Supporting Document 3-7

Human Health Effects Assessment Report

Twin Creeks Environmental Centre Landfill Optimization Project Environmental Assessment

WM Canada

Watford, Ontario

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Executive Summary

Intrinsik Corp. (Intrinsik) was contracted by HDR Corporation on behalf of WM Canada (WM) to prepare this Human Health Effects Assessment Report as part of the Twin Creeks Environmental Centre (TCEC) Landfill Optimization Project Environmental Assessment (EA). The EA is being carried out in accordance with the requirements of the *Ontario Environmental Assessment Act* (*OEAA*) and the EA Terms of Reference (ToR), which was approved by the Ministry of Environment, Conservation and Parks (MECP) on December 13, 2022. The Human Health Effects Assessment Report considers the:

- predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals, and gaseous contaminants at identified sensitive receptor locations within the Study Area; and
- frequency of any exceedance of applicable standards, limits, or guidelines at identified receptors.

The purpose of this Effects Assessment Report is to present the:

- selection of the Preferred Alternative;
- assessment of the environmental effects of the Preferred Alternative; and
- commitments and monitoring.

There are approximately 6 years of approved landfill airspace capacity remaining at the TCEC (i.e., capacity will be reached in approximately 2031). The proposed optimization would provide additional airspace of approximately 14.3 million cubic metres (m³), which could extend the site life by approximately 12 years (from 2031 to 2043) and may be achieved through alternative landfill configurations (alternative methods) within the existing 301-hectare TCEC site area. No changes are proposed to the size of the TCEC site area, approved service area, or annual fill rate.

Three alternative methods for carrying out the optimization were developed to a preliminary conceptual design level in the Conceptual Design Report (CDR).

Alternative Method 1 includes the increase of final landfill side slopes from 4H:1V to 3H:1V between the original grade and elevation 320 masl, transitioning to a 20H:1V upper slope and peaking at elevation 324.5 masl within the Expansion Landfill footprint (**Figure 1-1**). Under the proposed vertical expansion, the existing approved waste disposal footprint area of the TCEC would not change, but rather, the maximum permitted height of waste would be increased by 44.5 m, from 280 masl (the current approved elevation for top of waste) to 324.5 masl, which is the maximum elevation of the top of the final cover for Alternative Method 1. The 3H:1V side slopes will start at the existing landfill toe slope continuing to elevation 320 masl, and then transition to a finished grade of 5%. This will increase the current landfill capacity by approximately 14.3 million m³.

The produced landfill gas (LFG) estimated for the closed Old Landfill and Expansion Landfill with Alternative Method 1, estimates that the landfill will produce a peak amount of LFG of approximately 20,203 m³/h in 2043, of which 18,169 m³/h are estimated to be collected. Collection efficiency for the closed Old Landfill is assumed to be 67% as this gives the best fit with real operational data. For the Expansion Landfill and vertical expansion, the collection efficiency of 75% is assumed for areas with waste and LFG collection systems in place but without final cover. The collection efficiency is increased to 90% for areas with a final cover and an LFG collection system.

The TCEC has created a Best Management Practices Plan (BMPP) for dust that is implemented at the site and will be in effect during Alternative Method 1. Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of total solid particles (TSP) exceedances will be limited during the periods of heavy construction and beyond.

Alternative Method 2 includes the increase of final landfill side slopes from 4H:1V to 2.5H:1V between elevation 250 masl and elevation 310 masl, about 60 m in grade change, transitioning to a 20H:1V upper slope and peaking at elevation 319 masl (**Figure 1-2**) within the Expansion Landfill footprint. Under the proposed vertical expansion, the existing approved waste disposal footprint area of the TCEC would not change, but rather, the maximum permitted height of waste would be increased by 39 m, from 280 masl (the current approved elevation for top of waste) to 319 masl, which is the maximum elevation of the top of the final cover for Alternative Method 2. The 2.5H:1V side slopes will start at elevation 250 masl and continue to elevation 325 masl, and then transition to a grade of 5% and peaking at elevation 319 masl. This will increase the current landfill capacity by approximately 14.3 million m³.

The produced LFG estimated for the closed Old Landfill and Expansion Landfill with Alternative Method 2 is the same as Alternative Method 1. There are no operational changes anticipated to result from the landfill optimization, and it will operate consistently with current conditions with the same 1.4 million tonnes annual capacity.

The TCEC has created a BMPP for dust that is implemented at the site and will be in effect during Alternative Method 2. Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of TSP exceedances will be limited during the periods of heavy construction and beyond.

Alternative Method 3 includes the increase of final landfill side slopes from 4H:1V to 2.5H:1V between elevation 260 masl and elevation 360 masl, about 100 m in grade change, peaking at elevation 360 masl (**Figure 1-3**) within the Expansion Landfill footprint. Under the proposed vertical expansion, the existing approved waste disposal footprint area of the TCEC would not change, but rather, the maximum permitted height of waste would be increased by 80 m, from 280 masl (the current approved elevation for top of waste) to 360 masl, which is the maximum elevation of the top of the final cover for Alternative Method 3. The 2.5H:1V side slopes will start at the existing landfill toe slope continuing to elevation 360 masl, and then peaking at elevation 360 masl. This will increase the current landfill capacity by approximately 14.3 million m³.

The produced LFG estimated for the closed Old Landfill and Expansion Landfill with Alternative Method 3 is the same as Alternative Methods 1 and 2.

The TCEC has created a BMPP for dust that is implemented at the site and will be in effect during of Alternative Method 3. Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of TSP exceedances will be limited during the periods of heavy construction and beyond.

The study areas for the Human Health Effects Assessment are as follows:

- On-site Study Area: the existing TCEC; and
- Off-site Study Area: the lands within the vicinity of the TCEC extending approximately 1 km out from the On-site Study Area.

Based on an examination of the alternative methods, it is unlikely that any of the alternative methods would alter the conclusions of the Human Health Effects Assessment Report. As such, the purpose of this Human Health Effects Assessment Report is to present a comparison of the potential environmental effects of the Preferred Alternative on Human Health to the Human Health Risk Assessment (HHRA) work previously completed in 2005 as part of the original landfill EA. Alternative Method 2 has been identified as the overall Preferred Alternative for the EA based on the results of the other discipline assessments. Consequently, the effects assessment of the Preferred Alternative presented in this report is based on Alternative Method 2 and follows the methods outlined in the approved ToR incorporating the information contained in the CDR and the Human Health Existing Conditions Report.

Alternative Method 2 was identified as the Preferred Alternative based on the comparative evaluation of the net effects of the Alternative Methods that was conducted for the EA. The net effects of the Alternative Methods for each evaluation criterion were compared to determine where there were substantial differences between the Alternative Methods. Where substantial differences were identified for an evaluation criterion, the Alternative Method with the lowest level of effect or the greatest level of benefit was selected as preferred for that criterion. The Alternative Method that was selected as preferred most often over all of the evaluation criteria was identified as the Preferred Alternative. Alternative Method 2 was selected as preferred most often across the evaluation criteria and was therefore identified as the Preferred Alternative.

Using the evaluation criteria, indicators, rationale and data sources from the approved ToR and the existing conditions from the Human Health Existing Conditions Report, the effects assessment is carried out as follows:

- predict the future baseline conditions and potential environmental effects for Alternative Method 2 (**Section 3**);
- conduct an effects assessment on the Preferred Alternative, including the identification of mitigation measures and monitoring programs (**Section 4**); and
- compare the effects of the Preferred Alternative to those of the ‘Do Nothing’ Alternative (i.e., the Expansion Landfill as approved) (**Section 5**).

As part of the effects assessment, an assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA was completed. The predicted concentrations of chemicals of concern (COCs) in air in the year 2020 from the 2005 HHRA were compared to the data from the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports for air quality as well as the modelling for the Preferred Alternative (**Table 3-1**).

There are a significant number of chemicals modelled in the 2005 HHRA for which monitoring was not (or could not be) conducted in the 2019, 2020, 2021, 2022, and 2023 annual monitoring programs. For the modelling data for the Preferred Alternative, VOCs and tailpipe contaminants were modelled for the maximum predicted concentrations at each of the discrete receptor locations for four scenarios: 1) end of Stage 1 of the vertical expansion; 2) end of Stage 2 of the vertical expansion; 3) end of Stage 4 of the vertical expansion; and 4) future no build scenario (the 'Do Nothing' Alternative. The maximum concentrations out of Scenarios 1, 2 and 3 were selected for use in the effects assessment. For the rest of the contaminants, no additional modelling was conducted; instead, scaling factors were developed and applied to the modelling results from other contaminants to determine a reasonable ballpark estimate of potential concentrations. Additionally, many chemicals were measured at non-detect concentrations. As a result, these chemicals did not represent a potential risk to human health.

Measured concentrations of benzene, cadmium, 1,2-dichloroethane, lead, nickel, trichloroethylene, and vinyl chloride from the Annual Monitoring Reports were greater for the Preferred Alternative than the predicted emissions for ground-level air from the 2005 HHRA. Modelled concentrations for the Preferred Alternative of 1-dichloroethane, butan-2-ol, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1-dichloroethylene, mercuric chloride, methyl mercury, methyl mercaptan, bromodichloromethane, octane, dimethyl sulphide, ethyl mercaptan, chloroethane, hydrogen chloride, benzo(a)pyrene, carbon dioxide, carbon monoxide, and PM_{10} were greater for the Preferred Alternative than the predicted emissions for ground-level air from the 2005 HHRA. However, when these chemicals were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the conclusions of the 2005 HHRA, the predicted risk estimates for all chemicals under the Preferred Alternative were still orders of magnitude below the health-based benchmarks (**Section 3.2.2**).

A review of the assumptions made in the 2005 HHRA was completed and based on this review, the assumptions previously used in the 2005 HHRA are still valid, and therefore, the results of the assessment also remain valid.

Updated risk estimations were predicted based on revised exposure limits from a toxicological literature search to determine if there was a reduction in risk, an increase in risk, or no change in risk (**Table 3-2**). The current risk estimations were also predicted using up-to-date exposure limits and the expected impact on previous risk estimations. Based on this evaluation, a number of chemicals resulted in predicting an increase in inhalation or oral risk estimate due to more conservative exposure limits in

place now versus when the 2005 HHRA was completed. However, annual concentration ratio (CR) values predicted for chronic exposures to all combustion gases (i.e., CO_2, CO, SO_2, NO_x and HCl) in the current assessment are predicted to be within acceptable levels (i.e., all CR values were less than one) resulting from the change in exposure limits since the 2005 HHRA was conducted. This suggests that no measurable long-term adverse health impacts are predicted to result from landfill combustion gas emissions.

Additionally, all ½-hour and 1-hour CR values calculated at the maximum fence-line location are predicted to be less than a value of 1.0. Therefore, no short-term adverse health effects are predicted to occur as a result of exposure to combustion gases, with the exception of the 24-hour hydrogen sulphide (H_2S) CR value which has an increase in inhalation risk estimate of about 21-fold compared to the 2005 HHRA.

Although there is a potential risk to human health from H_2S due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. H_2S was measured as part of the Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023. The H_2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H_2S and Total Reduced Sulphurs (TRS) are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H_2S and TRS from landfill operations at all discrete receptors and the property boundary are low. Additionally, the 24-hour maximum predicted concentration of H_2S for the Preferred Alternative is 6.5 µg/m³. Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H_2S and TRS concentrations are below detection and elevated concentrations of H_2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour. The Air Quality Existing Conditions Report has recommended that emissions of LFG should continue to be managed by routine maintenance of the final cap and interim cover areas.

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location, and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was predicted to be extremely low in the 2005 HHRA.

The dominant source of Particulate Matter (PM) at the TCEC is predicted to be crustal (i.e., soil, dirt particles), as opposed to combustion-related, which has a markedly lower toxicity. Air concentrations of PM_{10} and $PM_{2.5}$ were modelled using very conservative assumptions, and as a result are likely to be overestimated. The PM guidelines applied in this assessment were based on epidemiology literature related to adverse health outcomes associated with exposure to combustion-related PM, and as such, they are highly conservative benchmarks for this site. No exceedances were predicted on an annual average basis for either PM_{10} or $PM_{2.5}$. The degree of, and frequency of exceedance over the PM guidelines for 24-hr time frames for $PM_{2.5}$ were predicted to

be extremely small (less than 1.3 times the guidelines, for less than 1 day/year in Year 6), and were restricted to only a very small area near the facility. The degree of, and frequency of, exceedance over guidelines for 24-hr time frames for PM_{10} was slightly greater than those predicted for $PM_{2.5}$, but still not considered to represent a health concern due to the characteristics of the PM present at the TCEC.

As part of the Annual Monitoring Programs, concentrations of TSP exceeded the MECP Ambient Air Quality Criteria (AAQC) of 120 µg/m³ in numerous samples between 2019 to 2022. For each TSP exceedance, watering activities for dust control purposes, including watering on-site roadways and construction sites was implemented. Measured metal concentrations were consistently below the applicable criteria in the 2019 to 2022 Annual Monitoring Reports. Concentrations of VOCs from 2019, 2020, 2021, and 2022 Annual Monitoring Programs were quite low and less than their respective air quality standards.

The majority of incremental lifetime cancer risk (ILCR) values calculated for both inhalation and oral risk were below the 1 in a million-cancer risk with the exception of benzo(a)pyrene (TEF) (Slope Factor (SF) of $1.23x10^{-6}$), bromodichloromethane (SF of $1.04x10^{-6}$), 1,1,2,2-tetrachloroethane (SF of $1.19x10^{-6}$), and vinyl chloride (SF of $7.87x10^{-6}$). The measured concentrations of bromodichloromethane and 1,1,2,2-tetrachloroethane as part of the annual monitoring programs (2019, 2020, 2021, 2022, 2023) has been below the reportable detection limits of 1.34 ug/m^3 & 0.69 ug/m^3 respectively in all samples across all five years. The maximum predicted concentration for the Preferred Alternative for bromodichloromethane and 1,1,2,2-tetrachloroethane was 0.11 µg/m³ and 0.056 µg/m³ respectively. Vinyl chloride was detected three times during the annual monitoring program in 2019, twice in August (0.08 ug/m^3 & 0.15 ug/m^3) and the maximum concentration of vinyl chloride was measured at 0.41 µg/m³ in September 2019, and was below detection in 2020, 2021 and 2022. Vinyl chloride was measured twice in 2023 at 0.05 ug/m^3 and 0.08 µg/m³ in September and July,. The arithmetic mean of vinyl chloride when including the detection limits was 0.099 ug/m^3 in 2019 and 0.065 ug/m^3 in 2023. The geometric mean for vinyl chloride including detection limits over the five years was 0.054 ug/m^3. Vinyl chloride was predicted to be 0.5 µg/m³ (24-hours) and 0.1 µg/m³ (annual) for the Preferred Alternative. The original modelling from the 2005 HHRA for benzo(a)pyrene was likely related to diesel vehicle emissions and specifically from the landfill itself and the maximum predicted concentration for the Preferred Alternative for benzo(a)pyrene was $4.2x10^{-5}$ µg/m³. As such, risks associated with benzo(a)pyrene, bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are anticipated to be minimal.

Based on the potential environmental effects for the Preferred Alternative, the effects assessment of the Preferred Alternative, and the comparison of the effects of the Preferred Alternative to those of the ‘Do Nothing’ Alternative, no measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to LFG combustion emissions, with the exception of worst-case H_2S concentrations, as mentioned above, when considering modelling results for the Preferred Alternative. Furthermore, any impacts from the Preferred Alternative compared to the ‘Do Nothing’

Alternative are considered minimal and there are no significant advantages or disadvantages associated with the Preferred Alternative.

Therefore, based on the comparison between the modelled changes in air concentrations related to the Preferred Alternative and the air concentrations modelled in the 2005 HHRA, the Preferred Alternative is not predicted to result in any additional unacceptable health risks above those identified and mitigated in the 2005 HHRA.

Acronyms, Units and Glossary

Acronyms

Acronym	Definition
AAQC	Ambient Air Quality Criterion
AQG	Air Quality Guideline
AQS	Air Quality Standard
B(a)P	Benzo(a)pyrene
BMPP	Best Management Practices Plan
CDR	Conceptual Design Report
CO	Carbon Monoxide
CO_2	Carbon Dioxide
COC	Chemicals of Concern
COPC	Contaminant of Potential Concern
CR	Concentration Ratio
EA	Environmental Assessment
ER	Exposure Ratio
EAA	Environmental Assessment Act
ECA	Environmental Compliance Approval
EVGS	Early Vertical Gas System
GHG	Greenhouse Gas
H_2S	Hydrogen Sulphide
HHRA	Human Health Risk Assessment
ILCR	Incremental Lifetime Cancer Risk
IUR	Inhalation Unit Risk $(\mu g/m^3)^{-1}$
JSL	Jurisdictional Screening Levels
LFG	Landfill Gas
MECP	Ontario Ministry of Environment, Conservation and Parks
MOE	Ontario Ministry of Environment (now MECP)
NO_X	Nitrogen Oxides
OEAA	Ontario Environmental Assessment Act
PAH	Polycyclic Aromatic Hydrocarbon
PCDD/PCDFs	Polychlorinated dibenzodioxins / polychlorinated dibenzofurans (Dioxins and Furans)
PIC	Products of Incomplete Combustion
PLCS	Primary Leachate Collection System
PM	Particulate Matter

Acronyms

Acronym	Definition
POI	Provincial Point of Impingement
RfC	Reference Concentration (µg/m³)
RfD	Reference Dose (µg/kg/day)
RNG	Renewable Natural Gas
RS	Reduced Sulphur Compounds
SF	Slope Factor $(\mu g/kg/day)^{-1}$
SO_2	Sulphur Dioxide
TCDD	2,3,7,8-Tetrachlorodibenzodioxin
TCEC	Twin Creeks Environmental Centre
TLV-TWA	Threshold limit value – Time-Weighted Average
TLV-STEL	Threshold limit value – Short-Term Exposure Limit
ToR	Terms of Reference
TRS	Total Reduced Sulphurs
TSP	Total Suspended Particulate
US EPA IRIS	United States Environmental Protection Agency Integrated Risk Information System
VOC	Volatile Organic Compound
WM	WM Canada
WHO	World Health Organization

Units

Unit	Definition
µg/m³	micrograms per cubic metre
ha	hectare
km	kilometre
m	metre
mm	millimetre
m³	cubic metres
m³/h	cubic meters per hour
masl	metres above sea level
scfm	standard cubic feet per minute

Glossary

Term	Definition
Ambient Air Quality Criterion (AAQC)	An AAQC is not a regulatory value. It is a concentration of a contaminant in air that is protective against adverse effects on health and/or the environment. AAQCs are used to assess general (ambient) air quality resulting from all sources of a contaminant to air.
Approval	Permission granted by an authorized individual or organization for an undertaking to proceed. This may be in the form of program approval, certificate of approval or provisional certificate of approval.
Atmospheric Environment	• The atmospheric environment includes air quality, odour, noise, and litter.
Capacity (Disposal Volume)	The total volume of air space available for disposal of waste at a landfill site for a particular design (typically in m^3); includes both waste and daily cover materials, but excludes the final cover.
Combustion Gases	Combustion Gases include sulphur dioxide, nitrogen dioxide, carbon monoxide, hydrogen chloride and hydrogen sulphide (evaluated within the “combustion gases” group due to its presence as a gas under ambient conditions and its irritating effects to the eyes and respiratory system)
Composting	The controlled microbial decomposition of organic matter, such as food and yard wastes, in the presence of oxygen, into finished compost (humus), a soil-like material. Humus can be used in vegetable and flower gardens, hedges, etc.
Composting facility	A facility designed to compost organic matter either in the presence of oxygen (aerobic) or absence of oxygen (anaerobic).
Contaminant of Concern (COC)	Chemical substances found at the site that are determined to pose an unacceptable risk to human health or the environment.
Contaminant of Potential Concern (COPC)	A contaminant which may or may not be causing risk or adverse effects to human health or the environment at a site.
Concentration Ratio (CR)	For combustion gases, potential health risks to residents for acute and chronic exposures were assessed as concentration ratio values (CR). CR values were calculated by dividing the predicted air concentration with the reference concentration (RfC), according to the following equation: Concentration Ratio = Predicted Air Concentration / Reference Concentration
Environment	As defined by the Environmental Assessment Act, environment means: • air, land or water; • plant and animal life, including human life; • the social, economic and cultural conditions that influence the life of humans or a community; • any building, structure, machine or other device or thing made by humans; • any solid, liquid, gas, odour, heat, sound, vibration or radiation resulting directly or indirectly from human activities; or any part or combination of the foregoing and the interrelationships between any two or more of them (ecosystem approach).
Environmental Assessment (EA)	A systematic planning process that is conducted in accordance with applicable laws or regulations aimed at assessing the effects of a proposed undertaking on the environment.

Glossary

Term	Definition
Exposure Ratio (ER)	Risk characterization for non-carcinogenic compounds consists of a comparison of the exposure limits (i.e., the rate of exposure that would not be expected to produce adverse effects) against the total estimated exposure. For non-carcinogenic chemicals, this comparison is expressed as an Exposure Ratio (ER), calculated by dividing the predicted exposure by the exposure limit. If the total exposure to a chemical is equal to or less than the exposure limit, i.e., the ER is 1.0 or less, then no adverse health effects would be expected.
Evaluation criteria	Evaluation criteria are considerations or factors taken into account in assessing the advantages and disadvantages of various alternatives being considered.
Greenhouse gas (GHG)	Any of the gases whose absorption of solar radiation is responsible for the greenhouse effect, including carbon dioxide, methane, ozone, and the fluorocarbons.
Guideline B-7	Groundwater quality management tool adopted by the MECP for the reasonable use of groundwater resources adjacent to waste disposal sites (Procedure B-7-1). The reasonable use concept outlines the MECP's expectation of sites that discharge contaminants that could impact groundwater resources and provides guidance toward the establishment of contaminant attenuation zones (CAZ).
Incremental Lifetime Cancer Risk (ILCR)	For carcinogenic chemicals, potential risks are expressed as an Incremental Lifetime Cancer Risk Level (ILCR) which is calculated by multiplying the estimated exposure by the cancer slope factor (q^{1*}). An ILCR of 1×10^{-6} is considered to be an acceptable risk level per pathway by the Ontario Ministry of the Environment.
Indicators	Indicators are specific characteristics of the evaluation criteria that can be measured or determined in some way, as opposed to the actual criteria, which are fairly general.
Landfill gas (LFG)	The gases produced from the wastes disposed in a landfill; the main constituents are typically carbon dioxide and methane, with small amounts of other organic and odour-causing compounds.
Landfill site	An approved engineered site/facility used for the final disposal of waste. Landfills are waste disposal sites where waste is spread in layers, compacted to the smallest practical volume, and typically covered by soil.
Leachate	Liquid that drains from solid waste in a landfill and which contains dissolved, suspended and/or microbial contaminants from the breakdown of this waste.
Metals	Metals: arsenic, cadmium, lead, and mercury
Mitigation	Measures taken to reduce adverse impacts on the environment.
Natural Environment	The natural environment, as defined for the EA, includes the atmospheric environment, geology and hydrogeology, the surface water environment, and the ecological environment.
Particulate Matter	Particulate Matter includes: Total Suspended Particulate, PM_{10} and $PM_{2.5}$
Proponent	A person who: • carries out or proposes to carry out an undertaking; or • is the owner or person having charge, management or control of an undertaking.
Receptor	The person, plant or wildlife species that may be affected due to exposure to a contaminant.
Terms of Reference (ToR)	A terms of reference is a document that sets out detailed requirements for the preparation of an Environmental Assessment.

