Report

Central Interceptor - Odour Assessment

Prepared for Watercare Services (Client)

By Beca Infrastructure Ltd (Beca)

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on behalf of	Beca Infrastructure Ltd		

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Executive Summary

Watercare Services Limited (Watercare) is proposing to construct a 13 km long, 3 – 5 m diameter tunnel, extending from Western Springs Park at the upstream extent, to the Mangere Wastewater Treatment Plant (WWTP) in Mangere (the Central Interceptor). Additional tunnels and pipelines will connect the tunnel to the existing Watercare network at key connection points. At Mangere WWTP a new major pump station will pump flow out of the tunnel and to the treatment plant.

This report represents a qualitative assessment of effects of discharges of odour from the Central Interceptor, and has been prepared by Beca Infrastructure Limited to support resource management approvals for the Central Interceptor and associated works. A qualitative assessment is appropriate for this Project. In addition, there is insufficient information available on likely odour emission rates for a realistic quantitative assessment to be undertaken – for example, using atmospheric dispersion modelling.

The assessment has considered the potential for odour discharges from the various types of surface equipment and structure that will be associated with the Central Interceptor - drop shafts, access shafts, control chambers, grit chambers, air intakes, air treatment facilities (ATFs) and a pump station. Site specific assessments have been undertaken for 19 separate sites, being locations where surface structures associated with the Central Interceptor will be located. Ten of these have been assessed in slightly more detail than the others, largely because the specific operational structures to be located at those sites could result in a higher potential for adverse effects on air quality.

Most of the 19 sites are located in residential areas or recreational reserves that are regarded as sensitive to discharges of odour.

Those ten sites for which a more detailed assessment has been undertaken are:

- Western Springs
- Lyon Avenue
- May Road
- PS23 (Frederick Street)
- Kiwi Esplanade / Ambury Park
- Mangere pump station
- Motions Road
- Rawalpindi Reserve
- PS25 (Miranda Reserve)
- Haycock Avenue

Air extract ventilation with odour removal (ATFs) will be used to maintain the Central Interceptor under negative pressure during normal operation (around 95-98% of the time). However, in significant wet weather events, air flows may exceed the capacity of the ventilation system, in which case the ATFs may be by-passed. In addition, during normal operations, should the downstream end of the tunnel become surcharged, air will not be able to flow to the ventilated ATFs, and therefore may come out of the various vent locations. This will occur around 6 to 8 times per year on average.

It is proposed that ATFs will initially be installed at Mangere pump station and PS23, with possible additional facilities at May Road, Western Springs Park and PS25 (Miranda Reserve), based on the results of subsequent reviews of the operational performance of the system. These will be designed to minimise discharges of odour from the normal operation of the system, and thus avoid consequent adverse effects on air quality and amenity values.

Although odour discharges may occur during large wet weather events, it is anticipated that the higher flows and the more dilute nature of the wastewater in such circumstances, along with the relatively low frequency of such events, would not result in significant adverse effects. Meteorological conditions during such events are also likely to result in effective and rapid dispersion of any odour.

Overall, this assessment concludes that, both during normal operation and during wet weather events, adverse effects due to discharges of odour from the Central Interceptor will be less than minor. The only exceptions to this would be:

- Discharges of moderately odorous air at air intakes/vents during significant wet weather events (if ATFs at May Road, PS25 and Western Springs Park are not installed), potentially giving rise to minor (but not more than minor) localised adverse effects,
- During the routine emptying of grit chambers when, due to the nature of the material being removed, minor (but not more than minor) localised adverse effects may occur for the short duration of the activity (typically less than 3-4 hours). Grit chambers will be located at Motions Road, Western Springs Reserve, and PS25 (Miranda Reserve), as well as the existing grit chamber at Rawalpindi Reserve. Watercare currently operates and maintains ten grit chambers, and historically routine cleaning activities have not caused significant odour nuisance.

In addition, there are likely to be positive air quality effects arising from reductions in odour discharges at PS23, the Lyon Avenue overflow and Branch 8

1 Introduction

1.1 Background

Watercare Services Ltd (Watercare) is planning to construct a new wastewater tunnel to collect wastewater flows from the Auckland isthmus area and transfer them across the Manukau Harbour to the Mangere Wastewater Treatment Plant (MWWTP).

The project extends across the Auckland isthmus from Western Springs in the north to the Mangere WWTP in the south.

1.2 Purpose of this Document

Watercare has commissioned a team of specialists to progress the engineering investigations and environmental studies required to support applications for the necessary approvals for the project under the Resource Management Act 1991 (RMA). Beca Infrastructure Limited (Beca) has been commissioned to undertake an assessment of effects of odour discharges associated with the operation of the Central Interceptor and its associated facilities.

1.3 Limitations

This document has been prepared by Beca for Watercare for the proposed Central Interceptor Project. Beca has relied upon information provided by Watercare and the project team in completing this assessment. Unless otherwise stated, Beca has not sought to independently verify this information as provided. This assessment is, therefore, based upon the accuracy and completeness of the information provided at the time it was prepared.

2 Project Description

2.1 Overview of Project

The overall concept proposed for the Central Interceptor is a gravity tunnel from the Western Springs area to the Mangere WWTP with various link sewers and connecting pipelines connecting the existing network to the main tunnel at key locations along this route.

The key elements of the project include:

- An approximately 13 km long 4.5 m diameter main tunnel from Western Springs to Mangere WWTP, up to 110 m below ground.
- Four link sewers connecting the main tunnel to the existing sewerage network.
- Associated connections to existing sewers.
- Associated structures at key sites along the route and at connections. At each site facilities include access shafts, drop shafts, and flow control structures. Grit chambers, air intakes, air vents, or ATFs are proposed at some sites.
- A limited number of overflow structures in nearby watercourses to enable the safe discharge of occasional overflows from the tunnel.
- A pump station located at the Mangere WWTP.
- Other associated works at and in the vicinity of the Mangere WWTP, including a rising main to connect to the WWTP and an emergency pressure relief structure to enable the safe discharge of flows in the event of pump station failure.

The main tunnel, link sewers, connection pipes and many of the associated structures will be underground. An overview of the layout of the Central Interceptor is shown in Figure 1.

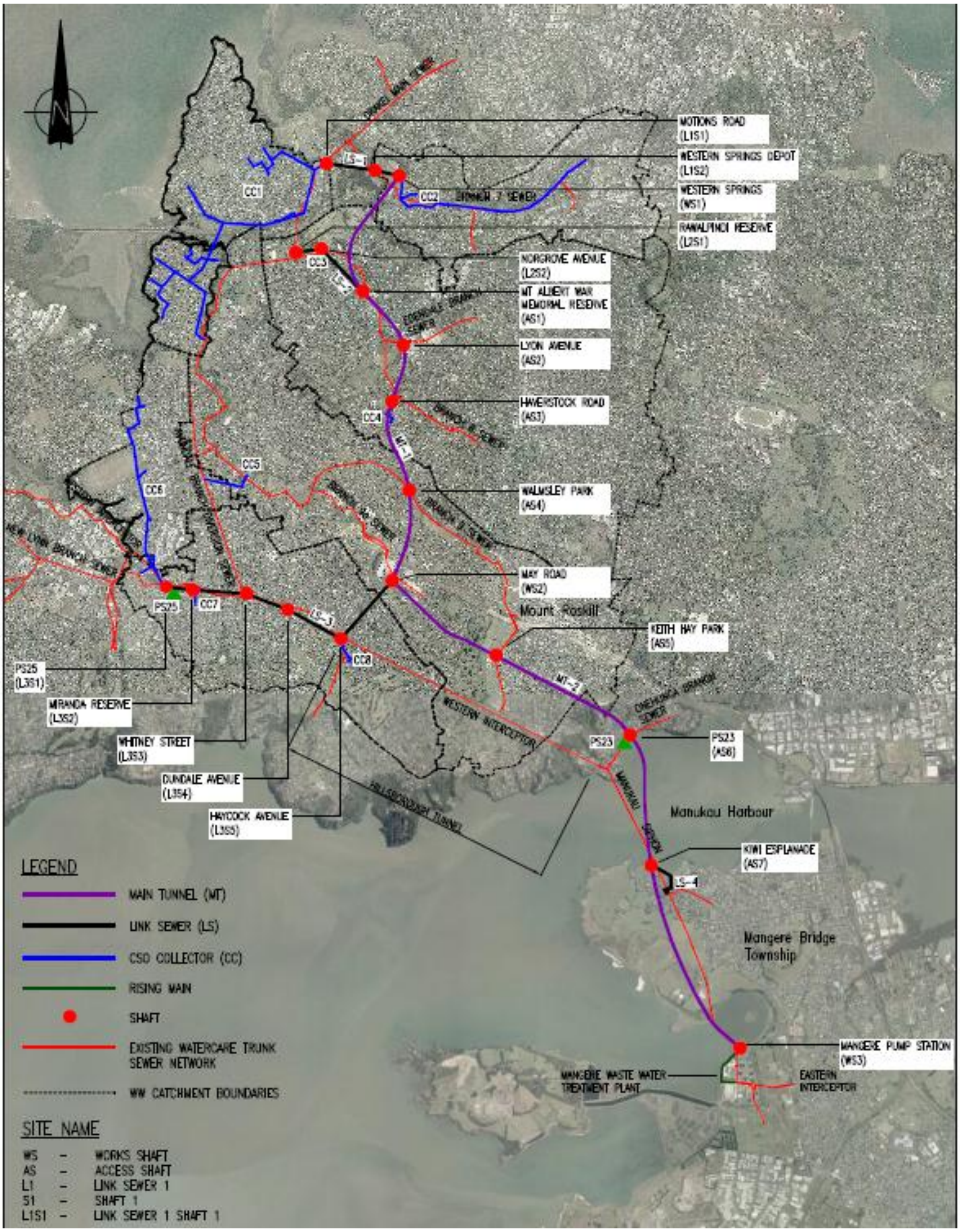

Figure 1 – Overview of proposed Central Interceptor and associated works

2.2 Overview of Project Operation

The Central Interceptor will collect wastewater and convey this to the Mangere WWTP for treatment, and will also provide significant retention capacity in wet weather for stormwater. The new pump station at the Mangere WWTP will be designed to operate up to the maximum available treatment capacity of the WWTP. When this capacity is exceeded, wastewater will be retained within the tunnel, gradually backing up towards May Road.

