43-0011

TVA

Tennessee Valley Authority, 1101 Market Street, BR 4A, Chattanooga, Tennessee 37402-2801

October 5, 2016

OCT 7 2016 AM 11:23

Ms. Michelle Walker Owenby, Director
Division of Air Pollution Control
Tennessee Department of Environment
and Conservation
William R. Snodgrass TN Tower
312 Rosa L Parks Avenue, 15th Floor
Nashville, Tennessee 37243

Dear Ms. Owenby:

TENNESSEE VALLEY AUTHORITY (TVA) – JOHNSONVILLE FOSSIL PLANT (JOF) – FINAL REPORT FOR 1-HOUR SO_2 MODELING RESULTS

Please find enclosed a report that describes the air dispersion modeling methodology and presents modeling results that demonstrate attainment with the 1-hour SO_2 NAAQS for designation purposes in the area surrounding JOF. Also enclosed is a disc containing the data referenced in the report.

If you have any questions or comments, please contact Cassi Wylie in Knoxville at (865) 632-7933.

Sincerely,

J. Thomas Waddell
Senior Manager
Air Permits, Compliance, and Monitoring

Enclosures

JOHNSONVILLE FOSSIL PLANT

MODELING RESULTS
1-HOUR SO_2 NAAQS DESIGNATION

NEW JOHNSONVILLE, TENNESSEE
SEPTEMBER 2016

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1.0 PURPOSE AND BACKGROUND

The purpose of this document is to present the dispersion modeling results that were performed to assess compliance with the 1-hour SO_2 NAAQS for designation purposes. The primary objective of the modeling analysis was to demonstrate that SO_2 emissions from TVA Johnsonville Fossil Plant (JOF) did not cause or contribute to a violation of the 1-hour SO_2 NAAQS. This analysis is being performed to characterize the designation status of Humphreys County, Tennessee, and surrounding areas. The modeling analysis was performed following the recommendations outlined in the SO_2 NAAQS Designations Modeling Technical Assistance Document (TAD), with reliance on all other applicable USEPA guidance documents (USEPA, 2016). Modeling methods and assumptions – such as model selection and options, source parameters, and meteorological data – were presented in the JOF modeling protocol for review by the Tennessee Department of Environment and Conservation (TDEC) in February 2016. This report presents modeling which incorporates changes in response to USEPA Region 4 and TDEC's comments on the modeling protocol.

2.0 SOURCE DESCRIPTION

JOF is located in New Johnsonville, Tennessee, along the eastern shore of Kentucky Lake (Tennessee River) north of Highway 70. The facility consists of 10 coal-fired boilers, 20 oil- and natural gas-fired combustion turbines (JCT 1-20), four (4) natural gas-fired fuel heaters, four (4) emergency diesel engines, a solid-fuel coal handling facility, and an ash handling facility. A site locality map (Figure 1) and a topographic map (Figure 2) provide details of the location and property boundaries.

TVA retired six (6) of the JOF coal-fired boilers (5 through 10) as of December 31, 2015; therefore, these units are not included in this analysis[1]. The four (4) remaining operating boilers (1 through 4) use a low-sulfur coal blend (less than two weight-percent sulfur) and ultra-low sulfur (15 parts per million by weight) fuel oil to limit SO_2 emissions. The remaining four boilers will be retired from service by December 31, 2017.

3.0 MODELING ANALYSIS

To determine maximum impacts on 1-hour ambient SO_2 levels for Humphreys County, Tennessee, and surrounding areas, the modeling analysis focused on the contributions of SO_2 from the four (4) coal-fired boilers and 20 combustion turbines at JOF, along with other nearby sources. The inputs used in the modeling analysis are detailed in the subsequent sections.

3.1 EMISSIONS

Actual-hourly emissions for the three-year period from 2012 to 2014 were modeled. The coal-fired boilers' hourly continuous emissions monitoring system (CEMS) data were obtained from a USEPA website supporting 1-hour SO_2 modeling[2]. Volumetric flow rates provided therein were reported in standard cubic feet per hour (scfh)[3]. Assuming pressure found at the stack exit is equal to pressure at

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[1] Federal Facilities Compliance Agreement (Docket No. CAA-04-2010-1760) and the Consent Decree (Civil Action No. 3:11-CV-00170) for Facilities of the Tennessee Valley Authority - Annual Progress Report - April 30, 2016, section D, page 6.

[2] https://www.epa.gov/air-emissions-modeling/state-level-hourly-sulfur-dioxide-so2-data/

[3] 40 CFR Part 72 Subpart A (Acid Rain Program General Provisions) defines standard conditions as 68°F and 29.92 inches of mercury (i.e., 29.92 in Hg). This definition is applicable to data collected under 40 CFR Part 75 (Continuous Emission Monitoring) [see Part 75, Subpart A, §75.3].

standard conditions, the volumetric flow rates in scfh were converted to actual cubic feet per hour (acfh) as followed:

$$V_a = V_S \times \frac{(T_a + 459.67°R)}{(T_s + 459.67°R)} \qquad [1]$$

where V_a is the stack-exit volumetric flow in acfh, V_s is the stack-exit volumetric flow at standard conditions, T_a is the actual stack-exit temperature (°F), and T_s is the stack-exit temperature at standard conditions (68°F). The hourly stack-exit velocities were subsequently calculated from the actual volumetric flow rates using the stack-exit cross-sectional area. Utilizing acfh more accurately represents stack-exit volumetric flow. Static stack parameters (height, diameter, and exit temperature) are provided in Table 1.

Table 1
JOF Coal-Fired Boilers 1 through 4 Routine-Operation Stack Parameters [1]

Parameter	Units	JOF
UTM Zone 16 Easting (NAD83)	m	411194
UTM Zone 16 Northing (NAD83)	m	3987702
Base Elevation	m	117.3
Stack Height	m	182.9
Stack Inside Diameter	m	9.8
Stack-Exit Temperature [2]	K	425

Notes:
1. All ten (10) coal-fired boilers' flue gases combine and exhaust to the atmosphere via one stack (JOF).
2. Modeled stack-exit temperature; Title V Permit Renewal Application, Johnsonville Fossil Plant, New Johnsonville, Tennessee, August 2007.

JOF's August 2007 Title V permit renewal application stack-exit temperatures were used in the modeling because stack-exit temperatures are not recorded by the CEMS. Averaged actual stack-exit temperatures recorded by unit-specific process thermocouples indicate less than 0.5 percent difference from the Title V values. Therefore, the Title V permit application stack-exit temperatures were deemed representative of actual temperatures operations from 2012-2014 (Table 2).

Table 2
Comparison of Modeled and Measured JOF Stack-Exit Temperatures

Parameter	Units	Stack-Exit Temperature
Title V Permit App. Stack-Exit Temp. [1]	K	425
2012-2014 Avg. Actual Stack-Exit Temp. [2]	K	426.2
Difference	K	1.2
Percent Difference	%	0.3

Notes:
1. Modeled stack-exit temperature; Title V Permit Renewal Application, JOF, New Johnsonville, Tennessee, August 2007.
2. Stack-exit temperatures measured by process thermocouples.

Emissions from on-site combustion turbines, JCT 1-20, were also modeled. There are two sets of combustion turbines at JOF: JCT 1-16 are identical and were installed prior to 1977; JCT 17-20 are identical and began operations in 2000. JCT 1-16 are categorized as low-mass emission units[4]; therefore, they are not required to have CEMS installed. To account for their operations, worst-case emissions (Table 3) were estimated based on annual fuel-oil analyses and oil-fired operations at maximum capacity (869.6×10^6 Btu/CT-hr at 0°F[5]). The worst-case emission estimates were used for every hour of the three-year period (see included optical disc).

Table 3
JCT 1-16 Maximum SO_2 Emission Estimates [1]

Year	Fuel Oil Suflur Content (%)	Fuel Oil Heat Content (Btu/gal)	SO_2 Emission [2] Factor (lb/10^6 Btu)	Max SO_2 Emission Rate (g/CT-s)
2012	0.000757	137,888	0.000735	0.0805
2013	0.00126	138,131	0.00122	0.134
2014	0.000851	138,174	0.000824	0.0903

Notes:
1. Fuel oil sulfur content and heat content obtained from plant's annual fuel-oil analysis.
2. Emission factor is adjusted for five (5) percent formation of SO_3.

For JCT 17-20, actual hourly emissions obtained from EPA's Clean Air Markets – Air Markets Program Data (CAMD) were modeled (see included optical disc). Stack parameters for JCT 1-20 are provided in Table 4.

