SE Odour Investigation Final Report

Document no: 230531135804_bfbd7519
Version: 5

The City of Calgary

SE Odour Investigation
September 20, 2023

SE Odour Investigation Final Report

Client Name:	The City of Calgary		
Project Name:	SE Odour Investigation		
Document No:	230531135804_bfbd7519	**Project No:**	CE855600
Version:	5	**Project Manager:**	Dean Wyman
Date:		**Prepared By:**	Jacobs
Document Status:	FINAL	**File Name:**	SE-Odour-Investigation-Final-Report-Sept.20 2023

Prepared by:

Author	Title
Jordan Norris	Environmental Scientist, Organic Waste Management
Darryl Chartrand	Expert Technologist, Air Quality
Kim Fries	Principal Technologist, Wastewater Treatment
Todd Williams	Global Principal for Biosolids
Dean Wyman	Senior Project Manager

CH2M HILL Canada Limited

First Tower, 2700
411 - 1st Street SE
Calgary, AB T2G 4Y5
Canada

T +1.403.407.8700
F +1.503.736.2003
www.jacobs.com

Executive Summary

The City of Calgary (The City) has observed a significant increase in complaints regarding odours beginning July 2022 compared to complaints received previously from several southeast (SE) communities, including New Brighton, Copperfield, McKenzie Towne, and Douglasdale/Glen. A number of interested parties have requested that The City identify and recommend appropriate mitigation for the possible causes of the odour. The City has retained CH2M HILL Canada Limited (Jacobs) to design and implement a comprehensive assessment of potential sources of odours from surrounding areas and recommend potential mitigation measures for The City, as appropriate.

The investigation focused on the Shepard Complex, which encompasses The City's operations in the area, and includes the Composting Facility, the Biosolids Lagoons, and the Shepard landfill site. Other odour sources within approximately 5 kilometres (km) from the Shepard Complex were also investigated. Information and data were provided to Jacobs to help identify potential odour source(s) and mitigations that will allow The City to take appropriate action. Jacobs visited the Shepard Complex in September 2022 and October 2022 to perform "fingerprint" sampling and evaluate operational conditions and odours through sampling and monitoring. Jacobs conducted a follow-up site visit in April 2023 to evaluate odours and operational conditions again prior to summer 2023.The investigations, data review, and evaluations conducted during the SE Odour Investigation project did not result in the identification of a single odour source impacting residents and causing odour complaints. Rather, many of the odour sources investigated likely contribute to offsite odour impacts in SE neighbourhoods. Jacobs has identified several suggestions for mitigating odour sources investigated during the project. Jacobs' recommendations are detailed in Section 5 of this report. The two recommendations that would lead to immediate improvements are as follows:

- The City establishing a process to regularly communicate with residents and other interested parties
- Installing a series of active real-time odour and odour compound monitoring sensors throughout adjacent community and along the Shepard Complex perimeter to gather real-time odour data

The real-time odour monitoring system will allow The City to gather real time odour data, which can be used along with wind back trajectories to identify likely sources. This system, when used along with future-casted winds, can proactively identify periods of elevated impacts.

This report is the final Project Summary Report. It summarizes the relevant assumptions, methodology, sampling and modelling results, conclusions, and recommendations of the project. Project tasks are titled as follows and are presented in the report sections referenced in parentheses:

Task 1 - Review of Background Documents (Section 2)

Task 2 - Ambient Air Monitoring and Source Sampling Program (Section 3)

Task 3 - Air Dispersion Modelling (Section 4)

Task 4 - Identification of Mitigation Measures for Key Odour Sources (Section 5)

Task 1 - Review of Background Documents

As part of Task 1, Jacobs reviewed the background data received from The City's Waste & Recycling Services (WRS) and Water Services (Water) departments. The purpose of the reviews was to help Jacobs focus on what circumstances (e.g., operational, meteorological, or odour sources) were likely leading to elevated odour emissions and increasing the likelihood of odour complaints.

Jacobs reviewed background information provided and knowledge of the operational activities conducted at the Shepard Complex to identify patterns or operational occurrences and circumstances that may have led to increased odour emissions. The following activities are likely to increase the probability of elevated odour intensity to surrounding areas:

- At the Biosolids Lagoons: transfer of biosolids to adjoining cells and temporary stockpiling of dewatered biosolids prior to trucking to a willow farm on concrete pad near the lagoon area
- At the Composting Facility: disturbing, moving, and loading finished compost and other materials at the Compost Storage Pad
- At the landfill: operations at the active face, especially when the active face is closest to the southern perimeter of the Shepard Complex

Jacobs reviewed previous odour work and findings to determine whether the results are consistent with onsite observations, and consistent with complaint logs prepared by Water and WRS. Correlating odour complaints with wind directions and considering various operational factors affecting odours aided Jacobs in determining the preferred time and circumstances to sample the suspected sites.

Jacobs also reviewed WRS' field odour investigation logs, and Jacobs noted that investigations took place on relatively low wind speed days and that investigations were conducted downwind of the Composting Facility. During these investigations, a City employee visited pre-determined downwind locations and used a Nasal Ranger, a type of field olfactometer, to quantify the intensity of the odours detected. The Nasal Ranger quantifies intensity of odour in terms of a dilution to threshold (D/T) scale: 2 D/T is a faint, almost imperceptible odour; and higher D/T values correspond to higher intensities. It was particularly noteworthy that the odours detected and measured were low intensity during these investigations.
The low odour intensity recorded during these investigations was consistent with the odour investigations conducted by Jacobs during a field visit the week of August 29, 2022. Jacobs developed an odour monitoring route that included 16 potential sources and receptors within 5 km of the Shepard Complex. Odour investigations were conducted in the evenings between 7 pm and 9 pm on August 30 and August 31 and during an odour complaint response with The City's staff on September 1. A field olfactometer was used at locations where odours were detected to quantify odour strength in terms of D/T values. The results of Jacob's field investigation showed low intensity odours at all monitoring locations with one exception:

- August 31, 2022 **–** The investigator detected a strong biosolids lagoon odour downwind and directly west of the Shepard Complex on 52 Street (St) SE approximately 250 metres from the nearest lagoon. A D/T of 7 was detected in this instance.

Other noteworthy odour detections included the following:

- August 30, 2022 **–** Investigator detected a slight Composting Facility odour downwind (northeast [NE]) of the Composting Facility along 114 Avenue (Ave) SE. Odour was not detectable through the olfactometer (and odour was described as "very weak").
- August 31, 2022 **–** A compost odour was detected downwind at the corner of 114 Ave SE and 52 St SE. Odour was not detectable through the olfactometer. Odour was described as "weak."
- August 31, 2022 **–** A compost odour was detected further downwind, approximately 4.25 km away, on Barlow Trail SE at the canal crossing. An odour measurement was not taken for safety reasons, but the intensity of the odour was similar to that found at the corner of 114 Ave SE and 52 St SE (and odour intensity was described as "weak").
- August 31, 2022 **–** A biosolids lagoon odour was detected downwind on Barlow Trail SE near the corner of 106 Ave SE. An odour measurement was not taken for safety reasons (and odour intensity was described as "weak").
- September 1, 2022 **–** Jacobs accompanied The City on an odour complaint investigation at a residence southwest (SW) of the site. Upon arrival at the complainant's home, no odour was detected (Odour intensity 0). Investigators walked the trail NE of the complainant's location and

identified compost-related odours at the baseball fields near the corner of 52 St SE and 130 Ave SE (with odour intensity described as "very weak"). Odour was not detectable through the olfactometer.

Based on the results of the preliminary investigation, Jacobs, in conjunction with The City's staff, identified the following "Key Sources" within 5 km of the Shepard Complex for further investigation:

- Shepard Biosolids Lagoons
- Shepard Landfill operations
- Calgary Composting Facility (curing, storage, and biofilter)
- Wastewater collection system in Douglasdale, Shepard Industrial, East Shepard Industrial, New Brighton, Copperfield, and McKenzie Towne
- Wetlands – south and east of the Shepard Complex
- Other industrial sources (industrial food processing - north, slurry disposal – east)
- Agricultural activities east of Stoney Trail
- Storm ponds and other water bodies, as appropriate

The Calgary Regional Airshed Zone (CRAZ) Southeast Calgary monitoring station located near the intersection of 46 St SE and 110 Ave SE is an adequate and reliable data source for the Shepard Complex. This station is operated by the Calgary Region Airshed Zone Society and is a non-profit association with members from government agencies (federal, provincial, and municipal), non-government organizations, industry, and the public. This monitoring station records numerous air quality and meteorological parameters such as the concentration of hydrogen sulphide (H_2S), nitrogen oxides, ozone, particulate matter, and total hydrocarbons, as well as wind speed, wind direction, humidity, and temperature.

Jacobs reviewed the CRAZ meteorological data and compared it with meteorology currently being used for the contractually required air dispersion modelling at the Composting Facility to verify whether they are an accurate representation of local weather patterns and, therefore, whether the model predictions were underestimating or overestimating impacts at any locations in the vicinity of the Shepard Complex. The purpose of this review was to determine whether the meteorology currently used for air modelling for the Composting Facility could be improved for Task 3 of the scope of work (air dispersion modelling) to better estimate possible effects from Shepard Complex emissions, particularly at the residential areas to the south, southwest, and west.

The notable findings from Jacobs Task 1 work are included in Table ES-1 and are organized by review area.

Table ES-1. Notable Findings by Review Area

Area of Investigation	Notable Findings
Operational Patterns and Circumstances	▪ The list of potential odour generating activities identified during this task was confirmed during field monitoring and sampling events.
Water Services and WRS Odour Investigation Forms	▪ Jacobs identified two potential areas of improvement in the Water complaints logs: - Provide a more detailed description of the odour complaints. - Include meteorological conditions associated with complaints. ▪ Jacobs identified two potential areas of improvement in the WRS complaints logs: - One wind direction is documented. However, if the winds vary over the period of the assessment, the wind directions at each of the locations should be recorded.

Area of Investigation	Notable Findings
	- WRS' odour investigations indicate whether the review was being conducted in response to a complaint, but the location of the complaint is not shown, and it is not clear which of the locations visited correspond to the complaint location. Water Services, however, do provide an address on their complaint log.
Calgary Regional Airshed Zone (CRAZ) Program Air Quality Data	▪ Monitor CRAZ SE meteorological and air quality data to assist in identifying possible elevated odorous compounds being emitted from the Complex. ▪ The City should analyze CRAZ SE data as part of the response to public complaints, when appropriate. ▪ The City should analyze the time period before and after complaints and assess whether elevated total hydrocarbons (or other odorous compounds such as H_2S, or both) concentrations were elevated and if winds were from the Complex. ▪ Monitor CRAZ data for elevated concentrations of compounds such as ozone and particulate matter that could be indicative of temperature inversions, which may impact air quality in general and may enhance odour concentrations and complaints specifically.
CRAZ Meteorological Data and Modelling Data Comparison	▪ WRF meteorological data used in the current contractually required air dispersion modelling are acceptable according to odour modelling. ▪ For Task 3 air modelling, Jacobs will update the WRF meteorological data using the years 2015 to 2019 inclusive obtained from Alberta Environment and Protected Areas.
Previous Odour Work and Findings	▪ There are numerous odour sources at, and within 5 km, of the Shepard Complex. ▪ When Jacobs was on-site, some potential odour sources were detected during the sampling and field monitoring periods and were further characterized using air samples and field olfactometers. ▪ Odours from the Shepard Complex tended to be low intensity during the sampling program. ▪ Odour complaints tend to occur from 6 pm to midnight, likely due to both meteorological conditions and more people being home or outdoors and therefore able to detect the odours.
CRAZ Alert Investigations, 2021 and 2022	▪ Odours are typically generated during quiescent conditions and material handling activities or movement.

Note:
WRF = Weather Research and Forecasting Model

In summary and based on this analysis, Jacobs is of the opinion that the WRF meteorological data used in the contractually required regular air dispersion modelling is acceptable. For the Task 3 air dispersion modelling, Jacobs has updated the WRF meteorological data using the years 2015 to 2019 inclusive obtained from Alberta Environment and Protected Areas (AEPA). Additional details of the air dispersion modelling methodology are presented in Section 4.

Task 2 - Ambient Air Monitoring and Source Sampling Program

The objective of Task 2 was to take odour and air samples at and near the emission sources and community receptors identified as part of Task 1. The following potential sources within 5 km of the Shepard Complex were identified for sampling:

- The Shepard Complex, which includes the following operations:
  - Shepard Biosolids Lagoons
  - Shepard Landfill
  - Calgary Composting Facility (consisting of curing building, storage area, and biofilter stacks)

- The East McKenzie Lift Station near 130 Ave SE and McIvor Boulevard SE
- Industrial Food Processing (Olfactometer Samples – September Only)

Other candidate locations (e.g., wetlands and agricultural areas) were identified in Task 1 but were not sampled due to no discernable odours at time of sampling. However, to further investigate the potential of additional sources not identified at time of sampling, Jacobs is recommending real-time monitoring along the site periphery to better identify odour source(s) and to quantify other parameters such as seasonality and emissions intensity to correlate this information to resident complaints.

The purpose of the ambient air monitoring was to determine whether odorous air impacting the community could be traced back to a specific source by determining whether the chemical nature or profile of the odour emissions is unique to one or just a few sources. This was done by taking air samples at the source locations listed previously as well as receptor locations downwind of the sources.

The receptor locations concentrated particularly on the residential areas to the south and southwest of the Shepard Complex where odours were noted. The air samples were then analyzed at an accredited laboratory to identify the chemical composition of the air at that time and identify which, if any, chemical species were highest in concentration for a source, or which were unique to a particular source, or both. This process is called 'chemical speciation' or 'fingerprinting' of the air samples.

Two rounds of chemical speciation investigations took place at identified sources and select receptor areas during these time periods:

1. August 29 to September 1, 2022 (called the "September" sampling)
2. October 17 to 26, 2022 (called the "October" sampling)

The air samples were collected using a variety of methods depending on the specific requirements for each group of chemicals:

- Evacuated canisters
- Thermal desorption tubes with calibrated pumps
- Passive diffusion tubes

The air samples taken for both the September and October programs were tested as listed in Table ES-2. Summary of Odour Source Emission Rates. These chemical groups were sampled because, based on Jacobs' experience, they are expected to be odorous compounds associated with and potentially emitted from the identified sources, and are typically sampled during odour investigations at similar sources. This group of chemicals was comprehensive, to help verify that specific emitted chemicals were sampled and potentially identified. Table ES-2 Summary of Odour Characteristics provides the chemical groups sampled and a general description of their characteristic odours. The odour associated with each of the chemical groups was not intended to be a comprehensive list of odours for all species in that group, but rather was intended to represent those typical of the group as a whole.

Table ES-2. Summary of Odour Source Emission Rates

Chemical Group	Characteristic Odour
▪ Reduced sulphides and mercaptans	▪ Rotten eggs, rotten cabbage, pungent, sulphury
▪ Ammonia	▪ Pungent, sharp
▪ Volatile organic compounds	▪ Various; can smell like solvents, chemicals, sweet
▪ Aldehydes and ketones	▪ Ketones can smell sweet, minty, acetone; smaller aldehydes can smell sweet and like rotten fruit
▪ Carboxylic acids	▪ Various ▪ Formic acid is pungent, penetrating. Acetic and propionic acids are pungent, vinegar; longer chain acids can smell like rancid butter, oils, or cheese.
▪ Triethylamine (August Sampling Only)	▪ Fishy

Additional odour source sampling was conducted during the period October 17 to 26 at the following locations:

- Calgary Composting Facility (biofilter, curing, and storage)
- Biosolids Lagoons
- Shepard Landfill
- East McKenzie Lift Station

The purpose of this sampling was to determine the rate of odour emissions from each of the sources. This involved determining the strength of odour of each of the samples, as well as the flux or flow of the odorous air from each of the source. The process of quantifying the strength of the odorous air at each source involves collecting odorous air samples directly at the surfaces of the sources where appropriate (e.g., lagoons, landfill active face, or compost storage areas) or directly within or near the emission stacks (e.g., biofilter stacks, lift station release point, or curing building fans). These samples were then sent to an accredited laboratory where trained assessors (called an 'odour panel') quantify the strength of the odours (noting that these odour strength units are called odour units [OUs] and are discussed further in Sections 3 and 4). The odour emission rates or odour flux are then determined by multiplying the strength of the odour by the flow measured during sample collection.

These odour emission rates were determined such that air dispersion modelling could be conducted for each of the sources, to gain insight into the aerial extent and magnitude on impacts at offsite receptors. The air modelling component of the Project is further discussed as Task 3 and is provided in Section 4.

The most significant of the odour sources are the Calgary Composting Facility (CCF) sources and the Biosolids Lagoons. It should be noted that the odour emission rates measured are representative of the conditions that were occurring during the sampling and that there would be some seasonal and diurnal variability expected for all sources listed. This is further discussed in the air dispersion modelling task provided in Section 4.

Jacobs conducted offsite odour surveys during the week of August 29, 2022, and during the week of October 17, 2022. Jacobs detected odours at all the locations and used the Nasal Ranger (August/September) or Scentroid (October) to measure odour intensity and character. Both the Nasal Ranger and the Scentroid are handheld portable olfactometer instruments that are designed to take and quantify the strength of odour air samples immediately by the operator in the field. The unit associated with strength of odorous air when collected by an olfactometer on the field is typically a D/T and is similar to the OUs discussed previously.

The following locations and activities are the most likely source(s) of odours impacting the neighbourhoods to the south and southwest:

- Shephard Landfill active tip face
- Biosolids lagoons
- Calgary Composting Facility biofilter
- Calgary Composting Facility Curing Building
- Calgary Composting Facility outdoor finished storage pad
- East McKenzie Lift Station

The locations are not listed in any order or 'ranking.' Additional sources may impact residences but are likely intermittent based on observations (e.g., industrial facilities, wetlands, or agricultural areas) and are likely not leading to widespread complaints, which was the focus of these studies. However, further study may be necessary to better characterize the possibility of short-term excursions of odour from these 'other' sources that were not identified or captured during the sampling programs.

Preliminary chemical speciation sampling results were inconclusive. The results of the sampling at the select residential receptor locations showed no clear correlation between the chemical measured and detected at the sources with those measured and detected at the residential locations.

The inconclusive nature of the results may be partially due to the limited number of samples taken, which are susceptible to significant variability in several parameters, such as the following:

- The results were reflective of a 'snapshot' of the emissions at the time of sampling. Odours may also change (increase or decrease) during different times of the day and year.
- Some sources (e.g., landfill) are likely highly variable and dependent on the waste content and characteristics.
- Sources such as Compost Facility curing, biofilter, and storage would be dependent on the nature of the compost at the time of sampling and specific operating conditions.
- Sources such as the East McKenzie Lift Station would vary with time of day depending on conveyance system and loading.
- The Shepard Biosolids lagoons are mostly frozen between mid-November to mid-April; therefore, odours from the lagoons are reduced. This reduced emission rate from the lagoons was accounted for in the dispersion modelling presented in Section 4.
- Receptor sampling in the area of the complaints to the south and southwest is dependent on prevailing winds. Additional sampling (i.e., enhanced geographically and temporally) would improve the profiling by reducing 'noise' and provide a better statistical correlation between source and receptor. One approach may be to adopt a real-time monitoring network that is able to use sensors located along the fence line of the Shepard Complex, along with an air dispersion model and concurrent meteorology to identify sources when elevated odorous species concentrations are detected at the sensors.

Odour sampling and total Calgary Composting Facility-wide emissions magnitude were similar (within a factor of 2) to previous programs at the Calgary Composting Facility. The biofilter results were somewhat lower, while curing and storage results were somewhat higher.

Odour characterization sampling, which provided the descriptive character of the odours (e.g., fecal, chemical, or earthy), indicated that several identified sources are noticeable at distances downwind, and all likely occasionally contribute to off-property impacts and odour complaints at different times.

Task 3 – Air Dispersion Modelling

The objective of Task 3 was to use the odour emissions measured from the various City-owned sources and a sophisticated air dispersion model to determine the impact from those sources at the residential areas where odour complaints originate.

The air dispersion model CALPUFF (Version 7.2.1) was used to estimate magnitude and frequency of impacts from the sources investigated. The model is recognized by AEPA for "Advanced" modelling and is able to account for the following:

- Better accuracy at low wind speed conditions
- Able to 'remember' odorous air parcels from hour-to-hour
- Uses hourly varying, 3-dimensional wind fields

The locations of the various potential City odorous sources identified and modelled as summarized in this report are shown on Figure 4-1. Those locations are as follows:

- Calgary Composting Facility Biofilter Stacks
- Calgary Composting Facility Curing Building
- Calgary Composting Facility Outdoor Storage Area
- Biosolids Lagoons
- Shepard Landfill Active Face
- East McKenzie Lift Station

The key objectives of the air dispersion modelling were to identify the magnitude of emissions from each of the identified sources; and then to quantify the aerial extent, frequency, and magnitude of impacts, particularly at the residential areas to the south and southwest. The air dispersion modelling showed that mixed odour concentrations in southern and southwestern areas can reach approximately 1 to 6 OU ("effective" 10-minute averages) at the 99.5 percentile, with all sources modelled. An odour concentration of 6 OU is near the threshold of odour perception and recognition under real-world conditions for most people.

The modelled concentrations where all sources are included reach 6 OU only at the areas closest to the Shepard Complex, while the concentrations reach 1 to 2 OU over most of the residential areas immediately to the south and southwest. This indicates that there is not a primary source or sources of odour that reflects the experience of SE area residents. However, based on the modelling, the Biosolids Lagoons appears to be the largest contributor to the total impacts, itself contributing 5 OU or more at the nearest parts of the residential area. The Calgary Composting Facility itself contributes as much as 1 to 2 OU at the nearest residential areas, while the remaining modelled sources do not appear to contribute significantly to that area (i.e., much less than 1 OU). The odour concentration contours maps that illustrate the extent of these contours for each of the sources individually and cumulatively are shown in Appendix D.

Based on information gathered during sampling the modelling shows that the Biosolids Lagoons and Calgary Composting Facility sources are likely impacting the residential area more frequently and with higher intensities than the other modelled sources, based on the odour sampling conducted and modelling assumptions used.

The meteorology associated with highest concentrations occurs during stable, warm conditions, which occur mostly in the evening and overnight, and this agrees with complaint logs. Stable conditions are usually characterized with calm light wind speeds and little turbulence, and they can be associated with periods of reduced visibility.

Odours can persist at locations and shift based on prevailing winds. Therefore, when investigations for odour complaints are received, wind directions from the previous few hours leading up to the time of complaint should be assessed in addition to the hour of the complaint.

Task 4 – Recommended Mitigations and Next Steps

Jacobs analyzed the operational conditions of the key odour sources that may have given rise to elevated odour emissions; subsequently, Jacobs generated suitable mitigation techniques, measures, and restrictions that are primarily focused on the root cause of the odour. This was accomplished through interviews with key operational personnel associated with the Shepard Complex and a site visit conducted April 4 through April 6, 2023.

Jacobs conducted interviews with key operational personnel associated with the Shepard Complex, primarily during the week of March 20, 2023. Prior to conducting interviews, Jacobs produced an interview form to capture responses and so that each interview participant was asked the same or similar questions.

Jacobs representatives visited the site April 4 through April 6, 2023, to review current operations and odour control measures at the site, to evaluate their effectiveness, and to recommend additional odour control measures. The recommendations generated are based on the site-specific characteristics of the key sources, as well as Jacobs' extensive global experience with similar facilities. Mitigation of some sources have several options available, with a wide variety of costs associated with the implementation and operating costs. A short-listing program was completed to identify appropriate mitigation measures. The selection of appropriate mitigations will need to be informed by other activities that are planned and ongoing in The City that could further influence odour generation. Finally, the identification of mitigation techniques should recognize future changes and avoid implementing techniques that could compromise other system modifications.

As the modelling indicates that there are likely several sources of odours generated at the Shepard Complex and that there is not a primary source of odour that reflects the experience of SE area residents, mitigation alternatives were reviewed for each City potential odour source identified.

Jacobs produced a table of recommended mitigations identified by Jacobs, The City, and interview participants, and through the odour study process that is presented in Appendix H. The recommended mitigations were evaluated using a multi-outcome decision analysis (MODA) to evaluate the recommended mitigations against a set of evaluation criteria and outcomes to determine the best mitigations for The City. The MODA considered 14 evaluation criteria evaluated against 3 outcomes and scored 1 through 5 for a total possible score of 70. MODA scoring was established to more heavily weight mitigations that could be implemented promptly to reduce the impact to residents. Results of the MODA are also included in Appendix H.

It is important to note that the number of recommendations pertaining to the Calgary Composting Facility does not indicate that it is a more likely source of odours than any of the other operational activities at the Shepard Complex. Although the modelled odour intensity from the Calgary Composting Facility was lower than the lagoons, given that the Calgary Composting Facility has four operational Source Areas to which recommendations could be applied, it is reasonable that the Calgary Composting Facility has more recommendations pertaining to it. Conversely, the biosolids lagoons are a large operation with fewer operational stages, and potential mitigation measures tended to be very high in operational impact and cost.

Based on the effectiveness and cost evaluation, Jacobs recommends implementation of the highest scoring mitigations, which are summarized in Table ES-3.

Table ES-3. Mitigations Recommended for Implementation Based on Evaluation and Next Steps

Source Area	Mitigations Recommended for Implementation	Next Steps for Implementation
General	The City should establish a process to regularly communicate with residents and other interested parties (i.e., Community Associations or similar) to increase knowledge of existing odour mitigation measures and any future plans/projects to reduce odours. (effective, very low cost)	Determine appropriate interested parties, communication methods and frequency, and discussion topics.
	Install a series of active real-time odour and odour compound monitoring sensors throughout adjacent community and along the Shepard Complex perimeter to gather real-time odour data. (effective, very low cost)	Complete odour modelling and confirm locations and number of monitoring sensors.
Shepard Lagoons	Improve and automate existing misting system. (effective, very low cost)	Determine existing operational parameters and identify areas for improvement.
	Surround lagoons with trees. (effective, low cost)	Determine source and type of trees.
Biosolids Storage Pad	Change operations of pad to increase retention time on pad (greater than 2 weeks laydown). (effective, very low cost)	Determine operational methods that can be implemented to reduce material movement and increase laydown time.
Landfill	Review types of waste allowed to be disposed of at landfill and eliminate odorous waste types where possible. (highly effective, study cost)	Determine high odour waste types currently delivered to the landfill.

Source Area	Mitigations Recommended for Implementation	Next Steps for Implementation
		Identify alternative disposal method/locations that would impact neighbours less. Obtain agreement to dispose of odorous wastes at a location less impactful to neighbours. Educate customers that odorous wastes will no longer be accepted at the landfill.
Composting Facility Outdoor Finished Storage Area	Limit the amount of finished material stored on the pad, and operations when wind is blowing towards residents. (extremely effective, low cost)	Identify a storage limit (i.e., area of the storage pad or volume of material). Determine a timeline for compliance. Review current operational procedures.
Composting Facility – Curing Building	Fix floor aeration issues. (highly effective, low cost)	Obtain a design and cost estimate to address the issues with the curing building aeration floor. Hire a contractor to begin phased implementation of designed floor upgrade.
	Optimize operating conditions within the Curing Building with the goal of producing a more mature and stable product before it is screened and sent to Finished Compost Pad.	Determine optimal pile size and spacing that will allow for more time in the curing building while being sized to the mass bed turner. Obtain a vendor quote for purchasing a larger mass bed turner. Perform an evaluation of labour resources and determine if sufficient people are available to perform operations, maintenance, and housekeeping tasks as required.
Composting Facility – Biofilter	Add stack height or other roof mounted fans to increase dispersion. (highly effective, very low cost)	Perform engineering calculations to determine most effective measure for improving dispersion.
	Performance of biofilter should be evaluated by establishing a rigorous biofilter performance monitoring program, which would include developing a comprehensive set of data and benchmarks against which to evaluate the efficiency and function of the biofilter. (effective, low cost)	Determine evaluation criteria, frequency, and methodology. Investigate chemical levels in the biofilter and leachate storage room by establishing investigation and sampling protocols. Apply results to develop an optimized media replacement schedule.

H_2S Concentrations in Sanitary Sewer Near the Shepard Complex

The City's Water Services group has been monitoring for H_2S at specific points in sanitary sewers near the Shepard Complex since January 2022, and have observed fluctuating concentrations during this time. H_2S in sanitary sewers has the potential to generate odours at surface and impact neighbours. The City will continue to monitor the sanitary collection system in the area and will mandate customers producing waste streams containing H_2S to investigate and mitigate their source.

Composting Facility Expansion

The City is in the process of expanding the composting facility capacity through the addition of a horizontal plug flow anaerobic digestion (HPFAD) system. This expansion was not considered as a mitigation during the project because the expansion is already under way. However, the expansion of the compost facility with the HPFAD system is expected to have several positive effects on managing and reducing odours at the expanded facility.

The HPFAD system is being designed to process 60,000 tonnes of the Green Cart material each year, which is more than half of the current incoming organic material amount and should result in odour reductions. Processing this amount of organic material through the enclosed HPFAD system will provide better odour control. The expansion will allow the compost facility to operate below capacity in the near term and to accommodate the increase in materials that come with a growing community. Odour improvements are expected to be maintained even as incoming organic material amounts increase.

Anaerobic digestion is an effective waste treatment process that helps break down organic matter in an accelerated, oxygen-free, environment. By incorporating a HPFAD system into the compost facility, a larger volume of waste can be processed through an enclosed process that will help control and reduce the amount of organic material that could potentially produce strong odours. This additional stage of organic degradation should result in a more mature and stable product being placed into the subsequent stages of the composting process. Enhanced maturity and stability occur when biological activity in the compost piles is significantly reduced. When this occurs before compost is placed outdoors, it will help to decrease odours.

By combining these factors, the compost facility expansion with a HPFAD system can positively impact odour management. It allows for better usage of composting capacity and better waste treatment; reduces organic decomposition time; provides controlled digestion conditions; implements odour containment measures; and optimizes the facility's overall design, all of which is expected to contribute to a reduction in odours at the expanded facility.

Contents

Appendices

Tables

Figures

Acronyms and Abbreviations

$\mu g/m^3$	microgram(s) per cubic metre
AEPA	Alberta Environment and Protected Areas
BTEX	benzene, toluene, ethylbenzene, and xylenes
CCF	Calgary Composting Facility
The City	The City of Calgary
CRAZ	Calgary Regional Airshed Zone
D/T	dilution to threshold
H_2S	hydrogen sulphide
HPFAD	horizontal plug flow anaerobic digestion
km	kilometre(s)
m	metre(s)
M	million(s)
m^2	square metre(s)
m/s	metre(s) per second
MODA	multi-outcome decision analysis
NE	northeast
NW	northwest
OU	odour unit(s)
OU/s	odour unit(s) per second
SE	southeast
THC	total hydrocarbons
VOC	volatile organic compound
Water	The City of Calgary's Water Services
WRF	Weather Research and Forecasting Model
WRS	The City of Calgary's Waste & Recycling Services

1. Introduction

The City of Calgary (The City) has received a significant increase in complaints regarding odours beginning July 2022 compared to complaints received previously from southeast communities, including New Brighton, Copperfield, McKenzie Towne, Douglasdale, and Douglasglen. A number of interested parties have requested that The City identify and recommend appropriate mitigation for the possible causes of the odour impacts. The City has retained CH2M HILL Canada Limited (Jacobs) to design and implement a comprehensive assessment of potential sources of odours from surrounding areas and recommend potential mitigation measures for City -operated and controlled sources, as appropriate. The investigation focused on the Shepard Complex, which encompasses The City's operations in the area, and includes the Composting Facility, the Biosolids Lagoons, and the Shepard landfill site. This area is bounded approximately by 114 Ave SE to the north, 52 St SE to the west, 130 Ave SE to the south, and an access Road that borders the Shepard Complex to the east. The investigation also included other additional odour sources within approximately 5 kilometres (km) from the Shepard Complex.

While the SE Odour Investigation project did not identify the primary source(s) of odour affecting SE residents, Jacobs has identified and recommended various mitigation opportunities related to City infrastructure that may be contributing to odour in the SE. Jacobs recommendations are detailed in Section 5 of this report.