In order to minimise discharges of odour from the Central Interceptor, the system will be designed to operate under negative pressure most of the times, with air extraction being provided via Primary and Secondary air treatment facilities (ATFs). The AEE gives the following outline of the recommended ventilation and odour management strategy:

- Primary ventilation and associated ATF's to extract and treat air during normal dry weather flow conditions (approximately 95-98% of the time);
- Secondary ventilation and associated ATF's where higher air emission rates are likely during moderate to significant wet weather events. However, if the capacity of the facilities exceeds a certain tunnel sewage level / sewage flow threshold level and/or a specified rate of increase of sewage flows and/or a specified rate of air emissions the ventilation system would be shut down until flows return to normal.
- The primary ATFs will not be in operation when the tunnel is at capacity in wet weather. It is considered that ventilation would not need to be explicitly provided to treat air emissions during significant wet weather flow events above a certain threshold flow event (say for events with a frequency of 2 in 5 years or less). Air will vent out of the Secondary ATF air discharge locations under positive pressure. Vent fans are not needed for this mode. [Note that this would include the events of this frequency where an air pocket is expected to be created between Kiwi Esplanade and PS23.] This is because:
  - The concentration of odorous gases in the air emissions would be very much lower than normal (both through dilution of the air and lower generation of the precursors/sulphides with lower BOD concentrations in the sewage);
  - Such events would be relatively infrequent and most likely of sufficiently short duration;
  - At worst any odour concerns would be limited to the "first flush" which would be managed by the secondary ventilation facilities provided; and
  - With normal dispersion no material odour concerns are likely and community impacts would be negligible.

It is understood that no decision has yet been made on the final ventilation arrangements for the Central Interceptor. This assessment, therefore, considers the effects of all air discharge options.

In order to balance air flows within the system, air intakes will be provided at a number of locations. These may include dampers or valves to provide 'on/off' control – i.e. to prevent 'short-circuiting' of air flows between air intakes and adjacent ATFs. Prior to the installation of additional ATFs at May Road, PS25 and/or Western Springs Park (or if some or all of these are not installed), discharges to air may occur via the air intakes during significant wet weather events (up to 6-8 times per year overall). This would occur if the wastewater flow exceeds the capacity of the Mangere Pump Station, causing the tunnel upstream of the pump station to fill completely, thus preventing air extraction via the Primary ATF at the Mangere Pump Station.

Pressure relief air vents will also be required at PS23 and/or Kiwi Esplanade/Ambury Park, to operate in the event that an air pocket is created between May Road and Mangere Pump Station. These will not include odour control, since this is likely to only occur in extreme wet weather events, when the potential for odour generation in the wastewater is lower. The same approach was adopted by Watercare for Project Hobson, which has had no record of odour nuisance in over two years of operation.

2.3 Staging of ATF Installation

It is proposed that ATFs be installed in a staged approach, depending on the outcome of performance reviews at each stage. Initially, the main Primary ATF will be located at the Mangere Pump Station (at the downstream end of the Central Interceptor with a Secondary ATF at PS23. Stage 2, following review of the performance of the Central Interceptor with these ATFs in place, would probably include either an additional Primary ATF at May Road or PS25 or increased capacity of the ATF at the Mangere Pump Station. Following a further review of the performance of the odour control system, Secondary ATFs may be installed at PS25 (if not already used for a Primary ATF) and/or at Western Springs Park.

The key drivers in these reviews will be the frequency of events that cause discharges via the air intakes and the occurrence of odour complaints that can be attributed to such discharges. If, in practice, air discharges from the air intakes do not cause noticeable adverse effects, installation of secondary ATFs (other than at PS23) would not be warranted. A similar approach has been adopted for Project Hobson, the new sewer tunnel under Hobson Bay, which includes air extraction via an ATF at PS64 (Orakei), with options to install ATFs at additional locations if these are required. Watercare has a process for capturing any odour nuisance complaints and internal procedures for investigating and resolving these as appropriate.

3 Discharges to Air

3.1 Potential Odour Sources

Once the Project is completed, there will be 19 sites where access or operational structures will be located at or above ground level. These are summarised in Table 1, which also provides an indication of the sensitivity of the receiving environment in each case.

Table 1 – Surface structures

Site Name[1]	Key Features	Receiving Environment
Western Springs (WS1)	Drop shafts Access Shaft Grit chamber Air intake Possible air treatment facility	Moderate sensitivity – playing fields
Mt Albert War Memorial Reserve (AS1)	Drop shaft Access Shaft	Public open space Residential within 30m
Lyon Avenue (AS2)	Drop shaft Access Shaft Possible air intake Overflow	Public open space Residential and commercial areas and playing fields within 50m
Haverstock Road (AS3)	Drop shaft Access Shaft Overflow	Public open space Residential within 40m
Walmsley Park (AS4)	Drop shaft Access Shaft Stoplog chamber	Public open space Residential within 30m
May Road (WS2)	Drop shaft Access Shaft Stoplog chamber Air intake Possible air treatment facility	Residential within 30m
Keith Hay Park (AS5)	Drop shaft Access Shaft Stoplog chamber	Within residential area Houses within 10m
PS23 (AS6)	Drop shaft Access Shaft Possible air intake Pressure relief air vent Pump station to be demolished Air treatment facility	Residential within 15m
Kiwi Esplanade / Ambury Park (AS7)	Drop shaft Access Shaft Pressure relief air vent	Public open space Residential within 100m (Kiwi Esplanade) or within 80m (Ambury Park)
Mangere Pump Station (WS3)	Pump station Air treatment facility Emergency pressure relief outlet	Within odour boundary of Mangere WWTP

[1] Refer to the main AEE for an explanation of the identifications used for each site)

Site Name[1]	Key Features	Receiving Environment
Motions Road (L1S1)	Drop shaft Connection chamber Grit chamber Pressure relief overflow	Public open space Within 100m of zoo entrance and 150m of two schools
Western Springs Depot (L1S2)	Small access shaft	Close to public open space
Rawalpindi Reserve (L2S1)	Drop shaft Connection chamber Grit chamber (existing grit chamber either retained or replaced) Pressure relief overflow	Public open space Residential within 30m
Norgrove Avenue (L2S2)	Drop shaft Connection chamber	Within residential area Houses within 20m
PS25 (L3S1)	Drop shaft Connection chamber Grit chamber Air intake Possible air treatment facility Pump station to be demolished	Public open space Residential within 70m
Miranda Reserve (L3S2)	Drop shaft	Public open space Residential within 30m
Whitney Street (L3S3)	Drop shaft	Within residential area Houses within 15m
Dundale Avenue (L3S4)	Access shaft	Public open space Within 30m of houses
Haycock Avenue (L4S1)	Drop shaft Access shaft Air intake Connection chamber	Within residential area Houses within 10m

Given the large number of individual sites to be assessed, the sites have been broadly categorised based on the potential for odour effects. All sites have been assessed to minimum requirements, however, more detailed assessments have been carried out for sites that are identified as having a greater potential for odour effects (for example grit chambers located close to residential areas warrant a more detailed assessment compared to access shaft locations).

3.2 Odour Generation

Sewage odour is caused by a variety of chemical compounds, including: hydrogen sulphide (H_2S), organic sulphur compounds (e.g. mercaptans), organic amines and volatile organic compounds (VOCs). Concentrations of these compounds tend to increase with the age of the sewage, especially under anaerobic conditions, which can commonly occur as a result of pump stations with long rising mains.

In addition to the concentrations of odorous compounds in wastewater, the other key driver in odour generation is turbulence of the wastewater itself. Increased turbulence, for example at junctions, drop shafts and pump stations, increases the rate of discharge of odour. The design of the Central Interceptor includes measures to minimise turbulence where practicable – for example, drop shafts are designed to induce vortex flows into a plunge pool[2].

3.3 Meteorological Factors

The extent of any effects arising from discharges of odour from the Central Interceptor is affected by meteorological conditions at the time of the discharge, as well as by the frequency, nature, intensity and duration of the discharge. In general, adverse effects of odour discharges are less likely under turbulent air flow and high wind speeds than in calm conditions.

Discharges to air are only likely to occur when wastewater volumes entering the tunnels exceed the capacity of the Mangere pump station, resulting in the main tunnel completely filling and a consequent loss of air extraction. On some occasions, this may result in the emergency pressure relief valves at Kiwi Esplanade / Ambury Park and/or PS23 opening to vent trapped air, which may be odorous. This is estimated to occur about twice in five years, based on flow modelling undertaken for this Project (which, in turn, was based on recorded rainfall in the catchment).

Because the flow modelling that was used to predict the likelihood of the emergency vent(s) operating was based on actual rainfall data, a relatively straightforward way to assess the likelihood of such emergency venting giving rise to adverse odour effects is to consider the wind speeds and directions recorded at nearby meteorological monitoring sites at the time of those events. However, with no more than two such events predicted in five years of modelling (i.e.. one each in the 2003 and 2004 modelling years), this would provide insufficient data on which to base any assessment. Therefore, consideration has also been given to less extreme rainfall events that could cause the tunnel to be filled at Mangere without causing the emergency vents to operate. For example, such events were predicted to occur 12 times in the 1999 modelling year[3]. The dates and times of these predicted events are listed in Table 2.

Wind speed and direction data were obtained from the CliFlo database for two of the closest meteorological monitoring stations to the Kiwi Esplanade vent location, at Onehunga and Wiri (NIWA 2012). The locations of these sites, which were operated for the former Auckland Regional Council, are indicated in Figure 2. Both sites are located in relatively flat terrain, with wind speed and direction instruments located on masts 10m above ground level. Hourly average wind speeds and directions recorded at these sites at the times that severe rainfall events are predicted to cause the tunnel to fill at Mangere during the 1999 modelling year are listed in Table 2.

