Dominion Energy Services, Inc.
5000 Dominion Boulevard
Glen Allen, VA 23060
DominionEnergy.com

Dominion Energy

July 10, 2018

BY: OVERNIGHT MAIL

Mr. Michael Kiss
Central Office
Virginia Department of Environmental Quality
1111 East Main Street, Suite 1400
Richmond, VA 23219

Subject: Atlantic Coast Pipeline, L.L.C.
Buckingham Compressor Station
Minor New Source Permit Application
Air Quality Modeling Report

Dear Mr. Kiss:

Please find attached the updated Air Quality Modeling Report for the new Buckingham Compressor Station. The air quality dispersion modeling analysis was conducted using the methodology described in the approved air quality modeling protocol which was submitted to Virginia Department of Environmental Quality on April 6, 2018. The report demonstrates that the Buckingham Compressor Station will be in compliance with National Ambient Air Quality Standards (NAAQS) and with Virginia air toxic rules.

If you have questions about this submittal, please do not hesitate to contact T.R. Andrake at (804) 273-2882 or at thomas.r.andrake@dominionenergy.com.

Sincerely,

Richard Gangle
Director Environmental Services

RG/tra

Attachments:

CC: Mr. Patrick Corbett, Virginia Department of Environmental Quality
Ms. Cheryl Mayo, Virginia Department of Environmental Quality

DOCUMENT CERTIFICATION STATEMENT

I certify under penalty of law that this document and all attachments were prepared under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gather and evaluate the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering and evaluating the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

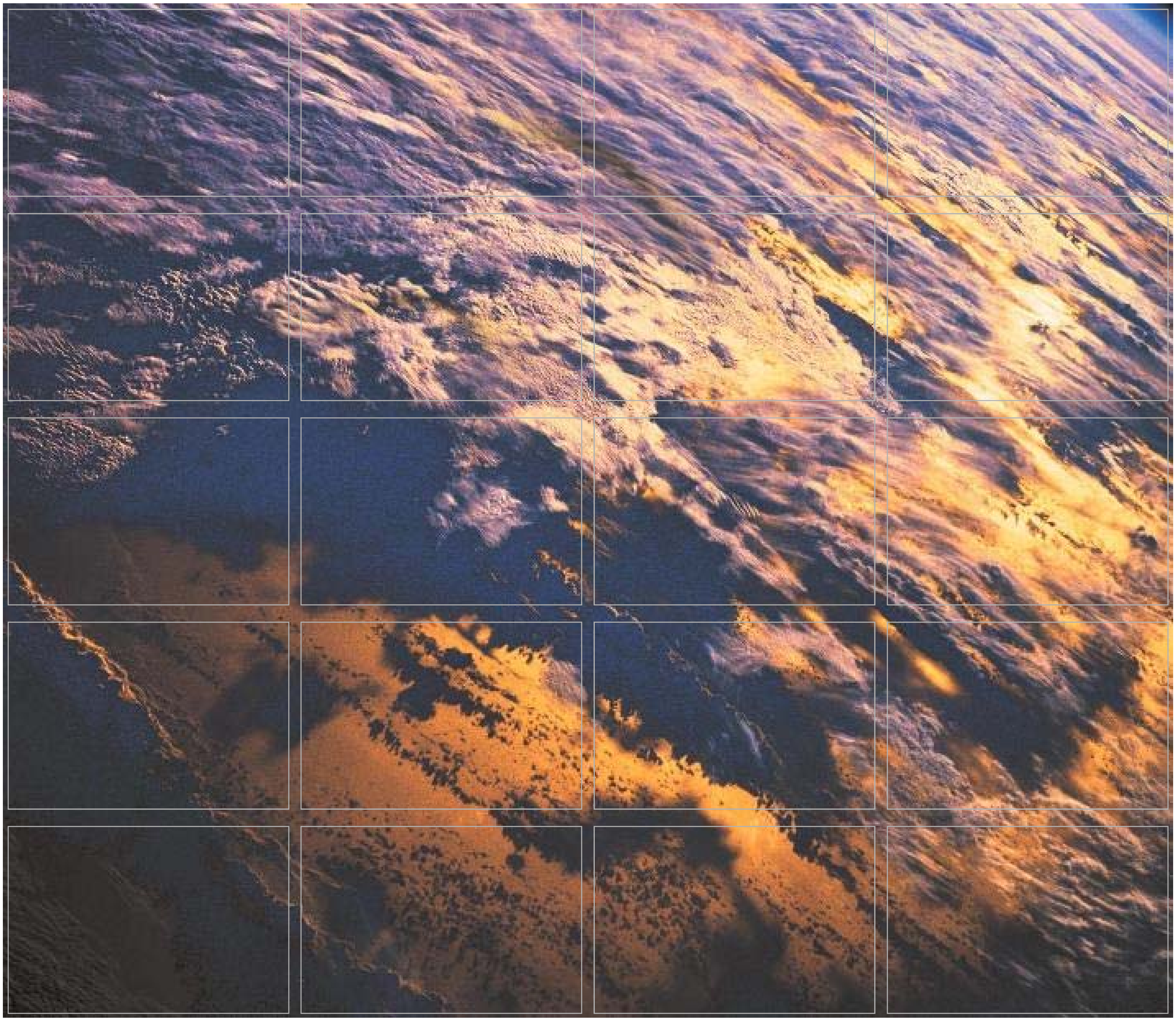
I certify that I understand that the existence of a permit under [Article 6 of the Regulations] does not shield the source from potential enforcement of any regulation of the board governing the major NSR program and does not relieve the source of the responsibility to comply with any applicable provision of the major NSR regulations.

SIGNATURE: ____________ DATE: 7/10/18

NAME: Leslie Hartz

TITLE: VP Pipeline Construction

COMPANY: Atlantic Coast Pipeline, LLC



Dominion Energy Transmission, Inc.
Atlantic Coast Pipeline, LLC
Buckingham County Compressor Station Air Quality Modeling Report

Buckingham County, Virginia

July 2018

Environmental Resources Management
75 Valley Stream Parkway, Suite 200
Malvern, PA 19355
www.erm.com

TABLE OF CONTENTS

List of Tables

List of Figures

APPENDICES

1.0 INTRODUCTION

Atlantic Coast Pipeline, LLC (Atlantic) and Dominion Energy Transmission, Inc. (DETI) are submitting this air quality modeling report to support the proposed construction and operation of a natural gas-fired compressor station located in Buckingham County, Virginia. Atlantic has contracted with DETI to construct and operate the proposed Atlantic Coast Pipeline (ACP). A Certificate was issued by the Federal Energy Regulatory Commission (FERC) to construct the ACP subject to receiving all other regulatory approvals.

A general area map showing the location of the compressor station is provided in **Appendix A**.

1.1 PROJECT OVERVIEW

Atlantic and DETI propose to construct, install, and operate a new natural gas-fired compressor station (Project). The Project is one of three proposed compressor stations for the ACP. The other two compressor stations are planned for Lewis County, West Virginia and Northampton County, North Carolina. The Project site is located in a rural setting in Buckingham County, Virginia. The project will consist of the installation and operation of the following combustion sources: four new combustion turbines, four line heaters, one auxiliary boiler, and one emergency generator. Vent stacks will be installed for each combustion turbine and for the station to purge/blowdown natural gas to ensure safe operation of the compressor station.

When completed, the compressor station will be a minor source of air emissions with respect to federal Prevention of Significant Deterioration and hazardous air pollutant standards, as well as a minor source with respect to the state Minor NSR program. The modeling of criteria pollutants was completed at the request of the Virginia Department of Environmental Quality (VADEQ).

1.2 OVERVIEW OF METHODOLOGY

An air quality dispersion modeling analysis has been conducted for the Project in order to assess impacts to the ambient air quality in the vicinity of the Project site. The methodology used in this analysis were described in an air quality modeling protocol submitted to VADEQ on April 6, 2018 (April 2018 protocol), and accepted by VADEQ on April 9, 2018. The criteria pollutants NO_2, CO, $PM_{2.5}$ and PM_{10} were included in the modeling analysis, as well as formaldehyde and hexane. Design value concentrations from the Project, combined with offsite sources and ambient background concentrations, were compared to the National Ambient Air Quality Standard (NAAQS) for each of the criteria pollutants. Maximum modeled concentrations of formaldehyde and hexane were compared to the significant ambient air concentrations specified in the Virginia Administrative Code (VAC), 9 VAC 5-60-330.

The modeling analysis was conducted using AERMOD version 16216r, which was the most recent version of the EPA regulatory air dispersion model at the time of the protocol submittal and approval. The model has been executed using the following supporting programs: AERMET (version 16216), AERSURFACE (version 13016), AERMAP (version 11103) and BPIP (version 04274).

2.0 PROJECT EMISSIONS AND SOURCE CHARACTERIZATION

2.1 PROJECT DESCRIPTION

The Project site is located in Buckingham County, VA. A plot plan of the proposed Project is presented in **Appendix B**.

The emission sources associated with the Project are listed below. All combustion sources are to be fueled with pipeline quality natural gas. Each of the combustion turbines are equipped with a vent stack that are used for purge events associated with unit startup activities and blowdown events associated with unit shutdown activities.

- One (1) Solar Titan 130 combustion turbine (CT) with a rated capacity of 20,500 hp[1];
- One (1) Solar Mars 100 CT with a rated capacity of 15,900 hp[1];
- One (1) Solar Taurus 70 CT with a rated capacity of 11,107 hp[1];
- One (1) Solar Centaur 50L CT with a rated capacity of 6,276 hp[1];
- One (1) Auxiliary Boiler with a maximum heat input of 6.384 million British Thermal Units per hour (MMBtu/hr);
- Four (4) Line Heaters with a maximum heat input of 21.22 million British Thermal Units per hour (MMBtu/hr);
- One (1) Caterpillar G3516C Emergency Generator with a rated capacity of 2,175 hp;
- Eight (8) vent stacks (four station vent stacks and one vent stack for each turbine);
- One (1) Hydrocarbon (Waste Oil) Tank with a 1,000 gallon capacity;

---

[1] The rated capacity for the compressor turbines represents the ISO rated capacity.

- One (1) Accumulator Tank with a 2,500 gallon capacity;
- One (1) Aqueous Ammonia Storage Tank with a 13,400 gallon capacity[2]; and
- Various station components and piping fugitive natural gas emissions (Includes gas piping and blowdown valves used for pigging operations)

2.2 PROJECT EMISSIONS

Modeling has been conducted for all applicable averaging periods for NO_2, PM_{10}, $PM_{2.5}$, CO and formaldehyde. An air quality modeling analysis was also conducted for hexane (1-hour averaging period) during normal operations, purging and blowdown events from turbine(s) associated with startup and shutdown, and for planned pigging events. The April 2018 protocol included modeling hexane for a planned site wide blowdown event associated with testing of the emergency shutdown (ESD) system once every five years at the facility. However, the facility design basis has been updated from a full site wide blowdown event every five years to annual capped testing of emergency shutdown valves. The revised emissions calculations reflect the reduced blowdown emissions. The revised emissions now show that the new worst case hexane emissions would occur during planned pigging events, which are discussed further in Section 2.2.4. Annual hexane was not modeled in this analysis because maximum expected annual emissions of hexane do not exceed the exemption emission rate established in 9 VAC 5-60-300 C. Although hourly hexane emissions also do not exceed the exemption emission rate, an analysis of hourly hexane emissions was retained for consistency purposes after discussions with VADEQ.

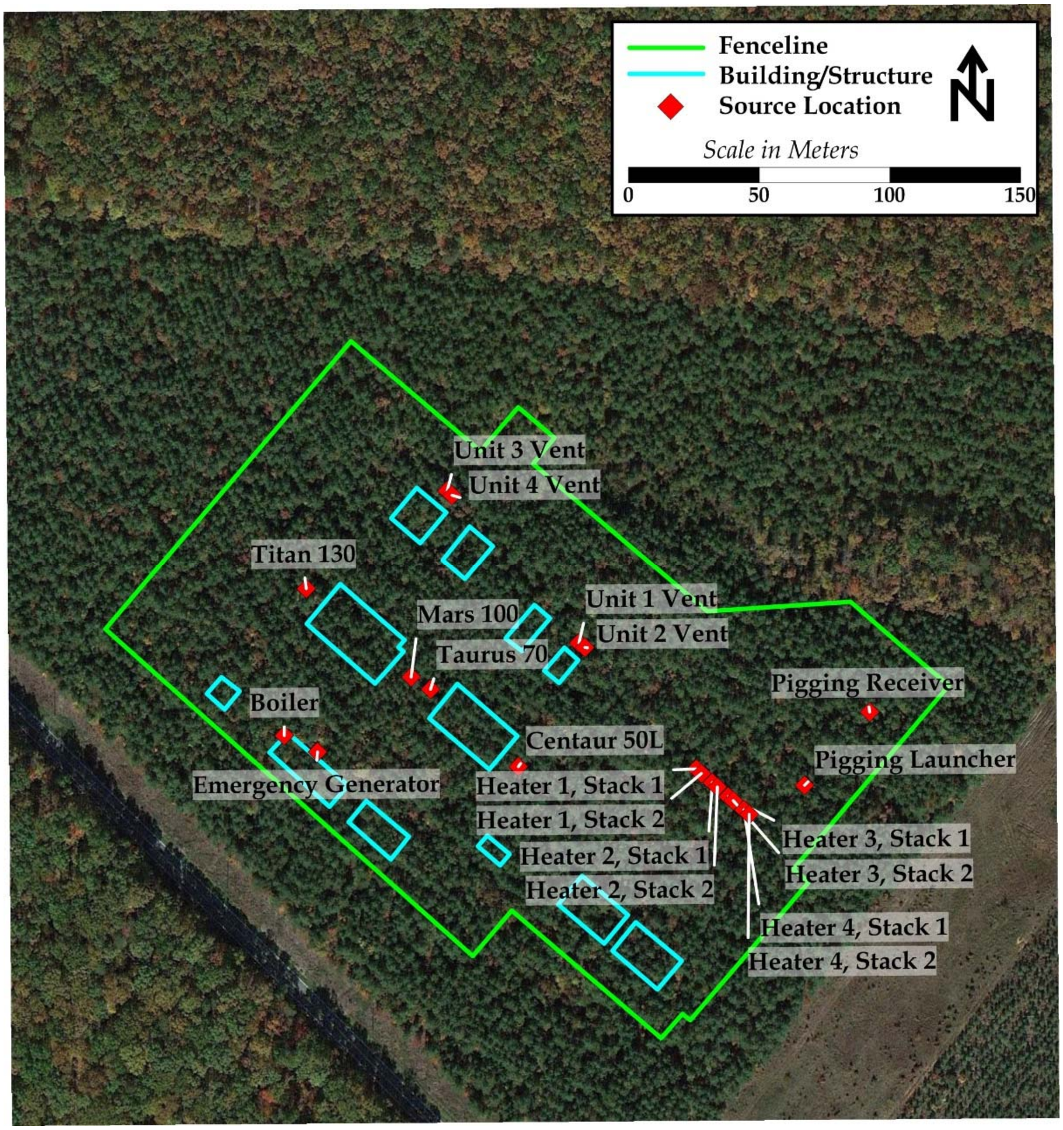
The turbines, line heaters and boiler have been modeled assuming continuous operation, or 8,760 hours per year. The four combustion turbines were evaluated for multiple loads and operating temperatures, as well as for startup and shutdown scenarios. The emergency generator has been modeled assuming 500 hours per year.

A copy of the emissions calculations contained in the air permit application are included in **Appendix C**. A summary of modeled stack parameters and emission rates, including blended emissions and stack parameters associated with startup and shutdown is included in **Appendix D**. An image showing the location of the modeled sources is provided in Figure 2-1.

---

[2] The aqueous ammonia tank is not a regulated source. The tank will be a closed system and no actual emissions are expected, however, the presence of the tank is acknowledged here for completeness.

Figure 2-1 Modeled Source Locations



2.2.1 *Combustion Turbine Operating Scenarios*

The project has been evaluated for a range of combustion turbine scenarios including startup and shutdown, as well as the following load and ambient temperature scenarios: 50%, 75%, and 100% loads at <0 °F, 0 °F, 59 °F, and 100 °F ambient temperatures (Table D-2, Appendix D). The worst case emissions and stack parameters were determined for each turbine load case (50%, 75%, and 100%) for each of the four turbines based on vendor specifications. The worst case emissions and parameters were selected for each turbine for each load case, across the various ambient operating temperature scenarios in order to arrive at a composite worst case emissions and parameter combination. The highest emission rate combined with the lowest stack exit velocity and temperature for each load case were selected as the worst case (see Table D-3, Appendix D). The highest emission rate, along with the worst case stack parameters, were also conservatively used for the annual averaging periods, except for the case of formaldehyde emission rates, which do not vary by scenario[3].

2.2.1.1 *Combustion Turbine Startup/Shutdown Scenarios*

The startup and shutdown scenarios for each turbine will last approximately ten minutes for all turbine models. During the ten minutes of startup or shutdown operation, the exhaust temperature and exit velocity are assumed to be equivalent to the composite worst case 50% load scenario. The emissions during the startup or shutdown are based on lb/event data provided by the turbine manufacturer. Atlantic and DETI have modeled the startup and shutdown scenario for the following short term pollutants and averaging period combinations:

- 1-hr NO_2
- 24-hr $PM_{2.5}$
- 24-hr PM_{10}
- 1-hr CO
- 8-hr CO
- 1-hr Formaldehyde

To characterize the startup and shutdown scenarios in the modeling analyses, the emissions and stack parameters for the startup and shutdown scenario needed to be blended with the normal operating emissions and stack parameters depending on the averaging period being modeled. The normal operating scenario resulting in the highest modeled concentration for that particular pollutant and averaging period was chosen for the blending of the startup and shutdown emissions and stack parameters[4]. Tables D-4 and D-5 in Appendix D contain supporting information relating to the characterization of the startup and shutdown in the modeling analysis.

2.2.2 *Combustion Turbine SoLoNO$_X$ Controls*

SoLoNOx controls will be installed on the proposed turbines and, other than during brief (< nominal 10 minute) startup and shutdown events, the turbines will only be operated in SoLoNOx mode. The SoLoNOx controls minimize emissions from the turbines and are expected to be operating at maximum efficiency throughout normal operations. As stated in the application, in the unlikely event that the inlet air to the combustion turbine is below 0° F, the

---

[3] Vendor emissions provided a specific formaldehyde emission rate, which was conservatively applied to all turbine load and ambient temperature scenarios. Vendor emissions for NO_X, CO and PM were specified by the vendor as variable dependent on turbine load and ambient temperature.

[4] Subject to agreement with VADEQ that the actual worst case (worst modeled concentration) scenario was chosen.

turbine manufacturer indicates that emissions can increase as a result of the need to ensure stable combustion. Such operation will not occur in most years. As a worst case, it was assumed that below 0° F operation could occur for up to 5 hours per year. (See Section 2.2.5 for further discussion of potential below 0° F operation).

2.2.3 *Emergency Generator*

The emergency generator has been modeled at 500 hours per year for the annual averaging period. For all short term averaging periods, the maximum hourly emission rate was modeled. This includes modeling the maximum hourly rate for 1-hour NO_2, CO, formaldehyde and hexane, as well as 8-hour CO and 24-hour $PM_{2.5}/PM_{10}$. The maximum hourly emissions rate of NO_X from the emergency generator has been conservatively included in the 1-hr NO_2 modeling analysis.

2.2.4 *Modeling for Hexane*

In the April 2018 protocol, three scenarios were selected to model for the toxic pollutant hexane: A station-wide blowdown event associated with testing of the ESD system, purging of the turbines during startup and normal operations. The station-wide blowdown event is no longer included in the modeling analysis as described in Section 2.2. Therefore, the modeling analysis has been updated consisting of the planned pigging event, since this is the highest emission rate, purging and blowdown of the turbine(s) which occur during startup and shutdown respectively, and normal operations. The 1-hour averaging period for hexane was initially included in the modeling protocol because the hourly emissions from the site-wide blowdown scenario had the potential to exceed the short term exemption emission rate listed at 9 VAC 5-60-300 C.

Following the VADEQ acceptance of the April 2018 protocol, Atlantic and DETI have made updates to the permit application that reflect changes to the proposed facility and will affect pollutant emissions, including significantly reducing hexane emissions. Atlantic and DETI have decided to implement operational controls, including a vent gas reduction system and “capped” emergency shutdown testing, to reduce the quantity of gas emitted during the required blowdown events, which will lower the short term emission rate of hexane to below the exemption threshold specified in 9 VAC 5-60-300 C. The recent emissions updates show that the short term exemption emission rate for hexane is no longer exceeded by the project for any scenario, but remains in the modeling analysis for consistency purposes after discussions with VADEQ. Annual hexane emissions are not expected to exceed the exemption emission rate and were not included in the April 2018 protocol. A comparison of hexane emissions to the exemption emission rate can be found in the emissions calculations of **Appendix C**, Table C-10.

The worst case scenario for hexane emissions is the planned pigging events. A planned pigging event involves launching a device known as a 'pig' through the pipes to inspect and/or clean the pipeline. The pig is then received at another end of the pipe. Both launching and receiving events have associated natural gas venting emissions (that may contain hexane). However in any given hour, only a launching or receiving event will occur. Both events will not occur during the same hour. Therefore, the events are modeled separately. Further, pigging operations are expected to only occur once every five to seven years as part of normal inspection and equipment maintenance operations. The emission points of hexane during a pigging event consist of small valves on the receiver or launcher piping that are opened following an event in order to depressurize the piping. Table D-6 of Appendix D details the stack characteristics used to represent both pigging events in the modeling analysis. Conservatively, the modeling has assumed normal operation of non-turbine equipment within the same hour as a pigging event.

The hexane emissions from the turbine vent stacks that occur during purging and blowdown of the turbine during startup and shutdown, respectively, scenarios were also modeled. These startup and shutdown scenarios will include hexane emissions from normal operation of non-turbine equipment, similar to the pigging scenarios. Details of the stack characteristics during these events are included in Tables D-7 and D-8 of Appendix D.

Finally, a third scenario for hexane has been modeled for normal operations of the entire facility (i.e. excluding startup/shutdown of the turbines and pigging events).

As a planned event, the pigging operations will only be conducted during daylight hours. More specifically, the launching and receiving events will be limited to occur only between the hours of 6:00 a.m. to 7:00 p.m., since these operations are labor intensive and typically performed during daylight hours. This has been accounted for in AERMOD by using the HROFDY option in the variable source emission factor (SO EMISFACT) keyword. The HROFDY option allows AERMOD to specify that the pigging release valves will only emit during the specified hours between 6:00 a.m. and 7:00 p.m. for the pig launching and/or receiving events. Conversely, the combustion turbine startup and shutdown scenarios and normal operation scenario have been modeled for all hours of the day.

2.2.5 Intermittent Emissions

USEPA has published guidance (USEPA 2011) for air quality modeling analyses for demonstrating compliance with the 1-hr NO_2 NAAQS. The guidance provides clarification of how intermittent emissions scenarios should be treated for a modeling analyses of 1-hr NO_2. Specifically, page 8 of the USEPA 2011 guidance states the following:

"…the intermittent nature of the actual emissions associated with emergency generators and startup/shutdown in many cases, when coupled with the probabilistic form of the standard, could result in modeled impacts being significantly higher than actual impacts would realistically be expected to be for these emissions scenarios. The potential overestimation in these cases results from the implicit assumption that worst-case emissions will coincide with worst-case meteorological conditions based on the specific hours on specific days of each of the years associated with the modeled design value based on the form of the hourly standard. In fact, the probabilistic form of the standard is explicitly intended to provide a more stable metric for characterizing ambient air quality levels by mitigating the impact that outliers in the distribution might have on the design value."

"Given the implications of the probabilistic form of the 1-hour NO_2 *NAAQS discussed above, we are concerned that assuming continuous operations for intermittent emissions would effectively impose an additional level of stringency beyond that intended by the level of the standard itself. As a result, we feel that it would be inappropriate to implement the 1-hour* NO_2 *standard in such a manner and recommend that compliance demonstrations for the 1-hour* NO_2 *NAAQS be based on emissions scenarios that can logically be assumed to be relatively continuous or which occur frequently enough to contribute significantly to the annual distribution of daily maximum 1-hour concentrations."*

Atlantic and DETI have carefully considered the USEPA guidance language highlighted above, and have determined that the emissions scenario associated with operations of the combustion turbines at ambient temperatures less than 0° F are intermittent emissions scenarios that are expected to occur in only very rare cases, and as such would not contribute significantly to the annual distribution of daily maximum 1-hour concentrations of NO_2. Over the five year period between 2012 and 2016, two nearby Automated Surface Observation System (ASOS) sites, the Lynchburg Regional Airport (KLYH, WBAN 13733) and the Charlottesville Albemarle Airport (KCHO, WBAN 93736), were analyzed for temperatures below 0° F. The ambient temperature was below 0° F for a total of 5 hours at KLYH, and 1 hour at KCHO. All of these extreme cold events occurred during the year 2015. Temperatures below 0° F were not recorded at either location in the remaining four years of meteorological data. Since the 1-hr NO_2 NAAQS is based on the 98th percentile (i.e., the eighth highest annually) of the daily maximum concentrations, the frequency of occurrence of this scenario is not high enough to have a significant effect on the design value of the standard itself. Therefore, the below 0° F case for the turbines was not considered in the 1-hr NO_2 modeling analysis. It is important to note that the below 0° F case for the turbines was modeled for all other averaging periods and pollutants, including annual NO_2.

2.3 BUILDING WAKE EFFECTS

The EPA's Building Profile Input Program (BPIP), Version 04274, has been used to determine the appropriate building dimensions to use to calculate the effects of downwash on the modeled sources in AERMOD. Building, structure, and tank dimensions and locations relative to the modeled sources were obtained from engineering drawings of the planned facility and input into BPIP. The stacks for all sources at the facility will not exceed the greater of the GEP formula height calculated by BPIP or 65 m (213 feet).

3.0 MODELING METHODOLOGY

3.1 MODEL SELECTION AND APPLICATION

The most recent version of EPA's AERMOD model at the time of the protocol submission and approval (version 16216r) has been used for predicting ambient impacts for each modeled compound.

Modeled design value concentrations of the criteria pollutants have been used to demonstrate that the Project, in addition to existing ambient concentrations of pollutants, will not cause a violation of any NAAQS. The values of the NAAQS are shown in Table 3-1. Maximum modeled concentrations of formaldehyde and hexane have been compared with the significant ambient air concentrations identified in the Virginia Administrative Code (VAC), shown in Table 3-2. Formaldehyde is the only air toxic that exceeded the exemption emission rates in accordance with 9 VAC 5-60-300 C, and therefore required an air quality modeling assessment. Although hexane did not exceed the exemption emission rates, it has been included in the modeling analysis, as described in Section 2.2.4. As documented in this report, the modeling confirms that the modeled concentrations of formaldehyde and hexane are below the concentration values established in 9 VAC 5-60-330 2.

3.2 AMBIENT AIR QUALITY STANDARDS

Table 3-1 presents a summary of the NAAQS that have been addressed for NO_2, PM_{10}, $PM_{2.5}$, and CO. Table 3-2 presents the significant concentrations of formaldehyde and hexane that have been used to address air toxics in accordance with 9 VAC 5-60-330 2.

Table 3-1 Ambient Air Quality Standards

Pollutant	Averaging Period	NAAQS [a]
PM_{10}	24-Hour	150 [b,c]
	Annual	50 [d,e]
$PM_{2.5}$	24-Hour	35 [f,g]
	Annual	12 [d,h]/15[d,i]
NO_2	1-Hour	188 [j,k]
	Annual	100 [l]
CO	1-Hour	40000 [m]
	8-Hour	10000 [m]

a) Primary standard unless otherwise noted.

b) Expected number of days per calendar year, on average, with arithmetic time-averaged concentration above standard is equal to or less than one. For modeling analyses, compliance is evaluated by comparing the high, 6th-high modeled concentration over five years (plus an appropriate background concentration) to the NAAQS.

c) For PM_{10} 24-hour average NAAQS analysis, modeled concentration is the highest 6th highest concentration over 5 years of NWS data.

d) Based on 3-year average of the annual mean concentrations.

e) AAQS REVOKED.

f) The 3-year average of the 98th percentile of 24-hour concentrations must not exceed standard. The NAAQS was revised effective December 18, 2006.

g) For the $PM_{2.5}$ 24-hour SIL analysis, modeled concentration is the highest of the 5-year averages of the maximum modeled 24-hour average $PM_{2.5}$ concentrations predicted each year at each receptor, based on 5 years of National Weather Service (NWS) data. Use of the SIL is subject to evaluation depending on the approach taken to address $PM_{2.5}$ secondary impacts. For the $PM_{2.5}$ 24-hr NAAQS analysis, the modeled concentration is the 98th percentile of the 5-year averages of the maximum modeled 24-hour average $PM_{2.5}$ concentrations (EPA memorandum, dated March 20, 2014, from S. Page, "Guidance for $PM_{2.5}$ Permit Modeling").

h) The highest average of the modeled annual averages across 5 years of NWS meteorological data is compared to the $PM_{2.5}$ annual average SIL and AAQS. Use of the SIL is subject to evaluation depending on the approach taken to address $PM_{2.5}$ secondary impacts. (EPA memorandum, dated March 20, 2014, from S. Page, "Guidance for $PM_{2.5}$ Permit Modeling").

i) Secondary standard.

j) The 3-year average of the 98th-percentile of the annual distribution of daily maximum 1-hour concentrations must not exceed standard.

k) For NO_2 1-hour NAAQS analysis, modeled concentration is the 98th percentile (H8H) of the annual distribution of daily maximum 1-hour concentrations averaged across 5 years of NWS data (EPA memorandum, dated June 28, 2010, from T. Fox, "Applicability of Appendix W Modeling Guidance for the 1-hour NO2 National Ambient Air Quality Standard").

l) No exceedances are allowed for annual averages to determine compliance with the NAAQS and to determine whether impacts are significant compared to the SIL.

m) One exceedance allowed per year.

Table 3-2 VAC Significant Ambient Air Concentrations

Pollutant	Averaging Period	Significant Concentration (µg/m³)
Formaldehyde	1- Hour	62.5 [a]
	Annual	2.4 [b]
Hexane	1-Hour	8800 [c]
	Annual	352 [c]

a) The TLV-STEL for formaldehyde is 2.5 mg/m³. The significant 1-hr ambient air concentration for an air toxic, as described by 9 VAC 5-60-330 2, is 1/40 of the TLV-STEL.
b) The TLV-TWA® for formaldehyde is 1.2 mg/m³. The significant annual ambient air concentration for an air toxic, as described by 9 VAC 5-60-330 2, is 1/500 of the TLV-TWA®.
c) The TLV-TWA® for hexane is 176 mg/m³. The significant 1-hr and annual ambient air concentration for an air toxic, as described by 9 VAC 5-60-330 2, is 1/20 and 1/500 of the TLV-TWA® respectively.

3.3 BACKGROUND POLLUTANT CONCENTRATIONS

For the cumulative air quality modeling analysis, representative background concentrations were included for NO_2, $PM_{2.5}$, PM_{10}, and CO. Atlantic and DETI have identified the most current nearby monitors that are representative, or conservatively representative, of Buckingham County. Selection of the background monitors was based on proximity and representativeness of the monitoring sites to the Project site, and is described in more detail in Section 3.3 of the April 2018 protocol. Table 3-3 summarizes the air quality data from the monitoring stations that were used for background concentrations. The locations of these air quality monitors in relation to the proposed Project site are presented in Appendix E.

Table 3-3 Summary of Background Concentrations

Pollutant	Averaging Period	Background Concentration (µg/m³)	Station ID	Station Location	Distance from Project (km)	
NO_2	1-hour	75.2[a]	511650003	Harrisonburg (Rockingham County), VA	99.5	NNW
	Annual	16.92[b]				
CO	1-hour	1374[c]	511611004	Vinton (Roanoke County), VA	113.6	WSW
	8-hour	1259.5[c]				
$PM_{2.5}$	24-hour	15[a]	516800015	Lynchburg, VA	56.5	WSW
	Annual	7.2[a]				
PM_{10}	24-hour	27[c]	510870014	Henrico County, VA	111.2	E

[a] Based on the 2016 design value.
[b] Based on the maximum concentration for the 2014-2016 period.
[c] Based on the high-second-high concentration for the 2014-2016 period.

All of the sites listed in Table 3-3 and shown in Appendix E are located in more developed regions, while the project site is located in a rural and less populated area. Based on population and population density data from the United States Census Bureau shown in Table 3-4, the area surrounding the project has both the lowest population and population per square mile of any of the monitoring sites that were considered in the selection process. This comparison indicates that any of the monitoring sites chosen from those listed in Table 3-4 will have conservatively high background concentrations relative to the less populated rural area of the project site.

Table 3-5 presents emissions by county, obtained from the 2014 National Emissions Inventory (NEI)[5]. The counties in Table 3-5 are the county where the project is located (Buckingham County) and the surrounding counties where air quality monitors are located. Emissions from Buckingham County are less than all other counties where air quality monitors are located. This demonstrates that any air quality monitoring data used from these surrounding counties would be inherently conservative as a representation of background ambient air quality in Buckingham County, since Buckingham has comparatively lower emissions than these other counties. Further discussions on the selection of the monitoring sites are provided in sections 3.3.1-3.3.4.

Table 3-4 Population Data for Background Monitors

Monitor Station Location	Station ID	County	County Population[a]	Population per Square Mile[b]
(Project Site)	-	Buckingham County, Virginia	17,048	29.6
Harrisonburg, VA	511650003	Rockingham County, Virginia	79,744	89.9
Richmond, VA	517600025	Richmond city, Virginia	223,170	3,414.7
Henrico County, VA	510870014	Henrico County, Virginia	326,501	1,313.4
Vinton, VA	511611004	Roanoke County, Virginia	94,031	368.7
Hopewell, VA	516700010	Hopewell city, Virginia	22,735	2,198.0
Albemarle County, VA	510030001	Albemarle County, Virginia	106,878	137.3
(near Albemarle County, VA)		Charlottesville city, Virginia	46,912	4,246.4
Lynchburg, VA	516800015	Lynchburg city, Virginia	80,212	1,538.2

a - Data from July 1, 2016

b - Data from 2010

Source of Data: http://www.census.gov/quickfacts

---

[5] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-data

Table 3-5 Emissions from Buckingham County and Surrounding Counties with Air Quality Monitors

Monitor Station Location	Station ID	County	2014 NEI Emissions (tons)			
			NO_X	CO	$PM_{2.5}$	PM_{10}
(Project Site)	-	Buckingham County, Virginia	540	4,057	440	1,834
Harrisonburg, VA	511650003	Rockingham County, Virginia	3,104	22,841	2,075	7,863
Richmond, VA	517600025	Richmond city, Virginia	5,497	26,151	772	1,848
Henrico County, VA	510870014	Henrico County, Virginia	6,810	37,888	1,067	2,710
Vinton, VA	511611004	Roanoke County, Virginia	2,220	12,781	538	1,789
Hopewell, VA	516700010	Hopewell city, Virginia	9,708	4,421	541	976
Albemarle County, VA	510030001	Albemarle County, Virginia	3,265	17,881	1,012	4,250
Lynchburg, VA	516800015	Lynchburg city, Virginia	1,725	10,153	576	1,294

3.3.1 Background NO_2 Monitor

The nearest NO_2 monitor to the project site is located just outside of Harrisonburg, Virginia and located approximately 99.5 km to the north-northwest of the project site. The next two closest monitors are located approximately 105 and 111 km to the east in the vicinity of Richmond, Virginia. Because the Harrisonburg site is both closer and located in a less populated area than the Richmond sites, this site was selected as the most representative and appropriate for NO_2 background concentrations.

