EAST KENTUCKY POWER COOPERATIVE

July 22, 2024

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

Re: Class I 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), the Federal Land Managers (FLMs) for Class I areas, 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 and Class I areas may be impacted. Prior to submittal of an air permit application to KDAQ, EKPC is hereby submitting a Class I modeling protocol to address the proposed modeling procedures necessary to evaluate pollutant impacts with respect to the Class I PSD increments and Air Quality Related Values (AQRVs) in Class I areas within 300 km of the proposed new source.

[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

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

Sincerely,

Jerry Purvis

Jerry Purvis, Vice President
East Kentucky Power Cooperative

Attachment

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

cc: B. Jackson, USDA Forestry Service, via email
R. Shewekah, Assistant Director, DAQ, via email
Z. Bittner, Branch Manager, DAQ, via email
A. Stacy, ARD POC, NPS, via email
M. Barna, ARD Modeler, NPS, via email
H. Salazer, ARD, Branch Lead, NPS, via email
J. Jernigan, Physical Scientist, NPS, via email
M. Key, Program Lead, NPS, via email
J. Renfro, Air Resource Specialist, NPS, 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

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EAST KENTUCKY POWER COOPERATIVE

CLASS I 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 I 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 will trigger PSD applicability.

The U.S. Environmental Protection Agency (EPA), the Federal Land Managers (FLMs) for Class I areas, 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 and Class I areas may be impacted. Prior to submittal of an air permit application to KDAQ, EKPC is hereby submitting a Class I modeling protocol to address the proposed modeling procedures necessary to evaluate pollutant impacts with respect to the Class I Air Quality Related Values (AQRVs) in Class I areas within 300 km of the proposed new source[2].

Class I Increment assessment will be performed using a screening procedure to determine whether modeled impacts are less than the applicable Class I Significant Impact Levels (SILs) within 50 km of the proposed new source. Since this screening procedure will be performed using the AERMOD modeling system, procedures for assessing Class I increment are presented in the Class II modeling protocol submitted to KDAQ for the project.

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[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] FLAG 2000 Response to Public Comments on Draft Phase I Report as well as published Class I modeling guidance documents from Region IV states including Florida, Alabama, North Carolina, South Carolina and Tennessee.

2.0 PROJECT DESCRIPTION AND LOCATION

2.1 PROJECT DESCRIPTION

The proposed facility 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 will consist of the RICE engines, natural gas-fired gas preheater, an emergency diesel generator, and a diesel-fired fire pump. Preliminary facility layout drawings for both configurations are presented in Appendix A.

Preliminary analysis of emissions for the RICE engine models under consideration for the project by EKPC indicates that the project will be a major source triggering the PSD requirements to conduct an air quality analysis to demonstrate that the proposed project will not adversely impact AQRVs. The pollutants for which PSD will be triggered are $PM_{2.5}$, PM_{10}, NO_2, CO, and VOC. Potential SO_2 and H2SO4 emissions will not trigger PSD for either configuration or fuel type, therefore no further analysis of direct SO_2 or H2SO4 emissions are required. As addressed in subsequent sections, SO_2 emissions are however accounted for as a precursor to $PM_{2.5}$ emissions and both SO_2 and H_2SO_4 emissions are included in the initial screening analysis to determine whether the new sources will have a significant impact on air quality in Class I areas.

Table 2-1 presents the preliminary annual potential emissions for both the 12 x 18 MW and the 11 x 20 MW configurations.

