February 27, 2023

Ms. Erin Burns
NYSDEC Region 5
Regional Permit Administrator, Division of Environmental Permits
1115 NYS Route 86, PO Box 296
Ray Brook, NY 12977

Via Email: erin.burns@dec.ny.gov

Subject: Saratoga Biochar Solutions, LLC
Notice of Incomplete Application
NYSDEC Permit Application ID 5-4144-00187/00001
STERLING File #2020-20

Dear Ms. Burns,

On behalf of Saratoga Biochar Solutions, LLC (SBS), Sterling Environmental Engineering, P.C. (STERLING) submits this letter providing AERMOD emissions model results as an addendum to the subject permit application in response to the January 12, 2023 Notice of Incomplete Application (NOIA) issued by the New York State Department of Environmental Conservation (NYSDEC). This letter also provides additional information to supplement the Disadvantaged Communities (DAC) assessment submitted on December 16, 2022 in accordance with the Climate Leadership and Community Protection Act (CLCPA) Section 7(3).

Response to Comments:

1. The AERMOD software has been updated to version 22112 as requested.
2. The building schematic is a digitized representation of the Facility building and stack locations based on model input parameters using actual dimensions from the Facility design drawings included in the permit application. The building schematic is the 3-dimensional representation of the building and emission points used in AERMOD for determining the influence of building downwash. The enclosed AERMOD analysis has been updated for clarity on the building and stack dimensions used in the model. The input parameters can be verified in the model files submitted to NYSDEC Division of Air.
3. The receptor grid has been adjusted to be measured from the fence line as opposed to the emission points. This has increased the model domain by approximately 100 meters in all directions.
4. There are no identified sensitive receptors in close proximity of the Facility. The AERMOD analysis has been updated to discuss results with respect to potential impacts to sensitive receptors in the model domain. Figure 1 shows potentially sensitive receptors within 1 mile of the Facility.
5. The AERMOD analysis has been updated to evaluate PM-2.5 and PM-10 individually.
6. Regional background concentrations have been developed in consultation with NYSDEC Division of Air and are included in the updated AERMOD analysis.
7. The emission rates and stack parameters have been reviewed in consultation with NYSDEC Division of Air for use in the updated AERMOD analysis.

AERMOD Modeling Protocol:

Air Dispersion Model:

- USEPA AERMOD version 21112 using Lakes Environmental AERMOD View version 11.2.0.

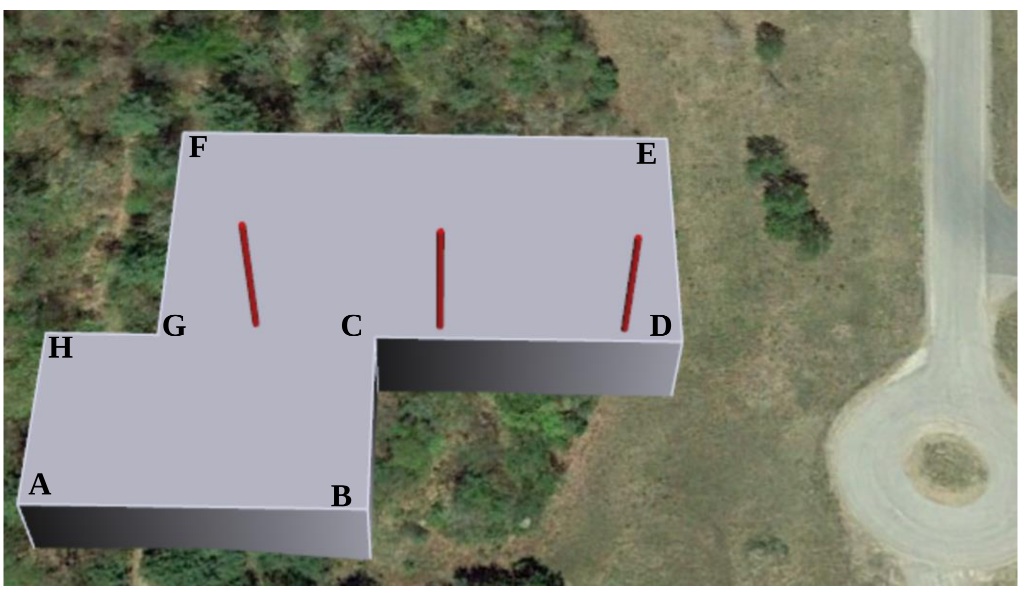
Emission Source:

Emission Point	X-Coordinate (m)	Y-Coordinate (m)	Diameter (ft)	Release Height Above Ground (ft)	Gas Exhaust Temperature	Gas Exit Velocity
Stack #1	613155.02	4793191.36	2.75	115	166.1ºF (74.5ºC)	95.8 fps (34,146 acfm)
Stack #2	613181.02	4793191.36	2.75	115	166.1ºF (74.5ºC)	95.8 fps (34,146 acfm)
Stack #2	613207.02	4793191.36	2.75	115	166.1ºF (74.5ºC)	95.8 fps (34,146 acfm)

Building Options:

- Single tier polygonal building at a height of 45.75 ft. See the model schematic below. Building downwash calculations were performed using USEPA Building Profile Input Program (BPIP) to obtain the building downwash zone of influence for use in AERMOD.

Segment	Length (ft)	Segment	Length (ft)
A-B	152	E-F	242
B-C	91	F-G	124
C-D	142	G-H	52
D-E	124	H-A	91



Building Schematic and Stack Emission Points for AERMOD Emissions Model

Emission Rate:

- Constant emission rate from three (3) stack emission points using the Potential to Emit (PTE) emission rates in the emission estimate tables included in Attachment 1. Note that the modeled condition conservatively assumed constant emissions occurring 365 days per year with no downtime.

Pollutants:

- Emissions were modeled for the following:
  - Criteria Pollutants: Particulate Matter, Nitrogen Dioxide, Sulfur Dioxide.
  - Non-Criteria Pollutants: Naphthalene, Hydrogen Sulfide, Mercury, Methyl Di/Trisulfides, Ammonia, Methyl/Ethyl Amines, Hydrogen Chloride, and Acetic Acid.

Receptors:

The model domain extended 10 km from the Facility fence line to the north, south, east, and west. The following receptor spacing was used:

- Fence line receptors along the property line at a 25 m spacing.
- Multi-tier receptor grid spacing at:
  - 70 m grid to 1,000 m from the Facility fence line.
  - 100 m grid from 1,000 m to 2,000 m from the Facility fence line.
  - 250 m grid from 2,000 m to 5,000 m from the Facility fence line.
  - 500 m grid from 5,000 m to 10,000 m from the Facility fence line.

Meteorology:

The following meteorology was used based on the source files provided by NYSDEC.

- Surface File: GFL1721.sfc
- Profile File: GFL1721.pfl
- Data Period: 01/01/2017 to 12/31/2021
- Surface Air Station: No. 14750
- Upper Air Station: No. 54775

Terrain:

AERMAP was used to process terrain elevations for the entire model domain, and elevations were applied to the source stacks and receptor locations.

- Terrain Option: Elevated
- Terrain Data: glens_falls-w.dem USGS DEM file with 1-Degree resolution
- AERMAP: DEM data file processed through AERMAP and applied to source stack emission points and all receptor locations.

AERMOD Output:

Model output are summarized in the attached Table 1. Background concentrations are summarized in the attached Table 2. Emission factors are summarized in Attachment 1. A wind rose diagram, summary tables of each model run, and corresponding plume contour plots are included in Attachment 2. The predominant wind direction is from the south-southwest. Each modeled pollutant is described in more detail in the following sections.

Particulate Matter

Particulate Matter is a Criteria Contaminant under the National Ambient Air Quality Standards (NAAQS) of the Clean Air Act. In accordance with DAR-1, particulate matter consisting primarily of nuisance particles is assigned an Environmental Rating of "B" and emissions are restricted by the following:

- The primary NAAQS for particulate matter (PM-2.5) is an annual mean of 12 μg/m^3 and a 24-hour 98th percentile of 35 μg/m^3.

Model output for PM-2.5 are summarized in the following table:

PM-2.5 Modeled Maximum Concentrations (μg/m^3)

	24-hour 98th Percentile	Annual
AERMOD Output	1.50	0.30
Background	15.70	5.78
Total Concentration	17.20	6.08

- The primary NAAQS for particulate matter (PM-10) is a 24-hour mean of 150 μg/m^3.

Model output for PM-10 are summarized in the following table:

PM-10 Modeled Maximum Concentrations (μg/m^3)

	24-hour
AERMOD Output	3.53
Background	42.30
Total Concentration	45.83

The modeled PM emission factor was conservatively assumed to be all PM-2.5 for comparison to the PM-2.5 NAAQS and all PM-10 for comparison to the PM-10 NAAQS. The PM concentrations achieve the applicable primary NAAQS. By achieving the NAAQS, the Facility achieves the necessary Degree of Air Cleaning Required.

Nitrogen Dioxide (NO_2)

Nitrogen dioxide is designated as a Criteria Contaminant under the NAAQS of the Clean Air Act. NO_2 emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the primary NAAQS as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 3).
- The primary NAAQS for nitrogen dioxide is an annual mean of 53 ppb (100 µg/m^3) and a 1-hour 98^{th} percentile maximum of 100 ppb (188 µg/m^3).

Model output are summarized in the following table:

NO_2 Modeled Maximum Concentrations (µg/m^3)

	1-hour 98^{th} Percentile	Annual
AERMOD Output	37.5	2.06
Background	61.0	12.70
Total Concentration	98.50	14.76

The modeled concentrations meet the NAAQS. By achieving the NAAQS, the Facility achieves the necessary Degree of Air Cleaning Required.

Sulfur Dioxide (SO_2)

Sulfur dioxide is designated as a Criteria Contaminant under the NAAQS of the Clean Air Act. SO_2 emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the primary NAAQS as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 3).
- The primary NAAQS for sulfur dioxide is a 1-hour 99^{th} percentile daily maximum of 75 ppb (195 µg/m^3).
- The 6 NYCRR Part 257 standard for sulfur dioxide is:
    - 99^{th} percentile of 3-hour average of 0.25 ppm (650 µg/m^3) and 3-hour maximum average of 0.5 ppm (1,300 µg/m^3) during a 12 month period.
    - 99^{th} percentile of 24-hour hour average of 0.10 ppm (260 µg/m^3) and 24-hour maximum average of 0.14 ppm (365 µg/m^3) during a 12 month period.
    - Annual 24-hour average of 0.03 ppm (80 µg/m^3) during a 12 month period.

Model output are summarized in the following table:

SO_2 Modeled Maximum Concentrations (μg/m³)

	1-hour 99th Percentile	3-hour	24-hour	Annual
AERMOD Output	39.55	38.56	24.13	2.04
Background	1.57	1.57	1.57	0.157
Total Concentration	41.12	40.13	25.70	2.20

The modeled concentrations meet the NAAQS and 6 NYCRR 257 ambient air quality standards. By achieving the NAAQS, the Facility achieves the necessary Degree of Air Cleaning Required.

Naphthalene

In accordance with DAR-1, naphthalene is designated as "M" for medium toxicity and is assigned an Environmental Rating of "B". Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 3.0 μg/m³.
- The SGC is 7,900.0 μg/m³.

Model output are summarized in the following table:

Naphthalene Modeled Maximum Concentrations (μg/m³)

1-hour	Annual
7.04	0.34

The maximum 1-hour concentration meets the SGC, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Hydrogen Sulfide (H_2S)

In accordance with DAR-1, hydrogen sulfide is designated as “M” for medium toxicity and is assigned an Environmental Rating of “B”. Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The 6 NYCRR Part 257 ambient air quality standard for hydrogen sulfide is a 1-hour average of 0.01 ppm (14 $\mu g/m^3$) due to the potential to cause odors that unreasonably interfere with the comfortable enjoyment of life and property.
- The AGC is 2.0 $\mu g/m^3$. There is no SGC.

Model output are summarized in the following table:

H_2S Modeled Maximum Concentrations ($\mu g/m^3$)

1-hour	Annual
1.25	0.06

The maximum 1-hour concentration meets the 6 NYCRR 257 ambient air quality standard, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Mercury

In accordance with DAR-1, mercury is designated as “H” for high toxicity and is assigned an Environmental Rating of “A”. Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 0.30 $\mu g/m^3$.
- The SGC is 0.60 $\mu g/m^3$.

Model output are summarized in the following table:

Mercury Modeled Maximum Concentrations ($\mu g/m^3$)

1-hour	Annual
0.028	0.0014

The maximum 1-hour concentration meets the SGC, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Methyl Disulfides and Trisulfides

This pollutant category includes di-methyl disulfide, which is the only methyl di/trisulfide listed in DAR-1. In accordance with DAR-1, di-methyl disulfide is designated as "M" for medium toxicity and is assigned an environmental rating of "B". Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 4.8 μg/m^3.
- The SGC is 14.0 μg/m^3.

The emission rate for Methyl Di/Trisulfides is the same as Hydrogen Sulfide; therefore, the modeled maximum concentrations for Hydrogen Sulfide are reported and Methyl Di/Trisulfides was not separately modeled. Model output are summarized in the following table:

Methyl Disulfides and Trisulfides Modeled Maximum Concentrations (μg/m^3)

1-hour	Annual
1.25	0.06

The maximum 1-hour concentration meets the SGC, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Ammonia (NH_3)

In accordance with DAR-1, ammonia is designated as "L" for low toxicity and is assigned an Environmental Rating of "C". Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 100.0 μg/m^3. There is no SGC.

Model output are summarized in the following table:

Ammonia Modeled Maximum Concentrations (μg/m^3)

1-hour	Annual
6.17	0.30

The modeled annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Methyl and Ethylamines

The pollutant category includes methylamine, di-methylamine, tri-methylamine, ethylamine, di-ethylamine, and tri-ethylamine. The most restrictive pollutant in the category is methylamine, which is designated as "M" for medium toxicity in accordance with DAR-1 and is assigned an environmental rating of "B". Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 15.0 μg/m^3.
- The SGC is 1,900 μg/m^3.

The emission rate for Methyl and Ethylamine is less than the emission rate for Ammonia; therefore, the modeled maximum concentrations for Ammonia are listed and separate modeling was not performed since the modeled results for the higher emission rate meet the applicable standard.

Model output are summarized in the following table:

Methyl and Ethylamines Modeled Maximum Concentrations (μg/m^3)

1-hour	Annual
<6.17	<0.30

The maximum 1-hour concentration meets the SGC, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Hydrogen Chloride

In accordance with DAR-1, hydrogen chloride is designated as "L" for low toxicity and is assigned an Environmental Rating of "C". Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 20.0 μg/m^3.
- The SGC is 2,100 μg/m^3.

The emission rate for Hydrogen Chloride is less than the emission rate for Hydrogen Sulfide; therefore, the modeled maximum concentrations for Hydrogen Sulfide are listed and separate modeling was not performed since the modeled results for the higher emission rate meet the applicable standard.

Model output are summarized in the following table:

Hydrogen Chloride Modeled Concentrations (μg/m^3)

1-hour	Annual
<1.25	<0.06

The maximum 1-hour concentration meets the SGC, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Acetic Acid

In accordance with DAR-1, acetic acid does not have a designated toxicity and is assigned an environmental rating of "C". Emissions are restricted by the following:

- The Degree of Air Cleaning Required must achieve the Guideline Concentration as demonstrated through air dispersion modeling (6 NYCRR 212-2.3 Table 4).
- The AGC is 60.0 μg/m^3.
- The SGC is 3,700 μg/m^3.

