the recommended outlet concentration.

Table 3-4 provides a summary of the key design parameters with a rough layout shown in Figure 3-11. The general layout for this option is shown in Appendix B .

Table 3-4: Design of biotrickling filter for Option 1

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	12,700	
Configuration	-	2 duty/1 assist	Intent is to allow full treatment in 2 operational units.
Dimensions	m x m (dia x H)	3 x 7.6	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	18.6 x 8.4	Dimensions of floor slab.
Media volume	m^3	34.9	Estimated for each vessel.
Removal rate	%	H_2S: 99.5% R-SH: 80%	

Parameter	Unit	Value	Comment
		VOC: 20% DMS: 0%	
Residual contaminants	ppm	H_2S: 0.1 R-SH: 0.04 VOC: 0.8 DMS: 0.02	Average load.
Water tank dimensions	m x m	2.6 x 2.2 Diameter x Height	
Fan capacity	kW	18	

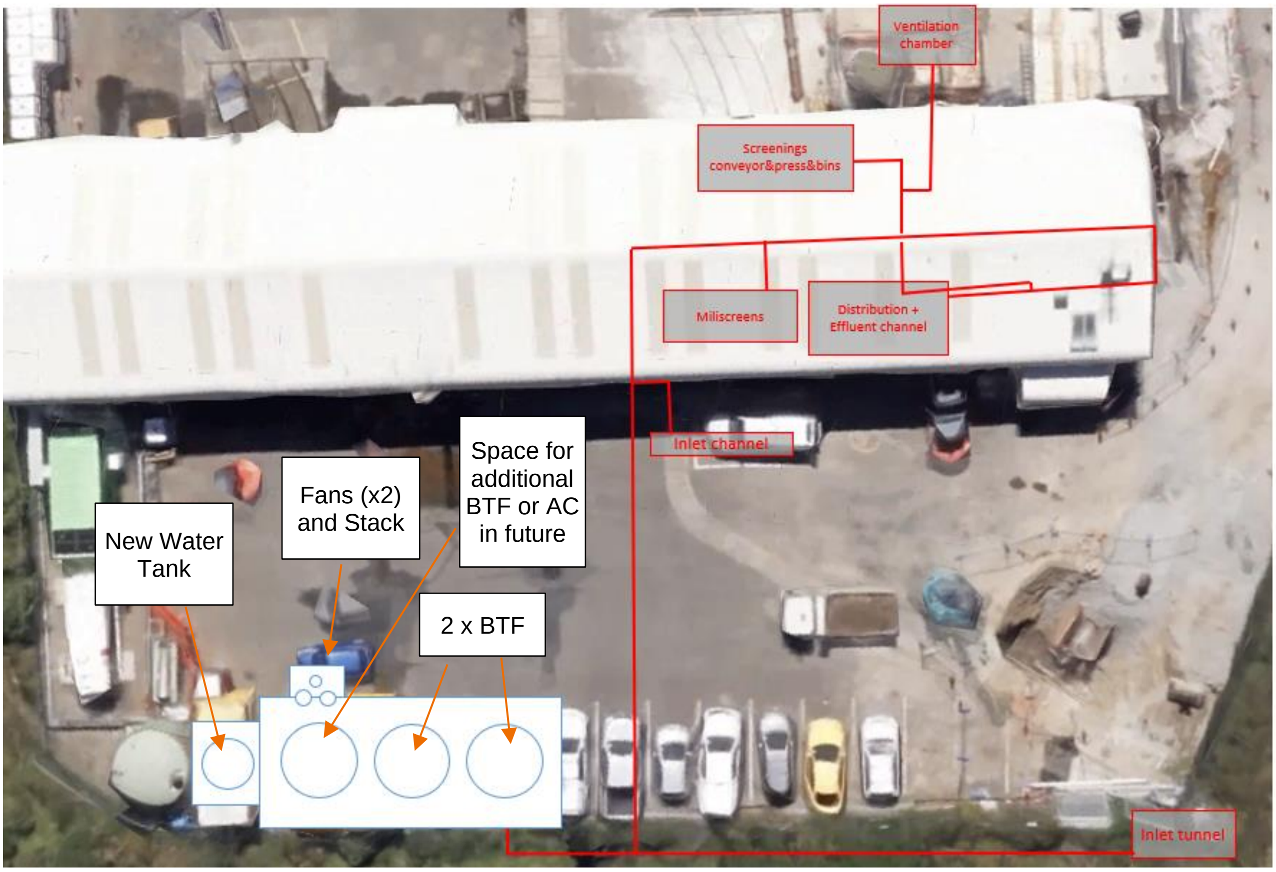


Figure 3-11: Option 1 – BTF Layout

It should be noted that the existing reclaimed effluent tank (shown adjacent to the new water tank) could potentially be reused for the OCU. The existing reclaimed effluent tank provides supply water to the centrifuges to be used as a backup in case the centrifuge reclaimed effluent feed pump (of which there is only a single duty pump) fails. There will be approximately 1 year where both the OCU and these centrifuges will both be operating. To reuse the existing reclaimed effluent tank for the OCU, additional redundancy could be provided in the centrifuge reclaimed effluent feed pump to reduce reliance on this reclaimed effluent tank.

Overall, there is potential to streamline the reclaimed effluent systems on site.

3.1.5 Biotrickling Filter with Activated Carbon

The BTFs were sized to achieve 95% of H_2S removal, and with the AC vessel providing residual treatment.is fulfilling the recommended outlet concentration providing redundancy for BTFs process, even for peak loads. This option involves the utilisation of biotrickling filters (BTF) along with activated carbon (AC) vessels to remove the contaminants by the concentration needed to reduce odour emissions, which are the same as the treatment in Section 3.1.5however the AC adsorber has been used as a polish filter in the end of the process, so that the BTF sizes can be decreased.

Additionally, a reclaimed water tank was also sized for the option to supply the necessary nutrients for the BTF system.

Table 3-5 provides a summary of the key design parameters with a rough layout shown in Figure 3-12. The general layout for this option is shown on Appendix B .

Table 3-5: Design of biotrickling filter along with activated carbon adsorbers for Option 1

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	12,700	
Configuration	-	BTF: 2 duty AC: 1 duty	The redundancy for the BTF system will be the AC vessel and vice versa
BTF dimensions	m x m (dia x H)	3 x 4.9	Estimated for each vessel. Dimensions may be modified by vendor.
AC dimensions	m x m (dia x H)	4 x 3.2	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	19.6 x 9.4	Dimensions of floor slab.
BTF media volume	m^3	16.1	Estimated for each vessel.
Carbon mass	kg	5,900	Each vessel. Based on the required contact time of 3s. The required carbon for 365 days service life is 2,800 kg.
BTFs removal rate	%	H_2S: 95% R-SH: 20% VOC: 20% DMS: 0%	
AC contaminant load	ppm	H_2S: 1.01 R-SH: 0.16 VOC: 0.8 DMS: 0.02	Average load.
Residual contaminants	-	Below detection limit	
Water tank dimensions	m x m (dia x H)	2.6 x 2.2	
Fan capacity	kW	22	
Heater capacity	kW	45	To give 10°C temperature increase

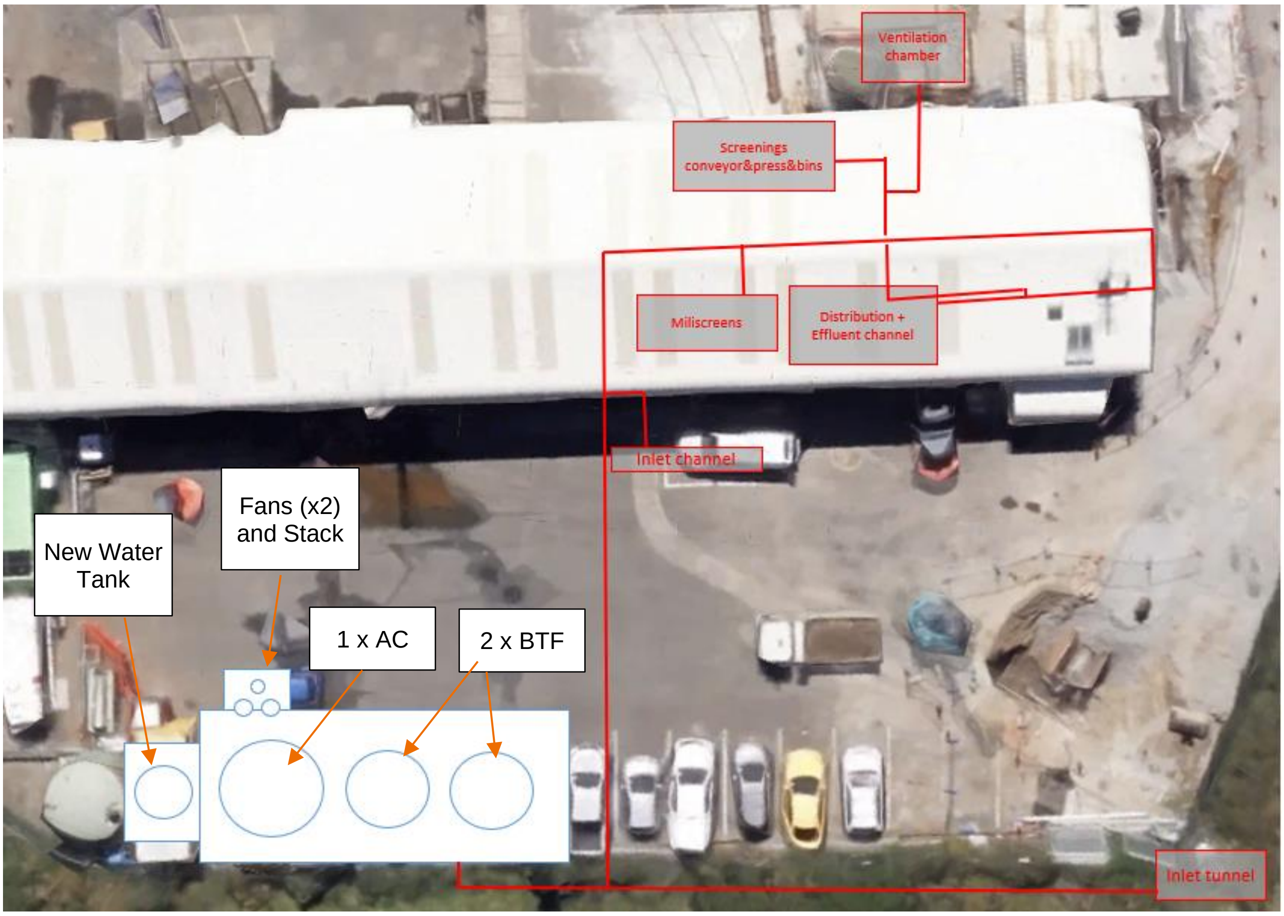


Figure 3-12: Option 1 – BTF + AC Layout

It should be noted that the existing reclaimed effluent tank (shown adjacent to the new water tank) could potentially be reused for the OCU. The existing reclaimed effluent tank provides supply water to the centrifuges to be used as a backup in case the centrifuge reclaimed effluent feed pump (of which there is only a single duty pump) fails. There will be approximately 1 year where both the OCU, and these centrifuges will both be operating. To reuse the existing reclaimed effluent tank for the OCU, additional redundancy could be provided in the centrifuge reclaimed effluent feed pump to reduce reliance on this reclaimed effluent tank.

3.2 Option 2 - Separate Odour Control Unit

3.2.1 Option 2a - Inlet Sewer Tunnel

For option 2a, which will ventilate foul air from the inlet tunnel extraction point into one individual OCU, the flow rate is 8,300 m^3/h. This foul air contains a high flow with a low load which is ideally suited to biological means, in particular biofilters.

3.2.1.1 Ductwork

Ductwork for Option 2a is relatively simple. The duct from the inlet sewer tunnel travels directly west until it reaches the OCU location, Location 4 (east part of the car park) for the AC, BTF and BTF+AC options and in Location 5 (south of the car park) for the biofilter option.

3.2.1.2 Activated carbon only

Table 3-6 provides a summary of the key design parameters with a rough layout shown in Figure 3-13. The general layout for this option is shown on Appendix B .

Table 3-6: Design parameters of activated carbon for Option 2a

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	8,300	
Configuration	-	1 duty/1 assist	Intent is to allow full treatment in 1 operational unit whilst the other is offline for media changeout
AC vessels dimensions	m x m (dia x H)	3.9 x 2.9	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	14.4 x 5.9	Dimensions of floor slab
Carbon mass	kg	5,300	Each vessel. Based on the required carbon for 365 days service life. The required carbon to maintain a contact time of 3s is 3,900 kg.
Residual contaminants	-	Below detection limit	
Fan capacity	kW	5.5	
Heater capacity	kW	30	For 10°C temperature rise

Figure 3-13: Option 2a – AC Layout

3.2.1.3 Biofilter

The open topped biofilters were sized to achieve 95% of H_2S removal. It should be noted that the load from other contaminants was negligible, and H_2S from the inlet tunnel is also lower than in Option 1. This means that a much lower contaminant removal rate is required, and a higher surface loading rate (and therefore smaller footprint) is required compared to the biofilter in Option 1.

Table 3-7 provides a summary of the key design parameters with a rough layout shown in Figure 3-14. The general layout for this option is shown in Appendix B .

