Emissions and Odour Measurements, Harvest Power

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Executive Summary

Harvest Power Inc., operates a composting and combined heat and power (CHP – or the Energy Garden) facility at 7028 York Road in Richmond, BC. The facility, formerly known as Fraser Richmond Soil & Fibre, operates under Metro Vancouver (MV) Air Permit GVA 1054 (amended May 11, 2013), which includes a number of monitoring and reporting requirements.

One of these requirements is that emissions and odour measurements be conducted at the CHP stack, the inlet and outlets of biofilters on site, and a number of waste and compost piles representing different stages in the composting process on site. These results were then to be used to assess emissions, and biofilter destruction removal efficiencies (DRE). This report fulfills that requirement for 2013.

The measured concentrations at all sampled locations were described, and emission rates were calculated where possible. Inlet and outlet biofilter concentrations were compared, and destruction removal efficiencies were calculated.

Calculated DRE rates indicate that biofilters are effective at removing overall odour (approx. 60% to 100% efficiency), with improvements in hedonic tone and character and reduced intensity also noted in three out of four biofilters. Biofilters also appeared to be effective at removing H_2S (approx. 90% to 100% efficiency). Biofilters appeared to be effective at removing non-methane hydrocarbons (NMHCs), although the rates of removal were lower (Approx. 40% to 100% efficiency).

The Energy Garden biofilter did not appear to be as effective at reducing odour as other biofilters on site, and Total Hydrocarbon (THC) concentrations were higher at the outlet than at the inlet.

The results are shown in Summary Tables 1, 2 &3:

Summary Table 1: CHP Measurements

	Flow (m^3/min)	Particulate Matter (mg/m^3)	VOC (mg/m^3)	NOx (mg/m^3)	SOx (mg/m^3)	CO (mg/m^3)
# 01 CHP Exhaust	66.6	7.6	899	471	60	892

Measurements corrected to 5% Oxygen

Summary Table 2: Energy Garden Biogas Measurements

	TRS as H_2S (mg/m^3)
# 02 CHP Biogas Inlet	4.1

Summary Table 3: Biofilter and Pile Measurements and Biofilter Destruction Removal Efficiencies.

	Odour Detection Threshold	Odour Hedonic Tone	Odour Intensity	NMHC* (ppmv)	THC* (ppmv)	H_2S (ppmv)
# 03 Energy Garden Biofilter Inlet	32,268	-3	4	5.17	374	1.36
# 03 Energy Garden Biofilter Outlet	13,560	-3	3	3.02	580	0.11
Calculated DRE for Source #3	58%	n/a	n/a	42 %	-55%	92%
# 04 Waste Receiving Piles	804	-1	1	1.57	267	0.002
# 05 Southwest Biofilter Inlet	98,880	-3	4	1,527	1,597	0.124
# 05 Southwest Biofilter Outlet	900	1	1	669	1,454	0.004
Calculated DRE for Source #5	99%	n/a	n/a	56%	9%	97%
# 06 Northeast Biofilter Inlet	106,452	-3	4		230	0.05
# 06 Northeast Biofilter Outlet	924	1	1		228	0.005
Calculated DRE for Source #6	99%	n/a	n/a		1%	90%
# 07 Ageing and Curing Piles	16,692	0	3	32.28	551	0.007
# 08 Screening Biofilter Inlet	11,112	-3	3	12.54	38.5	0.014
# 08 Screening Biofilter Outlet	396	1	1	nd		nd
Calculated DRE for Source #8	96%	n/a	n/a	100%	n/a	100%
#09 Overs, Middlings, and Fines Piles	5,508	-3	2	1.83		0.005
#10 Finished Product Piles	7,728	-2	2	0		0.1

*Two different approaches were taken to measure the volatile organic compound (VOC) concentrations; Non-methane hydrocarbons (NMHC) were measured with portable PID monitors while Total Hydrocarbons (THC) were measured with a portable FID &/or catalytic HC Detector. The PID and FID used at the beginning of the sampling project failed part-way through the sampling and so equipment was replaced with a different type of PID and a catalytic HC Detector. Where field data was suspected to be incorrect, it has been excluded from this report.

Table of Contents

1.0 INTRODUCTION 1

1.1 Metro Vancouver Air Permit GVA 1O54 1

2.0 PROCESS DESCRIPTION 3

3.0 SAMPLING PLAN 4

4.0 FIELD SAMPLING METHODOLOGY 4

4.1 Biofilters 4
4.2 Piles 4
4.3 Odour sampling 5
4.4 Total Reduced Sulphur Compounds Sampling 5
4.5 Field monitoring of VOC's and H_2S using portable instruments 5
4.6 Field monitoring of biofilter inlet flow by hot-wire anemometer 5
4.6.1 VOCs by Photo Ionization Detection (PID) and flame Ionization Detection (FID) 6
4.6.2 H_2S by Low-Concentration Analyser 6

5.0 SAMPLING CONDITIONS 7

6.0 SAMPLING RESULTS AND ASSESSMENT 7

6.1 Source # 01 Combined Heat and Power Unit discharging through a Stack 8
6.2 Source # 02 Energy Garden Biogas 8
6.3 Source # 03 Energy Garden Building discharging through a biofilter 9
6.3.1 Odour 9
6.3.2 VOCs, TRS, and H_2S 10
6.4 Source # 04 Waste Receiving and Handling discharging through Storage Pile(s) 12
6.5 Source # 05 Covered Aerated Static Pile (CASP) Composting System Southwest discharging through a biofilter 13
6.5.1 Odour 14
6.5.2 VOCs and H_2S 14
6.6 Source # 06 Covered Aerated Static Pile (CASP) Composting System Northeast discharging through a biofilter 16
6.6.1 Odour 17
6.6.2 VOCs and H_2S 17
6.7 Source # 07 Ageing Piles discharging through a Storage Pile(s) 19
6.8 Source # 08 Finished Compost Screening discharging through a biofilter 20
6.8.1 Odour 20
6.8.2 VOCs and H_2S 21
6.9 Source # 09 Overs, Mids and Fines Screening Piles 23
6.10 Source # 10 Finished Products Storage Piles discharging through a Storage Pile(s) 24

