TABLE D-7
REGENERATIVE THERMAL OXIDATION COST ANALYSIS FOR ROTARY DRYER
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RTO Price+ Freight+Instrumentation	$2,700,000	A	2(a)
95% Sales Tax	$81,000	0.03A	1(a)
Purchased Equipment Cost, PEC	$2,781,000	B	
Direct Installation Costs			
Foundations and Support	$222,480	0.08B	1(a)
Handling & Erection	$389,340	0.14B	1(a)
Electrical	$111,240	0.04B	1(a)
Piping	$55,620	0.02B	1(a)
Insulation for ductwork	$27,810	0.01B	1(a)
Painting	$27,810	0.01B	1(a)
Direct Installation Costs	$834,300		
Total Direct Costs, DC	$3,615,300		
Indirect Costs (Installation)			
Engineering	$278,100	0.10B	1(a)
Construction and field expenses	$139,050	0.05B	1(a)
Contractor Fees	$278,100	0.10B	1(a)
Start-up	$55,620	0.02B	1(a)
Performance test	$27,810	0.01B	1(a)
Contingencies	$83,430	0.03B	1(a)
Total i 1.64	$862,110		
Total Capital Investment	$4,477,410	TCI = DC + IC	
Operating Cost			
Capacity Factor For Direct Annual Costs	88.2%	used to establish hours/yr of operation	
Operating Labor			
Operator	$24,753	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Supervisor	$3,713	15% of operator	1(b)
Total	$28,466		
Maintenance			
Labor	$24,753	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Material	$24,753	100% of maintenance labor	1(b)
Total	$49,506		
Electricity			
Total Requirement	595	KW	2(c)
Unit cost	$0.070	$/kW-hr	2(c)
Total	$321,930		
Fuel			
Natural Gas	9.99	MMBTU/hr	3(a)
Cost	$6.00	$/MMBtu	2(b)
Total	$525,000		

Total Direct Annual Costs	*$924,903*		
Indirect Annual Costs			
Overhead	$46,784	60% of operating labor + maintenance	1(b)
Administrative Charges	$89,548	2% of TCI	1(b)
Property tax	$44,774	1% of TCI	1(b)
Insurance	$44,774	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RTO	10		
Capital Recovery Factor	0.163		
Total Capital Recovery Cost	$728,678		
Total Indirect Annual Costs	*$954,558*		
Total Annual Cost	**$1,879,460**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Provided to Wallace Lasonde of Enviva by Steve Jaasund from GEOENERGY Division of A.H. Lundberg Associates, Inc on March 21, 2011.
   a RTO Price/Quote
   b Natural Gas Cost and usage.
   c Electricity cost and power requirement.
3. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* -- Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Compressed Air Cost from Memo
4. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)

TABLE D-8
VOC BACT IMPACTS SUMMARY FOR ROTARY DRYER
ENVIVA PELLET SAMPSON, LLC

Control Options (lb/ODT)	Uncontrolled Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts			Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.107 (RTO)	288.3	90%	259.4	$4,477,410	$1,879,460	$7,245	5.21E+06	No
1.07 (Baseline)	288.3	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE D-9
CO BACT IMPACTS SUMMARY FOR ROTARY DRYER
ENVIVA PELLETS SAMPSON, LLC

Control Options (lb/MMBtu)	Baseline Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts			Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.042 (RTO)	230.45	80%	184.4	$4,477,410	$1,879,460	$10,194	5.21E+06	No
0.210 (Baseline)	230.45	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE D-10
BACT INPUT PARAMETERS AND EMISSIONS ESTIMATES FOR GREEN WOOD HAMMERMILLS
ENVIVA PELLET SAMPSON, LLC

Operating Assumptions:

Stack Flow Rate =	20,000	ACFM;
Exit Temperature =	332.59	deg K
Standard flow rate =	17,628.10	SCFM
lb/ODT Factor =	0.27	
Production Rate =	376,338	ODT/yr
Operating hours and days =	8,760	hrs/yr

RTO Capital Cost =	$	572,604	Estimated from RTO manufacturer using scfm
Estimated RTO Operating Cost (fuel and electricity) =	$	141,948	Estimated from RTO manufacturer using scfm

VOC Emissions Summary:

Pollutant	GREEN HAMMERMILL (tpy)
VOC	50.53

TABLE D-11
REGENERATIVE THERMAL OXIDATION COST ANALYSIS - GREEN WOOD HAMMERMILLS
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RTO Price+ Freight+Instrumentation	$572,604	A	2(a)
Sales Tax	$17,178	0.03A	1(a)
Purchased Equipment Cost, PEC	$589,782	B	
Direct Installation Costs			
Foundations and Support	$47,183	0.08B	1(a)
Handling & Erection	$82,570	0.14B	1(a)
Electrical	$23,591	0.04B	1(a)
Piping	$11,796	0.02B	1(a)
Insulation for ductwork	$5,898	0.01B	1(a)
Painting	$5,898	0.01B	1(a)
Direct Installation Costs	$176,935		
Total Direct Costs, DC	$766,717		
Indirect Costs (Installation)			
Engineering	$58,978	0.10B	1(a)
Construction and field expenses	$29,489	0.05B	1(a)
Contractor Fees	$58,978	0.10B	1(a)
Start-up	$11,796	0.02B	1(a)
Performance test	$5,898	0.01B	1(a)
Contingencies	$17,693	0.03B	1(a)
Total Indirect Costs, IC	$182,833		
Total Capital Investment	$949,550	TCI = DC + IC	
Operating Cost			
Operating Labor			
Operator	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Supervisor	$4,210	15% of operator	1(b)
Total	$32,275		
Maintenance			
Labor	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Material	$28,065	100% of maintenance labor	1(b)
Total	$56,130		
Electricity			
Total Requirement	92.60	KW	2(c)
Unit cost	$0.070	$/kW-hr	2(c)
Total	$56,779		
Fuel			
Natural Gas	1.62	MMBTU/hr	3(a)
Cost	$6.00	$/MMBtu	2(b)
Total	$85,169		

Total Direct Annual Costs	*$230,353*		
Indirect Annual Costs			
Overhead	$53,043	60% of operating labor + maintenance	1(b)
Administrative Charges	$18,991	2% of TCI	1(b)
Property tax	$9,495	1% of TCI	1(b)
Insurance	$9,495	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RTO	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$124,841		
Total Indirect Annual Costs	*$215,865*		
Total Annual Cost	**$446,218**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Provided toWaalace Lasonde of Enviva by Steve Jaasund from GEOENERGY Division of A.H. Lundberg Assoicates, Inc on March 21, 2011.
   a RTO Price/Quote
   b Natural Gas Cost and usage.
   c Electricity cost and power requirement.
3. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* -- Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Compressed Air Cost from Memo
4. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)

TABLE D-12
PELLET COOLER ASPIRATION SYSTEM - GREEN WOOD HAMMERMILLS
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RCO Price + auxiliary equipment + freight	$1,056,414	A	2(a), 6
Sales Tax	$31,692	0.03A	1(a)
Purchased Equipment Cost, PEC	$1,088,107	B	
Direct Installation Costs			
Foundations and Support	$87,049	0.08B	1(a)
Handling & Erection	$152,335	0.14B	1(a)
Electrical	$43,524	0.04B	1(a)
Piping	$21,762	0.02B	1(a)
Insulation for ductwork	$10,881	0.01B	1(a)
Painting	$10,881	0.01B	1(a)
Direct Installation Costs	$326,432		
Total Direct Costs, DC	$1,414,539		
Indirect Costs (Installation)			
Engineering	$108,811	0.10B	1(a)
Construction and field expenses	$54,405	0.05B	1(a)
Contractor Fees	$108,811	0.10B	1(a)
Start-up	$21,762	0.02B	1(a)
Performance test	$10,881	0.01B	1(a)
Contingencies	$32,643	0.03B	1(a)
Total Indirect Costs, IC	$337,313		
Total Capital Investment	$1,751,852	TCI = DC + IC	
Operating Cost			
Operating Labor			
Operator	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 4(a)
Supervisor	$4,210	15% of operator	1(b)
Total	$32,275		
Maintenance			
Labor	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 4(a)
Material	$28,065	100% of maintenance labor	1(b)
Total	$56,130		
Electricity			
Total Requirement	27	KW	Lundberg
Unit cost	$0.070	$/kW-hr	3(b)
Total	$16,441		
Fuel			
Natural Gas or fuel	0.1	MBTU/hr	3(a), 7
Cost	$6.00	$/MMBtu	6
Conversion	1020	Btu/ft^3	
Total	$4,421		
Compressed Air			
Requirement	4	SCFM	2(a), 4(b), 7
Cost	$0.31	$/1000 ft^3 air	4(b)
Total	$699		

Catalyst Costs			
Catalyst Cost (Present Value)	$48,197		2(b), 7
Catalyst Life	2		2(b)
Catalyst Cost (Future Value)	$51,619	F/P, 3.5%, 2 years	
Catalyst Cost (Annualized) Total	$24,581	A/F, 10%, 2 years	
Total Direct Annual Costs	*$134,546*		
Indirect Annual Costs			
Overhead	$53,043	60% of operating labor + maintenance	1(b)
Administrative Charges	$35,037	2% of TCI	1(b)
Property tax	$17,519	1% of TCI	1(b)
Insurance	$17,519	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RCO	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$230,323		
Total Indirect Annual Costs	*$353,439*		
Total Annual Cost	**$487,985**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Hertford Renewable Energy PSD Application (Hertford, North Carolina). Submitted 2008, Approved 2009.
   a RCO Price/Quote $5,143,578
   b Catalyst costs and life
   c Fuel Requirement was 2.5 MBTU/hr
   d 14 iwc for pressure drop and RCO electricity and utility usage were similar to RSCR
3. Enviva Vendor
   a Natural Gas Cost
   b Electricity cost
4. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* -- Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Electricity and Compressed Air Cost from Memo
5. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)
6. Scale-up capital cost factor from Ulrich, Gael D. Chemical Engineering Process Design and Economics, 2004 ($C1*(S2/S1)^{0.6}$) where S1 is Hertford boiler flow rate of 279,736ACFM and S2 is the Enviva green hammermill flow rate of 102,600 ACFM
7. Scaled up Direct Annual Costs linearly based on Hertford Application boiler flow rate of 279,736 ACFM and Enviva flow rate of of 20,000 ACFM. The resulting Qnew/Qinitial = 0.07

TABLE D-13
VOC BACT IMPACTS SUMMARY - GREEN WOOD HAMMERMILLS
ENVIVA PELLET SAMPSON, LLC

Control Options (lb/ODT)	Uncontrolled Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts			Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.027 (RTO)	50.53	90%	45.5	$949,550	$446,218	$9,813	8.11E+05	No
0.027 (RCO)	50.53	90%	45.5	$1,751,852	$487,985	$10,731	2.35E+05	No
0.27 (Baseline)	50.53	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE D-14
BACT INPUT PARAMETERS AND EMISSIONS ESTIMATES FOR HAMMERMILLS
ENVIVA PELLET SAMPSON, LLC

Hammermill Operating Assumptions:

Hammermill Stack Flow Rate =		120,000.00	ACFM; Estimated from Enviva Northhampton Stack Parameters
Pellet Cooler Exit Temperature =		311.00	deg K
Standard flow rate =		113,112.54	SCFM
lb/ODT Factor =		0.240	average annual emission factor
Production Rate =		537,625	ODT/yr
Operating hours and days =		8,760	hrs/yr
RTO Capital Cost =	$	2,512,012	Estimated from RTO manufacturer using scfm
Estimated RTO Operating Cost (fuel and electricity) =	$	772,536	

VOC Emissions Summary:

Pollutant	Hammermill VOC (tpy)
VOC	34.4

TABLE D-15
REGENERATIVE THERMAL OXIDATION COST ANALYSIS - HAMMERMILL
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RTO Price+ Freight+Instrumentation	$2,512,012	A	2(a)
Sales Tax	$75,360	0.03A	1(a)
Purchased Equipment Cost, PEC	$2,587,373	B	
Direct Installation Costs			
Foundations and Support	$206,990	0.08B	1(a)
Handling & Erection	$362,232	0.14B	1(a)
Electrical	$103,495	0.04B	1(a)
Piping	$51,747	0.02B	1(a)
Insulation for ductwork	$25,874	0.01B	1(a)
Painting	$25,874	0.01B	1(a)
Direct Installation Costs	$776,212		
Total Direct Costs, DC	$3,363,584		
Indirect Costs (Installation)			
Engineering	$258,737	0.10B	1(a)
Construction and field expenses	$129,369	0.05B	1(a)
Contractor Fees	$258,737	0.10B	1(a)
Start-up	$51,747	0.02B	1(a)
Performance test	$25,874	0.01B	1(a)
Contingencies	$77,621	0.03B	1(a)
Total Indirect Costs, IC	$802,086		
Total Capital Investment	$4,165,670	TCI = DC + IC	
Operating Cost			
Operating Labor			
Operator	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Supervisor	$4,210	15% of operator	1(b)
Total	$32,275		
Maintenance			
Labor	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Material	$28,065	100% of maintenance labor	1(b)
Total	$56,130		
Electricity			
Total Requirement	503.94	KW	**2(c)**
Unit cost	$0.070	$/kW-hr	**2(c)**
Total	$309,015		
Fuel			
Natural Gas	8.82	MMBTU/hr	**3(a)**
Cost	$6.00	$/MMBtu	**2(b)**
Total	$463,522		

Total Direct Annual Costs	*$860,941*		
Indirect Annual Costs			
Overhead	$53,043	60% of operating labor + maintenance	1(b)
Administrative Charges	$83,313	2% of TCI	1(b)
Property tax	$41,657	1% of TCI	1(b)
Insurance	$41,657	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RTO	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$547,676		
Total Indirect Annual Costs	*$767,346*		
Total Annual Cost	**$1,628,286**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Provided toWaalace Lasonde of Enviva by Steve Jaasund from GEOENERGY Division of A.H. Lundberg Assoicates, Inc on March 21, 2011.
   a RTO Price/Quote
   b Natural Gas Cost and usage.
   c Electricity cost and power requirement.
3. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* -- Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Compressed Air Cost from Memo
4. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)

TABLE D-16
HAMMERMILL - REGENERATIVE CATALYTIC OXIDATION COST ANALYSIS
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RCO Price + auxiliary equipment + freight	$3,095,459	A	2(a), 6
Sales Tax	$92,864	0.03A	1(a)
Purchased Equipment Cost, PEC	$3,188,323	B	
Direct Installation Costs			
Foundations and Support	$255,066	0.08B	1(a)
Handling & Erection	$446,365	0.14B	1(a)
Electrical	$127,533	0.04B	1(a)
Piping	$63,766	0.02B	1(a)
Insulation for ductwork	$31,883	0.01B	1(a)
Painting	$31,883	0.01B	1(a)
Direct Installation Costs	$956,497		
Total Direct Costs, DC	$4,144,820		
Indirect Costs (Installation)			
Engineering	$318,832	0.10B	1(a)
Construction and field expenses	$159,416	0.05B	1(a)
Contractor Fees	$318,832	0.10B	1(a)
Start-up	$63,766	0.02B	1(a)
Performance test	$31,883	0.01B	1(a)
Contingencies	$95,650	0.03B	1(a)
Total Indirect Costs, IC	$988,380		
Total Capital Investment	$5,133,200	TCI = DC + IC	
Operating Cost			
Operating Labor			
Operator	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 4(a)
Supervisor	$4,210	15% of operator	1(b)
Total	$32,275		
Maintenance			
Labor	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 4(a)
Material	$28,065	100% of maintenance labor	1(b)
Total	$56,130		
Electricity			
Total Requirement	161	KW	Lundberg
Unit cost	$0.070	$/kW-hr	3(b)
Total	$98,643		
Fuel			
Natural Gas or fuel	0.5	MBTU/hr	3(a), 7
Cost	$6.00	$/MMBtu	6
Conversion	1020	Btu/ft^3	
Total	$26,526		
Compressed Air			
Requirement	26	SCFM	2(a), 4(b), 7
Cost	$0.31	$/1000 ft^3 air	4(b)
Total	$4,194		

Catalyst Costs			
Catalyst Cost (Present Value)	$289,184		2(b), 7
Catalyst Life	2		2(b)
Catalyst Cost (Future Value)	$309,716	F/P, 3.5%, 2 years	
Catalyst Cost (Annualized) Total	$147,487	A/F, 10%, 2 years	
Total Direct Annual Costs	*$365,254*		
Indirect Annual Costs			
Overhead	$53,043	60% of operating labor + maintenance	1(b)
Administrative Charges	$102,664	2% of TCI	1(b)
Property tax	$51,332	1% of TCI	1(b)
Insurance	$51,332	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RCO	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$674,881		
Total Indirect Annual Costs	*$933,252*		
Total Annual Cost	**$1,298,505**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Hertford Renewable Energy PSD Application (Hertford, North Carolina). Submitted 2008, Approved 2009.
   a RCO Price/Quote $5,143,578
   b Catalyst costs and life
   c Fuel Requirement was 2.5 MBTU/hr
   d 14 iwc for pressure drop and RCO electricity and utility usage were similar to RSCR
3. Enviva Vendor
   a Natural Gas Cost
   b Electricity cost
4. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* -- Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Electricity and Compressed Air Cost from Memo
5. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)
6. Scale-up capital cost factor from Ulrich, Gael D. Chemical Engineering Process Design and Economics, 2004 $(C1*(S2/S1)^{2.6})$ where S1 is Hertford boiler flow rate of 279,736ACFM and S2 is the Enviva hammermill flow rate of 215,000 ACFM
7. Scaled up Direct Annual Costs linearly based on Hertford Application boiler flow rate of 279,736 ACFM and Enviva flow rate of of 215,000 ACFM. The resulting Qnew/Qinitial = 0.43

TABLE D-17
VOC BACT IMPACTS SUMMARY - HAMMERMILL
ENVIVA PELLET SAMPSON, LLC

Control Options (lb/ODT)	Uncontrolled Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts			Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.0240 (RTO)	34.37	90%	30.9	$4,165,670	$1,628,286	$52,643	4.41E+06	No
0.0240 (RCO)	34.37	90%	30.9	$5,133,200	$1,298,505	$41,981	1.41E+06	No
0.240 (Baseline)	34.37	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE D-18
BACT INPUT PARAMETERS AND EMISSIONS ESTIMATES FOR PELLET COOLERS
ENVIVA PELLET SAMPSON, LLC

Cooler Aspiration Operating Assumptions:

Pellet Cooler Stack Flow Rate =		72,000	total flow rate for all pellet coolers
Pellet Cooler Exit Temperature =		332.59	deg K
Standard flow rate =		63,461.16	SCFM
lb/ODT Factor =		0.85	average annual emission factor
Production Rate =		537,625	ODT/yr
Operating hours and days =		8,760	hrs/yr
RTO Capital Cost =	$	1,852,719	Estimated from RTO manufacturer using scfm
Estimated RTO Operating Cost (fuel and electricity) =	$	433,000	Estimated from RTO manufacturer using scfm

VOC Emissions Summary:

Pollutant	Pellet Cooler + Press Stack VOC (tpy)
VOC	227.64

TABLE D-19
FABRIC FILTER ECONOMICS IMPACTS EVALUATION FOR PELLET COOLERS
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Ref.
Total Capital Investment			
Direct Costs			
Purchased Equipment Costs			
Bagfilter with Ductwork	$1,200,000	A	1
Freight Estimate	$60,000	0.05A	2
Instrumentation	$120,000	0.10A	2
Sales Tax	$36,000	0.03A	2
Purchased Equipment Cost, PEC	**$1,416,000**	B	
Direct Installation Costs			
Foundations and Support	$56,640	0.04B	2
Handling & Erection	$708,000	0.50B	2
Electrical	$113,280	0.08B	2
Piping	$0	included in cost	1
Insulation for ductwork	$28,320	0.02B	1
Painting	$28,320	0.02B	2
Total	**$934,560**		
Total Direct Costs, DC	**$2,350,560**	*DC = B + 0.67 * B*	
Indirect Costs (Installation)			
Engineering	$141,600	0.10B	2
Construction and field expenses	$283,200	0.20B	2
Contractor Fees	$141,600	0.10B	2
Start-up	$14,160	0.01B	2
Performance test	$14,160	0.01B	2
Contingencies	$42,480	0.03B	2
Total Indirect Costs, IC	**$637,200**	*IC = 0.57 * B*	
Total Capital Investment	**$2,987,760**	**TCI = DC + IC**	
Operating Cost			
Direct Annual Costs			
Operating Labor			
Operator	$112,259	6 hr/d * 365 d/y * $51.26/hr	3(a), 5
Supervisor	$16,839	15% of operator	3(b)
Total	**$129,098**		
Maintenance			
Labor	$56,130	3 hr/d * 365 d/y * $51.26/hr	3(c)
Material	$56,130		3(d)
Total	**$112,259**		
Replacement parts (bag replacement, $390,673, every 3 years per GE, 3% interest)	**$138,103**		3
Electricity Costs			
Requirement	685,000	kw/yR	3(e)
Unit cost	$0.070	$/kW-hr	6
Total	**$47,950**		
Compressed Air	19,000		3(e)
	$19,000		
Total Direct Annual Costs	***$446,410***		

Indirect Annual Costs			
Overhead	$144,815	60% * (operating labor + maintenance)	3(e)
Administrative Charges	$59,755	2% of TCI	3(e)
Property tax	$29,878	1% of TCI	3(e)
Insurance	$29,878	1% of TCI	3(e)
Annual Interest Rate	10.0%		
Economic life of Bagfilter	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$392,812		
Total Indirect Annual Costs	***$657,137***		
Total Annual Cost	**$1,103,548**	*TAC = DAC + IDAC*	

1. Quote provided by Bruce Westerman of Mid South Engineering on 8/12/2013 estimate for bagfilter including ductwork. $200,000 per bagfilter.
2. Direct and Indirect capital costs associated with the purchase of the Fabric filter determined in accordance with EPA OAQPS APCCM Sec.6, Ch.1, Table 1.9
3. EPA OAQPS APCCM Sec.6, Ch.1, Table 1.11
   (a) Operator costs calculated @ 2 hr per shift 3 shifts per day day and 365 days of operation
   (b) Supervisor labor costs calculated @ 15% of operator cost as per APCCM guidance
   (c) Maintenance labor of 1 hour per shift 3 shifts per day
   (d) Maintenance material(s) calculated @ 100% of labor
   (e) Indirect annual costs calculated in accordance with APCCM guidance
4. EPA OAQPS APCCM Sec.6, Ch.1, Table 1.11
5. US Dept. of Labor - Bureau of Labor Statistics - $51.26/hr (Stationary Engineers and Boiler Operators, 2008 dollars)
6. Electricity unit cost provided by the Energy Information Administration
7. Capital recovery calculated assuming 15 years of equipment life @ a recovery rate of 10%
   Capital Recovery Factor (CRF)
   = (IR*(1+IR)^n)/((1+IR)^n - 1)

TABLE D-20
CYCLONE ECONOMICS IMPACTS EVALUATION FOR PELLET COOLERS
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Ref.
Total Capital Investment			
Direct Costs			
Purchased Equipment Costs			
Cyclone	$66,000	A	1
Freight Estimate	$3,300	0.05A	2
Instrumentation	$6,600	0.10A	2
Sales Tax	$1,980	0.03A	2
Purchased Equipment Cost, PEC	**$77,880**	B	
Direct Installation Costs			
Foundations and Support	$3,115	0.04B	2
Handling & Erection	$38,940	0.50B	2
Electrical	$6,230	0.08B	2
Piping	$779	0.01B	1
Insulation for ductwork	$1,558	0.02B	1
Painting	$1,558	0.02B	2
Total	**$52,180**		
Total Direct Costs, DC	**$130,060**	*DC = B + 0.67 * B*	
Indirect Costs (Installation)			
Engineering	$7,788	0.10B	2
Construction and field expenses	$15,576	0.20B	2
Contractor Fees	$7,788	0.10B	2
Start-up	$779	0.01B	2
Performance test	$779	0.01B	2
Contingencies	$2,336	0.03B	2
Total Indirect Costs, IC	**$35,046**	*IC = 0.57 * B*	
Total Capital Investment	**$165,106**	**TCI = DC + IC**	
Operating Cost			
Direct Annual Costs			
Operating Labor			
Operator	$0	0 hr/d * 365 d/y * $51.26/hr	3(a), 5
Supervisor	$0	15% of operator	3(b)
Total	$0		
Maintenance			
Labor	$0	3 hr/d * 365 d/y * $51.26/hr	3(c)
Material	$0		3(d)
Total	$0		
Electricity Costs			
Requirement	685,000	kw/yR	3(e)
Unit cost	$0.070	$/kW-hr	6
Total	**$47,950**		
Compressed Air	19,000		3(e)
	$19,000		
Total Direct Annual Costs	***$66,950***		

