FEASIBILITY REVIEW TECHNICAL DOCUMENT

TO: Matthew Lawson (City of Hamilton)

Feasibility Assessment for Odour Monitoring at GFL Landfill for City of Hamilton

C.C.
Rob Conley, Roster Captain (City of Hamilton), Paul Mulholland (City of Hamilton), Darren Dickson (AtkinsRéalis), Jenny Vieira (AtkinsRéalis)

DATE
April 11, 2024

FROM
Chris Bestfather (AtkinsRéalis), Yamara Moya (AtkinsRéalis), Nicholas Hakala (AtkinsRéalis)

REF.
699580

SUBJECT
Feasibility Review Technical Document

1. Notice to Reader

This report has been prepared and the work referred to in this report has been undertaken by AtkinsRéalis Canada Inc. (AtkinsRéalis) for the exclusive use of the City of Hamilton (the Client), who has been party to the development of the scope of work and understands its limitations. The methodology, findings, conclusions, and recommendations in this report are based solely upon the scope of work and subject to the time and budgetary considerations described in the proposal and/or contract pursuant to which this report was issued. Any use, reliance on, or decision made by a third party based on this report is the sole responsibility of such third party. AtkinsRéalis accepts no liability or responsibility for any damages that may be suffered or incurred by any third party because of the use of, reliance on, or any decision made based on this report.

The findings, conclusions, and recommendations in this report (i) have been developed in a manner consistent with the level of skill normally exercised by professionals currently practicing under similar conditions in the area, and (ii) reflect AtkinsRéalis best judgment based on information available at the time of preparation of this report. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our original contract and included in this report. The findings and conclusions contained in this report are valid only as of the date of this report and may be based, in part, upon information provided by others. If any of the information is inaccurate, new information is discovered, site conditions change, or applicable standards are amended, modifications to this report may be necessary.

This report must be read as a whole, as sections taken out of context may be misleading. If discrepancies occur between the preliminary (draft) and final versions of this report, it is the final version that takes precedence. Nothing in this report is intended to constitute or provide a legal opinion.

FEASIBILITY REVIEW TECHNICAL DOCUMENT

2. Introduction

AtkinsRéalis is pleased to provide this technical memorandum to the City of Hamilton (the “City”) describing alternate options and costs to complete air monitoring at the Green for Life (GFL) Environmental Inc. Landfill in Stoney Creek as per our Proposed Feasibility Assessment for Odour Monitoring at GFL Landfill (December 8, 2023).

Developing this memo falls under the existing City of Hamilton’s Contract C12 13 21 for provision of Professional and Consultant Services under the 2022-2024 Roster for Category 08, Solid Waste Management. The City has requested an evaluation of different options for air quality monitoring in proximity to GFL’s contaminated soil landfill in Stoney Creek. The evaluation includes a summary of the advantages and disadvantages of the different methods and provides approximate budgets to complete each of the items. The recommendations of the review can be taken to the City’s Committee or Council for review and approval for implementation beginning in the spring of 2024.

3. Background

Following submission of several public resident complaints regarding air quality and odour issues in the neighbourhoods surrounding the GFL Stoney Creek contaminated soil landfill, the Ministry of the Environment, Conservation and Parks (MECP) completed two rounds of air quality monitoring, for discontinuous periods of 9 and 6 days, in the summer and fall of 2023. Land use parcels around GFL Stoney Creek area are shown in Appendix A in Figure 1 (obtained from MECP report). Their findings were inconclusive, with limited numbers of compounds identified that could have health related impacts, although sulphur-based compounds were identified during the second monitoring event. Following ongoing concerns identified by neighbourhood associations, Hamilton Public Health Services (HPHS) were directed by Hamilton Council to “... explore the ways and means to provide independent third-party air monitoring for a minimum seven-day period at GFL Stoney Creek Landfill... “

3.1 Summary of MECP 2023 Sampling

In 2023 the MECP conducted two air monitoring assessments in August (August 8, 9, 10, 16, 17, 21, 24, 25, and 28) and September (September 1, 14, 15, 22, 28, 29) to quantify ground level concentrations of various harmful pollutants and to quantify odour levels surrounding the GFL site and in the impacted neighbourhoods. Numerous measurement sites both upstream and downstream of the facility were selected for monitoring during these periods based on wind metrics for the area. Wind data was collected from the on-site meteorological tower STN29247 during the sampling periods.

These surveys were conducted utilizing the MECP’s mobile air monitoring vehicle equipped with a portable Gas Chromatograph/Mass Spectrometer (GC/MS) unit for the measurement of volatile organic compounds (VOC), also known as the HAPSITE ER Chemical Identification System. The HAPSITE is a discrete sampling system that draws a known volume of air into the GC/MS over two minutes, followed by a 10-minute analysis. Once the analysis is complete, another sample is taken. The HAPSITE was calibrated to quantify the presence and concentrations of the following VOCs: Benzene, Trichloroethylene, Toluene, Tetrachloroethylene, Chlorobenzene, Ethylbenzene, Styrene, 1,2,4-trimethylbenzene, and Naphthalene.

FEASIBILITY REVIEW TECHNICAL DOCUMENT

Other compounds that were measured during the air monitoring surveys in September and August include: Nitrogen Oxides [NOx includes nitric oxide (NO) and nitrogen dioxide (NO_2)], hydrogen sulphide (H_2S), total reduced sulphur compounds (TRS), fine particulates ($PM_{2.5}$ and PM_{10}), and sulphur dioxide (SO_2) which were measured continuously with individual analysers during each of the air monitoring events, however due to power constraints not all of these were measured continuously, with priority given to SO_2 and TRS.

