APPENDIX A

EMISSION RATE CALCULATIONS

Appendix A - Gainesville Renewable Energy Center Emission Rate Calculations
List of Tables

Table A-1. Gainesville Renewable Energy Center
Annual Potential Emission Rate Summary

A. Criteria Pollutants and PM

Pollutant	Potential Emission Rates						
	BFB Boiler (tpy)	Material Handling Point Sources (tpy)	Material Handling Fugitive Sources (tpy)	Cooling Tower (tpy)	Emergency Generator Diesel Engine (tpy)	Emergency Firewater Pump Diesel Engine (tpy)	GREC Project Totals (tpy)
SO_2	243.9	0.0	0.0	0.0	0.00078	0.0020	**243.9**
NO_x	416.4	0.0	0.0	0.0	1.40	0.32	**418.1**
CO	713.8	0.0	0.0	0.0	1.46	0.39	**715.6**
VOC	77.3	0.0	0.0	0.0	0.60	0.14	**78.1**
PM (filterable)	89.2	28.0	11.6	1.5	0.063	0.023	**130.4**
PM_{10} (total)	249.8	28.0	2.3	1.0	0.063	0.023	**281.2**
$PM_{2.5}$ (total)	249.8	28.0	0.34	0.0032	0.063	0.023	**278.3**
Pb	0.12	Neg.	Neg.	Neg.	Neg.	Neg.	**0.12**

B. Hazardous Air Pollutants

Pollutant	Potential Emission Rates						
	BFB Boiler (tpy)	Material Handling Point Sources (tpy)	Material Handling Fugitive Sources (tpy)	Cooling Tower (tpy)	Emergency Generator Diesel Engine (tpy)	Emergency Firewater Pump Diesel Engine (tpy)	GREC Project Totals (tpy)
Organics							
Acetaldehyde	0.086	0.0	0.0	0.0	0.000032	0.00039	0.086
Acrolein	0.051	0.0	0.0	0.0	0.000010	0.000047	0.051
Benzene	0.73	0.0	0.0	0.0	0.00099	0.00047	0.73
1,3-Butadiene	-	0.0	0.0	0.0	0.000050	0.000020	0.000069
Dibenzofurans	0.000010	0.0	0.0	0.0	-	-	0.000010
Dioxins	0.000014	0.0	0.0	0.0	-	-	0.000014
Ethylbenzene	0.057	0.0	0.0	0.0	-	-	0.057
Formaldehyde	1.6	0.0	0.0	0.0	0.00010	0.00060	1.6
Methyl Chloroform	0.077	0.0	0.0	0.0	-	-	0.077
Methylene Chloride	0.29	0.0	0.0	0.0	-	-	0.29
PAH/POM	0.13	0.0	0.0	0.0	0.00043	0.00013	0.13
Toluene	0.12	0.0	0.0	0.0	0.00036	0.00021	0.13
o-Xylenes	0.093	0.0	0.0	0.0	-	-	0.093
Xylenes	0.033	0.0	0.0	0.0	0.00014	0.00025	0.034
Inorganics							
Hydrochloric Acid (HCl)	35.7	0.0	0.0	0.0	Neg	Neg	35.7
Hydrofluoric Acid (HF)	71.4	0.0	0.0	0.0	Neg	Neg	71.4
Metals							
Arsenic	0.030	Neg	Neg	Neg	Neg	Neg	0.030
Beryllium	0.0093	Neg	Neg	Neg	Neg	Neg	0.0093
Cadmium	0.021	Neg	Neg	Neg	Neg	Neg	0.021
Chromium	0.76	Neg	Neg	Neg	Neg	Neg	0.76
Lead	0.12	Neg	Neg	Neg	Neg	Neg	0.12
Manganese	0.35	Neg	Neg	Neg	Neg	Neg	0.35
Mercury	0.0084	Neg	Neg	Neg	Neg	Neg	0.0084
Nickel	0.091	Neg	Neg	Neg	Neg	Neg	0.091
Phosphorus	2.2	Neg	Neg	Neg	Neg	Neg	2.2
Maximum Individual HAP							**71.4**
Total HAPs							**113.9**

C. Sulfuric Acid Mist (H_2SO_4 Mist), Ammonia (NH_3), and Carbon Dioxide (CO_2)

Pollutant	Potential Emission Rates						
	BFB Boiler (tpy)	Material Handling Point Sources (tpy)	Material Handling Fugitive Sources (tpy)	Cooling Tower (tpy)	Emergency Generator Diesel Engine (tpy)	Emergency Firewater Pump Diesel Engine (tpy)	GREC Project Totals (tpy)
H_2SO_4 Mist	5.9	0.0	0.0	0.0	Neg.	Neg.	5.9
NH_3	37.3	0.0	0.0	0.0	0.0	0.0	37.3
CO_2	1,159,868	0.0	0.0	0.0	219.5	79.7	1,160,167

Neg. - negligible

Table A-2. Gainesville Renewable Energy Center
BFB Boiler Criteria Pollutant Emission Estimates

A. Emission Estimate Methodology

References - BFB Boiler Vendor Data and Boiler MACT Average Emission Factor (Pb).

$E_1 = EF \times HI$
$E_2 = EF \times HI \times OP \times (1 \text{ ton} / 2{,}000 \text{ lb})$

where:
E_1 = hourly emission rate; pounds per hour (lb/hr)
E_2 = annual emission rate; tons per year (ton/yr)
EF = emission factor; pounds per million British thermal units (lb/10^6 Btu)
HI = hourly BFB boiler higher heating value (HHV) heat input (10^6 Btu/hr);
OP = annual operating hours; hours per year (hr/yr)

B. Input Data

BFB Boiler Data	Units	BFB Boiler 100% Load (EU P-7)	BFB Boiler 70% Load (EU P-7)
Heat Input	10^6 Btu/hr, HHV	1,358	951
Power Output	MW (gross)	116	81
Annual Operating Hours	hr/yr	8,760	8,760

C. Calculations

Criteria Pollutants	BFB Boiler 100% Load (EU P-7)	BFB Boiler 70% Load (EU P-7)
NO_x		
lb/10^6 Btu, HHV	0.070	0.070
lb/hr	95.1	66.6
ton/yr	416.4	291.6
lb/MWh	0.82	0.82
CO		
lb/10^6 Btu, HHV	0.12	0.12
lb/hr	163.0	114.1
ton/yr	713.8	499.8
lb/MWh	1.4	1.4
VOC		
lb/10^6 Btu, HHV	0.013	0.013
lb/hr	17.7	12.4
ton/yr	77.3	54.1
lb/MWh	0.15	0.15
$PM/PM_{10}/PM_{2.5}$ (filterable)		
lb/10^6 Btu, HHV	0.015	0.015
lb/hr	20.4	14.3
ton/yr	89.2	62.5
lb/MWh	0.18	0.18
$PM/PM_{10}/PM_{2.5}$ (condensable)		
lb/10^6 Btu, HHV	0.027	0.027
lb/hr	36.7	25.7
ton/yr	160.6	112.5
lb/MWh	0.32	0.32
$PM/PM_{10}/PM_{2.5}$ (total)		
lb/10^6 Btu, HHV	0.042	0.042
lb/hr	57.0	39.9
ton/yr	249.8	174.9
lb/MWh	0.49	0.49
SO_2		
lb/10^6 Btu, HHV	0.041	0.041
lb/hr	55.7	39.0
ton/yr	243.9	170.8
lb/MWh	0.48	0.5
Pb		
lb/10^6 Btu, HHV	0.000021	0.000021
lb/hr	0.029	0.020
ton/yr	0.12	0.09
lb/MWh	0.00025	0.00025

Table A-3. Gainesville Renewable Energy Center
BFB Boiler Criteria Pollutant Emission Estimates - H_2SO_4 Mist, NH_3, and CO_2

A. Emission Estimate Methodology

References - BFB Boiler Vendor Data and AP-42 Table 1.6-3. (CO_2).

E_1 = EF x HI
E_2 = EF x HI x OP x (1 ton / 2,000 lb)

where:
E_1 = hourly emission rate; pounds per hour (lb/hr)
E_2 = annual emission rate; tons per year (ton/yr)
EF = emission factor; pounds per million British thermal units (lb/10^6 Btu)
HI = hourly BFB boiler higher heating value (HHV) heat input (10^6 Btu/hr);
OP = annual operating hours; hours per year (hr/yr)

B. Input Data

BFB Boiler Data	Units	BFB Boiler 100% Load (EU P-7)	BFB Boiler 70% Load (EU P-7)
Heat Input	10^6 Btu/hr, HHV	1,358	951
Power Output	MW (gross)	116	81
Annual Operating Hours	hr/yr	8,760	8,760

C. Calculations

Criteria Pollutants	BFB Boiler 100% Load (EU P-7)	BFB Boiler 70% Load (EU P-7)
H_2SO_4 Mist		
lb/10^6 Btu, HHV	0.0010	0.0010
lb/hr	1.4	1.0
ton/yr	5.9	4.2
lb/MWh	0.012	0.012
NH_3		
lb/10^6 Btu, HHV	0.0063	0.0063
lb/hr	8.5	5.9
ton/yr	37.3	25.9
lb/MWh	0.073	0.073
CO_2		
lb/10^6 Btu, HHV	195	195
lb/hr	264,810	185,445
ton/yr	1,159,868	812,249
lb/MWh	2,283	2,284

Table A-4. Gainesville Renewable Energy Center
BFB Boiler Pollutant Concentrations

A. BFB Boiler Exhaust Flow Rates - 100% Load

Item	BFB Boiler (100% Load)	
Exhaust Temperature	310.0	^{o}F
Exhaust Oxygen	3.62	volume %, dry
Exhaust Moisture	27.6	volume %
Volume of 1 lb-mole at 68^{o}F	385.1	dscf
Exhaust Flow Rates	520,638	acf/min @ 3.62% O_2
	376,942	dacf/min @ 3.62% O_2
	258,475	dscf/min @ 3.62% O_2
	19,279,608	dscf/hr @ 7.0% O_2
	321,327	dscf/min @ 7.0% O_2
	9,099	dscm/min @ 7% O_2

B. BFB Boiler Pollutant Concentrations - 100% Load

Pollutant	MW (lb/lb-mole)	Emission Rates - 100% Load			
		(lb/hr)	(mg/dscm)[1]	(ug/dscm)[1]	(ppmvd)[2]
SO_2	64.0	55.7	N/A	N/A	17.4
NO_x	46.0	95.1	N/A	N/A	41.3
CO	28.0	163.0	N/A	N/A	116.3
VOC	16.0	17.7	N/A	N/A	22.1
$PM/PM_{10}/PM_{2.5}$ (filterable)	N/A	20.4	16.9	N/A	N/A
$PM/PM_{10}/PM_{2.5}$ (total)	N/A	57.0	47.4	N/A	N/A
H_2SO_4 Mist	98.0	1.4	1.1	N/A	N/A
Mercury	200.6	0.0019	N/A	1.6	N/A
Ammonia	17.0	8.5	N/A	N/A	10.0
Lead	N/A	0.029	N/A	23.7	N/A

[1] At 68 ^{o}F
[2] At 7% oxygen

Table A-5. Gainesville Renewable Energy Center
BFB Boiler Hazardous Air Pollutant Emission Estimates

A. Emission Estimate Methodology

References - BFB Boiler Vendor Data, Fuel Analyses, and Boiler MACT Average Emission Factors.