Indirect Annual Costs			
Overhead	$0.00	60% * (operating labor + maintenance)	3(e)
Administrative Charges	$3,302	2% of TCI	3(e)
Property tax	$1,651	1% of TCI	3(e)
Insurance	$1,651	1% of TCI	3(e)
Annual Interest Rate	10.0%		
Economic life of Cyclone	10		
Capital Recovery Factor	0.163		
Total Capital Recovery Cost	$26,870		
Total Indirect Annual Costs	***$33,474***		
Total Annual Cost	**$100,424**	*TAC = DAC + IDAC*	

1. Quote provided by Bruce Westerman on 8/12/2013 estimate from Aircon Corporation for $11,000 per cyclone.
2. Direct and Indirect capital costs associated with the purchase of the cyclone determined in accordance with EPA OAQPS APCCM Sec.6, Ch.1, Table 1.9
3. EPA OAQPS APCCM Sec.6, Ch.1, Table 1.11
   (a) Assumed no operator cost required for simple cyclone.
   (b) Assumed no supervisor cost required for simple cyclone.
   (c) Maintenance labor of 1 hour per shift 3 shifts per day
   (d) Maintenance material(s) calculated @ 100% of labor
   (e) Indirect annual costs calculated in accordance with APCCM guidance.
4. EPA OAQPS APCCM Sec.6, Ch.1, Table 1.11
5. US Dept. of Labor - Bureau of Labor Statistics - $51.26/hr (Stationary Engineers and Boiler Operators, 2008 dollars)
6. Electricity unit cost provided by the Energy Information Administration
7. Capital recovery calculated assuming 15 years of equipment life @ a recovery rate of 10%
   Capital Recovery Factor (CRF)
   = (IR*(1+IR)^n)/((1+IR)^n - 1)

TABLE D-21a
TSP BACT IMPACTS SUMMARY FOR PELLET COOLERS
ENVIVA PELLET SAMPSON, LLC

Control Options (gr/scf)	Baseline Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts				Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Incremental Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.0066 (Bagfilter)	594.68	97%	576.8	$2,987,760	$1,103,548	$1,913	$24,098	6.85E+05	No
0.022 (Cyclone)	594.68	90%	535.2	$165,106	$100,424	$188	$188	6.85E+05	No
0.22 (Baseline)	594.68	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE D-21b
PM_{10} BACT IMPACTS SUMMARY FOR PELLET COOLERS
ENVIVA PELLET SAMPSON, LLC

Control Options (gr/scf)	Baseline Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts				Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Incremental Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.0017 (Bagfilter)	154.08	97%	149.5	$2,987,760	$1,103,548	$7,383	$92,776	6.85E+05	No
0.0057 (Cyclone)	154.08	90%	138.7	$165,106	$100,424	$724	$724	6.85E+05	No
0.057 (Baseline)	154.08	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No

TABLE D-21c
$PM_{2.5}$ BACT IMPACTS SUMMARY FOR PELLET COOLERS
ENVIVA PELLET SAMPSON, LLC

Control Options (gr/scf)	Baseline Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts				Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Incremental Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.00021 (Bagfilter)	18.92	97%	18.4	$2,987,760	$1,103,548	$60,126	$757,353	6.85E+05	No
0.0007 (Cyclone)	18.92	90%	17.0	$165,106	$100,424	$5,897	$5,897	6.85E+05	No
0.0070 (Baseline)	18.92	N/A	N/A	N/A	N/A	N/A	N/A	N/A	No

[1] Assuming overall reduction of Total PM. Speciation from engineering tests.

[2] Cost represents total cost for installation of bagfilter or cyclone on each pellet cooler.

TABLE D-22
REGENERATIVE THERMAL OXIDATION COST ANALYSIS - PELLET COOLER ASPIRATION SYSTEM
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RTO Price+ Freight+Instrumentation	$1,852,719	A	2(a)
Sales Tax	$55,582	0.03A	1(a)
Purchased Equipment Cost, PEC	$1,908,300	B	
Direct Installation Costs			
Foundations and Support	$152,664	0.08B	1(a)
Handling & Erection	$267,162	0.14B	1(a)
Electrical	$76,332	0.04B	1(a)
Piping	$38,166	0.02B	1(a)
Insulation for ductwork	$19,083	0.01B	1(a)
Painting	$19,083	0.01B	1(a)
Direct Installation Costs	$572,490		
Total Direct Costs, DC	$2,480,791		
Indirect Costs (Installation)			
Engineering	$190,830	0.10B	1(a)
Construction and field expenses	$95,415	0.05B	1(a)
Contractor Fees	$190,830	0.10B	1(a)
Start-up	$38,166	0.02B	1(a)
Performance test	$19,083	0.01B	1(a)
Contingencies	$57,249	0.03B	1(a)
Total Indirect Costs, IC	$591,573		
Total Capital Investment	$5,072,364	**TCI = DC + IC**	
Operating Cost			
Operating Labor			
Operator	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Supervisor	$4,210	15% of operator	1(b)
Total	$32,275		
Maintenance			
Labor	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 3(a)
Material	$28,065	100% of maintenance labor	1(b)
Total	$56,130		
Electricity			
Total Requirement	282.45	KW	**2(c)**
Unit cost	$0.070	$/kW-hr	**2(c)**
Total	$173,200		
Fuel			
Natural Gas	4.94	MMBTU/hr	**3(a)**
Cost	$6.00	$/MMBtu	**2(b)**
Total	$259,800		

Total Direct Annual Costs	*$521,404*		
Indirect Annual Costs			
Overhead	$53,043	60% of operating labor + maintenance	1(b)
Administrative Charges	$101,447	2% of TCI	1(b)
Property tax	$50,724	1% of TCI	1(b)
Insurance	$50,724	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RTO	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$666,883		
Total Indirect Annual Costs	*$922,820*		
Total Annual Cost	**$1,444,224**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Provided toWaalace Lasonde of Enviva by Steve Jaasund from GEOENERGY Division of A.H. Lundberg Assoicates, Inc on March 21, 2011.
   a RTO Price/Quote
   b Natural Gas Cost and usage.
   c Electricity cost and power requirement.
3. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* – Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Compressed Air Cost from Memo
4. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)

TABLE D-23
PELLET COOLER ASPIRATION SYSTEM - REGENERATIVE CATALYTIC OXIDATION COST ANALYSIS
ENVIVA PELLET SAMPSON, LLC

Capital Cost		Notes	Reference
Direct Costs			
Purchased Equipment Costs			
RCO Price + auxiliary equipment + freight	$2,278,326	A	2(a), 6
Sales Tax	$68,350	0.03A	1(a)
Purchased Equipment Cost, PEC	$2,346,675	B	
Direct Installation Costs			
Foundations and Support	$187,734	0.08B	1(a)
Handling & Erection	$328,535	0.14B	1(a)
Electrical	$93,867	0.04B	1(a)
Piping	$46,934	0.02B	1(a)
Insulation for ductwork	$23,467	0.01B	1(a)
Painting	$23,467	0.01B	1(a)
Direct Installation Costs	$704,003		
Total Direct Costs, DC	$3,050,678		
Indirect Costs (Installation)			
Engineering	$234,668	0.10B	1(a)
Construction and field expenses	$117,334	0.05B	1(a)
Contractor Fees	$234,668	0.10B	1(a)
Start-up	$46,934	0.02B	1(a)
Performance test	$23,467	0.01B	1(a)
Contingencies	$70,400	0.03B	1(a)
Total Indirect Costs, IC	$727,469		
Total Capital Investment	$5,778,148	**TCI = DC + IC**	
Operating Cost			
Operating Labor			
Operator	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 4(a)
Supervisor	$4,210	15% of operator	1(b)
Total	$32,275		
Maintenance			
Labor	$28,065	0.5 hr/s, 3 s/d, d/yr, $51.26/hr, CF	1(b), 4(a)
Material	$28,065	100% of maintenance labor	1(b)
Total	$56,130		
Electricity			
Total Requirement	97	KW	Lundberg
Unit cost	$0.070	$/kW-hr	3(b)
Total	$59,186		
Fuel			
Natural Gas or fuel	0.3	MBTU/hr	3(a), 7
Cost	$6.00	$/MMBtu	6
Conversion	1020	Btu/ft^3	
Total	$15,916		
Compressed Air			
Requirement	15	SCFM	2(a), 4(b), 7
Cost	$0.31	$/1000 ft^3 air	4(b)
Total	$2,516		

Catalyst Costs			
Catalyst Cost (Present Value)	$173,510		2(b), 7
Catalyst Life	2		2(b)
Catalyst Cost (Future Value)	$185,830	F/P, 3.5%, 2 years	
Catalyst Cost (Annualized) Total	$88,492	A/F, 10%, 2 years	
Total Direct Annual Costs	*$254,514*		
Indirect Annual Costs			
Overhead	$53,043	60% of operating labor + maintenance	1(b)
Administrative Charges	$115,563	2% of TCI	1(b)
Property tax	$57,781	1% of TCI	1(b)
Insurance	$57,781	1% of TCI	1(b)
Annual Interest Rate	10%		
Economic life of RCO	15		
Capital Recovery Factor	0.131		
Total Capital Recovery Cost	$759,675		
Total Indirect Annual Costs	*$1,043,843*		
Total Annual Cost	**$1,298,357**	*TAC = DAC + IDAC*	

1. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, September 2000, Section 3, Chapter 2.
   [a] Table 2.8: Capital Cost Factors for Thermal and Catalytic Incinerators (OAQPS 2-42); Vendor quote usually includes instrumentation
   [b] Table 2.10: Annual Costs for Thermal and Catalytic Incinerators Example Problem (OAQPS 2-45)
2. Hertford Renewable Energy PSD Application (Hertford, North Carolina). Submitted 2008, Approved 2009.
   a RCO Price/Quote $5,143,578
   b Catalyst costs and life
   c Fuel Requirement was 2.5 MBTU/hr
   d 14 iwc for pressure drop and RCO electricity and utility usage were similar to RSCR
3. Enviva Vendor
   a Natural Gas Cost
   b Electricity cost
4. Taken from *Methodology for Estimating Control Costs for Industrial, Commercial, Institutional Boilers and Process Heaters Nation Emissions Standards for Hazardous Air Pollutants* – Major Source ERG Memo April 2010.
   a Conservative estimate of loaded hourly wage
   b Electricity and Compressed Air Cost from Memo
5. U.S. EPA OAQPS, *EPA Air Pollution Control Cost Manual (6th Edition)*, July 2002, Section 6, Chapter 2.
   a Equation 2.40 for fan HP (OAQPS 2-42)
6. Scale-up capital cost factor from Ulrich, Gael D. Chemical Engineering Process Design and Economics, 2004 ($C1*(S2/S1)^{0.6}$) where S1 is Hertford boiler flow rate of 279,736ACFM and S2 is the Enviva pellet cooler flow rate of 102,600 ACFM
7. Scaled up Direct Annual Costs linearly based on Hertford Application boiler flow rate of 279,736 ACFM and Enviva flow rate of of 72,000 ACFM. The resulting Qnew/Qinitial = 0.26

TABLE D-24
VOC BACT IMPACTS SUMMARY - PELLET COOLER
ENVIVA PELLET SAMPSON, LLC

Control Options (lb/ODT)	Uncontrolled Emissions (tons/yr)	Control Efficiency	Emissions Reduction (tons/year)	Economic Impacts			Energy Impacts	Environmental Impacts
				Total Capital Cost ($)	Annual Cost ($/year)	Cost Effectiveness ($/ton)	Increase Over Baseline (kW*hr/yr)	Adverse Environmental Impacts? (Yes/No)
0.08 (RTO)	227.64	90%	204.9	$7,895,018.07	$2,447,348	$11,945	2.47E+06	No
0.08 (RCO)	227.64	90%	204.9	$8,600,801.93	$2,301,480	$11,233	8.46E+05	No
0.85 (Baseline)	227.64	N/A	N/A	N/A	N/A	N/A	N/A	No

[1] Use of RCO and RTO on the pellet coolers is presumed to require use of bagfilter instead of cyclones for improved PM control to protect the operational stability of the RCO and RTO. The incremental capital and annual operating costs for use of bagfilters has been added to the capital and annual operating costs of RTO and RCO controls, which were calculated in the previous two spreadsheets. Please refer to the PM BACT analysis for the pellet coolers for calculation of capital and operating costs of bagfilter and cyclone controls.

