EAST KENTUCKY POWER COOPERATIVE

July 22, 2024

Michael Kennedy
Director
Division for Air Quality
300 Sower Boulevard
Frankfort, Kentucky 40601

Re: Class II Modeling Protocol
Reciprocating Internal Combustion Engine Generation Project
Liberty Station

Dear Director Kennedy:

East Kentucky Power Cooperative, Inc. (EKPC) is proposing to construct Liberty Station, a Reciprocating Internal Combustion Engine (RICE) generation facility near Liberty, KY in Casey County[1]. The proposed site is in attainment or unclassifiable for all criteria pollutants. The proposed RICE engines will be fueled primarily by natural gas but also have the capability to be fueled by Ultra-Low Sulfur Fuel Oil as a backup supply, to provide up to 220 MW of power output. EKPC is evaluating two different RICE engine models and configurations, with final vendor and model selection to occur at a future date. Preliminary emissions data have been analyzed by EKPC and the facility will be a major source subject to Prevention of Significant Deterioration (PSD) permitting with several criteria pollutants exceeding their significant emission rates established in 401 KAR 51:017. Accordingly, air quality dispersion modeling will be required to address ambient air impacts of pollutants from the project that trigger PSD applicability.

The U.S. Environmental Protection Agency (EPA) and the Kentucky Division for Air Quality (KDAQ) recommend that a protocol be established by an applicant when air quality dispersion modeling is to be conducted in support of a permit application subject to PSD preconstruction review. Prior to submittal of an air permit application to KDAQ, EKPC is hereby submitting a Class II modeling protocol to address the proposed modeling procedures necessary to evaluate pollutant impacts with respect to the PSD increment and National Ambient Air Quality Standards (NAAQS) for KDAQ's review and approval.

We look forward to working with you on this project. Please contact me if you have questions regarding the project or the attached Class II Modeling Protocol.

---

[1] Although this protocol is for a site near Liberty, Kentucky, alternative sites in the region are still under consideration. Those sites are also located in areas that are in attainment or unclassifiable for criteria pollutants.

4775 Lexington Road
P.O. Box 707
Winchester, Kentucky 40392
www.ekpc.coop

Sincerely,

Jerry Purvis

Jerry Purvis, Vice President
East Kentucky Power Cooperative
Attachment

cc: B. Jackson, USDA Forestry Service, via email
R. Shewekah, Assistant Director, DAQ, via email
Z. Bittner, Branch Manager, DAQ, via email
M. Clark, EKPC, via email
K. Moore, EKPC, via email
C. Wathen, Kenvirons, via email
J. Cave; Stites & Harbison PLLC, Esq., via email

EAST KENTUCKY POWER COOPERATIVE

CLASS II MODELING PROTOCOL

RECIPRICATING INTERNAL COMBUSTION ENGINE (RICE) GENERATION PROJECT LIBERTY STATION

Prepared For:

EAST KENTUCKY POWER COOPERATIVE, INC.

Prepared By:

Kenvirons, LLC

Project Number 2024020

July 2024

Table of Contents

East Kentucky Power Cooperative, Inc.

Class II Modeling Protocol

Reciprocating Internal Combustion Engine (RICE) Generation Project – Liberty Station

1.0 INTRODUCTION

East Kentucky Power Cooperative, Inc. (EKPC) is proposing to construct a Reciprocating Internal Combustion Engine (RICE) generation facility at a greenfield site near Liberty, Kentucky. The proposed facility, Liberty Station, will be located in Casey County, which is in attainment or unclassifiable for all criteria pollutants.[1] The proposed RICE engines will be fueled primarily by natural gas but also have the capability to be fueled by Ultra-Low Sulfur Fuel Oil (ULSFO) as a backup supply, to provide up to 220 MW of power output. Currently EKPC is evaluating two different RICE engine models and configurations, with final vendor and model selection to occur at a future date. Preliminary emissions data have been analyzed by EKPC and the facility will be a major source subject to Prevention of Significant Deterioration (PSD) permitting with several criteria pollutants exceeding their significant emission rates established in 401 KAR 51:017. Accordingly, air quality dispersion modeling will be required to address ambient air impacts of pollutants from the project that trigger PSD applicability.

The U.S. Environmental Protection Agency (EPA) and the Kentucky Division for Air Quality (KDAQ) recommend that a protocol be established by an applicant when air quality dispersion modeling is to be conducted in support of a permit application subject to PSD preconstruction review. Prior to submittal of an air permit application to KDAQ, EKPC is hereby submitting a Class II modeling protocol to address the proposed modeling procedures necessary to evaluate pollutant impacts with respect to the Class I and Class II PSD increments and National Ambient Air Quality Standards (NAAQS).

[1] Although this protocol is for a site near Liberty, Kentucky, alternative sites in the region are still under consideration. Those sites are also located in areas that are in attainment or unclassifiable for criteria pollutants.

2.0 PROJECT DESCRIPTION AND LOCATION

Figure 2-1 shows the location of the proposed Liberty Station RICE facility and the area surrounding the source. The plant will consist of either twelve (12) RICE engines manufactured by Wartsila, each with a power output of 18 MW, or eleven (11) RICE engines manufactured by MAN Energy Solutions, each with a power output of 20 MW, dependent on final vendor selection. The primary fuel for the RICE engines will be natural gas with ULSFO as a backup fuel for reliability. Each of the engines in either configuration will be equipped with Selective Catalytic Reduction (SCR) for NOx control and Oxidation Catalysts (OXCat) for control of CO and VOC emissions. The engines' post-control will vent to two (2) common stacks, with 6 engines venting to each common stack in the 12 x 18 MW configuration and 6 engines venting to one stack and 5 engines venting to the other stack in the 11 x 20 MW configuration. There will also be ancillary sources associated with the proposed new facility. The proposed new sources of emissions subject to modeling will consist of the RICE engines, natural gas-fired gas preheater, an emergency diesel generator, a diesel-fired fire pump, and haul roads. The plant will also have additional ancillary sources of emissions such as storage tanks and SF_6 breakers that will not emit pollutants subject to modeling. Preliminary facility layout drawings for both configurations are presented in Appendix A.

Preliminary analysis of emissions for the RICE engine models under consideration by EKPC along with the other emissions units indicates that the facility will be a major source triggering the PSD requirements to conduct an air quality analysis to demonstrate that the proposed project will not cause or contribute to a violation of an applicable increment standard or NAAQS. The pollutants for which ambient air quality analyses will be required are $PM_{2.5}$, PM_{10}, NO_2, CO, and Ozone. Potential SO_2 emissions are not expected to trigger PSD for either configuration or fuel type, therefore no further analysis of direct SO_2 emissions would be required. As addressed in subsequent sections, SO_2 emissions will be accounted for as a precursor to secondary $PM_{2.5}$ emissions. Table 2-1 presents the preliminary annual potential emissions for both the 12 x 18 MW and the 11 x 20 MW configurations.

Dispersion modeling will be performed for the above pollutants, except for ozone, to assess the ambient air impacts resulting from the project emissions. An analysis for ozone will be performed in accordance with current EPA and KDAQ guidance. The modeling analyses described in this protocol will conform to Appendix W of 40 CFR Part 51 (Guideline on Air Quality Models, GAQM).

Figure 2-1
Project Location

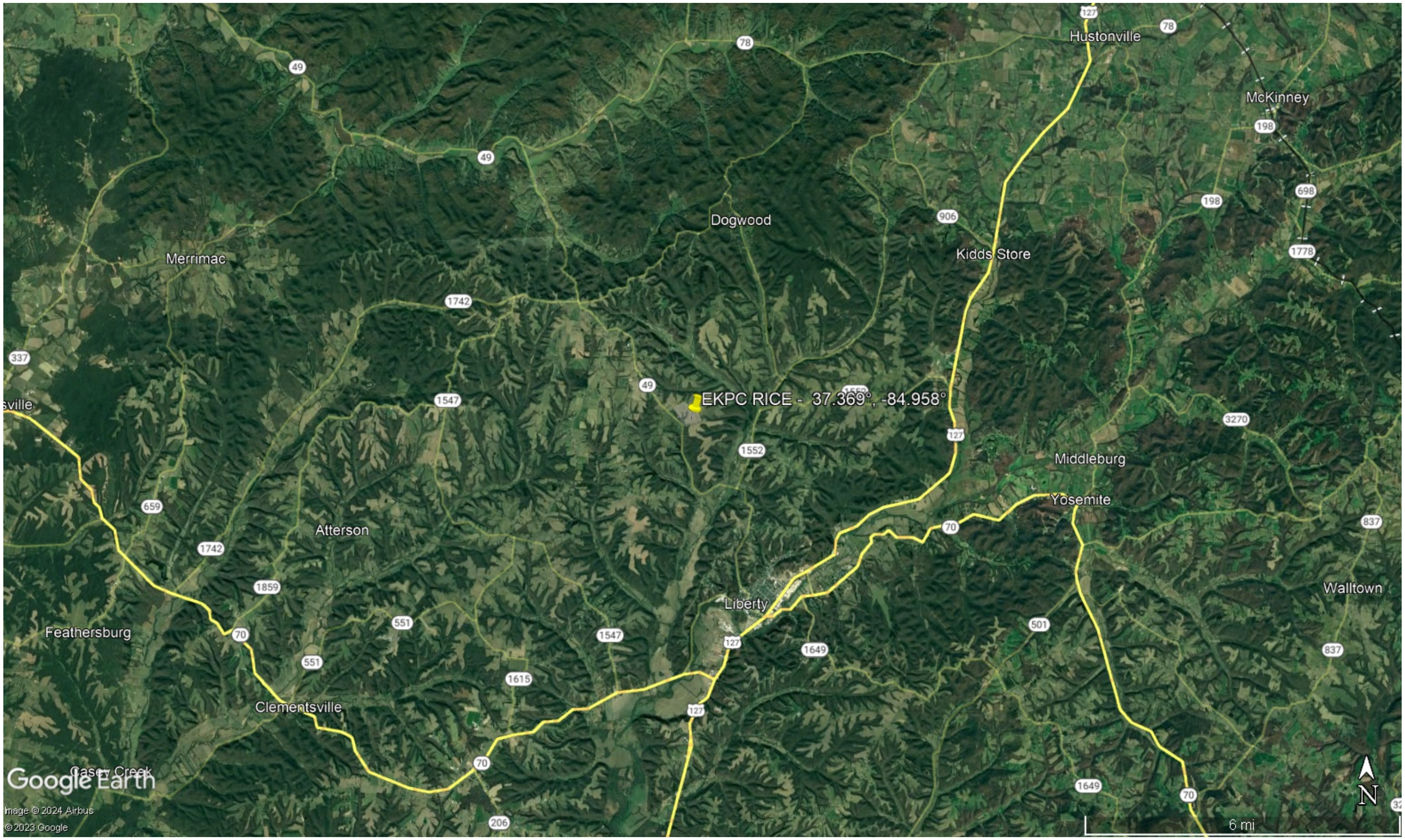


Table 2-1
Preliminary Project Potential Emissions

Potential Annual Emissions with Wartsila Engines (12 x 18 MW) Maximum of 100 Days on ULSFO						
Pollutant	RICE Engine Potential Emissions tons/year	Gas Preheater Potential Emissions tons/year	Generator Potential Emissions tons/year	Fire Pump Potential Emissions tons/year	Haul Road Potential Emissions tons/year	Total Potential Emissions tons/year
SO2	11.66	0.017	0.0021	0.00053	0	11.68
H2SO4	3.05	0	0	0	0	3.05
NOx	610.42	0.63	2.07	0.27	0	613.39
PM10/PM2.5	259.58	0.095	0.021	0.0098	0.0052	259.71
CO	363.71	1.05	0.49	0.11	0	365.36
VOC	316.06	0.069	0.017	0.0223	0	316.16
Potential Annual Emissions with MAN Engines (11 x 20 MW) Maximum of 100 Days on ULSFO						
Pollutant	RICE Engine Potential Emissions tons/year	Gas Preheater Potential Emissions tons/year	Generator Potential Emissions tons/year	Fire Pump Potential Emissions tons/year	Haul Road Potential Emissions tons/year	Total Potential Emissions tons/year
SO2	11.44	0.017	0.0021	0.00053	0	11.46
H2SO4	2.86	0	0	0	0	2.86
NOx	766.62	0.63	2.07	0.27	0	769.59
PM10/PM2.5	250.13	0.095	0.021	0.0098	0.0052	250.26
CO	263.32	1.05	0.49	0.11	0	264.97
VOC	832.80	0.069	0.017	0.0223	0	832.91

2.1 EXISTING AMBIENT AIR QUALITY

KDAQ operates an air quality monitoring network for the various pollutants subject to NAAQS throughout the state. As of this date, Casey County is designated as unclassifiable/attainment for all pollutants subject to NAAQS. Based on a review of permitted sources in Casey County as well as sources that are included in the Kentucky Emissions Inventory, the PSD minor source baseline dates for PM_{10}, $PM_{2.5}$, and NO_2 have not been triggered. The proposed EKPC facility will trigger the PSD minor source baseline date for these pollutants.

3.0 MODELING METHODOLOGY

Since some of the terrain within the modeling domain is above the proposed stack heights, the terrain is classified as complex, and as such, a model appropriate for use in complex terrain must be used. In accordance with the GAQM, the appropriate model for application to this domain is the EPA AERMOD dispersion model. For this modeling analysis, the latest version of the AERMOD model (version 23132) will be used for predicting ambient air impacts for each modeled pollutant. The highest predicted impacts (high-first-high, or H1H) will be used to determine whether pollutant concentrations exceed significant impact levels (SILs), whereby values below the SILs represent concentrations that are not expected to contribute to violations of any ambient air standards. For 1-hour averages, an average of H1H over five years will be used.

Table 3-1 presents the ambient air quality standards applicable to pollutants for which this project will require Class II ambient air modeling as well as SO_2. The 1-hour SILs listed for NO_2 and SO_2 are interim SILs based upon EPA guidance.[2] The SILs provided for $PM_{2.5}$ are based upon 2024 EPA guidance.[3] Modeling procedures to assess Class I increment consumption are discussed in Section 3.11.

Table 3-1
Ambient Air Quality Standards

Pollutant	Averaging Period	Class II SIL[a]	Class II PSD Increment[a]	NAAQS[a]
PM_{10}	24-Hour	5	30[g]	150[b]
	Annual	1	17[f]	-
$PM_{2.5}$	24-Hour	1.2	9[g]	35[c]
	Annual	0.13	4[f]	9[d]
NO_2	1-Hour	7.5	-	188[e]
	Annual	1	25[f]	100[f]
CO	1-Hour	2000	-	40000[g]
	8-Hour	500	-	10000[g]
SO_2	1-Hour	10	-	196[h]
	3-Hour	25	512[g]	1300[g]
	24-Hour	5	91[g]	365[g]
	Annual	1	20[f]	80[f]

[a] All concentrations are shown in micrograms/cubic meter (ug/m^3)

[2] Memorandum from Stephen D. Page, EPA Office of Air Quality Planning and Standards, Guidance Concerning the Implementation of the 1-hour NO_2 NAAQS for the Prevention of Significant Deterioration Program, June 29, 2010; Memorandum from Stephen D. Page, EPA Office of Air Quality Planning and Standards, Guidance Concerning the Implementation of the 1-hour SO_2 NAAQS for the Prevention of Significant Deterioration Program, August 23, 2010.

[3] Memorandum from Richard Wayland and Scott Mathias, EPA Office of Air Quality Planning and Standards, Supplement to the Guidance on Significant Impact Levels for Ozone and Fine Particles in the Prevention of Significant Deterioration Permitting Program, April 30, 2024.

[b] Not to be exceeded more than three times in 3 consecutive years
[c] The 3-year average of the 98th percentile 24-hour average concentrations
[d] Highest average of annual mean over 3 years
[e] 3-year average of the 98th percentile of the daily maximum 1-hour average concentrations
[f] Never to be exceeded
[g] Not to be exceeded more than once per year
[h] 3-year average of the 99th percentile of the daily maximum 1-hour concentration

The NAAQS for ozone (8-hour average) is 70 ppb. Ozone is not emitted directly but is formed in the atmosphere due to photochemical reactions involving precursors such as NOx and VOC. Therefore, ozone is not being explicitly modeled for this project. Section 3.9 of this protocol describes the evaluation approach for ambient air impacts of project emissions on ozone.

Application of the AERMOD model to evaluate air quality impacts from the project requires setting model control options, inputting source emission and stack parameter data, processing the appropriate meteorological and terrain data, setting receptor grids, and generating output necessary for the proper impact evaluation.

3.1 AERMOD MODEL OPTIONS

For all modeling runs conducted for the evaluation of the project's air quality impacts, the regulatory default option in AERMOD will be selected.

In order to include building wake effects, the Building Profile Input Program, PRIME version (BPIP-PRIME, version 04274) will be used to calculate downwash parameters for the modeled emission sources by using building, structure, and tank dimensions and heights relative to the modeled sources. Wake effects from any buildings with a sloped roof will be determined by BPIP-PRIME using multiple building tiers to account for the slope. None of the proposed stacks, including the combined stacks described for the RICE engines in Section 2.0, will exceed Good Engineering Practice (GEP) stack heights.

A necessary step in preparing a modeling exercise with AERMOD is proper classification of land use in the immediate vicinity of the proposed plant such that the appropriate dispersion coefficients will be employed (urban versus rural). As specified in Section 5.1 of the AERMOD Implementation Guide and in Section 7.2.1.1.b of the GAQM, land use within a 3 km radius around the plant property is analyzed to determine the percentage of each of the land use categories within the 3 km area. The Auer land use method was employed to determine the percentage of each of the land use categories listed in the National Land Cover Database within the focus area. If land use types from the Category 22 (Developed, Low Intensity), Category 23 (Developed, Medium Intensity), and Category 24 (Developed, High Intensity) exceed 50% or more of the land use categories within the 3 km area, then urban dispersion coefficients must be used.