This report is the final Project Summary Report. It summarizes the relevant assumptions, methodology, sampling and modelling results, conclusions, and recommendations of the project. Project tasks are titled as follows and are presented in the report sections referenced in parentheses:

Task 1 - Review of Background Documents (Section 2)

Task 2 - Ambient Air Monitoring and Source Sampling Program (Section 3)

Task 3 - Air Dispersion Modelling (Section 4)

Task 4 - Identification of Mitigation Measures for Key Odour Sources (Section 5)

2. Task 1 – Review of Background Documents

There are two main City of Calgary business units operating within the Shepard Complex, as follows:

1. Waste & Recycling Services (WRS)
2. Water Services (Water)

As part of Task 1, Jacobs reviewed the background data received from each business unit, which specifically focused on the following areas of investigation:

- Review the data to identify apparent patterns or operational occurrences and circumstances that may have led to the increase in odour emissions and impacts.
- Review and analyze the information on the complaint response forms and event logs to identify possible sources and potential correlations to the operational conditions that were occurring just prior to the complaints.
- If possible, correlate complaints with prevailing winds at the time of the complaint to identify potential odour sources. Analysis included hedonic tone and odour characteristics associated with the complaint to help in the identification and verification of the source.

2.1 Review of Operational Occurrences and Circumstances

Jacobs reviewed background information provided and knowledge of the operational activities that are conducted at the Shepard Complex. This review was done to identify apparent patterns or operational occurrences and circumstances that may have led to the increase in odour emissions. The following list presents operational activities that are likely to increase the probability of an elevated level of odour intensity that may result in impacts to surrounding areas:

- At the Biosolids Lagoons: transfer of biosolids to adjoining cells.
- At the Composting Facility (Compost Storage Pad): turning finished compost windrows, loading trucks with finished compost for off-haul, and loading and hauling other potentially odourous materials to the receiving building or to the active face of the landfill.
- At the landfill: operations at the active face, especially when the active face is closest to the southern perimeter of the Shepard Complex.

2.2 Review of Waste & Recycling Services and Water Services Odour Investigation Forms

2.2.1 311 Odour Complaint Investigation Review

Generally, the odour complaint process for the Shepard Complex occurs as follows:

- Calls are received through 311 (both Water Services and WRS).
- A service request is logged to initiate an investigation regarding the circumstances of the complaint/observation.
- Odour investigation forms are filled with relevant information (both Water Services and WRS).
- Additional details of the complaint are obtained; the circumstances that may have led to the issue and follow-up are provided as necessary.

The WRS Odour Complaint Details forms, contained in the Odour Log document focus on specific complaint events and provides details on various information and operational events around the time of those complaints. Odour Complaint Details from July 2021 to October 2022 were reviewed. The WRS

Odour Complaint Detail forms were reviewed in order to determine the adequacy and completeness of the information being gathered during public odour complaint investigations received by The City. Jacobs notes that when odour reviews are conducted, several locations are visited, the nature and character of the odours detected are noted for each site, and weather details are also noted.

Jacobs identified two potential areas of improvement in the WRS complaints logs:

1. One wind direction is documented. However, if the winds vary over the period of the assessment, the winds directions at each of the locations should be recorded.
2. The WRS forms and summary table in the Odour Log document also indicates whether the review was being conducted in response to a complaint, but the location of the complaint is not shown and it is not clear which of the locations visited correspond to the complaint location. Water Services, however, do provide an address on their complaint log.

2.2.2 Water Services Calgary Regional Airshed Zone Alert Investigations

Jacobs reviewed the Water Services Calgary Regional Airshed Zone (CRAZ) Alert Investigations from 2020 through 2022. The investigations focus on hydrogen sulphide (H_2S) readings from the CRAZ monitor located northwest of the Biosolids Lagoons, which is discussed further in subsequent sections of this report. The Water Services CRAZ Alert Investigation log also includes some information about complaints that may be associated with CRAZ Alerts. When an alert at the CRAZ monitoring station is logged (see the following section for more details on this monitoring station), details such as the measured concentration, wind speed and direction, pumping activities, complaints logged through 311 that may be due to the event, an assessment of concurrent operational details, and conclusions regarding the likelihood of the lagoons contribution to off-property impacts are provided. One area for improvement would be a more detailed description of the odour complaints, and inclusion of the meteorological conditions associated with those complaints as well. The focus of the logs is on the CRAZ H_2S readings and whether the lagoons directly contribute to those readings, but additional focus on the complaints, and likelihood of impacts from the source should be provided.

2.2.3 Waste and Recycling Services Odour Review Forms

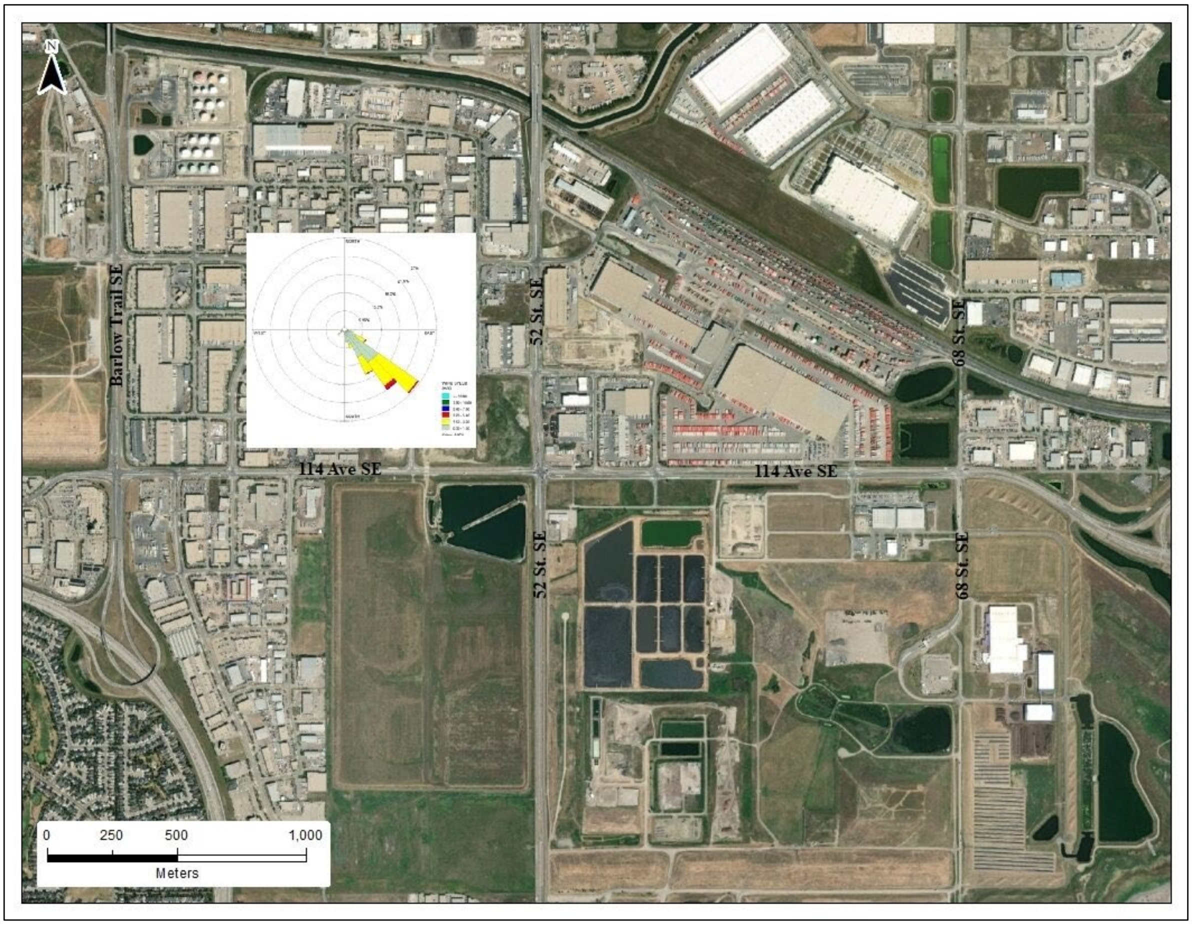
Jacobs also reviewed the Odour Reviews document developed by WRS for investigations conducted from February 2019 to August 2022. These forms summarize odour readings taken periodically by WRS staff, not in response to a 311 complaint, using field olfactometers, to determine which site activities and weather conditions may be leading to higher odours near the Calgary Composting Facility (CCF). These odour reading forms appear to be complete, in that they account for wind speed, direction, odours detected, odour character, and odour strength.

2.3 Review of Calgary Regional Airshed Zone Program Air Quality Data

The CRAZ provides monitoring and meteorological data for the Calgary area that are available for several stations in and near the Calgary metropolitan area. Jacobs reviewed the CRAZ program air quality data to determine its usability in monitoring the area; or if there are opportunities to leverage the work already being done by CRAZ in identifying potential odour issues.

Jacobs reviewed recent H_2S data as measured at the CRAZ southeast (SE) station monitor for the period January 2019 through June 2022. The station is located near the intersection of 46 St. SE and 110 Ave SE as shown in Figure 2-1. The 1-hour concentrations were sorted high to low, and the highest 500 concentration hours were identified. The wind speed and wind directions of these highest concentration hours are shown on a windrose plot inset at the location of the CRAZ monitoring station. It should be noted that the location of the windrose inset is approximately centered on the location of the CRAZ SE station.

Figure 2-1. Wind Rose of Top 500 hours of H_2S Concentrations as measured at the CRAZ SE Monitoring Station



The H_2S concentration range of the top 500 hours was 4.2 to 42.9 parts per billion (ppb). These concentrations likely range from noticeable to nuisance levels for the general population. These data show that the highest H_2S concentrations as measured at the CRAZ SE monitoring station occur when winds are primarily from the southeast, generally downwind of the northwest portion of the Shepard Complex, or additional sources further southeast. Windspeeds are typically light during the highest readings.

These findings agree with a study that was conducted by Alberta Environment and Protected Areas (AEPA) during October 2018 (*October 2018 Focused Study on H2S Exceedances at the Calgary Southeast Station,* Environmental Monitoring and Science Division, AEP, February 12, 2019).

There were no other sources that were identified in the study, although there were some occasions of elevated readings when the winds were not blowing from the direction of the Shepard Complex. These were explained as being either remnants of swirling winds or from additional unidentified source(s).

It should be noted that there are likely other compounds that are causing odour and odour complaints in and around the Shepard Complex besides H_2S. As part of Task 2 of the Scope of Work, Jacobs has taken air samples near many suspected odour sources with the objective of elucidating the chemical nature (i.e., the chemical fingerprint) of the odorous air and identifying which sources are likely the cause of the odours, particularly sources that are inconclusive based on current information.

Recommended Use of Calgary Regional Airshed Zone Monitoring Data

The CRAZ SE monitoring station (CRAZ_SE Data) records numerous air quality parameters such as hydrogen sulphide, nitrogen oxides, ozone, particulate matter, and total hydrocarbons (THC), and meteorological parameters such as wind speed, wind direction, humidity, and temperature. The CRAZ monitoring station does not measure odour or individual components of volatile organic compounds (VOCs) or THC. During periods of temperature inversions, ground level contaminant concentrations (such as ozone and THC) tend to increase due to reduced convective mixing and air dispersion.

The City can further integrate the CRAZ SE monitoring data in two ways for investigative purposes:

1. Monitor CRAZ SE meteorological and air quality data to assist in identifying possible elevated organic compounds (THC) concentrations being emitted from the Shepard Complex. The City should analyze CRAZ SE data as a response to public complaints. The City should analyze the time period before and after complaints and assess whether THC concentrations were elevated and the CRAZ SE monitor was downwind of the Complex. The THC measurements are not a specific indicator of odour *per se* and THC contains many different types of compounds and contributions from the Complex may not be readily discernable over other sources in the area. However, these data may be useful in identifying specific operational occurrences that may be leading to elevated hydrocarbons, and perhaps increased odour.
2. Monitor CRAZ data for elevated concentrations of compounds such as ozone and particulate matter that could be indicative of temperature inversions, which may impact air quality in general and may enhance odour concentrations and complaints specifically. Identifying these inversion episodes could provide useful context as an extenuating circumstance when communicating with the public when odour complaints are received and followed-up.

Review of Available Calgary Regional Airshed Zone Weather and Meteorological Data

Jacobs reviewed the CRAZ meteorological data and compared it with meteorology currently being used for the annual air dispersion modelling conducted by the CCF operator to verify accurate representation of local weather patterns. Meteorological data from the CRAZ monitoring and meteorological station for the years 2019 through June 2022 were compared with the data used for recent air dispersion modelling for the CCF, which were from the prognostic Weather Research and Forecasting Model (WRF) for the years 2002-2006. The comparisons are shown for annual wind roses, that contain all months and seasons, the summer wind roses that contain only data from June through August, and finally the autumn wind roses that show data from September through November. The summer and autumn wind roses were shown for comparison as these are the months where the highest number of public complaints were received, as well as odour emissions from various biogenic and industrial sources in the area.

In general, the agreement was good. For the annual wind roses, the prevailing winds were from the west and southeast. The frequencies of the winds from these main components are comparable. The main difference was a minor component from north-northwest to north-northeast that appears in the CRAZ data approximately 2.5 to 4% of the time for the various wind directions, while for the modelling data they were less frequent at 2 to 3% of the time for each direction. This small difference in wind direction frequency may be important as it may produce a slight underestimation of impacts at the receptors to the south.

Average wind speeds were in good agreement overall, 2.55 metres per second (m/s) for the CRAZ data and 2.37 m/s for the modelling data.

For the summer wind roses, the same general features were noted. Prevailing winds from the west and southeast. However, the northerly component was again somewhat underestimated in the modelling data. Finally, for the autumn wind roses, the modelling data has a very strong component from the west-northwest, approximately 11% of the time. This component was showing to be more disperse in the CRAZ data with a westerly component just less than 8% of the time, and west-northwest and west-southwest components about 6.5% of the time. Again, the winds from the north were somewhat underestimated in the modelling data compared to the CRAZ data but are acceptable.

In summary based on this analysis, Jacobs is of the opinion that the WRF meteorological data used in the annual air dispersion modelling is acceptable. Therefore, for the Task 3 CALPUFF air dispersion modelling, Jacobs will update the WRF meteorological data using the years 2015 to 2019 inclusive obtained from AEPA.

Figure 2-2. Annual Wind Roses

Modelling Met Data

CRAZ Met Data

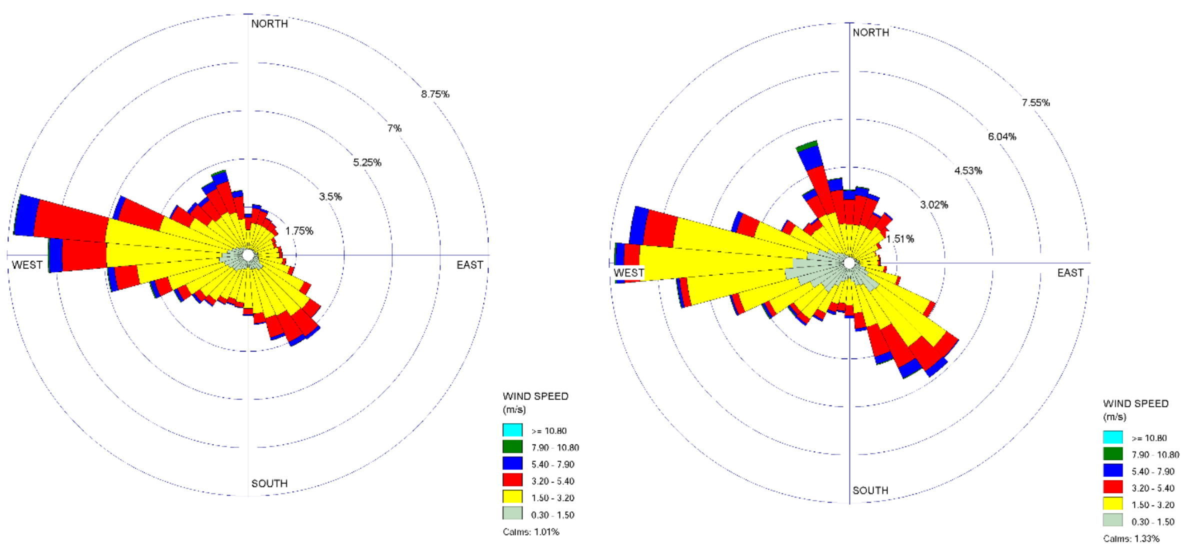


Figure 2-3. Summer Wind Roses

Modelling Met Data

CRAZ Met Data

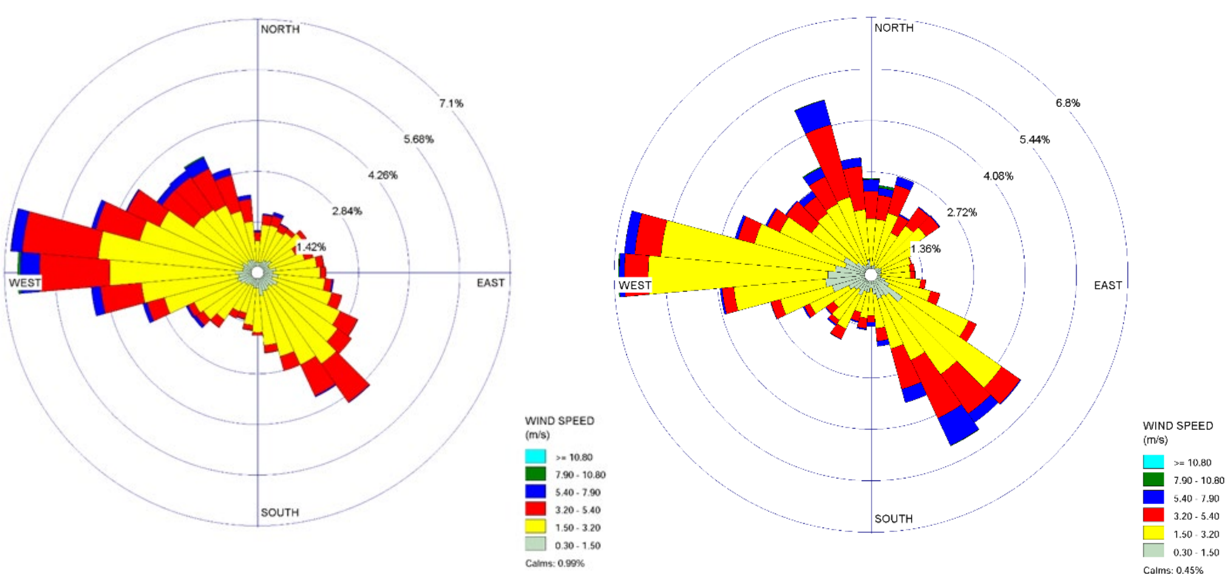
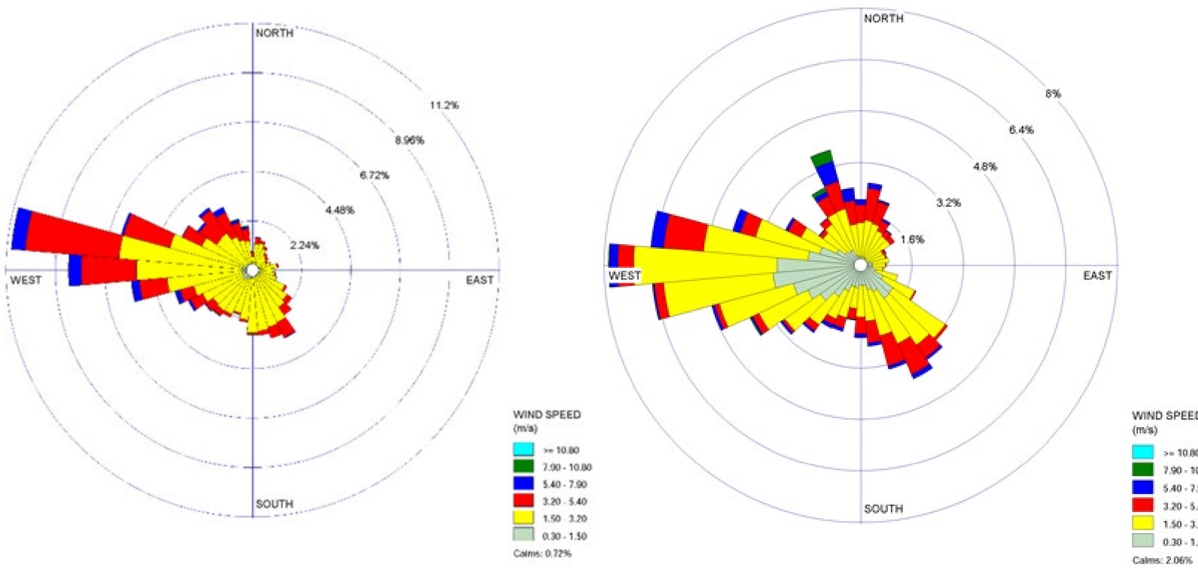


Figure 2-4. Autumn Wind Roses

Modelling Met Data | **CRAZ Met Data**



2.4 Review of Previous Odour Work and Findings

Jacobs reviewed previous odour work and findings to determine whether the results were consistent with onsite observations, and consistent with complaint logs prepared by WS and WRS. Correlating odour complaints with wind directions, and various operational factors affecting odours aided Jacobs in determining the preferred time and circumstances to sample the suspected sites.

Jacobs also reviewed the *Odour Services Requests* document prepared by WRS. The document presents information of the various service requests (as a result of odour complaints) that have been conducted from July to mid-August 2022. The City mapped out several days where numerous complaints were received, which showed the location of the complaints, the prevailing wind direction during the time when the complaints were received, and a summary of the hourly meteorology (including wind direction and speed) before and just after the time of complaints. The complaints were primarily in the New Brighton and Copperfield area to the south and southwest of the Shepard Complex, with occasional complaints in the Prestwick and Douglasdale area to the west and southwest of the Shepard Complex. The document shows that the highest number of complaints occur after approximately 6 pm to midnight.

It should be noted that a review of the CRAZ monitoring data (as discussed in Section 2.4) shows that a greater likelihood of the highest 500 H_2S concentrations also occur at these same times between 6 pm and midnight. Higher levels of H_2S were generally observed overnight and in the evenings, which is likely driven by decreased convective mixing and decreased dispersion conditions. Overnight, stable conditions allow for the accumulation of H_2S. This is consistent with an emissions source located at low altitudes near the ground. However, overnight temperatures are colder, which could decrease emissions from biogenic sources. Another factor in the increase in public complaints is more people are home and occupying outdoors areas (patios and walking trails for example), thereby increasing the likelihood of someone identifying a nuisance odour.

A review of the document shows generally that the Shepard Complex was generally upwind of the service request location at the time of the complaint submission. On some occasions however, the results are inconclusive. Occasionally the winds (as determined from the CCF onsite station) were from the east or even from the southwest and based on these wind directions, the odours may not have been from the Shepard Complex. One representative example of this was observed on August 4, 2022, when two complaints were received in the New Brighton area in the late evening, while winds were from the SW, meaning the Shepard Complex was primarily downwind of the complaint locations. However, earlier in the evening winds were from the N and NW and may have lingered before being identified by the complainants. Other similar examples where source origin is inconclusive were described both in the WRS as well as the Water Services logs.

Jacobs also reviewed WRS' field odour investigation logs, as noted herein. Jacobs noted that investigations took place on relatively low wind days and that investigations were conducted downwind of the Composting Facility. During these investigations a City employee visited pre-determined downwind locations and used a Nasal Ranger (which is a brand of field olfactometer) to quantify the intensity of the odours detected. It was particularly noteworthy that the odours detected and measured were low intensity during these investigations.

Based on the information reviewed, there were only two instances where a noticeable dilution to threshold (D/T) value was recorded using the olfactometer as listed in the following bullet points:

- June 20, 2022 – The investigator noted a noticeable finished compost odour approximately 700 m east of the Curing Building. The investigator recorded a D/T value of 2 in this instance.
- June 22, 2022 – The investigator noted a noticeable biofilter odour approximately 200 m east of the Biofilter Building. The investigator recorded a D/T value of 2 in this instance.

A D/T value is defined as the dilution factor of an odour sample that cannot be distinguished from odourless air by 50% of the members of an odour panel. In other words, a D/T of 2 means that the sampled air would have to be diluted by a factor of 2 to reach a level where 50% of the odour panel would just notice the odour.

2.4.1 Jacobs Field Investigation

The low odour intensity recorded during these investigations is consistent with the odour investigations conducted by Jacobs during a field visit the week of August 29, 2022. Jacobs developed an odour monitoring route that included 16 potential sources and receptors within 5 km of the Shepard Complex, shown on Figure 2-5. On Figure 2-5, yellow icons represent source locations investigated, green icons are receptor locations investigated, and red icons represent locations that were identified as possible preliminary sources but were not measured either due to distance from the investigation area or the sources were not noticeable when in the field and therefore were not further assessed. Odour investigations were conducted in the evenings between 7 pm and 9 pm on August 30th and August 31 and during an odour compliant response with The City on September 1.

A Nasal Ranger – Field Olfactometer was used at locations where odours were detected to measure intensity. The results of Jacob's field investigation showed low intensity odours at all monitoring locations with one exception.

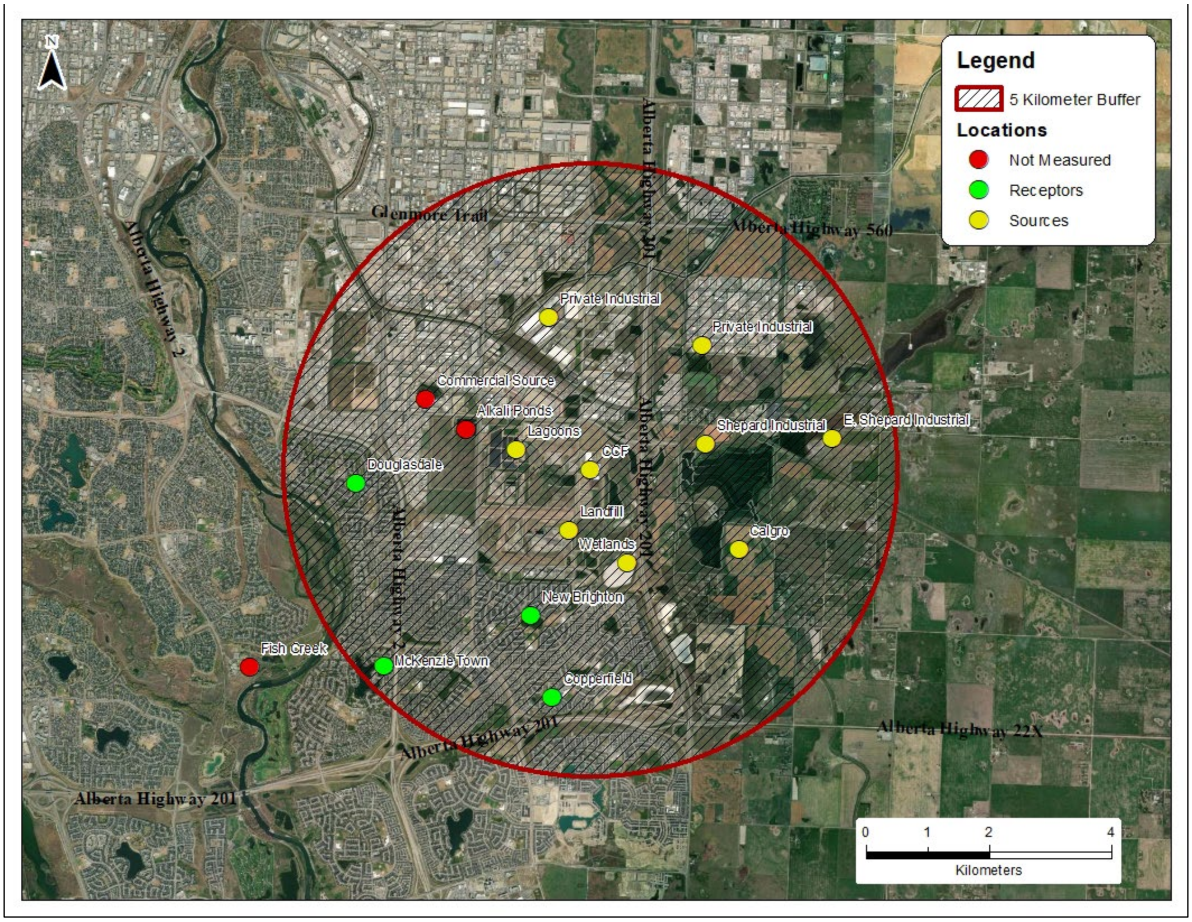
- August 31, 2022 – The investigator detected a very strong biosolids lagoon odour directly west of the Shepard Complex on 52 St SE approximately 0.25 km from the nearest lagoon. A D/T of 7 was detected in this instance.

Other noteworthy odour detections include the following:

- August 30, 2022 – Investigator detected a Composting Facility odour downwind (NE) of the Shepard Complex along 114 Ave SE. Odour was not detectable through the Nasal Ranger (Odour intensity 1 – very weak odour). The odour intensity scale is 0 to 6 and is described below.
- August 31, 2022 – A compost odour was detected downwind at the corner of 114 Ave SE and 52 St SE. Odour was not detectable through the Nasal Ranger. (Odour intensity 2 – weak odour).
- August 31, 2022 – A compost odour was detected further downwind, approximately 4.25 km away, on Barlow Trail SE at the canal crossing. An odour measurement was not taken for safety reasons, but the intensity of the odour was similar to that found at the corner of 114 Ave SE and 52 St SE (Odour intensity 2 weak odour).

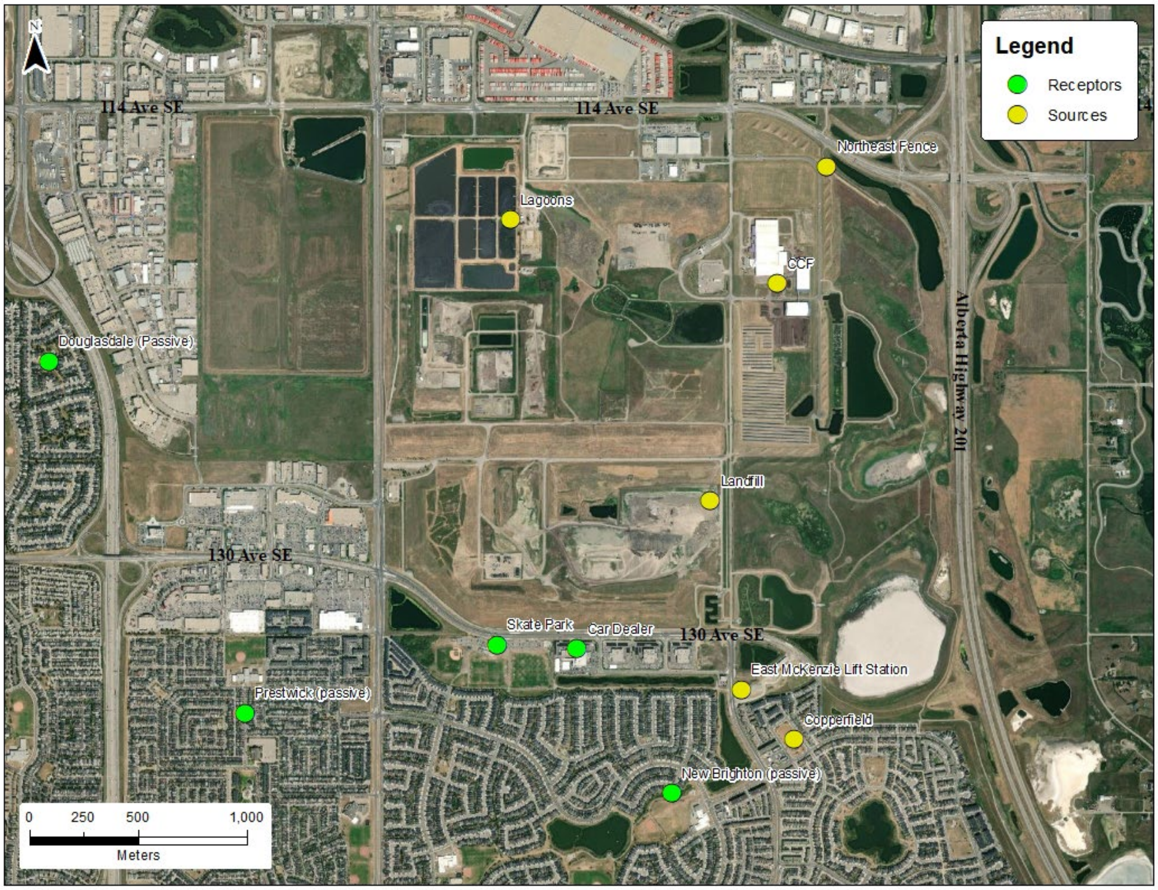
- August 31, 2022 – A biosolids lagoon odour was detected downwind on Barlow Trail SE near the corner of 106 Ave SE. An odour measurement was not taken for safety reasons (Odour intensity 2 weak odour).
- September 1, 2022 – Jacobs accompanied The City on an odour complaint investigation at a residence SW of the site. Upon arrival at the complainant's home no odour was detected (Odour intensity 0 – non-perceptible odour). Investigators walked the trail NE of the complainant's location and identified compost related odours at the baseball fields near the corner of 52 St SE and 130 Ave SE (Odour intensity 1 – very weak odour). Odour was not detectable through the Nasal Ranger.