[2] Information provided Central Interceptor Project team

[3] Information provided Central Interceptor Project team

As indicated in Table 2, hourly average wind speeds were greater than 2 m/s (7 km/h) during all except one of the predicted events during the 1999 modelling year. Calm conditions, under which adverse effects are more likely to occur, are generally regarded as hourly average wind speeds lower than 0.5-1.0 m/s. By way of comparison, during the two events predicted to require the operation of the emergency pressure relief air vents, hourly average wind speeds were in the range 2-3 m/s (refer Table 3).

Table 2 – Recorded hourly average wind speed and directions at the times the tunnel is predicted to fill at Mangere as a result of rainfall events in the 1999 modelling year

Date and time of event		Onehunga		Wiri	
		Wind speed (m/s)	Wind direction (degrees)	Wind speed (m/s)	Wind direction (degrees)
16/01/1999	21:10	3.0	65	2.6	54
26/02/1999	02:10	3.8	27	4.0	28
07/03/1999	22:05	2.3	357	3.2	343
06/04/1999	16:15	6.3	70	5.1	61
15/04/1999	17:35	3.2	314	2.8	327
30/04/1999	19:10	5.4	63	5.5	49
02/06/1999	08:45	1.4	325	1.7	345
26/07/1999	09:30	4.8	214	4.1	203
13/09/1999	13:30	2.5	42	3.2	43
08/10/1999	10:15	4.0	84	3.7	86
04/11/1999	12:45	6.5	67	6.0	61
11/11/1999	00:45	7.3	350	9.2	359

Table 3 – Recorded hourly average wind speed and directions at the times the emergency pressure relief air vents are required to operate as a result of extreme rainfall events in the 2003 and 2004 modelling years

Date and time of event		Onehunga		Wiri	
		Wind speed (m/s)	Wind direction (degrees)	Wind speed (m/s)	Wind direction (degrees)
20/04/2003	13:40	2.5	81	2.3	85
02/02/2004	08:00	2.6	61	3.2	33

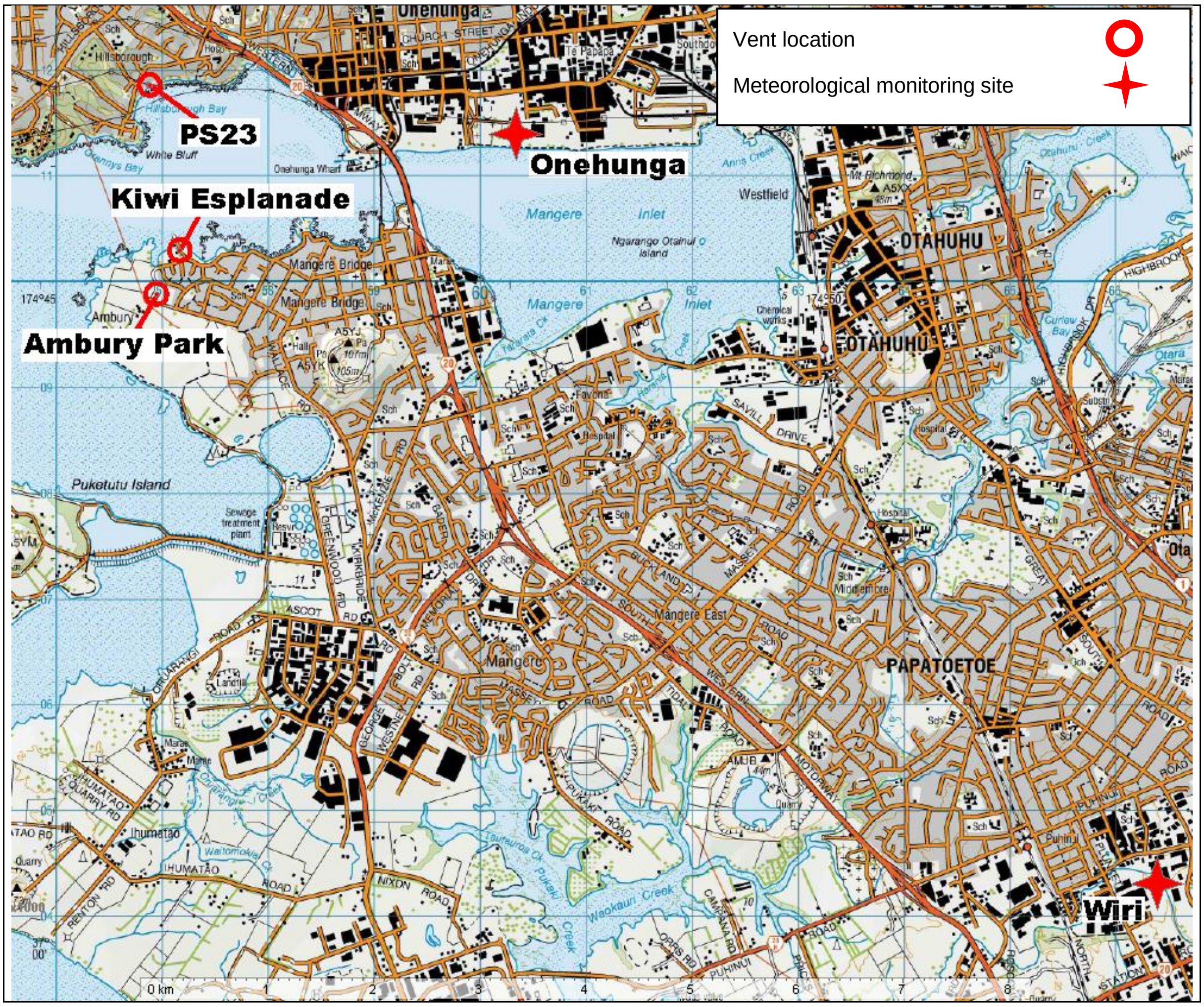

Figure 2 – Locations of meteorological monitoring sites

4 Assessment of Effects

4.1 Approach to this Assessment of Effects

This report presents a qualitative assessment of odour effects associated with the operation of the Central Interceptor. Beca considers that there is insufficient information available on likely odour emission rates for a realistic quantitative assessment to be undertaken – for example, using atmospheric dispersion modelling.

Policy 4.4.6 of the Auckland Regional Plan: Air, Land and Water 2010 states:

"In assessing noxious, dangerous, offensive or objectionable adverse effects from odour, dust, particulate, smoke or ash and visible discharges, consideration will be given to the Frequency, Intensity, Duration, Offensiveness and Location (FIDOL) of the discharge."

The FIDOL factors can be summarised as follows:

Frequency of exposure to a particular odour. One-off or very occasional incidents (e.g. odour associated with a major storm event) would be much less likely to be regarded as 'offensive or objectionable' than regular or frequent occurrences.

Intensity or strength of the odour.

Duration of a particular odour event.

Offensiveness relates to the 'hedonic tone' of an odour – i.e. is it pleasant, neutral or unpleasant. For example, the odour of baking bread may generally be regarded as pleasant, while sewage odour, especially that caused by discharges of H_2S, would generally be regarded as unpleasant or offensive.

Location of an activity and sensitivity of the receiving environment – what may be considered offensive or objectionable in a residential area, may not necessarily be considered offensive or objectionable in an industrial area.

In assessing whether a particular activity is likely to generate 'offensive or objectionable' discharges of odour – and, in consequence, whether significant adverse effects are likely, each of the FIDOL factors must be taken into account. For example, an odour of low intensity and moderate offensiveness that occurs daily or on several days over a limited period may be regarded as 'offensive or objectionable' (and therefore be a significant effect); whereas the same odour in the same location that only occurs once or twice a year may not be regarded as 'offensive or objectionable'. Conversely, a highly unpleasant odour may be regarded as 'offensive or objectionable' even though it only occurs occasionally – e.g. odour associated with the emptying and cleaning of grit traps – and would be regarded as a significant adverse effect unless adequate mitigation measures have been taken. These mitigation measures may include:

- Provision of an adequate separation distance between the discharge and sensitive receptors
- Installation of temporary / portable odour control measures (for temporary or short-term discharges) of a permanent odour control device (for mode frequent or long-term odour discharges)
- Adequate notification of periodic maintenance
- Scheduling periodic maintenance at times that minimise actual effects on people.

The following sections of the report provide a generic assessment of potential odour effects associated with the various surface structures and facilities associated with the Central Interceptor, including the frequency, intensity, duration and offensiveness of potential odour discharges (section

4.2) and site-by-site assessments (including location) for key sites with a greater potential for adverse effects (section 4.3) and for the remaining, lower risk, sites (section 4.4). Maps showing the locations of each of these sites can be found in the AEE drawing set.

Table 1 (page 6) summarises the operational facilities that will be located at each specific site, along with an indication of the proximity of sensitive receptors. With the exception of the pump station and associated facilities located at the Mangere WWTP, all other surface facilities and potential discharge points are located in close or relatively close proximity to sensitive receiving environments.

4.2 Generic Assessment of Effects for Surface Structures

4.2.1 Drop Shafts

Drop shafts are typically designed to generate cyclonic flow of water down the shaft, with a counterflow of air returning up the shaft. The specific design of drop shafts (scroll vortex with plunge pool) for the Central Interceptor is intended to minimise turbulence and the consequent release of displaced air and odour.

The frequency, intensity, duration and offensiveness of potential odour discharges from drop shafts are summarised in Table 4.

Table 4 – Potential odour discharges from drop shafts

Parameter	Comments
Frequency	Low – intermittent access may be required for inspections, at frequencies of up to once per year. The tunnel has been designed to minimise the need for frequent access.
Intensity	Low-moderate; drop shafts are likely to be under negative pressure with a net inflow of air via the access cover
Duration	Unlikely to exceed a few hours
Offensiveness	Moderate-high, depending on the quality of the wastewater arriving via the relevant connecting sewers

Under normal operating conditions, all drop shafts associated with the Central Interceptor will be maintained under negative pressure. Therefore, any discharges of odour via drop shafts under normal operating conditions will be negligible, and are highly unlikely to cause adverse effects in the surrounding area. The only exception to this would be if access were required for inspection or maintenance.