Table 4
JCT 1-20 Stack Parameters [1]

CT Source	UTM Zone 16 Easting (NAD83)	UTM Zone 16 Northing (NAD83)	Base Elevation (m)	Stack Height (m)	Stack Diameter (m) [2]	Stack-Exit Velocity (m/s)	Stack-Exit Temp (K)
JCT1	411278.5	3988466.4	118.40	9.75	3.70	49.1	830
JCT2	411288.4	3988439.9	118.40	9.75	3.70	49.1	830
JCT3	411303.2	3988399.2	118.40	9.75	3.70	49.1	830
JCT4	411313.0	3988372.8	118.40	9.75	3.70	49.1	830
JCT5	411316.5	3988327.8	118.40	9.75	3.70	49.1	830
JCT6	411326.3	3988301.5	118.40	9.75	3.70	49.1	830
JCT7	411341.5	3988260.7	118.40	9.75	3.70	49.1	830
JCT8	411350.1	3988237.1	118.40	9.75	3.70	49.1	830
JCT9	411354.1	3988193.9	118.40	9.75	3.70	49.1	830
JCT10	411364.4	3988166.7	118.40	9.75	3.70	49.1	830
JCT11	411379.2	3988127.1	118.40	9.75	3.70	49.1	830
JCT12	411389.4	3988099.8	118.40	9.75	3.70	49.1	830
JCT13	411463.4	3988127.6	118.40	9.75	3.70	49.1	830
Continued on Next Page							

4 40 CFR § 75.19
5 Revisions to July 1996 Title V Permit Application, Johnsonville Fossil Plant, New Johnsonville, Tennessee, December 2000.

Table 4 (Continued)
JCT 1-20 Stack Parameters [1]

CT Source	UTM Zone 16 Easting (NAD83)	UTM Zone 16 Northing (NAD83)	Base Elevation (m)	Stack Height (m)	Stack Diameter (m) [2]	Stack-Exit Velocity (m/s)	Stack-Exit Temp (K)
JCT14	411453.1	3988154.8	118.40	9.75	3.70	49.1	830
JCT15	411438.3	3988194.4	118.40	9.75	3.70	49.1	830
JCT16	411428.1	3988221.7	118.40	9.75	3.70	49.1	830
JCT17	411386.8	3988393.8	118.40	17.10	4.28	45.9	807
JCT18	411375.0	3988425.2	118.40	17.10	4.28	45.9	807
JCT19	411363.1	3988457.3	118.40	17.10	4.28	45.9	807
JCT20	411351.1	3988489.6	118.40	17.10	4.28	45.9	807

Notes:
1. Title V Permit Renewal Application, JOF, New Johnsonville, Tennessee, August 2007.
2. Equivalent diameter; stack-exit is rectangular.

JOF's ancillary combustion sources – the four (4) natural gas-fired fuel heaters (FH01-04) and the four (4) emergency diesel engines (DE01-04) – were excluded from modeling. According to Section 5.5 of the TAD, only sources that are continuous or frequent enough to contribute significantly to the annual distribution of maximum daily 1-hour concentrations should be considered. From 2012 to 2014, FH01-04 operated less than 10 percent of the year, and DE01-04 operated less than one (1) percent of the year. The ancillary combustion sources operate intermittently and produce very low emissions (see Table 5) which will not impact modeled concentrations.

Table 5
JOF Ancillary Combustion Sources' SO_2 Emissions (tons per year)

Year	JOF [1]	FH01-04	DE01-04
2012	11,597	4.21×10^{-4}	N/A [2]
2013	9,672	2.31×10^{-3}	2.90×10^{-5}
2014	17,517	2.29×10^{-3}	4.03×10^{-5}

Notes:
1. Total obtained from EPA's Clean Air Markets – Air Markets Program Data (CAMD), which is provided on the enclosed optical disc.
2. Actual emissions data for 2012 are not available. Engines are permitted to run less than 100 hours per year.

3.2 DOWNWASH

Actual stack heights were used for the JOF modeling analysis in accordance with the SO_2 TAD. In addition, building downwash was included in the modeling, with building parameters calculated using the USEPA's Building Profile Input Program for PRIME, BPIPPRM, Dated 04274 (USEPA, 2004d). According to the GEP technical support document, a structure is considered nearby if it is within 5L of the emissions source, where L is the lesser dimension (height or projected width) of the nearby structure (USEPA, 1985). The nearby major structures within the JOF boundary are the following:

- Draft system control building;
- Mechanical gas ductwork;
- Cogeneration building;
- Boilerhouse and powerhouse buildings;
- Precipitator buildings;
- Powerhouse office wing;
- Combustion turbine structures and enclosures.

The direction-specific effective building widths and heights required by AERMOD were calculated using BPIPPRM. The BPIPPRM input stack and building parameters for JOF are provided in Table 6, and the building locations are shown in Figure 3.

Table 6
BPIPPRM Input Structures for JOF

Building	Building No.[6]	BPIPPRM ID	Height (m)
Unknown structure/trailer near stack	1	UNKTRLR	4.27
Mechanical Gas Duct to Stack	2	MGD2STK	26.78
Draft System Control Building	3	DFTSYSCB	6.45
Mechanical Gas Transition Duct	4	MGTD	37.81
Cogeneration Building 2	5	COGENB2	11.58
Cogeneration Building 1	6	COGENB1	6.86
Powerhouse Turbine Bay East Annex	7	PWRHSTBE	6.31
Powerhouse Turbine Bay	8	PWRHSTB	19.66
Mechanical Gas Duct Unit 2	9	MGDU2	37.35
Mechanical Gas Duct Unit 3	10	MGDU3	36.89
Mechanical Gas Duct Unit 4	11	MGDU4	36.44
Mechanical Gas Duct Unit 5	12	MGDU5	35.83
Mechanical Gas Duct Unit 6	13	MGDU6	35.37
Mechanical Gas Duct Unit 7	14	MGDU7	34.76
Mechanical Gas Duct Units 8, 9, 10	15	MGDU8910	33.84
Powerhouse Boiler Bay	16	PWRHSBB	37.95
Mechanical Gas Duct, Damper & Turning Vane - Unit 10	17	MGDDTV10	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 9	18	MGDDTV9	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 8	19	MGDDTV8	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 7	20	MGDDTV7	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 6	21	MGDDTV6	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 5	22	MGDDTV5	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 4	23	MGDDTV4	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 3	24	MGDDTV3	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 2	25	MGDDTV2	44.35
Mechanical Gas Duct, Damper & Turning Vane - Unit 1	26	MGDDTV1	44.35
Precipitator Unit 1	27	PPTR1	57.15
Precipitator Unit 2	28	PPTR2	57.15
Precipitator Unit 3	29	PPTR3	57.15
Precipitator Unit 4	30	PPTR4	57.15
Precipitator Unit 5	31	PPTR5	57.15
Precipitator Unit 6	32	PPTR6	57.15

Continued on Next Page

[6] Building numbers are referenced in Figure 3.

Table 6 (Continued)
BPIPPRM Input Structures for JOF

Building	Building No.	BPIPPRM ID	Height (m)
Precipitator Unit 7	33	PPTR7	57.15
Precipitator Unit 8	34	PPTR8	57.15
Precipitator Unit 9	35	PPTR9	57.15
Precipitator Unit 10	36	PPTR10	57.15
Powerhouse Coal Conveyor/Bunker Bay	37	PWRHSCCB	29.11
Powerhouse Office Wing Building	38	PWRHSOW	5.49
Powerhouse Office Wing Building (Tier 1)	39	PWRHSOW1	9.30
Powerhouse Office Wing Building (Tier 2)	40	PWRHSOW1	11.13

The results from BPIPPRM showed that the Precipitator Units 1-3 (PPTR1-PPTR3) are the influencing structures affecting dispersion and plume rise from the stack. Table 7 displays a summary of the BPIPPRM results for the coal-fired boilers, including the GEP building parameters used by AERMOD.

Table 7
BPIPPRM Results for JOF

Stack	Actual Stack Height (m)	GEP Stack Height (m)	GEP Building Height (m)	GEP Projected Building Width (m)	GEP Equation Height (m)
JOF	182.88	142.72	57.15	57.16	142.72

The BPIPPRM input stack and building parameters for JCT 1-20 are provided in Table 8, and building locations are shown in Figure 4.

Table 8
BPIPPRM Input Structures for JCT 1-20

Building	Building No.[7]	BPIPPRM ID	Height (m)
CT Unit 1	1	CT1	9.14
CT Unit 20 Air Intake	6	CT20-AI	9.14
CT Unit 20 Air Inlet Duct	7	CT20-AID	6.71
CT Unit 2	8	CT2	9.14
CT Unit 19 Air Intake	9	CT19-AI	9.14
CT Unit 19 Air Inlet Duct	10	CT19-AID	6.71
CT Unit 3	11	CT3	9.14
CT Unit 18 Air Intake	12	CT18-AI	9.14
CT Unit 18 Air Inlet Duct	13	CT18-AID	6.71
CT Unit 4	14	CT4	9.14
CT Unit 17 Air Intake	15	CT17-AI	9.14
CT Unit 17 Air Inlet Duct	16	CT17-AID	6.71
CT Unit 5	17	CT5	9.14
CT Unit 6	18	CT6	9.14
CT Unit 7	19	CT7	9.14
CT Maint/Control Building Tier 1a	20	CT Maint-T1a	4.57
CT Maint/Control Building Tier 2	21	CT Maint-T2	6.10
Continued on Next Page			

[7] Building numbers are referenced in Figure 4.