$E_1 = EF \times HI$
$E_2 = EF \times HI \times OP \times (1 \text{ ton} / 2{,}000 \text{ lb})$

where:
E_1 = hourly emission rate; pounds per hour (lb/hr)
E_2 = annual emission rate; tons per year (ton/yr)
EF = emission factor; pounds per million British thermal units ($lb/10^6$ Btu)
HI = hourly BFB boiler higher heating value (HHV) heat input (10^6 Btu/hr);
OP = annual operating hours; hours per year (hr/yr)

B. Input Data

BFB Boiler Data	Units	BFB Boiler 100% Load (EU P-7)
Biomass Fuel Consumed	lb/hr	318,500
Heat Input	10^6 Btu/hr, HHV	1,358
Power Output	MW (gross)	116
Annual Operating Hours	hr/yr	8,760
Biomass Fuel Hg Concentration	ppmw	0.0060

C. Calculations

Hazardous Air Pollutant	FDEP ID Code	CAS Number	Emission Factor ($lb/10^6$ Btu)	Emission Factor Source[1]	BFB Boiler (100% Load) (lb/hr)	BFB Boiler (100% Load) (ton/yr)
Organics						
Acetaldehyde	H001	75-07-0	1.44E-05	1	0.0196	0.0857
Acrolein	H006	107-02-8	8.52E-06	1	0.0116	0.0507
Benzene	H017	71-43-2	1.23E-04	1	0.1670	0.7316
Dibenzofurans	H058	132-64-9	1.62E-09	1	0.0000022	0.0000096
Dioxins (equiv.)	H165	1746-01-6	2.38E-09	1	0.0000032	0.0000142
Ethylbenzene	H085	100-41-4	9.52E-06	1	0.0129	0.0566
Formaldehyde	H095	50-00-0	2.70E-04	1	0.3667	1.6060
Methyl Chloroform	H119	71-55-6	1.30E-05	1	0.0177	0.0773
Methylene Chloride	H128	75-09-2	4.90E-05	1	0.0665	0.2915
o-Xylenes	H187	95-47-6	1.57E-05	1	0.0213	0.0934
16-PAH (POM)	H151	-	2.16E-05	1	0.0293	0.1285
Toluene	H169	108-88-3	2.10E-05	1	0.0285	0.1249
Xylenes	H186	1330-20-7	5.59E-06	1	0.0076	0.0332
Total Organics					**0.75**	**3.3**
Inorganics						
Hydrogen Chloride	H106	7647-01-0	6.00E-03	2	8.1480	35.6882
Hydrogen Fluoride	H107	7664-39-3	1.20E-02	2	16.2960	71.3765
Total Inorganics					**24.4**	**107.1**
Metals						
Arsenic	H015	-	5.01E-06	1	0.0068	0.0298
Beryllium	H021	-	1.57E-06	1	0.0021	0.0093
Cadmium	H027	-	3.54E-06	1	0.0048	0.0211
Chromium	H046	-	1.28E-04	1	0.1738	0.7613
Lead	PB	-	2.10E-05	1	0.0285	0.1249
Manganese	H113	-	5.89E-05	1	0.0800	0.3503
Mercury	H114	-	1.41E-06	3	0.0019	0.0084
Nickel	H133	-	1.53E-05	1	0.0208	0.0910
Phosphorus	H148	7723-14-0	3.68E-04	1	0.4997	2.1889
Total Metals					**0.52**	**2.28**
			Maximum Individual HAP			**71.4**
			Total HAPs			**112.6**

[1] Emission Factors:
1 - Boiler MACT Docket; Development of Average Emission Factors and Baseline Emission Estimates for the Industrial, Commercial, and Institutional Boilers and Process Heaters National Emission Standard for Hazardous Air Pollutants, Eastern Research Group, October 2002.
2 - BFB boiler vendor data.
3 - Fuel analysis and mass balance.

[2] 16-PAH: Acenaphthene, acenaphthylene, anthracene, benz(a)anthracene, benzo(b)fluoranthene, benzo(e)pyrene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenz(ah)anthracene, fluoranthene, fluorene, ideno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene.

Table A-6. Gainesville Renewable Energy Center
BFB Boiler Startup Emission Estimates

References - BFB Boiler Vendor Data (duration of cold startup events and emission rates), GREC (annual frequency of cold startup events).

A. Input Data

Parameter	Units	Value
Duration of Each Cold Startup Event	hours	14
Number of Cold Startup Events Per Year	-	20

B. Hourly Startup Event Emission Estimates

Pollutant	Emission Rates (lb/hr)							
	Hour 1	Hour 2	Hour 3	Hour 4	Hour 5	Hour 6	Hour 7	
NO_x	23.94	39.48	39.16	71.02	67.47	93.35	156.34	
SO_2	0.00	0.00	0.00	0.00	0.00	0.00	1.34	
PM/PM_{10}	1.67	2.78	2.78	5.11	5.11	5.11	6.50	
CO	4.28	7.05	6.99	12.68	12.68	38.05	104.23	
VOC	0.38	0.63	0.63	1.14	1.14	3.42	9.38	
H_2SO_4 Mist	0.000	0.000	0.000	0.000	0.000	0.000	0.017	
NH_3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
Pollutant	**Emission Rates (lb/hr)**							**Totals**
	Hour 8	**Hour 9**	**Hour 10**	**Hour 11**	**Hour 12**	**Hour 13**	**Hour 14**	**(lb/event)**
NO_x	177.77	269.87	214.90	147.90	117.37	86.98	82.30	1,587.9
SO_2	2.14	8.02	9.09	9.09	9.09	9.09	11.23	59.1
PM/PM_{10}	7.33	9.72	9.72	9.44	9.44	9.44	11.67	95.8
CO	121.21	159.73	132.04	97.52	78.51	72.49	89.90	937.3
VOC	10.91	14.38	11.88	8.78	7.07	6.52	8.09	84.4
H_2SO_4 Mist	0.027	0.102	0.116	0.116	0.116	0.116	0.143	0.75
NH_3	0.51	0.78	0.80	0.79	16.07	16.32	15.25	50.5

C. Annual Startup Event Emission Estimates

Pollutant	Emissions (ton/yr)
NO_x	15.9
SO_2	0.59
PM/PM_{10}	0.96
CO	9.4
VOC	0.84
H_2SO_4 Mist	0.0075
NH_3	0.51

Table A-7. Gainesville Renewable Energy Center
BFB Boiler Shutdown Emission Estimates

References - BFB Boiler Vendor Data (duration of shutdown events and emission rates), GREC (annual frequency of shutdown events).

A. Input Data

Parameter	Units	Value
Duration of Each Shutdown Event	hours	3
Number of Shutdown Events Per Year	-	20

B. Hourly Shutdown Event Emission Estimates

Pollutant	Emission Rates (lb/hr)			Totals
	Hour 1	Hour 2	Hour 3	(lb/event)
NO_x	82.30	86.98	117.37	286.7
SO_2	11.23	9.09	9.09	29.4
PM/PM_{10}	11.67	9.44	9.44	30.6
CO	89.90	72.49	78.51	240.9
VOC	8.09	6.52	7.07	21.7
H_2SO_4 Mist	0.14	0.12	0.12	0.37
NH_3	15.25	16.32	16.07	47.6

C. Annual Shutdown Event Emission Estimates

Pollutant	Emissions (ton/yr)
NO_x	2.9
SO_2	0.29
PM/PM_{10}	0.31
CO	2.4
VOC	0.22
H_2SO_4 Mist	0.0037
NH_3	0.48

Table A-8. Gainesville Renewable Energy Center
Emergency Diesel Engine Criteria Pollutant and CO_2 Emission Estimates

A. Emission Estimate Methodology

References - NSPS Subpart IIII (NO_x, CO, VOC, and PM), Mass Balance (SO_2), and AP-42 Table 3.4-1 (CO_2).

E_1 = EF x P
E_2 = EF x P x OP x (1 ton / 2,000 lb)
EFSO2 = FOFLOW x FODENSITY x (FOSULFUR / 100) x (1 / P) x (2 lb SO_2 / lb S) x (453.59 g / lb)

where:
E_1 = hourly emission rate; pounds per hour (lb/hr)
E_2 = annual emission rate; tons per year (ton/yr)
EF = emission factor; grams per brake horsepower-hour (g/bhp-hr)
P = engine output; brake horsepower-hour (bhp-hr)
OP = annual operating hours; hours per year (hr/yr)
EFSO2 = SO_2 emission factor; grams per brake horsepower hour (g/bhp-hr)
FOFLOW = ULSD fuel oil flow rate; gallons per hour (gal/hr)
FODENSITY = ULSD fuel oil density; pounds per gallon (lb/gal)
FOSULFUR = ULSD fuel oil sulfur content; weight percent (weight %)

B. Input Data

Diesel Engine Data	Units	Emergency Fire Water Pump Diesel (EU P-9)	Emergency Generator Diesel (EU P-10)
Engine Output	bhp	275	757
	kW	205	564
Engine ULSD Fuel Oil Flow Rate	gal/hr	14.7	36.8
Engine Operating Hours	hr/yr	500	500
Applicable EPA Nonroad Tier	-	3	2
ULSD Fuel Oil Sulfur Content	weight %	0.0015	0.0015
ULSD Fuel Oil Density	lb/gal	7.08	7.08

C. Calculations

Criteria Pollutants and CO_2	Emergency Fire Water Pump Diesel (EU P-9)	Emergency Generator Diesel (EU P-10)
NOx		
g/bhp-hr[1]	2.1	3.4
lb/hr	1.3	5.6
ton/yr	0.32	1.4
CO		
g/bhp-hr	2.6	3.5
lb/hr	1.6	5.8
ton/yr	0.39	1.5
VOC		
g/bhp-hr[2]	0.90	1.4
lb/hr	0.55	2.4
ton/yr	0.14	0.60
$PM/PM_{10}/PM_{2.5}$		
g/bhp-hr	0.15	0.15
lb/hr	0.091	0.25
ton/yr	0.023	0.063
SO_2		
g/bhp-hr[3]	0.0051	0.0047
lb/hr	0.0031	0.0078
ton/yr	0.00078	0.0020
CO_2		
g/bhp-hr	526.2	526.2
lb/hr	319.0	878.1
ton/yr	79.7	219.5

[1] NO_x emission rate assumed equal to 70% of Subpart IIII NMHC + NO_x emission standard.
[2] VOC emission rate assumed equal to 30% of Subpart IIII NMHC + NO_x emission standard.
[3] Based on use of ULSD fuel oil.