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**	**Total Potential Emissions tons/year**
SO2	11.66	0.017	0.0021	0.00053	11.68
H2SO4	3.05	0	0	0	3.05
NOx	610.42	0.63	2.07	0.27	613.39
PM10/PM2.5	259.58	0.095	0.021	0.0098	259.71
CO	363.71	1.05	0.49	0.11	365.36
VOC	316.06	0.069	0.017	0.0223	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**	**Total Potential Emissions tons/year**
SO2	11.44	0.017	0.0021	0.00053	11.46
H2SO4	2.86	0	0	0	2.86
NOx	766.62	0.63	2.07	0.27	769.59
PM10/PM2.5	250.13	0.095	0.021	0.0098	250.26
CO	263.32	1.05	0.49	0.11	264.97
VOC	832.80	0.069	0.017	0.0223	832.91

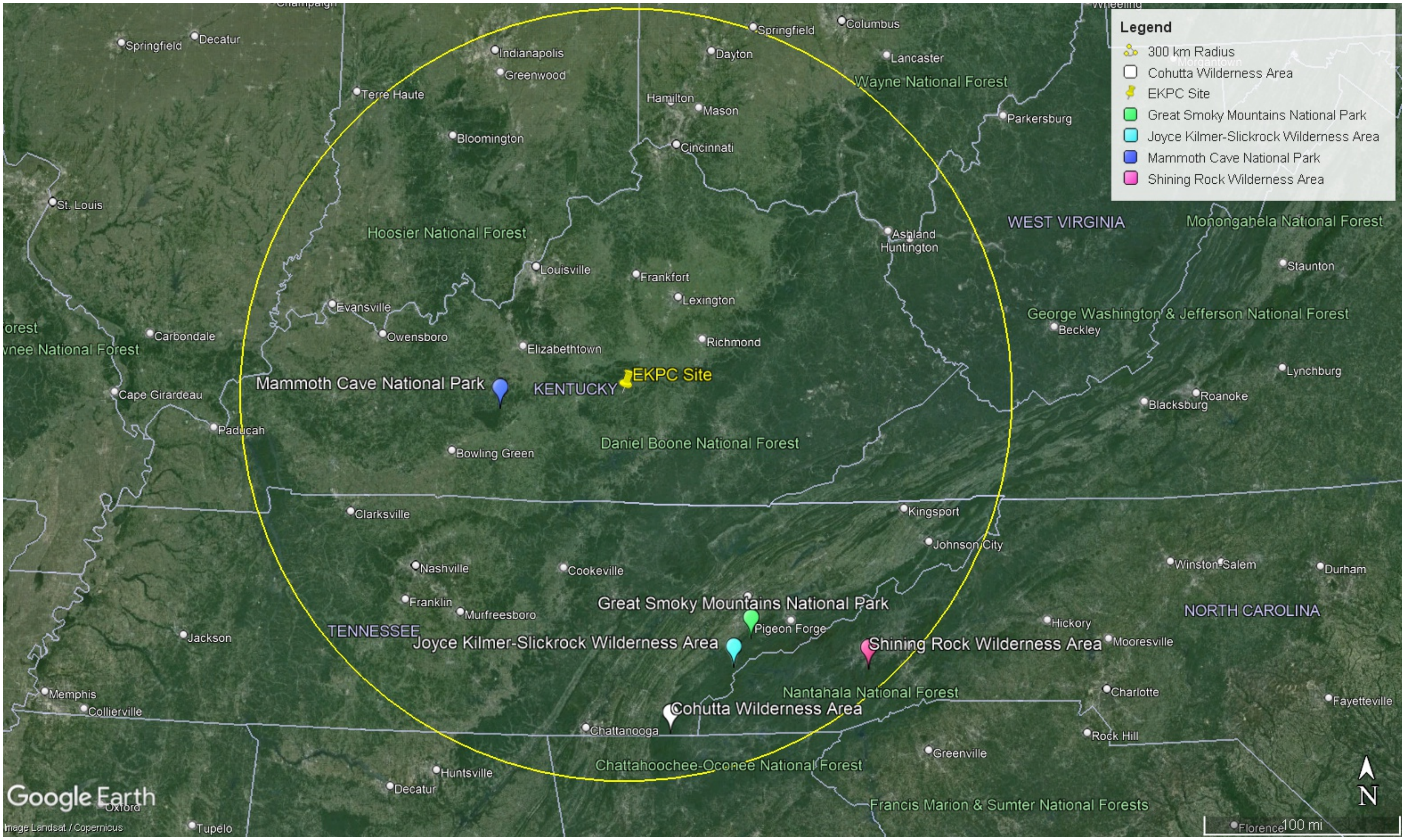
2.2 PROJECT LOCATION

The proposed facility will be located near Liberty in Casey County, Kentucky. Figure 2-1 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.