7.0 CONCLUSIONS 25

7.1 CHP Stack Measurements 25
7.2 Energy Garden Biogas Measurements 25
7.3 Biofilter and Pile Measurements 25

8.0 REFERENCES 27

9.0 STATEMENT OF QUALIFICATIONS 28

List of Tables

Table 1: A Summary of Monitoring and Sampling Requirements at Harvest Power 1

Table 2: Description of Hedonic Tone Table 3: Description of Intensity 8

Table 4: Summary of Results for Combined Heat and Power Unit Discharging Through a Stack .. 8

Table 5: Screening Results for Energy Garden Biofilter (chosen sample points in green) 9

Table 6: Summary of Odour Results for Energy Garden Biofilter 10

Table 7: Summary of VOCs and H_2S Results for Energy Garden Biofilter 11

Table 8: Summary of TRS Results for Energy Garden Biofilter 11

Table 9: Summary of Odour Results for Waste Receiving Piles 12

Table 10: Summary of VOCs and H_2S Results for Waste Receiving Piles 12

Table 11: Screening Results for Southwest Biofilter (chosen sample points in green) 13

Table 12: Summary of Odour Results for Southwest Biofilter 14

Table 13: Summary of VOCs and H_2S Results for Southwest Biofilter 15

Table 14: Screening Results for Northeast Biofilter (chosen sample points in green) 16

Table 15: Summary of Odour Results for Northeast Biofilter 17

Table 16: Summary of VOCs and H_2S Results for Northeast Biofilter 18

Table 17: Summary of Odour Results for Aging Piles 19

Table 18: Summary of VOCs and H_2S Results for Aging Piles 19

Table 19: Screening Results for Screening Biofilter (chosen sample points in green) 20

Table 20: Summary of Odour Results for Screening Biofilter 21

Table 21: Summary of VOCs and H_2S Results for Screening Biofilter 22

Table 22: Summary of Odour Results for Overs, Middlings, and Fines Storage Piles 23

Table 23: Summary of VOCs and H_2S Results for Overs, Middlings, and Fines Storage Piles 23

Table 24: Summary of Odour Results for Finished Products Storage Piles 24

Table 25: Summary of VOCs and H_2S Results for Finished Products Storage Piles 24

Table 26: Summary results of CHP measurements 25

Table 27: Summary results of Energy Garden Biogas Measurements 25

Table 28: Biofilter and Pile measurements and Biofilter Destruction Removal Efficiencies..... 26

List of Appendices

Appendix A Site Photos

Appendix B Sampling Plan

Appendix C Analytical & Odour Panel Results

Appendix D Equipment Calibration Certificates

Appendix E A. Lanfranco & Associates Inc., CHP Stack Measurements Report

1.0 INTRODUCTION

Harvest Power Inc. (Harvest) operates a food scrap and yard waste composting and cogeneration facility located at 7028 York Road, Richmond, BC. This facility, formerly known as Fraser Richmond Soil & Fibre, holds contracts with a number of municipalities in the BC Lower Mainland to collect food scraps and yard wastes from residential properties, and operates under MV Air Permit GVA #1054, amended May 11, 2013.

Envirochem Services Inc. (Envirochem) was retained by Harvest Power Canada Ltd. (Harvest Power) to conduct emissions and odour measurements at their facility as required by their permit.

1.1 METRO VANCOUVER AIR PERMIT GVA 1O54

The permit includes a number of monitoring and reporting requirements that are summarized on **Table 1** and discussed in this report.

Table 1: A Summary of Monitoring and Sampling Requirements at Harvest Power

Source	Description	Requirements (Parameters)
01	Combined Heat and Power Unit discharging through a Stack.	• Total Volatile Organic Compounds (as CH_4) • Nitrogen Oxides (as NO_2) • Sulphur Oxides (SO_2) • Particulate Matter, in the emission. • The inlet biogas was also sampled for total reduced sulphur (TRS) compounds
03	Energy Garden Building discharging through a biofilter.	• Odour concentration, Discharge rate, and Hedonic tone, in the emission • Total Volatile Organic Compounds (as CH_4) in the inlet and outlet. • The Destruction Removal Efficiency (DRE) of Total Volatile Organic Compounds through the biofilter. • Total Reduced Sulphur Compounds (TRS) (as H_2S) inlet and outlet. • The Destruction Removal Efficiency (DRE) of Total Reduced Sulphur Compounds (TRS) through the biofilter.
04	Waste Receiving and Handling discharging	• Odour concentration, Discharge rate, and Hedonic tone, in the emission

Source	Description	Requirements (Parameters)
	through Storage Pile(s).	
05	Covered Aerated Static Pile (CASP) Composting System Southwest discharging through a biofilter.	• Odour concentration, Discharge rate, and Hedonic tone, in the emission • Total Volatile Organic Compounds (as CH_4) in the inlet and outlet. • The Destruction Removal Efficiency (DRE) of Total Volatile Organic Compounds through the biofilter.
06	Covered Aerated Static Pile (CASP) Composting System Northeast discharging through a biofilter.	• Odour concentration, Discharge rate, and Hedonic tone, in the emission • Total Volatile Organic Compounds (as CH_4) in the inlet and outlet. • The Destruction Removal Efficiency (DRE) of Total Volatile Organic Compounds through the biofilter.
07	Aging Piles discharging through a Storage Pile(s).	• Odour concentration, Discharge rate, and Hedonic tone, in the emission
08	Finished Compost Screening discharging through a biofilter.	• Odour concentration, Discharge rate, and Hedonic tone, in the emission • Total Volatile Organic Compounds (as CH_4) in the inlet and outlet. • The Destruction Removal Efficiency (DRE) of Total Volatile Organic Compounds through the biofilter.
09	Overs, Middlings and Fines Storage Piles discharging through a Storage Pile(s).	• Odour concentration, Discharge rate, and Hedonic tone, in the emission
10	Finished Products Storage Piles discharging through a Storage Pile(s).	• Odour concentration, Discharge rate, and Hedonic tone, in the emission

2.0 PROCESS DESCRIPTION

The facilities include: Covered Aerated Static Piles (CASP); composting and odour control biofilters and other piles in various stages of composting. After composting is complete, the material is screened and sold as compost, mulch or soil, or is re-introduced into the aging process. In addition, Harvest Power captures biogas from food scraps and yard wastes which are placed into the High Solids Anaerobic Digestions (HSAD) and produced biogas is used to produce heat and power (CHP) See **Figure 1**.