Table A-9. Gainesville Renewable Energy Center
Emergency Diesel Engine Hazardous Air Pollutant Emission Estimates

A. Emission Estimate Methodology

References - AP-42 Tables 3.3-2. (EU P-9) and 3.4-4.(EU P-10), and engine vendor data..

E_1 = EF x HI
E_2 = EF x HI x OP x (1 ton / 2,000 lb)

where:
E_1 = hourly emission rate; pounds per hour (lb/hr)
E_2 = annual emission rate; tons per year (ton/yr)
EF = emission factor; pounds per million British thermal units (lb/10^6 Btu)
HI = engine heat input; million British thermal units per hour (10^6 Btu/hr)
OP = annual operating hours; hours per year (hr/yr)

B. Input Data

Diesel Engine Data	Units	Emergency Fire Water Pump Diesel (EU P-9)	Emergency Generator Diesel (EU P-10)
Engine Output	bhp	275	757
Engine ULSD Fuel Oil Flow Rate	gal/hr	14.7	36.8
ULSD Fuel Oil Heat Content, HHV	10^6 Btu/gal	138,000	138,000
Engine Heat Input, HHV	10^6 Btu/hr	2.0	5.1
Engine Operating Hours	hr/yr	500	500

C. Calculations

Hazardous Air Pollutant	Emergency Fire Water Pump Diesel (EU P-9)	Emergency Generator Diesel (EU P-10)
1,3-Butadiene		
lb/10^6 Btu	3.91E-05	3.91E-05
lb/hr	7.93E-05	1.99E-04
ton/yr	1.98E-05	4.96E-05
Acrolein		
lb/10^6 Btu	9.25E-05	7.88E-06
lb/hr	1.88E-04	4.00E-05
ton/yr	4.69E-05	1.00E-05
Acetaldehyde		
lb/10^6 Btu	7.76E-04	2.52E-05
lb/hr	1.57E-03	1.28E-04
ton/yr	3.94E-04	3.20E-05
Benzene		
lb/10^6 Btu	9.33E-04	7.76E-04
lb/hr	1.89E-03	3.94E-03
ton/yr	4.73E-04	9.85E-04
Formaldehyde		
lb/10^6 Btu	1.18E-03	7.89E-05
lb/hr	2.39E-03	4.01E-04
ton/yr	5.98E-04	1.00E-04
Naphthalene		
lb/10^6 Btu	8.48E-05	1.30E-04
lb/hr	1.72E-04	6.60E-04
ton/yr	4.30E-05	1.65E-04
Polycylic Aromatic Hydrocarbons (PAH)		
lb/10^6 Btu	1.68E-04	2.12E-04
lb/hr	3.41E-04	1.08E-03
ton/yr	8.52E-05	2.69E-04
Toluene		
lb/10^6 Btu	4.09E-04	2.81E-04
lb/hr	8.30E-04	1.43E-03
ton/yr	2.07E-04	3.57E-04
Xylenes		
lb/10^6 Btu	2.85E-04	1.93E-04
lb/hr	5.78E-04	9.80E-04
ton/yr	1.45E-04	2.45E-04

POTENTIAL EMISSION INVENTORY WORKSHEET

Gainesville Renewable Energy Center - Cooling Tower

Table A-10
Cooling Tower

EMISSION SOURCE TYPE

COOLING TOWERS - PM/PM_{10}

FACILITY AND SOURCE DESCRIPTION

Emission Source Description:	Mechanical Draft Cooling Tower
Emission Control Method(s)/ID No.(s):	Mist Eliminators
Emission Point Description:	

EMISSION ESTIMATION EQUATIONS

PM Emission Rate (lb/hr) = Recirculating Water Flow Rate (gpm) x (Drift Loss Rate (%) / 100) x 8.345 lb/gal x (TDS (ppmw) / 10^6) x 60 min/hr

PM Emission Rate (ton/yr) = PM Emission (lb/hr) x Operating Period (hrs/yr) x (1 ton/ 2,000 lb)

PM_{10} Emission Rate (lb/hr) = PM Emissions (lb/hr) x PM_{10}/PM Fraction

PM_{10} Emission Rate (ton/yr) = PM_{10} Emission (lb/hr) x Operating Period (hrs/yr) x (1 ton/ 2,000 lb)

Source: ECT, 2009.

INPUT DATA AND EMISSIONS CALCULATIONS

Cooling Tower Data

Operating Hours:	8,760	hrs/yr
Number of Cells:	4	
Recirculating Water Flow Rate:	78,000	gal/min
Drift Loss Rate:	0.0005	%
Total Dissolved Solids (TDS):	1,700	ppmw
PM_{10}/PM Fraction:	0.694	
$PM_{2.5}/PM$ Fraction:	0.00218	
Number of Towers:	1	

Pollutant	Potential Emission Rates (Per Cell)		Potential Emission Rates (Total)	
	(lb/hr)	(tpy)	(lb/hr)	(tpy)
PM	0.083	0.36	0.33	1.5
PM_{10}	0.058	0.25	0.23	1.0
$PM_{2.5}$	0.00018	0.00079	0.00072	0.0032

SOURCES OF INPUT DATA

Parameter	Data Source
Operating Hours (annual)	GREC, 2009.
Recirculating Water Flow Rate (gpm)	Zachry, 2009.
Drift Loss Rate (%)	Zachry, 2009.
Total Dissolved Solids (ppmw)	Zachry, 2009.
PM_{10}/PM Fraction:	ECT, 2009.

NOTES AND OBSERVATIONS

DATA CONTROL

Prepared by:	T. Davis, ECT	September 2009
Reviewed by:	L. Fagen, GREC	September 2009

Table A-11. Gainesville Renewable Energy Center Cooling Tower PM/PM_{10} Fractions

Procedure Citation:

AWMA Abstract No. 216, Session No. AM-1b, Orlando, 2001.
Calculating Realistic PM_{10} Emissions from Cooling Towers

Cooling Tower Design Data:

Cooling Tower Recirculating Water Total Dissolved Solids:	1,700	ppmw
Cooling Tower PM_{10} Density (assumed NaCl):	2.2	g/cm^3

Particle Size Distribution:

Droplet Diameter (µm)	Droplet Volume (m^3)	Droplet Mass (g)	Particle Mass (g)	Particle Volume (m^3)	Particle Diameter (µm)	Mass Fraction (%)
10	5.24E-16	5.24E-10	8.90E-13	4.05E-19	0.918	0.000
20	4.19E-15	4.19E-09	7.12E-12	3.24E-18	1.835	0.196
30	1.41E-14	1.41E-08	2.40E-11	1.09E-17	2.753	0.226
40	3.35E-14	3.35E-08	5.70E-11	2.59E-17	3.671	0.514
50	6.54E-14	6.54E-08	1.11E-10	5.06E-17	4.588	1.816
60	1.13E-13	1.13E-07	1.92E-10	8.74E-17	5.506	5.702
70	1.80E-13	1.80E-07	3.05E-10	1.39E-16	6.424	21.348
90	3.82E-13	3.82E-07	6.49E-10	2.95E-16	8.259	49.812
110	6.97E-13	6.97E-07	1.18E-09	5.39E-16	10.094	70.509
130	1.15E-12	1.15E-06	1.96E-09	8.89E-16	11.929	82.023
150	1.77E-12	1.77E-06	3.00E-09	1.37E-15	13.765	88.012
180	3.05E-12	3.05E-06	5.19E-09	2.36E-15	16.518	91.032
210	4.85E-12	4.85E-06	8.24E-09	3.75E-15	19.271	92.468
240	7.24E-12	7.24E-06	1.23E-08	5.59E-15	22.024	94.091
270	1.03E-11	1.03E-05	1.75E-08	7.96E-15	24.776	94.689
300	1.41E-11	1.41E-05	2.40E-08	1.09E-14	27.529	96.288
350	2.24E-11	2.24E-05	3.82E-08	1.73E-14	32.118	97.011
400	3.35E-11	3.35E-05	5.70E-08	2.59E-14	36.706	98.340
450	4.77E-11	4.77E-05	8.11E-08	3.69E-14	41.294	99.071
500	6.54E-11	6.54E-05	1.11E-07	5.06E-14	45.882	99.071
600	1.13E-10	1.13E-04	1.92E-07	8.74E-14	55.059	100.000

Linear Interpolation:

Droplet Diameter (µm)	Droplet Volume (m^3)	Droplet Mass (g)	Particle Mass (g)	Particle Volume (m^3)	Particle Diameter (µm)	Mass Fraction (%)
90	3.82E-13	3.82E-07	6.49E-10	2.95E-16	8.259	49.812
110	6.97E-13	6.97E-07	1.18E-09	5.39E-16	10.094	70.509
					10.000	**69.448**

Mass Fraction of Cooling Tower PM ≤ PM_{10}:	0.694

Sources: ECT, 2009
Zachry, 2009

Table A-12. Gainesville Renewable Energy Center Cooling Tower PM/$PM_{2.5}$ Fractions

Procedure Citation:

AWMA Abstract No. 216, Session No. AM-1b, Orlando, 2001.
Calculating Realistic PM_{10} Emissions from Cooling Towers

Cooling Tower Design Data:

Cooling Tower Recirculating Water Total Dissolved Solids:	1,700	ppmw
Cooling Tower PM_{10} Density (assumed NaCl):	2.2	g/cm^3

Particle Size Distribution:

Droplet Diameter (µm)	Droplet Volume (m^3)	Droplet Mass (g)	Particle Mass (g)	Particle Volume (m^3)	Particle Diameter (µm)	Mass Fraction (%)
10	5.24E-16	5.24E-10	8.90E-13	4.05E-19	0.918	0.000
20	4.19E-15	4.19E-09	7.12E-12	3.24E-18	1.835	0.196
30	1.41E-14	1.41E-08	2.40E-11	1.09E-17	2.753	0.226
40	3.35E-14	3.35E-08	5.70E-11	2.59E-17	3.671	0.514
50	6.54E-14	6.54E-08	1.11E-10	5.06E-17	4.588	1.816
60	1.13E-13	1.13E-07	1.92E-10	8.74E-17	5.506	5.702
70	1.80E-13	1.80E-07	3.05E-10	1.39E-16	6.424	21.348
90	3.82E-13	3.82E-07	6.49E-10	2.95E-16	8.259	49.812
110	6.97E-13	6.97E-07	1.18E-09	5.39E-16	10.094	70.509
130	1.15E-12	1.15E-06	1.96E-09	8.89E-16	11.929	82.023
150	1.77E-12	1.77E-06	3.00E-09	1.37E-15	13.765	88.012
180	3.05E-12	3.05E-06	5.19E-09	2.36E-15	16.518	91.032
210	4.85E-12	4.85E-06	8.24E-09	3.75E-15	19.271	92.468
240	7.24E-12	7.24E-06	1.23E-08	5.59E-15	22.024	94.091
270	1.03E-11	1.03E-05	1.75E-08	7.96E-15	24.776	94.689
300	1.41E-11	1.41E-05	2.40E-08	1.09E-14	27.529	96.288
350	2.24E-11	2.24E-05	3.82E-08	1.73E-14	32.118	97.011
400	3.35E-11	3.35E-05	5.70E-08	2.59E-14	36.706	98.340
450	4.77E-11	4.77E-05	8.11E-08	3.69E-14	41.294	99.071
500	6.54E-11	6.54E-05	1.11E-07	5.06E-14	45.882	99.071
600	1.13E-10	1.13E-04	1.92E-07	8.74E-14	55.059	100.000

Linear Interpolation:

Droplet Diameter (µm)	Droplet Volume (m^3)	Droplet Mass (g)	Particle Mass (g)	Particle Volume (m^3)	Particle Diameter (µm)	Mass Fraction (%)
20	4.19E-15	4.19E-09	7.12E-12	3.24E-18	1.835	0.196
30	1.41E-14	1.41E-08	2.40E-11	1.09E-17	2.753	0.226
					2.500	**0.218**

Mass Fraction of Cooling Tower PM ≤ PM_{10}:	0.00218

Sources: ECT, 2009
Zachry, 2009

Table A-13. Gainesville Renewable Energy Center
Point Emission Source $PM/PM_{10}/PM_{2.5}$ Emission Estimates
Material Transfer Operations with Baghouse or Bin Vent Filter

A. Emission Estimate Methodology

Reference - Mass Balance, ECT, 2009.

E_1 = c x Q x (60 min / hr) x (1 lb / 7,000 grains)
E_2 = c x Q x (60 min / hr) x (1 lb / 7,000 grains) x OP x (1 ton / 2,000 lb)

where:
E_1 = hourly emission rate (lb/hr)
E_2 = annual emission rate (ton/yr)
c = outlet $PM/PM_{10}/PM_{2.5}$ concentration; grains per standard cubic foot (gr/scf)
Q = exhaust flow rate; standard cubic feet per minute (scfm)
OP = annual operating hours (hrs/yr)

Note: Standard temperature = 68 ^{o}F.

B. Input Data

Parameter	Units	Value
Outlet $PM/PM_{10}/PM_{2.5}$ concentration (c), baghouse/bin vent outlet	gr/scf	0.015

C. Calculations

Emission Point	EU ID	Exhaust Flow Rate (scfm)	Operating Hours (hrs/yr)	$PM/PM_{10}/PM_{2.5}$ Emission Estimates (lb/hr)	(tpy)
Screen/Hog Building Baghouse	P-1	35,397	8,760	4.55	19.9
BFB Boiler Fuel Day Bin Vent Filter No. 1	P-2	3,933	8,760	0.51	2.2
BFB Boiler Fuel Day Bin Vent Filter No. 2	P-3	1,967	8,760	0.25	1.1
Fly Ash Silo Vacuum Blower No. 1	P-4	3,300	8,760	0.42	1.9
Fly Ash Silo Vacuum Blower No. 2	P-5	3,300	8,760	0.42	1.9
Fly Ash Silo Bin Vent Filter	P-6	1,886	8,760	0.24	1.1
Sorbent Silo Bin Vent Filter[1]	P-11	1,886	36	0.24	0.0044
Totals		**51,669**		**6.6**	**28.0**

[1] Operates up to 1 hour per day, 3 times per month.

Table A-14. Gainesville Renewable Energy Center
Fugitive Emission Source $PM/PM_{10}/PM_{2.5}$ Emission Estimates - Biomass Fuel Transfer Operations

A. Emission Estimate Methodology

Reference - AP-42, Section 13.2.4, Aggregate Handling and Storage Piles - Equation (1), EPA November 2006.

$E_1 = k \times (0.0032) \times [(U / 5)^{1.3}) / (M / 2)^{1.4}] \times [1 - (CE / 100)] \times T_1$

$E_2 = k \times (0.0032) \times [(U / 5)^{1.3}) / (M / 2)^{1.4}] \times [1 - (CE / 100)] \times T_2 \times (1 \text{ ton} / 2{,}000 \text{ lb})$

where:
E_1 = hourly emission rate (lb/hr)
E_2 = annual emission rate (ton/yr)
k = particle size multiplier
U = mean wind speed, miles per hour (mph)
M = material moisture content, weight percent (%)
CE = control efficiency (%)
T_1 = material transfer rate (ton/hr)
T_2 = material transfer rate (ton/yr)

B. Input Data

Parameter	Units	Value
Particle size multiplier (k), particle size <30 µm	-	0.74
Particle size multiplier (k), particle size <10 µm	-	0.35
Particle size multiplier (k), particle size <2.5 µm	-	0.053
Mean Wind Speed (U)	mph	6.5
Minimum Daily Moisture Content (M), Biomass Fuel	weight %	20
Annual Average Moisture Content (M), Biomass Fuel	weight %	45
Control Efficiency (CE) - Partial Enclosure	%	70

C. Calculations

Emission Point	EU ID	Material Transfer Rates		PM Emission Estimates					
				PM		PM_{10}		$PM_{2.5}$	
		(ton/hr)	(ton/yr)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
Biomass Fuel Truck Unloading Shed - Truck Unloading	FUG-1	600	1,395,030	0.0239	0.0089	0.0113	0.0042	0.00171	0.00064
Transfer from Conveyor No. 3 to Conveyor No. 5	FUG-2	300	1,395,030	0.0119	0.0089	0.0056	0.0042	0.00085	0.00064
Transfer from Conveyor No. 4 to Conveyor No. 5	FUG-3	300	1,395,030	0.0119	0.0089	0.0056	0.0042	0.00085	0.00064
Transfer from Conveyor No. 5 to Conveyor No. 6 (will not operate concurrently with FUG-5 and FUG-16)	FUG-4	600	1,395,030	0.0239	0.0089	0.0113	0.0042	0.00171	0.00064
Transfer from Conveyor No. 5 to Conveyor No. 7 (will not operate concurrently with FUG-4, FUG-6, and FUG-7)	FUG-5	600	1,395,030	0.0239	0.0089	0.0113	0.0042	0.00171	0.00064
Transfer from Conveyor No. 6 to Stacker No. 1 (Will not operate concurrently with FUG-5 and FUG-16)	FUG-6	600	1,395,030	0.0239	0.0089	0.0113	0.0042	0.00171	0.00064
Transfer from Stacker No. 1 to Storage Pile No. 1 (Will not operate concurrently with FUG-5 and FUG-16)	FUG-7	600	1,395,030	0.0239	0.0089	0.0113	0.0042	0.00171	0.00064
Automated Reclaim from Storage Pile No. 1 - Transfer from Reclaimer to Conveyor No. 8 (Will not operate concurrently with FUG-11 and FG-12) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-10	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Manual Reclaim from Storage Pile No. 1 - Transfer from Dozer to Drag Chain Hopper (Will not operate concurrently with FUG-10) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-11	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Manual Reclaim from Storage Pile No. 1 - Transfer from Drag Chain to Conveyor No. 8 (Will not operate concurrently with FUG-10) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-12	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 8 to Conveyor No. 9 (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-13	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 9 to Conveyor No. 10 (Will not operate concurrently with FUG-15) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-14	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 9 to Conveyor No. 11 (Will not operate concurrently with FUG-14) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-15	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 7 to Stock Pile No. 1 (Will not operate concurrently with FUG-4, FUG-6 and FUG-7)	FUG-16	600	1,395,030	0.0239	0.0089	0.0113	0.0042	0.00171	0.00064
Transfer from Trucks to Sawdust Pile	FUG-21	50	182,500	0.0020	0.0012	0.0009	0.0006	0.00014	0.00008
Manual Reclaim from Storage Pile No. 2 or Sawdust Pile - Transfer from Dozer to Drag Chain Hopper (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-24	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Manual Reclaim from Storage Pile No. 2 or Sawdust Pile - Transfer from Drag Chain to Conveyor No. 14 (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-25	250	182,500	0.0099	0.0012	0.0047	0.0006	0.00071	0.00008
Transfer from Conveyor No. 14 to Conveyor No. 10 (Will not operate concurrently with FUG-27) (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-26	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 14 to Conveyor No. 11 (Will not operate concurrently with FUG-26) (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-27	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 10 to Conveyor No. 12 (Will not operate concurrently with FUG-29)	FUG-28	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Transfer from Conveyor No. 11 to Conveyor No. 13 (Will not operate concurrently with FUG-28)	FUG-29	250	1,395,030	0.0099	0.0089	0.0047	0.0042	0.00071	0.00064
Totals				**0.2884**	**0.1717**	**0.1364**	**0.0812**	**0.0207**	**0.0123**

Table A-15. Gainesville Renewable Energy Center
Fugitive Emission Source PM/PM_{10}/$PM_{2.5}$ Emission Estimates - Biomass Storage Piles
Storage Pile Wind Erosion

A. Emission Estimation Methodology

Reference - EPA AP-42, Section 13.2.5, Industrial Wind Erosion, November 2006 - Equation (2).

$EF = k \times Sum(P_i)$, sum is from i to N (Equation 2)

where:

EF = emission factor ($g/m^2/yr$)
k = particle size multiplier (unitless)
N = number of disturbances per year
P_i = erosion potential function based on fastest mile between disturbances (g/m^2)
$P = 58 (u^* - u_t^*)^2 + 25 (u^* - u_t^*)$ (equation 3)
$P = 0$ for $u^* < u_t^*$
u^* is the friction velocity (= 0.053 times the fastest mile (m/s))
u_t^* = threshold friction velocity (m/s) = 1.02 m/s for overburden from AP-42 Table 13.2.5-2
The fastest mile is defined as the fastest observed one mile of wind from Jacksonville, FL for the years 1951 - 1980.