Figure 2-5. Odour Investigation Location, Week of August 29 to September 2, 2022



Jacobs also performed "fingerprint" sampling at several of the locations on the map presented as Figure 2-6. This is discussed further in Section 3.

Figure 2-6. Week of August 29, 2022, Fingerprint Sampling Map



During the fingerprint sampling, Jacobs detected odours at all of the locations and used the Nasal Ranger to measure odour intensity. When conducting odour investigations during fingerprint sampling, Jacobs staff characterized their findings using the following three descriptors and as noted on Figure 2-7.

- Odour Intensity scale:

  Not Detectable (0), Very Weak (1), Weak (2), Distinct (3), Strong (4), Very Strong (5), Extremely Strong (6)

- Hedonic Tone scale:

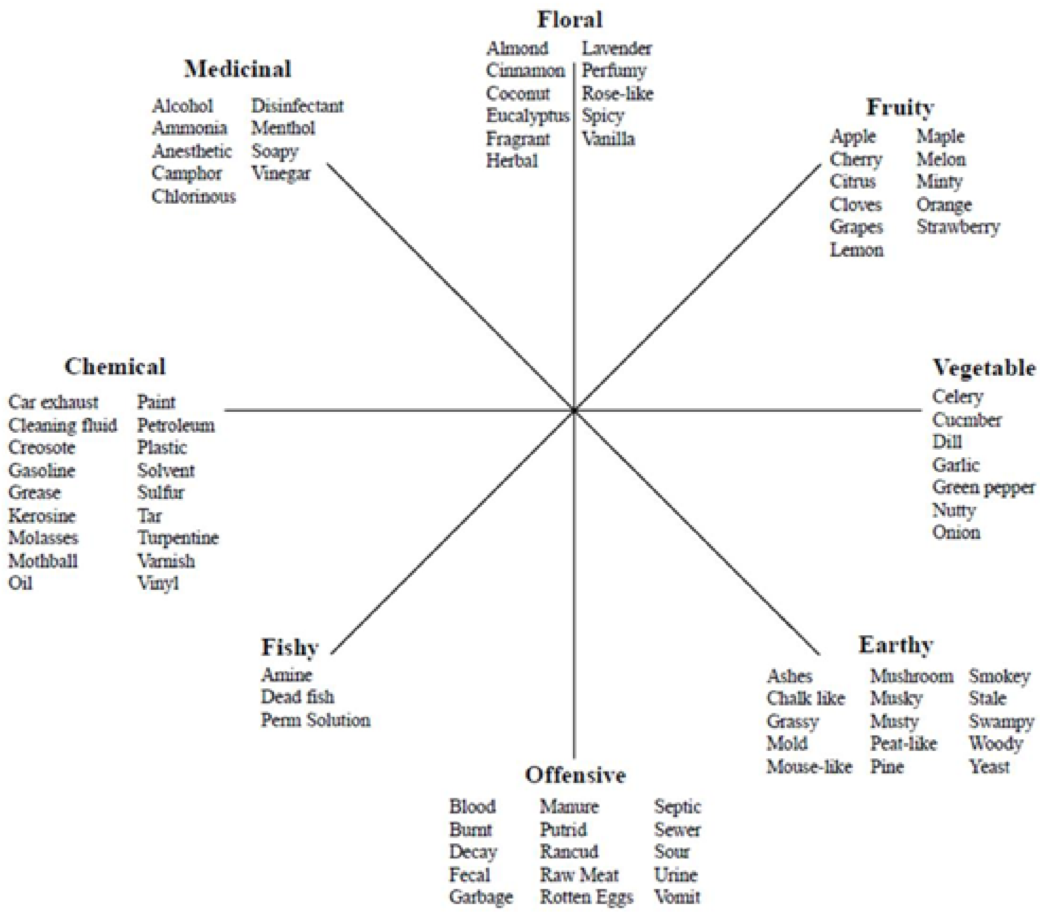
  Pleasant (1), Neutral (0), Unpleasant (-1), Revolting (-2), Nauseating (-3)

- Descriptors:

  See Figure 2-7

A summary of the odour characterization is also provided in Section 3 which discusses the Odour monitoring program results including odour characterization, odour chemical speciation, odour emission flux measurements, and passive sampling.

Figure 2-7. Odour Descriptors



2.5 Identification of Possible Odour Sources

Based on the results of the preliminary investigation and in conjunction with The City's staff, Jacobs identified possible odour sources and prioritized locations for further investigation; these are summarized in Table 2-1. These locations were based on review of the background documentation provided, ambient and source odour investigations, and discussions with The City and Composting Facility staff.

Table 2-1. Summary of Potential Odour Sources and Community Sampling Locations

Location	General Direction from Shepard Complex	Rationale and Comments
Odour Source Locations		
Alkaline Wetlands	S/SE	Intermittent source depending on rain; Identified by Public or Staff, or both
Stormwater ponds along Stoney Trail	SE	Intermittent source depending on rain; Identified by Public or Staff, or both
Biosolids Lagoons	At Shepard Complex	Identified by Public or Staff, or both

Location	General Direction from Shepard Complex	Rationale and Comments
Landfill	At Shepard Complex	Identified by Public or Staff, or both
Industrial source/Food Processing industry	NW	Identified by Public or Staff, or both. Public comment also suggests this is not a significant source
Curing Building	At Shepard Complex	Identified by Public or Staff, or both
Biofilter at Composting Facility	At Shepard Complex	Identified by Public or Staff, or both
Compost storage area	At Shepard Complex	Identified by Public or Staff, or both
Lift Station(s)/conveyance emission points	S	1-2 locations; Identified by Public or Staff, or both
Agricultural Area(s)	E	Identified by Public or Staff, or both
Community Locations		
Skate Park/Ball parks	S	Impacted Community Area
Car Dealerships	S	Impacted Community Area
New Brighton	S	Impacted Community Area
Copperfield	S	Impacted Community Area
Douglasdale or McKenzie Towne area	W or S	1-2 Locations depending on wind direction

3. Task 2 – Ambient Air Monitoring and Source Sampling Program

The objective of Task 2 was to take odour and air samples at and near the emission sources and community receptors identified as part of the Task 1 Scope of Work – Preliminary Investigations. As part of Tasks 1 and 2, the following potential sources within 5 km of the Shepard Complex were identified for sampling:

- The Shepard Complex, which includes the following:
  - Shepard Biosolids Lagoons
  - Shepard Landfill
  - CCF (consisting of curing building, storage area, and biofilter stacks)
- The East McKenzie Lift Station near 130 Ave. SE and McIvor Blvd. SE
- An Industrial source/Food processing industry (September only)

Other candidate locations were identified but were not sampled due to no discernable odours at time of sampling (e.g., wetlands and agricultural areas). Air sampling was done downwind of an Industrial source/food processing facility during the September program only, as there was no discernable odour downwind of that source during the October program.

There were three types of air/odour sampling conducted during the work:

1. Chemical Speciation Sampling, where samples were taken at key odour sources, as well as the residential receptor areas to the south, southwest, and west of the Shepard Complex. The purpose was to correlate specific chemicals emitted at the sources with specific chemical measured at the receptor areas during times of noticeable odour downwind from the Shepard Complex. This included both short-term collections (~1 hour) and longer-term passive sampler collections (~ 2 weeks).
2. Odour Emission Rate Sampling, where odour samples were taken from each of the key sources, to quantify the strength of the odours being emitted and to determine what the odour emission rates were for use within air dispersion modelling.
3. Odour characterization studies, where odour surveys were taken in the vicinity of the Shepard complex, and in the residential areas, to describe the intensity, hedonic tone, and characteristics of the odour. The purpose was to correlate the nature of the odours being emitted form sources, along with odours noted in the residential area, to qualitatively assign the likely origin of the nuisance odours.

3.1 Chemical Speciation Air Sampling Methodology

The purpose of the ambient air monitoring was to determine whether odorous air impacting the community can be traced back to a specific source by determining whether the chemical nature of the odour emissions is unique to one or a few sources. This was done by taking air samples at various locations:

- Source locations as listed herein
- Receptor locations downwind of the sources

The receptor locations concentrated particularly on the residential areas to the south and southwest when odours were noted. The air samples were then analyzed, to identify the chemical composition of the air at that time and at that receptor and identify which, if any, chemical species were unique to a particular source. This process is called "finger printing" of the air samples. Preliminary monitoring investigations focused on the objective of determining which specific chemical(s) were unique to specific source(s), and which of those chemicals, if any, were also found at the residential areas.

Two rounds of chemical speciation investigations took place at identified sources and select receptor areas:

1. August 29 to September 1, 2022 (called the September sampling)
2. October 17 to 26, 2022

The air samples were collected using a variety of methods depending on the requirements for specific groups of chemicals:

3. Evacuated canisters
4. Calibrated pumps with thermal desorption tubes
5. Passive diffusion tubes (discussed further in the following paragraphs)

Photographs of the collection equipment for these methods are shown in Appendix A.

The air samples taken for both the September and October programs were tested for the following. These chemical groups were sampled because, based on experience, they are expected to be odorous compounds associated with and potentially emitted from the identified sources, and are typically sampled during odour investigations at those sources. This group of chemicals was comprehensive, to help verify that specific emitted chemicals were sampled and potentially identified. Table 3-1 provides the chemical groups sampled and a general description of the characteristic odours. The odour associated with each of the chemical groups was not intended to be a comprehensive list of odours for all species in that group, just typical of the group as a whole.

Table 3-1. Characteristic Odours by Chemical Group

Chemical Group	Characteristic Odour
Reduced sulphides and mercaptans	Rotten eggs, rotten cabbage, pungent, sulphur-like.
Ammonia	Pungent, sharp.
Volatile Organic Compound(s)	Various. Can smell like solvents, chemicals, sweet,
Aldehydes and Ketones	Ketones can smell sweet, minty, acetone. Smaller aldehydes can smell sweet and like rotten fruit.
Carboxylic Acids	Various. Formic Acid is pungent, penetrating, Acetic and propionic acids are pungent, vinegar; longer chain acids can smell like rancid butter, oils, or cheese.
Triethylamine (August Sampling Only)	Fishy.

The October sampling also included Odour unit (OU) emission rate sampling at various Shepard Complex sources and the East McKenzie Lift Station. . An OU is the dilution factor at which the sample has a 50% probability of being detected by a trained human assessor. A photo log of the October sampling event is included in Appendix A. Table 3-2 summarizes the sources sampled for chemical speciation. Section 3.2 presents the results of these samples. The "receptor" locations are noted in the Table.

Table 3-2. Summary of Sources Sampled for Chemical Speciation

August/September	October
Compost Curing Building	Compost Curing Building
Compost Storage Pad	Compost Storage Pad
Compost Biofilter	Compost Biofilter
Biosolids Lagoons	Biosolids Lagoons
Compost Storage Building	Compost Storage Building
Landfill	Landfill

August/September	October
East McKenzie Lift Station	East McKenzie Lift Station
Food Processing Facility Industrial source (September only)	Skate Park - Receptor
Skate Park - Receptor	Copperfield (October only) - Receptor
Car Dealership (September only) - Receptor	Shepard Complex NE Fence line (October - downwind location) - Receptor

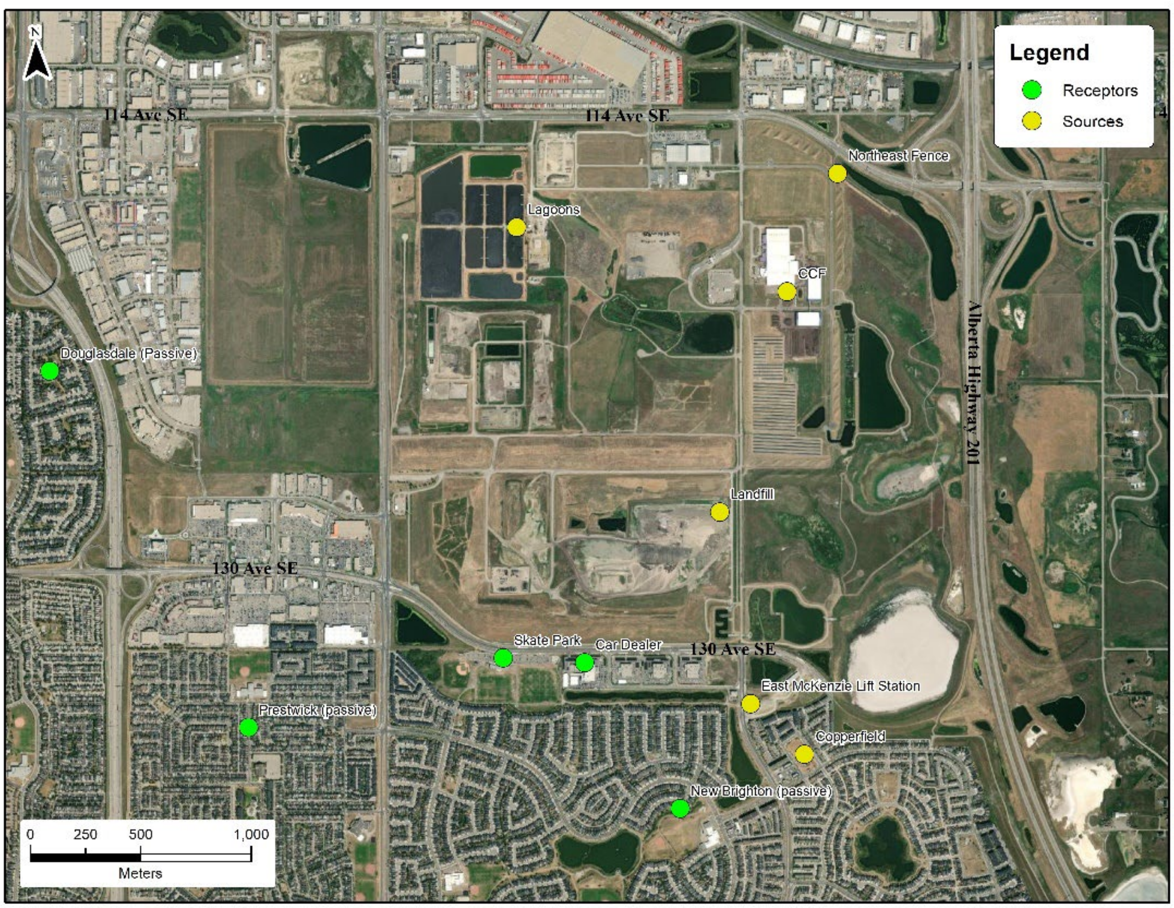
In addition to the air samples discussed, passive diffusion tubes were placed at select locations for a 2-week period from approximately October 19/20 to November 3, 2022. In total, 10 passive samples were placed at the following locations:

- 6 "Source" Locations: Lagoons, Storage, Curing, Lift Station, Biofilter, and Landfill
- 4 "Receptor" Locations: Prestwick St, Douglasdale, New Brighton, and skate park

These samples were tested for various Volatile Organic Compounds. These results are summarized in Section 3.2.

A map of August/September and October Sampling Locations is shown on Figure 3-1.The Industrial food processing site is not shown on the Figure to focus on the sites near the Shepard Complex and to the south. Only the Composting Facility site as a whole is shown in Figure 3-1, but it was comprised of three separate sampling locations: (1) the Biofilter Building and stacks, (2) the curing building and exhaust fans, and (3) the outdoor compost storage area.

Figure 3-1. Sampling Locations



3.2 Chemical Speciation Sampling Results

Table 3-3 summarizes the air concentration results of the various air constituents tested as described previously. The results show that the air constituent concentrations were below ambient air quality criteria and applicable health and safety standards. Several air compounds at the locations were less than laboratory method detection limits and were excluded from the tables. The full list of compounds tested is included in Appendix B. Less than detectable results are shown as blanks.

In Table 3-3 (September Results), the two right-most columns are results from samples taken from the skate park and the car dealership ("Receptor" locations), both of which are south of the Shepard Complex and are representative of potential odour impacts at the residences to the south. The winds were blowing primarily towards those stations when the samples were taken. All other columns in the Table are "Source" locations. The table shows that for the highest concentrations identified at the receptor locations, there are similar concentration for many of the source locations, indicating that most of the sources are contributing to the receptors, or the measured concentrations are near "background" levels, or both.

In Table 3-4 (October Results), the three receptor locations are the skate park, Copperfield, and Shepard Complex NE fenceline, and the results were sorted in a similar manner to that described for Table 3-3. Like Table 3-3, many of the compounds measured at greater than detection at the source locations also have more than one detection at the source locations. For H_2S at the Copperfield locations, there is a likely contribution(s) from the lift station or the biofilter, or both. Both sources were upwind of the Copperfield sampling location for at least part of the measurement period.

For the following tables, the results were sorted with the highest concentrations of compounds identified at the "Receptor" locations first to identify whether there was a clear correlation with those compounds and what is emitted from the source locations. After the highest concentrations at the receptor location were listed, the remaining significant compounds identified at the source locations were listed as well.

Odour thresholds for individual compounds are presented within the following tables (Table 3-3 through Table 3-5) for information purposes. It should be noted that, in reality, aggregate mixtures of various compounds may result in non-linear odour detection thresholds. This means that the odour Detection Threshold for a sample of air containing two or more odorous species may not be a simple linear function of the concentration/composition of each of the individual species. All results are provided in microgram(s) per cubic metre ($\mu g/m^3$).

Table 3-3. Summary of September Air Sampling Results

	Odour Threshold	Lagoons	Landfill	Storage	Curing	BioFilter	Industrial source/Food Processing	McKenzie Lift	Skate Park	Car Dealer
Acetic acid	2500	890	280	880	930		1700	390	670	550
Hexanal	100	5.9	6.9	7.7	7.8		8.1	6.5	7.9	7.1
Acetone	47500	9.0	12.0	21.0	47.0	83.0	15.0	5.5	11.0	14.0
Formaldehyde	600	4.9	4.8	5.4	6.3	18.0	5.2	4.0	4.8	4.8
Acetaldehyde	300	3.2	3.8	6.5	7.9	18.0	3.9	3.0	5.8	5.3
Benzaldehyde	180	2.9	4.7	2.8	3.1		5.2	2.9	4.5	5.9
Valeraldehyde	150	2.4	3.9	2.5	3.2		3.4	2.1	3.4	1.9
Butyraldehyde	26000	2.0	2.0	4.1	12.0	85.0	2.3	1.5	2.3	2.2
Chloromethane	500	0.91	0.89	0.68	1.16	3.72	0.87	0.87	0.87	0.89
Propylene	10000		0.36	3.27	10.3	28.4	1.41	0.67	0.62	0.53
Toluene	11000		0.49		0.53	3.81	1.58		1.17	0.41
Ethanol	19000	2.1	4.3	6.2	18.6	43.5	2.4		3.6	
Methyl ethyl ketone [MEK]	700	0.80	0.62	5.31	19.9	97.0	1.09		0.80	
Benzene, toluene, ethylbenzene, and xylenes (BTEX)						9.2	6.8			
Ethylbenzene	10000					0.87	0.87			
Ammonia	30	224		246	790	559				
Butyric acid	1			120	89					
Propionaldehyde	2700		3.7	2.1	4.3					
Total Reduced Sulphur	1					54				
Dimethyl sulphide	2.5					52				
Isovaleraldehyde	-					26.0				
Dimethyl disulphide	0.1					22.7				
Carbonyl sulphide	135					14				

	Odour Threshold	Lagoons	Landfill	Storage	Curing	BioFilter	Industrial source/Food Processing	McKenzie Lift	Skate Park	Car Dealer
Acrolein	39					12.0				
Carbon disulphide	24					7.2				
Hydrogen sulphide	1					6.1				

Notes:

Odour Threshold (or Odour Detection Threshold) refers to the theoretical minimum concentration of Odour stimulus necessary for detection by 50% of the population (US EPA, Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendments, 1990. March 1992)

Skate Park and Car dealer locations are representative of residential areas to the south and southwest. Winds were blowing towards the locations during sampling. The remaining columns are all “source” locations.

All results are provided in µg/m^3.

Table 3-4. Summary of October Air Sampling Results

	Odour Threshold	Lagoons	Landfill	Storage	Curing	Biofilter	McKenzie Lift	Skate Park	Copperfield	Shepard Complex NE Fence Line
Acetone	47500	2	11	7.6	34	67		9.9	4.3	12
Hydrogen sulphide	1					37	75		15.5	
Hexanal	100		8	4.1	1.9	1.7		1.6	2.9	3.5
Methyl ethyl ketone	700		1.36	6.10	9.85	12.1	1.36	2.36	0.88	0.82
Ethanol	19000		8.5	31.6	32.8	11.7	34.7	19.4	5.6	6.0
Acetaldehyde	300		5.6	3.4	5.9	11	1.7	9.8	1.4	9.5
Toluene	11000	1.73	0.90	0.64	2.56	3.81	2.07	3.62	1.96	0.72
Formaldehyde	600		6.2	3.6	1.5	3.3	2.4	11	2.3	5.4
Propionaldehyde	2400			1.5	2.4	2.1		1	1.4	2.2
Benzaldehyde	100		4.2	2	1	1.3		5.4	1.7	2.6
Valeraldehyde	150		3.4	2.2				8.4	1.2	2.2
BTEX, total	-				5.4	9.3	5.8	3.6		
Limonene	2800					235				

	Odour Threshold	Lagoons	Landfill	Storage	Curing	Biofilter	McKenzie Lift	Skate Park	Copperfield	Shepard Complex NE Fence Line
Ammonia (as NH_3)	30	512		174	1060	117	88.1			
Dimethyl sulphide	2.5					36				
Propylene	10000				5.20	23.7				
Carbonyl sulphide	135					14				
Dimethyl disulphide	0.1					11.9				
Carbon disulphide	24					10.9				
Xylenes, total	2700				1.7	3.7	3.0			
Methyl isobutyl ketone	410					1.3				
Acetic acid	2500		300	760	480					
Butyric acid	1			260	92					
Propionic acid	84			51	23					

Notes:

Odour Threshold (or Odour Detection Threshold) refers to the theoretical minimum concentration of Odour stimulus necessary for detection 50% of the population (US EPA, *Reference Guide to Odor Thresholds for Hazardous Air Pollutants Listed in the Clean Air Act Amendments*, 1990. March 1992)

Skate Park, Copperfield, and Shepard Complex NE Fence line locations are representative of receptor locations. Winds were blowing towards the locations during at least part of the sampling but may have shifted somewhat during collection. The remaining columns are all "source" locations.

All results are provided in $\mu g/m^3$.

3.2.1 Results of Passive Monitoring (VOCs)

Table 3-5 summarizes the VOC concentration results from the passive diffusion sampling collected over a period of two weeks. These values represent the average concentration of each of the compounds over the two week collection period. Compounds that were less than laboratory detection limits were excluded from the table; however, the full suite of tested compounds are provided in Appendix B. Blanks in Table 3-5 constitute values that were less than the lab detection limit.

The receptor locations are the skate park, Prestwick St, Douglasdale, and New Brighton, while the remaining locations are “source” locations. The only VOCs which were lab detected at the receptor locations were toluene at all four locations and xylenes at the skate park only. All of these were very low in concentration and most were detected at the source locations as well. Similar to the results discussed previously, there is no clear correlation between source and community/receptor profiles as the toluene concentrations are near background levels. All VOCs identified were less than odour thresholds.

Table 3-5. Summary of October Diffusion Tube Passive Air Sampler Results

	ODOUR THRESHOLD	LAGOONS	LANDFILL	STORAGE	CURING	BIOFILTER	SKATE PARK	LIFT STATION	PRESTWICK STREET	DOUGLASDALE	NEW BRIGHTON
Allyl chloride	3100		14.0	1.43				1.40			
Butadiene, 1,3-	3500					0.387					
Dichlorobenzene, 1,4-	1100					0.862					
Ethylbenzene	2300		1.57			0.456					
Toluene	11000	1.43	7.18	1.20	1.41	3.03	1.42	1.74	1.31	1.26	1.34
Xylenes, total	2700	1.16	7.89		0.974	1.68	1.62	1.75			

Notes:

"Receptor" locations are Skate Park, Prestwick, Douglasdale, and New Brighton. The remainder are "Source" locations.

All results are provided in $\mu g/m^3$.

3.3 Odour Emission Rate Sampling Methodology

Additional odour source sampling was conducted during the period October 17 to 26 at the following locations:

- CCF (biofilter, curing, and storage)
- Biosolids Lagoons
- Shepard Landfill
- East McKenzie Lift Station

Odour sampling involves collecting small quantities of air being emitted from a source (a stack or a surface), and having an accredited lab quantify the intensity of the odours within the sample. The quantification of odours is not specific to any one odorous compound but is a measure of the collective and cumulative odour of the entire sample. This quantification was done by a panel of testers, each of whom were provided increasingly undiluted aliquots of the sample air, until they were able to detect an odour, but not necessarily recognize the nature of the odour. This level of dilution of the sampled air is known as the D/T or otherwise known as an OU, which is dimensionless but often reported as OU/m^3.

The purpose of the sampling was to determine the rate of odour emissions from each of the sources. This involves determining the odour strength of each of the samples, as well as the flux or flow of the odorous air from each of the sources, both liquid or solids surfaces, or within the emission stacks. These odour emission rates were determined such that air dispersion modelling could be conducted for each of the sources, to gain insight into the aerial extent and magnitude on impacts at offsite receptors. The air modelling component of the Project is further discussed as Task 3 which is in Section 4 of the report.

The determination of surface emissions was conducted using a flux chamber at the Biosolids Lagoons, landfill active face, and compost storage areas. The surfaces at the landfill and at the compost storage areas were newly disturbed where possible to provide a higher level of odour emissions compared to undisturbed surface. Measurements at the lagoon were taken from quiescent surfaces. At the compost storage areas, pile temperatures were used to guide the choice of specific sampling locations. Measurements of exhaust flow rates and exit temperatures were also done at point sources (such as the biofilter stacks, curing fans, and the East McKenzie Lift Station exhaust) to facilitate air dispersion modelling.

3.4 Odour Emission Rate Sampling Results

3.4.1 Comparison of October 2022 Odour Results and Previous 2021 Results

Table 3-6 summarizes the odour unit emission rates measured during the October 2022 sampling program, with a comparison to those measured in 2021. The odour sampling conducted in 2021 (and years earlier) was to quantify that odour releases and impacts in the vicinity of the CCF are within contractually specified criteria. These measurement programs and supporting air dispersion modelling are conducted by a third-party and are only conducted at the CCF sources. The comparison to odour emission rates used in 2021 are provided for information and comparison purposes. Significant sources outside the CCF sources were not previously modelled. The most significant of the odour sources are the CCF sources and the biosolids lagoons. It should be noted that the odour emission rates listed in Table 3-6 are representative of the conditions that were occurring during the sampling and there is some seasonal and diurnal variability expected for all sources listed.

These results are for mixed odours where samples are taken from the sources listed herein and likely contain several different odorous chemicals within the samples. All odour samples were evaluated within 24 hours of sampling at Pinchin's Odour Laboratory using a triangular forced-choice, dynamic dilution olfactometer and a panel of eight trained assessors. The laboratory and operating procedures meet the requirements of ASTM Standard E679-04. The olfactometer complies with the CEN EN13725:2003

The assessors were selected and trained in general accordance with ASTM Publication 758 and screened in accordance with the CEN EN13725:2003.

Table 3-6. Comparison of Odour Emission Rates Measured during October 2022 Program with Those Measured in 2021

Source	October 2022 Emission Rates (OU/s)	2021 Odour Emission Rates (OU/s)
Curing Fans	33,435	19,046
Biofilter Stacks	79,723	183,248
Storage Piles indoor	3,080	552
Storage Piles outdoor	6,360	NA
Lift station	1,533	NA
Lagoons	~12,000-276,000	NA
Landfill	2,650	NA

Notes:

Measured lagoon emissions are for quiescent conditions
Emissions determined by averaging individual samples.

For 2021 modelling, eight piles were assumed with 873 square metres (m^2) of total surface area and total emissions of 552 OU/s from an assumed volume source.

OU/s = odour unit(s) per second

3.5 Community and Source Odour Sampling and Characterization

Jacobs conducted offsite odour surveys during the week of August 29, 2022, and during the week of October 17, 2022. Olfactometer observations were taken downwind of several identified sources to characterize the characteristics, hedonic tone, and intensity of the odours. Observations were also taken in residential areas when these locations were downwind of the Shepard Complex. Jacobs detected odours at all the locations and used the Nasal Ranger (September) or Scentroid (October) to measure odour intensity and character. Both the Nasal Ranger and the Scentroid are handheld portable olfactometer instruments that are designed to take and to quantify the intensity of odour air samples immediately by the operator in the field.

In August/September, observations were made at seven sources and two community receptors downwind of the Shepard Complex as listed in Table 3-7. The data presented in the table provides the character and intensity of the odours detected during sampling. The results of the odour survey are summarized in Table 3-8. Actual D/T values are not presented in Table 3-7, as the D/T values were not quantifiable using the field olfactometer; only hedonic tone, descriptors, and intensities are summarized. Odour intensity is shown on a scale of 0 to 6 where 0 is not perceptible and 6 is an extremely strong odour.

Table 3-7. Odour Characterization During September Olfactometry Sampling

	Source Name	Date	Wind Direction	Intensity	Hedonic Tone	Descriptor
1	Shepard Lagoons	August 31	WSW	4	-1	Fecal/Putrid/Septic/Sewer/Urine
2	Shepard Landfill	August 31	WSW	1	0	Decay/Garbage
3	Compost Storage	August 31	WSW	2	0	Earthy/Sour/Fruity

	Source Name	Date	Wind Direction	Intensity	Hedonic Tone	Descriptor
4	Curing Building	August 31	WSW	5	-1	Earthy/Fishy/Sour/Putrid
5	Biofilter Building	August 31	WSW	6	-1	Earthy/Acidic
6	Industrial Food Processing	September 1	NNE	3	-1	Putrid/Rancid/Sour/Raw Meat
7	Skate Park	September 1	NNE	3	-1	Decay/Garbage/Earthy/Sour/Fruity
8	McKenzie Towne Lift Station	September 1	NNE	5	-2	Septic/Fecal/Sewer/Urine
9	Car Dealerships	September 1	NNE	3	-1	Earthy/Sour/Fruity

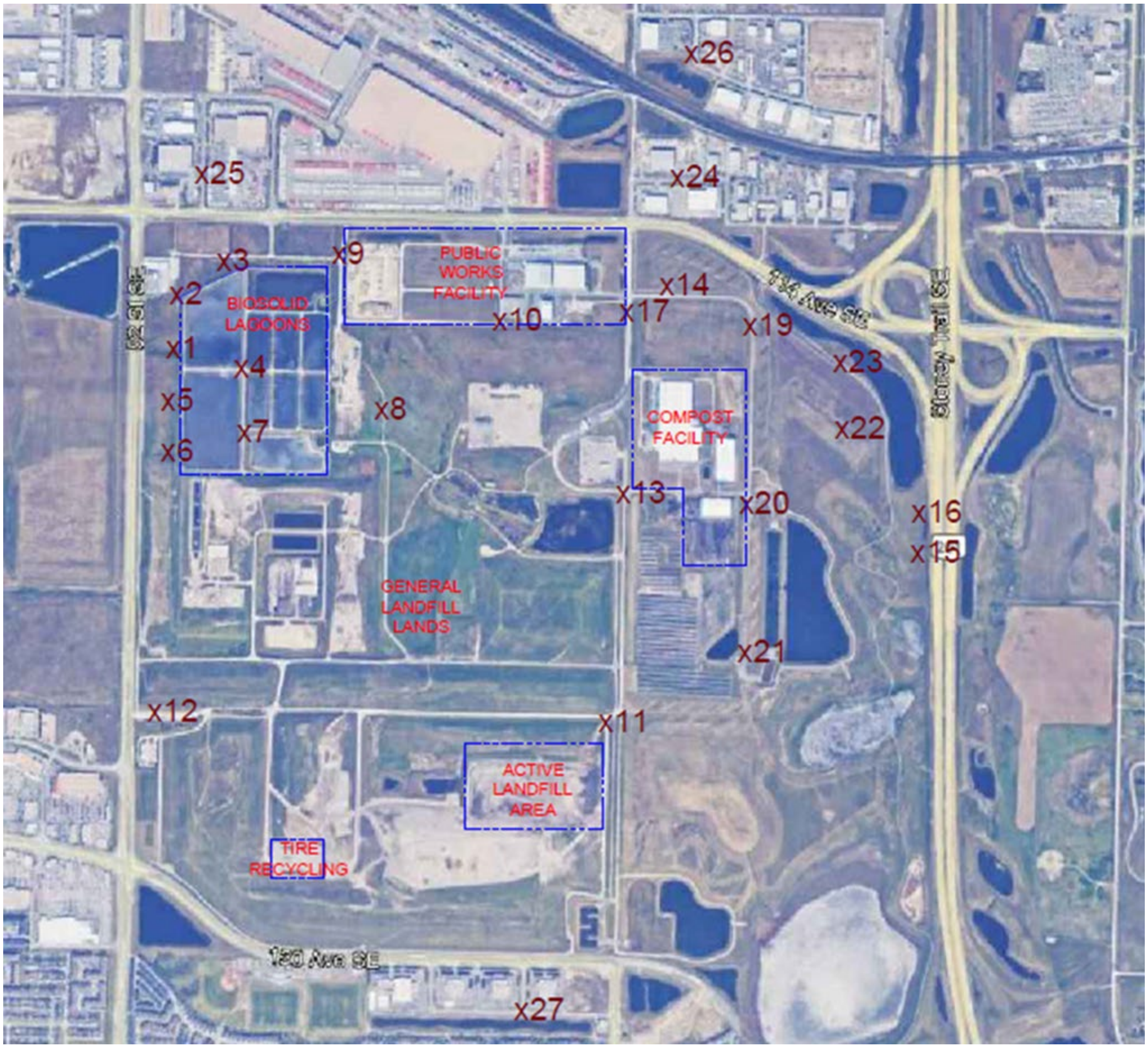
In October, additional odour characterization observations were taken, and based on the 27 measurements, there were four common descriptors used similar to what would be expected of the activities occurring throughout the Shepard Complex. October odour survey results are presented on Table 3-8. The odour strength listed for each location were determined using a field olfactometer. Observation locations are shown on Figure 3-2.

