REPORT

Carbon Dioxide Emission Intensity Report

Votorantim Cimentos North America

Submitted to:

St. Marys Cement
410 Bowmanville Avenue
Bownmanville, Ontario
L1C 7B5

Submitted by:

Golder Associates Ltd.
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19117137

January 2020

Distribution List

Electronic copy - Votorantim Cimentos North America

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1.0 INTRODUCTION

St Marys Cement (SMC), a company of Votorantim Cimentos North America (VCNA) is proposing to expand its current use Alternative Low Carbon Fuels (ALCFs) as an energy source for their Bowmanville Cement Plant. St Marys Cement Bowmanville Plant (SMCB) is located at 410 Bowmanville Avenue, in Bowmanville, Ontario, within the Municipality of Clarington. As part of SMC's strategy to reduce greenhouse gas (GHG) emissions and in keeping with best practices implemented around the world, SMC has retained Golder Associates Ltd. (Golder) to undertake a study to support the preparation of an ALCF Application under Ontario Regulation (O. Reg.) 79/15 of the *Environmental Protection Act* to expand the current use of ALCFs. The purpose of this report is to demonstrate that the carbon dioxide emission intensity of the proposed ALCF is less than the carbon dioxide emission intensity of the conventional fuels currently used at the SMCB as required by O. Reg. 79/15.

The carbon dioxide emission intensity is a form of measurement that allows different fuel types to be compared and is an indicator of the amount of carbon dioxide (CO_2), which is a Greenhouse Gas (GHG), that is emitted into the atmosphere when the fuel is combusted. A lower CO_2 emission intensity value means that a given material will release less CO_2.

In 2015, SMCB started using woody materials as an ALCF to replace approximately 8% of their conventional fuels (by weight) under their Environmental Compliance Approval (ECA) Number 7024-9XUK4C and Number 0469-9YUNSK. From September 2018 to December 2018, SMCB carried out a demonstration project to use residuals derived from industrial and/or post-consumer sources including plastic polymers, paper fibres and biomass and cellulosic materials (e.g. woody materials) as ALCFs at the SMCB under their ECA Number 1255-7QVJ2N and Number 4614-826K9W.

Since the initial ECA the O. Reg. 79/15 has come into place, SMC wishes to take advantage of this approval process and as part of the current ALCF Application, SMC is proposing to:

- increase the daily throughput of ALCFs from 96 tonnes per day to 400 tonnes per day;
- add biomass, cellulosic (e.g. woody materials) and plastic materials from the recent demonstration project at the SMCB to their approved list of ALCFs with the intention to substitute conventional fuels (coal and petroleum coke) to approximately 30% thermal replacement. These materials are derived from industrial and/or post-consumer sources, cannot be recycled, are not hazardous, are not derived from animals and are not derived from the processing and preparations of food;
- install new equipment at the SMCB to feed ALCFs; and
- increase the storage for alternative fuels at the SMCB in enclosed containers and buildings.

2.0 SITE DESCRIPTION

The SMCB is located on the north shore of Lake Ontario, directly south of Highway 401, and at the southern end of Bowmanville Avenue in Bowmanville, Ontario, as illustrated in Figure 1. The property is owned by SMC and is part of the Municipality of Clarington Wards 2 and 3.

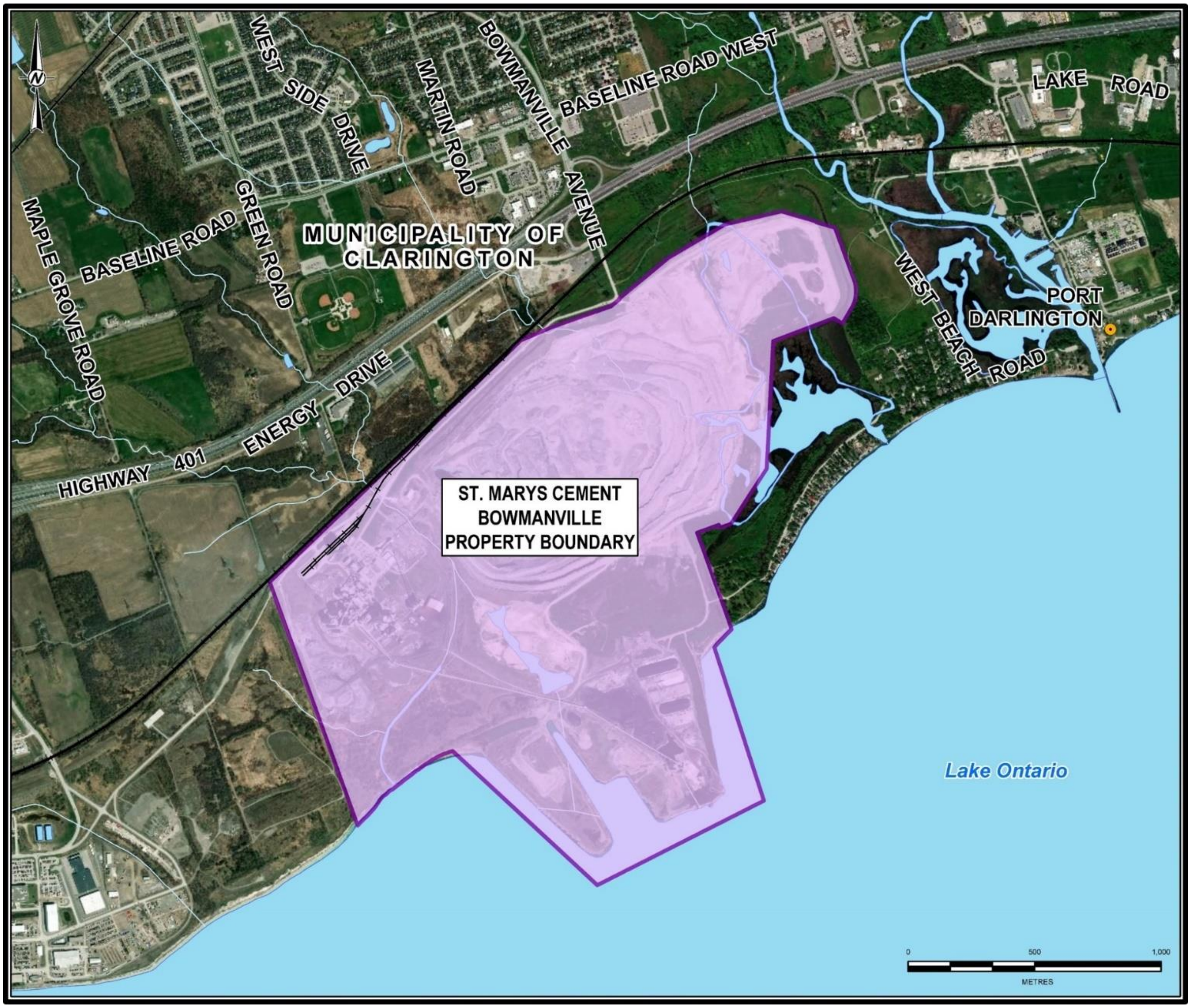

Figure 1: SMCB Location

The Site produces Portland cement by combining materials bearing calcium carbonate, silica, alumina and iron oxide at high temperatures to produce cement clinker. The clinker is then ground with finishing materials such as gypsum and limestone to produce cement. SMCB has a maximum production rate of 1.8 million tonnes of clinker per year and operates 24 hours per day, 7 days a week, 12 months per year with the exception of scheduled kiln shut-downs.

The primary North American Industrial Classification System (NAICS) codes for the Site are 327310 (cement manufacturing) and 212315 (limestone mining and quarrying).

2.1 Portland Cement Production Process

The production process described below was reproduced from the Facility's Emission Summary and Dispersion Modelling Report (BCX, 2014), which was submitted as part of the supporting documentation for SMC's ECA 0469-9YUNSK.

2.1.1 Raw Material Fuel Delivery and Storage

The main raw material (limestone) is supplied by the on-site limestone quarry. Limestone is transferred from the primary surge pile via an enclosed conveyor system to a secondary crusher/screen system which uses baghouses to control emissions. Processed limestone is then fed via enclosed conveyors to limestone storage silos.

Other raw materials (e.g., sand, iron, overburden and ash) are delivered by truck, additives (gypsum) and solid fuels (i.e., petroleum cokes) are delivered by ship. Gypsum and conventional solid fuel (i.e., petroleum coke and coal) are transported by truck from the dock to the Site.

Most raw materials are stored at the Site in storage silos or storage buildings. Conventional solid fuels from the dock are deposited into the fuel underground hopper from where they are then transferred into the fuel storage silos.