Table 8 (Continued)
BPIPPRM Input Structures for JCT 1-20

Building	Building No.	BPIPPRM ID	Height (m)
CT Maint/Control Building Tier 1b	22	CT Maint-T1b	4.57
SHED C (UNKNOWN)	23	Shed C	6.10
SHED B (UNKNOWN)	24	Shed B	5.49
SHED A (UNKNOWN)	25	Shed A	6.10
CT Unit 8	26	CT8	9.14
CT Unit 9	27	CT9	9.14
CT Unit 16	28	CT16	9.14
CT Unit 10	29	CT10	9.14
CT Unit 15	30	CT15	9.14
CT Unit 11	31	CT11	9.14
CT Unit 14	32	CT14	9.14
CT Unit 12	33	CT12	9.14
CT Unit 13	34	CT13	9.14

Table 9 displays a summary of the BPIPPRM results for the CT stacks, including the GEP building parameters used by AERMOD and the influencing structures affecting dispersion and plume rise.

Table 9
BPIPPRM Results for JCT 1-20

Stack	Actual Stack Height (m)	GEP Stack Height (m)	GEP Bldg Height (m)	GEP Proj Bldg Width (m)	GEP Eqn1 Height (m)	Influencing Structure
JCT1	9.75	65.00	9.14	12.35	22.85	CT1
JCT2	9.75	65.00	9.14	12.39	22.85	CT2
JCT3	9.75	65.00	9.14	12.35	22.85	CT3
JCT4	9.75	65.00	9.14	12.39	22.85	CT4
JCT5	9.75	65.00	9.14	12.35	22.85	CT5
JCT6	9.75	65.00	9.14	12.39	22.85	CT6
JCT7	9.75	65.00	9.14	12.35	22.85	CT7
JCT8	9.75	65.00	9.14	12.39	22.85	CT8
JCT9	9.75	65.00	9.14	12.00	22.85	CT9
JCT10	9.75	65.00	9.14	11.93	22.85	CT10
JCT11	9.75	65.00	9.14	12.00	22.85	CT11
JCT12	9.75	65.00	9.14	11.93	22.85	CT12
JCT13	9.75	65.00	9.14	11.93	22.85	CT13
JCT14	9.75	65.00	9.14	12.00	22.85	CT14
JCT15	9.75	65.00	9.14	11.93	22.85	CT15
JCT16	9.75	65.00	9.14	12.00	22.85	CT16
JCT17	17.10	65.00	9.14	10.24	22.75	CT18-AI
JCT18	17.10	65.00	9.14	9.14	22.75	CT17-AI
JCT19	17.10	65.00	9.14	9.14	22.75	CT18-AI
JCT20	17.10	65.00	9.14	11.10	22.75	CT20-AI

3.3 NEARBY SOURCES

In addition to JOF's contribution to the impacts of the 1-hr SO_2 NAAQS, emissions from nearby sources were evaluated. Emission inventories provided by TDEC were assessed using the following criteria to determine which nearby sources needed to be modeled: 1) sources located within 10 km of JOF with emissions of at least one (1) ton per year; and 2) sources located between 10 km and 50 km of JOF with a Q/D (annual emissions in tons / distance in km) greater than 20. Sources with a Q/D less than 20 and sources beyond 50 km were indirectly accounted for in the background monitored concentration. As discussed in Section 3.7, the SO_2 observations from the Mammoth Cave National Park Monitor (AIRS ID 21-061-0501) in Mammoth Cave, Kentucky, were used to account for the potential impacts of other natural sources, nearby small sources, and distant major sources.

Nearby sources within 50 km of JOF are shown in Figure 5 and Table 10. Sources included in the modeling analysis are shown in Table 11. Based on TDEC comments provided in March 2016 regarding the JOF modeling protocol[8], 15 sources from Dupont Titanium Technologies (Dupont) (now known as Chemours) and one source from Hood Container Corporation (Hood) were modeled. The Title V permit application for Dupont and the PSD permit application for Hood indicated that their sources were continuously operated[9]. Therefore, the 2014 annual SO_2 emissions provided by the TDEC emissions inventory were divided by 8,760 hours to estimate an hourly rate for each individual source.

Table 10
Nearby Sources within 50 km of JOF

Nearby Source	Distance from JOF (km)	2014 Total Annual Emissions (tons) [1]	Maximum Q/D [2]
Dupont Titanium Technologies (Dupont)	1.24	59.72	48.16
Erachem Comilog, Inc.	3.73	0.18	0.05
Hood Container Corporation (Hood)	7.11	52.71	7.41
West Camden Sanitary Landfill	13.86	16.60	1.20

Notes:
1. Annual emissions reflect facility-wide total of all SO_2 emission sources.
2. Maximum Q/D reflects the facility's total SO_2 emissions divided by the minimum distance to JOF. Distances to sources with zero (0) annual emissions (three for Dupont, one for Erachem Comilog, Inc.) were not used in the maximum Q/D determination.

There were no other nearby sources that met the screening criteria within 50 km of JOF. In addition, there were no clusters of sources within 50 km which, when combined, would potentially have an impact on the concentrations in the JOC vicinity.

8 TDEC Correspondence to TVA, March 18, 2016: "RE: TVA ALF, CUF, and JOF SO2 1-Hour Modeling Protocols."

9 Source information taken from Dupont Title V Permit Application (43-0007 June 26, 1997.pdf) and Hood Container Corporation PSD Permit Application (7-25-08 PSD permit application.pdf). Documents available through the TN Department of Environment and Conservation, Tennessee Division of Air Pollution Control (DAPC) permits website: http://environment-online.state.tn.us:8080/pls/enf_reports/f?p=19031:34001:0::NO.

Table 11
Nearby Sources Included in the Modeling Analysis [1,2]

Source	Source No. [3]	UTM 16 Easting (NAD83)	UTM 16 Easting (NAD83)	Base Elev. (m) [4]	Stack Height (m)	Stack Diam. (m)	Stack-Exit Vel. (m/s)	Stack-Exit Temp. (K)	SO_2 Emission Rate (g/s) [5]
Dupont	EP12A [6]	411718.2	3988829.3	116.7	24.38	0.61	25.05	449.82	0.00E+00
Dupont	EP12B [6]	411718.2	3988829.3	116.7	28.96	1.07	20.24	449.82	0.00E+00
Dupont	EP67D [6]	411493.6	3988800.5	115.8	39.62	1.52	18.23	399.82	0.00E+00
Dupont	EP70	411718.2	3988829.3	116.7	28.04	0.91	4.36	449.82	6.18E-04
Dupont	EP71	411718.2	3988829.3	116.7	32.00	1.01	24.54	449.82	1.09E-03
Dupont	EP32 [7]	411718.2	3988829.3	116.7	44.20	3.35	6.40	393.15	4.69E-03
Dupont	EP33 [7]	411718.2	3988829.3	116.7	44.20	3.35	6.40	393.15	4.46E-03
Dupont	EP67E	411718.2	3988829.3	116.7	40.39	0.76	13.78	328.15	1.77E-04
Dupont	EP63	411718.2	3988829.3	116.7	44.20	1.52	31.00	374.82	3.31E-03
Dupont	EP08	411718.2	3988829.3	116.7	77.72	0.37	32.40	308.15	7.77E-01
Dupont	EP09	411718.2	3988829.3	116.7	76.20	0.37	32.40	308.15	7.77E-01
Dupont	EP11A [7]	411729.4	3989938.5	109.7	21.34	0.30	28.96	335.93	6.65E-02
Dupont	EP11B [7]	411729.4	3989938.5	109.7	21.34	0.30	28.96	335.93	6.65E-02
Dupont	EP11C	411718.2	3988829.3	116.7	21.34	0.49	33.53	335.93	1.33E-02
Dupont	EP05	411718.2	3988829.3	116.7	21.95	1.07	4.24	338.15	1.25E-03
Dupont	EP13B	411718.2	3988829.3	116.7	27.22	0.79	28.29	449.82	1.17E-03
Dupont	EP13A	411718.2	3988829.3	116.7	29.41	0.70	6.31	449.82	6.47E-04
Dupont	EP64	411718.2	3988829.3	116.7	14.08	0.50	10.82	327.59	9.67E-04
Hood	5000S	415563.3	3993306.3	121.4	39.62	3.26	6.95	343.15	1.46E+00

Notes:
1. Provided by TDEC.
2. No building downwash was performed for these sources.
3. Source information taken from Dupont Title V Permit Application (43-0007 June 26, 1997.pdf) and Hood Container Corporation PSD Permit Application (7-25-08 PSD permit application.pdf). Documents available through the TN Department of Environment and Conservation, Tennessee Division of Air Pollution Control (DAPC) permits website: http://environment-online.state.tn.us:8080/pls/enf_reports/f?p=19031:34001:0::NO
4. Base elevations determined from AERMAP.
5. Because the sources are continuously operated, the hourly SO_2 emission rate for each source was calculated by taking the annual SO_2 emissions and dividing by 8,760 hours.
6. Sources had zero emissions reported for 2014. Therefore, they were not included in the modeling.
7. Sources are collocated and have same stack parameters; they were modeled as one combined source.

