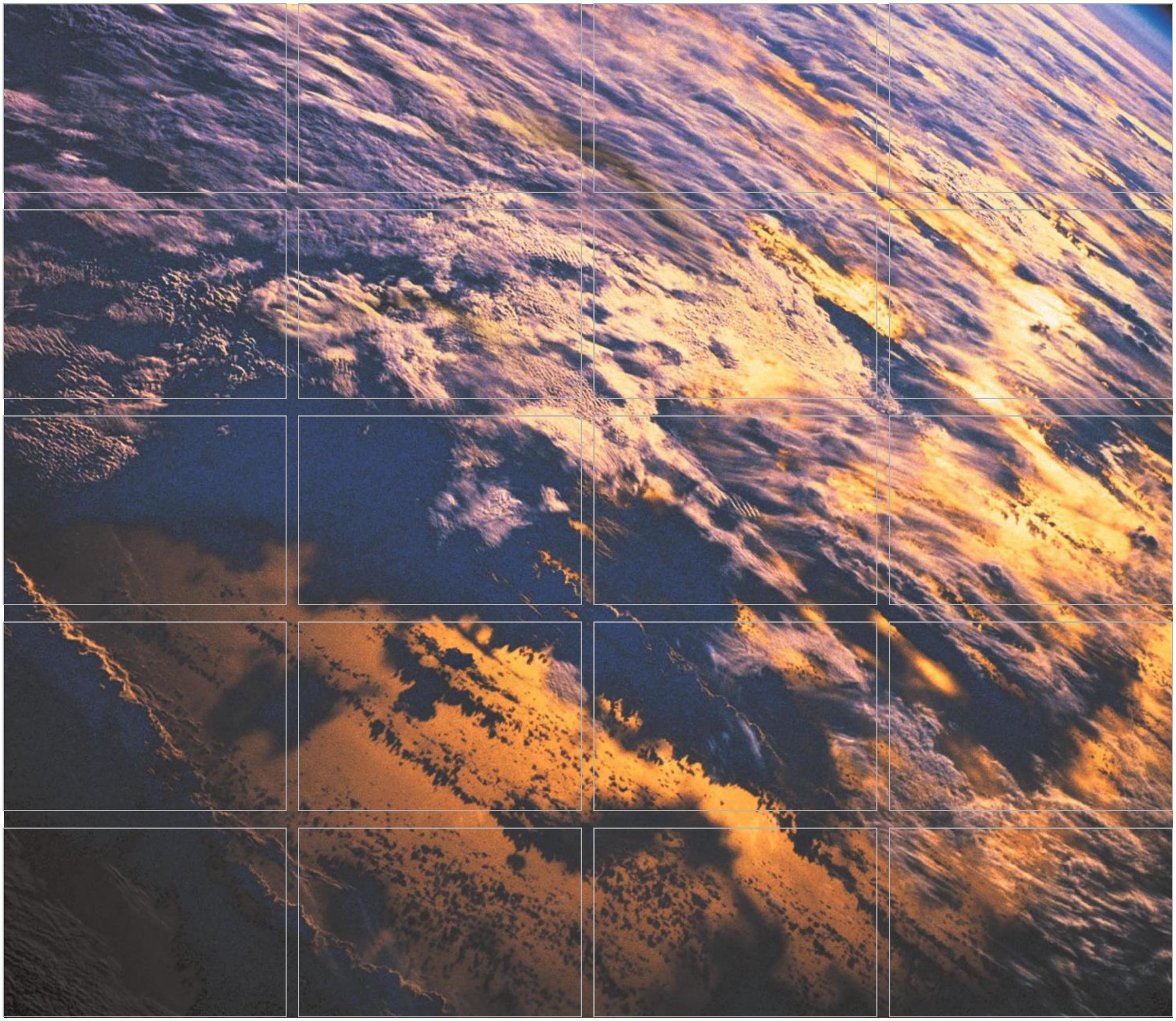


SO_2 Air Dispersion Modeling Report for Independence Steam Electric Station

August 2015

ERM Project No. 0268066

www.erm.com

The world's leading sustainability consultancy

ERM

SO_2 Air Dispersion Modeling Report for Independence Steam Electric Station

August, 2015

ERM Project No. 0268066

Peter T. Belmonte
Partner-in-Charge

Richard P. Hamel
Project Manager

Environmental Resources Management
One Beacon Street, 5th Floor
Boston, MA 02108
T: 617-646-7800
F: 617-267-6447