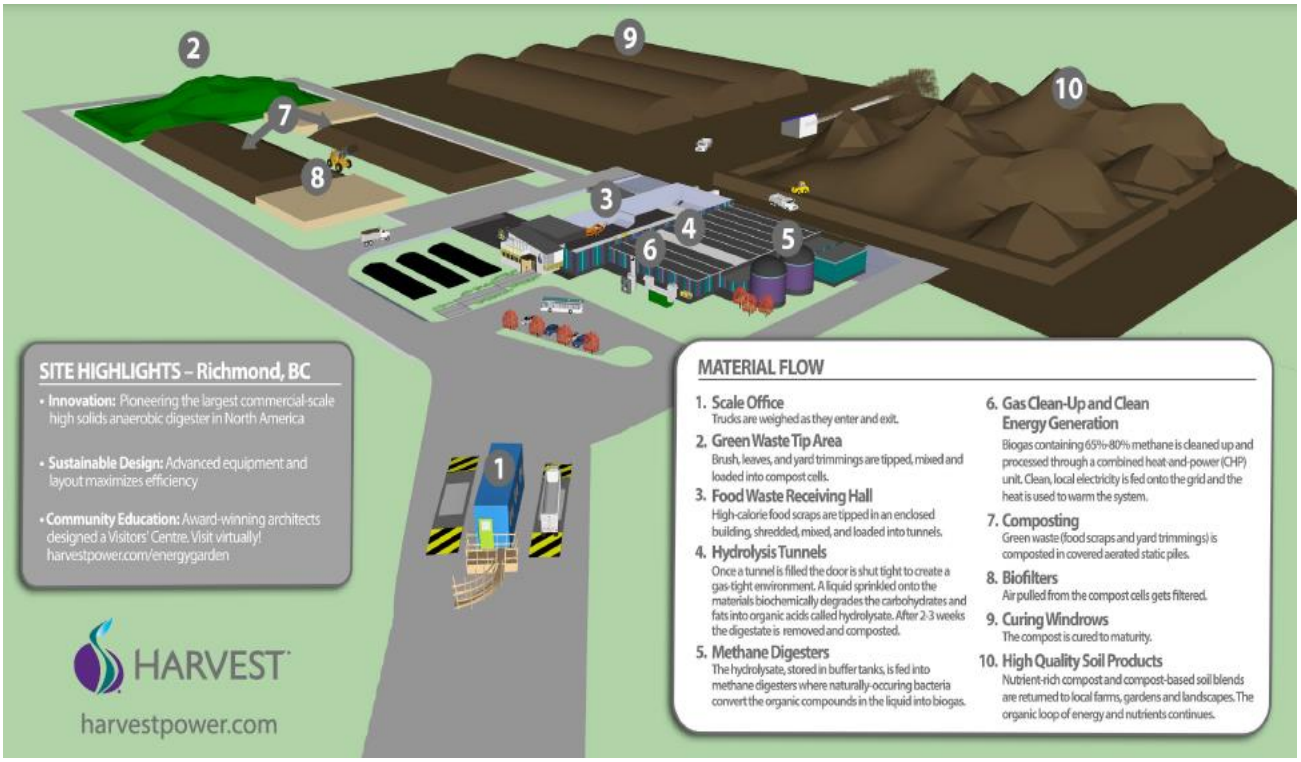

FIGURE 1: HARVEST'S ENERGY GARDEN AND COMPOSTING FACILITY SCHEMATIC

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3.0 SAMPLING PLAN

A draft work plan was agreed with Metro Vancouver (MV) prior to sampling taking place. This presented an outline of the methodology to be used for the emission and odour measurement program. Standard methods and proposed equipment and methods were discussed with MV. Based on these discussions, a consolidated version of the plan was prepared which is included in **Appendix B.** Field notes are available from Envirochem upon request.

4.0 FIELD SAMPLING METHODOLOGY

Sampling was conducted over four days. On December 3rd, 4th and 5th, Envirochem conducted sampling of all sources, with the exception of combined heat and power (CHP) stack and energy garden biogas, which were sampled by A. Lanfranco on December 6th.
The sampling methodologies for each source are discussed below. Clean, new Teflon™ sample line was used at each emission source to avoid cross contamination.
All equipment was calibrated, and the calibration certificates are included in **Appendix D.**

4.1 BIOFILTERS

As per the sampling plan, biofilter outlets were first 'screened', to identify three locations to take representative emission and odour measurements. To screen the outlets, measurements were taken at 16 locations across the biofilter surface, approx. 5cm from the surface, using handheld analysers. The results were reviewed to identify three locations which represented 'worst case' emissions from the biofilter outlet. Sampling was conducted at these three locations to form a triplicate outlet sample. Inlet samples were collected in series from a single sample port installed in the inlet duct.

Insofar as possible, all subsequent sampling was undertaken simultaneously at the inlet and outlet of biofilters, using identical equipment and methods, to ensure that results could be directly compared.

4.2 PILES

The sampling plan suggested that most piles could be screened prior to measurements taking place. This proved an unsuitable method, due to issues of safety and scale. As a result, piles were sampled in three representative, safe locations which were chosen by the sampling team on site.

4.3 ODOUR SAMPLING

Odour samples were collected in 40L Tedlar bags for off-site analysis by dynamic olfactometry with screened panelists. Three samples were collected at each location, using clean, purged dilution equipment and clean sample line. Bags were pre-conditioned and cleaned in advance, and were purged on site with diluted sample prior to collecting samples. Once collected and labeled, odour samples were placed in a black plastic bag to prevent the photo-degradation of any odorous compounds they might contain.

All odour samples were diluted with carbon-filtered compressed clean scuba air to avoid problems with condensation. Samples were diluted at 35:1 (Dilution Air: Sample Air). The dilution equipment used was the Scentroid SM100 in-field olfactometer (with the ability to collect diluted bag samples), and the Scentroid DS5 diluting sampler. Both are designed and calibrated specifically for the dilution of odour samples.

Sample collection was scheduled to ensure samples could be shipped in time to arrive at the analytical lab (Environmental Odour Consulting in Oakville, Ontario) next-day. Samples collected on the 3rd and 5th December arrived next day. Samples collected on 4th December arrived two days later rather than next day, due to shipping errors. Repeat analyses over time by the odour lab confirmed that no sample degradation had occurred.

