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Memorandum

To	City of Toronto	Page	1
CC			
Subject	ATTACHMENT 3-Greenhouse Gas Emissions HCTP Biosolids Options		
From	Pat Coleman, PhD P.Eng.		
Date	April 5, 2011	Project Number	60114260

1. Introduction

AECOM was requested to calculate the operational greenhouse gas emissions for processing biosolids from the Highland Creek Wastewater Treatment Plant (HCTP):

- **Scenario 1: Thermal Reduction**: Dewater the raw biosolids prior thermal reduction in new fluidized bed incinerators. The ash would be discharged to the existing ash lagoons. The ash would ultimately be hauled by truck to the Green Lane Landfill for disposal.

- **Scenario 2: Digestion followed by disposal in landfill**: Digest the raw biosolids in the existing mesophilic anaerobic digesters. The digested biosolids would be dewatered and hauled by truck to the Green Lane Landfill for disposal.

- **Scenario 3: Digestion followed by beneficial land application**: Digest the raw biosolids in the existing mesophilic anaerobic digesters. The digested biosolids would be dewatered and hauled by truck to offsite cake storage and ultimately to beneficial use on land.

2. Changes since Master Plan Update September 2009

The greenhouse gas analysis in the Biosolids Master Plan 2009 Update was based on the following premises:

- HCTP would continue to digest biosolids for the incineration option, to allow for contingency land application
- Fertilizer credits and emissions from land application and landfill would not be included.

Because digestion was common to all options, the emissions associated with the operation of the digesters were not included in the analysis. In the case where biosolids were not dewatered after digestion (e.g. land application of liquid biosolids), that scenario was credited for the electricity not consumed.

The analysis presented in this memo at the City's request is based on the incineration of raw, not digested, biosolids. Raw biosolids have a higher thermal value and lower water content than digested biosolids. Because no supplementary fuel is required by the incinerator to stabilize the dewatered raw biosolids, incineration of raw biosolids produces fewer greenhouse gas emissions than incineration of digested biosolids.

In order to be able to compare thermal reduction of raw biosolids with land disposal of digested biosolids, the boundary of the analysis was moved to include dewatering of raw biosolids (for Scenario 1) and digestion and dewatering digested biosolids (for Scenario 2 and 3). Emissions from the landfill and land applied biosolids are also included. Scenario 3 is credited for the inorganic fertilizer not required by the end user. The emissions associated with the production of polymer are included for all three scenarios.

The emission factors and activity data were updated to reflect changes to best practice and new data obtained since the Master Plan update. Carbon footprinting is a rapidly evolving field of study, and recommended emission factors continue to change as better data becomes available.

3. Methodology

3.1 Calculate emission

The emissions are calculated by multiplying the activity data by the appropriate emission factor.

For example, the emissions from the consumption of natural gas to heat the anaerobic digesters:

Natural gas consumed: 20,395,392 MJ/year
Emission factor: 0.05 g CO_2e/MJ
Emissions: 20,395,392 MJ/year * 0.05 g CO_2e/MJ = 1,019,770 g CO_2e/year

3.2 Categorize As Either a Scope 1, 2 or 3 Emission

The emissions are categorized as being either Scope 1,2 or 3 as follows:

- **Scope 1**: All direct GHG emissions (with the exception of direct CO_2 emissions from biogenic sources).
- **Scope 2**: Indirect GHG emissions associated with the consumption of purchased or acquired electricity, steam, heating, or cooling.
- **Scope 3**: All other indirect emissions not covered in Scope 2, such as emissions resulting from the extraction and production of purchased materials and fuels, transport-related activities in vehicles not owned or controlled by the reporting entity.

3.3 Prioritization of effort

The approach is to capture the significant emissions. The following table identifies these emissions.

Category	Scenario 1: Thermal Reduction	Scenario 2: Digestion/Landfill	Scenario 3: Digestion/Land Application
Scope 1	Nitrous oxide stack emissions Vehicle emissions	Fugitive methane emissions associated with biogas boilers/flare Natural gas for digester heat Vehicle emissions Landfill Fugitive Emissions	Fugitive methane emissions associated with biogas boilers/flare Natural gas for digester heat Vehicle emissions Tractor emissions (spreading)
Scope 2	Electricity Dewatering Thermal reduction	Electricity Digestion Dewatering	Electricity Digestion Dewatering
Scope 3	Polymer	Polymer	Polymer Emission after biosolids spread on the land
Scope 3 (credit)			Fertilizer offset

Fertilizer offset is the greenhouse gas emissions not created because the nutrients in the biosolids reduce the amount of inorganic fertilizer purchased by the biosolids end user (e.g. Farmer).

Vehicle emissions (biosolids and ash transport offsite) and tractor emissions related to spreading biosolids on agricultural land could be classified as Scope 3 emissions because the vehicles are not owned and operated by the City.

4. Results

4.1 Scope 1 Emissions

Category	Scenario 1: Thermal Reduction t CO_2e/year	Scenario 2: Digestion/Landfill t CO_2e/year	Scenario 3: Digestion/Land Application t CO_2e/year
Anaerobic Digestion			
Biogas Flare		34	34
Biogas Boiler		388	388
Natural Gas Boiler		1,020	1,020
Thermal Destruction	1,061		
Transport	36 Ash to Green Lane	769 Biosolids to Green Lane	1,127 Biosolids to Land Application
Spreading Biosolids			119
Landfill CH_4 emissions		1863	
Scope 1	**1,097**	**4,074**	**2,688**

4.2 Scope 2 (Electricity) Emissions

Category	Scenario 1: Thermal Reduction t CO_2e/year	Scenario 2: Digestion/Landfill t CO_2e/year	Scenario 3: Digestion/Land Application t CO_2e/year
Dewatering	259	173	173
Anaerobic Digester		572	572
Thermal Destruction	865		
Scope 2	**1,124**	**745**	**745**

4.3 Scope 3 Emissions

Category	Scenario 1: Thermal Reduction t CO_2e/year	Scenario 2: Digestion/Landfill t CO_2e/year	Scenario 3: Digestion/Land Application t CO_2e/year
Scope 3 (debit)	(Polymer) 1,868	(Polymer)1,243	(Polymer)1,243 (From applied biosolids) 3,568
Scope 3 (credit)			(Fertilizer offset) 2,739
Scope 3	**1,868**	**1,243**	**2,063**

4.4 Summary of Results

Category	Scenario 1: Thermal Reduction t CO_2e/year	Scenario 2: Digestion/Landfill t CO_2e/year	Scenario 3: Digestion/Land Application t CO_2e/year
Scope 1	1,097	4,074	2,688
Scope 2	1,124	745	745
Scope 1&2	**2,221**	**4,819**	**3,433**
Scope 3	1,868	1,234	2,063
Scope 1,2,3	**4,089**	**6,053**	**5,496**

The preferred option based on greenhouse gas emissions is Scenario 1: Thermal Reduction.

The basis of the above analysis is as follows:

- The analysis is based on operational emissions. Therefore, the emissions associated with electricity and natural gas transmission, natural gas extraction/refining and minor electricity consumers.
- The thermal reduction nitrous oxide emission factor is based on removing 80% of the nitrous oxide prior to discharge to the environment. A sensitivity analysis shows that this removal rate can be decreased to less than 55% before the ranking of the three scenarios changes.