Sorted and pre-processed (size reduced) clean wood and/or low carbon alternative fuel will be delivered by enclosed trucks and off-loaded into a storage and handling area inside a fully enclosed fuel building.

2.1.2 Raw Material Preparation

Limestone, sand, iron oxide and overburden sources are proportionately fed from the raw material storage silos and storage building via an enclosed conveyor belt system to a raw mill. Emissions from the raw mill are controlled by the kiln feed baghouse, venting through the main kiln stack. In the raw mill, the raw materials are ground and mixed to uniform particle size and dried. The raw mill uses the hot exhaust gases from the pre-heater tower to dry the raw meal. The dried raw meal is stored in the kiln feed silo.

2.1.3 Fuel Preparation

Conventional solid fuels are fed to the fuel milling system from the storage silos. Emissions are controlled by the fuel mill baghouse venting through the main kiln stack. Milled conventional fuel (fuel meal) is fed to the kiln burner and calciner burner through their individual fuel feed systems (i.e., two fuel meal silos and dust collectors).

Clean wood and/or low carbon alternative fuels will undergo additional size reduction inside the fuel building using a low speed rotary cutting system. The homogenized fuel will then be fed via enclosed screw feeder system directly into the pneumatic solid fuel delivery systems that feed the main kiln burner and/or the calciner burner. The burning zone temperature in the kiln and calciner are over 2,100 °C, and 1,375° C, respectively.

The alternative fuel feed system is fully integrated with the plant control system to regulate and limit the fuel substitution rates into the kiln and/or calciner to maintain the required temperature profile and system conditions.

All air from the fuel building and solid fuel delivery system will be directed through the kiln burner and/or calciner burner.

2.1.4 Clinker Production

Dried raw meal is fed, via air slides and bucket elevators, up to a dual string pre-heater tower consisting of a series of cyclones. As the raw meal progressively passes through a pre-heater string and its cyclones, it encounters progressively hotter gases from the kiln, the pre-heated material is fed into a pre-calciner where the material temperature is raised to 840 °C. In the kiln, the raw meal temperature is raised to over 1,500 °C. The chemical reactions and physical processes transform the raw meal into clinker. Flue gases from the kiln pass through the pre-heater strings and the bypass stream and raw mill to the kiln baghouse and are exhausted to the atmosphere via the main kiln stack.

The clinker product is cooled by passing ambient air across the product. This air is directed into the kiln for use as combustion air. The clinker is then further cooled in a reciprocating cooler, which achieves a lower clinker discharge temperature by passing an additional quantity of air through the clinker. This additional air passes through the cooler baghouse prior to being exhausted to the atmosphere though the cooler stacker.

Clinker exits the clinker cooler at an approximate temperature of 100 °C to 200 °C onto an enclosed conveyor system, which feeds one of four clinkers storage silos. Cooled clinker from the clinker storage silos is conveyed to the roller press where it is pre-ground. Pre-ground clinker is then transferred into the cement finish mill feed silos.

2.1.5 Cement Production

Cement finishing is accomplished in three individual ball grinding mills. Clinker, limestone and gypsum are milled together to produce cement. Emissions from the three finish mills are controlled by individual baghouses venting though two finish mill stacks.

The finished cement product is transferred into product storage silos. Product can be dispatched via tanker truck or by ship.

In addition to finished cement product, the Site also ships clinker. Cement and clinker are transported to the dock using an enclosed conveyor system.

3.0 CONVENTIONAL FUELS

The thermal requirements of the cement manufacturing process at the Site have been historically provided by combustion of a combination of diesel fuel (for pre-heating), coal and petroleum coke (sponge petroleum coke, fluid petroleum coke and shot-petroleum coke). Fuel fed to the main kiln burner ranges from 7 to 10 tonnes/hour and to the calciner burner from 15 to 25 tonnes per hour. This is equivalent to a total of approximately 646 tonnes of conventional fuel per day for the kiln and calciner combined at a maximum production rate of 5,800 tonnes of clinker per day.

Diesel is supplied by tanker truck and is mainly used during start-up to pre-heat the kiln system. Coal and petroleum coke are primarily supplied by ship, with some provided by truck.

4.0 ALTERNATIVE LOW-CARBON FUELS

Under O. Reg 79/15, ALCFs are fuels that have a carbon dioxide emission intensity that is less than the carbon dioxide emission intensity of the coal or coke in the place of which the fuel is combusted. In addition, an ALCF proposed for use must meet one of the following two descriptions:

1. The fuel:
   - Is not considered hazardous and must not be derived from animals or the processing and preparations of food;
   - Must be wholly derived from (or composed of) materials that are biomass or municipal waste or a combination of both; and
   - Must have a high heat value of at least 10,000 megajoules per tonne if it is not derived from or composed of materials that are solid biomass.
2. The fuel must be derived from or composed of organic matter, not including peat or peat derivatives, derived from a plant or micro-organism and grown or harvested for the purpose of being used as a fuel.

4.1 Proposed ALCFs

SMCB currently has an ECA to use woody materials (biomass) as an ALCF at the Site. Under the ALCF O. Reg. 79/15 Application, SMCB is proposing to add biomass, cellulosic (e.g. woody materials) and plastic materials derived from industrial and/or post consumer sources to their approved list of ALCFs at the site with the intention to substitute conventional fuels to approximately 30% thermal replacement, roughly equivalent to 400 tonnes of fuel. These materials may include, but are not limited to:

- Paper / paper fibre materials;
- Cardboard;
- Cotton;
- Diaper trimmings;
- Textiles (including but not limited to carpet cuttings, clothing);
- Construction and demolition materials;
- Non-recyclable plastics (including manufacturing rejects and trimmings);
- Ragger tails from carboard and paper recycling;
- Packaging material from consumer products; and
- Materials derived from agricultural crop production that cannot be consumed (not including materials derived from animals or animal by-products).

5.0 CARBON DIOXIDE EMISSION INTENSITY CALCULATIONS

In accordance with O. Reg. 79/15, the carbon dioxide emission intensity calculations must be based on chemical analysis data of the conventional fuels and proposed ALCFs. The sections below describe the sampling requirements, chemical analysis results and carbon dioxide emission intensity calculations.

It should be noted chemical analysis results are based on the chemical analysis data that were obtained for the purposes of the ALCF Application under O. Reg 79/15. As the carbon content of ALCFs may vary depending on the fuel supplier, SMCB plans to develop and implement a fuel testing program to regularly monitor the carbon dioxide intensity of the ALCF used at the Site.

5.1 Conventional Fuels Sampling

Samples of the conventional fuels that are used at SMCB were submitted for chemical analysis to estimate the total carbon content and high heat value of each fuel. In total, SMCB submitted six (6) samples each of fluid petroleum coke, petcoke and Coal A fuels for chemical analysis for the months of May to October 2019 and the carbon dioxide emission intensity calculations discussed in this report were completed in November 2019. These samples met the following criteria listed in Section 9(3) of O. Reg. 79/15:

a) only include samples taken and analyzed during the most recent six-month period during which the facility was operating before the determination is made;

b) include at least one sample taken and analyzed during each month of the six-month period mentioned in clause (a);

c) not include any samples taken more than 36 months before the determination is made; and

d) be representative of the coal or coke in the place of which alternative low-carbon fuel is proposed to be combusted.

In accordance with O.Reg.79/15, only prescribed chemical analysis methods were used to determine the total carbon content and high heat value of each fuel. The chemical analysis methods and sampling results are summarized in Table 1. A copy of the conventional fuel chemical analysis data is provided in Appendix A

5.2 ALCF Sampling

Three (3) samples each of the following materials were submitted for chemical analysis to estimate the biological carbon content, total carbon content and high heat value of each fuel:

- woody materials (biomass) and;
- biomass, cellulosic and plastic materials.

These samples met the following criteria listed in Section 10(2) of O. Reg. 79/15:

1) Only samples taken within 36 months before the determination is made shall be used.

2) One of the following methods shall be applied:

   i. Analysis in accordance with a prescribed chemical analysis method of at least one sample of the fuel.

ii. Analysis in accordance with a prescribed chemical analysis method of at least one sample of each of the individual materials that the fuel is composed of or derived from, using a weighted average of the carbon content and high heat value of the individual materials.

The number of samples analyzed must provide results that are sufficiently representative of the fuel or individual materials and must allow for adequate characterization of the fuel or individual materials.

Biological carbon content data for the ALCF samples were obtained from analytical testing using the ASTM D-6866 "*Standard Test Methods for Determining the Biobased Content of Solid, Liquid, and Gaseous Samples Using Radiocarbon Analysis*" biobased carbon testing methodology required by O. Reg. 79/15.