A St. Croix Sensory Nasal Ranger was used to quantify odour strength in the ambient air. All measurements were reported in Dilution-to-Threshold (D/T), which is a measurement of the number of dilutions needed to make the odourous ambient air “not-detectable” with D/T measurements ranging from <2 to 60. Results with a D/T <2 mean an odour was detected by the technician without equipment but was not quantifiable by the nasal ranger. Staff using this equipment were trained before the start of the odour assessment.

The following conclusions are summarized from each study:

August 8-25 Campaign:

Detected odours in the September campaign were described as garbage, leachate, musty, natural gas, sweet, sour, wet diaper, and urine. Odours were noted on 5 days; however, they were only quantifiable with the nasal ranger on August 28 (7 < D/T < 15). See Figure 10 from MECP report in Appendix A. The leachate pond and facility were identified as likely sources. VOC’s and respective H_2S and TRS concentrations measured in ambient air at the receptor points were found to be below their respective MECP limits while the odours were detected.

September 1-29 Campaign:

Odours identified each day were described as raw sulphur, leachate, herb, garbage, solvent chemical, burnt, rotten eggs and odour masking agents. The Nasal Ranger identified dilution ratios as high as D/T <15. See Figure 5 in Appendix A from the MECP report. Over the course of all sampling days, the survey suggests that the leachate pond and the GFL facility are likely the sources of the identified odours. VOC concentrations measured in the ambient air at the odour receptor points were found to be below their respective MECP limits while the odours were detected.

Measured 10-minute TRS exceedances were noted around the GFL facility and within residential areas with the highest 10-minute TRS concentrations measured immediately west of the leachate pond. See Figure 12 in Appendix A from MECP report. As measurements were not conducted over 24-hours it is possible that short-term peaks above the 10-minute limits is a common occurrence outside of the monitoring periods. The MECP report recommends evaluation using continuous 24-hour TRS monitoring to compare with the 24-hour TRS standard for health effects.

As discussed during scoping meetings between AtkinsRéalis and HPHS, exactly replicating the MECP methodology (as per *Operations Manual for Air Quality Monitoring in Ontario*) and recommended 24-hour monitoring for TRS would be expected to be inordinately expensive as it would require construction of a mobile monitoring unit equipped with multiple continuous monitoring devices. Also, exactly replicating MECP methodology may not be required to determine whether there are potential health related impacts, particularly if the suite of parameters being reviewed is narrowed. As such on Monday, December 4, 2023, Hamilton’s Public Health Committee approved the following recommendation: That Public Health Services Staff be directed to work with AtkinsRéalis to develop a feasibility study with options to perform air monitoring for a minimum seven-day period at the Green for Life Environmental Inc. Landfill, Stoney Creek…and report back to the Public Health Committee in Q1, 2024.

4. Sampling Plan Development

The sampling plans presented herein were developed with a focus on odour health limits (e.g., H_2S, TRS) and the impacts at the sensitive receivers (i.e., the residential areas located to the north and south of the GFL facility). These plans assume the MECP sampling reports accurately identify the odour sources as the GFL landfill and leachate pond and that their reported results are representative for screening in appropriate potential odour related compounds. The purpose of each of the air quality assessment plans is to provide options that could monitor concentrations in the vicinity of the landfill for selected hazardous contaminants that will allow an assessment of whether potential impacts to neighbouring properties represent a health risk or only an odour nuisance.

4.1 General Principles

Given the previously stated focus and assumptions, the sampling plan scope includes the following:

- Identify sources and most impacted receptors based on meteorology.
- Quantify measured concentrations for selected parameters at the sensitive receptor (ground) level.
- Assess health impacts with MECP limits.
- Justify and inform locations for future monitoring and which pollutants are of interest.

Listed studies should be scheduled seasonally, to reflect changing conditions, and are recommended to be initiated after ground thawing has occurred. The different ambient temperatures, wind patterns and receptor usage will be reflected by completing multiple seasonal sampling events and this will prevent conclusions from being drawn from the conditions encountered during a single event. Some thought should also be given to different times of day as to when maximum exposures are likely, such as coming home from school or work.

Sampling locations will be planned based on the results of the 2023 MECP monitoring campaigns and local meteorological station data to quantify upstream and downstream effects from the landfill and its operations. Air quality monitoring locations can also be situated based on field staff olfactory observations. Sampling durations shall be determined based on the program/technology selected and the applicable limits and averaging periods.

Listed programs shall be selected based on the pollutants of concern related to odours, and health concerns, and will be compared to their regulatory limits.

4.2 Sampling Plans

Each Sampling plan in this section will be compared based on the following criteria:

1. Preparation and quantity.
2. Sampling Method, including media and lab analysis.
3. Contaminants of Concern and detection limits.
4. Labour Requirements.
5. Timing and Frequency of the campaign.

Example pictures of sampling equipment and field set-up are provided in Appendix C.

4.2.1 Mobile Continuous Sampling

Mobile continuous sampling similar to the MECP monitoring was recommended which would apply the requirements in the *Operations Manual for Air Quality Monitoring in Ontario*.