APPENDIX E
MODELING PLOTS

APPENDIX E - MODELING PLOTS

Figure E-1. Topographic Map of Enviva Sampson Area

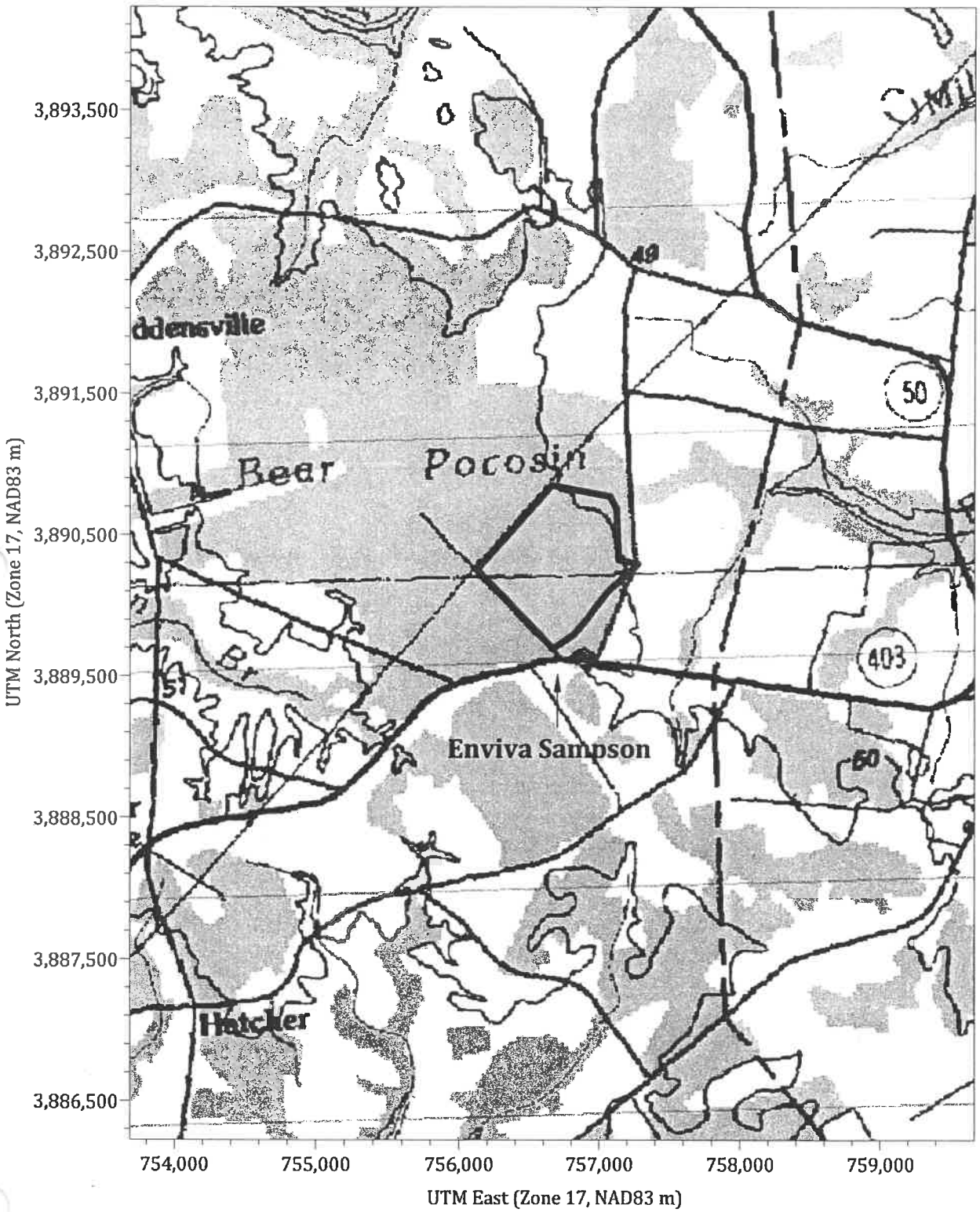


Figure E-2. Enviva Sampson Site Layout

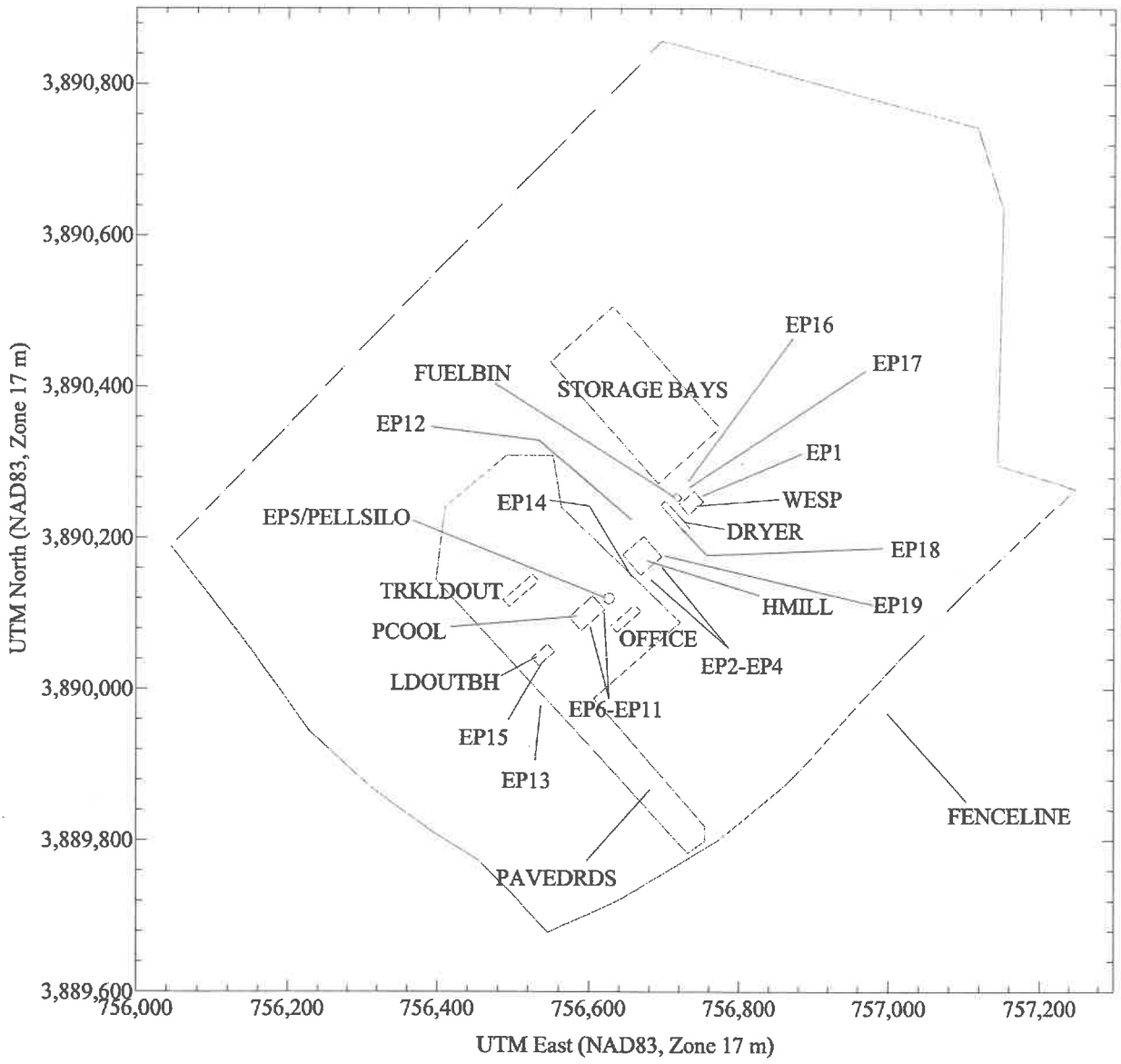


Figure E-3. Class I Significance Receptor Grid

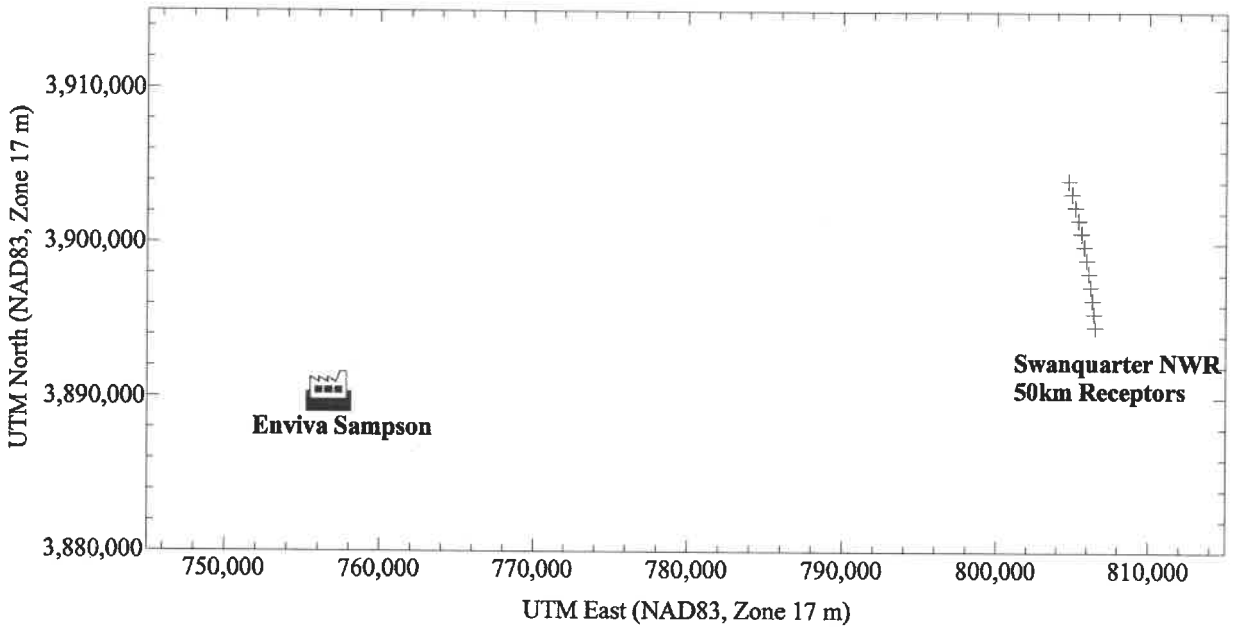