Overall potential for adverse effects from drop shafts will be low.

Odour mitigation during sewer maintenance is discussed in section 4.2.4 below.

4.2.2 Access Shafts

A number of access shafts will be located at key points within the Project, to allow access to the system for inspection and maintenance. As with drop shafts, under normal operating conditions, access shafts will be maintained under negative pressure.

The frequency, intensity, duration and offensiveness of potential odour discharges from access shafts are summarised in Table 5.

Table 5 – Potential odour discharges from access shafts

Parameter	Comments
Frequency	Low – intermittent access may be required for inspections, at frequencies of up to once or twice per year
Intensity	Low; access shafts are likely to be under negative pressure with a net inflow of air via the access cover, while turbulence of the wastewater will be minimal
Duration	Unlikely to exceed a few hours
Offensiveness	Moderate-high, depending on the level of odour in the sewer air space

Overall potential for adverse effects from access shafts will be low.

4.2.3 Connection and Control Chambers

Flow control chambers will be installed at a number of key points, incorporating remotely actuated penstocks. Likewise, stoplog and stopgate chambers will be required at connection points where long term flows may need to be diverted to or from the Central Interceptor. In all cases, these will be maintained under negative pressure, minimising discharges of odour during normal operation.

The frequency, intensity, duration and offensiveness of potential odour discharges from connection and control chambers are summarised in Table 6.

Table 6 – Potential Odour discharges from connection and control chambers

Parameter	Comments
Frequency	Low-moderate – periodic access required for maintenance, adjustment and removal of penstocks, stopgates and stoplogs – planned maintenance every six months and full annual inspections with additional maintenance/overhaul/ replacement as required
Intensity	Low; likely to be under negative pressure with a net inflow of air via the access cover, while turbulence of the wastewater will be minimal
Duration	Unlikely to exceed a few hours
Offensiveness	Moderate-high, depending on the level of odour in the sewer air space

Overall potential for adverse effects from connection and control chambers will be low.

4.2.4 Grit Chambers

Grit chambers will be located at four points on the project (Motions Road, Western Springs Park, PS25 (Miranda Reserve) and Rawalpindi Reserve), where major connections are made with the sewer network. There are existing grit chambers at or near two of these locations. At Rawalpindi Reserve, the existing grit chamber will be retained. The grit chamber at Motions Road will effectively supplant an existing grit chamber located within Auckland Zoo, although the latter will be retained to service local connections, and will require much less maintenance than previously (i.e. annual cleaning rather than quarterly).

The frequency, intensity, duration and offensiveness of potential odour discharges from grit chambers are summarised in Table 7.

Table 7 – Potential odour discharges from grit chambers

Parameter	Comments
Frequency	Low-moderate – access required for emptying and cleaning on a quarterly basis
Intensity	Moderate-high; anaerobic material being removed
Duration	Unlikely to exceed a few hours
Offensiveness	High – due to the anaerobic nature of the accumulated material and the length of time over which it has been accumulated

In normal operation, the grit chambers will be maintained under negative pressure with closed covers, thus largely avoiding discharges of odour. However, they will normally require emptying and cleaning at a maximum frequency of approximately four times a year.

Notwithstanding the odorous nature of the operation, Watercare does not currently employ physical odour controls during the cleaning of grit traps (or during any other inspection or maintenance of the sewer network, including cleaning of pump station wet wells). However, the following management approaches are applied:

- Prior notification is given to neighbouring householders and businesses
- Where appropriate, such activities are undertaken at times that would minimise disruption to neighbouring householders and businesses – e.g. in residential areas, grit traps are emptied and cleaned during the day, when many residents are likely to be out, while in some business areas, this would be undertaken outside normal working hours
- The duration and frequency of cleaning and maintenance operations is kept to a practicable minimum
- Material removed from grit chambers is transported in enclosed skips to appropriately authorised disposal facilities.

Watercare is not currently aware of any recent complaints regarding odour from the emptying and cleaning of grit chambers in sensitive locations (e.g. Rawalpindi Reserve)[4]. However, if odour from these essential maintenance activities does become an issue at any particular site, despite use of the measures outlined above, the only practicable additional measure to mitigate the effects of those discharges would be the use of odour suppressant or odour neutralising sprays. These can take a number of forms, including:

- Masking agents - mixtures of aromatic oils that cover up an objectionable odour with a more desirable one.
- Chemical counteractants – mixtures of aromatic oils that cancel or neutralise odour and reduce the intensity.
- Digestive deodorants – these contain bacteria or enzymes that eliminate odour through biochemical digestive processes.
- Odour neutralisers – solutions of oxidising agents such as chlorine dioxide that eliminate odour through chemical reactions.

Although the overall potential for adverse effects from grit chambers will be moderate to high, notwithstanding the intermittent and short duration of those discharges (typically only 3-4 hours), experience from the 10 existing grit chambers on Watercare's network is that, in practice,

[4] Personal communication from Chris Harbour of Watercare to the author.

maintenance of these does not give rise to odour complaints. It is probable that this is in large part due to the mitigation measures (described above) that are currently employed.

4.2.5 Air intakes

A number of air intakes will be required to balance air flows within the Central Interceptor. These may each incorporate remotely actuated dampers, which would be closed as required to prevent short-circuiting of air flows when the alternate air extraction systems are operating. The vents will also be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out via these vents. There is no intention at this stage to install flow control devices to prevent reverse air flow (i.e. air emissions) via these air intakes. Therefore, there is also the potential, during wet weather events when normal air extraction routes are unavailable, for air to be discharged via these vents. Beca understands that, based on the hydraulic modelling scenarios, this may happen 6-8 times per annum; however, it is likely that, in such circumstances, any air discharged will be somewhat less odorous than normal (due to the large volumes of storm water flowing through the system).

The frequency, intensity, duration and offensiveness of potential odour discharges from air intakes are summarised in Table 8.

Table 8 – Potential odour discharges from air intakes

Parameter	Comments
Frequency	Low-moderate – designed to act primarily as air intakes, but air discharges may occur during moderate to severe wet weather events. This could occur up to 10-15 times per year, depending on the ventilation arrangements – installation of additional Primary ATFs at May Road or PS25 would significantly reduce the frequency, as would installation of secondary ATFs at Western Springs Park and/or PS25, to a minimum frequency of once every 2-5 years (extreme wet weather events). Otherwise, odour emissions would only occur if dampers failed or the system was not under negative pressure – for example, due to failure of a Primary ATF.
Intensity	Low-moderate – except in the event of the failure of a Primary ATF, emissions would only be likely in heavy rainfall events, when the wastewater is heavily diluted with stormwater
Duration	Unlikely to exceed a few hours
Offensiveness	Low-moderate – see comment on intensity above

Overall potential for adverse effects from air intakes will be low-moderate.

4.2.6 Pump Station

The only pump station on the Central Interceptor will be located at the Mangere WWTP, to lift wastewater from the tunnel to the headworks of the WWTP. Existing pump stations at PS23 and PS25 (Miranda Reserve) will be removed.

The frequency, intensity, duration and offensiveness of potential odour discharges from the pump station are summarised in Table 9.

Table 9 – Potential odour discharges from the pump station

Parameter	Comments
Frequency	Normal operation – continuous – all discharges via air treatment facility Wet weather events – up to 10 times a year
Intensity	Normal operation – low – all discharges via ATF Wet weather events – moderate-high – pump station wet wells are highly turbulent, leading to significant discharges of potentially odorous gases
Duration	Normal operation – continuous Wet weather event - unlikely to exceed a few hours
Offensiveness	Normal operation – low – all discharges via ATF Wet weather events – unpleasant – pump station wet wells are highly turbulent, leading to significant discharges of potentially odorous gases; however, during wet weather events, only the 'first flush' of air is likely to be highly odorous, with subsequent emissions reduced by dilution of sewage with stormwater

All air extracted from the new pump station will be discharged to air via the new ATF located adjacent to the pump station. In consequence, the overall potential for adverse effects from the pump station – in normal operation – will be low.

4.2.7 Air Treatment Facilities

As outlined in section 2 of this report, in order to minimise discharges of odorous air from the Central Interceptor, two ATFs are proposed to be constructed, with provision for additional ATFs if required. Odour treatment may comprise biofilters, biotrickling filters, activated carbon adsorbers or combinations of biotrickling filters and activated carbon adsorbers. A discussion on the operating principles and advantages and disadvantages of each method is contained in section 5 of this report.

ATFs do not themselves give rise to potential odour effects; therefore, no 'FIDOL' type assessment has been made. Instead, they are designed to mitigate the potential odour effects from other parts of the system – in particular odour associated with air vented from the transport and storage of wastewater within the network.

4.3 Site-Specific Assessment – Key Sites

4.3.1 Introduction

This section provides an assessment of the likely effects of odour emissions from the Central Interceptor at key sites where activities or facilities with a relatively high potential for discharges will be located. These are:

- Western Springs (WS1 – section 4.3.2)
- Lyon Avenue (AS2 – section 4.3.3)
- May Road (WS2 – section 4.3.4)
- PS23 (AS6 – section 4.3.5)
- Kiwi Esplanade/Ambury Park (AS7 - – section 4.3.6)
- Mangere Pump Station (WS3 – section 4.3.7)
- Motions Road (L1S1 – section 4.3.8)
- Rawalpindi Reserve (L2S1 – section 4.3.9)
- PS25 (Miranda Reserve) (L3S1 – section 4.3.10)
- Haycock Avenue (L4S1 – section 4.3.11)

The assessments presented in this and the following sections (section 4.4) include a consideration of the ‘Location’ component for the FIDOL factors (refer section 4.1).