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1.0 *INTRODUCTION*

ERM Consulting & Engineering, Inc. (ERM), has prepared this report documenting that maximum model-predicted SO_2 impacts from Entergy Arkansas Inc.'s (Entergy) Independence Steam Electric Station (Independence) are in attainment with the 1-hour Sulfur Dioxide (SO_2) National Ambient Air Quality Standard (NAAQS) and will fulfill the requirements of the EPA's 1-Hour SO_2 Data Requirements Rule (DRR). This analysis shows that the ambient air quality in the vicinity of Independence, currently undesignated for the 1-hour SO_2 NAAQS, is within the standard and should be identified as "attainment" in the next cycle of designations.

This modeling report describes the modeling methodology that was used to evaluate potential impacts of SO_2 emissions from Independence on ambient air quality. Copies of the modeling files are provided in Appendix A, the Electronic Modeling Archive.

1.1 *Project Overview*

Unlike previous NAAQS attainment demonstrations, EPA has proposed to make 1-hour SO_2 NAAQS attainment determinations using ambient air monitoring data and/or air dispersion modeling. In situations where air modeling is used to make this determination, the approach described in EPA's proposed "Modeling Technical Assistance Document" (TAD)[1], which sets forth a significantly different technical approach compared to conventional regulatory modeling prescribed by 40 CFR Part 51, Appendix W (EPA's *Guideline on Air Quality Models*) could be used. This approach would also meet the requirements of the DRR.

EPA distinguishes the approaches described in the SO_2 Modeling TAD to "reflect a view that designations are intended to address current actual air quality (i.e., modeling simulates a monitor), and thus are unlike attainment plan modeling, which must provide assurances that attainment will occur." EPA's proposed approach would utilize several distinctive technical approaches, including but not limited to the following:

- Simulating actual emissions and exhaust conditions (e.g., temperature and flowrate) on an hourly basis reflecting actual operations for a specified historical time period;
- Representing actual stack heights, irrespective of the GEP regulations;
- Limiting modeled ambient air receptors to locations where monitoring could actually take place by excluding waterways, roadways, railways, restricted access property, and other locations that would conventionally be considered "ambient air" for regulatory and permitting purposes;

[1] http://epa.gov/oaqps001/sulfurdioxide/pdfs/SO2ModelingTAD.pdf

- Simulating a three-year period of meteorological and background monitoring data, concurrent with the actual operating conditions and emissions, to meet EPA's objective that "modeling simulates monitoring" in this context.

ERM performed a modeling analysis evaluating the impacts on ambient air quality from SO_2 emissions at Independence. As discussed in this report, ERM's approach to the modeling analysis used those refinements directly addressed in the proposed rule, i.e. the use of actual hourly emissions, actual stack heights, and seasonal diurnal ambient background concentrations.

As shown in this modeling report, SO_2 impacts from Independence emission sources, when combined with ambient air concentrations taken from a representative nearby monitor, are below the 1-hour SO_2 NAAQS.

This first section of this report describes the modeling methodology that was followed. Section 2 provides a description of the facility and the emissions included in the modeling. Model selection and the methodology used in the modeling are described in Section 3. The modeling results are presented in Section 4. References are provided in Section 5.

1.2 *Overview of Methodology*

ERM's assessments were conducted in a manner consistent with United States Environmental Protection Agency (EPA) air quality regulations and modeling guidelines that are generally adopted by Arkansas Department of Environmental Quality (ADEQ), including the following:

- *Guideline on Air Quality Models* – 40 CFR Part 51, Appendix W, Revised November 9, 2005.
- *AERMOD Implementation Guide*, Revised March 19, 2009;
- "SO_2 NAAQS Designations Modeling Technical Assistance Document (Draft)," December 2013;
- "SO_2 NAAQS Designations Monitoring Technical Assistance Document (Draft)," December 2013;
- "Data Requirements Rule for the 2010 1-Hour Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standard (NAAQS)," Pre-publication final rule, (submitted to the Federal Register on August 10, 2015, FRL-9928-18-OAR); and
- "Guidance for 1-hour SO_2 Nonattainment Area SIP Submissions," April 23, 2014.