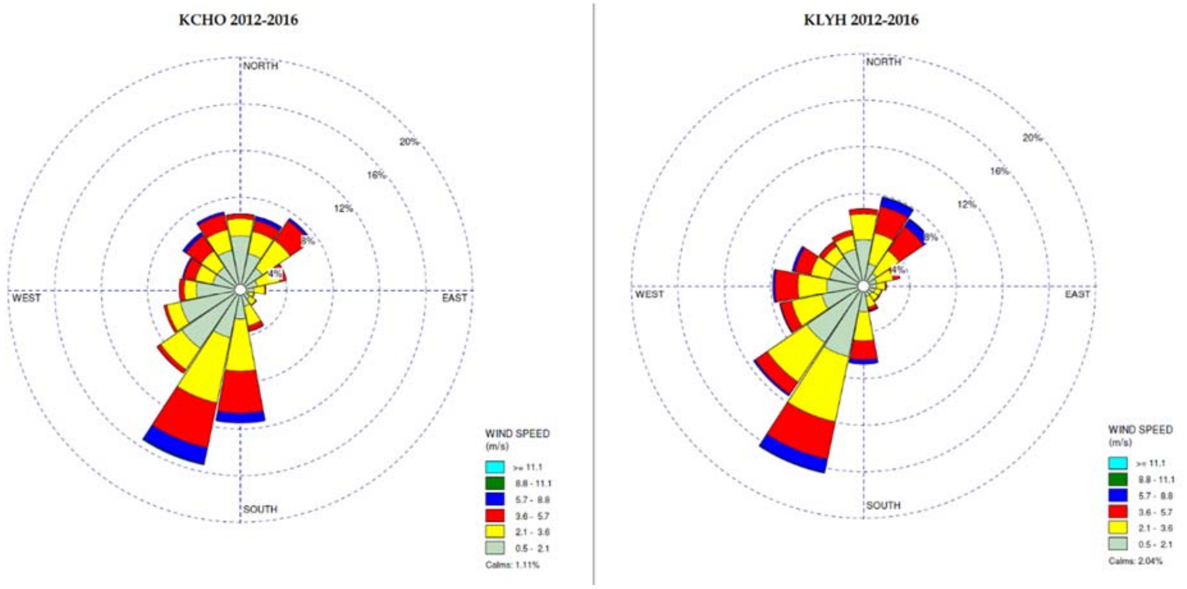
3.3.2 Background CO Monitor

The two closest CO monitors to the project site are located in the vicinity of Richmond, Virginia. These sites are located approximately 105 and 111 km to the east of the project site, respectively. The next closest monitor is located approximately 113.6 km to the west-southwest in an area just outside of Roanoke, in Vinton, Virginia. Although the Richmond sites are closest in distance to the project, the Vinton site is only slightly further away, and is located in a more rural setting. The Vinton site was selected as the most representative and appropriate for CO background concentrations.

3.3.3 Background $PM_{2.5}$ Monitor

The nearest $PM_{2.5}$ monitor to the project site is located just outside of Charlottesville, Virginia in Albemarle County, approximately 55.7 km to the north-northeast of the project site. The next furthest $PM_{2.5}$ monitor is located in Lynchburg, Virginia, approximately 56.5 km to the west-southwest. Although the Albemarle County monitor is not located within the city boundary of Charlottesville, it is in close proximity (approximately 5.8 km from the central area of the city). For these monitors, population data alone does not provide a clear indication of which monitor is more representative of the project location. Emissions data (Table 3-5) shows that the Albemarle County monitor is located in an area of higher $PM_{2.5}$ emissions, while the Lynchburg city $PM_{2.5}$ emissions are only slightly higher than those near the project site. As noted previously, both sites are approximately equidistant from the project site. In order to further evaluate monitor representativeness, a wind analysis was also conducted. Both cities have nearby airports with ASOS data, as mentioned in Section 2.2.1. Wind roses from both sites are displayed in Figure 3-1 below. The wind roses show that both sites have a predominantly south-southwesterly wind, which would put the Lynchburg area generally upwind from the project site and the Charlottesville area generally downwind of the project site. Because ambient background concentrations at the project site are more likely to be affected by the Lynchburg air quality, the Lynchburg monitor was chosen as the more representative $PM_{2.5}$ monitor.

Figure 3-1 Charlottesville Albemarle Airport (KCHO) and Lynchburg Regional Airport (KLYH) Wind Roses



3.3.4 Background PM_{10} Monitor

The nearest PM_{10} monitor to the project site is located just outside of Richmond, Virginia in Henrico County and located approximately 111 km to the east of the project site. The next closest monitor is located approximately 125 km to the east in Hopewell, Virginia. Because the Richmond site is both closer and has higher background concentrations than the Hopewell site, this site is chosen as the most conservative and appropriate for PM_{10} background concentrations.

3.4 *NO_X TO NO_2 CONVERSION*

For the NO_2 modeling analyses, Atlantic and DETI have used the Ambient Ratio Method 2 (ARM2) option in AERMOD to account for the formation of NO_2 from the emissions of NO_X from the Project sources. Atlantic and DETI have utilized ARM2 with the national default range of NO_2 to NO_X ratios (50% to 90%). When ARM2 is used, AERMOD assigns the appropriate ratio for each hour and receptor based on the total modeled concentration of NO_X. Every modeled NO_2 scenario has been run separately so that the correct value of total NO_X concentrations are used by ARM2 to find the appropriate NO_2/NO_X ratio.

3.5 *SECONDARY IMPACTS*

In December 2016, EPA released a guidance memorandum (USEPA 2016) for review and comment that described how modeled emission rates of precursors (MERPs) could be calculated as part of a Tier I ozone and secondary $PM_{2.5}$ formation analysis to assess a project's emissions of precursor compounds as they would relate to ozone and $PM_{2.5}$ "critical air quality thresholds". Atlantic and DETI have utilized the air quality modeling results included in the MERPs guidance to assess the projects impacts on secondary $PM_{2.5}$ formation and ozone formation as described in the paragraphs below.

In order to characterize expected maximum modeled impacts of secondary $PM_{2.5}$ and ozone from the proposed project, Atlantic and DETI have considered model results from the EPA hypothetical source that is closest to the project location. Specifically, model results from EPA Source 9 located in Dinwiddie County, VA were considered.

3.5.1 *$PM_{2.5}$ Formation*

$PM_{2.5}$ is emitted directly from the Project emissions sources, and formed in the atmosphere from Project $PM_{2.5}$ precursor emissions (NO_X and SO_2). Therefore, to account for the total air quality impact of $PM_{2.5}$, the modeled concentrations of primary $PM_{2.5}$ from the Project sources should be summed with a conservative concentration representative of $PM_{2.5}$ formed from Project $PM_{2.5}$ precursor emissions. Appropriate secondary $PM_{2.5}$ concentrations were determined based on the project emissions and the air quality modeling results included in the MERPs guidance, as described in the following paragraphs.

For the 24-hour averaging period, the $PM_{2.5}$ impacts are based on the highest daily 24-hour impact from a hypothetical NO_X source and a hypothetical SO_2 source that were identified from multiple model simulation results contained in the MERPs guidance. For NO_X, the eastern US (EUS) hypothetical source located at Dinwiddie, Virginia (source #9) with a surface release (L), annual NO_X emissions of 500 tpy, and a maximum impact of 0.13 µg/m^3 was used (see page 55 of the guidance document). Therefore, the estimated impact on the 24-hour secondary $PM_{2.5}$ formation from the project's NO_X emissions was determined as follows:

$(34.2 \text{ tpy } NO_X \text{ from Project}/500 \text{ tpy } NO_X) \times 0.13\ \mu g/m^3 = 0.00889\ \mu g/m^3$

For SO_2, the EUS hypothetical source located at Dinwiddie, Virginia (source #9) with a surface release (L), annual SO_2 emissions of 500 tpy, and a maximum impact of 0.56 µg/m^3 was used (see page 60 of the guidance document). Therefore, the estimated impact on the 24-hour secondary $PM_{2.5}$ formation from the project's SO_2 emissions was determined as follows:

$(8.30 \text{ tpy } SO_2 \text{ from Project}/500 \text{ tpy } SO_2) \times 0.56\ \mu g/m^3 = 0.00930\ \mu g/m^3$

As a result, the estimated total impact on the 24-hour secondary $PM_{2.5}$ formation would be 0.01819 µg/m^3. This concentration has been combined with the final 24-hour $PM_{2.5}$ model results in order to accurately capture the total $PM_{2.5}$ impacts from the project.

For the annual averaging period, this analysis was based on the highest annual average impact from a hypothetical NO_X source and a hypothetical SO_2 source that were identified from multiple model simulation results contained in the MERPs guidance. For NO_X, the EUS hypothetical source located at Dinwiddie, Virginia (source #9) with a surface release (L), annual NO_X emissions of 500 tpy, and a maximum impact of 0.005 µg/m^3 was used (see page 66 of the guidance document). Therefore, the estimated impact on the annual secondary $PM_{2.5}$ formation from the project's NO_X emissions was determined as follows:

$(34.2 \text{ tpy } NO_X \text{ from Project}/500 \text{ tpy } NO_X) \times 0.005\ \mu g/m^3 = 0.00034\ \mu g/m^3$

For SO_2, the EUS hypothetical source located at Dinwiddie, Virginia (source #9) with a surface release (L), annual SO_2 emissions of 500 tpy, and a maximum impact of 0.014 µg/m^3 was used (see page 71 of the guidance document). Therefore, the estimated impact on the annual secondary $PM_{2.5}$ formation from the project's SO_2 emissions was determined as follows:

$(8.30 \text{ tpy } SO_2 \text{ from Project}/500 \text{ tpy } SO_2) \times 0.014\ \mu g/m^3 = 0.000232\ \mu g/m^3$

As a result, the estimated total impact on the annual secondary $PM_{2.5}$ formation would be 0.000572 µg/m^3. This concentration has been combined with the final annual $PM_{2.5}$ model results in order to accurately capture the total $PM_{2.5}$ impacts from the project.

3.5.2 Ozone Formation

The project is a source of ozone precursor emissions (NO_X and VOC). An assessment of air quality impacts for ozone was conducted based on the project's emission rates of ozone precursors and the air quality modeling results included in EPA 2016, as described in the following paragraphs.

The estimated ozone impacts are based on the highest daily maximum 8-hour ozone impact from a hypothetical NO_X source and a hypothetical VOC source that were identified from multiple model simulation results contained in EPA 2016. For NO_X, the eastern US (EUS) hypothetical source located at Dinwiddie, Virginia (source #9) with a surface release (L), annual NO_X emissions of 500 TPY, and a maximum impact of 2.00 ppb was used (see page 44 of the guidance document). Therefore, the estimated ozone impact from the project's NO_X emissions was determined as follows:

(34.2 TPY NO_X from project/500 TPY NO_X MERP) × 2.00 ppb = 0.1368 ppb

For VOC, the EUS hypothetical source located at Dinwiddie, Virginia (source #9) with a surface release (L), annual VOC emissions of 500 TPY, and a maximum impact of 0.06 ppb was used (see page 49 of the guidance document). Therefore, the estimated ozone impact from the project's VOC emissions was determined as follows:

(9.77 TPY VOC from project/500 TPY VOC MERP) × 0.06 ppb = 0.00117 ppb

The monitored ozone design value for the area is approximately 60 ppb. The addition of the project's NO_X and VOC worst-case daily impacts to the design value equals 60.14 ppb which is well below the 8-hour ozone NAAQS of 70 ppb. It is important to note that this approach is highly conservative because it adds a daily maximum 8-hour ozone concentration to a design value. The project's actual modeled impact on the design value (4th highest ozone concentration averaged over 3 years) is likely to be less than the result obtained using this approach.

3.6 GEOGRAPHIC SETTING

3.6.1 Land Use Characteristics

The proposed facility will be located in rural Buckingham County, VA. Atlantic and DETI have analyzed the land use classifications within an area defined by a 3 km radius from the approximate center of the project site, and have determined that the land use within this area has 0% urban classification. This determination was used by analyzing the USGS NLCD 2011 data, where urban classifications were assumed to be category 23 (developed, medium intensity) and category 24 (developed, high intensity). A graphical and tabular representation of this land use analysis is provided in **Appendix F**. AERMOD was therefore executed in the default (rural) mode.

3.6.2 Terrain

The Project site is situated at approximately 590 feet elevation above mean sea level. Within about 10 km surrounding the Project site, the terrain is characterized by rolling hills, with elevations between 460 to 590 feet. There is also an area of relatively elevated terrain about 9.5 km to the southwest of the Project site that has a maximum elevation of 1400 feet. The latest version of EPA's AERMAP program (version 11103) has been used to determine the ground elevation and hill scale for each modeled receptor, based on data obtained from the USGS National Elevation Database (NED). The NED data was obtained at a horizontal resolution of 1/3 arc-second (10-m) for use in this analysis.

3.7 RECEPTOR GRIDS

For this modeling analysis, a total of five (5) separate receptor grids were combined to create an overall grid pattern:

- 25-meter spacing along the fence line;
- 50-meter spacing from the fence line extending to 1 km from the facility;
- 100-meter spacing from 1 km to 3 km from the facility;
- 250-meter spacing from 3 km to 10 km from the facility; and
- 500-meter spacing from 10 km to 20 km from the facility.

As noted previously, AERMAP has been used to define ground elevations and hill scales for each receptor. Atlantic and DETI have analyzed isopleths of modeled concentrations due to the proposed Project, and have determined that the receptor grid adequately accounts for the worst case impacts, and so no adjustments were needed. The facility fence line was used as the boundary to determine ambient air. No receptors were placed within this fence line boundary. A physical fence will control public access to the facility.

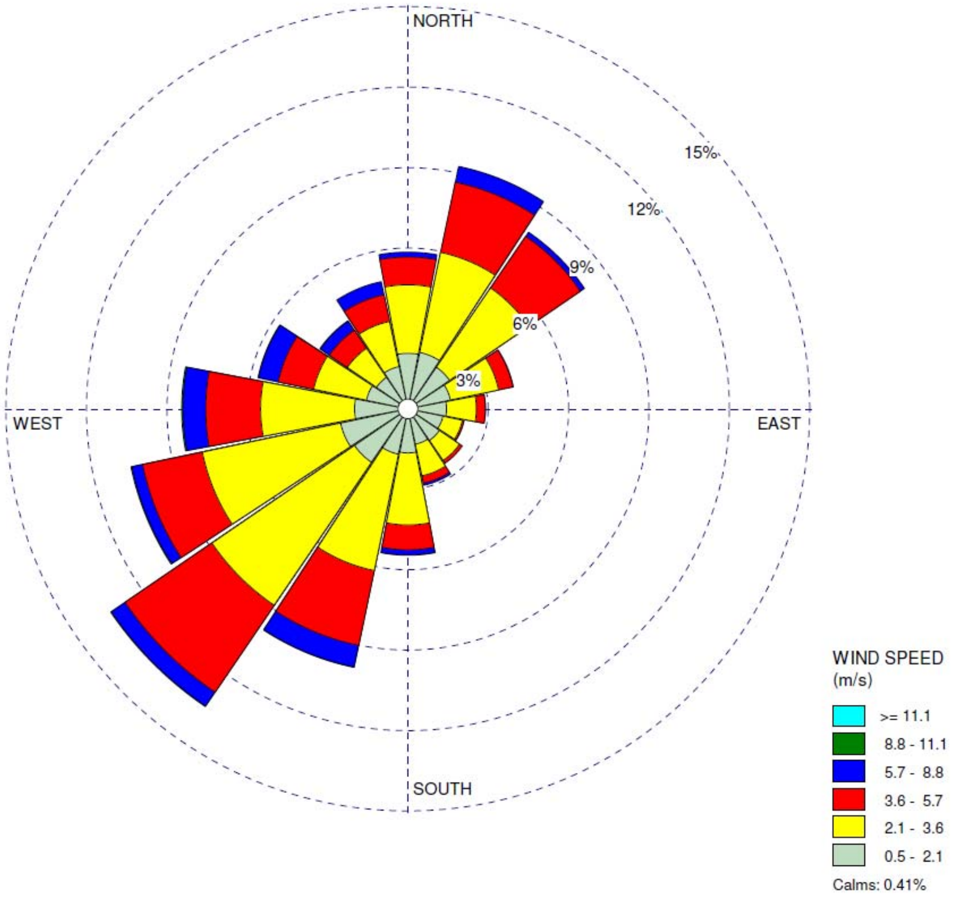
3.8 METEOROLOGICAL DATA FOR AIR QUALITY MODELING

Atlantic and DETI used prognostic meteorological data provided by the VADEQ as the source of input meteorological data for AERMOD. The prognostic meteorological data were extracted from the Weather Research and Forecasting (WRF) model with a 12 km horizontal resolution and processed using EPA's Mesoscale Model Interface (MMIF) program. MMIF extracts the WRF data for a single grid cell and converts the data into a format suitable for use in AERMET. The grid cell closest to the project site was provided by VADEQ. The location of the WRF data cell extracted with MMIF by VADEQ is provided in Table 3-6 below. The coordinate and distance to the project site are referenced to the center of the extracted grid cell. The prognostic meteorological data provided by VADEQ were processed through AERMET and ready for direct input into AERMOD. The data were processed using AERMET version 16216. A wind rose of the extracted meteorological data provided by VADEQ is presented in Figure 3-2.

Table 3-6 MMIF Data Details

MMIF Data Details	
Latitude (° N)	37.605
Longitude (° W)	78.592
Distance to Project Site (km)	6.14
Years Provided	2013, 2014, 2015

Figure 3-2 Wind Rose – WRF Meteorological Data Extracted by MMIF



3.9 OFFSITE INVENTORY

Atlantic and DETI have consulted with VADEQ to develop an inventory of nearby sources for use in the cumulative air quality modeling analysis. The nearby sources identified have been included along with the Project sources to determine the total modeled concentrations of the relative pollutants for comparison to the NAAQS. The modeled offsite sources included in this modeling analysis are provided in **Appendix G**. An ambient background concentration from the appropriate monitors, as described in Section 3.3, was also included in the cumulative analysis.

4.0 MODEL RESULTS PRESENTATION

Four (4) criteria pollutants, including NO_2, $PM_{2.5}$, PM_{10} and CO, and two (2) air toxic pollutants, formaldehyde and hexane, have been modeled. The background concentrations (described in Section 3.3) and nearby offsite sources (described in Section 3.9) have been combined with the appropriate model design values, using the sum of these values for comparison to the NAAQS. Maximum modeled concentrations of formaldehyde and hexane have been compared directly to the significant ambient air concentrations.

4.1 LOAD ANALYSIS RESULTS

The facility was modeled for different worst-case turbine load scenarios (see Section 2.2.1). The results of the turbine load analysis are provided in Table 4-1. The worst case scenario for each pollutant and averaging period was used for blending in the subsequent startup/shutdown NAAQS analyses.

Table 4-1 Load Analysis Results

	Modeled Concentrations ($\mu g/m^3$)[b]									
Load Scenario	**1-hour NO_2[a]**	**Annual NO_2[a]**	**1-hour CO**	**8-hour CO**	**24-hour $PM_{2.5}$**	**Annual $PM_{2.5}$**	**24-hour PM_{10}**	**Annual PM_{10}**	**1-hr Formaldehyde**	**Annual Formaldehyde**
50%	53.48	3.34	187.37	170.3	9.37	1.47	9.80	1.58	38.90	0.081
75%	53.49	3.38	187.38	169.7	9.46	1.49	9.88	1.60	38.90	0.079
100%	53.48	3.39	187.38	169.6	9.47	1.49	9.90	1.60	38.90	0.076

a - The < 0° F scenario was not considered for the 1-hour averaging period because of the intermittent source exemption. The annual averaging period did consider the < 0° F scenario.

b - Cells highlighted in blue represent the worst case scenario for a particular pollutant and averaging period

4.2 NAAQS ANALYSIS RESULTS

A cumulative modeling analysis was conducted for 1-hr and annual NO_2, 1-hr and 8-hr CO, 24-hr and annual $PM_{2.5}$, and 24-hr PM_{10}. Nearby offsite sources have been included in the cumulative modeling analysis, as explained in Section 3.9. Background concentrations (Section 3.3) and secondary impacts (Section 3.5) were also combined with the modeled design value concentrations before comparison to the NAAQS. The results of the NAAQS analysis are provided in Table 4-2 below, and are also presented in **Appendix H**.

As shown in Table 4-2, the NAAQS are not exceeded for any compound for any of the modeled scenarios. This indicates that the proposed Project will not cause or contribute to exceedances of the 1-hr or annual NO_2, the 1-hr or 8-hr CO, the 24-hr or annual $PM_{2.5}$, or the 24-hr PM_{10} NAAQS.

Table 4-2 NAAQS Analysis Results

Pollutant	Averaging Period	Load Scenario	Background Concentration (µg/m^3)	Secondary Impacts (µg/m^3)	Model Result (µg/m^3)[a]	NAAQS (µg/m^3)	Total Concentration (µg/m^3)[b]
NO_2	1-hour	50% Load	75.2	-	42.0	188	117.2
		75% Load		-	42.0		117.2
		100% Load		-	42.0		117.2
		Startup (blended with 75% load)		-	42.0		117.2
		Shutdown (blended with 75% load)		-	42.0		117.2
	Annual	50% Load	16.92	-	3.5	100	20.4
		75% Load		-	3.5		20.4
		100% Load		-	3.5		20.4
CO	1-hour	50% Load	1374	-	187	40,000	1561
		75% Load		-	187		1561
		100% Load		-	187		1561
		Startup (blended with 75% load)		-	303		1677
		Shutdown (blended with 75% load)		-	188		1562
	8-hour	50% Load	1259.5	-	122	10,305	1381
		75% Load		-	122		1381
		100% Load		-	122		1381
		Startup (blended with 50% load)		-	122		1382
		Shutdown (blended with 50% load)		-	122		1381
$PM_{2.5}$	24-hour	50% Load	15	0.01819	6.5	35	21.6
		75% Load			6.6		21.6
		100% Load			6.6		21.6
		Startup (blended with 100% load)			6.6		21.6
		Shutdown (blended with 100% load)			6.6		21.6
	Annual	50% Load	7.2	0.000572	1.5	12	8.7
		75% Load			1.5		8.7
		100% Load			1.5		8.7
PM_{10}	24-hour	50% Load	27	-	9.0	150	36.0
		75% Load		-	9.1		36.1
		100% Load		-	9.1		36.1
		Startup (blended with 100% load)		-	9.1		36.1
		Shutdown (blended with 100% load)		-	9.1		36.1

a - Modeled results do not include background concentrations or secondary impacts

b - Total concentration is the sum of the modeled concentration, the background concentration and the secondary impacts

4.3 AIR TOXICS MODEL RESULTS

An air toxics modeling analysis was conducted for normal operations for 1-hr and annual formaldehyde, and also for startup and shutdown during the 1-hr averaging period. Additionally, 1-hr hexane was modeled for a variety of scenarios: pigging operations (launching and receiving), purging from startup and blowdown from shutdown scenarios, and for normal operations. The highest modeled concentrations were compared with the significant concentrations for this pollutant. The results of the air toxics analyses are provided in Table 4-3 below and are also presented in **Appendix H**.

Table 4-3 Air Toxics Model Results

Pollutant	Averaging Period	Scenario	Significant Concentration (μg/m^3)	Model Result (μg/m^3)
Formaldehyde	1-hour	50% Load	62.5	38.9
		75% Load		38.9
		100% Load		38.9
		Startup (blended with 50% load)		40.5
		Shutdown (blended with 50% load)		40.2
	Annual	50% Load	2.4	0.081
		75% Load		0.079
		100% Load		0.076
Hexane	1-hour	Pigging (Launching)	8,800	6,277
		Pigging (Receiving)		6,897
		Purging from Startup Events		1,370
		Blowdown from Shutdown Events		4,518
		Normal Operations		20

As shown in Table 4-3, the significant concentration values are not exceeded for any compound for any of the modeled scenarios. This indicates that the proposed Project will not adversely affect human health.

4.4 CONCLUSIONS

The results of the air quality modeling analysis demonstrate that the proposed Buckingham Compressor Station Project does not cause or contribute to any exceedance of the NAAQS for NO_2, $PM_{2.5}$, PM_{10} and CO, and also does not exceed significant air toxics concentrations for formaldehyde and hexane.

All relevant electronic modeling files will be provided to VADEQ over a secure FTP site as part of this report. The following summarizes the contents of the electronic files:

- AERMOD input and output files for all NAAQS and toxics analyses
- AERMAP input and output
- MMIF meteorological data used in the analyses
- BPIP input and output
- Offsite inventory

5.0 REFERENCES

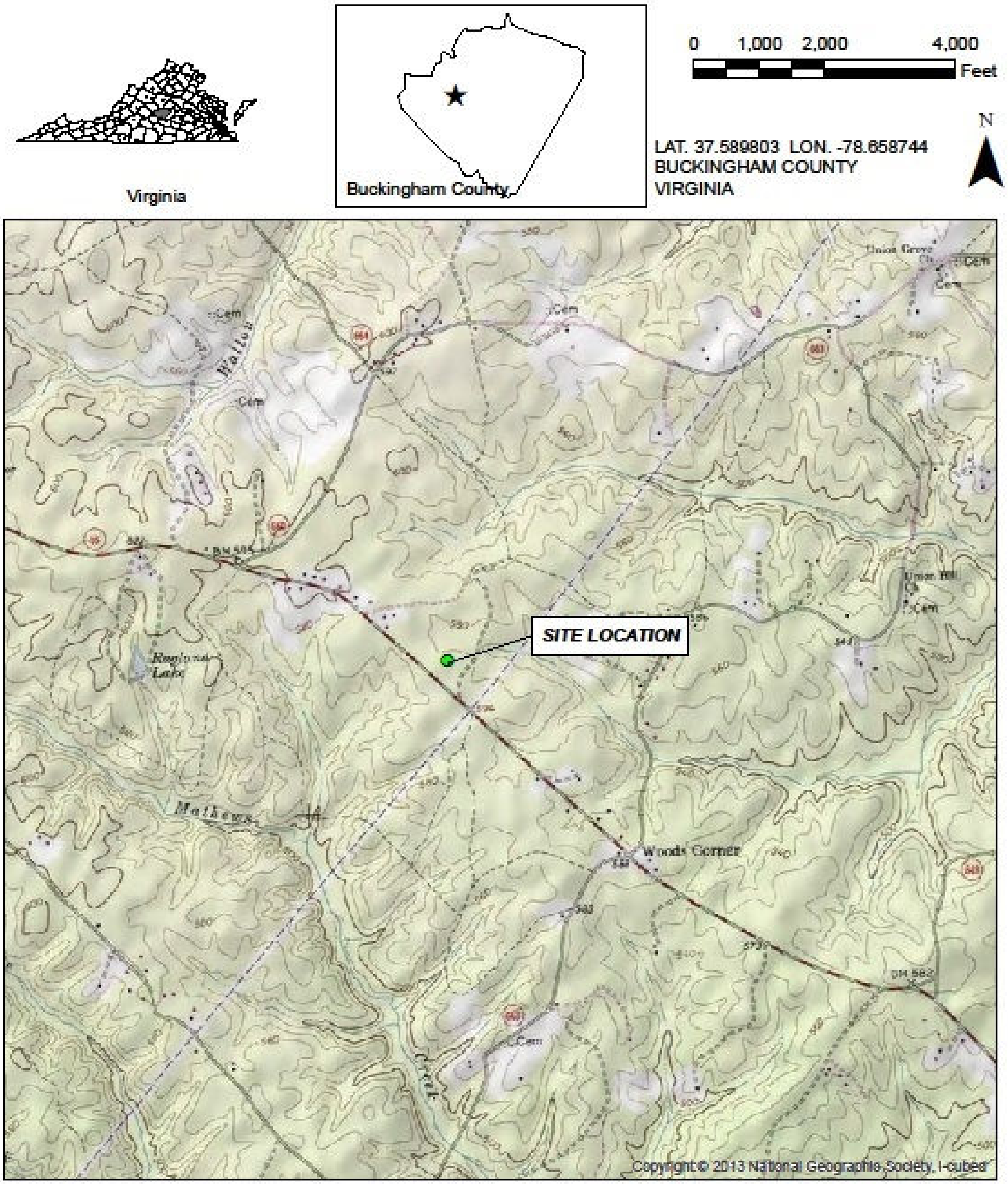
U.S. Environmental Protection Agency. (USEPA 2011) USEPA memo entitled "Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard", USEPA, Office of Air Quality Planning and Standards, Raleigh, NC. March 1, 2011.

U.S. Environmental Protection Agency. (USEPA 2016) USEPA memo entitled "Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program", USEPA Office of Air Quality Planning and Standards, Raleigh, NC. December 2, 2016.

U.S. Environmental Protection Agency. (USEPA 2017) USEPA memo entitled "Distribution of the EPA's modeling data used to develop illustrative examples in the draft Guidance on the Development of Modeled Emission Rates for Precursors (MERPs) as a Tier 1 Demonstration Tool for Ozone and $PM_{2.5}$ under the PSD Permitting Program", USEPA Office of Air Quality Planning and Standards, Raleigh, NC. February 23, 2017.

Proposed Facility Location

Appendix A



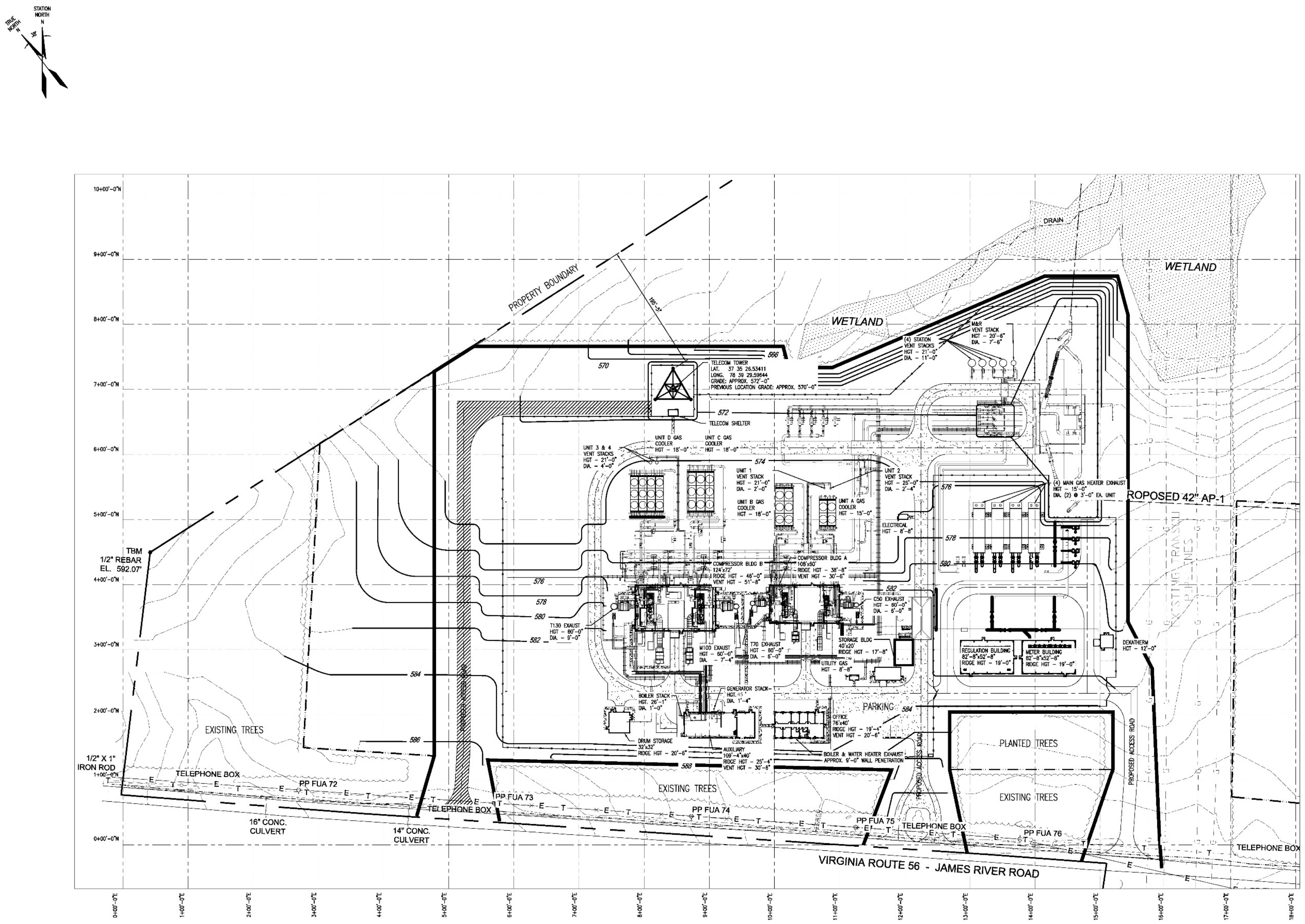
USGS 1:24K 7.5' Quadrangle:
Saint Joy, VA

SITE LOCATION MAP

ERM	**Dominion Transmission, Inc.** Atlantic Coast Pipeline, LLC Buckingham County Compressor Station	GIS Review: JR CHK'D: JR 0345197
Drawn By: SRV-07/11/16	**Environmental Resources Management**	Appendix A

Facility Plot Plan

Appendix B



LEGEND

580	CONTOUR
	ACP CENTER LINE
	EDGE OF ROAD
	FENCE
	DITCH
	RIGHT-OF-WAY
E	OVERHEAD UTILITY
G	BURIED PIPELINE
PP FUA 74	POWER POLE WITH IDENTIFICATION
● TBM	TEMPORARY BENCHMARK

REISSUED FOR
12/1/2017
INFORMATION

BASIC SYSTEMS
BASIC SYSTEMS, INC.
9255 CADIZ ROAD
CAMBRIDGE, OHIO 43725
(740) 432-3001

GENERAL NOTES AND COMMENTS:

V.T.D = VENDOR TO DETERMINE

SYM.	DATE	BY	REVISION INFORMATION	PROJECT/TASK	APP.
g	12/1/17	JLB	MOVED FENCE AT STATION BLOWDOWN AREA	64649.CS.CS2.1	
f	11/9/17	JLB	ADDED VENT SILENCER INFORMATION	64649.CS.CS2.1	
e	9/20/17	JLB	REVISED FENCE AT RECEIVER/LAUNCHER AREA	64649.CS.CS2.1	
d	8/30/17	JLB	REVISED APU STACK LOCATION	64649.CS.CS2.1	
c	8/17/2017	JLB	ISSUED FOR AIR PERMIT	64649.CS.CS2.1	
b	6/29/2017	JLB	ISSUED FOR 100% DESIGN REVIEW	64649.CS.CS2.1	
a	12/08/16	JLB	ISSUED FOR 75% DESIGN REVIEW	64649.CS.CS2.1	

SEAL

ORIGINAL CONSTRUCTION INFORMATION		
PROJECT/TASK:	64649.CS.CS2.1	
DRAWN:	mls	4/5/2016
CHECKED:		
APP. FOR BID:		
APP. FOR CONST.:		
SCALE:	1" = 60'-0"	

Atlantic Coast Pipeline, LLC.
925 White Oaks Blvd., Bridgeport, West Virginia 26330

FOR: BUCKINGHAM COMPRESSOR STATION

TITLE: SITE
LAYOUT PLAN

TOWN: WOODS CORNER
COUNTY: BUCKINGHAM, VA
DIR/FILE: I:\1800s\1866\Drawings
GROUP: PD
DWG. NO.: E9925A
REV.: g

Emissions Calculations

Appendix C

Table C-1 Permit to Construct Application Project Equipment List

ACP Buckingham Compressor Station - Buckingham County, Virginia

Emission Point ID	Source	Manufacturer	Model/Type	Rated Capacity
CT-01	Compressor Turbine	Solar Turbines	Mars 100-16000S	15,900 hp
CT-02	Compressor Turbine	Solar Turbines	Taurus 70-10802S	11,107 hp
CT-03	Compressor Turbine	Solar Turbines	Titan 130-20502S	20,500 hp
CT-04	Compressor Turbine	Solar Turbines	Centaur 50-6200LS	6,276 hp
WH-01	Boiler	Hurst	S45-G-152-60W	6.384 MMBtu/hr
LH-01	Line Heater	ETI	WB HTR	21.22 MMBtu/hr
LH-02	Line Heater	ETI	WB HTR	21.22 MMBtu/hr
LH-03	Line Heater	ETI	WB HTR	21.22 MMBtu/hr
LH-04	Line Heater	ETI	WB HTR	21.22 MMBtu/hr
EG-01	Emergency Generator	Caterpillar	G3516C	2,175 hp
FUG-01	Fugitive Leaks - Blowdowns	-	-	-
FUG-02	Fugitive Leaks - Piping	-	-	-
TK-1	Accumulator Tank	-	-	2,500 gal
TK-2	Hydrocarbon (Waste Oil) Tank	--	--	1,000 gal
TK-3	Ammonia Tank	--	--	13,400 gal

Notes:
1. The rated capacity for the compressor turbines represents the ISO rated capacity.

