Long Term Waste Disposal EA Terms of Reference

DRAFT WORKING BRIEF - Environmental Effects Inventory and Comparative Evaluation Method

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METROWORKS

EXECUTIVE SUMMARY

This Working Brief presents the method which will be used to assess the environmental effects of the alternative waste disposal solutions which the North American waste management marketplace may propose to Metro.

The environmental effects to be assessed, the means of measuring the magnitude of those effects, and the priority to be assigned to the effects which will result in identifying the preferred alternatives are described herein and are referred to as the "life cycle inventory and analysis model".

The model will allow the waste disposal alternatives to be comparatively evaluated in terms of their overall environmental performance. The potential environmental effects which Metro will assess are those macro-effects which will be caused by Metro contracting for waste disposal capacity, which affect the environment of Ontario, and which are not assessed through other environmental and land-use approval requirements.

The purpose of presenting this information is to solicit response, comment and advice from stakeholders on the model. Metro will consider this input in finalizing the model - which will be incorporated into Metro's Long Term Waste Disposal EA Terms of Reference. After approval of the EA TOR by the Minister, the model will constitute the terms under which Metro will fulfill the requirement of the Environmental Assessment Act that Metro evaluate the advantages and disadvantages of Metro's potential long term waste disposal undertaking.

AS A CONTEXT FOR THIS WORKING BRIEF, READERS ARE STRONGLY ENCOURAGED TO HAVE READ THE DOCUMENT: "LONG TERM WASTE DISPOSAL EA TERMS OF REFERENCE, DRAFT EA TOR, AUGUST 27, 1997".

1. INTRODUCTION

Metro has structured a residual solid waste disposal planning process which will enable Metro to identify its preferred waste disposal solution — being contract partnerships with waste disposal capacity suppliers (or supplier) that meet Metro's long term disposal capacity needs in a manner which addresses Metro's interests within the requirements of the Environmental Assessment Act.

Metro will use a two-stage process to identify and assess its alternatives in the context of the Environmental Assessment Act. Stage 1 "Request for Qualifications" (RFQ) will invite waste disposal capacity proposals from the private and public waste management marketplace and then use "mandatory qualification criteria" to identify those proposals which warrant assessment as alternatives. Stage 2 "Request for Proposals" (RFQ) will invite the proponents of those qualifying alternatives to submit project proposals. These project proposals will be assessed using comparative evaluation criteria to establish which proposals have top ranking environmental performance.

Documentation of this two-stage process will constitute Metro's Environmental Assessment which will be submitted in support of EA Act approval for Metro's undertaking. Metro's undertaking will be the proposal which is among the top ranked in terms of environmental performance and which is preferred by Metro as a result of Metro's due diligence reviews and the negotiations process to finalize contractual agreements. Metro's due diligence reviews and negotiations process will not be within the purview of Metro's Environmental Assessment.

In general, the potential environmental effects which Metro will assess are those macro-effects which will be caused by Metro contracting for waste disposal capacity, which affect the environment of Ontario, and which are not assessed through other environmental and land-use approval requirements. Metro will assess its alternative waste disposal solutions through the application of environmental comparative evaluation criteria. The specific environmental effects which Metro will consider are summarized as follows:

- emissions of pollutants to air, land and water associated with the disposal of Metro’s waste at the disposal facilities' offered through the marketplace and in the transportation of Metro’s waste to those facilities,

- traffic safety associated with waste transportation,

- energy resource management associated with the waste disposal facilities' operations and waste transportation,

- job creation and investment in Ontario, and

- waste disposal system costs (i.e. $ per tonne).

These effects address the EA Act's definition of the term "environment", which includes human health and safety, natural, socio-cultural and financial aspects of an undertaking.

2. THE ENVIRONMENT AND POTENTIAL EFFECTS THAT WILL BE ASSESSED

Metro will assess the potential effects of its waste disposal alternatives on the environment of Ontario. Metro will not assess effects that do not impact the environment in and of Ontario for the following reasons.

The EA Act requires that Metro consider the effects of its decisions on the environment of Ontario. Waste disposal facilities located in the U.S.A. are regulated under U.S. Federal, State and Municipal law. The basic approaches to regulation of waste disposal facilities and facilities' environmental performance in the provincial and state jurisdictions of Canada and the U.S.A. are reasonably similar. Metro does not have the responsibility or ability to judge in detail the efficacy of non-Ontario jurisdictions' regulation of waste disposal facilities where those facilities affect only the environment of the foreign jurisdictions and do not affect the environment of Ontario. Again, however, Metro will have regard for environmental effects which affect the environment of Ontario, whether or not those effects are generated/sourced in Ontario.