Figure E-4. Modeled SIL Receptor Grid

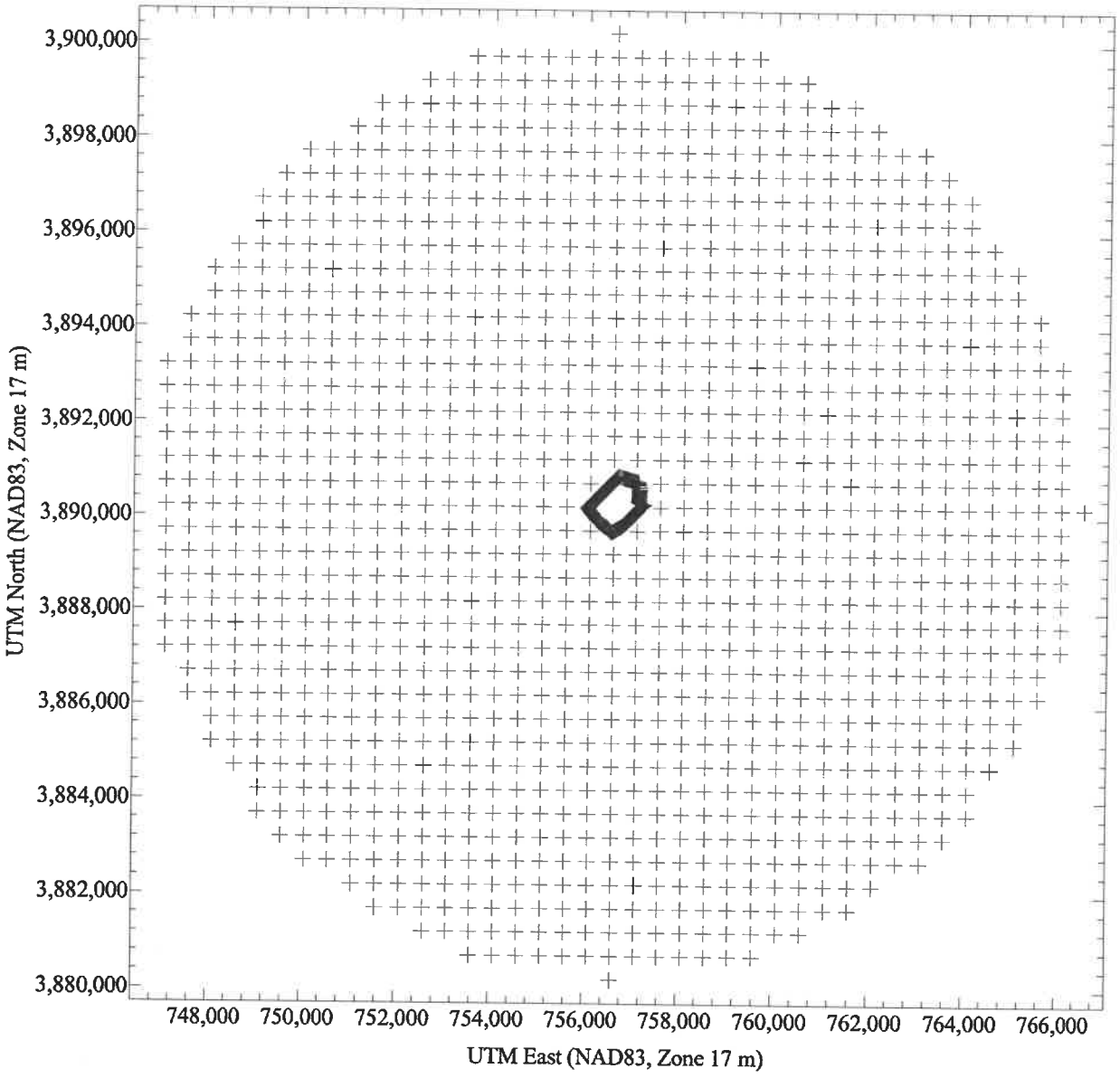


Figure E-5. Modeled NAAQS Receptor Grid

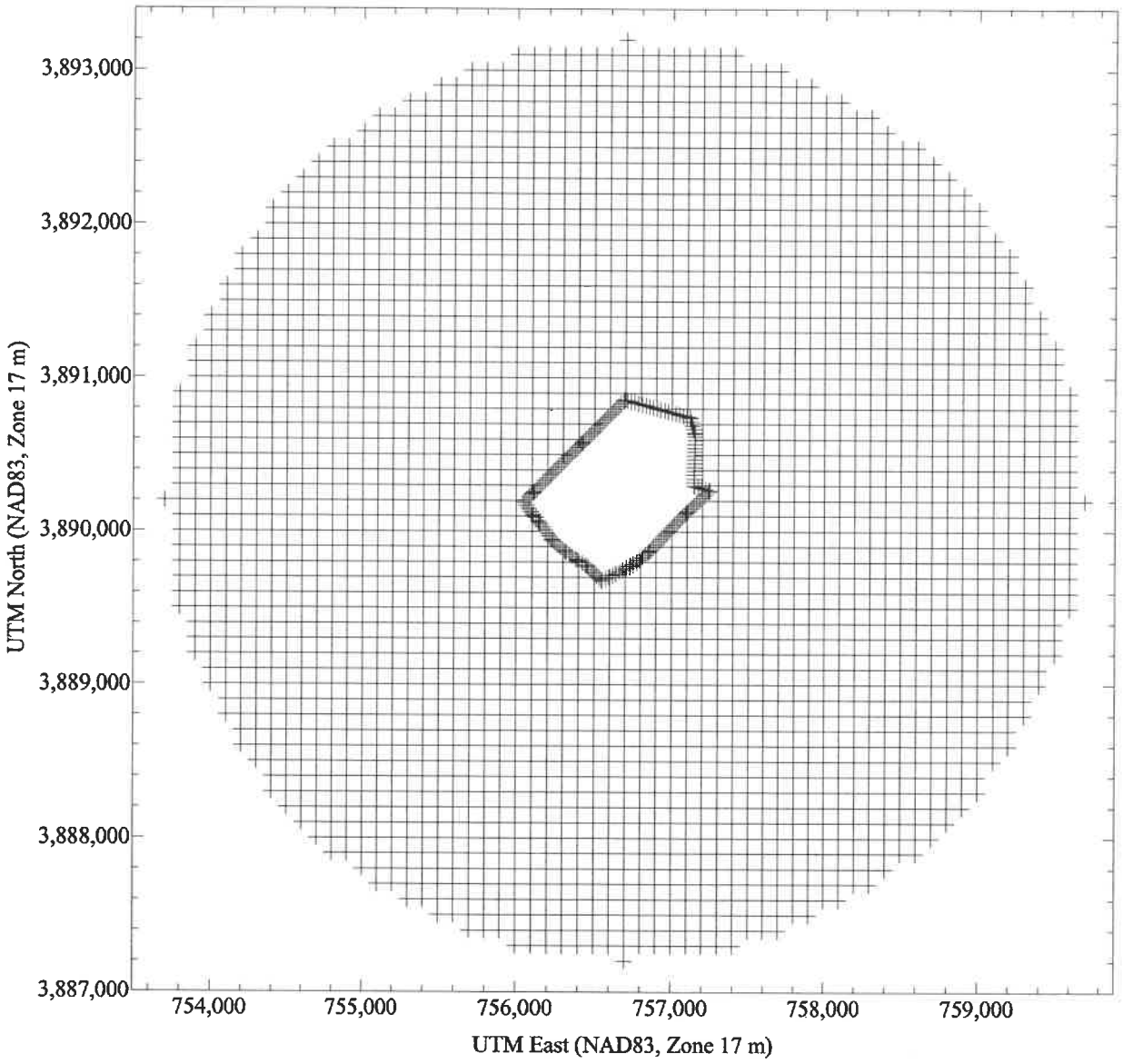


Figure E-6. NO2 1-hour SIL Impacts
(SIL = 10 ug/m3)

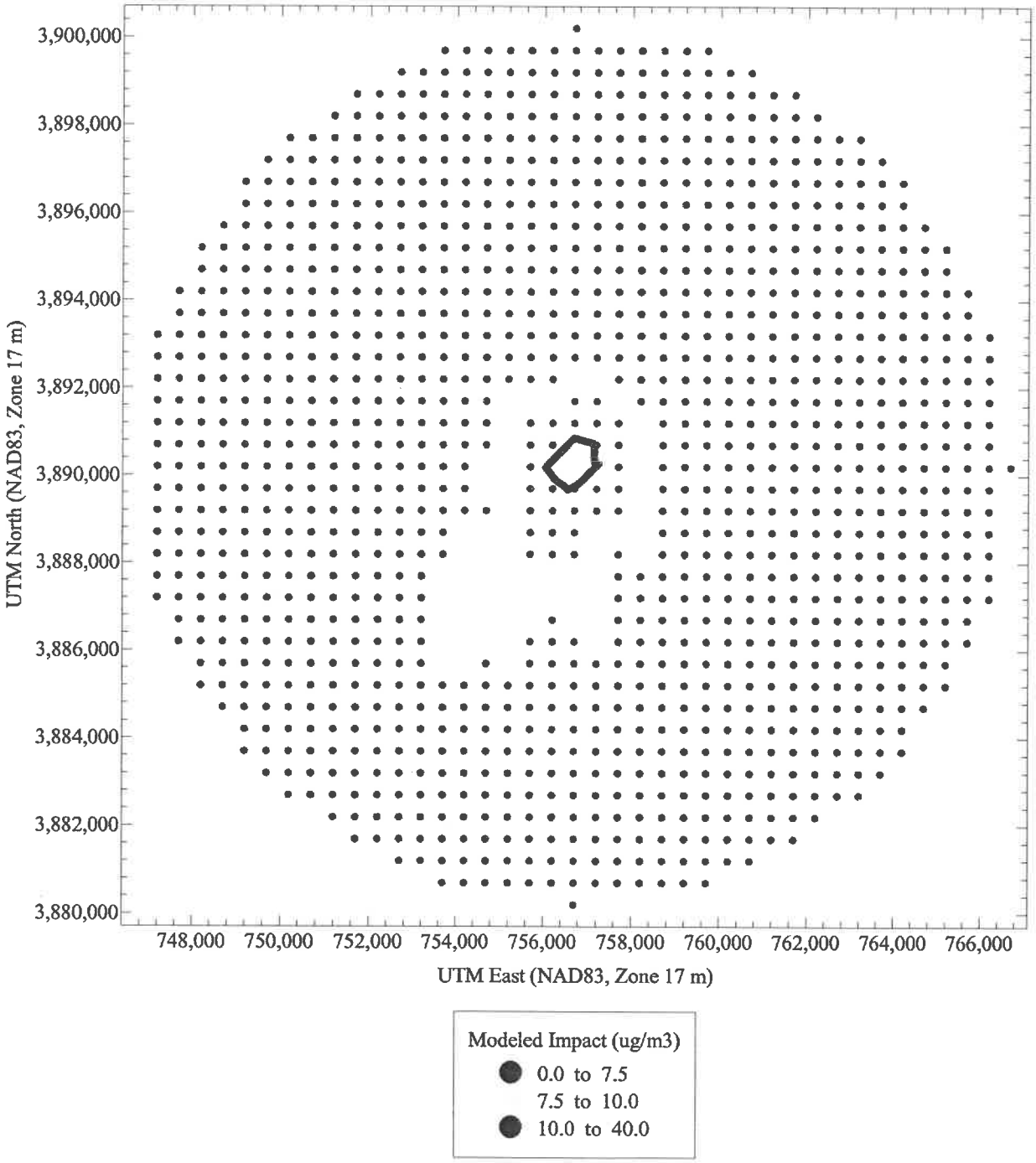


Figure E-7. NO2 Annual SIL Impacts
(SIL = 1 ug/m3)