Figure 2-1
Class I Areas with 300 km of Project Location



3.0 MODELING METHODOLOGY

The modeling approach that will be used to evaluate the proposed new facility's impacts on Class I areas within 300 km from the proposed source is described in the following sections. The Class I analysis will be performed in accordance with the EPA "Guideline on Air Quality Models" (GAQM) from 40 CFR 51, Appendix W (2017), the Federal Land Managers Air Quality Related Values Work Group Phase I Report (FLAG, 2010), and the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase II Summary Report, along with applicable guidance from EPA and the Kentucky Division for Air Quality (KDAQ).

The two key elements of a Class I analysis are a Class I increment analysis and an Air Quality Related Value (AQRV) analysis. The Class I increment analysis first step will be conducted by performing a screening approach to determine whether the proposed new sources will have a significant impact in a Class I area by comparing projected impacts from the new sources to the Class I EPA Significant Impact Levels (SILs) utilizing AERMOD. Procedures for the increment analysis are presented in the Class II modeling protocol submitted to KDAQ. The AQRV analysis for nearby Class I areas will include an evaluation of visibility as well as deposition of sulfur and nitrogen.

3.1 CLASS I AQRV ANALYSIS

The FLMs have provided guidance for applicants to perform an initial screening to determine if sources greater than 50 km from a Class I area trigger the AQRV analysis. This screening procedure, Q/D, is performed by first summing the annual potential emissions of SO_2, NOx, PM_{10}/$PM_{2.5}$, and H_2SO_4, based on the maximum allowable 24-hour emissions adjusted to reflect operation for 8,760 hours per year (Q in tons per year). If the Q/D value (D is the distance in km from the source to a Class I area) is less than or equal to 10, then the source will not be considered to have a significant impact on AQRVs in the Class I area and no further analysis is required (FLAG, 2010).

Table 3-1 presents the maximum theoretical worst-case potential daily (24-hour) emissions for the 12x18 MW configuration assuming operation on ULSFO at full load and including startup and shutdown emissions. The theoretical worst-case emissions were determined assuming startups/shutdowns occurring every hour of the day, with one cold start and 23 hot starts and associated shutdowns with the remaining time operating at 100% load. This combination of cold and hot starts represent the theoretical worst-case 24-hour operating scenario. Startup definitions and emissions for the two engine configurations are presented in Appendix B.

Table 3-1 – Preliminary Potential Max Daily Emissions – 12x18 MW Configuration

Worst-Case Potential Daily Emissions with Wartsila Engines (12 x 18 MW) ULSFO					
Pollutant	RICE Engine Potential Emissions tons/day	Gas Preheater Potential Emissions tons/day	Generator Potential Emissions tons/day	Fire Pump Potential Emissions tons/day	Total Potential Emissions tons/day
SO2	0.03	0.000047	9.88E-05	2.55372E-05	0.03
H2SO4	0.01	0	0	0	0.01
NOx	10.50	0.0017	0.10	0.013	10.62
PM10/PM2.5	1.28	0.00026	0.0010	0.00047	1.28
Total SO2, NOx, PM2.5, H2SO4					11.94

Table 3-2 presents a summary of preliminary potential emissions for the proposed new source with 11 MAN engines in the same manner as Table 3-1 for the Wartsila engines, except the worst-case startup conditions assume one warm start per day and 23 hot starts per day. This combination of warm and hot starts represent the theoretical worst-case 24-hour operating scenario for that configuration. For both configurations, the worst-case 24-hour total emissions of SO_2, NOx, $PM_{10}/PM_{2.5}$, and H_2SO_4 are when the engines are firing ULSFO.