Table 3-8. October Odour Survey Results Summary

Location	Sample Location	Date	Wind Direction	Odour Strength (OU)	Hedonic Tone	Descriptor
1	Lagoon W	17-Oct	W	2	0	N/A
2	Lagoon NW	17-Oct	W	2	0	N/A
3	Lagoon NW	17-Oct	W	13	-1	biosolids
4	Lagoon Centre	17-Oct	W	7	-1	biosolids
5	Lagoon W	17-Oct	W	2	0	N/A
6	Lagoon SW	17-Oct	W	3	0	grassy
7	Lagoon Centre	17-Oct	SW	3	-1	biosolids
8	Lagoon E	17-Oct	SW	3	0	aggregate odour
9	Lagoon NE	17-Oct	SW	3	0	earthy
10	Public Works Bldg. SW	17-Oct	SW	3	0	grassy, vegetation
11	Landfill NE	17-Oct	SW	9	-1	garbage
12	E Side of 52 ST SE, 450 m N of 130 Ave SE	17-Oct	SW	2	0	N/A
13	NW Corner of Storage Area	17-Oct	SW	60	-3	garbage
14	North of Composting Facility	17-Oct	SW	9	-1	garbage, compost
15	W side of Stoney Trail, 600 m east of Storage Bldg.	18-Oct	NW	6	-1	compost
16	W side of Stoney Trail, 600 m east of Storage Bldg.	18-Oct	NW	3	-1	earthy, damp wood

Location	Sample Location	Date	Wind Direction	Odour Strength (OU)	Hedonic Tone	Descriptor
17	W side of 68 St SE 260 m NNE of biofilter Bldg.	19-Oct	W	3	-1	biosolids
18	N of biofilter	19-Oct	W	3	0	earthy
19	NE of biofilter	19-Oct	W	5	-1	compost
20	E of storage Bldg.	19-Oct	W	7	-1	compost
21	SE of storage Bldg.	19-Oct	W	2	0	N/A
22	300 m E of Curing Bldg.	19-Oct	W	5	-1	compost
23	300 m NE of Curing	19-Oct	W	3	-1	compost
24	112 Ave SE	19-Oct	W	4	-1	compost
25	54 St SE	19-Oct	SW	5	-1	biosolids
26	70 St SE	19-Oct	SW	4	-1	compost
27	S of Car dealerships	25-Oct	NW	3	-1	garbage

Figure 3-2. Locations for October Odour Survey



3.6 Investigation Summary

Based on the investigations described, the following locations and activities are the most likely source(s) of odours impacting the neighbourhoods to the south and southwest:

- Shephard Landfill active tip face
- Biosolids lagoons
- Composting facility biofilter
- Composting Facility Curing Building
- Composting facility outdoor finished storage pad
- McKenzie Towne Lift Station

The locations are not listed in any order or 'ranking.' Additional sources may impact residences but are likely intermittent based on observations (e.g., industrial facilities, wetlands, or agricultural areas) and are likely not leading to widespread complaints, which was the focus of these studies. However, further study may be necessary to better characterize the possibility of short-term excursions of odour from these "other" sources that were not identified or captured during the sampling programs.

Preliminary chemical speciation sampling results are inconclusive. The results of the sampling at the select residential receptor locations identified showed no 'profiles' that clearly identify the preponderance and impacts from any one or two compounds from the sources. For example, the September results show several aldehydes and other VOCs such as chloromethane and propylene at the receptor locations. However, many of these same compounds were also detected at the source locations but many with concentrations comparable to those found at the receptor locations. Since the measurements were conducted in close proximity to the emission sources, it is expected that specific chemical compound concentrations would be higher at the sources, and somewhat diluted at the receptors. However, they are similar in magnitude meaning that they are likely at or near "background" levels at all locations. For the October results the conclusions are similar, with several VOCs being measured greater than detection at the receptors, but similar magnitude of concentrations at the sources. The H_2S emitted from the lift station and, to a lesser extent, the biofilter is likely impacting the Copperfield results, as those sources were directly upwind of that receptor.

The inconclusive nature of the results may be partially due to the limited number of samples taken, which are susceptible to significant variability such as the following:

- The results are reflective of a 'snapshot' of the emissions at the time of sampling.
- Some sources (e.g., landfill) are likely highly variable and dependent on the garbage content and characteristics.
- Sources such as curing, biofilter, and storage would be dependent on the nature of the compost at the time of sampling and specific operating conditions.
- Sources such as the East McKenzie Lift Station would vary with time of day depending on conveyance loading.
- Receptor sampling in the area of the complaints to the south and southwest was dependent on prevailing winds. Additional sampling (i.e., both geographically and temporally) would improve the profiling by reducing 'noise' and provide a better statistical correlation between source and receptor. One approach may be to adopt a real-time monitoring network that is able to use sensors located along the fence line of the Shepard Complex, along with an air dispersion model and concurrent meteorology to identify sources when elevated odorous species concentrations are detected at the sensors.

Efforts were made to refine sampling and analysis techniques in October campaign, but some odorous compounds may be emitted at concentrations less than laboratory detection limits (typically approximately 0.1 part per billion [ppb] to approximately 10 ppb) but can still be perceived by and be offensive to human receptors. The sources are likely variable due to temperature effects, changes in operations, changes in materials processed, and other factors.

Odour sampling and emissions magnitude were similar to previous programs at the CCF: the biofilter results were somewhat lower, while curing and storage results were somewhat higher. The methodology of sample collection in previous years at the CCF were similar to this study.

Odour characterization sampling, which provided the descriptive character of the odours (such as fecal, chemical, or earthy) indicated that several identified sources are noticeable at distances downwind, and all likely occasionally contribute to off-property impacts and odour complaints at different times.

4. Task 3 – Air Dispersion Modelling of Significant Odour Sources

The objective of Task 3 was to use the odour emissions measured from the various City-owned sources and a sophisticated air dispersion model to determine the impact from those sources at the residential areas where most of the odour complaints originate.

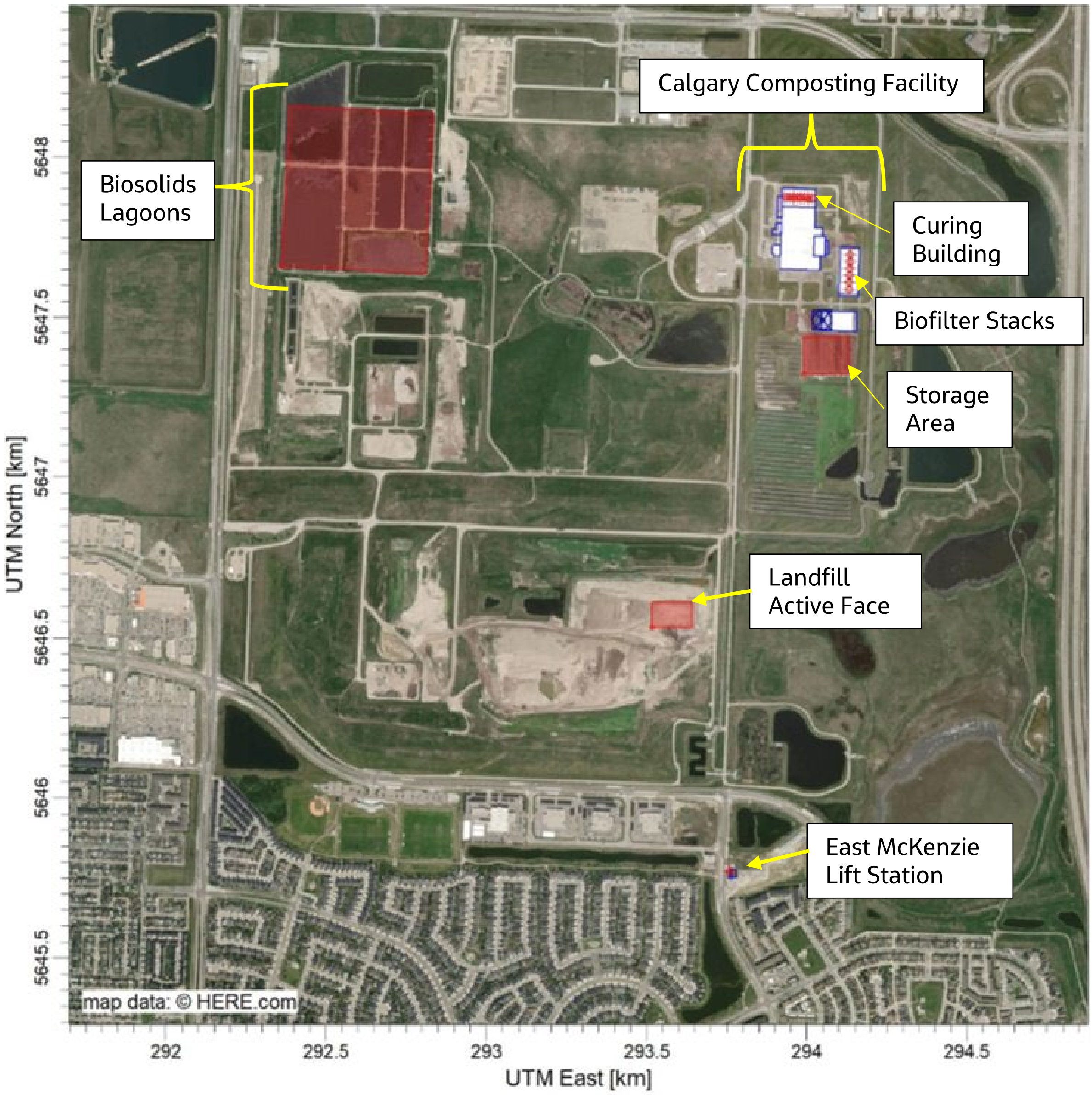
4.1 Air Modelling Methodology

The air dispersion model CALPUFF (Version 7.2.1) was used to estimate magnitude and frequency of potential impacts from the sources investigated. CALPUFF is a multi-layer non-steady state puff dispersion model that can simulate the effects of time- and space-varying meteorological conditions. The model is recognized by AEPA for "Advanced" modelling and is able to account for the following:

- Better accuracy at low wind speed conditions
- Able to 'remember' odorous air parcels hour-to-hour
- Uses hourly-varying 3-dimensional wind fields

The locations of The City's various potential odorous sources identified and modelled as summarized in this report are shown on Figure 4-1.

Figure 4-1. Locations of Modelled Sources



4.2 Meteorology

The meteorology used to drive the dispersion from the source emissions was taken from the Weather Research and Forecasting (WRF) model. WRF is an advanced mesoscale numerical weather prediction system, and the data were made available through AEPA for the 5-year period 2015 through 2019.

The WRF data were processed with version 6.5 of CALMET, the meteorological pre-processor of the CALPUFF modelling system. The processor used the WRF data as a 'first-guess' field and augments the wind field by making small adjustments based on micro-scale terrain and land use effects. Terrain data were incorporated into the model using 1:50K Canadian Digital Elevation Data (at approximately 23-m resolution). No additional surface observations or upper air data were used for the meteorological processing. Summer, winter, and annual wind roses from the processed data are shown in Appendix C.

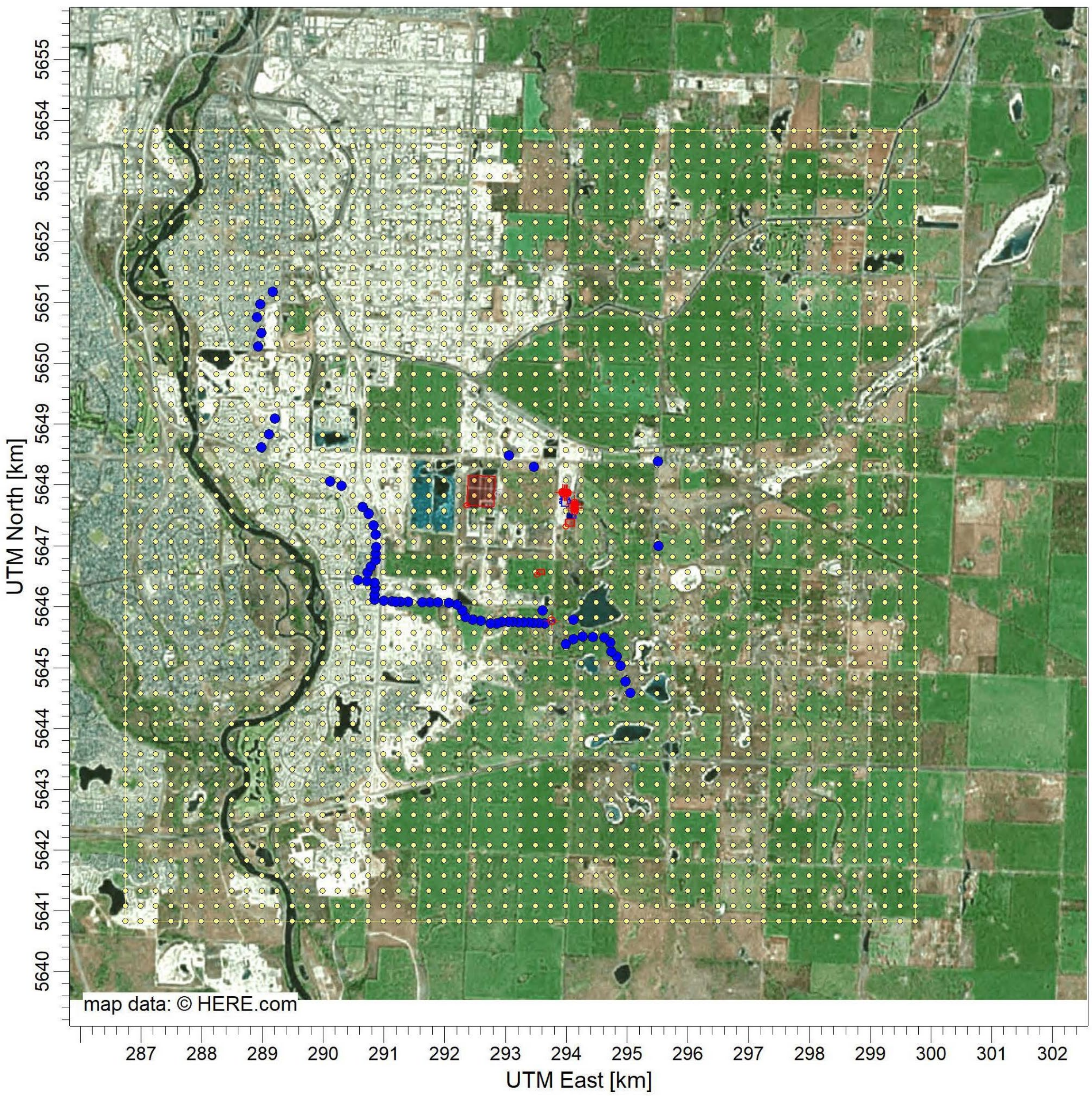
4.3 Receptors

In air dispersion modelling, receptors are locations at which the model calculates, on an hourly basis, the concentration impacts from the emitting sources. Receptors can be divided into two types:

- Gridded receptors – where the receptors are evenly spaced over the entire computational domain or grid (i.e., the entire modelled area of interest).
- Discrete or sensitive receptors – these are locations of special or specific interest, and generally include for odour modelling locations of complaints, residences, and includes locations where the public can congregate. These receptors are used so that the modelling calculations can be conducted at that specific location.

Figure 4-2 shows the extent of the receptors used in the analysis. The yellow dots correspond to gridded receptors spaced 250 metres (m) apart over the entire 13 km by 13 km computational grid. This computational grid was sufficient to encompass the impacted areas and also the residential areas where complaints were known to originate, The blue dots correspond to the near boundary of the various residential areas to the south, southwest, and west of the Shepard Complex. These receptors are meant to represent locations of likely worst-case impacts at the residential areas due to proximity to suspected odour sources.

Figure 4-2. Model Receptors



4.4 Averaging Period

CALPUFF uses 1-hour meteorology to drive dispersion of the odour sources. When using 1-hour meteorology, the model produces a minimum of 1-hour average output. Alberta has no specific guidance on modelling of mixed odour impacts within Alberta Air Modelling Guidelines 2021; therefore, the results from the model were converted to an equivalent "effective" 10-minute average concentration using the equation in s.17 of *O. Reg. 419/05* (in this case $(60/10)^{0.28}$ or 1.65) and as presented in Section 7.1.2 of the *Alberta Air Quality Modelling Guideline* (2021). The 10-minute averaging period has been introduced into this modelling to better align odour-based criteria with the complaint characteristics of people in communities impacted by odour (Ontario Ministry of the Environment 2005). An example of the conversion of an arbitrary modelled 1-hour average concentration of 23 odour units per cubic meter (OU/m^3) to an equivalent maximum 10-minute average concentration is shown in the following calculation:

$$\begin{aligned} \text{OU (10-minute average)} &= \text{OU (1-hour average)} * (60/10)^{0.28} \\ &= 23 * 1.65 \\ &= 38\ \text{OU/m}^3 \end{aligned}$$

This is based on a source that emits an odour with a 10-minute odour-based screening value. In this case, it is considered acceptable if the modelling shows, at a location of a human receptor, the standard or guideline is exceeded less than 0.5% of the time, which corresponds to approximately 44 hours per year (Alberta Air Modelling Guidelines 2021). This means that, for 99.5% of the time in any given year, the 10-minute odour-based screening value will be met. It should be stated that this does not mean that the highest 44 hours per year at any specific receptor will not lead to a public nuisance or complaint; instead, it is meant to represent the increased likelihood of a complaint should there be a high frequency of impacts at any given location.

4.5 Odour Emission Rate Sampling

The odour emission rate sampling method was discussed in the previous Section 3. Additional details of the air sampling program were provided in Section 2.

There is no standard sampling methodology for odours in the Province of Alberta; as such odour sampling was performed in accordance with the Ministry of Environment, Conservation and Parks (MECP) Ontario Source Testing Code, PIBs 1310e03, June 2010, Part G, Method ON-6, “Determination of Odour Emissions from Stationary Sources” (Method ON-6).

4.6 Odour Assessment Background

The following odour mixture concentration thresholds can be useful for odour assessments:

- Odour Detection Threshold (DT) or OU - The dilution factor at which the sample has a 50% probability of being detected by a human assessor. The DT is sometimes referred to as the Odour Threshold Value (OTV) or Odour Unit (OU). At the DT, the odour concentration in the diluted sample is 1 OU/m^3 by definition.
- Odour Recognition Threshold (RT) - The dilution factor at which 50% of the odour panel can assign appropriate characteristics or descriptors to an odour. RTs are typically 3 to 5 times the DT.

The DT and RT are values that may be obtained by an odour laboratory using dynamic olfactometry with an odour panel. For this study, only DTs were obtained from the laboratory for the various sampled sources and used in the modelling. These are typically the values used in odour impact studies.

The results presented herein are for mixed odours where samples were taken from the sources and likely contain several different odorous chemicals within the samples. All odour samples were evaluated within 24 hours of sampling at an accredited Odour Laboratory using a triangular forced-choice, dynamic dilution olfactometer and a panel of eight trained assessors. The laboratory and operating procedures meet the requirements of ASTM International Standard E679-04. The olfactometer complies with the European Committee for Standardization (CEN) EN13725:2003. The assessors were selected and trained in general accordance with ASTM International Publication 758 and screened in accordance with the CEN EN13725:2003.

4.7 Summary of Odour Emission Rates

4.7.1 Composting Facility - Curing Building Fans and Biofilter Stacks

The emissions from the curing building and biofilter stacks were measured on October 25 and 26, 2022. Curing building collection was done at the base of the six fans within the buildings where possible and unless otherwise noted herein. The biofilter samples were collected at all eight of the stack sampling ports just above the roof of the building.

Table 4-1. Summary of Curing Building Fans and Biofilter Stacks Odour Emissions

Source	Odour Concentration (OU/m³)	Volumetric Flow Rate[a] (Rm³/s)	Odour Emission Rate (OU/s)
Curing Building Fan 1	46	37.9 [b]	1,743
Curing Building Fan 2	50	35.1 [c]	1,754
Curing Building Fan 3	162	35.1 [c]	5,668
Curing Building Fan 4	166	35.1 [c]	5,822
Curing Building Fan 5	153	33.4 [b]	5,106
Curing Building Fan 6	393	33.9 [b]	13,342
Biofilter Fan 1	749	29.4 [b]	22,027
Biofilter Fan 2	173	31.4 [b]	5,424
Biofilter Fan 3	288	28.1 [b]	8,101
Biofilter Fan 4	173	32.5 [b]	5,623
Biofilter Fan 5	314	21.6 [b]	6,762
Biofilter Fan 6	288	30.1 [b]	8,672
Biofilter Fan 7	378	28.9 [b]	10,923
Biofilter Fan 8	410	29.8 [b]	12,191

[a] Reference conditions: 77 degrees Fahrenheit, 29.92 in. Hg or 25 degrees Celsius, 101.3 kilopascals

[b] Measured flow rate

[c] Volumetric flow rate was not measured due to inaccessibility to the fans from the boom lift; therefore, it was assumed to be the average flow rate of Fans 1, 5, and 6. Odour concentration was assumed to be the average of Curing Building Fans 1, 2, 4, 5, and 6 due to inaccessibility to the fan from the boom lift

Rm^3/s = Reference cubic metres of flue gas air per second

4.7.2 Biosolids Lagoons

The Biosolids Lagoons were sampled on October 17, 2022. Samples were taken from summer cells 1, 3, and 5, where accessible from the walkways. The average of the three samples was used for the remaining cells but was adjusted for seasonal effects (such as icing and slushy conditions) and is discussed further in the following paragraphs.

The samples were taken under quiescent conditions, during which no noticeable agitation from pumping activities was noted. The average of the three samples was taken as representative of quiescent conditions and applied to all non-agitated open lagoon areas, including the winter cells and other supernatant liquid holding areas.

Table 4-2. Summary of Biosolids Lagoons Emissions

Source	Average Odour Flux (OU/s/m²)	Approximate Source Area (m²)	Odour Emission Rate (OU/s)
Biosolids Lagoon	1.730	225,000	Variable – See herein for details
Biosolids Lagoon	0.727		
Biosolids Lagoon	1.223		
Average Quiescent Conditions	1.23		

Seasonal variability of the lagoon emissions was applied as summarized in Table 4-3. Monthly variability was applied based on expected open/frozen/quiescent/agitated areas, and where agitated areas assumed a 5-fold increase in odour emissions compared to quiescent conditions. The rationale for a 5-fold increase is based on Jacobs experience with odour sources and professional judgement. Slightly turbulent liquid source surfaces increase odour emissions relative to quiescent surfaces. It should be noted this scaling factor applied to agitated surfaces was an estimate based on professional judgment, but it is not anticipated to have a significant impact on model predictions as it is only applied to 4% of the filling area, or 800 m^2 in total of agitated surface. The scaling factors are weighted averages of open/slush, agitated/quiescent areas, where no emissions were assumed from frozen lagoon areas during winter, and cold months of November to April. The scaling factors listed in Table 4-3 were applied to the average 1.23 $OU/s/m^2$ emission rates listed in Table 4-2 for each of the months indicated. Calculations for each of the three time periods is also provided in Table 4-3.

Q(winter)	=	1.23 $OU/s/m^2$ * 0.044	=	0.054 $OU/s/m^2$
Q(summer)	=	1.23 * 1.014	=	1.25 $OU/s/m^2$
Q(April/Nov)	=	1.23 * 0.344	=	0.423 $OU/s/m^2$

Table 4-3 summarizes the seasonal and monthly adjustments made to the measured odour emission rates.

Table 4-3. Summary of Seasonal Variability of Lagoon Emissions

Season/Month	Scaling Factor (dimensionless)	Filling Area (open or slush)	Filling Area with pumping or agitation	Filling Area (m^2)	Non Filling (open or slush)	Non Filling Area (m^2)
Winter	0.044	30%	4%	20,000	0%	205,000
Summer	1.014	96%	4%	20,000	100%	205,000
April/November	0.344	60%	4%	20,000	30%	205,000

Emission rate calculation for the summer months:

Base emissions per unit area for quiescent conditions: 1.23 $OU/s/m^2$ (average from odour sampling)
Base total Surface Area = 225,000 m^2 (estimated per satellite imagery)
Base emissions = 225,000 * 1.23 = 276,750 OU/s
Filling Area = 20,000 m^2 (estimated)
Filling Area with agitation scaling factor = 5 (scaling factors for emissions of surface area with agitation - estimated)
Percentages of Open areas, filling areas, and areas with agitation are as listed in Table 4-3.

Summer Emissions = 1.23* (20,000* (96% + 5*4%) + 205,000) = 280,686 OU/s
Overall summer scaling factor = 280,686/276,750 = 1.014
Scaled Summer Emission Rate per unit area= 1.23 * 1.014 = 1.25 $OU/s/m^2$

Emission rate calculation for April/November:

April/November Emissions = 1,23*(205,000*30% + (20,000 * (60% + 5 * 4%)) = 95,325 OU/s
Overall Apr/Nov scaling factor = 95,325/276,750 = 0.344
Scaled April/November Emission Rate per unit area= 1.23 * 0.344 = 0.423 $OU/s/m^2$

Emission rate calculation for winter – note only filling area remains unfrozen/open:

Winter Emissions = 1.23 * (20,000 * (30% + 4% * 5)) = 12,300 OU/s
Overall Winter scaling factor = 12,300/276,750 = 0.044
Scaled Winter Emission Rate per unit area = 1.23 * 0.044 = 0.054 $OU/s/m^2$

4.7.3 Landfill Emissions

Landfill emissions were obtained on October 18, 2022, and are summarized in Table 4-4. The sampling was done at the active face of the landfill; for safety reasons, sampling was done at the eastern edge of the landfill. Two types of refuse were identified for sampling: (1) "fluff", which consisted of various automobile shedder materials, and (2) Shepard Complex residues. The lateral dimensions of the open face were estimated to be approximately 1 hectare (10,000 m^2) at the time of sampling; the average of the three samples were assigned to the remaining open face area. The source was assumed to emit continuously.

Table 4-4. Summary of Active Landfill Face Emissions

Source	Avg Odour Flux ($OU/s/m^2$)	Approximate Source Area (m^2)	Odour Emission Rate (OU/s)
Landfill (fluff)	0.182	10,000 – Active face only modelled	2,650
Landfill (Shepard Residues)	0.397		
Landfill (fluff)	0.216		
Average	0.265		

4.7.4 Calgary Composting Facility Storage Area

As with the Biosolids Lagoons and landfill, odour sampling of the CCF Storage area was conducted using a flux chamber methodology. Sampling was conducted on October 25, 2022; at each of the following sources, 10-minute samples were collected:

- Storage Building and compost piles (4 samples: BIO81-82, CITYSSO, SSO244-247 and SSO264-272)
- Freshly turned compost piles (2 samples: RTS, CITYSSO-FR)

Averages of emissions were used in modelling for all piles located outdoors and within the three-sided storage building. A surface area of 16,100 m^2 was used for the outdoor storage area. An "indoor" and adjacent surface area of 7,800 m^2 was modelled as a volume source. Table 4-5 summarizes the storage area odour results.

Table 4-5. Summary of Storage Area Odour Results

Source	OTV Net Average (OU/m^3)	Avg Odour Flux ($OU/s/m^2$)	Approximate Source Area (m^2)	Odour Emission Rate (OU/s)
BIO81-82	357	0.23	23,900	9,440
CITYSSO	778	0.5		
CITYSSO-FR	712	0.46		
RTS	550	0.35		
SSO224-247	653	0.42		
SSO264-272	549	0.35		
Average	Not applicable	0.395		

4.7.5 East McKenzie Lift Station

The East McKenzie Lift Station exhaust is located on the western side of the pump station located near 14320 McIvor Boulevard East. Triplicate samples were taken from the exhaust point on October 26, 2022, at approximate 2 pm Mountain Daylight Time. Exhaust flow and temperature were also measured concurrently with the air samples. The source emissions were assumed to be continuous. A summary of the odour results is shown in Table 4-6.

Table 4-6. Summary of East McKenzie Lift Station Odour Emissions Parameters

Source	Avg Odour Flux (OU/s/m²)	Approximate Exhaust Area (m²)	Odour Emission Rate (OU/s)
Lift Station[a]	793	0.23	1,533

[a] Point source height of release was 2.5 m above grade.

4.8 Summary of October 2022 Odour Emissions

Table 4-7 summarizes the emission rates used in the modelling as described herein. All sources were modelled as continuous. Only the Biosolids Lagoons were modelled with a seasonal variability, as described previously.

Table 4-7. Summary of Odour Source Emission Rates

Source	October 2022 Emission Rates (OU/second)	Comments and Assumptions
Curing Fans	33,435	Continuous source, measured flow and stack parameters
Biofilter Stacks	79,723	Continuous source, measured flow and stack parameters
Storage Piles (indoor)	3,080	Volume source for open–sided building and immediately adjacent piles, continuous source
Storage Piles (outdoor)	6,360	Continuous area source; 0.395 OU/s/m²; 16,100 m²
Lift Station	1,533	Continuous source, measured flow and stack parameters
Lagoons	~12,000 to 280,000	Variable source as described in Section 4.7.2
Landfill	2,650	Continuous area source; 0.265 OU/s/m²; Active face 10,000 m²

4.9 General Observations and Conclusions

Significant odour sources in the area of the Shepard Complex were modelled using CALPUFF, with the objective being to estimate the aerial extent and frequency of impact of each of the sources individually and all sources cumulatively. The additional objective of the modelling was to identify which source emissions should be the focus of the recommended mitigations.

An objective of the air dispersion modelling was to identify the magnitude of emissions from each of the identified sources, and then to quantify the aerial extent, frequency, and magnitude of impacts, particularly at the residential areas to the south and southwest. The air dispersion modelling showed that mixed odour concentrations in southern and southwestern areas can reach approximately 1 to 6 OU ("effective" 10-minute averages) at the 99.5 percentile, with all sources modelled. An odour concentration of 6 OU is near the threshold of odour perception and recognition under real-world conditions for most people.

The modelled concentrations where all sources are included reach 6 OU only at the areas closest to the Shepard Complex, while the concentrations reach 1 to 2 OU over most of the residential areas immediately to the south and southwest. This indicates that there is not a primary source or sources of odour that reflects the experience of SE area residents. However, based on the modelling, the biosolids lagoons appear to be the largest contributor to the total impacts, itself contributing 5 OU or more at the nearest parts of the residential area. The CCF contributes as much as 1 to 2 OU at the nearest residential areas itself, while the remaining modelled sources do not appear to contribute significantly to that area, much less than 1 OU. The odour concentration contours maps that illustrate the extent of these contours for each of the sources individually and cumulatively are shown in Appendix D.

The modelling shows that the biosolids lagoons and CCF sources are likely impacting the residential area more frequently and with higher intensities than the other modelled sources, based on the odour sampling conducted and modelling assumptions discussed previously. However, as the modelling indicates that there are likely several sources of odours generated at the Shepard Complex and that there is not a primary source of odour that reflects the experience of SE area residents, mitigation alternatives were reviewed for each City potential odour source identified.