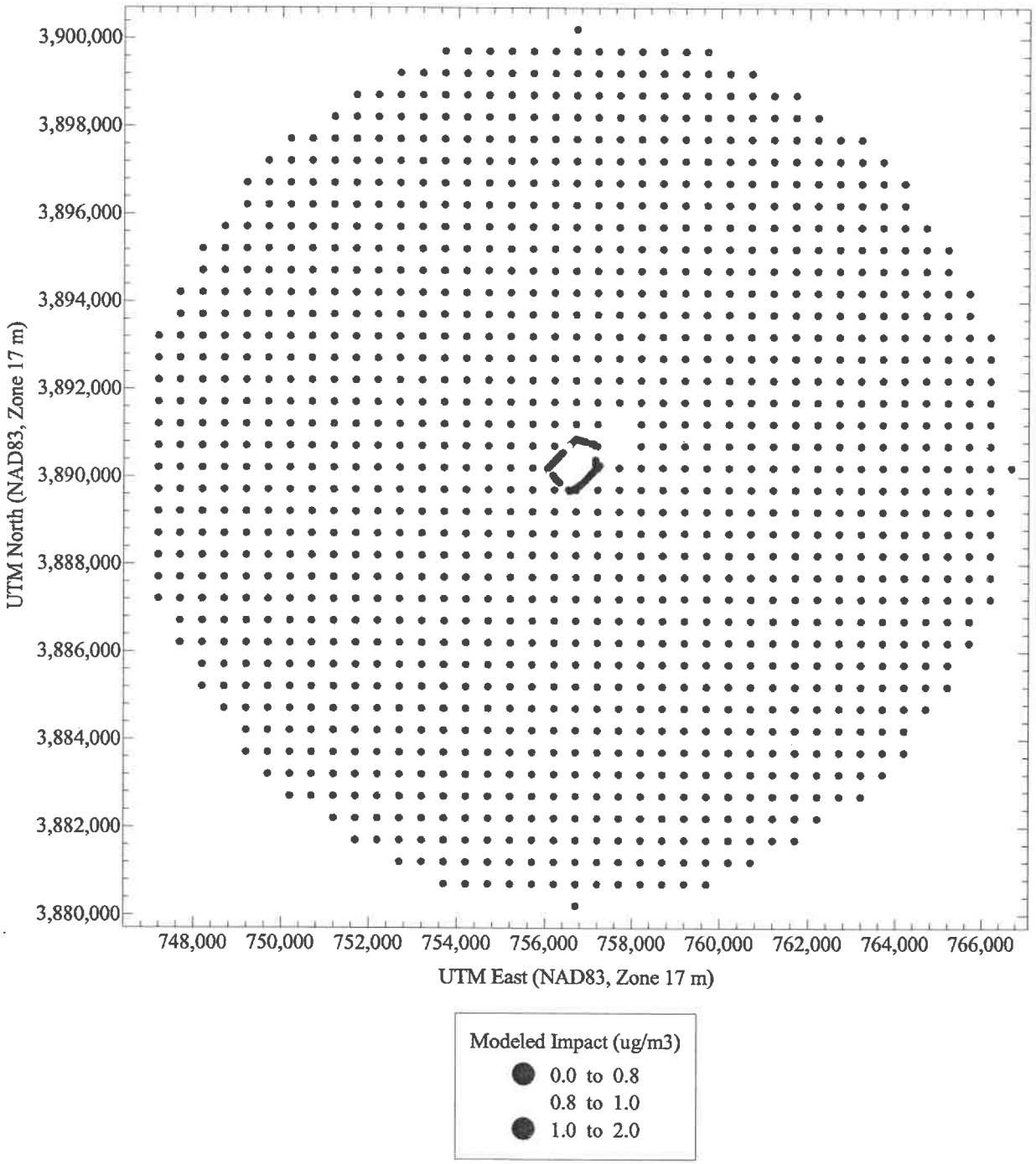


Figure E-8. PM2.5 24-hour SIL Impacts
(SIL = 1.2 ug/m3)

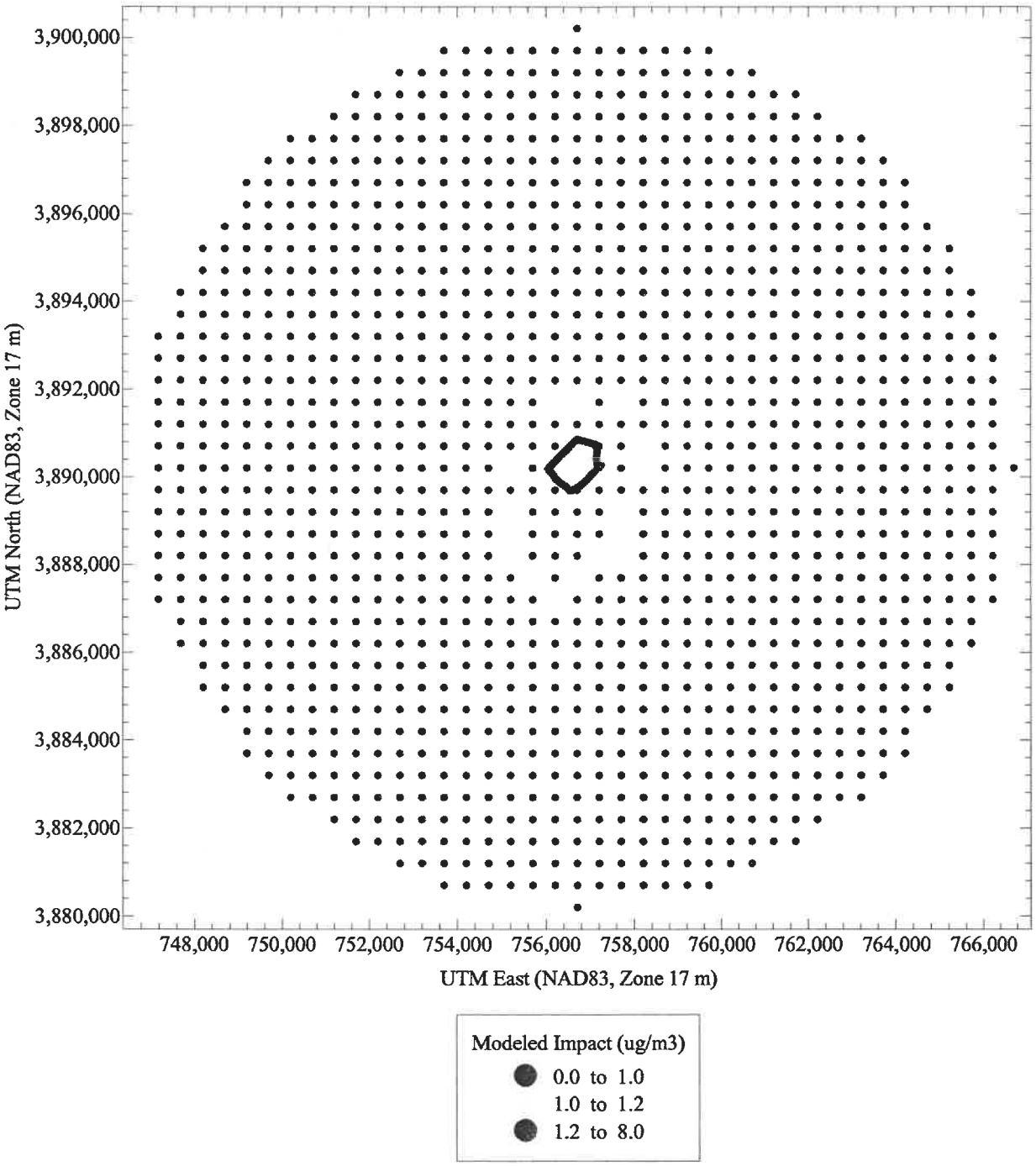


Figure E-9. PM2.5 Annual SIL Impacts
(SIL = 0.3 ug/m3)

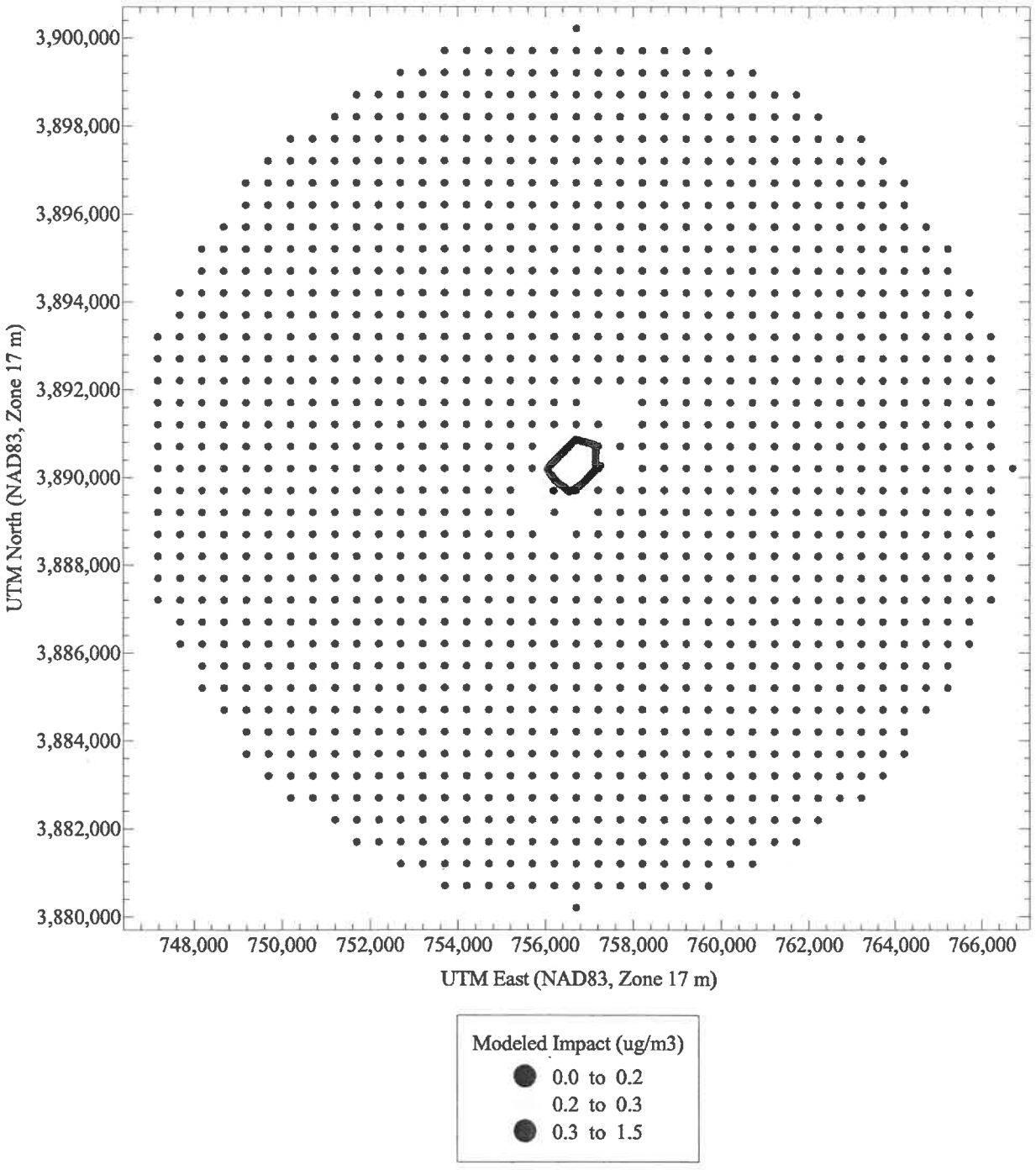


Figure E-10. PM10 24-Hour SIL Impacts
(SIL = 5 ug/m3)