Table 3-2 – Preliminary Potential Max Daily Emissions – 11x20 MW Configuration

Worst-Case Potential Daily Emissions with MAN Engines (11 x 20 MW) ULSFO					
Pollutant	RICE Engine Potential Emissions tons/day	Gas Preheater Potential Emissions tons/day	Generator Potential Emissions tons/day	Fire Pump Potential Emissions tons/day	Total Potential Emissions tons/day
SO2	0.03	0.000047	9.88E-05	2.55372E-05	0.03
H2SO4	0.01	0	0	0	0.01
NOx	6.15	0.0017	0.10	0.013	6.26
PM10/PM2.5	1.78	0.00026	0.0010	0.00047	1.78
Total SO2, NOx, PM2.5, H2SO4					8.09

While the 24-hour emissions presented in Tables 3-1 and 3-2 are based on the theoretical worst-case startup and shutdown operating scenarios while firing ULSFO, these are likely not realistic operating scenarios or what will end up being permitted. The actual modeling performed for the Class I area analysis will be based on the worst-case realistic 24-hour operating scenarios, which will account for 24-hour allowable emissions based on any limitations identified during the development of the permit application and the actual Class I modeling analysis.

Based on the distance between the proposed EKPC facility and the Class I areas and the worst-case theoretical 24-hour emissions presented in Tables 3-1 and 3-2, normalized to 8,760 hours a year, the results of the Q/D screening are as follows:

Class I Area	Distance from EKPC (D), km	Q with Wartsila Engines, tons/year*	Q/D, with Wartsila Engines	Q with MAN Engines, tons/year*	Q/D, with MAN Engines
Mammoth Cave	95.5	4359.8	45.7	2952.6	30.9
Great Smoky Mountains	213.5	4359.8	20.4	2952.6	13.8
Joyce Kilmer-Slickrock	228.3	4359.8	19.1	2952.6	12.9
Cohutta	265.5	4359.8	16.4	2952.6	11.1
Shining Rock	285.1	4359.8	15.3	2952.6	10.4

* - Worst-case 24-hour emissions from Tables 3-1 and 3-2 adjusted to 8,760 hours per year

Based on the Q/D screening, Q/D is greater than 10 for both configurations for all five of the Class I areas within 300 km, therefore triggering an AQRV analysis for:

- Mammoth Cave National Park (NPS)
- Great Smoky Mountains National Park (NPS)
- Joyce Kilmer-Slickrock Wilderness Area (FS)
- Cohutta Wilderness Area (FS)
- Shining Rock Wilderness Area (FS)

EKPC will therefore perform modeling using the CALPUFF modeling system to evaluate impacts from the proposed source on visibility and acid deposition in these Class I areas. For the Class I AQRV analysis, the following EPA-approved versions of the CALPUFF modeling system will be used:

- CALPUFF Version 5.825, Level 151215
- CALPOST Version 6.221, Level 080724
- POSTUTIL Version 1.56, Level 070627

CALPUFF modeling will be performed using the options and settings in the FLAG 2010 guidance as well as the 2006 EPA memo “Dispersion Coefficients for Regulatory Air Quality Modeling in CALPUFF”[3].

The Class I modeling will utilize three years (2001-2003) of 4-km CALMET meteorological data developed by the Visibility Improvement State and Tribal Association of the Southeast (VISTAS) and provided by the U.S. Fish and Wildlife Service (US-FWS). VISTAS developed five sub-regional 4-km CALMET meteorological databases, and subdomain #3 will be used for the Class I modeling. Due to the large size of the 4-km CALMET domain (VISTAS Domain 3), it will be desirable to reduce the size of the CALPUFF computational domain for each CALPUFF run. For the CALPUFF runs, the computational domain will be set such that the edges of each domain extend 50-60 km beyond both the sources and each of the Class I areas to minimize “edge effects.”