Parameter	Comment
Sample Method	Continuous similar to HAPSITE using GC/MS
Number of Samples	Daily with discrete sampling frequency and analysis within 15-min intervals
Contaminants of Concern	VOCs and Sulphur
Frequency and Duration	Daily as required
Results	Available same day

1. Preparation requirements include the construction and outfitting of a mobile-based laboratory with various continuous samplers. This equipment may be installed inside a vehicle itself or a trailer to allow for relocation of sampling points upwind and downwind of the source. A power source is required to support the sampling equipment.
2. The analysis vehicle may intake continuous samples of air and conduct analysis utilizing the suite of analysis equipment onboard. Significant calibration and quality assurance would be required to satisfy all requirements of the MECP operations manual.
3. Analysis capability for this purpose would include those compounds identified as detectable in the MECP studies: VOCs and odourous compounds (H_2S, TRS, etc.). detection limits and sampling periods for the contaminants of concern depend on the health-based limits (e.g., 10-minute, and 24-hour).
4. Operation of the mobile lab and maintenance of the equipment onboard requires dedicated technicians and operators that understand how to troubleshoot and interpret results. Correct operation and analysis require expert users.
5. The mobility of the lab allows for sampling in numerous different settings provided the vehicle can access the area. Provided there is time for calibration of the equipment and sufficient resources available sampling can be done quickly and respond to specific complaints.

4.2.2 Short-Term Fixed Location Canister Sampling

Short-term sampling with vacuum canisters is employed to characterize the air quality in a fixed location over periods of less than 24-hours. Samples are analysed by laboratory and provide an average concentration for several parameters.

Parameter	Value	Comments
Sample Method	Evacuated Canister with flow controller on inlet and tripod to elevate sample (~1.5 m above ground).	Initial pressure -29 in of Hg Final pressure -5 to -10 in of Hg
Number of Samples	4 fixed locations/day Sulphur analysis*	6L canister 8-hour sample Analysis Method ASTM D5504 (S630)
	1 fixed location/day VOC analysis*	6L canister 8-hour sample Analysis Method EPA TO-15 (S621B)
	4 portable samples deployed per day (Location to be determined based on odour observations or residential complaints) Sulphur analysis*	1.4L canisters for 10-min samples Analysis Method ASTM D5504 (S630)
Frequency and Duration	Daily for period of 7-days Total of 70 canister samples (includes 7 duplicates)	To capture daily variation in air quality. Can be repeated monthly or quarterly.
Results	Available within 10 business days (standard turnaround time)	Quicker turn-around times are available at additional costs.

**See list of sulphurous compounds and VOCs in Appendix B. Analysis is a sample GC scan for these compounds (not all may be detected).*

1. Preparation for this sampling methodology requires several laboratory supplied air sampling canisters which are in the selected sampling locations. Planning is required to identify the periods of time and locations likely to measure the most significant air quality impacts. The proposed sampling plan includes up to 5 fixed locations, 4 portable canisters (varied locations) with samples repeated over a period of 7 continuous days (e.g., Monday to Sunday).
2. Air samples are drawn into the canisters and sent for laboratory analysis. The recommended sampling periods for VOCs and odourous compounds in questions are non-continuous samples taken over periods of 8-hour as well as 10-minute; canisters would be picked up and distributed each day by air technicians.
3. Contaminants are screened by the laboratory and detection limits depend on the sample quality (See Appendix B).
4. Minimal training is required to setup each device and results interpretation is completed by a third party.
5. As these are non-continuous samples, the results present an average concentration over the sampling period, as such peaks in contaminant concentrations are not reported. However, 10-minute samples collected during the day (total of 20) are included to capture peaks (to be deployed based on observations in field). Generally, results are available in ten business days following laboratory receipt.

4.2.3 Long-Term Fixed Location Passive Sampling

Long-term sampling with passive sampling media is employed to characterize the air quality in a fixed location over periods of multiple days. Samples are analysed by laboratory and provide an average concentration for several parameters.

Parameter	Value	Comment
Sample Method	Adsorbent tube/cartridge with diffusion inlet (remains open for sample period).	Sampling media elevated and attached to pole/fence with weather shelter.
Number of Samples	8 fixed locations H_2S analysis* for period of 1-15 days	Initial siting and installation by tech., unsupervised for sampling period. Analysis Method Radiello 170 (RAD 170) Duplicate samples for QA/QC. Analysis Method EPA TO-17 (S620D)
	2 fixed locations VOC analysis* for a period of 2-14 days	
Frequency and Duration	Multiple days (e.g., 14 days) Total of 15 samples (includes 5 duplicates).	To capture long-term trends in air quality. Can be repeated monthly or quarterly.
Results	Available within 10 business days (standard turnaround time)	Quicker turn-around times are available at additional costs.

**See list of sulphurous compounds and VOCs in Appendix B.*

1. Adsorbent samples are placed in various locations; these are set and forget type of devices that don't require forced air or flow through them to capture samples.
2. Samples are taken in ambient air through diffusion processes in the adsorbent device (24-hours-2 weeks), each device is then collected at the end of the sampling period and dropped off for laboratory analysis.
3. Adsorbent devices are designed to capture specific contaminants and have been recommended to capture the specific contaminants identified. Because these devices utilize diffusion processes to capture pollutants, there is some sensitivity to environmental conditions (temperature) that must be considered.
4. Replacement tube/cartridges are simple to set up and require little time. Minimal Training is required, and results analysis is done by a third party.
5. As these are non-continuous samples only an average concentration over the sampling period would be reported. As such peaks during the sampling period are not reported.

The proposed sampling plans presented above are compared in TABLE 1 based on the quality of information provided, the timeliness, and approximate costs. The costs include basic, factual reporting but do not include extensive interpretation, public consultation, regulator meetings, presentations to committee or council, etc., each of which could be discussed as part of a detailed proposal.