The emission rate for Acetic Acid is less than the emission rate for Hydrogen Sulfide; therefore, the modeled maximum concentrations for Hydrogen Sulfide are listed and separate modeling was not performed since the modeled results for the higher emission rate meet the applicable standard.

Model output are summarized in the following table:

Acetic Acid Modeled Concentrations (μg/m^3)

1-hour	Annual
<1.25	<0.06

The maximum 1-hour concentration meets the SGC, and the maximum annual concentration meets the AGC for all process lines. By achieving the Guideline Concentrations, the Facility achieves the necessary Degree of Air Cleaning Required.

Discussion:

As indicated in the AERMOD output, emissions achieve the necessary air standards and quickly dissipate near the Facility. The Facility is located within the Moreau Industrial Park with no sensitive receptors in close proximity. The following table identifies potentially sensitive receptors within 1.0 mile of the Facility and are shown on the attached Figure 1:

Receptor	Distance (Miles)
Fort Edward Draft DAC (closest boundary)	0.3
Hudson Falls Draft DAC (closest boundary)	0.75
Home of Good Shepherd (assisted living center)	0.5
Fort Hudson Health System (healthcare provider)	0.8

As observed in the plume dispersion plots in Attachment 2, air standards are achieved at the locations of potentially sensitive receptors, and Facility emissions do not disproportionately impact the draft DACs in compliance with CLCPA Section 7(3).

Section 7(3) of the CLCPA also requires prioritizing reductions of greenhouse gas (GHG) emissions in draft DACs. The CLCPA states that "the department shall prioritize measures to maximize **net** reductions of greenhouse gas emissions and co-pollutants in DACs" (emphasis added). Biosolids are currently managed daily throughout New York State with a baseline GHG emission.

SBS retained the services of EcoEngineers to perform a life cycle analysis (LCA) on the manufactured Carbon Fertilizer™ to obtain a carbon intensity (CI) to quantify the greenhouse gas (GHG) footprint of the Facility for comparison to baseline disposal methods for biosolids. The LCA was performed using standard practices that are adopted under many carbon crediting programs, and a copy of the report is included in Attachment 3. The Facility has direct GHG emissions associated with feedstock transportation, energy use (i.e., electricity and natural gas), chemical use (i.e., air treatment scrubbers), and final product transportation. The carbon sequestration value of the manufactured Carbon Fertilizer™ alone exceeds the Facility's direct GHG emissions, yielding a carbon negative GHG footprint. The Facility also directly offsets GHG emissions associated with avoided biosolids disposal and displaced chemical fertilizer production. As indicated in the report, the Facility is expected to result in a gross GHG reduction of 235% and a net GHG reduction of 135% on a life cycle basis after deducting the Facility's direct GHG emissions. As the Facility diverts biosolids from current higher GHG emitting management practices, the net statewide GHG emissions will decrease.

Conclusions:

As described in this supplemental information and supported by the refined air emissions modeling, the Facility achieves applicable air quality standards and will not disproportionately impact or burden draft DACs. The Facility prioritizes reductions in GHG emissions and co-pollutants, and the Facility will include engineered air pollution control devices to mitigate potential impacts from air emissions.

We trust that this letter and supporting documentation satisfies NYSDEC's review comments and completes the assessment required by Section 7(3) of the CLCPA in support of obtaining a complete application.

Please contact me should you have any questions or comments.

Very truly yours,
STERLING ENVIRONMENTAL ENGINEERING, P.C.

Andrew M. Millspaugh, P.E.
Vice President
Andrew.Millspaugh@sterlingenvironmental.com

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Attachments

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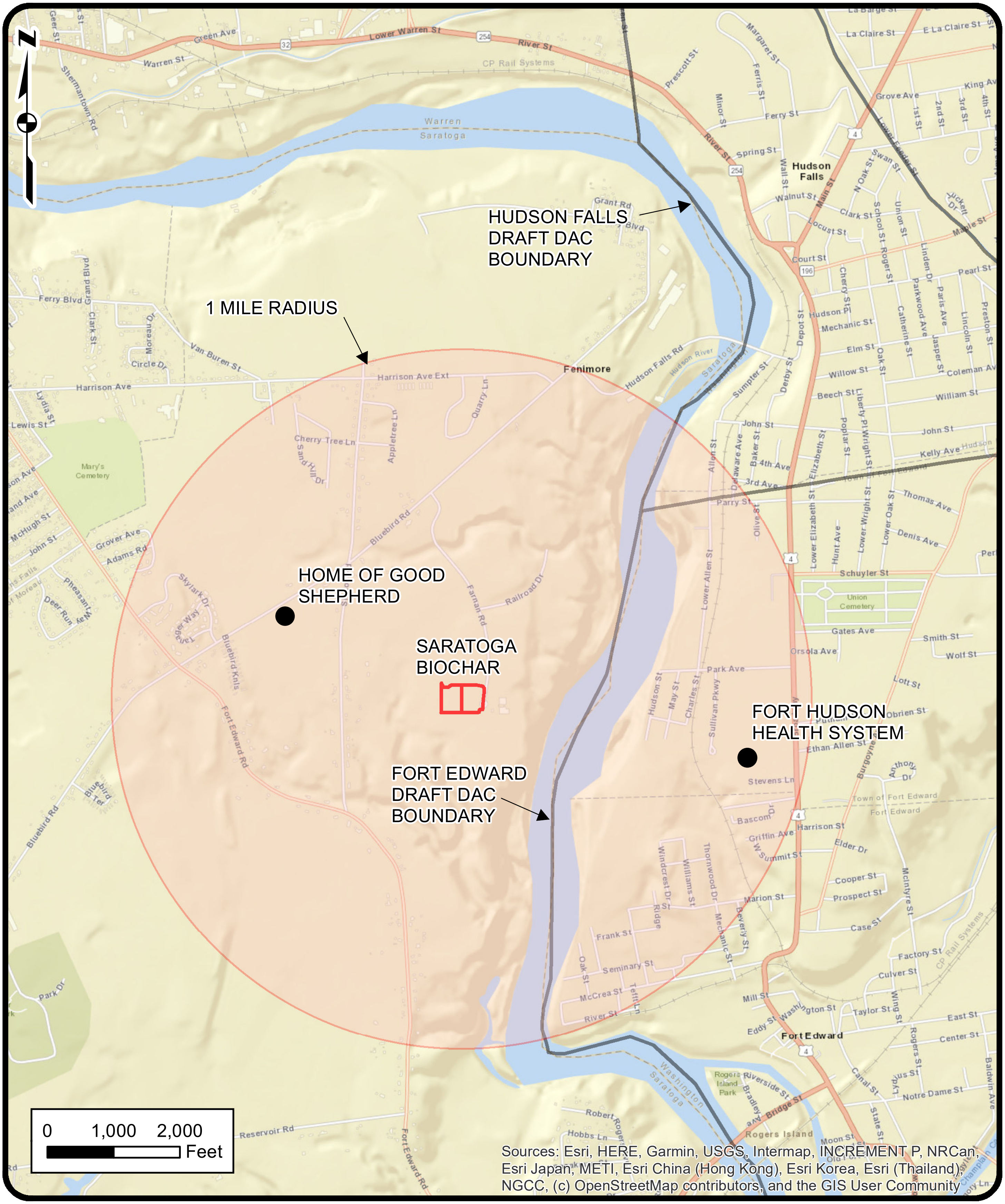
FIGURE



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POTENTIALLY SENSITIVE RECEPTORS
SARATOGA BIOCHAR SOLUTIONS, LLC
CARBON FERTILIZER MANUFACTURING FACILITY
TOWN OF MOREAU SARATOGA CO., NY

PROJ.NO. 2020-20	DATE: 2/24/2023	SCALE: 1 " = 2,000 '	DWG.NO. 2020-20005G	FIGURE 1

TABLES

Table 1
AERMOD Calculated Concentrations
Saratoga Biochar Solutions, LLC
Carbon Fertilizer Manufacturing Facility

Pollutant	Averaging Time	Limit (μg/m^3)	Modeled Concentration (μg/m^3)	Background Concentration (μg/m^3)	Total Concentration (μg/m^3)
PM-2.5	Annual	12	0.30	5.78	6.08
	24 Hr 98th Percentile	35	1.50	15.70	17.20
PM-10	24 Hr	150	3.53	42.30	45.83
Nitrogen Dioxide	Annual	100	2.06	12.70	14.76
	1 Hr 98th Percentile	188	37.5	61.0	98.50
Sulfur Dioxide	Annual	80	2.04	0.157	2.20
	24 Hr[5]	365	24.13	1.57	25.70
	24 Hr 99th Percentile[4,5]	260	24.13	1.57	25.70
	3 Hr[5]	1,300	38.56	1.57	40.13
	3 Hr 99th Percentile[4,5]	650	38.56	1.57	40.13
	1 Hr 99th Percentile	195	39.55	1.57	41.12
Naphthalene	Annual	3.0	0.34	--	0.34
	1 Hr	7,900	7.04	--	7.04
Hydrogen Sulfide	Annual	2.0	0.06	--	0.06
	1 Hr	14	1.25	--	1.25
Mercury	Annual	0.30	0.0014	--	0.0014
	1 Hr	0.60	0.028	--	0.028
Methyl Di/Trisulfides[1]	Annual	4.8	0.06	--	0.06
	1 Hr	14	1.25	--	1.25
Ammonia	Annual	100	0.30	--	0.30
	1 Hr	--	6.17	--	6.17
Methyl/Ethylamines[2]	Annual	15	<0.30	--	<0.30
	1 Hr	1,900	<6.17	--	<6.17
Hydrogen Chloride[3]	Annual	20	<0.06	--	<0.06
	1 Hr	2,100	<1.25	--	<1.25
Acetic Acid[3]	Annual	60.0	<0.06	--	<0.06
	1 Hr	3,700	<1.25	--	<1.25

NOTES:

1. The emission rate for Methyl Di/Trisulfides is the same as Hydrogen Sulfide; therefore, Methyl Di/Trisulfides was not separately modeled and the modeled result for Hydrogen Sulfide is listed.

2. The emission rate is less than the emission rate for Ammonia. The modeled results for Ammnoia are listed for comparison to the corresponding limits. Separate modeling was not performed since the modeled results for the higher emission rate meets the corresponding limits.

3. The emission rates for the identified pollutants are less than the emission rate for Hydrogen Sulfide. The modeled results for Hydrogen Sulfide are listed for comparison to the corresponding limits. Separate modeling for the identified pollutants was not performed since the modeled results for the higher emission rate meets the corresponding limits.
4. The maximum modeled concentration is also compared to 99th percentile limit.
5. The 1-Hour Background Concentration is applied to this averaging time.
6. -- = Not Applicable

Table 2
Calculated Background Concentrations
Saratoga Biochar Solutions, LLC
Carbon Fertilizer Manufacturing Facility

Station ID	Station City	Station State	Parameter	Concentrations (µg/m3)				Background Standard
				2021	2020	2019	Background	
500030004	Bennington	VT	PM2.5 Annual	6.11	5.62	5.62	5.78	Average of the annual concentrations over most recent 3 years
500030004	Bennington	VT	PM2.5 24-HR	15.5	18.0	13.7	15.7	Average of the 98th percentile concentration over most recent 3 years
500210002	Rutland	VT	PM10 24-HR	44	30	53	42.3	Average of highest 24-hr concentrations over most recent 3 years
500210002	Rutland	VT	NO2 Annual	11.2	10.8	12.7	12.7	Highest annual concentration over the most recent 3 years
500210002	Rutland	VT	NO2 1-HR	57.2	59.8	65.9	61.0	Average of the 98th percentile concentation over most recent 3 years
360410005	Piseco Lake	NY	SO2 Annual	0.157	0.079	0.131	0.157	Highest annual concentration over the most recent 3 years
360410005	Piseco Lake	NY	SO2 1-HR	1.57	1.57	1.57	1.57	Average of the 99th percentile concentration over most recent 3 years

NOTES:

1. Background Standards from Table 3 of DAR-10 NYSDEC Guidelines on Dispersion Modeling Procedures for Air Quality Impact Analysis
2. Background data obtained from USEPA Air Quality Systems Annual Summary Data
3. Background data for NO_2 and SO_2 were provided in ppb and converted to ug/m^3.

ATTACHMENT 1

EMISSIONS ESTIMATES

SARATOGA BIOCHAR SOLUTIONS, LLC
CARBON FERTILIZER MANUFACTURING FACILITY
MOREAU, NY

FACILITY EMISSIONS SUMMARY - EMISSION RATE POTENTIAL (ERP)

Biosolids input at 23% solids content and wood waste input at 60% solids. Syngas heating value at 8,616 BTU/lb (Case 1A).

Description:	**Carbon Fertilizer Manufacturing Facility**	
Fuel:	**Natural Gas & Syngas[3]**	
Capacity:	**10**	**wet tons/hour biosolids (per process line)**
Process Operations:	**8,760**	**hours/year (24 hr/day, 365 day/year)**
Air Extraction:	**34,146**	**actual cubic feet per minute (acfm, per process line)**

Description/ CAS number	Chemical name	Source Emission Rate[1] mg/m^3	Source Emission Rate lb/ft^3	Single Process Line Emission Rate Potential (ERP) lb/hr	(lb/yr)	(ton/yr)	Maximum Facility ERP (Three Process Lines) lb/hr	(lb/yr)	(ton/yr)
Criteria Pollutants:									
NY075-00-0	Particulate Matter (PM)[2]	50.50	3.15E-06	6.46	56,582	28.29	19.38	169,745	84.9
0NY210-00-0	Nitrogen Oxides (NOx)	34.53	2.16E-06	4.42	38,689	19.34	13.25	116,066	58.0
007446-09-5	Sulfur Dioxide (SO_2)	684.95	4.28E-05	87.61	767,438	383.72	262.82	2,302,313	1,151.2
Non-Criteria Pollutants:									
00124-38-9	Carbon Dioxide (CO_2)	49,636	3.10E-03	6,349	55,613,240	27,807	19,046	166,839,720	83,420
10024-97-2	Nitrous Oxide (N_2O)[4]	34.53	2.16E-06	4.42	38,689	19.34	13.25	116,066	58.0
07644-41-7	Ammonia (NH3)	112.50	7.02E-06	14.39	126,048	63.02	43.2	378,144	189.1
07783-06-4	Hydrogen Sulfide (H2S)	25.00	1.56E-06	3.20	28,011	14.01	9.6	84,032	42.0
multiple	Methyl and Ethylamines	11.30	7.05E-07	1.45	12,661	6.33	4.3	37,982	19.0
07647-01-0	Hydrochloric Acid	0.90	5.62E-08	0.12	1,008	0.50	0.3	3,025	1.5
00064-19-7	Acetic Acid	0.60	3.75E-08	0.08	672	0.34	0.2	2,017	1.0
multiple	Methyl Disulfides and Trisulfides	6.60	4.12E-07	0.84	7,395	3.70	2.5	22,184	11.1
00091-20-3	Naphthalene	1,136	7.09E-05	145.3	1,272,828	636.4	436	3,818,484	1,909
07439-97-6	Mercury	0.0226	1.41E-09	0.0029	25.4	0.013	0.0087	76.1	0.038

Notes:

1. Source Emission Rates provided by facility designer based on bench tests with representative biosolids. To be verified after startup of first process line.
2. All particulate matter assumed to be PM-2.5
3. Natural gas is only used in the pyrolysis reactor. Under normal operations, renewable syngas generated by the facility will fuel drying equipment.
4. Nitrous Oxide emissions included for greenhouse gas emissions assessment and conservatively assumed to be 100% of NOx emmission. PTE calculation assumes 99% N2O reduction through multi-stage thermal oxidizer.