The ALCF chemical analysis methods and sampling results are summarized in Table 2. A copy of the ALCF chemical analysis data is provided in Appendix A.

Table 1: Conventional Fuels Sampling Results

Date		May 30, 2019			June 24, 2019			July 20, 2019			August 30, 2019			September 26, 2019			October 28, 2019		
Fuel Type		Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"
Lab ID Number		12162-1	12162-2	12162-3	12297-3	12297-2	12297-1	12509-3	12509-2	12509-1	12793-3	12793-2	12793-1	13055-3	13055-2	13055-1	13055-6	13055-5	13055-4
High Heat Value (Calorific Value) ASTM Method E3870	MJ/kg	17.952	31.368	27.879	29.093	29.531	27.442	19.998	30.170	28.137	30.428	31.689	29.691	31.372	31.856	30.375	31.465	32.175	30.565
Carbon Weight Percentage ASTM Method D3178	%	44.16	76.86	46.65	75.29	73.37	66.79	56.79	76.22	68.39	82.53	79.21	71.33	82.37	78.35	71.72	69.43	78.42	72.73

Table 2: ALCF Sampling Results

Date		September 14, 2019			September 16, 2019		
Fuel Type		Woody Materials (Biomass)			Biomass, Cellulosic and Plastic Materials		
Lab ID Number		WOODMAT-01	WOODMAT-02	WOODMAT-03	PLASWOOD-01	PLASWOOD-02	PLASWOOD-03
High Heat Value (Calorific Value) ASTM Method E3870	MJ/kg	15.044	15.884	15.968	19.219	20.910	20.390
Carbon Weight Percentage ASTM Method D3178	%	39.54	39.21	39.95	48.46	43.85	46.06
Biological Carbon Weight Percentage ASTM Method D6866	%	99	100	100	63	49	81

5.3 Conventional Fuel Sample Calculation

The following formula was used to calculate the carbon dioxide emission intensity for each conventional fuel sampling result. An example calculation is presented below using the chemical analysis results for fluid petcoke sample 12162-1.

$$\textbf{Carbon dioxide emission intensity}\left[\frac{\textbf{kg CO}_2}{\textbf{MJ}}\right]$$

$$= \text{Total carbon content }[\%] \times \text{C to CO}_2\text{ conversion}\left[\frac{\text{kg CO}_2}{\text{kg C}}\right] \div \text{High heat value}\left[\frac{\text{MJ}}{\text{kg fuel}}\right]$$

Where:

$\textbf{Total carbon content} = 44.16\%$ (value from chemical analysis result for sample 12162– 1)

$\textbf{C to CO}_2\textbf{ conversion} = 3.67$

$\textbf{High heat value} = 17.952\ \frac{MJ}{kg}$ (value from chemical analysis result for sample WOODMAT– 12162 − 1)

Therefore:

$$\text{Carbon dioxide emission intensity} = 44.15\% \times 3.67\ \frac{\text{kg CO}_2}{\text{kg C}} \times \frac{1}{17.952}\ \frac{\text{kg fuel}}{\text{MJ}}$$

$$\text{Carbon dioxide emission intensity} = 0.0903\ \frac{\text{kg CO}_2}{\text{MJ}}$$

5.4 ALCF Example Calculation

In accordance with O. Reg. 79/15, the following formula was used to calculate the carbon dioxide emission intensity for each ALCF sampling result. An example calculation is presented below using the chemical analysis results for sample WOODMAT-01.

$$\textbf{Carbon dioxide emission intensity}\left[\frac{\textbf{kg CO}_2}{\textbf{MJ}}\right]$$

$$= \text{Non} - \text{biological carbon content }[\%] \times \text{C to CO}_2\text{ conversion}\left[\frac{\text{kg CO}_2}{\text{kg C}}\right] \div \text{High heat value}\left[\frac{\text{MJ}}{\text{kg fuel}}\right]$$

Where:

$\textbf{Non} - \textbf{biological carbon content}\ [\%] = \text{Total carbon content}\ [\%] \times (100\% - \text{Biological carbon content}\ [\%])$

$\textbf{Total carbon content} = 39.54\%$ (value from chemical analysis result for sample WOODMAT– 01)

$\textbf{Biological carbon content} = 99\%$ (value from chemical analysis result for sample WOODMAT– 01)

$\textbf{C to CO}_\mathbf{2}\ \textbf{conversion} = 3.67$

$\textbf{High heat value} = 15.044\ \frac{\text{MJ}}{\text{kg}}$ value from chemical analysis result for sample WOODMAT– 01)

Therefore:

$$\text{Non} - \text{biological carbon content} = 39.54\% \times (100\% - 99\%)$$

$$\text{Non} - \text{biological carbon content} = 0.40\%$$

$$\text{Carbon dioxide emission intensity} = 0.40\% \times 3.67\ \frac{\text{kg CO}_2}{\text{kg C}} \times \frac{1}{15.044}\ \frac{\text{kg fuel}}{\text{MJ}}$$

$$\text{Carbon dioxide emission intensity} = 0.001\ \frac{\text{kg CO}_2}{\text{MJ}}$$

5.5 Summary of Assessment

Once the carbon dioxide emission intensity values were calculated for each sampling result, an average intensity value was calculated for each fuel type and summarized in Table 3. For ease of comparison, Table 3 also includes an estimate of the carbon dioxide emissions from combustion of 400 tonnes of each fuel, the amount of ALCFs that SMC has proposed to use each day as part of this application, (see Section 1.0). An example calculation for carbon dioxide emissions from the use of 400 tonnes (400,000 kg) of woody materials (biomass) is presented below. Detailed sample calculations for the other fuels are provided in Appendix B.

$$\textbf{CO}_\mathbf{2}\ \textbf{emissions from 400 tonnes per day woody materials (biomass)} \left[\frac{\textbf{tonnes CO}_\mathbf{2}}{\textbf{day}}\right]$$

$$= \text{Fuel usage} \left[\frac{\text{kg}}{\text{day}}\right] \times \text{Average calorific value} \left[\frac{\text{MJ}}{\text{kg}}\right] \times \text{Average carbon intensity} \left[\frac{\text{kg CO}_2}{\text{MJ}}\right] \times \text{Conversion from kg to tonnes} \left[\frac{\text{tonne}}{\text{kg}}\right]$$

Where:

$\textbf{Fuel usage} = 400\ 000\ \frac{\text{kg}}{\text{day}}$

$$\textbf{Average calorific value} = 15.630\ \frac{\text{MJ}}{\text{kg}}\ \text{(average value from chemical analysis results of three WOODMAT samples)}$$

$$\textbf{Average carbon intensity} = 0.0003\ \frac{\text{kg CO}_2}{\text{MJ}}\ \text{(average value from three WOODMAT samples)}$$

$$\textbf{kg to tonne conversion} = 0.001\ \frac{\text{tonne CO}_2}{\text{kg CO}_2}$$

Therefore:

$$\text{CO}_2\ \text{emissions} = 400{,}000\ \text{kg} \times 15.630\ \frac{\text{MJ}}{\text{kg}} \times 0.0003\ \frac{\text{kg CO}_2}{\text{MJ}} \times 0.001\ \frac{\text{tonne CO}_2}{\text{kg CO}_2}$$

$$\text{CO}_2\ \text{emissions} = 5.8\ \text{tonne CO}_2$$

Table 3: Summary of Average Carbon Dioxide Emission Intensities

Fuel Type	Average Carbon Dioxide Emission Intensity [kg CO_2 / MJ]	Average Calorific Value [MJ/kg]	Carbon Dioxide Emissions per 400 tonnes of Fuel Combusted [tonnes CO_2]
Fluid Petcoke	0.0944	26.72	1008.8
Pet Coke	0.0909	31.13	1131.7
Coal "A"	0.0837	29.01	971.2
Woody Materials (Biomass)	0.0003	15.63	5.8
Biomass, Cellulosic (e.g. Woody Materials) and Plastic Materials	0.0299	20.17	250.5

The results demonstrate that the ALCFs have significantly lower carbon dioxide emission intensity values than conventional fuels. For example, the carbon dioxide emission intensity value of biomass, cellulosic (e.g. woody materials) and plastic materials represents a decrease of approximately 74% when compared to the carbon dioxide emission intensity of Coal “A”. Combustion of woody biomass (biomass) results in approximately 99% decrease in carbon dioxide emission intensity when compared to the carbon dioxide emission intensity of Coal “A”.

6.0 CONCLUSION

As part of SMC's strategy to reduce greenhouse gas (GHG) emissions and in keeping with best practices implemented around the world, SMC proposes to increase the current usage of ALCFs at the Site. The results of this carbon dioxide emission intensity report support this strategy, with estimated ALCF carbon dioxide emission intensity values at least 74% lower than the conventional fuel values.