3.4 MODEL SELECTION AND OPTIONS USED

For area designations under the 1-hour SO_2 primary NAAQS, the American Meteorological Society / Environmental Protection Agency Regulatory Model (AERMOD) should be used unless use of an alternative model can be justified (USEPA, 2005). Air quality dispersion modeling was performed using AERMOD (Version 15181) to obtain estimates of maximum ambient impacts (USEPA, 2004a; USEPA, 2015b). The options used within the model were the recommended default regulatory options, which included the following:

- Appropriate treatment of calms and use of missing meteorological data routines;
- Inclusion of actual receptor elevations;
- Incorporation of complex / intermediate terrain algorithms;
- Calculations of stack tip downwash and direction-specific building downwash.

According to the SO_2 TAD, the "urban" or "rural" determination of a source is important in determining the boundary layer characteristics that affect AERMOD's prediction of downwind concentrations as well as the possible invocation of the 4-hour half-life for urban SO_2 sources (USEPA, 2016). In order to determine the rural / urban characterization of a modeling study area and the dispersion coefficients to use in AERMOD, a land use analysis is required (USEPA, 2005). The USEPA guidance recommends the use of the Auer land use scheme within three (3) kilometers of a source to classify the predominant dispersion regime (USEPA, 2005). If the percentage of land use types that are characteristic of heavy industrial, light-moderate industrial, commercial, or compact residential account for 50 percent or more within the three kilometers, the modeling area is classified as urban, and the urban dispersion options in AERMOD should be used. Otherwise, the area is classified and modeled as rural.

The Auer method was used to determine the land use status of the area around JOF. A three-kilometer radius was centered on the JOF stack, and the land use was categorized based on the Auer classifications (Auer, 1978). The data source for the land cover was the 2011 National Land Cover Database (NLCD), with a data cell size (raster) of 30 meters by 30 meters. The results of the Auer land use analysis for the JOF study area are presented in Figure 6 and Table 12. The analysis indicates that the JOF study area is approximately 93.4% rural and 6.6% urban. Therefore, the rural option was used in AERMOD.

Table 12
Auer Land Use Percentages by Category: JOF Study Area

SO_2 Modeling Auer's Analysis - NLCD 2011				Johnsonville - 3 km Ring		
NLCD Value	NLCD 2011 Descriptions	Auer's Code	Auer's Class	Area (Sq. Meters)	Pecentage	Totals
23	Developed, Medium Intensity	R2/R3	Urban	1,006,878.33	3.56%	6.62%
24	Developed, High Intensity	I1/I2/C1		865,308.86	3.06%	
11	Open Water	A5	Rural	11,514,907.90	40.73%	93.38%
21	Developed, Open Space	A1/R4		1,268,793.72	4.49%	
22	Developed, Low Intensity	R1		1,212,095.74	4.29%	
31	Barren Land (Rock/Sand/Clay)	A3		210,124.23	0.74%	
41	Deciduous Forest	A4		7,035,955.91	24.89%	
42	Evergreen Forest	A4		1,237,009.79	4.38%	
52	Shrub/Scrub	A4		195,694.39	0.69%	
71	Grassland/Herbaceous	A3		174,952.86	0.62%	
81	Pasture/Hay	A3		157,957.97	0.56%	
82	Cultivated Crops	A2		1,413,007.87	5.00%	
90	Wood Wetlands	A4		1,541,204.26	5.45%	
95	Emergent Herbaceous Wetlands	A3		439,186.98	1.55%	
Analysis based on 30 meter by 30 meter raster cells extracted for each area.			*Grand Totals:*	*28,273,078.79*	*100.00%*	

3.5 METEOROLOGY

Given that site-specific meteorological data is not available for the JOF site, surface data collected by the NWS at the Nashville International Airport (BNA) in Nashville, Tennessee, were used. Data for the three-year period from 2012 to 2014 were used. Twice daily soundings for the same time period, also from the BNA airport, were used for the upper air data.

The data were processed using the AERMET (Version 15181) meteorological data preprocessor for AERMOD (USEPA, 2004b; USEPA, 2015a). In addition, 1-minute ASOS wind data available from the National Climatic Data Center (NCDC) for the BNA NWS site was processed with AERMINUTE (Version 15272) to generate hourly averaged wind speed and wind direction to supplement the standard hourly NWS observations. Because the BNA NWS site is an Ice Free Wind (IFW) station with a commission date of April 5, 2007, AERMINUTE flagged the 2012-2014 winds as non-calm. The wind speeds were converted from knots to meters per second (m/s) because the threshold for sonic anemometers is effectively zero. No minimum wind speed threshold values were set in AERMET.

Two sets of meteorology were modeled, one set using onsite surface characteristics and one using the surface characteristics of the NWS station. Details of the meteorological processing were provided in the modeling protocol (TVA, 2016).

3.6 MODELING DOMAIN AND RECEPTORS

For the purposes of 1-hour SO_2 designation determination, the modeling domain was a Cartesian grid centered at the JOF site which extended out 10 km in each direction. The domain was large enough to include nearby sources that could potentially cause a significant concentration gradient in the vicinity of JOF.

The modeling was performed using a series of nested gridded receptor sets. Boundary receptors were also placed along the perimeter of the fenced area of the JOF property and spaced 50 meters (m) apart. These boundary receptors corresponded to a permanent fence surrounding the property.

The nested receptor grids surrounded the facility site with the exception of those falling inside the fenced boundary area, which were removed. Because concentration gradients are most pronounced near a source, the receptor spacing varied with distance from the site with those nearest the site more closely spaced than those further away. The origin of each grid was located in the southwest corner. The receptor spacing is provided in Table 13.

Table 13
Receptor Grid Size and Spacing

Receptor Spacing (m)	Grid Size (km)	Grid Origin (km south and west of site)
100	6 × 6	3
250	10 × 10	5
500	20 × 20	10

Elevations for all receptors were extracted from U.S. Geological Survey (USGS) National Elevation Dataset (NED) files using the AERMAP terrain processor (Version 11103) of the AERMOD modeling system (http://nationalmap.gov/elevation.html) (USEPA, 2004c). A plot of receptor elevations is presented in Figure 7.

3.7 BACKGROUND AIR QUALITY

The SO_2 TAD states that the inclusion of ambient monitored background concentrations in the model results is important in determining the cumulative impact of the target source and other contributing nearby sources impacts (USEPA, 2016). The USEPA's March 1, 2011, memorandum also notes that ambient air quality data should generally be used to account for background concentrations (USEPA, 2011a).

An assessment of nearby SO_2 monitors was performed in order to determine the most appropriate monitor to represent ambient SO_2 background concentrations for the JOF modeling analysis (Table 14). The choice of nearby background monitors for JOF was limited because many monitors did not meet the data completeness requirements for determining compliance with the NAAQs. The Cumberland Heights and Meek's Property monitors located in Clarksville, Tennessee, did not have three years of usable data; all of the 2014 data was excluded as an exceptional event. The Christian County monitor located in Christian County, Kentucky, and the Trinity Lane monitor in Nashville, Tennessee, did not meet the USEPA data completeness criteria for the 2012-2014 modeling period. The Powell Street monitor in Paducah, Kentucky has three years of complete and valid data. However, it is impacted by numerous large nearby sources, making it unsuitable for characterizing air quality beyond the immediate vicinity of the monitor.

The Shelby Farms NCore monitor in Memphis, Tennessee, and the Mammoth Cave monitor at Mammoth Cave National Park in Mammoth Cave, Kentucky, both met the data completeness requirements for 2012-2014 and were deemed to be representative of ambient air quality in the vicinity of JOF. The Mammoth Cave monitor (AIRS ID 21-061-0501) was selected to represent background SO_2 concentrations because it is not influenced by large nearby sources[10]. This monitor is located approximately 128 miles northeast of JOF (Figure 1).