The steps that were undertaken by ERM to conduct the air dispersion modeling analyses are summarized below:

- Compiled information on the parameters and characteristics for all sources of SO_2 emissions at Independence including the main EGU's, the auxiliary boiler, the emergency diesel generator, and the fire pump engine;

- Developed a comprehensive receptor grid to capture the maximum off-site impacts from Independence sources using AERMAP (v.11103).

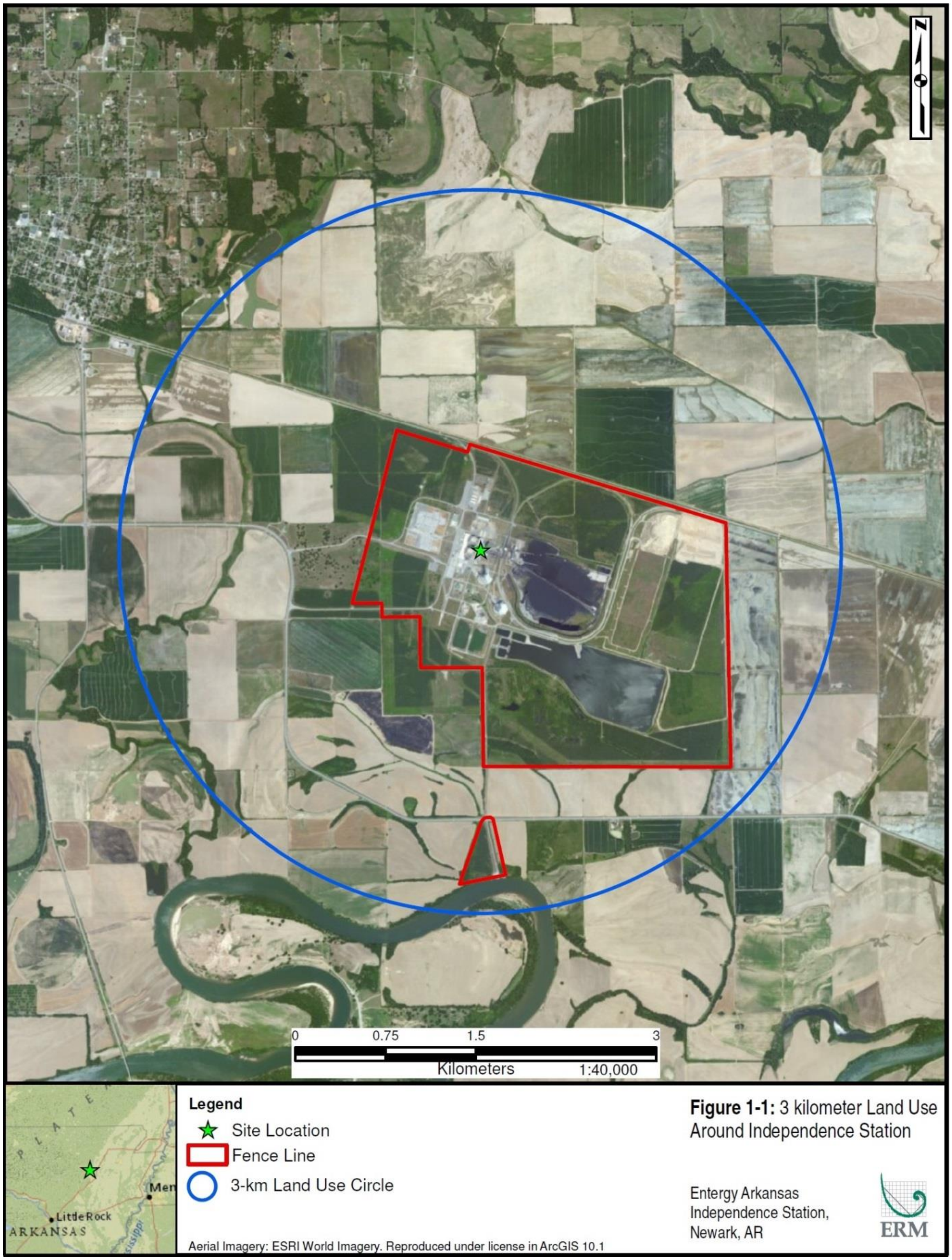
- Obtained ambient background concentration data for SO_2 from nearby monitors to represent sources not explicitly included in the modeling runs;

- Developed 3 years (2012-2014) of meteorological data using surface observations from Adams Field in Little Rock, AR with upper air data from North Little Rock Airport using the most recent version (v.15181) of AERMET, the meteorological data processor for AERMOD, and its two preprocessors: AERSURFACE (v.13016) and AERMINUTE (v.14337).