The results presented in this report are solely based on the chemical analysis data that were obtained for the purposes of the ALCF Application under O. Reg 79/15. SMCB plans to develop and implement a fuel testing program to regularly monitor the composition and carbon dioxide emission intensity of the ALCFs to be used at the Site.

7.0 LICENSED ENGINEERING PRACTITIONER STATEMENT

Ontario Regulation 79/15 requires that this Carbon Dioxide Intensity Report be prepared by a licensed engineering practitioner (LEP) as part of an ALCF approval application.

As the LEP who prepared this Carbon Dioxide Intensity Report, I confirm that, in accordance with Section 11.(1) of Ontario Regulation 79/15,

i) the carbon dioxide emission intensities of the coal or coke and of the alternative low-carbon fuel have been determined in accordance with Ontario Regulation 79/15, and

ii) the carbon dioxide emission intensity of the alternative low-carbon fuel proposed to be combusted is less than the carbon dioxide emission intensity of the coal or coke in the place of which the alternative low-carbon fuel is proposed to be combusted.

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Emily Lau, B.A.Sc., P.Eng., License Number 100099850

8.0 PROPONENT STATEMENT

Ontario Regulation 79/15 requires that this Carbon Dioxide Intensity Report be certified by the proponent or a person who is authorized by the proponent.

By signing below, Ruben Plaza, Corporate Environmental Manager, North America of Votorantim Cimentos North America, certifies that the information given to the licensed engineering practitioner to prepare the report is complete and accurate.

Ruben Plaza, Corporate Environmental Manager, North America

9.0 REFERENCES

BCX Environmental Consulting, 2014. Application and Supporting Documentation for an Environmental Compliance Approval (Air) Amendment with Limited Operational Flexibility, St. Marys Cement Inc. (Canada) – Bowmanville Plant, May 2014. Available at http://www.stmaryscement.com/Documents/SMC-BowmanvilleAlternativefuel_ECAAirsupportingdocumentation.pdf

Signature Page

Golder Associates Ltd.

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Principal, Senior Permitting and Environmental Assessment

EKL/FSC/ng

https://golderassociates.sharepoint.com/sites/104011/project files/07-deliverables/04_co2report/final/19117137-r-rev0 17jan2020 vcna carbon report.docx

APPENDIX A

Chemical Analysis Results

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 12162- 1 to 3
Date Report: June 11, 2019
Sample in: June 5, 2019
PO. No.: 6300163898

Attention: Jason Schultz / Janine Ralph

Re: Coal and Coke samples, May 30, 2019 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	12162-1	12162-2	12162-3
		Sample ID	Fluid Coke May 30, 2019	Pet Coke May 30, 2019	Coal 'A' May 30, 2019
Test	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	7718 17.952	13486 31.368	11986 27.879
2. Moisture content, As Received	E870	% wt.	14.41	10.18	12.46
3. Carbon, As Received	D3178	% wt.	44.16	76.86	46.65

Tested by : A.C.(Chemist)

Member of ASTM
JS:LN

Approved by James Szeto

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 12297- 1 to 3 (A)
Date Report: July 4, 2019
Sample in: June 27, 2019
PO. No.: 6300163898

Attention: Jason Schultz / Janine Ralph

Re: Coal and Coke samples, June 24, 2019 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	12297-1	12297-2	12297-3
		Sample ID	Coal A	Pet Coke	Fluid Coke
Test	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	11798 27.442	12697 29.531	12508 29.093
2. Moisture content, As Received	E870	% wt.	11.81	11.43	11.98
3. Carbon, As Received	D3178	% wt.	66.79	73.37	75.29

Tested by : A.C.(Chemist)

Member of ASTM
JS:LN

Approved by *James Szeto*

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1   Tel: (905) 361-2388   Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 12509- 1 to 3 (A)
Date Report: Aug 14, 2019
Sample in: Aug 7, 2019
PO. No.: 6300163898

Attention: Jason Schultz

Re: Coal and Coke samples, July 29, 2019 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	12509-1	12509-2	12509-3
		Sample ID	Coal A July	Pet Coke July	Fluid Coke July
Tests	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	12097 28.137	12971 30.170	8598 19.998
2. Moisture content, As Received	E870	% wt.	11.05	11.41	0.58
3. Carbon, As Received	D3178	% wt.	68.39	76.22	56.79

Tested by : A.C.(Chemist)

Member of ASTM
JS:LN

Approved by *James Szeto*

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1   Tel: (905) 361-2388   Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 12793- 1 to 3 (A)
Date Report: Oct 1, 2019
Sample in: Sept 19, 2019
PO. No.: 6300163898

Attention: Jason Schultz / Janine Ralph

Re: Coal and Coke samples, Aug 30, 2019 for analysis.
St. Mary Low Carbon Fuel project.

		Lab No.	12793-1	12793-2	12793-3
		Sample ID	Coal A August	Petcoke August	Fluid Coke August
Test	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	12765 29.691	13624 31.689	13082 30.428
2. Moisture content, As Received	E870	% wt.	7.70	9.17	6.16
3. Carbon, As Received	D3178	% wt.	71.33	79.21	82.53

Tested by : A.C.(Chemist)

Approved by *James Szeto*

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.
1295 Matheson Blvd. East, Mississauga, Ontario, L4W 1R1 Tel: (905) 361-2388 Fax: (905) 361-2411
E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 13055 - 1 to 3
Date Report: Nov 8, 2019
Sample in: Oct 31, 2019
PO No.: 6300163898

Attention: Jason Schultz/ Janine Ralph

Re: Coal and Coke samples Sept 26, 2019 for testing.
from: St. Mary Low Carbon Fuel project.

		Lab No.	13055-1	13055-2	13055-3
		Sample ID	Coal Sept 26, 19	Petcoke Sept 26, 19	Fluidcoke Sept 26, 19
Test	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	13059 30.375	13696 31.856	13488 31.372
2. Moisture content, As Received	E870	% wt.	4.95	9.26	5.27
3. Carbon, As Received	D3178	% wt.	71.72	78.35	82.37

Tested by : A.C.(Chemist)
Member of ASTM
JS:LN

Approved by James Szeto
James Szeto,B.Sc.
Chief Chemist

Petro Laboratories Inc.

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E-mail: petrolab@gmail.com

Laboratory Report

St. Marys Cement
400 Waverly Road South,
Bowmanville, Ontario
L1C 3K3

Lab no.: 13055 - 4 to 6
Date Report: Nov 8, 2019
Sample in: Oct 31, 2019
PO No.: 6300163898

Attention: Jason Schultz/ Janine Ralph

Re: Coal and Coke samples Sept 26, 2019 for testing.
from: St. Mary Low Carbon Fuel project.

		Lab No.	13055-4	13055-5	13055-6
		Sample ID	Coal Oct 28, 19	Petcoke Oct 28, 19	Fluidcoke Oct 28, 19
Test	**Method ASTM**	**Unit**	**Results**		
1. Calorific Value, As Received	E870	BTU/lb MJ/kg	13141 30.565	13833 32.175	13528 31.465
2. Moisture content, As Received	E870	% wt.	5.07	8.21	5.11
3. Carbon, As Received	D3178	% wt.	72.73	78.42	69.43

Tested by : A.C.(Chemist)

Approved by James Szeto

Member of ASTM
JS:LN

James Szeto,B.Sc.
Chief Chemist

Beta Analytic
TESTING LABORATORY

Beta Analytic Inc
4985 SW 74 Court
Miami, Florida 33155
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com

September 14, 2019

Emily Lau
Golder Associates Ltd.
6590 Century Avenue
Mississauga
Ontario, L5N 7K2
Canada

Dear Ms. Lau

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as “percent modern carbon (pMC)”. This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited on your report. The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

Beta Analytic
TESTING LABORATORY

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ISO/IEC 17025:2005-Accredited Testing Laboratory

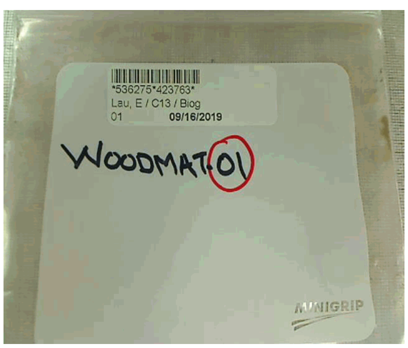
Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423763536275103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 14, 2019
Submitter Label	WOODMAT-01

RESULT: 99 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-536275
Percent modern carbon (pMC)	110.91 +/- 0.33 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



Package received - labeling COC


View of content (1mm x 1mm scale)


3510.8mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO2 in the air and/or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