If the land use types from those listed categories is less than 50%, then rural dispersion coefficients must be used. In order to determine these percentages, an online tool from the South Carolina Department of Health and Environmental Control (DHEC) was used by specifying the center of the proposed plant location in latitude-longitude and specifying a 3 km radius around those coordinates[4]. This tool then calculated the percentages of each of the land use categories from the Land Cover Database present in the area. Figure 3-1 provides a graphical depiction of the land use within 3 km of the proposed plant site. Table 3-2 shows the percentage of each of the land use categories present in the area. As this table shows, 98.8% of the land use within the 3 km radius of the proposed plant is classified as rural. It should be noted that there are no interstates or major heavily-traffic roadways within 50 km of the proposed site. Therefore, rural dispersion coefficients will be used for all AERMOD runs.

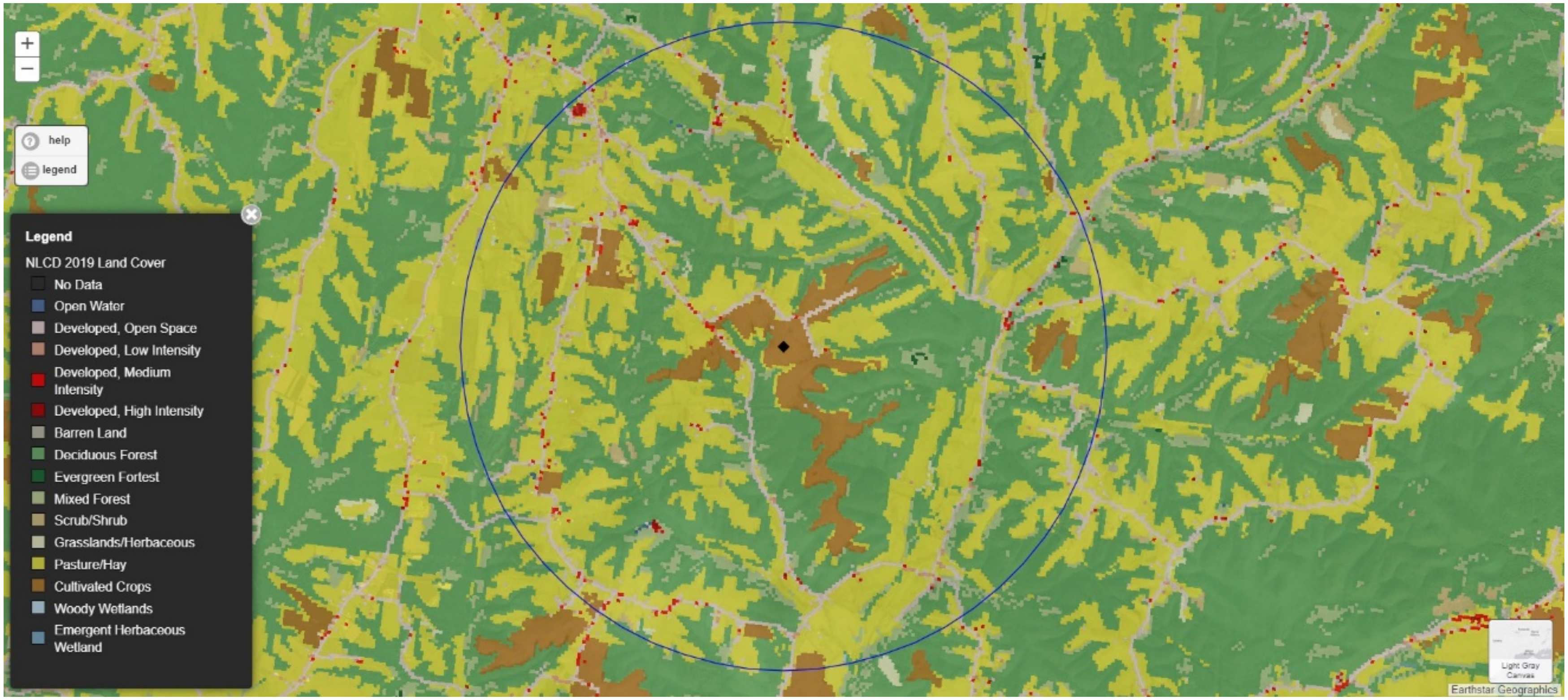
Table 3-2
Land Use within 3 km of Proposed Liberty Station Plant Site

Category	Landuse	Area(m^2)	Percent	Classification
11	Open Water	10,800	0.04%	Rural
21	Developed Open Space	1,515,600	5.37%	Rural
22	Developed Low Intensity	176,400	0.62%	Urban
23	Developed Medium Intensity	126,900	0.45%	Urban
24	Developed High Intensity	18,900	0.07%	Urban
31	Barren Land	19,800	0.07%	Rural
41	Deciduous Forest	11,754,000	41.64%	Rural
42	Evergreen Forest	11,700	0.04%	Rural
43	Mixed Forest	1,202,400	4.26%	Rural
52	Shrub Scrub	162,900	0.58%	Rural
71	Herbaceous	175,500	0.62%	Rural
81	Hay Pasture	11,215,800	39.74%	Rural
82	Cultivated Crops	1,832,400	6.49%	Rural
90	Woody Wetlands	1,800	0.01%	Rural
	Total Urban		**1.14%**	
	Total Rural		**98.86%**	

AERMOD model output options will be selected for each pollutant included in the modeling analysis to facilitate proper comparison to the relevant averaging periods and standards.

[4] https://gis.dhec.sc.gov/landcover/

Figure 3-1 – Liberty Station Proposed Plant Site –Land Use Within 3 km



3.2 SOURCE DATA AND LOAD MODELING

Sources of emissions from the project that will be modeled for evaluation of significant impacts against the applicable SILs will include the RICE engines, gas preheater, emergency generator, emergency fire pump, and haul roads (PM_{10} and $PM_{2.5}$ only). The emergency units will be included for all averaging periods except for 1-hour modeling as discussed below. All stack coordinates will be entered in UTM coordinates referenced to NAD83 datum. For the RICE engines, gas preheater, emergency generator, and fire pump, stack height and diameter will be entered in meters, stack temperature in degrees Kelvin, and stack exit velocity in units of meters per second. These sources will be modeled as point sources in AERMOD. Haul roads will be modeled as an array of volume sources with volume source parameters determined in accordance with U.S. EPA's Haul Road Workgroup Final Report (12/2011).

Since the RICE engines will have the capability to operate at different loads, the load scenarios applicable to operation of the units will each be modeled to define the worst-case load operating scenario for each applicable averaging period. Loads of 50%, 75%, and 100% will be modeled for the RICE engines. For the load modeling, EKPC is proposing to further define the worst-case from a model impact standpoint by modeling all engines venting to the common stacks at the various loads, modeling three engines exhausting to each common stack at the various loads, and modeling a single engine exhausting to each common stack at the various loads. This will ensure that different dispersion parameters (most notably stack gas velocity and temperature) are adequately evaluated to determine the worst-case number of engines operating plus the worst-case load.

Once the worst-case load operating scenario is identified for each applicable averaging period, that scenario will be used for subsequent modeling to determine whether significant impacts are triggered for any pollutant. Reasonable worst-case startup scenarios for the RICE units will also be included in the modeling. Based on information received from the RICE engine manufacturers, the worst-case startup scenario with respect to emissions is a cold start for the Wartsila engines (12 x 18 MW) and a warm start for the MAN engines (11 x 20 MW). Those startup scenarios will be paired with the worst-case load plus worst-case number of engines for the 1-hour and 8-hour modeling. If appropriate, EPA's guidance[5] for modeling intermittent activities may be applied to the 1-hour NO_2 analysis. For the 24-hour and annual modeling, the worst-case daily startup scenario for each engine will be 3 startups/shutdowns per day, with either a cold or warm start (depending on the engine model) along with two hot starts. Those scenarios will be modeled along with the worst-case load and worst-case number

[5] March 1, 2011 USEPA memorandum from Tyler Fox, Leader, Air Quality Modeling Group, C439-0, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard

of engines for the 24-hour and annual averaging periods. Startup definitions and emissions for the two engine configurations are presented in Appendix B.

The emergency generator and fire pump will not be modeled for 1-hour averages; however, their emissions will be included for the other averaging periods based upon USEPA guidance[6] on intermittent sources of emissions such as emergency generators. These units are operated as emergency units only and will be limited to less than 500 hours per year of operation (to accommodate operation in a true emergency). In addition, certain startup scenarios for the RICE engines that would be considered “intermittent” will not be modeled for 1-hour averaging periods.

If any of the applicable SILs are exceeded, then cumulative impact analysis for increment consumption and NAAQS will be conducted. It is anticipated that cumulative impact analyses will be triggered for PM_{10}, $PM_{2.5}$, and NO_2. Modeled impacts of CO are likely to be below the SILs for the 1-hour and 8-hour averaging periods applicable to those pollutants due to the high values of the SILs for CO. SO_2 emissions are not expected to trigger PSD review, so no Class II modeling will be required for SO_2 emissions.

3.3 METEOROLOGICAL DATA

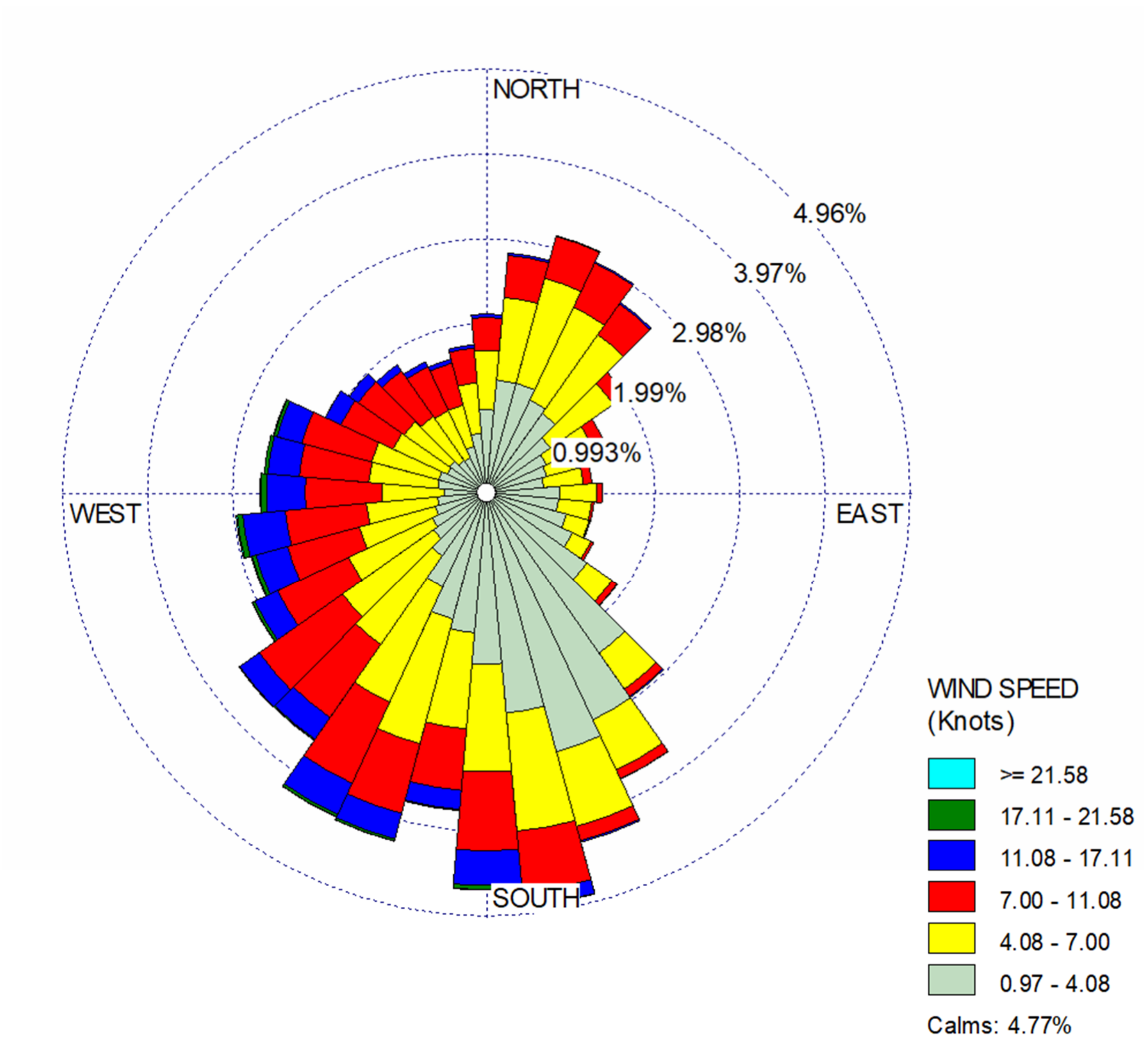
Pre-processed AERMOD-ready meteorological data required for the modeling will be provided by the Kentucky Division for Air Quality (KDAQ). The Division specifies which surface stations and upper air stations should be selected based on the county in which the source being modeled is located. Since the proposed source will be located in Casey County, Kentucky, KDAQ specifies the following surface and upper air stations for modeling sources in that location[7]:

Surface Station: London, Kentucky
Upper Air Station: Nashville, Tennessee

The most recent five years of available meteorological data from these stations, which cover the period from 2019 through 2023, will be used for all Class II modeling. Figure 3-3 shows a 5-year wind rose for the London, Kentucky surface station from 2019-2023.

[6] March 1, 2011 USEPA memorandum from Tyler Fox, Leader, Air Quality Modeling Group, C439-0, Additional Clarification Regarding Application of Appendix W Modeling Guidance for the 1-hour NO_2 National Ambient Air Quality Standard
[7] https://eec.ky.gov/Environmental-Protection/Air/Pages/Modeling%20and%20Meteorology.aspx

Figure 3-3
Five Year Wind Rose for 2019 - 2023 for the London, Kentucky Surface Meteorological Station



3.4 TERRAIN PROCESSING AND RECEPTOR INPUT

Receptor coordinates, elevations, and hill height scales will be produced by the latest version of the AERMAP terrain processing program for input into AERMOD. USGS Digital Elevation Models (DEMs) will be utilized by AERMAP to determine the terrain elevation at each receptor, the hill height scales, and source elevations (if necessary). The DEMs will be obtained from the USGS National Elevation Database (NED) in GeoTIFF format, with a resolution of 1/3 arc second (approximately 10 meters),and will extend beyond the 50 km modeling domain. All source and receptor coordinates were specified in terms of UTM coordinates in NAD83, with UTM Zone 16 set as the base zone for the modeling domain.

The initial receptor grid used for the assessment of impacts from the project will consist of a Cartesian receptor grid out to 50 km from the plant site. Receptors will be placed along the property (ambient air) boundary at 50 meter intervals, and will be placed at 100 meter intervals from the property boundary out to a distance of 3 km from the property boundary, then at 500 meter intervals out to a distance of 10 km. From 10 km – 50 km, the receptor spacing will be 1 km.

For controlling concentrations predicted to occur in the areas of coarse receptor spacing, as well as NAAQS or PSD increment modeling impacts within 90% of the standards predicted to occur in the areas of coarse receptor spacing, refined modeling using 100 m grids will be conducted.

For any pollutant and associated averaging period where project source impact modeling exceeds the relevant SILs, significant impact areas (SIAs) will be established.

3.5 SOURCE INVENTORIES FOR CUMULATIVE ANALYSES

As mentioned previously, it is anticipated that cumulative analyses to evaluate increment consumption and NAAQS will be triggered for PM_{10}, $PM_{2.5}$, and NO_2. In order to conduct the cumulative analyses for these pollutants, it is necessary to include all outside sources (sources outside the proposed plant property boundary) that are either within the established SIAs or have the potential to cause significant impacts within the SIAs. In order to identify these sources, the latest two years of available source emissions data from the statewide Kentucky Emissions Inventory (2021-2022) will be utilized.

Outside sources within the relevant SIAs will be included in the modeling using actual emissions per the GAQM and stack parameters listed in the emissions inventory. Outside sources that are not within the established SIAs will be subjected to a screening procedure to assess whether a significant impact on the SIAs warrants inclusion in the cumulative modeling. The screening procedure to be utilized is referred to as the "20D Rule", where if Q > 20D a source will be included in the cumulative modeling. Q represents the actual sourcewide emission rate (2-year average) in tons per year, and D represents the distance from the source to the SIA in km. Sources in close proximity to each other ("clusters") will be treated as a single source in the 20D analysis. Sources for which Q > 20D will be included in the cumulative analysis for determination of impacts for comparison with the relevant NAAQS. Such sources, as well as outside sources within the SIAs, will be included in the increment analysis if they were constructed/modified on or after the applicable major source and minor source baseline dates.

Intermittent sources such as emergency generators will not be included in the cumulative modeling analyses for 1-hour averaging periods based on the USEPA guidance cited in Section 3.2 of this modeling protocol.

3.6 BACKGROUND AIR QUALITY

In order to determine the contribution to total ambient air impacts from sources that are not explicitly modeled, ambient air quality data representative of the project area is used. The PSD regulations require an analysis of ambient air quality in the project area for each of the pollutants subject to PSD review. These data are used to develop background concentrations, which are added to modeled impacts (or qualitative impacts for ozone) to determine compliance with the applicable NAAQS. The pollutants for which ambient air background data are potentially required are NO_2, CO, PM_{10}, $PM_{2.5}$, and ozone.

EKPC is proposing the use of existing monitors operated by KDAQ to satisfy the ambient air monitoring requirement. In order to use existing monitoring data, the data that is ultimately chosen for background concentrations should be representative of the characteristics of the source being modeled (isolated source versus multiple sources in close proximity) as well as the characteristics of the area around the source being modeled. At the Casey County location, the proposed source is isolated. Section 8.3.2 of 40 CFR Part 51, Appendix W discusses the requirements for obtaining representative background concentrations for single isolated sources. These requirements include, but are not limited to, the following:

- Distance of the monitor to the proposed source being modeled
- Land use and terrain characteristics
- Large source emissions near a monitoring site
- Data completeness

Appendix W also states "If several monitors are available, preference should be given to the monitor with characteristics that are most similar to the project area. If there are no appropriate monitors located in the vicinity of the new or modifying source, a "regional site" may be used to determine background concentrations. A regional site is one that is located away from the area of interest but is impacted by similar or adequately representative sources."