4.4 TOTAL REDUCED SULPHUR COMPOUNDS SAMPLING

Total Reduced Sulfur Compounds (TRS) samples were collected at the inlet and outlet of the Energy Garden Biofilter. Samples were collected in 10L Tedlar Bags, using two lung collection devices. The samples were shipped to Maxxam lab that day, for analysis within 48 hours.

4.5 FIELD MONITORING OF VOC'S AND H_2S USING PORTABLE INSTRUMENTS

As per the sampling plan, VOCs and hydrogen sulphide (H_2S) concentrations were read at each emission source. Readings were recorded at one minute intervals, unless otherwise noted. Time and interval were recorded for each reading.

4.6 FIELD MONITORING OF BIOFILTER INLET FLOW BY HOT-WIRE ANEMOMETER

Biofilter inlet flows were measured and calculated by Harvest Power. To calculate biofilter inlet flow, twelve velocity measurements were taken (6 on horizontal plane, 6 on a vertical plane) in

equal cross-sectional surface area segments. Flows were calculated using this velocity data and an internal diameter of 40" (approx. 1m) for all inlet pipes.

4.6.1 VOCs by Photo Ionization Detection (PID) and flame Ionization Detection (FID)

Two different approaches were used to measure the volatile organic compounds (VOC) concentrations; Non-methane hydrocarbons (NMHC) were measured with potable photo ionization (PID) monitors while Total Hydrocarbons (THC) were measured with portable flame ionization (FID) &/or catalytic hydrocarbon detectors

These FID and PID portable instruments were used to provide field screening information at sample locations, and to measure concentrations at chosen sample points.

Since PID instruments detect NMHC, and FID instruments detect methane in addition to other hydrocarbon compounds. Use of both methods allowed for an assessment of the methane component of the emissions, as per the sampling plan. For PID and FID readings two TVA 1000B, two MiniRAE, and two RK Eagle set were used, which had been calibrated in advance.

During sampling, cold temperatures and warm saturated sample air resulted in condensation buildup in sample lines and on the sensors of the handheld measurements. On occasion, the PID instruments responded poorly to the humidity and moisture conditions encountered, typically producing false-positive readings which increased steadily regardless of source. FID instruments are generally free from humidity effects, except if water condenses on the sensor or if the flame is extinguished.

On December 3rd, PID readings from the TVA 1000B were noted to be erroneous, likely as a results of moisture, so a MiniRAE PID and RK Eagle Catalytic Hydrocarbon Reader with condensate traps were used for the remaining sampling. Despite the use of condensate traps, it was suspected that the traps became quickly overloaded and may have provided false positives.

Where humidity problems were identified, data has not been included in this report.

4.6.2 H_2S by Low-Concentration Analyser

Two calibrated Jerome 631-X Low-Concentration H_2S analysers were used for H_2S readings. No interferences were suspected to have occurred during the use of this analyser.

5.0 SAMPLING CONDITIONS

As described in the Methodology section of this report, the sampling program was carried out over four separate days from December 3rd to December 6th in 2013.

Weather throughout was dry, and cold, and there was frost in some locations. Piles were measured typically on a south facing slope, free from frost. Biofilters were measured during representative conditions (with fans and blowers operating normally). Where blowers did shut down temporarily, sampling was paused until they were reactivated, to ensure sampling was representative.

At source # 07, (Curing and Ageing piles) samples were collected in three locations, representing an old, new and mid-aged pile:

- Row #1 - built on Nov. 28, pile was 7 days old at time of sampling
- Row #3 - built on Nov. 15, pile was 13 days old at time of sampling
- Row #5 - built on Oct. 29, pile was 37 days old at time of sampling

6.0 SAMPLING RESULTS AND ASSESSMENT

Results of the sampling and analysis are summarized in the tables below. Average values and destruction removal efficiencies have been calculated where appropriate. Where a result was non-detect (nd), the result has been assumed to be zero. Data ranges indicating the difference between the maximum and minimum results are included where appropriate.

For the purposes of calculating destruction removal efficiencies and odour loading, odour detection threshold results have been treated as though they were concentrations (i.e. where 1 OU is taken to mean 1 OU/m^3).

Odour results for Hedonic Tone and Intensity were provided by the odour panel based on the scales shown in **Table 2** and **Table 3.**

Table 2: Description of Hedonic Tone

Description	Scale
Very Unpleasant	-3
Unpleasant	-2
Slightly Unpleasant	-1
Neutral	0
Slightly Pleasant	1
Pleasant	2
Very Pleasant	3

Table 3: Description of Intensity

Description	Scale
No Odour	0
Slight Odour	1
Moderate Odour	2
Strong Odour	3
Extreme Odour	4

6.1 SOURCE # 01 COMBINED HEAT AND POWER UNIT DISCHARGING THROUGH A STACK

The results from the CHP stack and biogas testing performed by A. Lanfranco on December 6th are summarized in **Table 4** and section 6.2. For more information including a discussion of the sampling program, see the full A. Lanfranco report, attached as Appendix E.

Table 4: Summary of Results for Combined Heat and Power Unit Discharging Through a Stack

	Flow (m^3/min std)	Particulate Matter	TVOC (as CH_4)	NO_x (as NO_2)	SO_x (as SO_2)	CO
		(mg/Sm^3 @ 5% O_2)				
Sample 1	66.2	13.5	905.4	478.2	60.2	903.5
Sample 2	66.4	4.7	879.1	466.6	57.2	890.9
Sample 3	67.2	4.7	913.6	469.5	61.4	880.2
Average	66.6	7.6	899.4	471.4	59.6	891.5

6.2 SOURCE # 02 ENERGY GARDEN BIOGAS

Energy garden biogas was measured for TRS by A. Lanfranco on 6th December. Measurements were taken in three separate 1 hour runs, and results were 4.7mg/m^3, 4.1mg/m^3, and 3.4mg/m^3, respectively. Average concentration was 4.1mg/m^3.

6.3 SOURCE # 03 ENERGY GARDEN BUILDING DISCHARGING THROUGH A BIOFILTER

Screening data from the biofilter outlet is included as **Table 5.** Grids 1, 5, and 14 (shaded) had the highest concentrations and were chosen as sample locations.