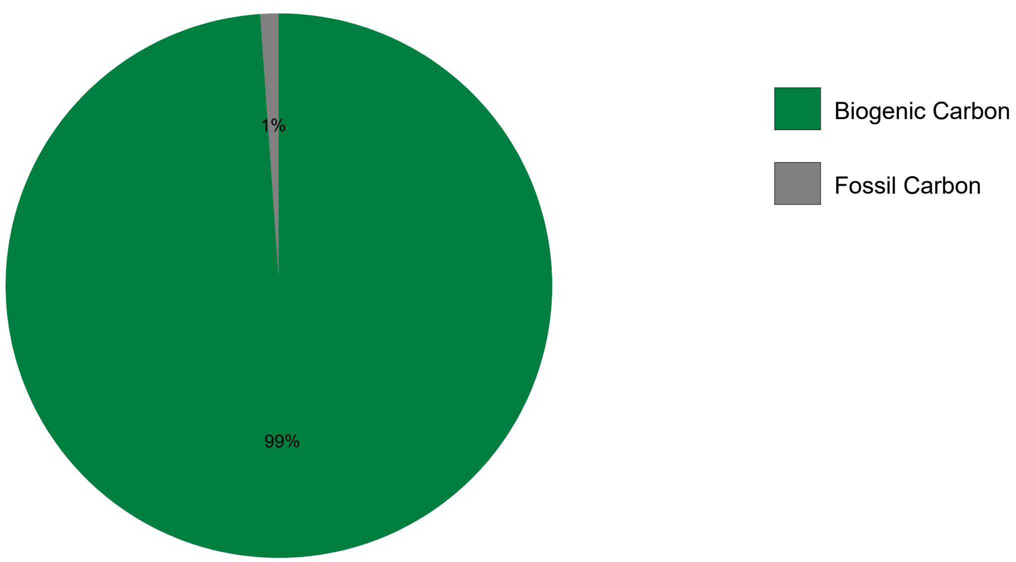
Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423763536275103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 14, 2019
Submitter Label	WOODMAT-01

RESULT: 99 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-536275
Percent modern carbon (pMC)	110.91 +/- 0.33 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



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% Biogenic Carbon Content ASTM D6866-18 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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Beta Analytic
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ISO/IEC 17025:2005-Accredited Testing Laboratory

September 14, 2019

Emily Lau
Golder Associates Ltd.
6590 Century Avenue
Mississauga
Ontario, L5N 7K2
Canada

Dear Ms. Lau

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as "% Biogenic Carbon". This indicates the percentage carbon from "renewable" (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as "percent modern carbon (pMC)". This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited on your report. The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

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Fax: 305-663-0964
info@betalabservices.com

Beta Analytic
TESTING LABORATORY

ISO/IEC 17025:2005-Accredited Testing Laboratory

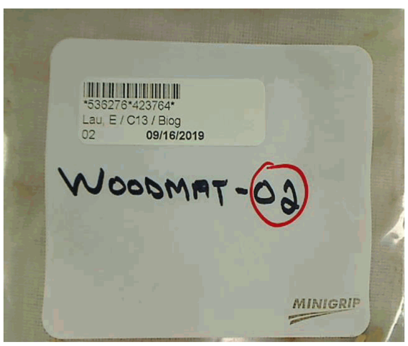
Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423764536276103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 14, 2019
Submitter Label	WOODMAT-02

RESULT: 100 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-536276
Percent modern carbon (pMC)	121.77 +/- 0.34 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



Package received - labeling COC

View of content (1mm x 1mm scale)

3594.3mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO2 in the air and/or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423764536276103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 14, 2019
Submitter Label	WOODMAT-02

RESULT: 100 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-536276
Percent modern carbon (pMC)	121.77 +/- 0.34 pMC
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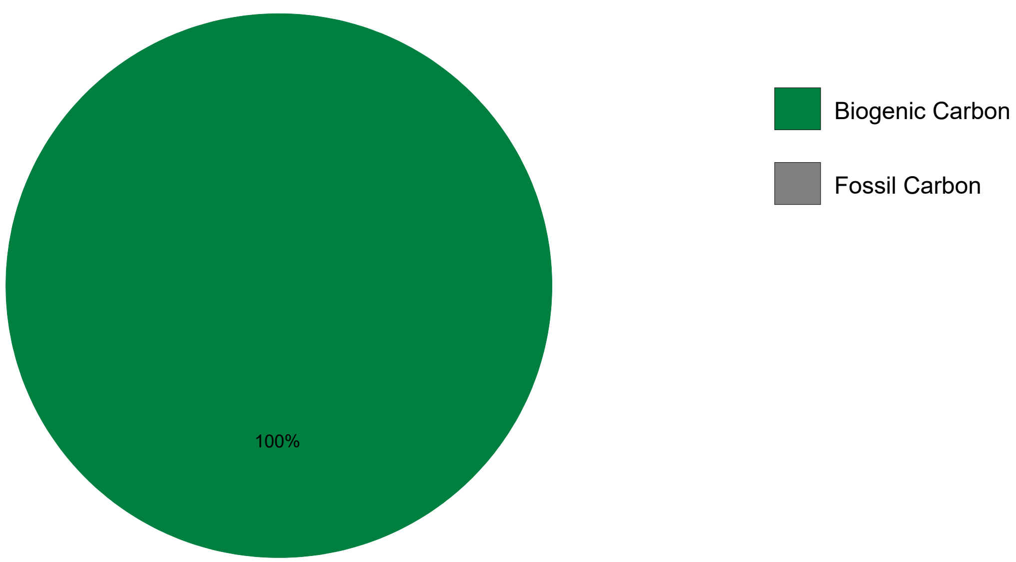

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% Biogenic Carbon Content ASTM D6866-18 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology “% biobased carbon”. Only ASTM D6866 uses the term “% biogenic carbon” when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms “% biobased carbon” and “% biogenic carbon” are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology “REF”.

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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September 14, 2019

Emily Lau
Golder Associates Ltd.
6590 Century Avenue
Mississauga
Ontario, L5N 7K2
Canada

Dear Ms. Lau

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as “% Biogenic Carbon”. This indicates the percentage carbon from “renewable” (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

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Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

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Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

Beta Analytic TESTING LABORATORY

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ISO/IEC 17025:2005-Accredited Testing Laboratory

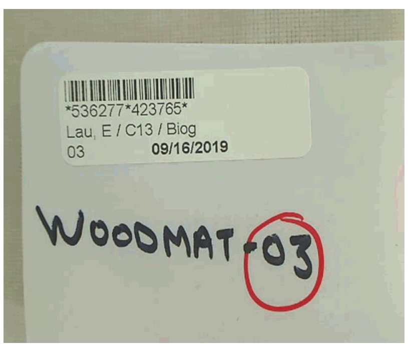
Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423765536277103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 14, 2019
Submitter Label	WOODMAT-03

RESULT: 100 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-536277
Percent modern carbon (pMC)	118.36 +/- 0.36 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



Package received - labeling COC

View of content (1mm x 1mm scale)

3604.7mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO2 in the air and /or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

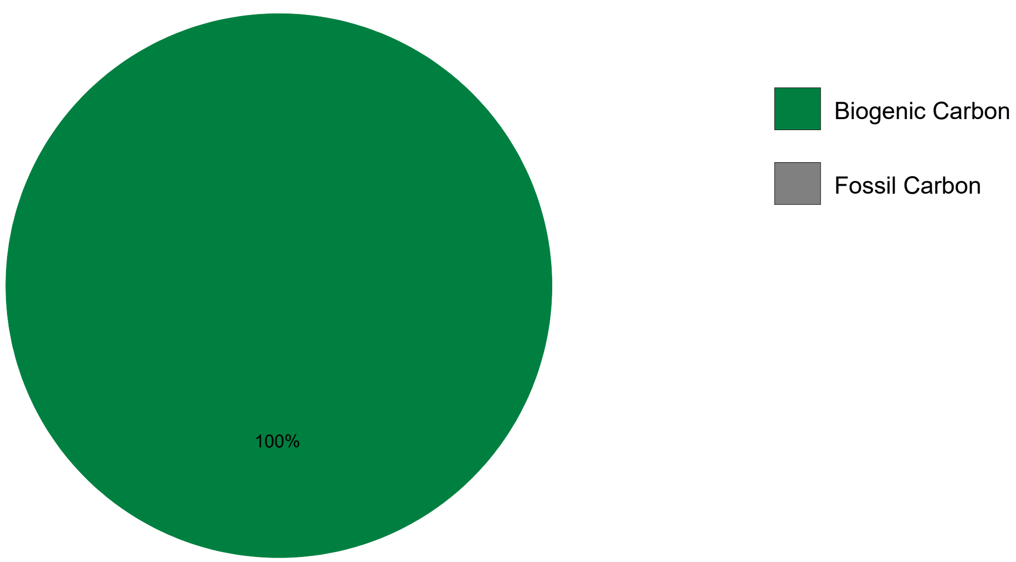
Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423765536277103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 14, 2019
Submitter Label	WOODMAT-03

RESULT: 100 % Biogenic Carbon Content (as a fraction of total carbon)

Laboratory Number	Beta-536277
Percent modern carbon (pMC)	118.36 +/- 0.36 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/[1/(100.0/112)]



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% Biogenic Carbon Content ASTM D6866-18 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

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The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology "REF".