3.6.1 $PM_{2.5}$ Background

Table C-1 in Appendix C presents the $PM_{2.5}$ monitors on a regional level under consideration for representative $PM_{2.5}$ background concentrations. Figure C-1 shows the locations of the monitors with the red circle denoting a 50 km radius around the proposed site as well as "large" sources of $PM_{2.5}$, which are $PM_{2.5}$ sources with facility-wide actual $PM_{2.5}$ emissions of greater than 100 tons per year (2-year average for 2021-2022).

The nearest $PM_{2.5}$ monitor to the proposed EKPC site and the only monitor within 50 km of the site is the Somerset, Kentucky monitor. However, that monitor has a large source of $PM_{2.5}$ emissions in close proximity and is located in a populated area with heavy vehicle traffic nearby. Table A-1 shows the Somerset monitor land use as "commercial" and the location setting as "suburban". Table C-2 shows the land use within a 3 km radius of the Somerset monitor. As this table shows, the land use immediately surrounding the monitor location is considered urban. The proposed EKPC site is in an isolated, rural area (land use is greater than 98% rural) with no major roads/highways in the vicinity with high vehicle traffic and no nearby large sources of $PM_{2.5}$ emissions. Therefore, even though the Somerset $PM_{2.5}$ monitor is the closest in proximity to the proposed site, this monitor is not representative of the proposed site.

All other $PM_{2.5}$ monitors are located further than 50 km from the proposed EKPC site. Continuing this analysis for the remaining $PM_{2.5}$ monitors, the locations that are identified as being in a suburban or urban location setting are all either impacted by nearby large sources or are in close proximity to populated areas and/or interstate/heavily-traveled roadways. The only other $PM_{2.5}$ monitors that are located in a location setting classified as rural are the Covington, Hendersonville (TN), Grayson Lake, Hopkinsville, and Bloomfield (IN) monitor sites. The Covington monitor site is impacted by large sources of $PM_{2.5}$ and is located very near an interstate and the Cincinnati/Northern Kentucky urban area. The Hendersonville site is similarly located in close proximity to an interstate and is likely impacted by sources in and near the Nashville metropolitan area. The Hopkinsville monitor is also located in close proximity to an interstate and a highly populated area.

The only $PM_{2.5}$ monitor that is located in a rural setting and not in close proximity to interstates or heavily traveled roadways is the Grayson Lake $PM_{2.5}$ monitor. There are also no large sources of $PM_{2.5}$ emissions that would reasonably impact that monitor location, much like the 50 km radius around the proposed plant site. Table C-3 shows the land use within a 3 km radius of the Grayson Lake monitoring site. This table shows the land use characteristics in the immediate vicinity of the monitor site to be very similar to the characteristics of the proposed project site (Grayson lake is 98.15% rural and the proposed project site is 98.86% rural). For these reasons, EKPC is proposing to use data from the Grayson Lake, Kentucky monitoring site for background for $PM_{2.5}$. Table 3-3 lists the design values for the 24-hour and annual averaging periods for the Grayson Lake $PM_{2.5}$ monitor to be used in the modeling analysis for $PM_{2.5}$.

Table 3-3 - $PM_{2.5}$ Monitor Design Values

Monitor	**2021 – 2023 24-hour Design Value (µg/m^3)**	**2021-2023 Annual Design Value (µg/m^3)**
Grayson Lake, Carter County, Kentucky	18.9	6.9

The 24-hour design value is based on the three-year average of the 98th percentile values for the 24-hour averaging period. The annual design value is based on the 3-year average of the arithmetic mean. As described in Section 3.7, if a less conservative second-level modeling analysis is needed for the 24-hour averaging period, seasonal values will be used in the modeling instead of the design value listed above.

It should be noted that EPA has published in the Federal Register[8] that there will be updates to $PM_{2.5}$ data from T640/T640X PM Mass Monitors to refine the data to adjust monitored concentrations for a potentially high bias identified with these types of continuous ambient monitors. It is unclear at this time whether the adjustments have been performed based on the information available from these monitors. The design values may be different than those listed in Table 3-3 pending final adjustment of the measured concentrations.

3.6.2 PM_{10} Background

Table C-4 in Appendix C presents the PM_{10} monitors on a regional level under consideration for representative PM_{10} background concentrations. Figure C-2 in Appendix C shows the locations of the monitors with the red circle denoting a 50 km radius around the proposed site as well as "large" sources of PM_{10}, which are PM_{10} sources with facility-wide actual PM_{10} emissions of greater than 100 tons per year (2-year average for 2021-2022).

Available PM_{10} monitoring locations are far more limited than the $PM_{2.5}$ monitors, with most of the monitors located near interstates/heavily-traveled roadways and/or very near urban areas. The nearest PM_{10} monitor to the proposed EKPC site is the Lexington, Kentucky PM_{10} monitoring site, which is located in a residential/suburban area in close proximity to heavily-traveled roadways and an urban area. The only PM_{10} monitor that is located in a rural area very similar to the proposed site and not impacted by large sources/urban areas is the Grayson Lake PM_{10} monitor. For the reasons listed in the $PM_{2.5}$ discussion along with the lack of any other representative PM_{10} monitors, EKPC is proposing to use data from the Grayson Lake, Kentucky monitor for $PM_{2.5}$ background.

Table 3-4 presents the current design values for the Grayson Lake PM_{10} monitor.

Table 3-4 - PM_{10} Monitor Design Values

Monitor	2021 – 2023 24-hour Design Value ($\mu g/m^3$)
Grayson Lake, Carter County, Kentucky	34.3

[8] EPA, 89 FR 42874

3.6.3 NO_2 Background

Table C-5 in Appendix C presents the NO_2 monitors on a regional level under consideration for representative NO_2 background concentrations. Figure C-3 in Appendix C shows the locations of the monitors with the red circle denoting a 50 km radius around the proposed site as well as "large" sources of NO_2, which are NO_2 sources with facility-wide actual NO_2 emissions of greater than 100 tons per year (2-year average for 2021-2022).

As with the PM_{10} monitors, NO_2 monitoring locations are limited with only 7 monitors in the region and none within 50 km of the proposed project site. Most of the monitors are located near interstates/heavily-traveled roadways and/or very near urban areas. Three of the seven—two in Louisville, and one in Lexington—are located in urban areas near high traffic, transportation routes and are not representative of background NO_2 in the area of the proposed project site, which is rural. Of the remaining NO_2 monitors, the two nearest to the proposed project site are the Northern Kentucky University NO_2 monitor and the Ashland, Kentucky NO_2 monitor. The only NO_2 monitoring location with a location setting of rural is the Northern Kentucky University NO_2 monitor (Campbell County, Kentucky). The Ashland NO_2 monitor is located in an urban setting in downtown Ashland, Kentucky.

Therefore, EKPC is proposing the Campbell County NO_2 monitor to provide the NO_2 background concentration for this modeling analysis. Use of NO_2 data from the Campbell County monitor should be representative, yet conservative, since the immediate surroundings for that monitor are rural yet regionally the monitor is likely impacted by sources of emissions in the Northern Kentucky/Cincinnati metropolitan area.

Table 3-5 presents the current design values for the Campbell County, Kentucky NO_2 monitor.

Table 3-5 - NO_2 Monitor Design Values

Monitor	2021 – 2023 1-hour Design Value (µg/m³)	2021-2023 Annual Design Value (µg/m³)
Campbell County, Kentucky	51.7	15

The 1-hour design value is based on the three-year average of the 98^{th} percentile values for the 24-hour averaging period. The annual design value is based on the 3-year average of the arithmetic mean. As described in Section 3.8, EKPC is proposing to use the “second-tier” season-hour approach outlined in the 2011 EPA guidance and re-iterated in the 2014 guidance for applying the background concentration to modeled impacts for the 1-hour averaging period.

3.6.4 CO Background

Table C-6 in Appendix C presents the CO monitors on a regional level under consideration for representative CO background concentrations. Figure C-4 in Appendix C shows the locations of the monitors with the red circle denoting a 50 km radius around the proposed site as well as “large” sources of CO, which are CO sources with facility-wide actual CO emissions of greater than 100 tons per year (2-year average for 2021-2022). As mentioned previously, a cumulative analysis for CO is not expected to be triggered due to the high magnitude of the applicable SILs for CO. If, however, a cumulative analysis is required EKPC is proposing the Mammoth Cave, Kentucky monitor for background values for CO. The Mammoth Cave monitor is the only CO monitor in the region that is not located in an urban area impacted by large sources of CO and is the closest CO monitor in proximity to the proposed project site.

Table 3-6 presents the current design values for the Mammoth Cave, Kentucky CO monitor.

Table 3-6 - CO Monitor Design Values

Monitor	2023 1-hour Design Value ($\mu g/m^3$)	2023 8-hour Design Value ($\mu g/m^3$)
Mammoth Cave, Kentucky	863	805

3.6.5 Ozone

The NAAQS for ozone (8-hour average) is 70 ppb. Ozone is not emitted directly but is formed in the atmosphere due to photochemical reactions involving precursors such as NOx and VOC. Therefore, ozone is not being explicitly modeled for this project. EKPC is employing the methodology outlined in EPA and KDAQ guidance using Modeled Emission Rates for Precursors (MERPs) for emissions of NOx and VOC from the RICE project as further described in Section 3.10. Background ozone is a key element of this methodology and will be used with existing ozone data from a representative regional ambient ozone monitor.

Table C-7 in Appendix C presents the ozone monitors on a regional level potentially under consideration for use as the background ozone concentration. Large sources of NO_2 and VOC were not depicted due to monitored ozone concentrations being impacted by many additional factors other than industrial source emissions such as mobile sources, biogenic sources, etc. Figure C-5 shows the location of the ozone monitors, with the red circle denoting a 50 km radius around the proposed site. Ozone monitors in large urban areas such as Louisville, Cincinnati/Northern KY, Nashville, Evansville, and Paducah have been excluded from the monitor listing since the use of data from an urban monitor would not be representative of a rural site such as the proposed project site.

There are two ozone monitors within 50 km of the proposed project site, the Mackville ozone monitor (which is the closest in proximity to the proposed site) and the Somerset ozone monitor. As demonstrated in Section 3.6.1 for the $PM_{2.5}$ monitor analysis and in Table C-2, the land use within a 3 km radius of the Somerset monitoring location is classified as greater than 50% urban. The land use within 3 km for the closest ozone monitor to the proposed project site, the Mackville ozone monitor, is shown in Table C-8. As this table shows, the land use within the immediate vicinity of the Mackville monitor is classified as greater than 99% rural. The Mackville site, like the proposed project site, is also located in an area that is not in close proximity to an urban area or an interstate where urban and mobile sources would impact the monitor values for ozone.

Therefore, EKPC is proposing to utilize the ambient monitoring ozone data from the Mackville monitor for ozone background. This monitor is also a CASTNET monitor, meaning that ozone data is collected for each hour of the year and not limited to “ozone season”. This is an important consideration for both the ozone background concentration selected to evaluate ozone precursor impacts (See Section 3.10) as well as availability of ozone background data for Tier 3 NO_2 modeling (See Section 3.8).

Table 3-7 presents the current design values for the Mackville, Kentucky ozone monitor based on the 3-year average of the 4th highest daily maximum 8-hr concentration.

Table 3-7 – Ozone Monitor 8-Hour Design Value

Monitor	**2021 – 2023 8-hour Design Value (ppb)**
Mackville, Kentucky	63

3.7 $PM_{2.5}$ MODELING

A cumulative analysis of $PM_{2.5}$ increment consumption and evaluation of the $PM_{2.5}$ NAAQS will be triggered if project impact modeling indicates impacts greater than the SILs. For evaluation of the $PM_{2.5}$ increment, all sources either within the SIAs or sources outside the SIAs identified for inclusion per Section 3.5 of this protocol that were constructed/modified on or after the $PM_{2.5}$ major source baseline date (October 20, 2010) will be modeled.

All sources of $PM_{2.5}$ either within the area of significant impacts or identified as potentially significantly impacting those areas will be included in the NAAQS modeling. Actual emission rates as listed in the 2021 and 2022 Kentucky Emissions Inventory will be used for outside sources included in the $PM_{2.5}$ modeling.

USEPA guidance for $PM_{2.5}$ permit modeling[9] requires PSD applications to address secondary formation of $PM_{2.5}$ due to emissions of $PM_{2.5}$ precursors such as NOx and SO_2. Direct emissions of $PM_{2.5}$ from the RICE project and any nearby sources of $PM_{2.5}$ that qualify for inclusion in the modeling analysis will be explicitly modeled. In order to evaluate the impact of EKPC's emissions of $PM_{2.5}$ precursors on $PM_{2.5}$, EKPC will employ the approach recommended in the GAQM using the Modeled Emission Rates for Precursors (MERPs).

The procedures and default MERPs specified in the KDAQ guidance document "Application of the EPA's Modeled Emission Rates for Precursors (MERPs) for Secondary Pollutant Formation in Kentucky[10]" will be first used to determine whether proposed increases in the $PM_{2.5}$ precursors (NOx and SO_2) will result in primary and secondary impacts using the following equation:

$$\frac{Max\ PM2.5\ Modeled\ Impact}{PM2.5\ SIL} + \frac{SO2\ Emission\ Rate}{SO2\ MERP} + \frac{NOx\ Emission\ Rate}{NOx\ MERP} < 1$$

If the initial screening analysis value is greater than 1, then a cumulative analysis must be performed using the following equation:

$$PM2.5\ Background\ +\ PM2.5\ DV\ + \left(\frac{SO2\ Emission\ Rate}{SO2\ MERP} + \frac{NOx\ Emission\ Rate}{NOx\ MERP}\right) x\ PM2.5\ SIL \le PM2.5\ NAAQS$$

The $PM_{2.5}$ DV is the AERMOD modeled design value from direct $PM_{2.5}$ modeling of project sources and nearby sources. The KDAQ MERPs guidance states "The $PM_{2.5}$ SILs are 0.2 µg/m3 for annual and 1.2 µg/m3 for daily. If the sum of the equation is less than or equal to 12.0 µg/m3 ($PM_{2.5}$ NAAQS), then the proposed

[9] July 29, 2022 USEPA memorandum – Guidance for Ozone and Fine Particulate Matter Permit Modeling
[10] https://eec.ky.gov/Environmental-Protection/Air/Documents/KY%20MERPs.pdf

emission increases will not contribute to a violation of the $PM_{2.5}$ NAAQS. If the sum is greater than the $PM_{2.5}$ NAAQS, then a Tier 2 demonstration will need to be considered, or the applicant may consider a less conservative MERP along with sufficient justification."

Since that guidance document was published, EPA has revised the annual $PM_{2.5}$ NAAQS from 12 ug/m^3 to 9 ug/m^3 and lowered the annual $PM_{2.5}$ SIL from 0.2 ug/m^3 to 0.13 ug/m^3. As an alternative to the default (most conservative) MERPs, should EKPC choose to use either more representative MERPs from the KDAQ documentation or from EPA's MERPs Qlik website, detailed justification for the use of alternate MERPs will be provided in the final modeling report.

For the annual $PM_{2.5}$ background concentration, EKPC is proposing to use the 3-year annual design value as presented in Table 3-3. For 24-hour $PM_{2.5}$ modeling, as a first-level approach, EKPC will apply the design value for the 24-hour averaging period based on the 3-year average of the 98th percentile 24-hour average $PM_{2.5}$ concentrations as presented in Table 3-3. If a less conservative second-level approach is deemed necessary to account for seasonal variations in $PM_{2.5}$ concentrations, EKPC will utilize four seasonal values from the $PM_{2.5}$ monitoring data that are combined with modeled $PM_{2.5}$ concentrations on a seasonal basis as outlined in the EPA "Guidance for Ozone and Fine Particulate Matter Permit Modeling" referenced previously.

3.8 NO_2 MODELING

Project impacts for NO_2 are expected to exceed the interim 1-hour SIL and trigger cumulative modeling for NAAQS. NO_2 increment modeling, if required, will be conducted using the source inventory compiled according to the procedures in Section 3.5 of this protocol, with sources constructed before the major source baseline date (February 8, 1988) excluded from the increment analysis.

For assessment of the NO_2 NAAQS, in addition to the GAQM in 40 CFR 51, Appendix W, EPA has provided additional guidance in four memorandums further clarifying guidelines regarding 1-hour NO_2 since the 1-hour standard has been final. Applicability of Appendix W Modeling Guidance for the 1-hour NO_2 NAAQS can be found in a memorandum dated June 28, 2010, from Tyler Fox (Leader of Air Quality Modeling Group). The basis for approval of a Tier 3 procedure is contained in the March 1, 2011, memorandum (Additional Clarification Regarding Application of Appendix W Guidance for the 1-Hour NO_2 NAAQS), also from Tyler Fox. A third EPA internal memorandum (Guidance Concerning the Implementation of the 1-Hour NO_2 NAAQS for the PSD Program) was written by Stephen Page (Director of the Office of Air Quality Planning and Standards) and is dated June 20, 2010. Finally, EPA issued a memorandum

(Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO_2 National Ambient Air Quality Standard), written by R. Chris Owen and Roger Brode (Air Quality Modeling Group) dated September 30, 2014.

Appendix W and the EPA guidance documentation for 1-hour NO_2 modeling recommends three approaches to estimate the NO_2 concentration:

Tier 1 – Total Conversion – Assumes all NOx emitted from a source is completely converted to NO_2.

Tier 2 – Ambient Ratio Method 2 (ARM2) – Modeled NO_2 impacts are multiplied by a default ambient minimum NO_2/NOx ratio of 0.5 and a maximum ratio of 0.9 to provide a conservative estimate of NOx to NO_2 conversion.

Tier 3 – Ozone Limiting Method (OLM) or Plume Volume Molar Ratio Method (PVMRM) – The OLM method assumes that the amount of NO in NOx converted to NO_2 at a particular receptor is controlled by the amount of available ozone, whereby the amount of NO_2 is limited if the ozone concentration is less than the NO concentration. If the ozone concentration is greater than or equal to the NO concentration, all NO is assumed to be converted to NO_2. The PVMRM method is essentially a refinement to OLM incorporating other variables such as the number of moles of NOx in a plume and the number of moles of ozone in the plume based upon the distance between the source and a receptor. Both of these methods also require specification of in-stack NO2/NOx ratios (either default or source-specific) and hourly background ozone data.