4.3.2 Western Springs

Western Springs Park will be the site of the northern end of the main Central Interceptor tunnel. In addition to an air intake, a drop shaft, access shafts and control chambers, there will be a grit chamber and (possibly) an ATF. These will be located near the northern edge of the sports park, within 20m of the edge of current rugby pitches. Residential areas are located approximately 100m to the east and 170m to the south. There may also be a control chamber and drop shaft close to the State Highway 16 off-ramp on Great North Road. The two main potential air discharge points at Western Springs are the grit trap (during routine cleaning) and displaced air vented via the air intake (i.e. either bypassing the ATF if it is installed or before it is installed). The drop shafts, access shafts and control chambers are unlikely to be significant sources of odour.

It is understood that Watercare is not aware of any significant odour issues associated with the existing sewer network in this area although some complaints have been received in the vicinity of Branch 7A and 7B sewers upstream of Western Springs Park.

The grit trap will require emptying and cleaning about four times per year. As noted in section 4.2.4, this can be a highly odorous activity, and all practicable means will be employed to minimise both the duration of the discharge and the effects of that discharge when it occurs. The closest sensitive receptors to the grit trap are the immediately adjacent sports fields. Emptying of the grit trap will generally be undertaken on weekdays, when the sports fields are not in use. The separation distance between the facilities at this location and the nearest residential receptors is likely to be sufficient to avoid more than minor adverse effects on those receptors during cleaning of grit traps.

The air intake vent will be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out. Depending on the final ventilation arrangements, during moderate to significant wet weather events that cause the main tunnel to fill before the Mangere pump station (thus prevent air extraction via the main ATF) it will be possible for air to be discharged via this intake. It is understood that this is estimated to be likely to occur less than 6 to 8 times per annum (probably only 2-5 times per annum if the ATF at May Road is installed).

As part of the staged approach to the ventilation control of the Project, if these air discharges are likely to cause significant odour issues, a secondary ATF (probably activated carbon) may be installed at this location. The ATF will only operate during heavy rainfall events, when air extraction via the ATF at the Mangere pump station (and the ATF at May Road or PS25, if installed) is not possible. A remotely actuated damper on the air intake vent would be closed as required to prevent short-circuiting of air flows when this secondary air extraction is operating.

Overall, given the overall operation of the Central Interceptor under negative pressure, the relatively infrequent emptying of the grit chamber (coupled with appropriate mitigation measures) and either the infrequency of air discharges via the air intake or the installation of a suitable ATF, adverse effects due to odour discharges at the Western Springs Park site will be no more than minor.

4.3.3 Lyon Avenue

Lyon Avenue is the site of an existing combined sewer overflow, which discharges via a large spillway channel immediately adjacent to an apartment block. Historically, there have been a number of odour issues at this site, partly from the spillway, but predominately due to the large opening for the overflow outlet. Aside from short-term odours during ‘first-flush’ via the overflow, these appear to have been partly resolved through construction of roofing over the spillway. With the commissioning of the Project, this overflow opening and spillway will be replaced by a culvert opening directly into the Meola Creek (which will operate at a lower frequency than the existing overflow), while odours from dry weather flows will be avoided by the connection into the new Central Interceptor.

Facilities to be located at Lyon Avenue include a drop shaft, access shaft, (possibly) an air intake vent and control chamber. The drop shaft, access shaft and control chamber are unlikely to be significant sources of odour.

Beca understands that an air intake may be required at the Lyon Avenue site, as part of the overall ‘flow balancing’ arrangements for the Project. This would be located over the main access shaft, approximately 60m from the nearby apartment blocks. The air intake vent will be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out. Depending on the final ventilation arrangements, during moderate to significant wet weather events that cause the main tunnel to fill before the Mangere pump station (thus prevent air extraction via the main ATF) it will be possible for air to be discharged via this intake. It is understood that this is estimated to be likely to occur less than 6 to 8 times per annum (less than twice in 5 years if the ATF(s) at May Road and/or PS25 is installed). As discussed in section 3.3 of this report, meteorological conditions during such events are likely to result in effective and rapid dispersion of any odour.

Although the site is located in close proximity to residential and commercial areas, with playing fields within 50m, adverse effects due to discharges of odour will be reduced compared to the current situation. This is a positive outcome for the site.

4.3.4 May Road

May Road is the proposed location for the main alternate ATF to that at the Mangere pump station. Other facilities to be located at this site include an air intake, a drop shaft, access shafts and control chambers. Residential premises are located within 30m to the southwest, while industrial and commercial premises (including wholesale food and food distribution) are located within 40-100m to the east and north. The drop shaft, access shafts and control chamber are unlikely to be significant sources of odour.

The May Road site is one of the alternate locations for a second Primary ATF in Stage 2 of the implementation of the ventilation for the Project. This ATF would be designed to draw air from Link Sewer 3 (from Miranda Reserve/PS25), to effectively manage air flows within the Central Interceptor. Alternately, if a second Primary ATF is installed at PS25, an air intake would be required at May Road. This air intake may incorporate a damper to allow flow balancing and should be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out.

As previously noted, no decision has yet been made on the final configuration of the ventilation system. The air intake referred to above is required for one of the ventilation options, but (for efficiency of design and construction) will probably be installed as part of the initial construction and sealed shut until required.

Given the overall operation of the Central Interceptor under negative pressure, adverse effects due to odour discharges at the May Road site will be no more than minor; this would also apply if the air intake is required in conjunction with air extraction and treatment at PS25. If air extract ventilation is required at the May Road site, this will be ducted via an air treatment facility and is unlikely to result in an increase in odour discharges or in consequent adverse effects.

4.3.5 Pump Station 23

Facilities to be located at the PS23 site include a pressure relief air vent, drop shaft, access shafts and control chambers and, possibly, an ATF and/or an air intake vent. Residential premises are located within 15m to the north, 40-50m to the northwest and 100m to the southwest of the site. The drop shaft, access shafts and control chamber are unlikely to be significant sources of odour.

At present there is a pump station on the site (PS23) which will be removed once the Central Interceptor is commissioned. This pump station is used to pump sewage from the Onehunga link sewer, via a rising main, to the Western Interceptor. Once the Central Interceptor is commissioned, the Onehunga link sewer will connect to the main tunnel via a drop shaft and the rising main will be abandoned.

The Onehunga link sewer is a recognised source of odour from the pump station, and this site has been a cause of occasional complaints to Watercare for a number of years. A small ultraviolet (UV)/ozone odour treatment facility has been installed to treat odorous air extracted from the pump station, with limited success. Removal of the pump station, with air being drawn to the main ATF at the Mangere pump station, should considerably reduce the likelihood of odour discharges occurring at this point.

However, it is also recognised that, during heavy rainfall events (around 6-8 times per year), this air extraction will not be possible. There is also the possibility that an 'air pocket' could be created in this area, if the main tunnel fills to both the north and south. In order to manage the resultant airflows, an activated carbon ATF will be installed at this site, along with a pressure relief air vent. The main purpose of the ATF would be to maintain tunnel ventilation with odour control during heavy rainfall events that prevent air being drawn through the ATF at the Mangere pump station.

Beca understands that an air intake may be required at the PS23 site, as part of the overall 'flow balancing' arrangements for the Project. This would be located over the main access shaft. The air intake vent will be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out, and will be able to be closed off when the ATF at this location is operating, to prevent 'short-circuiting' of air flows. Given the proposed installation of an emergency air vent at this site, discharges to air via the air intake vent during severe wet weather events are unlikely.

The pressure relief air vent would act as a bypass vent, used only in extreme rainfall events when an air pocket is formed in the tunnel between May Road and the Mangere Pump Station and air volumes to be vented exceed the capacity of the ATF, with the 'first flush' of air in such events still being discharged via the ATF. The two main mitigating factors for this discharge are the low frequency and short duration of operation (less than twice in 5 years, typically for less than 10 minutes each time) and the fact that the wastewater in the tunnel will be heavily diluted with stormwater (as a consequence of the rainfall event causing the discharge in the first place) and is thus likely to generate less odour than if it were from dry-weather flow. In addition, as discussed in section 3.3 of this report, meteorological conditions during the operation of the pressure relief vent are likely to result in effective and rapid dispersion of any odour. It is therefore considered that significant adverse effects due to this discharge of odour are unlikely.

There is already an existing penstock at this site. Watercare advise that, because PS23 is one of the top eight critical stations, maintenance patrols perform fortnightly operation checks in addition to the six-monthly and annual inspections referred to in section 4.2.3.[5] Since odour is only likely to be

[5] E-mail from Chris Harbour of Watercare to Neville Laverick of SKM, 7 July 2011.

discharged from control chambers when they are opened for inspection and maintenance; and the new control chamber is unlikely to require more frequent inspection and maintenance than the existing penstock, there will be no increase in odour from this source compared to the current situation.

Overall, the operation of the Central Interceptor is likely to reduce the frequency of odour discharges from this location, and consequently reduce the adverse effects on the environment.

4.3.6 Kiwi Esplanade / Ambury Park (AS7)

Immediately to the south of the Manukau Harbour, two alternate locations are being considered for access and connection facilities, one located within the Kiwi Esplanade Reserve, the other just within Ambury Farm Regional Park. The Kiwi Esplanade Reserve site (refer map AEE-MAIN-9A) will be located on the site of the existing toilet block, approximately 100m north of the nearest residential premises on Kiwi Esplanade. The site in Ambury Farm Regional Park (refer map AEE-MAIN-9B) is located approximately 100m north of the entrance to the park, and approximately 80m south-southeast of the nearest residential premises on Andes Avenue.

Whichever site is selected, facilities to be located at the site include a drop shaft, access shaft and a pressure relief air vent. The drop shaft and access shaft are unlikely to be significant sources of odour.