Table 14
Ambient SO_2 Monitors in the Vicinity of JOF [1]

Monitor	Site ID	Distance to JOF (miles)	3-yr Avg. 99th Percentile Concentration (ppb) [2]	Large Nearby Sources?
Cumberland Heights (Clarksville)	47-125-0106	46	Does not meet data completeness requirements	
Meek's Property (Clarksville)	47-125-0006	47	Does not meet data completeness requirements	
Trinity Lane (Nashville)	47-037-0011	70	Does not meet data completeness requirements	
Christian County	21-047-0006	71	Does not meet data completeness requirements	
Powell Street (Paducah)	21-145-1024	78	20.7	Yes, over 50,000 tpy
Shelby Farms NCore	47-157-0075	121	9.3	Yes, nearly 14,000 tpy
Mammoth Cave	21-061-0501	128	10.3	No

Notes:
1. USEPA Air Quality System (AQS) Data Mart: http://www3.epa.gov/airquality/airdata/.
2. The 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average SO_2 concentrations for the 2012-2014 period.

Following TAD guidance, the three-year average of the 99th percentile of the daily maximum 1-hour SO_2 concentrations from 2012-2014 was used to capture the impact of natural sources, minor nearby sources, and distant major sources in the vicinity of JOF which were not included in the modeling (Table 15). No wind directions were excluded to remove the impacts of JOF or other sources on the monitor.

[10] TVA (C. Wylie) conference call with USEPA Region IV (R. Gillam) and TDEC (H. Alrawi) on May 26, 2016, which concluded that the Mammoth Cave monitor was most appropriate for estimating background concentrations at JOF.

Table 15
Ambient SO_2 Concentrations Measured at Mammoth Cave National Park [1]

Year	99th Percentile 1-hr SO_2 Concentration (ppb)
2012	9
2013	11
2014	11
3-year Average	10.3

Note:
1. USEPA Air Quality System (AQS) Data Mart: http://www3.epa.gov/airquality/airdata/
2. The 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average SO_2 concentrations for the 2012-2014 period.

4.0 MODELING RESULTS AND CONCLUSION

For both meteorological scenarios, the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average SO_2 concentrations was calculated for each receptor; the value for the receptor with the highest concentration is presented in Table 16. These values include modeled impacts of emissions from JOF and nearby sources, as well as background concentrations. The modeling results show that SO_2 emissions from JOF from 2012 to 2014 resulted in maximum predicted impacts well below the 1-hour SO_2 NAAQS.

Table 16
Modeled Maximum Impacts of Actual Emissions (2012-2014)

Met Surface Characteristics	Receptor Location			1-hour SO_2	
	UTM Easting (m)	UTM Northing (m)	Elevation (m)	Maximum Modeled Impact (ppb) [1,2]	NAAQS (ppb) [2]
Onsite	413594	3988302	193.27	48.7	75
BNA	410294	3984802	109.38	44.4	75

Notes:
1. Modeled impacts include the impact of actual emissions from JOF, Dupont, and Hood; and background concentrations from the Mammoth Cave monitor.
2. 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour SO_2 concentrations.

A plot of the 3-year average of the 99th percentile of the annual distribution of daily maximum 1-hour average SO_2 concentrations for the onsite surface characteristics is presented in Figure 8. A similar plot for the NWS surface characteristics is shown in Figure 9. The distance to the receptor with the highest concentration was 2.47 km for the onsite surface characteristics and 3.04 km for the NWS surface characteristics. For both scenarios (NWS and JOF surface characteristics), the maximum predicted concentration occurred at receptors that fell inside the 100-meter spaced receptor grid.

The input and output files for the AERMOD model runs provide additional details on the dispersion modeling and are included on the enclosed optical disc.

The results of the modeling analysis show that maximum impacts from actual hourly emissions from JOF during the period from 2012 to 2014 did not cause or contribute to a violation of the 1-hour SO_2 NAAQS. Based on this and the consideration of other SO_2 sources in the area, an attainment designation for Humphreys County is recommended.

5.0 REFERENCES

Auer, 1978: Correlation of Land Use and Cover with Meteorological Anomalies. Journal of Applied Meteorology, 17(5), 636-643.

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USEPA, 2004c: User's Guide for the AERMOD Terrain Preprocessor (AERMAP). EPA-454/B-03-003. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

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USEPA, 2005: Guideline on Air Quality Models. 40 CFR Part 51 Appendix W.

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USEPA, 2015a: Addendum User's Guide for the AERMOD Meteorological Preprocessor (AERMET). EPA-454/B-03-002. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

USEPA, 2015b: Addendum User's Guide for the AMS/EPA REGULATORY MODEL - AERMOD. EPA-454/B-03-001. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

USEPA, 2016: SO_2 NAAQS Designations Modeling Technical Assistance Document, December 2013. U.S. Environmental Protection Agency, Research Triangle Park, NC 27711.