- Conducted an air dispersion modeling analysis using the most recent version of EPA's regulatory dispersion model, AERMOD (v.15181) and 3 years of actual emissions data from Independence emissions sources, as well as other major sources of SO_2 emissions in the region, consistent with the methodology described in the SO_2 Data Requirements Rule and SO_2 Modeling TAD.

- Summarized the results and compared them with the 1-hour SO_2 NAAQS to determine a recommended attainment designation for the vicinity of Independence.

Figure 1-1 Independence Station Surroundings and Land Use



2.0 *FACILITY DESCRIPTION AND REGULATORY SETTING*

2.1 *Facility Location*

The Independence Steam Electric Station is located in the town of Newark, Arkansas, in Independence County. The station is located about 2.5 miles southeast of downtown Newark. The site is accessed by Arkansas State Route 69. The station is approximately 82 miles northeast of Little Rock, Arkansas and 84 miles west-northwest of Memphis, Tennessee. Approximate site coordinates are 35.678^{o} North Latitude, 91.408^{o} West Longitude. The Universal Transverse Mercator ("UTM") coordinates of the facility are 644,087 Easting and 3,949,438 Northing (using North American Datum of 1983 - NAD83) in UTM Zone 15. The base elevation of the facility is 235′ (71.521m) above sea level. A full scale site plan of the power block area of Independence is shown in Figure 2.1, and Figure 2.2 shows the site location marked on a United States Geological Survey ("USGS") 7.5-minute topographic map.

2.2 *SO_2 Attainment Status*

In July 2013, EPA issued a rule designating 29 counties or partial counties as non-attainment for 1-hour SO_2. However, the vast majority of the country was not designated by EPA at that time due to the lack of monitors, or poor siting of existing monitors, for the purpose of capturing source based maximum ambient SO_2 concentrations. None of the counties surrounding Independence, including Independence, the county in which Independence is located, have been designated as attainment or non-attainment for the 1-hour SO_2 NAAQS.