Hourly background ozone data developed for VISTAS subdomain 3 will be used along with a monthly ambient ammonia background concentration of 10.0 parts per billion (ppb). The 10.0 ppb ammonia background is representative of rural, grassy areas such as the area in the immediate vicinity of the proposed plant site.

Pursuant to the 2010 FLAG guidance, emissions that reflect worst-case 24-hour emissions will be used in CALPUFF for the AQRV modeling. All realistic worst-case scenarios will be evaluated for the AQRV analysis.

Finally, receptor coordinates and elevations for input into CALUFF for the Class I areas will be from the National Park Service (NPS) database of Class I receptors[4].

3.1.1 VISIBILITY MODELING

Impacts of the proposed new source on visibility in the Class I areas will be assessed using CALPOST Method 8 based on the annual average background natural conditions in the 2010 FLAG guidance. Method 8 CALPOST inputs will also be based on the annual average background natural conditions from the 2010 FLAG documentation for each Class I area. Background hygroscopic and non-hygroscopic aerosol levels will be derived from the annual average natural conditions provided in Table 6 of the 2010 FLAG guidance. The monthly relative humidity adjustment factors for the Class I areas are input to the RHFAC array (Tables 7-9 in the 2010 FLAG guidance) in CALPOST. CALPOST will be used to calculate the impact of primary and secondary particulate emissions from the proposed new sources on visibility in the Class I areas to compare the resulting impacts to the 5 percent change in light extinction thresholds. Based on the

[3] March 16, 2006 EPA Memo from Dennis Atkinson and Tyler Fox
[4] https://www.nps.gov/subjects/air/class1.htm

FLAG guidance, the proposed new sources will not have a significant impact on visibility in the Class I areas if results are below the 5 percent threshold. Should there result in a more than a 5 % change in light extinction, an analysis of the temporal and spatial exceedances will be performed and discussed in the report.

3.1.2 ACID DEPOSITION MODELING

CALPUFF will be used to assess annual wet and dry deposition of sulfur and nitrogen compounds from emissions of NOx and SO_2 from the proposed new sources on the Class I areas. POSTUTIL and CALPOST will be employed to calculate the annual wet and dry deposition of sulfur and nitrogen compounds in units of kg/ha/yr.

The CALPUFF output files will contain the wet and dry deposition fluxes of both primary and secondary species. The wet and dry fluxes must be added to obtain the total flux of each species, at each receptor, each hour. The POSTUTIL processor will be configured in accordance with the FLAG and IWAQM guidance to sum the wet and dry fluxes, and to compute the total sulfur and nitrogen contributed by the modeled species for subsequent CALPOST processing.

Results will then be compared to the Deposition Analysis Threshold values of 0.010 kg S/ha/yr and 0.010 kg N/ha/yr (FLAG 2010 and 2011 NPS guidance[5]). If project emissions do not exceed the DAT for either nitrogen or sulfur, then the proposed source will not have a significant impact on sulfur or nitrogen deposition in Class I areas.