The proposed mitigations and details about opinions of potential costs and effectiveness were submitted to The City under Task 4 of Jacobs' scope of work. Modelled impacts may be underestimating actual impacts from some sources based on the number and geographic locations of logged complaints. This may be due to a number of factors including source variability that is not reflected in modelling. In reality, source variability would be dependent on a number of factors, such as the following:

- The modelling uses emission 'snap-shots' that are dependent on operational conditions and source characteristics at the time of sampling.
- Some sources (e.g., landfill) are likely highly variable and dependent on the garbage and organics content, volume, and characteristics.
- Sources such as curing, biofilter, and storage would be dependent on the nature of the compost at the time of sampling and the specific operating conditions.
- Sources such as the East McKenzie Lift Station would vary with time of day depending on conveyance loading.
- Sources such as the Biosolids Lagoons may have specific periods of time (e.g., daily or seasonally) when agitation due to pumping from the wastewater treatment plant is greater or less than 4% considered per Table 4-3. Also, the emission rates from the quiescent surfaces themselves will also vary diurnally and seasonally.
- Additional sources such as Industrial facilities, the nearby wetlands, agricultural sources, and Dufferin pumping station may occasionally contribute to odour in the area and quite possibly lead to complaints. However, the rationale for not assessing and modelling these sources were presented in Tasks 1 and 2.

Odours can persist at locations and shift based on prevailing winds. The meteorology associated with highest concentrations occurs during stable, warm conditions, which occur mostly in the evening and overnight: this agrees with complaint logs. Stable conditions are usually characterized with calm light wind speeds, little turbulence, and can be associated with of periods of reduced visibility. Appendix E shows the modelled top-20 maximum concentrations at two residential receptors, one to the south and one to the west. All modelled sources were included in these runs. Most wind directions of the highest concentrations are coming directly from the vicinity of the Shepard Complex area, but some winds appear to be from no source in particular for that hour. Since no other sources are modelled outside those presented on Figure 4-1, the odorous air was likely pooling in a particular location when winds were light and then were blown towards the receptor in subsequent hour(s) when winds shifted. This phenomenon means that, when investigations for odour complaints are received, wind directions from the previous few hours leading up to the time of complaint should be assessed as well, not just the hour of the complaint.

5. Task 4 - Identification of Mitigation Measures for Key Odour Source(s)

Jacobs analyzed the operational conditions of the key odour sources that give rise to elevated odour emissions and generated suitable mitigation techniques, measures, and restrictions, that are primarily focused on the root cause of the odour. This was accomplished through interviews with key operational personnel associated with the Shepard Complex and a site visit conducted April 4, 2023, through April 6, 2023.

Summary of Interviews

Jacobs conducted interviews with key operational personnel associated with the Shepard Complex, primarily during the week of March 20, 2023. Prior to conducting interviews Jacobs produced an interview form so that each interview participant was asked the same or similar questions and to capture responses. Table 5-1 presents the interview participants and participant organization. Chinook Resource Management Group (CRMG) is the third-party contractor that operates and maintains the CCF.

Table 5-1. Interview Participants and Organizations

Interview Participant Position	Organization
Leader, Landfill Operations	WRS – Landfill (Disposal Processing Services)
Operations Manager	CRMG
Engineer In Training	WRS - CCF
Superintendent, Landfill Operations	WRS - Landfill Operations
Performance Management Technologist	WRS - CCF
Leader, Program Management	WRS - CCF
General Manager	CRMG
Supervisor, Calgro	Water Services
Program Manager - Organics	WRS - CCF
Leader, Operational Performance	Operational Performance Wastewater Treatment
Operations Engineer, Operational Performance	Wastewater Collection
Senior Operations Engineer	Operational Performance Wastewater Treatment

Site Visit Summary

Jacobs representatives visited the Shepard Complex April 4, 2023, through April 6, 2023, to review current operations and odour control measures at the site to evaluate their effectiveness and recommend additional odour control measures. The recommendations generated are based on the site-specific characteristics of the key sources, as well as Jacobs' extensive global experience with similar facilities. Mitigation of some sources have several options available with a wide variety of costs associated with the implementation and operating costs. The selection of appropriate mitigations will need to be informed by other activities that are planned and ongoing in The City that could further influence odour generation. Finally, the identification of mitigation techniques should recognize future changes and avoid implementing anything that could compromise other system modifications.

Jacobs produced a table of recommended mitigations identified by Jacobs, The City, interview participants, and through the odour study process that is presented in Appendix H. The recommended mitigations were evaluated using a multi-outcome decision analysis (MODA) to evaluate the recommended mitigations against a set of evaluation criteria and outcomes to determine the best mitigations for The City. The MODA considered 14 evaluation criteria evaluated against 3 outcomes and scored 1 through 5 for a total possible score of 70. Results of the MODA are also included in Appendix H.

6. Conclusion, Recommendations, and Next Steps

The SE Odour Investigation project findings indicate that there are likely several sources of odours generated at the Shepard Complex and that there is not a primary source of odour that reflects the experience of SE area residents. Rather, many of the odour sources investigated likely contribute to offsite odour impacts to SE residents. While the SE Odour Investigation project did not identify the primary source of odours affecting SE residents, Jacobs has identified and recommended various mitigation opportunities related to City infrastructure that may be contributing to odour in the SE. The recommended mitigations, detailed on Table 6-1, are sorted by source area and include next steps required for implementation and are based on the findings of Jacobs' evaluation and investigations conducted during the Project.

The review of background documents conducted by Jacobs as part of Task 1 provided valuable insights into the operational occurrences and circumstances that may lead to elevated odour emissions from identified sources at The City's Shepard Complex. By analyzing operational activities and reviewing odour investigation forms, Jacobs identified potential areas of improvement in the complaint logs of Water Services and Waste & Recycling Services, such as providing more detailed descriptions of odour complaints and including meteorological conditions associated with the complaints. The review of CRAZ monitoring data revealed that the Shepard Complex Biosolids Lagoons may have occasionally contributed to elevated H_2S readings, but operational and meteorological factors indicated that multiple other sources were also contributing to odour emissions. The City can further integrate the CRAZ monitoring data for investigative purposes, particularly in identifying possible elevated organic compound concentrations and monitoring compounds indicative of temperature inversions. Overall, the review of previous odour work and findings, coupled with the analysis of wind directions and operational factors, helped determine the preferred time and circumstances to sample suspected sites and provided insights into the factors contributing to odour complaints, especially during the evening hours.

The focus of Task 2 was to identify, analyze, and quantify potential sources of odour emissions and assess their impact on the surrounding community through chemical speciation air sampling. Air samples were collected from various locations and the samples were analyzed to determine the chemical composition of the air and identify any unique chemical species associated with specific sources. The results from the chemical "fingerprinting" were inconclusive, in that there mostly appeared to be no clear delineation between odour components measured at the sources, and those measured at the receptor locations. The recommendation of real-time monitoring program for specific odour constituents in proximity to the sources would better help to delineate emissions from specific sources and correlate odour concentrations and resident complaints. In addition, odour rate quantification for the key odour sources was done to use the data within an air dispersion model, as part of Task 3. The findings highlighted the need for further investigation and potential mitigation measures to address the odour concerns.

Field odour investigations were also conducted as part of Task 2 to gain insight into the odour characteristics of emissions from the key sources and at locations downwind of those sources and in residential areas. The results indicated that multiple sources, including the lagoons, landfill, compost storage areas, curing buildings, and biofilter stacks, were identified and likely contributed to the odour at receptor locations and other downwind locations, including in residential areas to the south and southwest.

The aim of Task 3 was to assess the impact of odour emissions from various City-owned sources on residential areas where odour complaints were reported. Odour emission rate sampling was conducted at specific locations, and the emissions were assessed using recognized odour assessment thresholds. The findings of odour emission rates from different sources, contribute valuable insights into the potential impacts on the surrounding residential areas through the use of air dispersion modelling. The emission rates were used within the CALPUFF air dispersion model, recognized for its advanced capabilities in simulating the effects of varying meteorological conditions. The modelling process utilized meteorological data from the Weather Research and Forecasting (WRF) model and incorporated receptor locations, including gridded and discrete receptors, to calculate the concentration impacts from the emitting sources. The results were presented as effective 10-minute average odour concentration, to align with odour-based criteria and complaint characteristics.

As part of Task 4, Jacobs conducted a comprehensive analysis of the operational conditions of key odour sources at the Shepard Complex and developed suitable mitigation techniques, measures, and restrictions aimed at addressing the root causes of odour emissions. This was achieved through interviews with key operational personnel associated with the site and a thorough site visit. The interviews provided valuable insights and information which was used to inform Jacobs of potential odour sources and areas of potential improvement. Additionally, the site visit conducted April 3 through 6 of 2023 allowed Jacobs representatives to assess the effectiveness of current odour control measures, assess operations to identify and confirm odour sources, and make recommendations for additional mitigation measures based on their extensive global experience with similar facilities. The recommended mitigations, as well as those suggested by interview participants and identified during the odour study process, underwent evaluation using a MODA to determine their effectiveness and cost. Each mitigation was assigned a MODA score based on its performance, categorized as Extremely Effective, Highly Effective, Effective, Mildly Effective, or Ineffective and assigned a cost range. These scores were used to assess the potential impact of each mitigation to address odour concerns in the surrounding community. MODA scoring was established to more heavily weight mitigations that could be implemented promptly to reduce the impact to residents. The MODA evaluation is summarized in the following paragraphs. Details of the MODA are also included in Appendix H.

Each mitigation was evaluated based on its MODA score to determine effectiveness and cost based on the following scales.

Effectiveness was evaluated using the following criteria:

- Extremely Effective (58 to 70 points)
- Highly Effective (51 to 57 points)
- Effective (41 to 50 points)
- Mildly Effective (31 to 40 points)
- Ineffective (0 to 30 points)

Mitigation costs were evaluated using the following criteria (M=million Canadian dollars):

- Extremely Costly (greater than $30 M)
- High Cost ($15 to 30 M)
- Medium Cost ($8 to 15 M)
- Low Cost ($2 to 8 M)
- Very Low Cost (less than $2.0 M)
- Study Cost (implementation of recommendation may add significant cost)

Based on the effectiveness and cost evaluation Jacobs recommends implementation of the highest scoring mitigations presented in Table 6-1. As the modelling indicates, there are likely several sources of odours generated at the Shepard Complex and there is not a primary source of odour that reflects the experience of SE area residents. With the goal of taking prompt action to reduce impacts to SE area residents from all potential sources, Mitigation alternatives were reviewed for each City potential odour source identified.

It is important to note that the number of recommendations pertaining to the Calgary Composting Facility does not indicate that it is a more likely source of odours than any of the other operational activities at the Shepard Complex. Although the modelled odour intensity from the Calgary Composting Facility was approximately 20 percent lower than the lagoons, given that the Calgary Composting Facility has four operational Source Areas to which recommendations could be applied, it is reasonable that the Calgary Composting Facility has more recommendations pertaining to it. Conversely, the biosolids lagoons are a large operation with fewer operational stages, and potential mitigation measures tended to be very high in operational impact and cost.

In general, next steps for the recommended mitigations will include the following:

- Detailed cost estimation
- Conceptual design work to inform cost estimates
- Development of technical specifications for procurement
- Site visits to research suggested mitigations
- Reference checks

Specific next steps for each recommended mitigation are included in Table 6-1.

Table 6-1. Mitigations Recommended for Implementation Based on Evaluation and Next Steps

Source Area	Mitigations Recommended for Implementation	Next Steps for Implementation
General	The City should establish a process to regularly communicate with residents and other interested parties (i.e., Community Associations or similar) to increase knowledge of existing odour mitigation measures and any future plans/projects to reduce odours. (effective, very low cost)	Determine appropriate interested parties, communication methods and frequency, and discussion topics.
	Install a series of active real-time odour and odour compound monitoring sensors throughout adjacent community and along the Shepard Complex perimeter to gather real-time odour data. (effective, very low cost)	Complete odour modelling and confirm locations and number of monitoring sensors.
Shepard Lagoons	Improve and automate existing misting system. (effective, very low cost)	Determine existing operational parameters and identify areas for improvement.
	Surround lagoons with trees (effective, low cost)	Determine source and type of trees.
Biosolids Storage Pad	Change operations of pad to increase retention time on pad (greater than 2 weeks laydown). (effective, very low cost)	Determine operational methods that can be implemented to reduce material movement and increase laydown time.
Landfill	Review types of waste allowed to be disposed of at landfill and eliminate odorous waste types where possible. (highly effective, study cost)	Determine high odour waste types currently delivered to the landfill. Identify alternative disposal method/location. Obtain agreement to dispose of odorous wastes at new location. Educate customers that odorous wastes will no longer be accepted at the landfill.
Composting Facility – Outdoor Finished Storage Area	Limit the amount of finished material stored on the pad, and operations when wind is blowing towards residents. (extremely effective, low cost)	Identify a storage limit (i.e. area of the storage pad or volume of material). Determine a timeline for compliance. Review current operational procedures.
Composting Facility – Curing Building	Fix floor aeration issues. (highly effective, low cost)	Obtain a design and cost estimate to address the issues with the curing building aeration floor.

Source Area	Mitigations Recommended for Implementation	Next Steps for Implementation
		Hire a contractor to begin phased implementation of designed floor upgrade.
	Improve the operations within the Curing Building with the goal of producing a more mature and stable product before it is screened and sent to Finished Compost Pad.	Determine optimal pile size and spacing that will allow for more time in the curing building while being sized to the mass bed turner. Obtain a vendor quote for purchasing a larger mass bed turner. Perform an evaluation of labour resources and determine if sufficient people are available to perform operations, maintenance, and housekeeping tasks as required.
Composting Facility – Biofilter	Add stack height or other roof mounted fans to increase dispersion. (highly effective, very low cost)	Perform engineering calculations to determine most effective measure for improving dispersion.
	Performance of biofilter should be evaluated by establishing a rigorous biofilter performance monitoring program, which would include developing a comprehensive set of data and benchmarks against which to evaluate the efficiency and function of the biofilter. (effective, low cost)	Determine evaluation criteria, frequency, and methodology. Investigate chemical levels in the biofilter and leachate storage room by establishing investigation and sampling protocols. Apply results to develop an optimized media replacement schedule.

6.1 Other Mitigations Not Evaluated through MODA

The following mitigations are expected to have a positive effect on odours produced at the compost facility but they were not evaluated through the MODA analysis, because implementation of these mitigations is already underway or they require further investigation to make a recommendation.

6.1.1 Composting Facility Expansion

The City is in the process of expanding the composting facility capacity through the addition of a horizontal plug flow anaerobic digestion (HPFAD) system. This expansion was not considered as a mitigation during the project because the expansion is already under way. However, the expansion of the compost facility with the HPFAD system is expected to have several positive effects on managing and reducing odours at the expanded facility.

- The HPFAD system is being designed to process 60,000 tonnes of the Green Cart material each year, which is approximately half of the current incoming organic material amount and should result in odour reductions in the short term as a result. Processing this amount of organic material through the enclosed HPFAD system will provide better odour control. The expansion will allow the compost facility to operate below capacity in the near term and to accommodate the increase in materials that come with a growing community. Short term odour improvements are expected to be maintained even as incoming organic material amounts increase.
- Anaerobic digestion is an effective waste treatment process that helps break down organic matter in an accelerated, oxygen-free, environment. By incorporating a HPFAD system into the compost facility, a larger volume of waste can be processed through an enclosed process that will help

control and reduce the amount of organic material that could potentially produce strong odours. This additional stage of organic degradation should result in a more mature and stable product being placed into the subsequent stages of the composting process. Enhanced maturity and stability occur when biological activity in the compost piles is significantly reduced. When this occurs before compost is placed outdoors it will help to decrease odours.

By combining these factors, the compost facility expansion with a HPFAD system can positively impact odour management. It allows for better usage of composting capacity, for better waste treatment, reduces organic decomposition time, provides controlled digestion conditions, implements odour containment measures, and optimizes the facility's overall design, all of which is expected to contribute to a reduction in odours at the expanded facility.

6.1.2 H_2S Concentrations in Sanitary Sewer Near the Shepard Complex.

The City's Water Services group has been monitoring for H_2S at specific points in sanitary sewers near the Shepard Complex since January 2022, and have observed fluctuating concentrations during this time. H_2S in sanitary sewers has the potential to generate odours at surface and impact neighbours. The City will continue to monitor the sanitary collection system in the area and will mandate customers producing waste streams containing H_2S to investigate and mitigate their source.

Appendix A. Photographs of October 2023 Air Sampling (Task 2)

Photograph 1: Air Sampling inside Biofilter Building for the purposes of chemical speciation.

Photograph 2: Air Sampling near Biosolids Lagoons (Evacuated Canisters and Tubes with Pumps) Looking southwest.

Photograph 3: Taking an odour sample using a flux chamber and Lung Sampler at the outdoor compost storage area – Looking south.

Photograph 4: Passive sampling with a diffusion tube (under white "mushroom cap") near the Biosolids Lagoons (looking northwest)

Photograph 5: Air sampling at a Biofilter Stack (flow measurements with Pilot tube and air sampling into Tedlar bag [at left of stack]) – looking northeast.

Appendix B. Laboratory Results

Table B-1. Results Summary September Sampling

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
ammonia (as NH_3)	0.010	µg/m³	224		246	790	559				
Sulphur Compounds (Matrix: Air)											
carbon disulphide	6.2	µg/m³	<6.2	<6.2	<6.2	<6.2	7.2	<6.2	<6.2	<6.2	<6.2
carbonyl sulphide	10	µg/m³	<10	<10	<10	<10	14	<10	<10	<10	<10
diethyl disulphide	10	µg/m³	<10	<10	<10	<10	<10	<10	<10	<10	<10
diethyl sulphide	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<15
dimethyl disulphide	7.7	µg/m³	<7.7	<7.7	<7.7	<7.7	22.7	<7.7	<7.7	<7.7	<7.7
dimethyl sulphide	10	µg/m³	<10	<10	<10	<10	52	<10	<10	<10	<10
dimethylthiophene, 2,5-	18	µg/m³	<18	<18	<18	<18	<18	<18	<18	<18	<18
ethyl mercaptan	10	µg/m³	<10	<10	<10	<10	<10	<10	<10	<10	<10
ethyl methyl sulphide	12	µg/m³	<12	<12	<12	<12	<12	<12	<12	<12	<12
ethylthiophene, 2-	18	µg/m³	<18	<18	<18	<18	<18	<18	<18	<18	<18
hydrogen sulphide	5.6	µg/m³	<5.6	<5.6	<5.6	<5.6	6.1	<5.6	<5.6	<5.6	<5.6
isobutyl mercaptan	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<15
isopropyl mercaptan	12	µg/m³	<12	<12	<12	<12	<12	<12	<12	<12	<12

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
donemethyl mercaptan	7.9	µg/m³	<7.9	<7.9	<7.9	<7.9	<7.9	<7.9	<7.9	<7.9	<7.9
methylthiophene, 2-	16	µg/m³	<16	<16	<16	<16	<16	<16	<16	<16	<16
methylthiophene, 3-	16	µg/m³	<16	<16	<16	<16	<16	<16	<16	<16	<16
n-butyl mercaptan	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<15
propyl mercaptan	12	µg/m³	<12	<12	<12	<12	<12	<12	<12	<12	<12
sec-butyl mercaptan + thiophene	14	µg/m³	<21	<21	<21	<21	<21	<21	<21	<21	<21
t-butyl mercaptan	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<15
tetrahydrothiophene	14	µg/m³	<14	<14	<14	<14	<14	<14	<14	<14	<14
sulphur, total reduced (as H_2S), 22 compounds	63	µg/m³	<63	<63	<63	<63	<63	<63	<63	<63	<63
sulphur, total reduced (as H_2S), 10 compounds	33	µg/m³	<33	<33	<33	<33	54	<33	<33	<33	<33
sulphur, total reduced (as H_2S), NPRI 6	20	µg/m³	<20	<20	<20	<20	54	<20	<20	<20	<20
sulphur, total reduced (as H_2S), Ontario 4	16	µg/m³	<16	<16	<16	<16	43	<16	<16	<16	<16
Volatile Organic Compounds (Matrix: Air)											
acetone	2.4	µg/m³	20.9	15.4	35.9	57.0	86.9	14.5	13.8	<11.9	8.6
allyl chloride	0.63	µg/m³	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63	<0.63
benzene	0.32	µg/m³	<0.32	<0.32	<0.32	<0.32	1.05	0.42	<0.32	<0.32	<0.32

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
benzyl chloride	1.0	µg/m^3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
bromodichloromethane	1.3	µg/m^3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3	<1.3
bromoform	2.1	µg/m^3	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1
bromomethane	0.78	µg/m^3	<0.78	<0.78	<0.78	<0.78	<0.78	<0.78	<0.78	<0.78	<0.78
butadiene, 1,3-	0.44	µg/m^3	<0.44	<0.44	<0.44	<0.44	<1.81	<0.44	<0.44	<0.44	<0.44
carbon disulphide	1.6	µg/m^3	<1.6	<1.6	<1.6	<1.6	6.6	<1.6	<1.6	<1.6	<1.6
carbon tetrachloride	1.30	µg/m^3	<1.26	<1.26	<1.26	<1.26	<1.26	<1.26	<1.26	<1.26	<1.26
chlorobenzene	0.92	µg/m^3	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92	<0.92
chloroethane	0.53	µg/m^3	<0.53	<0.53	<0.53	<0.53	<0.53	<0.53	<0.53	<0.53	<0.53
chloroform	0.98	µg/m^3	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98	<0.98
chloromethane	0.41	µg/m^3	0.91	0.89	0.68	1.16	3.72	0.87	0.87	0.87	0.89
cyclohexane	0.69	µg/m^3	<0.69	<0.69	<0.69	<0.69	<0.69	<0.69	<0.69	<0.69	<0.69
dibromochloromethane	1.7	µg/m^3	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7	<1.7
dibromoethane, 1,2-	1.5	µg/m^3	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
dichlorobenzene, 1,2-	1.2	µg/m^3	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
dichlorobenzene, 1,3-	1.2	µg/m^3	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
dichlorobenzene, 1,4-	1.2	µg/m^3	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2	<1.2
dichlorodifluoromethane	1.0	µg/m^3	2.3	2.3	2.2	2.2	2.1	2.2	2.3	2.3	2.2
dichloroethane, 1,1-	0.81	µg/m^3	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
dichloroethane, 1,2-	0.81	µg/m³	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81	<0.81
dichloroethylene, 1,1-	0.79	µg/m³	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
dichloroethylene, cis-1,2-	0.79	µg/m³	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
dichloroethylene, trans-1,2-	0.79	µg/m³	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79	<0.79
dichloromethane	0.69	µg/m³	<0.69	<0.69	<0.69	<0.69	0.76	<0.69	<0.69	<0.69	<0.69
dichloropropane, 1,2-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
dichloropropylene, cis+trans-1,3-	1.3	µg/m³	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8	<1.8
dichloropropylene, cis-1,3-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
dichloropropylene, trans-1,3-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
dichlorotetrafluoroethane, 1,2- [Freon 114]	1.4	µg/m³	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
dioxane, 1,4-	0.72	µg/m³	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72
ethanol	1.9	µg/m³	2.1	4.3	6.2	18.6	43.5	2.4	3.6	<1.9	<1.9
ethyl acetate	0.72	µg/m³	<0.72	<0.72	<0.72	<0.72	8.72	<0.72	<0.72	<0.72	<0.72
ethylbenzene	0.43	µg/m³	<0.43	<0.43	<0.43	<0.43	0.87	0.87	<0.43	<0.43	<0.43
ethyltoluene, 4-	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	1.4	<1.0	<1.0	<1.0	<1.0
heptane, n-	0.82	µg/m³	<0.82	<0.82	<0.82	<0.82	2.95	<0.82	<0.82	<0.82	<0.82
hexachlorobutadiene	2.1	µg/m³	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1	<2.1
hexane, n-	0.70	µg/m³	<0.70	<0.70	<0.70	<0.70	1.69	<0.70	<0.70	<0.70	<0.70

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
hexanone, 2-	4.10	µg/m³	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10
isopropylbenzene	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
methyl ethyl ketone [MEK]	0.59	µg/m³	0.80	0.62	5.31	19.9	97.0	1.09	0.80	<0.59	<0.59
methyl isobutyl ketone [MIBK]	0.82	µg/m³	<0.82	<0.82	<0.82	<0.82	2.50	<0.82	<0.82	<0.82	<0.82
methyl-tert-butyl ether [MTBE]	0.72	µg/m³	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72	<0.72
naphthalene	0.52	µg/m³	<0.52	<0.52	<0.52	<0.52	1.84	<0.52	<0.52	<0.52	<0.52
propylene	0.34	µg/m³	<0.34	0.36	3.27	10.3	28.4	1.41	0.62	0.67	0.53
styrene	0.85	µg/m³	<0.85	<0.85	<0.85	<0.85	2.90	<0.85	<0.85	<0.85	<0.85
tetrachloroethane, 1,1,2,2-	1.4	µg/m³	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
tetrachloroethylene	1.4	µg/m³	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4
tetrahydrofuran	0.59	µg/m³	<0.59	<0.59	<0.59	<0.59	1.62	<0.59	<0.59	<0.59	<0.59
toluene	0.38	µg/m³	<0.38	0.49	<0.38	0.53	3.81	1.58	1.17	<0.38	0.41
trichloro-1,2,2-trifluoroethane, 1,1,2- [Freon 113]	1.5	µg/m³	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
trichlorobenzene, 1,2,4-	1.5	µg/m³	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5	<1.5
trichloroethane, 1,1,1-	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
trichloroethane, 1,1,2-	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
trichloroethylene	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1
trichlorofluoromethane	1.1	µg/m³	<1.1	1.1	<1.1	<1.1	<1.1	<1.1	1.3	<1.1	<1.1

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
trimethylbenzene, 1,2,4-	1.0	µg/m^3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trimethylbenzene, 1,3,5-	1.0	µg/m^3	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0
trimethylpentane, 2,2,4-	0.9	µg/m^3	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
vinyl acetate	1.8	µg/m^3	<1.8	<1.8	<1.8	<8.3	<3.9	<1.8	<1.8	<1.8	<1.8
vinyl bromide	0.9	µg/m^3	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9
vinyl chloride	0.51	µg/m^3	<0.51	<0.51	<0.51	<0.51	<0.51	<0.51	<0.51	<0.51	<0.51
xylene, m+p-	0.87	µg/m^3	<0.87	<0.87	<0.87	<0.87	2.26	2.95	<0.87	<0.87	<0.87
xylene, o-	0.43	µg/m^3	<0.43	<0.43	<0.43	<0.43	1.22	0.96	<0.43	<0.43	<0.43
xylenes, total	1.0	µg/m^3	<1.3	<1.3	<1.3	<1.3	3.5	3.9	<1.3	<1.3	<1.3
BTEX, total	1.2	µg/m^3	<2.4	<2.4	<2.4	<2.4	9.2	6.8	<2.4	<2.4	<2.4
Aldehydes (Matrix: Air)											
Acetaldehyde	Vary with sample flow	mg/m^3	0.0032	0.0038	0.0065	0.0079	0.0180	0.0039	0.0058	0.0030	0.0053
Formaldehyde		mg/m^3	0.0049	0.0048	0.0054	0.0063	0.018	0.0052	0.0048	0.004	0.0048
Acrolein		mg/m^3	<0.0014	<0.0012	<0.0013	<0.0022	0.012	<0.0021	<0.0018	<0.0014	<0.0019
Acetone		mg/m^3	0.0090	0.012	0.021	0.047	0.083	0.015	0.011	0.0055	0.014
Propionaldehyde		mg/m^3	<0.0014	0.0037	0.0021	0.0043	<0.0053	<0.021	<0.0018	<0.0014	<0.0019
Crotonaldehyde		mg/m^3	<0.0014	<0.0012	<0.0013	<0.0022	<0.0053	<0.021	<0.0018	<0.0014	<0.0019
Butyraldehyde		mg/m^3	0.002	0.002	0.0041	0.012	0.085	0.0023	0.0023	0.0015	0.0022

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
Benzaldehyde		mg/m^3	0.0029	0.0047	0.0028	0.0031	<0.0053	0.0052	0.0045	0.0029	0.0059
Isovaleraldehyde		mg/m^3	<0.0014	<0.0012	<0.0013	<0.0022	0.03	<0.0021	<0.0018	<0.0014	<0.0019
Valeraldehyde		mg/m^3	0.0024	0.0039	0.0025	0.0032	<0.0053	0.0034	0.0034	0.0021	0.0019
Tolualdehyde, o-		mg/m^3	<0.0014	<0.0012	<0.0013	<0.0022	<0.0053	<0.0021	<0.0018	<0.0014	<0.0019
Tolualdehyde, m+p-		mg/m^3	<0.0014	0.0013	<0.0013	<0.0022	<0.0053	<0.0021	<0.0018	<0.0014	<0.0019
Hexanal (Hexanaldehyde)		mg/m^3	0.0059	0.0069	0.0077	0.0078	<0.0053	0.0081	0.0079	0.0065	0.0071
Dimethylbenzaldehyde, 2,5-		mg/m^3	<0.0014	<0.0012	<0.0013	<0.0022	<0.0053	<0.0021	<0.0018	<0.0014	<0.0019
Organic Parameters (Matrix: Air)											
triethylamine	Varies with sample flow	mg/m^3	<0.065	<0.045	<0.053	<0.069	<0.14	<0.053	<0.053	<0.055	<0.063
Acetic acid		mg/m^3	0.89	0.28	0.88	0.93	<0.069	1.70	0.67	0.39	0.55
Glycolic Acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Propionic Acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Butyric acid		mg/m^3	<0.034	<0.029	0.12	0.089	<0.042	<0.039	<0.033	<0.030	<0.030
Formic acid		mg/m^3	<0.041	<0.018	<0.027	<0.041	<0.069	<0.040	<0.025	<0.028	<0.022
Lactic acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Malonic acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Pentanoic acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Fumaric acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030

Client Sample ID			Lagoons - 0505	Landfill - 0017	Storage - 0040	Curing - 0524	BioFilter - 0080	Industrial source/ Food Processing - 0232	Skate Park - 0414	McKenzie Lift - 0415	Car Dealer - 0518
Date Sampled			31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	31-Aug-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022	01-Sep-2022
Time Sampled			12:51	13:39	15:01	16:28	17:27	10:39	15:34	16:26	18:14
Analyte	Lowest Detection Limit	Units	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air	Sub-Matrix: Air
Succinic acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Tartaric acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030
Citric acid		mg/m^3	<0.034	<0.029	<0.032	<0.044	<0.042	<0.039	<0.033	<0.030	<0.030

Table B-2. Results Summary October Sampling

Client Sample ID	Lowest Detection Limit	Units	Curing	Biofilter	Lagoons	Storage	Skate Park	Copper-field	Copperfield Sample 2	McKenzie Lift	Shepard Complex NE Fence Line	Landfill	Landfill Duplicate
ammonia (as NH_3)	0.010	µg/m³	1060	117	512	174	0.0	0.0	-	88.1	0.0	0.0	-
carbon disulphide	6.2	µg/m³	<6.2	10.9	<6.2	<6.2	<6.5	<6.2	<6.2	<6.2	<6.8	<6.2	<6.2
carbonyl sulphide	10	µg/m³	<10	14	<10	<10	<10	<10	<10	<10	<10	<10	<10
diethyl disulphide	10	µg/m³	<10	<10	<10	<10	<10	<10	<10	<10	<11	<10	<10
diethyl sulphide	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<16	<15	<15
dimethyl disulphide	7.7	µg/m³	<7.7	11.9	<7.7	<7.7	<8.1	<7.7	<7.7	<7.7	<8.5	<7.7	<7.7
dimethyl sulphide	10	µg/m³	<10	36	<10	<10	<11	<10	<10	<10	<11	<10	<10
dimethylthiophene, 2,5-	18	µg/m³	<18	<18	<18	<18	<19	<19	<18	<18	<20	<18	<18
ethyl mercaptan	10	µg/m³	<10	<10	<10	<10	<11	<10	<10	<10	<11	<10	<10
ethyl methyl sulphide	12	µg/m³	<12	<12	<12	<12	<13	<13	<12	<12	<13	<12	<12
ethylthiophene, 2-	18	µg/m³	<18	<18	<18	<18	<19	<19	<18	<18	<20	<18	<18
hydrogen sulphide	5.6	µg/m³	<5.6	<5.6	<5.6	<5.6	<5.8	15.5	<5.6	75.3	<6.0	<5.6	<5.6
isobutyl mercaptan	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<16	<15	<15
isopropyl mercaptan	12	µg/m³	<12	<12	<12	<12	<13	<13	<12	<12	<13	<12	<12
methyl mercaptan	7.9	µg/m³	<7.9	<7.9	<7.9	<7.9	<8.3	<8.1	<7.9	<7.9	<8.5	<7.9	<7.9
methylthiophene, 2-	16	µg/m³	<16	<16	<16	<16	<17	<16	<16	<16	<17	<16	<16
methylthiophene, 3-	16	µg/m³	<16	<16	<16	<16	<17	<16	<16	<16	<17	<16	<16
n-butyl mercaptan	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<16	<15	<15
propyl mercaptan	12	µg/m³	<12	<12	<12	<12	<13	<13	<12	<12	<13	<12	<12
sec-butyl mercaptan + thiophene	14	µg/m³	<21	<21	<21	<21	<21	<21	<21	<21	<21	<21	<21
t-butyl mercaptan	15	µg/m³	<15	<15	<15	<15	<15	<15	<15	<15	<16	<15	<15
tetrahydrothiophene	14	µg/m³	<14	<14	<14	<14	<15	<15	<14	<14	<16	<14	<14