FEASIBILITY REVIEW TECHNICAL DOCUMENT

Table 1: Comparison of Sampling Methods

Sampling Plan	Description	Advantages	Disadvantages	Approximate Costs*
Mobile Continuous Sampling	Mobile analysis vehicle or trailer that is deployed with continuous sampling equipment.	• Accurate and reliable information. • Vehicle or trailer can be relocated to any accessible location. • Provides near instantaneous results. • Can sample multiple locations. • Sampling equipment can be re-purposed for specific pollutants or for monitoring other sources.	• Significant upfront costs and ongoing costs to operate analysis equipment and vehicle. • Ongoing maintenance fees to calibrate and repair analysis equipment. • Requires repeated monitoring and specialized staff to justify costs. • Limited market to sell equipment and recover expenses.	• On the order of >$1M for capital costs for vehicle/trailer, measurement equipment, power supply plus roughly $100,000 for staff and disbursements to operate the mobile detection unit for a period of 6 months.
Short-Term Fixed Location Canister Sampling	Canisters set in fixed sampling positions to characterized air quality. Non-continuous sampling periods for 8-hours and 10-minutes. Locations selected based on prevailing winds and sensitivity of receptors.	• Affordable and can be repeated. • No supporting infrastructure required. • Air samples can be analyzed for numerous pollutants. • No calibration requirements. • Minimal preparation time. • Limited staff time (pick-up and drop off) with staff available to make air quality observations and supervise sampling.	• Fixed monitoring locations (subject to meteorological effects). • Unmanned stations can be tampered with or subject to background source impacts (e.g., traffic) • 8-hour samples provide average concentration during periods (exclude 10 min peaks). • 10-day turn around time on results. • Limited supply on equipment and canister preparation time (2 weeks). • Relatively small sample volumes impact detection limits.	• Roughly $62,000 for 7-day sampling campaign with 70 total samples (costs include laboratory, equipment and staff fees).
Long-Term Fixed Location Passive Sampling	Tube/cartridge analysis in fixed positions for long periods of time to measure long-term exposures. Non-continuous sampling for periods of 1-2 weeks. Locations selected based on prevailing winds and sensitivity of receptors	• Affordable • No supporting infrastructure apart from weather shelter • Monitors in daytime and nighttime conditions. • Minimal preparation time. • No calibration requirements. • Very little day to day staff time required after installation. • Media can be deployed and picked up periodically. • Results can be used to inform preferred locations for additional fixed continuous monitoring stations or future campaigns. • Complimentary to short-term sampling.	• Fixed monitoring locations (subject to meteorological effects) • Unmanned samplers can be tampered with or subject to background source impacts (e.g., traffic). • Average concentrations of air quality during period (excludes peaks). • High values difficult to explain (limited observations). • Results available several days after sampling. • Fixed sampling period. • Relatively small sampling volumes can impact detection limits and reduce analyte screening list. • Atmospheric effects may impact accuracy of measured results (temperature and diffusion rate).	• Roughly $20,000 for sampling campaign with10 total samples (costs include laboratory, equipment and staff fees).

**Approximate costs based on sampling plan assumptions and typical approaches. Detailed cost estimates can be provided based on requirements and schedule.*

4.2.4 Short-Term Ammonia Fixed Location Sampling

In addition to the program described in the preceding sections that focusses on sulphurous compounds, H_2S and VOCs, the Provincial Officer's Order included continuous monitoring of ammonia in the Air monitoring plan (i.e., potential odour source concern). There is a MECP 24-hour limit for ammonia with a health-based limit; however, the MECP didn't include sampling for ammonia during the ambient air monitoring surveys that were completed in the fall of 2023. Short-duration ammonia sampling requires a different methodology and equipment than either; grab samples for immediate and short-duration monitoring for sulphurous compounds and VOCs (SUMMA cannisters) or; the longer-term passive sampling (adsorbent tubes). Short-duration ammonia sampling uses adsorbent tubes coupled with pumps to collect samples (a more detailed methodology can be provided upon request). Ammonia sampling of this nature would be employed to characterize the air quality in a fixed location over the daytime (i.e., 8 to 12 hour) period, with the results adjusted to align with the 24-hour health limit. Samples are analysed by laboratory and provide an average concentration for several parameters.

Parameter	Value	Comment
Sample Method	Adsorbent tube/cartridge with active collection (pump draws air for sample period).	Sampling media elevated and attached to pole/fence with battery powered pump.
Number of Samples	1 fixed location per day Ammonia analysis for period of 8-hours	Initial siting and installation by tech., unsupervised for sampling period. Analysis Method NIOSH 6015 Duplicate samples for QA/QC.
Frequency and Duration	Multiple single day samples. Total of 14 samples (includes 7 duplicates).	To capture short-term trends in air quality. Can be repeated monthly or quarterly.
Results	Available within 10 business days (standard turnaround time)	Quicker turn-around times are available at additional costs.

1. Adsorbent sample tubes are attached to a sampling pump with tubing and located in selected locations. The operation of the pump is checked periodically during the sample period. The proposed sampling plan includes up to 1 fixed location per day, with samples repeated over a period of 7 continuous days (e.g., Monday to Sunday).
2. Samples are taken in ambient air through an active air sampling process in the adsorbent tube (8-hours), each device is then collected at the end of the sampling period and dropped off for laboratory analysis.
3. Adsorbent devices are designed to capture specific contaminants and the NIOSH method is designed to measure ammonia.
4. Replacement tube/cartridges are simple to set up and require little time. Minimal Training is required, and results analysis is done by a third party.
5. As these are non-continuous samples only an average concentration over the sampling period would be reported. As such, peaks during the sampling period are not reported. 8-hour samples would be compared to the MECP 24-hour limit for ammonia.