Glossary

Term	Definition
Undertaking	Is defined in the Environmental Assessment Act as follows: • An enterprise or activity or a proposal, plan or program in respect of an enterprise or activity by or on behalf of Her Majesty in right of Ontario, by a public body or public bodies or by a municipality or municipalities; • A major commercial or business enterprise or activity or a proposal, plan or program in respect of a major commercial or business enterprise or activity of a person or persons other than a person or persons referred to in clause (1) that is designated by the regulations; or • An enterprise or activity or a proposal, plan or program in respect of an enterprise or activity of a person or persons, other than a person or persons referred to in clause (a), if an agreement is entered into under section 3.0.1 in respect of the enterprise, activity, proposal, plan or program (“enterprise”).
Volatile Organic Compounds (VOCs)	Volatile organic compounds are compounds that have a high vapor pressure and low water solubility. Volatile Organic Compounds include: 1,1-Dichloroethane, Methylene chloride, Dimethylsulphide, 1,2-Dichloroethane, Methyl mercaptan, Chloroethane, Butan-2-ol, Trichloroethylene, 1,1,2-Trichloroethane, Bromodichloromethane, Benzene, 1,1,2,2-Tetrachloroethane, Vinyl Chloride, Ethyl mercaptan, 1,1-Dichloroethylene, and Octane
Waste	Refuse from places of human or animal habitation; unwanted materials left over from a manufacturing process.

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1 Introduction

Intrinsik Corp. (Intrinsik) was contracted by HDR Corporation on behalf of WM Canada (WM) to prepare this Human Health Effects Assessment Report as part of the Twin Creeks Environmental Centre (TCEC) Landfill Optimization Project Environmental Assessment (EA). The EA is being carried out in accordance with the requirements of the *Ontario Environmental Assessment Act* (*OEAA*) and the EA Terms of Reference (ToR), which was approved by the Ministry of Environment, Conservation and Parks (MECP) on December 13, 2022.

The *OEAA* defines the environment in a broad, general sense that comprises physical, biological, and human considerations. In this EA, the environment has been separated broadly into the natural, socio-economic, cultural, and built aspects, with environmental components and evaluation criteria identified within each aspect as listed in **Table 1-1**, consistent with the approved ToR. The organization of the Effects Assessment Reports is also provided in **Table 1-1.**

Table 1-1. Environmental Aspects, Components, and Evaluation Criteria

Environmental Aspect	Environmental Component	Evaluation Criteria	Effects Assessment Report
Natural Environment	Atmospheric Environment	• Air Quality – Dust • Air Quality – Landfill Gas and Combustion By-Products • Air Quality – Blowing Litter • Odour • Noise	• Air Quality
			• Odour
			• Noise
	Hydrogeology	• Groundwater Quality • Groundwater Quantity	• Hydrogeology
	Surface Water Environment	• Surface Water Quality • Surface Water Quantity	• Surface Water Quality
			• Surface Water Quantity
	Ecological Environment	• Terrestrial Ecosystems • Aquatic Ecosystems	• Ecological Environment
Socio-Economic Environment	Social Environment	• Human Health • Effects on Local Community	• Human Health
			• Socio-Economic Environment
	Economic Environment	• Economic Effects on Local Community	
	Visual Landscape	• Visual Impact of Facility	• Visual Landscape
Cultural Environment	Cultural Environment	• Cultural Heritage Resources • Archaeological Resources	• Cultural Heritage Resources
			• Archaeological Resources
Built Environment	Transportation	• Traffic Operations	• Transportation
	Current and Planned Future Land Use	• Effects on Current and Future Land Uses	• Land Use

The Human Health Effects Assessment considers the modelled changes in air concentrations related to the Preferred Alternative compared to the air concentrations modelled in the 2005 Human Health Risk Assessment (HHRA) that was part of the original landfill EA to determine if the predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals, and gaseous contaminants, at identified sensitive receptor locations within the Off-site Study Area as well as the frequency of any exceedance of applicable standards, limits, or guidelines at identified receptors would change as a result of the Project. As part of the EA, the alternative methods will be comparatively assessed and evaluated for the other environmental components (i.e., those components forming the natural, socio-economic, cultural, and built environments), using their proposed evaluation criteria, indicators, and data sources to determine the Preferred Alternative.

Based on an examination of the proposed alternative methods, it is unlikely that any of the alternative methods would alter the conclusions of the Human Health Effects Assessment Report. As such, the purpose of this Human Health Effects Assessment Report is to present a comparison of the potential environmental effects of the Preferred Alternative on Human Health to the Human Health Risk Assessment (HHRA) work previously completed in 2005 as part of the original landfill EA. Alternative Method 2 has been identified as the overall Preferred Alternative for the EA based on the results of the other discipline assessments. Consequently, the Effects Assessment of the Preferred Alternative presented in this report is based on Alternative Method 2 and follows the methods outlined in the approved ToR incorporating the information contained in the CDR and the Human Health Existing Conditions Report.

This Human Health Effects Assessment Report is one component of the EA. The EA Study Report will incorporate the information presented herein as appropriate, and this report will be included with the EA Study Report as a supporting document.

1.1 Project and Alternative Methods

There are approximately 6 years of approved landfill airspace capacity remaining at the TCEC (i.e., capacity will be reached in approximately 2031). The proposed landfill optimization would provide additional airspace of approximately 14.3 million cubic metres (m^3), which could extend the site life by approximately 12 years (from 2031 to 2043) and may be achieved through alternative landfill configurations (alternative methods) within the existing 301-hectare TCEC site area. No changes are proposed to the size of the TCEC site area, approved service area, haul route, or annual fill rate.

Three alternative methods for carrying out the landfill optimization were developed to a preliminary conceptual design level in the Conceptual Design Report (CDR) (WSP, 2025) and are described below as they are relevant to human health.

1.1.1 Alternative Method 1

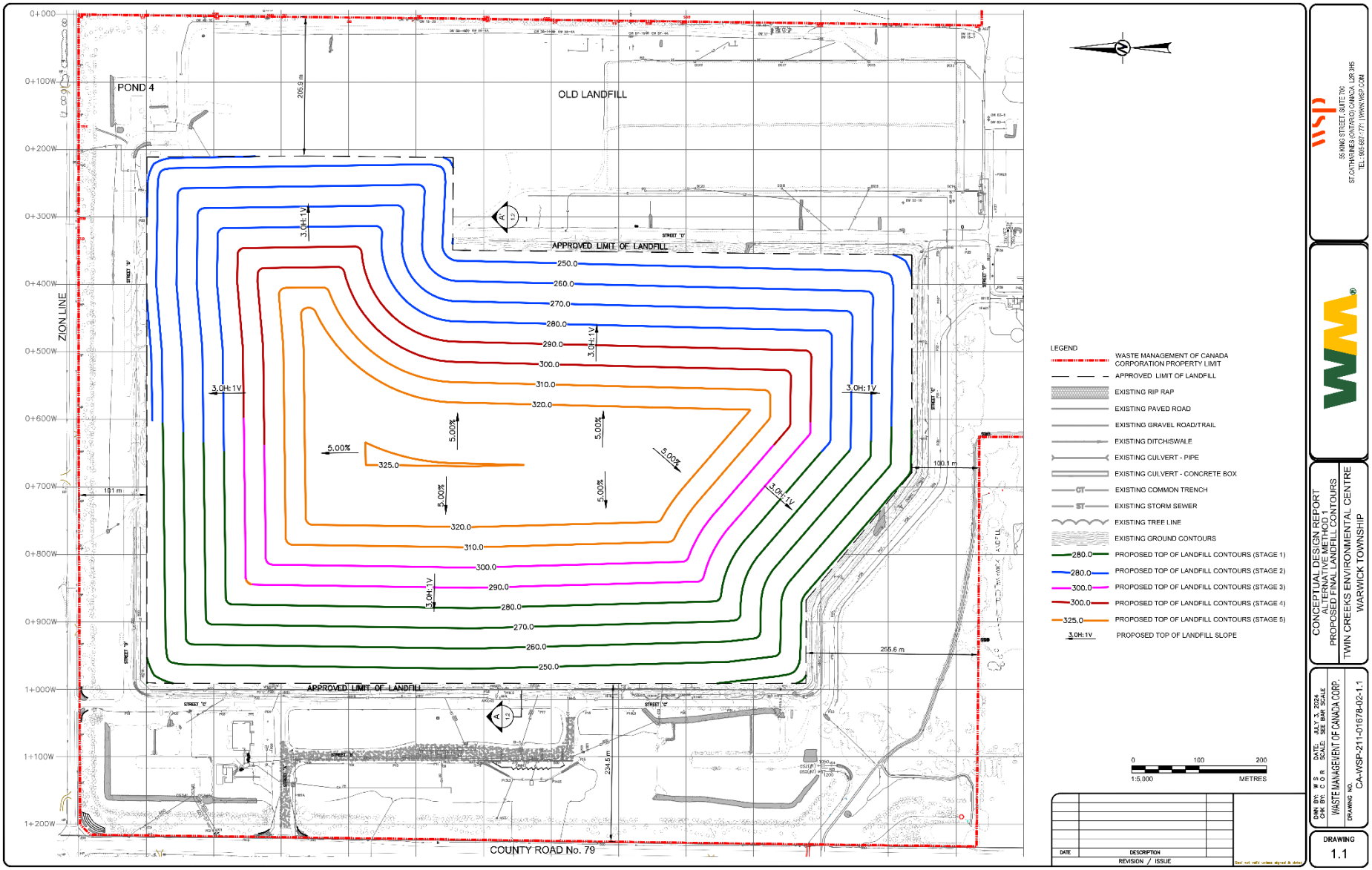
Alternative Method 1 includes the increase of final landfill side slopes from 4H:1V to 3H:1V between the original grade and elevation 320 metres above sea level (masl),

transitioning to a 20H:1V upper slope and peaking at elevation 324.5 masl within the Expansion Landfill footprint (**Figure 1-1**). Under the proposed vertical expansion, the existing approved waste disposal footprint area of the TCEC would not change, but rather, the maximum permitted height of waste would be increased by 44.5 m, from 280 masl (the current approved elevation for top of waste) to 324.5 masl, which is the maximum elevation of the top of the final cover for Alternative Method 1. The 3H:1V side slopes will start at the existing landfill toe slope continuing to elevation 320 masl, and then transition to a finished grade of 5%. This will increase the current landfill capacity by approximately 14.3 million m^3.

The produced landfill gas (LFG) estimated for the closed Old Landfill and Expansion Landfill with Alternative Method 1, estimates that the landfill will produce a peak amount of LFG of approximately 20,203 m^3/h in 2043, of which 18,169 m^3/h are estimated to be collected. Collection efficiency for the closed Old Landfill is assumed to be 67% as this gives the best fit with real operational data. For the Expansion Landfill and vertical expansion, the collection efficiency of 75% is assumed for areas with waste and LFG collection systems in place but without final cover. The collection efficiency is increased to 90% for areas with a final cover and an LFG collection system.

The TCEC has created a Best Management Practices Plan (BMPP) for dust that is implemented at the site and will be in effect during Alternative Method 1. Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of total solid particles (TSP) exceedances will be limited during the periods of heavy construction and beyond.

Figure 1-1. Alternative Method 1 (WSP, 2025)



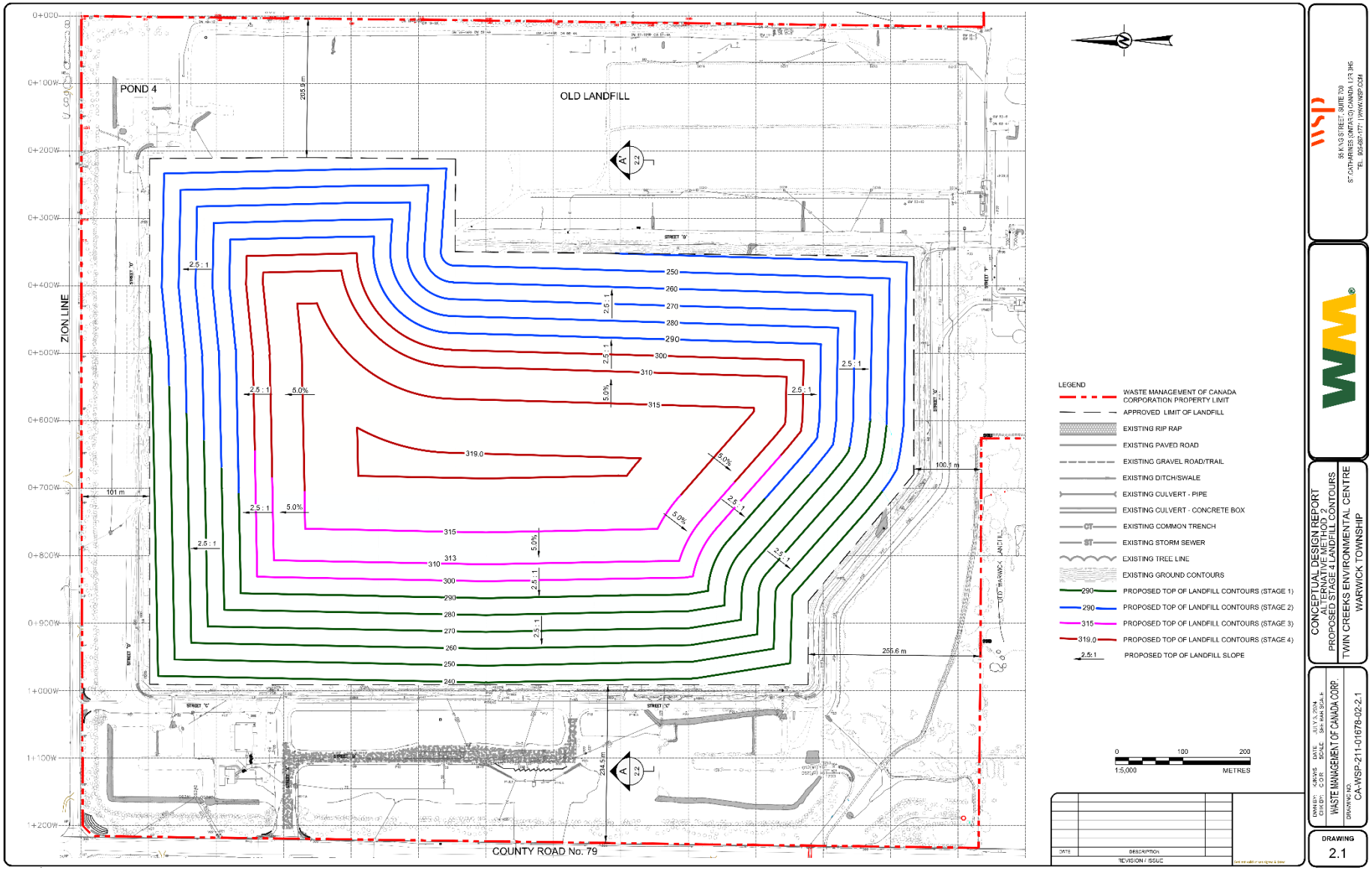
1.1.2 Alternative Method 2

Alternative Method 2 includes the increase of final landfill side slopes from 4H:1V to 2.5H:1V between elevation 250 masl and elevation 310 masl, about 60 m in grade change, transitioning to a 20H:1V upper slope and peaking at elevation 319 masl (**Figure 1-2**) within the Expansion Landfill footprint. Under the proposed vertical expansion, the existing approved waste disposal footprint area of the TCEC would not change, but rather, the maximum permitted height of waste would be increased by 39 m, from 280 masl (the current approved elevation for top of waste) to 319 masl, which is the maximum elevation of the top of the final cover for Alternative Method 2. The 2.5H:1V side slopes will start at elevation 250 masl and continue to elevation 325 masl, and then transition to a grade of 5% and peaking at elevation 319 masl. This will increase the current landfill capacity by approximately 14.3 million m³.

The produced LFG estimated for the closed Old Landfill and Expansion Landfill with Alternative Method 2 is the same as Alternative Method 1. There are no operational changes anticipated to result from the landfill optimization and it will operate consistent with current conditions with the same 1.4 million tonnes annual capacity.

The TCEC has created a BMPP for dust that is implemented at the site and will be in effect during Alternative Method 2. Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of TSP exceedances will be limited during the periods of heavy construction and beyond.

Figure 1-2. Alternative Method 2 (i.e., the Preferred Alternative) (WSP, 2025)



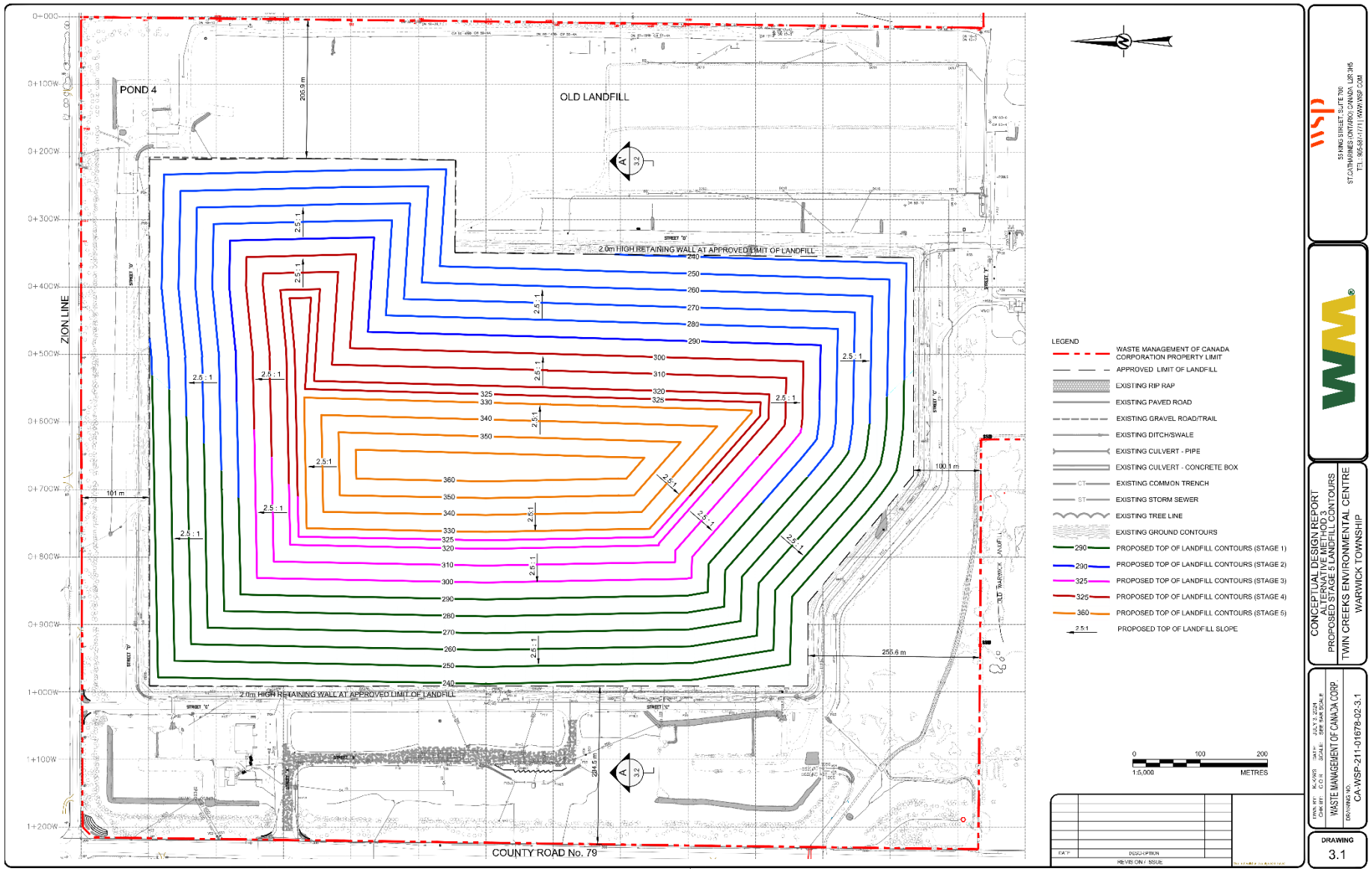
1.1.3 Alternative Method 3

Alternative Method 3 includes the increase of final landfill side slopes from 4H:1V to 2.5H:1V between elevation 260 masl and elevation 360 masl, about 100 m in grade change, peaking at elevation 360 masl (**Figure 1-3**) within the Expansion Landfill footprint. Under the proposed vertical expansion, the existing approved waste disposal footprint area of the TCEC would not change, but rather, the maximum permitted height of waste would be increased by 80 m, from 280 masl (the current approved elevation for top of waste) to 360 masl, which is the maximum elevation of the top of the final cover for Alternative Method 3. The 2.5H:1V side slopes will start at the existing landfill toe of slope continuing to elevation 360 masl, and then peaking at elevation 360 masl. This will increase the current landfill capacity by approximately 14.3 million m³.

The produced LFG estimated for the closed Old Landfill and Expansion Landfill with Alternative Method 3 is the same as Alternative Method 1 and 2.

The TCEC has created a BMPP for dust that is implemented at the site and will be in effect during of Alternative Method 3. Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of TSP exceedances will be limited during the periods of heavy construction and beyond.

Figure 1-3. Alternative Method 3 (WSP, 2025)



2 Effects Assessment Methods

Using the evaluation criteria, indicators, rationale and data sources from the approved ToR and the existing conditions from the Human Health Existing Conditions Report, the effects assessment is carried out as follows:

- predict the future baseline conditions and potential environmental effects for Alternative Method 2 (**Section 3**);
- conduct an effects assessment on the Preferred Alternative, including the identification of mitigation measures and monitoring programs (**Section 4**); and
- compare the effects of the Preferred Alternative to those of the 'Do Nothing' Alternative (i.e., the Expansion Landfill as approved) (**Section 5**).

2.1 Predict Potential Environmental Effects for Preferred Alternative (Alternative Method 2)

The potential environmental effects for the Preferred Alternative are identified within the study areas based on the application of the evaluation criteria, indicators and data sources in the approved ToR and based on the maximum allowable waste receipt level for the TCEC landfill. The potential effects can be positive or negative, direct or indirect, and short- or long-term. Mitigation measures are identified to minimize or mitigate the potential effects and then the net effects are evaluated taking into consideration the application of mitigation measures. The study areas, evaluation criteria, indicators, data sources, and key design considerations and assumptions for Human Health are provided below.

2.1.1 Study Areas

The TCEC landfill is located within the Township of Warwick, in the County of Lambton, approximately 1 km north of the Village of Watford. The TCEC is situated south of Highway 402 and southeast of the intersection of Nauvoo Road and Zion Line. The municipal street address of the TCEC is 5768 Nauvoo Road, Watford, Ontario. The area being considered for the landfill optimization is within the approved Expansion Landfill footprint located within the northern portion of the 301 ha TCEC site.

The study areas include the existing TCEC site as well as the potentially-affected surrounding areas. The general On-site and Off-site Study Areas identified for the EA in the approved ToR (HDR, 2022) are as follows:

- On-site Study Area: the existing TCEC;
- Off-site Study Area: the lands within the vicinity of the TCEC extending approximately 1 km out from the On-site Study Area.

The TCEC originally began operation in 1972 as the 'Warwick Landfill'. The landfill provides safe and convenient disposal services for communities, businesses and

industries serving the Province of Ontario. This landfill is approved to receive municipal, industrial, commercial, and institutional solid non-hazardous wastes, including non-hazardous contaminated soil.

WM has owned and operated the TCEC since 1996. An EA was conducted in 2005 (the Warwick Landfill Expansion EA) to expand the landfill within the 301 ha site boundary. A HHRA was prepared as part of the 2005 Warwick Landfill Expansion EA. The landfill was approved under the O*EAA* for expansion in 2007, and waste was first deposited into the expansion in November 2009. The site was originally approved for a waste capacity of 3,072,000 m³ within an area of 32.4 ha. The approval of the Expansion Landfill increased the total airspace capacity to 26,508,000 m³ within a total site area of 301 ha.