Client Sample ID	Lowest Detection Limit	Units	Curing	Biofilter	Lagoons	Storage	Skate Park	Copperfield	Copperfield Sample 2	McKenzie Lift	Shepard Complex NE Fence Line	Landfill	Landfill Duplicate
sulphur, total reduced (as H_2S), 22 compounds	63	µg/m³	<63	<63	<63	<63	<63	<63	<63	75	<63	<63	<63
sulphur, total reduced (as H_2S), 10 compounds	33	µg/m³	<33	37	<33	<33	<33	<33	<33	75	<33	<33	<33
sulphur, total reduced (as H_2S), NPRI 6	20	µg/m³	<20	37	<20	<20	<20	<20	<20	75	<20	<20	<20
sulphur, total reduced (as H_2S), Ontario 4	16	µg/m³	<16	24	<16	<16	<16	<16	<16	75	<16	<16	<16
acetone	2.4	µg/m³	29.9	28.3	7.8	53.4	13.8	15.0	11.6	18.0	14.5	10.2	9.7
allyl chloride	0.63	µg/m³	<0.63	<0.63	<0.63	<0.63	<0.66	<0.63	<0.63	<0.63	<0.69	<0.63	<0.63
benzene	0.32	µg/m³	1.15	1.28	<0.32	<0.32	<0.32	<0.32	<0.32	0.73	<0.35	0.45	<0.32
benzyl chloride	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0
bromodichloromethane	1.3	µg/m³	<1.3	<1.3	<1.3	<1.3	<1.4	<1.3	<1.3	<1.3	<1.5	<1.3	<1.3
bromoform	2.1	µg/m³	<2.1	<2.1	<2.1	<2.1	<2.2	<2.1	<2.1	<2.1	<2.3	<2.1	<2.1
bromomethane	0.78	µg/m³	<0.78	<0.78	<0.78	<0.78	<0.82	<0.78	<0.78	<0.78	<0.85	<0.78	<0.78
butadiene, 1,3-	0.44	µg/m³	<0.44	<1.15	<0.44	<0.44	<0.46	<0.44	<0.44	<0.44	<0.49	<0.44	<0.44
carbon disulphide	1.6	µg/m³	<1.6	6.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7	<1.6	<1.6
carbon tetrachloride	1.30	µg/m³	<1.26	<1.26	<1.26	<1.26	<1.32	<1.26	<1.26	<1.26	<1.38	<1.26	<1.26
chlorobenzene	0.92	µg/m³	<0.92	<0.92	<0.92	<0.92	<0.97	<0.92	<0.92	<0.92	<1.01	<0.92	<0.92
chloroethane	0.53	µg/m³	<0.53	<0.53	<0.53	<0.53	<0.55	<0.53	<0.53	<0.53	<0.58	<0.53	<0.53
chloroform	0.98	µg/m³	<0.98	<0.98	<0.98	<0.98	<1.02	<0.98	<0.98	9.77	<1.07	<0.98	<0.98
chloromethane	0.41	µg/m³	1.28	3.74	<0.41	0.50	0.91	0.99	0.95	1.20	1.12	1.07	1.03
cyclohexane	0.69	µg/m³	<0.69	<0.69	<0.69	<0.69	<0.72	<0.69	<0.69	<0.69	<0.76	<0.69	<0.69
dibromochloromethane	1.7	µg/m³	<1.7	<1.7	<1.7	<1.7	<1.8	<1.7	<1.7	<1.7	<1.9	<1.7	<1.7

Client Sample ID	Lowest Detection Limit	Units	Curing	Biofilter	Lagoons	Storage	Skate Park	Copper-field	Copperfield Sample 2	McKenzie Lift	Shepard Complex NE Fence Line	Landfill	Landfill Duplicate
dibromoethane, 1,2-	1.5	µg/m³	<1.5	<1.5	<1.5	<1.5	<1.6	<1.5	<1.5	<1.5	<1.7	<1.5	<1.5
dichlorobenzene, 1,2-	1.2	µg/m³	<1.2	<1.2	<1.2	<1.2	<1.3	<1.2	<1.2	<1.2	<1.3	<1.2	<1.2
dichlorobenzene, 1,3-	1.2	µg/m³	<1.2	<1.2	<1.2	<1.2	<1.3	<1.2	<1.2	<1.2	<1.3	<1.2	<1.2
dichlorobenzene, 1,4-	1.2	µg/m³	<1.2	<1.2	<1.2	<1.2	<1.3	<1.2	<1.2	<1.2	<1.3	<1.2	<1.2
dichlorodifluoromethane	1.0	µg/m³	2.0	1.9	1.9	1.9	1.9	1.9	1.9	1.6	1.9	2.1	2.1
dichloroethane, 1,1-	0.81	µg/m³	<0.81	<0.81	<0.81	<0.81	<0.85	<0.81	<0.81	<0.81	<0.89	<0.81	<0.81
dichloroethane, 1,2-	0.81	µg/m³	<0.81	<0.81	<0.81	<0.81	<0.85	<0.81	<0.81	<0.81	<0.89	<0.81	<0.81
dichloroethylene, 1,1-	0.79	µg/m³	<0.79	<0.79	<0.79	<0.79	<0.83	<0.79	<0.79	<0.79	<0.87	<0.79	<0.79
dichloroethylene, cis-1,2-	0.79	µg/m³	<0.79	<0.79	<0.79	<0.79	<0.83	<0.79	<0.79	<0.79	<0.87	<0.79	<0.79
dichloroethylene, trans-1,2-	0.79	µg/m³	<0.79	<0.79	<0.79	<0.79	<0.83	<0.79	<0.79	<0.79	<0.87	<0.79	<0.79
dichloromethane	0.69	µg/m³	2.85	1.32	<0.69	<0.69	<0.73	<0.69	<0.69	<0.69	<0.76	<0.69	<0.69
dichloropropane, 1,2-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9
dichloropropylene, cis+trans-1,3-	1.3	µg/m³	<1.8	<1.8	<1.8	<1.8	<1.9	<1.8	<1.8	<1.8	<2.0	<1.8	<1.8
dichloropropylene, cis-1,3-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9
dichloropropylene, trans-1,3-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9
dichlorotetrafluoroethane, 1,2- [Freon 114]	1.4	µg/m³	<1.4	<1.4	<1.4	<1.4	<1.5	<1.4	<1.4	<1.4	<1.5	<1.4	<1.4
dioxane, 1,4-	0.72	µg/m³	<0.72	<0.72	<0.72	<0.72	<0.76	<0.72	<0.72	<0.72	<0.79	<0.72	<0.72
ethanol	1.9	µg/m³	32.8	11.7	<3.6	31.6	19.4	5.6	4.0	34.7	6.0	8.5	7.7
ethyl acetate	0.72	µg/m³	<0.72	3.24	<0.72	<0.72	1.12	<0.72	<0.72	<0.72	<0.79	<0.72	<0.72
ethylbenzene	0.43	µg/m³	<0.43	0.52	<0.43	<0.43	<0.43	<0.43	<0.43	<0.43	<0.48	<0.43	<0.43
ethyltoluene, 4-	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0

Client Sample ID	Lowest Detection Limit	Units	Curing	Biofilter	Lagoons	Storage	Skate Park	Copper-field	Copperfield Sample 2	McKenzie Lift	Shepard Complex NE Fence Line	Landfill	Landfill Duplicate
heptane, n-	0.82	µg/m³	<0.82	2.46	<0.82	<0.82	<0.86	<0.82	<0.82	<0.82	<0.90	<0.82	<0.82
hexachlorobutadiene	2.1	µg/m³	<2.1	<2.1	<2.1	<2.1	<2.2	<2.1	<2.1	<2.1	<2.3	<2.1	<2.1
hexane, n-	0.70	µg/m³	<0.70	1.97	<0.70	<0.70	<0.74	<0.70	<0.70	<0.70	<0.78	<0.70	<0.70
hexanone, 2-	4.10	µg/m³	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10	<4.10	<4.51	<4.10	<4.10
isopropylbenzene	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0
limonene	11	µg/m³	<11	235	<11	<11	<12	<11	<11	<11	<12	<11	<11
methyl ethyl ketone [MEK]	0.59	µg/m³	9.85	12.1	<0.59	6.10	2.36	0.88	0.65	1.36	0.82	1.36	<0.59
methyl isobutyl ketone [MIBK]	0.82	µg/m³	<0.82	1.31	<0.82	<0.82	<0.86	<0.82	<0.82	<0.82	<0.90	<0.82	<0.82
methyl-tert-butyl ether [MTBE]	0.72	µg/m³	<0.72	<0.72	<0.72	<0.72	<0.76	<0.72	<0.72	<0.72	<0.79	<0.72	<0.72
naphthalene	0.52	µg/m³	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.52	<0.58	<0.52	<0.52
pinene, alpha-	11	µg/m³	<11	<56	<11	<11	<12	<11	<11	<11	<12	<11	<11
propylene	0.34	µg/m³	5.20	23.7	<0.34	<12.7	<1.48	<1.10	<0.55	<1.26	<0.43	<1.10	<0.69
styrene	0.85	µg/m³	<0.85	1.11	<0.85	<0.85	<0.89	<0.85	<0.85	<0.85	<0.94	<0.85	<0.85
tetrachloroethane, 1,1,2,2-	1.4	µg/m³	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.5	<1.4	<1.4
tetrachloroethylene	1.4	µg/m³	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.4	<1.5	<1.4	<1.4
tetrahydrofuran	0.59	µg/m³	1.12	2.12	<0.59	<0.59	<0.62	<0.59	<0.59	<0.59	<0.65	<0.59	<0.59
toluene	0.38	µg/m³	2.56	3.81	1.73	0.64	3.62	1.96	<0.38	2.07	0.72	0.90	0.83
trichloro-1,2,2-trifluoroethane, 1,1,2- [Freon 113]	1.5	µg/m³	<1.5	<1.5	<1.5	<1.5	<1.6	<1.5	<1.5	<1.5	<1.7	<1.5	<1.5
trichlorobenzene, 1,2,4-	1.5	µg/m³	<1.5	<1.5	<1.5	<1.5	<1.6	<1.5	<1.5	<3.9	<1.6	<1.5	<1.5
trichloroethane, 1,1,1-	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.2	<1.1	<1.1
trichloroethane, 1,1,2-	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.2	<1.1	<1.1

Client Sample ID	Lowest Detection Limit	Units	Curing	Biofilter	Lagoons	Storage	Skate Park	Copper-field	Copperfield Sample 2	McKenzie Lift	Shepard Complex NE Fence Line	Landfill	Landfill Duplicate
trichloroethylene	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.1	<1.2	<1.1	<1.1
trichlorofluoromethane	1.1	µg/m³	<1.1	<1.1	<1.1	<1.1	<1.2	<1.1	<1.1	<1.1	<1.2	3.0	3.1
trimethylbenzene, 1,2,4-	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	2.1	<1.1	<1.0	<1.0
trimethylbenzene, 1,3,5-	1.0	µg/m³	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.0	<1.1	<1.0	<1.0
trimethylpentane, 2,2,4-	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9
vinyl acetate	1.8	µg/m³	<1.8	<1.8	<1.8	<2.4	<1.8	<1.8	<1.8	<1.8	<1.9	<1.8	<1.8
vinyl bromide	0.9	µg/m³	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<0.9	<1.0	<0.9	<0.9
vinyl chloride	0.51	µg/m³	<0.51	<0.51	<0.51	<0.51	<0.54	<0.51	<0.51	<0.51	<0.56	<0.51	<0.51
xylene, m+p-	0.87	µg/m³	1.22	2.52	<0.87	<0.87	<0.91	<0.87	<0.87	2.21	<0.96	<0.87	<0.87
xylene, o-	0.43	µg/m³	0.52	1.22	<0.43	<0.43	<0.43	<0.43	<0.43	0.82	<0.48	<0.43	<0.43
xylenes, total	1.0	µg/m³	1.7	3.7	<1.3	<1.3	<1.3	<1.3	<1.3	3.0	<1.4	<1.3	<1.3
BTEX, total	1.2	µg/m³	5.4	9.3	<2.4	<2.4	3.6	<2.4	<2.4	5.8	<2.7	<2.4	<2.4
Formaldehyde		Varies with sample flow	1.5	3.3	<DL	3.6	11	2.3	<DL	2.4	5.4	6.2	3.5
Acetaldehyde			5.9	11	<DL	3.4	9.8	1.4	<DL	1.7	9.5	5.6	3
Acrolein			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Acetone			34	67	2	7.6	9.9	4.3	<DL	<DL	12	11	8.3
Propionaldehyde			2.4	2.1	<DL	1.5	1	1.4	<DL	<DL	2.2	<DL	2.6
Butyraldehyde			7.8	20	<DL	1.9	6.4	1.3	<DL	<DL	2.2	3.1	2.4
Benzaldehyde			1	1.3	<DL	2	5.4	1.7	<DL	<DL	2.6	4.2	2.5
Valeraldehyde			<DL	<DL	<DL	2.2	8.4	1.2	<DL	<DL	2.2	3.4	1.8
Hexanal			1.9	1.7	<DL	4.1	1.6	2.9	<DL	<DL	3.5	8	4.8
Glycolic Acid			<DL	<DL	<DL	27	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Lactic acid			18	<DL	29	32	<DL	<DL	<DL	<DL	<DL	33	<DL

Client Sample ID	Lowest Detection Limit	Units	Curing	Biofilter	Lagoons	Storage	Skate Park	Copperfield	Copperfield Sample 2	McKenzie Lift	Shepard Complex NE Fence Line	Landfill	Landfill Duplicate
malonic acid			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
Fumaric acid			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
succinic acid			12	<DL	24	28	<DL	<DL	<DL	<DL	<DL	24	<DL
l-tartaric acid			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
citric acid			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
propionic acid			23	<DL	<DL	51	<DL	<DL	<DL	<DL	<DL	<DL	<DL
butyric acid			92	<DL	<DL	260	<DL	<DL	<DL	<DL	<DL	<DL	<DL
citric acid			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL
acetic acid			480	<DL	<DL	760	<DL	<DL	<DL	<DL	<DL	300	<DL
formic acid			<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL	<DL

Appendix C. Annual and Seasonal Windroses from Model Meteorology (2015 to 2019)

Figure C-1. Annual (January to December)

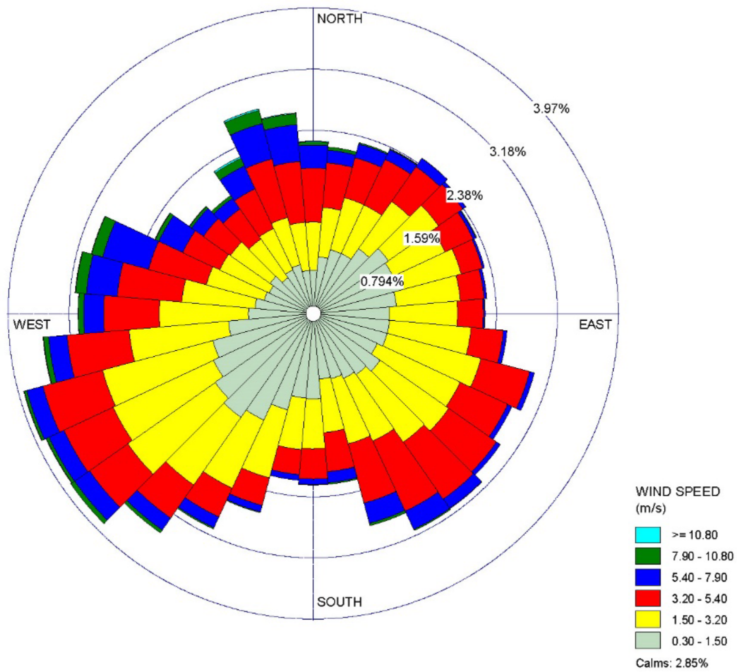


Figure C-2. Summer (June to August)

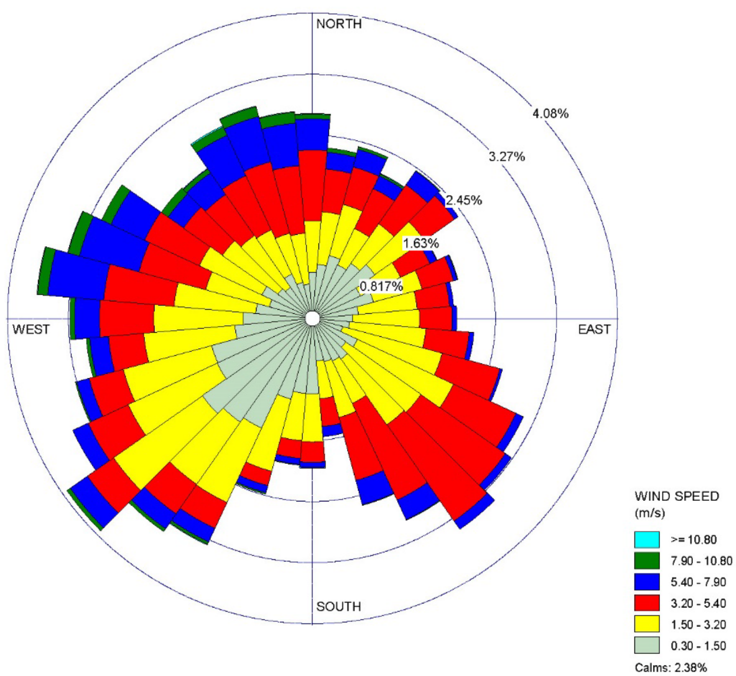
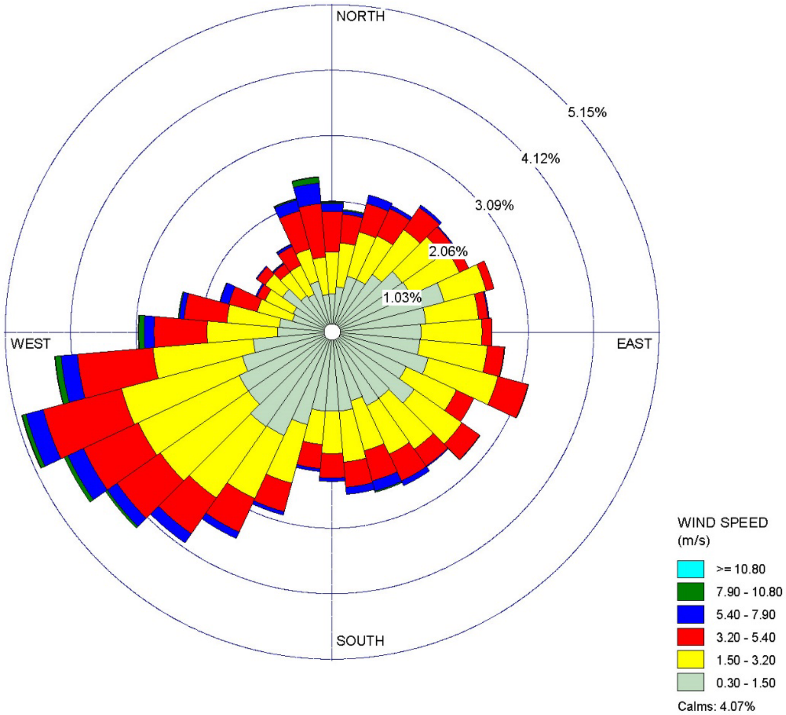


Figure C-3. Winter (December to February)



Appendix D. Odour Contour Maps (99.5 Percentile 10-minute Odour Unit Results)

The following figures all use the same contours as shown on the right of each figure and the same lateral extents for ease of comparison of relative impacts. All contours use the 99.5 percentile concentrations, and effective 10-minute averages. Percentile concentrations are derived from the full 5-year modelling period (i.e., the top 219 hourly concentrations over the 5-year period at each receptor were discarded, and the highest remaining effective 10-minute concentrations are shown in the contours).