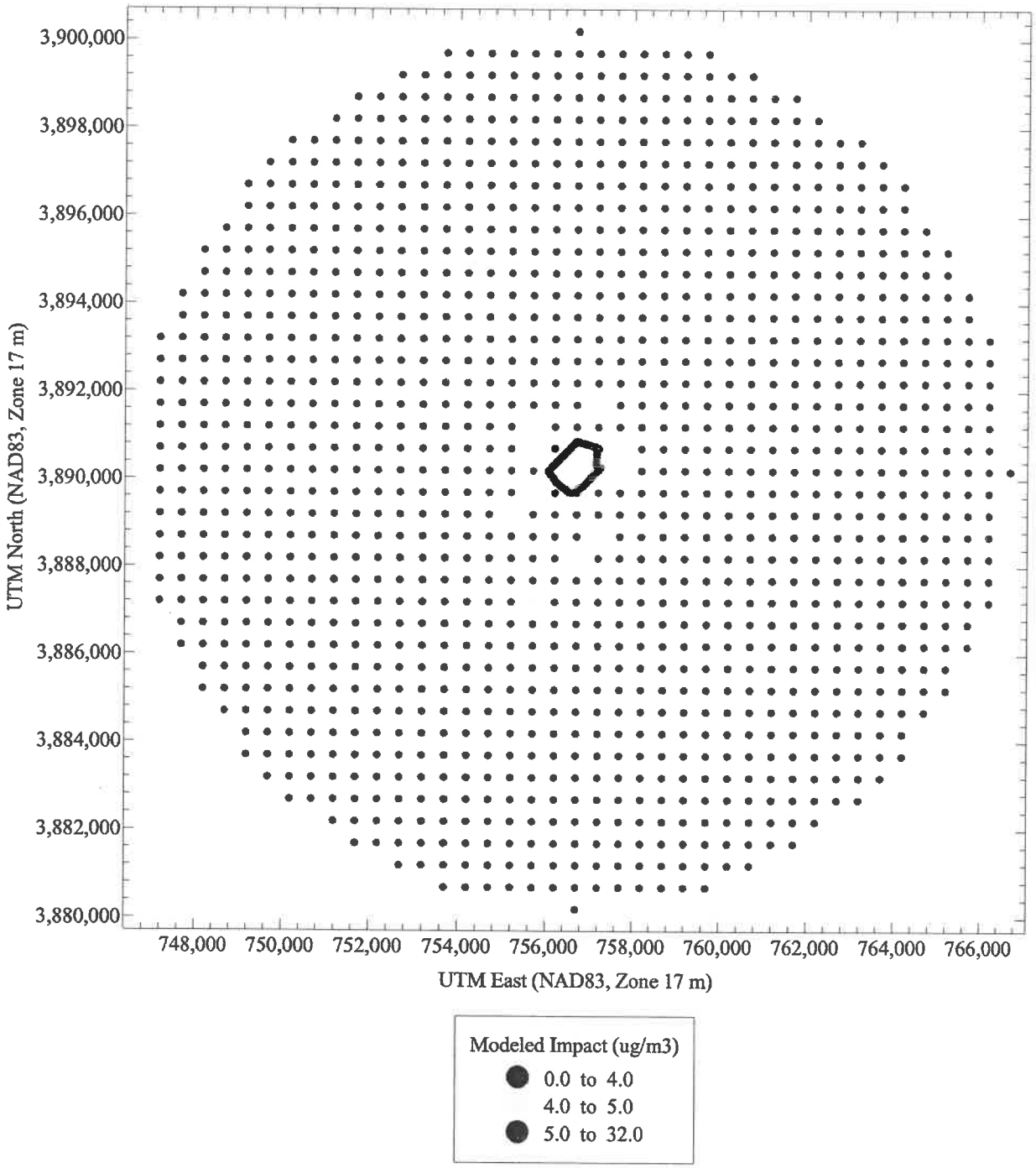
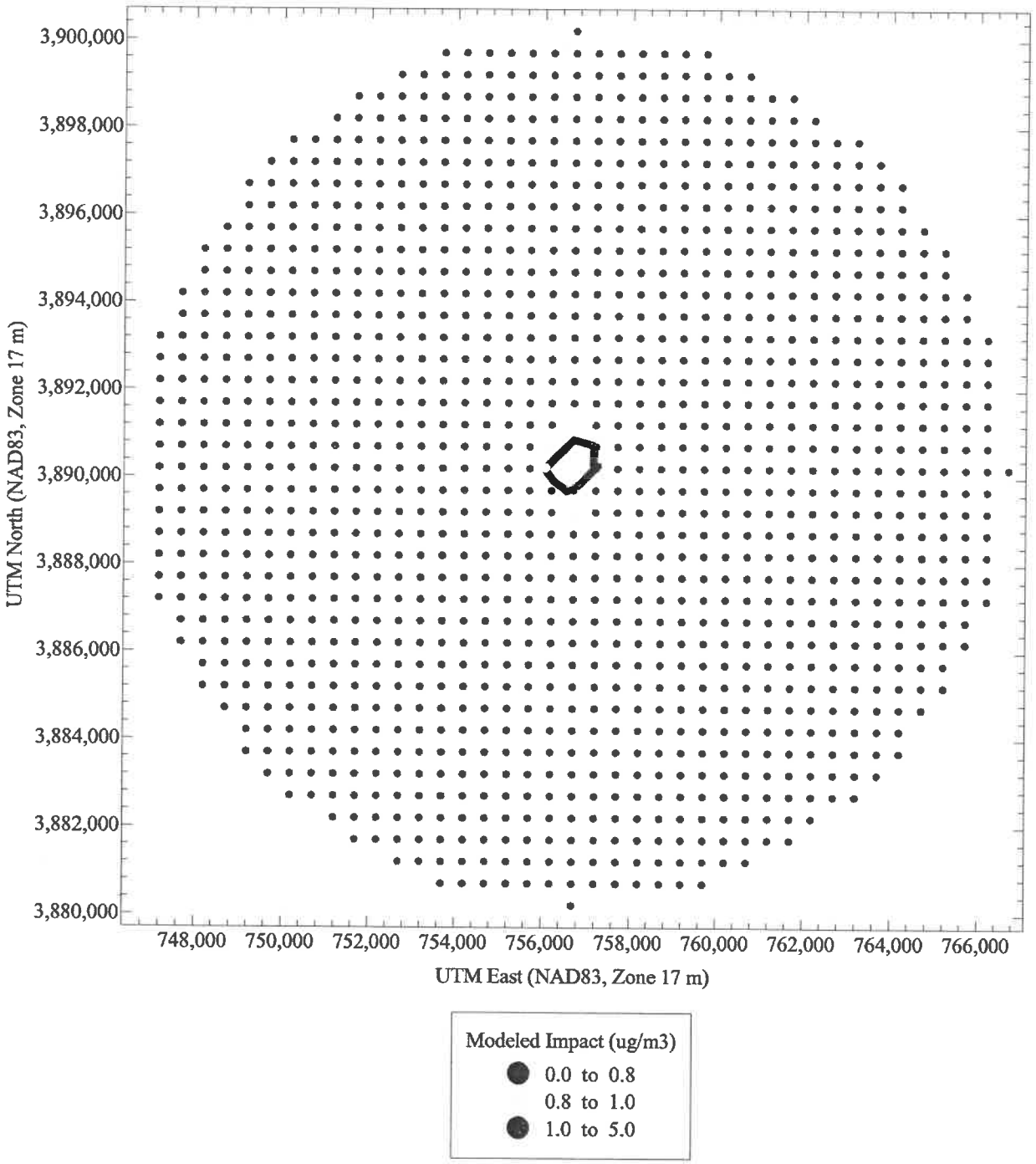
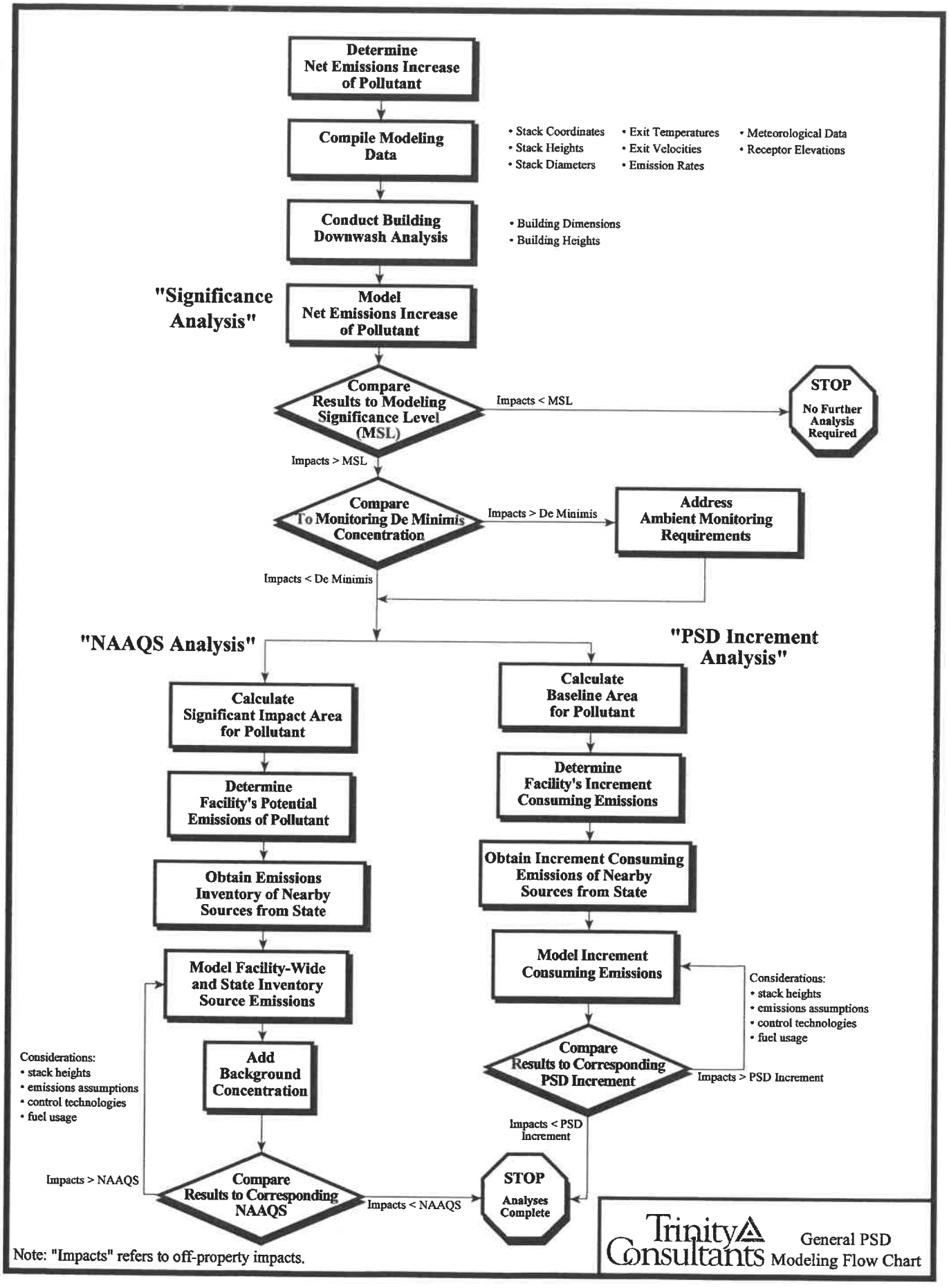


Figure E-11. PM10 Annual SIL Impacts
(SIL = 1 ug/m3)



APPENDIX F
PSD MODELING FLOWCHART

APPENDIX F - PSD MODELING FLOWCHART


Determine Net Emissions Increase of Pollutant
Compile Modeling Data
• Stack Coordinates
• Stack Heights
• Stack Diameters
• Exit Temperatures
• Exit Velocities
• Emission Rates
• Meteorological Data
• Receptor Elevations
Conduct Building Downwash Analysis
• Building Dimensions
• Building Heights
"Significance Analysis"
Model Net Emissions Increase of Pollutant
Compare Results to Modeling Significance Level (MSL)
Impacts < MSL
STOP
No Further Analysis Required
Impacts > MSL
Compare To Monitoring De Minimis Concentration
Impacts > De Minimis
Address Ambient Monitoring Requirements
Impacts < De Minimis
"NAAQS Analysis"
"PSD Increment Analysis"
Calculate Significant Impact Area for Pollutant
Determine Facility's Potential Emissions of Pollutant
Obtain Emissions Inventory of Nearby Sources from State
Model Facility-Wide and State Inventory Source Emissions
Add Background Concentration
Considerations:
• stack heights
• emissions assumptions
• control technologies
• fuel usage
Impacts > NAAQS
Compare Results to Corresponding NAAQS
Impacts < NAAQS
STOP
Analyses Complete
Calculate Baseline Area for Pollutant
Determine Facility's Increment Consuming Emissions
Obtain Increment Consuming Emissions of Nearby Sources from State
Model Increment Consuming Emissions
Considerations:
• stack heights
• emissions assumptions
• control technologies
• fuel usage
Compare Results to Corresponding PSD Increment
Impacts > PSD Increment
Impacts < PSD Increment
Note: "Impacts" refers to off-property impacts.
Trinity Consultants
General PSD Modeling Flow Chart