Table 5: Screening Results for Energy Garden Biofilter (chosen sample points in green)

INLET Duct

GRID NO:	**1**	**GRID NO:**	**2**	**GRID NO:**	**3**	**GRID NO:**	**4**
PID:	2.9	PID:	1.8	PID:	2.1	PID:	1.6
FID:	280	FID:	180	FID:	190	FID:	110
GRID NO:	**5**	**GRID NO:**	**6**	**GRID NO:**	**7**	**GRID NO:**	**8**
PID:	1.3	PID:	1.2	PID:	1.6	PID:	1
FID:	250	FID:	220	FID:	180	FID:	180
GRID NO:	**9**	**GRID NO:**	**10**	**GRID NO:**	**11**	**GRID NO:**	**12**
PID:	1.4	PID:	0.9	PID:	0.7	PID:	1.2
FID:	190	FID:	200	FID:	170	FID:	210
GRID NO:	**13**	**GRID NO:**	**14**	**GRID NO:**	**15**	**GRID NO:**	**16**
PID:	1.7	PID:	1.3	PID:	1.2	PID:	1.4
FID:	160	FID:	240	FID:	140	FID:	130

North

*All concentrations in ppm

6.3.1 Odour

Odour samples were collected from the inlet and outlet on December 5, 2013. Odour results are shown in **Table 6**. The biofilter removed 58% of odour and reduced intensity. It does not appear that Hedonic tone and character were improved.

Table 6: Summary of Odour Results for Energy Garden Biofilter

		Flow (m^3/s)	Odour (OU)	Odour Loading (OU/s)	Hedonic Tone	Intensity	Character
Inlet	**Sample 1**	4.88	31,536	153,896	-3	4	sour/garbage
	Sample 2	4.88	38,556	188,153	-3	4	rotten food/garbage
	Sample 3	4.88	26,712	130,355	-3	3	rotten food/garbage
	Average	4.88	32,268	157,468	-3	4	
Outlet	**Sample point 1**	4.88	16,488	80,461	-3	3	cabbage/sour/pickles
	Sample point 14	4.88	11,376	55,515	-3	3	sour/cabbage
	Sample point 5	4.88	12,816	62,542	-3	3	sour/cabbage
	Average	4.88	13,560	66,173	-3	3	
	DRE %			57.98			

6.3.2 VOCs, TRS, and H_2S

VOCs and H_2S readings and TRS bag samples were taken at the inlet and outlet of the biofilter. Also, two bag samples were collected separately from inlet and outlet to analyse VOCs in the lab, which were analyzed by A. Lanfranco. Data and DRE values are summarized in **Table 7** and **Table 8**.

H_2S was not detected in 4 out of 6 bag samples, but was detected in low concentrations by the Jerome 631-X analyser. The lab RDL was 0.2ppmv, and the Jerome analyser is capable of detecting lower concentrations (0.001ppmv).

Table 7: Summary of VOCs and H_2S Results for Energy Garden Biofilter

		NMHC via PID (ppmv)		THC via FID and Bag (ppmv)			H_2S (ppmv)	
		Value	Data Range	Average	Data Range	THC*	Value	Data Range
Inlet	**Sample 1**	6.12	0.60	297	10	83	1.183	0.200
	Sample 2	-	-	409	130		1.457	0.100
	Sample 3	4.22	0.40	417	90		1.429	0.100
	Average	5.17		374			1.356	
Outlet	**Sample point 1**	2.58	0.10	874	90	107	0.152	0.208
	Sample point 14	3.62	0.50	476	10		0.152	0.030
	Sample point 5	2.86	0.10	390	70		0.025	0.010
	Average	3.02		580			0.110	
	DRE %	42		-55		-28	92	

* Data from sample bags which were analyzed by A. LANFRANCO

Table 8: Summary of TRS Results for Energy Garden Biofilter

		TRS* (ppmv)			
		H_2S	Methyl mercaptan	Dimethyl sulfide	Dimethyl disulfide
Inlet	**Sample 1**	0.50	<0.20	<0.20	<0.20
	Sample 2	<0.40	<0.20	<0.20	<0.20
	Sample 3	<0.40	<0.20	<0.20	<0.20
	Average				
Outlet	**Sample point 1**	0.40	<0.20	<0.20	<0.20
	Sample point 14	<0.40	<0.20	<0.20	<0.20
	Sample point 5	<0.40	<0.20	<0.20	<0.20
	Average				
	DRE %				

* Data from sample bags which were analyzed by MAXXAM Lab

The biofilter removed 42% of NMHC, and 92% of H_2S, while THC levels (including methane) appeared to increase.

6.4 SOURCE # 04 WASTE RECEIVING AND HANDLING DISCHARGING THROUGH STORAGE PILE(S)

Odour, VOCs, and H_2S data for the Waste Receiving Piles, including average values are presented in **Table 9** and **Table 10.** Odour discharge rate was not calculated as no flow was detected at the pile surface.

Table 9: Summary of Odour Results for Waste Receiving Piles

	Odour (OU)	Hedonic Tone	Intensity	Character
Sample point 1	540	-1	1	chemical/rotten food
Sample point 2	1296	-1	2	waste food/rotten food
Sample point 3	576	-1	1	chemical/rotten food
Average	804	-1	1	

Table 10: Summary of VOCs and H_2S Results for Waste Receiving Piles

	NMHC PID (ppmv)		THC FID (ppmv)		H_2S (ppmv)	
	Value	Data Range	Value	Data Range	Value	Data Range
Sample point 1	1.57	0.10	267	10.00	0.002	0.001
Sample point 2						
Sample point 3						
Average	1.57		267		0.002	

6.5 SOURCE # 05 COVERED AERATED STATIC PILE (CASP) COMPOSTING SYSTEM SOUTHWEST DISCHARGING THROUGH A BIOFILTER

Screening data from the biofilter outlet is included as **Table 11.** Grids 5, 6, and 9 had the highest concentrations and were chosen as sample locations.