Table 3-7 - Design of open-topped biofilter for option 2a

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	8,300	
Bed configuration	-	3 duty/1 assist	
Dimensions	m x m (L x W)	8 x 6	Estimated for each bed, and media depth of 1.2m.
Footprint	m x m (L x W)	46.5 x 18.5	Dimensions of earthworks.
Media volume	m^3	55.2	Estimated for each bed.
Removal rate	%	H_2S: 95% R-SH: 0% VOC: 0% DMS: 0%	
Surface loading rate	m^3/m^2h	60.1	Governed by contaminant removal rates
Residual contaminants	ppm	H_2S: 0.07 R-SH: 0.0 VOC: 1.0 DMS: 0.0	Average load.
Fan capacity	kW	9.3	

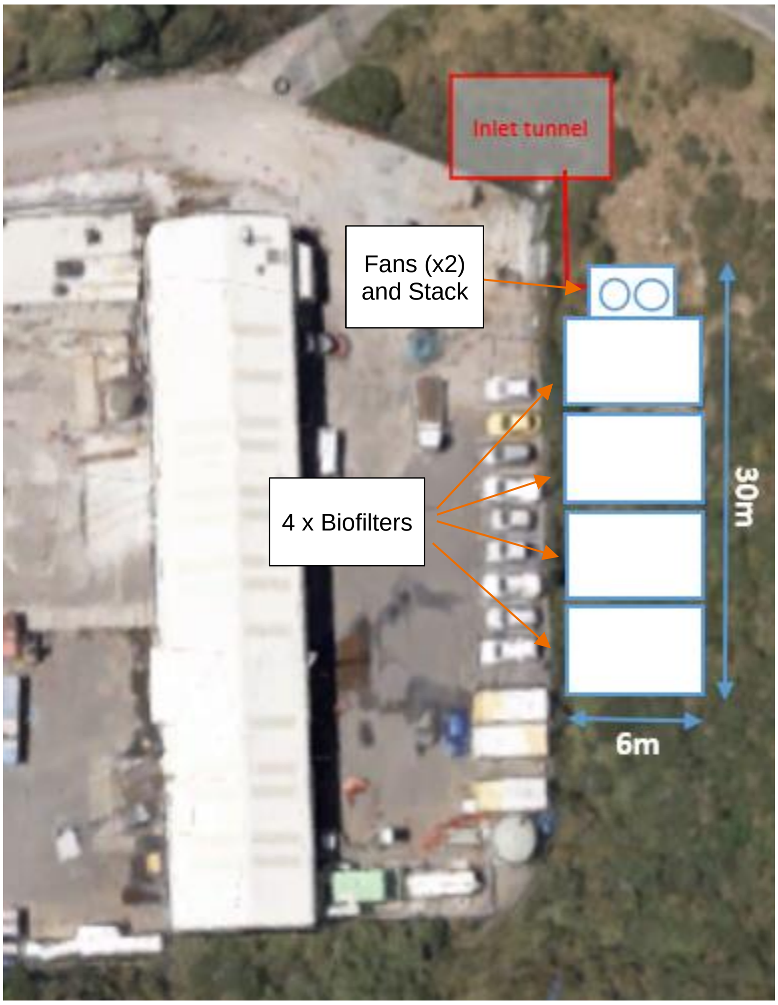


Figure 3-14: Option 2a – Biofilter Layout

3.2.1.4 Biotrickling filter alone

The BTFs were sized to achieve 95% of H_2S removal, and, for the average load, this efficiency was enough to reach the recommended outlet concentration. It should be noted that the load from other contaminants was negligible, and H_2S from the inlet tunnel is also lower than in Option 1. This means that a much lower contaminant removal rate is required, and smaller media volume is required compared to the BTF in Option 1. Also, given the low loading, a separate water tank would not be required.

Table 3-8 provides a summary of the key design parameters with a rough layout shown in Figure 3-15. The general layout for this option is shown in Appendix B .

Table 3-8: Design of biotrickling filter for option 2a

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	8,300	
Configuration	-	1 duty/1 assist	
Dimensions	m x m (dia x H)	2 x 7.1	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	10.6 x 4	Dimensions of floor slab.
Media volume	m^3	13.7	Estimated for each vessel.
Removal rate	%	H_2S: 95.0% R-SH: 0% VOC: 20% DMS: 0%	
Residual contaminants	ppm	H_2S: 0.1 R-SH: 0.0 VOC: 0.8 DMS: 0.0	Average load.
Fan capacity	kW	7.5	

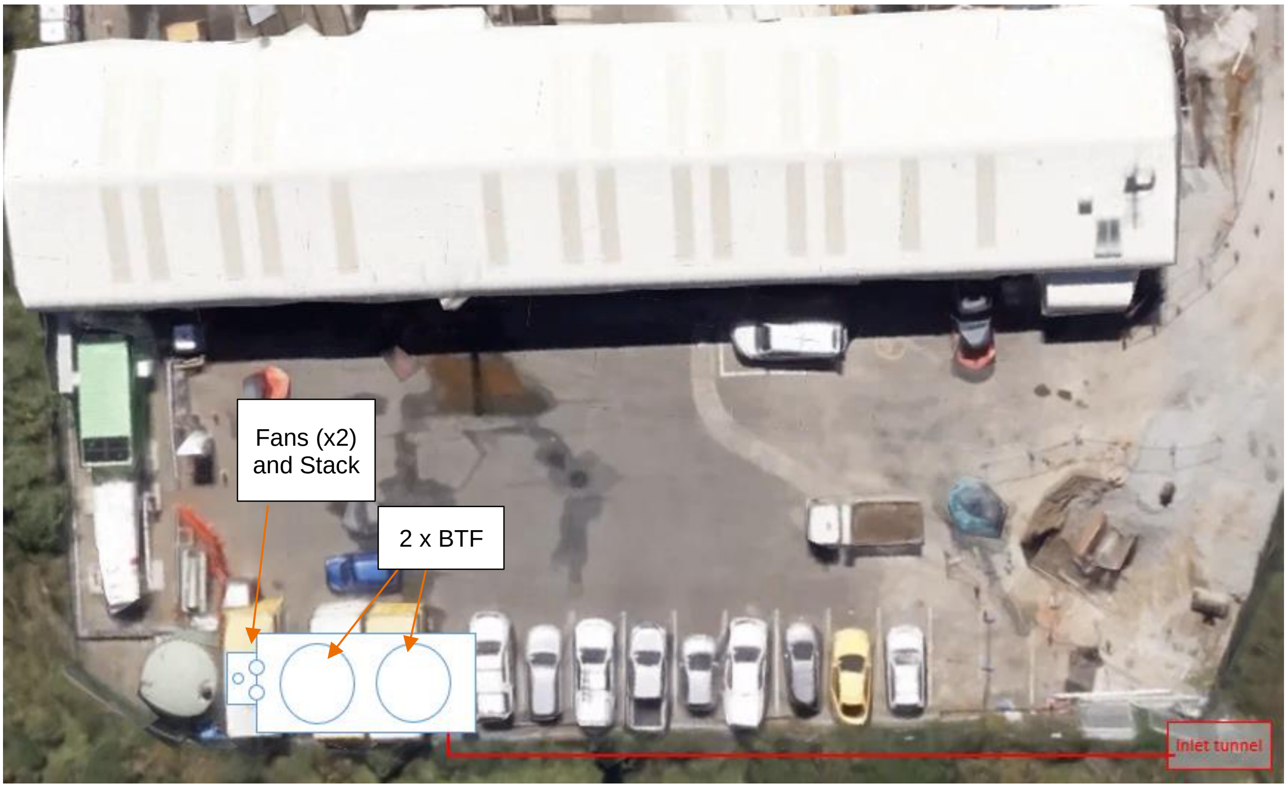


Figure 3-15: Option 2a – BTF Layout

3.2.1.5 Biotrickling filter with activated carbon

The BTFs were sized to achieve 50% H_2S removal, with the AC vessel providing residual treatment.

Table 3-9 provides a summary of the key design parameters with a rough layout shown in Figure 3-16. The general layout for this option is shown in Appendix B .

Table 3-9: Design of biotrickling filter along with activated carbon adsorbers for option 2a

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	8,300	
Configuration	-	BTF: 2 duty AC: 1 assist	The redundancy for the BTF system will be the AC vessel and vice versa
BTF dimensions	m x m (dia x H)	2 x 4.8	Estimated for each vessel. Dimensions may be modified by vendor.
AC dimensions	m x m (dia x H)	3.2 x 2.7	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	15.3 x 5.2	Dimensions of floor slab.
BTF media volume	m^3	6.4	Estimated for each vessel.
Carbon mass	kg	3,900	Each vessel. Based on the required contact time of 3s. The required carbon for 365 days service life is 1,500 kg.
BTFs removal rate	%	H_2S: 50% R-SH: 0% VOC: 20% DMS: 0%	
AC contaminant load	ppm	H_2S: 0.78 R-SH: 0.0 VOC: 0.8 DMS: 0.0	Average load.
Residual contaminants	-	Below detection limit	
Fan capacity	kW	15	
Heater capacity	kW	30	To give 10°C temperature increase

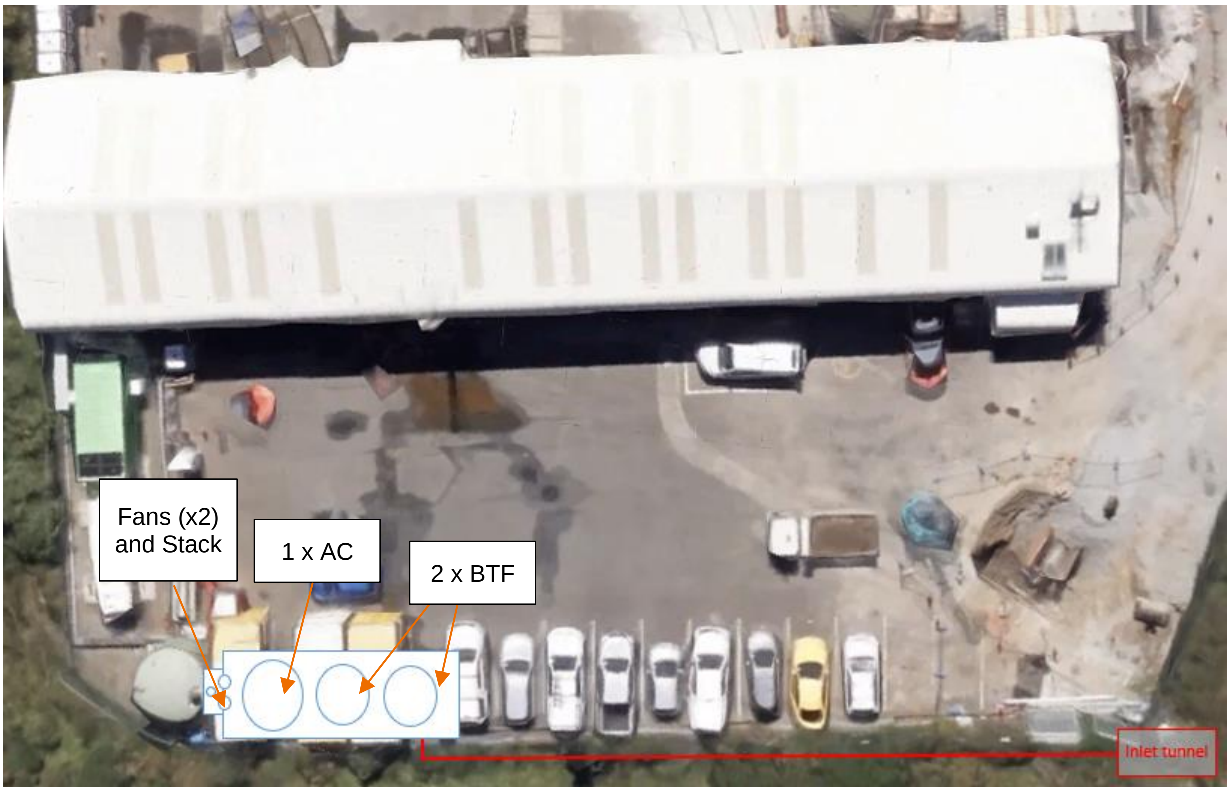


Figure 3-16: Option 2a – BTF+AC Layout

3.2.2 Option 2b - Other Odour-emitting Sources

For Option 2b, which will ventilate foul air from the other sources of odour into one individual OCU, the flow rate is 4,400 m^3/h however with a more concentrated load then option 2a. The load could become more variable than in Option 1 as it will be more related to turbulence in the plant, without the benefit of dilution with flows from the inlet tunnel. This low flow, high load foul air is best suited to biotrickling filters with the option of an AC for residual treatment if the load pattern is too variable.

3.2.2.1 Ductwork

Option 2b has the OCU located at Location 2 (north of the existing centrifuge area) for the AC, BTF and BTF+AC options and in Location 1 (west of site) for the biofilter option.

For the biofilter option, the ductwork arrangement will be very similar to that for Option 1, with the exception that the inlet channel duct will enter the building, instead of travelling outside the building. This is shown in Figure 3-17 with the overall layout shown in Figure 3-18.

Figure 3-17: Option 2b inlet channel duct

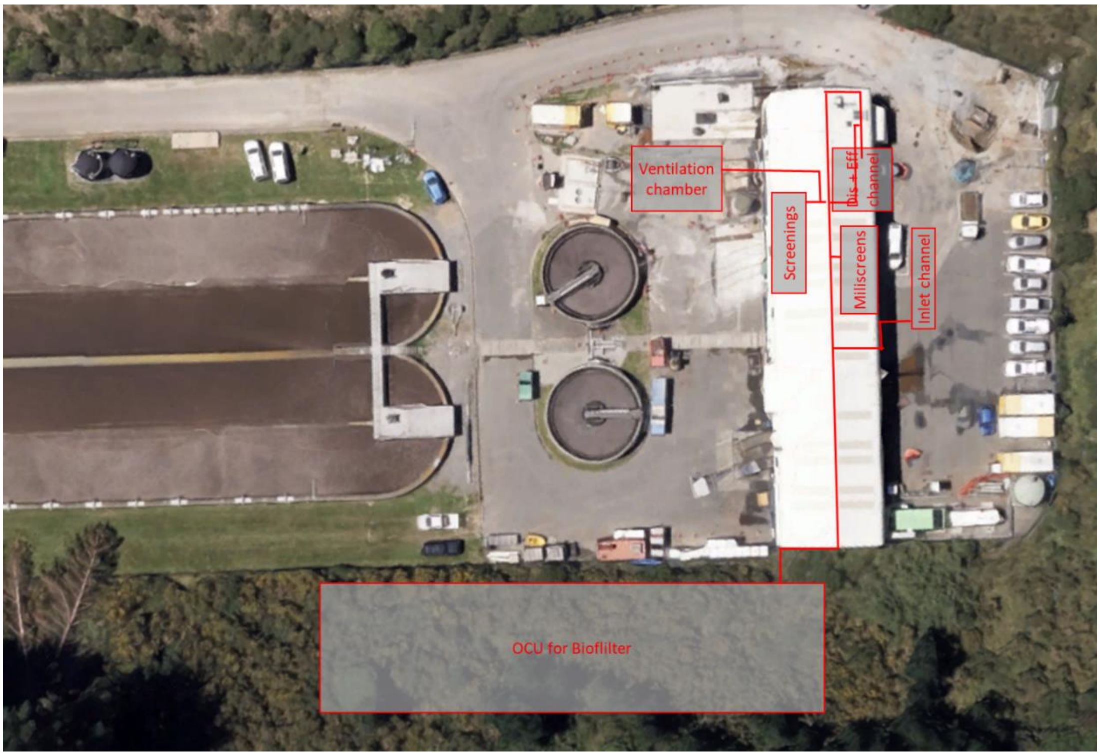


Figure 3-18: Option 2b Biofilter duct arrangement

For all other technologies, ductwork in the screenings area will be similar to that for Option 1, however ducts will be arranged to travel outside the northern end of the building instead of through the existing DN150 hole and the existing duct. This is shown in Figure 3-19.