To illustrate this principal, Metro will have regard for certain air emissions from waste disposal facility alternatives located in the U.S.A (and the transportation of waste to those facilities). Emissions of greenhouse gases from the facilities (and transportation to the facilities) affects the global environment and in turn Ontario's environment. Depending upon geographic location, a percentage of smog precursor air emissions affects Ontario's air quality. On the other hand, a

U.S.A. landfill which discharges leachate to a local groundwater, and which does not affect Great Lakes water quality, does not affect the environment of Ontario.

Metro will assess the effects which could be caused by Metro's undertaking - transportation and disposal of Metro's waste. Metro will not assess the effects that may be caused by a facility's disposal of waste other than Metro's waste. For example, if a facility is disposing of 1,000,000 tonnes per year, comprised of 500,000 tonnes of Metro's waste and 500,000 tonnes of waste generated by others, Metro will assess the effects caused by Metro's 500,000 tonnes. Metro will not assess the overall effects of the facility, which effects are not directly related to Metro's waste.

The specific effects which Metro will assess are set out in the evaluation criteria presented in Table 1, Section 3 of this document. The criteria were defined and their priorities assigned as a result of stakeholder consultation. The criteria address the broad definition of the term environment as given in the EA Act. They address the potential macro-effects upon the environment of Ontario of both the operation of the alternative waste disposal facilities and the transportation of Metro's waste to those facilities.

In identifying its preferred waste disposal solution from among its alternatives, Metro will have regard for **human health and safety and the natural environment** through consideration of the "total loadings" of priority pollutants associated with Metro's waste, emitted from the waste disposal facilities and waste haul vehicles, and the effect of waste haul on traffic safety. **It is noted that all facilities which Metro evaluates must be found to be in compliance with the environmental, occupational health and safety and land use planning/zoning requirements of their relevant locational jurisdictions.** These requirements address the aspects of public health, worker and natural environmental protection by limiting the exposure concentrations of pollutants in the area of a facility's site. By considering the absolute quantity (vs. concentration) of emissions (i.e. "total loadings") that may be caused by disposing of Metro's waste, Metro will be addressing the macro-effect of its undertaking on the environment of Metro and of Ontario. Metro will not duplicate the consideration of the "micro-effects" upon the local environment which are addressed in the course of facilities obtaining site specific environmental licensing (e.g. Environmental Protection Act Certificate of Approval) and land use permits.

Metro will have regard for the **socio-cultural elements of the environment** by considering the extent to which the alternative facilities and their waste haul systems have the potential to generate net increased direct and indirect employment and investment in goods sourced from Ontario. It is noted that the potential to affect socio-cultural resources local to facilities are addressed through land use designation and zoning permit requirements. These requirements manifest both Provincial and local municipal interests and values (e.g. Provincial Policy Statements pertaining to agricultural foodlands and wetlands presentation, etc.; and, local environmental sensitive areas protection designations, heritage protection designations, general land use compatibility and including local traffic safety and traffic flows). Metro will not duplicate these requirements in Metro's environmental assessment.

Metro will have regard for the **financial effects** of its waste disposal decision by considering the system costs of the alternatives.

3. COMPARATIVE EVALUATION PROCESS

Metro's Stage 2 RFP will require that respondents submit information which describes the environmental performance (in accordance with the criteria, presented in the following table) associated with their facilities managing Metro's waste (disposal facilities and waste haul). The environmental performance of facilities must include the effects associated with transporting, receiving, processing and disposing of waste and managing disposal facility residues (e.g. EFW ash, landfill leachate and landfill gas) and closure and post-closure care over the contaminating life-span of the facility.