Table 11: Screening Results for Southwest Biofilter (chosen sample points in green)

INLET DUCT

GRID NO:	**1**	**GRID NO:**	**2**	**GRID NO:**	**3**	**GRID NO:**	4
PID:	7.2	PID:	5.9	PID:	2.2	PID:	-0.05
FID:	300	FID:	400	FID:	80	FID:	20
GRID NO:	**5**	**GRID NO:**	**6**	**GRID NO:**	**7**	**GRID NO:**	**8**
PID:	11.8	PID:	9.2	PID:	22.8	PID:	20.5
FID:	600	FID:	800	FID:	70	FID:	50
GRID NO:	**9**	**GRID NO:**	**10**	**GRID NO:**	**11**	**GRID NO:**	**12**
PID:	12.7	PID:	24	PID:	28.5	PID:	18.9
FID:	500	FID:	400	FID:	150	FID:	150
GRID NO:	**13**	**GRID NO:**	**14**	**GRID NO:**	**15**	**GRID NO:**	**16**
PID:	18.8	PID:	23.5	PID:	28.9	PID:	17.7
FID:	300	FID:	200	FID:	300	FID:	100

North

*All concentrations in ppm

6.5.1 Odour

Odour samples were collected on December 3rd. Odour results are shown in **Table 12**. The biofilter removed 99% of odour, improved hedonic tone and character and reduced intensity.

Table 12: Summary of Odour Results for Southwest Biofilter

		Flow (m^3/s)	Odour (OU)	Odour Loading (OU/s)	Hedonic Tone	Intensity	Character
Inlet	**Sample 1**	6.83	92,052	628,715	-3	4	rotten food/garbage
	Sample 2	6.83	92,052	628,715	-3	4	rotten food/garbage
	Sample 3	6.83	112,536	768,621	-3	4	rotten food
	Average	6.83	98,880	675,350	-3	4	
Outlet	**Sample point 5**	6.83	684	4,672	1	1	fresh wood/sweet
	Sample point 6	6.83	1,116	7,622	1	1	fresh wood/sweet
	Sample point 9	6.83	900	6,147	1	1	fresh wood/sweet
	Average	6.83	900	6,147	1	1	
	DRE %			99.1			

6.5.2 VOCs and H_2S

VOCs and H_2S readings were taken at the inlet and outlet of the biofilter, and two bag samples were collected separately from inlet and outlet, for VOC analysis by A. Lanfranco. Results are presented in **Table 13**.

Table 13: Summary of VOCs and H_2S Results for Southwest Biofilter

		PID (ppmv)		FID (ppmv)			H_2S (ppmv)	
		Value	Data Range	Value	Data Range	THC*	Value	Data Range
Inlet	**Sample 1**	22	15	2,159	762	802	0.121	0.020
	Sample 2	904	601	1,077	474		-	-
	Sample 3	3,655	3,501	1,556	257		0.126	0.050
	Average	1,527		1,597			0.124	
Outlet	**Sample point 5**	1,012	1,080	1,635	850	993	0.004	0.000
	Sample point 6	629	1,864	1,359	145		0.004	0.001
	Sample point 9	368	251	1,368	283		0.004	0.001
	Average	669		1,454			0.004	
	DRE %	56		9		-24	97	

* Data from sample bags which were analyzed by LANFRANCO

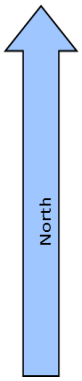
The biofilter removed 56% of VOCs, 9% of THCs, and 97% of H_2S.

6.6 SOURCE # 06 COVERED AERATED STATIC PILE (CASP) COMPOSTING SYSTEM NORTHEAST DISCHARGING THROUGH A BIOFILTER

Screening data from the biofilter outlet is included as **Table 14**. Grids 4, 12, and 14 had the highest concentrations and were chosen as sample locations.

Table 14: Screening Results for Northeast Biofilter (chosen sample points in green)

GRID NO:	1	GRID NO:	2	GRID NO:	3	GRID NO:	4
PID:	-	PID:	-	PID:	-	PID:	-
FID:	25	FID:	35	FID:	28	FID:	44
GRID NO:	5	GRID NO:	6	GRID NO:	7	GRID NO:	8
PID:	-	PID:	-	PID:	-	PID:	-
FID:	22	FID:	19	FID:	30	FID:	22
GRID NO:	9	GRID NO:	10	GRID NO:	11	GRID NO:	12
PID:	-	PID:	-	PID:	-	PID:	-
FID:	25	FID:	25	FID:	35	FID:	41
GRID NO:	13	GRID NO:	14	GRID NO:	15	GRID NO:	16
PID:	-	PID:	-	PID:	4570-	PID:	-
FID:	32	FID:	38	FID:	18	FID:	29



INLET DUCT

*All concentrations in ppm

6.6.1 Odour

Odour samples were collected from the inlet and outlet on December 3, 2013. Odour results are shown in **Table 15**. The biofilter removed 99% of odour, improved hedonic tone and character, and reduced intensity.

Table 15: Summary of Odour Results for Northeast Biofilter

		Flow (m^3/s)	Odour (OU)	Odour Loading (OU/s)	Hedonic Tone	Intensity	Character
Inlet	**Sample 1**	8.38	86,076	721,317	-3	4	rotten food/sharp/pungent
	Sample 2	8.38	147,204	1233,570	-3	4	rotten food/ pungent
	Sample 3	8.38	86,076	721,317	-3	4	pungent/sharp
	Average	8.38	106,452	892,068	-3	4	
Outlet	**Sample point 14**	8.38	1,260	10,559	1	1	fresh wood/woodchip
	Sample point 12	8.38	900	7,542	1	1	fresh wood/sweet
	Sample point 4	8.38	612	5,129	1	1	fresh wood/sweet
	Average	8.38	924	7,743	1	1	
	DRE %			99.13			

6.6.2 VOCs and H_2S

VOCs and H_2S readings were taken at the inlet and outlet of the biofilter. Data and DRE values are summarized in **Table 16.**

PID readings are not included - the equipment had moisture interference and the data were not reliable.

Table 16: Summary of VOCs and H_2S Results for Northeast Biofilter

		THC FID (ppmv)		H_2S (ppmv)	
		Value	Data Range	Value	Data Range
Inlet	**Sample 1**	375	213	0.088	0.087
	Sample 2	-	-	0.034	0.009
	Sample 3	86	120	0.027	0.005
	Average	231		0.050	
Outlet	**Sample point 14**	221	18	0.004	0.001
	Sample point 12	234	41	0.009	0.000
	Sample point 4	230	3	0.002	0.001
	Average	228		0.005	
	DRE %	1		90	

The biofilter removed 1% of THC and 90% of H_2S.