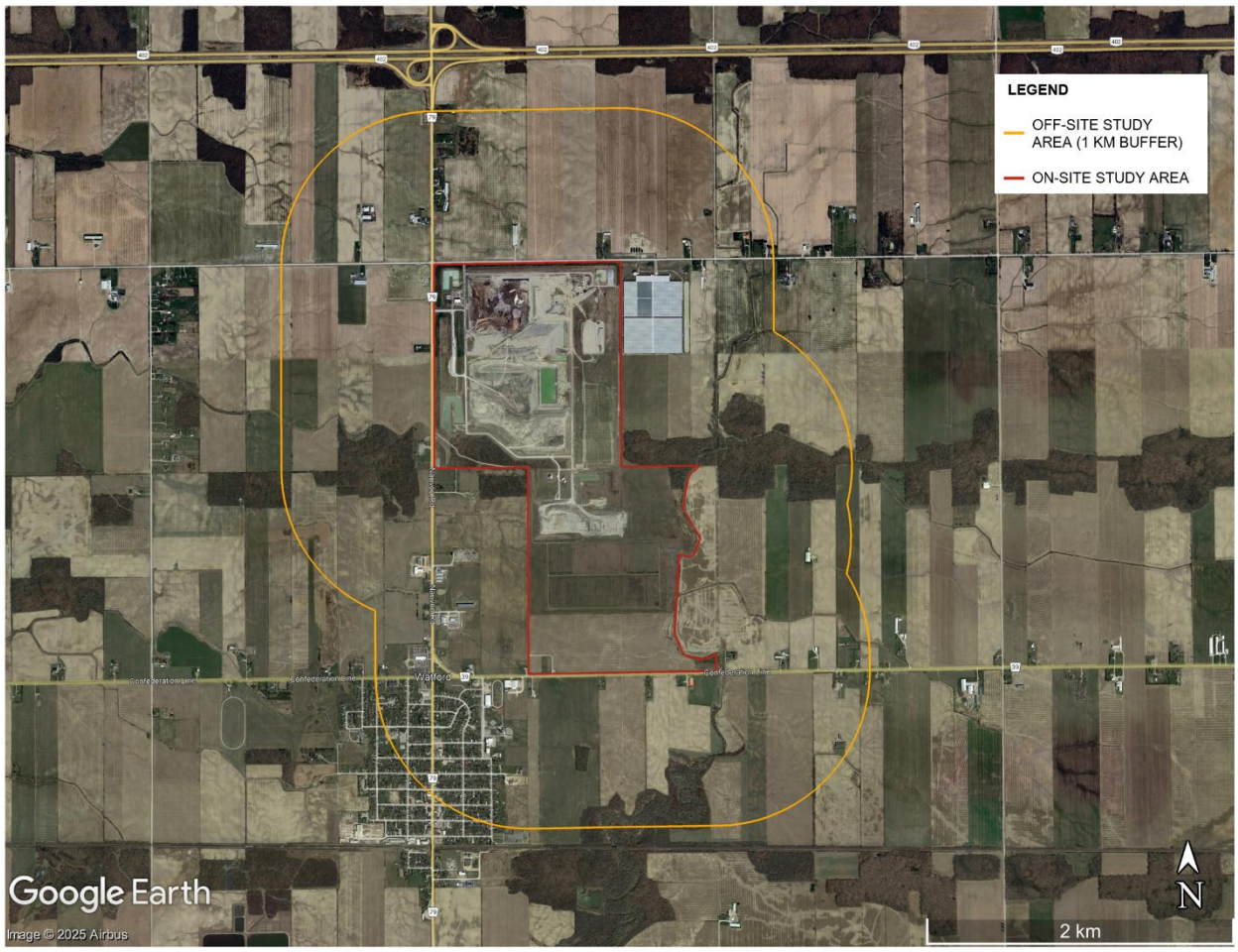
The Environmental Compliance Approval (ECA Waste) A032203 for the TCEC allows the landfill to receive up to a maximum of 1,400,000 tonnes per year of waste including contaminated soil for disposal at the site. There is approximately 8 years of approved airspace capacity remaining at the Expansion Landfill (i.e., capacity will be reached in approximately 2031). The approved landfill airspace is currently achieved with 4:1 side slopes to an elevation of 265.7 masl and then with 20:1 side slopes up to the landfill peak elevation of 280 masl. A two-metre-thick final cover results in a landfill peak at 282 masl. The existing natural surface elevation in the area is approximately 245 masl.

The general study areas defined for the EA include both the On-site Study Area (the existing TCEC) and the Off-site Study Area (the lands within the vicinity of the TCEC extending approximately 1 km out from the On-site Study Area). The Off-site Study Area used in the 2005 HHRA extended to 3.5 km from the site boundary consistent with the air quality study completed at the time. The air quality discipline for the current TCEC Landfill Optimization EA has extended the Off-site Study Area to 5 km from the TCEC site boundary. While data from the current air quality effects assessment will be used as comparison to the 2005 HHRA, the highest ground-level air concentrations would be expected to occur in close proximity to the landfill. As such, the additional 1.5 km of Off-site Study Area used for Air Quality (i.e., 5 km versus 3.5 km) is unlikely to affect the comparison to the 2005 HHRA.

The 2005 HHRA utilized the air quality study completed by RWDI which encompassed receptors within 3.5 km of the landfill site, extending past Highway 402 to the north and including the nearby village of Watford to the south (Intrinsik, 2005). According to the Air Quality Existing Conditions Report (RWDI, 2025c), the off-site study area extended ~5 km from the existing TCEC. However, the focus of the modelling for the Air Quality Existing Conditions Report was on identified residential receptors in the immediate vicinity (within ~1 kilometer) of the active landfill area (RWDI, 2025c).

For human health existing conditions, the general Off-site Study Area has been extended to include lands within approximately 1 km from the TCEC, consistent with the Air Quality discipline as shown on **Figure 2-1**. These general study areas are used for the purposes of the Human Health Effects Assessment.

Figure 2-1. On-site and Off-site Study Areas for Human Health (HDR, 2022)



2.1.2 Evaluation Criteria, Indicators, and Data Sources

The evaluation criteria, rationale, indicators, and data sources used for Human Health as per the approved ToR are provided in **Table 2-1.** Evaluation Criteria, Indicators, and Data Sources for Human Health.

Table 2-1. Evaluation Criteria, Indicators, and Data Sources for Human Health

Evaluation Criteria	Rationale	Indicators	Data Sources
Social Environment			
Human Health	Construction and operation activities at a waste disposal site can lead to increase to increased levels of particulates (dust) and related metals in the air.	• Predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals at identified sensitive receptor locations within the Study Area. Refer to **Table 2-2** for a complete list of assessed contaminants. • Frequency of any exceedance of applicable standards, limits, or guidelines at identified receptors.	• Data used in the previous 2005 risk assessment. • Available background ambient air data. • Ground-level air concentrations modelled by Air Quality team for proposed Preferred Alternative and associated frequency data. • Results from Existing Conditions Reports for Air Quality, Surface Water Quality and Hydrogeology • Off-site receptors identified in coordination with other disciplines. • Published health-based regulatory benchmarks or toxicity reference values (TRVs) for each contaminant of concern (e.g., WHO, 2021; MECP, 2022; HC, 2021). • WM Annual Monitoring Reports for the TCEC.
	Waste disposal site and associated operations can emit gaseous contaminants that can degrade air quality.	• Predicted acute and chronic health-based concentration ratios arising from air concentrations of gaseous contaminants at identified sensitive receptor locations within the Study Area. Refer to **Table 2-2** for a complete list of assessed contaminants. • Frequency of any exceedance of applicable standards, limits, or guidelines at identified receptors.	

2.1.3 Key Considerations and Assumptions

The key existing conditions elements, design considerations, and assumptions for the Human Health Effects Assessment are described below.

The 2005 HHRA evaluated a number of key exposure pathways including:

- Inhalation of air (both gaseous and particulate-bound chemicals) while indoors and outdoors (primary);
- Inhalation of soils and dusts (primary);
- Ingestion of soils and dusts (secondary);
- Ingestion of locally grown produce (secondary);
- Ingestion of local derived beef and dairy products (secondary);
- Ingestion of breast milk (secondary); and
- Dermal exposure to soils and dust (secondary).

The approach for this evaluation is not to complete a reassessment of risk on a pathway-by-pathway point of view, other than the primary pathway of inhalation of air, soils and dusts. Rather, this health effects assessment will evaluate whether there have been significant changes in chemicals or emissions from the TCEC facility compared to those modelled as part of the 2005 HHRA approvals, whether any of the exposure assumptions have changed, or the toxicological knowledge surrounding a given chemical has changed. By evaluating changes in emissions, the current health effects assessment and qualitatively evaluate the implications on each of the exposure pathways evaluated in the 2005 HHRA to determine whether the conclusions would still hold under existing conditions.

In this way, the secondary pathways are being qualitatively evaluated in this assessment report by assuming that a quantitative evaluation of expected changes in emissions based on the proposed changes will cascade to these secondary pathways. Given these pathways are correlated with emissions, the relative change in emissions (and TRV) can be used to estimate relative changes in risk predictions for these pathways without completing a full human health risk assessment.

2.1.3.1 Key Elements of Existing Conditions

To characterize existing conditions for Human Health, the following data collection and review was undertaken:

- A review of assumptions from the 2005 HHRA;
- A review of results from recent WM TCEC Annual Monitoring Reports (2019, 2020, 2021, 2022 and 2023);
- A review of field studies and existing conditions from the air quality, surface water quality, and groundwater quality disciplines;
- A comparison of the results of the chemical analyses from the recent TCEC annual monitoring program against assumptions made in the 2005 HHRA;
- An assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA; and
- A review of recent toxicological literature (WHO, 2021; MECP, 2022) for changes to the exposure limits applied to chemicals described in the 2005 HHRA, and to identify exposure limits for new chemicals of concern (COCs).

The 2005 HHRA employed the standard HHRA framework to assess COCs. At the time, the Ontario Ministry of the Environment (MOE, now MECP) required that WM include an initial list of 17 non-methane organic compounds which were identified as posing the greatest concern to human health at landfill sites in Ontario. As a result of the peer review process and consideration of leachate treatment options, additional compounds, including products of incomplete combustion, particulate matter and metals, were selected for inclusion in the 2005 HHRA as shown in **Table 2-2**.

Table 2-2. Contaminants of Concern for Human Health

COC Group	COC Source	COC		
Landfill Gases	Landfill gases produced by decomposition of landfill wastes	• 1,1-dichloroethane • 1,2-dichloroethane • Butan-2-ol • 1,1,2-trichlorethane • 1,1,2,2-tetrachloroethylene • 1,1-dichloroethylene	• Methylene chloride • Methyl mercaptan • Trichloroethylene • Bromodichloromethane • Vinyl chloride • Octane	• Dimethylsulphide • Chloroethane • Hydrogen sulphide • Benzene • Ethyl mercaptan
Combustion Gases and Products of Incomplete Combustion	Landfill flare and leachate treatment options (evaporation/ incineration)	• Sulphur dioxide • Hydrogen chloride	• Nitrogen dioxide • Benzo(a)pyrene-TEQ (representing carcinogenic PAH group)	• Carbon monoxide • Dioxin/Furans (TEQ)
Particulate	Crustal sources (i.e., soil) due to on- and off-site activities; contaminated soils; and various combustion sources including motor vehicle exhaust	• Total Suspended Particulate (TSP)	• PM_{10}	• $PM_{2.5}$
Metals	Leachate treatment option (evaporation/ incineration)	• Arsenic • Mercury	• Cadmium • Nickel	• Lead

There are a significant number of chemicals modelled in the 2005 HHRA for which monitoring was not (or could not be) conducted in the 2019, 2020, 2021, 2022, and 2023 annual monitoring programs. As such, it was not possible to evaluate existing conditions, in comparison to the predicted modelled concentrations, for these chemicals. Additionally, many chemicals were measured at non-detect concentrations. As a result, these chemicals do not represent a potential risk to human health. Benzene, lead, nickel, and Total Suspended Particulate (TSP) had detected concentrations measured in the Air Quality Monitoring Program as part of the 2022 Annual Monitoring Report (RWDI, 2023). Benzene, cadmium, 1,2-dichloroethane, lead, methylene chloride, nickel, trichloroethylene, TSP, and vinyl chloride, had detected concentrations measured in the Air Quality Monitoring Program as part of the 2023 Annual Monitoring Report (RWDI, 2024). TSP was not modelled in the 2005 HHRA. Measured concentrations of benzene, cadmium, 1,2-dichloroethane, lead, nickel, trichloroethylene, and vinyl chloride from the 2023 Annual Monitoring Report were greater than the predicted emissions for ground-level air from the 2005 HHRA (RWDI, 2024). However, when benzene, cadmium, 1,2-dichloroethane, lead, nickel, trichloroethylene and vinyl chloride were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the

conclusions of the 2005 HHRA, the predicted risk for all of the chemicals were still orders of magnitude below the health-based benchmark.

The only new COC to be flagged in the Human Health Existing Conditions Report as a potential risk based on the modelled emissions for the 2005 HHRA was hydrogen sulphide (H_2S) due to an increase in inhalation risk estimate of about 21-fold. This resulted in a worst-case predicted concentration ratio (CR) of 3.3 or in other words a predicted concentration that is slightly higher than 3-fold above the 24-hour AAQC (regulatory value changed from 150 µg/m³ to 7 µg/m³).

It is noteworthy that while all COCs modelled in the 2005 HHRA have been monitored at various points in the ongoing monitoring program used to characterize existing conditions, not all exposure durations were necessarily monitored. For example, in some cases, short-term exposures (i.e., 1-hour or 24-hour) were monitored, but annual averages were not reported. Alternatively, in some cases, no 1-hour concentrations were measured, but 24-hour and annual averages were reported. In these cases, conclusions with respect to these chemicals were made qualitatively when monitoring information was unavailable. Ultimately, all COCs modelled in the 2005 HHRA have been evaluated in the current health effects assessment by at least one relevant exposure period so as to be able to flag any significant change in conditions that might impact overall conclusions on health outcomes related to the proposed project.

2.1.3.2 Key Design Considerations

From the CDR, the LFG collection system will be progressively expanded as waste is placed and cells reach final grades. In addition to waste placement, the LFG collection system expansion will be constructed as part of the landfill development sequence (WSP, 2025).

LFG is currently collected from the closed Old Landfill and Expansion Landfill. The LFG collection system includes conventional vertical wells within the closed Old Landfill footprint and mostly Early Vertical Gas System (EVGS) wells within the Expansion Landfill. The Expansion Landfill also draws gas from the Primary Leachate Collection System (PLCS). All wells are connected to a network of laterals and sub-headers directing flow to the LFG Facility through a 900 mm diameter header pipe, which is sufficient to handle the generated LFG after vertical expansion. LFG is discharged to the on-site blower building and to fully enclosed flares (WSP, 2025).

The EVGS wells are extended upward as landfill operations progress and cells are filled. The LFG collection system is extended sequentially following horizontal and vertical growth of the Expansion Landfill. At approximately 15-metre intervals, additional gas subheaders and laterals are installed within the landfill. Condensate drains by gravity into several drain traps equipped with compressed air powered pumps which transfer liquid by forcemain for disposal into the PLCS. Vertical wells are extended as the waste placement progresses to minimize odours and reduce the amount of LFG escaping.

The expanded LFG collection system will be similar to the existing design and will comprise vertical wells, LFG subheaders, and LFG laterals that are connected to the main 900 mm header pipe located along the perimeter of the landfill (WSP, 2025).

The LFG collection system has a collection efficiency of approximately 75% for areas without final cover based on operational data and can be increased to 90% for areas with final clay cover. It is anticipated that this level of collection efficiency will continue to be achieved for all Alternative Methods. At peak LFG generation, approximately 18,169 m³/hour of LFG will be collected and require treatment (WSP, 2025).

The landfill has four approved LFG flares. Flares 1 to 4 provide a combined capacity of approximately 25,847 m³/h or 15,213 scfm. The new Renewable Natural Gas (RNG) Facility, which is currently being constructed at the TCEC, has the capacity to process up to 13,592 m³/h or 8,000 scfm of LFG on a dry basis and transform it into RNG, reducing greenhouse gas (GHG) emissions over the operating life of the site and during post-closure years. Additionally, Flares 5 and 6 are being constructed as part of the RNG Facility and will provide a capacity of 10,188 m³/h or 5,996 scfm (WSP, 2025).

In total, the TCEC has an approved combined treatment/flare operational capacity of 49,627 m³/h or 29,209 scfm (considering the four flares, the RNG Facility capacity and two flares), which provides an excess capacity of approximately 63% more than the estimated peak volume of LFG being collected at the site (WSP, 2025).

2.1.3.3 Key Assumptions

An evaluation of potential health effects was conducted in 2005 for the proposed expansion of the Warwick Landfill in the form of a detailed HHRA by Cantox Environmental Inc. (now Intrinsik Corp.). A review of the assumptions made in the 2005 HHRA was completed and is presented in **Table 2-3** below. Based on **Table 2-3**, the assumptions previously used in the 2005 HHRA are still valid, and therefore, the results of the assessment remain valid.

Table 2-3. Assumptions Used in the 2005 HHRA vs. Current HHRA Assumptions

Assumption Description	2005 Assumption	Current HHRA Assumption	Difference
Body Weight (kg)	• 8.2 kg infant • 16.5 kg toddler • 32.9 kg child • 59.7 kg teen • 70.7 kg adult	Same as 2005 assumptions	No change
Surface area of hands (m^2)	• 0.032 m² infant • 0.043 m² toddler • 0.059 m² child • 0.08 m² teen • 0.089 m² adult	Same as 2005 assumptions	No change
Breathing/Inhalation Rate (m³/day)	• 2.2 m³/day infant • 8.3 m³/day toddler • 14.5 m³/day child • 15.6 m³/day teen	Same as 2005 assumptions	No change

Table 2-3. Assumptions Used in the 2005 HHRA vs. Current HHRA Assumptions

Assumption Description	2005 Assumption	Current HHRA Assumption	Difference
	• 16.6 m^3/day adult		
Soil Ingestion Rate (g/day)	• 0.03 g/day infant • 0.2 g/day toddler • 0.05 g/day child • 0.05 g/day teen • 0.05 g/day adult	Same as 2005 assumptions	No change
Human Receptors (e.g., infant, toddler, child, adolescent, adult)	Female preschool child (7 months to 4 years) was used to represent the most sensitive individual. For highly bioaccumulative compounds such as dioxins and furans, exposures to mother's milk during the infant life stage were also considered. In order to conservatively assess potential incremental lifetime cancer risk levels (ILCR) to carcinogenic chemicals, a female composite or lifetime receptor, which includes all life stages, was included: • Infant (0 to 6 months); • preschool child or toddler (7 months to 4 years); • child (5 to 11 years); • adolescent (12 to 19 years); and • adult (>20 years).	Same as 2005 assumptions	No change
Exposure Pathways (people were assumed to be exposed to COPCs in the emissions of the proposed Warwick Landfill expansion via the following pathways)	• Inhalation of Air • Inhalation of Soils and Dusts • Ingestion of Soils and Dusts • Ingestion of Locally Grown Produce • Ingestion of Locally Derived Beef and Dairy Products • Ingestion of Breast Milk • Dermal Exposure to Soils and Dust It was conservatively assumed that all hypothetical residential receptors would spend 24 hours per day, 7 days per week, 52 weeks per year for 70 years at the maximum residential receptor location while supplementing their typical diet with fruits, produce, meat and dairy products from the nearby farming community.	Same as 2005 assumptions	No change
Receptor Location	• Maximum fence-line location • Maximum discrete receptor location	Total Suspended Particulate and Metals in ambient air • Southeast • Northeast • Western Fence line ambient VOCs sampling (RWDI, 2020; 2021; 2022; 2023; 2025c; 2024): • Concurrent upwind and downwind samples	Yes

Table 2-3. Assumptions Used in the 2005 HHRA vs. Current HHRA Assumptions

Assumption Description	2005 Assumption	Current HHRA Assumption	Difference
		Groundwater Sampling (RWDI, 2025a): • Select monitoring well locations at the landfill • Off-site monitoring location Cemetery Well • Interface aquifer monitoring wells for VOCs Surface Water sampling (RWDI, 2025b): • Surface Water Compliance Monitoring Program (SS1, SS10, SS16, SP1, SP2, SP3, SP4) • Surface water poplar system monitoring program (SS14A, SS14B SS15A) • Surface water poplar plantation (SS17A, SS17B) • SS18A, SS18B) • Off-site (SW1, SW2, SW3, SW4, SW5)	
Exposure Scenarios	• Baseline/Background (i.e., current conditions) • Year 1 (2005) • Year 6 (2010) • Year 11 (2015) • Year 16 (2020) • Year 21 (2025) • Year 26 (2030)	Annual Monitoring Reports for 2019, 2020, 2021, 2022, 2023	Yes

The 2005 HHRA evaluated health risks at the maximum discrete receptor location during six operating years (or scenarios) within the landfill's projected 25-year lifespan between 2005 and 2030. For each operating year (or scenario), health risks associated with exposures to the following emission sources were addressed:

- LFGs as a result of naturally decaying waste;
- Combustion gases and products of incomplete combustion (PIC) from flaring LFGs;
- Dust, including total suspended particulate and fine particulate matter (i.e., PM_{10} and $PM_{2.5}$) arising from truck traffic on paved and unpaved roads and earthworks activities; and,
- Metals and PICs from the leachate incineration treatment option.

The conclusions from the review and assessment of assumptions in the 2005 HHRA indicated that based on the review of results from the recent annual monitoring

programs, the review of existing conditions for air quality, groundwater quality and surface quality, and the review of assumptions as well as the conclusions from the 2005 HHRA, no measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case H_2S concentrations, under existing conditions. It was recommended that polycyclic aromatic hydrocarbons (PAHs), using benzo(a)pyrene as a surrogate, be added to the suite of chemicals being monitored in future air quality sampling events.

2.2 Comparative Evaluation and Identification of the Preferred Alternative

Alternative Method 2 was identified as the Preferred Alternative based on the comparative evaluation of the net effects of the Alternative Methods that was conducted for the EA. The net effects of the Alternative Methods for each evaluation criterion were compared to determine where there were substantial differences between the Alternative Methods. Where substantial differences were identified for an evaluation criterion, the Alternative Method with the lowest level of effect or the greatest level of benefit was selected as preferred for that criterion. The Alternative Method that was selected as preferred most often over all of the evaluation criteria was identified as the Preferred Alternative. Alternative Method 2 was selected as preferred most often across the evaluation criteria and was therefore identified as the Preferred Alternative.

2.3 Effects Assessment of the Preferred Alternative

An assessment of the environmental effects of the Preferred Alternative (i.e., Alternative Method 2) is carried out considering the same criteria, indicators, and data sources, considering potential mitigation/management measures and cumulative effects. The effects assessment of the Preferred Alternative will be compiled and presented in the EA Study Report.

2.4 Comparison of the Preferred Alternative against the ‘Do Nothing’ Alternative

The effects of the Preferred Alternative are compared against the predicted effects of the currently approved Expansion Landfill based on similar environmental criteria and indicators, with the understanding that the criteria and indicators used in the current effects assessment may differ from those used for the effects assessment of the Expansion Landfill. The effects are compared against each other in terms of magnitude, extent, and duration. The advantages and disadvantages of the Preferred Alternative compared to the ‘Do Nothing’ Alternative are identified. The comparison of the effects of the Preferred Alternative against the ’Do Nothing’ Alternative will be compiled and presented in the EA Study Report.

3 Net Effects Assessment

To identify the potential effects of the Project on Human Health, the conceptual design of Alternative Method 2 for the landfill optimization is examined to determine if it will have an effect on:

- predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals, and gaseous contaminants at identified sensitive receptor locations within the Study Area; and
- frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors.

The results of the net effects assessment for Alternative Method 2 are provided in **Sections 3.1** and **3.2**, below.

3.1 Future Baseline Conditions

Based on the Human Health Existing Conditions Report, the baseline conditions that will exist when the Project begins indicates that no measurable long-term or short-term adverse health impacts will occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case H_2S concentrations, under existing conditions.

More specifically, annual CR values predicted for chronic exposures to all combustion gases (i.e., CO_2, CO, SO_2, NO_x and HCl) were predicted to be within acceptable levels (i.e., all CR values were less than one). This suggests that no measurable long-term adverse health impacts were predicted to result from LFG combustion emissions.

Additionally, all ½-hour and 1-hour CR values calculated at the maximum fence-line location were predicted to be less than a value of 1.0. Therefore, no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases, with the exception of the 24-hour H_2S CR value which had an increase in inhalation risk estimate of about 21-fold compared to the 2005 HHRA.