Short-Term Ammonia Fixed Location Sampling has similar advantages and disadvantages as Long-Term Fixed Location Passive Sampling described in Table 1.

Approximate Costs

Roughly $6,000 for a 7-day sampling campaign with 14 total samples (costs include laboratory and equipment excluding staff fees). Assuming that the ammonia sampling is combined with the Short-Term Fixed Location Canister Sampling, the total costs of the combined cannister and ammonia sampling plan would be approximately $68,000.

5. Limitations

The sampling plans described are based on assumptions and the following limitations are noted.

- Requesting MECP review or comment on the final sampling methodology prior to completing the work is recommended if the data is to be submitted to the MECP (i.e., consultation to deviate from the Operations Manual requirements) for use in enforcement or to supplement their own sampling events.
- The sampling plans are designed with a focus on MECP health-based limits, which differ from odour sampling plans. Odours can be subjective and not all public react similarly; as such they are considered a nuisance which can impede ability to enjoy property.
- It was assumed the parameters not detected in significant quantities in the 2023 MECP monitoring campaigns were not required to be included in the proposed sampling plans (e.g., NOx, $PM_{2.5}$, PM_{10}, and SO_2), although this could be added at additional cost.
- Although planning can anticipate patterns in wind directions and changes in the intensity of odour emissions; the results of fixed location monitoring campaigns are limited to the period and locations monitored (i.e., results may not reflect peak concentrations). Repeated sampling campaigns (e.g., seasonally; before and after GFL landfill modifications, etc.) would allow measurement of the range and change in air quality.
- Lab costs and analysis are based on quotes and discussions with ALS Global (Environmental Services) which is accredited by the Standards Council of Canada (SCC). The timeline and media requirements include: seven business days advance notice to prepare/deliver media (up to 35 canisters/tubes), for bigger orders a 10-day notice is required.
- The listed prices are approximate values only, actual costs will be detailed in a cost estimate following the selection of a preferred sampling plan. Costs for labour assume typical industry rates (i.e., similar for an open bid call); however, if awarded costs can be updated to City Roster rates. Quotes from labs may differ depending on equipment availability, and staffing availability.
- Installation of a local meteorological station is available as an alternative for collecting weather data during the sampling campaigns if Hamilton Air Monitoring Network meteorological tower (HAMN STN29247 GFL Facility) is unavailable or has quality or other issues with data.

6. Conclusions and Recommendations

Three sampling plans are outlined in this technical memo for the purposes of determining health impacts in the areas surrounding the GFL Landfill. These alternative air quality monitoring plans provide a measured approach to quantifying

the air quality on short-term and long-term time scales. The advantages and disadvantages of these methods are outlined as well as the approximate costs.

The proposed sampling plans are provided based on the results of the MECP 2023 monitoring, best practices, and discussions with the City of Hamilton; however alternative plans can be developed upon request. For example, the short-term canister and long-term passive sampling plans could be combined to include both daily canister monitoring and long-term passive sampling. Such a comprehensive plan would provide combined information about short-term (daily) impacts as well as long-term exposures.

Although the MECP identified ammonia as a potential leachate odour source in the Provincial Officer's Order, they did not perform ammonia monitoring during their Ambient Air Monitoring Assessment Surveys. Short-term ammonia fixed location sampling is therefore only provided as a complimentary option that could be combined with the short-term fixed location canister sampling program.

The recommended sampling plan for the City to implement as an initial screening is the short-term fixed location canister sampling program. This method would measure air quality for a 7-day period which could be implemented in the spring when landfill odours are expected to become significant. For the results of the study to be statistically significant additional sampling campaigns are recommended with a minimum of three per year (e.g., one week in spring, summer, and fall) to measure and compare seasonality of air quality. Depending on the results of the sampling campaign(s), the subsequent sampling plans can be adapted (e.g., number of samples, analytes, locations, period between sampling campaigns, etc.) and the usefulness of long-term tube/cartridge sampling can be evaluated.

7. References

GFL Environmental August 2023 Air Monitoring On-Site Assessment Survey, Stoney Creek, Ontario; Ministry of the Environment, Conservation and Parks; September 1, 2023.

GFL Environmental September 2023 Ambient Air Monitoring Assessment Survey, Stoney Creek, Ontario; Ministry of the Environment, Conservation and Parks; October 5, 2023.

Provincial Officer's Order; Issued to GFL Environmental Inc., Order number 1-237438590; Tamara Posadowski, October 17, 2023.

Operations Manual for Air Quality Monitoring in Ontario; Ministry of the Environment, Conservation and Parks; July 1 2018
https://www.ontario.ca/document/operations-manual-air-quality-monitoring-ontario-0