B. Input Data

Parameter	Units	Value
Threshold friction velocity (u_t^*)	m/s	1.02
Frequency of disturbance	dy/yr	365
Frequency of wind events resulting in wind erosion	dy/mo	1
Particle size multiplier (k), particle size <30 µm	-	1
Particle size multiplier (k), particle size <10 µm	-	0.5
Particle size multiplier (k), particle size <2.5 µm	-	0.075

C. Calculations

Erosion Potential Emission Factors

Month	Fastest Mile (mph)	Fastest Mile (m/s)	u* (m/s)	$(u^*-u_t^*)$	$(u^*-u_t^*)^2$	P_{PM} (g/m^2)	P_{PM10} (g/m^2)	$P_{PM2.5}$ (g/m^2)
Jan	41	18.33	0.97	-0.05	0.002	0.00	0.00	0.00
Feb	52	23.25	1.23	0.21	0.045	7.91	3.95	0.59
Mar	44	19.67	1.04	0.02	0.001	0.59	0.30	0.04
Apr	48	21.46	1.14	0.12	0.014	3.73	1.86	0.28
May	62	27.72	1.47	0.45	0.202	22.92	11.46	1.72
Jun	76	33.98	1.80	0.78	0.609	54.87	27.43	4.11
Jul	49	21.90	1.16	0.14	0.020	4.68	2.34	0.35
Aug	52	23.25	1.23	0.21	0.045	7.91	3.95	0.59
Sep	82	36.66	1.94	0.92	0.852	72.47	36.23	5.43
Oct	72	32.19	1.71	0.69	0.470	44.43	22.22	3.33
Nov	60	26.82	1.42	0.40	0.161	19.39	9.70	1.45
Dec	62	27.72	1.47	0.45	0.2016	22.92	11.46	1.72
Maximum Erosion Potential						**72.47**	**36.23**	**5.43**
Annualized Emission Factor (gm/m^2-yr)						**8.61**	**4.30**	**0.65**

Wind Erosion Emissions

Emission Source	EU ID	Total Area (m^2)	Disturbed Area (%)	Total (m^2)	Control Efficiency (%)	PM (tpy)	PM_{10} (tpy)	$PM_{2.5}$ (tpy)
Storage No. 1	FUG-8	21,000	10	2,100	50	0.0100	0.0050	0.00075
Stockpile No. 1	FUG-17	3,200	50	1,600	50	0.0076	0.0038	0.00057
Storage Pile No. 2	FUG-19	14,000	25	3,500	50	0.0166	0.0083	0.00125
Sawdust Pile	FUG-22	2,000	50	1,000	50	0.0047	0.0024	0.00036
Totals		**40,200**		**8,200**		**0.0389**	**0.0195**	**0.00292**

Assumptions: Control efficiency for water spray assumed to be 50%.
Annual emissions based on annualized emission factor which assumes one wind erosion event per month.

Table A-16. Gainesville Renewable Energy Center
Fugitive Emission Source PM/PM_{10}/$PM_{2.5}$ Emission Estimates - Biomass Storage Piles
Dozer Operations on Storage Piles

A. Emission Estimate Methodology

Reference - AP-42, Section 11.9, Western Surface Coal Mining - Table 11.9-1, EPA October 1998.

$E_1 = ([5.7 \times (s)^{1.2}] / (M)^{1.3}]) \times [1 - (CE / 100)] \times DZ$

$E_2 = ([5.7 \times (s)^{1.2}] / (M)^{1.3}]) \times [1 - (CE / 100)] \times DZ \times (1 \text{ ton} / 2{,}000 \text{ lb})$

$E_3 = ([k \times 1.0 \times (s)^{1.5}] / (M)^{1.4}]) \times [1 - (CE / 100)] \times DZ$

$E_4 = (k \times 1.0 \times [(s)^{1.5} / (M)^{1.4}]) \times [1 - (CE / 100)] \times DZ \times (1 \text{ ton} / 2{,}000 \text{ lb})$

where:
E_1 = PM hourly emission rate (lb/hr)
E_2 = PM annual emission rate (ton/yr)
s = material silt content (%)
M = material moisture content (%)
CE = control efficiency (%)
DZ = number of dozers

E_3 = PM_{10}/$PM_{2.5}$ hourly emission rate (lb/hr)
E_4 = PM_{10}/$PM_{2.5}$ annual emission rate (ton/yr)
k = particle size scaling factor

B. Input Data

Parameter	Units	Value
Material silt content (s)	%	0.20
Material moisture content (M)	%	20
Control Efficiency (CE) - watering, as necessary	%	50
Number of dozers		3
Particle size scaling factor, particle size <10 µm	-	0.75
Particle size scaling factor, particle size <2.5 µm	-	0.105

C. Calculations

Emission Point	EU ID	Operating Hours		PM Emission Estimates					
				PM		PM_{10}		$PM_{2.5}$	
		(hrs/day)	(hrs/yr)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
Dozer Operations on Storage Pile No. 1	FUG-9	24	8,760	0.025	0.11	0.0015	0.0066	0.00021	0.00093
Dozer Operations on Stock Pile No. 1	FUG-18	24	8,760	0.025	0.11	0.0015	0.0066	0.00021	0.00093
Dozer Operations on Storage Pile No. 2	FUG-20	24	8,760	0.025	0.11	0.0015	0.0066	0.00021	0.00093
Dozer Operations on Sawdust Pile	FUG-23	24	8,760	0.025	0.11	0.0015	0.0066	0.00021	0.00093
Totals				**0.10**	**0.44**	**0.0061**	**0.027**	**0.00085**	**0.0037**

Table A-17. Gainesville Renewable Energy Center
Fugitive Emission Source PM/PM_{10}/$PM_{2.5}$ Emission Estimates - Biomass Fuel Transfer Operations
Biomass Fuel Truck Travel on Paved Facility Roadways

A. Emission Estimate Methodology

Reference - AP-42, Section 13.2.1, Paved Roads - Equation (1), EPA November 2006.

$E_1 = (k \times [(sL / 2)^{0.65}] \times [(W / 3)^{1.5}] - C) \times [(1 - (P / 4N)] \times [1 - (CE / 100)] \times VMT_1$

$E_2 = (k \times [(sL / 2)^{0.65}] \times [(W / 3)^{1.5}] - C) \times [(1 - (P / 4N)] \times [1 - (CE / 100)] \times VMT_2 \times (1 \text{ ton} / 2{,}000 \text{ lb})$

where:
E_1 = hourly emission rate (lb/hr)
E_2 = annual emission rate (ton/yr)
k = particle size multiplier (lb/VMT)
sL = road surface silt loading (g/m^2)
W = average weight of vehicles (tons)
C = vehicle fleet exhaust, brake and tire wear (lb/VMT)
P = number of "wet" days/yr with 0.01 inches of precipitation
N = number of days in averaging period
CE = control efficiency (%)
VMT_1 = vehicle miles traveled (veh-mi/hr) = round-trip distance x number of trucks/hr
VMT_2 = vehicle miles traveled (veh-mi/yr) = round-trip distance x number of trucks/yr

B. Input Data

Parameter	Units	Value
Particle size multiplier (k), particle size <30 µm	lb/VMT	0.082
Particle size multiplier (k), particle size <10 µm	lb/VMT	0.016
Particle size multiplier (k), particle size <2.5 µm	lb/VMT	0.0024
Road Surface Silt Loading (sL), Table 13.2.1-3	g/m^2	0.6
Average Truck Weight (Average of empty and full truck weights)	tons	25
Fleet exhaust, brake and tire wear (C), particle size <30 µm	lb/VMT	0.00047
Fleet exhaust, brake and tire wear (c), particle size <10 µm	lb/VMT	0.00047
Fleet exhaust, brake and tire wear (c), particle size <2.5 µm	lb/VMT	0.00036
Number of "Wet" Days Per Year (P), Figure 13.2.1-2	-	115
Number of Days in Averaging Period (N)	-	365
Control Efficiency (CE) - Watering & Sweeping, as necessary	%	75
Round-Trip Distance - Biomass Fuel Trucks	mi	1.8
Round-Trip Distance - By-Product & Miscellaneous Trucks	mi	2.0

C. Calculations

Emission Point	EU ID	Number of Trucks		PM Emission Estimates					
				PM		PM_{10}		$PM_{2.5}$	
		(trucks/hr)	(trucks/yr)	(lb/hr)	(tpy)	(lb/hr)	(tpy)	(lb/hr)	(tpy)
Biomass Fuel Truck Travel on Facility Paved Roadways	FUG-30	24	55,801	9.1	10.6	1.8	2.1	0.26	0.31
By-Product & Miscellaneous Truck Travel on Facility Paved Roadways	FUG-31	1	2,080	0.30	0.4	0.06	0.08	0.009	0.011
Totals				**9.4**	**11.0**	**1.8**	**2.1**	**0.27**	**0.32**

Table A-18. Gainesville Renewable Energy Center
Fugitive Emission Source $PM/PM_{10}/PM_{2.5}$ Emission Estimates
Construction Excavation and Fill Activity

A. Emission Estimate Methodology

Reference - AP-42, Section 13.2.4, Aggregate Handling and Storage Piles - Equation (1), EPA November 2006.

$$E = k \times (0.0032) \times [(U / 5)^{1.3}) / (M / 2)^{1.4}] \times [1 - (CE / 100)] \times T \times (1 \text{ ton} / 2{,}000 \text{ lb})$$
$$T = MD \times MT$$

where:
E = emission rate (tons)
k = particle size multiplier
U = mean wind speed, miles per hour (mph)
M = material moisture content, weight percent (%)
CE = control efficiency (%)
T = material transfer rate (tons)
MD = material delivered to site (tons)
MT = number of material transfers

B. Input Data

Parameter	Units	Value
Fill Material Density, Typical	lb/ft^3	100
Fill Material Delivered to Site (MD)	yd^3	40,000
	ft^3	1,080,000
	tons	54,000
Number of Material Transfers (MT)	-	2
Particle Size Multiplier (k), particle size <30 µm	-	0.74
Particle Size Multiplier (k), particle size <10 µm	-	0.35
Particle Size Multiplier (k), particle size <2.5 µm	-	0.053
Mean Wind Speed (U)	mph	6.5
Average Moisture Content (M), Fill Material	weight %	8
Control Efficiency, Watering (CE)	%	50

C. Calculations

Emission Point	Material Transfer (tons)	PM Emission Estimates		
		PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
Construction Excavation and Fill Activity	108,000	0.013	0.0061	0.00092

Table A-19. Gainesville Renewable Energy Center
Fugitive Emission Source PM/PM_{10}/$PM_{2.5}$ Emission Estimates
Grading and Earth Moving Activity

A. Emission Estimate Methodology

Reference - AP-42, Section 11.9, Western Surface Coal Mining - Table 11.9-1, EPA July 1998.