Figure 2-1 Independence Station Site Plan

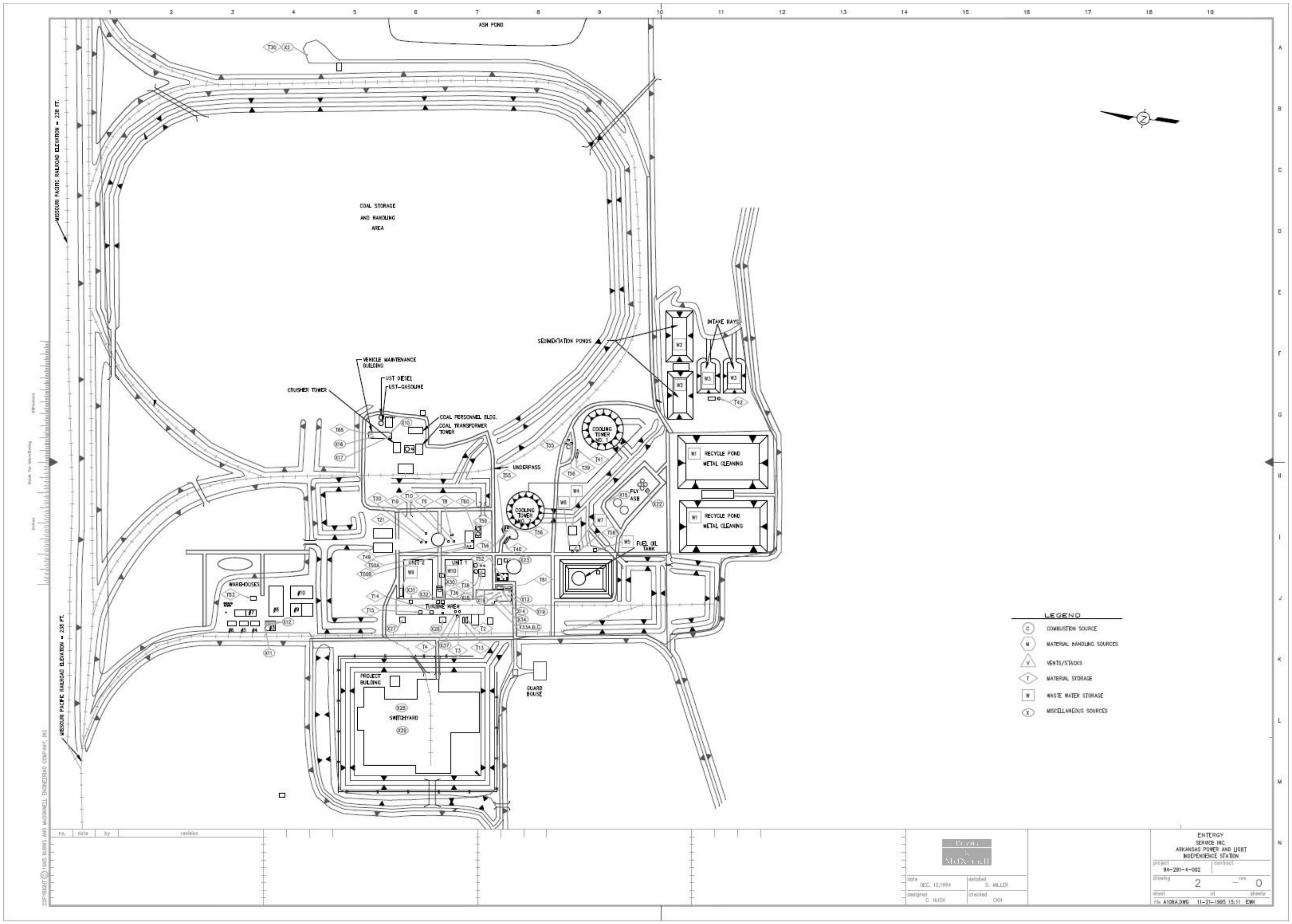
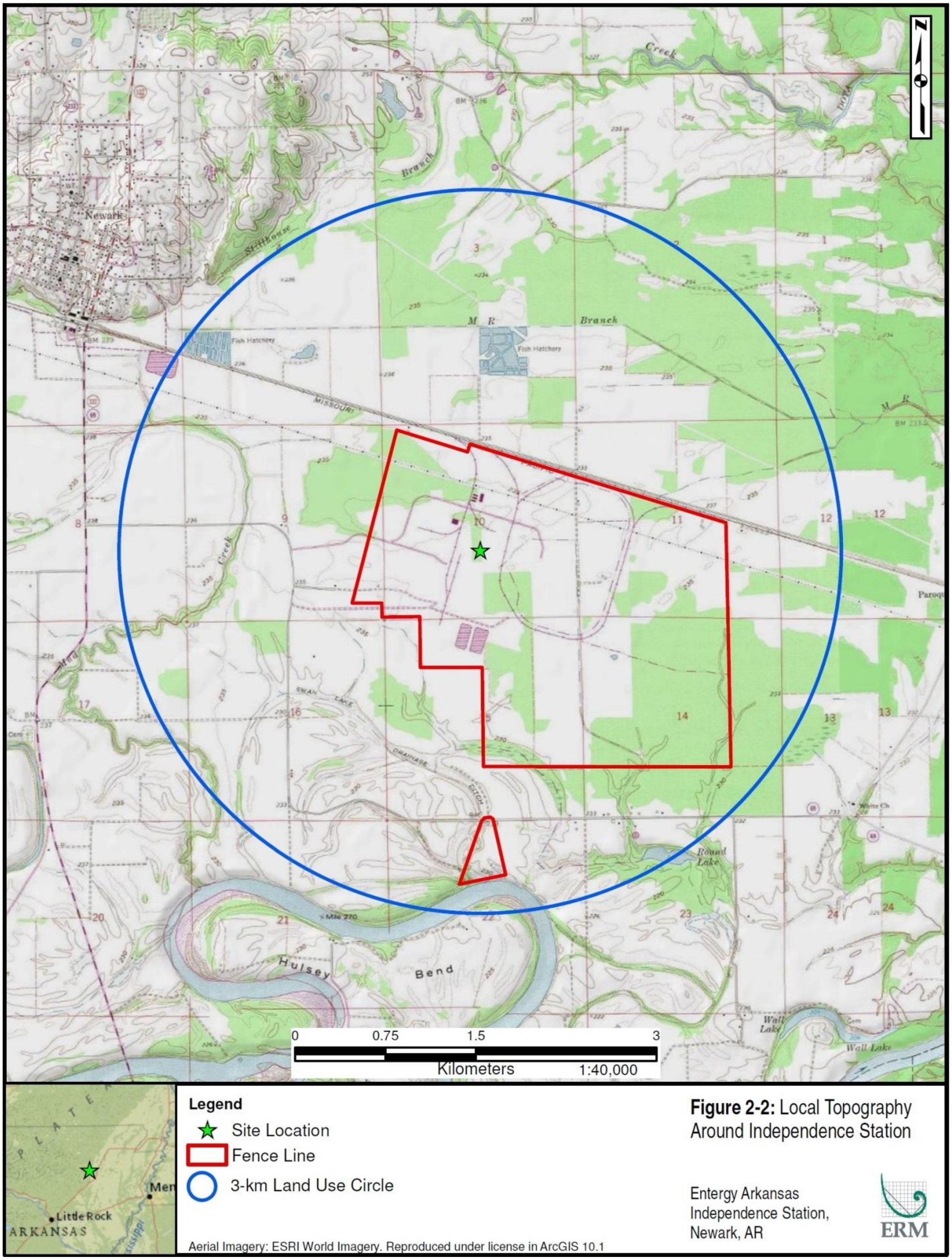