Table C-2 Potential Emissions From Combustion Sources
ACP Buckingham Compressor Station - Buckingham County, Virginia

Turbine Operational Parameters:

Normal Hours of Operation:	8,722
Hours at Low Load (<50%)	0
Hours of Low Temp. (< 0 deg. F)	5
Hours of Start-up/Shut-down	33.3
Total Hours of Operation (hr/yr):	8,760

Emergency Generator Operational Hours:

Normal Hours of Operation:	500

Boiler/Heater Operational Parameters:

Normal Hours of Operation:	8,760

Pre-Control Potential to Emit

	Power			Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia (tpy)	HAP (tpy)
Combustion Sources	**Rating**	**Units**	**Fuel**	**NO_x**	**CO**	**VOC**	**SO_2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO_2**	**CH_4**	**N_2O**	**CO_2e**	**NH_3**	**Total HAP**
Solar Mars 100 Turbine	15,900	hp	Natural Gas	20.4	34.6	1.98	2.12	3.58	3.58	3.58	8.86	74,015	5.35	1.87	74,705	8.09	1.73
Solar Taurus 70 Turbine	11,107	hp	Natural Gas	13.5	22.8	1.31	1.40	2.37	2.37	2.37	5.85	48,856	3.53	1.23	49,312	5.75	1.14
Solar Titan 130 Turbine	20,500	hp	Natural Gas	24.8	41.9	2.40	2.57	4.34	4.34	4.34	10.7	89,662	6.49	2.26	90,499	10.2	2.09
Solar Centaur 50L Turbine	6,276	hp	Natural Gas	8.68	14.6	0.838	0.897	1.52	1.52	1.52	3.76	31,420	2.27	0.792	31,713	3.57	0.732
Hurst S45 Boiler	6.384	MMBtu/hr	Natural Gas	1.37	2.30	0.151	0.091	0.052	0.052	0.052	0.156	3,290	0.063	0.060	3,309	0	0.052
ETI Line Heater 1 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 2 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 3 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 4 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
Caterpillar G3516C EGen (Woods Corner)	2,175	hp	Natural Gas	0.599	2.40	0.599	0.012	0.144	0.144	0.144	0.037	531	4.80	0	651	0	0.657
Total (tons/yr)				**73.1**	**132**	**9.27**	**8.29**	**12.5**	**12.5**	**12.5**	**30.8**	**291,513**	**23.3**	**7.02**	**294,187**	**27.6**	**7.09**

Turbine Control Efficiencies

Control Technology	**NO_x**	**CO**	**VOC**
Selective Catalytic Reduction	58%	-	-
Oxidation Catalyst	-	92%	50%

Post-Control Potential to Emit

	Power			Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia (tpy)	HAP (tpy)
Combustion Sources	**Rating**	**Units**	**Fuel**	**NO_x**	**CO**	**VOC**	**SO_2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO_2**	**CH_4**	**N_2O**	**CO_2e**	**NH_3**	**Total HAP**
Solar Mars 100 Turbine	15,900	hp	Natural Gas	8.52	2.77	0.989	2.12	3.58	3.58	3.58	8.86	74,015	5.35	1.87	74,705	8.09	0.863
Solar Taurus 70 Turbine	11,107	hp	Natural Gas	5.63	1.83	0.653	1.40	2.37	2.37	2.37	5.85	48,856	3.53	1.23	49,312	5.75	0.570
Solar Titan 130 Turbine	20,500	hp	Natural Gas	10.3	3.35	1.20	2.57	4.34	4.34	4.34	10.7	89,662	6.49	2.26	90,499	10.2	1.05
Solar Centaur 50L Turbine	6,276	hp	Natural Gas	3.62	1.17	0.419	0.897	1.52	1.52	1.52	3.76	31,420	2.27	0.792	31,713	3.57	0.366
Hurst S45 Boiler	6.384	MMBtu/hr	Natural Gas	1.37	2.30	0.151	0.091	0.052	0.052	0.052	0.156	3,290	0.063	0.060	3,309	0	0.052
ETI Line Heater 1 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 2 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 3 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 4 (Woods Corner)	21.22	MMBtu/hr	Natural Gas	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
Caterpillar G3516C EGen (Woods Corner)	2,175	hp	Natural Gas	0.599	2.40	0.599	0.012	0.144	0.144	0.144	0.037	531	4.80	0	651	0	0.657
Total (tons/yr)				**33.8**	**27.6**	**6.01**	**8.29**	**12.5**	**12.5**	**12.5**	**30.8**	**291,513**	**23.3**	**7.02**	**294,187**	**27.6**	**4.24**

Notes:

(1) Turbine emissions are calculated by the following formula: ER * Run Hours / 2000 * (1 - Control Efficiency)
ER = Emission Rate for particular equipment and pollutant (lbs/hr)
2000 = The amount of lbs in a ton

(2) Caterpillar G3516C EGen emissions are calculated by the following formula: Power Rating * Run Hours * EF / 2000
Power Rating = Engine rating (hp)
EF = Emission Factor from either manufacturer's data or AP-42 (lb/hp-hr)
2000 = The amount of lbs in a ton

(3) Hurst S45 Boiler and ETI Line Heater emissions calculated by the following formula: EF * Power Rating * Run Hours / HHV / 2000
EF = Emission Factor from either manufacturer's data or AP-42 (lb/MMscf)
Power Rating = Boiler/Heater heat capacity (MMBtu/hr)
HHV = Natural Gas High Heating Value (1020 MMBtu/MMscf)
2000 = The amount of lbs in a ton

(4) Turbines are equipped with Selective Catalytic Reduction (SCR) and oxidation catalyst for control of NOx (58%), CO (92%), and VOC (50%)

(5) Caterpillar G3516C EGen hp taken from manufacturer data

(6) Hurst S45 Boiler assumed to have low-NOx burners

(7) See the "HAP Emissions" worksheet for a more detailed breakdown of HAP emissions

(8) See Emissions Factors table for Emissions Factors for each operating scenario

(9) Each start-up/shut-down event assumed to last 10 minutes

Table C-3A Event Based Potential Emissions From Combustion Sources
ACP Buckingham Compressor Station - Buckingham County, Virginia

Startup Emissions

Combustion Sources	Power Rating	Units	Fuel	Startup Events	Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia	HAP
					NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3	Total HAP
Solar Mars 100 Turbine	15,900	hp	Natural Gas	100	0.050	2.30	0.200	5.00E-04	8.64E-04	8.64E-04	8.64E-04	0.002	19.3	0.800	0.004	40.3	0.015	0.130
Solar Taurus 70 Turbine	11,107	hp	Natural Gas	100	0.050	4.40	0.900	5.00E-04	8.64E-04	8.64E-04	8.64E-04	0.002	19.1	3.50	0.007	108	0.011	0.245
Solar Titan 130 Turbine	20,500	hp	Natural Gas	100	0.050	2.75	0.350	0.001	0.002	0.002	0.002	0.004	33.1	1.50	0.004	71.8	0.019	0.150
Solar Centaur 50L Turbine	6,276	hp	Natural Gas	100	0.015	1.05	0.150	5.00E-04	4.32E-04	4.32E-04	4.32E-04	0.001	9.20	0.700	0.002	27.1	0.007	0.060
Total (tons/yr)					**0.165**	**10.5**	**1.60**	**0.003**	**0.004**	**0.004**	**0.004**	**0.009**	**80.6**	**6.50**	**0.016**	**248**	**0.053**	**0.585**

Shutdown Emissions

Combustion Sources	Power Rating	Units	Fuel	Shutdown Events	Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia	HAP
					NOx	CO	VOC	SO2	PMF	PMF-10	PMF-2.5	PMC	CO2	CH4	N2O	CO2e	NH3	Total HAP
Solar Mars 100 Turbine	15,900	hp	Natural Gas	100	0.050	0.328	0.125	0.001	0.001	0.001	0.001	0.004	33.8	1.05	0.007	62.0	0.015	0.115
Solar Taurus 70 Turbine	11,107	hp	Natural Gas	100	0.050	0.248	0.200	5.00E-04	0.001	0.001	0.001	0.002	23.7	1.60	0.005	65.0	0.011	0.085
Solar Titan 130 Turbine	20,500	hp	Natural Gas	100	0.100	0.364	0.225	0.002	0.002	0.002	0.002	0.005	47.3	1.85	0.007	95.6	0.019	0.128
Solar Centaur 50L Turbine	6,276	hp	Natural Gas	100	0.050	0.148	0.125	5.00E-04	7.20E-04	7.20E-04	7.20E-04	0.002	15.9	0.900	0.003	39.3	0.007	0.050
Total (tons/yr)					**0.250**	**1.09**	**0.675**	**0.004**	**0.005**	**0.005**	**0.005**	**0.013**	**121**	**5.40**	**0.021**	**262**	**0.053**	**0.378**

Total SUSD Emissions (tons/yr)	**0.415**	**11.6**	**2.28**	**0.006**	**0.009**	**0.009**	**0.009**	**0.022**	**201**	**11.9**	**0.037**	**510**	**0.105**	**0.963**

Compressor Blowdown Emissions - Controlled

Source Designation:	FUG-01

Blowdown Startup Events (April 2018 Update: Values updated to reflect compressor purge volumes)

		CT-01	CT-02	CT-03	CT-04
Blowdown from Startup	scf/event	3,768	1,884	4,083	1,095
Volumetric flow rate	scf-lbmol	385	385	385	385
Gas Molecular Weight	lb-lbmol	17.17	17.17	17.17	17.17
Startup Blowdown	lb/event	168	84.0	182	48.8

Blowdown Shutdown Events (December 2017 Update: Values updated to reflect VGR system limiting blowdown volume, based on blowing down from 30 PSIG [44.7 PSIA])

		CT-01	CT-02	CT-03	CT-04
Blowdown from Shutdown	scf/event	12,087	5,142	13,443	2,600
Volumetric flow rate	scf-lbmol	385	385	385	385
Methane Molecular Weight	lb-lbmol	17.17	17.17	17.17	17.17
Shutdown Blowdown	lb/event	539	229	600	116

Gas Composition

Pollutant	Molecular Weight (lb/lb-mol)	Molar (Volume) Fraction (mol%)	Wt. Fraction[1] (wt. %)
Total Stream Molecular Weight	17.17		
Non-VOC			
Carbon Dioxide	44.01	1.041%	**2.67%**
Nitrogen	28.01	0.994%	**1.62%**
Methane	16.04	94.206%	**88.00%**
Ethane	30.07	2.923%	**5.12%**
VOC			
Propane	44.10	0.546%	**1.40%**
n-Butane	58.12	0.084%	**0.28%**
IsoButane	58.12	0.079%	**0.27%**
n-Pentane	72.15	0.022%	**0.09%**
IsoPentane	72.15	0.024%	**0.10%**
n-Hexane	86.18	0.032%	**0.16%**
n-Heptane	100.21	0.049%	**0.29%**
Total VOC Fraction	53.28	**0.836%**	**2.59%**
Total HAP Fraction	86.18	0.032%	**0.16%**

Blowdown from Startup Events

Combustion Sources	Startup Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
Solar Mars 100 Turbine	10	0.022	0.022	0.739	18.5	0.001
Solar Taurus 70 Turbine	10	0.011	0.011	0.370	9.25	6.75E-04
Solar Titan 130 Turbine	10	0.024	0.024	0.801	20.1	0.001
Solar Centaur 50L Turbine	10	0.006	0.007	0.215	5.38	3.92E-04
Total (tons/yr)		**0.063**	**0.064**	**2.13**	**53.2**	**0.004**

Blowdown from Shutdown Events

Combustion Sources	Shutdown Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
Solar Mars 100 Turbine	10	0.070	0.072	2.37	59.4	0.004
Solar Taurus 70 Turbine	10	0.030	0.031	1.01	25.3	0.002
Solar Titan 130 Turbine	10	0.078	0.080	2.64	66.0	0.005
Solar Centaur 50L Turbine	10	0.015	0.015	0.510	12.8	9.31E-04
Total (tons/yr)		**0.192**	**0.198**	**6.53**	**163**	**0.012**

Site-Wide Blowdown Events (April 2018 Update: The gas vented from the site wide blowndown event reflects the amount vented during a capped event for testing of the ESD system.)

Site-Wide Blowdown	280	scf/event
Volumetric flow rate	385	scf-lbmol
Site-Wide Blowdown	12.5	lb/event

Blowdown from Site-Wide Events

Sources	Site-Wide Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
ACP-2	1	1.62E-04	1.67E-04	0.005	0.138	1.00E-05
Total (tons/yr)		**1.62E-04**	**1.67E-04**	**0.005**	**0.138**	**1.00E-05**

Blowdown from Pigging Events (June 2018 Update: Values based on 1200 PSIG [1214.7 PSIA])

Gas Vented Per Launcher Even	1,563	lb/event
Gas Vented Per Receiver Event	1,630	lb/event

Sources	Pigging Events	VOC	GHG Emissions (tpy)			HAPs
			CO2	CH4	CO2e	
Pig Launcher	4	0.081	0.083	2.75	68.9	0.005
Pig Receiver	4	0.085	0.087	2.87	71.8	0.005
Total (tons/yr)		**0.166**	**0.170**	**5.62**	**141**	**0.010**

Total Blowdown Emissions (ton/yr)	**0.421**	**0.433**	**14.3**	**357**	**0.026**
Total Uncontrolled Blowdown Emissions (ton/yr)	**64.1**	**65.9**	**2,174**	**54,412**	**3.97**
Total Blowdown Emission Control Efficiency	**99.3%**	**99.3%**	**99.3%**	**99.3%**	**99.3%**

Table C-3B Potential Uncontrolled Emissions From Blowdowns

ACP Buckingham Compressor Station - Buckingham County, Virginia

Compressor Blowdown Emissions - Uncontrolled

Source Designation:	FUG-01

Blowdown Startup Events (April 2018 Update: Values updated to reflect compressor purge volumes)

		CT-01	CT-02	CT-03	CT-04
Blowdown from Startup	scf/event	3,768	1,884	4,083	1,095
Volumetric flow rate	scf-lbmol	385	385	385	385
Gas Molecular Weight	lb-lbmol	17.17	17.17	17.17	17.17
Startup Blowdown	lb/event	168	84.0	182	48.8

Blowdown Shutdown Events (May 2018 Update: Values updated to reflect blowdown volume, based on blowing down from 1400 PSIG [1414.7 PSIA])

		CT-01	CT-02	CT-03	CT-04
Blowdown from Shutdown	scf/event	382,546	162,739	425,469	82,284
Volumetric flow rate	scf-lbmol	385	385	385	385
Methane Molecular Weight	lb-lbmol	17.17	17.17	17.17	17.17
Shutdown Blowdown	lb/event	17,062	7,258	18,977	3,670

Gas Composition

Pollutant	**Molecular Weight (lb/lb-mol)**	**Molar (Volume) Fraction (mol%)**	**Wt. Fraction[1] (wt. %)**
Total Stream Molecular Weight	17.17		
Non-VOC			
Carbon Dioxide	44.01	1.041%	**2.67%**
Nitrogen	28.01	0.994%	**1.62%**
Methane	16.04	94.206%	**88.00%**
Ethane	30.07	2.923%	**5.12%**
VOC			
Propane	44.10	0.546%	**1.40%**
n-Butane	58.12	0.084%	**0.28%**
IsoButane	58.12	0.079%	**0.27%**
n-Pentane	72.15	0.022%	**0.09%**
IsoPentane	72.15	0.024%	**0.10%**
n-Hexane	86.18	0.032%	**0.16%**
n-Heptane	100.21	0.049%	**0.29%**
Total VOC Fraction	53.28	**0.836%**	**2.59%**
Total HAP Fraction	86.18	0.032%	**0.16%**

Blowdown from Startup Events

Combustion Sources	**Startup Events**	**VOC**	**GHG Emissions (tpy)**			**HAPs**
			CO2	**CH4**	**CO2e**	
Solar Mars 100 Turbine	100	0.218	0.224	7.39	185	0.013
Solar Taurus 70 Turbine	100	0.109	0.112	3.70	92.5	0.007
Solar Titan 130 Turbine	100	0.236	0.243	8.01	201	0.015
Solar Centaur 50L Turbine	100	0.063	0.065	2.15	53.8	0.004
Total (tons/yr)		**0.626**	**0.644**	**21.3**	**532**	**0.039**

Blowdown from Shutdown Events

Combustion Sources	**Shutdown Events**	**VOC**	**GHG Emissions (tpy)**			**HAPs**
			CO2	**CH4**	**CO2e**	
Solar Mars 100 Turbine	100	22.1	22.8	751	18,791	1.37
Solar Taurus 70 Turbine	100	9.41	9.68	319	7,994	0.583
Solar Titan 130 Turbine	100	24.6	25.3	835	20,899	1.52
Solar Centaur 50L Turbine	100	4.76	4.90	161	4,042	0.295
Total (tons/yr)		**60.9**	**62.7**	**2,067**	**51,725**	**3.771**

Site-Wide Blowdown Events (December 2017 Update: Total potential site-wide blowdown event volume updated based detailed design and reflects all equipment and piping at the station pressurized to maximum extent prior to the event. This site wide event occurs once every 5 years.) Values based on blowing down from 1400 PSIG [1414.7 PSIA]

Site-Wide Blowdown	4,100,000	scf/event
Volumetric flow rate	385	scf-lbmol
Site-Wide Blowdown	182,866	lb/event

Blowdown from Site-Wide Events

Sources	**Site-Wide Events**	**VOC**	**GHG Emissions (tpy)**			**HAPs**
			CO2	**CH4**	**CO2e**	
ACP-2	1	2.37	2.44	80.5	2,014	0.147
Total (tons/yr)		**2.37**	**2.44**	**80.5**	**2,014**	**0.147**

Blowdown from Pigging Events (June 2018 Update: Values based on 1200 PSIG [1214.7 PSIA])

Gas Vented Per Launcher Even	1,563	lb/event
Gas Vented Per Receiver Event	1,630	lb/event

Sources	**Pigging Events**	**VOC**	**GHG Emissions (tpy)**			**HAPs**
			CO2	**CH4**	**CO2e**	
Pig Launcher	4	0.081	0.083	2.75	68.9	0.005
Pig Receiver	4	0.085	0.087	2.87	71.8	0.005
Total (tons/yr)		**0.166**	**0.170**	**5.62**	**141**	**0.010**

Total Blowdown Emissions (tons/yr)	**64.1**	**65.9**	**2,174**	**54,412**	**3.97**

Table C-4 Combustion Source Criteria Pollutant Emission Factors
ACP Buckingham Compressor Station - Buckingham County, Virginia

Solar Turbine Normal Operation Emission Factors (lb/hr)																
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**SO2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO2**	**CH4**	**N2O**	**CO2e**	**NH3**	**Total HAP**
Solar Centaur 50L Turbine	Natural Gas	lb/hr	1.99	3.35	0.192	0.206	0.348	0.348	0.348	0.861	7,201	0.520	0.181	7,268	0.818	0.168
Solar Taurus 70 Turbine	Natural Gas	lb/hr	3.09	5.22	0.299	0.320	0.542	0.542	0.542	1.34	11,197	0.810	0.283	11,301	1.32	0.261
Solar Mars 100 Turbine	Natural Gas	lb/hr	4.67	7.91	0.453	0.485	0.821	0.821	0.821	2.03	16,963	1.23	0.428	17,121	1.85	0.395
Solar Titan 130 Turbine	Natural Gas	lb/hr	5.67	9.58	0.549	0.588	0.996	0.996	0.996	2.46	20,549	1.49	0.519	20,741	2.33	0.479

Notes
(1) Pre-Control Emission Rates for NOx, CO, VOC, PMF, PMC, and CO2 taken from Solar Turbine Data at 100% load and 0 degrees F
(2) Emission Factors for SO2, CH4, N2O, and HAP taken from AP-42 in (lbs/MMBtu) and multiplied by turbine fuel throughput by Solar Turbine at 100% load and 0 degree F to get Emission Rates
(3) Assume PMF=PMF-10=PMF-2.5; Filterable and Condensable based on Solar Turbine Emission Factor and ratio of AP-42 Table 3.1 factors
(4) NH3 emission rates based on a 10 ppm ammonia slip from the SCR based on manufacturer information
(5) CO2e emission rate calculated by multiplying each GHG (CO2, CH4, N2O) by its Global Warming Potential (GWP) and adding them together
(6) CO2 GWP = 1; CH4 GWP = 25; N2O GWP = 298 [40 CFR Part 98]

Solar Turbine Alternate Operation Emission Factors (lb/hr)								
			< 0 degrees F			**Solar Turbine Low Load F**		
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**NOx**	**CO**	**VOC**
Solar Centaur 50L Turbine	Natural Gas	lb/hr	9.27	13.4	0.384	15.4	1,340	7.68
Solar Taurus 70 Turbine	Natural Gas	lb/hr	14.4	20.9	0.598	24.0	2,088	12.0
Solar Mars 100 Turbine	Natural Gas	lb/hr	21.8	31.6	0.906	36.4	3,164	18.1
Solar Titan 130 Turbine	Natural Gas	lb/hr	26.5	38.3	1.10	44.1	3,832	22.0

Notes
(1) Pre-Control low temperature Emission Rates for NOx, CO, VOC. Conservatively assume 42 ppm NOx, 100 ppm CO, and 5 ppm VOC (10% of UHC) per Table 1 of Solar PIL 167 dated 6/6/2012
(2) Pre-Control low load Emission Rates for NOx, CO, VOC. Conservatively assume 70 ppm NOx, 10,000 ppm CO, and 100 ppm VOC (10% of UHC) per Table 4 of Solar PIL 167 dated 6/6/2012
(3) Alternate Operation Emission Factor = Normal Operation Emission Factor * (ppm alternate operation) / (ppm normal operation)
Example calculation - Centaur 50L NOx (lb/hr) @ < 0 deg. F = 1.99 lb/hr * (42 ppm / 9 ppm) = 9.27 lb/hr

Solar Turbine Start-up Emission Factors (lb/event)																
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**SO2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO2**	**CH4**	**N2O**	**CO2e**	**NH3**	**Total HAP**
Solar Centaur 50L Turbine	Natural Gas	lb/event	0.3	21	3	0.01	0.009	0.009	0.009	0.021	184	14	0.03	543	0.136	1.2
Solar Taurus 70 Turbine	Natural Gas	lb/event	1	88	18	0.01	0.017	0.017	0.017	0.043	381	70	0.13	2,170	0.220	4.9
Solar Mars 100 Turbine	Natural Gas	lb/event	1	46	4	0.01	0.017	0.017	0.017	0.043	385	16	0.07	806	0.309	2.6
Solar Titan 130 Turbine	Natural Gas	lb/event	1	55	7	0.02	0.032	0.032	0.032	0.078	662	30	0.08	1,436	0.388	3.0

Notes
(1) Start-up Emissions of NOx, CO, VOC, CO2, and CH4 based on Solar Turbines Incorporated Product Information Letter 170: Emission Estimates at Start-up, Shutdown, and Commissioning for SoLoNOx Combustion Products (21 February 2018).
(2) Start-up Emissions of SO2, PM, N2O, and HAP based on Solar estimations.
(3) NH3 emission rates based on a 10 ppm ammonia slip from the SCR based on manufacturer information and a start-up duration of 10 minutes.
(4) CO2e emission rate calculated by multiplying each GHG (CO2, CH4, N2O) by its Global Warming Potential (GWP) and adding them together.
(5) CO2 GWP = 1; CH4 GWP = 25; N2O GWP = 298 [40 CFR Part 98].

Solar Turbine Shutdown Emission Factors (lb/event)																
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**SO2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO2**	**CH4**	**N2O**	**CO2e**	**NH3**	**Total HAP**
Solar Centaur 50L Turbine	Natural Gas	lb/event	1	37	5	0.01	0.014	0.014	0.014	0.036	318	18	0.06	786	0.136	2.0
Solar Taurus 70 Turbine	Natural Gas	lb/event	1	62	8	0.01	0.020	0.020	0.020	0.050	473	32	0.09	1,300	0.220	3.4
Solar Mars 100 Turbine	Natural Gas	lb/event	1	82	5	0.02	0.029	0.029	0.029	0.071	676	21	0.13	1,240	0.309	4.6
Solar Titan 130 Turbine	Natural Gas	lb/event	2	91	9	0.03	0.043	0.043	0.043	0.107	945	37	0.14	1,912	0.388	5.1

Notes
(1) Shut-down Emissions of NOx, CO, VOC, CO2, and CH4 based on Solar Turbines Incorporated Product Information Letter 170: Emission Estimates at Start-up, Shutdown, and Commissioning for SoLoNOx Combustion Products (21 February 2018).
(2) Shut-down Emissions of SO2, PM, N2O, and HAP based on Solar estimations.
(3) NH3 emission rates based on a 10 ppm ammonia slip from the SCR based on manufacturer information and a shut-down duration of 10 minutes.
(4) CO2e emission rate calculated by multiplying each GHG (CO2, CH4, N2O) by its Global Warming Potential (GWP) and adding them together.
(5) CO2 GWP = 1; CH4 GWP = 25; N2O GWP = 298 [40 CFR Part 98].

Engine and Boiler Emission Factors																
Equipment Type	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**SO2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO2**	**CH4**	**N2O**	**CO2e**	**NH3**	**Total HAP**
Hurst S45 Boiler	Natural Gas	lb/MMscf	50	84	5.5	3.33	1.9	1.9	1.9	5.7	120,000	2.3	2.2	120,713	0	1.89
ETI Line Heater	Natural Gas	lb/MMscf	10.2	37.7	5.5	3.33	1.22	1.22	1.22	3.67	120,000	2.3	2.2	120,713	0	1.89
Caterpillar G3516C EGen	Natural Gas	lb/hp-hr	1.10E-03	4.41E-03	1.10E-03	2.25E-05	2.65E-04	2.65E-04	2.65E-04	6.84E-05	0.977	8.82E-03	0	1.20	0	1.21E-03

Notes
(1) Emission factors for Hurst S45 Boiler taken from AP-42 Tables 1.4-1 & 1.4-2
(2) Hurst S45 Boiler assumed to have low-NOx burners
(3) NOx, CO, PMF, PMF-10, PMF-2.5, and PMC emission factors for ETI Line Heater provided by ETI and converted to lb/MMscf using 1020 MMBtu/MMscf
(4) For ETI Line Heater, assumed 75% of PM is PMC and 25% of PM is PMF; based on ratio of PMF and PMC emission factors from AP-42 Table 1.4-2
(5) VOC, SO2, CO2, CH4, and N2O emission factors for ETI Line Heater from AP-42 Table 1.4-2
(6) NOx, CO, VOC, CO2, and CH4 emission factors for Caterpillar EGen taken from Caterpillar manufacturer data
(7) SO2, PMF, PMF-10, PMF-2.5, PMC, and N2O emission factors for Caterpillar EGen taken from AP-42 Table 3.2-1 and converted using Caterpillar manufacturer fuel data
(8) Assume PMF=PMF-10=PMF-2.5
(9) CO2e emission rate calculated by multiplying each GHG (CO2, CH4, N2O) by its Global Warming Potential (GWP) and adding them together
(10) CO2 GWP = 1; CH4 GWP = 25; N2O GWP = 298 [40 CFR 98]
(11) See the "HAP Emissions" worksheet for a more detailed breakdown of HAP emissions
(12) SO2 emission factors for Hurst S45 Boiler, ETI Line Heater, and Caterpillar Egen were scaled up based on the sulfur content of the natural gas.

Controlled Solar Turbine Normal Operation Emission Factors (lb/hr)						
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**Total HAP**
Solar Centaur 50L Turbine	Natural Gas	lb/hr	0.828	0.268	0.096	0.084
Solar Taurus 70 Turbine	Natural Gas	lb/hr	1.29	0.418	0.150	0.131
Solar Mars 100 Turbine	Natural Gas	lb/hr	1.95	0.633	0.227	0.198
Solar Titan 130 Turbine	Natural Gas	lb/hr	2.36	0.766	0.275	0.240

Notes
1. Control efficiency of SCR and Oxidation Catalyst applied during normal operations.

Controlled Solar Turbine Alternate Operation Emission Factors (lb/hr)								
			< 0 degrees F			**Solar Turbine Low Load F Operation**		
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**NOx**	**CO**	**VOC**
Solar Centaur 50L Turbine	Natural Gas	lb/hr	3.86	1.07	0.192	6.44	107	3.84
Solar Taurus 70 Turbine	Natural Gas	lb/hr	6.01	1.67	0.299	10.0	167	5.98
Solar Mars 100 Turbine	Natural Gas	lb/hr	9.09	2.53	0.453	15.1	253	9.06
Solar Titan 130 Turbine	Natural Gas	lb/hr	11.0	3.07	0.549	18.4	307	11.0

Notes
1. Control efficiency of SCR and Oxidation Catalyst applied during low temperature (< 0 deg. F) and low load operations.

Controlled Solar Turbine Start-up Emission Factors						
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**Total HAP**
Solar Centaur 50L Turbine	Natural Gas	lb/event	0.3	21	3	1.2
Solar Taurus 70 Turbine	Natural Gas	lb/event	1	88	18	4.9
Solar Mars 100 Turbine	Natural Gas	lb/event	1	46	4	2.6
Solar Titan 130 Turbine	Natural Gas	lb/event	1	55	7	3.0
Solar Centaur 50L Turbine	Natural Gas	lb/hr	0.990	21.9	3.16	1.27
Solar Taurus 70 Turbine	Natural Gas	lb/hr	2.07	89.4	18.2	5.01
Solar Mars 100 Turbine	Natural Gas	lb/hr	2.62	48.1	4.38	2.76
Solar Titan 130 Turbine	Natural Gas	lb/hr	2.97	57.6	7.46	3.20

Notes
1. Control efficiency of SCR and Oxidation Catalyst not applied during start-up operations.
2. Lb/hr rates based on one start-up event (10 minutes) and 50 minutes of normal (NOx, HAP) or low temperature operation (CO, VOC)

Controlled Solar Turbine Shutdown Emission Factors						
Equipment Name	**Fuel**	**Units**	**NOx**	**CO**	**VOC**	**Total HAP**
Solar Centaur 50L Turbine	Natural Gas	lb/event	1	2.96	2.50	1.00
Solar Taurus 70 Turbine	Natural Gas	lb/event	1	4.96	4.00	1.70
Solar Mars 100 Turbine	Natural Gas	lb/event	1	6.56	2.50	2.30
Solar Titan 130 Turbine	Natural Gas	lb/event	2	7.28	4.50	2.55
Solar Centaur 50L Turbine	Natural Gas	lb/hr	1.69	3.85	2.66	1.07
Solar Taurus 70 Turbine	Natural Gas	lb/hr	2.07	6.35	4.25	1.81
Solar Mars 100 Turbine	Natural Gas	lb/hr	2.62	8.67	2.88	2.46
Solar Titan 130 Turbine	Natural Gas	lb/hr	3.97	9.83	4.96	2.75

Notes
1. Control efficiency of SCR not applied during shutdown operations.
2. Control efficiency of Oxidation Catalyst applied during shutdown operations.
3. Lb/hr rates based on one shutdown event (10 minutes) and 50 minutes of normal (NOx, HAP) or low temperature operation (CO, VOC)

Table C-5 Hazardous Air Pollutant (HAP) Emissions From Combustion Sources

ACP Buckingham Compressor Station - Buckingham County, Virginia

		Annual HAP Emissions (lb/yr)						
Quantity @ ACP-2		**1**	**1**	**1**	**1**	**1**	**4**	**1**
Pollutant	**HAP?**	**Solar Centaur 50L Turbine**	**Solar Titan 130 Turbine**	**Solar Taurus 70 Turbine**	**Solar Mars 100 Turbine**	**Hurst S45 Boiler**	**ETI Line Heater**	**Caterpillar G3516C Egen**
		6,276	**20,500**	**11,107**	**15,900**	**6.384**	**21.22**	**2,175**
		hp	**hp**	**hp**	**hp**	**MMBTU/hr**	**MMBTU/hr**	**bhp**
		54.98	**157.2**	**85.62**	**129.64**			
		MMBtu/hr	**MMBtu/hr**	**MMBtu/hr**	**MMBtu/hr**			
1,1,2,2-Tetrachloroethane	Yes							0.183
1,1,2-Trichloroethane	Yes							0.146
1,1-Dichloroethane	Yes							0.108
1,2,3-Trimethylbenzene	No							0.098
1,2,4-Trimethylbenzene	No							0.307
1,2-Dichloroethane	Yes							0.117
1,2-Dichloropropane	Yes							0.123
1,3,5-Trimethylbenzene	No							0.050
1,3-Butadiene	Yes							2.269
1,3-Dichloropropene	Yes							0.121
2,2,4-Trimethylpentane	Yes							2.341
2-Methylnaphthalene	No					0.001	0.004	0.059
3-Methylchloranthrene	No					0.000	0.000	
7,12-Dimethylbenz(a)anthracene	No					0.001	0.003	
Acenaphthene	No					0.000	0.000	0.004
Acenaphthylene	No					0.000	0.000	0.009
Acetaldehyde	Yes							21.472
Acrolein	Yes							21.527
Anthracene	No					0.000	0.000	0.002
Benz(a)anthracene	No					0.000	0.000	0.001
Benzene	Yes					0.115	0.383	5.368
Benzo(a)pyrene	No					0.000	0.000	0.000
Benzo(b)fluoranthene	No					0.000	0.000	0.000
Benzo(e)pyrene	No							0.000
Benzo(g,h,i)perylene	No					0.000	0.000	0.000
Benzo(k)fluoranthene	No					0.000	0.000	0.000
Biphenyl	Yes							0.011
Butane	No					115.137	382.709	13.143
Butyr/Isobutyraldehyde	No							1.209
Carbon Tetrachloride	Yes							0.168
Chlorobenzene	Yes							0.123
Chloroethane	Yes							
Chloroform	Yes							0.130
Chrysene	No					0.000	0.000	0.002
Cyclohexane	No							0.852
Cyclopentane	No							0.262
Dibenzo(a,h)anthracene	No					0.000	0.000	
Dichlorobenzene	Yes					0.066	0.219	
Ethane	No					169.965	564.951	196.180
Ethylbenzene	Yes							0.299
Ethylene Dibromide	Yes							0.203
Fluoranthene	No					0.000	0.001	0.001
Fluorene	No					0.000	0.001	0.005
Formaldehyde	Yes	693.540	1,982.984	1,080.045	1,635.331	4.112	13.668	1,246.715
Hexane (or n-Hexane)	Yes					98.689	328.036	1.231
Indeno(1,2,3-c,d)pyrene	No					0.000	0.000	0.000
Isobutane	No							10.376