$E_1 = 0.040 \times (S^{2.5}) \times VMT \times (1 \text{ ton} / 2{,}000 \text{ lb})$

$E_2 = 0.051 \times (S^{2.0}) \times 0.60 \times VMT \times (1 \text{ ton} / 2{,}000 \text{ lb})$

$E_3 = 0.051 \times (S^{2.0}) \times 0.031 \times VMT \times (1 \text{ ton} / 2{,}000 \text{ lb})$

$VMT = S \times T \times N$

where:
E_1 = PM emission rate; tons
S = mean vehicle speed, mph
VMT = vehicle miles traveled
E_2 = PM_{10} emission rate; tons
E_3 = $PM_{2.5}$ emission rate; tons
T = total operating hours; hrs/grading equipment
N = number of grading equipment

B. Input Data

Parameter	Units	Value
Construction Activity Duration	days	120
Mean Construction Vehicle Speed, Typical	mph	2.0
Number of Construction Equipment	-	15
Construction Equipment Operating Hours	hrs/dy	10
	hrs - total	1,200

C. Calculations

Emission Point	Vehicle Miles Traveled (VMT)	PM Emission Estimates		
		PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
Construction Grading and Earth Moving Activity	36,000	4.1	1.7	0.89

Table A-20. Gainesville Renewable Energy Center
Fugitive Emission Source PM/PM_{10}/$PM_{2.5}$ Emission Estimates
Construction Truck Travel on Unpaved Facility Roadways

A. Emission Estimate Methodology

Reference - AP-42, Section 13.2.2, Unpaved Roads - Equation (1a), EPA November 2006.

$$E = (k \times [(s / 12)^{a}] \times [(W / 3)^{b}] \times [1 - (CE / 100)] \times VMT \times (1 \text{ ton} / 2{,}000 \text{ lb})$$
$$TM = SOIL + MISC$$
$$VMT = (TM/LOAD) \times L$$

where:
E = emission rate (tons)
k = particle size multiplier (lb/VMT)
s = surface material silt content (%)
a = particle size constant
W = average weight of construction trucks (tons)
b = particle size constant
CE = control efficiency (%)
SOIL = soil (fill) material handled (tons)
MISC = miscellaneous material handled (tons)
TM = total material handled (tons)
VMT = vehicle miles traveled (veh-mi)
LOAD = average truck load (tons)
L = average travel distance (miles)

B. Input Data

Parameter	Units	Value
Particle Size Multiplier (k), particle size <30 µm	lb/VMT	4.9
Particle Size Multiplier (k), particle size <10 µm	lb/VMT	1.5
Particle Size Multiplier (k), particle size <2.5 µm	lb/VMT	0.15
Surface Material Silt Content (s), Table 13.2.2-1	%	8.5
Particle Size Multiplier (a), particle size <30 µm	-	0.7
Particle Size Multiplier (a), particle size <10 µm	-	0.9
Particle Size Multiplier (a), particle size <2.5 µm	-	0.9
Average Weight of Construction Trucks (W)	tons	30
Particle Size Multiplier (b), particle size <30 µm	-	0.45
Particle Size Multiplier (b), particle size <10 µm	-	0.45
Particle Size Multiplier (b), particle size <2.5 µm	-	0.45
Control Efficiency (CE) - Watering, as necessary	%	50
Soil (Fill) Material Handled (SOIL)	tons	108,000
Miscellaneous Material Handled (MISC)	tons	5,400
Average Truck Load (LOAD)	tons	20
Average Truck Travel Distance (L)	mi	2.0

C. Calculations

Emission Point	Vehicle Miles Traveled (VMT)	PM Emission Estimates		
		PM (tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
Construction Truck Travel on Facility Unpaved Roads	11,340	30.8	8.8	0.88

Table A-21. Gainesville Renewable Energy Center
Fugitive Emission Source $PM/PM_{10}/PM_{2.5}$ Emission Estimates
Construction Wind Erosion

A. Emission Estimation Methodology

Reference - EPA AP-42, Section 13.2.5, Industrial Wind Erosion, November 2006 - Equation (2).

$EF = k \times Sum(P_i)$, sum is from i to N (Equation 2)

where:

EF = emission factor ($g/m^2/yr$)
k = particle size multiplier (unitless)
N = number of disturbances per year
P_i = erosion potential function based on fastest mile between disturbances (g/m^2)
$P = 58 (u^* - u_t^*)^2 + 25 (u^* - u_t^*)$ (equation 3)
$P = 0$ for $u^* < u_t^*$
u^* is the friction velocity (= 0.053 times the fastest mile (m/s))
u_t^* = threshold friction velocity (m/s) = 1.02 m/s for overburden from AP-42 Table 13.2.5-2
The fastest mile is defined as the fastest observed one mile of wind from Jacksonville, FL for the years 1951 - 1980.

B. Input Data

Parameter	Units	Value
Threshold friction velocity (u_t^*)	m/s	1.02
Frequency of disturbance	dy/yr	365
Frequency of wind events resulting in wind erosion	dy/mo	1
Particle size multiplier (k), particle size <30 µm	-	1
Particle size multiplier (k), particle size <10 µm	-	0.5
Particle size multiplier (k), particle size <2.5 µm	-	0.075

C. Calculations

Erosion Potential Emission Factors

Month	Fastest Mile (mph)	Fastest Mile (m/s)	u* (m/s)	$(u^*-u_t^*)$	$(u^*-u_t^*)^2$	P_{PM} (g/m^2)	P_{PM10} (g/m^2)	$P_{PM2.5}$ (g/m^2)
Jan	41	18.33	0.97	-0.05	0.002	0.00	0.00	0.00
Feb	52	23.25	1.23	0.21	0.045	7.91	3.95	0.59
Mar	44	19.67	1.04	0.02	0.001	0.59	0.30	0.04
Apr	48	21.46	1.14	0.12	0.014	3.73	1.86	0.28
May	62	27.72	1.47	0.45	0.202	22.92	11.46	1.72
Jun	76	33.98	1.80	0.78	0.609	54.87	27.43	4.11
Jul	49	21.90	1.16	0.14	0.020	4.68	2.34	0.35
Aug	52	23.25	1.23	0.21	0.045	7.91	3.95	0.59
Sep	82	36.66	1.94	0.92	0.852	72.47	36.23	5.43
Oct	72	32.19	1.71	0.69	0.470	44.43	22.22	3.33
Nov	60	26.82	1.42	0.40	0.161	19.39	9.70	1.45
Dec	62	27.72	1.47	0.45	0.2016	22.92	11.46	1.72
Maximum Erosion Potential						**72.47**	**36.23**	**5.43**
Annualized Emission Factor (gm/m^2-yr)						**8.61**	**4.30**	**0.65**

Wind Erosion Emissions

Emission Source	Total Area (m^2)	Disturbed Area (%)	Total (m^2)	Control Efficiency (%)	PM tons)	PM_{10} (tons)	$PM_{2.5}$ (tons)
Construction	263,044	5	13,152	50	0.062	0.031	0.0047

Assumptions: Control efficiency for water spray assumed to be 50%.
Annual emissions based on annualized emission factor which assumes one wind erosion event per month.
Total area that will be disturbed during construction is approximately 65 acres.

Table A-22. Gainesville Renewable Energy Center
Construction Diesel Engine Criteria Pollutant Emission Estimates

A. Emission Estimate Methodology

References - NSPS Subpart IIII (NO_x, CO, VOC, and PM) and Mass Balance (SO_2).

E = EF x P x N x OP x (1 ton / 2,000 lb)
EFSO2 = FOFLOW x FODENSITY x (FOSULFUR / 100) x (1 / P) x (2 lb SO_2 / lb S) x (453.59 g / lb)

where:

E = annual emission rate; tons per year (ton/yr)
EF = emission factor; grams per brake horsepower-hour (g/bhp-hr)
P = engine output; brake horsepower-hour (bhp-hr)
N = number of construction equipment diesel engines
OP = annual operating hours; hours per year (hr/yr)
EFSO2 = SO_2 emission factor; grams per brake horsepower hour (g/bhp-hr)
FOFLOW = ULSD fuel oil flow rate; gallons per hour (gal/hr)
FODENSITY = ULSD fuel oil density; pounds per gallon (lb/gal)
FOSULFUR = ULSD fuel oil sulfur content; weight percent (weight %)

B. Input Data

Diesel Engine Data	Units	Construction Equipment Diesel Engines
Diesel Engine Output, Typical (P)	bhp	500
	kW	373
Construction Activity Duration	days	550
Construction Equipment Operating Hours, Per Engine, (OP)	hrs/dy	5
	hrs - total	2,750
Number of Construction Equipment Diesel Engines[1] (N)	-	23
Engine ULSD Fuel Oil Flow Rate (FOFLOW)	gal/hr	198
	gal/dy	990
	gal - total	544,500
EPA Nonroad Tier, Assumed (EF)	-	2
ULSD Fuel Oil Sulfur Content (FOSULFUR)	weight %	0.0015
ULSD Fuel Oil Density (FODENSITY)	lb/gal	7.08

C. Calculations

Criteria Pollutants	Construction Equipment Diesel Engines
NO_x g/bhp-hr[2]	3.4
tons	117.1
CO g/bhp-hr	2.6
ton/yr	90.6
VOC g/bhp-hr[3]	1.4
ton/yr	50.2
$PM/PM_{10}/PM_{2.5}$ g/bhp-hr	0.15
ton/yr	5.2
SO_2 g/bhp-hr[4]	0.038
ton/yr	1.3

[1] Total estimated number of diesel engines; conservatively assumed that all equipment will be in use at the same time.
[2] NO_x emission rate assumed equal to 70% of Subpart IIII NMHC + NO_x emission standard.
[3] VOC emission rate assumed equal to 30% of Subpart IIII NMHC + NO_x emission standard.
[4] Based on use of ULSD fuel oil.