Figure 2-2 Independence Station Local Topography



2.3 *Source Parameters and Emission Rates*

For this 1-hour SO_2 NAAQS modeling demonstration, all sources of SO_2 at the facility were included in the modeling. Per the 1-hour SO_2 Data Requirements Rule and SO_2 Modeling TAD, the most recent 3 years of actual emissions data were used where available, and the actual stack heights of all sources were used in the modeling. The following provides a description of all Independence SO_2 emission sources and how they were represented in the model. Table 2-1 summarizes the characteristics of the emissions sources that were included in the modeling. The actual emissions data used in the modeling are described below:

- Units No. 1 and No. 2 (Source ID: SN01 and SN02). There are two boilers in operation at the Independence Station, Unit 1 and Unit 2. Units 1 and 2 are vented to a common, dual-flue stack. For these main units, three years (2012-2014) of actual hourly emissions, stack temperature, and exhaust flow rate data were input into the model. This emissions data was provided by Entergy from prior submittals to the EPA's Clean Air Markets Database, while temperature and exhaust flow rates were provided by Entergy from the facility CEM system. As per the 1-hour SO_2 Data Requirements Rule, the actual 1000 ft. height of the main stack was represented in each case. The two Units at the facility were modeled as separate sources, each emitting from their own flue. This is a conservative representation because it neglects potentially enhanced buoyancy from a combined plume from both flues.

- Auxiliary Boiler (Source ID: SN05). The auxiliary boiler was also modeled using actual hourly emissions data. For this source, however, exhaust temperature and velocity were not available, so for all hours the exit temperature and velocity were set to the values located in the ADEQ source registration tables for the auxiliary boiler.

- Emergency Diesel Generator (Source ID: SN20) and Emergency Fire Pump Engine (Source ID: SN21). The two emergency engines at the facility both have horizontal exhaust releases. This is represented in the modeling by setting the exit velocity of each source to 0.001 m/s to simulate the lack of vertical momentum out of the stack. Emissions data were only available on a month by month total emission basis for each engine. To convert that data into an emission rate for modeling, for each engine the total annual emissions for each year was determined and the highest annual total selected. That total was then divided by 52 to represent that the engines are tested once per week during the year. The resulting emission rate was then used as the lb/hr emission rate in the modeling. Based on information provided by facility staff, the emergency generator is tested weekly on Wednesdays, while the fire pump is tested on Friday evenings. To simulate this standard practice, the emergency generator was set in the modeling using the HRDOW7 emission factor (i.e., variable by hour of day and 7 days per week) to emit during an 8 hour period on Wednesdays from 8 AM to 4 PM, and the fire pump was set to operate on Friday's from 4 PM until Midnight. While this significantly overestimates the total emissions of the emergency engines, because the form of the 1-hour SO_2 standard only considers the hour with the highest concentration each day, at least 7 of these hours are "dropped" and thus only one hour worth of emission is potentially included in the maximum daily impacts.