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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September 16, 2019

Emily Lau
Golder Associates Ltd.
6590 Century Avenue
Mississauga
Ontario, L5N 7K2
Canada

Dear Ms. Lau

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as "% Biogenic Carbon". This indicates the percentage carbon from "renewable" (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as "percent modern carbon (pMC)". This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

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Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423766536278103841

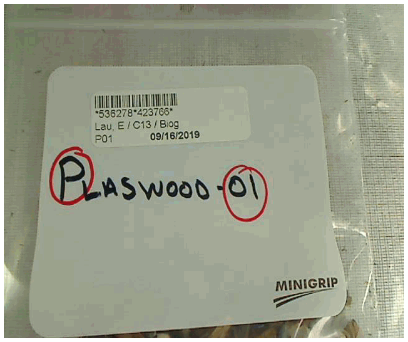
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 16, 2019
Submitter Label	PLASWOOD-01

RESULT: 63 % Biogenic Carbon Content (as a fraction of total carbon)

Per the client request, the subsample selected for the analysis was as well mixed as possible.

Laboratory Number	Beta-536278
Percent modern carbon (pMC)	62.57 +/- 0.15 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC


View of content (1mm x 1mm scale)


4550.7mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO2 in the air and/or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

Beta Analytic
TESTING LABORATORY

Beta Analytic Inc
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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423766536278103841

Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 16, 2019
Submitter Label	PLASWOOD-01

RESULT: 63 % Biogenic Carbon Content (as a fraction of total carbon)

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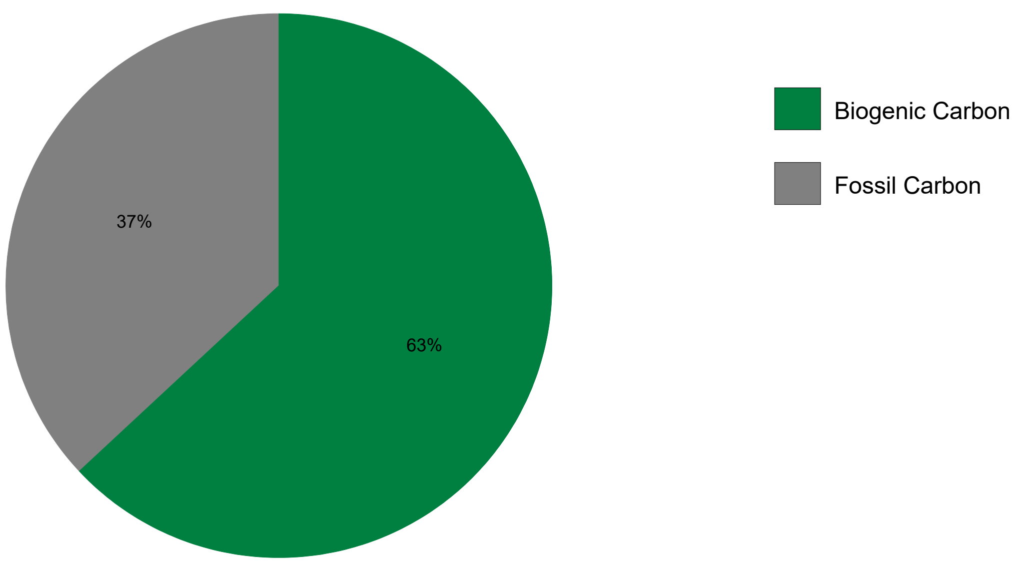

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% Biogenic Carbon Content ASTM D6866-18 Method B (AMS)

Explanation of Results

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The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology "% biobased carbon". Only ASTM D6866 uses the term "% biogenic carbon" when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms "% biobased carbon" and "% biogenic carbon" are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology "REF".

Interpretation and application of the results is straightforward. A value of 100% biobased or biogenic carbon would indicate that 100% of the carbon came from plants or animal by-products (biomass) living in the natural environment and a value of 0% would mean that all of the carbon was derived from petrochemicals, coal and other fossil sources. A value between 0-100% would indicate a mixture. The higher the value, the greater the proportion of naturally sourced components in the material.

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September 16, 2019

Emily Lau
Golder Associates Ltd.
6590 Century Avenue
Mississauga
Ontario, L5N 7K2
Canada

Dear Ms. Lau

Please find enclosed your radiocarbon (C14) report for the material recently submitted. The result is reported as "% Biogenic Carbon". This indicates the percentage carbon from "renewable" (biomass or animal by-product) sources versus petroleum (or otherwise fossil) sources . For reference, 100 % Biogenic Carbon indicates that a material is entirely sourced from plants or animal by-products and 0 % Biogenic Carbon indicates that a material did not contain any carbon from plants or animal by-products. A value in between represents a mixture of natural and fossil sources.

The analytical measurement is cited as "percent modern carbon (pMC)". This is the percentage of C14 measured in the sample relative to a modern reference standard (NIST 4990C). The % Biogenic Carbon content is calculated from pMC by applying a small adjustment factor for C14 in carbon dioxide in air today. It is important to note is that all internationally recognized standards using C14 assume that the plant or biomass feedstocks were obtained from natural environments.

Reported results are accredited to ISO/IEC 17025:2005 Testing Accreditation PJLA #59423 standards and all chemistry was performed here in our laboratory and counted in our own accelerators in Miami, Florida.

The international standard method utilized for this analysis is cited on your report. The report also indicates if the result is relative to total carbon (TC) or only total organic carbon (TOC). When interpreting the results, please consider any communications you may have had with us regarding the analysis. If you have any questions please contact us. We welcome your inquiries.

Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

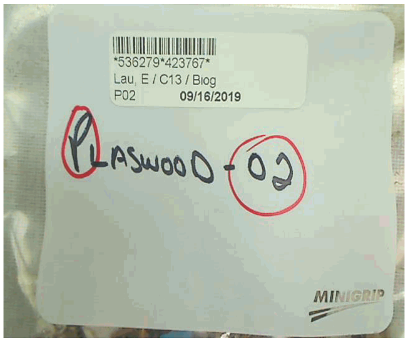
Certificate Number: 423767536279103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 16, 2019
Submitter Label	PLASWOOD-02

RESULT: 49 % Biogenic Carbon Content (as a fraction of total carbon)

Per the client request, the subsample selected for the analysis was as well mixed as possible.

Laboratory Number	Beta-536279
Percent modern carbon (pMC)	48.80 +/- 0.18 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC


View of content (1mm x 1mm scale)


4220.6mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

Precision on the RESULT is cited as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the RESULT relies on the measured carbon in the analyzed material having been in recent equilibrium with CO2 in the air and/or from fossil carbon (from living more than 40,000 years ago such as petroleum or coal. The RESULT only applies to relative carbon content, not to relative mass content. The RESULT is calculated by adjusting pMC by the applicable "Atmospheric adjustment factor (REF)" cited in this report.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423767536279103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 16, 2019
Submitter Label	PLASWOOD-02

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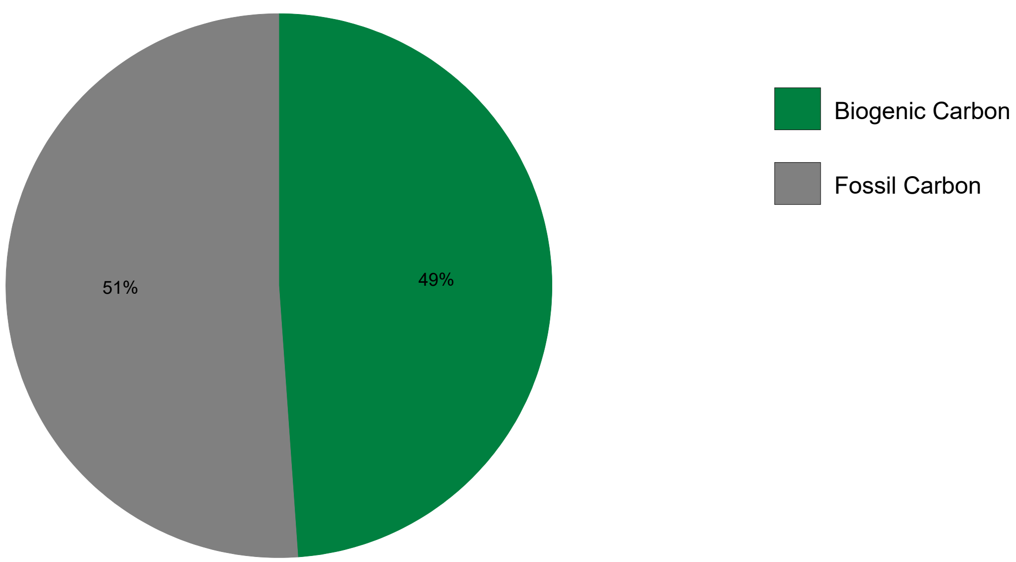
Laboratory Number	Beta-536279
Percent modern carbon (pMC)	48.80 +/- 0.18 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