Figure D-1. Composting Facility - All Sources

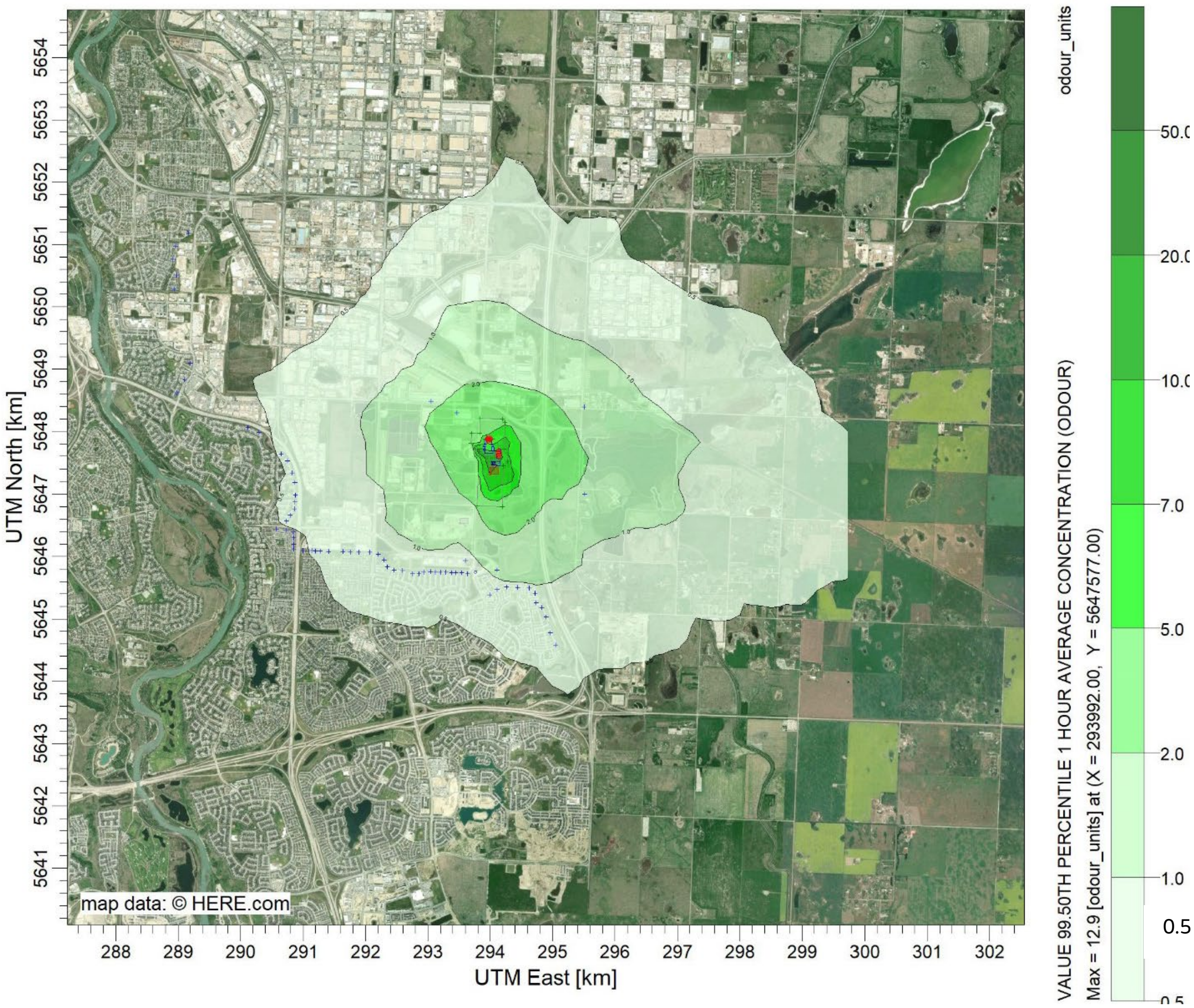


Figure D-2. Composting Facility - Biofilter Stacks

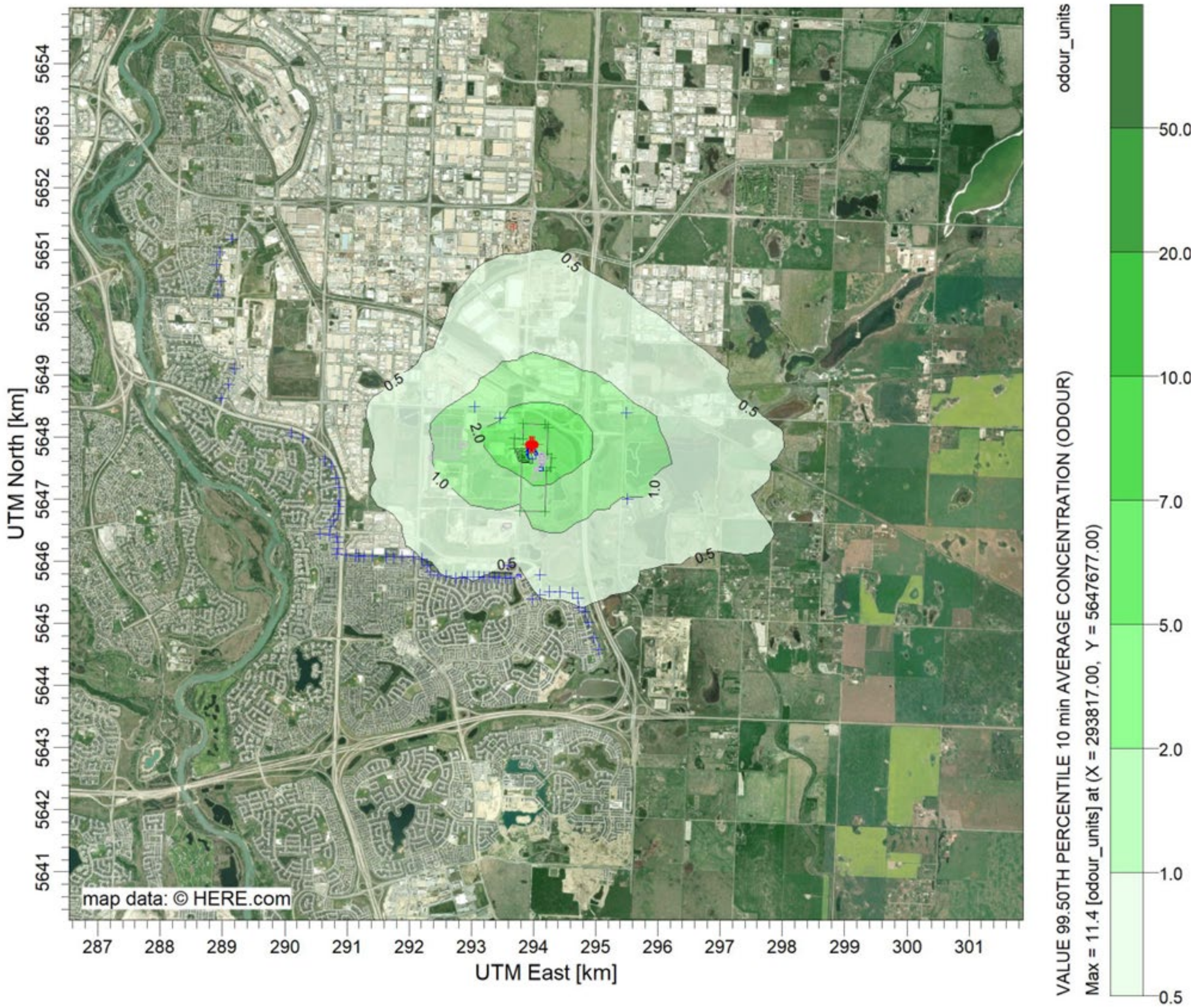


Figure D-3. Composting Facility - Curing Building

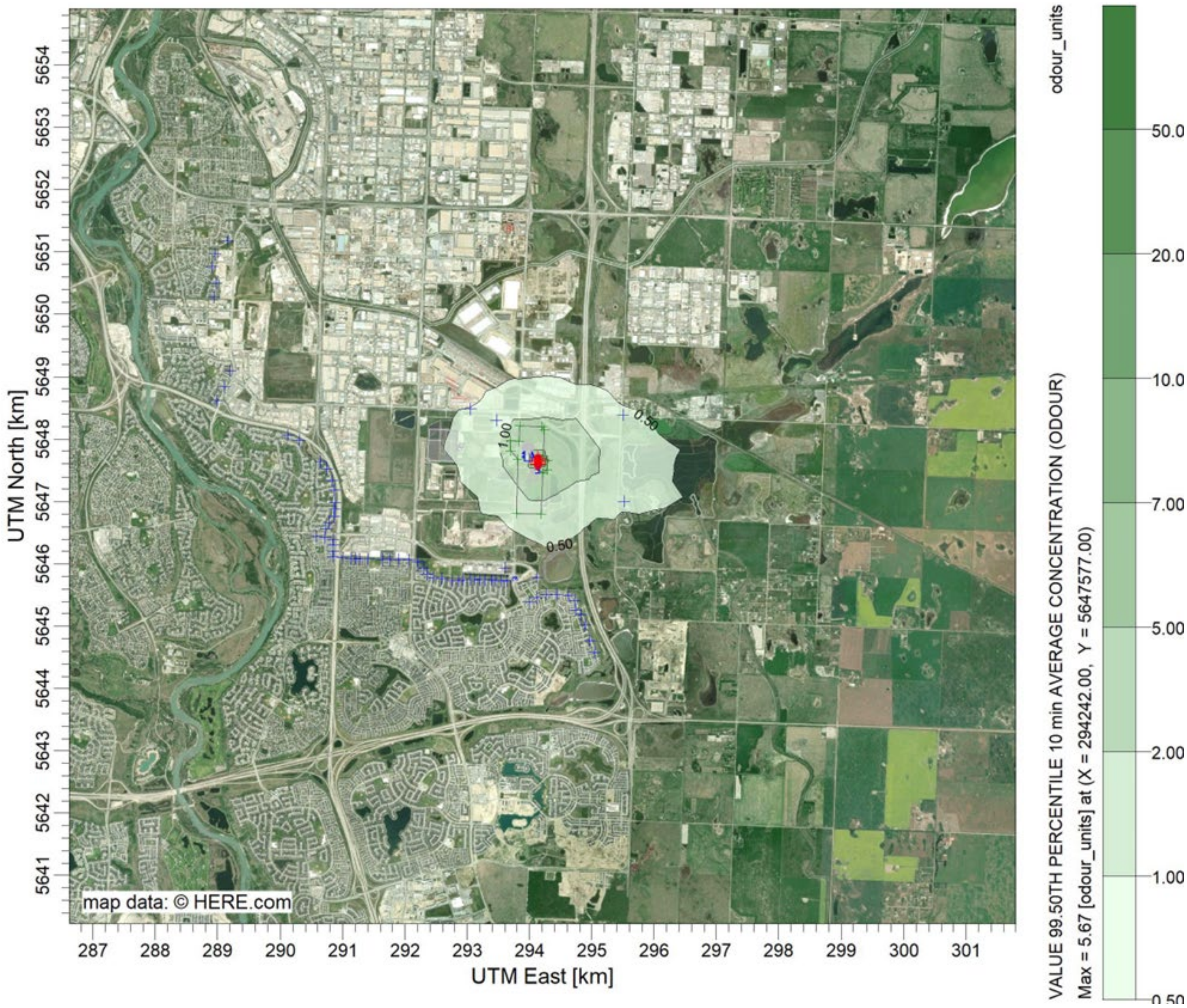


Figure D-4. Composting Facility - Compost Storage Area

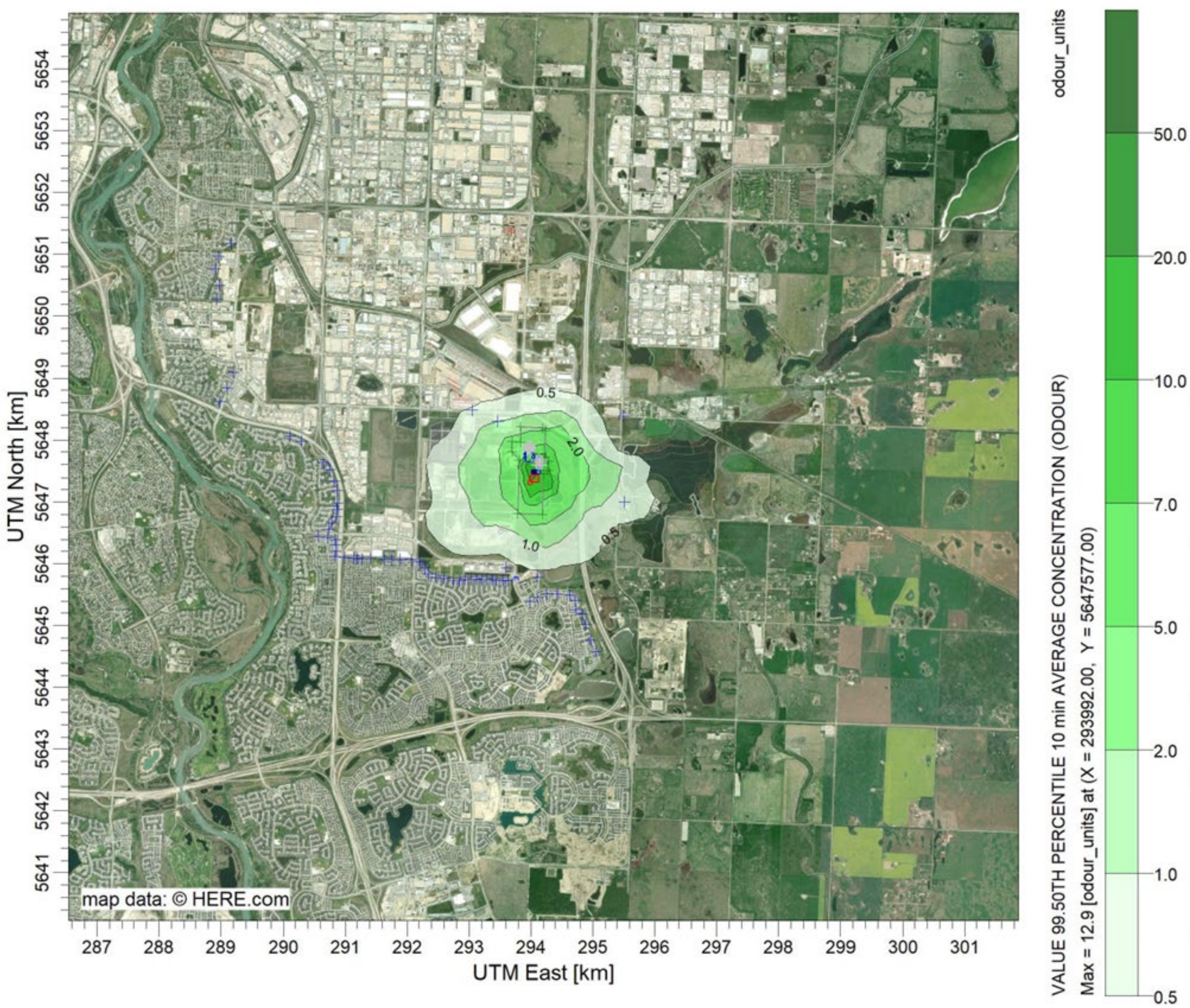


Figure D-5. East McKenzie Lift Station

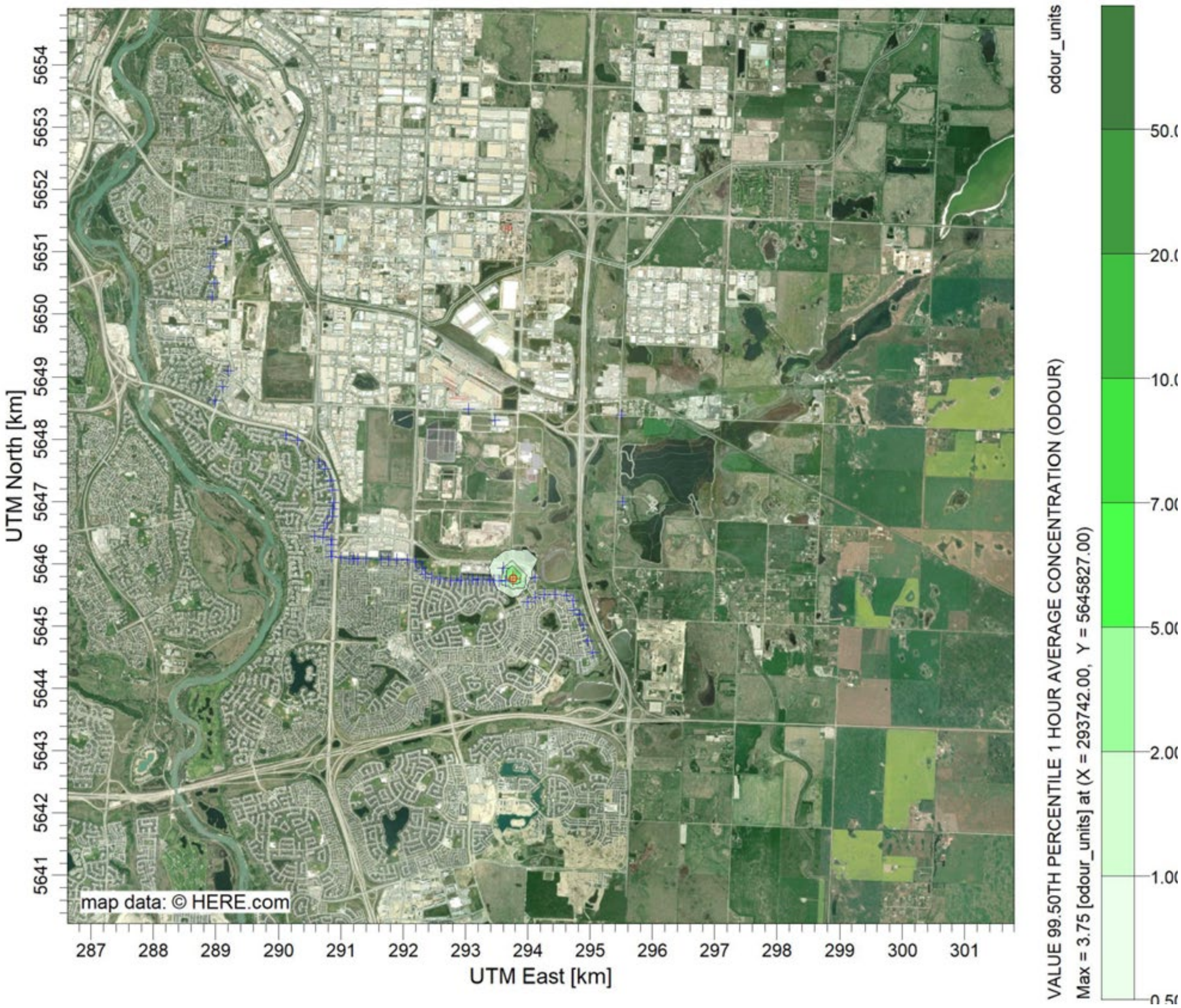


Figure D-6. Landfill Active Face

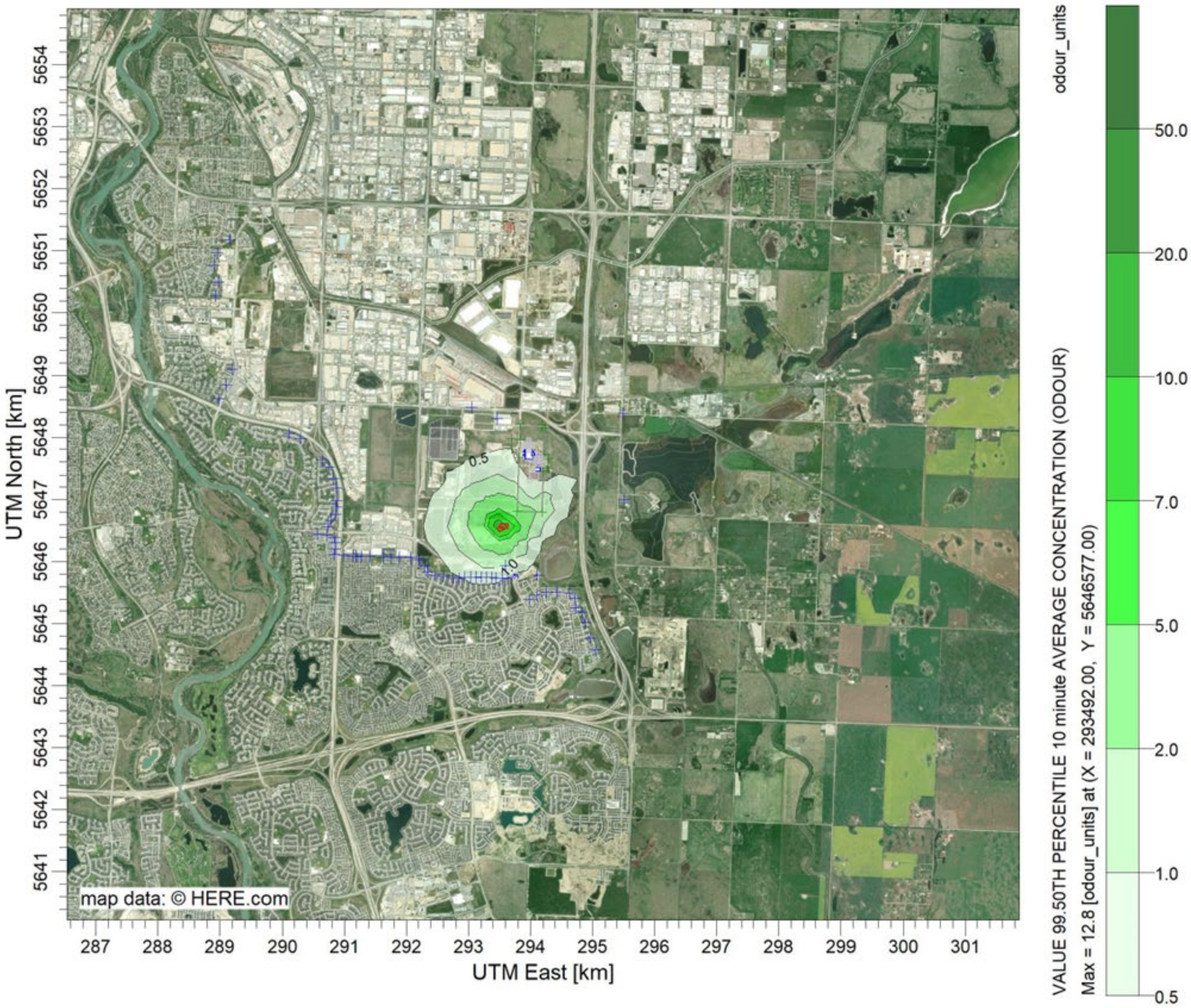


Figure D-7. Biosolids Lagoons

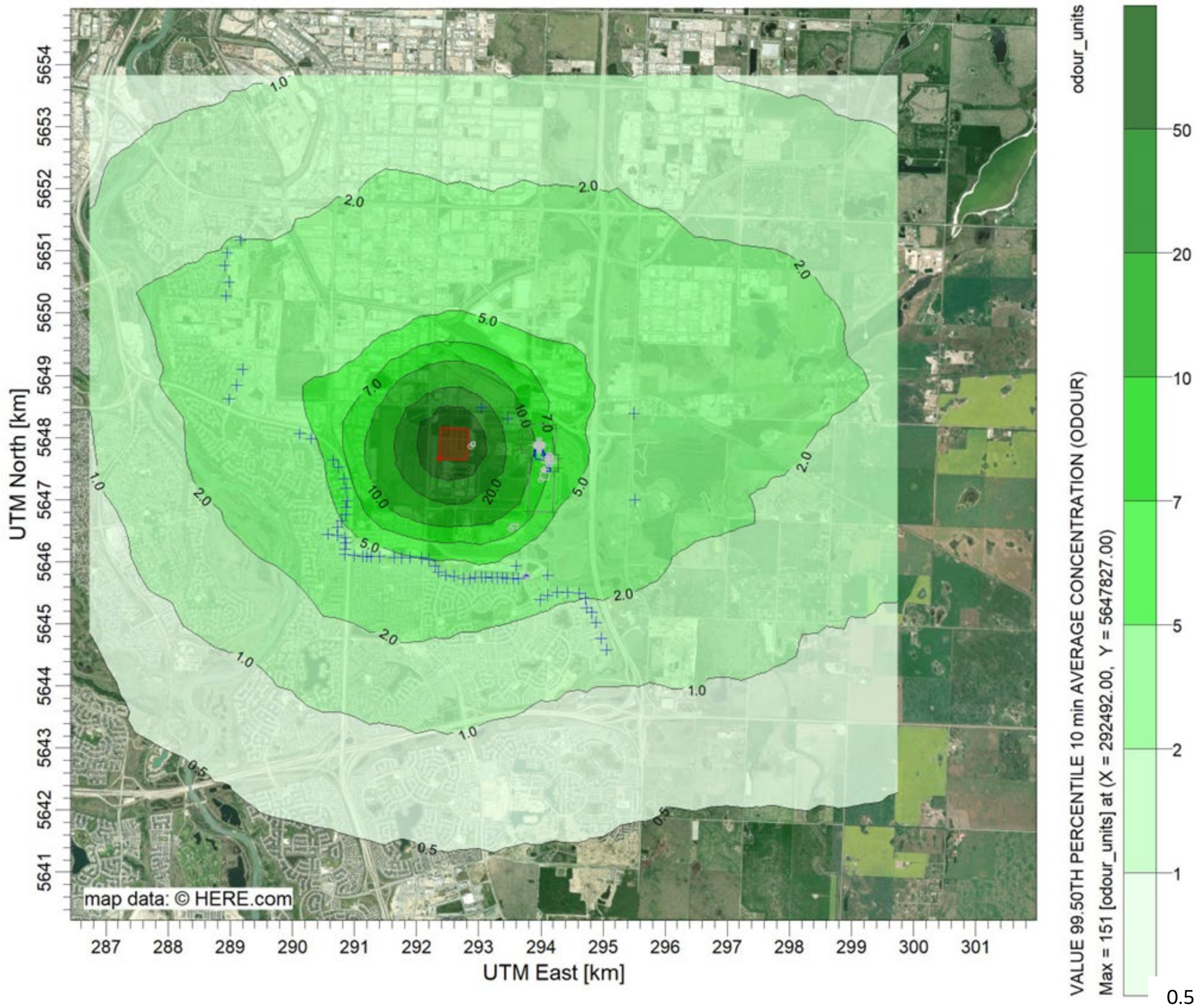
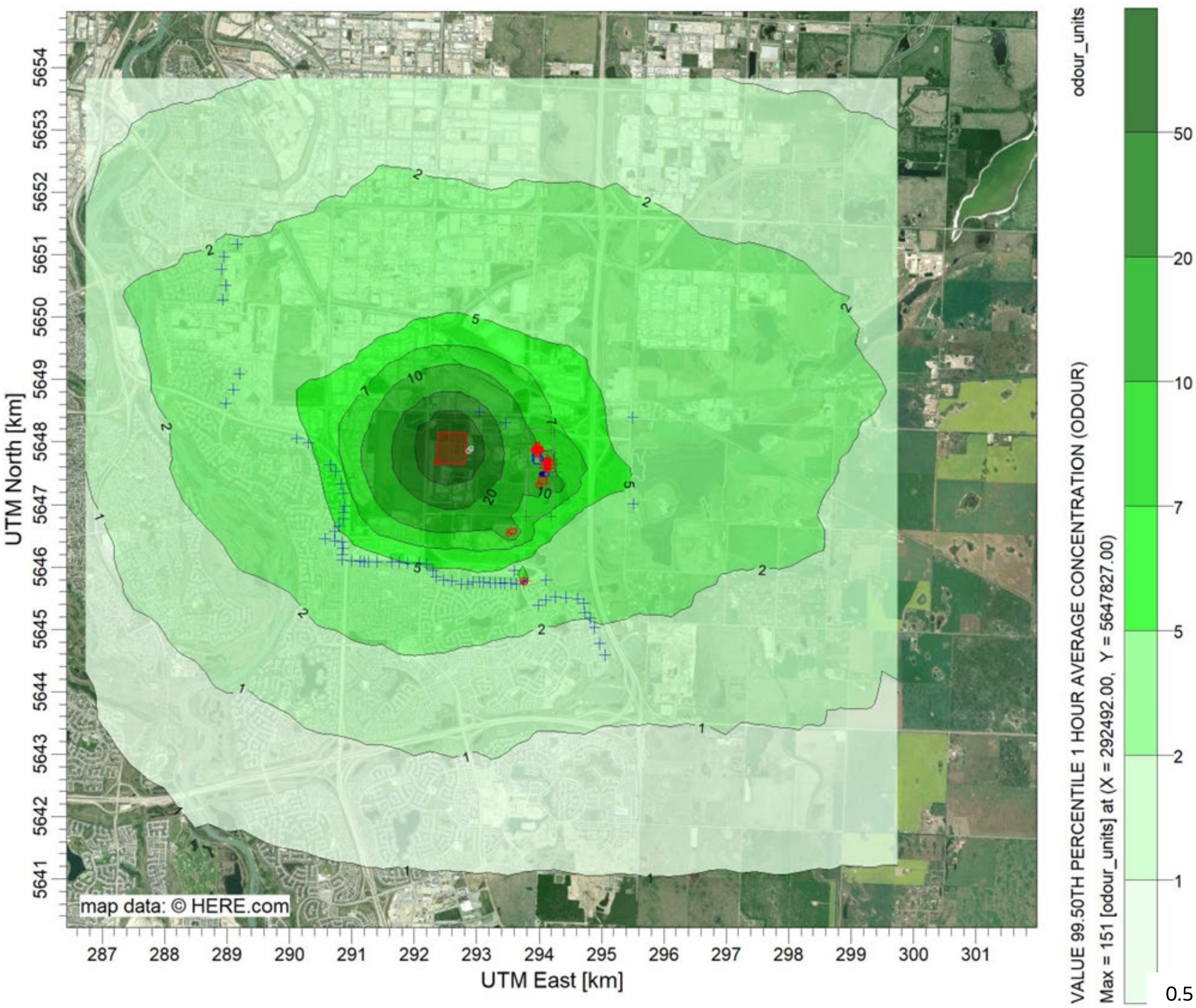
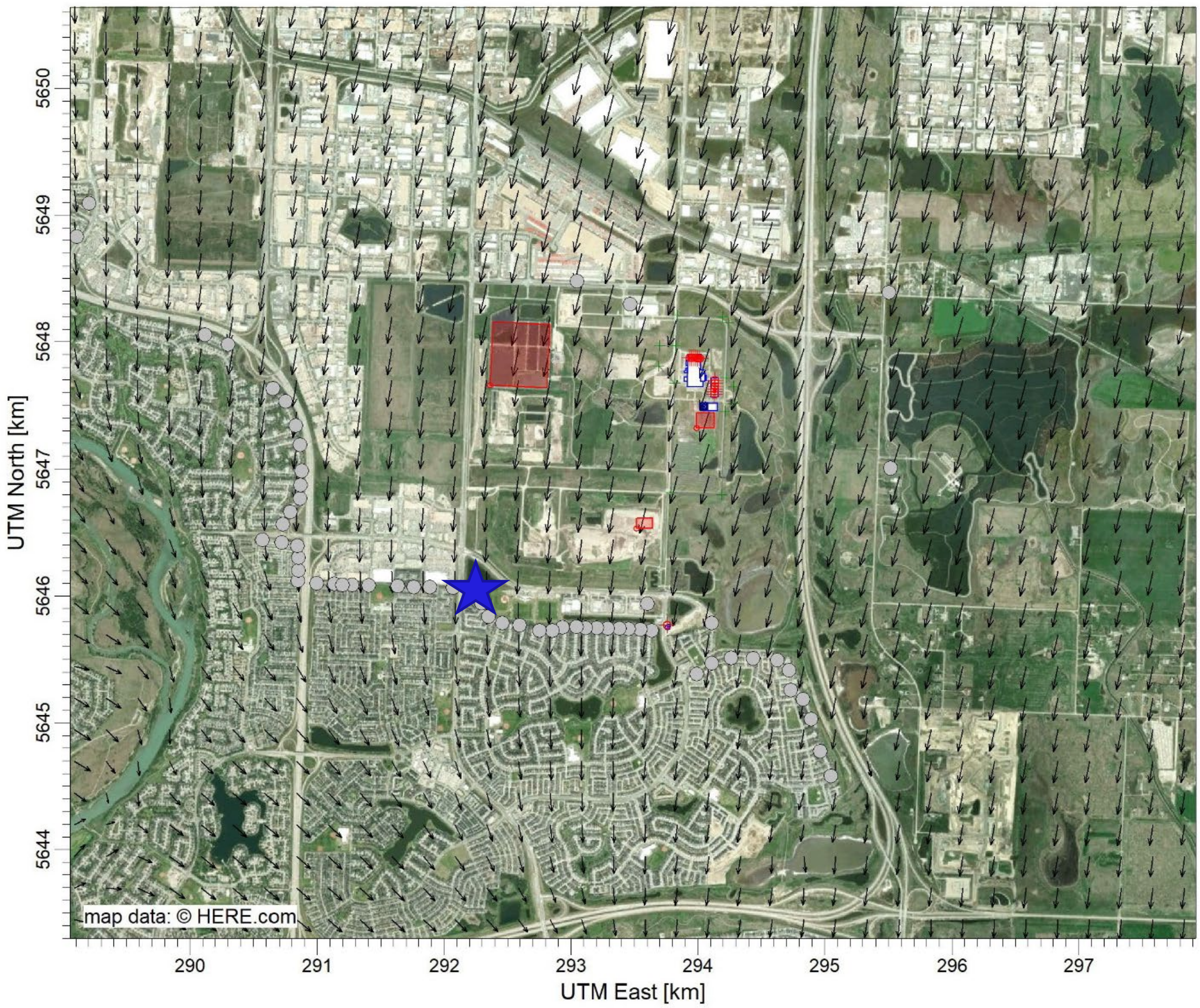


Figure D-8. All Modelled Sources



Appendix E. Top 20 Odour Concentrations at Select Residential Receptors

Figure E-1. Receptor SSE of 130 Avenue SE and 52 Street SE



Wind vectors shown correspond to the hour of the highest model predicted concentration.

Please note that Table E-1 and Table E-2 are the maximum 20 modelled concentrations over the 5-year period. The contours shown in Appendix D are 99.5 percentile values, meaning that the highest 219 hours over the 5-year period at each receptor are removed.

Table E-1. Top 20 Modelled Concentrations at Receptor SSE of 130 Avenue SE and 52 Street SE

Year	Day of Year	Hour	Odour Units	Wind Speed (m/s)	Wind Direction (degrees blowing from)	Temperature (Kelvin)	PG (atmospheric stability classification)
2019	246	2300	25.4	1.15	16.37	288.42	6
2016	303	2100	22.5	1.15	4.53	275.53	6
2015	219	2300	17.1	0.71	15.99	287.88	6
2015	212	0	15.4	1.57	4.37	287.1	6
2015	292	500	14.4	1.1	22.4	278.94	6
2015	273	2100	13.6	0.95	15.81	285.77	6
2016	273	200	13.4	1.52	7.73	276.4	6
2015	136	100	13.4	0.78	15.28	280.52	6
2016	273	300	13.3	1.2	8.73	276.46	6
2016	266	200	13.3	1.44	6.66	278.39	6
2016	266	300	13.2	1.75	4.78	277.71	6
2016	258	2200	13.1	0.68	349.27	288.22	6
2017	249	2200	12.5	1.12	13.02	290.83	6
2016	273	0	12.4	1.2	3.49	277.1	6
2019	190	0	12.4	1.12	16.45	284.16	6
2016	280	400	12.4	0.86	355.95	272.35	6
2016	258	2100	12.2	0.66	347.65	288.38	6
2017	129	2200	12.2	1.04	91.45	283.06	6
2018	172	100	11.89	0.9	34.76	287.65	6
2016	220	300	11.7	0.57	9.07	285.88	6

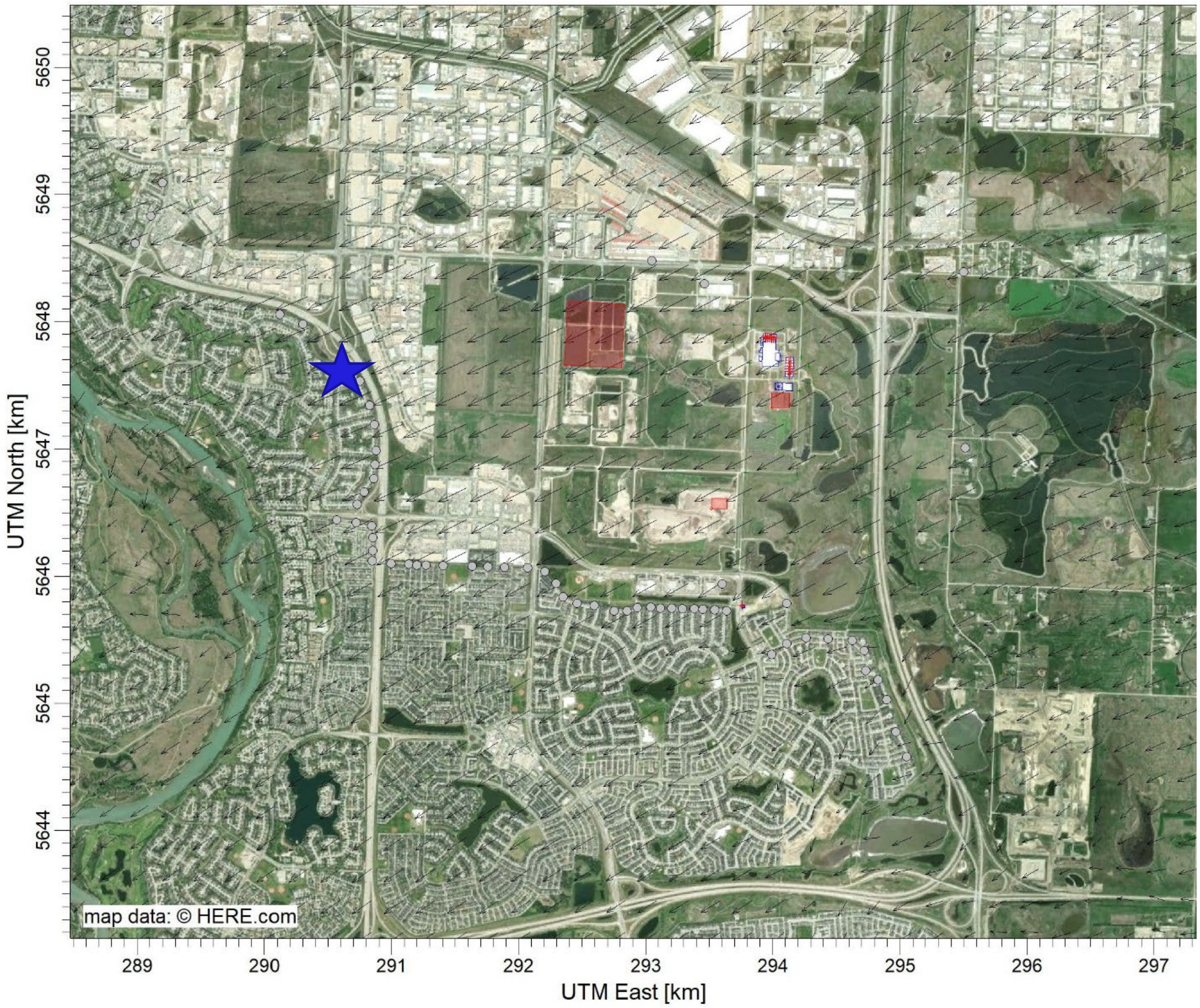
Wind Directions are the “blowing from” direction.

PG = Pasquill Gifford atmospheric stability classification [for example see: Hanna, S. R. et al, AMS Workshop on Stability Classification Schemes and Sigma Curves – Summary of Recommendations, Bulletin of the American Meteorological Society, Vol. 58, No. 12 (1977)].

PG=6 corresponds to a “stable” atmospheric stability

OU concentrations listed are the top 20 maximum concentrations at this receptor.

Figure E-2. Receptor Near Barlow Trail and Highway 2



Wind vectors shown correspond to the hour of the highest model predicted concentration.

Table E-2. Top 20 Modelled Concentrations at Receptor Near Barlow Trail and Highway 2

Year	Jday	Hour	Odour Units	Wind Speed (m/s)	Wind Direction (degrees blowing from)	Temperature (Kelvin)	PG (atmospheric stability classification)
2018	250	200	18.4	0.81	62.02	282.86	6
2015	124	300	18.3	1.28	87.91	276.05	6
2017	242	100	16.5	1.37	66.78	287.73	6
2017	242	400	15.9	1.05	56.33	285.54	6
2016	242	500	15.7	1.25	48.42	278.84	6
2015	298	100	15.0	1.06	55.06	272.84	6
2018	250	0	15.0	0.77	48.6	284.15	6
2018	172	200	14.4	1.02	60.42	286.74	6
2019	187	500	13.6	0.6	63.31	283.92	4
2017	224	400	13.3	1.12	42.57	286.43	6
2016	135	300	13.2	1.07	61.19	275.12	6
2015	279	500	13.0	.86	60.03	273.61	6
2018	277	200	13.0	0.53	45.35	267.8	4
2018	295	300	12.9	1.16	30.83	273.32	6
2015	289	200	12.5	0.81	73.5	274.3	6
2018	221	0	12.3	0.27	358.33	293.16	6
2015	289	400	12.2	0.76	68.93	274	6
2018	138	2300	12. 2	0.27	54.34	280.8	6
2018	211	0	12.0	0.54	53.32	289.99	6
2016	287	300	11.8	0.96	55.91	270.48	6

OU concentrations listed at the top 20 maximum concentrations at this receptor.