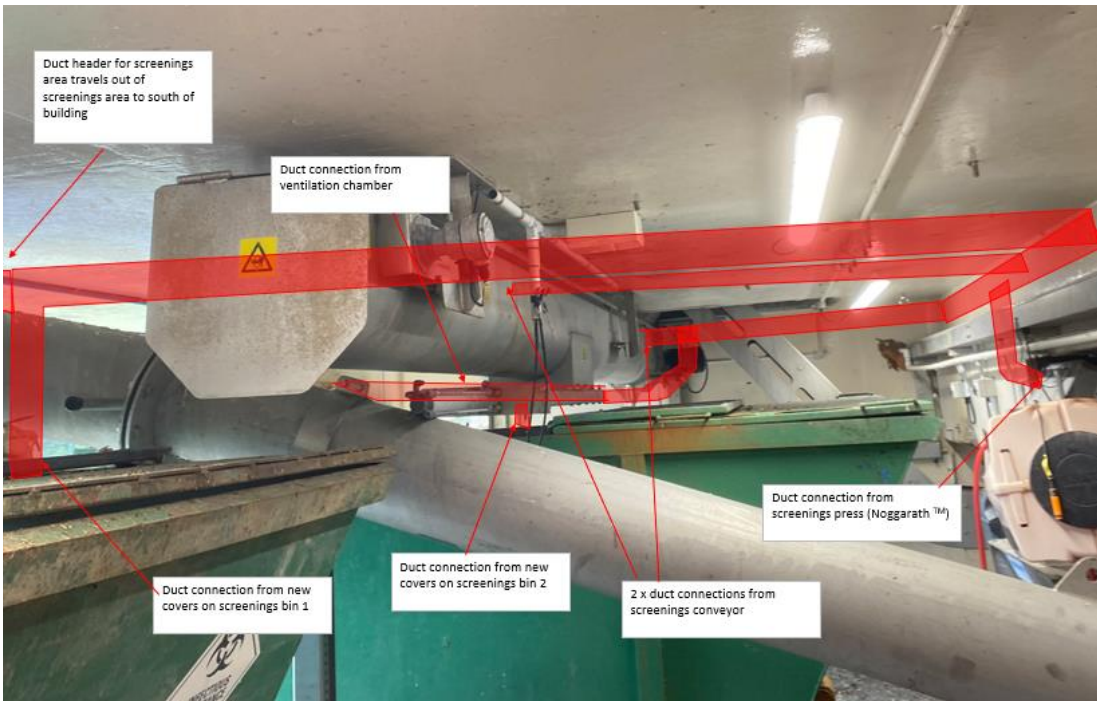


Figure 3-19: Option 2b (AC, BTF and BTF+AC) Ductwork within screenings area

The distribution chamber will be ventilated via dedicated duct that will travel along the top of the building, as per Option 1 (however it won't join with the screenings header duct). This is shown in Figure 3-20.

Figure 3-20: Option 2b (AC, BTF and BTF+AC) Duct from distribution chamber travels to top of peaked roof

This header will then pick up the Milliscreens and the inlet channel duct. The inlet channel duct will come above ground outside the building and penetrate the side of the building before joining the main duct header as shown in Figure 3-17. Instead of travelling to the south of the building, the main header will travel to the north of the building where it will drop to the screens level, before exiting through a new penetration in the northern end of the building as shown in Figure 3-21. The main header duct will then pick up flows from the screenings and ventilation chamber, before heading to the OCU location as shown in Figure 3-22 with the overall layout shown in Figure 3-23.

Figure 3-21: Option 2b (AC, BTF and BTF+AC) Milliscreens ductwork (only one shown) and main duct header.

Figure 3-22: Option 2b (AC, BTF and BTF+AC) Main header to the north of building

Figure 3-23: Ductwork arrangement for AC, BTF and AC+BTF technologies for Option 2b

It is recommended that each duct to each process unit be provided with a lockable damper complete with manual flow measurement points to allow commissioning and flow adjustment during the lifespan of the odour extraction system.

3.2.2.2 Activated carbon only.

Table 3-10 provides a summary of the key design parameters with a rough layout shown in Figure 3-24. The general layout for this option is shown in Appendix B .

Table 3-10: Design parameters of activated carbon for option 2b

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	4,400	
Configuration	-	2 duty/1 assist	Intent is to allow full treatment in 1 operational unit whilst the other is offline for media changeout
AC vessels dimensions	m x m (dia x H)	2 x 8.4	Estimated for each vessel. Dimensions might be specified by vendor.
Footprint	m x m (L x W)	13.8 x 4	Dimensions of floor slab
Carbon mass	kg	24,700	Each vessel. Based on the required carbon for 365 days service life. The required carbon to maintain a contact time of 3s is 2,100 kg.
Residual contaminants	-	Below detection limit	
Fan capacity	kW	10	
Heater capacity	kW	15	For 10°C temperature rise

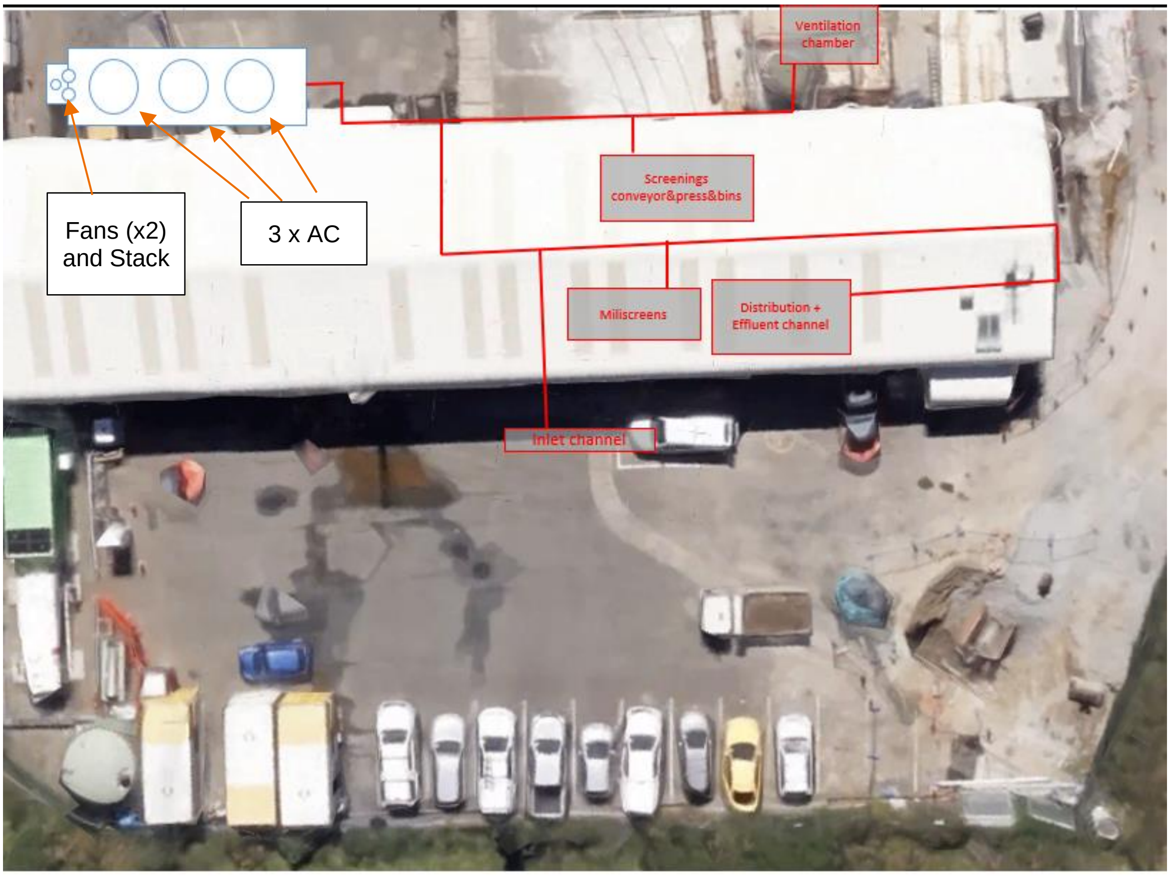


Figure 3-24: Option 2b – AC Layout

3.2.2.3 Biofilter

The open-topped biofilters were sized to achieve 99.8% of H_2S removal with additional removal for non-H_2S substances. It should be noted that the base of the biofilter will be acidic to promote autotrophic H_2S removing biomass, whilst the upper areas will operate at a neutral pH to promote heterotrophic biomass which remove other contaminants.

Table 3-11 provides a summary of the key design parameters with a rough layout shown in Figure 3-25. The general layout for this option is shown in Appendix B .

Table 3-11: Design of open-topped soil beds biofilter for option 2b

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	4,400	
Bed configuration	-	3 duty/1 assist	Intent is to allow full treatment in 3 operational units whilst one is offline for media changeout
Dimensions	m x m (L x W)	15 x 16	Estimated for each bed, and media depth of 1.2m.
Footprint	m x m (L x W)	66.4 x 20	Dimensions of earthworks.
Media volume	m^3	288	Estimated for each bed.
Bed Depth	m	1.2	
Removal rate	%	H_2S: 99.8% R-SH: 95% VOC: 40% DMS: 40%	

Parameter	Unit	Value	Comment
Residual contaminants	ppm	H_2S: 0.1 R-SH: 0.028 VOC: 0.6 DMS: 0.04	Average load.
Surface Loading Rate	m^3/m^2h	6.1	Governed by contaminant removal rates
Fan capacity	kW	9.3	

Figure 3-25: Option 2b – Biofilter Layout

3.2.2.4 Biotrickling filter alone

The BTFs were sized to achieve 99.8% of H_2S removal, and, for the average load, this efficiency was enough to reach the recommended outlet concentration.

Table 3-12 provides a summary of the key design parameters with a rough layout shown in Figure 3-26. The general layout for this option is shown in Appendix B .

Table 3-12: Design of biotrickling filter for Option 2b

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	4,400	
Configuration	-	2 duty/1 assist	Intent is to allow full treatment in 2 operational units.

Parameter	Unit	Value	Comment
Dimensions	m x m (dia x H)	2 x 7.9	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	15.6 x 6.8	Dimensions of floor slab.
Media volume	m^3	17.3	Estimated for each vessel.
Removal rate	%	H_2S: 99.8% R-SH: 93% VOC: 20% DMS: 20%	
Residual contaminants	ppm	H_2S: 0.1 R-SH: 0.04 VOC: 0.8 DMS: 0.05	Average load.
Water tank dimensions	m x m (dia x H)	2.6 x 2.2	
Fan capacity	kW	7.5	