TABLE 1

STAGE 2 RFP COMPARATIVE EVALUATION CRITERIA

	Criteria	Measure	Priority (weighting factor points out of a total of 100 points)
1.	**Human Health and Safety, Natural Environment**		**40**
1.1	• Substance emissions to air, land and water associated with waste disposal facility operations and waste haul	• Quantity of the following priority pollutants categories released to the environment, expressed as the quantity of substance emitted per tonne of waste managed (transported and disposed):	30
		- greenhouse gases (CO_2, CH_4, N_2O expressed as global warming potential CO_2 equivalents) **(climate change)** - acid gases (NOx, SOx and HCl) **(acid precipitation)** - smog precursors (NOx, PM_{10} and VOCs) **(smog formation)** - heavy metals (Pb, CD, and Hg) and trace organics (dioxins, vinyl chloride, PAH's) **(health risk)** - effluent (COD, ammonia, nitrates and chlorides) **(water quality change)** - **land consumed** (as measured by the area ("footprint") of the residual waste disposed. (The priority weighting of each of the above five (5) pollutant categories relative to each other will be assigned by Metro based upon the rigour (quantity, currency, statistical probability of accuracy) of the measurement data which is available.)	

1.2	• Traffic safety associated with waste haul	• Traffic safety exposure factors for road and rail, incorporating school bus routes, major at-grade crossings, special intersections, etc. (derived from MTO level of service ratings and National Transportation Safety Board (rail) data)	5
1.3	• Energy resources management	• Net energy resource consumption/production, in terms of heat energy per tonne of waste managed: - type and quantity of fuel consumption re waste haul - energy balance of waste disposal facilities' operations (i.e. energy consumed and energy generated in the case of EFW or landfill gas energy recovery)	5
2.	**Social**		**20**
2.1	• Employment - Jobs located in Ontario (directly as a result of waste management and indirect jobs that are a result of the multiplier effect of waste management on the economy)	• Value of jobs per tonne	15
2.2	• Investment in goods sourced from Ontario.	• $ investment per tonne	5
3.	**Financial**		**40**
3.1	• System Costs: - disposal cost (including site approvals, development and operating costs if Metro co-proponency is proposed) and including waste haul charges and all internal costs that may be associated with the proposal, such as any modifications which Metro would have to make to its transfer stations.	• Net present value $/tonne	40

	Other Criteria		
	Criteria addressing other potential environmental effects (in addition to criteria cited above) associated with the waste disposal bids, as may be identified during the Criteria Review/Refinement Task, following Stage 1 RFQ	• To be determined following Stage 1 and prior to Stage 2	**To be determined following Stage 1 and prior to Stage 2.**

Section 4 of this Working Brief presents a detailed explanation of how the environmental performance of the alternative waste disposal systems will be measured. The following is a summary discussion of this method.

A lifecycle methodology will be used to quantify the environmental performance of the alternative waste disposal solutions with respect to Criteria 1.1 (substance emissions to air, land and water). The lifecycle assessment will quantify the pollutants emitted directly by a waste disposal facility's operation including waste transport to the facility (e.g. pollutants emitted in the exhaust of transportation vehicles, pollutants in landfill leachate and gas discharges, pollutants in EFW air emissions, etc.). The lifecycle approach also accounts for the pollutants emitted in the production of energy/fuel resources which are consumed and produced by the waste disposal alternatives, (e.g. pollutants emitted in the production of diesel fuel, electricity, etc.).

Criteria 1.1 will measure the effects of the alternatives on human health and safety/natural environment in terms of macro-environmental effects. **Macro-environmental effects are manifest in those persistent environmental parameters which represent the significant majority of the total potential pollutants which would impact the environment and which, because of their persistency, potentially result in impacts at a scale well beyond their point of discharge.**

Criteria 1.2 - Traffic Safety will be measured using safety indexing factors which account for the circumstances which have the propensity to cause traffic accidents.

Criteria 1.3 will account for the net energy consumed/produced in transporting and disposing of waste.

The employment and investment performance of the alternative waste disposal solutions (criteria 2.1 and 2.2) will be considered in terms of value directly attributed to the alternatives, as well as the indirect benefits accruing as a result of the multiplier effect of waste management jobs and investment on the economy.

Criteria 3.1 is a simple measure of the financial costs (i.e. $ per tonne) of the alternatives.

The use of lifecycle assessments in waste management evaluation/decision-making has, until recently, been limited by the absence of standardized methodologies for their conduct, and by the lack of credible, current data on material/energy use and emissions from various extraction, production, use and disposal processes. Over the last few years, a number of agencies have undertaken the development of standard methodologies for lifecycle assessments. These include the Society of Environmental Toxicology and Chemistry (1991), Canadian Standards Association (1994), and ISO 14040 (June, 1997). As a result of these efforts, there is now broad agreement on a methodology for carrying out environmental lifecycle inventory analysis. A number of industry initiatives have been undertaken or are underway in Canada, Europe and the United States to establish databases on material/energy use and pollutants releases for use in lifecycle assessments. These standardized methodologies and performance databases have been incorporated into the model presented in the following section of this Working Brief.