The pressure relief vent is intended as a back-up to that at PS23, to operate in the event that an 'air pocket' is created as the main tunnel fills to both the north and south. When this vent is in use, there will be discharges of odorous air. However, the 'air pocket' that this vent is designed to vent will only occur during or immediately after periods of very heavy rain in the catchment – estimated to occur less than once every 2-5 years, with the air vent required to operate for only a short period on each occasion (typically less than about 10 minutes). At such times, wastewater in the tunnel will be heavily diluted with stormwater (as a consequence of the rainfall event causing the discharge in the first place) and is thus likely to generate less odour than the normal dry-weather flows.

During heavy rainfall events that cause the main tunnel to fill before the Mangere pump station (thus preventing air extraction via the main ATF), it will be possible for air to be discharged via the pressure relief air vent. This will occur approximately 6 to 8 times per year during operational scenario 3 and is expected to occur for around 10 to 30 minutes depending on the rate of fill within the tunnel. A passive air treatment filter may be installed at the AS7 shaft site to treat discharges under these circumstances. This proposed shaft is the most downstream shaft where air will discharge in tunnel storage mode conditions. The air will be pushed out the vent as the tunnel fills and in the process will be treated by the passive air treatment filter.

From an air quality perspective, given the infrequent operation of the vent, there is a reasonable separation distance between the main potential odour discharge point (the vent) and the nearest sensitive receptors (residential premises) at both locations. In addition, as discussed in section 3.3 of this report, meteorological conditions during the operation of the pressure relief vent are likely to result in effective and rapid dispersion of any odour.

Whichever site is selected, the combination of separation distance, infrequent operation of the vent and reduced odour of wastewater in the tunnel (due to dilution), should be sufficient to avoid more than minor adverse effects associated with odour discharges.

4.3.7 Mangere Pump Station

Facilities to be installed at the Mangere WWTP for the Central Interceptor include control chambers, a large pump station, emergency pressure relief structure, and the main ATF (biofilter or biotrickling filter and activated carbon [BTF + AC]). This location is well within the existing odour boundary for the Mangere WWTP. Facilities for the Central Interceptor will be located at the northern end of the Mangere WWTP, on the site of existing buildings close to Mangere Lagoon – the nearest point on the existing odour boundary is over 300m to the east.

Beca understands that Watercare's preference is to install a biofilter at the Mangere Pump Station site, rather than a BTF+AC system. Given the separation distance between the pump station and the nearest point on the odour boundary, together with a relatively consistent load on the biofilter, it is considered that this is likely to provide adequate and effective control of odour discharges.

All air extracted from the Central Interceptor, including the new pump station, will be drawn through the ATF at this site, although there is the potential for odour discharges when the emergency pressure relief structure is operating (estimated to occur only in very rare situations). As such, the operation of the Central Interceptor will not noticeably add to the odour already being discharged from other parts of the WWTP, and is highly unlikely to cause adverse effects on the environment.

4.3.8 Motions Road

Motions Road is the start of the first microtunnel (2.4m diameter) feeding into the main, 4.5m diameter tunnel. Access shafts, control chambers, a drop shaft, a grit chamber and two new overflow structures will be constructed at this point, with one existing local reticulation overflow structure being removed. The site is located in public open space, immediately adjacent to a well-used walkway and pedestrian bridge, less than 100m northwest of the entrance to Auckland Zoo and within 100-150m of two schools (Western Springs College to the north and Pasadena Intermediate School to the southwest), with school playing fields within 60m to the west. The nearest residential areas are located approximately 250m to the west. The drop shaft, access shafts and control chamber are unlikely to be significant sources of odour.

Watercare's records indicate that odour from the existing sewer network has not been a significant issue in this location.

The grit chamber will require emptying and cleaning about four times per year. As noted in section 4.2.4, this can be a highly odorous activity, and all practicable means will be employed to minimise both the duration of the discharge and the effects of that discharge when it occurs. The separation distance between the facilities at this location and the nearest residential receptors is likely to be sufficient to avoid more than minor adverse effects on those receptors during cleaning of grit traps. However, there are likely to be large numbers of people present on any day of the week on the walkway and bridge, at either the two neighbouring schools or at the zoo or the nearby MOTAT 2 (further to the north on Motions Road), so careful planning will be required to schedule this activity at times that are least likely to cause adverse effects.

The reduction in sewer overflows into the adjacent Meola Creek (through the increased capacity provided by the Central Interceptor) may reduce the frequency of fugitive discharges of odour from this source. Although there will be two overflows at this location, these are likely to be operated at a very low frequency.

Overall, adverse effects at this location are likely to be less than minor except, possibly, during cleaning of the grit chamber, when minor localised adverse effects may occur for a short duration.

4.3.9 Rawalpindi Reserve

Facilities to be located in Rawalpindi Reserve include control chambers, a drop shaft, a grit chamber (existing) and an overflow structure. Several existing sewer overflows will be removed. Residential properties are located within 30m to the west and 40m to the southeast of the site, immediately adjacent to Rawalpindi Reserve, while parts of Chamberlain Park Golf Course are located less than 70m to the east. The drop shaft and control chamber are unlikely to be significant sources of odour.

The existing grit chamber at the site will be retained, and will require emptying at similar intervals as at present.

Watercare's records indicate that there is a history of odour complaints from the lower reaches of Branch 8.

The reduction in sewer overflows into the adjacent Meola Creek (through the increased capacity provided by the Central Interceptor) will reduce the frequency of any fugitive discharges of odour from this source. Although an existing overflow is being retained (and enlarged), this is likely to be operated at a much lower frequency than the current overflows and the overflows will be more dilute during the few larger events when it discharges.

4.3.10 PS25 (Miranda Reserve)

An existing pump station (PS25) is located toward the western end of Miranda Reserve, as part of the Western interceptor. With the construction of the Central Interceptor this will become redundant and will be demolished. New facilities to be installed at this location include a control chamber, grit chamber and drop shaft at the head of a 2.4m diameter microtunnel feeding into the main Central Interceptor at May Road. The site is surrounded by residential areas on all sides, the closest houses being 60-80m from the site. The two main potential air discharge points at this site are the grit trap (during routine cleaning) and the ATF (if installed). The drop shaft and control chamber are unlikely to be significant sources of odour.

Historically, odour from the existing sewer network at PS25 (due to the long retention times in the system upstream of PS25) has been a cause of complaint. In response, a biofilter has been installed which has proven effective mitigation. Removal of PS25, with air being drawn through the Central Interceptor (or to a new ATF, if installed) will avoid the potential discharge of odour from that source.

If an ATF is constructed at this site, two alternate ATFs are proposed – either a small Primary ATF (biotrickling filter plus activated carbon) to extract air under normal operation from Link Sewer 3 (with air intakes at May Road and/or Haycock Avenue) or a Secondary ATF (activated carbon only) to operate only during heavy rainfall events, when air extraction via the ATF at the Mangere pump station (and that at May Road, if installed) is not possible.

The grit trap will require emptying and cleaning about four times per year. As noted in section 4.2.4, this can be a highly odorous activity, and all practicable means will be employed to minimise both the duration of the discharge and the effects of that discharge when it occurs. Given the proximity of the site to nearby houses, there will still be a significant risk of odour discharges arising from the emptying of grit traps causing adverse effects in the immediate area. However, this will be undertaken during the normal working day, when many residents are likely to be out and is of short duration.

The air intake will incorporate a remotely actuated damper, which will be closed as required to prevent short-circuiting of air flows when the alternate air extraction system at the site (if installed) is operating. The vent will also be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out.

Depending on the final ventilation arrangements, during moderate to significant wet weather events that cause the main tunnel to fill before the Mangere pump station (thus preventing air extraction via the main ATF) it will be possible for air to be discharged via this intake. It is understood that this is estimated to be likely to occur around 6 to 8 times per annum (probably only once every 2-5 years if the ATFs are installed at May Road and PS25). As discussed in section 3.3 of this report, meteorological conditions during such events are likely to result in effective and rapid dispersion of any odour. It should be noted that, if a Primary ATF is installed at this site, an air intake will no longer be required.

Notwithstanding the risk of occasional discharges of odour during the emptying of the grit chamber, this is largely offset by the benefit arising from the avoidance of a potentially more significant odour discharge by the removal of PS25. In consequence, the overall adverse odour effects of the Project at this location are likely to be no more than minor.

4.3.11 Haycock Avenue

At Haycock Avenue, there will be a drop shaft, connection chambers and possibly an air intake, immediately surrounded by residential properties, with the nearest house only 10m to the southeast. Discharges of odour via the drop shaft and connection chambers will be avoided through effective sealing of inspection covers when not in use and the use of air extraction to keep the Central Interceptor tunnels under negative pressure.

The air intake will incorporate a remotely actuated damper, which will be closed as required to prevent short-circuiting of air flows when the alternate air extraction system at the site is operating. The vent will also be designed to minimise the potential for winds blowing across the vent creating venturi effects within the duct, thus drawing odorous air out. Depending on the final ventilation arrangements, during moderate to significant wet weather events that cause the main tunnel to fill before the Mangere Pump Station (thus prevent air extraction via the main ATF) it will be possible for air to be discharged via this intake. It is understood that this is estimated to be likely to occur around 6 to 8 times per annum (probably only once every 2-5 years if the ATFs at May Road and/or PS25 (Primary or Secondary) are installed). As discussed in section 3.3 of this report, meteorological conditions during such events are likely to result in effective and rapid dispersion of any odour.

4.4 Site-Specific Assessment – Other Locations

4.4.1 Mt Albert War Memorial Reserve

Facilities to be located at the Mt Albert War Memorial Reserve include a drop shaft, access shafts and control chambers, none of which are likely to be significant sources of odour. Watercare’s records indicate that odour from the existing sewer network has not been a significant issue in this location. Although the site is located in a public reserve; with residential dwellings located less than 30m to the west and south, adverse effects due to discharges of odour in this area are unlikely.