Table A-23A. Gainesville Renewable Energy Center
As-Received Biomass Fuel Composition - Summary

	Wood Type	Hardwoods			Slash Pine			Sand Pine		
Parameter[1]	Units	Minimum	Maximum	Average	Minimum	Maximum	Average	Minimum	Maximum	Average
Moisture	weight %	41.27	62.52	52.89	43.64	60.86	51.77	47.49	59.67	53.58
Ash	weight %	0.59	0.76	0.67	0.14	0.25	0.19	0.32	0.38	0.35
Carbon	weight %	18.56	29.47	22.86	18.69	29.45	24.21	19.58	25.58	22.58
Sulfur	weight %	0.006	0.014	0.011	0.006	0.012	0.008	0.005	0.009	0.007
Nitrogen	weight %	0.04	0.13	0.08	0.05	0.11	0.08	0.11	0.12	0.12
Heat Content, HHV	Btu/lb	3,123	4,861	3,898	3,387	4,765	4,155	3,621	4,721	4,171
Chlorine	ppmw	16	30	23	11	33	17	9	16	13
Fluorine	ppmw	42	110	69	29	82	57	180	191	186
Antimony	ppmw	0.20	0.47	0.33	0.25	0.53	0.37	0.55	0.60	0.58
Arsenic	ppmw	0.10	0.47	0.24	0.13	0.53	0.31	0.55	0.60	0.58
Beryllium	ppmw	0.014	0.047	0.028	0.018	0.053	0.034	0.055	0.060	0.058
Cadmium	ppmw	0.014	0.056	0.035	0.017	0.029	0.023	0.046	0.067	0.057
Chromium	ppmw	0.68	1.20	0.94	0.16	3.70	1.77	2.00	3.60	2.80
Cobalt	ppmw	0.020	0.110	0.080	0.025	0.140	0.057	0.730	2.300	1.515
Lead	ppmw	0.036	0.120	0.071	0.045	0.130	0.083	0.110	0.140	0.125
Manganese	ppmw	36	37	37	0	33	13	15	22	19
Mercury	ppmw	0.004	0.006	0.005	0.004	0.006	0.005	0.006	0.006	0.006
Nickel	ppmw	0.31	0.61	0.46	0.37	1.50	0.88	1.10	1.90	1.50
Selenium	ppmw	0.29	0.83	0.48	0.38	0.80	0.60	0.32	0.57	0.45

	Wood Type	Loblolly Pine			Data Summary - All Wood Types			BFB Boiler Design Wood Mix	
Parameter[1]	Units	Minimum	Maximum	Average	Minimum	Maximum	Average	Dry	As-Received
Moisture	weight %	57.32	59.66	58.49	41.27	62.52	53.63	0.00	50.00
Ash	weight %	0.24	0.39	0.32	0.14	0.76	0.45	0.98	0.49
Carbon	weight %	19.09	20.15	19.62	18.56	29.47	22.71	48.95	24.48
Sulfur	weight %	0.006	0.008	0.007	0.0050	0.014	0.0085	0.018	0.0090
Nitrogen	weight %	0.09	0.11	0.10	0.040	0.13	0.089	0.18	0.090
Heat Content, HHV	Btu/lb	3,548	3,787	3,668	3,123	4,861	3,999	8,529	4,265
Chlorine	ppmw	15	18	17	9	33	18	40	20
Fluorine	ppmw	117	117	117	29	191	205		
Antimony	ppmw	0.45	0.54	0.50	0.20	0.60	0.42		
Arsenic	ppmw	0.45	0.54	0.50	0.10	0.60	0.37		
Beryllium	ppmw	0.045	0.054	0.050	0.014	0.060	0.039		
Cadmium	ppmw	0.025	0.051	0.038	0.014	0.067	0.043		
Chromium	ppmw	1.00	1.20	1.10	0.16	3.70	2.61		
Cobalt	ppmw	0.250	2.300	1.275	0.020	2.300	0.550		
Lead	ppmw	0.059	0.110	0.085	0.036	0.140	0.087	0.200	0.100
Manganese	ppmw	5	47	26	0	47	37		
Mercury	ppmw	0.005	0.005	0.005	0.004	0.006	0.005	0.011	0.006
Nickel	ppmw	0.59	0.63	0.61	0.31	1.90	1.32		
Selenium	ppmw	0.44	0.47	0.46	0.29	0.83	0.51		

[1] As-received

Table A-23B. Gainesville Renewable Energy Center
As-Received Biomass Fuel Composition - Hardwoods

Parameter[1,2]	Sample ID	AR-007	AR-009	AR-011	Data Summary			
	Units				Minimum	Maximum	Average	Median
Moisture	weight %	54.89	62.52	41.27	41.27	62.52	52.89	54.89
Ash	weight %	0.67	0.59	0.76	0.59	0.76	0.67	0.67
Carbon	weight %	20.56	18.56	29.47	18.56	29.47	22.86	20.560
Sulfur	weight %	0.014	0.006	0.014	0.006	0.014	0.011	0.01
Nitrogen	weight %	0.13	0.04	0.08	0.04	0.13	0.08	0.08
Heat Content, HHV	Btu/lb	3,711	3,123	4,861	3,123	4,861	3,898	3,711
Chlorine	ppmw	16	30	23	16	30	23	23
Fluorine	ppmw	110	42	55	42	110	69	55
Antimony	ppmw	0.47	0.20	0.31	0.20	0.47	0.33	0.31
Arsenic	ppmw	0.47	0.10	0.16	0.10	0.47	0.24	0.16
Beryllium	ppmw	0.047	0.014	0.023	0.014	0.047	0.028	0.023
Cadmium	ppmw	~~0.120~~	0.014	0.056	0.014	0.056	0.035	0.035
Chromium	ppmw	1.20	0.68	~~12.0~~	0.68	1.20	0.94	0.94
Cobalt	ppmw	0.110	0.020	0.110	0.020	0.110	0.080	0.110
Lead	ppmw	0.120	0.036	0.057	0.036	0.120	0.071	0.057
Manganese	ppmw	37	36	~~190~~	36	37	37	37
Mercury	ppmw	0.0050	0.0040	0.0060	0.0040	0.0060	0.0050	0.0050
Nickel	ppmw	0.61	0.31	~~5.90~~	0.31	0.61	0.46	0.46
Selenium	ppmw	0.29	0.31	0.83	0.29	0.83	0.48	0.31

[1] As-received

[2] Values shown with strikeout font are outliers and were not used in data summary statistics

Table A-23C. Gainesville Renewable Energy Center
Biomass Fuel Composition - Slash Pine

Parameter[1,2]	Sample ID	AR-001	AR-004	AR-010	AR-012	Data Summary			
	Units					Minimum	Maximum	Average	Median
Moisture	weight %	60.86	49.38	43.64	53.20	43.64	60.86	51.77	60.86
Ash	weight %	0.14	0.19	~~1.06~~	0.25	0.14	0.25	0.19	0.19
Carbon	weight %	18.69	24.37	29.45	24.34	18.69	29.45	24.21	18.69
Sulfur	weight %	0.007	0.006	0.012	0.007	0.006	0.012	0.008	0.007
Nitrogen	weight %	0.08	0.11	0.06	0.05	0.05	0.11	0.08	0.08
Heat Content, HHV	Btu/lb	3,387	4,376	4,765	4,093	3,387	4,765	4,155	3,387
Chlorine	ppmw	12	11	12	33	11	33	17	12
Fluorine	ppmw	74	82	43	29	29	82	57	74
Antimony	ppmw	0.41	0.53	0.30	0.25	0.25	0.53	0.37	0.41
Arsenic	ppmw	0.41	0.53	0.15	0.13	0.13	0.53	0.31	0.41
Beryllium	ppmw	0.041	0.053	0.022	0.018	0.018	0.053	0.034	0.041
Cadmium	ppmw	0.029	0.026	0.021	0.017	0.017	0.029	0.023	0.029
Chromium	ppmw	2.10	0.16	3.70	1	0.16	3.70	1.77	2.10
Cobalt	ppmw	0.034	0.140	0.030	0.025	0.025	0.140	0.057	0.034
Lead	ppmw	0.100	0.130	0.055	0.045	0.045	0.130	0.083	0.100
Manganese	ppmw	12	0.27	7.4	33	0	33	13	12
Mercury	ppmw	0.004	0.005	0.006	0.005	0.004	0.006	0.005	0.004
Nickel	ppmw	1.10	0.53	1.50	0.37	0.37	1.50	0.88	1.10
Selenium	ppmw	0.38	0.59	0.80	0.61	0.38	0.80	0.60	0.38

[1] As-received

[2] Values shown with strikeout font are outliers and were not used in data summary statistics

Table A-23D. Gainesville Renewable Energy Center
Biomass Fuel Composition - Sand Pine

Parameter[1]	Sample ID	AR-003	AR-006	Data Summary			
	Units			Minimum	Maximum	Average	Median
Moisture	weight %	59.67	47.49	47.49	59.67	53.58	59.67
Ash	weight %	0.32	0.38	0.32	0.38	0.35	0.32
Carbon	weight %	19.58	25.58	19.58	25.58	22.58	19.58
Sulfur	weight %	0.009	0.005	0.005	0.009	0.007	0.009
Nitrogen	weight %	0.11	0.12	0.11	0.12	0.12	0.11
Heat Content, HHV	Btu/lb	3,621	4,721	3,621	4,721	4,171	3,621
Chlorine	ppmw	16	9	9	16	13	16
Fluorine	ppmw	191	180	180	191	186	191
Antimony	ppmw	0.55	0.60	0.55	0.60	0.58	0.55
Arsenic	ppmw	0.55	0.60	0.55	0.60	0.58	0.55
Beryllium	ppmw	0.055	0.060	0.055	0.060	0.058	0.055
Cadmium	ppmw	0.046	0.067	0.046	0.067	0.057	0.046
Chromium	ppmw	2.00	3.60	2.00	3.60	2.80	2.00
Cobalt	ppmw	2.300	0.730	0.730	2.300	1.515	2.300
Lead	ppmw	0.140	0.110	0.110	0.140	0.125	0.140
Manganese	ppmw	22	15.00	15	22	19	22
Mercury	ppmw	0.006	0.006	0.006	0.006	0.006	0.006
Nickel	ppmw	1.10	1.90	1.10	1.90	1.50	1.10
Selenium	ppmw	0.32	0.57	0.32	0.57	0.45	0.32

[1] As-received

Table A-23E. Gainesville Renewable Energy Center
Biomass Fuel Composition - Loblolly Pine

Parameter[1,2]	Sample ID	AR-002	AR-005	Data Summary			
	Units			Minimum	Maximum	Average	Median
Moisture	weight %	57.32	59.66	57.32	59.66	58.49	57.32
Ash	weight %	0.24	0.39	0.24	0.39	0.32	0.24
Carbon	weight %	20.15	19.09	19.09	20.15	19.62	20.15
Sulfur	weight %	0.006	0.008	0.006	0.008	0.007	0.006
Nitrogen	weight %	0.11	0.09	0.09	0.11	0.10	0.11
Heat Content, HHV	Btu/lb	3,787	3,548	3,548	3,787	3,668	3,787
Chlorine	ppmw	18	15	15	18	17	18
Fluorine	ppmw	117	~~1,331~~	117	117	117	117
Antimony	ppmw	0.54	0.45	0.45	0.54	0.50	0.54
Arsenic	ppmw	0.54	0.45	0.45	0.54	0.50	0.54
Beryllium	ppmw	0.054	0.045	0.045	0.054	0.050	0.054
Cadmium	ppmw	0.051	0.025	0.025	0.051	0.038	0.051
Chromium	ppmw	1.00	1.20	1.00	1.20	1.10	1.00
Cobalt	ppmw	2.300	0.250	0.250	2.300	1.275	2.300
Lead	ppmw	0.059	0.110	0.059	0.110	0.085	0.059
Manganese	ppmw	47	5.40	5	47	26	47
Mercury	ppmw	0.005	0.005	0.005	0.005	0.005	0.005
Nickel	ppmw	0.59	0.63	0.59	0.63	0.61	0.59
Selenium	ppmw	0.47	0.44	0.44	0.47	0.46	0.47