Although there is a potential risk to human health from H_2S due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. H_2S was measured as part of the Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023 (RWDI, 2025c). The H_2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H_2S and Total Reduced Sulphurs (TRS) are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H_2S and TRS from landfill operations at all discrete receptors and the property boundary are low (RWDI, 2025c). Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H_2S and TRS

concentrations are below detection and elevated concentrations of H_2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour (RWDI, 2025c).

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location, and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was predicted to be extremely low in the 2005 HHRA.

The majority of ILCR values calculated for both inhalation and oral risk were below the 1 in a million-cancer risk with the exception of benzo(a)pyrene (TEF) (Slope Factor (SF) of $1.23x10^{-6}$), bromodichloromethane (SF of $1.04x10^{-6}$), 1,1,2,2-tetrachloroethane (SF of $1.19x10^{-6}$), and vinyl chloride (SF of $7.87x10^{-6}$). The measured concentrations of bromodichloromethane and 1,1,2,2-tetrachloroethane as part of the annual monitoring programs (2019, 2020, 2021, 2022, 2023) has been below the reportable detection limits of 1.34 ug/m^3 & 0.69 ug/m^3 respectively in all samples across all five years. Vinyl chloride was detected three times during the annual monitoring program in 2019, twice in August (0.08 ug/m^3 & 0.15 ug/m^3) and the maximum concentration of vinyl chloride was measured at 0.41 µg/m³ in September 2019. Vinyl chloride was below detection in 2020, 2021 and 2022, and was measured twice in 2023 at 0.05 ug/m^3 and 0.08 µg/m³ in September and July. The arithmetic mean of vinyl chloride when including the detection limits was 0.099 ug/m^3 in 2019 and 0.065 ug/m^3 in 2023. The geometric mean for vinyl chloride including detection limits over the five years was 0.054 ug/m^3. As such, risks associated with bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are anticipated to be minimal. We have no current measured or modelled data for benzo(a)pyrene. However, original modelling from the 2005 HHRA was likely related to diesel vehicle emissions and the specifically from the landfill itself.

3.2 Alternative Method 2

The assessment of effects for Alternative Method 2 is described below for the environmental criteria and indicators of Human Health and is summarized in **Table 3-3**.

3.2.1 Potential Changes since 2005 HHRA

The 2005 EA/HHRA was based on an annual fill rate of 750,000 tonnes/year. In 2017, through the EA Screening process, the approved fill rate was increased to 1.4M tonnes/year. The conclusions of the 2005 HHRA were confirmed for the current proposed expansion as part of the analysis conducted for the Human Health Existing Conditions Report. Given the current proposed expansion involves no change in the landfill footprint, approved service area, or annual fill rate, one would not expect significant changes in the assumptions used or the conclusions found in the original 2005 HHRA.

An assessment of new chemicals identified for potential health risks, and the reassessment of chemicals detected in recent annual compliance monitoring at concentrations higher, or lower than those considered in the 2005 HHRA was completed as part of this Human Health Effects Assessment Report. The predicted concentrations of COCs in air in the year 2020 from the 2005 HHRA were compared to the data from the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports for air quality as well as for the Preferred Alternative (**Table 3-1**).

There are a significant number of COCs not listed in the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring datasets as many of these are not included in standard monitoring regimes but were theoretically modelled as was done for the 2005 HHRA. The data set also includes modelling and measurements from the Air Quality Existing Conditions Report (RWDI, 2025c) for a more fulsome analysis. Monitoring results showing “ND” values in the table below indicate sampled COCs for which concentrations were below the analytical detection limit, while results showing “-” indicate these COCs were either not sampled and/or modelled.

For the modelling data for the Preferred Alternative, VOCs, and tailpipe contaminants were modelled for the maximum predicted concentrations at each of the discrete receptor locations for four scenarios: 1) end of Stage 1 of the vertical expansion; 2) end of Stage 2 of the vertical expansion; 3) end of Stage 4 of the vertical expansion; and 4) future no build scenario (the ‘Do Nothing’ Alternative). The maximum concentration out of Scenarios 1, 2 and 3 was selected for use in **Table 3-1**. For the rest of the contaminants, no additional modelling was conducted. Instead, scaling factors were developed and applied to the modelling results from other contaminants to determine a reasonable ballpark estimate of potential concentrations. The scaling was conducted as follows:

1. Methyl mercaptan, dimethyl sulphide, and ethyl mercaptan:
    a. Scaling factors were developed based on the concentration of each compound in the raw LFG and the concentration of H_2S in the raw LFG. The concentrations in raw LFG were based on gas samples collected from TCEC in 2023. These scaling factors were used with the results of the H_2S modelling for the 24-hour and 10-minute averaging periods to estimate off-site concentrations of each compound.
2. 1,1-Dichloroethane, Butan-2-ol, 1,1,2-Trichloroethane, 1,1,2,2-Tetrachloethane, 1,1-Dichloroethylene, Methylene chloride, Trichloroethylene, Bromodichloromethane, Octane, Chloroethane, Methyl mercury, Mercuric chloride, Carbon Dioxide:
    a. Separate scaling factors were developed based on the concentration of each compound in the raw LFG and the concentration of both benzene and vinyl chloride in the raw LFG.
    b. These scaling factors were then used with the results of both the benzene and vinyl chloride modelling for the 24-hour and annual averaging periods. Since the dominant sources are slightly different between vinyl chloride and benzene, results based on both of these compounds are provided.

c. The concentration in raw LFG for most contaminants was based on gas samples collected from TCEC in 2023. The exceptions to this are:

   i. Octane and Butan-2-ol were not tested in 2023, so gas testing data from TCEC from 2003 were used.

   ii. Methyl mercury was not tested in 2023 or 2003, so default concentrations from the US EPA AP-42 Chapter 2.4 were used.

   iii. Mercuric Chloride was not tested in 2023 or 2003, and default concentrations for this contaminant were not available in AP-42. Therefore, default concentrations for Total Mercury from US EPA Chapter 2.4 were used.

3. Carbon Monoxide, Benzo(a)pyrene, and Hydrogen Chloride:

   a. Scaling factors for carbon monoxide (CO) were developed based on the relative emission rate of CO and NO_x from the US EPA MOVES software and the relative emission rates of CO and NO_x from LFG flares from US EPA Chapter 2.4. The two scaling factors were compared and the AP-42 based flaring factor was higher (more conservative), so the flaring scaling factor was used for CO.

   b. A scaling factor for benzo(a)pyrene (B(a)P) was developed based on the relative emission rate of B(a)P and NO_x from MOVES. AP-42 Chapter 2.4 does not provide emissions data for B(a)P. Therefore, the scaling factor from MOVES was used for B(a)P.

   c. A scaling factor for HCl was developed based on the concentration of total chloride in the raw LFG, based on 2003 testing. This Chlorine concentration was applied to the maximum volume of LFG combusted by all 6 flares and the resulting emission of HCl were determined. The HCl emission rate was compared to the NOx emission rate from the flares in order to develop the scaling factor for HCl.

   d. The scaling factors for these contaminants were applied to the results of the NO_x modelling for the 1-hour and 24-hour averaging periods to estimate concentrations of these contaminants.

   The highest scaling factors from Scenario 3 were utilized for the current assessment and presented below as the 'Maximum Predicted Concentrations for Preferred Alternative (ug/m^3)' in **Table 3-1** when applicable. The spreadsheets containing the scaled outputs are provided in Appendix B. The modelling data for the Preferred Alternative did not include metals as these chemicals were included in the 2019-2023 Annual Monitoring Reports and concentrations are not expected to change.

Table 3-1. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports as well as Predicted Concentrations for the Preferred Alternative (Alternative Method 2) (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 AQMR Maximum Sampling Results (µg/m³)	2020 AQMR Maximum Sampling Results (µg/m³)	2021 AQMR Maximum Sampling Results (µg/m³)	2022 AQMR Maximum Sampling Results (µg/m³)	2023 AQMR Maximum Sampling Results (µg/m³)	Maximum Predicted Concentrations for Preferred Alternative (µg/m³)	Maximum Concentration – Existing Conditions / Preferred Alternative Predicted Concentration
Landfill Gases	Landfill gases produced by decomposition of landfill wastes	1,1-Dichloroethane	2.09E-03[3]	ND	ND	ND	ND	ND	0.044	0.044
		1,2-Dichloroethane	4.37E-03[3]	ND	ND	ND	ND	0.49	0.4 (24-hr) 0.1 (annual)	0.49
		Butan-2-ol	2.04E-02[1]	-	-	-	-	ND[7]	2.2	2.2
		1,1,2-Trichloroethane	5.35E-04[3]	ND	ND	ND	ND	ND	0.044	0.044
		1,1,2,2-Tetrachloroethane	5.94E-03[3]	ND	ND	ND	ND	ND	0.056	0.056
		1,1-Dichloroethylene	1.96E-03[1]	ND	ND	ND	ND	ND	0.033	0.033
		Methylene chloride	-	2.12	5.87	ND	ND	4.20	0.63	5.87
		Mercuric Chloride	1.90E-08[1]	-	-	-	-	-	0.00035	0.00035
		Methyl Mercury	1.90E-08[1]	-	-	-	-	-	0.0000012	0.0000012
		Methyl mercaptan	1.57E-01[1]	-	-	-	-	ND	0.16	0.16
		Trichloroethylene	2.14E-03[3]	ND	0.70	ND	ND	0.97	0.36	0.97
		Bromodichloromethane	1.68E-02[3]	ND	ND	ND	ND	ND	0.11	0.11
		Vinyl Chloride	5.62E-03[3]	0.41	ND	ND	ND	0.08	0.5 (24-hr) 0.1 (annual)	0.5
		Octane	1.75E-02[1]	-	-	-	-	ND[7]	2.9	2.9
		Dimethylsulphide	1.08E-02[1]	-	-	-	-	ND	0.16	0.16
		Ethylmercaptan	1.08E-02[1]	-	-	-	-	-	0.084	0.084
		Chloroethane	6.69E-03[3]	ND	ND	ND	ND	ND	0.12	0.12
		Hydrogen sulphide – annual maximum	5.20E-01[2]	-	-	-	-	-	-	-

Table 3-1. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports as well as Predicted Concentrations for the Preferred Alternative (Alternative Method 2) (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 AQMR Maximum Sampling Results (µg/m³)	2020 AQMR Maximum Sampling Results (µg/m³)	2021 AQMR Maximum Sampling Results (µg/m³)	2022 AQMR Maximum Sampling Results (µg/m³)	2023 AQMR Maximum Sampling Results (µg/m³)	Maximum Predicted Concentrations for Preferred Alternative (µg/m³)	Maximum Concentration – Existing Conditions / Preferred Alternative Predicted Concentration
		Hydrogen sulphide – 1-hr maximum	2.33E+01[2]	-	-	-	-	-	23.3 (10 min)	-
		Hydrogen sulphide – 24-hr maximum	-	-	-	-	-	27[6]	6.5	27
		Benzene	4.34E-03[3]	0.83	0.70	1.12	0.38	0.54	1.2 (24-hr) 0.4 (annual)	1.2
Combustion Gases and Products of Incomplete Combustion	Landfill flare and leachate treatment options (evaporation/incineration)	Sulphur dioxide – annual maximum	1.31E+00[2]	-	-	-	-	3.4[6]	3.4	3.4
		Sulphur dioxide – 1-hr maximum	1.26E+02[2]	-	-	-	-	77[6]	77	77
		Sulphur dioxide – 24-hr maximum	2.50E+01[2]	-	-	-	-	2.0[6]	-	2.0
		Hydrogen chloride– annual maximum	8.34E-02[2]	-	-	-	-	-	-	-
		Hydrogen chloride– ½-hr maximum	9.23E+00[2]	-	-	-	-	-	108 (1-hr)	108
		Hydrogen chloride– 24-hr maximum	1.61E+00[2]	-	-	-	-	-	19	19
		Nitrogen Oxides– annual maximum	9.91E-01[2]	-	-	-	-	-	-	-
		Nitrogen Oxides– 1-hr maximum	9.50E+01[2]	-	-	-	-	299[6]	267	299
		Nitrogen Oxides– 24-hr maximum	1.91E+01[2]	-	-	-	-	57[6]	50	57
		Benzo(a)pyrene	1.23E-09[3]	-	-	-	-	-	4.2E-05 (24-hr)	4.2E-05

Table 3-1. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports as well as Predicted Concentrations for the Preferred Alternative (Alternative Method 2) (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 AQMR Maximum Sampling Results (µg/m³)	2020 AQMR Maximum Sampling Results (µg/m³)	2021 AQMR Maximum Sampling Results (µg/m³)	2022 AQMR Maximum Sampling Results (µg/m³)	2023 AQMR Maximum Sampling Results (µg/m³)	Maximum Predicted Concentrations for Preferred Alternative (µg/m³)	Maximum Concentration – Existing Conditions / Preferred Alternative Predicted Concentration
		Carbon dioxide – annual maximum	3.41E+03[2]	-	-	-	-	-	22,760	22,760
		Carbon dioxide – ½-hr maximum	3.77E+05[2]	-	-	-	-	-	-	-
		Carbon dioxide – 24-hr maximum	6.57E+04[2]	-	-	-	-	-	199,484	199,484
		Carbon monoxide – annual maximum	2.55E+00[2]	-	-	-	-	-	-	-
		Carbon monoxide – ½-hr maximum	2.82E+02[2]	-	-	-	-	-	209 (1-hr)	209
		Carbon monoxide – 24-hr maximum	4.90E+01[2]	-	-	-	-	-	36	36
		Dioxin/Furans (TEQ)	-	-	-	-	-	0.02[6]	0.02	0.02
		2,3,7,8-TCDD (TEQ)[4]	2.48E-12[1]	-	-	-	-	-	-	-
		2,3,7,8-TCDD (TEQ)[5]	2.20E-12[1]	-	-	-	-	-	-	-
Particulate	Crustal sources (i.e., soil) due to on- and off-site activities; contaminated soils; and various combustion sources including motor vehicle exhaust	Total Suspended Particulate (TSP)	-	588	263	134	347	211	34 (annual) 215 (24-hr)	588
		PM_{10} – Annual maximum	2.23E-01[2]	-	-	-	-	-	-	-
		PM_{10} – 24-hr maximum	4.30E+00[2]	-	-	-	-	103[6]	79	107
		$PM_{2.5}$ – Annual maximum	2.23E-01[2]	-	-	-	-	8.6[6]	7.7	8.6
		$PM_{2.5}$ – 24-hr maximum	4.30E+00[2]	-	-	-	-	29[6]	21	29

Table 3-1. Predicted Concentrations of COCs in Air in Year 2020 from Original 2005 HHRA vs. 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports as well as Predicted Concentrations for the Preferred Alternative (Alternative Method 2) (µg/m³)

COC Group	COC Source	COC	Year 2020 Predicted Emissions for Ground-level Air Concentrations from 2005 HHRA	2019 AQMR Maximum Sampling Results (µg/m³)	2020 AQMR Maximum Sampling Results (µg/m³)	2021 AQMR Maximum Sampling Results (µg/m³)	2022 AQMR Maximum Sampling Results (µg/m³)	2023 AQMR Maximum Sampling Results (µg/m³)	Maximum Predicted Concentrations for Preferred Alternative (µg/m³)	Maximum Concentration – Existing Conditions / Preferred Alternative Predicted Concentration
Metals	Leachate treatment option (evaporation/incineration)	Arsenic	1.05E-07[3]	ND	0.005	ND	ND	ND	-	0.005
		Cadmium	2.85E-07 [1]	ND	0.002	ND	ND	0.001	-	0.002
		Lead	3.32E-06[1]	0.029	0.119	0.036	0.01	0.091	-	0.119
		Mercury	1.90E-08[1]	-	-	-	-	-	-	-
		Nickel	1.42E-06[1]	0.007	0.026	0.007	0.005	0.013	-	0.026

Source: Intrinsik Corp. (formerly Cantox Environmental), 2006; RWDI, 2020; 2021; 2022; 2023; 2025c; 2024.
AQMR Annual Air Quality Monitoring Report
ND Non-detect concentration. Monitoring results showing "ND" values in the table below indicate sampled COCs for which concentrations were below the analytical detection limit.
'-' Indicates these COCs were either not sampled and/or modelled.

[1] Annual Ground-Level Air Concentrations of Non-Carcinogenic COPCs for each Future Operating Year at the Maximum Discrete Receptor Location (µg/m³) (RWDI, 2003a).

[2] Predicted Emissions from Year 2020 for Ground-level Air Concentrations (µg/m³) of Combustion Gases and Particulate Matter (PM_{10} and $PM_{2.5}$) at the Maximum Residential Location under the Landfill Flare plus the Evaporation/Incineration Leachate Treatment Option.

[3] 70-year Annual Average Ground-Level Air Concentrations of all Carcinogenic COPCs at the Maximum Discrete Receptor.

[4] Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare plus the evaporation/incineration treatment option.

[5] Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare only scenario. In other words, the contribution from the evaporation/incineration treatment methods is excluded from these predictions.

[6] Value is modelled from the Air Quality Existing Conditions Report (RWDI, 2025c).

[7] The following compounds were not detected above 1ppbv via a library search: 1,2,3-Trimethylbenzene, 2-Methylhexane, 2-Methylpentane, 3-Methylpentane, 3-Methylhexane, 2-Methylbutane, Butyl Acetate, Decane, Limonene, m/p ethyl toluene, m-cymene, methyl cyclohexane, chlorodifluoromethane, n-butanal, nonane, o-ethyl toluene, propylbenzene, 2-butanol, pentane, and octane (RWDI, 2024).

Based on the above evaluation, there are a significant number of chemicals modelled in the 2005 HHRA for which monitoring was not (or could not be) conducted in the 2019, 2020, 2021, 2022, and 2023 annual monitoring programs. As such, for the Human Health Effects Assessment report, scaling factors were developed and applied to the modelling results from other contaminants to determine a reasonable ballpark estimate of potential concentrations in order to complete a comparison to the predicted modelled concentrations. Additionally, many chemicals were measured at non-detect concentrations. As a result, these chemicals did not represent a potential risk to human health. TSP was not modelled in the 2005 HHRA.

3.2.2 Toxicological Literature Changes and Expected Impact

A review of recent toxicological literature for changes to the exposure limits applied to COCs described in the 2005 HHRA, and to identify exposure limits for new COCs, was completed as part of the Human Health Existing Conditions assessment. Exposure limits used in the 2005 HHRA were compared to the current exposure limits to determine if there was a reduction in risk, an increase in risk, or no change in risk (**Table 3-2**). The current risks were also predicted using the current exposure limits and the expected impact on previous risk estimations.

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Combustion Gases						
Carbon Dioxide	Inhalation	RfC	214,000	*214,000*	→ assumed no change	0.016
		TLV-TWA	-	9,000	-	-
		TLV-STEL	-	54,000	-	-
Carbon Monoxide	Inhalation	RfC	3,140	*3,140*	→ assumed no change	0.00081
		15-min AQG	-	100,000	-	-
		1-hr AAQC	38,200	36,200	→ little change	0.0078
		8-hr AQG	-	15,700	-	-
		24-hr AAQC	15,700	4,000	↑ increase in inhalation risk estimate of about 4-fold	0.12
Hydrogen Chloride	Inhalation	RfC	20	*20*	→ assumed no change	0.0042
		1-hr AAQC	2,100	*2,100*	→ assumed no change	0.0044
		24-hr AAQC	20	20	→ no change	0.081
Hydrogen Sulphide	Inhalation	RfC	1	*1*	→ assumed no change	0.52
		1-hr AAQC	30	*30*	→ assumed no change	0.78
		24-hr AAQC	150	7	↑ increase in inhalation risk estimate of about 21-fold	**3.3**
NO_x	Inhalation	RfC	40	*40*	→ assumed no change	0.025
		1-hr AAC	400	200	↑ increase in inhalation risk estimate of about 2-fold	0.48
		24-hr AAQC	200	25	↑ increase in inhalation risk estimate of about 8-fold	0.76
		Annual AQG	-	10	-	-
SO_x	Inhalation	RfC	50	*50*	→ assumed no change	0.026
		10-minute AQG	-	500	-	-
		1-hr AQS	350	*350*	→ assumed no change	0.36
		24-hr AQS	125	40	↑ increase in inhalation risk estimate of about 3-fold	0.63

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Metals						
Arsenic	Inhalation	IUR	0.0043	0.00015	↓ reduction in risk estimate of about 29-fold	1.58E-11
	Oral	SF	0.0015	0.0095	↑ increase in risk estimate	9.98E-10
		RfD	0.3	0.12	↑ increase in oral risk estimate of about 2.5-fold	8.75E-07
Cadmium	Inhalation	IUR	0.0018	0.0098	↑ increase in risk estimate of about 5.5-fold	2.79E-09
		RfC	-	0.03	-	9.50E-06
	Oral	RfD	0.5	0.032	↑ increase in oral risk estimate of about 15-fold	8.91E-06
Lead	Inhalation	RfC	6.48	0.5	↑ increase in inhalation risk estimate of about 13-fold	6.64E-06
	Oral	RfD	1.85	None Selected	-	-
Mercury	Inhalation	RfC	0.301	0.09	↑ increase in inhalation risk estimate of about 3.3-fold	2.11E-07
	Oral	RfD	0.3 (Mercuric chloride)	0.3	→ no change	6.33E-08
	Sub-chronic Oral	RfD	NV	3	-	6.33E-09
Methyl Mercury	Oral	RfD	0.1	0.1	→ no change	1.90E-07
Nickel	Inhalation	IUR	0.00038	0.00024	↓ slight reduction in inhalation risk estimate	3.41E-10
		RfC	NV	0.06	-	2.37E-05
	Oral	RfD	20	2.8	↑ increase in oral risk estimate of about 7-fold	5.07E-07

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Particulate Matter						
TSP	NA	Annual AAQC (visibility)	60	60	→ no change	**4.4**
		24-hour AAQC (visibility)	120	120	→ no change	**2.2**
PM_{10}	Inhalation	Annual AQS	50	15	↑ increase in inhalation risk estimate of about 3.3-fold	0.015
		24-hour AAQC	50	45	→ little change	0.096
$PM_{2.5}$	Inhalation	Annual mean	15	8.8	↑ increase in inhalation risk estimate of about 1.7-fold	0.025
		24-hour WM	30	27	→ little change	0.16
Chlorinated Polycyclic Aromatics						
2,3,7,8-substituted TCDD	Inhalation	RfC	0.000035	0.000035[d]	→ no change	7.1E-08[e] 6.3E-08[f]
	Oral	RfD	0.00001	0.00001[d]	→ no change	2.48E-7[e] 2.20E-7[f]
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene (TEF)	Inhalation	IUR	0.087	0.0006	↓ reduction in inhalation risk estimate of about 145-fold	7.38E-13
		RfC	-	0.002	-	6.15E-07
	Oral	SF	0.0005	0.001	↑ increase in risk estimate	**1.23E-06**
		RfD	-	0.3	-	4.10E-09
		Sub-chronic RfD	-	5	-	2.46E-10
Benzo(a)pyrene (whole mixture model)	Inhalation	IUR	0.027	-	-	-
	Oral	SF	0.00028	-	-	-
	Dermal	q_1*	0.013	-	-	-