4.4.2 Haverstock Road

Surface facilities associated with the Central Interceptor at the Haverstock Road site will be located near the eastern boundary of the Plant & Food Research facility at 120 Mt Albert Road. Facilities to be located at this site include access shafts, drop shaft and control chamber, along with a relocated overflow. This overflow replaces existing overflows from the reticulation network, but is likely to operate at a much lower frequency due to the increased capacity available in the Central Interceptor. Watercare’s records indicate that odour from the existing sewer network has not been a significant issue in this location. Although the site is located less than 30m from residential dwellings, the potential for adverse effects due to discharges of odour will be reduced compared to the current situation.

4.4.3 Keith Hay Park

Facilities to be located in Keith Hay Park include a drop shaft, access shaft and control chamber, none of which are likely to be significant sources of odour. Although the site is located in a residential area, with residential dwellings immediately adjacent to the north, south and east and a public reserve to the west, adverse effects due to discharges of odour in this area are unlikely.

4.4.4 Walmsley Park

Facilities to be located in Walmsley Park, adjacent to Sandringham Road Extension, include a drop shaft, access shaft and control chamber, none of which are likely to be significant sources of odour. Watercare's records indicate that odour from the existing sewer network has not been a significant issue in this location. Although the site is located in a public reserve; with residential dwellings located less than 30m to the west and south and less than 50m to the northeast, adverse effects due to discharges of odour in this area are unlikely.

4.4.5 Western Springs Depot

It is proposed that a relatively small (2.4m diameter) access shaft will be located at the Western Springs Depot, west of the Western Springs Speedway. Although this access shaft is close to public open space (Western Springs Park), it is unlikely to be a significant source of odour and, in consequence, adverse effects are unlikely.

4.4.6 Norgrove Avenue

Facilities to be located at Norgrove Avenue include a drop shaft and a connection chamber, neither of which are likely to be significant sources of odour. There will also be a new overflow to replace two existing overflows. This overflow is likely to operate at a much lower frequency than the existing ones, due to the increased capacity available in the Central Interceptor. Watercare's records indicate that there has been a history of odour complaints from the lower reaches of Branch 8. Although houses are located within 10-20m of the surface facilities at this site, the potential for adverse effects due to discharges of odour will be reduced compared to the current situation.

4.4.7 Miranda Reserve

At the eastern end of Miranda Reserve, adjacent to Blockhouse Bay Road, will be a drop shaft, providing a connection for the local reticulation network and CSOs. Although this drop shaft is located in a public open space, currently used as a children's playground, and within 30m of houses, adverse effects due to discharges of odour will be unlikely.

4.4.8 Whitney Street

A drop shaft is to be located close to the intersection of Whitney Street and Mulgan Street, within the road reserve in front of 124 Whitney Street. This location is surrounded by residential dwellings, with the nearest house approximately 15m east of the shaft. Notwithstanding this proximity to houses, provided the inspection cover to the drop shaft is kept closed, adverse effects due to discharges of odour will be unlikely.

4.4.9 Dundale Avenue

A 2.4m diameter access shaft is to be located in public open space on the northern side of Dundale Avenue, with houses within 30m to the north and 40m to the south. A preschool is located approximately 40m to the northeast. Notwithstanding this proximity to sensitive receptors, provided the inspection cover to the access shaft is kept closed and the system under negative pressure, adverse effects due to discharges of odour will be unlikely.

4.5 Conclusion

Overall, it is concluded that air discharges from the Central Interceptor can be managed to meet the relevant criteria in the Auckland Council Regional Plan: Air, Land and Water. In addition, there are likely to be positive effects arising from reductions in odour discharges at PS23, the Lyon Avenue overflow and Branch 8.

5 Odour Control Systems

5.1 Introduction

In New Zealand, the most common types of odour emission control systems used on sewage reticulation networks are biofilters and UV/ozone systems. The systems proposed for the Central Interceptor Project are either activated carbon adsorbers or a combination of biotrickling filter and activated carbon. A discussion of each of these systems, and their advantages and disadvantages, is provided below.

5.2 Biofilters

In biofilters, the odorous gas stream is passed through a bed comprised of soil, bark, compost or any mixture of these components, laid over an inert support. Micro-organisms in the bed material break down organic compounds to carbon dioxide, water, mineral salts and other harmless products.

Biofilters have proven highly effective in removing sewage-type odours, being used for that purpose at many WWTPs, sewage pump stations and other sewer ventilation points across New Zealand. Examples of highly successful applications of biofilters in Auckland include the Mangere and Rosedale WWTPs, Mairangi Bay pump station and the sewer vent on Plunket Avenue, Wiri. Biofilters have been installed at 24 locations across Watercare's Wastewater Transmission Network, to control odour from pump stations, siphons and pressure relief vents, where they have all but eliminated historical odour issues.

In order to provide effective odour removal, the ratio of total gas volume to bed cross sectional area should be less than about $50m^3/m^2/hr$. With a typical maximum bed depth of about 1m (to prevent excessive back pressure), biofilters tend to require a relatively large footprint. Aside from this, control requirements include:

- Maximum inlet gas temperature of 35°C
- Humidity of the inlet gas stream at least 50-60%
- pH of the bed media in the range 7-8
- Adequate moisture in the bed, which may require the use of water spray irrigation (ARC 2002).

Although normal biofilters can remove moderate concentrations of H_2S, high inlet concentrations of H_2S can lead to the production of excessive amounts of sulphuric acid, which will adversely affect the structure of the biofilter and the micro-organisms that are vital to effective operation. However, there is no evidence that this has been an issue for the biofilters currently installed on Watercare's network.

5.3 Biotrickling Filters

Biotrickling filters (BTFs) operate on similar principles to biofilters, with micro-organisms breaking down the odorous organic compounds, except that they also utilise a counter-current flow of liquid through a man-made support medium, which enables BTFs to treat higher concentrations of H_2S than conventional biofilters. There are a range of BTF configurations, depending on the particular manufacturer; however, the basic treatment types can be classified as autotrophic and heterotrophic. Autotrophic microorganisms are very effective at removing simple chemical species such as H_2S, but are less effective at removing other reduced sulphur compounds and VOCs, whereas heterotrophic microorganisms will remove reduced sulphur compounds and VOCs with varying degrees of efficiency, but have little effect on H_2S. Some BTF configurations use separate autotrophic and heterotrophic stages.

Table 10 presents a comparison of some of the performance specifications for a biofilter installed at Melbourne Water's Eastern Treatment Plant and a proposed BTF plus activated carbon (refer section 5.4) system to be installed at its East Drop structure site.[6]

Table 10 – Emission control specifications

Parameter	Eastern Treatment Plant Biofilter		East Drop BTF + AC	
	Inlet	Outlet	Inlet	Outlet
H_2S concentration	Average 13 ppm Maximum 24 ppm	<0.1 ppm (without vent stack) <0.5 ppm (with vent stack	Average 60 ppm Peak 100 ppm	>99.9 % removal <0.05 ppm at peak load
Total mercaptans	Not specified	Not specified	8 – 12 ppm	>99 % removal <0.01 ppm at peak load
Dimethyl sulphide	Not specified	Not specified	3 – 5 ppm	>99 % removal <0.01 ppm at peak load
VOCs	Not specified	Not specified	Not specified	>99 % removal
Ammonia	Not specified	Not specified	8 – 12 ppm	>99 % removal
Odour concentration	Range 2,500 – 36.000 OU Peak 51,000 OU	<500 OU (without vent stack) <2,000 OU (with vent stack	Not specified	<500 OU

As can be seen from Table 10, BTFs can be designed to treat much higher concentrations of H_2S than is normal for traditional biofilters (i.e. greater than ~50 ppm) while, in conjunction with activated carbon adsorption, achieving similar odour discharge concentrations[7].

BTFs, like biofilters, require the pH of the treatment bed to be maintained at about pH 7-8; in consequence, automatic dosing of the recirculating liquor will be required to counteract the production of sulphuric acid. In addition, a pilot study on the application of BTF technology at a WWTP in the United States (Webster, et al. 2006) identified a need to provide a constant top-up feed of fresh liquor, with the equivalent volume discharged to waste, to provide effective control of mercaptans and organic sulphides. Without this constant fresh liquor feed, overall odour removal rates were typically in the range 25-60%, with consequent high odour discharge concentrations; With the top-up feed in place, the apparent odour removal efficiency was better than 95%. Although odour is not completely removed, consequential odour nuisance is avoided.

Compared to traditional biofilters, BTFs require a smaller footprint (because they are less restricted by maximum bed depth) and can effectively treat waste gas streams with much higher inlet concentrations of H_2S. However, the need for constant dosing of BTFs with alkali (usually sodium hydroxide) imposes additional health and safety and maintenance requirements, while BTFs also require an additional nutrient feed to maintain the micro-organisms, which in a biofilter is provided by the filter medium itself.

[6] Data provided by the Central Interceptor Project team

[7] Measurement of actual odour emission rates and odour removal efficiencies for biofilters is heavily affected by the natural odour of the biofilter itself.

Both BTFs and biofilters typically require complete replacement of the support medium at intervals of about 5-10 years. Biofilters may also require maintenance of the bed at more frequent intervals (than BTFs) to prevent crusting over or short-circuiting, although this has not been Watercare's experience with the existing biofilters on the network.

5.4 Activated Carbon

Both biofilters and BTFs are best suited to relatively constant flows of odorous waste gases. The micro-organisms in them that break down odorous chemicals take time to establish in sufficient numbers to provide effective odour control. Therefore, for locations where the odour control facility will be required only intermittently, activated carbon (AC) adsorbers are more effective. These can provide effective removal of H_2S and odorous organic species (mercaptans, reduced sulphides and VOCs) at efficiencies in excess of 95%. However, in prolonged use or where exposed to very high inlet concentrations, the AC can become saturated, leading to a failure of emission control.

The AC adsorbers could be partially regenerated between operating periods by reversing the air flow – using them as air intakes to the system.

The major drawback with AC adsorbers is the high operating cost – the AC must be replaced every one to two years to maintain effective odour removal capacity.