Table C-5 Hazardous Air Pollutant (HAP) Emissions From Combustion Sources

ACP Buckingham Compressor Station - Buckingham County, Virginia

		Annual HAP Emissions (lb/yr)						
Quantity @ ACP-2		**1**	**1**	**1**	**1**	**1**	**4**	**1**
Pollutant	**HAP?**	**Solar Centaur 50L Turbine**	**Solar Titan 130 Turbine**	**Solar Taurus 70 Turbine**	**Solar Mars 100 Turbine**	**Hurst S45 Boiler**	**ETI Line Heater**	**Caterpillar G3516C Egen**
		6,276	**20,500**	**11,107**	**15,900**	**6.384**	**21.22**	**2,175**
		hp	**hp**	**hp**	**hp**	**MMBTU/hr**	**MMBTU/hr**	**bhp**
Methanol	Yes							6.862
Methylcyclohexane	No							0.935
Methylene Chloride	Yes							0.407
n-Nonane	No							0.085
n-Octane	No							0.206
Naphthalene	Yes					0.033	0.111	0.266
PAH	Yes							0.371
Pentane (or n-Pentane)	No					142.551	473.830	4.234
Perylene	No							0.000
Phenanthrene	No					0.001	0.003	0.010
Phenol	Yes							0.116
Propane	No					87.724	291.588	79.413
Propylene Oxide	Yes							
Pyrene	No					0.000	0.001	0.002
Styrene	Yes							0.152
Tetrachloroethane	No							
Toluene	Yes					0.186	0.620	2.665
Vinyl Chloride	Yes							0.068
Xylene	Yes							0.742
Arsenic	Yes					0.011	0.036	
Barium	No					0.241	0.802	
Beryllium	Yes					0.001	0.002	
Cadmium	Yes					0.060	0.200	
Chromium	Yes					0.077	0.255	
Cobalt	Yes					0.005	0.015	
Copper	No					0.047	0.155	
Manganese	Yes					0.021	0.069	
Mercury	Yes					0.014	0.047	
Molybdenum	No					0.060	0.200	
Nickel	Yes					0.115	0.383	
Selenium	Yes					0.001	0.004	
Vanadium	No					0.126	0.419	
Zinc	No					1.590	5.285	
Lead	Yes					0.027	0.091	
Total HAPs		734.478	2,100.035	1,143.798	1,731.861			1,314.305
Total HAP/unit (lb/yr)		**734**	**2,100**	**1,144**	**1,732**	**104**	**344**	**1,314**
Total HAP/unit (TPY)		**0.367**	**1.05**	**0.572**	**0.866**	**0.052**	**0.172**	**0.657**

Hazardous Air Pollutant

Notes:
(1) Emissions above are on a per unit basis
(2) Calculations for the Caterpillar G3516C Egen assume 500 hours of operation; all other calculations assume 8,760 hours of operation
(3) Heat rates for Solar Turbines taken from Solar Datasheets
(4) Solar turbines have a 50% HAP control efficiency due to the Oxidation Catalyst

Table C-6 Combustion Source HAP Emission Factors

ACP Buckingham Compressor Station - Buckingham County, Virginia

Pollutant	HAP?	Solar Centaur 50L Turbine	Solar Titan 130 Turbine	Solar Taurus 70 Turbine	Solar Mars 100 Turbine	Hurst S45 Boiler; ETI Line Heater	Caterpillar G3516C Egen
		lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMscf	lb/hp-hr
1,1,2,2-Tetrachloroethane	Yes						1.69E-07
1,1,2-Trichloroethane	Yes						1.34E-07
1,1-Dichloroethane	Yes						9.95E-08
1,2,3-Trimethylbenzene	No						9.01E-08
1,2,4-Trimethylbenzene	No						2.82E-07
1,2-Dichloroethane	Yes						1.07E-07
1,2-Dichloropropane	Yes						1.13E-07
1,3,5-Trimethylbenzene	No						4.58E-08
1,3-Butadiene	Yes						2.09E-06
1,3-Dichloropropene	Yes						1.11E-07
2,2,4-Trimethylpentane	Yes						2.15E-06
2-Methylnaphthalene	No					2.40E-05	5.44E-08
3-Methylchloranthrene	No					1.80E-06	
7,12-Dimethylbenz(a)anthracene	No					1.60E-05	
Acenaphthene	No					1.80E-06	3.38E-09
Acenaphthylene	No					1.80E-06	8.07E-09
Acetaldehyde	Yes						1.97E-05
Acrolein	Yes						1.98E-05
Anthracene	No					2.40E-06	1.83E-09
Benz(a)anthracene	No					1.80E-06	8.55E-10
Benzene	Yes					2.10E-03	4.94E-06
Benzo(a)pyrene	No					1.20E-06	1.45E-11
Benzo(b)fluoranthene	No					1.80E-06	2.17E-11
Benzo(e)pyrene	No						5.95E-11
Benzo(g,h,i)perylene	No					1.20E-06	6.31E-11
Benzo(k)fluoranthene	No					1.80E-06	1.08E-11
Biphenyl	Yes						1.01E-08
Butane	No					2.10E+00	1.21E-05
Butyr/Isobutyraldehyde	No						1.11E-06
Carbon Tetrachloride	Yes						1.54E-07
Chlorobenzene	Yes						1.13E-07
Chloroethane	Yes						
Chloroform	Yes						1.20E-07
Chrysene	No					1.80E-06	1.71E-09
Cyclohexane	No						7.84E-07
Cyclopentane	No						2.41E-07
Dibenzo(a,h)anthracene	No					1.20E-06	
Dichlorobenzene	Yes					1.20E-03	
Ethane	No					3.10E+00	1.80E-04
Ethylbenzene	Yes						2.75E-07
Ethylene Dibromide	Yes						1.87E-07
Fluoranthene	No					3.00E-06	9.19E-10
Fluorene	No					2.80E-06	4.30E-09
Formaldehyde	Yes	2.88E-03	2.88E-03	2.88E-03	2.88E-03	7.50E-02	1.15E-03
Hexane (or n-Hexane)	Yes					1.80E+00	1.13E-06
Indeno(1,2,3-c,d)pyrene	No					1.80E-06	2.53E-11
Isobutane	No						9.54E-06

Table C-6 Combustion Source HAP Emission Factors

ACP Buckingham Compressor Station - Buckingham County, Virginia

Pollutant	HAP?	Solar Centaur 50L Turbine	Solar Titan 130 Turbine	Solar Taurus 70 Turbine	Solar Mars 100 Turbine	Hurst S45 Boiler; ETI Line Heater	Caterpillar G3516C Egen
		lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMBtu	lb/MMscf	lb/hp-hr
Methanol	Yes						6.31E-06
Methylcyclohexane	No						8.60E-07
Methylene Chloride	Yes						3.74E-07
n-Nonane	No						7.84E-08
n-Octane	No						1.89E-07
Naphthalene	Yes					6.10E-04	2.45E-07
PAH	Yes						3.41E-07
Pentane (or n-Pentane)	No					2.60E+00	3.89E-06
Perylene	No						1.26E-11
Phenanthrene	No					1.70E-05	8.98E-09
Phenol	Yes						1.07E-07
Propane	No					1.60E+00	7.30E-05
Propylene Oxide	Yes						
Pyrene	No					5.00E-06	1.49E-09
Styrene	Yes						1.39E-07
Tetrachloroethane	No						
Toluene	Yes					3.40E-03	2.45E-06
Vinyl Chloride+A32	Yes						6.28E-08
Xylene	Yes						6.82E-07
Arsenic	Yes					2.00E-04	
Barium	No					4.40E-03	
Beryllium	Yes					1.20E-05	
Cadmium	Yes					1.10E-03	
Chromium	Yes					1.40E-03	
Cobalt	Yes					8.40E-05	
Copper	No					8.50E-04	
Manganese	Yes					3.80E-04	
Mercury	Yes					2.60E-04	
Molybdenum	No					1.10E-03	
Nickel	Yes					2.10E-03	
Selenium	Yes					2.40E-05	
Vanadium	No					2.30E-03	
Zinc	No					2.90E-02	
Lead	Yes					5.00E-04	
Total Haps		3.05E-03	3.05E-03	3.05E-03	3.05E-03	1.89E+00	1.21E-03

Hazardous Air Pollutant

Notes:

(1) Emission factors for Solar turbines from Solar PIL 168 Revision 4 (dated 14 May 2012)

(2) Emission factors for Hurst S45 Boiler and ETI Line Heater from AP-42 Tables 1.4-2, 1.4-3, and 1.4-4

(3) Emission factors for Caterpillar G3516C Egen from AP-42 Table 3.2-1; formaldehyde emission factor from Caterpillar manufacturer data

(4) Emission factors for Solar natural gas turbines and Caterpillar natural gas emergency generators converted using 1 KWh = 3412 Btu and 1 kw = 1.341 hp

Table C-7 Potential Emissions From Fugitive Leaks
ACP Buckingham Compressor Station - Buckingham County, Virginia

Fugitive Emissions (FUG)

Source Designation:	FUG-02

Operational Parameters:

Annual Hours of Operation (hr/yr):	8,760

Pipeline Natural Gas Fugitive Emissions

Equipment	Service	Emission Factor[1]	Source Count[2]	Total HC Potential Emissions		VOC Weight Fraction	VOC Emissions	CO_2 Weight Fraction	CO_2 Emissions	CH_4 Weight Fraction	CH_4 Emissions	HAP Weight Fraction	HAP Emissions
		kg/hr/source		lb/hr	tpy		tpy		tpy		tpy		tpy
Valves	Gas	4.50E-03	755	7.49	32.8	0.026	0.851	0.027	0.875	0.880	28.9	1.61E-03	0.053
Pump Seals	Gas	2.40E-03		0.000	0.000	0.026	0.000	0.027	0.000	0.880	0.000	1.61E-03	0.000
Others (compressors and others)	Gas	8.80E-03	4	0.078	0.340	0.026	0.009	0.027	0.009	0.880	0.299	1.61E-03	5.46E-04
Connectors	Gas	2.00E-04	4	0.002	0.008	0.026	2.00E-04	0.027	2.06E-04	0.880	0.007	1.61E-03	1.24E-05
Flanges	Gas	3.90E-04	509	0.438	1.92	0.026	0.050	0.027	0.051	0.880	1.69	1.61E-03	0.003
Open-ended lines	Gas	2.00E-03		0.000	0.000	0.026	0.000	0.027	0.000	0.880	0.000	1.61E-03	0.000
			Total	8.01	35.1	-	0.910	-	0.936	-	30.9	-	0.056

1. EPA Protocol for Equipment Leaks Emissions Estimate (EPA-453/R-95-017) Table 2-4: Oil and Gas Production Operations Emission Factors.
2. Component count based on Basic Systems Engineering Estimate.
3. Source count for fugitive emissions includes equipment from ACP-2 and the Woods Corner M&R station.

Equations:

Potential Emissions (lb/hr) = Emission Factor (kg/hr/source) * Source Count * (2.20462 lb/1 kg)

Potential Emissions (tons/yr) = $(lb/hr)_{Potential}$ × Hours of Operation (hr/yr) × (1 ton/2,000 lb)

Gas Composition

Pollutant	Molecular Weight (lb/lb-mol)	Molar (Volume) Fraction (mol %)	Weight Fraction (wt %)
Total Stream Molecular Weight	17.17		
Non-VOC			
Carbon Dioxide	44.01	1.041%	**2.67%**
Nitrogen	28.01	0.994%	1.62%
Methane	16.04	94.21%	**88.00%**
Ethane	30.07	2.923%	5.12%
VOC			
Propane	44.10	0.546%	1.40%
n-Butane	58.12	0.084%	0.28%
IsoButane	58.12	0.079%	0.27%
n-Pentane	72.15	0.022%	0.09%
IsoPentane	72.15	0.024%	0.10%
n-Hexane	86.18	0.032%	0.16%
n-Heptane	100.21	0.049%	0.29%
Total VOC Fraction			**2.59%**
Total HAP Fraction			**0.16%**

Gas speciation based on a natural gas hydrocarbon composition
from Engineering Technology Incorporated Combustion Analysis.

Table C-8A Tank Emissions

ACP Buckingham Compressor Station - Buckingham County, Virginia

Source Designation:	TK-1, TK-2, TK-3

Tank Parameters

Source	Type of Tank	Contents	Capacity (gal)	Throughput gal/yr	Tank Diam. ft	Tank Length ft	Paint Color	Paint Condition
TK-1	Horizontal, fixed	Lube Oil	2,500	12,500	5.33	15.0	Light Grey	Good
TK-2	Horizontal, fixed	Produced Fluids	1,000	5,000	4.00	9.83	Light Grey	Good

Total Emissions

Source	VOC Emissions								GHG Emissions			
	Flashing Losses		Working Losses		Breathing Losses		Total Losses		CO2		CH4	
	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy	lb/hr	tpy
TK-1[1]	NA	NA	9.70E-07	4.25E-06	4.00E-06	1.75E-05	4.97E-06	2.18E-05	0	0	0	0
TK-2[2]	NA	NA					0.033	0.144	0.002	0.009	0.004	0.017

1. Losses were calculated for TK-1 using EPA's TANKS 4.09d software with default breather vent settings.
2. Losses were calculated for TK-2 using E&P Tanks Software. See attached for output.
3. Losses (Emissions) from TK-3 13,400-gallon Ammonia tank assumed to be insignificant.

Table C-8B Tank Unloading Emissions
ACP Buckingham Compressor Station - Buckingham County, Virginia

Source Designation:	LR-1, LR-2

Chemical Parameters

Chemical	Vapor Mol. Weight [1] (lb/lb-mol)	Avg. Vapor Pressure [1] (psia)	Avg. Temperature [2] (deg. R)	Saturation Factor [3]	Throughput [4]
					Mgal/yr
Waste Oil	380	0.0001	519.67	0.6	12.5
Pipeline Liquids	65.06	7.7	519.67	0.6	0.500

References:

1. Vapor molecular weight and vapor pressure based on EPA Tanks output for TK-1 and E&P output for TK-2.
2. Based on average ambient temperature data for the area.
3. Saturation Factor based on "Submerged Loading: dedicated normal service" in Table 5.2-1 of AP-42, Ch. 5.2.
4. Throughput based upon expected percent of hydrocarbons. The pipeline liquids tank contains water, with potential for trace oil, estimated at 10% oil max.

Total Potential Emissions

Source	Total Loading Losses[1]		Pump Capacity [2]	Max Hourly Losses[3]
	Average	Annual		
	(lbs/Mgal)	(tpy)	(gal/min)	lb/hr
Waste Oil Truck Loading	5.47E-04	3.42E-06	90	0.001
Pipeline Liquids Truck Loading	7.21	0.002	90	0.720

References:

1. AP-42, Ch. 5.2, Equation 1 (Loading Loss = 12.46 x (Saturation Factor x TVP x Molecular Weight) / Temp.)
2. Assumed pump rate.
3. Emissions based upon expected percent of hydrocarbons in throughput liquid. The pipeline liquids tank contains water with potential for trace oil, estimated at 10% oil max.

Speciated Potential Emissions

Source	Contents	VOC Weight Fraction[1] (%)	HAP Weight Fraction[1] (%)	Total VOC Emissions		Total HAP Emissions		CO2/VOC Ratio	CH4/VOC Ratio	Total CO2 Emissions		Total CH4 Emissions	
				lb/hr	tpy	lb/hr	tpy			lb/hr	tpy	lb/hr	tpy
Waste Oil Truck Loading	Waste Oil	100%	100%	0.001	3.42E-06	0.001	3.42E-06	---	---	0	0	0	0
Pipeline Liquids Truck Loading	Pipeline Liquids	100%	6.94%	0.720	0.002	0.050	1.25E-04	6.25%	11.8%	0.045	1.13E-04	0.085	2.13E-04

References:

1. VOC and HAP weight fractions are based on TK-1 and TK-2 tank emissions speciation. Assumed 100% HAP for TK-1 to be conservative.
2. CO2/VOC and CH4/VOC Ratios based on TK-1 tank emissions.

Table C-9 Project Potential Emissions

ACP Buckingham Compressor Station - Buckingham County, Virginia

Source	ID	Criteria Pollutants (tpy)								GHG Emissions (tpy)				Ammonia (tpy)	HAP (tpy)
		NOx	**CO**	**VOC**	**SO2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO2**	**CH4**	**N2O**	**CO2e**	**NH3**	**Total HAP**
Solar Mars 100 Turbine	CT-01	8.62	5.39	1.31	2.12	3.58	3.58	3.58	8.87	74,068	7.20	1.88	74,808	8.12	1.11
Solar Taurus 70 Turbine	CT-02	5.73	6.47	1.75	1.40	2.37	2.37	2.37	5.86	48,899	8.63	1.24	49,485	5.77	0.900
Solar Titan 130 Turbine	CT-03	10.5	6.46	1.77	2.57	4.35	4.35	4.35	10.8	89,742	9.84	2.27	90,666	10.2	1.32
Solar Centaur 50L Turbine	CT-04	3.68	2.37	0.694	0.898	1.52	1.52	1.52	3.76	31,445	3.87	0.796	31,779	3.58	0.476
Hurst S45 Boiler	WH-01	1.37	2.30	0.151	0.091	0.052	0.052	0.052	0.156	3,290	0.063	0.060	3,309	0	0.052
ETI Line Heater 1 (Woods Corner)	LH-01	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 2 (Woods Corner)	LH-02	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 3 (Woods Corner)	LH-03	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
ETI Line Heater 4 (Woods Corner)	LH-04	0.929	3.44	0.501	0.304	0.112	0.112	0.112	0.335	10,935	0.210	0.200	11,000	0	0.172
Caterpillar G3516C EGen (Woods Corner)	EG-01	0.599	2.40	0.599	0.012	0.144	0.144	0.144	0.037	531	4.80	0	651	0	0.657
Fugitive Leaks - Blowdowns	FUG-01	-	-	0.421	-	-	-	-	-	0.433	14.3	-	357	-	0.026
Fugitive Leaks - Piping	FUG-02	-	-	0.910	-	-	-	-	-	0.936	30.9	-	772	-	0.056
Accumulator (Waste Oil) Tank	TK-1	-	-	2.52E-05	-	-	-	-	-	-	-	-	-	-	2.52E-05
Pipeline Fluids Tank	TK-2	-	-	0.146	-	-	-	-	-	0.009	0.017	-	0.439	-	0.010
Total (tons/yr)		**34.2**	**39.2**	**9.77**	**8.30**	**12.5**	**12.5**	**12.5**	**30.8**	**291,715**	**80.4**	**7.05**	**295,827**	**27.7**	**5.30**

Source	ID	Criteria Pollutants (lb/hr)								GHG Emissions (lb/hr)				Ammonia (lb/hr)	HAP (lb/hr)
		NOx	**CO**	**VOC**	**SO2**	**PMF**	**PMF-10**	**PMF-2.5**	**PMC**	**CO2**	**CH4**	**N2O**	**CO2e**	**NH3**	**Total HAP**
Solar Mars 100 Turbine	CT-01	9.09	48.1	4.38	0.485	0.821	0.821	0.821	2.03	16,963	22.0	0.487	17,121	1.85	4.93
Solar Taurus 70 Turbine	CT-02	6.01	89.4	18.2	0.320	0.542	0.542	0.542	1.34	11,197	70.7	0.365	11,588	1.32	5.12
Solar Titan 130 Turbine	CT-03	11.2	57.6	7.46	0.588	0.996	0.996	0.996	2.46	20,549	38.2	0.572	20,741	2.33	5.50
Solar Centaur 50L Turbine	CT-04	4.22	21.9	3.16	0.206	0.348	0.348	0.348	0.861	7,201	18.4	0.211	7,268	0.818	2.14
Hurst S45 Boiler	WH-01	0.313	0.526	0.034	0.021	0.012	0.012	0.012	0.036	751	0.014	0.014	756	0	0.012
ETI Line Heater 1 (Woods Corner)	LH-01	0.212	0.785	0.114	0.069	0.025	0.025	0.025	0.076	2,496	0.048	0.046	2,511	0	0.039
ETI Line Heater 2 (Woods Corner)	LH-02	0.212	0.785	0.114	0.069	0.025	0.025	0.025	0.076	2,496	0.048	0.046	2,511	0	0.039
ETI Line Heater 3 (Woods Corner)	LH-03	0.212	0.785	0.114	0.069	0.025	0.025	0.025	0.076	2,496	0.048	0.046	2,511	0	0.039
ETI Line Heater 4 (Woods Corner)	LH-04	0.212	0.785	0.114	0.069	0.025	0.025	0.025	0.076	2,496	0.048	0.046	2,511	0	0.039
Caterpillar G3516C EGen (Woods Corner)	EG-01	2.40	9.59	2.40	0.049	0.577	0.577	0.577	0.149	2,124	19.2	0	2,604	0	2.63
Fugitive Leaks - Blowdowns	FUG-01	-	-	82.8	-	-	-	-	-	85.2	2,810	-	70,330	-	5.13
Fugitive Leaks - Piping	FUG-02	-	-	0.208	-	-	-	-	-	0.214	7.05	-	176	-	0.013
Accumulator Tank	TK-1	-	-	0.001	-	-	-	-	-	-	-	-	-	-	0.001
Hydrocarbon (Waste Oil) Tank	TK-2	-	-	0.753	-	-	-	-	-	0.045	0.085	-	2.17	-	0.052
Total (lb/hr) [1]		**34.1**	**230**	**120**	**1.95**	**3.40**	**3.40**	**3.40**	**7.19**	**68,857**	**2,986**	**1.83**	**140,630**	**6.32**	**25.7**

1. Total hourly emission rates represent a worst case value for the purposes of the permit application and do not represent total hourly emissions under normal operation.

Table C-10 Toxic Air Pollutant (TAP) Emissions from Sources Subject to Rule 6-5

ACP Buckingham Compressor Station - Buckingham County, Virginia

Pollutant	CAS No.	TLV (mg/m³)[1]			Exemption Threshold (ET)[1]	
					Hourly	Annual
		TWA	STEL	CEIL	lb/hr	ton/yr
1,3-Butadiene	106990	22	-	-	1.452	3.19
2,2,4-Trimethylpentane	540841	350	-	-	22.8	50.75
Acetaldehyde	75070	180	270	-	8.91	26.1
Acrolein	107028	0.23	0.69	-	0.02277	0.03335
Benzene	71432	32	-	-	2.112	4.64
Ethylbenzene	100414	434	543	-	17.919	62.93
Formaldehyde	50000	1.2	2.5	-	0.0825	0.174
Hexane	110543	176	-	-	11.616	25.52
Naphthalene	91203	52	79	-	2.607	7.54
PAH[2]	---	52	79	-	2.607	7.54
Propylene Oxide	75569	48	-	-	3.168	6.96
Toluene	108883	377	565	-	18.645	54.665
Xylenes	1330207	434	651	-	21.483	62.93

Potential Hourly Emissions (lb/hr)[3]														
Pollutant	CT-01	CT-02	CT-03	CT-04	Stn. Suctn. 1	Stn. Suctn. 2	Stn. Dischrg. 1	Stn. Dischrg. 2	Launcher	Receiver	TK-1	TK-2	Total	ET
1,3-Butadiene	2.94E-04	4.22E-04	2.31E-04	1.45E-04	---	---	---	---	---	---	---	---	0.001	1.452
2,2,4-Trimethylpentane	---	---	---	---	---	---	---	---	---	---	0.001	0.000	0.001	22.8
Acetaldehyde	0.027	0.039	0.022	0.014	---	---	---	---	---	---	---	---	0.102	8.91
Acrolein	0.004	0.006	0.003	0.002	---	---	---	---	---	---	---	---	0.016	0.02277
Benzene	0.008	0.012	0.006	0.004	---	---	---	---	---	---	0.001	0.000	0.032	2.112
Ethylbenzene	0.022	0.031	0.017	0.011	---	---	---	---	---	---	0.001	0.000	0.083	17.919
Formaldehyde	2.56	4.70	3.09	1.17	---	---	---	---	---	---	---	---	11.5	0.0825
Hexane[4]	0.003	0.003	0.003	0.003	---	---	---	---	---	2.62	0.001	0.002	2.63	11.616
Naphthalene	8.90E-04	0.001	7.00E-04	4.39E-04	---	---	---	---	---	---	---	---	0.003	2.607
PAH	0.002	0.002	0.001	7.44E-04	---	---	---	---	---	---	---	---	0.006	2.607
Propylene Oxide	0.020	0.028	0.016	0.010	---	---	---	---	---	---	---	---	0.074	3.168
Toluene	0.089	0.128	0.070	0.044	---	---	---	---	---	---	0.001	0.000	0.332	18.645
Xylenes	0.044	0.063	0.034	0.022	---	---	---	---	---	---	0.001	0.000	0.164	21.483

Potential Annual Emissions (ton/yr)[3]														
Pollutant	CT-01	CT-02	CT-03	CT-04	Stn. Suctn. 1	Stn. Suctn. 2	Stn. Dischrg. 1	Stn. Dischrg. 2	Launcher	Receiver	TK-1	TK-2	Total	ET
1,3-Butadiene	1.45E-04	1.07E-04	1.64E-04	6.17E-05	---	---	---	---	---	---	---	---	4.79E-04	3.19
2,2,4-Trimethylpentane	---	---	---	---	---	---	---	---	---	---	2.52E-05	0.000	2.52E-05	50.75
Acetaldehyde	0.014	0.010	0.015	0.006	---	---	---	---	---	---	---	---	0.045	26.1
Acrolein	0.002	0.002	0.002	9.19E-04	---	---	---	---	---	---	---	---	0.007	0.03335
Benzene	0.004	0.003	0.005	0.002	---	---	---	---	---	---	2.52E-05	0.000	0.013	4.64
Ethylbenzene	0.011	0.008	0.012	0.005	---	---	---	---	---	---	2.52E-05	0.000	0.036	62.93
Formaldehyde	1.04	0.848	1.25	0.448	---	---	---	---	---	---	---	---	3.59	0.174
Hexane[4]	0.020	0.017	0.020	0.015	1.91E-06	1.91E-06	1.55E-06	1.55E-06	0.005	0.005	2.52E-05	0.010	0.092	25.52
Naphthalene	4.39E-04	3.25E-04	4.97E-04	1.87E-04	---	---	---	---	---	---	---	---	0.001	7.54
PAH	7.44E-04	5.50E-04	8.41E-04	3.16E-04	---	---	---	---	---	---	---	---	0.002	7.54
Propylene Oxide	0.010	0.007	0.011	0.004	---	---	---	---	---	---	---	---	0.032	6.96
Toluene	0.044	0.032	0.050	0.019	---	---	---	---	---	---	2.52E-05	0.000	0.145	54.665
Xylenes	0.022	0.016	0.024	0.009	---	---	---	---	---	---	2.52E-05	0.000	0.071	62.93

Table C-10 Toxic Air Pollutant (TAP) Emissions from Sources Subject to Rule 6-5

ACP Buckingham Compressor Station - Buckingham County, Virginia

Emissions Modeling Summary							
Unit/Stack ID	**Formaldehyde**		**Hexane**				
			Normal	**Startup**	**Shutdown**	**Pig Launching**	**Pig Receiving**
	lb/hr	**ton/yr**	**lb/hr**	**lb/hr**	**lb/hr**	**lb/hr**	**lb/hr**
CT-01	2.56	1.04	---	---	---	---	---
CT-02	4.70	0.848	---	---	---	---	---
CT-03	3.09	1.25	---	---	---	---	---
CT-04	1.17	0.448	---	---	---	---	---
CT Bldg. A[5]	---	---	0.006	0.006	0.006	0.006	0.006
CT Bldg. B[5]	---	---	0.006	0.006	0.006	0.006	0.006
CT-01 Vent	---	---	---	0.270	0.866	---	---
CT-02 Vent	---	---	---	0.135	0.368	---	---
CT-03 Vent	---	---	---	0.292	0.963	---	---
CT-04 Vent	---	---	---	0.078	0.186	---	---
Launcher	---	---	---	---	---	2.51	---
Receiver	---	---	---	---	---	---	2.62
WH-01	4.69E-04	0.002	0.011	0.011	0.011	0.011	0.011
LH-01	0.002	0.007	0.037	0.037	0.037	0.037	0.037
LH-02	0.002	0.007	0.037	0.037	0.037	0.037	0.037
LH-03	0.002	0.007	0.037	0.037	0.037	0.037	0.037
LH-04	0.002	0.007	0.037	0.037	0.037	0.037	0.037
EG-01	2.49	0.623	0.002	0.002	0.002	0.002	0.002
TK-1	---	---	0.001	0.001	0.001	0.001	0.001
TK-2	---	---	0.002	0.002	0.002	0.002	0.002
TOTAL	***14.0***	***4.24***	***0.180***	***0.956***	***2.56***	***2.69***	***2.80***

Key:

Potential Emissions Exceed Exemption Threshold

Notes:

1. TLV and ET values from "Toxics_Spreadsheet.xlsx", downloaded from the Virginia DEQ - Air Toxics website.
2. PAH not listed in Virginia DEQ toxics spreadsheet; to be conservative, assumed the same TLV and ET values as naphthalene.
3. Calculated as follows:
    CT-01 through CT-04; Stn. Suctn. 1 and 2; Stn. Dischrg. 1 and 2; Launcher and Receiver: From Tables C-11 and C-12.
    TK-1: From E&P Tanks.
    TK-2: HAP composition unknown; assumed 100% of VOC emissions for each HAP commonly emitted from hydrocarbon tanks.
4. Turbine hourly rates are from fugitive emissions. Maximum event emissions occur during pig receiving events. Startup, shutdown, sitewide, launching, and receiving events would not coincide in the same hour. For TK-1, assumed all loading rack HAP emissions are hexane.
5. Each compressor building houses two turbines. Fugitive emissions are emitted from building vents instead of the turbine combustion exhaust.

Table C-11 Toxic Air Pollutant (TAP) Emissions from Combustion Turbines - Combustion
ACP Buckingham Compressor Station - Buckingham County, Virginia

Hourly Emissions - Normal Operations						
Pollutant	CAS No.	Emission Factor (lb/MMBtu)[1]	Emission Rates (lb/hr)[2,3]			
			CT-01	CT-02	CT-03	CT-04
			129.64 MMBtu/hr	85.62 MMBtu/hr	157.2 MMBtu/hr	54.98 MMBtu/hr
1,3-Butadiene	106990	4.30E-07	2.79E-05	1.84E-05	3.38E-05	1.18E-05
Acetaldehyde	75070	4.00E-05	0.003	0.002	0.003	0.001
Acrolein	107028	6.40E-06	4.15E-04	2.74E-04	5.03E-04	1.76E-04
Benzene	71432	1.20E-05	7.78E-04	5.14E-04	9.43E-04	3.30E-04
Ethylbenzene	100414	3.20E-05	0.002	0.001	0.003	8.80E-04
Formaldehyde	50000	2.88E-03	0.187	0.123	0.226	0.079
Naphthalene	91203	1.30E-06	8.43E-05	5.57E-05	1.02E-04	3.57E-05
PAH	---	2.20E-06	1.43E-04	9.42E-05	1.73E-04	6.05E-05
Propylene Oxide	75569	2.90E-05	0.002	0.001	0.002	7.97E-04
Toluene	108883	1.30E-04	0.008	0.006	0.010	0.004
Xylenes	1330207	6.40E-05	0.004	0.003	0.005	0.002

Event Emissions - Startup						
Pollutant	CAS No.		Emission Rates (lb/event)[4]			
			CT-01	CT-02	CT-03	CT-04
Total HAP	---		2.6	4.9	3.0	1.2
Formaldehyde	50000		2.4	4.6	2.9	1.1
Non-Formaldehyde HAP	---		0.2	0.3	0.1	0.1

Event Emissions - Startup						
Pollutant	CAS No.	Non-Formaldehyde HAP Composition[5]	Emission Rates (lb/event)[6]			
			CT-01	CT-02	CT-03	CT-04
1,3-Butadiene	106990	0.136%	2.71E-04	4.07E-04	1.36E-04	1.36E-04
Acetaldehyde	75070	12.6%	0.025	0.038	0.013	0.013
Acrolein	107028	2.02%	0.004	0.006	0.002	0.002
Benzene	71432	3.78%	0.008	0.011	0.004	0.004
Ethylbenzene	100414	10.1%	0.020	0.030	0.010	0.010
Formaldehyde	50000	---	2.40	4.60	2.90	1.10
Naphthalene	91203	0.410%	8.19E-04	0.001	4.10E-04	4.10E-04
PAH	---	0.693%	0.001	0.002	6.93E-04	6.93E-04
Propylene Oxide	75569	9.14%	0.018	0.027	0.009	0.009
Toluene	108883	41.0%	0.082	0.123	0.041	0.041
Xylenes	1330207	20.2%	0.040	0.061	0.020	0.020

Event Emissions - Shutdown						
Pollutant	CAS No.		Emission Rates (lb/event)[4]			
			CT-01	CT-02	CT-03	CT-04
Total HAP	---		4.6	3.4	5.1	2.0
Formaldehyde	50000		4.3	3.2	4.8	1.9
Non-Formaldehyde HAP	---		0.3	0.2	0.3	0.1

Event Emissions - Shutdown						
Pollutant	CAS No.	Non-Formaldehyde HAP Composition[5]	Emission Rates (lb/event)[6,7]			
			CT-01	CT-02	CT-03	CT-04
1,3-Butadiene	106990	0.136%	2.03E-04	1.36E-04	2.03E-04	6.78E-05
Acetaldehyde	75070	12.6%	0.019	0.013	0.019	0.006
Acrolein	107028	2.02%	0.003	0.002	0.003	0.001
Benzene	71432	3.78%	0.006	0.004	0.006	0.002
Ethylbenzene	100414	10.1%	0.015	0.010	0.015	0.005
Formaldehyde	50000	---	2.15	1.60	2.40	0.950
Naphthalene	91203	0.410%	6.15E-04	4.10E-04	6.15E-04	2.05E-04
PAH	---	0.693%	0.001	6.93E-04	0.001	3.47E-04
Propylene Oxide	75569	9.14%	0.014	0.009	0.014	0.005
Toluene	108883	41.0%	0.061	0.041	0.061	0.020
Xylenes	1330207	20.2%	0.030	0.020	0.030	0.010

Total HAP Emission Factor (lb/MMBtu)	
AP-42	1.03E-03
Solar Data	3.05E-03

Formaldehyde Emission Factor (lb/MMBtu)	
AP-42	7.10E-04
Solar Data	2.88E-03

Non-Formaldehyde HAP Emission Factor (lb/MMBtu)	
AP-42	3.17E-04
Solar Data	1.70E-04

VOC Control Device Efficiency[10]	
Ox. Cat.	50%

Worst Case Schedule (hr/yr)[10]	
Normal Ops.	8,726.7
Startup	16.7
Shutdown	16.7

Max. Events (event/yr)[11]	
Startup	100
Shutdown	100

Table C-11 Toxic Air Pollutant (TAP) Emissions from Combustion Turbines - Combustion
ACP Buckingham Compressor Station - Buckingham County, Virginia

Maximum Hourly Emissions						
Pollutant	**CAS No.**		**Emission Rates (lb/hr)[8]**			
			CT-01	**CT-02**	**CT-03**	**CT-04**
1,3-Butadiene	106990		2.94E-04	4.22E-04	2.31E-04	1.45E-04
Acetaldehyde	75070		0.027	0.039	0.022	0.014
Acrolein	107028		0.004	0.006	0.003	0.002
Benzene	71432		0.008	0.012	0.006	0.004
Ethylbenzene	100414		0.022	0.031	0.017	0.011
Formaldehyde	50000		2.56	4.70	3.09	1.17
Naphthalene	91203		8.90E-04	0.001	7.00E-04	4.39E-04
PAH	---		0.002	0.002	0.001	7.44E-04
Propylene Oxide	75569		0.020	0.028	0.016	0.010
Toluene	108883		0.089	0.128	0.070	0.044
Xylenes	1330207		0.044	0.063	0.034	0.022

Maximum Annual Emissions						
Pollutant	**CAS No.**		**Emission Rates (ton/yr)[9]**			
			CT-01	**CT-02**	**CT-03**	**CT-04**
1,3-Butadiene	106990		1.45E-04	1.07E-04	1.64E-04	6.17E-05
Acetaldehyde	75070		0.014	0.010	0.015	0.006
Acrolein	107028		0.002	0.002	0.002	9.19E-04
Benzene	71432		0.004	0.003	0.005	0.002
Ethylbenzene	100414		0.011	0.008	0.012	0.005
Formaldehyde	50000		1.04	0.848	1.25	0.448
Naphthalene	91203		4.39E-04	3.25E-04	4.97E-04	1.87E-04
PAH	---		7.44E-04	5.50E-04	8.41E-04	3.16E-04
Propylene Oxide	75569		0.010	0.007	0.011	0.004
Toluene	108883		0.044	0.032	0.050	0.019
Xylenes	1330207		0.022	0.016	0.024	0.009

Notes:

1. Emission factors (except formaldehyde) from AP-42 Chapter 3, Section 3.1, Table 3.1-3. Formaldehyde emission factor from Solar PIL 168 Revision 4 (dated 14 May 2012)
2. Calculated as: [Fuel Flow (MMBtu/hr) * Emission Factor (lb/MMBtu) * (1 - Control Efficiency)]
3. Based on lower heating value (LHV) of fuel in Solar Turbines Emissions Estimates.
4. Based on Solar estimations.
5. Calculated based on AP-42 Chapter 3, Section 3.1, Table 3.1-3 emission factors. An example is shown below for toluene.