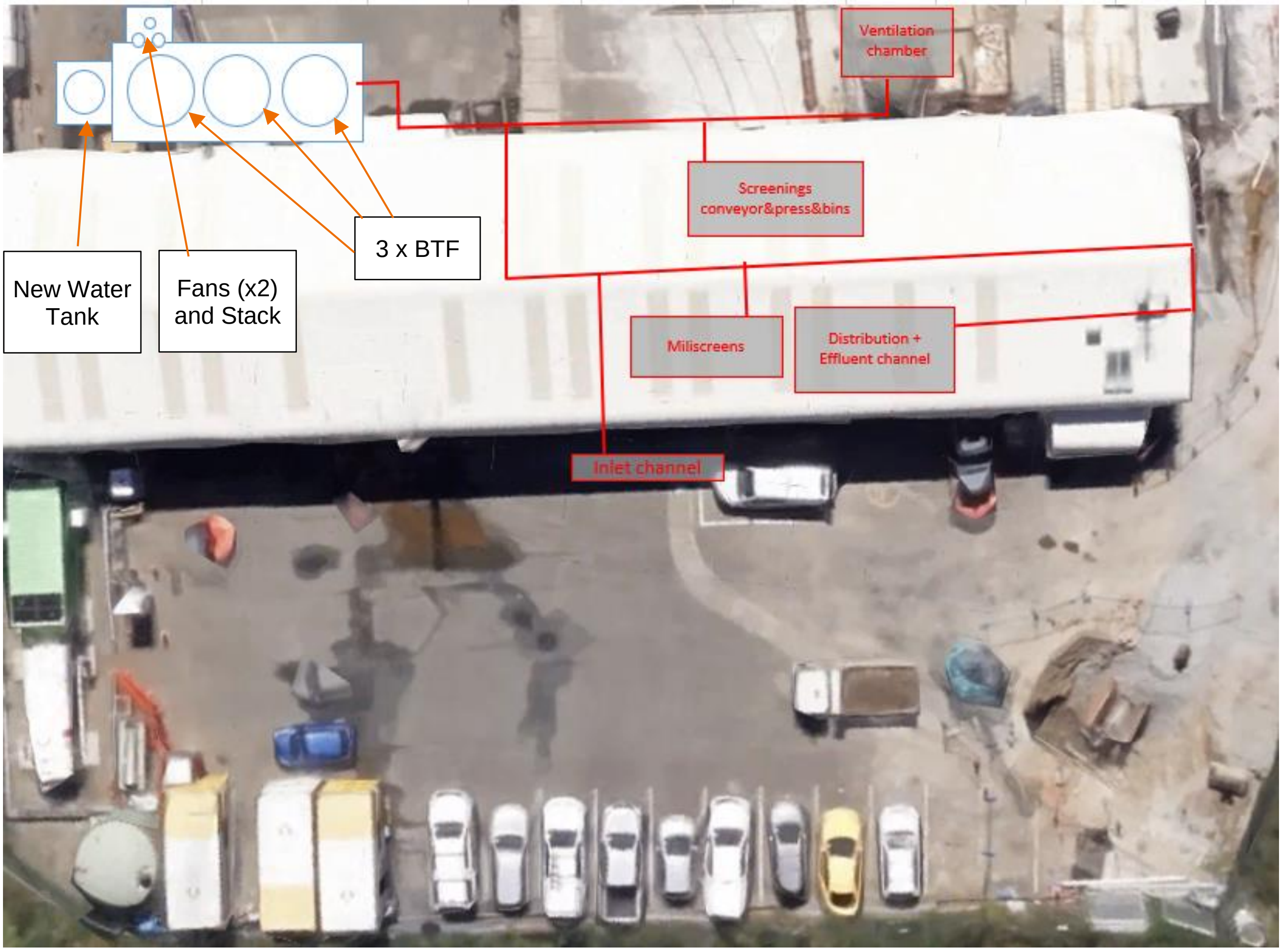


Figure 3-26: Option 2b – BTF Layout

3.2.2.5 Biotrickling filter with activated carbon

The BTFs were sized to achieve 95% of H_2S removal, and the AC vessel providing residual treatment.

Table 3-13 provides a summary of the key design parameters with a rough layout shown in Figure 3-27. The general layout for this option is shown in Appendix B .

Table 3-13: Design of biotrickling filter along with activated carbon adsorbers for Option 2b

Parameter	Unit	Value	Comment
Foul air flow rate	m^3/h	4,400	
Configuration	-	BTF: 2 duty AC: 1 assist	The redundancy for the BTF system will be the AC vessel and vice versa
BTF dimensions	m x m (dia x H)	2 x 7.8	Estimated for each vessel. Dimensions may be modified by vendor.
AC dimensions	m x m (dia x H)	2.3 x 2.2	Estimated for each vessel. Dimensions may be modified by vendor.
Footprint	m x m (L x W)	15.9 x 7.1	Dimensions of floor slab.
BTF media volume	m^3	16.6	Estimated for each vessel.
Carbon mass	kg	2,050	Each vessel. Based on the required contact time of 3s. The required carbon for 365 days service life is 1,500 kg.
BTFs removal rate	%	H_2S: 95% R-SH: 80% VOC: 20% DMS: 20%	
AC contaminant load	ppm	H_2S: 2.8 R-SH: 0.1 VOC: 0.8 DMS: 0.05	Average load.
Residual contaminants	-	Below detection limit	
Water tank dimensions	m x m (dia x H)	2.6 x 2.2	
Fan capacity	kW	22	
Heater capacity	kW	15	

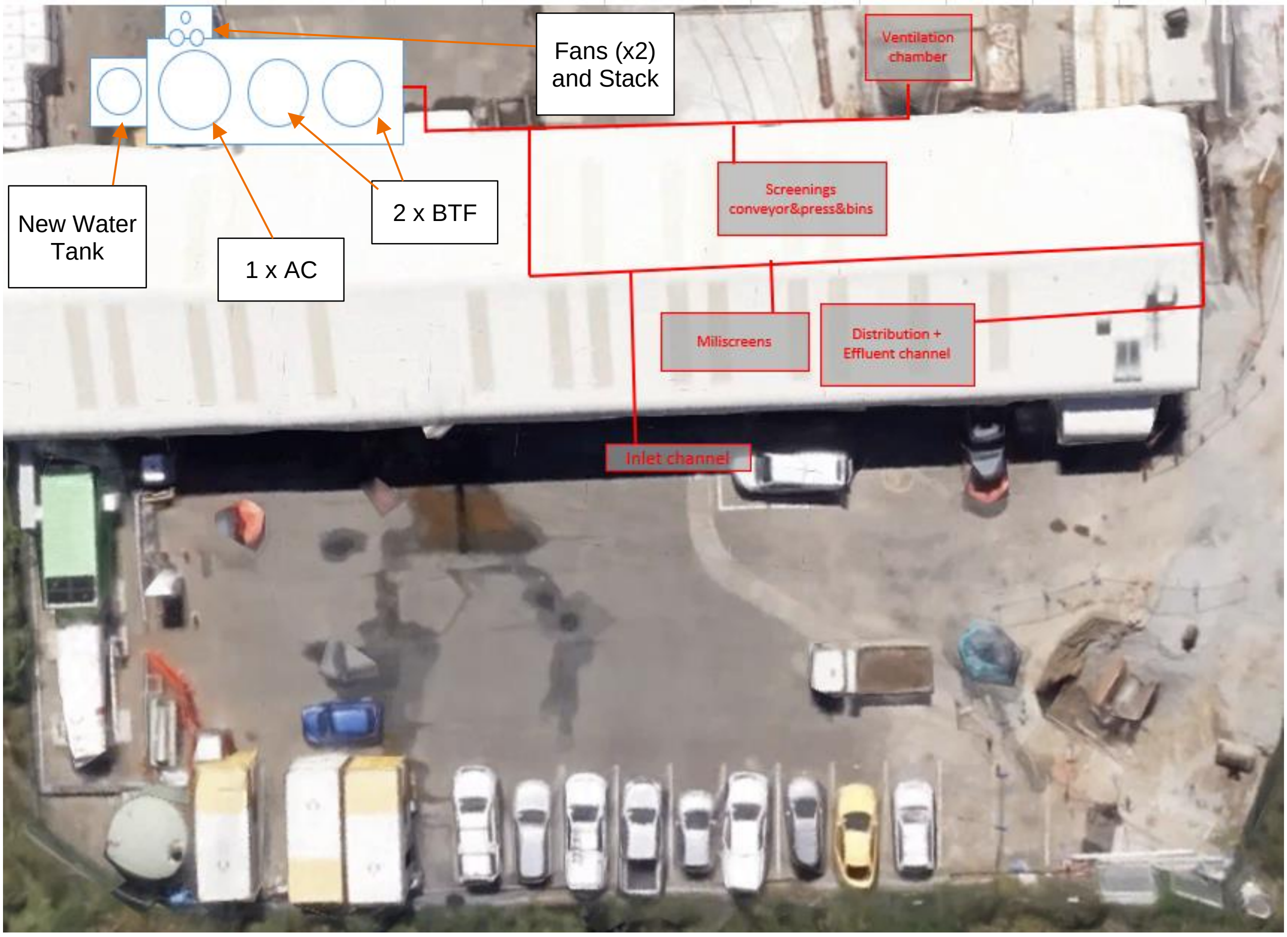


Figure 3-27: Option 2b – BTF+AC Layout

4 Multi Criteria Analysis

The multi criteria analysis criterion were agreed between Stantec and Wellington Water. The non-cost criteria are as follows:

- Operational simplicity
- Odour performance – i.e., ability to remove odorous compounds.
- Impact on workplace health and safety (WHS). This was split into the following areas:
  - H_2S gas exposure performance - in particular referencing the upcoming changes to the workplace exposure standards for hydrogen sulphide
  - Non-H_2S WHS performance – relating to all other health and safety risks associated with the option.
- Future flexibility to service additional loads.
- Ease of construction / commissioning.

In addition to the non-cost criteria, the following cost criteria were also assessed:

Each criterion was assessed as low, moderate, or high in accordance with Table 4-1 below, and the costs were assessed based on the colour code criteria as shown in Table 4-2, Table 4-3 and Table 4-4.

Table 4-1: MCA Assessment Criteria

Criteria	Low	Moderate	High
Operational simplicity	**Low** - Significant increase in staff input required for operation once installed.	**Moderate** - Some additional input from staff required for operation once installed.	**High** – No additional input from staff required for operation once installed.
Odour performance	**Low** - No improvement to existing odour performance.	**Moderate** - Improvements to odour performance with some limitations.	**High** - The odour levels are likely to be improved.
H_2S gas exposure performance	**Low** - No change to H_2S gas release concentration profile in working areas.	**Moderate** – Improvement in containment and/or treatment of H_2S with high residual concentrations possible.	**High** – Improvement in containment and/or treatment of H_2S, with low residual concentrations possible.
Non-H_2S WHS performance This considers performance in relation to non-H_2S related hazards that the option introduces, such as acidic blowdown or frequent medium to high-risk operation and maintenance activities.	**Low** - Frequent staff handling of hazardous chemicals for operation or other medium to high-risk operation and maintenance activities.	**Moderate** – Periodic staff handling of hazardous chemicals for operation and infrequent medium to high-risk operation and maintenance activities.	**High** - No material non-H_2S related WHS risk increase due to implementing this option.
Future Flexibility to Service Additional Loads	**Low** - Additional loads from existing sources will not be treated without additional upgrades.	**Moderate** - Additional loads from existing sources will be partially treated.	**High** - Additional loads from existing sources will be treated.
Ease of Construction/ Commissioning	**Low** - Construction is required, and there is insufficient space on-site.	**Moderate** - Construction is required, and there is adequate space on-site.	**High** - No construction is required in this option.
Estimated Capital Cost	Estimated capital cost.		
Annual O&M Cost	Annual operational and maintenance costs.		
NPV	Total cost to implement option.		
Recommendation	Recommended; Not recommended (but suitable); Not recommended.		

Table 4-2 – CAPEX cost colour code criteria

	CAPEX	
Criteria	**Minimum**	**Maximum**
Very Low	$ 3,000,000	$ 4,000,000
Low	$ 4,000,001	$ 6,100,000
Medium	$ 6,100,001	$ 9,000,000
High	$ 9,000,001	$ 20,000,000

CAPEX		
Criteria	Minimum	Maximum
Very High	$ 20,000,001	$ 40,000,000

Table 4-3 - OPEX cost colour code criteria

OPEX		
Criteria	Minimum	Maximum
Very Low	$ 10,000	$ 50,000
Low	$ 50,001	$ 100,000
Medium	$ 100,001	$ 250,000
High	$ 250,001	$ 450,000
Very High	$ 450,001	$ 1,000,000

Table 4-4 - Whole life cost colour code criteria

NPV Total		
Criteria	Minimum	Maximum
Very Low	$ 1,000,000	$ 6,000,000
Low	$ 6,000,001	$ 10,000,000
Medium	$ 10,000,001	$ 20,000,000
High	$ 20,000,001	$ 30,000,000
Very High	$ 30,000,001	$ 40,000,000

Table 4-5 for additional details below.

Table 4-5: Developed multi criteria analysis

	Option 1 Single odour control unit ventilating all infrastructure on site				Option 2a Inlet tunnel ventilated to one odour control unit				Option 2b Other odour sources ventilated to another odour control unit			
Treatment option	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon
Operational simplicity	Moderate – Some additional input from staff required for operation once installed, due to additional equipment such as heater, yearly carbon media changes and additional instrumentation.	High – Minimal additional input from staff required for operation once installed however media changeout (every 2-5 years) will be significant activity.	Moderate – Some additional input from staff required for operation once installed, due to additional equipment such as water tank for nutrient dosing, pumps, and additional instrumentation.	Low – Highest of additional input from staff required for operation once installed, due to additional equipment, 2 processes, frequent media carbon changes and additional instrumentation.	Moderate – Some additional input from staff required for operation once installed, due to additional equipment such as heater, yearly carbon media changes and additional instrumentation.	High – Minimal additional input from staff required for operation once installed however media changeout (every 2-5 years) will be significant activity.	Moderate – Some additional input from staff required for operation once installed, due to additional equipment such as water tank for nutrient dosing, pumps, and additional instrumentation.	Low – Highest of additional input from staff required for operation once installed, due to additional equipment, 2 processes, frequent media carbon changes and additional instrumentation.	Moderate – Some additional input from staff required for operation once installed, due to additional equipment such as heater, yearly carbon media changes and additional instrumentation.	High – Minimal additional input from staff required for operation once installed however media changeout (every 2-5 years) will be significant activity.	Moderate – Some additional input from staff required for operation once installed, due to additional equipment such as water tank for nutrient dosing, pumps, and additional instrumentation.	Low – Highest of additional input from staff required for operation once installed, due to additional equipment, 2 processes, frequent media carbon changes and additional instrumentation