FACILITY EMISSIONS SUMMARY - POTENTIAL TO EMIT (PTE)

Biosolids input at 23% solids content and wood waste input at 60% solids. Syngas heating value at 8,616 BTU/lb (Case 1A).

Description:	**Carbon Fertilizer Manufacturing Facility**	
Fuel:	**Natural Gas & Syngas[3]**	
Capacity:	**10**	**wet tons/hour biosolids (per process line)**
Process Operations:	**7,840**	**hours/year (24 hr/day, 365 day/year, 90% uptime)**
Air Extraction:	**34,146**	**actual cubic feet per minute (acfm, per process line)**

Description/ CAS number	Chemical name	Source Emission Rate[1] mg/m^3	Source Emission Rate lb/ft^3	Single Process Line Potential to Emit (PTE) lb/hr	Single Process Line PTE (lb/yr)	Single Process Line PTE (ton/yr)	Maximum Facility PTE (Three Process Lines) lb/hr	Maximum Facility PTE (lb/yr)	Maximum Facility PTE (ton/yr)
Criteria Pollutants:									
NY075-00-0	Particulate Matter (PM)[2]	5.00	3.12E-07	0.64	5,014	2.51	1.92	15,042	7.52
0NY210-00-0	Nitrogen Oxides (NOx)	34.53	2.16E-06	4.42	34,626	17.31	13.25	103,879	51.9
007446-09-5	Sulfur Dioxide (SO_2)	34.25	2.14E-06	4.38	34,343	17.17	13.14	103,029	51.5
Non-Criteria Pollutants:									
00124-38-9	Carbon Dioxide (CO_2)	49,636	3.10E-03	6,349	49,773,850	24,887	19,046	149,321,549	74,661
10024-97-2	Nitrous Oxide (N_2O)[4]	0.35	2.16E-08	0.044	346	0.17	0.13	1,039	0.5
07644-41-7	Ammonia (NH3)	5.00	3.12E-07	0.64	5,014	2.51	1.9	15,042	7.5
07783-06-4	Hydrogen Sulfide (H2S)	1.00	6.24E-08	0.13	1,003	0.50	0.4	3,008	1.5
multiple	Methyl and Ethylamines	2.00	1.25E-07	0.26	2,006	1.00	0.8	6,017	3.0
07647-01-0	Hydrochloric Acid	0.90	5.62E-08	0.12	903	0.45	0.3	2,708	1.4
00064-19-7	Acetic Acid	0.60	3.75E-08	0.08	602	0.30	0.2	1,805	0.9
multiple	Methyl Disulfides and Trisulfides	1.00	6.24E-08	0.13	1,003	0.50	0.4	3,008	1.5
00091-20-3	Naphthalene	5.68	3.55E-07	0.73	5,696	2.85	2.18	17,088	8.5
07439-97-6	Mercury	0.0226	1.41E-09	0.0029	22.7	0.011	0.0087	68.1	0.034

Notes:

1. Source Emission Rates provided by facility designer based on bench tests with representative biosolids. To be verified after startup of first process line.
2. All particulate matter assumed to be PM-2.5
3. Natural gas is only used in the pyrolysis reactor. Under normal operations, renewable syngas generated by the facility will fuel drying equipment.
4. Nitrous Oxide emissions included for greenhouse gas emissions assessment and conservatively assumed to be 100% of NOx emmission. PTE calculation assumes 99% N2O reduction through multi-stage thermal oxidizer.

ATTACHMENT 2

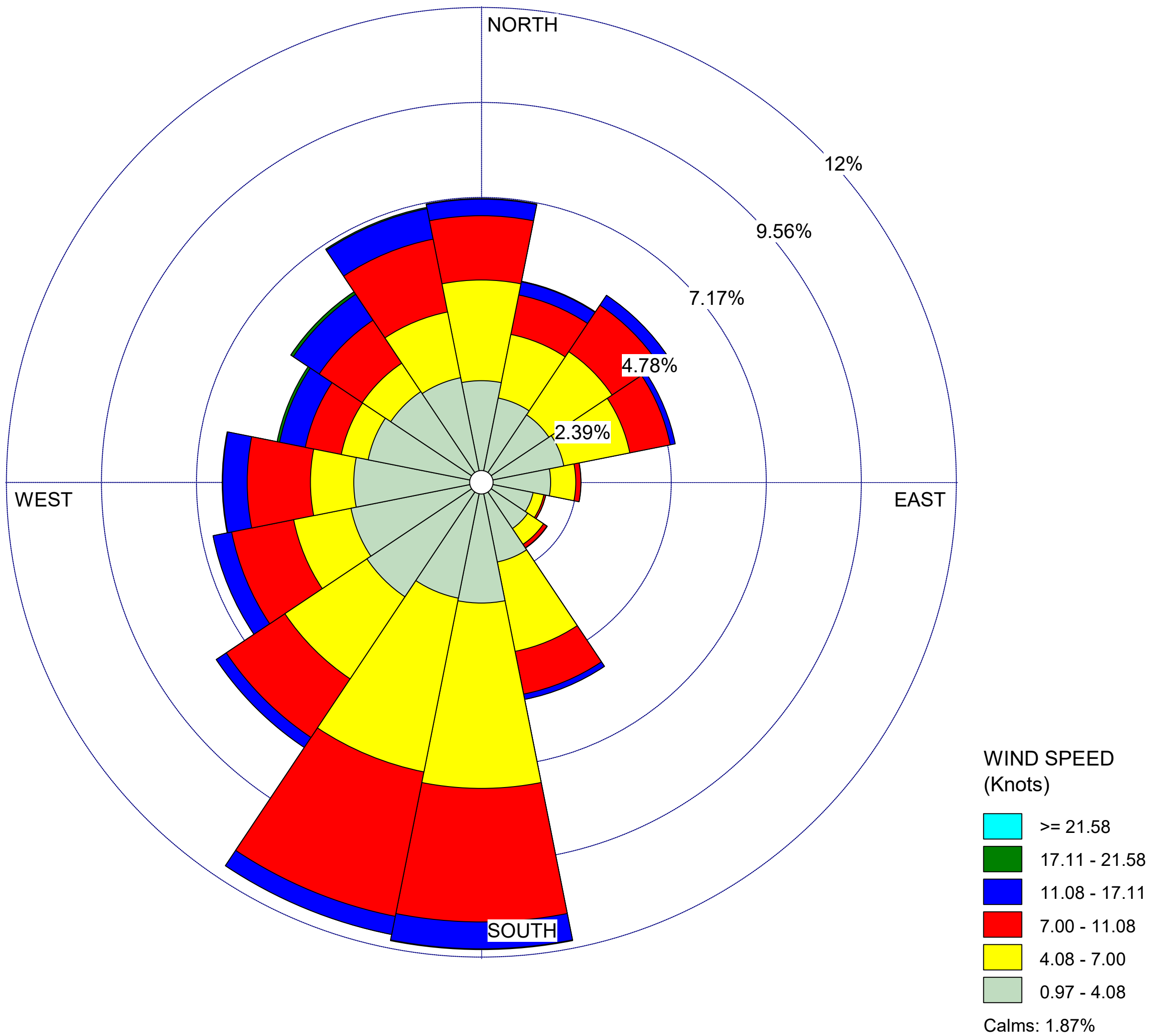
AERMOD OUTPUT

WIND ROSE PLOT:

KGFL - Glens Falls Airport, Glens Falls, NY
2017-2021

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: **Start Date: 1/1/2017 - 00:00** **End Date: 12/31/2021 - 23:59**	COMPANY NAME:	
		MODELER:	
	CALM WINDS: **1.87%**	TOTAL COUNT: **43458 hrs.**	
	AVG. WIND SPEED: **5.39 Knots**	DATE: **7/7/2022**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

ATTACHMENT 2A

PARTICULATE MATTER (PM-2.5)

Results Summary

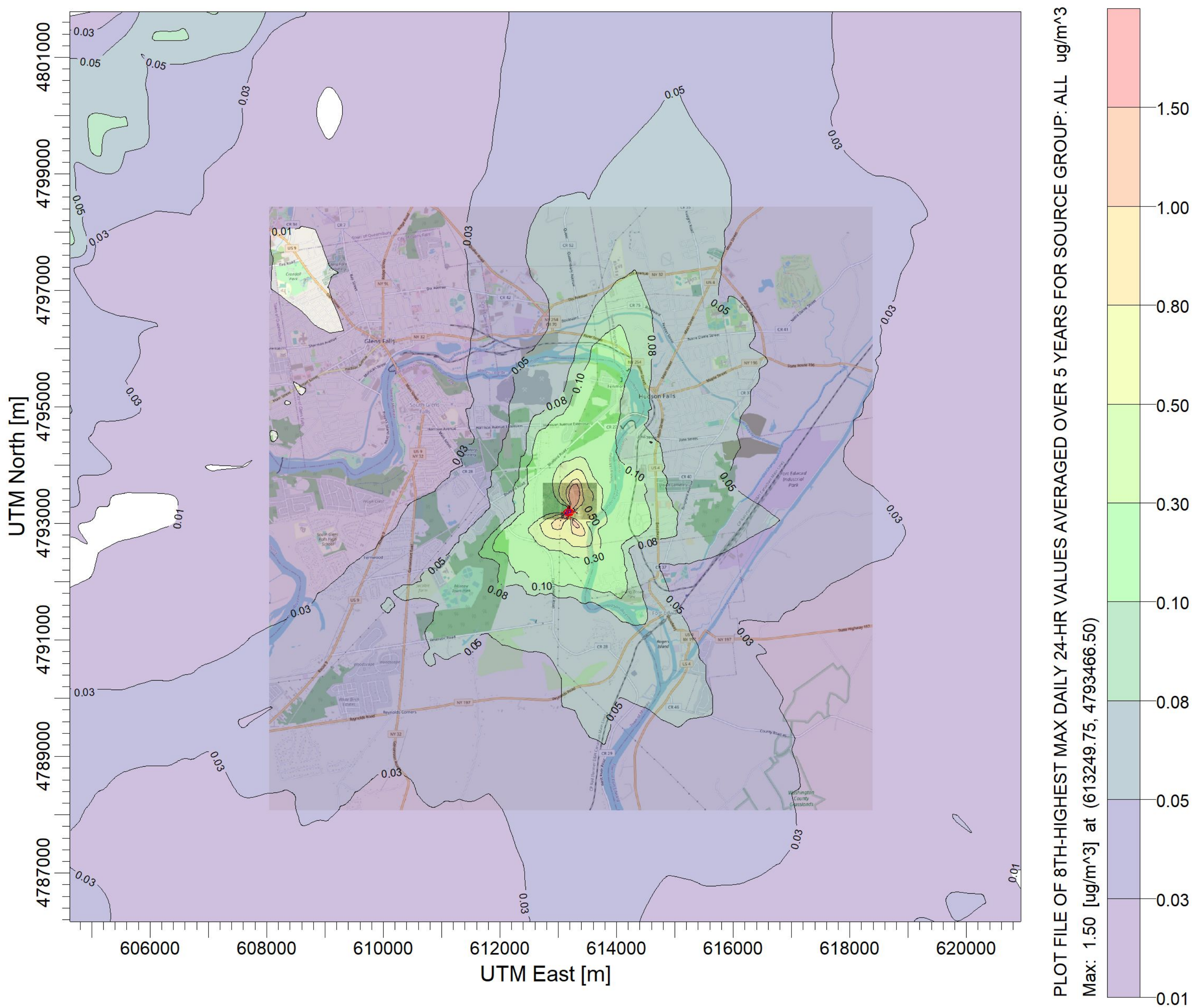
Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

PM-2.5 NAAQS - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
24-HR	1ST	2.66861	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	
24-HR	8TH	1.49937	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	
ANNUAL		0.29780	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

PM-2.5 - 24 HR NAAQS

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

1.50 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/16/2023

SCALE: 1:106,338

0 3 km

PROJECT NO.:

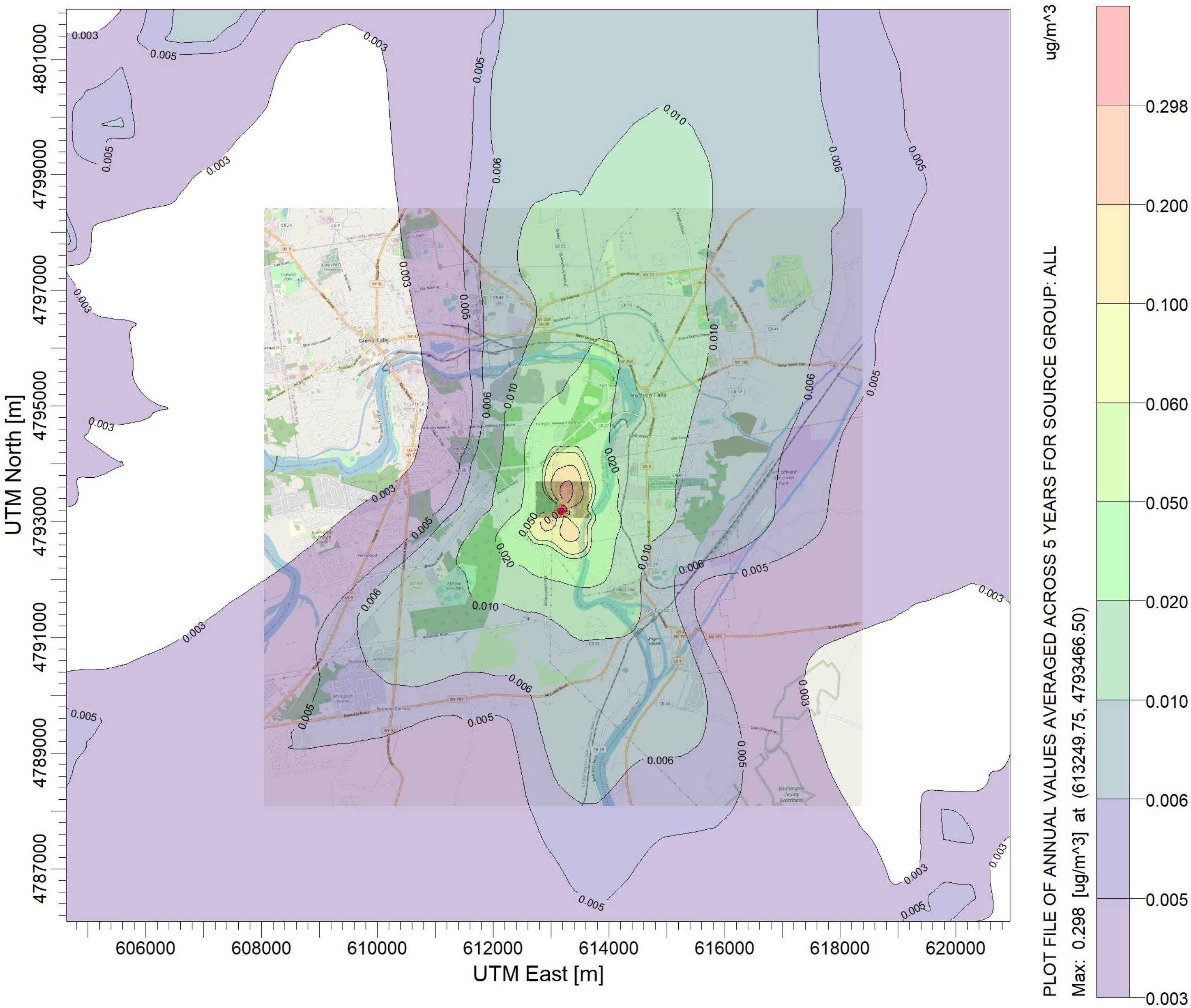
2020-20

AERMOD View - Lakes Environmental Software

C:\Lakes\AERMOD View\SBSMoreau\SBSMoreau.isc

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

PM-2.5 - Annual

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

0.298 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/16/2023

SCALE: 1:107,395

0 3 km

PROJECT NO.:

2020-20

AERMOD View - Lakes Environmental Software

C:\Lakes\AERMOD View\SBSMoreau\SBSMoreau.isc

ATTACHMENT 2B

PARTICULATE MATTER (PM-10)

Results Summary

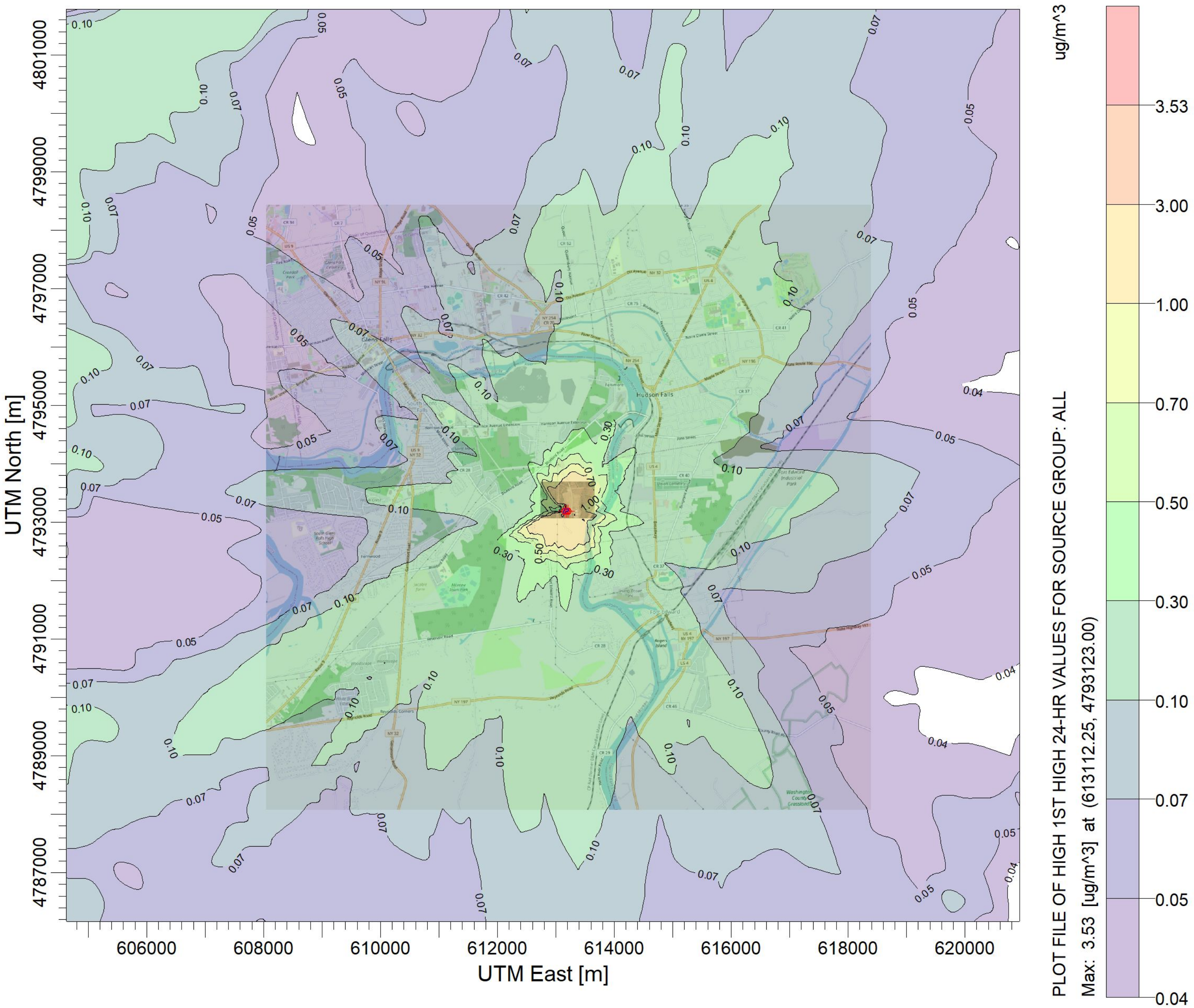
Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

PM10 - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
24-HR	1ST	3.52515	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	4/16/2018, 24
24-HR	8TH	2.38239	ug/m^3	613132.54	4793144.32	73.50	0.00	73.50	10/27/2021, 24
ANNUAL		0.29780	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

PM-10_NAAQS

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

3.53 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/16/2023

SCALE: 1:106,338

0 3 km

PROJECT NO.:

2020-20

ATTACHMENT 2C

NITROGEN DIOXIDE (NO_2)

Results Summary

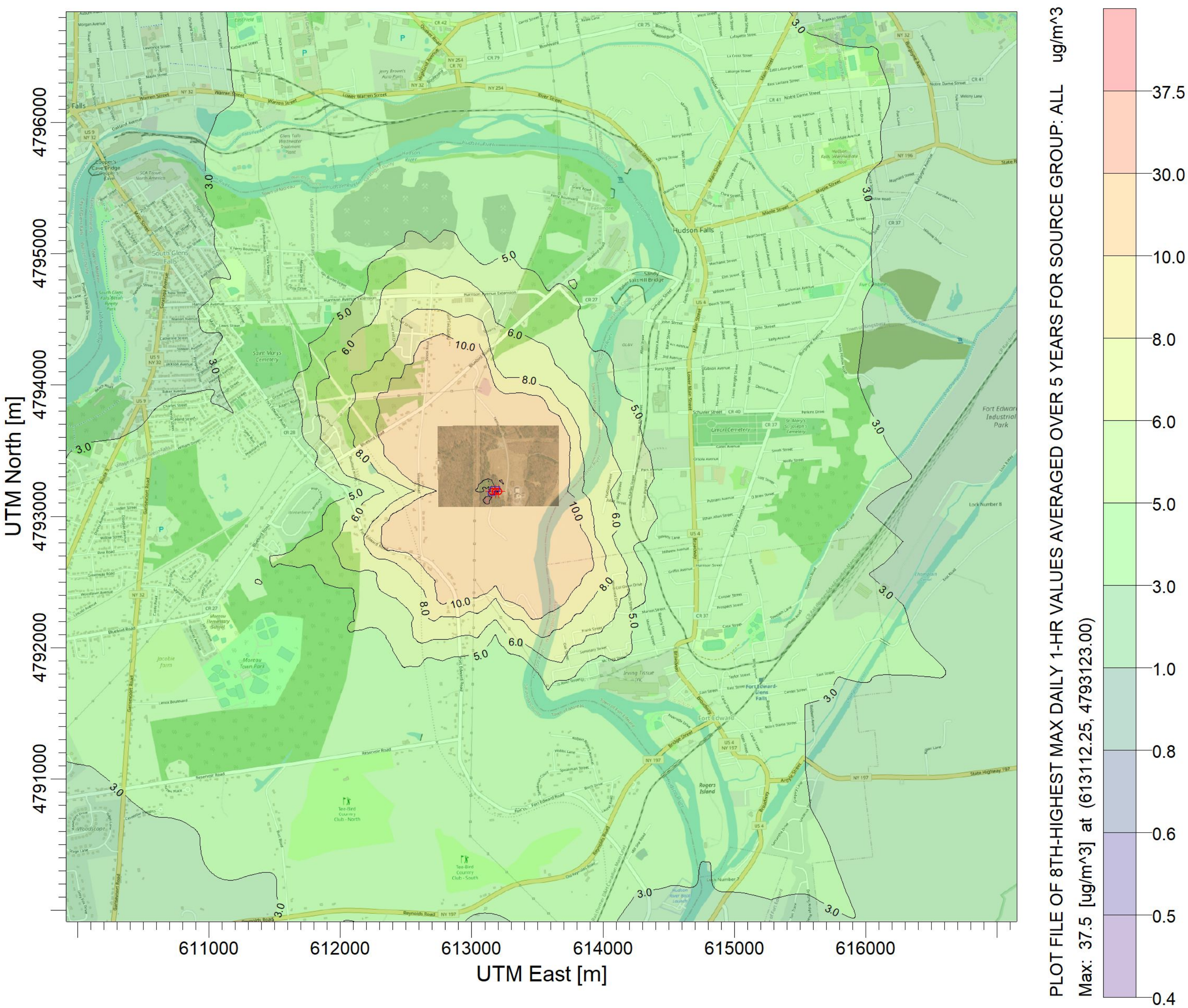
Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

NO2 - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	42.31248	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	
1-HR	8TH	37.50452	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	
ANNUAL		2.05669	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

NO2-NAAQS

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

37.5 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/14/2023

SCALE: 1:47,182

0 1 km

PROJECT NO.:

2020-20

AERMOD View - Lakes Environmental Software

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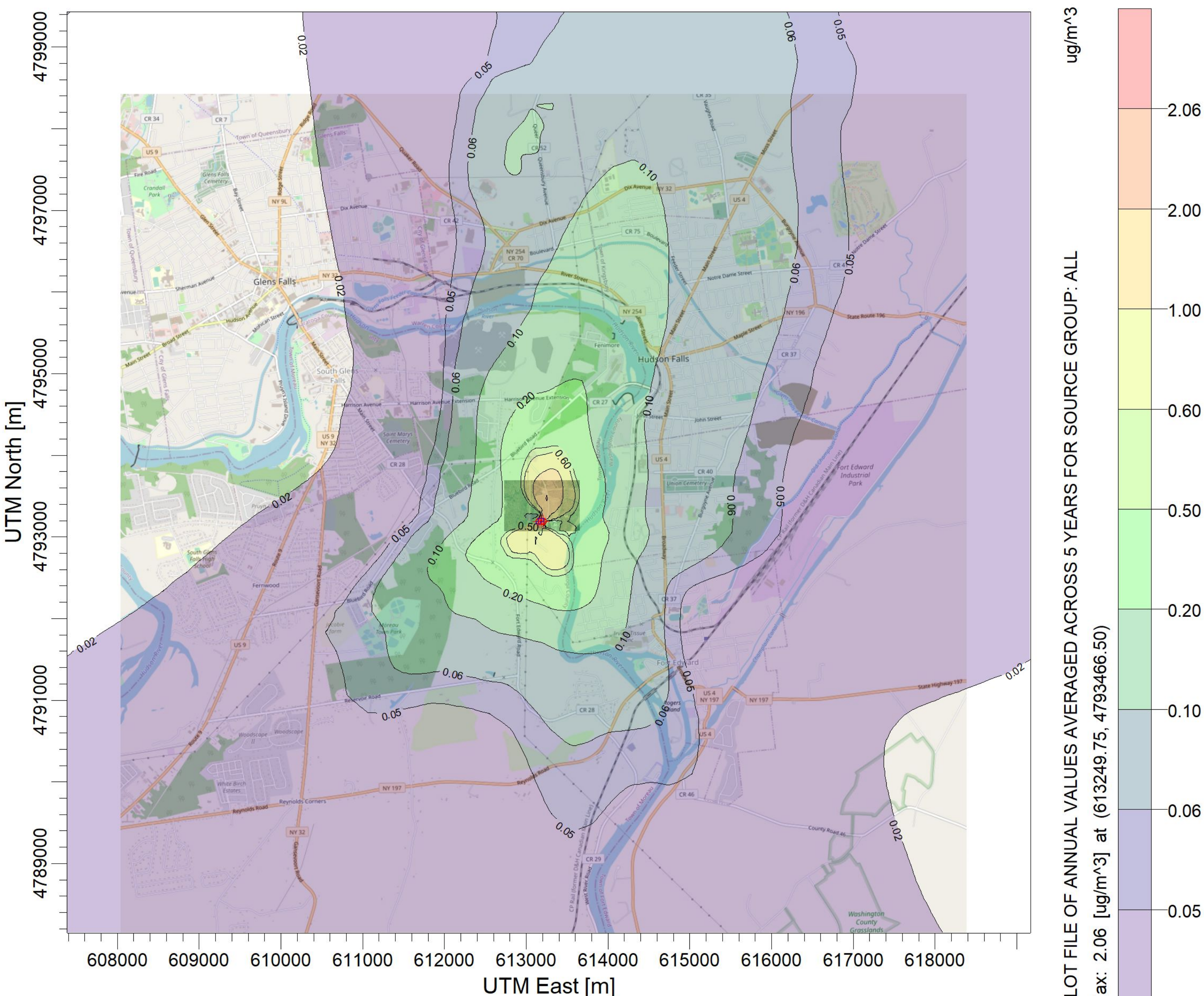
PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:	NO2 - Annual
SOURCES:	**3**
RECEPTORS:	**5165**
OUTPUT TYPE:	**Concentration**
MAX:	**2.06 ug/m^3**
COMPANY NAME:	**Sterling Environmental Engineering, P.C.**
MODELER:	**AMM**
DATE:	**2/14/2023**
SCALE:	1:76,828 (0 — 2 km)
PROJECT NO.:	**2020-20**

ATTACHMENT 2D

SULFUR DIOXIDE (SO_2)

Results Summary

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

SO2 - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	41.92956	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	
1-HR	4TH	39.55148	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	
ANNUAL		2.03807	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