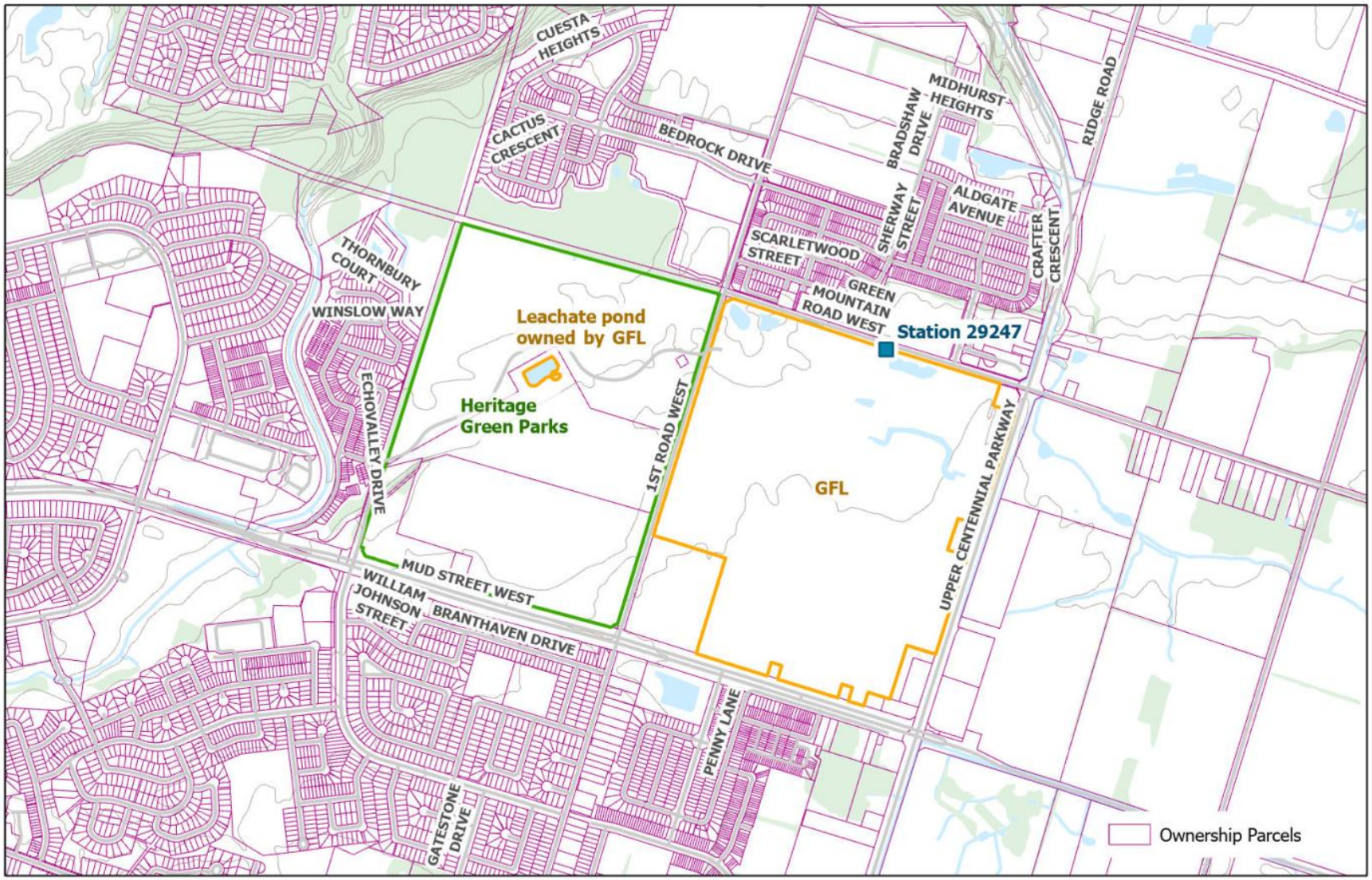
Appendix A

Figures from MECP Reports

Ontario

Figure 1 - GFL Environmental September 2023

Ministry of the Environment Conservation and Parks



Information provided by:
Ministry of the Environment and Climate Change
Ministry of Natural Resources and Forestry

Coordinate System: NAD 1983 UTM Zone 17N
Projection: Transverse Mercator
Datum: North American 1983

N

0 100 200 M

Published September 2023

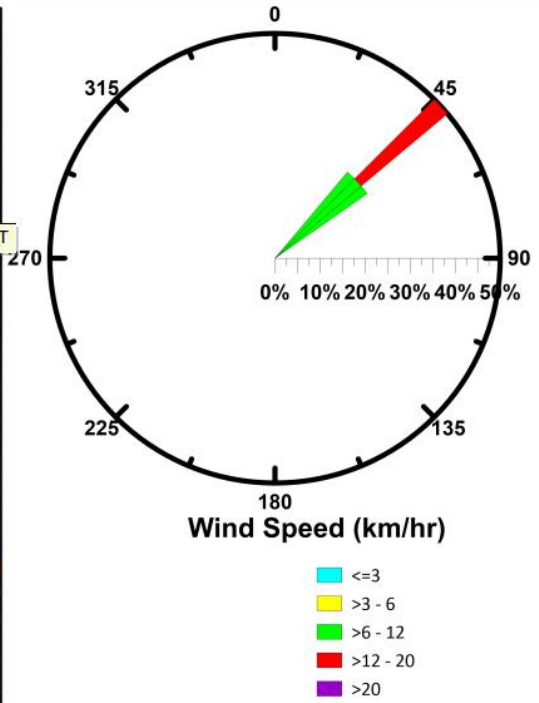
Printed in Ontario, Canada

AtkinsRéalis

Ontario

Figure 10 - GFL Environmental August 2023
Air Monitoring On-Site Assessment Survey - Aug 28, 2023