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% Biogenic Carbon Content ASTM D6866-18 Method B (AMS)

Explanation of Results

The result was obtained using the radiocarbon isotope (also known as Carbon-14, C14 or 14C), a naturally occurring isotope of carbon that is radioactive and decays in such a way that there is none left after about 45,000 years following the death of a plant or animal. Its most common use is radiocarbon dating by archaeologists. An industrial application was also developed to determine if consumer products and CO2 emissions were sourced from plants/biomass or from materials such as petroleum or coal (fossil-based). By 2003 there was growing demand for a standardized methodology for applying Carbon-14 testing within the regulatory environment. The first of these standards was ASTM D6866-04, which was written with the assistance of Beta Analytic. Since ASTM was largely viewed as a US standard, European stakeholders soon began demanding an equivalent CEN standard while global stakeholders called for ISO standardization.

The analytical procedures for measuring radiocarbon content using the different standards are identical. The only difference is the reporting format. Results are usually reported using the standardized terminology "% biobased carbon". Only ASTM D6866 uses the term "% biogenic carbon" when the result represents all carbon present (Total Carbon) rather than just the organic carbon (Total Organic Carbon). The terms "% biobased carbon" and "% biogenic carbon" are now the standard units in regulatory and industrial applications, replacing obscure units of measure historically reported by radiocarbon dating laboratories e.g. disintegrations per minute per gram (dpm/g) or radiocarbon age.

The result was obtained by measuring the ratio of radiocarbon in the material relative to a National Institute of Standards and Technology (NIST) modern reference standard (SRM 4990C). This ratio was calculated as a percentage and is reported as percent modern carbon (pMC). The value obtained relative to the NIST standard is normalized to the year 1950 AD so an adjustment was required to calculate a carbon source value relative to today. This factor is listed on the report sheet as the terminology "REF".

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September 16, 2019

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Golder Associates Ltd.
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Sincerely,

Chris Patrick
Digital signature on file

Chris Patrick Director

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

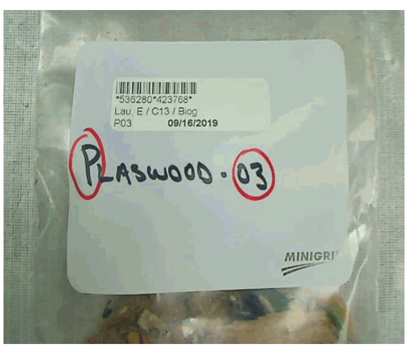
Certificate Number: 423768536280103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 16, 2019
Submitter Label	PLASWOOD-03

RESULT: 81 % Biogenic Carbon Content (as a fraction of total carbon)

Per the client request, the subsample selected for the analysis was as well mixed as possible.

Laboratory Number	Beta-536280
Percent modern carbon (pMC)	80.58 +/- 0.2 pMC
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



Package received - labeling COC

View of content (1mm x 1mm scale)


3820.0mg analyzed (1mm x 1mm scale)

Disclosures: All work was done at Beta Analytic in its own chemistry lab and AMSs. No subcontractors were used. Beta's chemistry laboratory and AMS do not react or measure artificial C 14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

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ISO/IEC 17025:2005-Accredited Testing Laboratory

Summary of Results - % Biogenic Carbon Content
ASTM D6866-18 Method B (AMS)

Certificate Number: 423768536280103841
Validation: Chris Patrick
Digital signature on file

Submitter	Emily Lau
Company	Golder Associates Ltd.
Date Received	September 05, 2019
Date Reported	September 16, 2019
Submitter Label	PLASWOOD-03

RESULT: 81 % Biogenic Carbon Content (as a fraction of total carbon)

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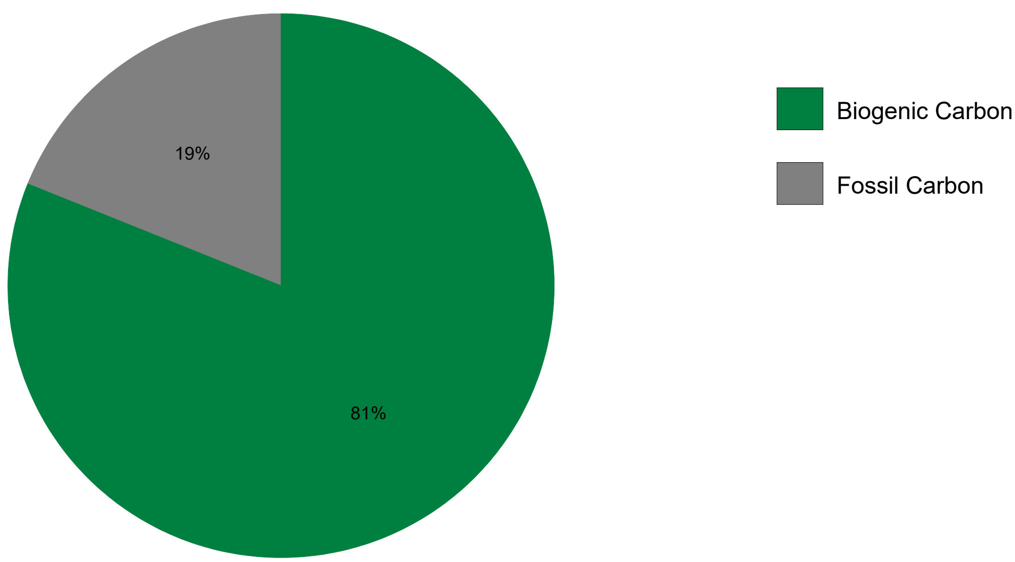
Atmospheric adjustment factor (REF)	100.0; = pMC/1.000



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Explanation of Results

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APPENDIX B

Carbon Dioxide Emission Intensity Calculations

Carbon Dioxide Emission Intensity Calculation for Conventional Fuels

VCNA proposes to replace 30% or up to 400 tonnes per day of conventional fuels (coal and petroleum coke) with alternative low carbon fuels. The estimated conventional fuel usage is 1333 tonnes per day.

Methodology

As per O.Reg. 79/15 section 9.(1) the carbon dioxide emission intensity of coal or petroleum coke (coke) is calculated using the following formula:

Carbon dioxide emission intensity = CC_{total} x 3.67/HHV

where,

CC_{total} = total carbon content of coal or coke [kg C / tonne fuel]
HHV = high heat value of coal or coke [MJ / tonne fuel]

Conventional fuel samples were sent for analysis once per month for 6 months. A carbon intensity value was calculated for each of the test results. The results were then averaged over the number of total tests per fuel to obtain an average carbon intensity for each fuel.

Carbon dioxide emissions from each fuel were estimated using the average percentage of each fuel used in the 2019 fuel blend, multiplied by the total daily fuel usage and the carbon intensity.