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
Volatile Organic Compounds						
Benzene	Inhalation	IUR	0.0000077	0.0000022	↓ reduction in inhalation risk estimate of about 3.5-fold	9.55E-09
		RfC	1.7	30	↓ reduction in risk estimate	0.00015
	Oral	SF	0.000055	0.000085	↑ increase in risk estimate	3.69E-07
		RfD	3	4	↓ reduction in risk estimate	0.0011
Bromodichloromethane	Inhalation	IUR	0.000018	-	-	-
		RfC	70	-	-	-
	Oral	SF	0.000062	0.000062	→ no change	**1.04E-06**
		RfD	20	20	→ no change	0.00084
2-Butanol (1-butanol used as surrogate chemical)	Inhalation	RfC	9.1	*9.1*	→ assumed no change	0.0022
		24-hr AAQS	-	920	-	2.22E-05
	Oral	RfD	100	*100*	→ assumed no change	0.00020
Chloroethane	Inhalation	IUR	0.00000083	*0.00000083*	→ assumed no change	5.54E-09
		RfC	10,150	*10,150*	→ assumed no change	6.59E-07
		24-hr AAQS	-	5,600	-	1.19E-06
	Oral	SF	0.0000029	*0.0000029*	→ assumed no change	1.94E-08
		RfD	400	*400*	→ assumed no change	1.67E-05
1,1-Dichloroethane	Inhalation	IUR	0.0000016	-	-	-
		RfC	490	170	↑ increase in risk estimate of about 2.8-fold	1.23E-05
	Oral	SF	0.0000057	-	-	-
		RfD	100	40	↑ increase in oral risk estimate of about 2.5-fold	5.23E-05
		Sub-chronic RfD	-	400	-	5.23E-06

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
1,2-Dichloroethane	Inhalation	IUR	0.0000024	0.000026	↑ increase in risk estimate	1.14E-07
		RfC	4.9	400	↓ reduction in risk estimate	1.09E-05
	Oral	SF	0.00000833	0.000091	↑ increase in risk estimate	3.98E-07
		RfD	30	20	↑ increase in oral risk estimate of about 1.5-fold	0.00022
		Sub-chronic RfD	-	200	-	2.19E-05
1,1-Dichloroethylene	Inhalation	RfC	200	200	→ no change	9.80E-06
		Sub-chronic RfC	-	79.3	-	2.47E-05
	Oral	RfD	50	50	→ no change	3.92E-05
Dimethyl sulphide	Inhalation	RfC	875	*875*	→ assumed no change	1.23E-05
	Oral	RfD	250	*250*	→ assumed no change	4.32E-05
Ethyl mercaptan (methyl mercaptan used as a surrogate)	Inhalation	RfC	2.0	*2.0*	→ assumed no change	5.41E-03
	Oral	RfD	0.57	*0.57*	→ assumed no change	0.019
Methyl mercaptan	Inhalation	RfC	2.0	*2.0*	→ assumed no change	7.87E-02
	Oral	RfD	0.57	*0.57*	→ assumed no change	0.28
Methylene chloride	Inhalation	IUR	0.00000047	0.000000023	↓ reduction in inhalation risk estimate of about 20.5-fold	4.37E-16
		RfC	-	400	-	4.75E-11
		Sub-chronic RfC	-	400	-	4.75E-11
	Oral	SF	0.0000075	0.000002	↓ reduction in oral risk estimate of about 3.75-fold	3.80E-14
		RfD	60	6	↑ increase in oral risk estimate of about 10-fold	3.17E-09
Octane	Inhalation	RfC	18,410	*18,410*	→ assumed no change	9.51E-07
	Oral	RfD	5,000	*5,000*	→ assumed no change	3.50E-06

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)
1,1,2,2-Tetrachloroethane	Inhalation	IUR	0.00000833	-[b]	-	-
	Oral	SF	0.00000833	0.0002	↑ increase in risk estimate	**1.19E-06**
		RfD	-	20	-	0.00030
		Sub-chronic RfD	-	500	-	1.19E-05
1,1,2-Trichloroethane	Inhalation	IUR	0.000016	0.000016	→ no change	8.56E-09
	Oral	SF	0.000057	0.000057	→ no change	3.05E-08
		RfD	4	4	→ no change	0.00013
		Sub-chronic RfD	-	40	-	1.34E-05
Trichloroethylene	Inhalation	IUR	0.00011	0.0000041	↓ reduction in inhalation risk estimate of about 28-fold	8.77E-09
		RfC	35	2	↑ increase in inhalation risk estimate of about 17-fold	0.0011
	Oral	SF	0.0004	0.000046	↑ increase in oral risk estimate of about 9-fold	9.84E-08
		RfD	0.3	0.5	↓ reduction in risk estimate	0.0043
Vinyl chloride	Inhalation	IUR	0.0000088	0.0000088[c]	→ no change	4.95E-08
		RfC	102	60	↑ increase in risk estimate of about 1.7-fold	9.37E-05
	Oral	SF	0.0014	0.0014	→ no change	**7.87E-06**
		RfD	3	3	→ no change	0.0019

Note: IUR values in the original 2005 HHRA were presented in $(\mu g/kg/d)^{-1}$. For comparison purposes, these were converted to $(\mu g/m^3)^{-1}$ values by multiplying by (20/70).
Italicized current exposure limits were assumed to be the same as the exposure limit used in original 2005 HHRA (Cantox).
Bolded values were identified to exceed a value of 1.0 for CRs/ERs or a value of 1 in a million-cancer risk (ILCRs)
NV No value selected.
[a] Units: Reference Concentration (RfC): $\mu g/m^3$; Reference Dose (RfD): µg/kg/day; Inhalation Unit Risk (IUR): $(\mu g/m^3)^{-1}$; Oral Slope Factor (SF): $(\mu g/kg/day)^{-1}$.
[b] MECP (2022) endorsed the US EPA IRIS (1994) IUR of 5.8x10-5 $(\mu g/m^3)$-1 for 1,1,2,2-tetrachloroethane. US EPA IRIS conducted a review of the available toxicological data and derived new exposure limits for 1,1,2,2-tetrachloroethane in 2010. Based on the available data, US EPA IRIS (2010) no longer endorses the IUR derived in 1994 and has not derived a new IUR for 1,1,2,2-tetrachloroethane. Therefore, it was not considered appropriate to adopt the MECP (2022) endorsed IUR for 1,1,2,2-tetrachloroethane for the assessment.

Table 3-2. Updated Exposure Limits for Chemicals Assessed in 2005 HHRA and Impact of Changes in Exposure Limits on Previous Risk Estimations

Chemical	Route	Type[a]	Exposure Limit used in Cantox HHRA (2005)[a]	Current Exposure Limit[a]	Expected Impact on Previous Risk Estimations Compared With 2005 Exposure Limits Inhalation	Updated Risk Predictions based on Revised Exposure Limit [g] (CRs/ERs/ILCRs)

[c] The US EPA IRIS (2000) established two distinct unit risk values for vinyl chloride – one protective of exposure during adulthood (i.e., 4.4x10-6 per µg/m³) and one protective of exposure from birth (i.e., 8.8x10-6 per µg/m³). MOE (2011) has selected the child-specific unit risk value as their recommended value to be protective of all sensitive members of the population in the derivation of the generic site conditions standards. However, as the current assessment is evaluating the potential long-term health risks to the adult worker under a commercial exposure scenario, the adult-specific US EPA unit risk value was selected.

[d] An updated exposure limit was not available. Therefore, the exposure limit used in the Cantox HHRA (2005) was selected.

[e] Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare plus the evaporation/incineration treatment option.

[f] Represents predicted ground-level air concentrations of total PCDD/PCDFs (expressed as 2,3,7,8-TCDD equivalence) as a result of the landfill flare only scenario. In other words, the contribution from the evaporation/incineration treatment methods is excluded from these predictions.

[g] Updated risk predictions were based on the current exposure limits as well as the Year 2020 Predicted Emissions for Ground-level Air Concentrations from the original 2005 HHRA.

3.2.3 Predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals at identified sensitive receptor locations within the Study Area

Measured concentrations of cadmium, lead, and nickel from the Annual Monitoring Reports were greater than the predicted emissions for ground-level air from the 2005 HHRA. In addition, predicted concentrations of PM_{10} for the Preferred Alternative were greater than the predicted emissions for ground-level air from the 2005 HHRA. However, when these chemicals were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the conclusions of the 2005 HHRA, the predicted risk for all of the chemicals were still orders of magnitude below the health-based benchmark (see **Section 3.2.2**).

3.2.3.1 Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors

Based on **Section 3.2.3**, the predicted risk for all chemicals were orders of magnitude below the health-based benchmarks.

3.2.4 Predicted acute and chronic health-based concentration ratios arising from air concentrations of gaseous contaminants at identified sensitive receptor locations within the Study Area

The only new COC to be flagged as a potential risk based on the modeled emissions for the 2005 HHRA was H_2S due to an increase in inhalation risk estimate of about 21-fold. This resulted in a worst-case predicted CR of 3.3 or in other words a predicted concentration that is slightly higher than 3-fold above the 24-hour AAQC (regulatory value changed from 150 to 7 µg/m³).

Measured concentrations of benzene, 1,2-dichloroethane, trichloroethylene, and vinyl chloride from the Annual Monitoring Reports were greater than the predicted emissions for ground-level air from the 2005 HHRA. In addition, predicted concentrations of 1,1-dichloroethane, butan-2-ol, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1-dichloroethylene, mercuric chloride, methyl mercury, methyl mercaptan, bromodichloromethane, octane, dimethyl sulphide, ethyl mercaptan, chloroethane, hydrogen chloride, benzo(a)pyrene, and carbon dioxide, and carbon monoxide for the Preferred Alternative were greater than the predicted emissions for ground-level air from the 2005 HHRA. However, when these chemicals were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the conclusions of the 2005 HHRA, the predicted risk for all of the chemicals were still orders of magnitude below the health-based benchmark (see **Section 3.2.2**).

Inhalation risks from the calculated ILCR values for benzo(a)pyrene (TEF) (SF of $1.23x10^{-6}$), bromodichloromethane (SF of $1.04x10^{-6}$), 1,1,2,2-tetrachloroethane (SF of $1.19x10^{-6}$), and vinyl chloride (SF of $7.87x10^{-6}$) were predicted. However, the

measured concentrations of bromodichloromethane and 1,1,2,2-tetrachloroethane as part of the 2019, 2020, 2021, 2022, and 2023 annual monitoring programs have been below the reportable detection limits of 1.34 ug/m^3 & 0.69 ug/m^3 respectively in all samples across all five years, and the maximum predicted concentration for the Preferred Alternative for bromodichloromethane and 1,1,2,2-tetrachloroethane was 0.11 µg/m³ and 0.056 µg/m³, respectively. Vinyl chloride was detected three times during the annual monitoring program in 2019, twice in August (0.08 ug/m^3 & 0.15 ug/m^3) and the maximum concentration of vinyl chloride was measured at 0.41 µg/m³ in September 2019 Vinyl chloride was below detection in 2020, 2021 and 2022, was measured twice in 2023 at 0.05 ug/m^3 and 0.08 µg/m³ in September and July. Vinyl chloride was predicted to be 0.5 µg/m³ (24-hours) and 0.1 µg/m³ (annual) for the Preferred Alternative. The arithmetic mean of vinyl chloride when including the detection limits was 0.099 ug/m^3 in 2019 and 0.065 ug/m^3 in 2023. The geometric mean for vinyl chloride including detection limits over the five years was 0.054 ug/m^3. The original modelling from the 2005 HHRA for benzo(a)pyrene was likely related to diesel vehicle emissions and specifically from the landfill itself and the maximum predicted concentration for the Preferred Alternative for benzo(a)pyrene was $4.2x10^{-5}$ µg/m³. As such, risks associated with benzo(a)pyrene, bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are anticipated to be minimal.

3.2.4.1 Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors

Although there is a potential risk to human health from H2S due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. H2S was measured as part of the Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023 (RWDI, 2025c). The H2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H2S and TRS are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H2S and TRS from landfill operations at all discrete receptors and the property boundary are low (RWDI, 2025c). Additionally, the 24-hour maximum predicted concentration of H2S for the Preferred Alternative is 6.5 µg/m³. Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H2S and TRS concentrations are below detection and elevated concentrations of H2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour (RWDI, 2025c). The Air Quality Existing Conditions Report has recommended that emissions of LFG should continue to be managed by routine maintenance of the final cap and interim cover areas (RWDI, 2025c).

3.2.5 Summary

A summary of the effects assessment of the Preferred Alternative (Alternative Method 2) is summarized below in **Table 3-3**.

Table 3-3. Net Effects Assessment – Preferred Alternative (Alternative Method 2)

Evaluation Criteria	Indicator	Key Design Considerations and Assumptions	Potential Effects	Mitigation Measures	Net Effects
Human Health	Predicted acute and chronic health-based concentration ratios arising from air concentrations of **particulate matter (dust) and related metals** at identified sensitive receptor locations within the Study Area Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors	• The predicted concentrations of COCs in air in the year 2020 from the 2005 HHRA were compared to the data from the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports for air quality as well as for the Preferred Alternative • A significant number of COCs were not listed in the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring datasets as many of these are not included in standard monitoring regimes and were therefore theoretically modelled as was done for the 2005 HHRA • Scaling factors were developed and applied to the modelling results from contaminants that weren't VOCs or tailpipe contaminants to determine a reasonable ballpark estimate of potential concentrations. • A review of recent toxicological literature for changes to the exposure limits applied to COCs described in the 2005 HHRA, and to identify exposure limits for new COCs, was completed • Exposure limits used in the 2005 HHRA were compared to the current exposure limits to determine if there was a reduction in risk, an increase in risk, or no change in risk • The current risks were also predicted using the current exposure limits and the expected	• Measured concentrations of cadmium, lead, and nickel from the Annual Monitoring Reports were greater than the predicted emissions for ground-level air from the 2005 HHRA. • Additionally, predicted concentrations of PM_{10} for the Preferred Alternative were greater than the predicted emissions for ground-level air from the 2005 HHRA. • However, when these chemicals were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the 2005 HHRA, the predicted risk for all chemicals under the Preferred Alternative was still orders of magnitude below the health-based benchmarks • No exceedances were predicted on an annual average basis for either PM_{10} or $PM_{2.5}$. The degree of, and frequency of exceedance over the PM guidelines for 24-hr time frames for $PM_{2.5}$ were predicted to be extremely small (less than 1.3 times the guidelines, for less than 1 day/year in Year 6), and were restricted to only a very small area near the facility. The degree of, and frequency of, exceedance over guidelines for 24-hr time frames for PM_{10} was slightly greater than those predicted for $PM_{2.5}$, but still not considered to represent a health concern due to the	• The TCEC has created a Best Management Practices Plan (BMPP) for dust that is implemented at the site and will be in effect during Alternative Method 2 • Through the combined efforts of the mitigation measures and implementation of the Dust BMPP, the number of total solid particles (TSP) exceedances will be limited during the periods of heavy construction and beyond	• None

Table 3-3. Net Effects Assessment – Preferred Alternative (Alternative Method 2)

Evaluation Criteria	Indicator	Key Design Considerations and Assumptions	Potential Effects	Mitigation Measures	Net Effects
		impact on previous risk estimations	characteristics of the PM present at the TCEC.		
	Predicted acute and chronic health-based concentration ratios arising from air concentrations of **gaseous contaminants** at identified sensitive receptor locations within the Study Area Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors	• The predicted concentrations of COCs in air in the year 2020 from the 2005 HHRA were compared to the data from the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring Reports for air quality as well as for the Preferred Alternative • A significant number of COCs were not listed in the 2019, 2020, 2021, 2022 and 2023 Annual Monitoring datasets as many of these are not included in standard monitoring regimes and were therefore theoretically modelled as was done for the 2005 HHRA • Scaling factors were developed and applied to the modelling results from contaminants that weren't VOCs or tailpipe contaminants to determine a reasonable ballpark estimate of potential concentrations. • A review of recent toxicological literature for changes to the exposure limits applied to COCs described in the 2005 HHRA, and to identify exposure limits for new COCs, was completed • Exposure limits used in the 2005 HHRA were compared to the current exposure limits to determine if there was a reduction in risk, an increase in risk, or no change in risk	• Predicted concentrations of 1,1-dichloroethane, butan-2-ol, 1,1,2-trichloroethane, 1,1,2,2-tetrachloroethane, 1,1-dichloroethylene, mercuric chloride, methyl mercury, methyl mercaptan, bromodichloromethane, octane, dimethyl sulphide, ethyl mercaptan, chloroethane, hydrogen chloride, benzo(a)pyrene, carbon dioxide, and carbon monoxide for the Preferred Alternative were greater than the predicted emissions for ground-level air from the 2005 HHRA. • Additionally, measured concentrations of benzene, 1,2-dichloroethane, trichloroethylene, and vinyl chloride from the Annual Monitoring Reports were greater than the predicted emissions for ground-level air from the 2005 HHRA. • However, when these chemicals were evaluated as to what these higher concentrations may mean with respect to the margin of safety indicated in the 2005 HHRA, the predicted risk for all chemicals under the Preferred Alternative was still orders of magnitude below the health-based benchmarks • H_2S was flagged as a potential risk based on the modelled emissions for the 2005 HHRA due to an	• Recommended that polycyclic aromatic hydrocarbons, using benzo(a)pyrene as a surrogate, be added to the suite of chemicals being monitored in future air quality sampling events. • The Air Quality Existing Conditions Report has recommended that emissions of LFG should continue to be managed by routine maintenance of the final cap and interim cover areas (RWDI, 2025c).	• Risks associated with bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are anticipated to be minimal • No measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case H_2S concentrations

Table 3-3. Net Effects Assessment – Preferred Alternative (Alternative Method 2)

Evaluation Criteria	Indicator	Key Design Considerations and Assumptions	Potential Effects	Mitigation Measures	Net Effects
		• The current risks were also predicted using the current exposure limits and the expected impact on previous risk estimations	increase in inhalation risk estimate of about 21-fold. This resulted in a worst-case predicted CR of 3.3 or in other words a predicted concentration that is slightly higher than 3-fold above the 24-hour AAQC (regulatory value changed from 150 to 7 µg/m³). • Inhalation risks from the calculated ILCR values for benzo(a)pyrene (TEF) (SF of 1.23E-06), bromodichloromethane (SF of 1.04E-06), 1,1,2,2-tetrachloroethane (SF of 1.19E-06), and vinyl chloride (SF of 7.87E-06) were predicted.		

4 Effects Assessment of the Preferred Alternative

Alternative Method 2 has been identified as the overall Preferred Alternative for the EA based on the results of the other discipline assessments. Consequently, the effects assessment of the Preferred Alternative presented in **Section 3** is based on Alternative Method 2.

5 Comparison of the Preferred Alternative against the 'Do Nothing' Alternative

The effects of the Preferred Alternative are compared against the predicted effects of the currently approved Expansion Landfill based on similar environmental criteria and indicators, with the understanding that the criteria and indicators used in the current effects assessment may differ from those used for the effects assessment of the Expansion Landfill. The effects are compared against each other in terms of magnitude, extent, and duration below. The advantages and disadvantages of the Preferred Alternative compared to the 'Do Nothing' Alternative are identified.

5.1 Effects of the 'Do Nothing' Alternative

The 2016 Environmental Screening for the fill rate increase identified some changes to Air Quality; however, the health study was not updated at that time and no net effects were anticipated. The original health study was included in the 2005 EA and as such, effects from the previous environmental assessment completed in 2005 are included below.

Human Health Risk Assessment of the Proposed Warwick Landfill Expansion (2005)

The 2005 HHRA evaluated the potential human health impacts on nearby residential communities, that could arise from expected airborne emissions associated with that proposed landfill expansion (i.e., the now approved and operating landfill, the 'Expansion Landfill').

5.1.1 Predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals at identified sensitive receptor locations within the Study Area

Chronic Human Health Impacts

ILCR estimates for all COPCs (including metals) were below the acceptable risk level of one-in-one million (1×10^{-6}).

Chronic human health risks associated with exposure to emissions resulting from the landfill flare plus evaporation/incineration activities (i.e., lead, cadmium, arsenic, nickel and mercury) were not considered significant.

Short-term Human Health Impacts

All 24-hour exposure durations were evaluated at the maximum discrete receptor location and at the maximum fenceline location. No short-term adverse health effects were expected to occur as a result of exposure to combustion gases at the maximum receptor location under the landfill flare only or landfill flare plus evaporation/incineration options.

All ½-hour and 1-hour CR values calculated at the maximum fence-line location were less than a value of 1.0 under both the landfill flare only and landfill flare plus evaporation/incineration options.

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location, and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was extremely low. This conclusion is based on the following information:

- The dominant source of PM at this site was predicted to be crustal, as opposed to combustion-related, which has a markedly lower toxicity;
- Air concentrations of PM_{10} and $PM_{2.5}$ were modeled using very conservative assumptions, and as a result were likely to be overestimated; and
- The PM guidelines applied in this assessment were based on epidemiology literature related to adverse health outcomes associated with exposure to combustion-related PM, and as such, they are highly conservative benchmarks for this site.

Thus, while TSP exceedances have been noted in the annual monitoring data, as there were infrequent and minor exceedances for PM_{10} and $PM_{2.5}$, this suggests that any TSP exceedances are primarily due to the airborne presence of larger crustal materials arising from earthworks. While a nuisance, this particulate size fraction is not generally believed to have significant health concerns (i.e., they do not penetrate deep into a person's airway due to the larger size).

5.1.1.1 Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors

No exceedances were predicted on an annual average basis for either PM10 or PM2.5. The degree of, and frequency of exceedance over these PM guidelines for 24-hr time frames for PM2.5 were extremely small (less than 1.3 times the guidelines, for less than 1 day/year in Year 6), and were restricted to only a very small area near the facility. The degree of, and frequency of, exceedance over guidelines for 24-hr time frames for PM10 was greater than those predicted for PM2.5, but still not considered to represent a health concern due to the characteristics of the PM present at this site.

5.1.2 Predicted acute and chronic health-based concentration ratios arising from air concentrations of gaseous contaminants at identified sensitive receptor locations within the Study Area

Chronic Human Health Impacts

Long-term non-cancer human health risks as a result of predicted exposures to LFG from the Expansion Landfill were considered minimal at the maximum discrete receptor location. All LFG exposure ratios were less than a value of 1.0.

ILCR estimates for all COPCs (including metals, products of incomplete combustion and volatile organic compounds from all sources) were below the acceptable risk level of one-in-one million (1×10^{-6}). The upper 95th percentile ILCR estimate for total chlorinated VOCs as a group were also less than an ILCR of one-in-one million (1×10^{-6}).

Chronic human health risks associated with exposure to emissions resulting from the landfill flare plus evaporation/incineration activities (i.e., dioxin/furans, benzo(a)pyrene) were not considered significant. The upper 95th percentile ILCR for benzo(a)pyrene of 4.3×10^{-11} at the maximum discrete receptor location was approximately 23,000-fold lower than the acceptable ILCR of one-in-one million (1×10^{-6}). For many non-carcinogenic compounds (e.g., dioxins and furans), predicted landfill flare and evaporation/incineration emissions from the proposed expansion produced human health risks several orders of magnitude lower than those associated with background and/or existing levels. Predicted landfill flare plus evaporation/incineration related exposures to dioxins at Year 26 (the highest projected emissions rate) were approximately 15,000-fold lower than those associated with ambient or background levels in Ontario and more than 10,000-fold less than the level considered acceptable. It is noted that the contribution from the evaporation/incineration leachate treatment option to PAHs and dioxin exposure estimates was minimal, if not indistinguishable in the case of PAHs, relative to the contribution from the landfill flare only scenario.

Long-term human health risks associated with exposure to emissions resulting from the landfill flare only scenario (i.e., PAHs, dioxin/furans) were also considered insignificant. Estimates of ILCRs resulting from exposure to PAHs were several orders

of magnitude lower than the acceptable level of one-in-one million. As in the landfill flare plus evaporation/incineration scenario, exposure to dioxins in Year 26 were substantially lower (26,000-fold lower) than ambient or background exposures in Ontario.

Annual CR values predicted for chronic exposures to all combustion gases (i.e., CO_2, CO, SO_2, NO_x and HCl) at the maximum discrete receptor location for both the landfill flare only and the landfill flare plus leachate incineration were within acceptable levels (i.e., all CR values were less than a value of one). This suggests that no measurable long-term adverse health impacts would result from LFG combustion emissions at the maximum discrete receptor location. Facility related annual CR values were almost 10-fold lower than background NO_x and SO_2 CR values.

Short-term Human Health Impacts

All 24-hour exposure durations were evaluated at the maximum discrete receptor location and at the maximum fenceline location. No short-term adverse health effects were expected to occur as a result of exposure to combustion gases at the maximum receptor location under the landfill flare only or landfill flare plus evaporation/incineration options.