	Option 1 Single odour control unit ventilating all infrastructure on site				Option 2a Inlet tunnel ventilated to one odour control unit				Option 2b Other odour sources ventilated to another odour control unit			
Treatment option	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon
Odour performance	High – Robust treatment process. Treated air is discharged through a vent stack which enables good dispersion. At some point, the expected outlet concentration will start to deteriorate as carbon is saturated.	Moderate – Improvements to odour performance with significant limitations. Treated air is discharged at ground level, so dispersion is limited, which will not be a problem for the residential area, though it can be an issue at the treatment plant area.	Moderate – Improvements to odour performance with some limitations. Treated air is discharged through a vent stack which enables good dispersion.	High – Very robust treatment process. Treated air is discharge through a vent stack which enables good dispersion. At some point, the expected outlet concentration may change due to carbon saturation, however this will be slow as BTF will remove most load.	High – Robust treatment process. Treated air is discharged through a vent stack which enables good dispersion. At some point, the expected outlet concentration will start to deteriorate as carbon is saturated.	Moderate – Improvements to odour performance with significant limitations. Treated air is discharged at ground level, so dispersion is limited, which will not be a problem for the residential area, though it can be an issue at the treatment plant area.	Low – Improvements to odour performance with some limitations. Treated air is discharged through a vent stack which enables good dispersion. Load is unlikely to be able to sustain continuous good performance without secondary treatment (such as AC)	High – Very robust treatment process. Treated air is discharge through a vent stack which enables good dispersion. At some point, the expected outlet concentration may change due to carbon saturation, however this will be slow as BTF will remove most load.	High – Robust treatment process. Treated air is discharged through a vent stack which enables good dispersion. At some point, the expected outlet concentration will start to deteriorate as carbon is saturated.	Moderate – Improvements to odour performance with significant limitations. Treated air is discharged at ground level, so dispersion is limited, which will not be a problem for the residential area, though it can be an issue at the treatment plant area.	Moderate – Improvements to odour performance with some limitations. Treated air is discharge through a vent stack which enables a good dispersion. At some point, the expected outlet concentration might change due to decreased BTF performance.	High – Very robust treatment process. Treated air is discharge through a vent stack which enables good dispersion. At some point, the expected outlet concentration may change due to carbon saturation, however this will be slow as BTF will remove most load.
H_2S gas exposure performance	High – Improvement in containment and treatment of H_2S with high residual concentrations possible if abnormal operation occurs. However, treated air is discharged through a vent stack which enables good dispersion.	Low – Improvement in containment and treatment of H_2S Treated air is discharged at ground level, so dispersion is limited, which would be a high exposure risk if abnormal operation (such as breakthrough) occurs. Breakthrough is more likely with this technology due to large area.	Moderate – Improvement in containment and/or treatment of H_2S with high residual concentrations possible if abnormal operation occurs. However, treated air is discharge through a vent stack which enables good dispersion.	High – Improvement in containment and/or treatment of H_2S, with low residual concentrations possible. BTFs and AC have a high efficiency removing H_2S with in-built redundancy, and treated air is discharged through a vent stack which enables good dispersion.	High – Improvement in containment and treatment of H_2S with high residual concentrations possible if abnormal operation occurs. However, treated air is discharged through a vent stack which enables good dispersion. H_2S from this gas stream is already low (peaks below STEL) anyway.	Moderate – Improvement in containment and treatment of H_2S Treated air is discharged at ground level, so dispersion is limited, which would be a high exposure risk if abnormal operation (such as breakthrough) occurs. However H_2S from this gas stream is already low (peaks below STEL) anyway.	High – Improvement in containment and/or treatment of H_2S with high residual concentrations possible if abnormal operation occurs. However, treated air is discharged through a vent stack which enables good dispersion. H_2S from this gas stream is already low (peaks below STEL) anyway.	High – Improvement in containment and/or treatment of H_2S, with low residual concentrations possible. BTFs and AC have a high efficiency removing H_2S with in-built redundancy, and treated air is discharged through a vent stack which enables good dispersion. H_2S from this gas stream is already low (peaks below STEL) anyway.	High – Improvement in containment and treatment of H_2S with high residual concentrations possible if abnormal operation occurs. However, treated air is discharged through a vent stack which enables good dispersion.	Low – Improvement in containment and treatment of H_2S Treated air is discharged at ground level, so dispersion is limited, which would be a high exposure risk if abnormal operation (such as breakthrough) occurs. Breakthrough is more likely with this technology due to large area and high H_2S loading.	Moderate – Improvement in containment and/or treatment of H_2S with high residual concentrations possible if abnormal operation occurs. However, treated air is discharged through a vent stack which enables good dispersion.	High – Improvement in containment and/or treatment of H_2S, with low residual concentrations possible. BTFs and AC have a high efficiency removing H_2S with in-built redundancy, and treated air is discharged through a vent stack which enables good dispersion.
Non-H_2S WHS performance **This considers performance in relation to non-H_2S related hazards that the option introduces, such as acidic blowdown or frequent medium to high-risk operation and maintenance activities**	Moderate – infrequent medium to high-risk operation and maintenance activities with AC changeout.	Low – Periodic staff handling of low pH blowdown for operation and infrequent medium risk media changeout.	Moderate – Periodic staff handling of low pH blowdown for operation and very infrequent (every 10 years) medium to high-risk operation and maintenance activities for media changeout.	Moderate – Periodic staff handling of hazardous chemicals for operation and infrequent medium to high-risk operation and maintenance activities. Possible exposure to a low pH liquor in case of maintenance and high	Moderate – Infrequent medium to high-risk operation and maintenance activities with AC changeout. Somewhat high operational temperature for AC system.	Low – Periodic staff handling of low pH blowdown for operation and infrequent medium risk media changeout.	Moderate – Periodic staff handling of low pH blowdown for operation and very infrequent (every 10 years) medium to high-risk operation and maintenance activities for media changeout.	Moderate – Periodic staff handling of low pH blowdown. Somewhat high operational temperature for AC system. Infrequent medium to high-risk operation and maintenance activities with AC changeout.	Moderate – Infrequent medium to high-risk operation and maintenance activities with AC changeout. Somewhat high operational temperature for AC system.	Low – Periodic staff handling of low pH blowdown for operation and infrequent medium risk media changeout.	Moderate – Periodic staff handling of low pH blowdown for operation and very infrequent (every 10 years) medium to high-risk operation and maintenance activities for media changeout.	Moderate – Periodic staff handling of low pH blowdown. Somewhat high operational temperature for AC system. Infrequent medium to high-risk operation and maintenance activities with AC changeout. very infrequent (every 10 years) medium to high-risk

Treatment option	Option 1 Single odour control unit ventilating all infrastructure on site: Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Option 2a Inlet tunnel ventilated to one odour control unit: Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Option 2b Other odour sources ventilated to another odour control unit: Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon
				temperature system for AC operation.				very infrequent (every 10 years) medium to high-risk operation and maintenance activities for BTF media changeout.				operation and maintenance activities for BTF media changeout.
Future Flexibility to Service Additional Loads	Moderate – Additional loads from existing sources will be partially treated but AC would be depleted quicker.	Low – Additional loads from existing sources will be partially treated depending on the nature of the load however additional capacity would likely be needed.	Moderate – Additional loads from existing sources will be partially treated depending on the nature of the load.	Moderate – Additional loads from existing sources will be fully treated, however AC may be depleted quicker.	Moderate – Additional loads from existing sources will be partially treated but AC would be depleted quicker.	Low – Additional loads from existing sources will be partially treated depending on the nature of the load however additional capacity would likely be needed.	Moderate – Additional loads from existing sources will be partially treated depending on the nature of the load.	Moderate – Additional loads from existing sources will be fully treated, however AC may be depleted quicker.	Moderate – Additional loads from existing sources will be partially treated but AC would be depleted quicker.	Low – Additional loads from existing sources will be partially treated depending on the nature of the load however additional capacity would likely be needed.	Moderate – Additional loads from existing sources will be partially treated depending on the nature of the load.	Moderate – Additional loads from existing sources will be fully treated, however AC may be depleted quicker.
Ease of construction/ commissioning	Moderate - Construction is required, however there is adequate space on-site. Commissioning is relatively easy.	Low - Construction is required, and there is insufficient space on-site. Significant earthworks will be necessary. Commissioning is relatively easy.	Moderate – Construction is required, however there is adequate space on-site. Commissioning is relatively easy but can take weeks for biomass to establish.	Moderate - Construction is required, however there is adequate space on-site. Commissioning is more difficult with two process units but still relatively easy.	Moderate - Construction is required, however there is adequate space on-site. Commissioning is relatively easy.	Low - Construction is required, and there is insufficient space on-site. Significant earthworks will be necessary. Commissioning is relatively easy.	Moderate – Construction is required, however there is adequate space on-site. Commissioning is relatively easy but can take weeks for biomass to establish.	Moderate - Construction is required, however there is adequate space on-site. Commissioning is more difficult with two process units but still relatively easy.	Moderate - Construction is required, however there is adequate space on-site. Commissioning is relatively easy.	Low - Construction is required, and there is insufficient space on-site. Significant earthworks will be necessary. Commissioning is relatively easy.	Moderate – Construction is required, however there is adequate space on-site. Commissioning is relatively easy but can take weeks for biomass to establish.	Moderate - Construction is required, however there is adequate space on-site. Commissioning is more difficult with two process units but still relatively easy.
Estimated Capital Cost	Low	Very High	Medium	Medium	Very Low	Low	Low	Low	Low	Low	Very Low	Very Low
Annualised O&M Cost	Very High	Medium	Low	Medium	Medium	Very Low	Very Low	Medium	High	Very Low	Very Low	Medium
NPV	Medium	Very High	Low	Medium	Very Low	Very Low	Very Low	Low	Medium	Very Low	Very Low	Very Low
Recommendation	Not recommended	Not recommended	Recommended	Not recommended (but suitable)	Not recommended (but suitable)	Not recommended (but suitable)	Not recommended	Not recommended	Not recommended	Not recommended	Not recommended (but suitable)	Not recommended (but suitable)
Reason for recommendation	Whilst the capital cost is low, the operating cost (and AC use) is very high	OCU is very large, requiring significant earthworks. Higher risk of breakthrough of contaminants with such a large biofilter leading to on site WHS impacts and offsite odour impacts.	Greatest balance of cost vs operation for Option 1 with stack providing added dispersion. Could potentially be designed without 3rd BTF tower (i.e. less redundancy) with the intent to throttle flows back when one BTF is out of service. This would then allow space to add AC if the	This option would provide the most robust treatment of any option, however is more costly than a BTF alone. Additional cost of AC may not be worth the additional level of treatment. Can move from BTF only to BTF+AC option (this option) should odour impact still persist after	Ongoing AC costs are large and offset cheaper capital cost.	A biofilter is ideally suited to a large flow, low load situation, however even so it is a large biofilter. Significant earthworks (but less than other biofilter options) would be required to implement this option.	There may not be sufficient H_2S in the feed stream to create a stable biomass in a BTF. This would lead to periods of breakthrough.	Whilst this option would provide the most robust treatment for Option 2a, given the flow is lowly loaded anyway, this level of treatment is considered overkill	The increased operating cost of implementing AC on this foul air stream would essentially negate the cost reductions from splitting the foul air streams	OCU is very large, requiring significant earthworks. Higher risk of breakthrough of contaminants with such a large biofilter leading to on site WHS impacts and offsite odour impacts.	Greatest balance of cost vs operation for Option 2b with stack providing added dispersion. Could potentially be designed without 3rd BTF tower (i.e. less redundancy) with the intent to throttle flows back when one BTF is out of service. This would then allow space to add AC if the load	This option would provide the most robust treatment of any technology for Option 2b, however is more costly than a BTF alone. Can move from BTF only to BTF+AC option (this option) should odour impact still persist after implementing BTF only option.

	Option 1 Single odour control unit ventilating all infrastructure on site				Option 2a Inlet tunnel ventilated to one odour control unit				Option 2b Other odour sources ventilated to another odour control unit			
Treatment option	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon	Activated Carbon	Biofilter	Biotrickling filter alone	Biotrickling filter with activated carbon
			load became too variable for BTF alone.	implementing BTF only option.							became too variable for BTF alone.	

For Option 2 costs, a combination of 2a and 2b has been conducted for different technologies. This can be found in Table 4-6 for net present values only.

Table 4-6: Net present values for technology combinations for Option 2

NPV		Option 2b			
		AC	Biofilter	BTF	BTF+AC
Option 2a	AC	Medium	Medium	Low	Medium
	Biofilter	Medium	Medium	Low	Medium
	BTF	Medium	Medium	Low	Medium
	BTF+AC	Medium	Medium	Medium	Medium

In most instances, the cost of splitting the flow and treating them separately (Option 2) is greater than the cost of the recommended technology for Option 1 (being a BTF only for an NPV in the Low cost range).

Given the additional non-cost impacts of having two separate technologies, such as the need to operate and maintain two different odour control units, whilst (for some combinations) being cost competitive with Option 1, no combination of Option 2 has sufficient benefits to be considered a preferred option.

5 Conclusions and Recommendations

As stated before, the purpose of this project is to recommend a solution for the odour impacts currently present at the site. It should be noted that whilst the overall aim is to achieve less than 2 ou at the nearest sensitive receptor, as recommended by the Good Practice Guide for Assessing and Managing Odour, no dispersion modelling has yet been conducted to verify the impact.

The odour control options investigated by Stantec were as follows:

- Option 1 – A single odour control unit (OCU) treating flow from all extraction points on site.
- Option 2 – Separate treatment systems being:
  - Option 2a – One OCU treating flow from the Inlet Tunnel only. This foul air stream has a high flow but a low load.
  - Option 2b – One OCU treating flow from the rest of the extraction points. This foul air stream has a low flow but a high load.

Process flow diagrams and duct routes were developed for each option based on the available space on site.

The following OCU treatment technology options were investigated for each flow option:

- Activated Carbon (AC)
- Biofilter
- Biological Trickling Filter (BTF)
- BTF + AC in series.

Each technology for each option was assessed in a multi-criteria assessment that evaluated the following criteria:

- Operational complexity
- Odour performance – i.e., ability to remove odorous compounds
- Impact on workplace health and safety (WHS). This was split into the following areas:
  - H_2S gas exposure performance - in particular referencing the upcoming changes to the workplace exposure standards for hydrogen sulphide
  - Non-H_2S WHS performance – relating to all other health and safety risks associated with the option.
- Future flexibility to service additional loads.
- Construction / Commissioning requirements.

The assessment concluded that those options with a stack, which provided added dispersion for treated air, were more beneficial from an odour impact and a work health and safety aspect than biofilters which dispersed treated air at ground level. The biofilter options also required a large footprint (except for in Option 2a where the loads were relatively low) and given the space constraints on site, these biofilters were more expensive at Porirua WWTP than they would be at other sites.