Non-Formaldehyde HAP Composition of Toluene:
= Toluene Emission Factor / Total Non-Formaldehyde HAP Emission Factor
= 1.30E-04 lb/MMBtu / 3.17E-04 lb/MMBtu
= 41.0%

6. Calculated as (except for formaldehyde): [Non-Formaldehyde HAP Composition * Non-Formaldehyde HAP Emission Rate (lb/event)]
7. Assume oxidation catalyst control for shutdown events.
8. Emissions from startup and shutdown events are higher than emissions from normal operations. Startup and shutdown events are 10 minutes in duration each.

However, only one startup or shutdown event would occur in a given hour. Therefore, maximum hourly emissions are calculated as the maximum of the following:
[Startup Event Emission Rate (lb/event) * 1 event/hr + Normal Operation Emission Rate (lb/hr) * 1 hr / 60 min * 50 min]
[Shutdown Event Emission Rate (lb/event) * 1 event/hr + Normal Operation Emission Rate (lb/hr) * 1 hr / 60 min * 50 min]

9. Calculated as: [Normal Operations Emission Rate (lb/hr) * Worst-Case Normal Operations Schedule (hr/yr) + Startup Emission Rate (lb/event) * Max. Startup Events (event/yr) + Shutdown Emission Rate (lb/event) * Max. Shutdown Events (event/yr)] * 1 ton/2,0000 lb
10. From Table C-2.
11. From Table C-3.

Table C-12 Toxic Air Pollutant (TAP) Emissions from Combustion Turbines - Blowdowns & Fugitives

ACP Buckingham Compressor Station - Buckingham County, Virginia

Hexane Emissions - Blowdown from Startup Events				
Parameter	**CT-01 Vent**	**CT-02 Vent**	**CT-03 Vent**	**CT-04 Vent**
Blowdown Gas (lb/event)[1]	168	84.0	182	48.8
Hexane Emissions (lb/event)[2]	0.270	0.135	0.292	0.078

Hexane Emissions - Blowdown from Shutdown Events				
Parameter	**CT-01 Vent**	**CT-02 Vent**	**CT-03 Vent**	**CT-04 Vent**
Blowdown Gas (lb/event)[1]	539	229	600	116
Hexane Emissions (lb/event)[2]	0.866	0.368	0.963	0.186

Hexane Emissions - Blowdown from Sitewide Events								
Parameter	**CT-01 Vent**	**CT-02 Vent**	**CT-03 Vent**	**CT-04 Vent**	**Stn. Suctn. 1**	**Stn. Suctn. 2**	**Stn. Dischrg. 1**	**Stn. Dischrg. 2**
Blowdown Gas (lb/event)[3]	1.37	0.624	1.62	0.250	2.37	2.37	1.94	1.94
Hexane Emissions (lb/event)[2]	0.002	0.001	0.003	4.01E-04	0.004	0.004	0.003	0.003

Hexane Emissions - Fugitive Leaks				
Parameter	**CT-01**	**CT-02**	**CT-03**	**CT-04**
Fugitive Leak Gas (lb/hr)[4]	2.00	2.00	2.00	2.00
Hexane Emissions (lb/hr)[5]	0.003	0.003	0.003	0.003

Hexane Emissions - Pigging Events		
Parameter	**Launcher**	**Receiver**
Fugitive Leak Gas (lb/event)[1]	1,563	1,630
Hexane Emissions (lb/event)[2]	2.51	2.62

Maximum Hourly Hexane Emissions - Blowdowns and Pigging										
Parameter	**CT-01 Vent**	**CT-02 Vent**	**CT-03 Vent**	**CT-04 Vent**	**Stn. Suctn. 1**	**Stn. Suctn. 2**	**Stn. Dischrg. 1**	**Stn. Dischrg. 2**	**Launcher**	**Receiver**
Hexane Emissions (lb/hr)[6]	---	---	---	---	---	---	---	---	---	2.62

Maximum Hourly Hexane Emissions - Fugitives				
Parameter	**CT-01**	**CT-02**	**CT-03**	**CT-04**
Hexane Emissions (lb/hr)	0.003	0.003	0.003	0.003

Maximum Annual Hexane Emissions - Blowdowns and Pigging										
Parameter	**CT-01 Vent**	**CT-02 Vent**	**CT-03 Vent**	**CT-04 Vent**	**Stn. Suctn. 1**	**Stn. Suctn. 2**	**Stn. Dischrg. 1**	**Stn. Dischrg. 2**	**Launcher**	**Receiver**
Hexane Emissions (ton/yr)[7]	0.006	0.003	0.006	0.001	1.91E-06	1.91E-06	1.55E-06	1.55E-06	0.005	0.005

Maximum Annual Hexane Emissions - Fugitives				
Parameter	**CT-01**	**CT-02**	**CT-03**	**CT-04**
Hexane Emissions (ton/yr)[8]	0.014	0.014	0.014	0.014

Gas Composition (wt. %)[1]	
Hexane	0.161%

Maximum Sitewide Blowdown Gas (lb)[1]	
Per Event	12.5
Per Hour	12.5

Sitewide Blowdown Gas Stack Distribution (wt. %)[9]	
CT-01 Vent	11%
CT-02 Vent	5%
CT-03 Vent	13%
CT-04 Vent	2%
Stn. Suctn. 1	19%
Stn. Suctn. 2	19%
Stn. Dischrg. 1	15.5%
Stn. Dischrg. 2	15.5%

Max. Blowdown Events (event/yr)[1]	
Startup	10
Shutdown	10
Sitewide	1

Operating Schedule (hr/yr)[4]	
Fug. Leaks	8,760

Pigging Events (event/yr)[1]	
Pig Launcher	4
Pig Receiver	4

Notes:

1. From Table C-3.
2. Calculated as: [Blowdown Gas * Hexane Gas Composition]
3. Calculated as: [Maximum Sitewide Blowdown Gas * Sitewide Blowdown Gas Stack Distribution].
4. From Table C-7. Distribuited the total facility-wide fugitive leaks evenly across each turbine.
5. Calculated as: [Fugitive Leak Gas * Hexane Gas Composition]
6. Maximum event emissions occur during pig receiving events. Startup, shutdown, sitewide, launching, and receiving events would not coincide in the same hour.
7. Calculated as: [Startup Event Emissions (lb/event) * Max. Startup Events (event/yr) + Shutdown Event Emissions (lb/event) * Max. Shutdown Events (event/yr) + Sitewide Event Emissions (lb/event) * Max. Sitewide Events (event/yr)] * 1 ton / 2,000 lb
   Launcher and Receiver emissions calculated as: Pigging Event Emissions (lb/event) * Pigging Events (event/yr) * 1 ton / 2,000 lb
8. Calculated as: [Fugitive Leak Emissions (lb/hr) * Operating Schedule (hr/yr)] * 1 ton / 2,000 lb
9. Based on engineering assumptions. Assumed vol. % is equivalent to wt. %.

Solar Turbines Emissions Estimates

Titan 130-20502S

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
50% load																
0	11,083	116.71	24.164	9	4.20	25	7.11	25	4.07	2.5	0.407	15,276	0.02	2.57	906	367,603
59	10,015	105.62	24.127	9	3.79	25	6.40	25	3.66	2.5	0.366	13,736	0.02	2.32	991	312,469
100	8,160	96.22	21.577	9	3.38	25	5.73	25	3.28	2.5	0.328	12,281	0.02	2.12	1,050	273,036
75% load																
Temp, F	**HP**	**fuel flow, mmbtu/hr LHV**	**Thermal Eff, %**	**NOx (ppm)**	**NOx (lb/hr)**	**CO (ppm)**	**CO (lb/hr)**	**UHC (ppm)**	**UHC (lb/hr)**	**VOC (ppm)**	**VOC (lb/hr)**	**CO2 lb/hr**	**PM10/2.5 lb/mmbtu**	**PM10/2.5 lb/hr**	**Exhaust Temp (F)**	**Exhaust Flow (lb/hr)**
0	16,299	137.63	30.132	9	4.96	25	8.38	25	4.80	2.5	0.480	18,005	0.02	3.03	899	413,002
59	15,022	124.33	30.743	9	4.46	25	7.53	25	4.32	2.5	0.432	16,165	0.02	2.74	955	357,845
100	12,240	109.93	28.329	9	3.87	25	6.54	25	3.75	2.5	0.375	14,028	0.02	2.42	1,019	304,112
100% load																
Temp, F	**HP**	**fuel flow, mmbtu/hr LHV**	**Thermal Eff, %**	**NOx (ppm)**	**NOx (lb/hr)**	**CO (ppm)**	**CO (lb/hr)**	**UHC (ppm)**	**UHC (lb/hr)**	**VOC (ppm)**	**VOC (lb/hr)**	**CO2 lb/hr**	**PM10/2.5 lb/mmbtu**	**PM10/2.5 lb/hr**	**Exhaust Temp (F)**	**Exhaust Flow (lb/hr)**
0	21,732	157.20	35.175	9	5.67	25	9.58	25	5.49	2.5	0.549	20,549	0.02	3.46	900	437,967
59	20,030	142.50	35.765	9	5.11	25	8.64	25	4.95	2.5	0.495	18,518	0.02	3.14	944	392,542
100	16,320	125.55	33.072	9	4.42	25	7.47	25	4.28	2.5	0.428	16,018	0.02	2.76	994	340,129

Controlled Emission Rates w/SCR and Oxidation Catalyst

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
50% load														
0	11,083	116.71	24.164	3.75	1.75	2	0.569	25	4.07	1.25	0.204	15,276	0.02	2.57
59	10,015	105.62	24.127	3.75	1.58	2	0.512	25	3.66	1.25	0.183	13,736	0.02	2.32
100	8,160	96.22	21.577	3.75	1.41	2	0.458	25	3.28	1.25	0.164	12,281	0.02	2.12
75% load														
Temp, F	**HP**	**fuel flow, mmbtu/hr LHV**	**Thermal Eff, %**	**NOx (ppm)**	**NOx (lb/hr)**	**CO (ppm)**	**CO (lb/hr)**	**UHC (ppm)**	**UHC (lb/hr)**	**VOC (ppm)**	**VOC (lb/hr)**	**CO2 lb/hr**	**PM10/2.5 lb/mmbtu**	**PM10/2.5 lb/hr**
0	16,299	137.63	30.132	3.75	2.07	2	0.670	25	4.80	1.25	0.240	18,005	0.02	3.03
59	15,022	124.33	30.743	3.75	1.86	2	0.602	25	4.32	1.25	0.216	16,165	0.02	2.74
100	12,240	109.93	28.329	3.75	1.61	2	0.523	25	3.75	1.25	0.188	14,028	0.02	2.42
100% load														
Temp, F	**HP**	**fuel flow, mmbtu/hr LHV**	**Thermal Eff, %**	**NOx (ppm)**	**NOx (lb/hr)**	**CO (ppm)**	**CO (lb/hr)**	**UHC (ppm)**	**UHC (lb/hr)**	**VOC (ppm)**	**VOC (lb/hr)**	**CO2 lb/hr**	**PM10/2.5 lb/mmbtu**	**PM10/2.5 lb/hr**
0	21,732	157.20	35.175	3.75	2.36	2	0.766	25	5.49	1.25	0.275	20,549	0.02	3.46
59	20,030	142.50	35.765	3.75	2.13	2	0.691	25	4.95	1.25	0.248	18,518	0.02	3.14
100	16,320	125.55	33.072	3.75	1.84	2	0.598	25	4.28	1.25	0.214	16,018	0.02	2.76

Example Calculation of ppm to lb/hr conversion

100% load, 0 degrees F, Controlled

H2O Volume % (Actual)	O2 (Actual)	Exhaust Flow (lb/hr)	MW(EX)	NWP	O2% Dry	NOx (ppm)	NOx (ppmA)	MW(P)	NOx (lb/hr)	CO (ppm)	CO (ppmA)	MW(P)	CO (lb/hr)
5.91	14.39	437,967	28.59	0.941	15.3	3.75	3.35	46	2.36	2	1.79	28	0.767
						UHC (ppm)	**UHC (ppmA)**	**MW(P)**	**UHC (lb/hr)**	**VOC (ppm)**	**VOC (lb/hr)**		
						25	22.4	16	5.48	1.25	0.274		

Notes:
1. NWP is the non-water fraction portion of the exhaust
2. ppmA is the ppm at actual test conditions
3. MW(EX) is the molecular weight of the exhaust
4. MW(P) is the molecular weight of the pollutant
5. NWP = (100 - H2O Volume % (Actual)) / 100
6. O2% Dry = O2% (Actual) / NWP
7. ppmA = ppm * NWP * (20.9 - O2% Dry) / (20.9 - 15)
8. lb/hr = (ppmA / 1,000,000) * EMF * (MW(P) / MW(EX))
9. Differences between example calculation and emissions estimates are due to rounding.

Solar Turbines Emissions Estimates

Mars 100-16000S

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	8,962	97.29	23.440	9	3.50	25	5.93	25	3.39	2.5	0.339	12,753	0.02	2.14	864	322,744
59	7,760	85.24	23.162	9	3.05	25	5.16	25	2.96	2.5	0.296	11,107	0.02	1.88	949	275,560
100	6,580	75.95	22.046	9	2.67	25	4.52	25	2.59	2.5	0.259	9,713	0.02	1.67	1,009	240,842

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	13,180	115.67	28.993	9	4.17	25	7.05	25	4.04	2.5	0.404	15,149	0.02	2.54	870	355,319
59	11,640	101.99	29.037	9	3.65	25	6.18	25	3.54	2.5	0.354	13,280	0.02	2.24	916	310,038
100	9,870	90.11	27.869	9	3.17	25	5.36	25	3.07	2.5	0.307	11,519	0.02	1.98	965	271,481

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	17,574	129.64	34.493	9	4.67	25	7.91	25	4.53	2.5	0.453	16,963	0.02	2.85	864	366,922
59	15,519	116.41	33.920	9	4.18	25	7.06	25	4.04	2.5	0.404	15,148	0.02	2.56	908	334,207
100	13,160	104.09	32.169	9	3.67	25	6.20	25	3.55	2.5	0.355	13,299	0.02	2.29	945	298,619

Controlled Emission Rates w/SCR and Oxidation Catalyst

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	8,962	97.29	23.440	3.75	1.46	2	0.474	25	3.39	1.25	0.170	12,753	0.02	2.14
59	7,760	85.24	23.162	3.75	1.27	2	0.413	25	2.96	1.25	0.148	11,107	0.02	1.88
100	6,580	75.95	22.046	3.75	1.11	2	0.362	25	2.59	1.25	0.130	9,713	0.02	1.67

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	13,180	115.67	28.993	3.75	1.74	2	0.564	25	4.04	1.25	0.202	15,149	0.02	2.54
59	11,640	101.99	29.037	3.75	1.52	2	0.494	25	3.54	1.25	0.177	13,280	0.02	2.24
100	9,870	90.11	27.869	3.75	1.32	2	0.429	25	3.07	1.25	0.154	11,519	0.02	1.98

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	17,574	129.64	34.493	3.75	1.95	2	0.633	25	4.53	1.25	0.227	16,963	0.02	2.85
59	15,519	116.41	33.920	3.75	1.74	2	0.565	25	4.04	1.25	0.202	15,148	0.02	2.56
100	13,160	104.09	32.169	3.75	1.53	2	0.496	25	3.55	1.25	0.178	13,299	0.02	2.29

Example Calculation of ppm to lb/hr conversion

100% load, 0 degrees F, Controlled

H20 Volume % (Actual)	O2 (Actual)	Exhaust Flow (lb/hr)	MW(EX)	NWP	O2% Dry	NOx (ppm)	NOx (ppmA)	MW(P)	NOx (lb/hr)	CO (ppm)	CO (ppmA)	MW(P)	CO (lb/hr)
5.82	14.49	366,922	28.60	0.942	15.4	3.75	3.30	46	1.95	2	1.76	28	0.632

UHC (ppm)	UHC (ppmA)	MW(P)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)
25	22.0	16	4.52	1.25	0.226

Notes:
1. NWP is the non-water fraction portion of the exhaust
2. ppmA is the ppm at actual test conditions
3. MW(EX) is the molecular weight of the exhaust
4. MW(P) is the molecular weight of the pollutant
5. NWP = (100 - H2O Volume % (Actual)) / 100
6. O2% Dry = O2% (Actual) / NWP
7. ppmA = ppm * NWP * (20.9 - O2% Dry) / (20.9 - 15)
8. lb/hr = (ppmA / 1,000,000) * EMF * (MW(P) / MW(EX))
9. Differences between example calculation and emissions estimates are due to rounding.

Solar Turbines Emissions Estimates

Taurus 70-10802S

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	6,051	62.27	24.724	9	2.24	25	3.79	25	2.17	2.5	0.217	8,156	0.02	1.37	885	198,513
59	5,430	55.14	25.055	9	1.97	25	3.34	25	1.91	2.5	0.191	7,177	0.02	1.21	962	169,254
100	4,342	47.92	23.055	9	1.69	25	2.85	25	1.63	2.5	0.163	6,124	0.02	1.05	1,015	148,260

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	9,076	75.38	30.637	9	2.72	25	4.59	25	2.63	2.5	0.263	9,865	0.02	1.66	868	224,320
59	8,145	66.30	31.259	9	2.38	25	4.02	25	2.30	2.5	0.230	8,625	0.02	1.46	925	192,967
100	6,512	57.05	29.043	9	2.01	25	3.40	25	1.95	2.5	0.195	7,286	0.02	1.26	986	164,067

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	12,102	85.62	35.962	9	3.09	25	5.22	25	2.99	2.5	0.299	11,197	0.02	1.88	854	237,484
59	10,860	79.24	34.869	9	2.84	25	4.81	25	2.75	2.5	0.275	10,301	0.02	1.74	940	213,302
100	8,683	68.40	32.299	9	2.41	25	4.07	25	2.33	2.5	0.233	8,730	0.02	1.50	999	183,855

Controlled Emission Rates w/SCR and Oxidation Catalyst

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	6,051	62.27	24.724	3.75	0.935	2	0.303	25	2.17	1.25	0.109	8,156	0.02	1.37
59	5,430	55.14	25.055	3.75	0.823	2	0.267	25	1.91	1.25	0.096	7,177	0.02	1.21
100	4,342	47.92	23.055	3.75	0.703	2	0.228	25	1.63	1.25	0.082	6,124	0.02	1.05

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	9,076	75.38	30.637	3.75	1.13	2	0.367	25	2.63	1.25	0.132	9,865	0.02	1.66
59	8,145	66.30	31.259	3.75	0.990	2	0.322	25	2.30	1.25	0.115	8,625	0.02	1.46
100	6,512	57.05	29.043	3.75	0.838	2	0.272	25	1.95	1.25	0.098	7,286	0.02	1.26

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	12,102	85.62	35.962	3.75	1.29	2	0.418	25	2.99	1.25	0.150	11,197	0.02	1.88
59	10,860	79.24	34.869	3.75	1.19	2	0.385	25	2.75	1.25	0.138	10,301	0.02	1.74
100	8,683	68.40	32.299	3.75	1.01	2	0.326	25	2.33	1.25	0.117	8,730	0.02	1.50

Example Calculation of ppm to lb/hr conversion

100% load, 0 degrees F, Controlled

H20 Volume % (Actual)	O2 (Actual)	Exhaust Flow (lb/hr)	MW(EX)	NWP	O2% Dry	NOx (ppm)	NOx (ppmA)	MW(P)	NOx (lb/hr)	CO (ppm)	CO (ppmA)	MW(P)	CO (lb/hr)
5.93	14.36	237,484	28.59	0.941	15.3	3.75	3.37	46	1.29	2	1.80	28	0.418

UHC (ppm)	UHC (ppmA)	MW(P)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)
25	22.5	16	2.99	1.25	0.149

Notes:
1. NWP is the non-water fraction portion of the exhaust
2. ppmA is the ppm at actual test conditions
3. MW(EX) is the molecular weight of the exhaust
4. MW(P) is the molecular weight of the pollutant
5. NWP = (100 - H2O Volume % (Actual)) / 100
6. O2% Dry = O2% (Actual) / NWP
7. ppmA = ppm * NWP * (20.9 - O2% Dry) / (20.9 - 15)
8. lb/hr = (ppmA / 1,000,000) * EMF * (MW(P) / MW(EX))
9. Differences between example calculation and emissions estimates are due to rounding.

Solar Turbines Emissions Estimates

Centaur 50-6200LS

Assumptions: pipeline natural gas, sea level, 4"/4" inlet/outlet losses, nominal performance

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	3,377	39.52	21.741	9	1.42	25	2.41	25	1.38	2.5	0.138	5,188	0.02	0.869	834	140,425
59	3,059	35.43	21.973	9	1.27	25	2.15	25	1.23	2.5	0.123	4,621	0.02	0.779	912	120,608
100	2,472	30.97	20.306	9	1.09	25	1.84	25	1.06	2.5	0.106	3,965	0.02	0.681	962	104,180

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	5,066	47.54	27.110	9	1.72	25	2.90	25	1.66	2.5	0.166	6,233	0.02	1.05	845	154,053
59	4,589	42.35	27.569	9	1.52	25	2.57	25	1.47	2.5	0.147	5,520	0.02	0.932	905	134,139
100	3,707	36.96	25.524	9	1.30	25	2.20	25	1.26	2.5	0.126	4,729	0.02	0.813	955	116,535

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr	Exhaust Temp (F)	Exhaust Flow (lb/hr)
0	6,754	54.98	31.256	9	1.99	25	3.35	25	1.92	2.5	0.192	7,201	0.02	1.21	867	162,463
59	6,119	51.13	30.450	9	1.84	25	3.10	25	1.78	2.5	0.178	6,656	0.02	1.12	952	145,994
100	4,943	44.78	28.085	9	1.58	25	2.67	25	1.53	2.5	0.153	5,724	0.02	0.985	1,000	128,506

Controlled Emission Rates w/SCR and Oxidation Catalyst

50% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	3,377	39.52	21.741	3.75	0.593	2	0.193	25	1.38	1.25	0.069	5,188	0.02	0.869
59	3,059	35.43	21.973	3.75	0.530	2	0.172	25	1.23	1.25	0.062	4,621	0.02	0.779
100	2,472	30.97	20.306	3.75	0.455	2	0.147	25	1.06	1.25	0.053	3,965	0.02	0.681

75% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	5,066	47.54	27.110	3.75	0.715	2	0.232	25	1.66	1.25	0.083	6,233	0.02	1.05
59	4,589	42.35	27.569	3.75	0.633	2	0.206	25	1.47	1.25	0.074	5,520	0.02	0.932
100	3,707	36.96	25.524	3.75	0.543	2	0.176	25	1.26	1.25	0.063	4,729	0.02	0.813

100% load

Temp, F	HP	fuel flow, mmbtu/hr LHV	Thermal Eff, %	NOx (ppm)	NOx (lb/hr)	CO (ppm)	CO (lb/hr)	UHC (ppm)	UHC (lb/hr)	VOC (ppm)	VOC (lb/hr)	CO2 lb/hr	PM10/2.5 lb/mmbtu	PM10/2.5 lb/hr
0	6,754	54.98	31.256	3.75	0.828	2	0.268	25	1.92	1.25	0.096	7,201	0.02	1.21
59	6,119	51.13	30.450	3.75	0.765	2	0.248	25	1.78	1.25	0.089	6,656	0.02	1.12
100	4,943	44.78	28.085	3.75	0.658	2	0.214	25	1.53	1.25	0.077	5,724	0.02	0.985

Example Calculation of ppm to lb/hr conversion

100% load, 0 degrees F, Controlled

H20 Volume % (Actual)	O2 (Actual)	Exhaust Flow (lb/hr)	MW(EX)	NWP	O2% Dry	NOx (ppm)	NOx (ppmA)	MW(P)	NOx (lb/hr)	CO (ppm)	CO (ppmA)	MW(P)	CO (lb/hr)
5.58	14.75	162,463	28.61	0.944	15.6	3.75	3.17	46	0.827	2	1.69	28	0.269
						UHC (ppm)	**UHC (ppmA)**	**MW(P)**	**UHC (lb/hr)**	**VOC (ppm)**	**VOC (lb/hr)**		
						25	21.1	16	1.92	1.25	0.096		

Notes:

1. NWP is the non-water fraction portion of the exhaust
2. ppmA is the ppm at actual test conditions
3. MW(EX) is the molecular weight of the exhaust
4. MW(P) is the molecular weight of the pollutant
5. NWP = (100 - H2O Volume % (Actual)) / 100
6. O2% Dry = O2% (Actual) / NWP
7. ppmA = ppm * NWP * (20.9 - O2% Dry) / (20.9 - 15)
8. lb/hr = (ppmA / 1,000,000) * EMF * (MW(P) / MW(EX))
9. Differences between example calculation and emissions estimates are due to rounding.

Stack Parameters and Emissions

Appendix D

Table D-1 Ancillary Equipment Emissions and Stack Parameters

Source	Model ID	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Velocity (ft/s)	Exit Gas Temperature (°F)	Pollutant Emission Rates									
						NO_X (lb/hr)	NO_X (TPY)	CO (lb/hr)	CO (TPY)	$PM_{2.5}/PM_{10}$ (lb/hr)	$PM_{2.5}/PM_{10}$ (TPY)	Formaldehyde (lb/hr)	Formaldehyde (TPY)	Hexane (lb/hr)	Hexane (TPY)
Emergency Generator	EGEN	45	1.33	146.5	867	2.40	0.599	9.59	2.40	0.725	0.181	2.49	0.623	0.002	0.001
Hot Water Auxiliary Boiler[a]	AUXB	26.1	1.0	48.2	838	0.313	1.37	0.526	2.30	0.048	0.208	0.000469	0.002	0.011	0.049
Line Heater 1 Stack 1[a]	HT11	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 1 Stack 2[a]	HT12	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 2 Stack 1[a]	HT21	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 2 Stack 2[a]	HT22	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 3 Stack 1[a]	HT31	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 3 Stack 2[a]	HT32	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 4 Stack 1[a]	HT41	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Line Heater 4 Stack 2[a]	HT42	15	3.0	9.9	982	0.106	0.4647	0.3927	1.719	0.051	0.223	0.001	0.0034	0.019	0.082
Accumulator Tank[b]	TNK1	8.6	0.3	0.003	Ambient	-	-	-	-	-	-	-	-	0.001	0.000025
Pipeline Liquids Tank[b]	TNK2	7.3	0.3	0.003	Ambient	-	-	-	-	-	-	-	-	0.002	0.010

Source[c]	Model ID	Building Height (ft)	Building Length (ft)	Hexane (lb/hr)	Hexane (TPY)
Solar Taurus 70 and Centaur 50L Turbine Building Fugitives	CT12	46	94.5[d]	0.006	0.028
Solar Titan 130 and Mars 100 Turbine Building Fugitives	CT34	38.7	80.5[e]	0.006	0.028

a - Stack is modeled with a stack cap

b - Tanks 1 and 2 assumed to have a conservative exit velocity of 0.001 m/s and ambient stack temperatures (0 K in the model)

c - Turbine building fugitives are modeled as volume sources

d - Building length is an equivalent building length based on dimensions of 124 and 72 feet

e - Building length is an equivalent building length based on dimensions of 108 and 60 feet

Table D-2 Combustion Turbine Load Analysis

Source	Load Scenario	Ambient Temperature Scenario[a]	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Temperature (°F)[a,c]	Exit Gas Velocity (ft/s)[a,c]	Pollutant Emission Rates (lb/hr)[a,c]		
							NO_X[b]	CO	$PM_{2.5}/PM_{10}$
Solar Mars 100 Turbine	50%	0° F	60	7.3	**750**	74.3	**1.46**	0.47	**2.14**
Solar Taurus 70 Turbine			60	6.0	**750**	70.1	**0.94**	0.30	**1.37**
Solar Titan 130 Turbine			60	9.0	**750**	59.2	**1.75**	0.57	**2.57**
Solar Centaur 50L Turbine			60	6.0	**700**	48.0	**0.59**	0.19	**0.87**
Solar Mars 100 Turbine		59° F	60	7.3	750	71.9	1.27	0.41	1.88
Solar Taurus 70 Turbine			60	6.0	750	67.1	0.82	0.27	1.21
Solar Titan 130 Turbine			60	9.0	750	57.0	1.58	0.51	2.32
Solar Centaur 50L Turbine			60	6.0	700	46.7	0.53	0.17	0.78
Solar Mars 100 Turbine		100° F	60	7.3	760	**69.1**	1.11	0.36	1.67
Solar Taurus 70 Turbine			60	6.0	750	**64.5**	0.70	0.23	1.05
Solar Titan 130 Turbine			60	9.0	760	**54.6**	1.41	0.46	2.12
Solar Centaur 50L Turbine			60	6.0	700	**44.5**	0.46	0.15	0.68
Solar Mars 100 Turbine		< 0° F	60	7.3	750	74.3	**6.81**	**1.90**	2.14
Solar Taurus 70 Turbine			60	6.0	750	70.1	**4.36**	**1.21**	1.37
Solar Titan 130 Turbine			60	9.0	750	59.2	**8.17**	**2.28**	2.57
Solar Centaur 50L Turbine			60	6.0	700	48.0	**2.77**	**0.77**	0.87
Solar Mars 100 Turbine	75%	0° F	60	7.3	**750**	82.4	**1.74**	0.56	**2.54**
Solar Taurus 70 Turbine			60	6.0	**750**	77.6	**1.13**	0.37	**1.66**
Solar Titan 130 Turbine			60	9.0	**750**	65.9	**2.07**	0.67	**3.03**
Solar Centaur 50L Turbine			60	6.0	**700**	53.5	**0.72**	0.23	**1.05**
Solar Mars 100 Turbine		59° F	60	7.3	750	77.7	1.52	0.49	2.24
Solar Taurus 70 Turbine			60	6.0	750	73.1	0.99	0.32	1.46
Solar Titan 130 Turbine			60	9.0	750	62.5	1.86	0.60	2.74
Solar Centaur 50L Turbine			60	6.0	700	51.5	0.63	0.21	0.93
Solar Mars 100 Turbine		100° F	60	7.3	760	**73.8**	1.32	0.43	1.98
Solar Taurus 70 Turbine			60	6.0	750	**69.0**	0.84	0.27	1.26
Solar Titan 130 Turbine			60	9.0	760	**58.6**	1.61	0.52	2.42
Solar Centaur 50L Turbine			60	6.0	725	**48.2**	0.54	0.18	0.81
Solar Mars 100 Turbine		< 0° F	60	7.3	750	82.4	**8.11**	**2.26**	2.54
Solar Taurus 70 Turbine			60	6.0	750	77.6	**5.29**	**1.47**	1.66
Solar Titan 130 Turbine			60	9.0	750	65.9	**9.64**	**2.68**	3.03
Solar Centaur 50L Turbine			60	6.0	700	53.5	**3.34**	**0.93**	1.05
Solar Mars 100 Turbine	100%	0° F	60	7.3	**750**	84.6	**1.95**	0.63	**2.85**
Solar Taurus 70 Turbine			60	6.0	**750**	80.8	**1.29**	0.42	**1.88**
Solar Titan 130 Turbine			60	9.0	**750**	70.1	**2.36**	0.77	**3.46**
Solar Centaur 50L Turbine			60	6.0	**700**	58.1	**0.83**	0.27	**1.21**
Solar Mars 100 Turbine		59° F	60	7.3	750	82.9	1.74	0.56	2.56
Solar Taurus 70 Turbine			60	6.0	750	82.4	1.19	0.38	1.74
Solar Titan 130 Turbine			60	9.0	750	67.7	2.13	0.69	3.14
Solar Centaur 50L Turbine			60	6.0	725	58.3	0.77	0.25	1.12
Solar Mars 100 Turbine		100° F	60	7.3	750	**79.8**	1.53	0.50	2.29
Solar Taurus 70 Turbine			60	6.0	760	**77.9**	1.01	0.33	1.50
Solar Titan 130 Turbine			60	9.0	760	**63.7**	1.84	0.60	2.76
Solar Centaur 50L Turbine			60	6.0	750	**55.0**	0.66	0.21	0.99
Solar Mars 100 Turbine		< 0° F	60	7.3	750	84.6	**9.09**	**2.53**	2.85
Solar Taurus 70 Turbine			60	6.0	750	80.8	**6.01**	**1.67**	1.88
Solar Titan 130 Turbine			60	9.0	750	70.1	**11.03**	**3.07**	3.46
Solar Centaur 50L Turbine			60	6.0	700	58.1	**3.86**	**1.07**	1.21

a - Cells that are highlighted in light grey and bold font are values that were chosen for the worst case scenario to be modeled (the lowest turbine T and exit velocity for that particular load percentage, or the highest emission rate for that particular load percentage).

b - Two sets of worst case emission rates were chosen for NO_2: one for the 1-hour averaging period and one for the annual averaging period. The < 0° F scenario was not considered for the 1-hour averaging period because of the intermittent source exemption, but was considered for the annual averaging period.

c - In cases where the 0° F scenario data was the same as the < 0° F scenario data, and these values were chosen for the worst case scenario, only the 0° F scenario is highlighted in this table for simplicity.

Table D-3 Worst Case Scenarios Determined from Turbine Load Analysis

						Pollutant Emission Rates (lb/hr)[a]					
Source	**Load Scenario**	**Stack Height (ft)**	**Exit Diameter (ft)**	**Exit Gas Temperature (°F)**	**Exit Gas Velocity (ft/s)**	**NO_X (1-hour)[a]**	**NO_X (Annual)**	**CO (1-hour, 8-hour)**	**$PM_{2.5}/PM_{10}$ (24-hour, Annual)**	**Formaldehyde (1-hour)[b]**	**Formaldehyde (Annual)[b,c]**
Solar Mars 100 Turbine	50%	60	7.3	750	69.1	1.46	6.81	1.90	2.14	0.19	0.24
Solar Taurus 70 Turbine		60	6.0	750	64.5	0.94	4.36	1.21	1.37	0.12	0.19
Solar Titan 130 Turbine		60	9.0	750	54.6	1.75	8.17	2.28	2.57	0.23	0.29
Solar Centaur 50L Turbine		60	6.0	700	44.5	0.59	2.77	0.77	0.87	0.08	0.10
Solar Mars 100 Turbine	75%	60	7.3	750	73.8	1.74	8.11	2.26	2.54	0.19	0.24
Solar Taurus 70 Turbine		60	6.0	750	69.0	1.13	5.29	1.47	1.66	0.12	0.19
Solar Titan 130 Turbine		60	9.0	750	58.6	2.07	9.64	2.68	3.03	0.23	0.29
Solar Centaur 50L Turbine		60	6.0	700	48.2	0.72	3.34	0.93	1.05	0.08	0.10
Solar Mars 100 Turbine	100%	60	7.3	750	79.8	1.95	9.09	2.53	2.85	0.19	0.24
Solar Taurus 70 Turbine		60	6.0	750	77.9	1.29	6.01	1.67	1.88	0.12	0.19
Solar Titan 130 Turbine		60	9.0	750	63.7	2.36	11.03	3.07	3.46	0.23	0.29
Solar Centaur 50L Turbine		60	6.0	700	55.0	0.83	3.86	1.07	1.21	0.08	0.10

a - The < 0° F scenario was not considered for the 1-hour averaging period because of the intermittent source exemption. The 1-hour averaging period therefore has lower emission rates than the annual averaging period which did consider the < 0° F scenario.

b - Vendor emissions provided a specific formaldehyde emission rate, which was conservatively applied to all turbine load and ambient temperature scenarios.

c - Worst case annual formaldehyde emission rates include normal operations combined with 100 startup and shutdown events per year.