Comparison of the total loadings of pollutants generated over the lifecycle (transportation and facility operations) of waste disposal alternatives is increasingly being used to evaluate the environmental effects of waste management options. Waste management planning activities in a number of industrialized countries (United States, United Kingdom, Switzerland, France, Germany and Canada) are being designed to make environmental assessment approvals' decisions based upon consideration of the total pollutant loadings of alternatives.

A **weighted additive method** will be used to comparatively evaluate the alternatives that are offered to Metro by the marketplace. In summary, the weighted additive method will require that the effects of the disposal alternatives be expressed as numeric ratios of each other and that explicit numeric weights for the criteria be used. By combining the environmental effects with the criteria weights, numeric overall performance scores will be generated for each alternative. This

methodology will allow for the integration of the disparate effects of financial costs, environmental quality and social elements. By comparing the overall performance scores a ranking of the alternatives will be identified. The following illustrates this method.

A numeric expression of each of the alternatives' environmental performance in accordance with each of the evaluation criteria (e.g. kilograms of greenhouse gases emitted per tonne of waste transported and disposed) will be generated. The performance numbers of each alternative will then be expressed as a percentage of the total effect of all alternatives in regard to each criteria. For example, three alternatives may have the following potential effects in regard to greenhouse gas emissions:

- Alternative A: 800 kg CO_2 equivalent greenhouse gas emissions per tonne waste = 26% of total
- Alternative B: 1,000 kg CO_2 equivalent greenhouse gas emissions per tonne waste = 33% of total
- Alternative C: 1,200 kg CO_2 equivalent greenhouse gas emissions per tonne waste = 40% of total

Total: 3,000

I.e. Alternative A will be allocated 26 environmental debit points.

A similar calculation will be done for each of the categories: acid gas, smog precursors, heavy metals and trace organics, effluent and land consumed. This will generate a “gross” performance measure for each alternative in terms of Criteria 1.1. These gross performance numbers will then be multiplied by the priority weighting factor assigned Criteria 1.1 to generate a “weighted” performance number. (In the example given, Criteria 1.1 has a priority of 30 points).

The weighted performance numbers for all criteria (i.e. 1.1 through 3.1) will be added to yield an overall weighted performance for each alternative. Comparison of these overall performance figures will yield a ranking of the alternatives.

The following section describes the method by which the criteria 1.1 and 1.3 will be measured.

4. THE ENVIRONMENTAL LIFE CYCLE INVENTORY MODEL

4.1 Introduction

The total lifecycle energy and pollutant implications of a waste disposal alternative are calculated by adding together energy consumed and emissions released by the following processes:

- the transportation of waste (emissions from the vehicles that transport the waste from the transfer station to the waste disposal facility); and,
- the disposal of the waste at the EFW or landfill; and,
- the production of the energy (e.g. natural gas, diesel, electricity) used by the transportation vehicles and waste disposal facilities.

Figure 1 illustrates the life cycle elements of a waste disposal system.

This section of the Working Brief outlines the methodology for estimating emissions from each of the above processes and defines the input data that would be required from the bidders. Wherever possible, default values will be provided for these inputs to assist bidders who are not able to provide the required information. The basis for the development of these defaults is documented is outlined in the following sections. Default values will be conservative, representing either minimum acceptable values (i.e. standards or guidelines, where existing) or the minimum average performance from performance range databases. Thus, in general, bidders will be better off supplying actual bidder value data rather than defining their performance through use of default values. Metro will, subject bidder value information to an engineering review as the basis for Metro accepting such performance claims.

4.2 Estimating the Environmental Effects of Transportation Operations

The transportation of waste contributes to the life cycle energy consumption and emissions associated with a waste disposal alternative in two ways:

- energy is consumed and emissions are released by the combustion of the fuel in the vehicle (tail pipe emissions)

- energy is consumed and emissions occur during the production and delivery of the fuel used in the vehicle.

Transportation missions are estimated from the type and quantity of fuel used. Bidders will be asked to provide information on the total quantity of fuel used annually to transport the waste to the facility. If a bidder does not have information on total fuel consumption, this will be derived from the distance travelled based upon default value fuel efficiencies of truck and rail haul.