EKPC proposes to initially employ the Tier 2 Ambient Ratio Method with the default minimum multiplier of 0.5 and default maximum multiplier of 0.9 for the 1-hour averaging period and annual averaging periods. For the 1-hour averaging period, worst-case NO_2 emissions scenarios may necessitate a less conservative Tier 3 analysis. Should this be the case, EKPC is proposing to employ the PVMRM option based on the 2014 EPA guidance which states "PVMRM is most appropriate with relatively isolated and elevated sources, while OLM is more appropriate for area sources, near-surface releases, or scenarios with multiple sources where plume overlap is likely to occur." Due to the isolated nature of the proposed plant with NO2 emissions from elevated sources, the use of PVMRM as the Tier 3 option is most appropriate.

A key component of a Tier 3 NO_2 analysis is the specification of in-stack NO_2/NOx ratios for the project sources and nearby sources. Should EKPC choose to employ site-specific NO_2/NOx ratios for the project NO_2 sources from the EPA ISR Database or other references, the rationale and justification for the use of site-specific ratios will be documented in the final modeling report. If site-specific ratios are not used, then EKPC proposes to use the default NO_2/NOx ratio of 0.5 for the project sources and a ratio of 0.2 for more distant nearby sources (greater than 1-3 km).

Another important consideration for the Tier 3 approach using PVMRM is the inclusion of hourly ozone monitoring data that is concurrent with the 5 years of meteorological data being used (2019-2023). EKPC is proposing to use the 2019-2023 hourly ozone data for the Mackville, Kentucky ozone monitor described in Section 3.6.5 for application of PVMRM to the 1-hour NO_2 modeling demonstration. The 2010 EPA memo from Tyler Fox states the following:

> "The representativeness of (ozone data) takes on somewhat greater importance in the context of a 1-hour NO_2 standard than for an annual standard, for obvious reasons. In the case of hourly background ozone concentrations, methods used to substitute for periods of missing data may play a more significant role in determining the 1-hour NO_2 modeled design value, and should therefore be given greater scrutiny, especially for data periods that are likely to be associated with peak hourly concentrations based on meteorological conditions and source characteristics. In other words, ozone data substitution methods that may have been deemed appropriate in prior applications for the annual standard may not be appropriate to use for the new 1-hour standard."

EKPC proposes to use the Mackville hourly ozone data along with a procedure developed by the Minnesota Pollution Control Agency (MPCA), where missing data is filled in as follows:

1) Ozone gaps should be filled in during preprocessing
2) Use linear interpolation for single missing hours
3) When missing more than a single hour, replace data gaps with monthly/hourly maxima

The Minnesota guidance is included in Appendix D. The ozone background data to be used for the Tier 3 1-hour NO_2 modeling will be provided with the final modeling report.

Finally, it will be necessary to add the representative background NO_2 concentration to the modeled impacts to provide evaluation against the NAAQS. For the annual averaging period, the annual design value from the representative background NO_2 monitor listed in Table 3-5 will be added to the maximum annual arithmetic average over the 5 years of meteorological data to provide the total impact for comparison to the NAAQS.

For the 1-hour averaging period, EKPC is proposing to use the "second-tier" season-hour approach outlined in the 2011 EPA guidance and re-iterated in the 2014 guidance. This approach uses "multiyear averages of the 98th-percentile of the available background concentrations by season and hour-of-day, excluding periods when the source in question is expected to impact the monitored concentration." EPA recommends using the third-highest value in each season hour-of-day for modeling, which excludes the highest 8 values from the analysis rather than the highest 4 and thus more closely mimics the standard, which excludes the highest 7 values. To accomplish this, EKPC will use the most recent 5 years of hourly NO_2 monitoring data from the Campbell County, Kentucky NO_2 monitor and determine the highest value (after exclusion of the highest 8 values) for each season and hour-of-day. Should a particular single hourly value be missing from the monitor data, interpolation will be used with the previous and following hour to substitute the missing data. If more than one consecutive hour is missing within a particular year of monitor data, the data will not be substituted as long as data from the same hour and season are available from the other years. In the very unlikely event that an entire hour is missing for all of the five years of monitor data, the data for that hour will be substituted with the highest season-hour value for the season. The SEASHR option in AERMOD will be employed to facilitate adding the background concentration to each predicted hourly NO_2 impact. The background data to be used in the 1-hour NO_2 total impact modeling will be provided with the final modeling report.

3.9 CO and PM_{10} MODELING

Modeled impacts of CO from the proposed project are not expected to exceed the respective SILs for the 1-hour or 8-hour averaging periods. If, during the course of project impact modeling, results do indicate exceedance of the SILs, then cumulative modeling will be performed to assess NAAQS for CO and will be completely addressed in the final modeling report.

A cumulative analysis may be be required for PM_{10} to assess increment and NAAQS if project source modeling indicates that the SIL(s) are exceeded. For PM_{10} increment consumption modeling, sources in the inventory as described in Section 3.5 of this protocol will be modeled if they were constructed on or after the major source baseline date of January 6, 1975. Once cumulative modeling is performed for PM_{10}, it will be necessary to add the background design concentration to the maximum predicted impacts to provide evaluation against the NAAQS.

No non-default AERMOD options or case-by-case secondary impact analyses will be necessary if cumulative modeling for these pollutants is required.

3.10 OZONE IMPACTS

As stated in Section 3.0 of this protocol, the NAAQS for ozone (8-hour average) is 70 ppb. Ozone is not emitted directly but is formed in the atmosphere due to photochemical reactions involving precursors such as NOx and VOC. Therefore, ozone is not being explicitly modeled for this project.

In order to evaluate the impact of EKPC's emissions of ozone precursors on ozone, EKPC will employ the approach recommended in the GAQM using the Modeled Emission Rates for Precursors (MERPs). The procedures and default MERPs specified in the KDAQ MERPs documentation referenced for the $PM_{2.5}$ secondary analysis will be used to (1) determine whether the project NOx and VOC emissions will result in primary and secondary impacts, and (2) if the initial screening analysis shows impacts exceeding the ozone SIL of 1 ppb, performing a cumulative analysis for ozone as described in the KDAQ MERPs documentation. Should the cumulative analysis be triggered, the background design concentration for ozone from the Mackville, Kentucky monitor will be used along with the default MERPs to arrive at a total cumulative ozone concentration for comparison with the NAAQS.

As an alternative to the default (most conservative) MERPs, should EKPC choose to use either more representative MERPs from the KDAQ documentation or from EPA's MERPs Qlik website, detailed justification for the use of alternate MERPs will be provided in the final modeling report.

3.11 CLASS I AREA INCREMENT ANALYSIS

In order to assess PSD increment consumption in Class I areas, EKPC is proposing a screening methodology that consists of the same modeling procedure applied for Class II modeling assessments when modeled impacts are compared to the relevant SILs. The pollutants that will be subject to this analysis are NO_2, PM_{10}, and $PM_{2.5}$. To perform this procedure, EKPC is proposing to use the AERMOD dispersion model to assess impacts within 50 km of the proposed source using the same model options and meteorological data described previously for the Class II modeling, along with the worst-case load and startup/shutdown scenarios for each pollutant as identified by the Class II modeling. Model results are then compared to the relevant Class I SILs, and if less than the SILs no further refined modeling is needed for assessment of Class I increment. Table 3-8 presents the Class I SILs for the pollutants that will trigger PSD review.

Table 3-8
Class I PSD SILs

Pollutant	Averaging Period	Class I SIL ug/m^3
NO_2	1-Hour	N/A
	Annual	0.10
PM_{10}	24-Hour	0.32
	Annual	0.16
$PM_{2.5}$	24-Hour	0.27
	Annual	0.03

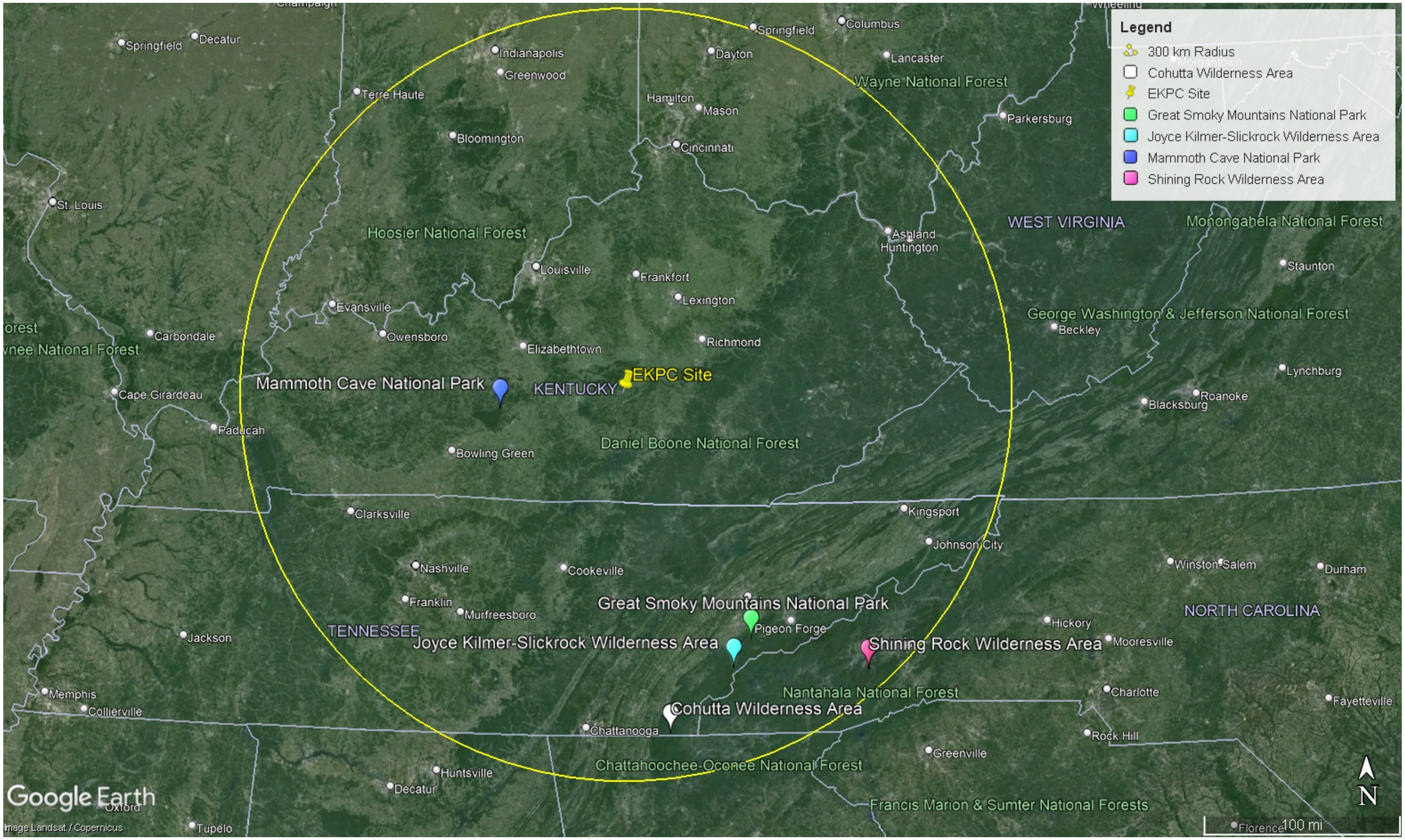
Figure 3-4 shows the location of the proposed source relative to the Class I areas within a 300 km radius of the proposed facility and are therefore subject to evaluation:

- Mammoth Cave National Park (NPS) – 95.5 km
- Great Smoky Mountains National Park (NPS) – 213.5 km
- Joyce Kilmer-Slickrock Wilderness Area (FS) – 228.3 km
- Cohutta Wilderness Area (FS) – 265.5 km
- Shining Rock Wilderness Area (FS) – 285.1 km

The distances were calculated by computing the distance from the proposed EKPC source to the nearest receptor in each Class I area, with the receptor coordinates for the Class I areas obtained from the National Parks Service website. There are no Class I areas within 50 km of the facility.

The increment modeling will be performed using a 360-degree receptor ring placed at 50 km from the proposed EKPC site with a receptor spacing of approximately 500 meters. Due to the distances between the EKPC site and the subject Class I areas, If predicted concentrations at 50 km are below the SILs, the concentrations in the Class I areas will likewise be below the SILs.

Figure 3-4
Class I Areas with 300 km of Project Location



3.11.1 $PM_{2.5}$ Modeling for Class I Increment

EPA guidance for $PM_{2.5}$ permit modeling[11] requires PSD applications to address secondary formation of $PM_{2.5}$ due to emissions of $PM_{2.5}$ precursors such as NOx and SO_2. Direct emissions of $PM_{2.5}$ from the RICE project will be explicitly modeled. In order to evaluate the impact of EKPC's emissions of $PM_{2.5}$ precursors on $PM_{2.5}$ Class I increment, EKPC will employ the approach recommended in the GAQM using the Modeled Emission Rates for Precursors (MERPs). The procedures and default MERPs specified in the KDAQ guidance document "Application of the EPA's Modeled Emission Rates for Precursors (MERPs) for Secondary Pollutant Formation in Kentucky[12]" will be used to determine whether proposed increases in the $PM_{2.5}$ precursors (NOx and SO_2) will result in impacts using the following equation:

$$\frac{Max\ PM2.5\ Modeled\ Impact}{PM2.5\ Class\ I\ SIL} + \frac{SO2\ Emission\ Rate}{SO2\ MERP} + \frac{NOx\ Emission\ Rate}{NOx\ MERP} < 1$$

If the initial screening analysis value is greater than 1, then a cumulative analysis must be performed to assess Class I $PM_{2.5}$ increment consumption. EKPC will coordinate with KDAQ and the FLMs concerning the requirements for a full cumulative technical evaluation should this be the case.

3.12 IMPACTS ON GROWTH, SOILS, VEGETATION, AND VISBILITY

EKPC, as part of the modeling analysis, will provide an assessment of projected residential, commercial, and industrial growth that will occur as a result of the RICE project. This analysis will be qualitative in nature and is not expected to reveal any impacts on air emissions outside of the project sources.

Also, EKPC will address impacts on soils and vegetation in the area using guidance and procedures specified in the EPA document "A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals" (EPA 450/2-81-078, December 1980).

Project impacts on visibility for sensitive Class II receptors will be addressed as applicable.

---

[11] July 29, 2022 USEPA memorandum – Guidance for Ozone and Fine Particulate Matter Permit Modeling
[12] https://eec.ky.gov/Environmental-Protection/Air/Documents/KY%20MERPs.pdf

3.13 AIR TOXICS ANALYSIS

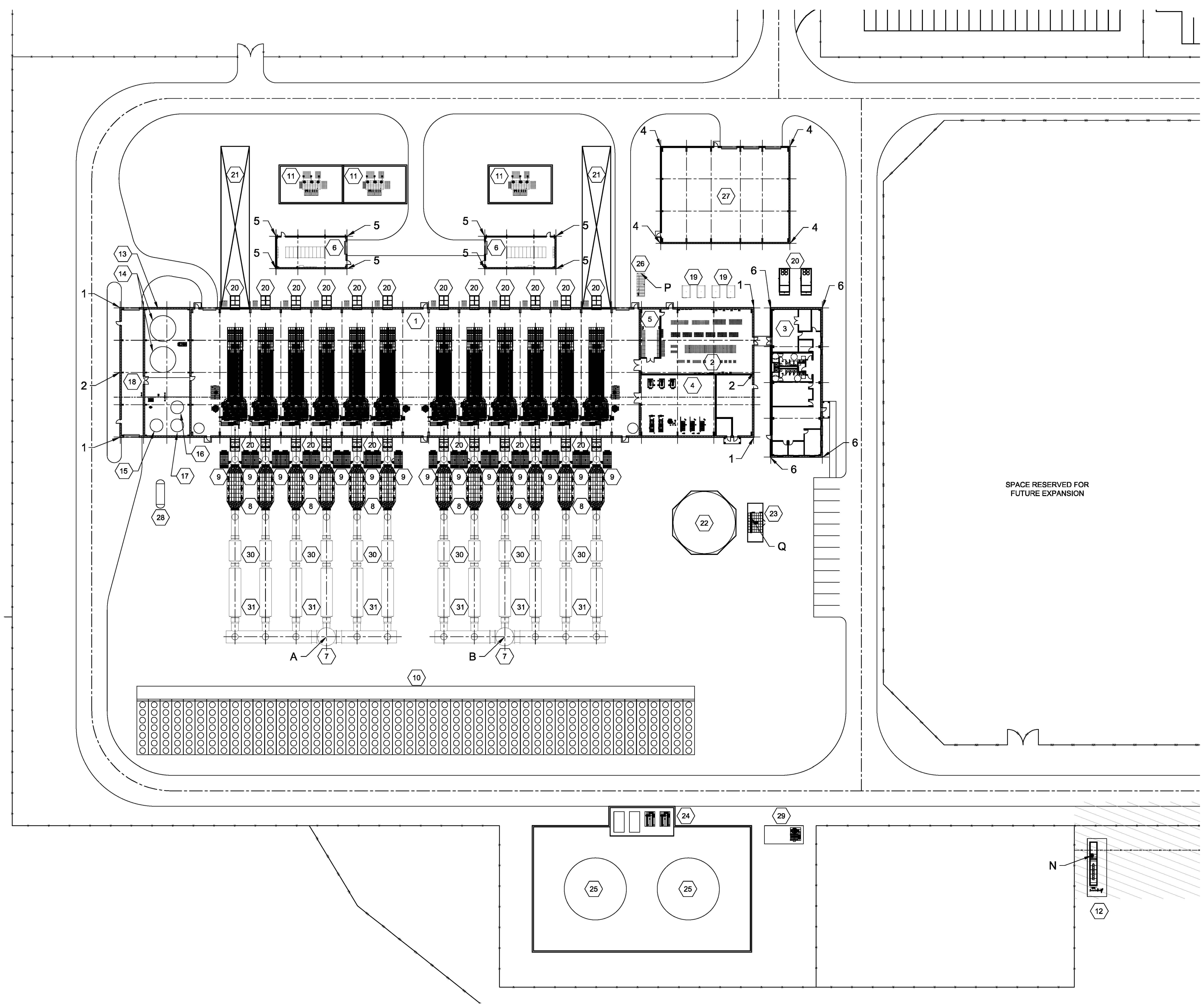
Analysis of Impacts from emissions of toxic air pollutants calculated to be emitted by the proposed project sources will be performed using the EPA Regional Screening Level (RSL) values. Modeling conducted to determine project impacts will be used to scale predicted impacts to levels at which a particular toxic air pollutant is emitted. Calculation of the annual ambient impact using the results of the modeling for a pollutant with an annual standard will be performed by dividing the individual air toxic compound annual emissions by the chosen modeled pollutant annual emissions, then multiplying that ratio by the maximum chosen pollutant annual impact to provide an estimated annual air toxic concentration.