Activated carbon options were identified as having low relative capital costs and good operating properties, however the electricity costs associated with the heater and the amount of activated carbon needed for replacement on an annual basis made this technology financially infeasible.

The assessment concluded that, given the stable loads expected to the OCU, a BTF alone would be sufficient for treatment and the value from a secondary activated carbon stage would be unlikely to offset the cost of providing it.

Whilst all options and technologies were investigated, including costing for combinations of different technologies for Option 2, the overall cost for Option 2 (splitting flows to two separate OCUs) was greater than for Option 1 (single OCU) with no added benefit.

Based on the multi-criteria analysis discussed above, Stantec conclusions and recommendations are as follows.

- Provide ducting as proposed for Option 1
- Provide a single odour control unit based on a biological trickling filter (BTF) technology in the existing car park.

During the next phase of design, the following activities are recommended:

- Confirm cover arrangements with site operations to ensure a custom-built cover can be provided for the screening's bins. If a custom-built cover cannot be designed, new enclosed bins may be required
- Confirm design of OCU with more up to date H_2S data from the newly installed H_2S monitors
- Confirm if any electrical components are located within the sewer tunnel, the hazardous rating of which could be affected by the reduction in ventilation proposed.
- Confirm duct routes.

- Confirm suitable reclaimed effluent sources. Site wide reclaimed effluent system should be considered.
- Confirm likely offsite odour impacts of preferred solution using dispersion modelling.
- Confirm following potential optimization of preferred design:
  - Redundancy – provide no in-built redundancy for the preferred BTF option (i.e. 2 duty towers instead of 2 duty + 1 assist). Instead, redundancy would be to bypass the BTF and vent to atmosphere, as is currently occurring, yet would be discharged and dispersed via a stack.
  - Staging – If using the above redundancy provisions, allow space for a potential AC system downstream of the BTF is load becomes too variable to be able to be treated through BTF alone.
  - Confirm whether the existing water tank can be reused. This may require a standby centrifuge feed water pump be installed to increase redundancy for the duration after the OCU has been built and before the centrifuge has been decommissioned.

A high-level schedule for the implementation of the preferred solution is provided in Figure 5-1 below.

Task Name	Start Date	End Date	Dec-23	Jan-24	Feb-24	Mar-24	Apr-24	May-24	Jun-24	Jul-24	Aug-24	Sep-24	Oct-24	Nov-24	Dec-24	Jan-25	Feb-25	Mar-25	Apr-25	May-25	Jun-25	Jul-25	Aug-25	Sep-25	Oct-25
Porirua WWTP Odour Management	2023-12-01	2025-10-01																							
Concept Design	2023-12-01	2024-03-30																							
Concept Design Approval	2024-04-01	2024-04-30																							
Detailed Design	2024-05-01	2024-10-31																							
Procurement (Contract and long lead items)	2024-08-01	2025-05-31																							
Construction	2025-03-01	2025-08-30																							
Commissioning	2025-09-01	2025-09-30																							
Practical Completion	2025-10-01	2025-10-01																							

Figure 5-1: Schedule for implementation of preferred odour control solution

6 References

- Metcalf & Eddy, Inc. (2003) *Wastewater Engineering: Treatment and Reuse*. 4th Ed. McGraw Hill Higher Education.
- Ministry for the Environment. 2016. Good Practice Guide for Assessing and Managing Odour. Wellington: Ministry for the Environment.
- Worksafe New Zealand (2023). Workplace exposure standards and biological exposure indices.
- Wellington Regional Council. 2021. Air Discharge Permit consent conditions WGN200229.

APPENDICES

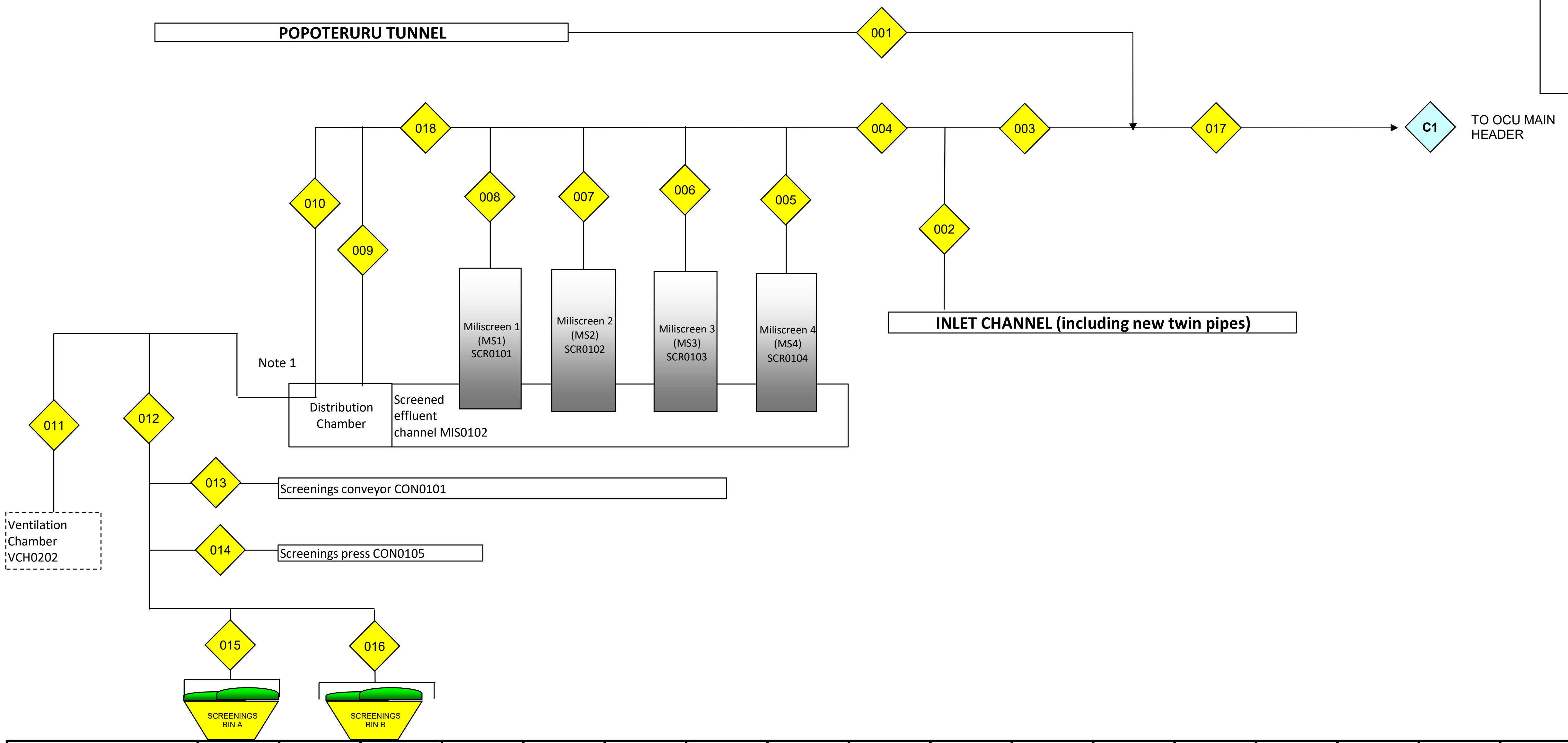
We design with community in mind

Appendix A Process flow diagrams

A.1 Option 1

NOTES

1. SCREENINGS DUCT TO RUN THROUGH EXISTING DUCT AND THROUGH DISTRIBUTION CHAMBER



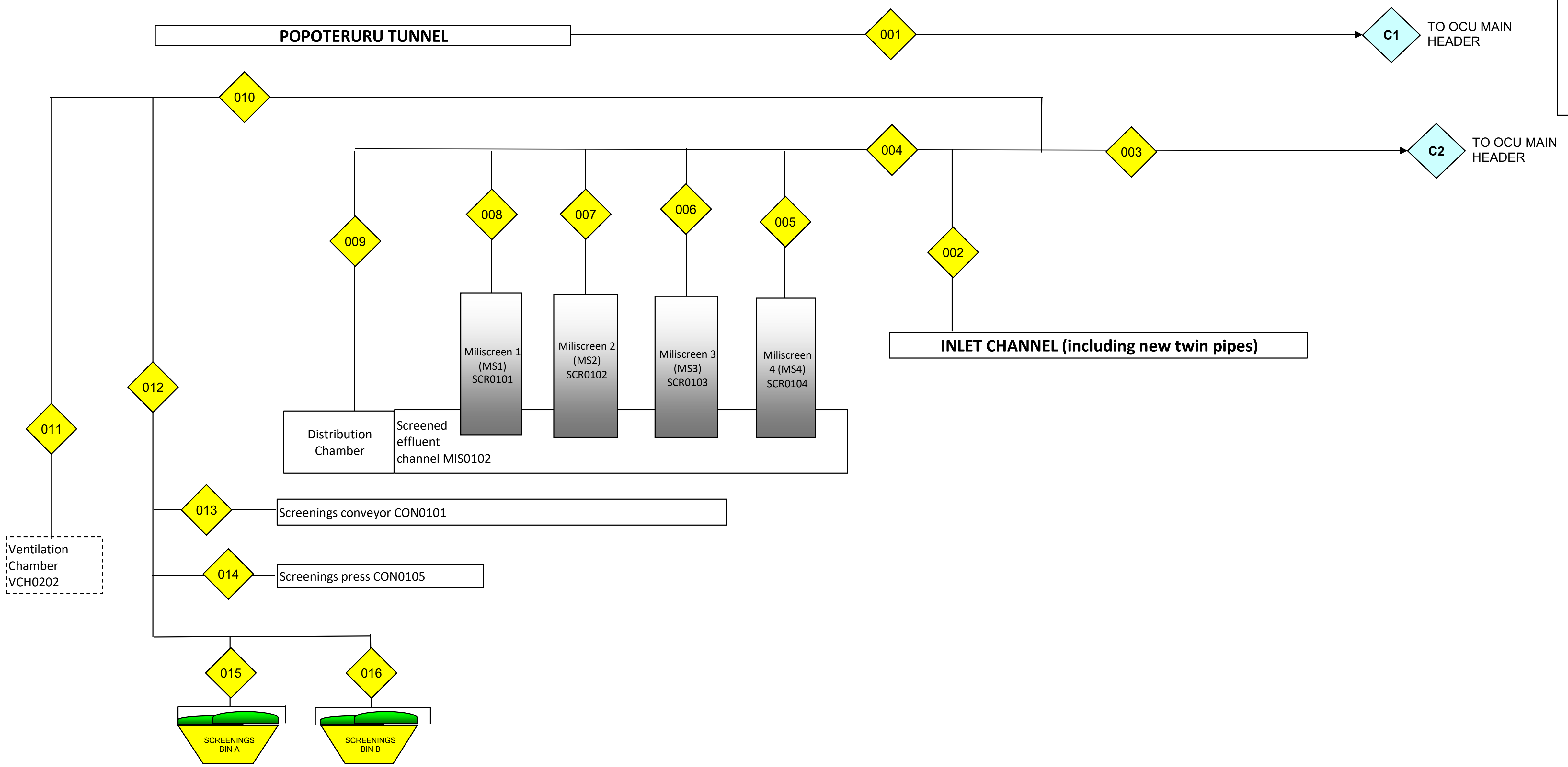
Line Number		001	002	003	004	005	006	007	008	009	010	011	012	013	014	015	016	017	018		
Gas Flowrate	m³/hr	8,280	1,178	4,360	3,183	215	215	215	215	1,831	493	206	287	27	90	85	85	12,640	2,323		
Design Duct Velocity	m/s	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Design Duct Diameter	mm	541	204	393	336	87	87	87	87	254	132	85	101	31	56	55	55	669	287	0	0
Actual Duct Diameter	mm	550	250	400	350	100	100	100	100	300	150	100	150	100	100	100	100	700	300	100	100
Actual Duct Velocity	m/s	9.7	6.7	9.6	9.2	7.6	7.6	7.6	7.6	7.2	7.7	7.3	4.5	0.9	3.2	3.0	3.0	9.1	9.1	0.0	0.0
Pressure	Pa																				
Temperature	°C																				
Line Number																					
Gas Flowrate	m³/hr																				
Design Duct Velocity	m/s	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
Design Duct Diameter	mm	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Actual Duct Diameter	mm	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100	100
Actual Duct Velocity	m/s	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
Pressure	Pa																				
Temperature	°C																				

Stantec

PROJECT	Porirua WWTP BPO Assessment		
DESCRIPTION	Process Flow Diagram of Extraction System		
CALCULATED BY	JC	DATE	18/09/23
CHECKED BY	AW	DATE	22/09/23
REVIEWED BY	AS	DATE	25/09/23

A.2 Option 2

NOTES



Line Number		001	002	003	004	005	006	007	008	009	010
Gas Flowrate	m^3/hr	8,280	1,178	4,360	2,690	215	215	215	215	1,831	493
Design Duct Velocity	m/s	10	10	10	10	10	10	10	10	10	10
Design Duct Diameter	mm	541	204	393	308	87	87	87	87	254	132
Actual Duct Diameter	mm	550	250	400	350	100	100	100	100	300	150
Actual Duct Velocity	m/s	9.7	6.7	9.6	7.8	7.6	7.6	7.6	7.6	7.2	7.7
Pressure	Pa										
Temperature	°C										
Line Number											
Gas Flowrate	m^3/hr										
Design Duct Velocity	m/s	10	10	10	10	10	10	10	10	10	10
Design Duct Diameter	mm	0	0	0	0	0	0	0	0	0	0
Actual Duct Diameter	mm	100	100	100	100	100	100	100	100	100	100
Actual Duct Velocity	m/s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pressure	Pa										
Temperature	°C										