5.5 UV/ozone

In UV/ozone systems, UV light is used to generate highly reactive oxygen free-radicals. These will either react with organic chemicals in the waste gas stream, or with oxygen to form ozone. They have the advantage of a small footprint and a lack of moving parts – no extraction fans are required. However, Watercare's experience, and the author's own experience, with such systems indicates only mixed success in treating odour – for example, there continue to be complaints regarding odour at PS23, despite the UV/ozone treatment that has been installed.

5.6 Odour Control for the Central Interceptor

A comparison of the relative advantages and disadvantages of the various odour control technologies is shown in Table 11.

Table 11 – Summary of advantages and disadvantages of air treatment technologies

Technology	Advantages	Disadvantages
Biofilter	■ Able to treat effectively a broad range of odorous compounds including reduced sulphur compounds and VOCs ■ Very suitable where the air emission targets are not onerous and/or where there is reasonable separation between the facility and nearest neighbours /odour receptors ■ Can run unattended as relatively easy to maintain and operate (post construction) ■ Simple control and instrumentation ■ Relatively low capital and running costs ■ Low energy requirements ■ Have lowest life cycle costs ■ No secondary pollution	■ Can accommodate gradual changes in constituent loading but are less capable in dealing with rapid changes in load. ■ Treated odorous emissions are often discharged at ground level (i.e. no vent stacks) and while notionally distributed "over a wide area", this can result in less effective or ineffective dispersion results with greater risk of adverse off-site impacts. ■ As H_2S concentrations and odorous air volumes increase, relatively larger land areas are required (for the same level of treatment) if organic media is used. ■ The life of organic composting beds/media is typically up to 8 years; ■ Short-circuiting of the media and inadequate air treatment at higher flow rates is a risk (but

Technology	Advantages	Disadvantages
	■ Has a significant capital cost advantage.	can be managed at design stage) ■ Inadequate maintenance (e.g. ensuring the media is continually wetted) will adversely impact performance. ■ In some jurisdictions (e.g. Australia) the waste media is treated as "prescribed waste" for disposal to controlled landfill site. ■ Leachate is produced and needs to be carefully controlled (e.g. disposed of back to sewer) to ensure other odour problems are not created. ■ Potential risk of acidification.
Biotrickling Filters (BTFs)	■ Are efficient when used in high H_2S applications ■ Have a shorter detention time than biofilters (and can therefore be "smaller") ■ Relatively simple design with relatively low operating costs and maintenance requirements – comparable to a biofilter. ■ Can run unattended with little operator involvement required - as many contemporary facilities are designed to do, although BTFs are more operationally "complex" than biofilters). ■ Relatively small footprint.	■ Overall odour removal performance not as robust as a biofilter ■ Have less/limited success with reduced sulphur and other complex odorous compounds – performance & efficiency is more limited across the broader spectrum of odorous compounds – unless specifically designed with autotrophic and heterotrophic stages sequentially. ■ Require a significant amount of time (hours to days) to achieve or recover full performance after a shutdown or plant upset. ■ Leachate is produced and needs to be carefully controlled (e.g. disposed of back to sewer) to ensure other odour problems are not created. ■ Media requires periodic replacement every 3 to 10 years (supplier and system dependent).
Activated Carbon (AC)	■ Consistently higher levels of overall performance and easier to attain balanced removal of H_2S, other reduced sulphur compounds, organics and VOCs.	■ AC media must be disposed of as prescribed waste (at media replacement). ■ On its own AC would have a very high operating cost and frequent media replacement for high air flows and odour loads from ventilated transfer networks.
BTF + Activated Carbon (AC)	■ Efficient removal of high H_2S concentration streams and attains the optimal balance to manage high H_2S inlet (BTF) and low residual H_2S concentrations; ■ Consistently higher levels of overall performance and easier to attain balanced removal of H_2S, other reduced Sulphur compounds, organics and VOCs (with an inbuilt two stage autotrophic and heterotrophic facility). ■ High level of process performance and reliability - the AC absorber can ensure high overall removal efficiency during the recovery period after plant shutdown (e.g. maintenance) or after an upset ■ AC provides flexibility in maintenance regimes ■ Reasonably small footprint (although somewhat larger than for biofilters – but with equal or better performance. ■ Less focus on and frequent replacement of	■ A constant supply of secondary effluent or potable water is required (to which nutrients are added to provide the nutrient-rich recirculating stream for optimal performance). ■ AC media must typically be disposed of as a "prescribed waste" to a controlled landfill when 'exhausted' and requires replacement. ■ Capital costs comparatively high. ■ Higher pressure drop across plant resulting in higher fan power costs ■ Air exiting the BTF needs to be dehumidified before passing to the AC unit, otherwise the effectiveness and life of the AC is greatly reduced. This is generally not very difficult or costly The energy operating cost would indicatively be approximately the same energy cost as for the extraction fans and typically represent approximately 10% of the overall ATF operations and maintenance cost (which is dominated by the media

Technology	Advantages	Disadvantages
	support media (compared with biofilters).	replacement cost). ■ Somewhat greater visual impact than a biofilter.

It is proposed to install an activated carbon adsorption system at PS23. If odour control is required at Western Springs Park, this is also likely to be an activated carbon adsorption system, as would a secondary ATF at PS25 (Miranda Reserve).

The main odour control facility at Mangere pump station is proposed to be either a biofilter or a combination of a BTF with AC adsorption to provide additional removal of VOCs after the BTF. The proposed odour extraction and control systems at May Road, if required, will be similar to the BTF with AC adsorption proposed for the Mangere pump station, as would the Primary ATF option at PS25 (Miranda Reserve), albeit on a smaller scale. Each of these BTF systems will incorporate a pre-filter (to remove entrained fats and grease), two BTF stages (autotrophic and heterotrophic) and two AC units. The BTF stages and AC units will each be capable of operating in series or parallel, so that while maintenance is being carried out there will always be two BTF stages and one AC unit or one BTF and two AC units in operation.

Table 12 summarises the design size requirements for each ATF, while Table 13 summarises the maintenance requirements for the different systems. Routine maintenance requiring the shut-down of any part of an ATF is likely to occur at intervals of less than 1-2 years (replacement of AC media).

Table 12 – ATF design size requirements

Site	Air Volume *	ATF Type	Maximum Footprint *
Mangere Pump Station	30 m^3/s	Biofilter or BTF + AC	85m x 45m
PS23	5 m^3/s	BTF + AC	25m x 10m
May Road	24 m^3/s	BTF + AC	70m x 37m
Western Springs	5 m^3/s	AC	30m x 15m
PS25 (Miranda Reserve)	5 m^3/s 6 m^3/s	AC option BTF + AC option	40m x 15m

* Design air volumes and footprints of the different systems have been supplied by the project team

Table 13 – ATF maintenance requirements

Maintenance Activity	BTF	AC	Frequency
Routine inspection	√	√	Weekly
Test standby generator	√	√	Monthly
Refuel generator	√	√	6-monthly
Replenish nutrient	√		6-monthly
Replace activated carbon		√	1-2 years
Replace BTF media	√		5-10 years
Air extraction duct maintenance	√	√	>10 years
Asset removal and/or replacement	√	√	5-10 years

Although BTF plus activated carbon may be the recommended odour control option at all Primary ATF sites, Watercare may opt for biofilters on the basis that these are known technology, with which it has had many years of successful experience. Both biofilters and BTF/AC combinations should achieve effective control of odours from the Central Interceptor. However, the long-term performance of biofilters may be adversely affected if high concentrations of H_2S (in excess of 50 ppm) are present in the air being drawn from the tunnels.

6 Conclusions

This assessment has considered the potential discharges into air from the operation of the proposed Central Interceptor and associated Link Sewers. 19 separate sites have been considered, being locations where surface structures associated with the Central Interceptor will be located. Ten of these have been assessed in slightly more detail than the others, largely because the specific operational structures to be located at those sites could result in a higher potential for adverse effects on air quality.

Most of the 19 sites are located in residential areas or recreational reserves that are regarded as sensitive to discharges of odour.

Those ten sites for which a more detailed assessment has been undertaken are:

- Western Springs
- Lyon Avenue
- May Road
- PS23
- Kiwi Esplanade / Ambury Park
- Mangere pump station
- Motions Road
- Rawalpindi Reserve
- PS25 (Miranda Reserve)
- Haycock Avenue

Air extract ventilation with odour removal will be used to maintain the Central Interceptor under negative pressure during normal operation. However, in extreme wet weather events, air flows may exceed the capacity of the ventilation system, in which case the odour removal plant may be by-passed.

It is proposed that ATFs are initially installed at Mangere pump station and PS23, with possible additional facilities at May Road, Western Springs Park and PS25 (Miranda Reserve), based on the results of subsequent reviews of the operational performance of the system. These will be designed to minimise discharges of odour from the normal operation of the system including (in the case of ATFs at PS23, Western Springs Park and PS25) air discharges associated with moderate to severe wet weather events), and thus avoid consequent adverse effects on air quality and amenity values.

Although odour discharges may occur during extreme wet weather events (likely to occur at a frequency of less than twice in 5 years), it is anticipated that the higher flows and the more dilute nature of the wastewater in such circumstances, along with the relatively low frequency of such events, would not result in significant adverse effects. In addition, meteorological conditions during such events are likely to result in effective and rapid dispersion of any odour.

Overall, this assessment concludes that, both during normal operation and during wet weather events, adverse effects due to discharges of odour from the Central Interceptor will be less than minor. The only exceptions to this would be:

- Discharges of moderately odorous air during moderate to severe wet weather events (if ATFs at May Road, PS25 and Western Springs Park are not installed), potentially giving rise to minor (but not more than minor) localised adverse effects

- During the routine emptying of grit traps when, due to the nature of the material being removed, minor (but not more than minor) localised adverse effects may occur for the short duration of the activity (typically less than 3-4 hours).

Overall, it is concluded that air discharges from the Central Interceptor can be managed to meet the relevant criteria in the Auckland Council Regional Plan: Air, Land and Water. In addition, there are likely to be positive effects arising from reductions in odour discharges at PS23, the Lyon Avenue overflow and Branch 8.

7 References

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