With the exception of SO_2 in Year 26, all ½-hour and 1-hour CR values calculated at the maximum fence-line location were less than a value of 1.0 under both the landfill flare only and landfill flare plus evaporation/incineration options.

5.1.2.1 Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors

Given the conservatism of the World Health Organization's SO_2 air quality criterion and the exposure assumptions employed, the 1-hour SO_2 CR value of 1.1 observed in operational year 2030 at the maximum fence-line location under the landfill flare plus evaporation/incineration option was considered to be of minimal significance.

5.2 Comparison of the Preferred Alternative against the 'Do Nothing' Alternative

An evaluation of potential health effects was conducted in the 2005 HHRA for the Expansion Landfill. A review of the assumptions made in the 2005 HHRA was completed in the Human Health Existing Conditions Report as part of the current EA and based on this review, the assumptions previously used in the 2005 HHRA are still valid, and therefore, the results of the assessment remain valid.

Updated risks were predicted based on revised exposure limits from a toxicological literature search. Based on the expected impact on previous risk estimations compared to the exposure limits used in the 2005 HHRA (**Table 3-2**), a number of chemicals resulted in predicting an increase in inhalation or oral risk estimate.

5.2.1 Predicted acute and chronic health-based concentration ratios arising from air concentrations of particulate matter (dust) and related metals at identified sensitive receptor locations within the Study Area

Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location, and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM_{10} and $PM_{2.5}$ was predicted to be extremely low in the 2005 HHRA.

5.2.1.1 Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors

As part of the Annual Monitoring Programs, concentrations of TSP exceeded the MECP Ambient Air Quality Criteria (AAQC) of 120 µg/m³ in numerous samples between 2019 to 2022. For each TSP exceedance, watering activities for dust control purposes, including watering on-site roadways and construction sites was implemented. Measured metal concentrations were consistently below the applicable criteria in the 2019 to 2022 Annual Monitoring Reports. Concentrations of VOCs from 2019, 2020, 2021, and 2022 Annual Monitoring Programs were quite low and less than their respective air quality standards.

The dominant source of PM at this site is predicted to be crustal (i.e., soil, dirt particles), as opposed to combustion-related, which has a markedly lower toxicity. Air concentrations of PM_{10} and $PM_{2.5}$ were modeled using very conservative assumptions, and as a result are likely to be overestimated. The PM guidelines applied in this assessment were based on epidemiology literature related to adverse health outcomes associated with exposure to combustion-related PM, and as such, they are highly conservative benchmarks for this site. No exceedances were predicted on an annual average basis for either PM_{10} or $PM_{2.5}$. The degree of, and frequency of exceedance over these PM guidelines for 24-hr time frames for $PM_{2.5}$ were predicted to be extremely small (less than 1.3 times the guidelines, for less than 1 day/year in Year 6), and were restricted to only a very small area near the facility. The degree of, and frequency of, exceedance over guidelines for 24-hr time frames for PM_{10} was slightly greater than those predicted for $PM_{2.5}$, but still not considered to represent a health concern due to the characteristics of the PM present at the TCEC.

5.2.2 Predicted acute and chronic health-based concentration ratios arising from air concentrations of gaseous contaminants at identified sensitive receptor locations within the Study Area

Annual CR values predicted for chronic exposures to all combustion gases (i.e., CO_2, CO, SO_2, NO_x and HCl) were predicted to be within acceptable levels (i.e., all CR values were less than one) (Intrinsik, 2005). This suggests that no measurable long-term adverse health impacts were predicted to result from LFG combustion emissions.

Additionally, all ½-hour and 1-hour CR values calculated at the maximum fence-line location were predicted to be less than a value of 1.0 (Intrinsik, 2005). Therefore, no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases, with the exception of the 24-hour H_2S CR value which had an increase in inhalation risk estimate of about 21-fold compared to the 2005 HHRA.

The majority of ILCR values calculated for both inhalation and oral risk were below the 1 in a million-cancer risk with the exception of benzo(a)pyrene (TEF) (SF of $1.23x10^{-6}$), bromodichloromethane (SF of $1.04x10^{-6}$), 1,1,2,2-tetrachloroethane (SF of $1.19x10^{-6}$), and vinyl chloride (SF of $7.87x10^{-6}$).

5.2.2.1 Frequency of any exceedance of applicable standards, limits, or guidelines from air concentrations at identified receptors

Although there is a potential risk to human health from H_2S due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. H_2S was measured as part of the Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023 (RWDI, 2025c). The H_2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H_2S and TRS are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H_2S and TRS from landfill operations at all discrete receptors and the property boundary are low (RWDI, 2025c). Additionally, the 24-hour maximum predicted concentration of H_2S for the Preferred Alternative is 6.5 µg/m³. Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H_2S and TRS concentrations are below detection and elevated concentrations of H_2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour (RWDI, 2025c). The Air Quality Existing Conditions Report has recommended that emissions of LFG should continue to be managed by routine maintenance of the final cap and interim cover areas (RWDI, 2025c).

The measured concentrations of bromodichloromethane and 1,1,2,2-tetrachloroethane as part of the annual monitoring programs have been below the reportable detection limits of 1.34 ug/m^3 & 0.69 ug/m^3 respectively, in all samples across all five years (2019, 2020, 2021, 2022, 2023). The maximum predicted concentration for the Preferred Alternative for bromodichloromethane and 1,1,2,2-tetrachloroethane was 0.11 µg/m³ and 0.056 µg/m³ respectively. Vinyl chloride was detected three times during the annual monitoring program in 2019, twice in August (0.08 ug/m^3 & 0.15 ug/m^3) and the maximum concentration of vinyl chloride was measured at 0.41 µg/m³ in September2019. Vinyl Chloride was below the detection limit of 0.05 ug/m^3 in 2020, 2021 and 2022, was measured twice at 0.05 ug/m^3 and 0.08 µg/m³ in September and July 2023, and was predicted to be 0.5 µg/m³ (24-hours) and 0.1 µg/m³ (annual) for the Preferred Alternative. The arithmetic mean of vinyl

chloride when including the detection limits was 0.099 ug/m^3 in 2019 and 0.065 ug/m^3 in 2023. The geometric mean for vinyl chloride including detection limits over the five years was 0.054 ug/m^3. The original modelling from the 2005 HHRA for benzo(a)pyrene was likely related to diesel vehicle emissions and specifically from the landfill itself and the maximum predicted concentration for the Preferred Alternative for benzo(a)pyrene was 4.2x10^{-5} µg/m³. As such, risks associated with benzo(a)pyrene, bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are anticipated to be minimal.

5.3 Advantages and Disadvantages of the Preferred Alternative

The differences in net effects between the Preferred Alternative and the 'Do Nothing Alternative' are used to determine the advantages and disadvantages of the Preferred Alternative. The advantages and disadvantages of the Preferred Alternative are listed in **Table 5-1**.

Based on the review of results from the recent annual monitoring programs, the review of existing conditions for air quality, groundwater quality and surface quality, and the review of assumptions as well as the conclusions from the 2005 HHRA, no measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case H_2S concentrations, under existing conditions. When considering modelling results for the Preferred Alternative, no measurable long-term or short-term adverse health impacts were predicted to occur as a result of exposure to landfill combustion gas emissions, with the exception of worst-case H_2S concentrations.

Although there is a potential risk to human health from H_2S due to the change in the toxicological benchmark, this is based on conservative predicted modelling completed in the 2005 HHRA. H_2S was measured as part of the Air Quality Existing Conditions Report. One hundred and nine (109) samples were valid out of the one hundred and twenty-three (123) total samples collected between June 2nd, 2023 and September 30th, 2023 (RWDI, 2025c). The H_2S criteria was exceeded three (3) times during the sampling period with predicted concentrations of 27 µg/m³, 9.2 µg/m³, and 8.2 µg/m³. Overall, predicted concentrations of H_2S and TRS are dominated by elevated background values results from elevated laboratory detection limits and the predicted concentrations of H_2S and TRS from landfill operations at all discrete receptors and the property boundary are low (RWDI, 2025c). Additionally, the 24-hour maximum predicted concentration of H_2S for the Preferred Alternative is 6.5 µg/m³. Therefore, impacts associated with landfilling operations are expected to be low. The ambient monitoring data shows that a majority of the time measured H_2S and TRS concentrations are below detection and elevated concentrations of H_2S and TRS are rare, but do occur which may contribute to occurrences of off-site odour (RWDI, 2025c). The Air Quality Existing Conditions Report has recommended that emissions of LFG should continue to be managed by routine maintenance of the final cap and

interim cover areas (RWDI, 2025c). Risks associated with bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are also anticipated to be minimal.

Therefore, any impacts from the Preferred Alternative compared to the 'Do Nothing Alternative' are considered minimal and there are no significant advantages or disadvantages associated with the Preferred Alternative.

Table 5-1. Advantages and Disadvantages of the Preferred Alternative (Alternative Method 2)

Evaluation Criteria	Advantages (i.e., Conclusions from 2005 HHRA)	Disadvantages (i.e., Predicted Risks from Effects Assessment)
Human Health	• Long-term cancer and non-cancer human health risks as a result of predicted exposures to LFGs from the Warwick Landfill expansion were considered minimal. • Chronic human health risks associated with exposure to emissions resulting from the landfill flare plus evaporation/incineration activities (dioxin/furans, benzo(a)pyrene, lead, cadmium, arsenic, nickel and mercury) were not considered significant. • Long-term human health risks associated with exposure to emissions resulting from the landfill flare only scenario (PAHs, dioxin/furans) were also considered insignificant. • No measurable long-term adverse health impacts were predicted to result from landfill combustion gas emissions • The 2005 HHRA concluded that no short-term adverse health effects were predicted to occur as a result of exposure to combustion gases under the landfill flare only or landfill flare plus evaporation/incineration options. • Given the small magnitude and low frequency of exceedances predicted for PM_{10} and $PM_{2.5}$ under assumed worst-case conditions at the maximum residential receptor location (exact location not specified in the 2005 HHRA), and the level of conservatism used in the 2005 HHRA, the likelihood of adverse health effects occurring as a result of exposure to PM^{10} and $PM_{2.5}$ was predicted to be extremely low in the 2005 HHRA.	• Worst-case H_2S concentrations may result in adverse health impacts as a result of exposure to landfill combustion gas emissions. WM should continue to manage emissions of LFGs by routine maintenance of the final cap and interim cover areas. • Risks associated with bromodichloromethane, 1,1,2,2-tetrachloroethane and vinyl chloride are anticipated to be minimal. Recommended that polycyclic aromatic hydrocarbons, using benzo(a)pyrene as a surrogate, continue to be monitored in future air quality sampling events.

6 Commitments and Monitoring

To confirm that the commitments related to Human Health are carried out, and that the proposed mitigation measures will address the predicted effects for Human Health, monitoring is proposed for construction as well as operations and maintenance of the Project. Monitoring for compliance will be undertaken to confirm that the Project complies with the commitments and mitigation measures identified in the effects assessment.

The commitments associated with Human Health are listed in **Section 6.1**. The proposed environmental effects monitoring is provided in **Section 6.2**. Compliance monitoring for Human Health is described in **Section 6.3**.

6.1 Human Health Commitments

The following includes commitments and mitigation measures previously recommended either through the Air Quality or Human Health Assessments:

- The Air Quality Existing Conditions Report has recommended that WM should continue to manage emissions of LFG by routine maintenance of the final cap and interim cover areas (RWDI, 2025c).
- WM continues to complete an annual air quality monitoring program to assess air quality. It is recommended that polycyclic aromatic hydrocarbons, using benzo(a)pyrene as a surrogate, continue to be monitored in future air quality sampling events.
- WM has previously prepared and implemented an odour BMPP to minimize the off-site impacts associated with odour (RWDI, 2025c).
- The TCEC has also created a BMPP for dust that is implemented at the site to limit the number of TSP exceedances during heavy constructions (RWDI, 2025c).

6.2 Environmental Effects Monitoring for Human Health

Monitoring plans are developed as part of the detailed effects assessments carried out for the Preferred Alternative to confirm:

- the net effects are as predicted;
- unanticipated negative effects are addressed; and
- the effectiveness of the proposed mitigation measures.

The Air Quality Effects Assessment Report contains the environmental effects monitoring for the Preferred Alternative.

6.3 Human Health Compliance Monitoring

Compliance monitoring will be undertaken to confirm that the construction, operation, and maintenance of the Project are carried out in accordance with the mitigation measures and commitments identified in the effects assessment. Compliance monitoring is summarized in the Air Quality Effects Assessment Report. The results of compliance monitoring, including details of the effectiveness of mitigation measures and fulfillment of commitments, will be provided to the MECP.

7 References

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APPENDIX A

SUMMARY OF EXPOSURE LIMITS FOR HUMAN RECEPTORS

A-1.0 SUMMARY OF EXPOSURE LIMITS FOR HUMAN RECEPTORS

The following table provides a summary of the exposure limits used in the original Cantox (2005) HHRA as well as the updated exposure limits used in the Effects Assessment Report. The updated exposure limits are identified with the light green row shading. IUR values in the original Cantox (2005) were also presented as q_1* with $(\mu g/kg/d)^{-1}$ units. These are presented in the table below and were converted to $(\mu g/m^3)^{-1}$ units by multiplying by (20/70) to facilitate comparison to the updated IUR benchmarks.

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Combustion Gases						
Carbon Dioxide	Inhalation	RfC	0.0000214	Asphyxiation	-	-
Carbon Monoxide	Inhalation	RfC	3,140	Health effects	Not specified	Calculated from MOE, 2001
		1-hr AAQC	30,820			Calculated from MOE, 2001
		24-hr AAQC	15,700			MOE, 2001
Hydrogen Chloride	Inhalation	RfC	20	Mild hyperplasia of the nasal, tracheal and laryngeal mucosa	Albert *et al.*, 1982; Sellakumar, 1985	U.S. EPA, 1995a
		1-hr AAQC	2,100	Upper respiratory symptoms (humans)	Stevens *et al.*, 1992	Cal EPA, 2000a
		24-hr AAQC	20	Health effects	Not specified	MOE, 2001
Hydrogen Sulphide	Inhalation	RfC	1.0	Inflammation of the nasal mucosa (mice)	CIIT, 1983	U.S. EPA, 1995b
		1-hr AAQC	30	Odour effects	Not specified	MOE, 2001
		24-hr AAQC	150	Eye irritation (humans)	Savolainen, 1982	WHO, 2000
Hydrogen Sulphide	Inhalation	24-hr AAQC	7	Health effects	Not specified	MECP, 2020
NO_x	Inhalation	RfC	40	Respiratory effects	Numerous; weight of evidence assessment	WHO, 1997
		1-hr AAC	400	Health effects	Not specified	MOE, 2001
		24-hr AAQC	200	Health effects	Not specified	MOE, 2001
NOx	Inhalation	1-hr AAQC	200	Health effects	Not specified	MECP, 2020
		24-hr AAQC	25	Health effects	Not specified	MECP, 2020
SO_x	Inhalation	RfC	50	Respiratory effects in asthmatics	Numerous; weight of evidence assessment	WHO, 1987
		1-hr AQS	350	Changes in lung function is asthmatics	Not specified	WHO, 1987
		24-hr AQS	125	Exacerbation of respiratory symptoms in sensitive individuals	Not specified	WHO, 1987; 2000
SOx	Inhalation	24-hr AQS	40	Health effects	Not specified	MECP, 2020
Metals						
Arsenic	Inhalation	IUR	0.0043 (0.015 per µg/kg/d)	Lung tumours (human)	Brown and Chu, 1983a,b,c; Lee-Feldstein, 1983; Higgins, 1982; Enterline and Marsh, 1982	U.S. EPA, 1995c

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
	Oral	SF	0.0015	Vascular and dermal effects (rats)	Tseng, 1977; Tseng *et al.*, 1968	U.S. EPA, 1995c
		RfD	0.3	Hyperpigmentation, keratosis, and possible vascular complications	Tseng, 1977; Tseng *et al.*, 1968	U.S. EPA, 1995c
Arsenic	Inhalation	IUR	0.00015	Occupational lung cancer	Based on occupational exposure studies on the Tacoma smelter cohort (Enterline et al., 1995), the Swedish Ronnskar smelter cohort (Jarup et al., 1989; Viren and Silvers, 1994), and the Montana cohort (Lubin et al., 2000; 2008)	MOECC, 2017; TCEQ, 2012
	Oral	SF	0.0095	Lung and bladder cancer prevalence (humans)	Based on meta-analysis of epidemiological studies evaluating chronic environmental exposure (drinking water) to arsenic in Southwestern Taiwan (Chen et al., 1985; 1988); Cordoba, Argentina (Hopenhayn-Rich et al., 1996; 1998); and Chile (Smith et al., 1998)	Cal EPA, 2004
		RfD	0.12	Cerebrovascular disease (humans)	Chiou et al., 1997	MOECC, 2017; Cal EPA, 2004
Cadmium	Inhalation	IUR	0.0018 (0.0063 per µg/kg/d)	Cancer mortality (humans)	Thun *et al.*, 1985	U.S. EPA, 1991d
	Oral	RfD	0.5	Proteinuria from drinking water exposure (humans)	U.S. EPA, 1985a	U.S. EPA, 1991d
Cadmium	Inhalation	IUR	0.0098	Lung tumours (rats)	Takenaka *et al.,* 1983; Oldiges *et al.*, 1984	MOE, 2011; HC, 1996
		RfC	0.03	Not provided	Not provided	MOE, 2011
	Oral	RfD	0.032	Kidney effects (humans)	Buchet *et al.*, 1990	MOE, 2011
Lead	Inhalation	RfC	6.48 (1.85 µg/kg/d)	Subclinical neurobehavioural and developmental effects in children	Not specified	MOE, 1996
	Oral	RfD	1.85			
Lead	Inhalation	Risk-specific does (provisional)	0.5	Neuro-developmental Toxicity (cognitive function)	EFSA, 2013 (based on Lanphear et al., 2005)	Health Canada, 2021
Elemental Mercury	Inhalation	RfC	0.301 (0.086 µg/kg/d)	CNS and neurobehavioural effects (humans)	Fawer *et al.*, 1983; Piikivi and Tolonen, 1989; Piikivi and Hanninen, 1989; Piikivi,1989; Ngim *et al.*, 1992; Liang *et al.*, 1993	U.S EPA, 1995e
Mercury	Inhalation	RfC	0.09			MOE, 2011
	Oral	RfD	0.3	Autoimmune effects (rats)	Druet *et al.*, 1978; Bernaudin *et al.*, 1981; Andres, 1984; US EPA, 1987	MOE, 2011; U.S. EPA, 1995e
	Sub-Chronic Oral	RfD	3	Not provided	Not provided	MOE, 2011; modified from U.S. EPA, 1995e

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Mercuric Chloride	Oral	RfD	0.3	Autoimmune effects	U.S. EPA, 1987	U.S. EPA, 1995f
Methyl Mercury	Oral	RfD	0.1	Developmental neuropsychological impairment (humans)	Grandjean *et al.*, 1997; Budtz-Jurgensen *et al.*, 1999	U.S. EPA, 2001
Nickel	Inhalation	IUR	0.00038 (0.00133 per µg/kg/d)	Lung cancer (humans)	Andersen, 1992; Andersen *et al.*, 1996; Doll *et al.*, 1977; Chovil *et al.*,1981; Magnus *et al.*, 1982.	WHO, 2000
	Oral	RfD	20	Decreased body and organ weights	Ambrose *et al.*, 1976	U.S. EPA, 1991a
Nickel	Inhalation	IUR	0.00024	Lung cancer (occupational study)	Chovil *et al.,* 1981; Enterline and Marsh, 1982; Peto *et al*., 1984; Magnus *et al.*, 1982	MOE, 2011; U.S. EPA, 1991a
		RfC	0.06	Not provided	Not provided	MOE, 2011; modified from TERA 1999
	Oral	RfD	2.8	Post-implantation/perinatal mortality (rats)	SLI, 2000a; SLI, 2000b	MECP, 2019; EFSA, 2015
Particulate Matter						
TSP	NA	Annual AAQC	60	Visibility/soiling	not cited	MOE, 2001
	NA	24-hour AAQC	120	Visibility/soiling	not cited	MOE,2001
PM_{10}	Inhalation	Annual AQS	50	health effects (respiratory/cardiac)	Multiple epidemiology studies	U.S. EPA, 1997
	Inhalation	24-hour AAQC	50	health effects (respiratory/cardiac)	Multiple epidemiology studies	MOE, 2001
PM_{10}	Inhalation	Annual AQS	15	Health effects	Not specified	MECP, 2020
	Inhalation	24-hour AAQC	45	Health effects	Not specified	MECP, 2020
$PM_{2.5}$	Inhalation	Annual mean	15	health effects (respiratory/cardiac)	Multiple epidemiology studies	U.S. EPA, 1997
	Inhalation	24-hour WMCC	30	health effects (respiratory/cardiac)	Multiple epidemiology studies	WMCCDCPMO,1999
$PM_{2.5}$	Inhalation	Annual mean	8.8	Health effects	Not specified	MECP, 2020
	Inhalation	24-hour WMCC	27	Health effects	Not specified	MECP, 2020
Chlorinated Polycyclic Aromatics						
2,3,7,8-substituted TCDD	Inhalation	RfC	0.000035 (0.00001 µg/kg/d)	Reproductive dysfunction	Murray *et al.*, 1979	MOE, 1996
	Oral	RfD	0.00001			
Polycyclic Aromatic Hydrocarbons						
Benzo(a)pyrene (TEF)[b]	Inhalation	IUR	0.087 (0.3 per µg/kg/d)	Increased cancer risk (humans)	Numerous studies	WHO, 2000
	Oral	SF	0.0005	Squamous cell papillomas and carcinomas in mice	Neal & Rigdon, 1967	WHO, 1998a
Benzo(a)pyrene (Whole Mixture Model)	Inhalation	IUR	0.027 (0.095 per	Tumors (rodents; humans)	Numerous studies	MOE, 1997; personal communication with

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
			µg/kg/d)			MOE
	Oral	SF	0.00028	Route extrapolation (in accordance with MOE)	-	MOE, 1997; personal communication with MOE
	Dermal	SF	0.013	Route extrapolation (in accordance with MOE)	-	MOE, 1997; personal communication with MOE
Benzo(a)pyrene	Oral	RfD	0.3	Neurodevelopmental effects and neurobehavioural changes	HC DW, 2016; US EPA IRIS, 2017	MECP, 2019; US EPA, 2017
		Sub-chronic RfD	5.0	Kidney abnormalities in males (rats)	Knuckles et al., 2001	MECP, 2019; modified Cal EPA DW, 2010
		SF	0.001	Increase in alimentary tract tumours (forestomach, esophagus, tongue, larynx) (mouse)	Beland & Culp, 1998;	MECP, 2019; US EPA, 2017; Kalberlah et al., 1995
	Inhalation	RfC	0.002	Decreased embryo/fetal survival (rats)	Archibong et al., 2002	MECP, 2019; US EPA, 2017
		IUR	0.0006	Respiratory tract and pharynx tumours (hamsters)	Thyssen *et al.,* 1981	MECP, 2019; US EPA, 2017; Kalberlah et al., 1995
Volatile Organic Compounds						
Benzene	Inhalation	IUR	0.0000077 (0.000027 per µg/kg/d)	Leukemia (humans)	Rinsky *et al.*, 1981, 1987; Paustenbach *et al.*, 1993; Crump and Allen, 1984; Crump, 1994; U.S. EPA, 1998	U.S. EPA, 2003
		RfD	1.7	Not specified	NCEA value	U.S. EPA Region IX, 2002
	Oral	SF	0.000055	Leukemia (humans)	Rinsky *et al.*, 1981, 1987; Paustenbach *et al.*, 1993; Crump, 1994; U.S. EPA, 1998, 1999	U.S. EPA, 2003
		RfD	3	Not specified	NCEA value	U.S. EPA Region IX, 2002
Benzene	Oral	SF	0.000085	Not provided	Not provided	MOE, 2011
		RfD	4	Decreased lymphocyte cell count (occupational exposure)	Rothman *et al.,* 1996	MOE, 2011; US EPA IRIS, 2003
	Inhalation	IUR	0.0000022	Leukemia (occupational exposure)	Rinsky *et al*., 1981; 1987; Paustenbach *et al.*, 1993; Crump and Allen, 1984; Crump, 1994	MOE, 2011; US EPA, 2000a
		RfC	30	Decreased lymphocyte cell count (occupational exposure)	Rothman *et al*., 1996	MOE, 2011; US EPA, 2003
Bromodichloromethane	Inhalation	IUR	0.000018 (0.000062 per µg/kg/d)	Route extrapolation by U.S. EPA	-	U.S. EPA Region IX, 2002
		RfC	70 (20 µg/kg/d)	Route extrapolation by U.S. EPA	-	U.S. EPA Region IX, 2002