Data supporting the actual emissions used for the 5 sources included in the modeling are provided in the spreadsheets *ISES_Hourly Actual Emissions 2012-2014.xlsx, ISES Aux Boiler Data 010112 to 123114.xlsx,* and *ISES Em Gen Hours and Emissions 2012-2014.xlsx* included in Appendix A: The Electronic Modeling Archive.

Table 2-1 Independence Station Point Sources – Stack Parameters

Description	*Model Source*	*Stack Height*		*Exit Temperature*		*Exit Velocity*		*Stack Diameter*	
		(ft)	*(m)*	*(F)*	*(K)*	*(ft/sec)*	*(m/s)*	*(ft.)*	*(m)*
Unit 1 Boiler[1]	SN01	1000	304.80	---	---	---	---	25.7	7.83
Unit 2 Boiler[1]	SN02	1000	304.80	---	---	---	---	25.7	7.83
Auxiliary Boiler	SN05	15	4.57	475	519.26	65.0	19.81	3.0	0.91
Emergency Diesel Engine	SN20	14	4.27	963	790.54	----	0.001[2]	0.8	0.25
Emergency Fire Pump	SN22	14	4.27	700	644.26	----	0.001[2]	0.4	0.13

1. For the 2 main boilers, exit temperature and exit velocity varied on an hourly basis based on actual emissions data.
2. Emergency Diesel Engine and Emergency Fire Pump stacks are horizontal, so modeled exit velocity was 0.001 m/s for both.

3.0 *AIR DISPERSION MODELING ANALYSIS*

ERM conducted the modeling analysis for Independence to quantify ambient impacts of SO_2 relative to the 1-hour NAAQS following the proposed approach described in the SO_2 Modeling TAD.

3.1 *Model Selection and Application*

The latest version of USEPA's AERMOD model (v.15181) was used for predicting ambient impacts for 1-hour SO_2. Regulatory default options were used in the analysis. Model predicted impacts from Independence were combined with those of other large sources in the area and an ambient background concentration to represent emissions not explicitly modeled and compared to the 1-hour SO_2 NAAQS to determine the recommended attainment status of the area in the vicinity of the facility.

3.2 *The 1-hour SO_2 NAAQS*

This study focuses on the maximum model-predicted 1-hour SO_2 impacts of Independence and compares them to the 1-hour SO_2 NAAQS. The new standard came into effect in August, 2010. The form of the standard is the 99th percentile of the 3-year average 1-hour daily maximum concentration, and the standard was set to 75 ppb (196.5 $\mu g/m^3$).

3.3 *Meteorological Data*

Guidance for regulatory air quality modeling recommends the use of one year of on-site meteorological data or five years of representative off-site meteorological data. The SO_2 Modeling TAD however, specifies that 3 years of meteorological data concurrent to the actual emissions data being input into the model be used. Since on-site data are not available for the Independence site, meteorological data available from the National Weather Service (NWS) were used in this analysis.

Three years (2012-2014) of surface observations from the NWS tower at Adams Field Airport in Little Rock, AR (WBAN No. 13963) and concurrent upper air data from North Little Rock Municipal Airport in North Little Rock, AR (WBAN No. 03952) were processed with the most recent version of AERMET (v.15181) the meteorological preprocessor for AERMOD, along with the two pre-processors to AERMET: AERSURFACE (v.13016) and AERMINUTE (v.14337). AERMET was applied to create the two meteorological data files required for input to AERMOD.

AERMET requires specification of site characteristics including surface roughness (z_o), albedo (r), and Bowen ratio (B_o). These parameters were developed according to the guidance provided by EPA in the AERMOD Implementation Guide (AIG) (EPA, 2008a) using AERSURFACE. The area within 1 km of the meteorological tower at Adams Field was broken into 12 sectors of 30 degrees each to analyze the surface characteristics in each 30 degree arc around the tower. AERMET uses the surface characteristics in the sector from which the wind approaches the tower as part of the meteorological data processing for each hour.

In AERSURFACE, the various land cover categories are linked to a set of seasonal surface characteristics. As such, AERSURFACE requires specification of the seasonal category for each month of the year. The following five seasonal categories are offered by AERSURFACE:

1. Midsummer with lush vegetation;
2. Autumn with unharvested cropland;
3. Late autumn after frost and harvest, or winter with no snow;
4. Winter with continuous snow on ground; and
5. Transitional spring with partial green coverage or short annuals.