6.7 SOURCE # 07 AGEING PILES DISCHARGING THROUGH A STORAGE PILE(S)

Odour, VOCs, and H_2S data for Ageing Piles are summarized in **Table 17.** No measurable flow was found at any of the three sample locations.

Table 17: Summary of Odour Results for Aging Piles

	Flow (m^3/s)	Odour (OU)	Hedonic Tone	Intensity	Character
Sample point 1 Row #1 (New Pile)	ND	21,384	2	3	fresh wood
Sample point 2 Row #3 (Mid Pile)	ND	26,496	-3	4	rotten food
Sample point 3 Row #5 (Old Pile)	ND	2,196	1	2	fresh wood
Average		16,692	0	3	

Table 18: Summary of VOCs and H_2S Results for Aging Piles

	NMHC PID (ppmv)		THC FID (ppmv)		H_2S (ppmv)	
	Value	Data Range	Value	Data Range	Value	Data Range
Sample point 1 Row #1 (New Pile)	91.40	20.00	-	-	0.018	0.017
Sample point 2 Row #3 (Mid Pile)	4.40	1.50	422	60	0.004	0.002
Sample point 3 Row #5 (Old Pile)	1.04	0.20	680	210	0.000	0.000
Average	33		551		0.007	

6.8 SOURCE # 08 FINISHED COMPOST SCREENING DISCHARGING THROUGH A BIOFILTER

Screening data from the biofilter outlet is included as **Table 19**. Grids 2, 4, and 7 were selected based on experience with other biofilters, as VOCs were non-detect at all screening locations. These locations were then used to collect odour samples and measure VOCs.

Table 19: Screening Results for Screening Biofilter (chosen sample points in green)

INLET DUCT

GRID NO: 1 PID: 0 FID: -	**GRID NO: 2** PID: 0 FID: -	**GRID NO: 3** PID: 0 FID: -	**GRID NO: 4** PID: 0 FID: -
GRID NO: 8 PID: 0 FID: -	**GRID NO: 7** PID: 0 FID: -	**GRID NO: 6** PID: 0 FID: -	**GRID NC 5** PID: 0 FID: -
GRID NO: 9 PID: 0	**GRID NO: 10** PID: 0	**GRID NO: 11** PID: 0	**GRID NO: 12** PID: 0
GRID NO: 16 PID: 0 FID: -	**GRID NO: 15** PID: 0 FID: -	**GRID NO: 14** PID: 0 FID: -	**GRID NO: 13** PID: 0 FID: -

North

Note: concentrations were below detect, so sample points were selected based on experience with other biofilters All concentrations in ppm

6.8.1 Odour

Odour samples were collected from the inlet and outlet on December 4, 2013. Odour results are shown in **Table 20.** The biofilter removed 96% of odour, improved hedonic tone and character, and reduced intensity.

Table 20: Summary of Odour Results for Screening Biofilter

		Flow (m^3/s)	Odour (OU)	Odour Loading (OU/s)	Hedonic Tone	Intensity	Character
Inlet	**Sample 1**	5.77	17,172	99,082	-3	3	rotten food/sharp/garbage
	Sample 2	5.77	10,332	59,616	-3	3	rotten food/sharp/garbage
	Sample 3	5.77	5,832	33,651	-3	3	rotten food
	Average	5.77	11,112	64,116	-3	3	
Outlet	**Sample point 2**	5.77	360	2,077	1	1	sweet/wood
	Sample point 7	5.77	504	2,908	1	1	sweet
	Sample point 4	5.77	324	1,869	1	1	sweet/wood
	Average	5.77	396	2,285	1	1	
	DRE %			96.4			

6.8.2 VOCs and H_2S

VOCs and H_2S readings were taken at the inlet and outlet of the biofilter. Data and DRE values are summarized in **Table 21.** VOC and H_2S were not detectable at the outlet. THCs could not be measured at the outlet. The biofilter removed 100% of VOCs and H_2S.

Table 21: Summary of VOCs and H_2S Results for Screening Biofilter

		PID (ppmv)		FID (ppmv)		H_2S (ppmv)	
		Value	Data Range	Value	Data Range	Value	Data Range
Inlet	Sample 1	24.90	18.0	38.50	4.00	0.016	0.006
	Sample 2	0.18	0.30	-	-	0.012	0.007
	Sample 3	-	-	-	-	-	-
	Average	12.54		38.50		0.014	0.007
Outlet	Sample point 2	-	-	-	-	ND	
	Sample point 7	ND		-	-	ND	
	Sample point 4	ND		-	-	ND	
	Average	ND				ND	
	DRE %	100				100	

6.9 SOURCE # 09 OVERS, MIDDDLINGS AND FINES SCREENING PILES

Odour, VOCs, and H_2S data for Overs, Middlings (Mids), and Fines Piles are summarized in **Table 22** and **Table 23**. Odour discharge rate was not calculated as flow was not measured.

Table 22: Summary of Odour Results for Overs, Middlings, and Fines Storage Piles

	Odour (OU)	Hedonic Tone	Intensity	Character
Sample point 1 (Overs)	3,960	-3	2	rotten food/garbage
Sample point 2 (Mids)	11,376	-3	3	garbage/chemical/compost
Sample point 3 (Fines)	1,188	-2	2	rotten food/garbage
Average	5,508	-3	2	

Table 23: Summary of VOCs and H_2S Results for Overs, Middlings, and Fines Storage Piles

	PID (ppmv)		H_2S (ppmv)	
	Value	Data Range	Value	Data Range
Sample point 1 (Overs)	0.22	0.20	0.000	0.000
Sample point 2 (Mids)	4.38	0.50	0.013	0.000
Sample point 3 (Fines)	0.90	0.00	0.002	0.001
Average	1.8		0.005	

6.10 SOURCE # 10 FINISHED PRODUCTS STORAGE PILES DISCHARGING THROUGH A STORAGE PILE(S)

Odour, VOCs, and H_2S data for Finished Product Piles are summarized in **Table 24** and **Table 25**. Odour discharge rate was not calculated as flow was too low to be measured. THC was not measured.