Results Summary

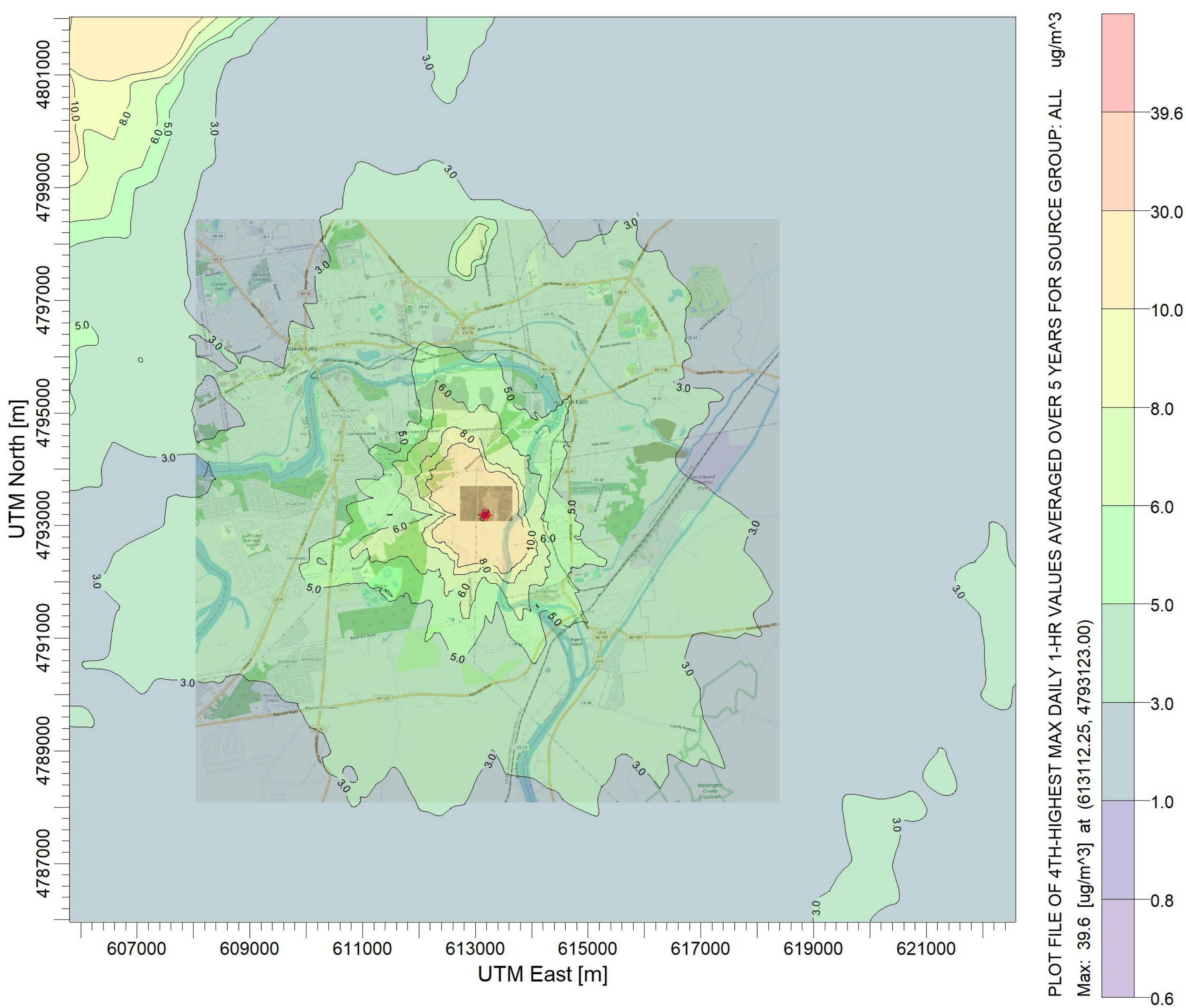
Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

SO2 - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
3-HR	1ST	38.55889	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	4/16/2018, 6
24-HR	1ST	24.12526	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	4/16/2018, 24

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

SO2_1HR NAAQS

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

39.6 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/16/2023

SCALE: 1:109,436

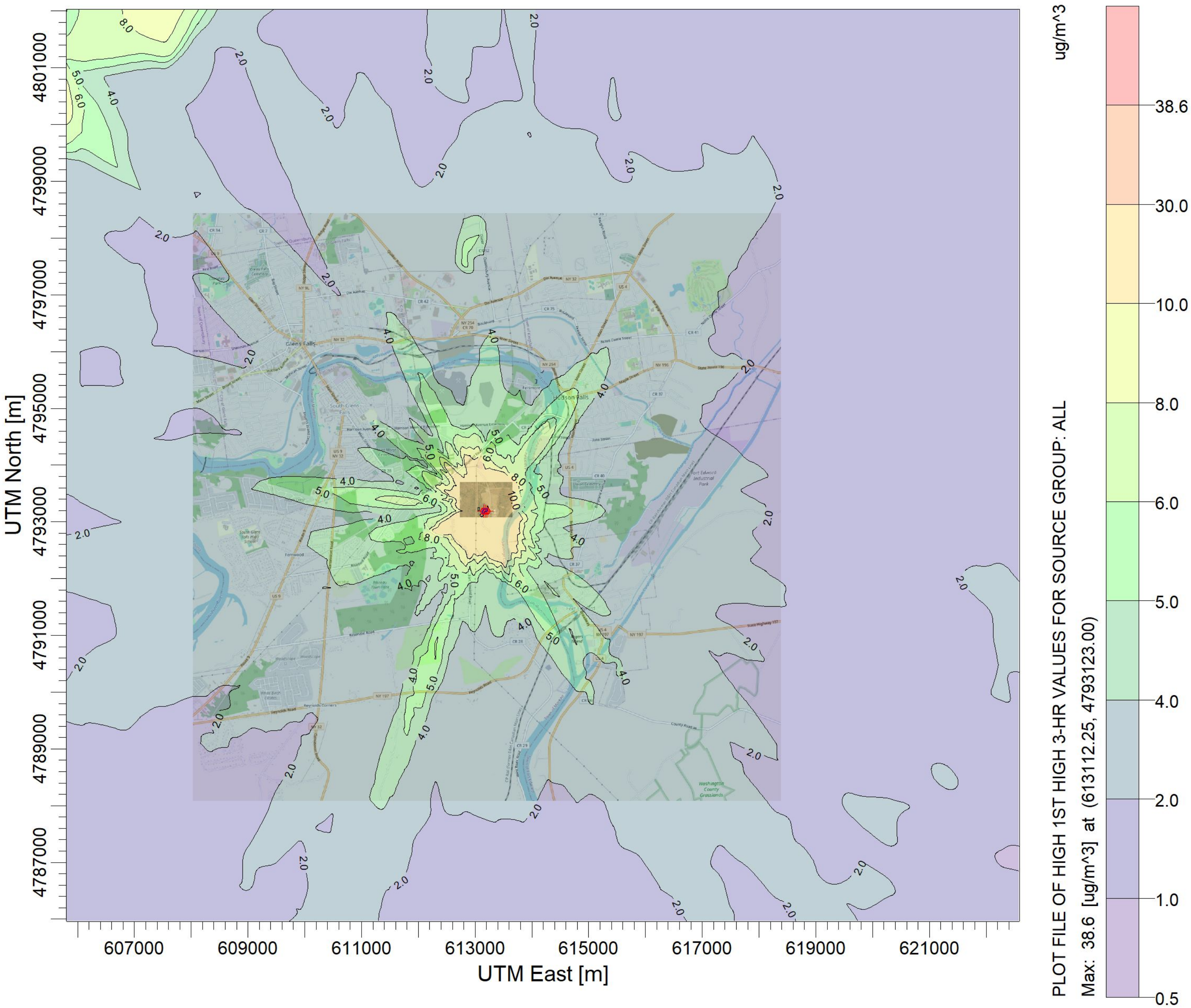
0 3 km

PROJECT NO.:

2020-20

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

SO2_3HR

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

38.6 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:109,436

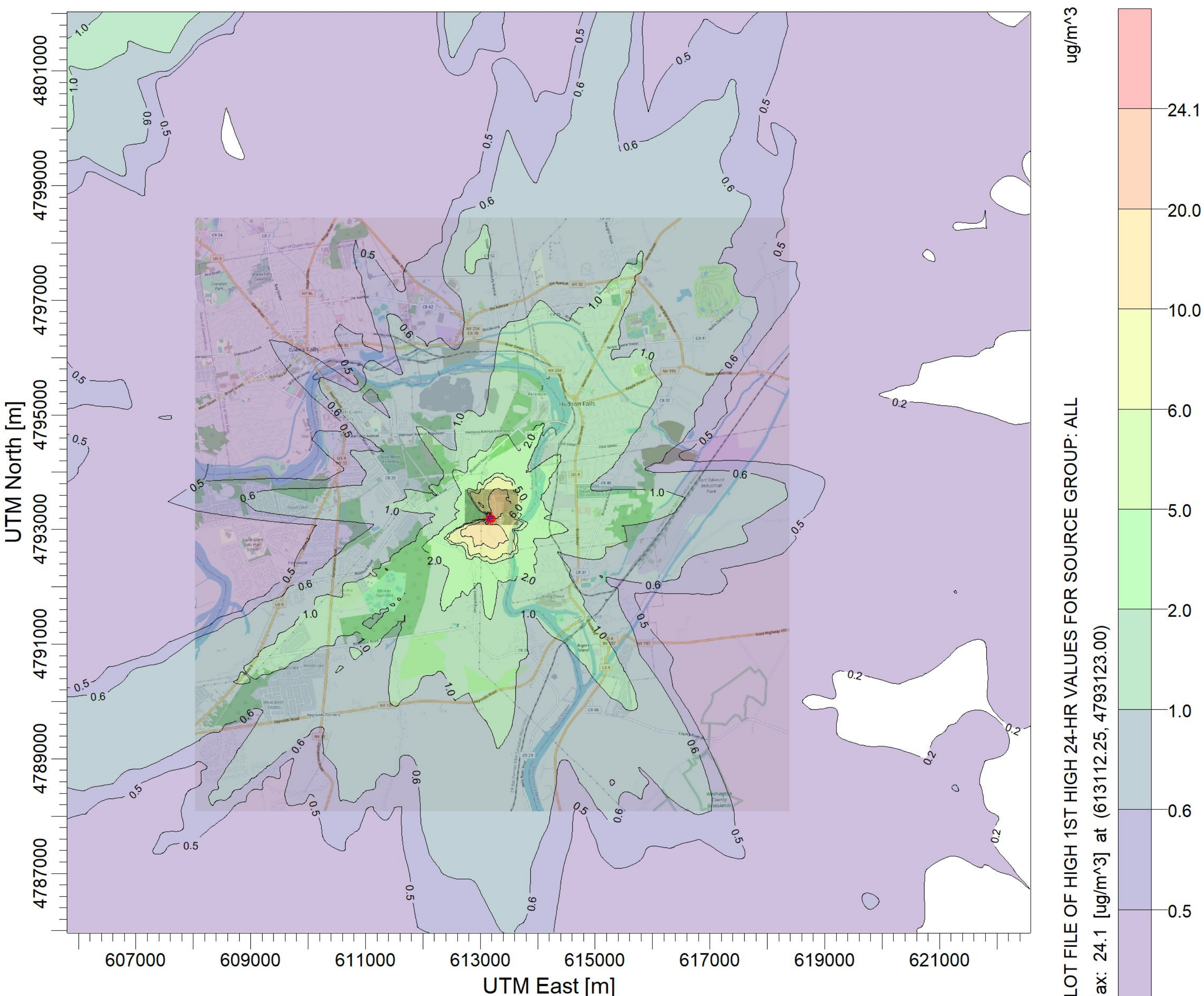
0 3 km

PROJECT NO.:

2020-20

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

SO2_24HR

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

24.1 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:109,436

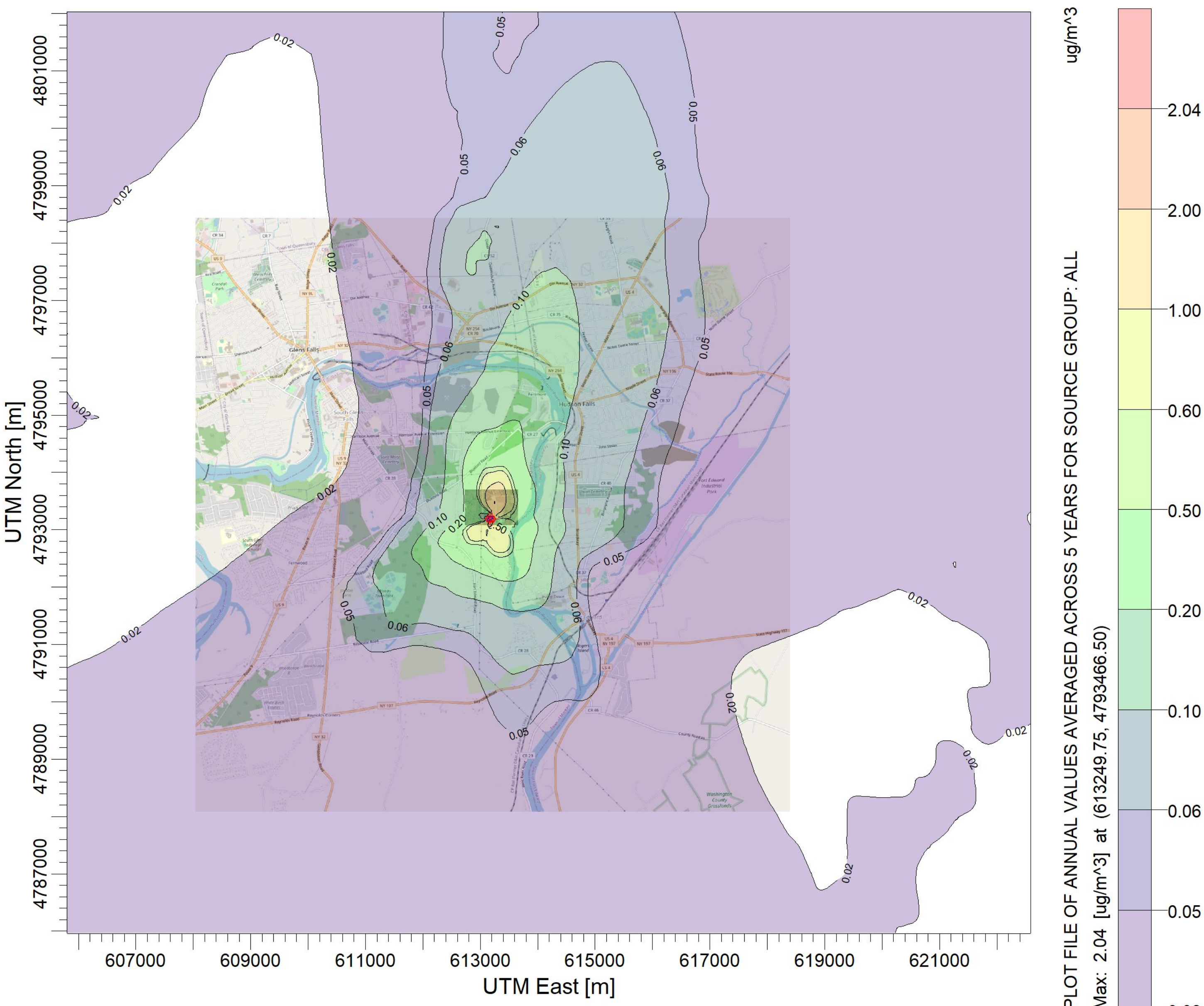
0 3 km

PROJECT NO.:

2020-20

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

SO2_Annual

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

2.04 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/16/2023

SCALE: 1:109,436

0 3 km

PROJECT NO.:

2020-20

ATTACHMENT 2E

NAPHTHALENE

Results Summary

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

NAPH - Concentration - Source Group: ALL

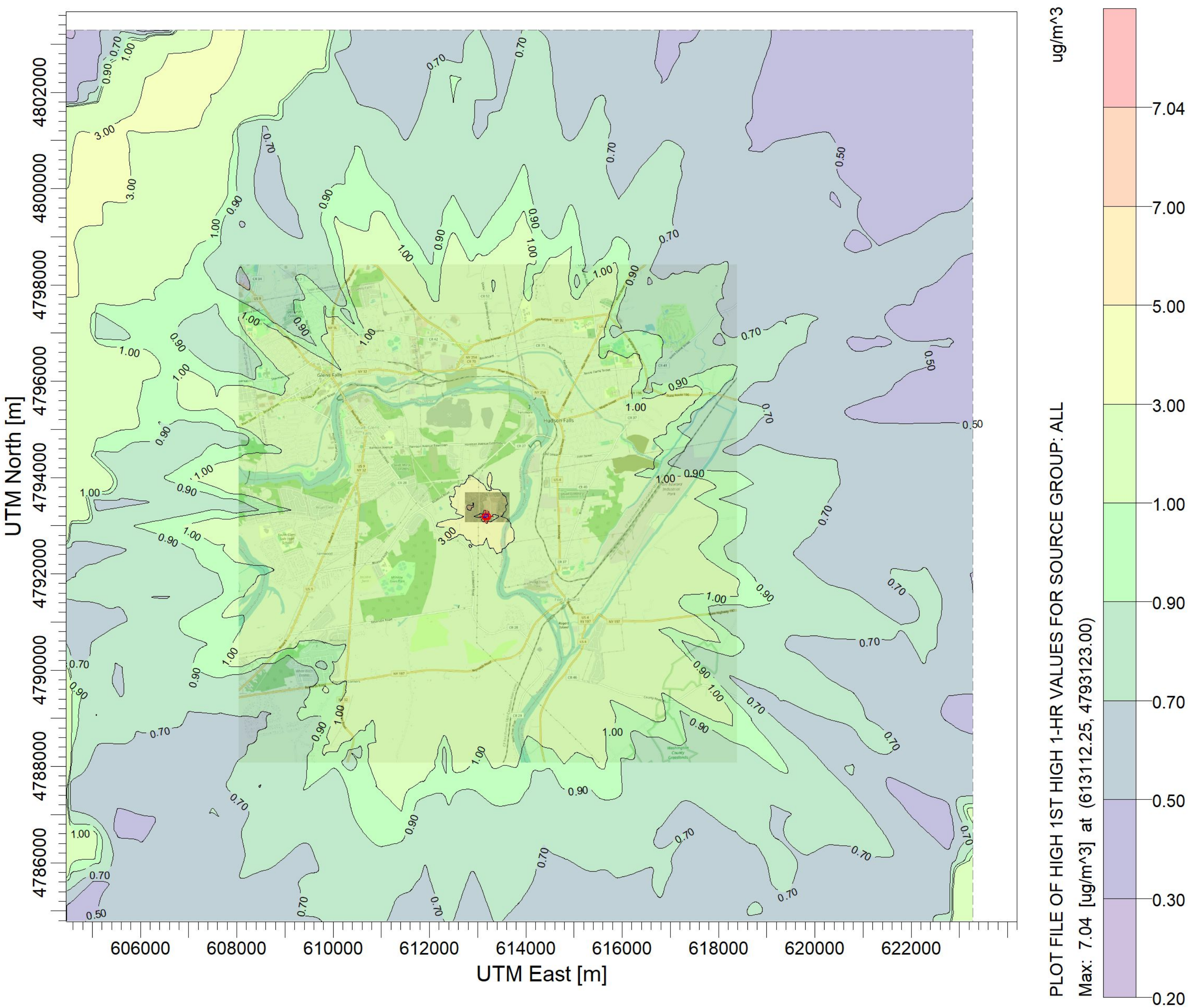
Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	7.04259	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	3/31/2020, 12
ANNUAL		0.33968	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

COMMENTS:

Naphthalene - 1HR



SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

7.04 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:128,682

0 4 km

PROJECT NO.:

2020-20

AERMOD View - Lakes Environmental Software

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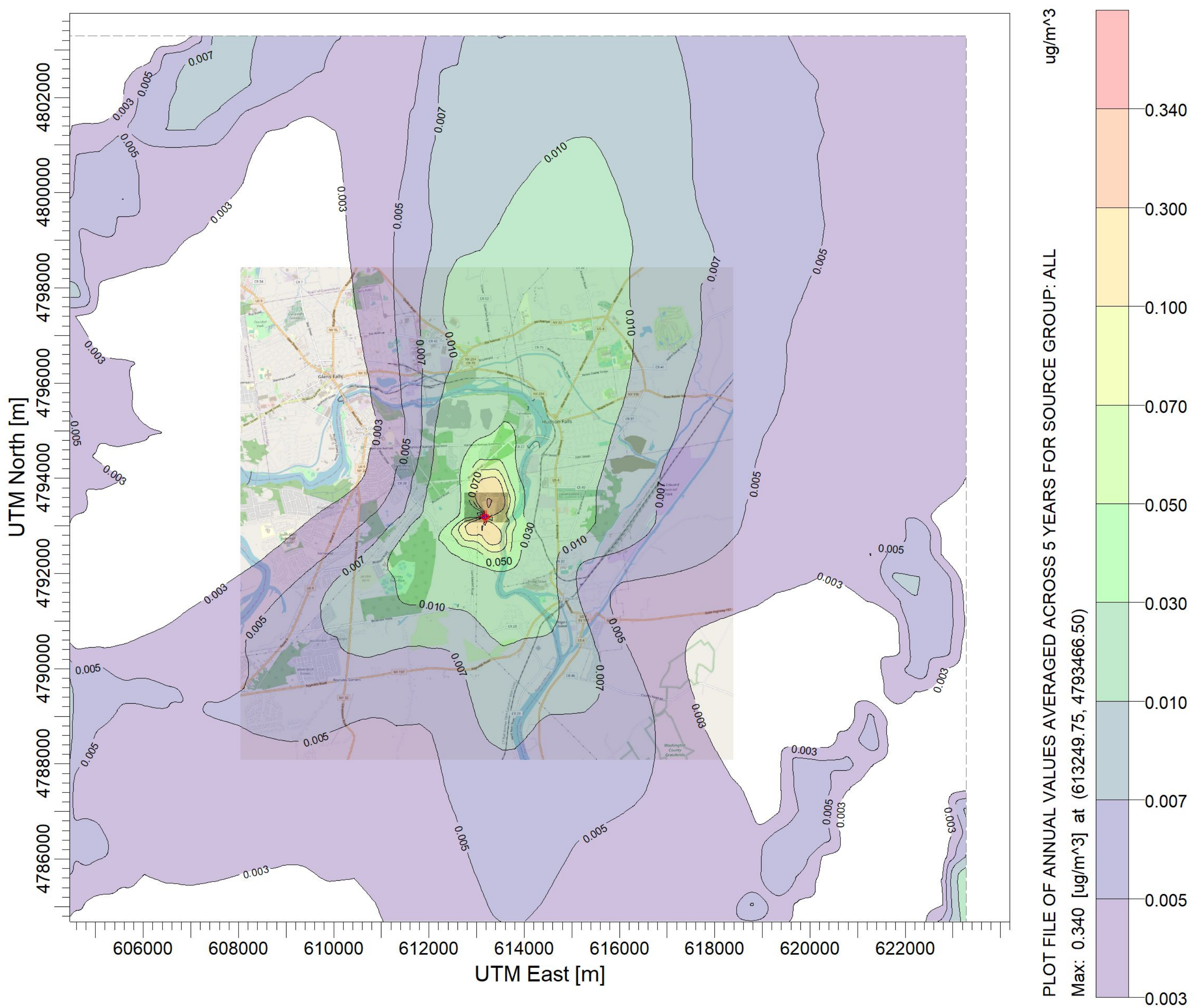
PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

Naphthalene - Annual

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

0.340 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:129,968

0 4 km

PROJECT NO.:

2020-20

ATTACHMENT 2F

HYDROGEN SULFIDE

Results Summary

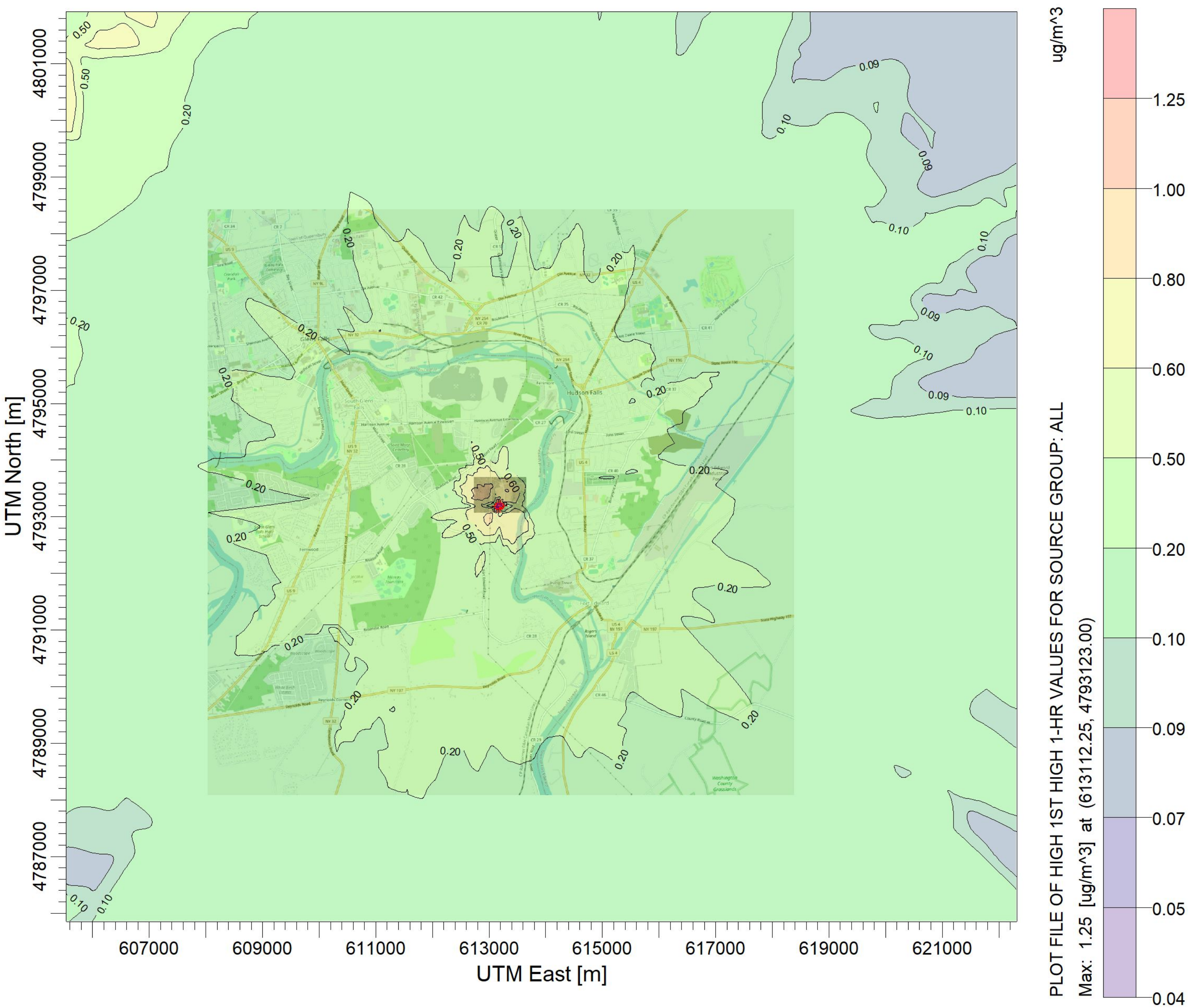
Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

H_2S - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	1.25416	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	3/31/2020, 12
ANNUAL		0.06049	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

H2S - 1HR

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

1.25 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:109,437

0 3 km

PROJECT NO.:

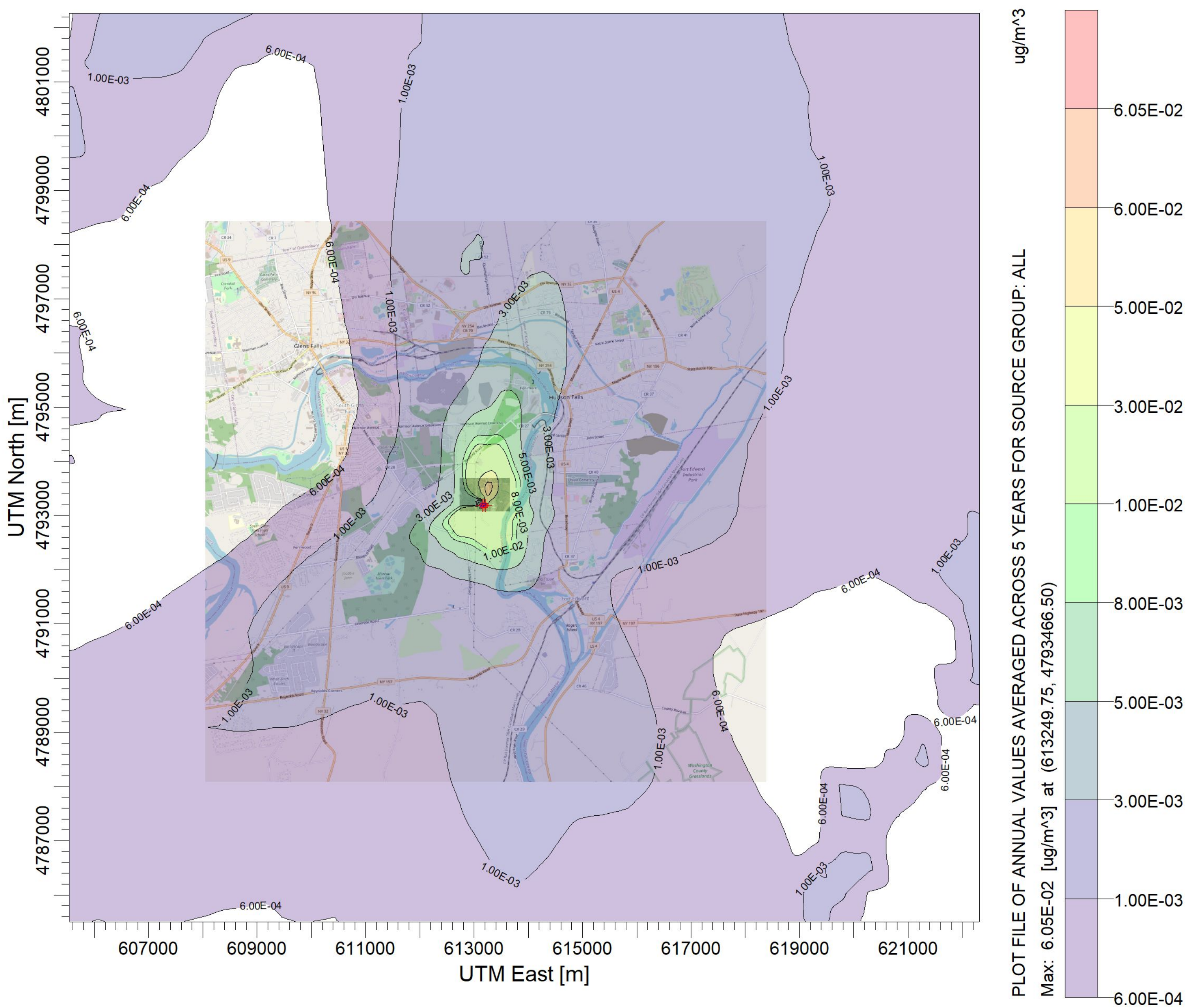
2020-20

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

COMMENTS:

H2S - Annual



SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

6.05E-02 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:114,119

0 3 km

PROJECT NO.:

2020-20

ATTACHMENT 2G

MERCURY

Results Summary

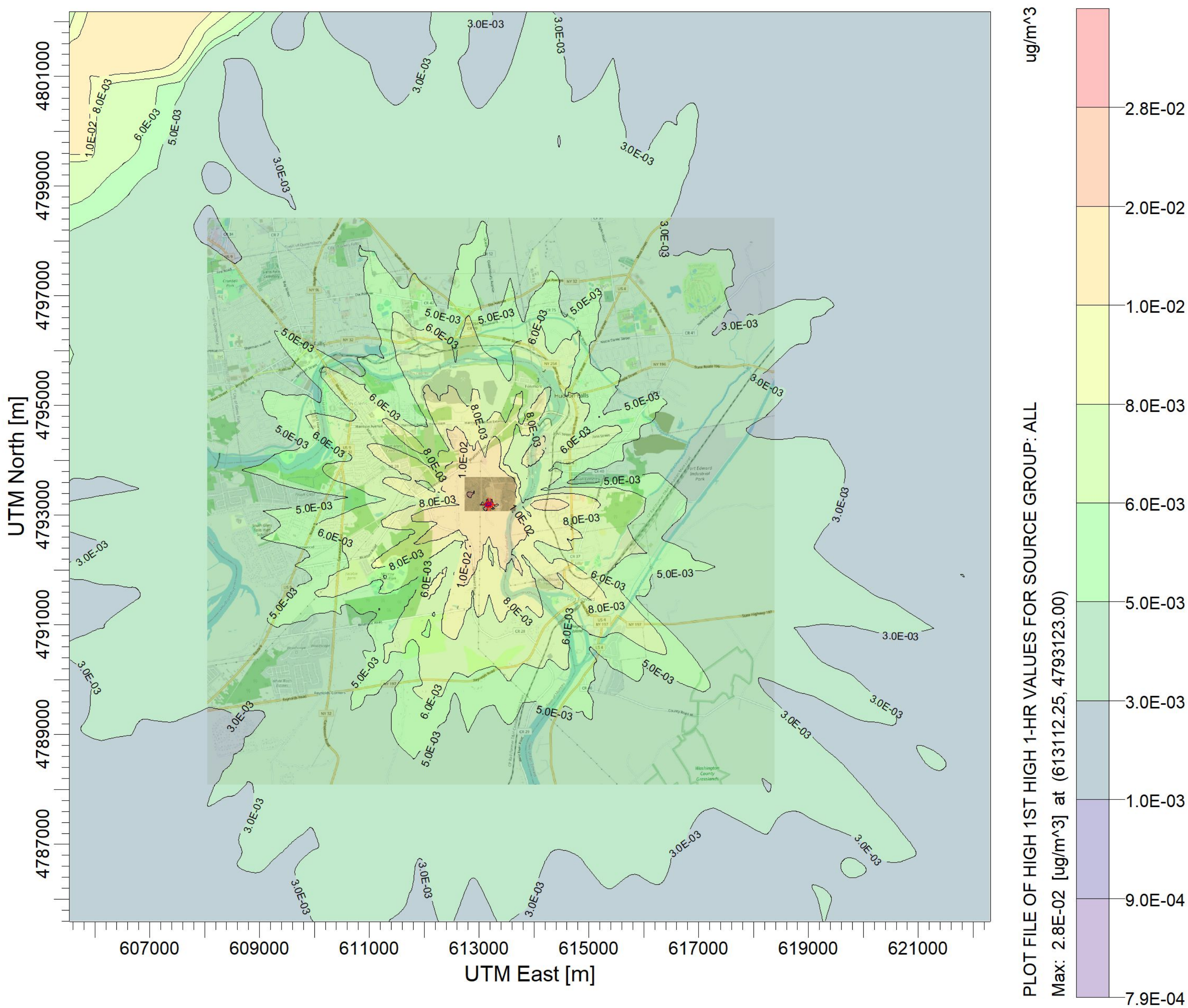
Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

HG - Concentration - Source Group: ALL

Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	0.02798	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	3/31/2020, 12
ANNUAL		0.00135	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

HG - 1 Hour

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

2.8E-02 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:112,960

0 3 km

PROJECT NO.:

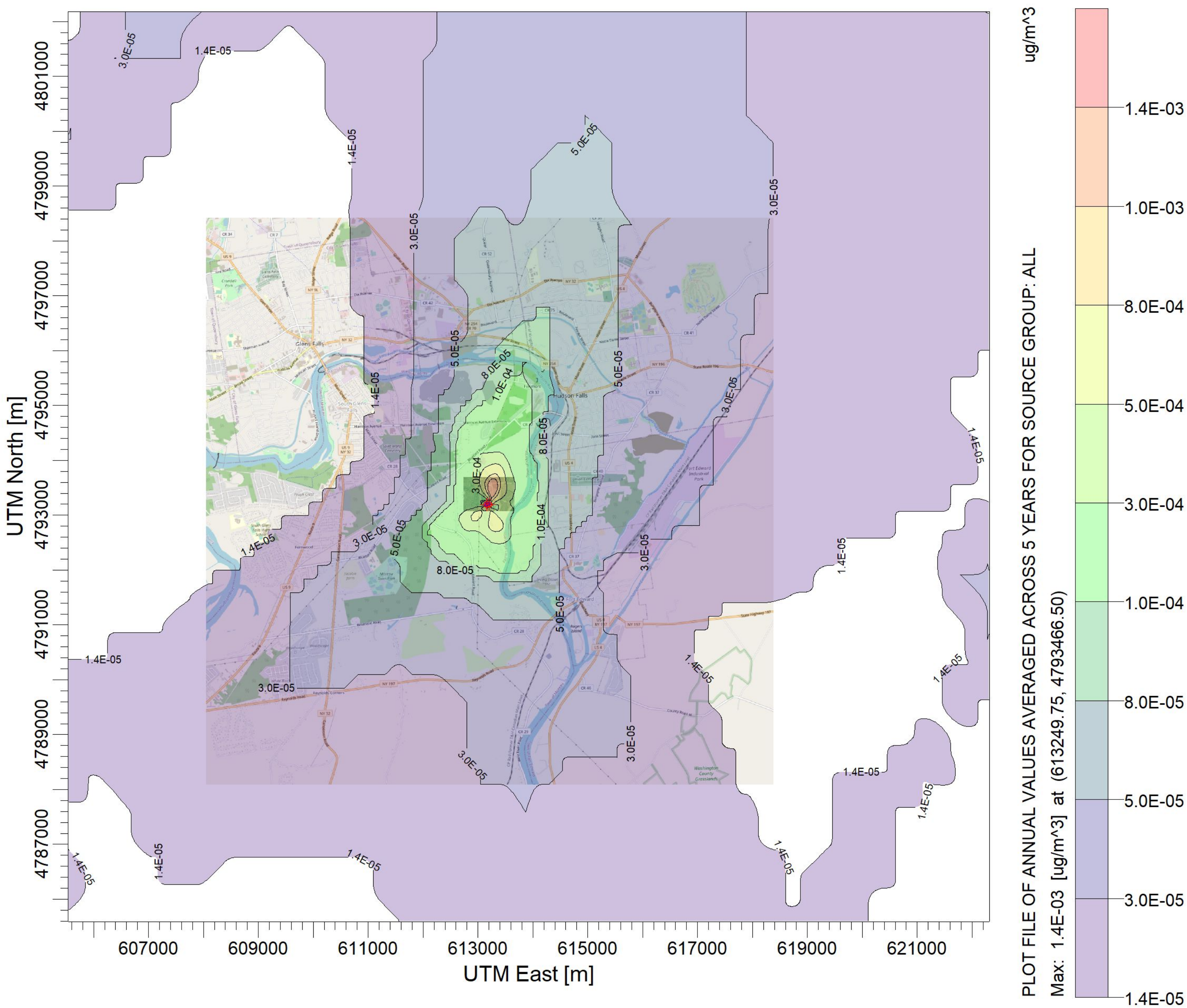
2020-20

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

COMMENTS:

HG - Annual



SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

1.4E-03 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/17/2023

SCALE: 1:112,960

0 3 km

PROJECT NO.:

2020-20

ATTACHMENT 2H

AMMONIA

Results Summary

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

NH3 - Concentration - Source Group: ALL

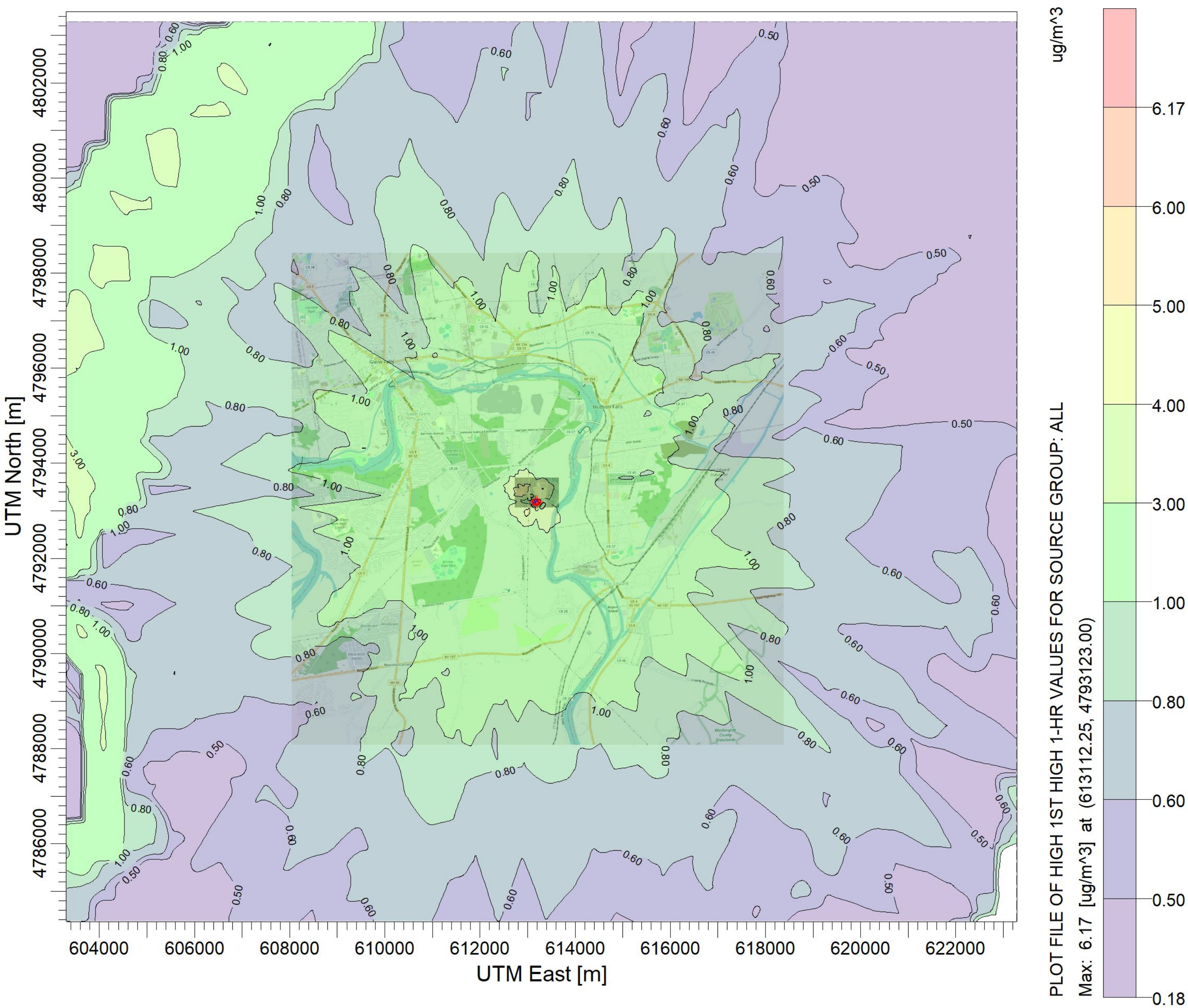
Averaging Period	Rank	Peak	Units	X (m)	Y (m)	ZELEV (m)	ZFLAG (m)	ZHILL (m)	Peak Date, Start Hour
1-HR	1ST	6.17432	ug/m^3	613112.25	4793123.00	73.89	0.00	73.89	3/31/2020, 12
ANNUAL		0.29780	ug/m^3	613249.75	4793466.50	72.27	0.00	72.27	

PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions

COMMENTS:

NH3 - 1 Hour



SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

6.17 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/22/2023

SCALE: 1:130,289

0 4 km

PROJECT NO.:

2020-20

AERMOD View - Lakes Environmental Software

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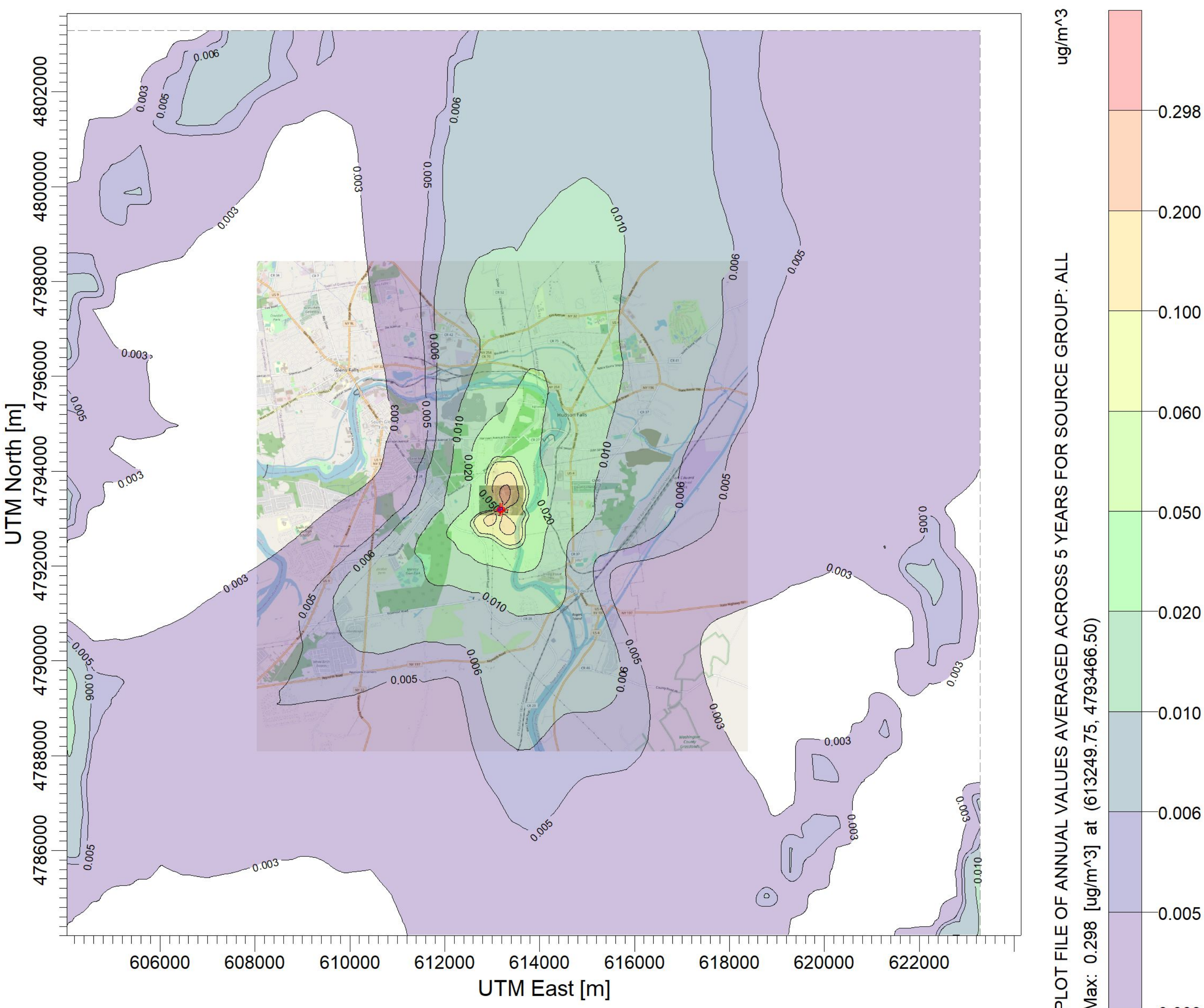
PROJECT TITLE:

Saratoga Biochar Solutions - Moreau Facility - Stack Emissions



COMMENTS:

NH3 - Annual

SOURCES:

3

RECEPTORS:

5165

OUTPUT TYPE:

Concentration

MAX:

0.298 ug/m^3

COMPANY NAME:

Sterling Environmental Engineering, P.C.