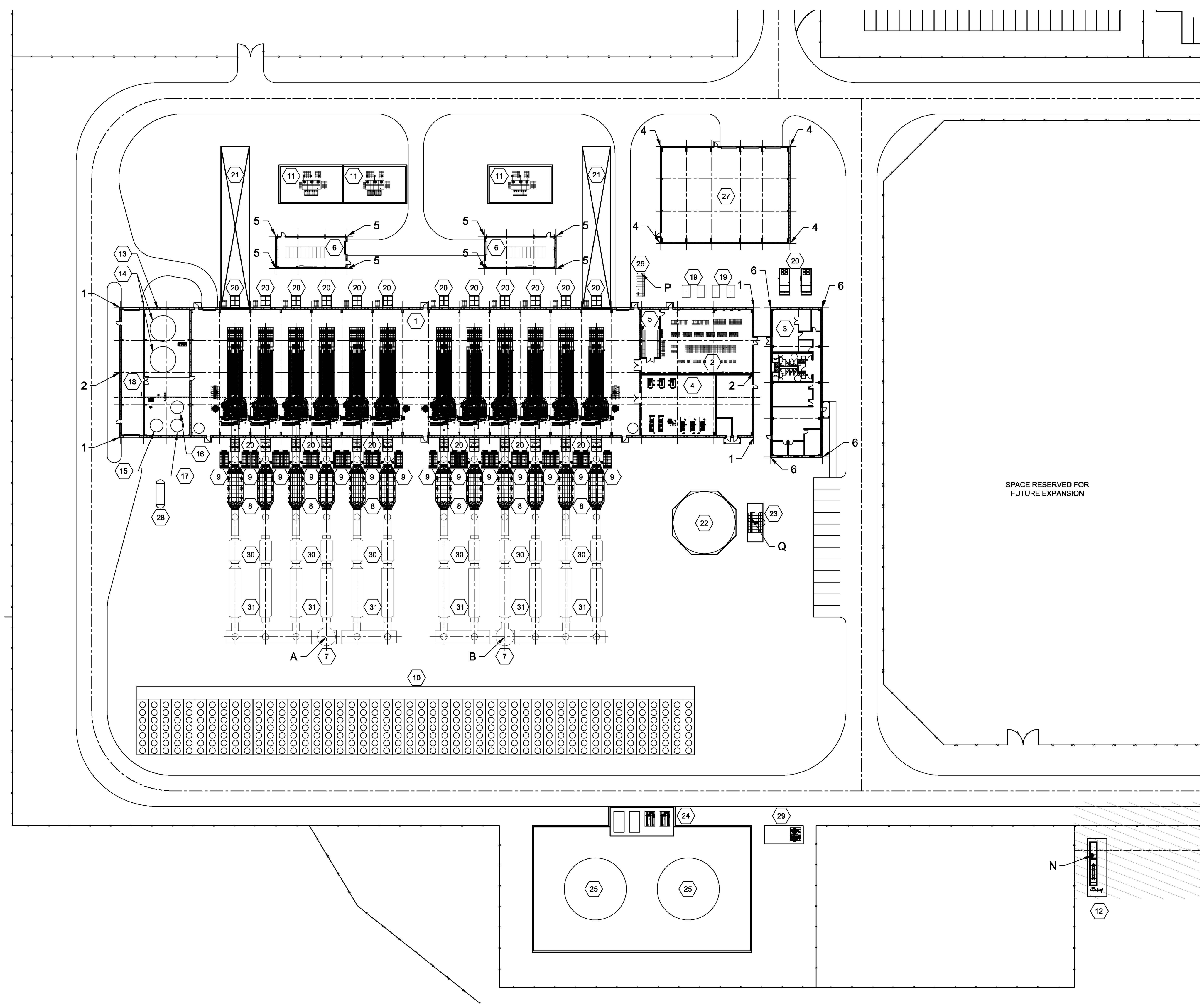
[5] Federal Land Manager's Interagency Guidance for Nitrogen and Sulfur Deposition Analyses, November 2011

4.0 MODEL RESULTS PRESENTATION

For this modeling analysis, impacts of emissions from the proposed new sources on AQRVs in Class I areas will be performed using the CALPUFF modeling system. 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 I 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.