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
	Oral	SF	0.000062	Tubular cell adenoma and adenocarcinoma	NTP, 1987	U.S. EPA, 1993
		RfD	20	Renal effects	NTP, 1986	U.S. EPA, 1993
Bromodichloromethane	Oral	SF	0.000062	Kidney tumours (mice)	NTP, 1987a	MOE, 2011; US EPA, 1993
		RfD	20	Kidney and liver lesions (mice)	NTP, 1986; 1987a	MOE, 2011; US EPA, 1991; ATSDR, 1989
2-Butanol (1-butanol used as surrogate chemical)	Inhalation	RfC	9.1 (2.6 µg/kg/d)	Not specified	NCEA value	U.S. EPA Region IX, 2002
	Oral	RfD	100	Hypoactivity and ataxia in rats	U.S. EPA, 1986	U.S. EPA, 1991b
Chloroethane	Inhalation	IUR	0.00000083 (0.0000029 per µg/kg/d)	Route extrapolated (by U.S. EPA Region IX)	-	U.S. EPA Region IX, 2002
		RfC	10,150 (2,900 µg/kg/d)	Delayed fetal ossification	Scortichini *et al.*, 1986	U.S. EPA, 1991c
	Oral	SF	0.0000029	Not specified	NCEA value	U.S. EPA Region IX, 2002
		RfD	400	Not specified	NCEA value	U.S. EPA Region IX, 2002
1,1-Dichloroethane	Inhalation	IUR	0.0000016 (0.0000057 per µg/kg/d)	Route extrapolation by Cal EPA	-	U.S. EPA Region IX, 2002
		RfC	490 (140 µg/kg/d)	Not specified	HEAST value	U.S. EPA, Region IX, 2002
	Oral	SF	0.0000057	Mammary gland adenocarcinoma (in rats)	NCI, 1977	U.S. EPA Region IX, 2002
		RfD	100	Not specified	HEAST value	U.S. EPA, Region IX, 2002
1,1-Dichloroethane	Oral	RfD	40	Kidney damage (cats)	Hoffman *et al.* 1971	MOE, 2011; modified from Cal EPA, 2003
		Sub-chronic RfD	400	Kidney damage (cats)	Hoffman *et al.* 1971	MOE, 2011; Cal EPA, 2003
	Inhalation	RfC	170	Kidney damage (cats)	Hoffman *et al.* 1971	MOE, 2011
1,2-Dichloroethane	Inhalation	IUR	0.0000024 (0.00000833 per µg/kg/d)	Route extrapolation (by WHO)	-	WHO, 1998b
		RfC	4.9 (1.4 µg/kg/d)	Not specified	NCEA value	U.S. EPA, Region IX, 2002
	Oral	SF	0.00000833	Various tumours in rats and mice	NCI, 1978a	WHO, 1998b
		RfD	30	Not specified	NCEA value	U.S. EPA, Region IX, 2002

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
1,2-Dichloroethane	Oral	SF	0.0000091	Hemangiosarcomas (rats)	NCI, 1978a	MOE, 2011; US EPA, 1991d
		RfD	20	Not provided	Not provided	MOE, 2011; modified from ATSDR, 2001
		Sub-chronic RfD	200	Increased absolute and relative kidney weights (rats and mice)	NTP, 1991	MOE, 2011; ATSDR, 2001
	Inhalation	IUR	0.000026	Route extrapolation from US EPA IRIS (1991) oral carcinogenicity assessment	NCI, 1978	MOE, 2011; US EPA, 1991d
		RfC	400	Hepatotoxicity (elevated liver enzyme levels in serum of rats)	Spreafico *et al.*, 1980	MOE, 2011; Cal EPA, 2000a
1,1-Dichloroethylene	Inhalation	RfC	200 (57.1 µg/kg/d)	Liver toxicity (fatty changes in rats)	Quast *et al.*, 1986	U.S. EPA, 2002
	Oral	RfD	50	Liver toxicity (fatty changes in rats)	Quast *et al.*, 1983	U. S. EPA, 2002
1,1-Dichloroethylene	Oral	RfD	50	Hepatocellular mid-zonal fatty changes (rats)	Quast *et al.*, 1983	MOECC, 2017; US EPA, 2002; WHO CICAD, 2003
	Inhalation	RfC	200	Fatty changes in liver (rats)	Quast *et al.*, 1986	MOECC, 2017; US EPA, 2002; WHO CICAD, 2003
		Sub-chronic RfC	79.3	Hepatic effects in guinea pigs	Prendergast *et al.* 1967	MOE, 2011, ATSDR 1994
Dimethyl sulphide	Inhalation	RfC	875 (250 µg/kg/d)	Route extrapolation (by Cantox)	-	Derived "*de novo*" from primary literature
	Oral	RfD	250	Increased thyroid weight	Butterworth *et al.*, 1974	Derived "*de novo*" from primary literature
Ethyl mercaptan (methyl mercaptan used as a surrogate)	Inhalation	RfC	2.0 (0.57 µg/kg/d)		NCEA value	U.S. EPA Region IX, 2002
	Oral	RfD	0.57	Route extrapolation (by U.S. EPA)	-	U.S. EPA Region IX, 2002
Methyl mercaptan	Inhalation	RfC	2.0 (0.57 µg/kg/d)		NCEA value	U.S. EPA Region IX, 2002
	Oral	RfD	0.57	Route extrapolation (by U.S. EPA)	-	U.S. EPA Region IX, 2002
Methylene chloride	Inhalation	IUR	0.00000047 (0.00000165 per µg/kg/d)	Combined adenomas and carcinomas	NTP, 1986b	U.S. EPA, 1991e
	Oral	SF	0.0000075	Hepatocellular adenomas or carcinomas (NTP) and hepatocellular cancer and neoplastic nodules (NCA)	NTP, 1986b; NCA, 1983	U.S. EPA, 1991e
		RfD	60	Liver toxicity	NCA, 1982	U.S. EPA, 1991e

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Methylene chloride	Oral	SF	0.000002	Hepatocellular carcinomas or adenomas (mice)	Serota *et al.*, 1986b	US EPA, 2011a
		RfD	6	Hepatic effects (hepatic vacuolation, liver foci) (rats)	Serota *et al.*, 1986a	US EPA, 2011 a
	Inhalation	IUR	0.000000023	Not available	Not available	MOE, 2011
		RfC	400	Significantly elevated carboxyhemoglobin levels (> 2%) (occupational exposure)	DiVincenzo and Kaplan, 1981	MOE, 2011; Cal EPA 2000b
		Sub-chronic RfC	400	Significantly elevated carboxyhemoglobin levels (> 2%) (occupational exposure)	DiVincenzo and Kaplan, 1981	MOE, 2011; Cal EPA 2000b
Octane	Inhalation	RfC	18,410 (5,260 µg/kg/d)	Neurotoxicity	Edwards *et al.*, 1997	CCME, 2000
	Oral	RfD	5,000	Neurotoxicity	Edwards *et al.*, 1997	CCME, 2000
1,1,2,2- Tetrachloroethane	Inhalation	IUR	0.00000238 (0.00000833 per µg/kg/d)	Route extrapolation (by WHO)	-	WHO, 1998c
	Oral	SF	0.00000833	Hepatocellular carcinoma (mice)	NCI, 1978b	WHO, 1998c
1,1,2,2-Tetrachloroethane	Oral	SF	0.0002	Hepatocellular carcinoma (mice)	NCI, 1978b	MOE, 2011; US EPA, 2010
		RfD	20	Increased relative liver weight (rats)	NTP, 2004	US EPA, 2010
		Sub-chronic RfD	500	Increased relative liver weights (rats)	NTP, 2004	MOE, 2011; ATSDR, 2008
	Inhalation	IUR	-[b]	-	-	-
1,1,2-Trichloroethane	Inhalation	IUR	0.000016 (0.000056 per µg/kg/d)	Route extrapolation (by U.S. EPA)	-	U.S. EPA,1991f
	Oral	SF	0.000057	Hepatocellular carcinoma (mice)	NCI, 1978c	U.S. EPA, 1991f
		RfD	4	Clinical serum chemistry	Sanders *et al.*, 1985; White *et al.*, 1985	U.S. EPA, 1991f
1,1,2-Trichloroethane	Oral	SF	0.000057	Hepatocellular carcinomas (mice)	NCI, 1978c	MOE 2011; US EPA,1994
		RfD	4	Clinical serum chemistry changes as indicator of liver effects (mice)	Sanders *et al.*, 1985; White *et al.*, 1985	MOE 2011; US EPA, 1995g
		Sub-chronic RfD	40	Not provided	Not provided	MOE 2011; modified from US EPA, 1995g
	Inhalation	IUR	0.000016	Hepatocellular carcinomas (mice)	NCI, 1978c	MOE 2011; US EPA, 1994

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			
Trichloroethylene	Inhalation	IUR	0.00011 (0.0004 per µg/kg/d)	Not specified	NCEA value	U.S. EPA Region IX, 2002
		RfC	35 (10 µg/kg/d)	Not specified	NCEA value	U.S. EPA Region IX, 2002
	Oral	SF	0.0004	Not specified	NCEA value	U.S. EPA Region IX, 2002
		RfD	0.3	Not specified	NCEA value	U.S. EPA Region IX, 2002
Trichloroethylene	Oral	SF	0.000046	Kidney cancer risk (occupational exposure)	Charbotel *et al.*, 2006	MOECC, 2017; US EPA, 2011b
		RfD	*0.5*	*Decreased thymus weight (mice), decreased plaque-forming cell (PFC) response and increased delayed-type hypersensitivity (mice), increased fetal cardiac malformations (rats)*	*Keil et al., 2009; Peden-Adams et al., 2006; Johnson et al., 2003*	*MOECC, 2017; US EPA, 2011b; ATSDR, 2013*
	Inhalation	IUR	0.0000041	Kidney cancer risk (occupational exposure)	Charbotel *et al.*, 2006	MOECC, 2017; US EPA, 2011b
		RfC	*2*	*Decreased thymus weight (mice), increased fetal cardiac malformations (rats)*	*Keil et al., 2009; Johnson et al., 2003*	*MOECC, 2017; US EPA, 2011b; ATSDR, 2013*
Vinyl chloride	Inhalation	IUR	0.00000088 (0.000031 per µg/kg/d)	Liver tumors (rats) – Continuous lifetime exposure from birth	Maltoni *et al.*, 1981, 1984	U.S. EPA, 2000b
		RfC	102 (29 µg/kg/d)	Liver cell polymorphisms (rats) – route extrapolation	Til *et al.*, 1983, 1991	U.S. EPA, 2000b
	Oral	SF	0.0014	Liver tumors (rats) – Continous lifetime exposure from birth	Feron *et al.*, 1981	U.S. EPA, 2000b
		RfD	3	Liver cell polymorphisms (rats)	Til *et al.*, 1983, 1991	U.S. EPA, 2000b
Vinyl chloride	Oral	SF	0.0014	Liver angiosarcoma, hepatocellular carcinoma, and neoplastic nodules (rats)	Feron *et al.*, 1981	MOE, 2011; US EPA, 2000b
		RfD	3	Liver cell polymorphism (rats)	Til *et al.*, 1983; 1991	MOE, 2011; US EPA, 2000b; ATSDR, 2006
	Inhalation	IUR[c]	0.0000088	Liver angiosarcomas, angiomas, hepatomas, and neoplastic nodules (rats)	Maltoni *et al.*, 1981; 1984	MOE, 2011; US EPA, 2000b
		RfC	60	Centrilobular hypertrophy in livers (rats)	Thornton *et al.*, 2002	MOECC, 2017; TCEQ., 2009

[a] units – RfC/AAQC/AQS – ug/m^3; RfD – ug/kg/d; SF - (ug/kg/day)$^{-1}$; IUR – (ug/m^3)$^{-1}$

Table A-1 Summary of Exposure Limits for Human Receptors

Chemical	Route	Exposure Limit		Endpoint	Study	Reference
		Type	Value[a]			

[b] MOE (2011) endorsed the US EPA IRIS (1994) IUR of 5.8×10^{-5} $(\mu g/m^3)^{-1}$ for 1,1,2,2-tetrachloroethane. US EPA IRIS conducted a review of the available toxicological data and derived new exposure limits for 1,1,2,2-tetrachloroethane in 2010. Based on the available data, US EPA IRIS (2010) no longer endorses the IUR derived in 1994 and has not derived a new IUR for 1,1,2,2-tetrachloroethane. Therefore, it was not considered appropriate to adopt the MOE (2011) endorsed IUR for 1,1,2,2-tetrachloroethane for the assessment.

[c] The US EPA IRIS (2000) established two distinct unit risk values for vinyl chloride – one protective of exposure during adulthood (*i.e.*, 4.4×10^{-6} per $\mu g/m^3$) and one protective of exposure from birth (*i.e.*, 8.8×10^{-6} per $\mu g/m^3$). MOE (2011) has selected the child-specific unit risk value as their recommended value to be protective of all sensitive members of the population in the derivation of the generic site conditions standards. However, as the current assessment is evaluating the potential long-term health risks to the adult worker under a commercial exposure scenario, the adult-specific US EPA unit risk value was selected.

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APPENDIX B

SCENARIO 3 - SCALED RESULTS FOR ADDITIONAL CONTAMINANTS FOR HUMAN HEALTH RISK ASSESSMENT

Scenario 3 - Scaled Results for Additional Contaminants for Human Health Risk Assessment

data source
\\gue-nsif-f01\volam-jobs-dfs\jobs\2021\2101750\4. Analysis\14\04PreferredAlternative\04 Scenario 3 (End of Stage 4)\06Results\20241029 TCEC 2101750 ResultsReportTable_Scn3_DustUpdatesWithoutMitigation_ScalingGlenn_mdkb_qa.xlsx

Scaled based on **Hydrogen Sulphide**

	Hydrogen Sulphide	Methyl mercaptan				Hydrogen Sulphide	Methyl mercaptan		
	24-Hour Modelled Concentrations (µg/m^3) [1]	24-hour Scaled Concentration (µg/m^3)	24-hour Scaled Concentration (µg/m^3)	24-hour Scaled Concentration (µg/m^3)		10-minute Modelled Concentrations (µg/m^3) [1]	10-minute Scaled Concentration (µg/m^3)	10-minute Scaled Concentration (µg/m^3)	10-minute Scaled Concentration (µg/m^3)
Scaling Factor [2]	**1**	**0.1399**	**0.1862**	**0.0986**		**1**	**0.1399**	**0.1862**	**0.0986**
Max GLC	8.51E-01	1.19E-01	1.58E-01	8.39E-02		N/A	N/A	N/A	N/A
R1	4.05E-02	5.66E-03	7.53E-03	3.99E-03		4.38E-01	6.13E-02	8.16E-02	4.32E-02
R2	6.84E-02	9.57E-03	1.27E-02	6.75E-03		3.35E-01	4.69E-02	6.24E-02	3.31E-02
R3	7.26E-02	1.02E-02	1.35E-02	7.16E-03		3.67E-01	5.14E-02	6.84E-02	3.62E-02
R4	6.77E-02	9.47E-03	1.26E-02	6.67E-03		3.88E-01	5.43E-02	7.22E-02	3.82E-02
R5	6.27E-02	8.77E-03	1.17E-02	6.18E-03		3.04E-01	4.25E-02	5.66E-02	2.99E-02
R6	6.58E-02	9.21E-03	1.23E-02	6.49E-03		3.32E-01	4.64E-02	6.17E-02	3.27E-02
R7	6.54E-02	9.14E-03	1.22E-02	6.44E-03		4.12E-01	5.77E-02	7.68E-02	4.06E-02
R8	4.47E-02	6.25E-03	8.32E-03	4.41E-03		3.55E-01	4.97E-02	6.61E-02	3.50E-02
R9	1.01E-01	1.41E-02	1.88E-02	9.95E-03		5.92E-01	8.29E-02	1.10E-01	5.84E-02
R10	3.66E-02	5.12E-03	6.82E-03	3.61E-03		2.80E-01	3.92E-02	5.22E-02	2.76E-02
R11	6.31E-02	8.82E-03	1.17E-02	6.22E-03		3.26E-01	4.56E-02	6.07E-02	3.21E-02
R12	9.86E-02	1.38E-02	1.84E-02	9.72E-03		3.87E-01	5.41E-02	7.21E-02	3.81E-02
R13	7.70E-02	1.08E-02	1.43E-02	7.59E-03		3.71E-01	5.20E-02	6.91E-02	3.66E-02
R14	6.50E-02	9.09E-03	1.21E-02	6.41E-03		3.65E-01	5.10E-02	6.79E-02	3.59E-02
R15	7.57E-02	1.06E-02	1.41E-02	7.46E-03		4.29E-01	6.00E-02	7.99E-02	4.23E-02
R16	4.41E-02	6.16E-03	8.20E-03	4.34E-03		3.48E-01	4.87E-02	6.48E-02	3.43E-02
R17	4.20E-02	5.88E-03	7.82E-03	4.14E-03		4.16E-01	5.82E-02	7.75E-02	4.10E-02
R18	4.12E-02	5.77E-03	7.68E-03	4.06E-03		3.81E-01	5.33E-02	7.09E-02	3.76E-02
R19	4.20E-02	5.88E-03	7.82E-03	4.14E-03		4.16E-01	5.82E-02	7.75E-02	4.10E-02
R20	3.75E-02	5.25E-03	6.99E-03	3.70E-03		4.42E-01	6.18E-02	8.23E-02	4.36E-02
R21	3.64E-02	5.09E-03	6.77E-03	3.58E-03		4.40E-01	6.16E-02	8.19E-02	4.34E-02
R22	3.26E-02	4.56E-03	6.07E-03	3.21E-03		4.25E-01	5.95E-02	7.91E-02	4.19E-02
R23	3.06E-02	4.27E-03	5.69E-03	3.01E-03		4.16E-01	5.82E-02	7.74E-02	4.10E-02
R24	2.59E-02	3.62E-03	4.82E-03	2.55E-03		3.85E-01	5.39E-02	7.17E-02	3.80E-02
STR1	N/A	N/A	N/A	N/A		7.61E-01	1.06E-01	1.42E-01	7.50E-02
		0.12	0.16	0.08	0.00	0.59	0.08	0.11	0.06

[1] Maximum modelled concentration of hydrogen sulphide without background (µg/m^3)
[2] Results scaled based on modelled concentration of hydrogen sulphide and scaling factor for each contaminant.
[3] Scaling factor based on the relative proportion of the compound in raw landfill gas compared to hydrogen sulphide

Scaled based on **Benzene**

	24-Hour Modelled Concentrations (µg/m^3) [1]	24-hour Scaled Concentration (µg/m^3) [2]					
	Benzene	1,1-Dichloroethane	Butan-2-ol	1,1,2-Trichloroethane	1,1,2,2-Tetrachloethane	1,1-Dichloroethylene	Methylene chloride
Scaling Factor [2]	**1**	**0.0420**	**2.1126**	**0.0420**	**0.0529**	**0.0312**	**0.5980**
Max GLC	3.24E-01	1.36E-02	6.84E-01	1.36E-02	1.71E-02	1.01E-02	1.94E-01
R1	4.00E-02	1.68E-03	8.46E-02	1.68E-03	2.12E-03	1.25E-03	2.39E-02
R2	1.24E-01	5.19E-03	2.61E-01	5.19E-03	6.54E-03	3.85E-03	7.39E-02
R3	6.89E-02	2.90E-03	1.46E-01	2.90E-03	3.65E-03	2.15E-03	4.12E-02
R4	1.51E-01	6.33E-03	3.18E-01	6.33E-03	7.96E-03	4.70E-03	9.00E-02
R5	4.85E-02	2.04E-03	1.02E-01	2.04E-03	2.57E-03	1.51E-03	2.90E-02
R6	5.03E-02	2.11E-03	1.06E-01	2.11E-03	2.66E-03	1.57E-03	3.01E-02
R7	6.85E-02	2.88E-03	1.45E-01	2.88E-03	3.63E-03	2.14E-03	4.10E-02
R8	4.45E-02	1.87E-03	9.39E-02	1.87E-03	2.35E-03	1.39E-03	2.66E-02
R9	4.83E-02	2.03E-03	1.02E-01	2.03E-03	2.55E-03	1.51E-03	2.89E-02
R10	3.31E-02	1.39E-03	6.98E-02	1.39E-03	1.75E-03	1.03E-03	1.98E-02
R11	3.10E-02	1.30E-03	6.56E-02	1.30E-03	1.64E-03	9.68E-04	1.86E-02
R12	4.57E-02	1.92E-03	9.65E-02	1.92E-03	2.42E-03	1.42E-03	2.73E-02
R13	3.51E-02	1.48E-03	7.42E-02	1.48E-03	1.86E-03	1.09E-03	2.10E-02
R14	3.40E-02	1.43E-03	7.17E-02	1.43E-03	1.80E-03	1.06E-03	2.03E-02
R15	2.87E-02	1.21E-03	6.07E-02	1.21E-03	1.52E-03	8.96E-04	1.72E-02
R16	3.58E-02	1.50E-03	7.55E-02	1.50E-03	1.89E-03	1.12E-03	2.14E-02
R17	4.68E-02	1.97E-03	9.89E-02	1.97E-03	2.48E-03	1.46E-03	2.80E-02
R18	4.25E-02	1.79E-03	8.97E-02	1.79E-03	2.25E-03	1.32E-03	2.54E-02
R19	4.68E-02	1.97E-03	9.89E-02	1.97E-03	2.48E-03	1.46E-03	2.80E-02
R20	3.06E-02	1.29E-03	6.46E-02	1.29E-03	1.62E-03	9.54E-04	1.83E-02
R21	2.70E-02	1.13E-03	5.70E-02	1.13E-03	1.43E-03	8.41E-04	1.61E-02
R22	2.48E-02	1.04E-03	5.23E-02	1.04E-03	1.31E-03	7.73E-04	1.48E-02
R23	2.51E-02	1.06E-03	5.31E-02	1.06E-03	1.33E-03	7.84E-04	1.50E-02
R24	2.12E-02	8.89E-04	4.47E-02	8.89E-04	1.12E-03	6.60E-04	1.26E-02
STR1	NA	NA	NA	NA	NA	NA	NA
		1.36E-02	6.84E-01	1.36E-02	1.71E-02	1.01E-02	1.94E-01