Ministry of the Environment Conservation and Parks

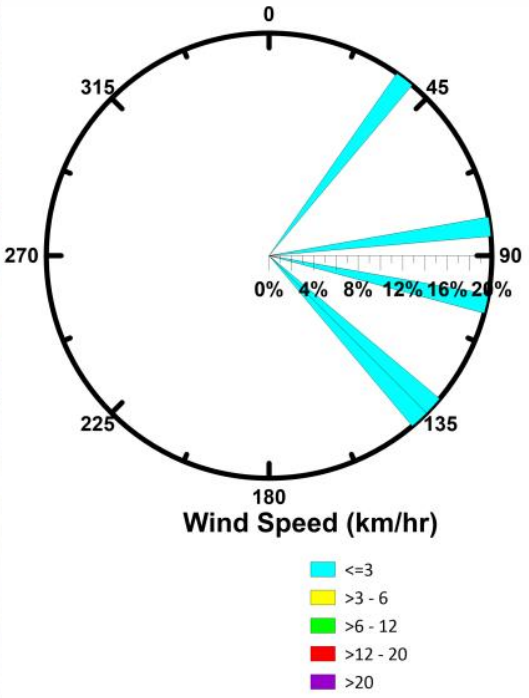


Date	Time (Location)	Name	HAPSITE Comments:	Other compounds (PM, H_2S, Nox, CO or SO_2)	Odours observations	General Comments
28-Aug-23	12:33	1	Toluene: 8.7 ug/m3 1-3-dimethylbenzene: 3.6 ug/m3	Slightly elevated H2S	Yes	Odour Survey Conducted. Odours detected
	12:55		No Compounds Detected	Measured H2S concentrations as high as 8.4 ppb	Yes	
	13:12					
	13:28	2	No Compounds Detected	-		
	13:47					
	14:05	3			No	
	14:22	4	No Compounds Detected	-	Yes	
	14:47	5	No Compounds Detected	-	No	
	15:03	6	No Compounds Detected	-	Yes	

Ontario

Figure 5 - GFL Environmental September 2023
Ambient Air Monitoring Assessment - Odour Survey - Sep 22, 2023

Ministry of the Environment Conservation and Parks



Due to equipment limitations, wind directions with wind speeds <3km/hr are unreliable

Date	Time (Location)	Name	Odours observations	D/T Ratio	General Comments
22-Sep-23	0:10	A	No	-	Complainant House #1
	0:20	B	Yes	D/T<2	Complainant House #2 - Sour smell
	0:30	C	Yes	4<D/T<7	Inside GFL Facility - Reference only - Rotten eggs
	0:40	D	Yes	4<D/T<7	Inside GFL Facility - Reference only - Rotten eggs
	0:55	E	Yes	4<D/T<7	Inside GFL Facility - Reference only - Rotten eggs
	1:28	F	Yes	D/T<2	GFL mist machine - deodourizer/ sweet
	1:43	G	No	-	Complainant House #3
	1:54	H	No	-	Complainant House #4
	2:06	I	No	-	Complainant House #5
	2:13	J	No	-	Complainant House #6
	2:30	K	No	-	Complainant House #7
	2:52	L	Yes	D/T<2	GFL mist machine - deodourizer/ sweet
	3:15	M	Yes	D/T<2	Sour smell
	3:32	N	Yes	2<D/T<4	Sour smell
	4:08	O	Yes	D/T<2	Sour smell
	4:25	P	Yes	2<D/T<4	Leachate/ waste
	4:43	Q	Yes	4<D/T<7	Rotten Eggs
	4:51	R	Yes	7<D/T<15	Rotten Eggs
	4:58	S	Yes	2<D/T<4	Rotten Eggs

Ontario

Figure 12 - GFL Environmental September 2023
Summary of 10-min TRS Exceedance locations

Ministry of the Environment Conservation and Parks

Information provided by:
Ministry of the Environment and Climate Change
Ministry of Natural Resources and Forestry

Coordinate System: NAD 1983 UTM Zone 17N
Projection: Transverse Mercator
Datum: North American 1983

N

0 50 100 M

Published September 2023

AtkinsRéalis

Appendix B

List of Analytes and Detection Limits

Canister Sampling Analyte List

VOCs Compounds using canister	Method S621 RDL- ppbv	RDL- µg/m³
Acetone	1	2.4
Benzyl chloride	0.2	1
Bromodichloromethane	0.2	1.3
Dibromochloromethane	0.2	1.7
Dichloropropylene, cis-1,3-	0.2	0.91
Dioxane, 1,4-	0.2	0.72
Hexachlorobutadiene	0.2	2.1
Isopropylbenzene	0.2	0.98
Methyl-tert-butyl ether [MTBE]	0.2	0.72
Propylene	0.2	0.34
Styrene	0.2	0.85
Tetrachloroethane, 1,1,2,2-	0.2	1.4
Trichlorofluoromethane	0.2	1.1
Vinyl bromide	0.2	0.87
Vinyl chloride	0.2	0.51
Allyl chloride	0.2	0.63
Benzene	0.1	0.32
Bromoform	0.2	2.1
Bromomethane	0.2	0.78
BTEX, total	0.3	1.2
Butadiene, 1,3-	0.2	0.44
Carbon disulfide	0.5	1.6
Carbon tetrachloride	0.2	1.3
Chlorobenzene	0.2	0.92
Chloroethane	0.2	0.53
Chloroform	0.2	0.98
Chloromethane	0.2	0.41
Cyclohexane	0.2	0.69
Dibromoethane, 1,2-	0.2	1.5
Dichlorobenzene, 1,2-	0.2	1.2