Emission factors for CO_2 and CH_4 from transportation of waste will be developed based on Environment Canada's emission inventory for greenhouse gas emissions.

Transportation related emissions of NOx, and VOC will be based on the U.S. EPA AP-42 emission factors for mobile sources. PM emissions from transportation could be estimated based upon the new U.S. standard for heavy duty diesel trucks. SOx emission factors will be developed based on the sulphur content of diesel fuel. Emissions of dioxins in tail pipe emissions can be estimated using data from a recent study carried out by the American Petroleum Institute and Engine Manufacturers Association (1996).

The information required to estimate emissions from transportation vehicles is shown in Table 4.1, below.

Table 4.1

Inputs for Estimating Transportation Emissions

Input/Parameter	Default Values (truck)	Default Values (rail)	Bidder's Value
Distance waste is transported (km)			
Type of fuel used	Diesel		
Quantity of fuel used ('000 litres)	Calculated assuming a fuel efficiency of 2.5 km/litre and the distance provided by the bidder		

4.3 Estimating the Environmental Effects of EFW Alternatives

The net lifecycle energy consumed by the disposal of waste in an energy recovery facility is estimated as follows:

$E_{net} = E_{consumed} - E_{recovered}$

where,

E_{net} = net energy recovered by the facility

$E_{consumed}$ = energy consumed by the operation of the EFW facility

$E_{recovered}$ = energy recovered from the combusted waste

The information required to estimate the net energy recovered from the facility is shown in Table 4.2. For energy from waste plants, $E_{consumed}$ typically represents 10% of the energy recovered. A default value (expressed in MJ/tonne of waste received) will be developed for use where the bidder does not have data specific to his facility.

The net emissions associated with disposing waste in an EFW are calculated as follows:

$Em_{net} = Em_{combustion} + Em_{energy\ consumed} - Em_{energy\ produced}$

where,

Em_{net} = net emissions

$Em_{combustion}$ = emissions from the combustion of the waste

$Em_{energy\ consumed}$ = emissions associated with the production and delivery of the energy consumed

$Em_{energy\ produced}$ = emissions that would have been generated by the production of the energy that is now recovered at the EFW facility

The information required to calculate waste combustion emissions is shown in Table 4.3.

Emissions associated with the production and delivery of the energy that is consumed by the EFW facility are calculated from the information on the quantity and type of energy used and default emission factors developed for the production of natural gas, fuel oil, and electricity. The derivation of these emission factors is explained in Section 4.5.

Table 4.2

Inputs for Estimating the Net Energy Recovered at an EFW Facility

Input/Parameter	Default Value	Bidder's Value
The quantity of Metropolitan Toronto's waste sent to the EFW Facility (tonnes/per year)*		
Average heat value of the waste (kJ/tonne)	Calculated from the composition of the waste	
Form of energy recovered, indicate electricity or steam		
Fuel type (s) replaced:	Steam production: natural gas: Electricity production** natural gas fuel oil other fossil fuels hydroelectricity nuclear	Steam production: natural gas: ___% fuel oil: ___% Electricity production: coal:- ___% natural gas: ___% fuel oil: ___% other fossil fuels: ___% hydroelectricity: ___% nuclear: ___%
Efficiency of energy recovery	electricity: % steam : %	
Energy consumed by facility operations	kwh/tonne	

*to be estabilised by Metropolitan Toronto prior to releasing the Request for Proposals
** based on the mix of fuels used to generate electricity in Ontario.

The production of energy at an EFW facility displaces energy production by conventional means (e.g. natural gas fired boilers, thermal power plants). This results in reduced or avoided emissions at those facilities. The life cycle approach credits these avoided emissions (also known as 'offset burdens') to the energy from waste facility. Offset burdens are calculated from the quantity and type of fuels that are displaced and emission factors for the production, delivery and combustion of those fuels.

If the bidder provides information on the direct emissions from the EFW facility, these will be used. If facility specific data is not provided, default emissions will be based on the assumption that the unit will operate to the emission standards in Guideline A-7. CO_2 emissions (for which there are no standards) will be estimated from the carbon content of the individual materials in the waste stream (provided as defaults) and the composition of the waste received at the EFW.

Data on liquid effluents from wet scrubbers (where applicable) and housekeeping operations will be solicited from bidders.