4.0 MODEL RESULTS PRESENTATION

For this modeling analysis, $PM_{2.5}$, PM_{10}, NO_2, and CO will be modeled using the AERMOD modeling system. Maximum ambient ground level concentrations will be identified for the appropriate averaging periods, determination of significant impacts, and increment consumptions and NAAQS evaluation as applicable. The analysis will present all project source emissions and nearby and surrounding source emissions as described in Section 3.5 of this protocol. Stack parameters and locations will be provided for each emission point included in the modeling. Results will be expressed in tabular and graphic formats, and electronic modeling files will be provided with the Class II modeling report.

APPENDIX A

PRELIMINARY SITE LAYOUT DRAWINGS



EQUIP COORDS

ITEM	NORTHING	EASTING	HEIGHT
N	N: 2018229.805	E: 1870408.641	25'-0"
P	N: 2018717.679	E: 1870704.424	25'-0"
Q	N: 2018570.128	E: 1870558.390	15'-0"

STACK COORDS

ITEM	NORTHING	EASTING
A	N: 2018843.930	E: 1870354.280
B	N: 2018714.979	E: 1870403.780

BUILDING HEIGHTS

ITEM	HEIGHT
1	34'-0"
2	45'-0"
3	NOT USED
4	25'-0"
5	23'-0"
6	15'-0"

SITE KEY

1	ENGINE HALL
2	LOW VOLTAGE ROOM
3	ADMIN-CONTROL AREA
4	MECHANICAL ROOM
5	BATTERY ROOM
6	MEDIUM VOLTAGE BLDG
7	SILENCERS - STACKS
8	SELECTIVE CATALYTIC REDUCER
9	CHARGE AIR FILTER
10	RADIATORS
11	STEP-UP TRANSFORMER AND CONTAINMENT
12	GAS CONDITIONING
13	OIL-UREA CONTAINMENT
14	UREA TANK
15	NEW LUBE OIL TANK
16	SERVICE LUBE OIL TANK
17	WASTE LUBE OIL TANK
18	OIL-UREA / AMMONIA UNLOADING STATION
19	STATION TRANSFORMER
20	HVAC UNITS
21	HEAVY HAUL
22	FIRE WATER TANK
23	FIRE PUMPS
24	FUEL PUMPS
25	LIQUID FUEL TANKS WITH CONTAINMENT
26	AUX GENERATOR
27	WAREHOUSE
28	OIL WATER SEPARATOR
29	GAS FILTER/SEPARATOR
30	RESONATOR
31	HORIZONTAL SILENCER

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
B	04/29/24	WRL		ADDED COORDINATES FOR STACKS AND EQUIPMENT
A	03/04/24	WRL		PRELIMINARY MIRRORED SINGLE STACK LAYOUT

POWER BLOCK ENLARGED PLAN

0 16' 32' 64'

SCALE IN FEET

TRUE NORTH 21°0'0" PLAN NORTH NORTH

BURNS McDONNELL

designed | detailed W. LESNIAK

EAST KENTUCKY POWER COOPERATIVE

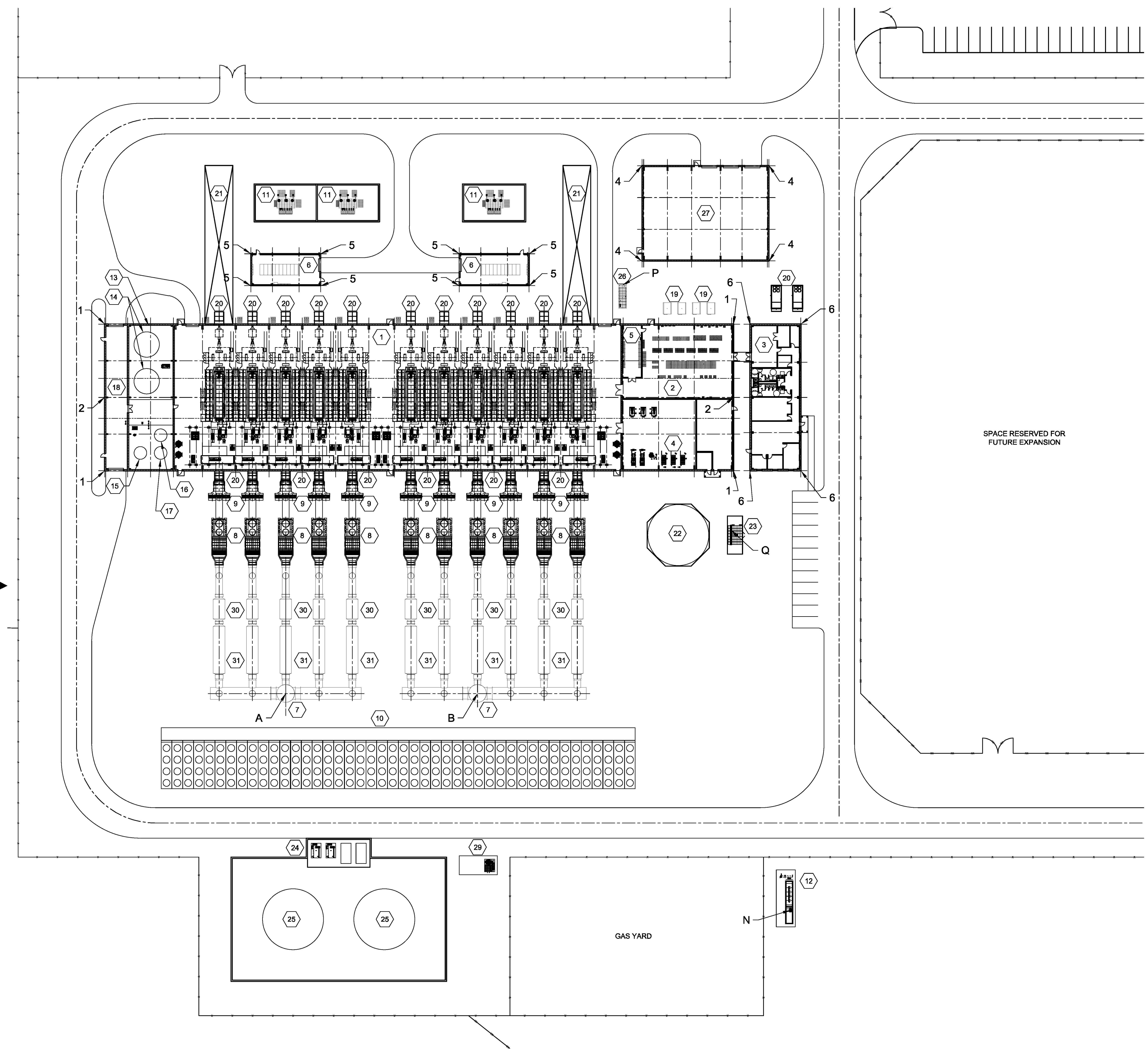
LIBERTY SITE 3
12 x 18MW GAS RECIP ENGINE PLANT
SINGLE STACK OPTION B
ENLARGED PLAN

project 157785 | contract

drawing GA122 — rev. B

sheet of sheets

file 157785_12X18MW-GA122-LIBRTY3-SNGLESTK-OPTB.



EQUIP COORDS

ITEM	NORTHING	EASTING	HEIGHT
N	N: 2018413.659	E: 1870297.371	25'-0"
P	N: 2018714.056	E: 1870710.100	25'-0"
Q	N: 2018565.071	E: 1870560.331	15'-0"

STACK COORDS

ITEM	NORTHING	EASTING
A	N: 2018846.622	E: 1870314.147
B	N: 2018705.417	E: 1870368.350

BUILDING HEIGHTS

ITEM	HEIGHT
1	34'-0"
2	45'-0"
3	NOT USED
4	25'-0"
5	23'-0"
6	15'-0"

SITE KEY

1	ENGINE HALL
2	LOW VOLTAGE ROOM
3	ADMIN-CONTROL AREA
4	MECHANICAL ROOM
5	BATTERY ROOM
6	MEDIUM VOLTAGE BLDG
7	SILENCERS - STACKS
8	SELECTIVE CATALYTIC REDUCER
9	CHARGE AIR FILTER
10	RADIATORS
11	STEP-UP TRANSFORMER AND CONTAINMENT
12	GAS CONDITIONING
13	OIL-UREA CONTAINMENT
14	UREA TANK
15	NEW LUBE OIL TANK
16	SERVICE LUBE OIL TANK
17	WASTE LUBE OIL TANK
18	OIL-UREA / AMMONIA UNLOADING STATION
19	STATION TRANSFORMER
20	HVAC UNITS
21	HEAVY HAUL
22	FIRE WATER TANK
23	FIRE PUMPS
24	FUEL PUMPS
25	LIQUID FUEL TANKS WITH CONTAINMENT
26	AUX GENERATOR
27	WAREHOUSE
28	OIL WATER SEPARATOR
29	GAS FILTER/SEPARATOR
30	RESONATOR
31	HORIZONTAL SILENCER

PRELIMINARY - NOT FOR CONSTRUCTION

no.	date	by	ckd	description
B	04/29/24	WRL		ADDED COORDINATES FOR STACKS AND EQUIPMENT
A	03/11/24	WRL		PRELIMINARY

POWER BLOCK ENLARGED PLAN

0 16' 32' 64'
SCALE IN FEET

TRUE NORTH 21°0'0"
PLAN NORTH
NORTH

BURNS McDONNELL

designed
detailed W. LESNIAK

EAST KENTUCKY POWER COOPERATIVE

LIBERTY SITE 3
11 x 20MW GAS RECIP ENGINE PLANT
SINGLE STACK ENLARGED PLAN OPTION B
BASED ON MAN ENGINES

project 157785
contract
drawing **GA162 – B** rev.
sheet of sheets
file 157785_11XMAN-GA162-LIBRTY3-OPTB.DWG

Z:\CLIENTS\ENR\EKPC\157785_RECIPSTUDY\2_DESIGN\MECH\DWGS\GNRL_ARRANGMNT\157785_11XMAN-GA162-LIBRTY3-OPTB.DWG 3/11/2024 2:48 PM WLESNIAK

APPENDIX B

RICE ENGINE STARTUP/SHUTDOWN DEFINITIONS

Startup Definitions and Emissions for Wartsila Engines (12x18 MW)

Cold Start:

- Catalyst material temperature close to ambient, needs full heating
- Typical standby time before cold engine starts is generally greater than two days
- Worst-case 30-minute startup duration to steady state with full load attained at 5 minutes

Warm Start:

- Catalyst material temperature above ambient but needs some heating
- Typical after engine is down for 12 hours
- Worst-case 30-minute startup duration to steady state with full load attained at 5 minutes

Hot Start:

- Catalyst material close to operating temperature
- Typical after engine is down for 6 hours
- Worst-case 30-minute startup duration to steady state with full load attained at 5 minutes

Shutdown:

- Estimated shutdown duration is 60 seconds

Expected Emissions During Startup (Natural Gas)

Pollutant	Cold Start, lb/startup	Warm Start, lb/startup	Hot Start, lb/startup
NOx (as NO_2)	20	14	9
CO	19	16	11
VOC (as CH_4)	3	1.9	1.7
PM	4	4	4

Expected Emissions During Startup (ULSFO)

Pollutant	Cold Start, lb/startup	Warm Start, lb/startup	Hot Start, lb/startup
NOx (as NO_2)	105	77	61
CO	8	7	6
VOC (as CH_4)	4	3.5	3
PM	6	6	6

Expected Emissions During Shutdown

Pollutant	Shutdown on Gas, lb/shutdown	Shutdown on ULSFO, lb/shutdown
NOx (as NO_2)	0.06	0.4
CO	0.09	0.12
VOC (as CH_4)	0.09	0.15

Startup Definitions and Emissions for MAN Engines (11x20 MW)

Cold Start:

- Catalyst material temperature close to ambient, needs full heating
- Typical standby time before cold engine starts is generally greater than 12 hours
- Worst-case 30-minute startup duration to steady state with full load attained at approximately 22 minutes
- Note: Cold start emissions for all pollutants except for CO on ULSFO will be less than warm starts because a cold start is not able to attain full load nearly as fast as a warm start (22 minutes vs. 2 minutes).

Warm Start:

- Catalyst material temperature above ambient but needs some heating
- Typical after engine is down for 1 to 12 hours.
- Worst-case 30-minute startup duration to steady state with full load attained at approximately 2 minutes

Hot Start:

- Catalyst material close to operating temperature
- Typical after engine is down for less than 1 hour
- Worst-case 4-minute startup duration to steady state with full load attained at 1 minute

Shutdown:

- Estimated shutdown duration is 2 minutes

Expected Emissions During Startup (Natural Gas)

Pollutant	Cold Start, lb/startup	Warm Start, lb/startup	Hot Start, lb/startup
NOx (as NO_2)	27.5	40.9	3.3
CO	18.8	36.7	2.9
VOC (as CH_4)	13.5	22.7	2.38
PM	2.3	1	0.3

Expected Emissions During Startup (ULSFO)

Pollutant	Cold Start, lb/startup	Warm Start, lb/startup	Hot Start, lb/startup
NOx (as NO_2)	66	204	8
CO	11.5	11	1.5
VOC (as CH_4)	5.7	8.9	0.73
PM	4.8	7.9	0.6

Expected Emissions During Shutdown

Pollutant	Shutdown on Natural Gas, lb/shutdown	Shutdown on ULSFO, lb/shutdown
NOx (as NO_2)	0.9	1.5
CO	2.8	1
VOC (as CH_4)	2.81	0.53
PM	0.1	0.4

APPENDIX C

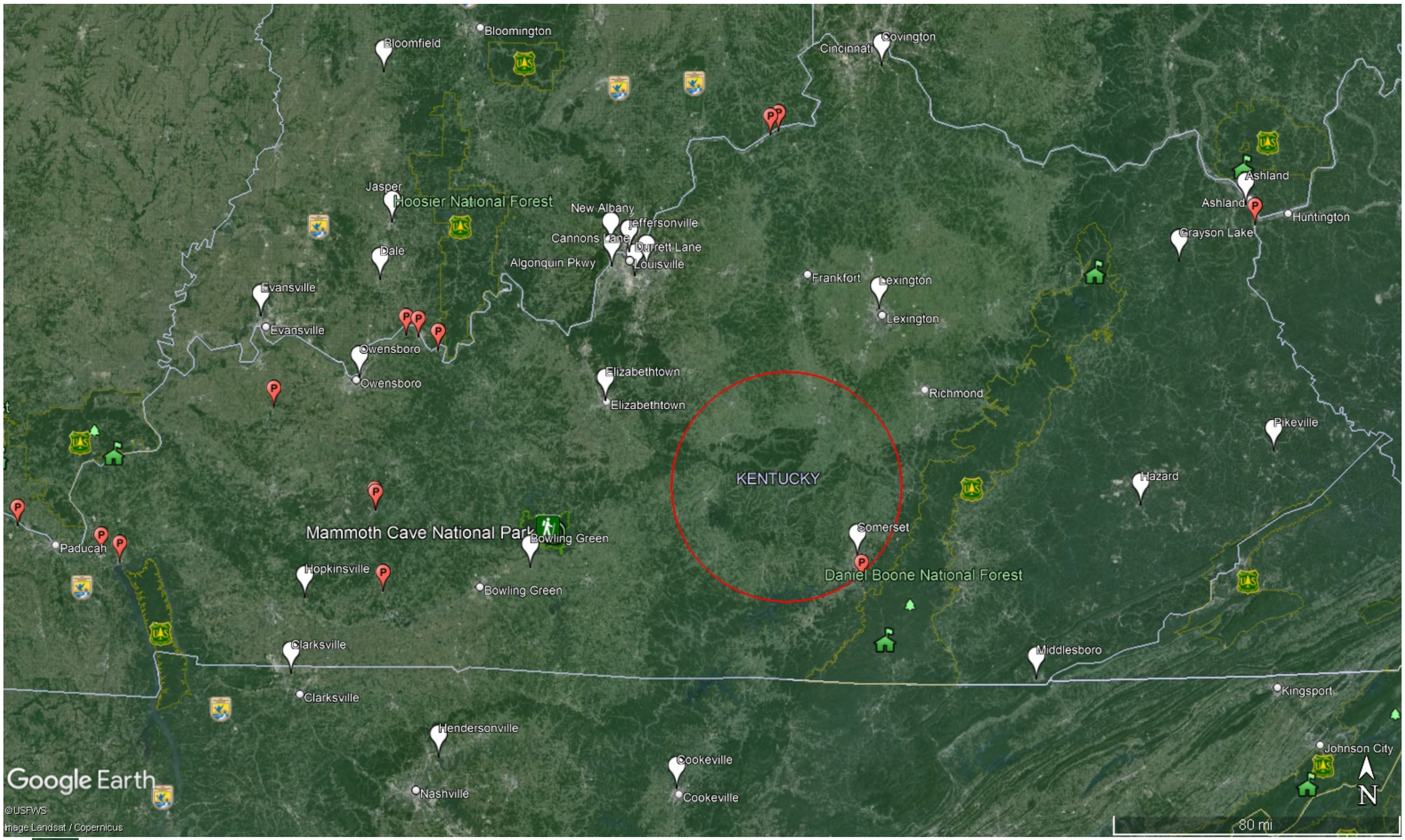
AMBIENT MONITORING LOCATIONS

Table C-1
$PM_{2.5}$ Monitoring Locations

Monitor Location	Latitude	Longitude	Elevation (m)	Distance From EKPC (km)	Elevation Difference (m)	Land Use	Location Setting
Somerset, KY	37.09798	-84.61152	306	43.1	-25	COMMERCIAL	SUBURBAN
Elizabethtown, KY	37.70561	-85.852629	250	87.4	-81	RESIDENTIAL	SUBURBAN
Lexington, KY	38.06503	-84.49761	302	87.4	-29	RESIDENTIAL	SUBURBAN
Bowling Green, KY	37.04926	-86.21487	194	117.0	-137	RESIDENTIAL	SUBURBAN
Jeffersonville, IN	38.28819	-85.741337	107	123.3	-224	INDUSTRIAL	SUBURBAN
Middlesboro, KY	36.60843	-83.73694	346	137.7	15	RESIDENTIAL	SUBURBAN
Cookeville, TN	36.1857	-85.492107	358	140.1	27	RESIDENTIAL	SUBURBAN
Hazard, KY	37.28329	-83.20932	280	155.1	-51	RESIDENTIAL	SUBURBAN
Covington, KY	39.02188	-84.47445	251	188.7	-80	AGRICULTURAL	RURAL
Owensboro, KY	37.78078	-87.075307	127	192.3	-204	COMMERCIAL	SUBURBAN
Hendersonville, TN	36.29756	-86.653137	143	192.4	-188	INDUSTRIAL	RURAL
Grayson Lake, KY	38.23887	-82.9881	211	198.4	-120	RESIDENTIAL	RURAL
Dale, IN	38.16752	-86.983214	142	199.1	-189	INDUSTRIAL	SUBURBAN
Jasper, IN	38.3918	-86.929668	125	207.3	-206	COMMERCIAL	URBAN AND CENTER CITY
Pikeville, KY	37.4826	-82.53532	207	214.5	-124	COMMERCIAL	URBAN AND CENTER CITY
Hopkinsville, KY	36.91171	-87.323337	215	215.9	-116	AGRICULTURAL	RURAL
Clarksville, TN	36.61141	-87.384666	149	231.6	-182	RESIDENTIAL	SUBURBAN
Ashland, KY	38.45934	-82.64041	200	236.9	-131	RESIDENTIAL	SUBURBAN
Evansville, IN	38.01333	-87.577222	116	241.6	-215	COMMERCIAL	SUBURBAN