PG=6 corresponds to a “stable” atmospheric conditions

PG=4 corresponds to a “neutral” atmospheric conditions

Appendix F. Evaluated Mitigations Table and MODA Tables

Table F-1. Recommended Mitigations

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
General						
	Shut down all operations at the site and relocate to a location outside The City of Calgary limits away from sensitive receptors.			**Mitigation not evaluated as this would just move odour issue to another location. Additionally, it would have an incredibly high cost and have significant impact to operations.**		
	Install an "odour misting system" on the perimeter fence of the Shepard Complex.	Several odour misters along the periphery odour sources or between odour sources and residential areas.	▪ May be useful during period of low winds and warm temperatures ▪ Can be activated during periods of suspected elevated odour emissions	▪ Relatively high cost due to the large coverage area ▪ Maintenance may be an issue during cold(er) periods ▪ Misting nozzles will likely become clogged by dust ▪ Mist scent will not travel a sufficient distance to impact odours in neighbourhoods	▪ [38] ▪ Mildly Effective	▪ Low Cost
	Install a series of active odour monitoring sensors throughout the adjacent community and along the Shepard perimeter to gather real time odour data, similar to the system Edmonton installed around EWMC and Clover Bar WWTP (e.g., Airdar, Scentroid, with Aermod, or CALPUFF).	Several sensors that gather real time odour data, which can be used along with wind back trajectories to identify likely sources. Can be used along with future-casted winds to proactively identify periods of elevated impacts.	▪ Useful for better identifying odour sources ▪ Good track history of similar facilities using such technology	▪ Can be costly to procure, set up, maintain, and run ▪ Requires specialized knowledge to run, maintain, and interpret findings	▪ [42] ▪ Effective	▪ Very Low Cost
	The City should establish a process to regularly communicate with residents and other interested parties (i.e., Community Associations or similar) to increase knowledge of existing odour mitigation measures and any future plans/projects to reduce odours .	City employees would hold regular (3 to 4 times per year) town hall meetings: Educate the public on The City's operations and odours. ▪ Engage with stakeholders and solicit feedback. ▪ Organize tours and opportunities for residents/stakeholders to be heard ▪ Establish a chain of commitments, actions, results, and feedback.	▪ Can help gain trust with the public ▪ Can help the facility address root causes of odours ▪ Implements a response to the social aspect of odours ▪ High value ▪ If done correctly, will result in neighbourhood champions for the facility		▪ [50] ▪ Effective	▪ Very Low Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Surround site with trees or build a buffer or wall around the site to improve dispersion and reduce visibility to public.	Plant a tree buffer or a structural wall, with or without trees on top, can be constructed around the entire perimeter of the Shepard site. This would limit nuisance noise emissions in adjacent areas. The same type of enhanced turbulence is induced, improving dispersion.	▪ Likely increase turbulence of emitted odorous air and therefore increase dispersion	▪ Decrease in odour emanating from site may be modest	▪ [43] ▪ Effective	▪ Medium Cost
Biosolids Lagoons						
	Install a permeable cover over the lagoons.	A cover constructed of floating plastic blocks could be installed to limit wind induced turbulence. Installation of a cover would likely mandate a change to the sludge transfer system from cell to cell, as it would constrain or even eliminate the ability to place mobile pumps in the lagoons to convey thickened sludge from one cell to the other.	▪ Odour emissions would be reduced since surface turbulence would be lessened ▪ Facility could remain at its current location	▪ Moderately high cost ▪ Constrains the ability to transfer sludge from cell to cell using mobile equipment	▪ [45] ▪ Effective	▪ Medium Cost
	Install an impermeable cover over the lagoons.	A cover constructed of an impermeable material could be installed to capture emissions. The headspace would be exhausted to a waste gas burner, where the emitted gases would be combusted. Installation of a cover would mandate a change to the sludge transfer system from cell to cell, as it would eliminate the ability to place mobile pumps in the lagoons to convey thickened sludge from one cell to the other.	▪ Odour emissions would be eliminated because they would be captured by the cover and any gases that would be generated would be exhausted to a waste gas burner or odour control system. GHG emissions would be lowered because methane (emission factor = 17) would be converted to CO_2 and nitrogenous compounds would be converted to NOx	▪ High cost ▪ Likely would need to augment exhaust gases with natural gas to ensure flammability, which would increase O&M costs ▪ Eliminates the ability to transfer sludge from cell to cell using mobile equipment	▪ [43] ▪ Effective	▪ High Cost
	Improve and automate the existing misting system.	The current misting system is located along the western boundary of the lagoon site and is manually started during warmer days with a timer halting misting system operation (usually after 8 to 12 hours).Expanding the system, exploring the use of different masking agents, and automating its use would improve its ability to reduce odours in downwind areas.	▪ Odour emissions from the lagoons would be more effectively masked, especially during the periods of the day outside normal working hours at the lagoons ▪ Relatively low-cost solution	▪ Does not eliminate the odours, just masks them ▪ Slight disruption of existing operations during implementation	▪ [44] ▪ Effective	▪ Very Low Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Surround lagoons with trees.	The area around the lagoons is relatively barren. Planting trees around the site boundary reduces the visual impact of the lagoons and associated operations and induces turbulence at the boundary, which improves air dispersion.	▪ Odour emissions from the lagoons would be more effectively dispersed due to the natural barrier ▪ Visual impact of lagoons and lagoon-related operations would be reduced, which often lowers complaint numbers; it should be noted that the lagoons are really not visible from surrounding public areas ▪ Relatively low-cost solution ▪ No disruption of normal operations during implementation	▪ Does not eliminate the odours, just enhances dispersion	▪ [49] ▪ Effective	▪ Low Cost
	Build buffer wall around lagoons to improve dispersion.	Rather than plant a tree buffer, a structural wall can be constructed similar to the acoustic walls used along The City's major thoroughfares to limit nuisance noise emissions in adjacent areas. The same type of enhanced turbulence is induced, improving dispersion.	▪ Odour emissions from the lagoons would be more effectively dispersed due to the structural barrier ▪ Visual impact of lagoons and lagoon-related operations would be reduced, which often lowers complaint numbers ▪ Moderately low-cost solution ▪ No disruption of normal operations during implementation ▪ Concrete buffer wall can be built to desired size	▪ Does not eliminate the odours, just enhances dispersion	▪ [49] ▪ Effective	▪ Medium Cost
	Construct a system that would lower the concentration of odour-causing compounds in the biosolids stored at the Shepard Biosolids Lagoons.	Systems such as PAD are being considered at the Shepard Lagoon for other reasons but would also reduce odour emission potential. This potential is reduced because of the reduction in volatile solids obtained, the substantial reduction of nitrogenous compounds in the sludge and the elimination of sulphides that are present in anaerobically digested sludge (sulphides would still be generated in the lagoon environment).	▪ Odour emissions from the lagoons would be substantially reduced due to the transformation in sludge characteristics that would be achieved through a PAD process ▪ Synergies with the need to reduce recycle nitrogen and phosphorus loads that are transferred from the lagoons to the Bonnybrook WWTP ▪ Lowers the amount of biosolids (5 to 15 percent) that need to be managed through the volatile solids reduction achieved in the process ▪ Lowers GHG emissions from the lagoons	▪ Moderately costly option ▪ Increases operational requirements at the Shepard Biosolids Lagoons ▪ Slight disruption of normal operations during implementation	▪ [43] ▪ Effective	▪ High Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Add chemicals (ferric salts) to sludge before it gets to lagoons.		▪ With enough chemicals, sulphide evolution from lagoons could be limited to some degree ▪ Operation of the chemical system is relatively straightforward	▪ Not commonly done for sludge although common for wastewater ▪ Plans for differing phosphorus sequestration or recovery could be compromised ▪ Chemicals used for H_2S removal are highly acidic, thereby requiring special handling, isolation, and incorporation of other features to address safety concerns	▪ [34] ▪ Mildly Effective	▪ Medium Cost
Biosolid Storage Pad						
	Fully enclose the pad and provide treatment to exhaust air.	The pad could be enclosed within a building that was exhausted to an odour control facility. The building would not be weatherproof and would only provide containment of the working area. The odour control system would likely be an engineered media biofilter that would also be enclosed and exhausted in a way that enhanced dispersion (stack or up-draft high dispersion fan).	▪ Odours from the operation of the storage pad would be substantially reduced	▪ High cost ▪ Increases operational requirements at the Shepard Lagoons ▪ Would disrupt normal operations during implementation	▪ [39] ▪ Mildly Effective	▪ High Cost
	Change operations of pad to increase retention time on pad (to more than 2 weeks of laydown).		▪ Increasing retention time will lead to formation of "natural crust" that will reduce odours	▪ Change to existing operational practices may create space limitations on the pad	▪ [45] ▪ Effective	▪ Very Low Cost
Landfill						
	Install a portable misting system.	Install a movable misting system that can be activated when temperatures rise and wind direction points towards impacted neighbourhoods.	▪ Odour emissions from the active landfill tip face would be more effectively masked	▪ Does not eliminate the odours, just masks them	▪ [40] ▪ Effective	▪ Very Low Cost
	Use giant turbulence fans near the active face to disperse odours.	Giant fans were installed between Potrero Hills landfill, and nearby residents reacted positively to the addition.	▪ Cause some air mixing	▪ Costly ▪ Effective for the compounds causing issues?	▪ [38] ▪ Mildly Effective	▪ Very Low Cost
	Use movable walls to increase dispersion.	Use large movable walls to increase air dispersion.	▪ Cause some air mixing	▪ Could be cumbersome to move around multiple times a day as wind direction changes	▪ [44] ▪ Effective	▪ Very Low Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Cover the industrial liquid waste ponds to the west of lagoons (at the site boundary) and treat off gasses.	Verify, if possible, the odour source (via sampling). Determine what is being disposed of in these lagoons.	▪ Industrial waste ponds are close to southern residents	▪ Covers would be expensive ▪ A treatment system would be expensive ▪ Ponds are relatively small and unlikely to cause odours significant enough to justify the cost of a cover and treatment system	▪ [40] ▪ Mildly Effective	▪ Low Cost
	Verify that industrial liquid waste ponds to the west of the lagoons all have adequate aeration.	Verify through air sampling whether these lagoons are creating odours.	▪ Can be done using a portable handheld hydrogen sulphide meter ▪ A permanent meter can be installed that controls aerators to improve oxygenation in the ponds	▪ Would require additional time to perform monitoring ▪ Energy costs and maintenance requirements would increase	▪ [38] ▪ Mildly Effective	▪ Study Cost
	Review types of waste allowed to be disposed of at the landfill and eliminate odorous waste types.	Complete review of all waste types received at the landfill to identify those that may generate odours; then, discuss impacts if these waste types were no longer accepted.	▪ Easy to accomplish using scale data	▪ Possible revenue loss ▪ Customer dissatisfaction	▪ [53] ▪ Highly Effective	▪ Study Cost
East McKenzie Lift Station						
	Upgrade or replace the current ultraviolet odour control system.	Install an activated carbon unit to remove odorous air from wet well area.	▪ Carbon unit will likely control odour better than the current ultraviolet unit	▪ Higher O&M costs	▪ [49] ▪ Effective	▪ Low Cost
Composting Facility – Outdoor Finished Storage Area						
	Fully enclose the entire Finished Compost Storage Area to achieve negative pressure, and vent process air through biofilter.	As was previously recommended, the finished material storage pad could be covered with a fabric building, similar to what is currently in place. The building could be placed under negative aeration and airflows directed to a biofilter.	▪ Large volume of finished material would be odour controlled	▪ Expensive to cover the whole finished area ▪ Add additional need for biofilter media which has already been difficult to acquire ▪ Additional O&M cost to run blowers and replace biofilter media	▪ [43] ▪ Effective	▪ Extremely High Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Limit the amount of finished material stored on the pad.	This can be accomplished in several ways or a combination of ways: 1. Finished material would be moved to an area nearer to most end users, preferably several kilometers away from residents and homes. 2. Material currently stored on the finished pad that is being held for customers would need to be taken at the time the material is ordered. 3. Use of the finished pad to store overs would no longer be allowed. 4. Limit the available space for finished material storage to the concrete pad and building.	▪ Would be a low capital option ▪ Would remove the material with the highest volume onsite to an offsite location away from residents ▪ Overs disposal would occur regularly rather than in large chunks ▪ Land south of the concrete pad and building could be used for additional purposes	▪ Would require a change in customer behaviour, as they would have to modify their operations to adjust to any change in how the finished product is stored at the site ▪ Peak production times and peak usage times do not always align ▪ Would likely increase O&M to transport material offsite or to dispose of overs more regularly, or both	▪ [58] ▪ Extremely Effective	▪ Very Low Cost
	Confirm Standard Operating Procedures are in place to avoid turning material or loading out trucks when wind is blowing toward residents.	Verify that the operations plan includes procedures for considering wind direction and timing prior to handling material outdoors.	▪ Altering the schedule for when materials are handled on the storage pad should not affect flexibility ▪ Thoughtful finished material handling will still be applicable at any capacity ▪ Likely result in less dust creation thereby reducing "visual odours"	▪ There are odours on the finished storage pad when material is not being handled, and most odour complaints arise in the evenings when screening and loading are not occurring ▪ Not likely to reduce odour complaints significantly	▪ [54] ▪ Highly Effective	▪ Study Cost
Composting Facility – Curing Building						
	Fix floor aeration issues.	Aeration floor in curing building is clogged or plugged to the point that air is not likely flowing through the system.	▪ Would improve compost process and likely result in more mature and aerobic compost ▪ More mature and stable compost placed on the storage pad	▪ Will likely result in significant changes to the floor, grates, and the blowers	▪ [53] ▪ Highly Effective	▪ Low Cost
	Increase time in curing; and turn windrows regularly and optimize moisture.	Material monitored during summer 2022 was found to be dry and relatively inactive. Moisture conditioning should be adjusted seasonally. In the absence of fixing the aeration floor, the piles should be turned more frequently to provide an injection of air.	▪ More time in curing under better aeration should result in better maturity and stability prior to moving material outdoors to the finished pad	▪ Will require additional labour and material management	▪ [59] ▪ Extremely Effective	▪ Very Low Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Change building envelope to be under negative pressure.	Place the building under negative aeration, and route air through a biofilter (such as organic or BioREM) to treat odours to scrub off gas from the building.	▪ Odours from building will be controlled or mitigated	▪ Will result in additional biofilter maintenance	▪ [53] ▪ Highly Effective	▪ Medium Cost
	Improve the operations within the Curing Building with the goal of producing a more mature and stable product before it is screened and sent to Finished Compost Pad.	Determine optimal pile size and spacing that will allow for more time in the curing building while being sized to the mass bed turner. Obtain aa vendor quote for purchasing a larger mass bed turner. Perform an evaluation of labour resources and determine if sufficient people are available to perform operations, maintenance, and housekeeping tasks as required.	▪ Low cost/low effort option ▪ Would result in reduced "visual odours"	▪ None	▪ [62] ▪ Extremely Effective	▪ Very Low Cost
	Flip curing fans to positive aeration. Capture off gas from the building and treat it in an air pollution control device (such as a biofilter or carbon filter).	The in-floor aeration in the Curing Building is currently ineffective and slats are getting clogged. Air in the Curing Building is currently being off-gassed without treatment.	▪ Aerating material in the curing building should improve material stability and maturity prior to moving the material to the storage pad ▪ The odours being off-gassed from the curing building will be treated and mitigated significantly	▪ Will result in an increase in maintenance on the treatment system and to maintain the floor	▪ [55] ▪ Highly Effective	▪ Medium Cost
Composting Facility – Biofilter						
	Add stack height or other roof-mounted fans to increase dispersion.	Increasing stack height or increasing exit velocity will reduce odour impacts by increasing initial buoyancy of emitted air.	▪ Simple solution to install ▪ Can add dilution air with dispersion fans along with increasing stack height to gain significant dispersion improvement	▪ Higher stack height may have visual impacts	▪ [54] ▪ Highly Effective	▪ Very Low Cost
	Add biochar to biofilter media mixture.	Adding small percentage of biochar will absorb odours and improve overall effectiveness.	▪ Simple to add when changing out media	▪ Life of char unknown: once saturated, performance may once again decline	▪ [42] ▪ Effective	▪ Very Low Cost
	Add carbon treatment of air after existing biofilter.	Add carbon vessels to capture existing biofilter building exhaust. This will require a higher-pressure fan to maintain flow through double system.	▪ Will remove odorous compounds in exhaust that the biofilter by itself will not remove	▪ Adds complexity and additional system to monitor ▪ Media change out frequency will be more frequent than biofilter media changeout cycles	▪ [44] ▪ Effective	▪ Medium Cost

Odour Source	Possible Mitigation	Detailed Description of Possible Mitigation	Pros	Cons	Effectiveness Extremely Effective (58 – 70 points) Highly Effective (51 – 57 points) Effective (41 – 50 points) Mildly Effective (31 – 40 points) Ineffective (0 – 30 points)	Estimated Cost Extremely Costly (more than $30 M) High Cost ($15 to 30 M) Medium Cost ($8 to 15 M) Low Cost ($2 to 8 M) Very Low Cost (less than $2.0 M) Study Cost (implementation of recommendation may add significant cost)
	Increase frequency of biofilter media replacement.	Replace with 100% fresh media every 2 years maximum or when performance degrades due to higher headloss or more surface emissions.	▪ This is standard practice and should be performed without fail	▪ None	▪ [50] ▪ Effective	▪ Low Cost
	Replace existing biofilter with other air pollution mitigation technologies (such as granular activated carbon).	This will provide better overall odour removal performance. A redesign of the exhaust air distribution piping is needed, as well as possibly changing out fans.	▪ Will reduce overall size of odour control footprint	▪ Media replacement will be more frequent that biofilter media	▪ [49] ▪ Effective	▪ High Cost
	Investigate the use of inorganic biofilter media or modified organic media.	This will provide better overall odour removal performance in a smaller footprint. A redesign of the exhaust air distribution piping is needed, as well as possibly changing out fans.	▪ Will reduce overall size of odour control footprint ▪ Media has much longer life than organic media, so much less frequent media replacement is possible (minimum 10 years, and possibly as much as 20 years)	▪ None	▪ [46] ▪ Effective	▪ Study Cost
	Performance of biofilter could be improved and performance should be evaluated by establishing a rigorous biofilter performance monitoring program which would include developing a comprehensive set of data and benchmarks against which to evaluate the efficiency and function of the biofilter. (effective, low cost)	Determine evaluation criteria, frequency, and methodology. Investigate chemical levels in the biofilter and leachate storage room by establishing investigation and sampling protocols.	▪ Simple to do ▪ Adds much more definition of biofilter performance throughout the various cells and will allow for identifying poor performance areas faster than an overall sampling at the stacks ▪ Could identify quick operational fixes based on findings	▪ Added labour to collect and analyze data	▪ [56] ▪ Highly Effective	▪ Very Low Cost

Table F-2. General Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	Scores (1 to 5, 5 is best): 1. Shut down and relocate all operations.	2. Install odour misting along Shepard perimeter.	3. Install a series of active odour monitoring sensors throughout adjacent community and along the Shepard perimeter to gather real time odour data.	4.The City should establish a process to regularly communicate with residents and other interested parties i.e., Community Associations etc. in order to increase knowledge of existing odour mitigation measures and any future plans/projects to reduce odours	5.Construct a buffer or wall around site to improve dispersion.
Functional Performance								
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale		3.0	4.0	5.0	4.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area		3.0	1.0	1.0	3.0
Implementation								
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes		3.0	3.0	2.0	3.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)		3.0	3.0	3.0	2.0
Operations and Maintenance								
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis		4.0	3.0	3.0	5.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity		3.0	3.0	4.0	4.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both		3.0	4.0	5.0	3.0
Social and Community								
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation		3.0	4.0	4.0	3.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years		2.0	3.0	4.0	3.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas		2.0	2.0	3.0	3.0
Resource Efficiency								
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption		2.0	2.0	4.0	2.0

Evaluation Criteria	Measurement Scales			Scores (1 to 5, 5 is best)				
	Best Outcome	Medium Outcome	Worst Outcome	1. Shut down and relocate all operations.	2. Install odour misting along Shepard perimeter.	3. Install a series of active odour monitoring sensors throughout adjacent community and along the Shepard perimeter to gather real time odour data.	4.The City should establish a process to regularly communicate with residents and other interested parties i.e., Community Associations etc. in order to increase knowledge of existing odour mitigation measures and any future plans/projects to reduce odours	5.Construct a buffer or wall around site to improve dispersion.
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities		2.0	4.0	5.0	3.0
Environmental								
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities		2.0	3.0	3.0	2.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration		3.0	3.0	4.0	3.0
			Sum		38.0	42.0	50.0	43.0

Notes:
The City = The City of Calgary
CO_2 = carbon dioxide
GHG = greenhouse gas

Table F-3. Shepard Biosolids Lagoons Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	1. Install permeable cover over lagoons.	2. Install impermeable cover over lagoons.	3. Improve and automate existing misting system.	4. Surround lagoons with trees.	5. Build buffer/wall around lagoons to improve dispersion.	6. Construct system that would lower the concentration of odour-causing compounds in the biosolids stored at the Shepard Biosolids Lagoons.	7. Add chemicals (ferric salts) to sludge before it gets to lagoons.
Functional Performance										
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	3.0	4.0	3.0	4.0	4.0	5.0	2.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	3.0	5.0	3.0	3.0	3.0	4.0	4.0
Implementation										
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	2.0	2.0	4.0	4.0	4.0	4.0	2.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	4.0	4.0	3.0	3.0	3.0	3.0	3.0
Operations and Maintenance										
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	4.0	3.0	5.0	5.0	5.0	2.0	3.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	2.0	2.0	3.0	4.0	4.0	2.0	3.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	4.0	2.0	3.0	5.0	5.0	3.0	2.0
Social and Community										
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	3.0	3.0	3.0	3.0	3.0	2.0	3.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	3.0	2.0	3.0	2.0	3.0	1.0	3.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	3.0	2.0	3.0	2.0	3.0	3.0	3.0

Evaluation Criteria	Measurement Scales: Best Outcome	Medium Outcome	Worst Outcome	1. Install permeable cover over lagoons.	2. Install impermeable cover over lagoons.	3. Improve and automate existing misting system.	4. Surround lagoons with trees.	5. Build buffer/wall around lagoons to improve dispersion.	6. Construct system that would lower the concentration of odour-causing compounds in the biosolids stored at the Shepard Biosolids Lagoons.	7. Add chemicals (ferric salts) to sludge before it gets to lagoons.
Resource Efficiency										
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	3.0	3.0	3.0	3.0	3.0	4.0	2.0
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	3.0	3.0	2.0	3.0	3.0	4.0	1.0
Environmental										
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	4.0	5.0	2.0	3.0	3.0	4.0	2.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	4.0	3.0	4.0	5.0	3.0	2.0	1.0
			Sum	45.0	43.0	44.0	49.0	49.0	43.0	34.0

Notes:
The City = The City of Calgary
CO_2 = carbon dioxide
GHG = greenhouse gas
H_2S = hydrogen sulphide
PAD = post aerobic digestion
WWTP = wastewater treatment plant

Table F-4. Biosolids Storage Pad Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	1 Fully enclose the pad, and provide treatment to exhaust air.	2. Change operations of pad to increase retention time on pad (greater than 2 weeks laydown)
Functional Performance					
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	4.0	3.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	4.0	2.0
Implementation					
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	3.0	3.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	2.0	3.0
Operations and Maintenance					
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	2.0	3.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	2.0	4.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	3.0	4.0
Social and Community					
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	3.0	3.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	2.0	4.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	5.0	4.0
Resource Efficiency					
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	2.0	3.0
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	2.0	3.0
Environmental					
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	2.0	3.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	3.0	3.0
			Sum	39.0	45.0

Notes:
CO_2 = carbon dioxide
GHG = greenhouse gas

Table F-5. Landfill Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	Scores (1 to 5, 5 is best): 1. Install portable misting system.	2. Use giant turbulence fans near active face to disperse odours.	3. Provide movable walls to increase dispersion.	4. Provide industrial liquid waste ponds to the west of lagoons (site boundary); cover and treat off gasses.	5. Provide industrial liquid waste ponds to the west of lagoons; ensure all have adequate aeration in them.	6. Review types of waste allowed to be disposed of at landfill, and eliminate odorous waste types.
Functional Performance									
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	3.0	3.0	3.0	4.0	3.0	4.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	3.0	3.0	3.0	4.0	3.0	3.0
Implementation									
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	3.0	3.0	3.0	3.0	3.0	3.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	3.0	3.0	3.0	3.0	3.0	4.0
Operations and Maintenance									
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	3.0	3.0	4.0	2.0	2.0	4.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	3.0	3.0	4.0	2.0	2.0	4.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	3.0	3.0	3.0	3.0	3.0	4.0
Social and Community									
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	3.0	2.0	3.0	3.0	3.0	4.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	3.0	3.0	3.0	3.0	3.0	4.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	3.0	2.0	3.0	4.0	3.0	4.0
Resource Efficiency									
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	3.0	2.0	3.0	2.0	2.0	4.0

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	Scores (1 to 5, 5 is best): 1. Install portable misting system.	2. Use giant turbulence fans near active face to disperse odours.	3. Provide movable walls to increase dispersion.	4. Provide industrial liquid waste ponds to the west of lagoons (site boundary); cover and treat off gasses.	5. Provide industrial liquid waste ponds to the west of lagoons; ensure all have adequate aeration in them.	6. Review types of waste allowed to be disposed of at landfill, and eliminate odorous waste types.
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	2.0	3.0	3.0	2.0	3.0	5.0
Environmental									
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	2.0	2.0	3.0	2.0	2.0	3.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	3.0	3.0	3.0	3.0	3.0	3.0
			Sum	40.0	38.0	44.0	40.0	38.0	53.0

Notes:

CO_2 = carbon dioxide

GHG = greenhouse gas

Table F-6. East McKenzie Lift Station Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	Scores (1 to 5, 5 is best): 1. Upgrade or replace current UV odour control system.
Functional Performance				
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	4.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	5.0
Implementation				
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	4.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	5.0
Operations and Maintenance				
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	2.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	2.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	4.0
Social and Community				
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	3.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	3.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	4.0
Resource Efficiency				
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	3.0
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	3.0
Environmental				
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	3.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	4.0
			Sum	49.0

Notes:
CO_2 = carbon dioxide
GHG = greenhouse gas
UV = ultraviolet

Table F-7. Composting Facility Outdoor Storage Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Measurement Scales: Medium Outcome	Measurement Scales: Worst Outcome	Scores (1 to 5, 5 is best): 1. Fully enclose the entire Finished Compost Storage Area to achieve negative pressure, and vent process air through biofilter.	Scores: 2. Limit the amount of finished material stored on the pad.	Scores: 3. Confirm SOP is in place to avoid turning material or loading out trucks when wind is blowing toward residents.
Functional Performance						
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	5.0	5.0	3.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	5.0	4.0	2.0
Implementation						
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	3.0	5.0	5.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	3.0	4.0	5.0
Operations and Maintenance						
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	4.0	5.0	4.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	2.0	5.0	5.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	4.0	5.0	5.0
Social and Community						
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	3.0	3.0	4.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	2.0	5.0	5.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	5.0	5.0	4.0
Resource Efficiency						
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	1.0	3.0	3.0
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	2.0	3.0	3.0
Environmental						
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	1.0	3.0	3.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	3.0	3.0	3.0
			Sum	43.0	58.0	54.0

Notes:
CO_2 = carbon dioxide
GHG = greenhouse gas
SOP = standard operating procedure

Table F-8. Composting Facility Curing Building Recommendations Scoring Evaluation

Evaluation Criteria	Measurement Scales: Best Outcome	Medium Outcome	Worst Outcome	Scores (1 to 5, 5 is best): 1. Fix floor aeration issues.	2. Increase time in curing, and turn windrows regularly and optimize moisture.	3. Change building envelope to be under negative pressure.	4. Improve the operations within the Curing Building with the goal of producing a more mature and stable product before it is screened and sent to Finished Compost Pad.	5. Flip curing fans to positive aeration, and capture off gas from building and treat in air pollution control device (such as biofilter or carbon filter).
Functional Performance								
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	5.0	5.0	5.0	5.0	5.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	3.0	3.0	4.0	4.0	5.0
Implementation								
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	5.0	5.0	5.0	5.0	5.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	3.0	2.0	5.0	5.0	5.0
Operations and Maintenance								
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	3.0	5.0	3.0	5.0	4.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	3.0	5.0	3.0	5.0	3.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	5.0	5.0	5.0	5.0	4.0
Social and Community								
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	3.0	3.0	3.0	3.0	3.0

Evaluation Criteria	Measurement Scales			Scores (1 to 5, 5 is best)				
	Best Outcome	Medium Outcome	Worst Outcome	1. Fix floor aeration issues.	2. Increase time in curing, and turn windrows regularly and optimize moisture.	3. Change building envelope to be under negative pressure.	4. Improve the operations within the Curing Building with the goal of producing a more mature and stable product before it is screened and sent to Finished Compost Pad.	5. Flip curing fans to positive aeration, and capture off gas from building and treat in air pollution control device (such as biofilter or carbon filter).
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	3.0	5.0	1.0	5.0	1.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	4.0	5.0	5.0	4.0	5.0
Resource Efficiency								
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	3.0	3.0	2.0	3.0	2.0
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	5.0	5.0	5.0	5.0	3.0
Environmental								
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	3.0	3.0	2.0	3.0	5.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	5.0	5.0	5.0	5.0	5.0
			Sum	53.0	59.0	53.0	62.0	55.0

Notes:
CO_2 = carbon dioxide
GHG = greenhouse gas

Table F-9. Composting Facility Biofilter Recommendations Scoring Evaluation

Evaluation Criteria	Best Outcome	Medium Outcome	Worst Outcome	1. Add stack height or other roof mounted fans to increase dispersion.	2. Add biochar to biofilter media mixture.	3. Add carbon treatment of air after existing biofilter.	4. Increase frequency of biofilter media replacement.	5. Replace existing biofilter with other air pollution mitigation technologies (e.g., GAC).	6. Investigate use of inorganic biofilter media or modified organic media.	7. Performance of biofilter could be improved and performance should be evaluated by establishing a rigorous biofilter performance monitoring program which would include developing a comprehensive set of data and benchmarks against which to evaluate the efficiency and function of the biofilter.
Functional Performance										
1.1 Proven performance	Option has, or is currently being, implemented at more than 3 other sites of similar scale with published positive performance results	Successfully proven performance at 1 to 3 facilities of similar scale with positive results	No experience at other facilities of similar scale	5.0	2.0	5.0	5.0	4.0	3.0	5.0
1.2 Likely to have a material impact on odours in surrounding communities	Will significantly reduce odours that originate in surrounding areas	Will partially reduce odours that originate in surrounding area	Will cause minimal if any reduction in odours that originate in surrounding area	3.0	3.0	5.0	4.0	5.0	4.0	4.0
Implementation										
2.1 Future flexibility	Compatible with future treatment technologies or add-on processes, requiring little to no modification	Moderate modifications would be required for compatibility with future treatment technologies or add-on processes	Little to no compatibility with future technologies or add-on processes	4.0	3.0	4.0	3.0	3.0	4.0	5.0
2.2 Option is configurable to meet long-term capacity projections	Ability to meet long-term capacity requirements	Ability to meet long-term capacity (year 2035)	Ability to meet short-term capacity (year 2028)	4.0	4.0	3.0	5.0	4.0	4.0	4.0
Operations and Maintenance										
3.1 Operational complexity	Option does not require significant additional training or special competencies of existing staff and no new staff hires would be required	Option can be accommodated by existing staff, but additional specialized training is required	Option requires new operating staff with specific skills or involvement of multiple City of Calgary departments (e.g., maintenance, purchasing, and others) on a regular basis	4.0	3.0	3.0	3.0	2.0	3.0	4.0
3.2 Maintenance complexity	Does not introduce new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces 1 or 2 new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	Introduces several new types of equipment that need special skills, unique replacement components, or regular, long duration maintenance efforts to preserve operational integrity	4.0	2.0	2.0	3.0	2.0	3.0	4.0
3.3 Safety	Can be designed to eliminate most risks to operators such as confined space entry, and exposure risks from gases, chemicals, or electrical generating systems	Can be designed to significantly reduce most risks to operators by eliminating confined space entry, and reducing exposure risks from gases, chemicals, or electrical generating systems	Cannot be designed to eliminate all risks to operators and may include risks such as confined space entry; exposure risks from gases, chemicals, electrical generating systems; or both	4.0	3.0	4.0	3.0	5.0	4.0	4.0
Social and Community										
4.1 Community impact – noise and traffic	Will reduce noise emanating from the site, or reduce truck traffic to and from the site (or a combination thereof) without requiring significant mitigation measures	Achieves no other significant change to the current situation at the site	Presents a measurable increase in noise or truck traffic and will require substantial mitigation	4.0	4.0	4.0	4.0	4.0	4.0	4.0
4.2 Engender public trust in The City's efforts to minimize odour issues	Residents are convinced to trust The City's commitments to mitigate odour issues within 6 months	Residents somewhat trust The City's commitments to mitigate odour issues, partly because the implementation cannot be completed for 1 year	Residents are not convinced that they should trust The City's efforts to mitigate odour issues, possibly because the implementation cannot be completed within 2 years	4.0	3.0	4.0	4.0	4.0	2.0	3.0
4.3 Community impact – odour complaints	Will significantly reduce odour complaints that originate in surrounding areas	Will partially reduce odour complaints that originate in surrounding areas	Will cause minimal if any reduction in complaints that originate in surrounding areas	4.0	4.0	4.0	4.0	5.0	3.0	4.0
Resource Efficiency										
5.1 Beneficial use of energy	Reinforces The City's approach to the use of 'green' energy by improving energy balance (heat and electrical power) at the facility	Maintains the same level of heat and energy consumption	Causes a net increase in electrical and heat energy consumption	2.0	3.0	1.0	4.0	2.0	4.0	3.0
5.2 Chemical or additive use	Does not significantly increase chemical or additive use; or has reduced net chemical use compared to current situation and does not require the addition of substantial chemical dosing infrastructure	Requires similar chemical or additive use; or no new hazardous chemical systems compared to existing and requires minor additional infrastructure for chemical dosing	Requires a net increase in chemical and additive use or hazardous chemicals (or both) compared to existing and requires new chemical dosing facilities	5.0	2.0	2.0	2.0	4.0	4.0	4.0
Environmental										
6.1 GHG emissions	Reduces energy consumption, reduces potential emissions of GHGs (i.e., methane, nitrous oxide, CO2), or lowers the demand for commodities that add to emissions elsewhere (Scope 3 GHGs), or a positive combination of the three	No significant change to the levels of energy consumption, GHGs, and demand for commodities	Significantly increases energy consumption, potential GHG emissions, or demand for commodities	2.0	3.0	1.0	3.0	2.0	2.0	4.0
6.2 Risk of other environmental impacts	No environmental risks; or no improvement or regeneration of the environment	Minor risks to the environment that need mitigation and only small regeneration of the environment	Significant impact on the environment and no regeneration	5.0	3.0	2.0	3.0	3.0	2.0	4.0
			Sum	54.0	42.0	44.0	50.0	49.0	46.0	56.0

Notes:

CO_2 = carbon dioxide

GAC = granular activated carbon

GHG = greenhouse gas

H2S = hydrogen sulphide

O&M = operations and maintenance