APPENDIX G
REGIONAL SOURCE INVENTORY

APPENDIX G - REGIONAL SOURCE INVENTORY

Table G-1. Modeled NO_x Inventory Sources

Model ID	Description	UTM-E (m)	UTM-N (m)	Elevation (m)	Emission Rate (g/s)	Stack Height (m)	Exit Temp. (k)	Exit Velocity (m/s)	Stack Diameter (m)
HFLEE1	IC Turbine 10/11	764,564.0	3,918,961.0	24.97	3.76E-01	30.48	878.71	48.77	5.39
HFLEE2	LEE IC Turbine 12/13	764,564.0	3,918,961.0	24.97	6.30E-01	30.48	878.71	48.77	5.39
HFLEE3	IC Turbine 2/3/4 Stack	764,564.0	3,918,961.0	24.97	2.27E-02	10.36	758.71	31.88	3.44
HFLEE4	Units 1&2 Stack	764,564.0	3,918,961.0	24.97	2.41E+01	91.44	410.93	27.43	4.11
HFLEE5	Unit 3 Boiler Stack	764,564.0	3,918,961.0	24.97	4.99E+01	91.44	421.48	40.60	5.79
HFLEE6	Unit 14	764,564.0	3,918,961.0	24.97	3.64E-01	30.48	878.71	48.77	5.39

APPENDIX H
ELECTRONIC MODELING FILES

APPENDIX H - ELECTRONIC MODELING FILES

APPENDIX I

APPENDIX I - ENVIVA DRYER LETTER

enviva

7200 Wisconsin Avenue
Suite 1000
Bethesda, MD 20814 USA

+1 (301) 657 5560
fax (301) 657 5567

www.envivabiomass.com

July 16, 2014

William D. Willets, P.E.
Chief, Permitting Section
North Carolina DENR, Division of Air Quality
1641 Mail Service Center
Raleigh, NC 27699-1641

Via e-mail to william.willets@ncdenr.gov and First Class Mail

RE: Enviva Pellets Sampson, LLC – Air Permit Application Review

Dear Mr. Willets:

The purpose of this letter is to provide DAQ with updated information regarding the dryer to be constructed at Enviva's Sampson County facility, and to provide additional information on the critical differences between existing pellet dryers with VOC emission controls, and the dryer proposed to be constructed without controls at the Sampson facility. Attached to this e-mail are three documents: (1) Kilpatrick Townsend's memorandum to DAQ dated October 10, 2013 (submitted previously), (2) a letter from TSI (a dryer manufacturer) dated December 6, 2013 (submitted previously), and (3) an updated letter from TSI dated July 16, 2014 (new submission).

Enviva has selected TSI as the vendor to construct the dryer at Enviva's Sampson facility. Enviva believes that the attached June 2014 letter from TSI further supports Enviva's contention that the dryer planned for construction at the Enviva Sampson facility represents an inherently lowering emitting pellet dryer that is substantially different from any pellet dryer currently in operation and equipped with RTO control. Importantly, TSI is the manufacturer of the dryers at Green Circle, Georgia Biomass, and German Pellets (equipped with RTOs). In its 112(g) MACT analysis, DAQ had previously raised concerns about the German Pellets dryer (of the three, the closest comparison to Sampson) being similar to the dryer proposed by Enviva. TSI's June 2014 letter points out further and quite significant distinctions between the dryer proposed by Enviva and existing dryers with RTO controls.

The following is a full statement of Enviva's argument that the proposed Sampson dryer should not be required to be controlled under a 112(g) MACT condition.

1. Laboratory and performance testing by Dr. John Richards, Ph.D. of Air Control Techniques has confirmed that smoldering and combustion of raw materials in the drying process result in dramatically higher VOC and HAP emissions. Enviva Sampson will be designed to combine carefully managed dryer

temperature, retention time, gas mixing space, and moisture content of the wood to minimize smoldering and combustion in the dryer. The TSI dryer for Sampson will use a combination of (1) engineered mixing of dryer flue gas with furnace hot gases beyond previous TSI dryers, (2) an improved dryer drum flighting system to further segregate particles by size for appropriately paced drying while preventing hot gas streaking, (3) reduced air leakage into the system, and (4) high humidity in the dryer. These elements of the proposed dryer result in lower VOC and HAP emissions.

2. TSI has determined that the key to minimizing VOC and HAP emissions from a wood pellet dryer is to minimize the temperature of wood within the dryer drum. While competitors are attempting to limit overall air temperature, the TSI dryer uses a high humidity environment (wet bulb temperature of about 170 degrees F, and actually "sweating" moisture from the wood) to achieve the same goal more effectively. Enviva's operations are also distinguished from competitors by drying to a higher moisture content in the final wood product exiting the dryer. Enviva Sampson will typically dry raw material down to approximately 17%, compared to Enviva's competitors such as German Pellets that dry wood down to <10%. The net result of precision wood temperature and moisture management in the dryer, coupled with not drying the wood as completely as competitors (maintenance of a higher moisture content in wood exiting the dryer), is lower emissions of HAP and VOCs; i.e. an inherently lower-emitting dryer.

3. Critical engineering differences between the dryer proposed for Enviva's Sampson facility and existing dryers controlled by RTOs are discussed in detail in the June 2014 TSI letter. These include a newly designed recycle bustle, the use of two turbulators (rather than the typical one), considerably longer hot gas ductwork (3x that of German Pellets) to allow for more homogeneous gas mixing and resulting temperature control, and a redesigned flighting system. Please see the June 2014 TSI letter for more details.

4. The net result of the innovative TSI design is an inherently lower emitting dryer with projected uncontrolled VOC emissions of approximately 0.95 lbs/oven dried ton when using a 75% softwood / 25% hardwood mix.

Please contact me if I can provide any additional information to assist in your review of the Enviva Pellets Sampson permit application.

Sincerely,

Norb Hintz, P.E.
Senior Vice President, Chief Engineer

Attachments
cc: Kevin Godwin, NC DAQ
Dale Overcash, Trinity Consultants
Alan McConnell, Esq.

Enviva LP | 7200 Wisconsin Ave . Suite 1000 | Bethesda, MD 20814 USA
+1 (301) 657 5560 | fax (301) 657 5567 | www.envivabiomass.com

tsi
Responsible Innovation

Enviva
North Carolina

July 16th, 2014

RE: VOC and HAP emissions

The purpose of this document is to discuss the VOC and HAP emissions from Single Pass Recycle Rotary Dryer Drums. This document is to be used only by Enviva and North Carolina State Emissions Agency; this document is not to be shared with any other parties.

TSI is a major supplier of Dryer Systems to the Oriented Strand Board Plants, Particle Board Plants, and Pellet Plants. To date TSI has supplied Dryer Systems to four of the World's largest Pellet Plants, those being Green Circle in Florida (600,000 mtpy), Georgia Biomass in Georgia (750,000 mtpy), German Pellets in Texas (600,000 mtpy), and German Pellets in Louisiana which is currently under construction (1,200,000 mtpy). TSI has also supplied Dryer Systems to a number of smaller Pellet Plants like Solvay in Mississippi (200,000 mtpy), Lee Energy in Alabama (150,000 tpy), Allegheny Wood Products in West Virginia (75,000 tpy), Geneva Wood in Maine (125,000 tpy), etc... TSI only supplies Single Pass Recycle Rotary Dryer Drums.

Throughout the three major projects (the Green Circle, Georgia Biomass, and German Pellets) TSI has steadily improved the performance of VOC emissions from the Dryer Systems. This document will focus at these three plants because they are about the same size as Enviva's future plants (about 500,000 metric tons/year) and because all three of these pellet plants process 100% Southern Yellow Pine, which is the major contributor to VOC and HAP emissions when compared to Hardwoods.

Emissions					
	VOC Emissions (Lbs/ODT)	Recycle Bustle	No. of Turbulators	Linear Feet From Recycle Bustle to wood chips	Dryer Drum Design to move dust from inlet
Green Circle	3.41	Yes	None	7'	No
Georgia Biomass	2.64	Yes	One (1)	10'	Yes
German Pellets	1.12	Yes	One (1)	28'	Yes
Enviva	0.8 (projected)	Yes	Two (2)	90'	Yes (further improvements)

As shown above TSI has steadily reduced VOC emissions from Green Circle (project completed in 2008), to Georgia Biomass (project completed in 2010), to German Pellets (project completed in 2013). As noted above, all of these plants process 100% Southern Yellow Pine, and dry wood chips between 7% and 10% moisture content wet-weight-basis.

Enviva's plants will also dry wood between 20% and 15% moisture content wet-weight-basis; this will further reduce VOC emissions since this type of drying is less 'aggressive'.

20818 44th Avenue W,, Ste 201, Lynnwood, Washington. USA
+1 (425) 771–1190 . Fax +1 (425) 775– 8363

IMPROVEMENTS:

The key to minimizing VOC & HAP emissions is essentially to minimize the temperature of the wood within the Drum. The wood always contains water, as it is not dried bone dry, and as such if it is exposed to 'moist' gas stream the wood should not exceed the Dryer System gas stream 'wet-bulb' temperature. The 'wet-bulb' temperature within a TSI Dryer System is typically about 170°F; thus the wood should never exceed 170°F. The 'moist' gas stream means that gasses impacting the wood are high in moisture, which protects wood from overheating and essentially 'sweats' water from the wood. To provide 'moist' gas stream to the Dryer System the mixing of 'dry' Furnace hot gas and 'moist' Dryer System recycle gas must be done very carefully. The 'dry' Furnace gas will enter the Dryer System Recycle Bustle at about 1500°F where it will connect the 'moist' (50% humidity) Dryer System flue gas at about 250°F. Conventional wisdom states that gasses at different temperatures will mix to a final homogeneous temperature. However, from the time the two gasses enter the Recycle Bustle till the gasses are at the Dryer Drum inlet is typically only about 0.25 second, and thus not enough time for the two gasses to mix completely. Result is streaks of gasses entering the Drum at 1500°F and 250°F and some gasses that have mixed at a temperature of about 700°F. Thus, most of the emissions are generated where 1500°F gasses impact the wood within the Drum.

To mix the two gasses TSI has improved the design of the Recycle Bustle, along with implementation of the Turbulator, which is essentially a mixer that forces turbulence and thus mixing of the two gas streams. TSI has also increased the length of hot gas ductwork between the Recycle Bustle and the Dryer Drum to allow longer time for the two gas streams to mix. Improved Recycle Bustle, along with Turbulators and longer mixing residence time, will ensure complete homogeneous humid gas mixture impacting wood within the Drum, thus minimizing VOC emissions.

For the Enviva plant, TSI will employ identical Recycle Bustle from German Pellets pellet plant, along with two (2) Turbulators (instead of one) to further create turbulence and promote gas mixing, and finally three times the mixing residence time (from 28' to 90' of linear duct) to ensure thorough mixing.

The second component to minimizing VOC & HAP emissions is the Drum's flighting system. Most of the emissions come from the small fines that enter the Dryer Drum; these don't require much energy to dry and thus can easily get bone dry and overheat, thus generating more emissions. The TSI flighting system has also been continually improved over the three aforementioned projects and TSI has identified another improvement that it can make within the Drum's flighting system to essentially move the fines away from the Drum's inlet as quickly as possible in order to minimize its exposure to high heat in that area. This additional improvement at the Enviva's plant will further drive VOC emissions lower.

Projected VOC & HAP emissions from a TSI Dryer System for the Enviva plant processing 70 BDTPH with 60% pine and 40% hardwoods:

1) VOC: 0.80 lbs/ODT
2) HAPs: 0.08 lbs/ODT

Projected VOC & HAP emissions from a TSI Dryer System for the Enviva plant processing 70 BDTPH with 75% pine and 25% hardwoods:

3) VOC: 0.95 lbs/ODT
4) HAPs: 0.1275 lbs/ODT

Best Regards,

Zlatko Savovic
TSI,Inc.
(425) 239-7490
zsavovic@tsi-inc.net
www.tsi-inc.net