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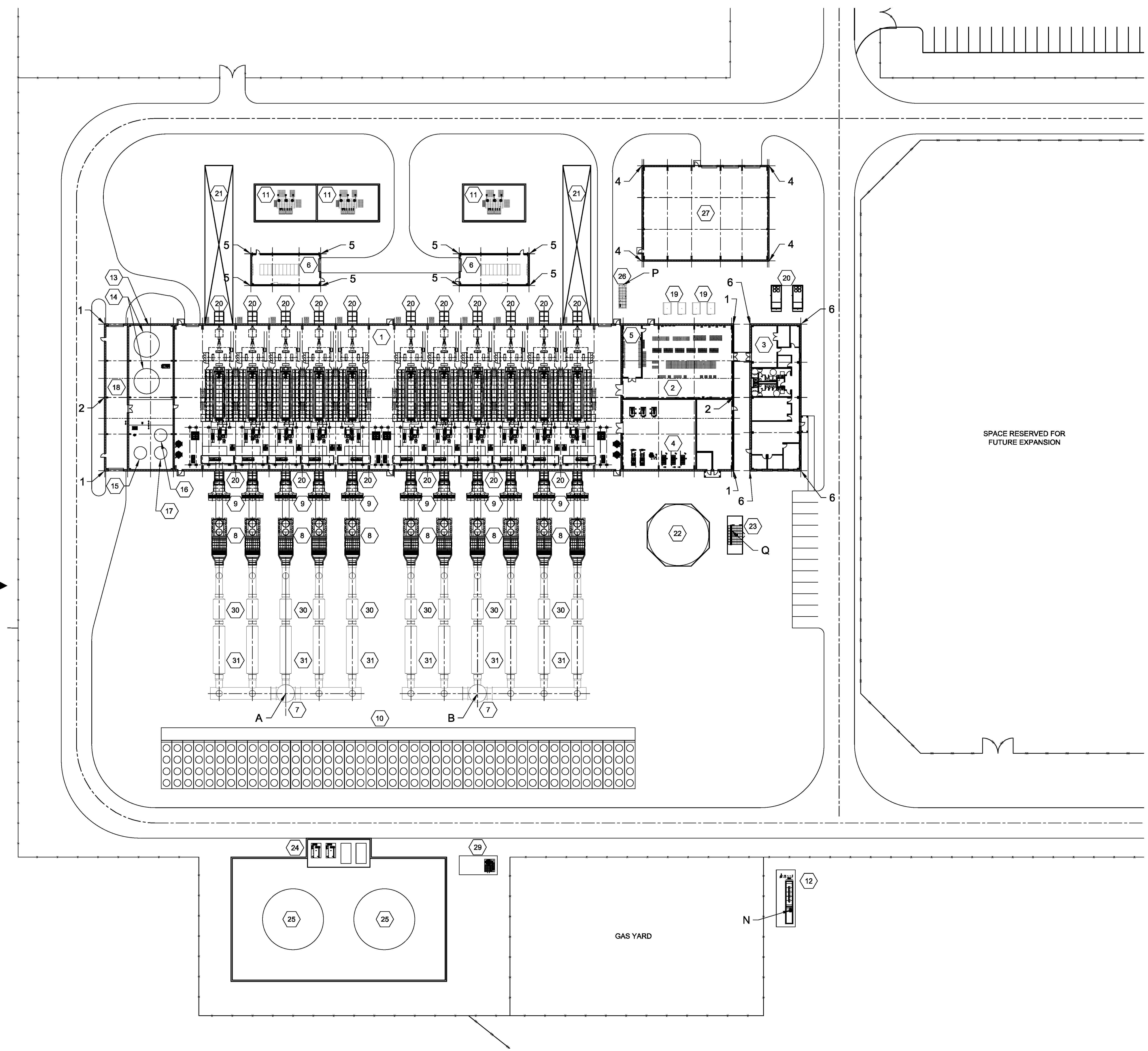

EQUIP COORDS			
ITEM	NORTHING	EASTING	HEIGHT
N	N: 2018413.659	E: 1870297.371	25'-0"
P	N: 2018714.056	E: 1870710.100	25'-0"
Q	N: 2018565.071	E: 1870560.331	15'-0"

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
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no.	date	by	ckd	description
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POWER BLOCK ENLARGED PLAN

0 16' 32' 64'
SCALE IN FEET

TRUE NORTH 21°0'0" PLAN NORTH NORTH

BURNS McDONNELL

EAST KENTUCKY POWER COOPERATIVE

designed
detailed W. LESNIAK

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 – rev. B
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

STARTUP DEFINITIONS AND EMISSIONS FOR RICE ENGINES

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