Table D-4 Stack Parameters to Be Blended for Startup and Shutdown Operations

Turbine	Scenario	Exhaust Flow (ACFM)	Stack Exhaust T (°F)	Emission Rates (lb/hr)			
				NO_X	CO	$PM_{2.5}/PM_{10}$	Formaldehyde
Solar Mars 100 Turbine	50% Load (Worst Case 8-hr CO and 1-hr Formaldehyde Scenario)	175,009	750.00	-	1.90	-	0.19
Solar Taurus 70 Turbine		109,495	750.00	-	1.21	-	0.12
Solar Titan 130 Turbine		208,269	750.00	-	2.28	-	0.23
Solar Centaur 50L Turbine		75,409	700.00	-	0.77	-	0.08
Solar Mars 100 Turbine	75% Load (Worst Case 1-hr NO_2 and 1-hr CO Scenario)	186,958	750.00	1.74	2.26	-	-
Solar Taurus 70 Turbine		117,059	750.00	1.13	1.47	-	-
Solar Titan 130 Turbine		223,809	750.00	2.07	2.68	-	-
Solar Centaur 50L Turbine		81,739	700.00	0.72	0.93	-	-
Solar Mars 100 Turbine	100% Load (Worst Case 24-hr $PM_{2.5}$ and 24-hr PM_{10} Scenario)	202,230	750.00	-	-	2.85	-
Solar Taurus 70 Turbine		132,216	750.00	-	-	1.88	-
Solar Titan 130 Turbine		242,963	750.00	-	-	3.46	-
Solar Centaur 50L Turbine		93,296	700.00	-	-	1.21	-

Turbine	Scenario	Exhaust Flow (ACFM)[a]	Stack Exhaust T (°F)[a]	Emission Rates (lb/event)			
				NO_X	CO	$PM_{2.5}/PM_{10}$	Formaldehyde
Solar Mars 100 Turbine	Startup	175,009	750.00	1	46	0.06	2.40
Solar Taurus 70 Turbine		109,495	750.00	1	88	0.06	4.60
Solar Titan 130 Turbine		208,269	750.00	1	55	0.11	2.90
Solar Centaur 50L Turbine		75,409	700.00	0.3	21	0.03	1.10
Solar Mars 100 Turbine	Shutdown	175,009	750.00	1	6.56	0.1	2.15
Solar Taurus 70 Turbine		109,495	750.00	1	4.96	0.07	1.60
Solar Titan 130 Turbine		208,269	750.00	2	7.28	0.15	2.40
Solar Centaur 50L Turbine		75,409	700.00	1	2.96	0.05	0.95

a - Startup and shutdown exhaust flow and T are assumed to be the same as the worst case 50% scenario.

Table D-5 Modeled Startup / Shutdown Operations

Source	Scenario[a,b]	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Velocity (ft/s)[d]	Exit Gas Temperature (°F)[d]	Pollutant Emission Rates (lb/hr)[c]							
						Startup NO_x	Shutdown NO_x	Startup CO	Shutdown CO	Startup $PM_{2.5}$/PM_{10}	Shutdown $PM_{2.5}$/PM_{10}	Startup Formaldehyde	Shutdown Formaldehyde
Solar Mars 100 Turbine	1-hr (NO_x)	60	7.33	72.99	750.00	2.45	2.45	-	-	-	-	-	-
Solar Taurus 70 Turbine		60	6.00	68.26	750.00	1.94	1.94	-	-	-	-	-	-
Solar Titan 130 Turbine		60	9.00	57.96	750.00	2.72	3.72	-	-	-	-	-	-
Solar Centaur 50L Turbine		60	6.00	47.56	700.00	0.90	1.60	-	-	-	-	-	-
Solar Mars 100 Turbine	1-hr (CO)	60	7.33	72.99	750.00	-	-	47.88	8.44	-	-	-	-
Solar Taurus 70 Turbine		60	6.00	68.26	750.00	-	-	89.22	6.18	-	-	-	-
Solar Titan 130 Turbine		60	9.00	57.96	750.00	-	-	57.23	9.51	-	-	-	-
Solar Centaur 50L Turbine		60	6.00	47.56	700.00	-	-	21.77	3.73	-	-	-	-
Solar Mars 100 Turbine	8-hour (CO)	60	7.33	69.06	750.00	-	-	7.61	2.68	-	-	-	-
Solar Taurus 70 Turbine		60	6.00	64.54	750.00	-	-	12.19	1.81	-	-	-	-
Solar Titan 130 Turbine		60	9.00	54.56	750.00	-	-	9.10	3.14	-	-	-	-
Solar Centaur 50L Turbine		60	6.00	44.45	700.00	-	-	3.38	1.13	-	-	-	-
Solar Mars 100 Turbine	24-hour ($PM_{2.5}$/PM_{10})	60	7.33	79.73	750.00	-	-	-	-	2.83	2.84	-	-
Solar Taurus 70 Turbine		60	6.00	77.84	750.00	-	-	-	-	1.87	1.87	-	-
Solar Titan 130 Turbine		60	9.00	63.59	750.00	-	-	-	-	3.44	3.44	-	-
Solar Centaur 50L Turbine		60	6.00	54.92	700.00	-	-	-	-	1.20	1.20	-	-
Solar Mars 100 Turbine	1-hr (Formaldehyde)	60	7.33	69.06	750.00	-	-	-	-	-	-	2.56	2.31
Solar Taurus 70 Turbine		60	6.00	64.54	750.00	-	-	-	-	-	-	4.70	1.70
Solar Titan 130 Turbine		60	9.00	54.56	750.00	-	-	-	-	-	-	3.09	2.59
Solar Centaur 50L Turbine		60	6.00	44.45	700.00	-	-	-	-	-	-	1.17	1.02

a - Startup and shutdown are expected to last for 10 minutes each.

b - Startup and shutdown emissions and stack parameters were blended with worst case normal operation emissions and stack parameters for the relevant averaging periods. The properties that were blended together can be found in Table D-4.

c - Emission rates reflect the addition of lb/event (for startup or shutdown) with the normal operation emissions in lb/hr for the duration of the averaging period. For example, the amount of NO_x emitted during 1 hour of startup for the Centaur 50L is equal to 0.3 lbs + (0.72 lb/hr for 50 minutes, or 0.6 lbs) = 0.9 lb/hr.

- Another example: the amount of CO emitted during 8 hours with a shutdown of the Mars 100 is equal to (7 hours * 1.9 lb/hr) + 6.56 lbs + (1.9 lb/hr for 50 minutes, or 1.58 lbs) = 21.44 lb over the 8 hour period, or 2.68 lb/hr.

d - Stack exhaust temperature and exhaust exit velocity are calculated by weighting the duration of the startup/shutdown scenario and the normal operation scenario by the percentage of the averaging periods that each respectively represents. For example, 24 hours with one startup is 0.7% startup and 99.3% normal operations. Therefore, the stack exhaust temperature for the Titan 130 (startup for $PM_{2.5}$/PM_{10}) would be (0.7% * 750° F) + (99.3% * 750° F) = 750° F.

Table D-6 Pigging Scenarios - Stack Parameters and Hexane Emissions[a]

Source	Model ID	Stack Type	Stack Description	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Velocity (ft/s)	Exit Gas Temperature (°F)[b]	Hexane (lb/hr)
Pig Receiver[c]	PIGR	Point	Vertical	7.5	0.2	465.3	Ambient	2.62
Pig Launcher[c]	PIGL	Point	Vertical	7.5	0.2	446.2	Ambient	2.51

a - All ancillary equipment listed in Table D-1 was also included in the pigging scenario modeling

b - Ambient stack temperatures are represented as 0 K in the model

c - Pigging events will only operate between the hours of 6:00 a.m. and 7:00 p.m.

Table D-7 Purging from Startup Scenario - Stack Parameters and Hexane Emissions[a]

Source	Model ID	Stack Type	Stack Description	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Velocity (ft/s)	Exit Gas Temperature (°F)[b]	Hexane (lb/hr)
Solar Centaur 50L Turbine Vent Stack	UNT1	Point	Capped Vertical	21	2.0	5.8	Ambient	0.08
Solar Taurus 70 Turbine Vent Stack	UNT2	Point	Capped Vertical	26	2.3	7.3	Ambient	0.13
Solar Mars 100 Turbine Vent Stack	UNT3	Point	Capped Vertical	21	4.0	5.0	Ambient	0.27
Solar Titan 130 Turbine Vent Stack	UNT4	Point	Capped Vertical	21	4.0	5.4	Ambient	0.29

a - All ancillary equipment listed in Table D-1 was also included in the startup scenario modeling

b - Ambient stack temperatures are represented as 0 K in the model

Table D-8 Blowdown from Shutdown Scenario - Stack Parameters and Hexane Emissions[a]

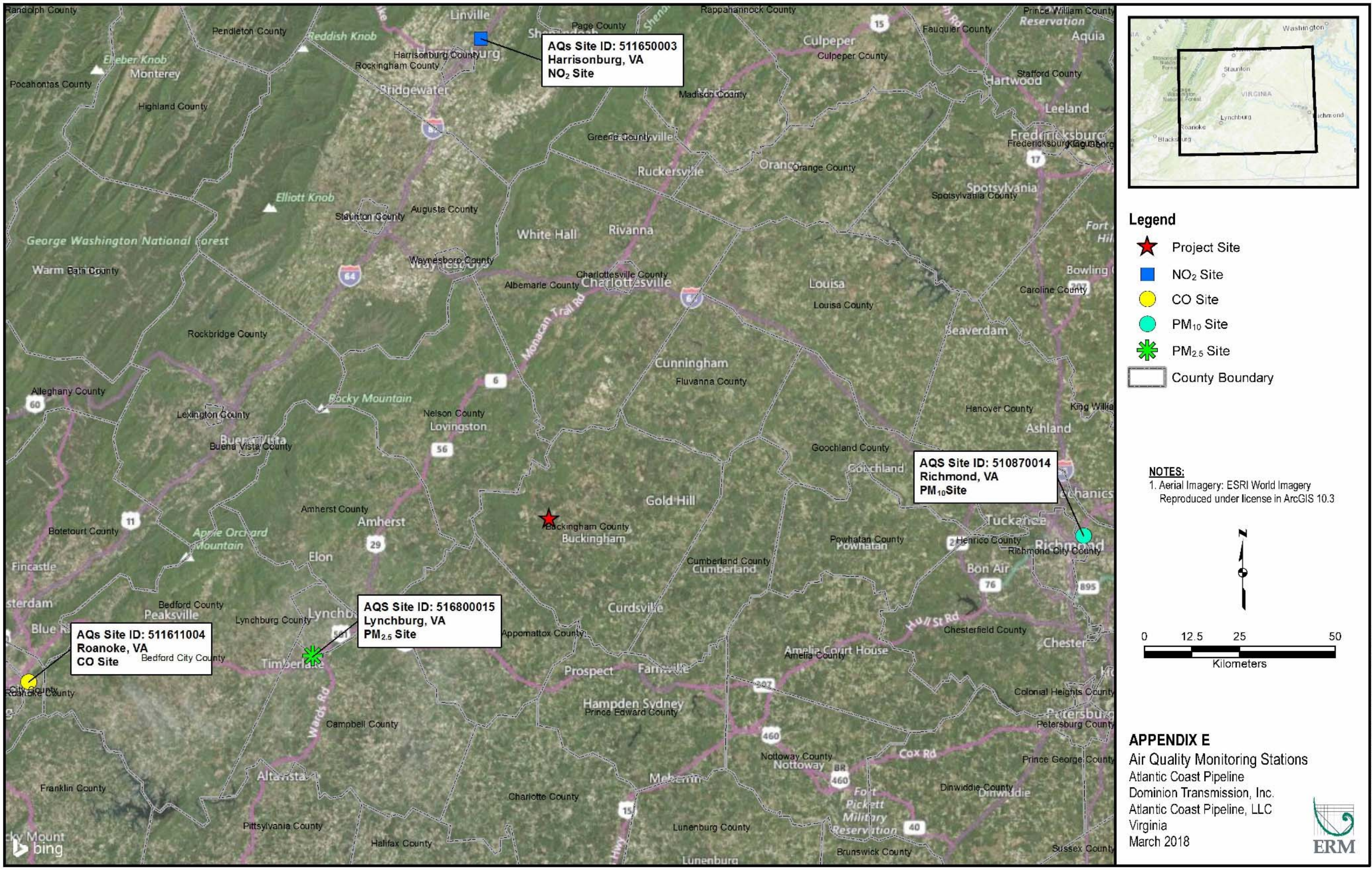
Source	Model ID	Stack Type	Stack Description	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Velocity (ft/s)	Exit Gas Temperature (°F)[b]	Hexane (lb/hr)
Solar Centaur 50L Turbine Vent Stack	UNT1	Point	Capped Vertical	21	2.0	13.8	Ambient	0.19
Solar Taurus 70 Turbine Vent Stack	UNT2	Point	Capped Vertical	26	2.3	20.0	Ambient	0.37
Solar Mars 100 Turbine Vent Stack	UNT3	Point	Capped Vertical	21	4.0	16.0	Ambient	0.87
Solar Titan 130 Turbine Vent Stack	UNT4	Point	Capped Vertical	21	4.0	17.8	Ambient	0.96

a - All ancillary equipment listed in Table D-1 was also included in the shutdown scenario modeling

b - Ambient stack temperatures are represented as 0 K in the model

Regional Air Quality Monitoring Locations

Appendix E



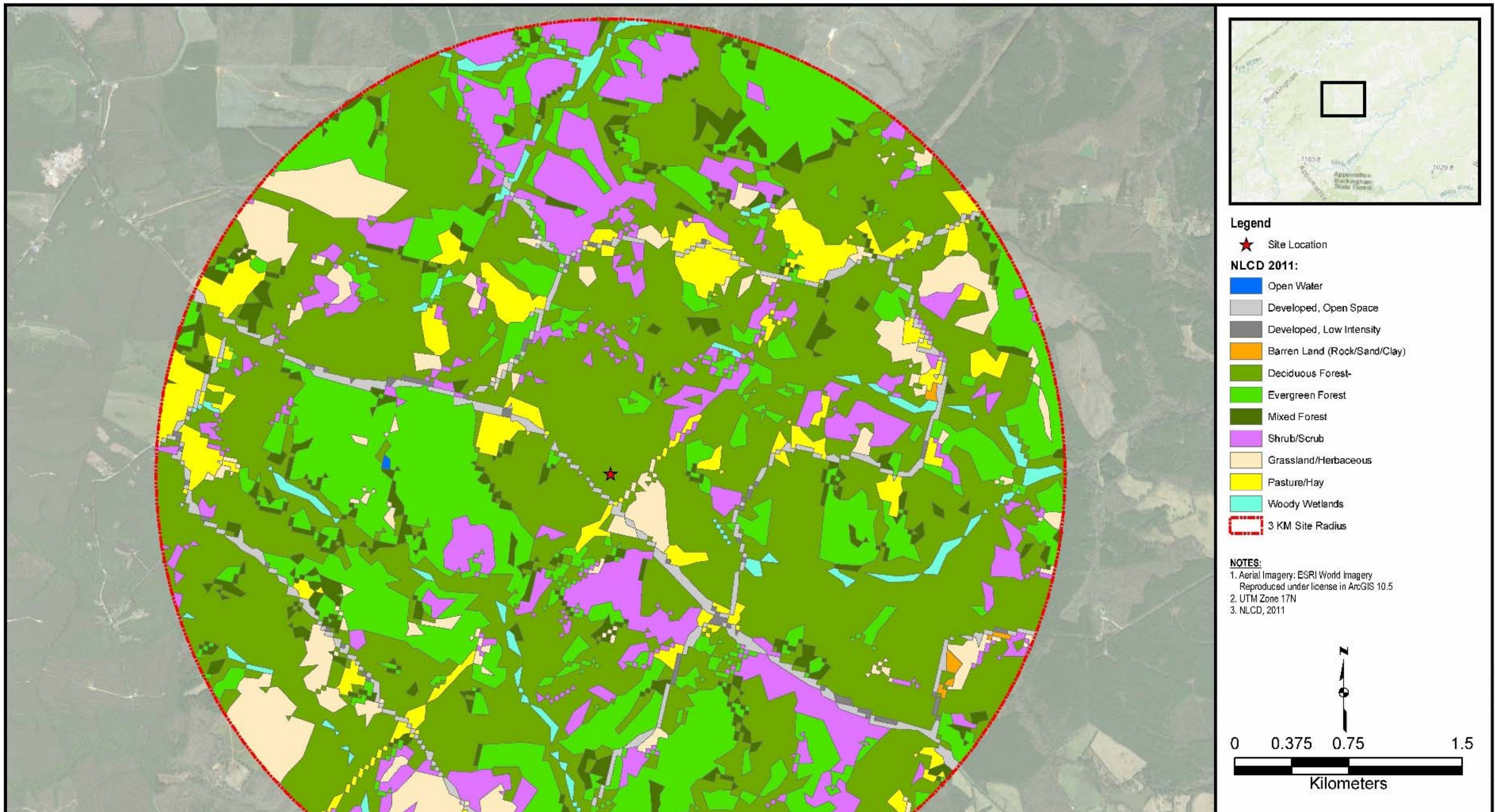
NOTES:
1. Aerial Imagery: ESRI World Imagery
Reproduced under license in ArcGIS 10.3

APPENDIX E
Air Quality Monitoring Stations
Atlantic Coast Pipeline
Dominion Transmission, Inc.
Atlantic Coast Pipeline, LLC
Virginia
March 2018

ERM

Land Use Analysis

Appendix F



NOTES:
1. Aerial Imagery: ESRI World Imagery
   Reproduced under license in ArcGIS 10.5
2. UTM Zone 17N
3. NLCD, 2011

APPENDIX F
NLCD 2011 Landuse Map
Dominion Transmission, Inc.
Atlantic Coast Pipeline, LLC
Buckingham County, Virginia
March 2018

ACP - Buckingham Site, Virginia			
NLCD 2011 (3KM Radius)			
Grid Code	**Grid Code Description**	**Acres**	**% Total**
11	Open water	1.01	0.01%
21	Developed, Open Space	169.12	2.42%
22	Developed, Low Intensi	24.41	0.35%
31	Barren Land	6.73	0.10%
41	Deciduous Forest	3410.61	48.84%
42	Evergreen Forest	1497.83	21.45%
43	Mixed Forest	293.76	4.21%
52	Shrub/Scrub	709.44	10.16%
71	Grassland/Herbaceous	417.15	5.97%
81	Pasture/Hay	349.61	5.01%
90	Woody Wetlands	103.84	1.49%
TOTAL		**6983.50**	**100.00%**

***UTM Zone 17 N**

Offsite Inventory

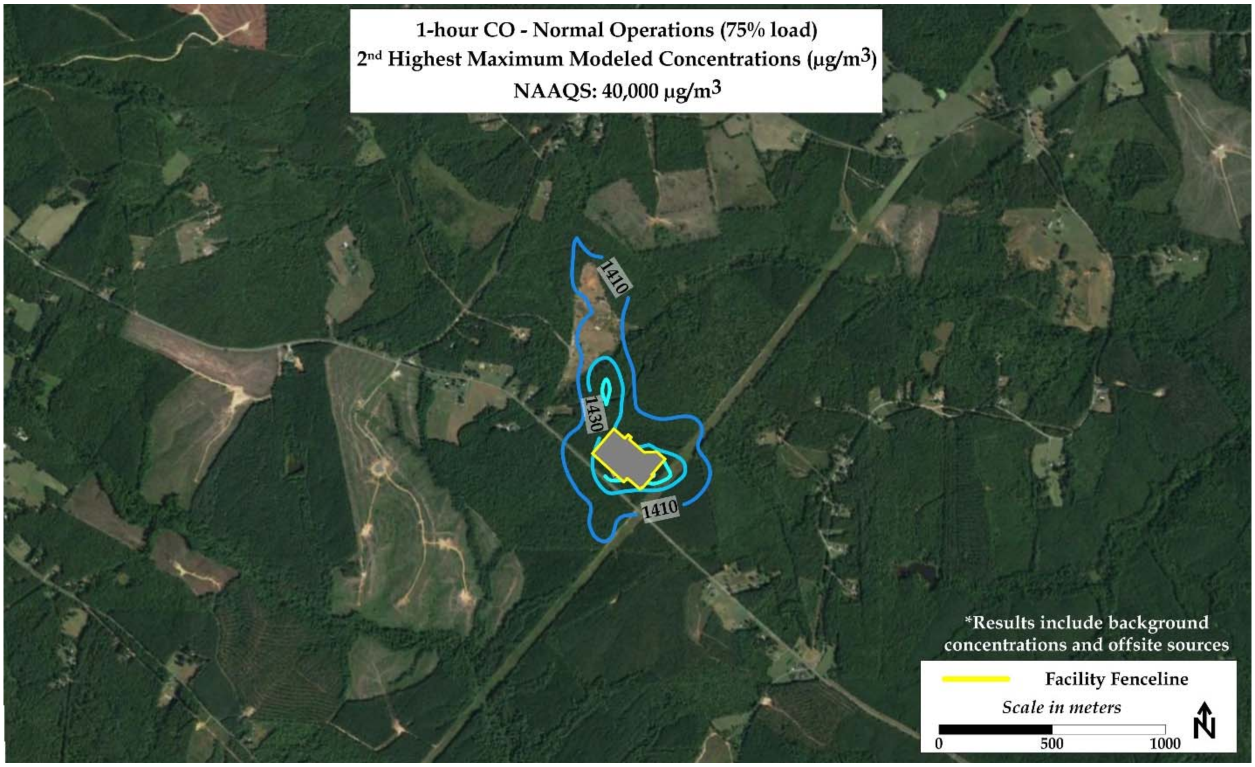
Appendix G

Facility	Source	Distance from Project Site (km)	Model ID	Stack Height (ft)	Exit Diameter (ft)	Exit Gas Velocity (ft/s)	Exit Gas Temperature (°F)	Pollutant Emission Rates[a]							
								NO_X (lb/hr)	NO_X (TPY)	CO (lb/hr)	CO (TPY)	$PM_{2.5}$ (lb/hr)	$PM_{2.5}$ (TPY)	PM_{10} (lb/hr)	PM_{10} (TPY)
Kyanite Mining Corp Mullite Plant	(2) Rotary Kiln Calciners	19.6	KMC_MP	70	1.67	49.0	289	2.19	9.6	0.2	1.1	0.14	0.6	1.41	6.17
Greif Packaging LLC	Boilers - North and South	23.8	GPL_01	100	9.0	19.4	400	9.02	39.5	7.8	34.0	0.70	3.1	0.70	3.07
Greif Packaging LLC	Boilers - North and South	23.8	GPL_02	100	9.0	19.4	400	9.02	39.5	7.8	34.0	0.70	3.1	0.70	3.07
Greif Packaging LLC	BLR03 Spare Boiler	23.8	GPL_03	51	4.5	45.1	400	0.31	1.4	0.3	1.1	0.02	0.1	0.02	0.10
Greif Packaging LLC	BLR03 Spare Boiler	23.8	GPL_04	51	4.5	45.1	400	0.31	1.4	0.3	1.1	0.02	0.1	0.02	0.10
Greif Packaging LLC	BLR05 Mixed Fuel Boiler	23.8	GPL_05	100	6.0	70.2	363	59.45	260.4	62.1	271.9	2.96	12.9	2.96	12.95
Greif Packaging LLC	BLR05 Mixed Fuel Boiler	23.8	GPL_06	100	6.0	70.2	363	59.45	260.4	62.1	271.9	2.96	12.9	2.96	12.95
Greif Packaging LLC	BLR05 Mixed Fuel Boiler	23.8	GPL_07	100	6.0	70.2	363	59.45	260.4	62.1	271.9	2.96	12.9	2.96	12.95
Greif Packaging LLC	CR05 Recovery Boiler	23.8	GPL_08	100	6.5	37.2	400	27.21	119.2	43.8	191.7	3.28	14.4	3.28	14.38
Greif Packaging LLC	CR05 Recovery Boiler	23.8	GPL_09	100	6.5	37.2	400	0.0	0.0	0.0	0.0	3.28	14.4	3.28	14.38
Buckingham Correctional Center	(3) Coal Boilers	16.4	BCC_01	8	2.8	11.5	500	0.92	4.0	1.1	4.7	0.37	1.6	0.60	2.62
Buckingham Correctional Center	(3) Coal Boilers	16.4	BCC_02	8	2.8	11.5	500	0.92	4.0	1.1	4.7	0.37	1.6	0.60	2.62
Buckingham Correctional Center	(3) Coal Boilers	16.4	BCC_03	8	2.8	11.5	500	0.92	4.0	1.1	4.7	0.37	1.6	0.60	2.62
Buckingham Correctional Center	Adhesive Spray Booth	16.4	BCC_04	20	2.8	50.9	70	0.0	0.0	0.0	0.0	0.14	0.6	0.14	0.60
Kyanite Mining Corporation Willis	East Ridge Dryer and Cooler	21.0	KMC_W1	50	3.0	58.0	143	2.85	12.5	6.0	26.3	0.21	0.9	0.28	1.25
Kyanite Mining Corporation Willis	Willis Mountain Kyanite Dryer and Cooler	21.0	KMC_W2	40	2.5	27.1	116	0.37	1.6	2.7	12.0	0.06	0.3	0.08	0.35
Kyanite Mining Corporation Willis	Willis Mountain Quartz Dryer	21.0	KMC_W3	20	2.1	8.2	62	0.007	0.0	0.1	0.4	0.01	0.1	0.02	0.08
Kyanite Mining Corporation Willis	Diesel Engine	21.0	KMC_W4	20	1.0	212.2	300	0.48	2.1	0.0001	0.0005	0.00004	0.0002	0.00004	0.0002

a - Offsite source emission rates are from VADEQ 2016 inventory, release point actual emissions in TPY

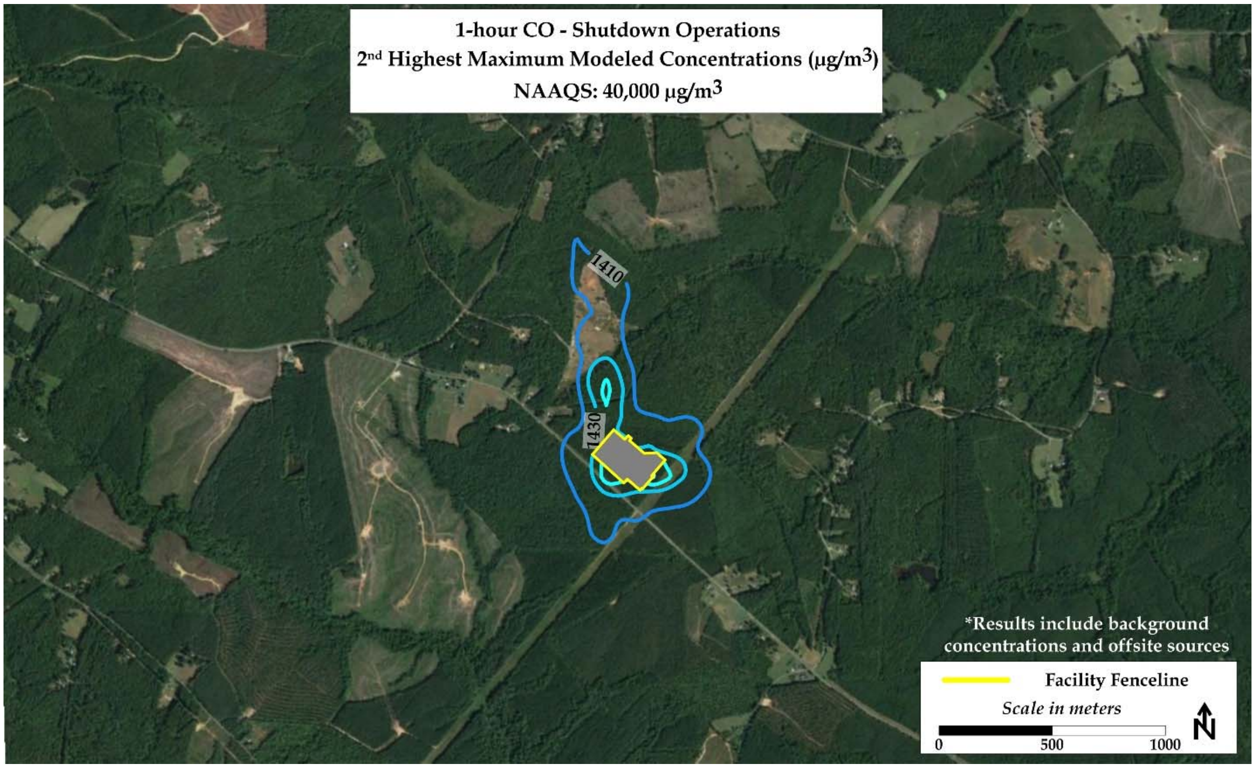
Contours of Worst Case Modeled Concentrations

Appendix H



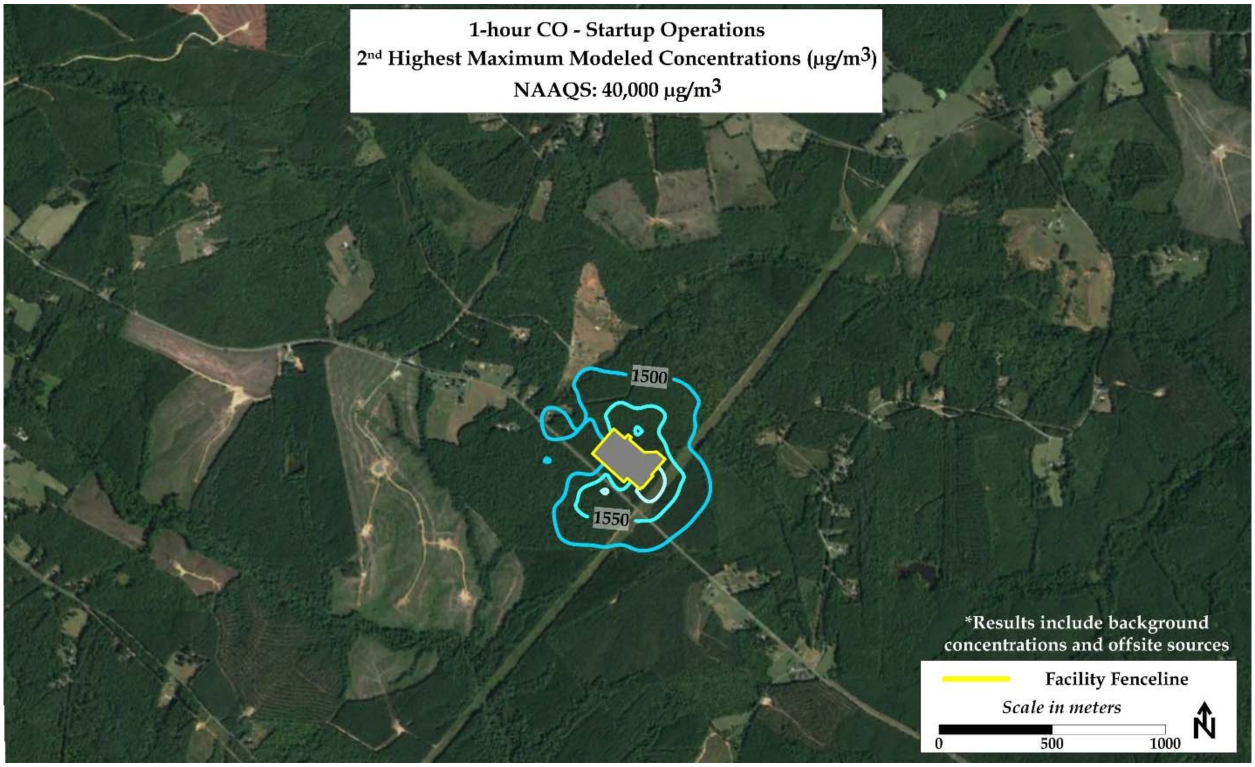
1-hour CO - Normal Operations (75% load)
2nd Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 40,000 μg/m^3

*Results include background concentrations and offsite sources



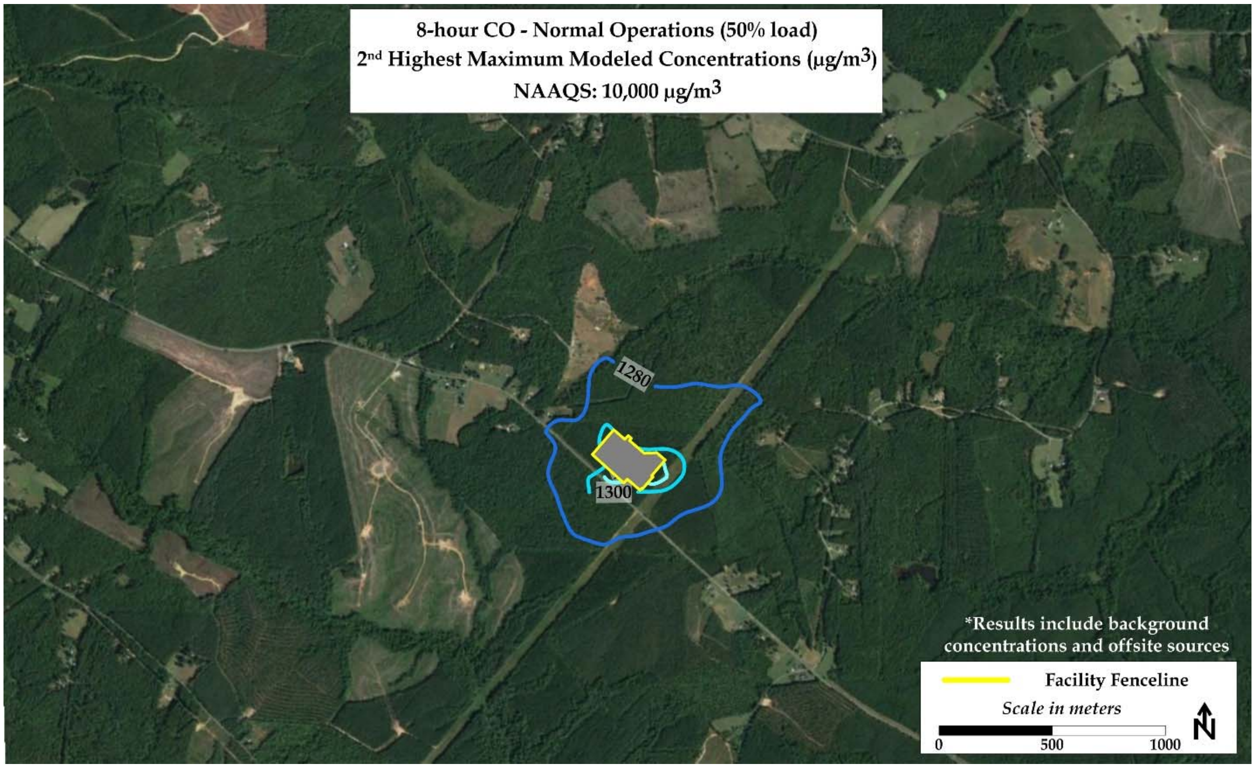
1-hour CO - Shutdown Operations
2nd Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 40,000 μg/m^3