[1] As-received

[2] Values shown with strikeout font are outliers and were not used in data summary statistics

Table A-23D. Gainesville Renewable Energy Center
Biomass Fuel Composition - Sand Pine

Parameter[1]	Sample ID	AR-003	AR-006	Data Summary			
	Units			Minimum	Maximum	Average	Median
Moisture	weight %	59.67	47.49	47.49	59.67	53.58	59.67
Ash	weight %	0.32	0.38	0.32	0.38	0.35	0.32
Carbon	weight %	19.58	25.58	19.58	25.58	22.58	19.58
Sulfur	weight %	0.009	0.005	0.005	0.009	0.007	0.009
Nitrogen	weight %	0.11	0.12	0.11	0.12	0.12	0.11
Heat Content, HHV	Btu/lb	3,621	4,721	3,621	4,721	4,171	3,621
Chlorine	ppmw	16	9	9	16	13	16
Fluorine	ppmw	191	180	180	191	186	191
Antimony	ppmw	0.55	0.60	0.55	0.60	0.58	0.55
Arsenic	ppmw	0.55	0.60	0.55	0.60	0.58	0.55
Beryllium	ppmw	0.055	0.060	0.055	0.060	0.058	0.055
Cadmium	ppmw	0.046	0.067	0.046	0.067	0.057	0.046
Chromium	ppmw	2.00	3.60	2.00	3.60	2.80	2.00
Cobalt	ppmw	2.300	0.730	0.730	2.300	1.515	2.300
Lead	ppmw	0.140	0.110	0.110	0.140	0.125	0.140
Manganese	ppmw	22	15.00	15	22	19	22
Mercury	ppmw	0.006	0.006	0.006	0.006	0.006	0.006
Nickel	ppmw	1.10	1.90	1.10	1.90	1.50	1.10
Selenium	ppmw	0.32	0.57	0.32	0.57	0.45	0.32

[1] As-received

Table A-24. Gainesville Renewable Energy Center
Fuel Use

A. BFB Boiler

Fuel	Annual Operating Hours (hrs/yr)	Heat Content, HHV		Maximum Heat Input (10^6 Btu/hr, HHV)	Maximum Heat Input (10^6 Btu/yr, HHV)	Biomass		Natural Gas[1]	
		Units	Value			Hourly (ton/hr)	Annual (ton/yr)	Hourly (10^6 ft^3/hr)	Annual (10^6 ft^3/yr)
Biomass (as received)	8,760	Btu/lb	4,264	1,358	11,896,080	159.3	1,395,030		
Natural Gas[1]	280	Btu/ft^3	1,050	341	46,000			0.324	43.81

B. Emergency Generator Diesel Engine (750 kW)

Fuel	Annual Operating Hours (hrs/yr)	Heat Content, HHV		Maximum Heat Input (10^6 Btu/hr, HHV)	Maximum Heat Input (10^6 Btu/yr, HHV)	ULSD	
		Units	Value			Hourly (10^3 gal/hr)	Annual (10^3 gal/yr)
Ultra Low Sulfur Diesel (ULSD)	500	Btu/gal	138,000	2.0	1,014	0.015	7.350

C. Emergency Firewater Pump Diesel Engine (300 HP)

Fuel	Annual Operating Hours (hrs/yr)	Heat Content, HHV		Maximum Heat Input (10^6 Btu/hr, HHV)	Maximum Heat Input (10^6 Btu/yr, HHV)	ULSD	
		Units	Value			Hourly (10^3 gal/hr)	Annual (10^3 gal/yr)
Ultra Low Sulfur Diesel (ULSD)	500	Btu/gal	138,000	5.1	2,539	0.037	18.400

[1] Only used during startups. Basis: 20 cold startups per year, 14 hours per cold startup, and 2,300 x 10^6 Btu/cold startup event

Table A-25. Gainesville Renewable Energy Center
Point Source Stack Parameters

Point Emission Source	Emission ID	Height		Diameter		Temperature		Area		Standard Flow Rate[1]		Actual Flow Rate		Velocity	
		(ft)	(m)	(ft)	(m)	(^oF)	(K)	(ft^2)	(m^2)	(ft^3/min)	(m^3/min)	(ft^3/min)	(m^3/min)	(ft/sec)	(m/s)
Screen/Hog Building Baghouse	P-1	50.0	15.24	3.25	0.99	77	298.2	8.30	0.77	35,397	1,002.3	36,000	1,019.4	72.33	22.04
BFB Boiler Fuel Bin Vent Filter No. 1	P-2	100.0	30.48	1.5	0.46	77	298.2	1.77	0.16	3,933	111.4	4,000	113.3	37.73	11.50
BFB Boiler Fuel Bin Vent Filter No. 2	P-3	100.0	30.48	1.0	0.30	77	298.2	0.79	0.07	1,967	55.7	2,000	56.6	42.44	12.94
Fly Ash Silo Vacuum Blowers (each)	P-4, P-5	70.0	21.34	1.5	0.46	100	310.9	1.77	0.16	3,300	93.5	3,500	99.1	33.01	10.06
Fly Ash Silo Bin Vent Filter	P-6	77.0	23.47	1.0	0.30	100	310.9	0.79	0.07	1,886	53.4	2,000	56.6	42.44	12.94
BFB Boiler - 100%	P-7A	230.0	70.10	12.00	3.66	310	427.6	113.10	10.51	357,125	10,112.7	520,600	14,741.8	76.72	23.38
BFB Boiler - 70%	P-7B	230.0	70.10	12.00	3.66	302	423.2	113.10	10.51	249,477	7,064.4	359,900	10,191.2	53.04	16.17
Cooling Tower Cells (Per Cell)	P-8A thru P-8D	53.1	16.20	36.75	11.20	93	307.0	1,060.73	98.54	2,315,503	65,567.8	2,425,000	68,668.4	38.10	11.61
Emergency Generator Diesel Engine (Kohler Model 500REOZVB or equiv.)	P-9	15.0	4.57	0.67	0.20	893	751.5	0.35	0.03	1,523	43.1	3,899	110.4	186.16	56.74
Emergency Fire Water Pump Diesel Engine (Caterpillar C9 ACERT 275 BHP or equiv.)	P-10	10.0	3.05	0.50	0.15	855	730.4	0.20	0.02	904	25.6	2,250	63.7	190.99	58.21
Sorbent Silo Bin Vent Filter	P-11	51.0	15.54	1.0	0.30	100	310.9	0.79	0.07	1,886	53.4	2,000	56.6	42.44	12.94

[1] At 68^{o}F.

Table A-26. Gainesville Renewable Energy Center
Fugitive Volume Source Release Parameters

Fugitive Emission Source	EU ID	Release Height		Volume Source Parameters								
				Length of Side		Vertical Dimension		Initial Lateral Dimension, S_y		Initial Vertical Dimension, S_z		PM_{10}
		(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(ft)	(m)	(g/s)
Biomass Fuel Truck Unloading Shed - Truck Unloading	FUG-1	10.0	3.0	20.00	6.10	20.0	6.10	4.65	1.42	4.65	1.418	0.00142
Transfer from Conveyor No. 3 to Conveyor No. 5	FUG-2	3.5	1.1	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00071
Transfer from Conveyor No. 4 to Conveyor No. 5	FUG-3	3.5	1.1	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00071
Transfer from Conveyor No. 5 to Conveyor No. 6 (will not operate concurrently with FUG-5 and FUG-16)	FUG-4	45.5	13.9	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00142
Transfer from Conveyor No. 5 to Conveyor No. 7 (will not operate concurrently with FUG-4, FUG-6, and FUG-7)	FUG-5	57.5	17.5	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00142
Transfer from Conveyor No. 6 to Stacker No. 1 (Will not operate concurrently with FUG-5 and FUG-16)	FUG-6	67.1	20.5	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00142
Transfer from Stacker No. 1 to Storage Pile No. 1 (Will not operate concurrently with FUG-5 and FUG-16)	FUG-7	42.3	12.9	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00142
Automated Reclaim from Storage Pile No. 1 - Transfer from Reclaimer to Conveyor No. 8 (Will not operate concurrently with FUG-11 and FG-12) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-10	3.5	1.1	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Manual Reclaim from Storage Pile No. 1 - Transfer from Dozer to Drag Chain Hopper (Will not operate concurrently with FUG-10) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-11	2.5	0.8	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Manual Reclaim from Storage Pile No. 1 - Transfer from Drag Chain to Conveyor No. 8 (Will not operate concurrently with FUG-10) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-12	5.0	1.5	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 8 to Conveyor No. 9 (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-13	3.5	1.1	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 9 to Conveyor No. 10 (Will not operate concurrently with FUG-15) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-14	3.5	1.1	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 9 to Conveyor No. 11 (Will not operate concurrently with FUG-14) (Will not operate concurrently with Storage Pile No. 2 or Sawdust Pile Reclaim)	FUG-15	3.5	1.1	2.00	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 7 to Stock Pile No. 1 (Will not operate concurrently with FUG-4, FUG-6 and FUG-7)	FUG-16	30.0	9.1	2.0	0.61	2.0	0.61	0.47	0.14	0.47	0.142	0.00142
Transfer from Trucks to Sawdust Pile	FUG-21	5.0	1.5	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00012
Manual Reclaim from Storage Pile No. 2 or Sawdust Pile - Transfer from Dozer to Drag Chain Hopper (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-24	2.5	0.8	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Manual Reclaim from Storage Pile No. 2 or Sawdust Pile - Transfer from Drag Chain to Conveyor No. 14 (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-25	5.0	1.5	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 14 to Conveyor No. 10 (Will not operate concurrently with FUG-27) (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-26	3.5	1.1	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 14 to Conveyor No. 11 (Will not operate concurrently with FUG-26) (Will not operate concurrently with Storage Pile No. 1 Reclaim)	FUG-27	3.5	1.1	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 10 to Conveyor No. 12 (Will not operate concurrently with FUG-29)	FUG-28	110.9	33.8	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Transfer from Conveyor No. 11 to Conveyor No. 13 (Will not operate concurrently with FUG-28)	FUG-29	110.9	33.8	2.0	0.61	1.0	0.30	0.47	0.14	0.23	0.071	0.00059
Biomass Truck Traffic on Paved Facility Roadways[1]	FUG-30	13.1	4.0	180.3	54.95	24.4	7.44	41.93	12.78	5.68	1.73	0.06941
Miscellaneous Truck Traffic on Paved Facility Roadways[1]	FUG-31	13.1	4.0	180.3	54.95	24.4	7.44	41.93	12.78	5.68	1.73	0.00339

[1] 24-hour average PM_{10} emission rate.