The evaluation will be structured so that the quantity of ash generated by the EFW facility can either be input by the bidder or alternatively be estimated from the waste composition and the ash contents of the individual materials.

The environmental effects of ash generated by disposal of waste at an EFW will be calculated as per waste disposed of at a landfill site (refer to Section 4.4), unless ash is managed via utilization (as opposed to disposal).

4.4 Estimating the Environmental Effects of Landfilling Alternatives

The net energy consumed by landfilling operations is calculated as follows:

$E_{net} = E_{consumed} - E_{recovered}$

where,

E_{net} = net energy recovered

$E_{consumed}$ = energy consumed by landfilling operations

$E_{recovered}$ = energy recovered from landfill gas

If a landfill does not have a gas collection and utilization system, $E_{recovered} = 0$. The information required to estimate the net energy consumed by the landfill is shown in Table 4.4. A default values for the energy used in landfilling operations can be developed based on estimates published in a recent Environment Canada study that examined energy utilization in waste management (Environment Canada, 1996).

Emissions associated with the production and delivery of the energy used at the facility are estimated from the quantity and type of fuel used and emission factors developed for the production, delivery and combustion of various fuels. The production of energy from landfill gas displaces energy production by conventional means (e.g. natural gas fired boilers, thermal power plants, etc.). This results in reduced or avoided emissions at those facilities. The lifecycle approach credits these avoided emissions (also known as ‘offset burdens’) to the landfill gas

Table 4.3
Inputs for Estimating EFW Facility Emissions

Input Parameter	Default Value	Bidder's Value
Volume of flue gas/tonne of waste		
Tonnes of ash produced/tonne of waste	Calculated from the ash content of the materials in the waste and its composition..	Fly ash: tonnes Bottom ash:___tonnes
Greenhouse Gas Emissions		
CO2 (tonnes)	Calculated from the carbon content of the individual materials in the waste and the composition of the waste	
Acid Gases	Based on Guideline A-7	
NOx (mg/Rm3)		
SO2 (mg/Rm3)	*	
HCl		
Smog Precursors	Based on Guideline A-7	
NOx	*	
PM		
VOC		
Heavy metals & trace organics - Air	Based on Guideline A-7	
Pb		
Hg		
Cd		
Dioxins (TEQ)		
Emissions to water		
COD (kg)		
Chlorides (kg)		
Ammonia (kg)		
Residual Solid Waste	bottom ash + fly ash	

recovery system. Offset burdens are calculated from the quantity and type of fuels that are displaced and emission factors for the production, delivery and combustion of those fuels discussed in Section 4.5

The net emissions from landfilling operations are calculated as follows:

$$Em_{net} = Em_{biodegradation} + Em_{gas\ combustion} + Em_{energy\ consumption} - Em_{energy\ recovery}$$

where,

Em_{net} = net emissions

$Em_{biodegradation}$ = emission of landfill gas

$Em_{combustion}$ = emissions from the combustion of landfill gas (if gas is collected and combusted)

$Em_{energy\ consumed}$ = emissions associated with the production and delivery of the energy consumed

$Em_{energy\ recovery}$ = emissions that would have been generated by the production of the energy that is now recovered at the EFW facility

The information required to estimate emissions from direct emissions from landfills is shown in Table 4.5.

Default emission factors for methane will be developed based on data collected by Environment Canada on emissions from Canadian landfills. It is proposed that default emission factors for VOCs from landfills be estimated using data reported in U.S. EPA AP-42 draft emission factors for municipal solid waste landfills (September, 1995). Default values for emissions from landfill gas combustion systems will be developed from emissions reported in the AP-42 as well as, testing undertaken by Environment Canada at six Canadian landfills.

Default values for leachate generation will be developed based on the annual precipitation. A review of the literature suggests that the volume of flow produced from a MSW landfill varies between 8% - 24% of the annual precipitation or 65% of the precipitation received during the winter months (personal comm. - B. Coulter 1997 and Birkbeck, et. al., 1984). Stegmann and Ehring (1989) found that the mean leachate volume was approximately 18% of annual precipitation.

The efficiency of leachate collection systems is not well documented. In general, a state-of- the-art collection system is capable of collecting 100% of the leachate produced at a landfill site. Older sites would be expected to have lower collection efficiencies. Bidders will be asked to provide information on leachate collection efficiencies. Defaults representing minimum performance will be developed for use where the bidder is not able to provide site specific data.