Monitor locations, elevations, land use, and location settings from EPA's Air Data Website: https://www.epa.gov/outdoor-air-quality-data

Figure C-1
PM2.5 Monitors and Large Sources



$PM_{2.5}$ Monitors **$PM_{2.5}$ Large Sources**

Table C-2
Land Use within 3 km of Somerset $PM_{2.5}$ Monitor

Category	Landuse	Area(m^2)	Percent	Classification
11	Open Water	55,800	0.20%	Rural
21	Developed Open Space	4,095,900	14.52%	Rural
22	Developed Low Intensity	6,634,800	23.51%	Urban
23	Developed Medium Intensity	5,245,200	18.59%	Urban
24	Developed High Intensity	2,497,500	8.85%	Urban
31	Barren Land	246,600	0.87%	Rural
41	Deciduous Forest	2,662,200	9.43%	Rural
42	Evergreen Forest	15,300	0.05%	Rural
43	Mixed Forest	1,108,800	3.93%	Rural
52	Shrub Scrub	72,900	0.26%	Rural
71	Herbaceous	73,800	0.26%	Rural
81	Hay Pasture	4,950,900	17.55%	Rural
82	Cultivated Crops	517,500	1.83%	Rural
90	Woody Wetlands	37,800	0.13%	Rural
95	Emergent Herbaceous Wetlands	2,700	0.01%	Rural
	Total Urban		**50.95%**	
	Total Rural		**49.05%**	

Table C-3
Land Use within 3 km of Grayson Lake $PM_{2.5}$ Monitor

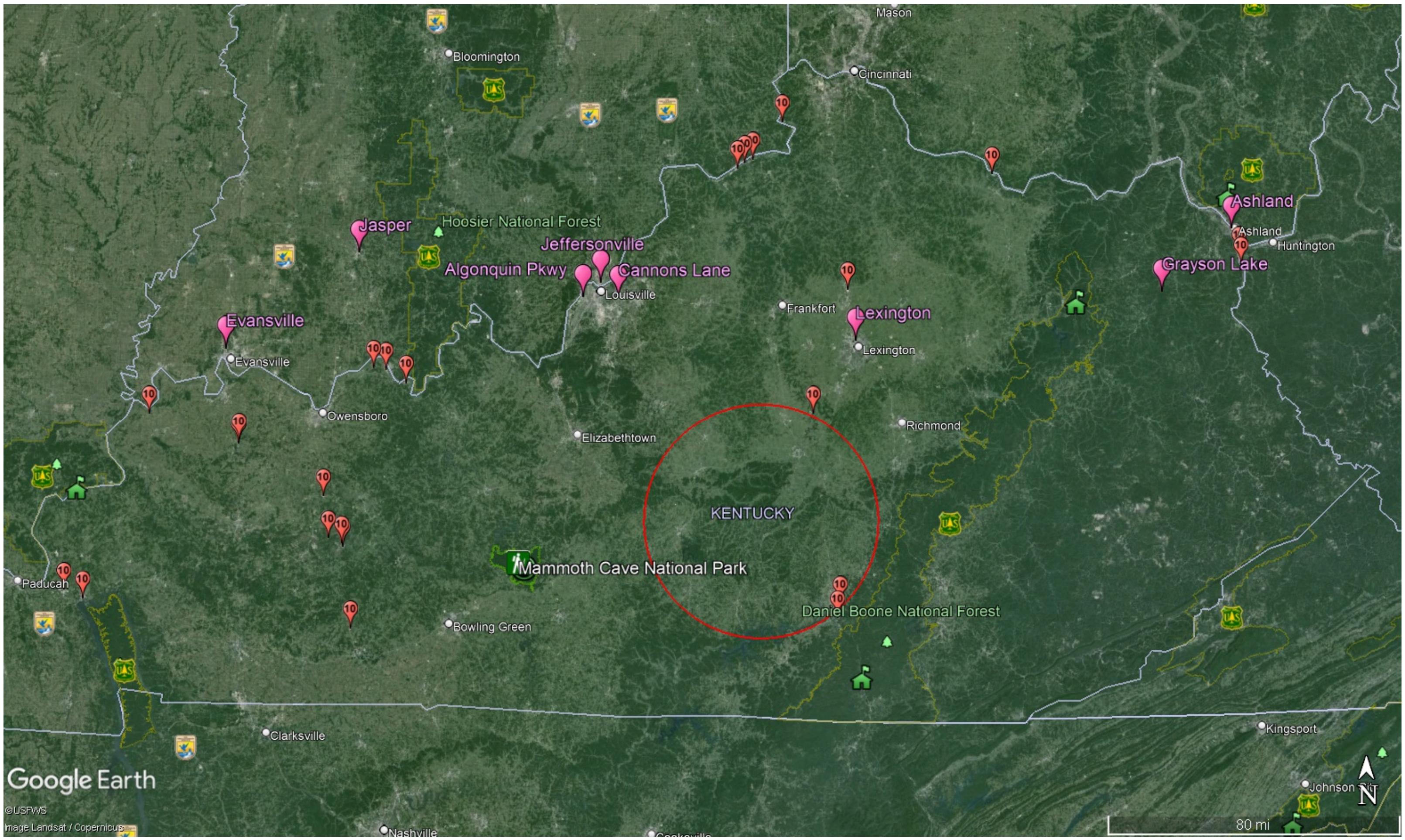
Category	Landuse	Area(m^2)	Percent	Classification
11	Open Water	1,944,900	6.89%	Rural
21	Developed Open Space	687,600	2.44%	Rural
22	Developed Low Intensity	394,200	1.40%	Rural
23	Developed Medium Intensity	110,700	0.39%	Urban
24	Developed High Intensity	17,100	0.06%	Urban
31	Barren Land	45,000	0.16%	Rural
41	Deciduous Forest	21,343,500	75.63%	Rural
42	Evergreen Forest	280,800	1.00%	Rural
43	Mixed Forest	1,850,400	6.56%	Rural
52	Shrub Scrub	66,600	0.24%	Rural
71	Herbaceous	56,700	0.20%	Rural
81	Hay Pasture	1,411,200	5.00%	Rural
90	Woody Wetlands	11,700	0.04%	Rural
	Total Urban		**1.85%**	
	Total Rural		**98.15%**	

Table C-4
PM_{10} Monitoring Locations

Monitor Location	Latitude	Longitude	Elevation (m)	Distance From EKPC (km)	Elevation Difference (m)	Land Use	Location Setting
Lexington Primary	38.06503	-84.49761	302	87.4	-29	RESIDENTIAL	SUBURBAN
Cannons Lane	38.22876	-85.65452	127	113.6	-204	RESIDENTIAL	SUBURBAN
Algonquin Parkway	38.23158	-85.82678	137	122.7	-194	INDUSTRIAL	SUBURBAN
Jeffersonville, IN	38.28819	-85.741337	107	123.3	-224	INDUSTRIAL	SUBURBAN
Grayson Lake, KY	38.23887	-82.9881	211	198.4	-120	RESIDENTIAL	RURAL
Jasper, IN	38.3918	-86.929668	125	207.3	-206	COMMERCIAL	URBAN AND CENTER CITY
Ashland, KY	38.47676	-82.63137	167	238.6	-164	INDUSTRIAL	URBAN AND CENTER CITY
Evansville, IN	38.01333	-87.577222	116	241.6	-215	COMMERCIAL	SUBURBAN

Monitor locations, elevations, land use, and location settings from EPA’s Air Data Website: https://www.epa.gov/outdoor-air-quality-data

Figure C-2
PM10 Monitors and Large Sources



 **PM10 Monitors**

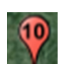
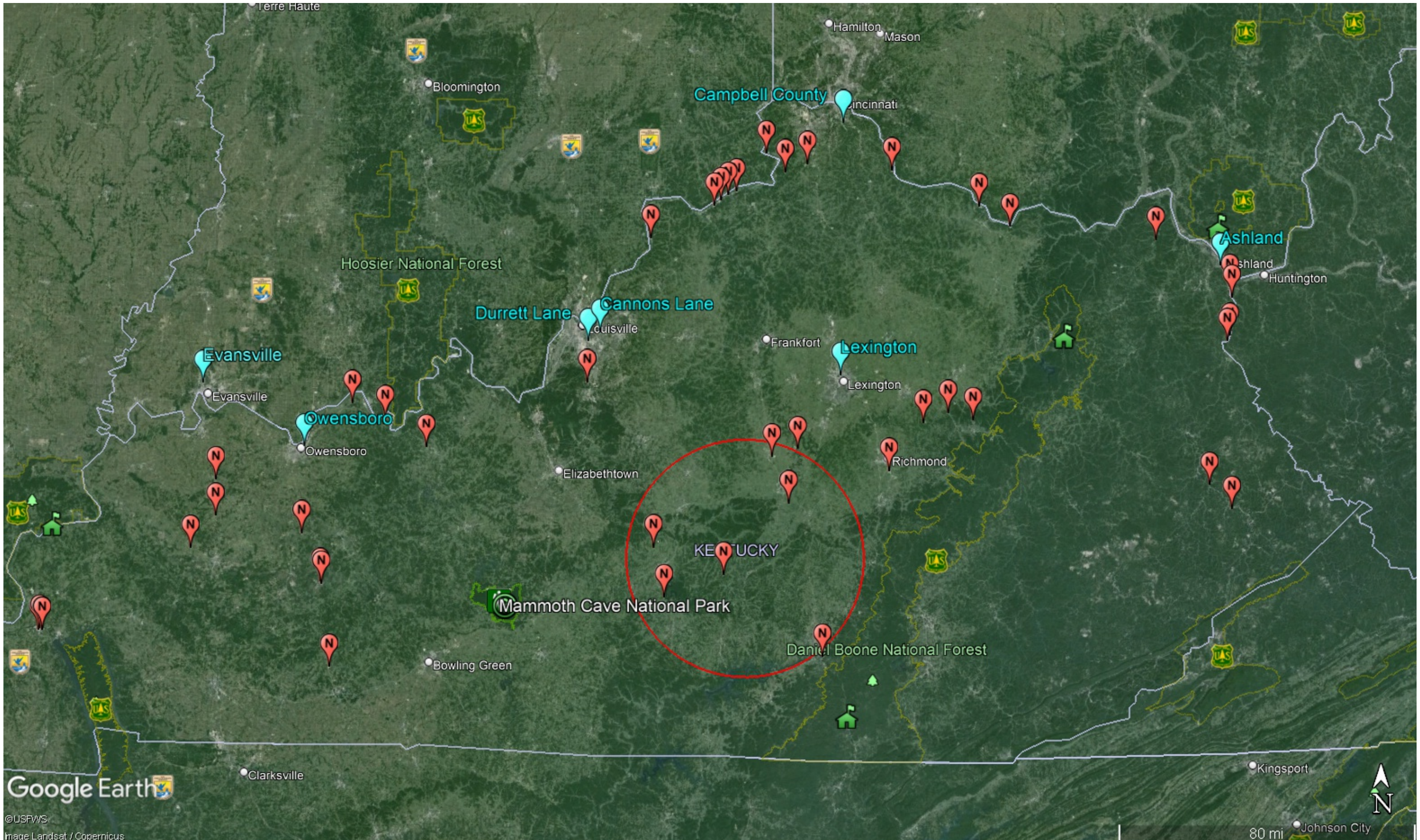
 **PM10 Large Sources**

Table C-5
NO_2 Monitoring Locations

Monitor Location	Latitude	Longitude	Elevation (m)	Distance From EKPC (km)	Elevation Difference (m)	Land Use	Location Setting
Lexington, KY	38.06503	-84.49761	302	87.4	-29	RESIDENTIAL	SUBURBAN
Durrett Lane	38.1936	-85.7119	127	113.2	-204	RESIDENTIAL	URBAN AND CENTER CITY
Cannons Lane	38.22876	-85.65452	127	113.6	-204	RESIDENTIAL	SUBURBAN
Campbell County, KY	39.02188	-84.47445	251	188.7	-80	AGRICULTURAL	RURAL
Owensboro, KY	37.78078	-87.075307	127	192.3	-204	COMMERCIAL	SUBURBAN
Ashland, KY	38.45934	-82.64041	200	236.9	-131	RESIDENTIAL	SUBURBAN
Evansville, IN	38.01333	-87.577222	116	241.6	-215	COMMERCIAL	SUBURBAN

Monitor locations, elevations, land use, and location settings from EPA’s Air Data Website: https://www.epa.gov/outdoor-air-quality-data

Figure C-3
NO_2 Monitors and Large Sources



NO_2 Monitors

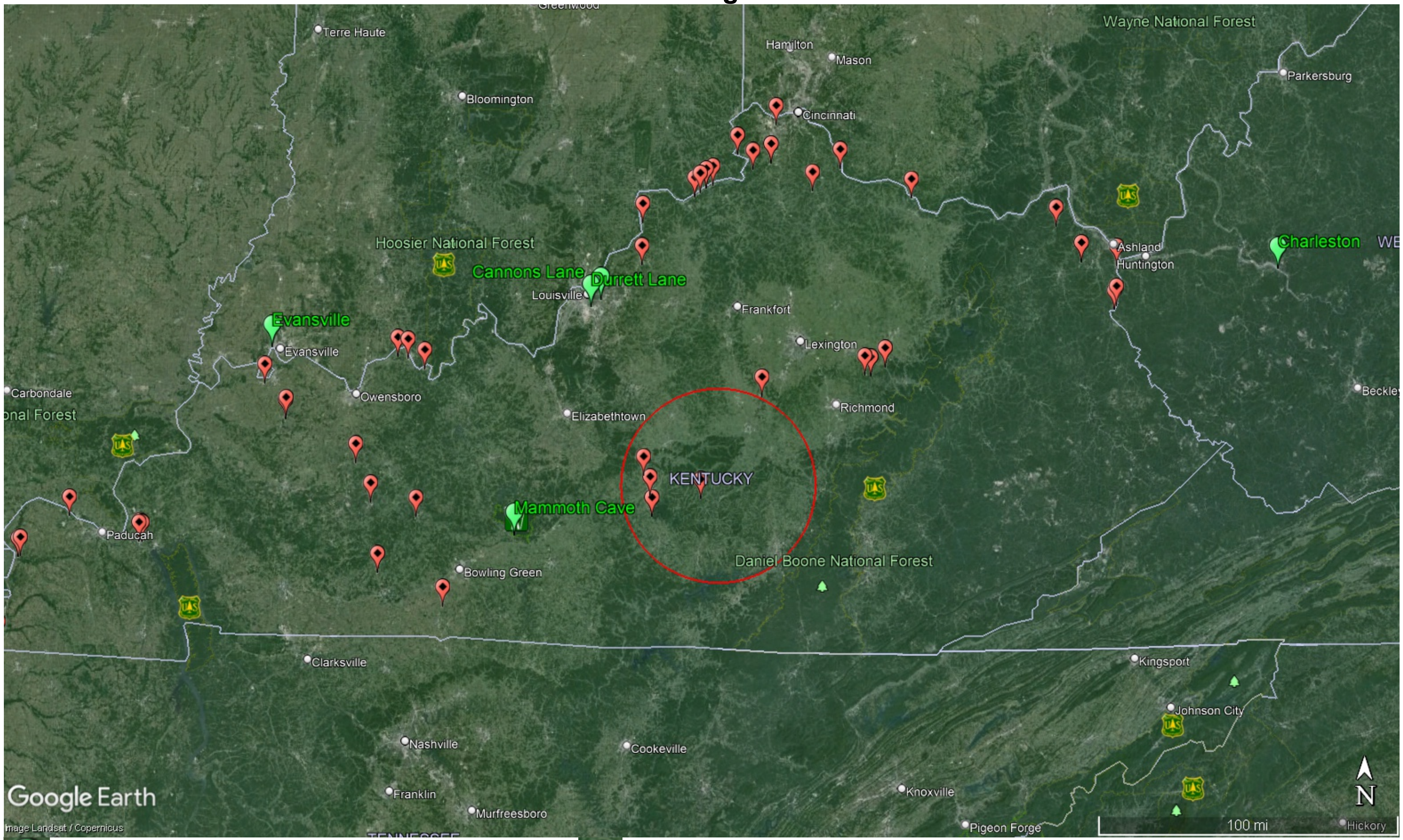
NO_2 Large Sources

Table C-6
CO Monitoring Locations

Monitor Location	Latitude	Longitude	Elevation (m)	Distance From EKPC (km)	Elevation Difference (m)	Land Use	Location Setting
Durrett Lane	38.1936	-85.7119	127	113.2	-204	RESIDENTIAL	URBAN AND CENTER CITY
Cannons Lane	38.22876	-85.65452	127	113.6	-204	RESIDENTIAL	SUBURBAN
Mammoth Cave, KY	37.13179	-86.142953	230	108.3	-101	FOREST	RURAL
Evansville, IN	37.97768	-87.596836	90	242.1	-241	COMMERCIAL	URBAN AND CENTER CITY
Charleston WV	38.34626	-81.621161	223	312.7	-108	COMMERCIAL	URBAN AND CENTER CITY