Figure 1
Site Locality Map

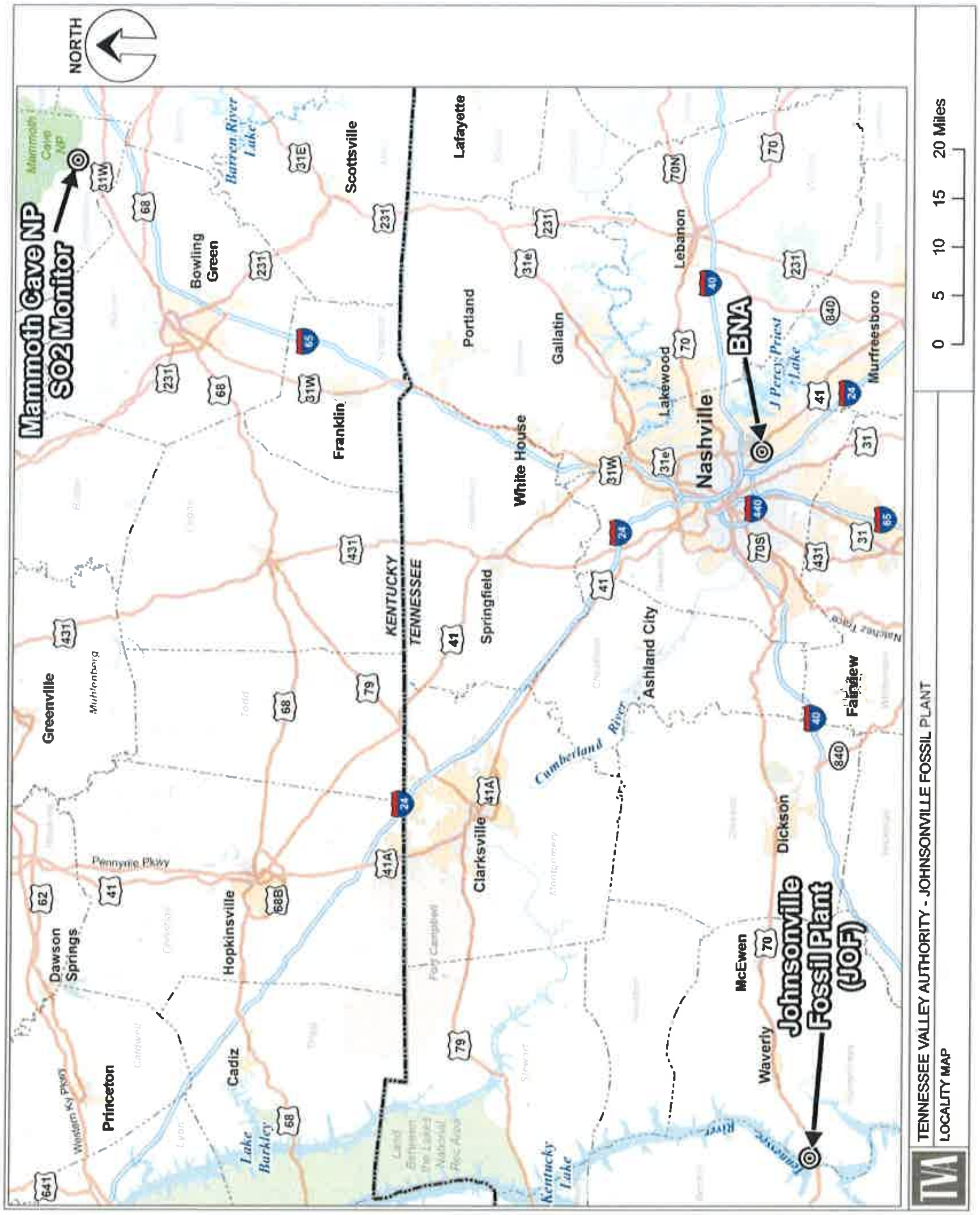

Figure 2
Topographical Map

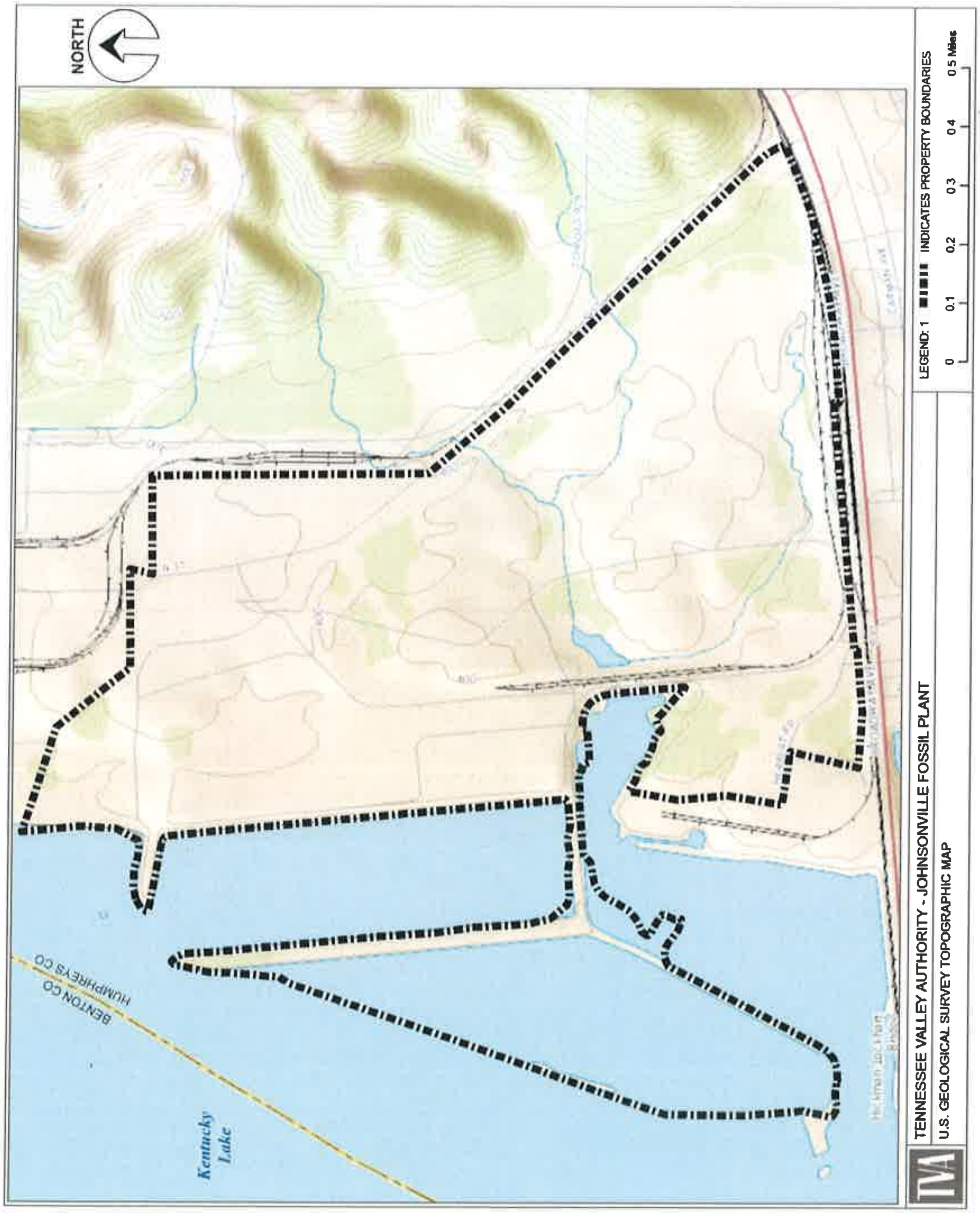

Figure 3
Building Locations for Stack Downwash Analysis

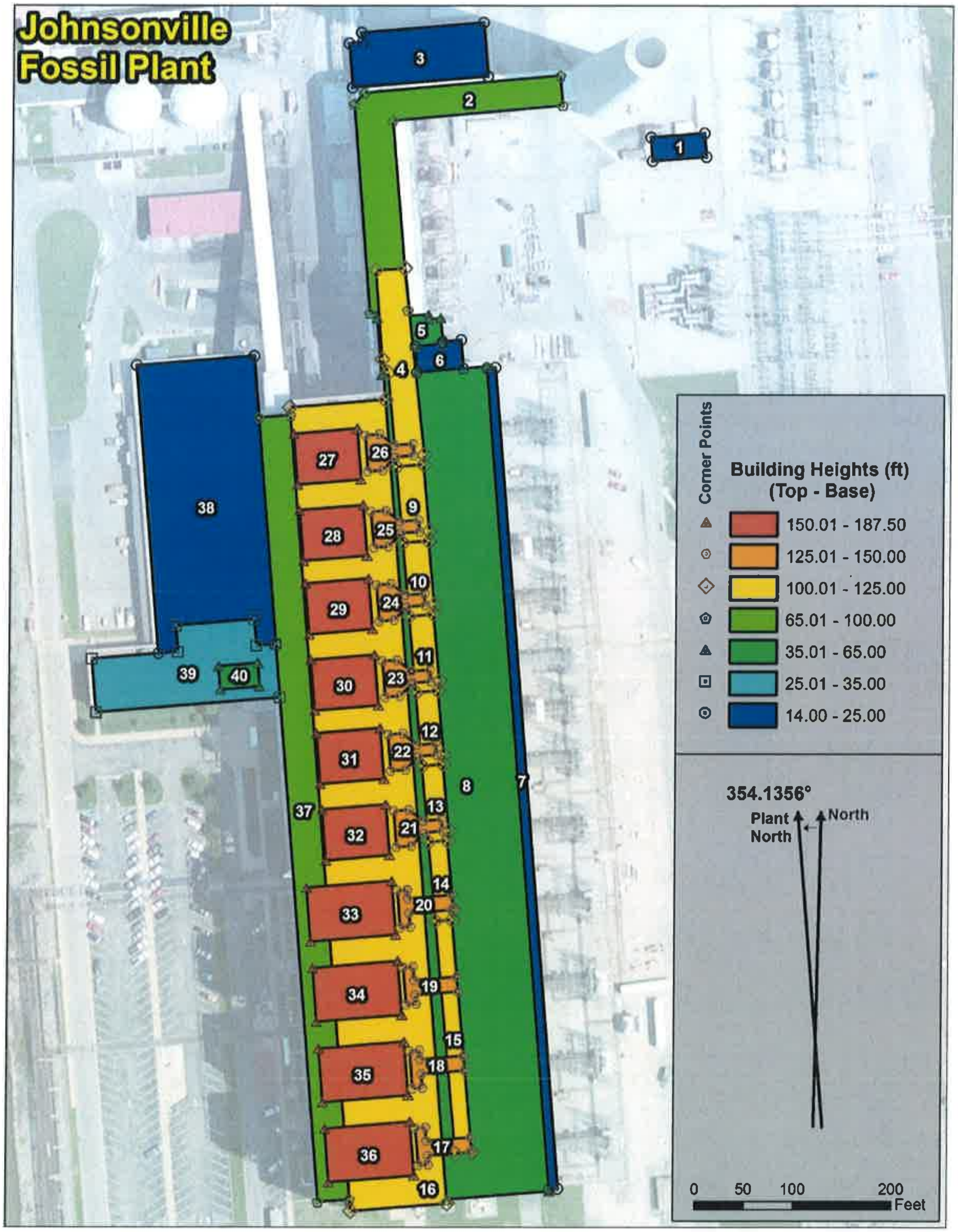

Figure 4
CT Building Locations for Stack Downwash Analysis