Leachate treatment removal efficiencies for chlorides, ammonia, and COD will be developed based on minimum performance.

4.5 Estimating the Environmental Effects of Energy Production and Use

Energy is consumed throughout the waste management system for transportation and material handling and processing. The production, delivery and use of this energy is a major source of a number of the pollutants considered in this study. In considering the contribution of energy consumption to lifecycle emissions, two elements must be considered:

- fuel combustion emissions
- emissions from the production and delivery of the fuel or electricity (or, precombustion emissions)

Sources for the emission factors used to estimate energy related emissions are discussed below.

Fuel Combustion Emissions

Data on emissions from fuel combustion emissions of CO_2 and CH_4 used in this study were obtained from the Environment Canada report on 1990 greenhouse gas emissions (Jaques, 1992). NOx and SOx emissions associated with the combustion of fuels were derived from the U.S. EPA AP-42 emission factors for stationary sources (U.S. EPA, 1993).

Pre-combustion Emissions

Data on emissions from the production and delivery of fuel in Canada are not available. These are therefore estimated from U.S. and U.K data obtained from ongoing work being undertaken by

Table 4.4
Inputs for Estimating Net Energy Consumed by Landfill Facilities

Input/Parameter	Default Value	Bidder's Value
The quantity of Metropolitan Toronto's waste sent to the landfill (tonnes/per year)*		
Composition of the waste	To be provided by Metropolitan Toronto	To be provided by Metropolitan Toronto
Landfill gas generation rate	Calculated from the composition of the waste and the biodegradability of the waste components	
Composition of landfill gas	% methane; % CO_2	Methane: ___% Carbon-dioxide: ___ %
Average heat value of landfill gas (if energy is recovered)	MJ/Nm^3	
Landfill gas recovery rate		
Volume of flue gas from the combustion of landfill gas	m^3/m^3 of landfill gas	
Form of energy recovered, indicate electricity or steam	Electricity	
Fuel type (s) replaced:	Steam production: natural gas: 100% Electricity production**: coal: natural gas: fuel oil: other fossil fuels: hydroelectricity: nuclear:	Steam production: natural gas: ___% fuel oil: ___% Electricity production: coal:- ___% natural gas: ___% fuel oil: ___% other fossil fuels: ___% hydroelectricity: ___% nuclear: ___%
Efficiency of energy recovery	electricity: steam :	
Quantity and type of energy consumed by facility operations	MJ/tonne Diesel	

Table 4.5

Inputs for Estimating Landfill Facility Emissions

Parameter	Default landfill gas emissions*	Default landfill gas combustion emissions	Bidder's Value
Greenhouse Gases CO2 (tonnes) CH_4 (tonnes)	Calculated from the composition of the waste and the biodegradability of the waste components	All captured methane assumed to be converted into CO_2	
Acid Gases NOx		mg/Nm^3	
SO2		mg/Nm^3	
HCl	mg/Nm^3	mg/Nm^3	
Smog Precursors NOx		mg/Nm^3	
VOC (tonnes)	mg/Nm^3	Calculated assuming % removal	
Emissions of Heavy Metals and Trace Organics - Air Pb		mg/Nm^3	
Hg		mg/Nm^3	
Cd		mg/Nm^3	
Dioxins (TEQ) (mg)			
Emissions to Water Leachate generated per tonne of waste	litres/tonne		
Leachate Quality: Chlorides (mg/litre) Ammonia (mg/litre) COD (mg/litre)			
Leachate collection efficiency	%		
Treatment removal efficiencies: BOD (%) Cl (%) NH3 (%)			
Residual Waste (tonnes)			

the U.S. EPA and the U.K Department of the Environment as input into life cycle studies of municipal solid waste management options.

Electricity, which is used in a number of waste management functions, represents an energy source derived from a number of different fuels. Emission factors for the generation of electricity in Ontario must therefore reflect the different methods of power generation used in the province (fossil fuel combustion, nuclear, hydroelectric). The emission factors for CO_2 will be developed from energy demand and supply data reported by Statistics Canada and emission inventories for these pollutants from the power generation sector developed by Environment Canada. North American data on emissions from the different methods of power generation have been used wherever possible. Where North American data is not available, default emission factors are based on electricity generation at fossil fuel (coal, oil and natural gas), nuclear and hydro-electric power stations in the U.K. report referenced above and applied to the percentages of power produced by each of these methods in Ontario.