Line Number		011	012	013	014	015	016				
Gas Flowrate	m^3/hr	206	287	27	90	85	85				
Design Duct Velocity	m/s	10	10	10	10	10	10	10	10	10	10
Design Duct Diameter	mm	85	101	31	56	55	55	0	0	0	0
Actual Duct Diameter	mm	100	150	100	100	100	100	100	100	100	100
Actual Duct Velocity	m/s	7.3	4.5	0.9	3.2	3.0	3.0	0.0	0.0	0.0	0.0
Pressure	Pa										
Temperature	°C										
Line Number											
Gas Flowrate	m^3/hr										
Design Duct Velocity	m/s	10	10	10	10	10	10	10	10	10	10
Design Duct Diameter	mm	0	0	0	0	0	0	0	0	0	0
Actual Duct Diameter	mm	100	100	100	100	100	100	100	100	100	100
Actual Duct Velocity	m/s	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Pressure	Pa										
Temperature	°C										

Stantec

PROJECT	Porirua WWTP BPO Assessment		
DESCRIPTION	Process Flow Diagram of Extraction System		
CALCULATED BY	JC	DATE	18/09/23
CHECKED BY	AW	DATE	22/09/23
REVIEWED BY	AS	DATE	25/09/23

Appendix B Layout drawings

PORIRUA WWTP ODOUR BPO ASSESSMENT
VENTILATION OPTION 1 - OCU INSTALATION - SOIL BED

No.	REVISION DETAILS	DWN	DATE
A	INITIAL ISSUE	JC	9/10/23

CONSULTANT DETAILS: Stantec

CONSULT. REFERENCE No. 31014000

		DATE	COMPANY
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CHECKED	AW	13/10/23	STANTEC
APPROVED	AS	18/10/23	STANTEC

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
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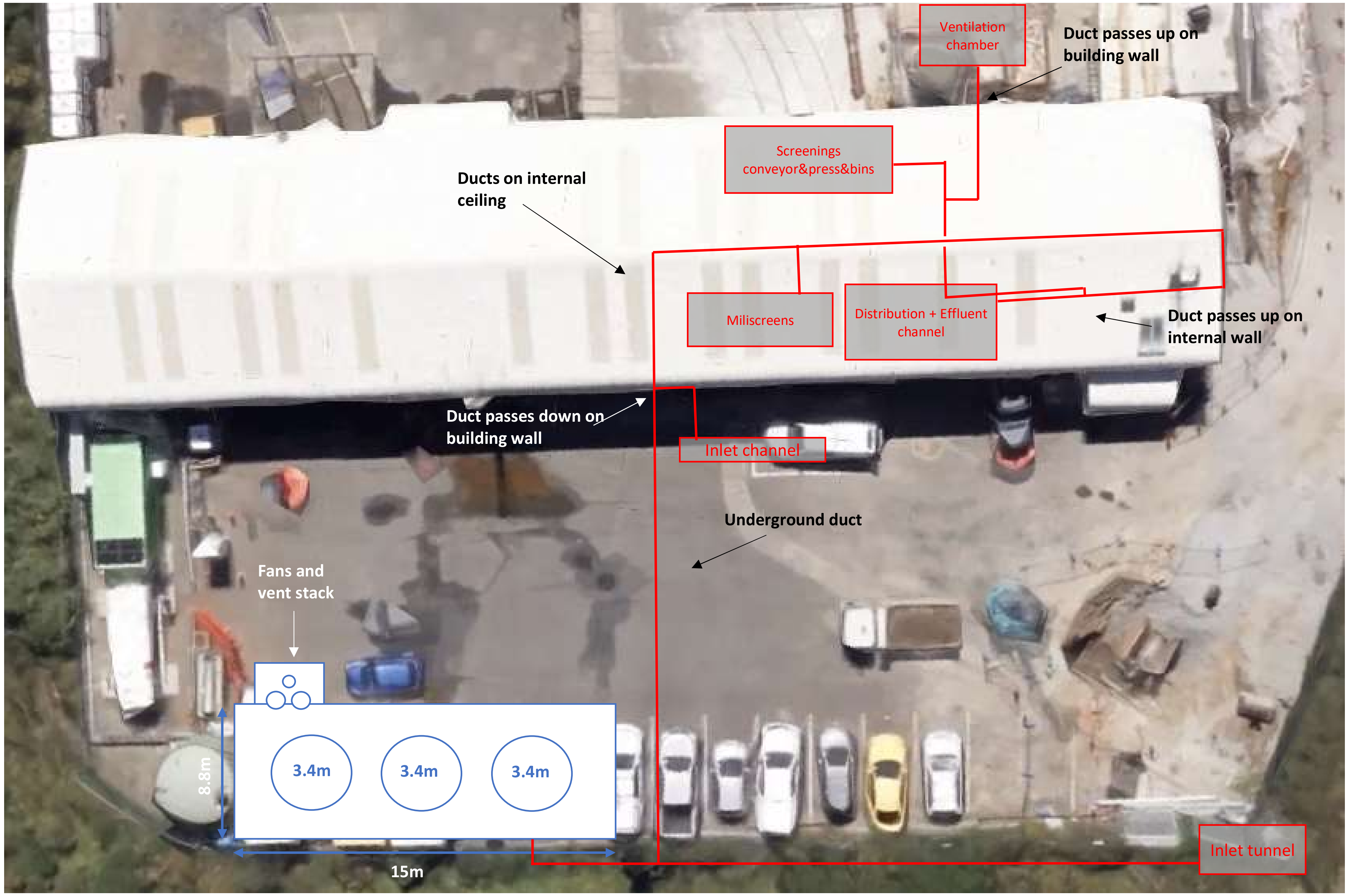

No.	REVISION DETAILS	DWN	DATE
A	INITIAL ISSUE	JC	9/10/23

CONSULTANT DETAILS: Stantec

CONSULT. REFERENCE No.: 300104000

Wellington Water

		DATE		COMPANY	
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APPROVED	AS	DATE	18/10/23	COMPANY	STANTEC

TITLE

PORIRUA WWTP ODOUR BPO ASSESSMENT
VENTILATION OPTION 1 - OCU INSTALATION - ACTIVATED CARBON FILTER

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
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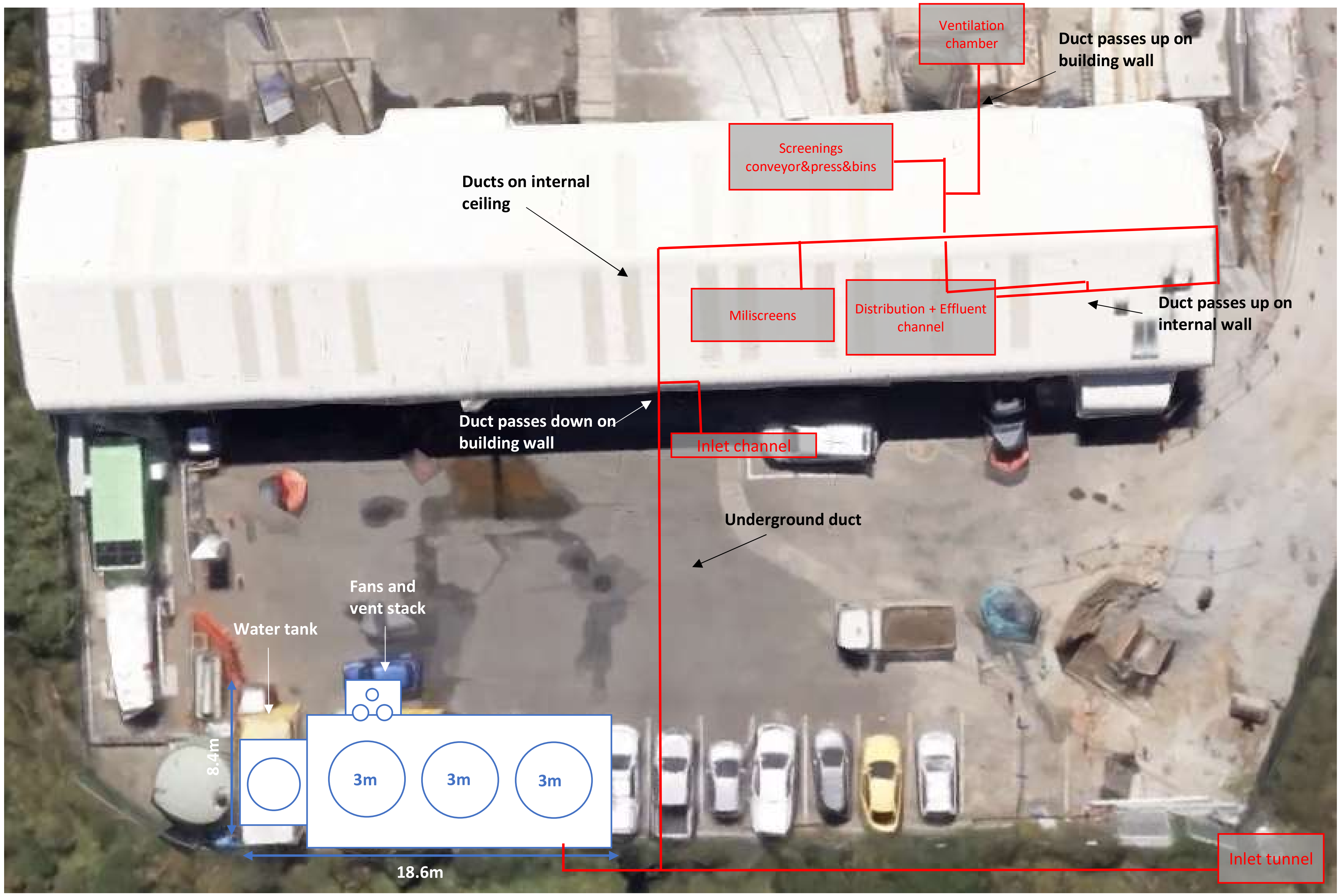

A	INITIAL ISSUE	JC	9/10/23
No.	REVISION DETAILS	DWN	DATE

CONSULTANT DETAILS
Stantec
Wellington Water

CONSULT. REFERENCE No.
300104000

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APPROVED	AS	DATE	18/10/23	COMPANY STANTEC

TITLE
PORIRUA WWTP ODOUR BPO ASSESSMENT VENTILATION OPTION 1 - OCU INSTALLATION - BIOLOGICAL TRICKLING FILTER

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
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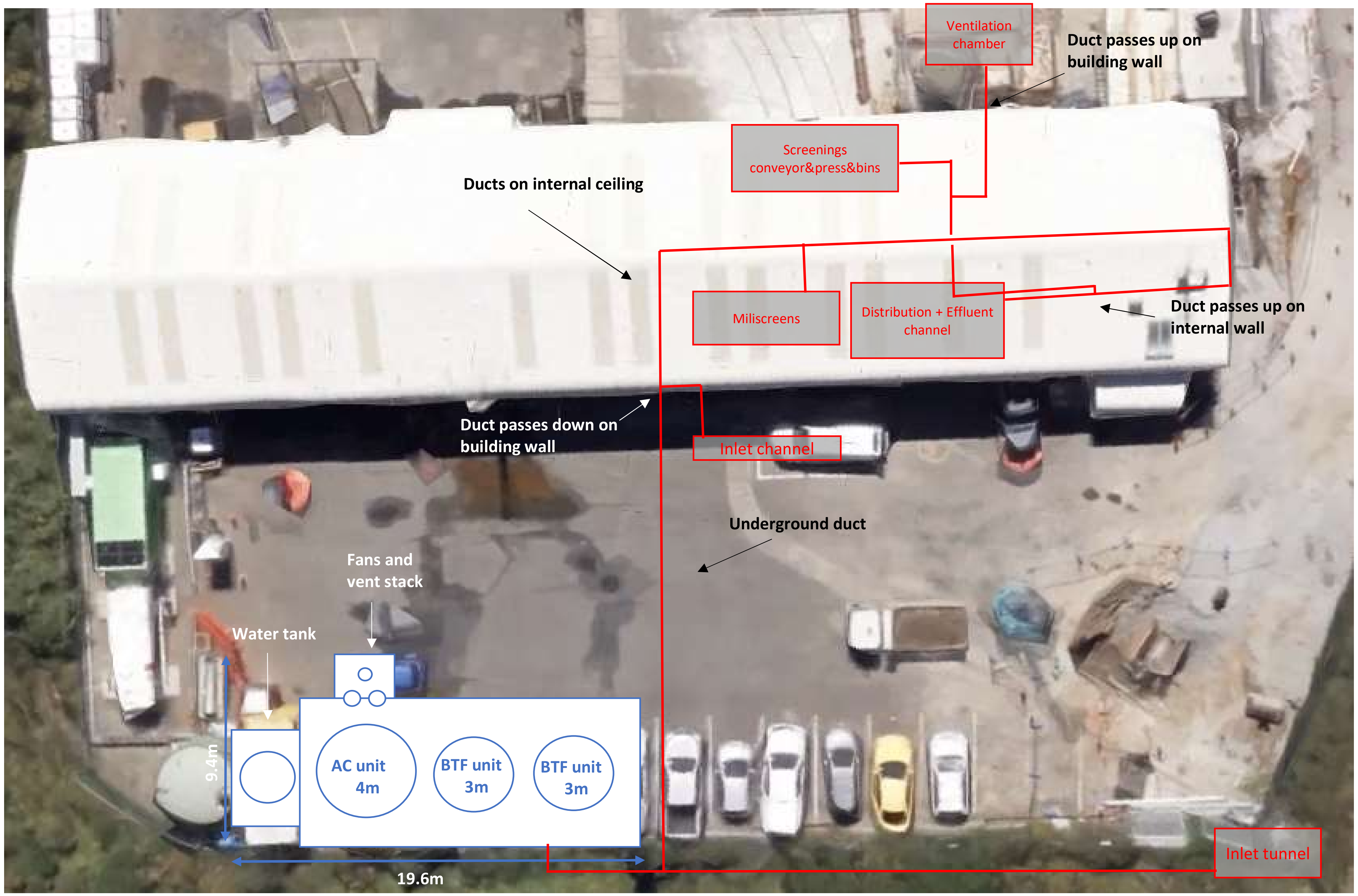