*Results include background concentrations and offsite sources



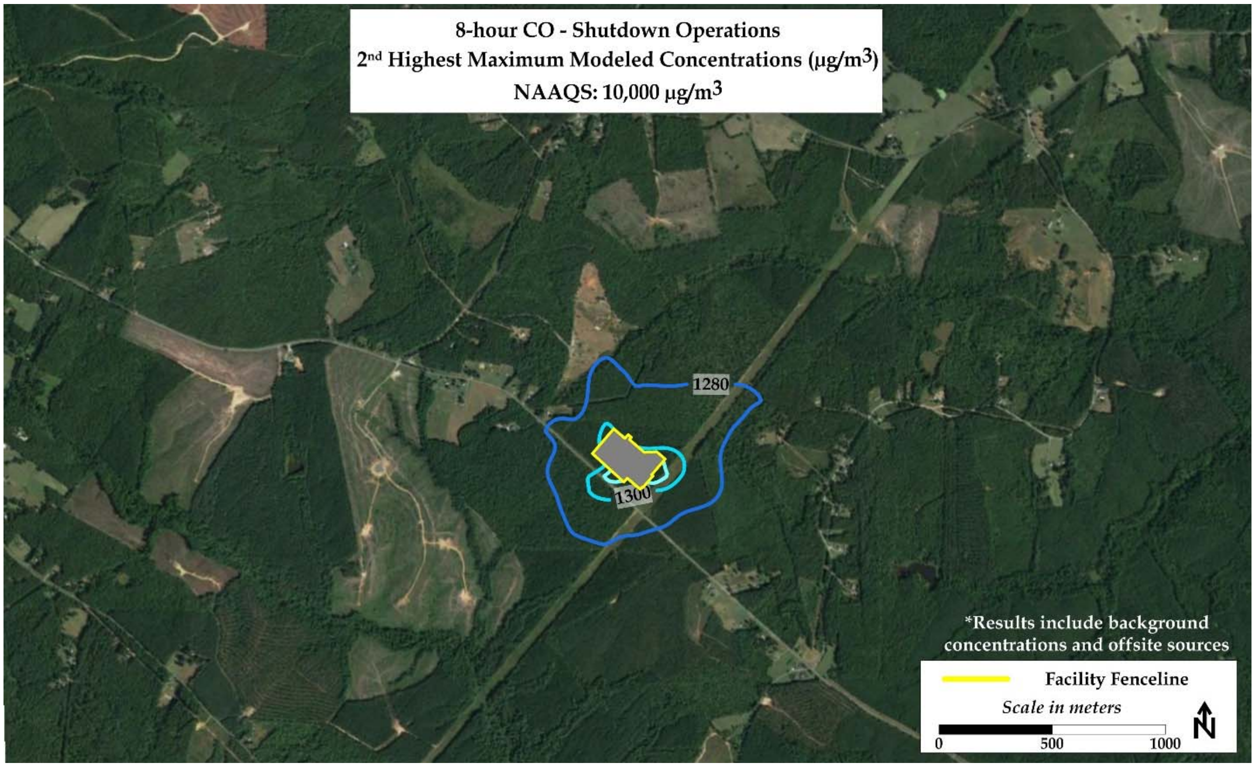
1-hour CO - Startup Operations
2nd Highest Maximum Modeled Concentrations (μg/m3)
NAAQS: 40,000 μg/m3

*Results include background concentrations and offsite sources

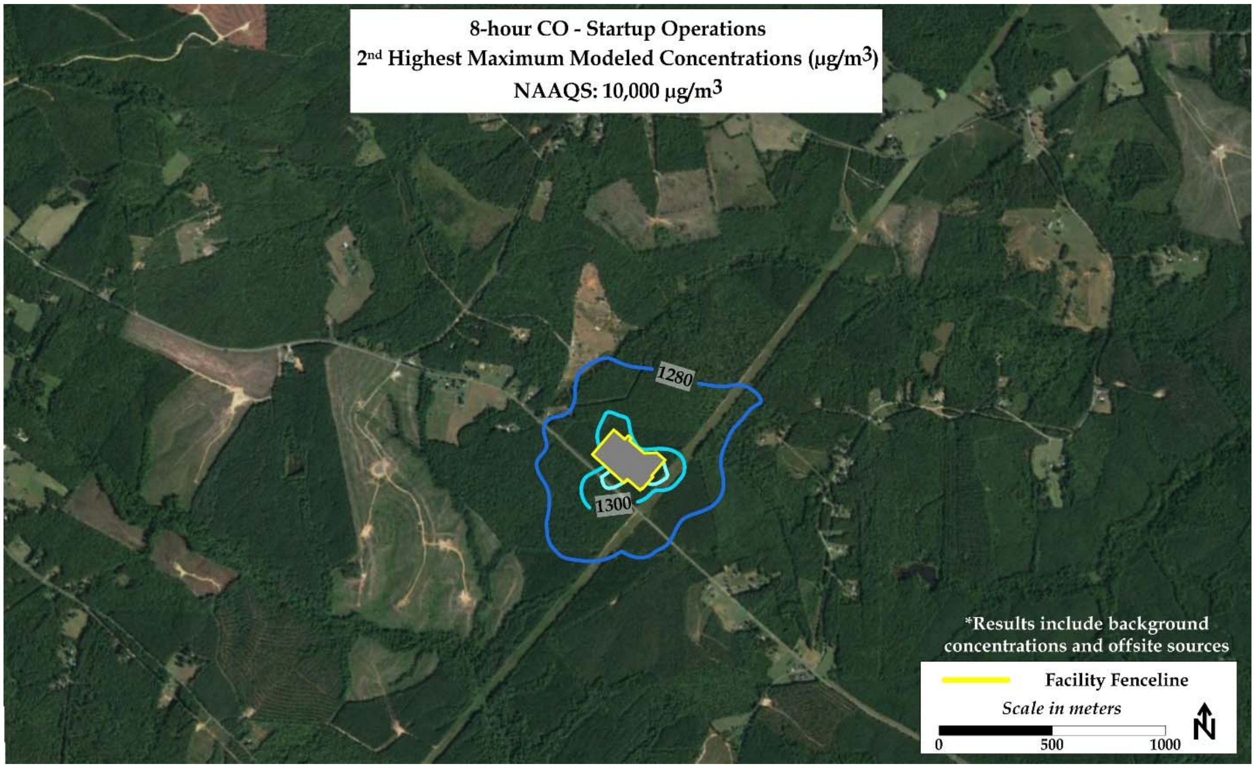


8-hour CO - Normal Operations (50% load)
2nd Highest Maximum Modeled Concentrations (μg/m3)
NAAQS: 10,000 μg/m3

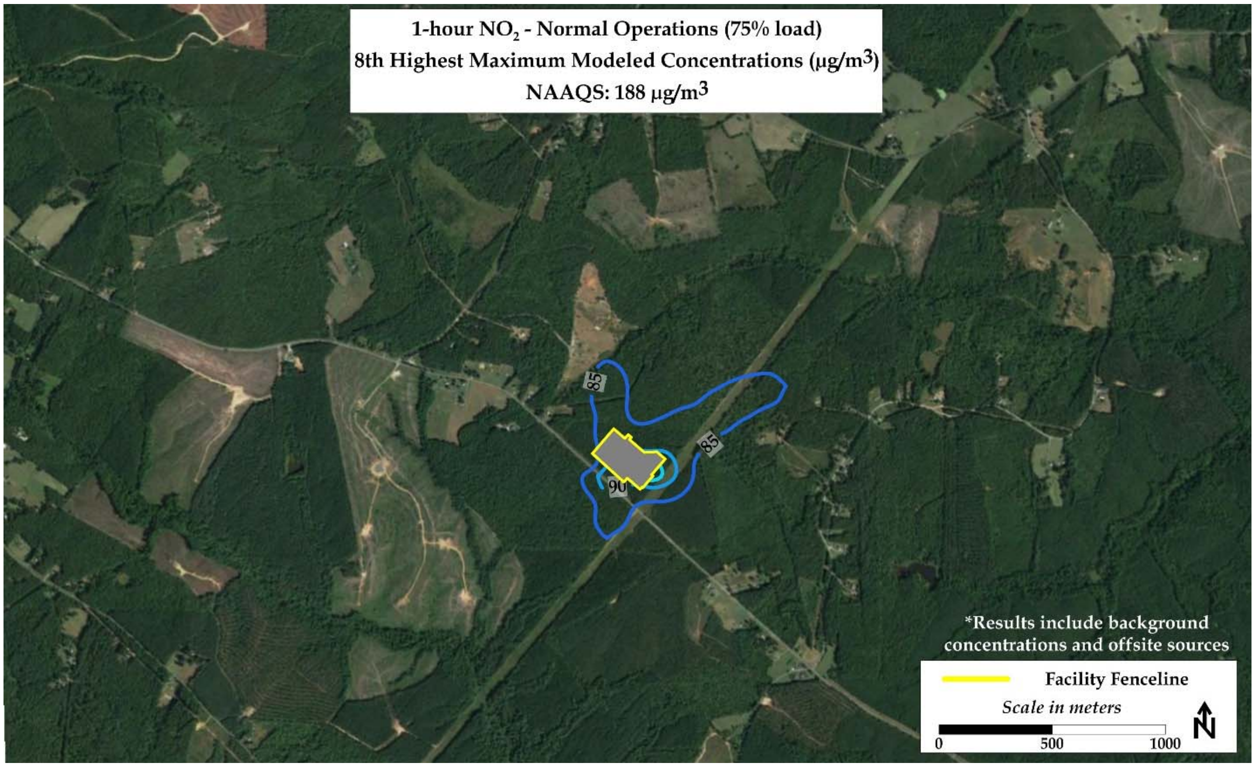
*Results include background concentrations and offsite sources



8-hour CO - Shutdown Operations
2nd Highest Maximum Modeled Concentrations (μg/m³)
NAAQS: 10,000 μg/m³

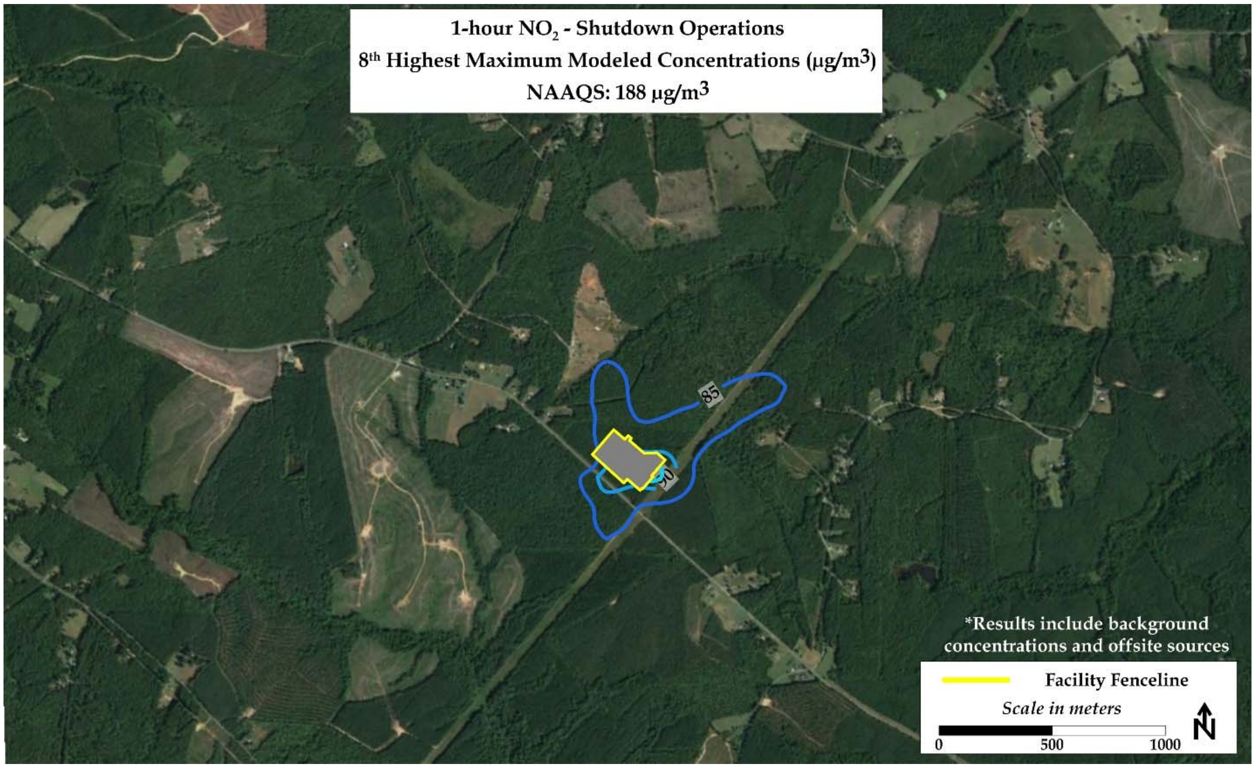


8-hour CO - Startup Operations
2nd Highest Maximum Modeled Concentrations (μg/m³)
NAAQS: 10,000 μg/m³



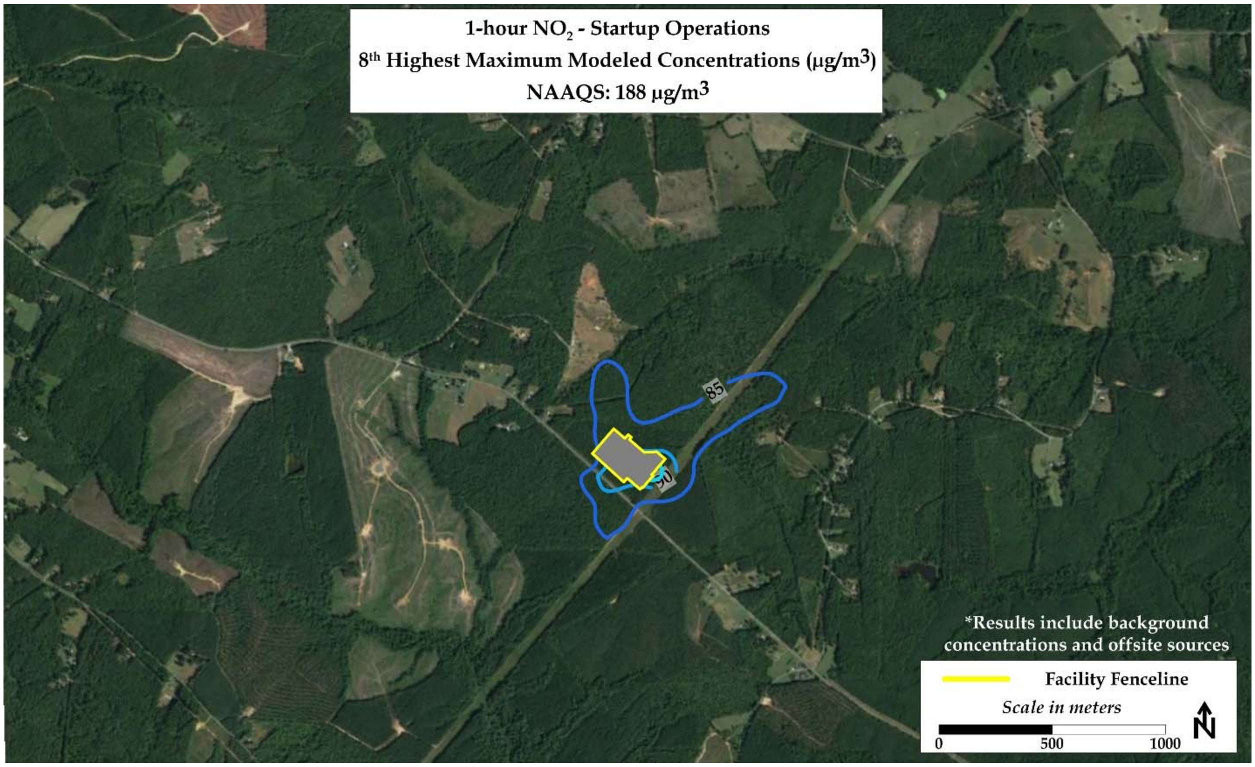
1-hour NO_2 - Normal Operations (75% load)
8th Highest Maximum Modeled Concentrations (µg/m^3)
NAAQS: 188 µg/m^3

*Results include background concentrations and offsite sources



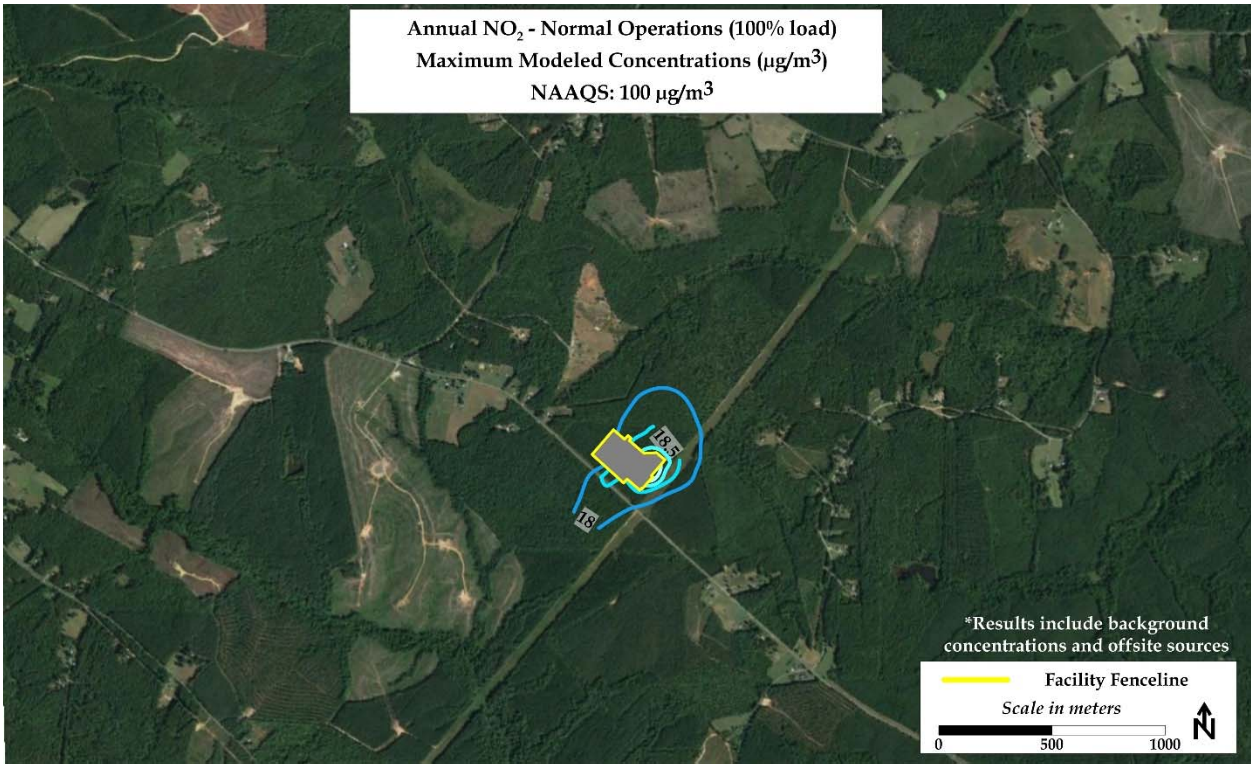
1-hour NO_2 - Shutdown Operations
8th Highest Maximum Modeled Concentrations (µg/m^3)
NAAQS: 188 µg/m^3

*Results include background concentrations and offsite sources



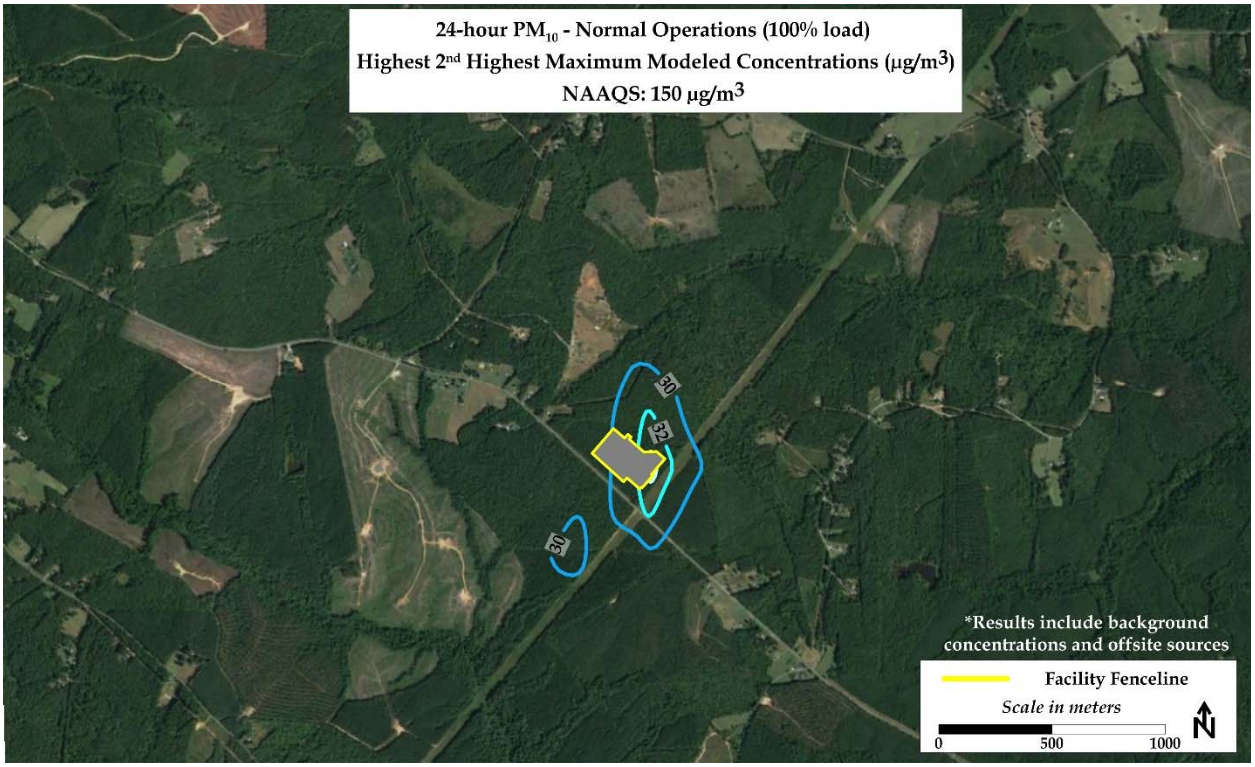
1-hour NO_2 - Startup Operations
8th Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 188 μg/m^3

*Results include background concentrations and offsite sources



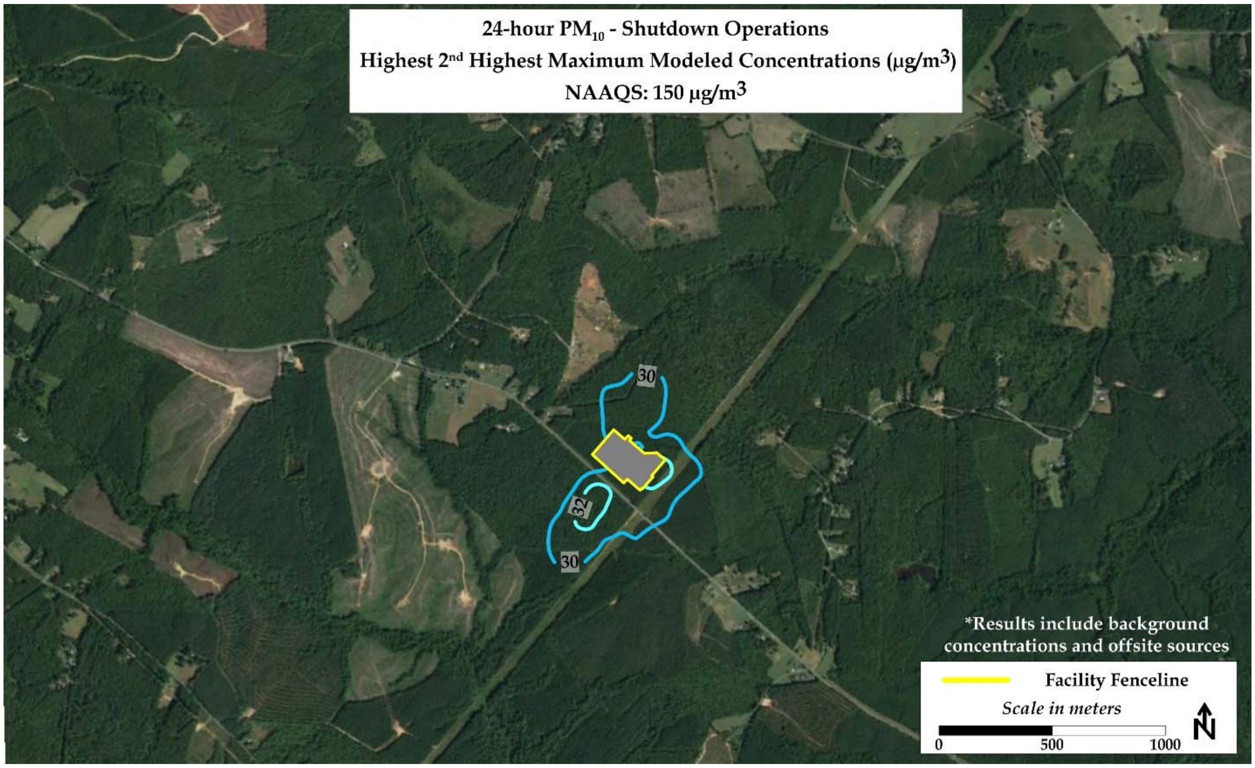
Annual NO_2 - Normal Operations (100% load)
Maximum Modeled Concentrations (μg/m^3)
NAAQS: 100 μg/m^3

*Results include background concentrations and offsite sources



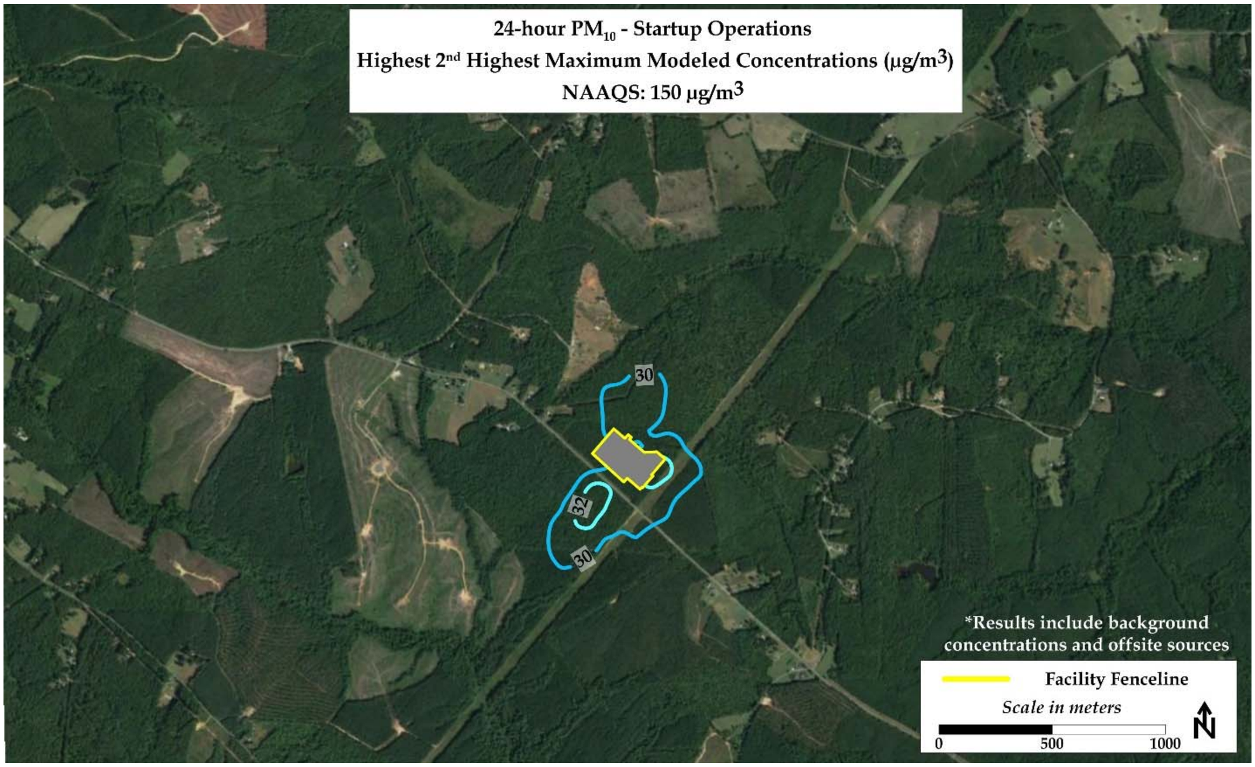
24-hour PM_{10} - Normal Operations (100% load)
Highest 2nd Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 150 μg/m^3

*Results include background concentrations and offsite sources



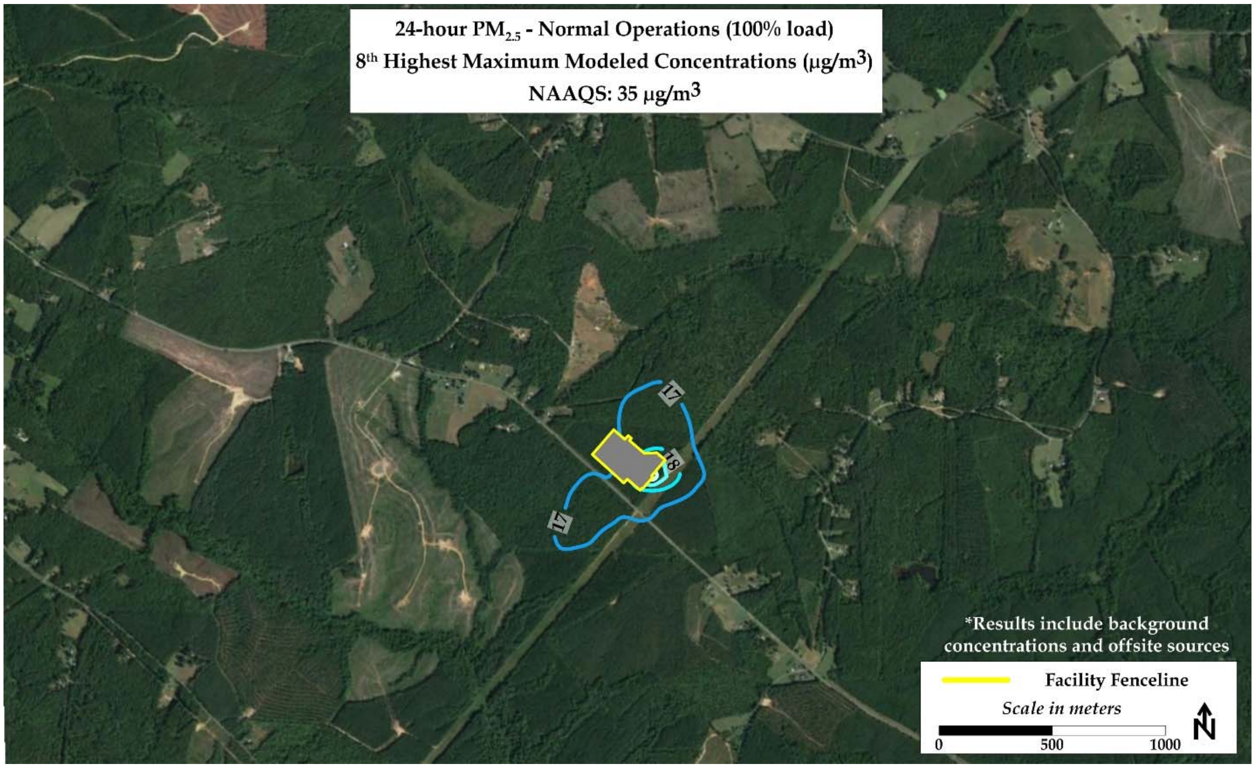
24-hour PM_{10} - Shutdown Operations
Highest 2nd Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 150 μg/m^3

*Results include background concentrations and offsite sources



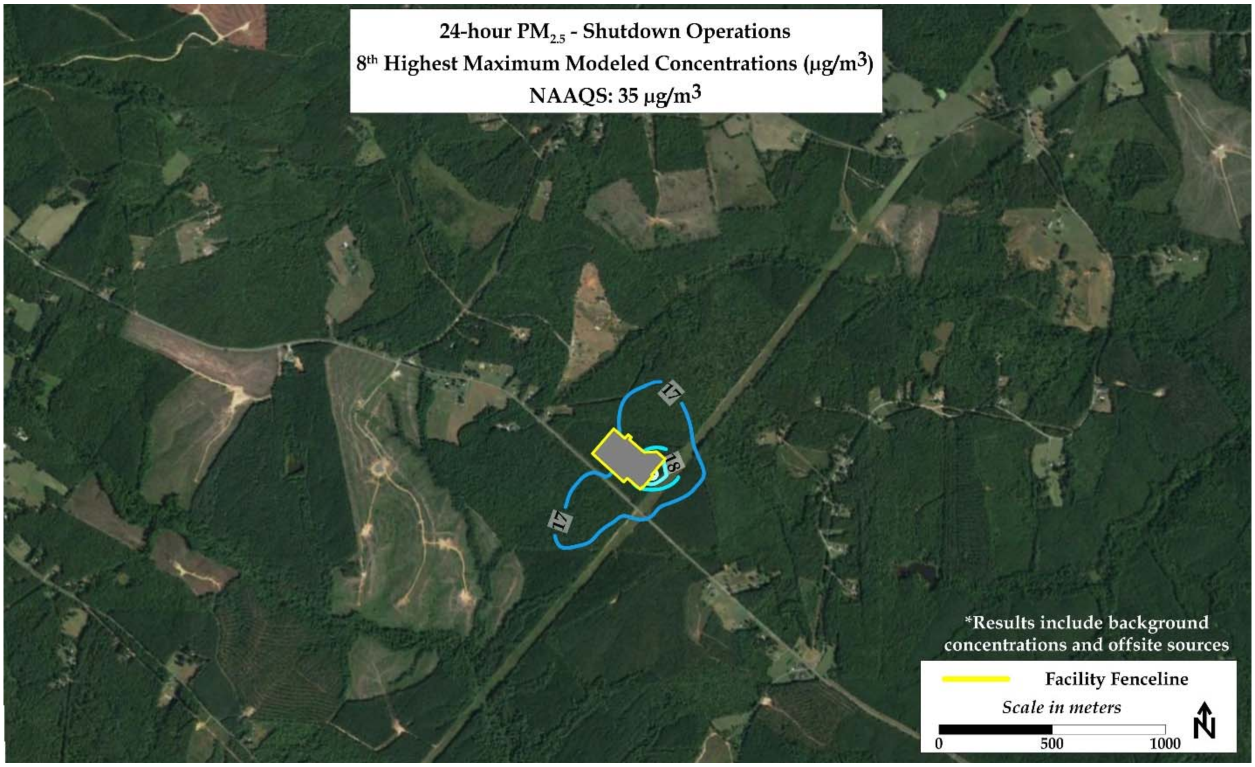
24-hour PM_{10} - Startup Operations
Highest 2nd Highest Maximum Modeled Concentrations (µg/m^3)
NAAQS: 150 µg/m^3