	24-hour Scaled Concentration (µg/m^3) [2]						
	Trichloroethylene	Bormodichloromethane	Octane	Chloroethane	Methyl mercury	Mercuric chloride	Carbon Dioxide
Scaling Factor [2]	**0.3385**	**0.1033**	**2.7862**	**0.1158**	**1.14E-06**	**0.0003**	**189365**
Max GLC	1.10E-01	3.34E-02	9.02E-01	3.75E-02	3.69E-07	1.09E-04	6.13E+04
R1	1.36E-02	4.13E-03	1.12E-01	4.64E-03	4.56E-08	1.34E-05	7.58E+03
R2	4.18E-02	1.28E-02	3.44E-01	1.43E-02	1.41E-07	4.14E-05	2.34E+04
R3	2.33E-02	7.12E-03	1.92E-01	7.98E-03	7.86E-08	2.31E-05	1.30E+04
R4	5.10E-02	1.55E-02	4.19E-01	1.74E-02	1.72E-07	5.05E-05	2.85E+04
R5	1.64E-02	5.01E-03	1.35E-01	5.62E-03	5.53E-08	1.63E-05	9.18E+03
R6	1.70E-02	5.19E-03	1.40E-01	5.82E-03	5.73E-08	1.69E-05	9.52E+03
R7	2.32E-02	7.08E-03	1.91E-01	7.93E-03	7.81E-08	2.30E-05	1.30E+04
R8	1.51E-02	4.59E-03	1.24E-01	5.15E-03	5.07E-08	1.49E-05	8.42E+03
R9	1.63E-02	4.99E-03	1.35E-01	5.59E-03	5.50E-08	1.62E-05	9.14E+03
R10	1.12E-02	3.41E-03	9.21E-02	3.83E-03	3.77E-08	1.11E-05	6.26E+03
R11	1.05E-02	3.20E-03	8.65E-02	3.59E-03	3.54E-08	1.04E-05	5.88E+03
R12	1.55E-02	4.72E-03	1.27E-01	5.29E-03	5.21E-08	1.53E-05	8.65E+03
R13	1.19E-02	3.62E-03	9.78E-02	4.06E-03	4.00E-08	1.18E-05	6.65E+03
R14	1.15E-02	3.51E-03	9.46E-02	3.93E-03	3.87E-08	1.14E-05	6.43E+03
R15	9.72E-03	2.97E-03	8.00E-02	3.33E-03	3.27E-08	9.63E-06	5.44E+03
R16	1.21E-02	3.69E-03	9.96E-02	4.14E-03	4.08E-08	1.20E-05	6.77E+03
R17	1.58E-02	4.83E-03	1.30E-01	5.42E-03	5.33E-08	1.57E-05	8.86E+03
R18	1.44E-02	4.38E-03	1.18E-01	4.92E-03	4.84E-08	1.42E-05	8.04E+03
R19	1.58E-02	4.83E-03	1.30E-01	5.42E-03	5.33E-08	1.57E-05	8.86E+03
R20	1.04E-02	3.16E-03	8.52E-02	3.54E-03	3.49E-08	1.03E-05	5.79E+03
R21	9.13E-03	2.78E-03	7.51E-02	3.12E-03	3.07E-08	9.04E-06	5.11E+03
R22	8.38E-03	2.56E-03	6.90E-02	2.87E-03	2.82E-08	8.31E-06	4.69E+03
R23	8.51E-03	2.60E-03	7.00E-02	2.91E-03	2.87E-08	8.43E-06	4.76E+03
R24	7.16E-03	2.18E-03	5.89E-02	2.45E-03	2.41E-08	7.09E-06	4.01E+03
STR1	NA	NA	NA	NA	NA	NA	NA
	1.10E-01	3.34E-02	9.02E-01	3.75E-02	3.69E-07	1.09E-04	6.13E+04

[1] Maximum modelled concentration of benzene without background (µg/m^3)
[2] Results scaled based on modelled concentration of benzene and scaling factor for each contaminant.
[3] Scaling factor based on the relative proportion of the compound in raw landfill gas compared to benzene

Scaled based on **Benzene**

	Annual Modelled Concentrations (µg/m^3) [1]	Annual Scaled Concentration (µg/m^3) [2]					
	Benzene	1,1-Dichloroethane	Butan-2-ol	1,1,2-Trichloroethane	1,1,2,2-Tetrachloethane	1,1-Dichloroethylene	Methylene chloride
Scaling Factor [2]	**1**	**0.0420**	**2.1126**	**0.0420**	**0.0529**	**0.0312**	**0.5980**
Max GLC	3.87E-02	1.63E-03	8.17E-02	1.63E-03	2.05E-03	1.21E-03	2.31E-02
R1	3.23E-03	1.36E-04	6.82E-03	1.36E-04	1.71E-04	1.01E-04	1.93E-03
R2	7.27E-03	3.06E-04	1.54E-02	3.06E-04	3.85E-04	2.27E-04	4.35E-03
R3	5.50E-03	2.31E-04	1.16E-02	2.31E-04	2.91E-04	1.72E-04	3.29E-03
R4	2.33E-03	9.80E-05	4.92E-03	9.80E-05	1.23E-04	7.27E-05	1.39E-03
R5	2.93E-03	1.23E-04	6.19E-03	1.23E-04	1.55E-04	9.14E-05	1.75E-03
R6	8.02E-03	3.37E-04	1.69E-02	3.37E-04	4.24E-04	2.50E-04	4.80E-03
R7	3.84E-03	1.61E-04	8.11E-03	1.61E-04	2.03E-04	1.20E-04	2.30E-03
R8	9.23E-03	3.88E-04	1.95E-02	3.88E-04	4.88E-04	2.88E-04	5.52E-03
R9	4.71E-03	1.98E-04	9.95E-03	1.98E-04	2.49E-04	1.47E-04	2.82E-03
R10	4.89E-03	2.06E-04	1.03E-02	2.06E-04	2.59E-04	1.53E-04	2.92E-03
R11	3.28E-03	1.38E-04	6.93E-03	1.38E-04	1.74E-04	1.02E-04	1.96E-03
R12	3.89E-03	1.64E-04	8.22E-03	1.64E-04	2.06E-04	1.21E-04	2.33E-03
R13	3.38E-03	1.42E-04	7.14E-03	1.42E-04	1.79E-04	1.05E-04	2.02E-03
R14	2.94E-03	1.24E-04	6.21E-03	1.24E-04	1.56E-04	9.17E-05	1.76E-03
R15	2.78E-03	1.17E-04	5.87E-03	1.17E-04	1.47E-04	8.67E-05	1.66E-03
R16	2.72E-03	1.14E-04	5.75E-03	1.14E-04	1.44E-04	8.48E-05	1.63E-03
R17	2.42E-03	1.02E-04	5.11E-03	1.02E-04	1.28E-04	7.55E-05	1.45E-03
R18	2.17E-03	9.12E-05	4.58E-03	9.12E-05	1.15E-04	6.77E-05	1.30E-03
R19	1.92E-03	8.07E-05	4.06E-03	8.07E-05	1.02E-04	5.99E-05	1.15E-03
R20	2.18E-03	9.17E-05	4.61E-03	9.17E-05	1.15E-04	6.80E-05	1.30E-03
R21	1.93E-03	8.11E-05	4.08E-03	8.11E-05	1.02E-04	6.02E-05	1.15E-03
R22	2.55E-03	1.07E-04	5.39E-03	1.07E-04	1.35E-04	7.95E-05	1.52E-03
R23	2.08E-03	8.74E-05	4.39E-03	8.75E-05	1.10E-04	6.49E-05	1.24E-03
R24	6.32E-03	2.66E-04	1.34E-02	2.66E-04	3.34E-04	1.97E-04	3.78E-03
STR1	N/A	NA	NA	NA	NA	NA	NA
		1.63E-03	8.17E-02	1.63E-03	2.05E-03	1.21E-03	2.31E-02

	Annual Scaled Concentration (µg/m^3) [2]						
	Trichloroethylene	Bormodichloromethane	Octane	Chloroethane	Methyl mercury	Mercuric chloride [4]	Carbon Dioxide
Scaling Factor [2]	**0.3385**	**0.1033**	**2.7862**	**0.1158**	**1.14E-06**	**0.0003**	**189365**
Max GLC	1.31E-02	4.00E-03	1.08E-01	4.48E-03	4.41E-08	1.30E-05	7.33E+03
R1	1.09E-03	3.34E-04	9.00E-03	3.74E-04	3.68E-09	1.08E-06	6.12E+02
R2	2.46E-03	7.51E-04	2.03E-02	8.42E-04	8.29E-09	2.44E-06	1.38E+03
R3	1.86E-03	5.68E-04	1.53E-02	6.37E-04	6.27E-09	1.84E-06	1.04E+03
R4	7.89E-04	2.41E-04	6.49E-03	2.70E-04	2.66E-09	7.81E-07	4.41E+02
R5	9.92E-04	3.03E-04	8.16E-03	3.39E-04	3.34E-09	9.83E-07	5.55E+02
R6	2.71E-03	8.28E-04	2.23E-02	9.29E-04	9.14E-09	2.69E-06	1.52E+03
R7	1.30E-03	3.97E-04	1.07E-02	4.45E-04	4.38E-09	1.29E-06	7.27E+02
R8	3.12E-03	9.53E-04	2.57E-02	1.07E-03	1.05E-08	3.10E-06	1.75E+03
R9	1.59E-03	4.86E-04	1.31E-02	5.45E-04	5.37E-09	1.58E-06	8.92E+02
R10	1.66E-03	5.05E-04	1.36E-02	5.66E-04	5.57E-09	1.64E-06	9.26E+02
R11	1.11E-03	3.39E-04	9.14E-03	3.80E-04	3.74E-09	1.10E-06	6.21E+02
R12	1.32E-03	4.02E-04	1.08E-02	4.50E-04	4.43E-09	1.30E-06	7.37E+02
R13	1.14E-03	3.49E-04	9.42E-03	3.91E-04	3.85E-09	1.13E-06	6.40E+02
R14	9.95E-04	3.04E-04	8.19E-03	3.40E-04	3.35E-09	9.86E-07	5.57E+02
R15	9.41E-04	2.87E-04	7.75E-03	3.22E-04	3.17E-09	9.32E-07	5.26E+02
R16	9.21E-04	2.81E-04	7.58E-03	3.15E-04	3.10E-09	9.12E-07	5.15E+02
R17	8.19E-04	2.50E-04	6.74E-03	2.80E-04	2.76E-09	8.12E-07	4.58E+02
R18	7.35E-04	2.24E-04	6.05E-03	2.51E-04	2.47E-09	7.28E-07	4.11E+02
R19	6.50E-04	1.98E-04	5.35E-03	2.22E-04	2.19E-09	6.44E-07	3.64E+02
R20	7.38E-04	2.25E-04	6.07E-03	2.52E-04	2.48E-09	7.31E-07	4.13E+02
R21	6.53E-04	1.99E-04	5.38E-03	2.23E-04	2.20E-09	6.47E-07	3.65E+02
R22	8.63E-04	2.63E-04	7.10E-03	2.95E-04	2.91E-09	8.55E-07	4.83E+02
R23	7.04E-04	2.15E-04	5.80E-03	2.41E-04	2.37E-09	6.98E-07	3.94E+02
R24	2.14E-03	6.53E-04	1.76E-02	7.32E-04	7.20E-09	2.12E-06	1.20E+03
STR1	NA	NA	NA	NA	NA	NA	NA
	1.31E-02	4.00E-03	1.08E-01	4.48E-03	4.41E-08	1.30E-05	7.33E+03

[1] Maximum modelled concentration of benzene without background (µg/m^3)
[2] Results scaled based on modelled concentration of benzene and scaling factor for each contaminant.
[3] Scaling factor based on the relative proportion of the compound in raw landfill gas compared to benzene
[4] No data available for the concentration of mercuric chloride in landfill gas; therefore, total mercury was used.

Scaled based on **Vinyl Chloride**

	24-Hour Modelled Concentrations (µg/m^3) [1]	24-Hour Scaled Concentration (µg/m^3) [2]					
	Vinyl Chloride	1,1-Dichloroethane	Butan-2-ol	1,1,2-Trichloroethane	1,1,2,2-Tetrachloethane	1,1-Dichloroethylene	Methylene chloride
Scaling Factor [2]	**1**	**0.1084**	**5.4453**	**0.1084**	**0.1364**	**0.0804**	**1.5413**
Max GLC	4.09E-01	4.43E-02	2.23E+00	4.43E-02	5.57E-02	3.29E-02	6.30E-01
R1	1.62E-02	1.76E-03	8.82E-02	1.76E-03	2.21E-03	1.30E-03	2.50E-02
R2	2.12E-02	2.30E-03	1.15E-01	2.30E-03	2.89E-03	1.71E-03	3.27E-02
R3	2.52E-02	2.73E-03	1.37E-01	2.73E-03	3.43E-03	2.02E-03	3.88E-02
R4	2.29E-02	2.48E-03	1.25E-01	2.48E-03	3.12E-03	1.84E-03	3.53E-02
R5	1.93E-02	2.09E-03	1.05E-01	2.09E-03	2.63E-03	1.55E-03	2.97E-02
R6	2.39E-02	2.59E-03	1.30E-01	2.59E-03	3.26E-03	1.92E-03	3.69E-02
R7	2.75E-02	2.98E-03	1.50E-01	2.98E-03	3.75E-03	2.21E-03	4.23E-02
R8	1.67E-02	1.81E-03	9.08E-02	1.81E-03	2.27E-03	1.34E-03	2.57E-02
R9	4.36E-02	4.72E-03	2.37E-01	4.72E-03	5.94E-03	3.50E-03	6.72E-02
R10	2.41E-02	2.62E-03	1.31E-01	2.62E-03	3.29E-03	1.94E-03	3.72E-02
R11	2.35E-02	2.54E-03	1.28E-01	2.54E-03	3.20E-03	1.89E-03	3.62E-02
R12	3.69E-02	4.00E-03	2.01E-01	4.00E-03	5.03E-03	2.97E-03	5.69E-02
R13	2.33E-02	2.53E-03	1.27E-01	2.53E-03	3.18E-03	1.87E-03	3.59E-02
R14	2.29E-02	2.48E-03	1.25E-01	2.48E-03	3.12E-03	1.84E-03	3.53E-02
R15	2.69E-02	2.91E-03	1.46E-01	2.91E-03	3.66E-03	2.16E-03	4.14E-02
R16	1.36E-02	1.47E-03	7.38E-02	1.47E-03	1.85E-03	1.09E-03	2.09E-02
R17	1.87E-02	2.03E-03	1.02E-01	2.03E-03	2.55E-03	1.50E-03	2.88E-02
R18	1.64E-02	1.78E-03	8.92E-02	1.78E-03	2.23E-03	1.32E-03	2.53E-02
R19	1.87E-02	2.03E-03	1.02E-01	2.03E-03	2.55E-03	1.50E-03	2.88E-02
R20	1.41E-02	1.53E-03	7.69E-02	1.53E-03	1.93E-03	1.14E-03	2.18E-02
R21	1.28E-02	1.38E-03	6.95E-02	1.38E-03	1.74E-03	1.03E-03	1.97E-02
R22	1.08E-02	1.17E-03	5.89E-02	1.17E-03	1.48E-03	8.70E-04	1.67E-02
R23	1.02E-02	1.10E-03	5.53E-02	1.10E-03	1.39E-03	8.17E-04	1.57E-02
R24	9.00E-03	9.75E-04	4.90E-02	9.75E-04	1.23E-03	7.24E-04	1.39E-02
STR1	N/A	NA	NA	NA	NA	NA	NA
		4.43E-02	2.23E+00	4.43E-02	5.57E-02	3.29E-02	6.30E-01

	24-Hour Scaled Concentration (µg/m^3) [2]						
	Trichloroethylene	Bormodichloromethane	Octane	Chloroethane	Methyl mercury	Mercuric chloride [4]	Carbon Dioxide
Scaling Factor [2]	**0.8725**	**0.2662**	**7.1816**	**0.2984**	**2.94E-06**	**0.0009**	**488093**
Max GLC	3.57E-01	1.09E-01	2.94E+00	1.22E-01	1.20E-06	3.53E-04	1.99E+05
R1	1.41E-02	4.31E-03	1.16E-01	4.83E-03	4.76E-08	1.40E-05	7.91E+03
R2	1.85E-02	5.65E-03	1.52E-01	6.33E-03	6.23E-08	1.83E-05	1.04E+04
R3	2.20E-02	6.70E-03	1.81E-01	7.51E-03	7.39E-08	2.17E-05	1.23E+04
R4	2.00E-02	6.09E-03	1.64E-01	6.83E-03	6.73E-08	1.98E-05	1.12E+04
R5	1.68E-02	5.13E-03	1.39E-01	5.76E-03	5.67E-08	1.67E-05	9.42E+03
R6	2.09E-02	6.37E-03	1.72E-01	7.14E-03	7.03E-08	2.07E-05	1.17E+04
R7	2.40E-02	7.31E-03	1.97E-01	8.20E-03	8.07E-08	2.37E-05	1.34E+04
R8	1.46E-02	4.44E-03	1.20E-01	4.98E-03	4.90E-08	1.44E-05	8.14E+03
R9	3.80E-02	1.16E-02	3.13E-01	1.30E-02	1.28E-07	3.77E-05	2.13E+04
R10	2.11E-02	6.43E-03	1.73E-01	7.20E-03	7.09E-08	2.09E-05	1.18E+04
R11	2.05E-02	6.24E-03	1.68E-01	7.00E-03	6.89E-08	2.03E-05	1.15E+04
R12	3.22E-02	9.82E-03	2.65E-01	1.10E-02	1.08E-07	3.19E-05	1.80E+04
R13	2.03E-02	6.21E-03	1.67E-01	6.96E-03	6.85E-08	2.02E-05	1.14E+04
R14	2.00E-02	6.10E-03	1.64E-01	6.83E-03	6.73E-08	1.98E-05	1.12E+04
R15	2.34E-02	7.15E-03	1.93E-01	8.01E-03	7.89E-08	2.32E-05	1.31E+04
R16	1.18E-02	3.61E-03	9.74E-02	4.05E-03	3.98E-08	1.17E-05	6.62E+03
R17	1.63E-02	4.97E-03	1.34E-01	5.58E-03	5.49E-08	1.62E-05	9.12E+03
R18	1.43E-02	4.36E-03	1.18E-01	4.89E-03	4.82E-08	1.42E-05	8.00E+03
R19	1.63E-02	4.97E-03	1.34E-01	5.58E-03	5.49E-08	1.62E-05	9.12E+03
R20	1.23E-02	3.76E-03	1.01E-01	4.22E-03	4.15E-08	1.22E-05	6.90E+03
R21	1.11E-02	3.40E-03	9.16E-02	3.81E-03	3.75E-08	1.10E-05	6.23E+03
R22	9.44E-03	2.88E-03	7.77E-02	3.23E-03	3.18E-08	9.35E-06	5.28E+03
R23	8.86E-03	2.70E-03	7.30E-02	3.03E-03	2.99E-08	8.78E-06	4.96E+03
R24	7.85E-03	2.40E-03	6.46E-02	2.69E-03	2.64E-08	7.78E-06	4.39E+03
STR1	NA	NA	NA	NA	NA	NA	NA
	3.57E-01	1.09E-01	2.94E+00	1.22E-01	1.20E-06	3.53E-04	1.99E+05

[1] Maximum modelled concentration of vinyl chloride without background (µg/m^3)
[2] Results scaled based on modelled concentration of vinyl chloride and scaling factor for each contaminant.
[3] Scaling factor based on the relative proportion of the compound in raw landfill gas compared to vinyl chloride
[4] No data available for the concentration of mercuric chloride in landfill gas; therefore, total mercury was used.

Scaled based on **Vinyl Chloride**

	Annual Modelled Concentrations (µg/m^3) [1]	Annual Scaled Concentration (µg/m^3) [2]					
	Vinyl Chloride	1,1-Dichloroethane	Butan-2-ol	1,1,2-Trichloroethane	1,1,2,2-Tetrachloethane	1,1-Dichloroethylene	Methylene chloride
Scaling Factor [2]	**1**	**0.1084**	**5.4453**	**0.1084**	**0.1364**	**0.0804**	**1.5413**
Max GLC	4.53E-02	4.90E-03	2.46E-01	4.90E-03	6.17E-03	3.64E-03	6.98E-02
R1	1.31E-03	1.42E-04	7.13E-03	1.42E-04	1.79E-04	1.05E-04	2.02E-03
R2	2.11E-03	2.29E-04	1.15E-02	2.29E-04	2.88E-04	1.70E-04	3.25E-03
R3	1.97E-03	2.13E-04	1.07E-02	2.13E-04	2.69E-04	1.58E-04	3.04E-03
R4	1.68E-03	1.82E-04	9.15E-03	1.82E-04	2.29E-04	1.35E-04	2.59E-03
R5	2.14E-03	2.32E-04	1.17E-02	2.32E-04	2.92E-04	1.72E-04	3.30E-03
R6	3.41E-03	3.70E-04	1.86E-02	3.70E-04	4.65E-04	2.74E-04	5.26E-03
R7	1.65E-03	1.79E-04	8.98E-03	1.79E-04	2.25E-04	1.33E-04	2.54E-03
R8	2.45E-03	2.65E-04	1.33E-02	2.66E-04	3.34E-04	1.97E-04	3.78E-03
R9	1.64E-03	1.78E-04	8.93E-03	1.78E-04	2.24E-04	1.32E-04	2.53E-03
R10	1.81E-03	1.96E-04	9.86E-03	1.96E-04	2.47E-04	1.46E-04	2.79E-03
R11	1.35E-03	1.46E-04	7.35E-03	1.46E-04	1.84E-04	1.09E-04	2.08E-03
R12	1.49E-03	1.61E-04	8.11E-03	1.61E-04	2.03E-04	1.20E-04	2.30E-03
R13	1.34E-03	1.45E-04	7.30E-03	1.45E-04	1.83E-04	1.08E-04	2.07E-03
R14	1.21E-03	1.31E-04	6.59E-03	1.31E-04	1.65E-04	9.73E-05	1.86E-03
R15	1.15E-03	1.25E-04	6.26E-03	1.25E-04	1.57E-04	9.25E-05	1.77E-03
R16	1.10E-03	1.19E-04	5.99E-03	1.19E-04	1.50E-04	8.84E-05	1.70E-03
R17	9.70E-04	1.05E-04	5.28E-03	1.05E-04	1.32E-04	7.80E-05	1.50E-03

	Annual Scaled Concentration (µg/m^3) [2]						
	Trichloroethylene	Bormodichloromethane	Octane	Chloroethane	Methyl mercury	Mercuric chloride [4]	Carbon Dioxide
Scaling Factor [2]	**0.8725**	**0.2662**	**7.1816**	**0.2984**	**2.94E-06**	**0.0009**	**488093**
Max GLC	3.95E-02	1.20E-02	3.25E-01	1.35E-02	1.33E-07	3.91E-05	2.21E+04
R1	1.14E-03	3.49E-04	9.41E-03	3.91E-04	3.85E-09	1.13E-06	6.39E+02
R2	1.84E-03	5.62E-04	1.52E-02	6.30E-04	6.20E-09	1.82E-06	1.03E+03
R3	1.72E-03	5.24E-04	1.41E-02	5.88E-04	5.79E-09	1.70E-06	9.62E+02
R4	1.47E-03	4.47E-04	1.21E-02	5.01E-04	4.94E-09	1.45E-06	8.20E+02
R5	1.87E-03	5.70E-04	1.54E-02	6.39E-04	6.29E-09	1.85E-06	1.04E+03
R6	2.98E-03	9.08E-04	2.45E-02	1.02E-03	1.00E-08	2.95E-06	1.66E+03
R7	1.44E-03	4.39E-04	1.18E-02	4.92E-04	4.85E-09	1.43E-06	8.05E+02
R8	2.14E-03	6.52E-04	1.76E-02	7.31E-04	7.20E-09	2.12E-06	1.20E+03
R9	1.43E-03	4.37E-04	1.18E-02	4.89E-04	4.82E-09	1.42E-06	8.00E+02
R10	1.58E-03	4.82E-04	1.30E-02	5.40E-04	5.32E-09	1.56E-06	8.83E+02
R11	1.18E-03	3.59E-04	9.70E-03	4.03E-04	3.97E-09	1.17E-06	6.59E+02
R12	1.30E-03	3.97E-04	1.07E-02	4.45E-04	4.38E-09	1.29E-06	7.27E+02
R13	1.17E-03	3.57E-04	9.62E-03	4.00E-04	3.94E-09	1.16E-06	6.54E+02
R14	1.06E-03	3.22E-04	8.69E-03	3.61E-04	3.56E-09	1.05E-06	5.91E+02
R15	1.00E-03	3.06E-04	8.26E-03	3.43E-04	3.38E-09	9.94E-07	5.61E+02
R16	9.60E-04	2.93E-04	7.90E-03	3.28E-04	3.23E-09	9.51E-07	5.37E+02
R17	8.46E-04	2.58E-04	6.97E-03	2.89E-04	2.85E-09	8.38E-07	4.73E+02