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TITLE
PORIRUA WWTP ODOUR BPO ASSESSMENT VENTILATION OPTION 1 - OCU INSTALATION - BIOLOGICAL TRICKLING FILTER AND ACTIVATED CARBON

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
A3	NTS	N/A			A

No.	REVISION DETAILS	DWN	DATE
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TITLE

PORIRUA WWTP ODOUR BPO ASSESSMENT
VENTILATION OPTION 2 - OCU INSTALATION - SOIL BED

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
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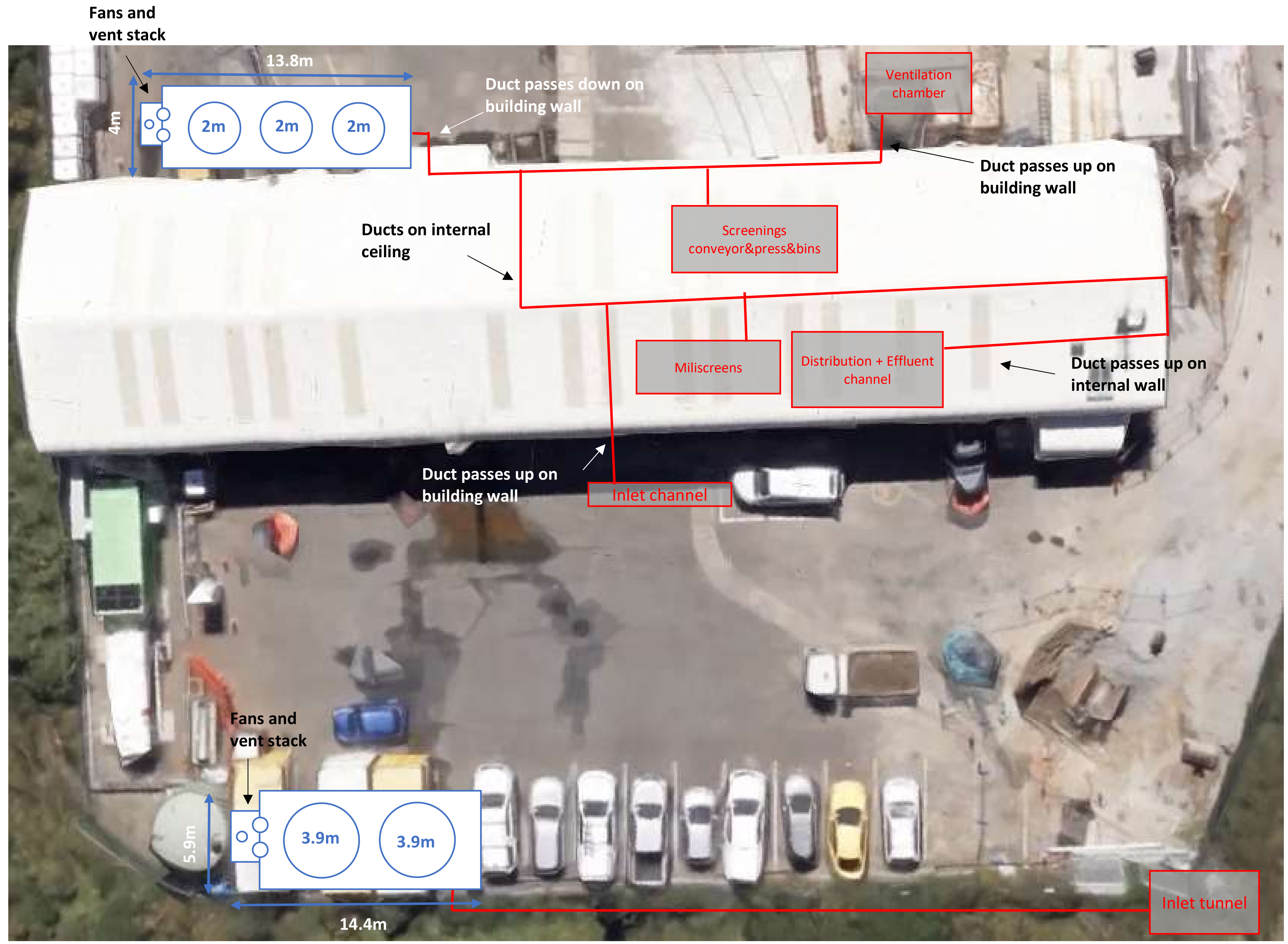
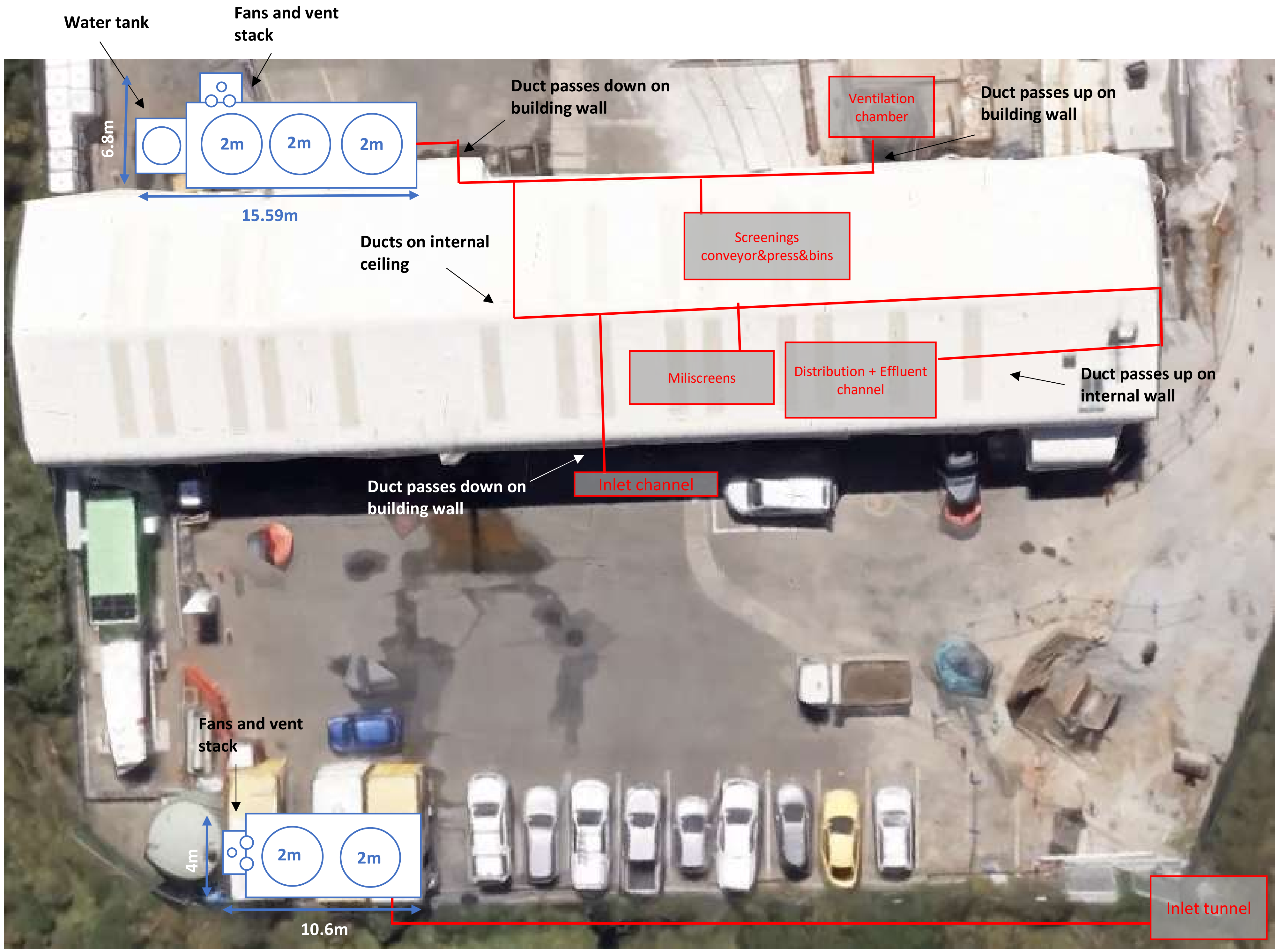


A	INITIAL ISSUE	JC	9/10/23	CONSULTANT DETAILS: Stantec	Wellington Water	DESIGNED: JC	DATE: 9/10/23	COMPANY: STANTEC	TITLE: PORIRUA WWTP ODOUR BPO ASSESSMENT VENTILATION OPTION 2 - OCU INSTALATION - ACTIVATED CARBON FILTER	
No.	REVISION DETAILS	DWN	DATE			DRAWN: JC	DATE: 9/10/23	COMPANY: STANTEC		
						CHECKED: AW	DATE: 13/10/23	COMPANY: STANTEC		
				CONSULT. REFERENCE No.: 300104000		APPROVED: AS	DATE: 18/10/23	COMPANY: STANTEC	SIZE: A3; SCALE: NTS; INDEX No.: N/A; DRAWING No.:; SHEET:	REV No.: A



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TITLE

PORIRUA WWTP ODOUR BPO ASSESSMENT
VENTILATION OPTION 2 - OCU INSTALATION - BIOLOGICAL TRICKLING FILTER

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
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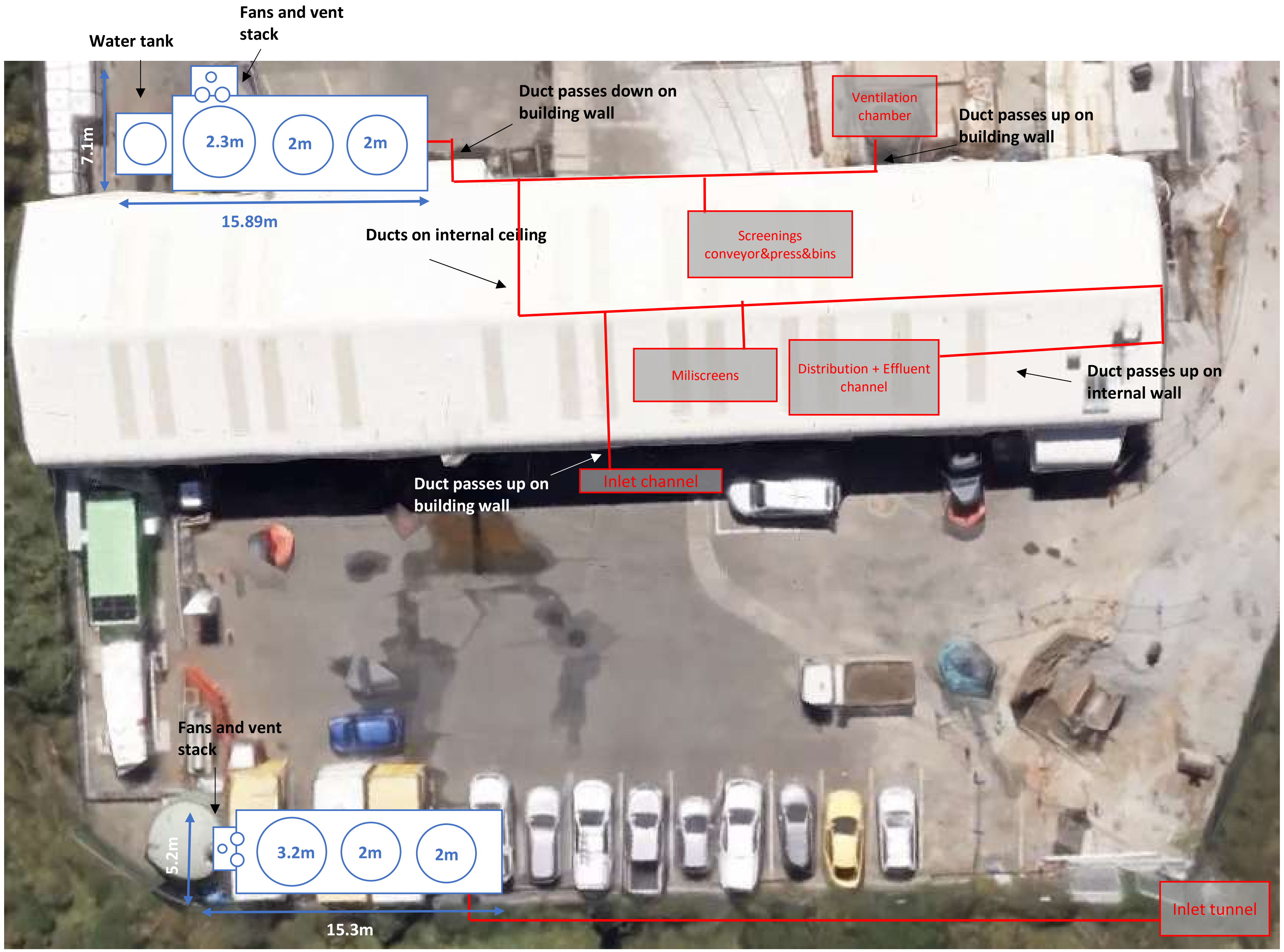

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TITLE: PORIRUA WWTP ODOUR BPO ASSESSMENT VENTILATION OPTION 2 - OCU INSTALLATION - BIOLOGICAL TRICKLING FILTER AND ACTIVATED CARBON

SIZE	SCALE	INDEX No.	DRAWING No.	SHEET	REV No.
A3	NTS	N/A			A

DESIGN WITH COMMUNITY IN MIND

Communities are fundamental. Whether around the corner or across the globe, they provide a foundation, a sense of place and of belonging. That's why at Stantec, we always design with community in mind.

We care about the communities we serve—because they're our communities too. This allows us to assess what's needed and connect our expertise, to appreciate nuances and envision what's never been considered, to bring together diverse perspectives so we can collaborate toward a shared success.

We're designers, engineers, scientists, and project managers, innovating together at the intersection of community, creativity, and client relationships. Balancing these priorities results in projects that advance the quality of life in communities across the globe.

Stantec trades on the TSX and the NYSE under the symbol STN.
Visit us at stantec.com or find us on social media.

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