*Results include background concentrations and offsite sources

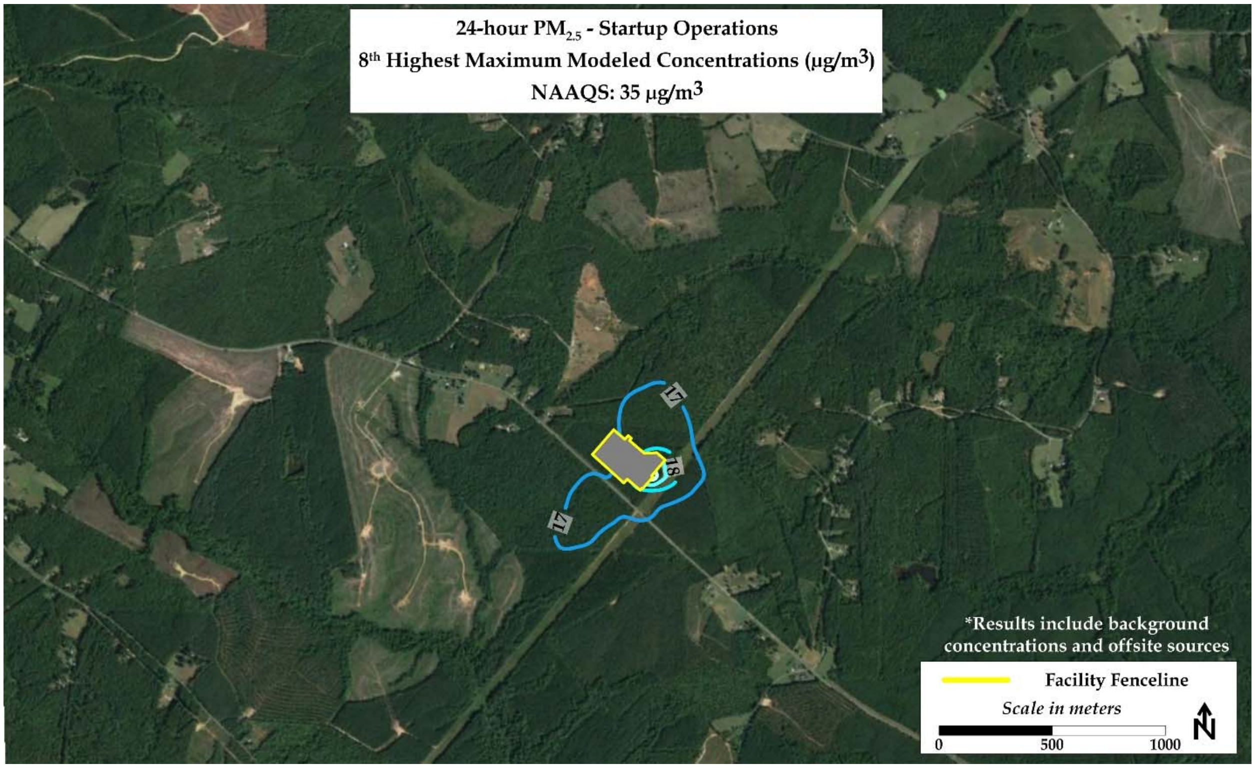


24-hour $PM_{2.5}$ - Normal Operations (100% load)
8th Highest Maximum Modeled Concentrations (µg/m^3)
NAAQS: 35 µg/m^3

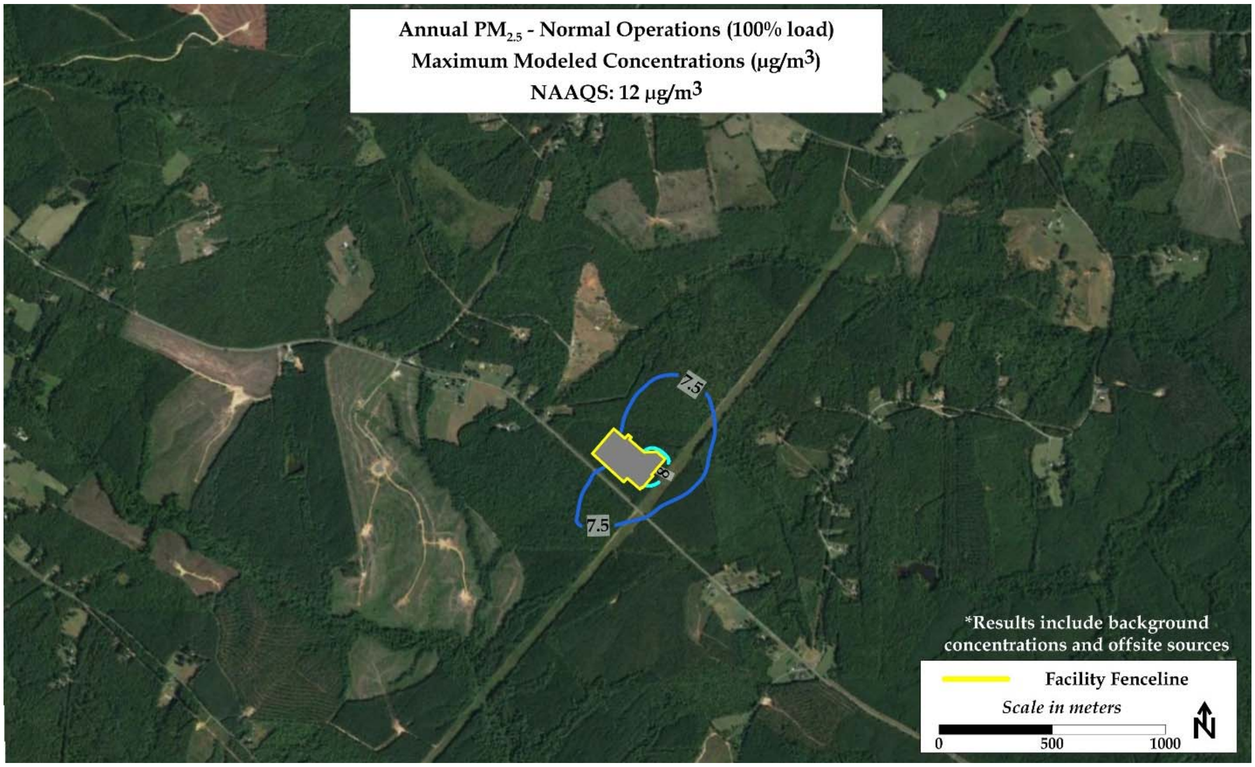
*Results include background concentrations and offsite sources



24-hour $PM_{2.5}$ - Shutdown Operations
8th Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 35 μg/m^3

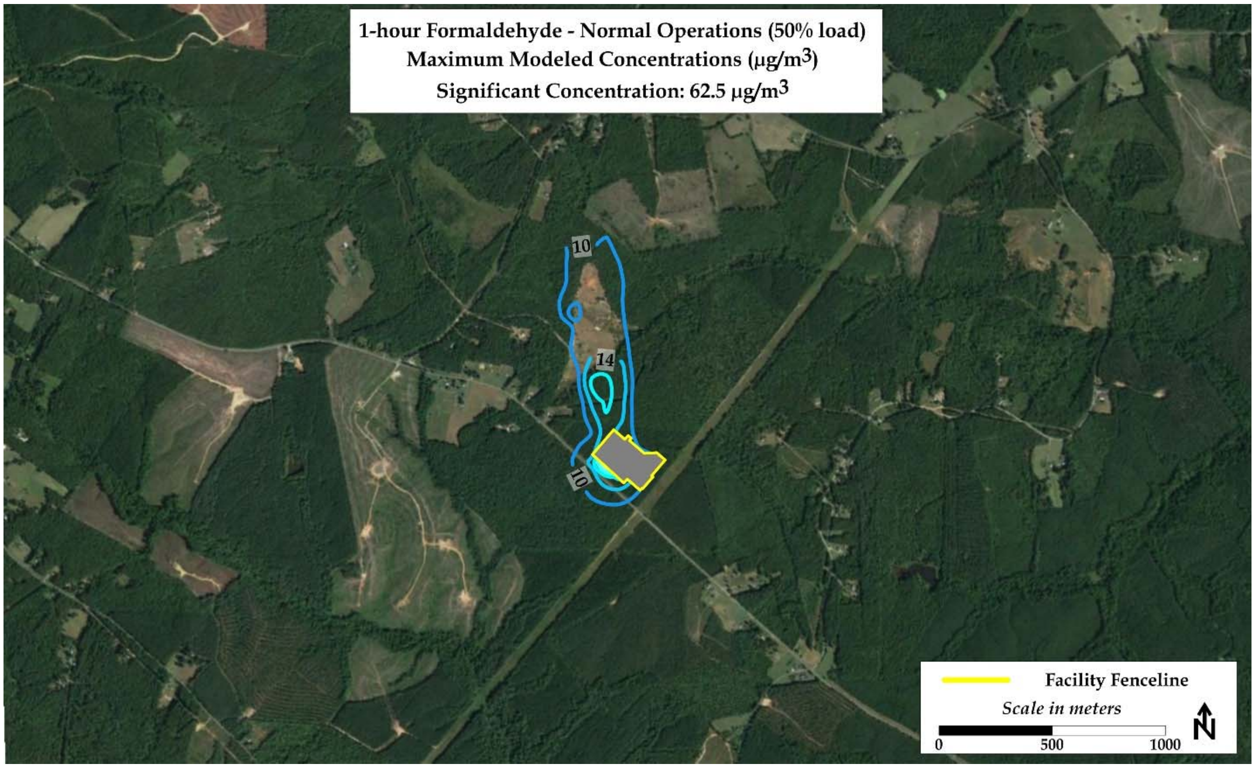


24-hour $PM_{2.5}$ - Startup Operations
8th Highest Maximum Modeled Concentrations (μg/m^3)
NAAQS: 35 μg/m^3

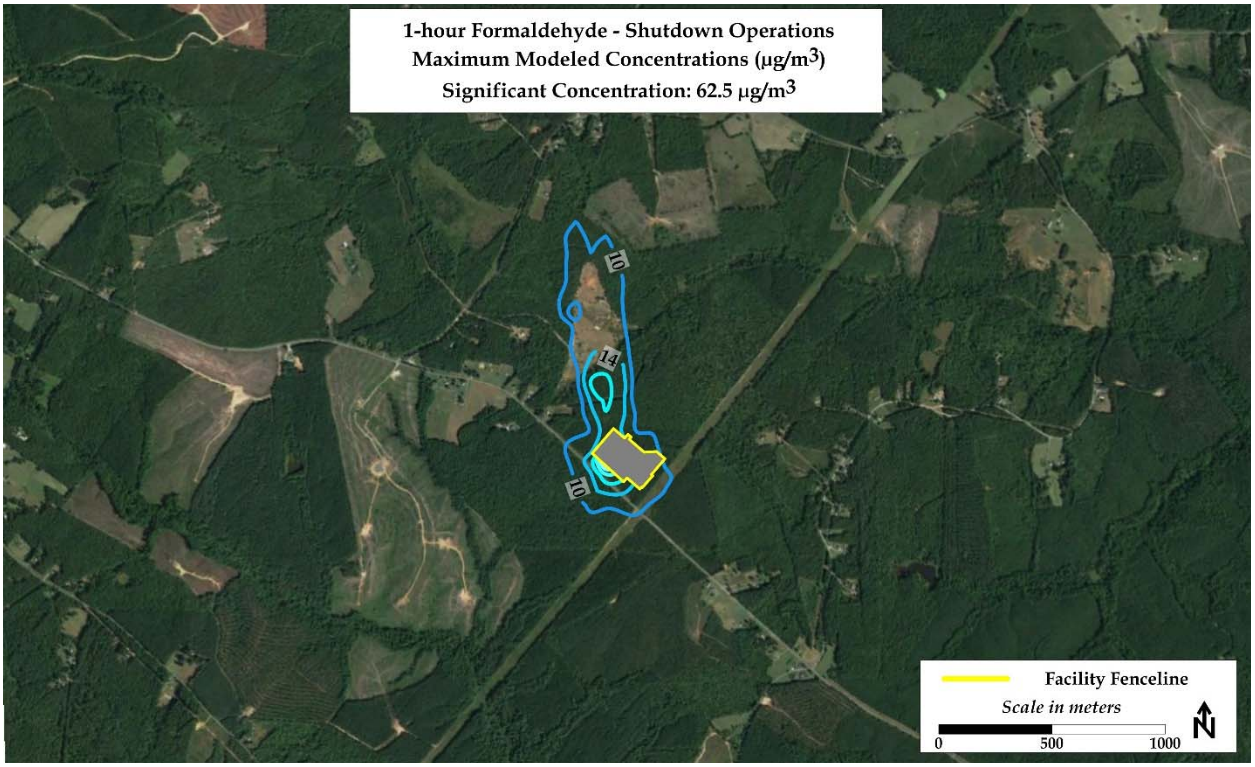


Annual $PM_{2.5}$ - Normal Operations (100% load)
Maximum Modeled Concentrations ($\mu g/m^3$)
NAAQS: 12 $\mu g/m^3$

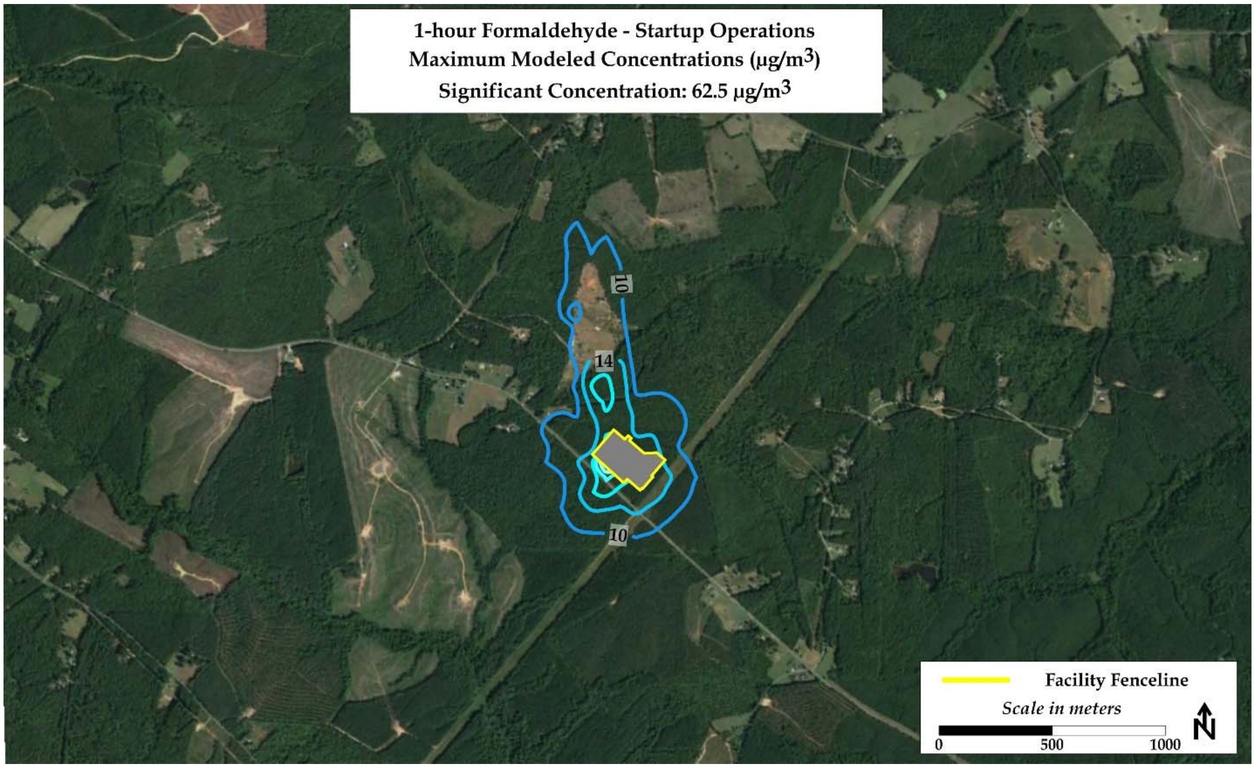
*Results include background concentrations and offsite sources



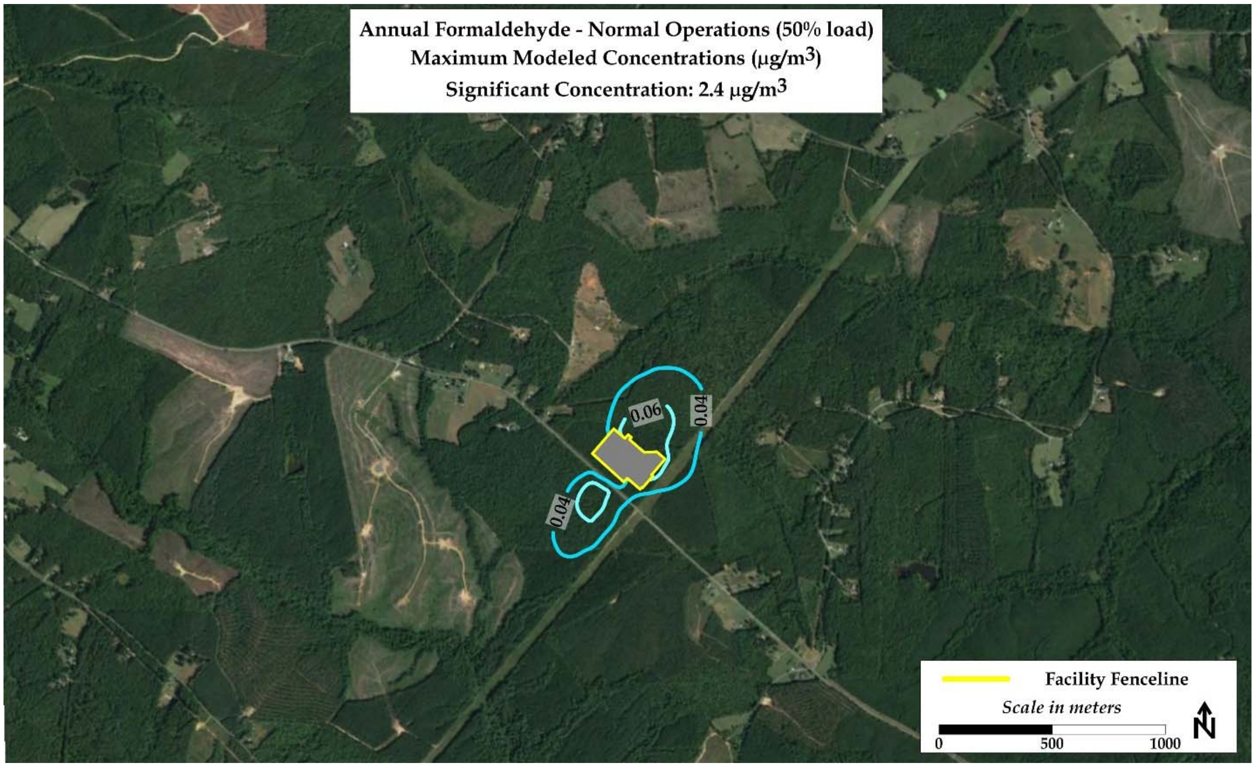
1-hour Formaldehyde - Normal Operations (50% load)
Maximum Modeled Concentrations ($\mu g/m^3$)
Significant Concentration: 62.5 $\mu g/m^3$



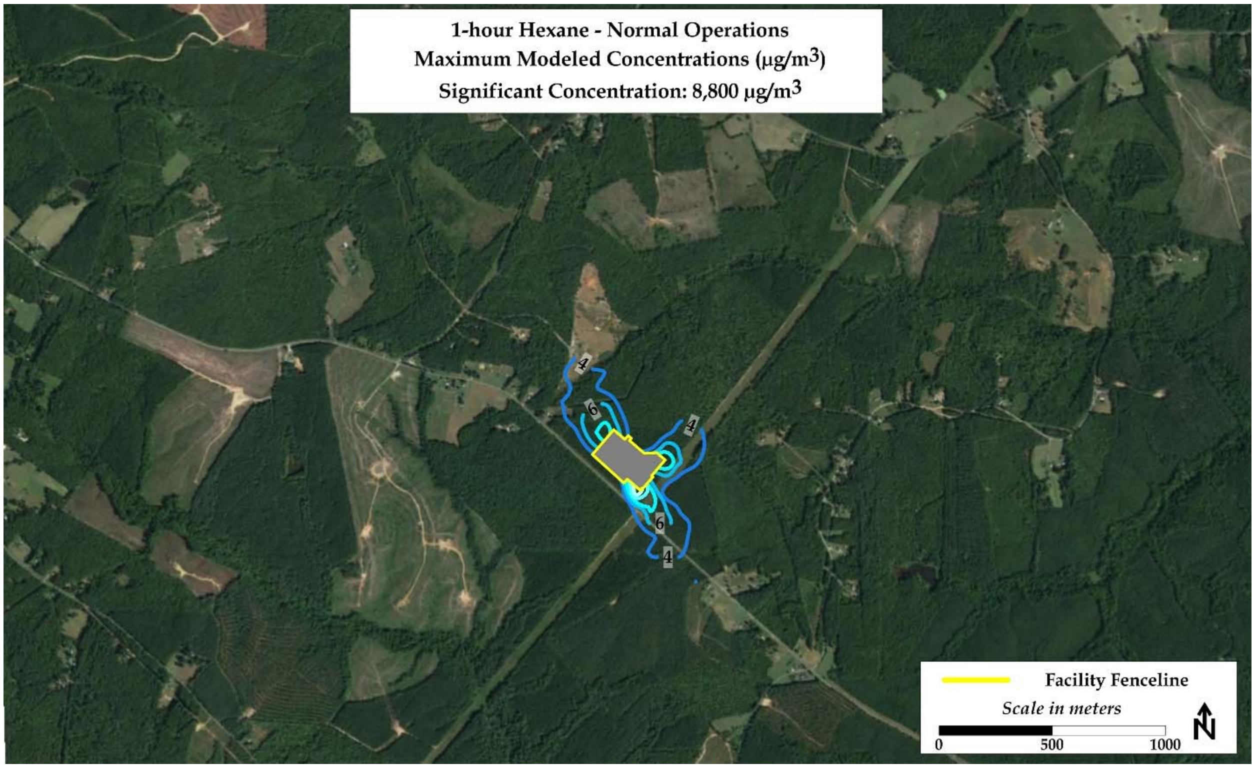
1-hour Formaldehyde - Shutdown Operations
Maximum Modeled Concentrations (μg/m^3)
Significant Concentration: 62.5 μg/m^3



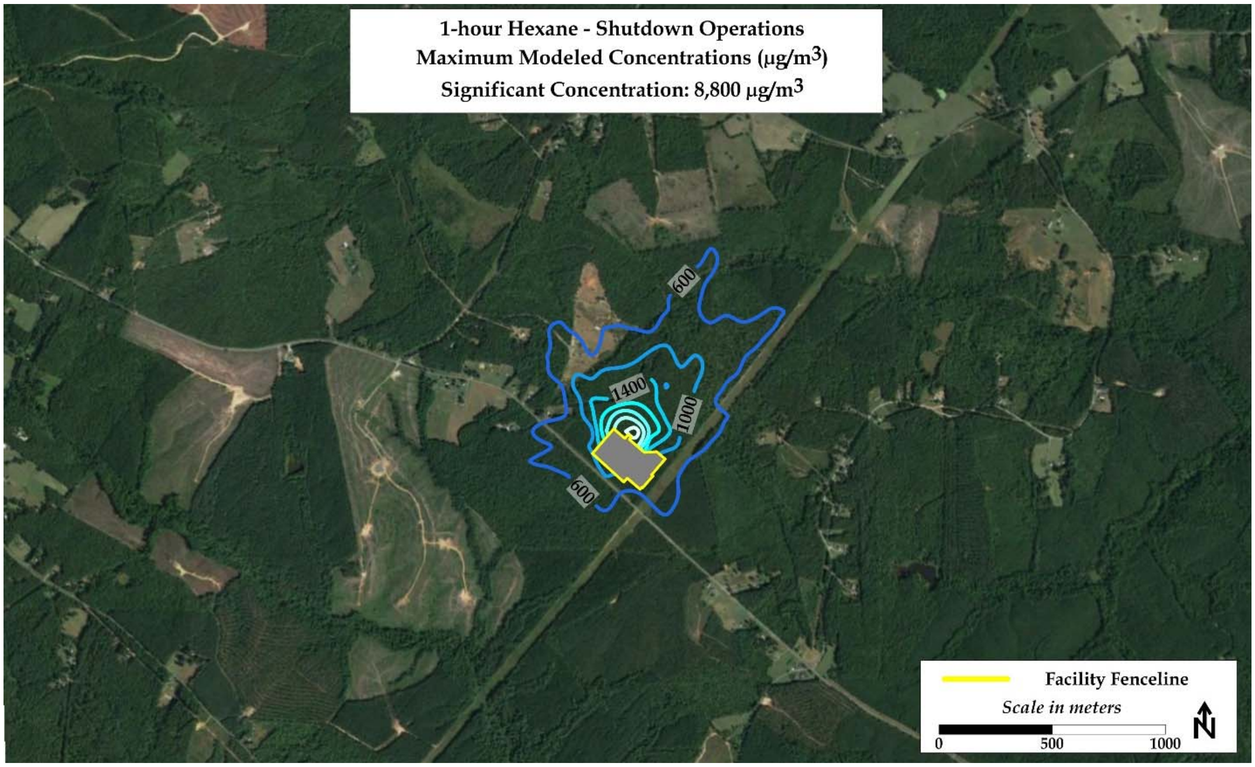
1-hour Formaldehyde - Startup Operations
Maximum Modeled Concentrations (μg/m^3)
Significant Concentration: 62.5 μg/m^3

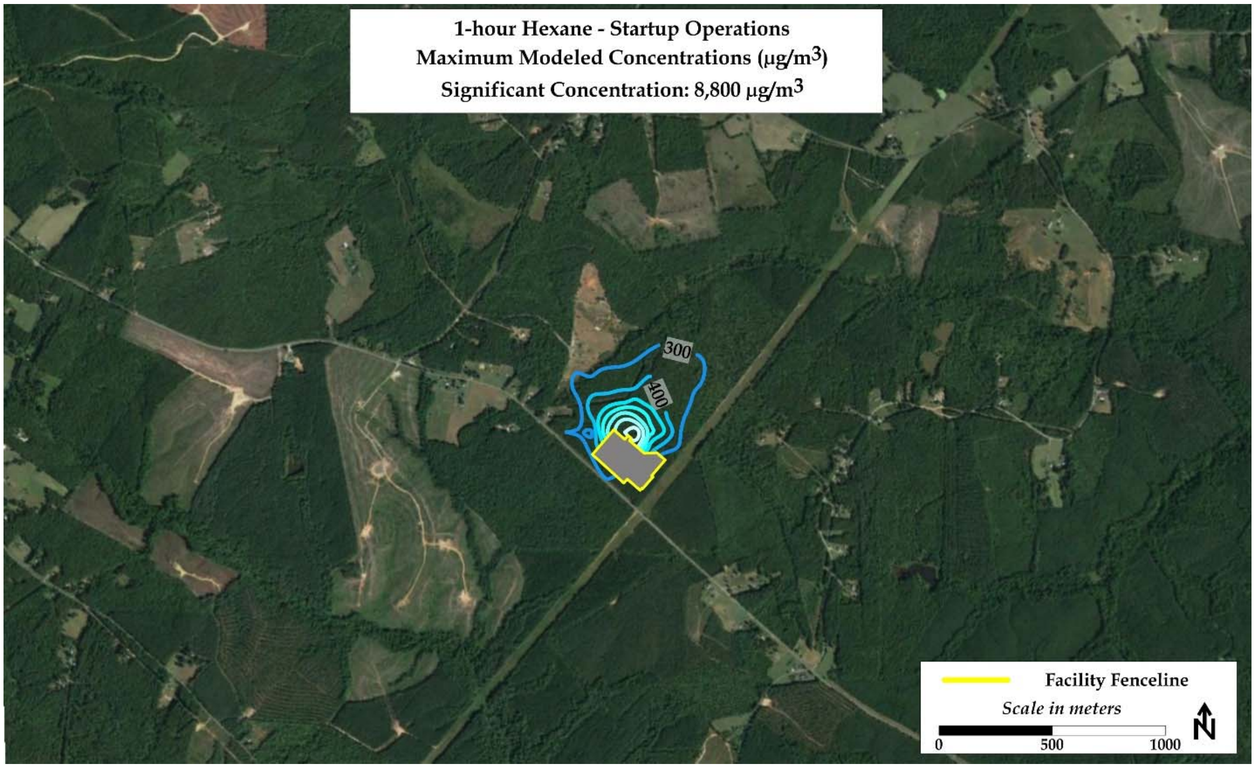


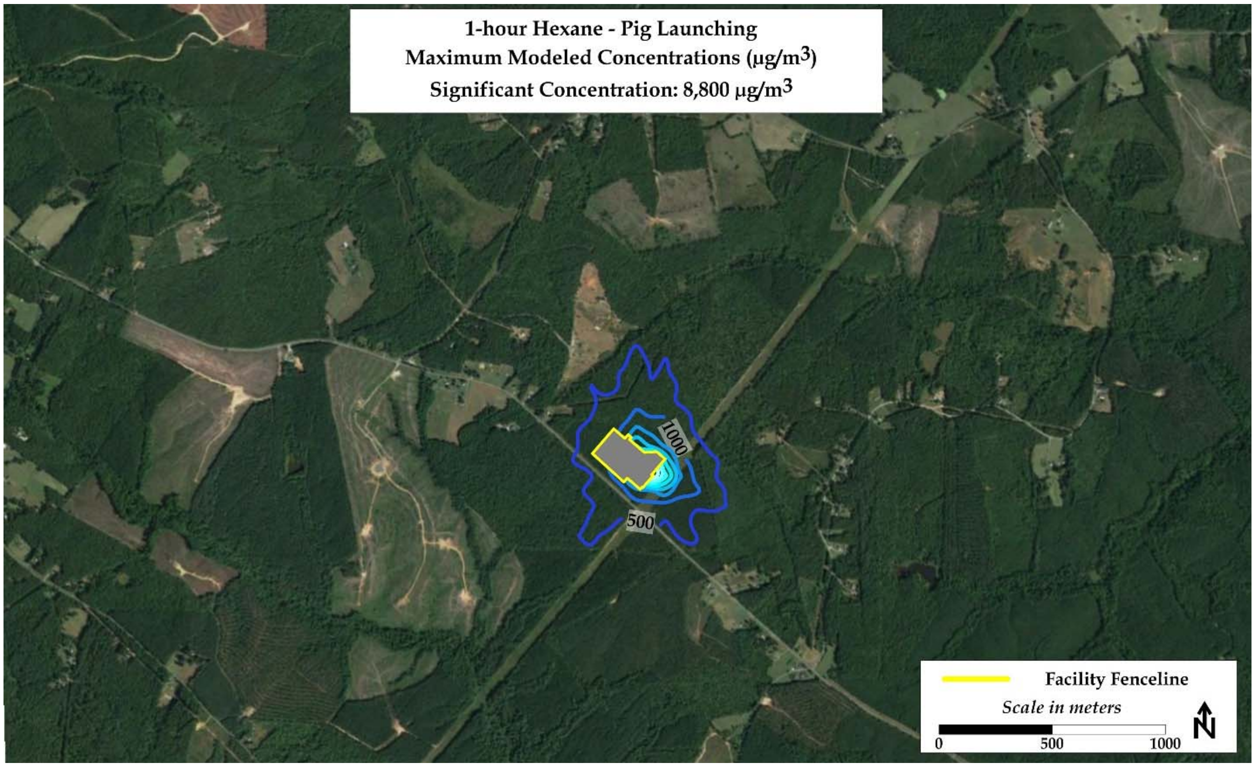
Annual Formaldehyde - Normal Operations (50% load)
Maximum Modeled Concentrations (μg/m^3)
Significant Concentration: 2.4 μg/m^3



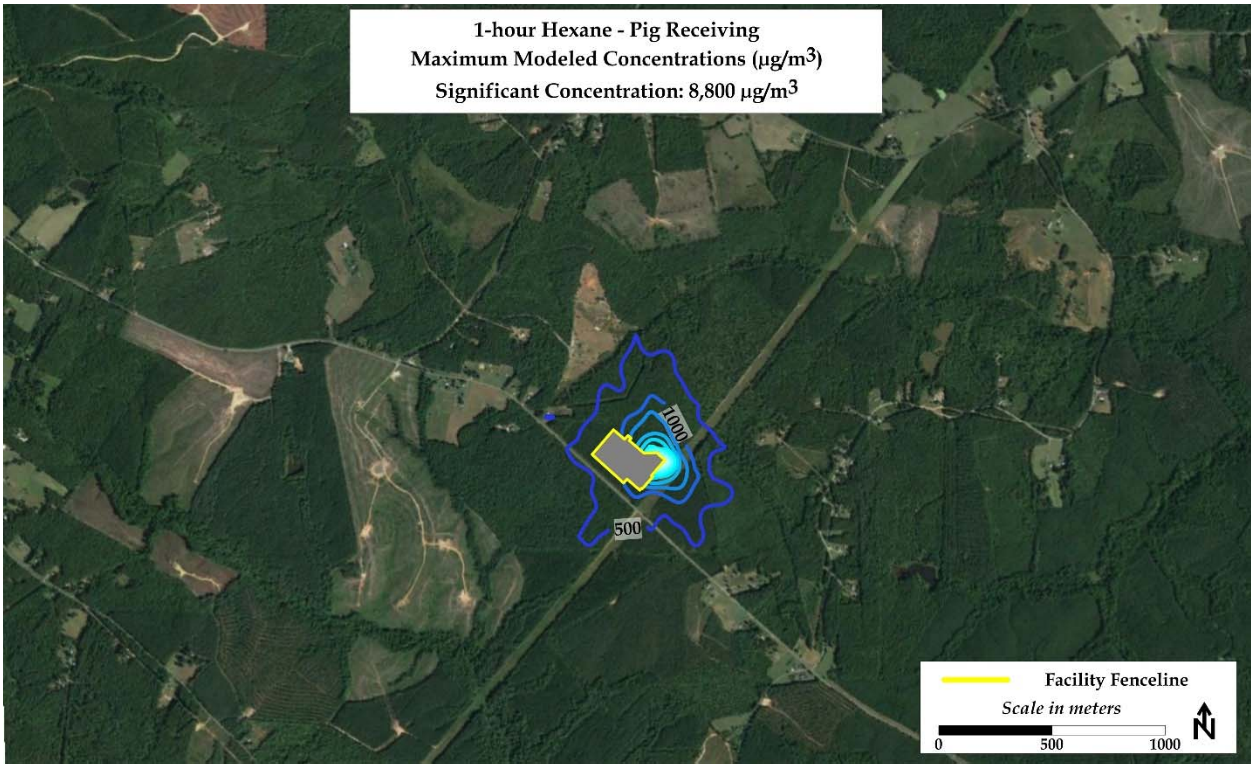
1-hour Hexane - Normal Operations
Maximum Modeled Concentrations (μg/m^3)
Significant Concentration: 8,800 μg/m^3


1-hour Hexane - Shutdown Operations
Maximum Modeled Concentrations ($\mu g/m^3$)
Significant Concentration: 8,800 $\mu g/m^3$


1-hour Hexane - Startup Operations
Maximum Modeled Concentrations ($\mu g/m^3$)
Significant Concentration: 8,800 $\mu g/m^3$



1-hour Hexane - Pig Launching
Maximum Modeled Concentrations (µg/m^3)
Significant Concentration: 8,800 µg/m^3



1-hour Hexane - Pig Receiving
Maximum Modeled Concentrations (µg/m^3)
Significant Concentration: 8,800 µg/m^3