Table 24: Summary of Odour Results for Finished Products Storage Piles

	Odour (OU)	Hedonic Tone	Intensity	Character
Sample point 1 (Product Pile 1)	3,204	-1	2	compost/wood
Sample point 2 (Product Pile 2)	6,012	-1	2	fresh compost/wood
Sample point 3 (Product Pile 3)	13,968	-3	3	compost/sharp/pungent
Average	7,728	-2	2	

Table 25: Summary of VOCs and H_2S Results for Finished Products Storage Piles

	PID (ppmv)		H_2S (ppmv)	
	Value	Data Range	Value	Data Range
Sample point 1 (Product Pile 1)	0.00	0.00	0.167	0.073
Sample point 2 (Product Pile 2)	0.00	0.00	0.184	0.080
Sample point 3 (Product Pile 3)	0.00	0.00	0.126	0.150
Average	0		0.1	

7.0 CONCLUSIONS

Based on the results of a comprehensive program of odour and chemical sampling, undertaken between December 3rd and December 6th 2013, the following conclusions are presented:

7.1 CHP STACK MEASUREMENTS

The CHP stack measurements were conducted as per the sampling plan, and the results are shown in **Table 26.**

Table 26: Summary results of CHP measurements

	Flow (m^3/min)	Particulate Matter (mg/m^3)	VOC (mg/m^3)	NOx (mg/m^3)	SOx (mg/m^3)	CO (mg/m^3)
# 01 CHP Exhaust	66.6	7.6	899	471	60	892

Measurements corrected to 5% Oxygen

7.2 ENERGY GARDEN BIOGAS MEASUREMENTS

TRS as H_2S was measured in the energy garden biogas, and the results are shown in **Table 27.**

Table 27: Summary results of Energy Garden Biogas Measurements

	TRS as H_2S (mg/m^3)
# 02 CHP Biogas Inlet	4.1

7.3 BIOFILTER AND PILE MEASUREMENTS

The results of the biofilter and pile measurements are shown in **Table 28.** Calculated efficiencies indicate that biofilters are effective at removing overall odour (Approx. 60% to 100% efficiency), with improvements in hedonic tone, character and reduced intensity also noted in three out of four cases. Biofilters also appeared to be effective at removing H_2S (Approx. 90% to 100% efficiency).

Biofilters appeared to be effective at removing VOCs, although the rates of removal were lower (Approx. 40% to 100% efficiency).

The Energy Garden biofilter did not appear to be as effective as other biofilters on site at reducing odour, and THC concentrations were higher at the outlet than at the inlet.

Table 28: Biofilter and Pile measurements and Biofilter Destruction Removal Efficiencies

	Odour Detection Threshold	Odour Hedonic Tone	Odour Intensity	NMHC* (ppmv)	THC* (ppmv)	H_2S (ppmv)
# 03 Energy Garden Biofilter Inlet	32,268	-3	4	5.17	374	1.36
# 03 Energy Garden Biofilter Outlet	13,560	-3	3	3.02	580	0.11
Calculated Destruction Removal Efficiency	58%	n/a	n/a	42 %	-55%	92%
# 04 Waste Receiving Piles	804	-1	1	1.57	267	0.002
# 05 Southwest Biofilter Inlet	98,880	-3	4	1,527	1,597	0.124
# 05 Southwest Biofilter Outlet	900	1	1	669	1,454	0.004
Calculated Destruction Removal Efficiency	99%	n/a	n/a	56%	9%	97%
# 06 Northeast Biofilter Inlet	106,452	-3	4		230	0.05
# 06 Northeast Biofilter Outlet	924	1	1		228	0.005
Calculated Destruction Removal Efficiency	99%	n/a	n/a		1%	90%
# 07 Ageing and Curing Piles	16,692	0	3	32.28	551	0.007
# 08 Screening Biofilter Inlet	11,112	-3	3	12.54	38.5	0.014
# 08 Screening Biofilter Outlet	396	1	1	nd		nd
Calculated Destruction Removal Efficiency	96%	n/a	n/a	100%	n/a	100%
#09 Overs, Mids and Fines Piles	5,508	-3	2	1.83		0.005
#10 Finished Product Piles	7,728	-2	2	0		0.1

*Two different approaches were taken to measure the volatile organic compound (VOC) concentrations; Non-methane hydrocarbons (NMHC) were measured with potable PID monitors while Total Hydrocarbons (THC) were measured with a portable FID &/or catalytic HC Detector

8.0 REFERENCES

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Harvest power Inc., website, www.harvestpower.com

9.0 STATEMENT OF QUALIFICATIONS

Paul Beauchemin

Paul Beauchemin, P. Eng., EP (EMSLA), is director and Partner of Envirochem Services Inc., an environmental management and energy consultancy headquartered in Vancouver, BC. Paul has over 25 years of experience in environmental engineering and management. He was an environmental engineer for three levels of government, from municipal to federal, and is past president of the Air and Waste Management Association's Pacific North west International Section (PNWIS) and recipient of their "Distinguished Achievement Award" in recognition of his "outstanding contribution to air quality management in the Pacific Northwest Region, and to the Association".

Edward Haythornthwaite

Edward Haythornthwaite, BAgrSc, MSc, DIC, has four years of experience in Air Quality monitoring in the BC and in London, UK. Edward holds a Master of Science Degree in Environmental Technology from Imperial College London, where he specialized in Environmental Analysis and Assessment. Edward has experience in a wide range of air quality monitoring techniques and data analysis methods, and his monitoring work at the City of London has contributed to Air Quality policy in the UK and the EU. Edward is an associate member of the Institute of Air Quality Management (UK), where he contributed to Best Practice Guidance on Construction Dust Guidance.

Farzad Dehkordi

Farzad Dehkordi, MSc, has master's degree in Environmental and Civil Engineering from IUT, Iran with over 10 years of experience in air quality monitoring and control, solid waste management, data analysis and modeling, water and wastewater treatment, water quality control, environmental Management System and OHSAS 18001 auditing, and construction. Farzad has been working in a various industrial sectors such as steel making, power plants, water quality management as an auditor and environmental coordinator.

Tim Weaver

Tim Weaver, BSc, has four years of experience in air quality monitoring, forestry and general environmental consultancy in British Columbia and the Lower Mainland. Tim has served in emissions sectors including biomass combustion, landfills, rendering plants, shredding facilities, wood pellet plants, sawmills and pulp mills. Tim has extensive training and experience in a wide variety of air emissions and field monitoring, data analyses / interpretation and sampling techniques. Tim holds a Bachelor of Science Degree from the University of British Columbia, and is near completion of Bachelor of Technology in Environmental Engineering Technology from the British Columbia Institute of Technology.