Monitor locations, elevations, land use, and location settings from EPA's Air Data Website: https://www.epa.gov/outdoor-air-quality-data

Figure C-4
CO Monitors and Large Sources



CO Monitors

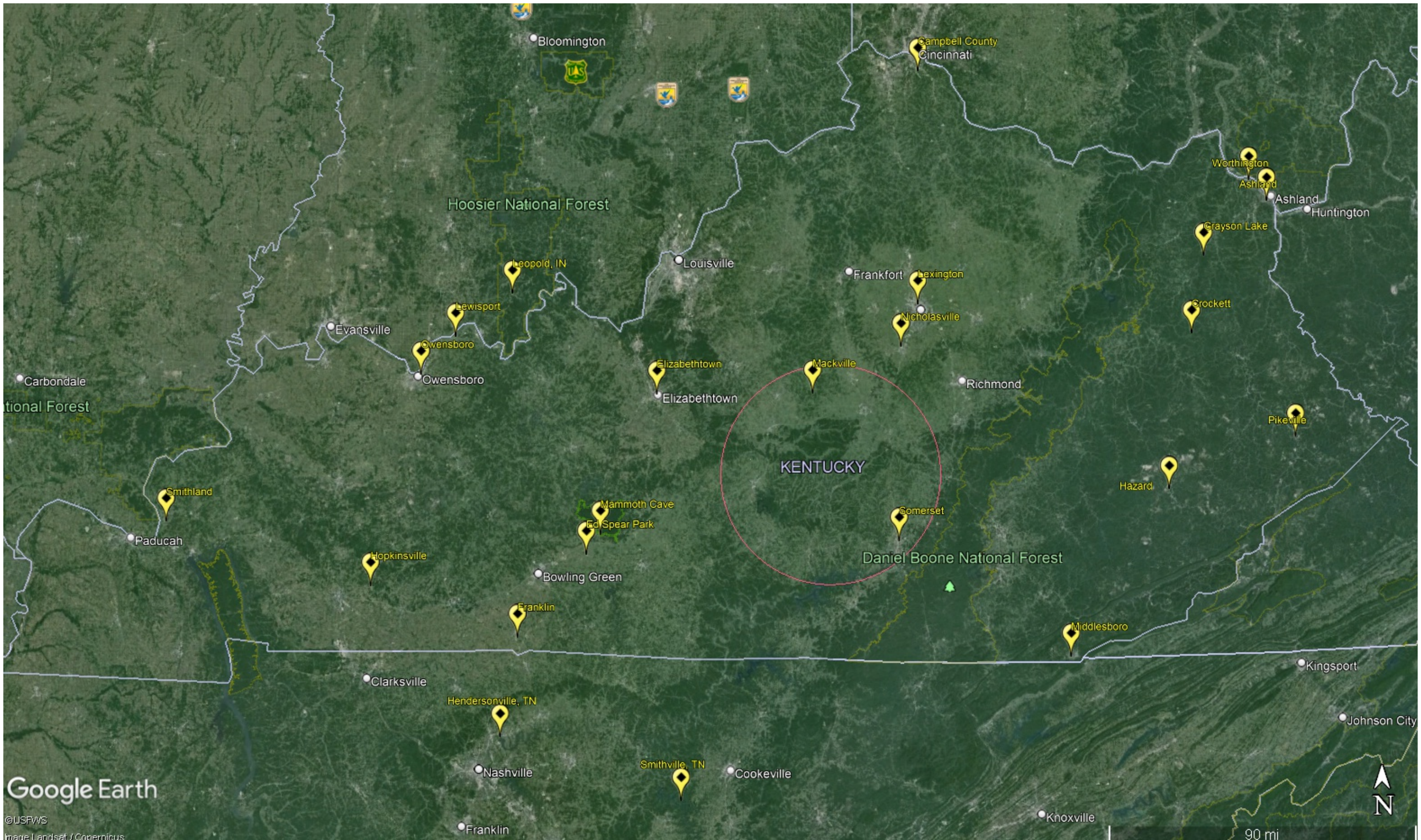
CO Large Sources

Table C-7
Ozone Monitoring Locations

Monitor Location	Latitude	Longitude	Elevation (m)	Distance From EKPC (km)	Elevation Difference (m)	Land Use	Location Setting
Mackville, KY	37.7046	-85.0485	353	38.2	22	AGRICULTURAL	RURAL
Somerset, KY	37.09798	-84.61152	306	43.1	-25	COMMERCIAL	SUBURBAN
Nicholasville, KY	37.89147	-84.58825	283	66.6	-48	COMMERCIAL	SUBURBAN
Elizabethtown, KY	37.70561	-85.852629	250	87.4	-81	RESIDENTIAL	SUBURBAN
Lexington, KY	38.06503	-84.49761	302	87.4	-29	RESIDENTIAL	SUBURBAN
Mammoth Cave, KY	37.13179	-86.142953	230	108.3	-101	FOREST	RURAL
Ed Spear Park, KY	37.04926	-86.21487	194	117.0	-137	RESIDENTIAL	SUBURBAN
Middlesboro, KY	36.60843	-83.73694	346	137.7	15	RESIDENTIAL	SUBURBAN
Hazard, KY	37.28329	-83.20932	280	155.1	-51	RESIDENTIAL	SUBURBAN
Franklin, KY	36.70861	-86.566284	221	160.7	-110	COMMERCIAL	RURAL
Smithville, TN	36.0388	-85.7331	302	163.4	-29	FOREST	RURAL
Leopold, IN	38.11515	-86.60325	201	166.9	-130	AGRICULTURAL	RURAL
Crockett, KY	37.9214	-83.0662	455	177.7	124	FOREST	RURAL
Lewisport, KY	37.93829	-86.89719	122	182.2	-209	RESIDENTIAL	RURAL
Campbell County, KY	39.02188	-84.47445	251	188.7	-80	AGRICULTURAL	RURAL
Owensboro, KY	37.78078	-87.075307	127	192.3	-204	COMMERCIAL	SUBURBAN
Hendersonville, TN	36.29756	-86.653137	143	192.4	-188	INDUSTRIAL	RURAL
Grayson Lake, KY	38.23887	-82.9881	211	198.4	-120	RESIDENTIAL	RURAL
Pikeville, KY	37.4826	-82.53532	207	214.5	-124	COMMERCIAL	URBAN AND CENTER CITY
Hopkinsville, KY	36.91171	-87.323337	215	215.9	-116	AGRICULTURAL	RURAL
Worthington, KY	38.54814	-82.731163	165	235.4	-166	RESIDENTIAL	SUBURBAN
Ashland, KY	38.45934	-82.64041	200	236.9	-131	RESIDENTIAL	SUBURBAN
Smithland, KY	37.15539	-88.394024	110	305.3	-221	AGRICULTURAL	RURAL

Monitor locations, elevations, land use, and location settings from EPA’s Air Data Website: https://www.epa.gov/outdoor-air-quality-data

Figure C-5
Ozone Monitors



Ozone Monitors

Table C-8
Land Use within 3 km of Mackville Ozone Monitor

Category	Landuse	Area(m^2)	Percent	Classification
11	Open Water	8,100	0.03%	Rural
21	Developed Open Space	1,115,100	3.95%	Rural
22	Developed Low Intensity	72,000	0.26%	Urban
23	Developed Medium Intensity	23,400	0.08%	Urban
24	Developed High Intensity	3,600	0.01%	Urban
31	Barren Land	52,200	0.19%	Rural
41	Deciduous Forest	10,855,800	38.48%	Rural
42	Evergreen Forest	176,400	0.63%	Rural
43	Mixed Forest	2,786,400	9.88%	Rural
52	Shrub Scrub	97,200	0.34%	Rural
71	Herbaceous	222,300	0.79%	Rural
81	Hay Pasture	12,362,400	43.82%	Rural
82	Cultivated Crops	436,500	1.55%	Rural
	Total Urban	**0.35%**	**1.85%**	
	Total Rural		**99.65%**	

APPENDIX D

TIER 3 NO_2 MODELING – Filling Missing Ozone Data for OLM and PVMRM Applications – Minnesota Pollution Control Agency

Minnesota Pollution Control Agency

Technical Guidance

Filling Missing Ozone Data for OLM and PVMRM Applications

I. Introduction

As noted in a June 28th, 2010 EPA memo from Tyler Fox to the regional air division directors, with the new 1-hour NO2 NAAQS standards, more attention must be paid to ozone concentrations that go into modeled NO2 calculations.

> "The representativeness of (ozone data) takes on somewhat greater importance in the context of a 1-hour NO2 standard than for an annual standard, for obvious reasons. In the case of hourly background ozone concentrations, methods used to substitute for periods of missing data may play a more significant role in determining the 1-hour NO2 modeled design value, and should therefore be given greater scrutiny, especially for data periods that are likely to be associated with peak hourly concentrations based on meteorological conditions and source characteristics. In other words, ozone data substitution methods that may have been deemed appropriate in prior applications for the annual standard may not be appropriate to use for the new 1-hour standard."

In addition, the memo stated that, "hourly monitored ozone concentrations used with the OLM and PVMRM options must be concurrent with the meteorological data period used in the modeling analysis."

Currently the MPCA uses concurrent hourly monitored ozone files in OLM and PVMRM applications. While ozone monitors are sparse in some parts of Minnesota, these hourly ozone files contain the most refined data available for use in model calculations. Unfortunately, along with the sparsity of monitors comes the problem of missing data. In light of EPA's statements above on the importance of ozone substitution methods pertaining to missing data, this paper examines a technique that will refine the way missing ozone hours are filled when using Minnesota ozone data.

II. Ozone Behavior

In order to understand how to accurately represent missing hours, it's important to understand the behavior of ozone in Minnesota. Data from the Shakopee, MN (summer) and Blaine, MN (winter) monitors from 2006-2010 have been combined to show how average ozone varies seasonally in Minnesota (Figure 1). Sunlight helps create ozone so it makes sense that the longer days of the warm season produce more ozone than the shorter days of the cold season. For instance in figure 1 you can see a general increase in ozone as length of day increases and a general decrease as length of day decreases. The exact cause of the April peak in this data is unknown. In a study conducted between 1977 and 1981 in Minnesota by Pratt et al (1983) a similar spring peak in average ozone was noted, however the peak was in May instead of April. That study cited work by Johnson and Viezee (1981) that showed stratospheric intrusions of ozone have a higher impact on tropospheric ozone values in the spring. Another possibility is that smoke from seasonally prescribed burns contributes higher levels of background ozone.

Seasonal Cycle

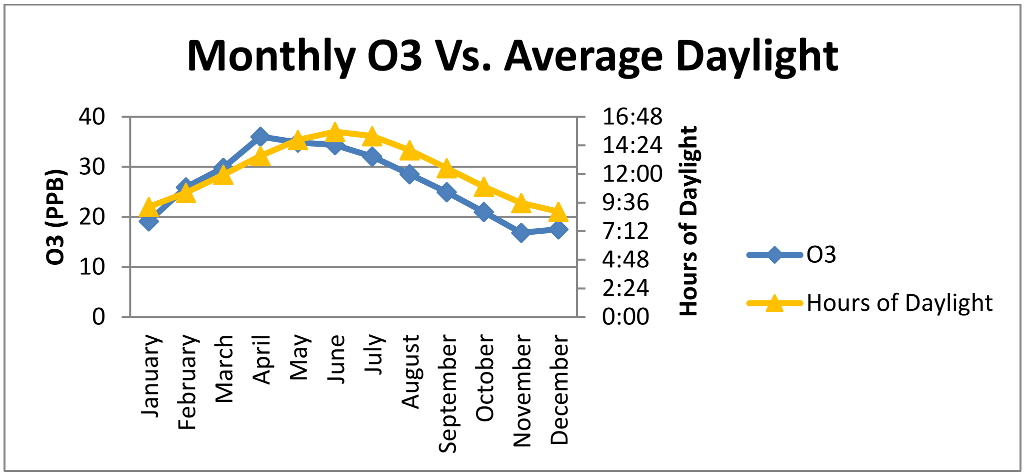


Figure 1: The more daylight, the more ozone

In addition to the seasonal ozone cycle, there's also a daily ozone cycle. Since sunlight helps create ozone, the longer the sun has been up, the more ozone that's potentially produced. That's one reason ozone is normally highest in the afternoon. Ozone values are also normally highest in the afternoon because the reactions that create ozone speed up with warmer temperatures. On the flip side, the lowest ozone values normally occur after the sun has been down for a significant length of time; during the cool morning hours. Figure 2 shows maximum and average values of ozone for morning, afternoon and night for each month in the Shakopee and Blaine data. The time periods were partitioned with morning starting at sunrise and running until noon, afternoon starting at noon and running until sunset, and night starting at sunset and running until sunrise. Average monthly sunrise and sunset times in Minneapolis were used for the calculations.

Daily Cycle

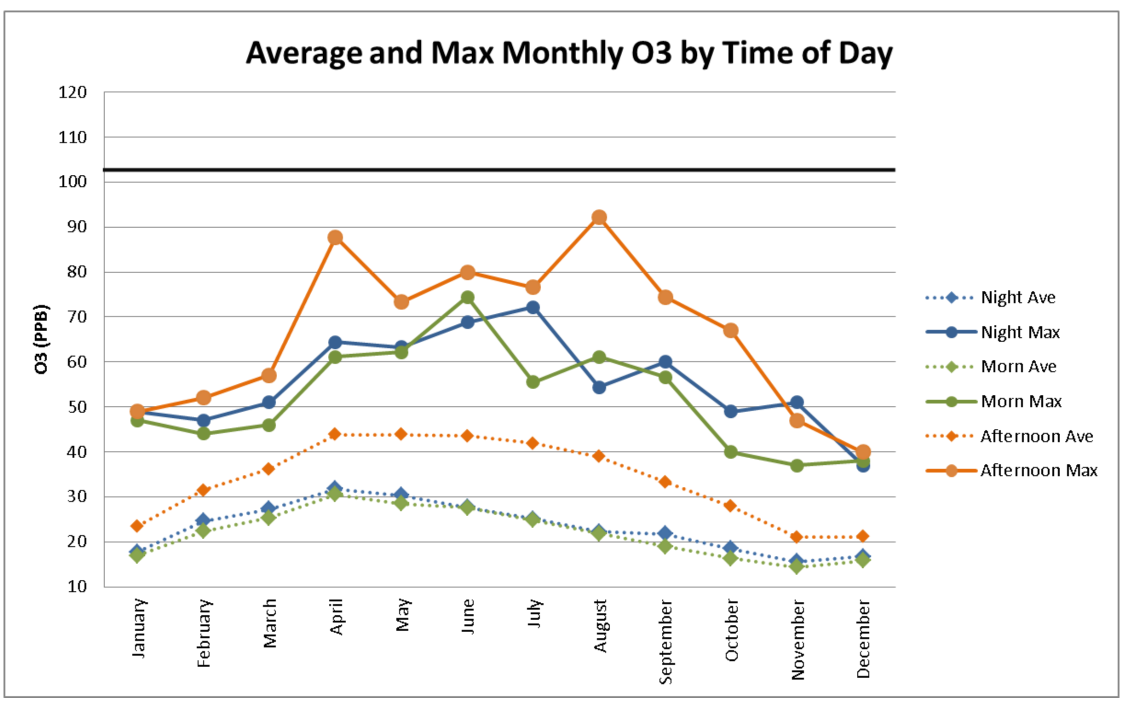


Figure 2: Ozone is normally at its peak in the afternoon, while minimums occur in the morning.

As expected, the highest maximum values normally occurred during the afternoon, while the lowest values normally occurred in the morning. Since each season and hour have different potential for ozone production, a representative method for filling missing data must take into account the seasonal and diurnal variation of ozone.

III. OLM and PVMRM Missing Hours

The tier 3 NO2 modeling methods of OLM and PVMRM outlined in 40 CFR Part 51 section 5.2.3 are becoming increasingly common as facilities try to meet the 1-hr NO2 standards. The OLM method converts NOx to NO2 by reacting NOx with ambient ozone. NO2 formation is limited if the O3 concentration is less than the NOx concentration. If the O3 concentration is greater than or equal to the NOx concentration, all NOx is converted to NO2. PVMRM calculates NOx plume volume at each receptor and then takes the ratio of the number of moles of O3 in the plume to the number of moles of NOx in the plume. That ratio is then multiplied by the NOx concentrations modeled in AERMOD to determine the final NO2 concentrations. While OLM and PVMRM applications at the MPCA use hourly monitored ozone data, we found there was no consistent agency wide approach for filling in missing hours. This challenge came to light when a value of **102 ppb (bold line Figure 2)** was proposed for filling in missing hours in the Shakopee/Blaine ozone data above. There are two potential problems with using 102 ppb:

1) That value is a max hourly value from data recorded in 2012, while the meteorological data came from the 2006-2010 timeframe. As stated in the EPA memo at the start of this paper, the ozone data must be concurrent with the meteorological data.

2) That value is not representative on multiple fronts. First it's 10 ppb higher than any value recorded in the Shakopee/Blaine data within the 2006-2010 timeframe. Second, it's a significant overestimate during the cold season and for many night and morning hours as it lacks any of the observed seasonal and diurnal variations.