Sample Calculation

Carbon dioxide emission intensity = CC_{total} x 3.67/HHV

Carbon dioxide emission intensity = $\frac{44.16\ \%\,C}{} \times \frac{3.67\ kg\ CO_2}{kg\ C} \times \frac{1\ kg}{17.952\ MJ}$

Carbon dioxide emission intensity = $\frac{0.0903\ kg\ CO_2}{MJ}$

Amount of fuel replaced by ALCF = 400 tonne/day

CO2 Emissions from Fluid Petcoke = total fuel usage [tonne/day] x fluid petcoke average carbon intensity [kg CO_2/tonne] x conversions

CO2 Emissions from Fluid Petcoke = $\frac{400\ tonne}{day} \times \frac{26.718\ MJ}{kg} \times \frac{1000\ kg}{tonne} \times \frac{0.0944\ kg\ CO_2}{MJ} \times \frac{1\ tonne\ CO_2}{1000\ kg\ CO_2}$

CO2 Emissions from Fluid Petcoke = $\frac{1008.8\ tonne}{day}$

Made by: EKL
Checked by: KSA/BSF

Summary of Carbon Dioxide Intensity

Number of samples per fuel 6

		Lab No.	12162-1	12162-2	12162-3	12297-3	12297-2	12297-1	12509-3	12509-2	12509-1	12793-3	12793-2	12793-1	13055-3	13055-2	13055-1	13055-6	13055-5	13055-4
		Sample ID	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"	Fluid Petcoke	Pet Coke	Coal "A"
		Date	**May 30, 2019**			**June 24, 2019**			**July 20, 2019**			**August 30, 2019**			**September 26, 2019**			**October 28, 2019**		
Test	**ASTM Method**	**Unit**	**Results**																	
HHV, Calorific Value, As Received	E870	BTU/lb	7718	13486	11986	12508	12697	11798	8598	12971	12097	13082	13624	12765	13488	13696	13059	13528	13833	13141
		MJ/kg	17.952	31.368	27.879	29.093	29.531	27.442	19.998	30.170	28.137	30.428	31.689	29.691	31.372	31.856	30.375	31.465	32.175	30.565
3. Carbon, As Received	D3178	% wt.	44.16	76.86	46.65	75.29	73.37	66.79	56.79	76.22	68.39	82.53	79.21	71.33	82.37	78.35	71.72	69.43	78.42	72.73
CO_2 Intensity	_	kg CO_2/MJ	0.0903	0.0899	0.0614	0.0950	0.0912	0.0893	0.1042	0.0927	0.0892	0.0995	0.0917	0.0882	0.0964	0.0903	0.0867	0.0810	0.0894	0.0873

Fuel	Average Calorific Value [MJ/kg]	Average Carbon Intensity [kg CO_2/tonne]	CO_2 Emissions [t CO_2/ 400 t fuel]
Fluid Petcoke	26.718	0.0944	1008.8
Pet Coke	31.132	0.0909	1131.7
Coal "A"	29.015	0.0837	971.2

0.0902576

Carbon Dioxide Emission Intensity Calculation for Woody Materials (Biomass)

VCNA proposes to replace 30% or up to 400 tonnes per day of conventional fuels (coal and petroleum coke) with alternative low carbon fuels. The estimated conventional fuel usage is 1333 tonnes per day.

Methodology

As per O.Reg. 79/15 section 9.(1) the carbon dioxide emission intensity of a fuel, in this case woody materials (biomass), proposed to be combusted as an alternative low carbon fuel is calculated using the following formula:

Carbon dioxide emission intensity = $CC_{non\text{-}bio}$ x 3.67/HHV

where,

$CC_{non\text{-}bio}$ = non-biological carbon content of fuel [kg C / tonne fuel]
HHV = high heat value of fuel [MJ / tonne fuel]

A non-biological carbon value was calculated for each of the samples by subtracting the biological carbon portion from total carbon. The non-biological carbon content value was used to calculate a carbon dioxide emission intensity for each fuel sample.

The average carbon dioxide emission intensity for woody biomass was then used to calculate daily carbon dioxide emissions from the combustion of 400 tonnes of woody materials (biomass).

Sample Calculation

$CC_{non\text{-}bio}$ = total carbon [%wt] x (1 - biological carbon [% wt])
$CC_{non\text{-}bio}$ = 40% x (100% - 99%)
$CC_{non\text{-}bio}$ = 0.4%

Carbon dioxide emission intensity of sample WOODMAT-01 = $\dfrac{0.4\%\ C}{} \times \dfrac{3.67\ kg\ CO_2}{kg\ C} \times \dfrac{1\ kg}{15.632\ MJ}$

Carbon dioxide emission intensity of sample WOODMAT-01 = $\dfrac{0.0009\ kg\ CO_2}{MJ}$

Total alternative fuel usage = 400 tonne/day

CO_2 emissions from woody materials (biomass) = total fuel usage [tonne/day] x average calorific value [MJ/kg] x average carbon intensity [kg CO_2/MJ] x conversions

CO_2 emissions from woody materials (biomass) = $\dfrac{400\ tonne}{day} \times \dfrac{15.632\ MJ}{kg} \times \dfrac{1000\ kg}{tonne} \times \dfrac{0.0009\ kg\ CO_2}{MJ} \times \dfrac{1\ tonne\ CO_2}{1000\ kg\ CO_2}$

CO_2 emissions from woody materials (biomass) = $\dfrac{5.81\ tonne}{day}$

Summary of Carbon Dioxide Intensity

Test	ASTM Method	Sample ID	WOODMAT-01	WOODMAT-02	WOODMAT-03	Average
		Date	14-Sep-19	14-Sep-19	14-Sep-19	
		Unit	Results			
HHV, Calorific Value As Received	E870	BTU/lb	6468	6829	6865	6720.67
		MJ/kg	15.044	15.884	15.968	15.63
Carbon, As Received	D3178	% wt.	39.54	39.21	39.95	39.57
Biological Carbon	D6866	% wt.	99%	100%	100%	100%
Non-biological Carbon	—	%wt	0.40%	0.00%	0.00%	0.13%
CO_2 Intensity	—	kg CO_2/MJ	**0.001**	**0.000**	**0.000**	**0.0003**

Carbon Dioxide Emission Intensity Calculation for Biomass, Cellulosic and Plastic Materials

VCNA proposes to replace 30% or up to 400 tonnes per day of conventional fuels (coal and petroleum coke) with alternative low carbon fuels. The estimated conventional fuel usage is 1333 tonnes per day.

Methodology

As per O.Reg. 79/15 section 9.(1) the carbon dioxide emission intensity of a fuel, in this case biomass, cellulosic and plastic materials, proposed to be combusted as an alternative low carbon fuel is calculated using the following formula:

Carbon dioxide emission intensity = $Cc_{non\text{-}bio}$ x 3.67/HHV

where,

$CC_{non\text{-}bio}$ = non-biological carbon content of fuel [kg C / tonne fuel]
HHV = high heat value of fuel [MJ / tonne fuel]

A non-biological carbon value was calculated for each of the samples by subtracting the biological carbon portion from total carbon. The non-biological carbon content value was used to calculate a carbon dioxide emission intensity for each fuel sample.

The average carbon dioxide emission intensity for biomass, cellulosic and plastic materials was then used to calculate daily carbon dioxide emissions from the combustion of 400 tonnes of biomass, cellulosic and plastic materials.

Sample Calculation

$CC_{non\text{-}bio}$ = total carbon [%wt] x (1 - biological carbon [% wt])
$CC_{non\text{-}bio}$ = 46% x (100% - 63%)
$CC_{non\text{-}bio}$ = 17%

Carbon dioxide emission intensity of sample PLASWOOD-01 = $\frac{17.1\%\ \text{C}}{} \Big| \frac{3.67\ \text{kg } CO_2}{\text{kg C}} \Big| \frac{1\ \text{kg}}{20.173\ \text{MJ}}$

Carbon dioxide emission intensity of sample PLASWOOD-01 = $\frac{0.0310\ \text{kg } CO_2}{\text{MJ}}$

Total alternative fuel usage = 400 tonne/day

CO_2 emissions from biomass, cellulosic and plastic materials = total fuel usage [tonne/day] x average calorific value [MJ/kg] x average carbon intensity [kg CO_2/MJ] x conversions

CO_2 emissions from biomass, cellulosic and plastic materials = $\frac{400\ \text{tonne}}{\text{day}} \Big| \frac{20.173\ \text{MJ}}{\text{kg}} \Big| \frac{1000\ \text{kg}}{\text{tonne}} \Big| \frac{0.0310\ \text{kg } CO_2}{\text{MJ}} \Big| \frac{1\ \text{tonne } CO_2}{1000\ \text{kg } CO_2}$

CO_2 emissions from biomass, cellulosic and plastic materials = $\frac{250.52\ \text{tonne}}{\text{day}}$

Summary of Carbon Dioxide Intensity

Test	ASTM Method	Sample ID / Date / Unit	PLASWOOD-01	PLASWOOD-02	PLASWOOD-03	Average
		Date	16-Sep-19	16-Sep-19	16-Sep-19	
		Unit	Results			
HHV, Calorific Value As Received	E870	BTU/lb	8263	8990	8766	8673
		MJ/kg	19.219	20.910	20.390	20.173
Carbon, As Received	D3178	% wt.	48.46	43.85	46.06	46.12
Biological Carbon	D6866	% wt.	63%	49%	81%	64%
Non-biological Carbon	—	%wt	18%	22%	9%	17%
CO_2 Intensity	—	kg CO_2/MJ	0.0342	0.0394	0.0161	0.0299

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