MODELER:

AMM

DATE:

2/22/2023

SCALE: 1:132,404

0 — 4 km

PROJECT NO.:

2020-20

AERMOD View - Lakes Environmental Software

C:\Lakes\AERMOD View\SBSMoreau\SBSMoreau.isc

ATTACHMENT 3

CARBON INTENSITY ANALYSIS

February 21, 2023

Bryce Meeker
President
Saratoga Biochar Solutions, LLC
bryce@elementcarbonhv.com

RE: PRELIMINARY CARBON INTENSITY ANALYSIS OF A CARBON FERTILIZER PRODUCT PRODUCED VIA PYROLYSIS OF WWTP BIOSOLIDS AND WASTE WOOD

Dear Mr. Meeker,

This life cycle analysis (LCA) report, prepared for Saratoga Biochar Solutions, LLC (Saratoga), is a carbon intensity (CI) analysis of the "carbon fertilizer" product produced via pyrolysis of wastewater treatment plant (WWTP) biosolids and waste wood in Saratoga, NY. The CI was assessed using the standards and approach of life-cycle analysis (LCA) adopted under many carbon crediting programs, including the Low Carbon Fuel Standard (LCFS) program in California. This letter report represents the opinion of the EcoEngineers staff specializing in providing LCA services since 2009. The following sections provide background, procedures, analysis results, and conclusions.

1.0 Purpose of Analysis

This report is provided at the request of Saratoga to evaluate the CI of its carbon fertilizer product - a product produced via pyrolysis of WWTP biosolids and waste wood. Furthermore, potential strategies for lowering the CI of the carbon fertilizer are also evaluated and recommendations are provided.

2.0 Project Background

Saratoga plans to use a pyrolysis process to convert WWTP biosolids and waste wood into a carbon fertilizer product. The project is at a business planning/preliminary design stage with a goal of starting construction in 2023. Main feedstock of the project is WWTP biosolids with a 77% water content, of which current disposal methods are outlined below in Table 1. Minor feedstock is chipped waste wood (tree cuttings, etc.) from municipalities with a 40% water content that would otherwise be composted.

Table 1. Biosolids management methods in the State of New York.[1]

BIOSOLIDS MANAGEMENT METHOD	QUANTITY (DRY TONS)	% BY DRY WEIGHT	# OF POTWS	% OF POTWS
LANDFILLING*				
IN-STATE	230,303	61%	-	-
OUT-OF-STATE	27,160	7%	-	-
LANDFILLING TOTAL	**257,463**	**68%**	**310**	**53%**
BENEFICIAL USE				
LAND APPLICATION	12,888	3%	37	6%
COMPOSTING	45,012	12%	47	8%
HEAT DRYING/PELLETIZATION	897	<1%	3	<1%
MINE RECLAMATION**	2,202	<1%	3	<1%
BENEFICIAL USE TOTAL	**60,999**	**16%**	**90**	**16%**
INCINERATION	**58,031**	**16%**	**87**	**15%**
OTHER* **	**1,170**	**<1%**	**93**	**16%**
TOTAL	**377,663**	**100%**	**580**	**100%**

Pyrolysis is the heating of organic compounds in the absence of oxygen. Pyrolysis is one of the technologies used to convert carbon rich feedstocks into multiple products that could be used for different purposes. A nutrient soil amendment called "carbon fertilizer" is the major product generated by the process which can be used in agriculture. The carbon fertilizer product is expected to replace chemical fertilizers because it will be marketed with a NPK value for direct use in soils. Additionally, the fixed carbon in the product is expected to stay in the soil for many years, in line with many existing literatures related to biochar soil application, effectively resulting in a carbon sequestration. Other than the carbon fertilizer product, the pyrolysis process also generates pyrogas, which is used to run feedstock dryers. In addition, grid electricity and natural gas are also used as process energy.

3.0 Procedures and Methodology Used to Evaluate CI and the CI Reduction Strategies

EcoEngineers performed the following work to estimate the CI of the carbon fertilizer in the proposed project, and to provide recommendations on CI reduction strategies:

- Gathered information on the proposed project from Saratoga staff and conducted calls to gain a general understanding of the project
- Reviewed data provided by Saratoga and resolved questions on the data for clarity
- Processed the data to create model inputs for the LCA model. The LCA model was developed based on the CA-GREET 3.0 Model[2] published by California Air Resources Board (CARB). In addition, current version of GREET model (GREET.net, version 2021)[3] was used to examine the reasonableness of the results obtained by using CA-GREET 3.0 model.
- Summarized the outputs from the LCA model, discussed the impacts of different CI components, and any additional considerations that Saratoga staff should be aware of

[1] New York State Department of Environmental Conservation, Division of Materials Management. 2018. Biosolids Management in New York State. Accessed on 06/24/2022 at https://www.dec.ny.gov/chemical/97463.html

[2] California Air Resources Board. Released in 2018. Accessed on 06/24/2022 at https://ww2.arb.ca.gov/resources/documents/lcfs-life-cycle-analysis-models-and-documentation

[3] Argonne National Laboratory. Released in 2021. Accessed on 06/24/2022 at https://greet.es.anl.gov/index.php?content=greetdotnet

4.0 Data, Assumptions, and Scenarios for the Project

The system boundary for the evaluation starts from WWTP biosolids and waste wood transport and ends at carbon fertilizer soil application. Environmental impacts after soil application, such as increased or decreased greenhouse gas emissions due to the change of soil microbiological activities, crop yields, soil erosions, etc., are not included in the system boundary, mainly due to the high uncertainty related to these impacts and the lack of scientific data and consensus and/or actual field measurement data. The functional unit (FU) adopted is 1 ton carbon fertilizer on an as-is basis.

Saratoga provided the following documents for the project:

- General CI estimate data request for biochar from pyrolysis of biomass 31.10.2022
- Saratoga Biochar Solutions Equity Summary_30Mar2022
- 7031-2401 PFD Data Full HMB Cases - Rev 2 with Biosolids and Wood Split_EcoEngineers
- HPTP Proposal Element Carbon i131277 - Rev 3

Key parameters extracted/developed from the documents above are listed in Table 2. EcoEngineers reviewed and had no issues with the reasonableness of these parameters, but is not responsible for the accuracy of the data provided by Saratoga.

Whether, and how, to quantify the emissions in business-as-usual (BAU) scenarios (also called baseline scenarios), and the credits that may be assigned to the project due to the avoidance of such emissions, are questions that can have different answers when different carbon crediting platforms or methodologies are applied. In this analysis, the avoided emission credits from landfilling, composting and incineration were estimated based on the methodology adopted under CA LCFS for low carbon fuel production. However, it is not guaranteed that such avoided emission credits will be recognized by a carbon crediting platform.

Table 2. Key parameters for this analysis

Parameter	Value	Unit
Biosolids Feedstock		
Mass	75,120	Tons/yr
Transport Distance	70	Mile
Moisture Content	77	%
Waste Wood Feedstock		
Mass	2,504	Tons/yr
Transport Distance	35	Mile
Moisture Content	40	%
Electricity	5,134	MWh/yr
Natural Gas	56,536	MMBtu/yr
SO_2 Chemicals	822,588	lbs/yr
NH_3 Chemicals	315,068	lbs/yr
Carbon Fertilizer Product		
Mass	7,720	Tons/yr
Transport Distance	70	Mile
Moisture Content	10	%
N	4.9	% of TS
P2O5	10.14	% of TS
K2O	0.82	% of TS
Organic Carbon	35.96	% of TS
Fixed Carbon (FC) Content	28.09	% of TS
H	0.73	% of TS
H/C_{org}	0.24	Molar ratio
H/C_{FC}	0.31	Molar ratio

5.0 Results and Discussion

Table 3 shows the CI analysis results along with the contribution from the different inputs to the final CI score. All the impact are shown as per functional unit (FU), which is 1 ton carbon fertilizer as-is.

Table 3. CI analysis results and GHG reduction

	Per ton[1]	P1, ton/a
Carbon Fertilizer™ Produced, ton	**1.000**	**7,720**
Feedstock Transport	0.096	740
Natural Gas	0.544	4,197
Electricity	0.169	1,307
Chemicals	0.057	444
Carbon Fertilizer Transport	0.010	75
SBS Gross Carbon Intensity (CI)	**0.876**	**6,763**
Carbon Sequestration Value	(0.927)	(7,156)
CI with Carbon Sequestration	**(0.051)**	**(393)**
Fertilizer Mfg. Displaced, ton CO_2e	(0.315)	(2,432)
CI with Carbon Sequestration and Fertilizer Displacement	**(0.366)**	**(2,825)**
Disposal Avoided, ton CO_2e	(0.836)	(6,451)
CI with Carbon Sequestration, Fertilizer Displacement, and Avoided Disposal Credits	**(1.202)**	**(9,277)**

Several key findings and potential CI reduction strategies from the analysis include:

1. The total CI of carbon fertilizer, excluding the avoided emission credits from the baseline scenarios, was -0.051 ton CO_2e/ton carbon fertilizer. At 7,720 tons/year production rate, total GHG reduction in this scenario is 2,825 tons CO_2e per year when it is assumed the carbon fertilizer displace fossil fertilizers on a lb nutrient to lb nutrient basis. GREET.net model gave an almost identical GHG reduction value.
2. When considered, the avoided emission credits by diverting the feedstock from landfilling, composting, and incineration contribute -0.836 ton CO_2e/ton carbon fertilizer to the total CI, resulting in an additional 6,451 tons CO_2e GHG reduction per year.
3. The top contributors to the final total CI are carbon sequestration credits, avoided emission credits from baseline scenarios, and process energy including natural gas and electricity. And the CI result is more sensitive to these parameters than others.
4. Reduction of process energy use and/or the use of low CI process energy (such as waste heat, solar power, wind power etc.) has the potential to reduce the overall CI.
5. Another potential option to lower the CI is to use a combined heat and power (CHP) system powered by natural gas or by low-CI biogas for process energy.
6. Another potential way to reduce the CI is to capture and sequester the CO_2 generated during the pyrolysis process. By doing the carbon capture and sequestration (CCS), credits can be assigned back to the final carbon fertilizer product and therefore lower the overall CI.

6.0 Conclusions and Recommendations

Having reviewed the information provided by Saratoga and discussed with Saratoga staff over the period of this analysis, EcoEngineers evaluated the Cl of the carbon fertilizer produced via pyrolysis of WWTP biosolids and waste wood. The calculated CI is -0.051 ton CO_2e/ton carbon fertilizer without avoided emission credits from baseline and fertilizer displacement. When factoring in the avoided emission credits from fertilizer displacement another -0.315 ton CO_2e/ton carbon fertilizer is added, hence yielding a -0.366 ton CO_2e/ton carbon fertilizer CI score. The disposal avoided emissions corresponds to -0.836 ton CO_2e/ton carbon fertilizer. When fertilizer the CI after the fertilizer displacement is integrated with the avoided disposal emissions, a total of -1.202 ton CO_2e/ton carbon fertilizer is reached. At the projected production rate of this project, over 2,800 tons of GHG emissions could be reduced without considering avoided emission credits from baseline, and over 9,200 tons while considering them. Furthermore, this report presented the key parameters that influence the CI and the potential ways to lower the CI of the carbon fertilizer product.

This report is based on the information provided by Saratoga, current regulations and general LCA methodologies, previous experience working with low carbon programs, and the opinion of EcoEngineers staff. This report is intended solely for Saratoga and is not intended for use by any other parties except with the express permission of Saratoga.

Sincerely,

Dr. Zhichao Wang, Ph.D, PE
Senior Engineer / LCA Director

Background & Qualifications of EcoEngineers

EcoEngineers is a leading renewable energy consulting firm and USEPA approved auditor with core services that include audit, compliance management, and consulting. Our consulting team is comprised of engineers, regulatory and compliance specialists, financial and life-cycle analysts - all of whom hold deep expertise in federal, state, and international energy regulations that set a price on carbon and create carbon markets. The low carbon value of renewable energy is represented by the economic value of fungible energy credits. EcoEngineers work improves regulatory compliance and quality of credits to protect the value of investments.

EcoEngineers provides LCFS services to renewable diesel, biodiesel, cellulosic ethanol, renewable natural gas and other renewable fuel producers and has extensive experience working with the California LCFS program and the CA-GREET models. EcoEngineers also provides LCA services under other carbon programs like BC RLCF. EcoEngineers has an LCA team dedicated to modeling fuel pathways using a variety of LCA tools and has submitted over 300 applications to California Air Resources Board (CARB) for registration under the LCFS. EcoEngineers has helped more than 100 pathways certified under the newly adopted LCFS regulation effective since January 2019, and is helping producers on an ongoing basis.

EcoEngineers provides RFS2 New Pathway Applications, Efficient Producer Petitions, 3rd Party Engineering Reviews, Part 80 Registrations and other services to producers of renewable diesel, ethanol, biodiesel, heating oil, renewable natural gas and other RFS participants. Additionally, as part of the suite of compliance services we offer, EcoEngineers is an EPA approved Q-RIN Quality Assurance Program (QAP) provider under the RFS program and conducts quarterly audits of over 160 domestic and international renewable fuel production facilities to ensure compliance under federal regulations. Our compliance management services provide RIN Academy Workshops, guidance on RIN generation protocol and compliance monitoring plans, and a proprietary RIN management platform.