IV. Review of State Specific Methods

A review of state specific methods yields a range of processes and approaches to filling missing ozone hours. Several states mentioned allowing linear interpolation for short periods of missing data. Table 1 shows which time periods were chosen by each of those states and the year the recommendations were made.

	4 Hours	3 Hours	1 Hour
Michigan (2010)	X		
Florida (2010)		X	
California (2010)			X
California (2011)			X
Florida (2013)		X	

Table 1. Time periods of missing data where linear interpolation was recommended

When data was missing for a period longer than the allowed linear interpolation period, a variety of other methods were recommended. Table 2 contains a brief summary of those methods as well as the year the recommendations were made.

A few of the methods from table 2 will not be considered for implementation in Minnesota at this time:

1) The Nearby Monitor method used by California assumes there are other monitors in the vicinity that are available to supplement ozone data when a primary monitor is not collecting data. This may be true in some

states with an abundance of monitors, but in Minnesota there's no guarantee another monitor will be available to fill in missing hours.

2) The Day Before/After method used by Florida substitutes hourly values from the day before or after the day with the missing data. This method assumes there are not more than two consecutive days of missing data. That assumption was not true of the Shakopee and Blaine dataset which had entire months missing.

3) The Monthly Average method used by South Dakota takes an average of all the hours in a month for the entire modeled period and substitutes the average value for any missing hours. This method ignores diurnal variability and therefore has the potential to underestimate afternoon and evening ozone concentrations.

The methods found to be most feasible, protective and representative for Minnesota are methods that have been discussed by California(2011) and Arizona (2012, 2013). Those states offered a variety of options ranging from conservative to more representative methods. The most conservative options use either the H1H from the modeled period or a H1H annual value for each modeled year. The more representative options offer max seasonal, max monthly, and finally max monthly/hourly values to fill in missing hours. This final option captures both the seasonal and diurnal variability of ozone.

	Period H1H	Max Annual	Max Seasonal	Max Monthly	Month/hour max	Nearby Monitor	Day Before/After	Monthly Ave.
Michigan (2010)				X				
Florida (2010)							X	
California (2010)						X		
South Dakota (2011)								X
California (2011)		X	X	X	X			
Arizona (2012)					X			
Florida (2013)							X	
Arizona (2013)	X		X	X	X			

Table 2. Methods applied to fill in longer periods with missing data

In an August 2012 correspondence between the Arizona Department of Environmental Quality (ADEQ), Rosemont Copper and JBR Environmental Consultants, Inc. in relation to an Environmental Impact Statement, the ADEQ stated that in order to be defensible, the potential maximum ozone concentrations for specific missing hours should be estimated and input to the ozone file during pre-processing. ADEQ then provided a table broken down into monthly/hourly maxima that occurred over the modeled period to be substituted for missing hours. MPCA proposes using a strategy similar to the ADEQ strategy, thereby capturing both the seasonal and diurnal variability in ozone background files.

V. New Method for Minnesota

In the interest of protecting the NAAQS but striving for seasonally and diurnally representative ozone data, MPCA is adopting the following strategy for creating ozone files for OLM and PVMRM applications.

1) Ozone gaps should be filled in during preprocessing
2) Use linear interpolation for single missing hours
3) When missing more than a single hour, replace data gaps with monthly/hourly maxima from MPCA tables.

VI. Examples of Minnesota's New Method

The following observations are taken from the same Shakopee/Blaine dataset discussed above. The -99000 indicates hour 3 is missing from the January 7th, 2006 ozone data. Since this is just one missing hour, the value should be filled using linear interpolation.

	Year	Month	Day	Hour	(ppm)	(ppb)
142	6	1	6	22	0.008	8
143	6	1	6	23	0.016	16
144	6	1	6	24	0.018	18
145	6	1	7	1	0.019	19
146	6	1	7	2	0.021	21
147	6	1	7	3	-99	-99000
148	6	1	7	4	0.02	20
149	6	1	7	5	0.019	19
150	6	1	7	6	0.018	18
151	6	1	7	7	0.014	14
152	6	1	7	8	0.013	13

Table 3. Sample data with a single missing hour

$$Hour\ 2 = 21$$
$$Hour\ 4 = 20$$

$$\frac{21 + 20}{2} = 20.5\ \ After\ rounding, Hour\ 3\ should\ be\ replaced\ with\ 21$$

The next example is from the same dataset a few days later. As shown in table 4, we're missing hours 14, 15 and 16.

	Year	Month	Day	Hour	(ppm)	(ppb)
249	6	1	11	9	0.001	1
250	6	1	11	10	0.005	5
251	6	1	11	11	0.009	9
252	6	1	11	12	0.015	15
253	6	1	11	13	0.017	17
254	6	1	11	14	-99	-99000
255	6	1	11	15	-99	-99000
256	6	1	11	16	-99	-99000
257	6	1	11	17	0.003	3
258	6	1	11	18	0.002	2
259	6	1	11	19	0.002	2
260	6	1	11	20	0.002	2
261	6	1	11	21	0.002	2

Table 4. Sample data with more than a single missing hour

In this case the recommendation is to use the following table of maximum monthly and hourly values from the Shakopee and Blaine 2006-2010 data, produced by the MPCA to replace the missing hours.

Example Table

Hour	January	February	March	April	May	June	July	August	September	October	November	December
1	44	44	45	60	60	60	61	50	59	43	44	37
2	45	43	46	59	57	59	58	49	58	38	44	37
3	44	42	46	58	56	60	57	50	56	36	43	37
4	46	42	44	58	52	60	56	51	50	37	42	36
5	45	42	43	57	52	56	51	52	48	30	40	36
6	49	42	44	54	57	58	53	52	44	37	38	35
7	47	42	44	51	62	57	50	52	46	38	36	36
8	46	41	42	47	54	53	48	43	44	39	37	37
9	46	41	42	49	57	60	50	44	46	38	37	37
10	46	43	44	53	57	70	53	52	52	40	37	37
11	45	44	46	61	60	74	56	61	57	38	37	38
12	44	46	48	68	68	76	63	63	60	44	38	39
13	48	47	49	69	72	78	71	72	61	52	43	40
14	49	49	51	70	72	79	72	87	63	58	46	40
15	48	49	57	70	72	77	70	92	64	63	47	40
16	47	52	57	86	73	77	74	90	69	67	47	39
17	45	51	57	88	72	80	76	86	74	64	43	36
18	46	49	56	74	72	78	77	66	70	54	45	36
19	46	47	52	76	70	73	71	63	58	49	50	37
20	47	41	51	71	66	70	61	54	54	45	51	37
21	49	43	47	64	63	69	60	53	54	42	47	36
22	49	43	48	62	60	69	72	54	58	41	44	35
23	45	42	47	60	58	68	66	54	58	45	43	36
24	45	44	45	56	59	62	63	52	60	44	45	37
Max	49	52	57	88	73	80	77	92	74	67	51	40

Table 5. Sample max monthly/hourly table of ozone values (ppb) to replace missing data

As seen in table 5, hours 14-16 would be replaced with 49, 48, and 47 ppb respectively. Looking back at table 4, these numbers are likely still very conservative estimates for these hours, but they are also much more representative than using the 102 ppb value originally proposed.

VII. Effect of the New Method on Modeled Results

MPCA conducted a sensitivity test using this new method to determine whether it could have practically significant effects on modeled NO2 results. The outcome of this testing showed that if the modeled maximum occurs on an hour with missing data, this method could have significant effects on modeled results depending on release height, release temperature and emission rate.

The following is example output from this testing. The example uses flat terrain, a stack height of 11m (mode of all permitted NOx sources in MN), a release temperature of 447 K (mean of all permitted NOx sources in MN), a diameter of .3m (mode of all permitted NOx sources in MN) and the tier 3 method of OLM.

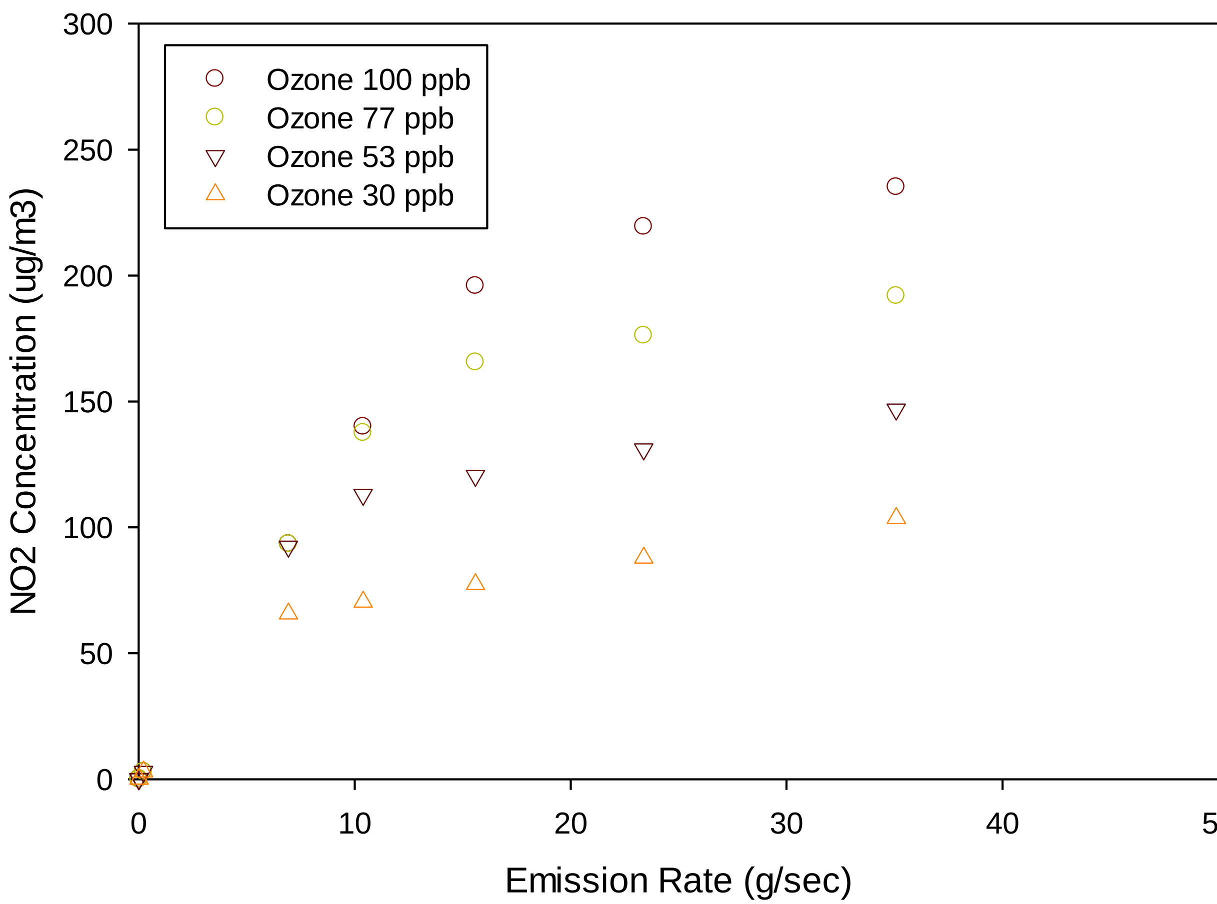


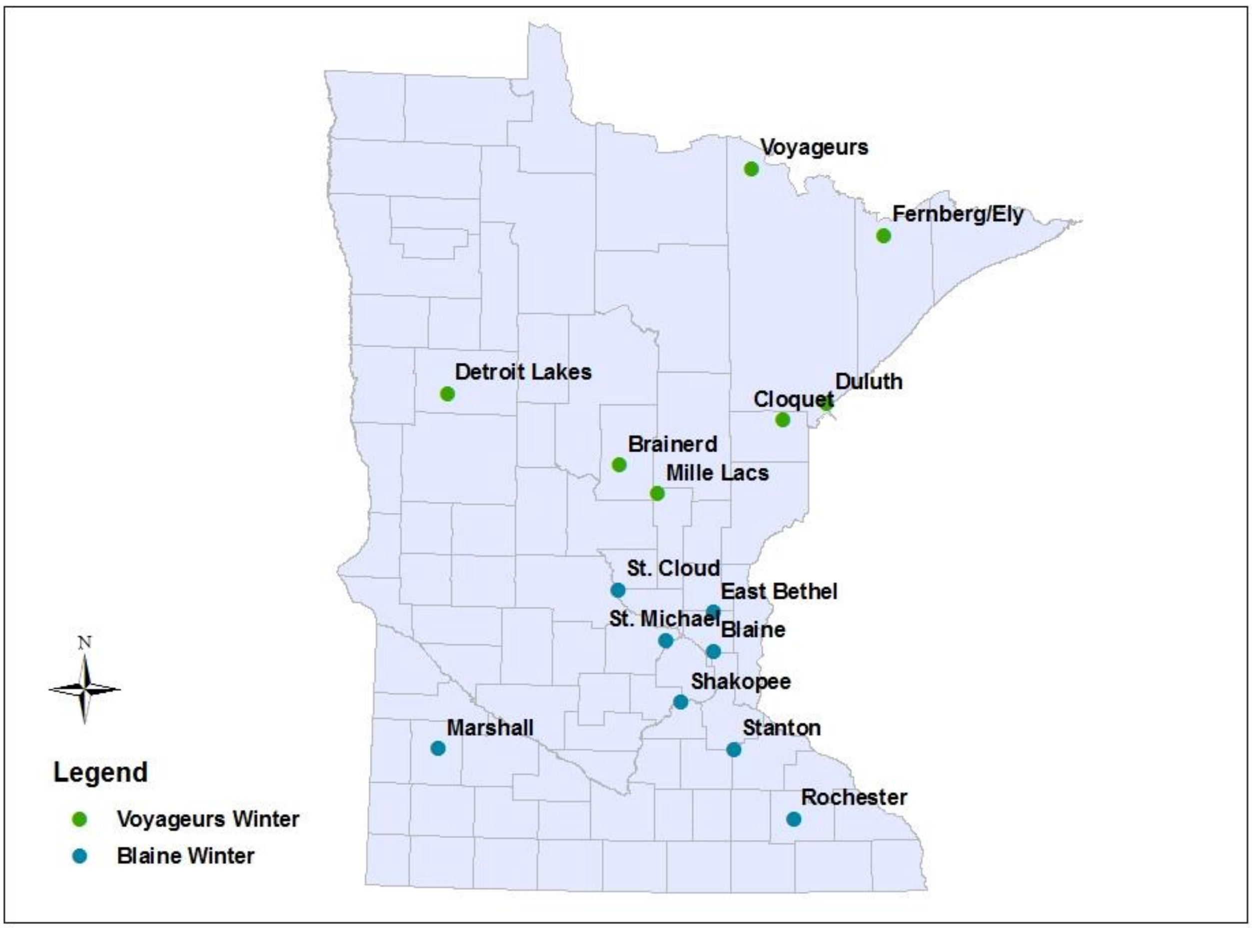
Figure 3. Ozone values can have practically significant impact on modeled results.

If figure 3 is examined for the 10.4 g/s emission rate, substituting 30 ppb instead of 100 ppb gives ~70 ug/m^3 decrease in modeled NO2 concentrations. So using more representative but still protective ozone values, can indeed have a significant impact on modeled results.

VIII. IMPLEMENTATION

MPCA has completed automation of the ozone filling methods described in this paper. These methods were used to fill in missing hours during the warm season (April-September) for all monitors in Minnesota and during the cold season for the two cold season monitors: Voyageurs and Blaine. Voyageurs and Blaine were used to fill in Oct-Mar values for all the other monitors. Voyageurs was generally used for monitors in the northern part of Minnesota, with Blaine filling in winter hours for southern Minnesota.

Winter Ozone Assignments



If a project proposer plans to use OLM or PVMRM for an NO2 modeling demonstration, MPCA recommends contacting the air modeler assigned to the project to request the pre-processed hourly ozone file for the proposed background monitor. <u>The use of the pre-processed data will need to be documented in section K of the modeling protocol form (AQDM-01).</u> The pre-processed ozone files are from 2006-2010 monitoring data to be concurrent with the meteorological data currently processed with AERMET 12345. MPCA is in the process of updating its meteorological data to AERMET 14134 for the period of 2008-2012. As the meteorological data are updated, new concurrent hourly ozone files will be created.

References

Atmospheric Dynamics, Inc. 1-Hour NO2 Modeling Assessment. Los Esteros Critical Energy Facility, 2 Nov. 2010. Web.

Environmental Consulting and Technology, Inc. Supplemental Air Quality Dispersion Modeling Protocol. (Use of Tier 3 Method for 1-hour NO2 Modeling). Jacksonville Lime Facility, Mar. 2013. Web.

Hellwig, Vinson. Response to Comments Document. Michigan Department of Natural Resources and Environment, Air Quality Division, 2 Aug. 2010. Web.

Johnson, Warren, William Viezee. "Stratospheric Ozone in the Lower Troposphere-I. Presentation and Interpretation of Aircraft Measurements" *Atmospheric Environment 15.7 (1981): 1309-1323. Print.*

Liang, Fuyan. Review of ADEQ Guidance and Case Study. Trinity Consultants, 2 Apr. 2013. Web.

Malcolm Pirnie, Inc. Supplemental Air Quality Modeling Protocol for 1-hour NO2 and SO2 NAAQS. Solid Waste Authority of Palm Beach County, Aug. 2010. Web.

Pratt, Gregory. "Ozone and Oxides of Nitrogen in the Rural Upper-Midwestern U.S.A." *Atmospheric Environment* 17.10 (1983): 2013-2023. Print.

Rombough, Kyrik. Letter from South Dakota Department of Environment and Natural Resources to EPA Region 8, 11 Feb. 2011. Web.

U.S. Environmental Protection Agency. (2014) Clarification on the Use of AERMOD Dispersion Modeling for Demonstrating Compliance with the NO2 National Ambient Air Quality Standard. Research Triangle Park, NC

Villalvazo, Leland. NO2 NAAQS Guidance. San Joaquin Valley APCD, 7 Jun. 2011. Web.

Wilson, Jamie. Letter from JBR Environmental Consultants, Inc. to the Coronado National Forest Supervisor, 9 Oct. 2012. Web.