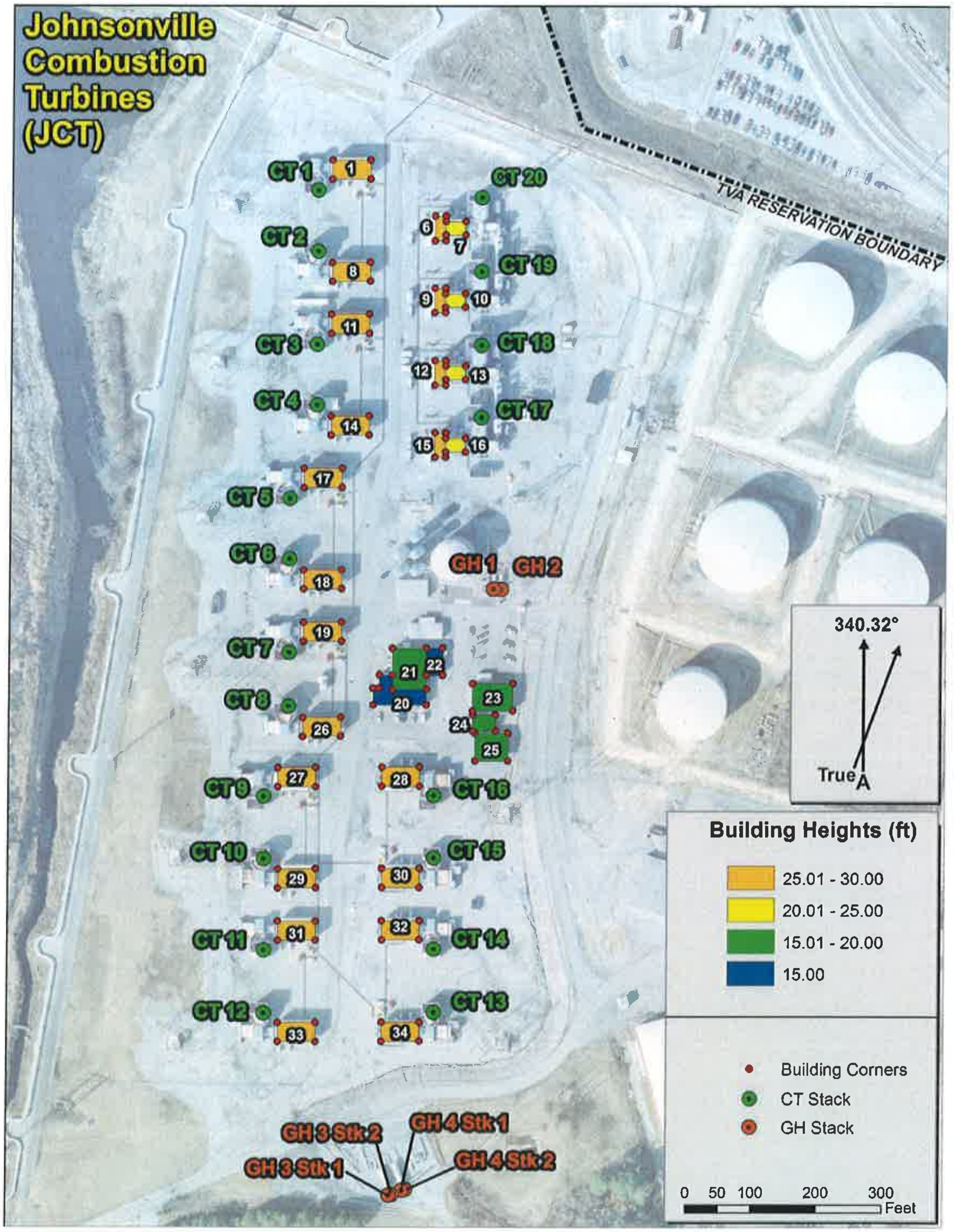

Figure 5
Nearby SO_2 Sources within 50 km of JOF

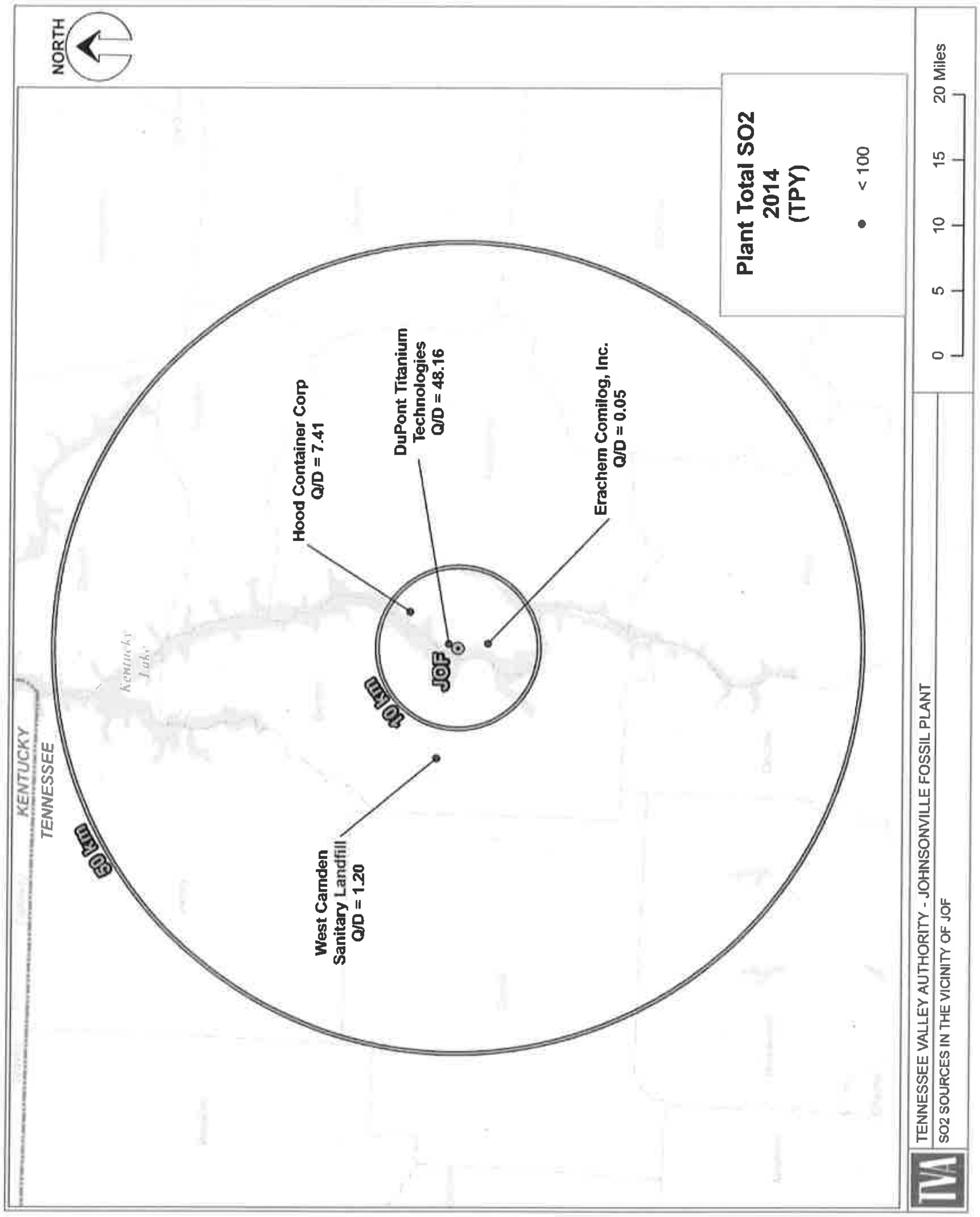

Figure 6
Auer Land Use Analysis - JOF Study Area

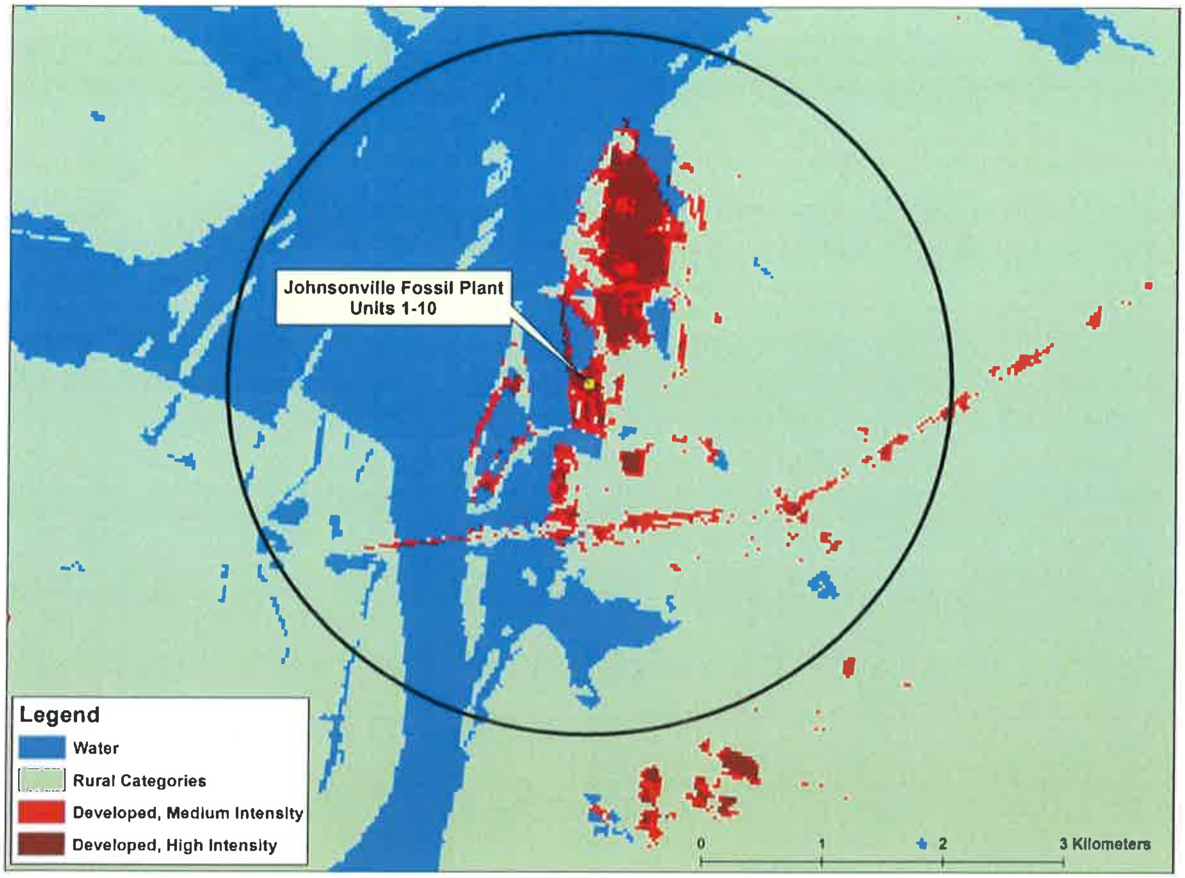

Figure 7
JOF Receptor Elevation Plot