Sulphur Compounds using canister	Method S630 RDL- ppbv	RDL- µg/m³
Carbon disulfide	2	6.2
Carbonyl sulfide	4	9.8
Diethyl disulfide	2	10
Diethyl sulfide	4	15
Dimethyl disulfide	2	7.7
Dimethyl sulfide	4	10
Dimethylthiophene, 2,5-	4	18
Ethyl mercaptan	4	10
Ethyl methyl sulfide	4	12
Ethylthiophene, 2-	4	18
Hydrogen sulfide	4	5.6
Isobutyl mercaptan	4	15
Isopropyl mercaptan	4	12
Methyl mercaptan	4	7.9
Methylthiophene, 2-	4	16
Methylthiophene, 3-	4	16
n-Butyl mercaptan	4	15
Propyl mercaptan	4	12
sec-butyl mercaptan + thiophene	6	14
t-Butyl mercaptan	4	15
Tetrahydrothiophene	4	14
Total compounds	**22**	**22**
	ppbv	**µg/m³**
Lowest RDL	**2**	**5.6**
Max RDL	**6**	**18**

Sulfur, total reduced (as H2S), 22 compounds	**25**

Dichlorobenzene, 1,3-	0.2	1.2
Dichlorobenzene, 1,4-	0.2	1.2
Dichlorodifluoromethane	0.2	0.99
Dichloroethane, 1,1-	0.2	0.81
Dichloroethane, 1,2-	0.2	0.81
Dichloroethylene, 1,1-	0.2	0.79
Dichloroethylene, cis-1,2-	0.2	0.79
Dichloroethylene, trans-1,2-	0.2	0.79
Dichloromethane	0.2	0.69
Dichloropropane, 1,2-	0.2	0.92
Dichloropropylene, cis+trans-1,3-	0.3	1.29
Dichloropropylene, trans-1,3-	0.2	0.91
Dichlorotetrafluoroethane, 1,2- [Freon 114]	0.2	1.4
Ethyl acetate	0.2	0.72
Ethylbenzene	0.1	0.43
Ethyltoluene, 4-	0.2	0.98
Heptane, n-	0.2	0.82
Hexane, n-	0.2	0.7
Hexanone, 2-	1	4.1
Methyl ethyl ketone [MEK]	0.2	0.59
Methyl isobutyl ketone [MIBK]	0.2	0.82
Naphthalene	0.1	0.52
Tetrachloroethylene	0.2	1.4
Tetrahydrofuran	0.2	0.59
Toluene	0.1	0.38
Trichloro-1,2,2-trifluoroethane, 1,1,2- [Freon 113]	0.2	1.5
Trichlorobenzene, 1,2,4-	0.2	1.5
Trichloroethane, 1,1,1-	0.2	1.1
Trichloroethane, 1,1,2-	0.2	1.1
Trichloroethylene	0.2	1.1
Trimethylbenzene, 1,2,4-	0.2	0.98
Trimethylbenzene, 1,3,5-	0.2	0.98
Trimethylpentane, 2,2,4-	0.2	0.93
Vinyl acetate	0.5	1.8
Xylene, m+p-	0.2	0.87

Xylene, o-	0.1	0.43
Xylenes, total	0.3	1.3
Total VOCs to analyze	**67**	**67**
	ppbv	**µg/m³**
Lowest RDL	**0.1**	**0.32**
Max RDL	**1**	**4.1**

Passive Tube Analyte List

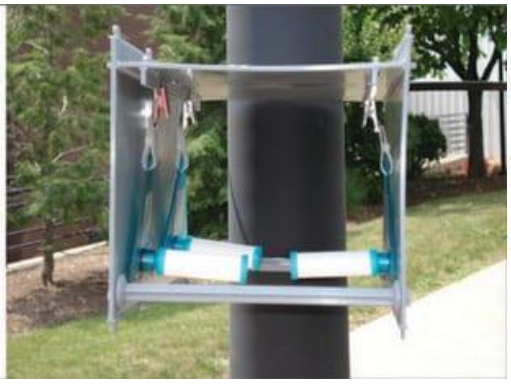
VOCs Compounds	**Method S620D RDL- µg/sample**	**RDL- µg/m³**
Allyl chloride	0.01	0.973
Benzene	0.004	0.301
BTEX, total	0.015	1.16
Butadiene, 1,3-	0.004	0.325
Chlorobenzene	0.004	0.389
Dichlorobenzene, 1,2-	0.004	0.441
Dichlorobenzene, 1,3-	0.004	0.451
Dichlorobenzene, 1,4-	0.004	0.441
Dichloroethane, 1,1-	0.004	0.348
Dichloroethane, 1,2-	0.004	0.348
Dichloroethylene, 1,1-	0.02	1.741
Dichloroethylene, cis-1,2-	0.02	1.711
Dichloropropane, 1,2-	0.004	0.382
Ethylbenzene	0.004	0.431
Ethyltoluene, 4-	0.004	0.484
Styrene	0.004	0.397
Tetrachloroethylene	0.004	0.413
Toluene	0.004	0.382
Trichloroethane, 1,1,1-	0.004	0.389
Trichloroethylene	0.004	0.397
Trimethylbenzene, 1,3,5-	0.004	0.484
Xylene, m+p-	0.008	0.863
Xylene, o-	0.004	0.431
Xylenes, total	0.01	0.965
Total VOCs to analyze	**24**	**24**
	µg/sample	**µg/m³**
Lowest RDL	**0.004**	**0.301**
Max RDL	**0.02**	**1.741**
Analysis Method Radiello 170	**RDL**	
H_2S	0.57	ppb

Appendix C

Examples of Sampling Equipment and Field Set-up

Short-Term Fixed Location Canister Sampling Equipment

Long-Term Fixed Location Passive Sampling Equipment



Continuous Sampling Equipment

HAPSITE

St. Croix Sensory Nasal Ranger (Nasal Ranger)