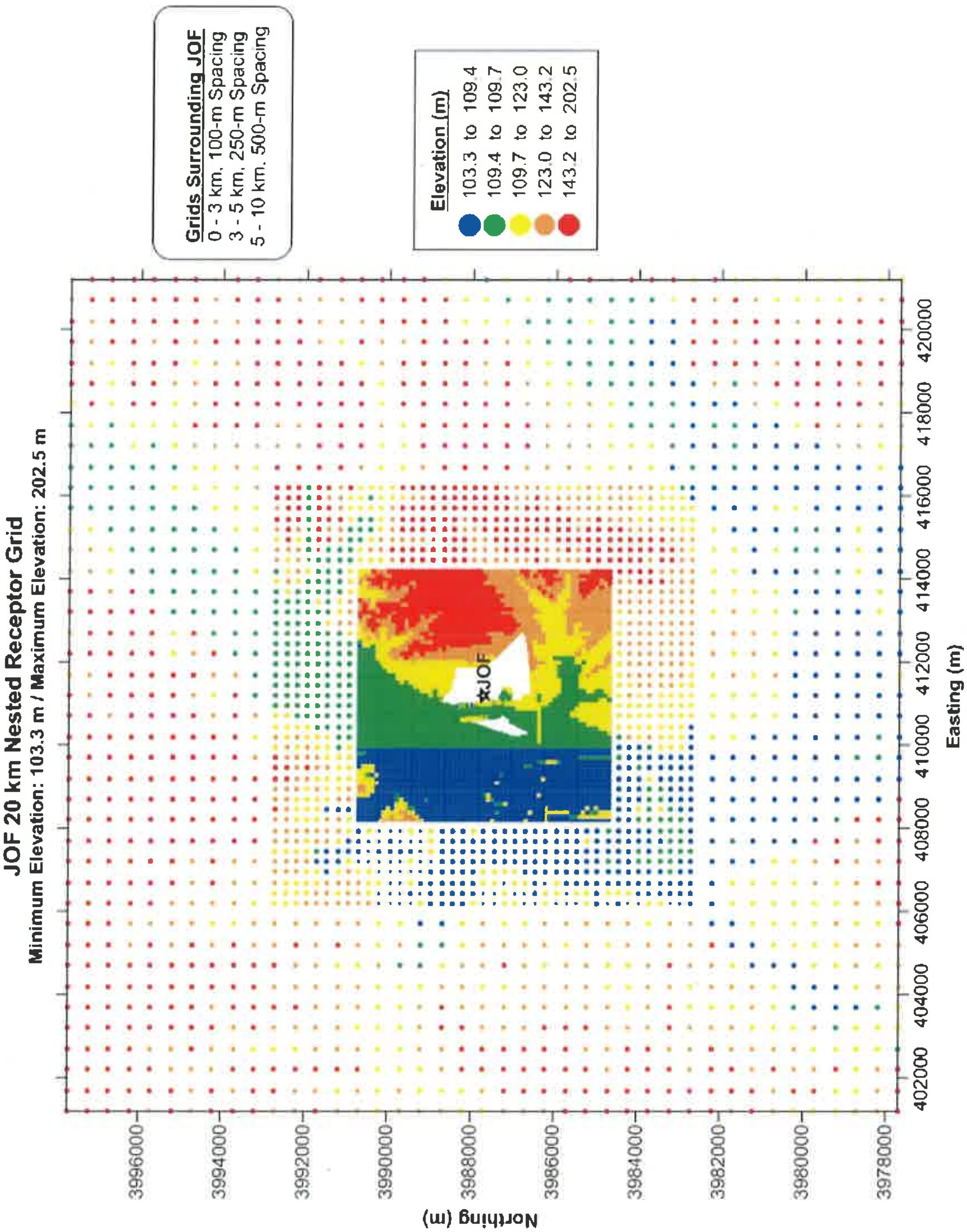

Figure 8
99^{th} Percentile 1-hour SO_2 Concentration Plot using Onsite Surface Characteristics

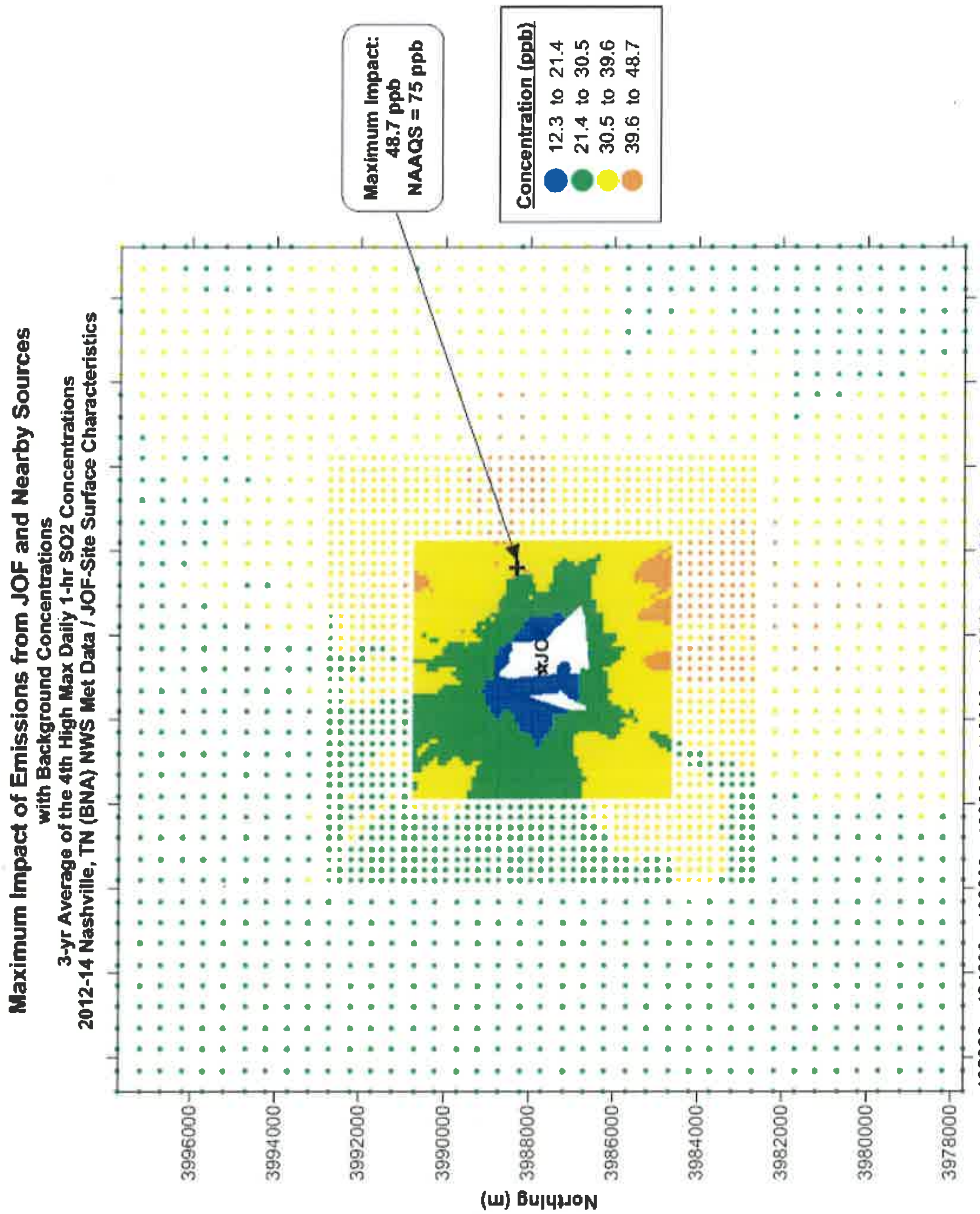

Figure 9
99th Percentile 1-hour SO_2 Concentration Plot using NWS Surface Characteristics