The AERSURFACE run was performed using the seasonal temporal resolution option. The default seasonal distribution was used: December, January, and February were categorized as winter with no snow, March, April, and May as spring, June, July, and August as summer, and September, October, and November as fall. The precipitation was assumed to be average over the 3-year period.

Additionally, 1-minute ASOS wind data, collected at the Adams Field meteorological tower, were processed using the AERMINUTE pre-processor for AERMET. The data characteristics of Adams Field are shown in Table 3-1. Figure 3-1 shows the relative location of Adams Field and Independence Station, and Figure 3-2 shows the 3-year wind rose for Adams Field.

Table 3-1 Characteristics of the Adams Field – Little Rock Meteorological Data

Distance from Independence Station	80.1 miles
Average Wind Speed	3.42 m/s
Percent Calm Hours	1.10%
Data Completeness	99.95%

All files associated with the meteorological data processing are included in Appendix A: The Electronic Modeling Archive.

3.4 *Receptor Grid*

A comprehensive Cartesian receptor grid extending out to approximately 20 kilometers (km) from Independence was used in the AERMOD modeling analysis to assess maximum ground-level 1-hour SO_2 concentrations. The Modeling TAD states that the receptor grid must be sufficient to determine ambient air quality in the vicinity of the source being studied. The 20-kilometer receptor grid is more than sufficient to resolve the maximum 1-hour SO_2 impacts in the area around Independence, and it clearly illustrates decreasing SO_2 concentration gradients in relation to the plant.

The Cartesian receptor grid consisted of the following receptor spacing:

- 50-meter spacing along the facility fence line;
- 100-meter spacing extending from the fence line to 5 kilometers;
- 500-meter spacing extending from 5 to 10 kilometers; and
- 1,000-meter spacing extending from 10 to 20 kilometers.

The above receptor data was used without modification in the modeling. Per the 1-hour SO_2 Modeling TAD, a number of receptors located over the White River could be excluded from the modeling domain because ambient monitors could not reasonably be placed at these locations, but these receptors were retained in this analysis as a measure of conservatism.

Terrain elevations from National Elevation Data ("NED") from USGS were processed using the most recent version of AERMAP (v.11103) to develop the receptor terrain elevations required by AERMOD. NED data files contain profiles of terrain elevations, which in conjunction with receptor locations are used to generate receptor height scales. The height scale is the terrain elevation in the vicinity of a receptor that has the greatest influence on dispersion at that location and is used for model computations in complex terrain areas. The near-field (within 5 kilometers) and far-field (full grid) receptor grids are shown in Figures 3-3 and 3-4, respectively.

3.5 *Good Engineering Practice Stack Height Analysis*

As described in the SO_2 Modeling TAD, when modeling actual emissions from a facility in order to evaluate the attainment status of an area with regard to the 1-hour SO_2 NAAQS, the full height of all stacks is allowed in the modeling regardless of their GEP Formula Heights. Therefore, no GEP stack height analysis is necessary for this study. Each source was modeled with its actual stack height in the analysis, and downwash effects were considered through the use of EPA's building profile input program (BPIP).

3.6 *Ambient SO_2 Background Data for Cumulative Modeling*

It was assumed, after initial modeling, that impacts from Independence sources would exceed the 1-hour SO_2 Significant Impact Level (SIL) of 7.9 $\mu g/m^3$. As a result, ambient background data from the closest, most representative SO_2 monitor to Independence was downloaded from the ADEQ ambient monitoring website to represent other sources of SO_2 in the area. A review of the data showed that the most representative monitor for use in the modeling is located in Little Rock (Monitor ID# 05-119-0007).

EPA guidance allows simulation of background values that vary by season and hour of day that could simulate a lower value than the 99th percentile. The modeling was performed with a set of seasonal diurnal values developed using the methodology described in the USEPA March 1st, 2011 Clarification Memorandum for 1-hour NO_2 Modeling. Though this memorandum primarily addresses NO_2 modeling, page 20 describes the process for developing seasonal diurnal background values for SO_2 as well.

The location of the selected ambient monitor relative to Independence is shown in Figure 3-1. The seasonal diurnal values used are shown in Table 3-2.

Table 3-2 Seasonal Diurnal SO_2 Concentrations at Little Rock Monitor (μg/m³)

Hour[1]	*Winter*	*Spring*	*Summer*	*Fall*
1	6.89	5.67	4.80	5.50
2	7.85	5.32	4.28	6.19
3	7.33	6.19	4.45	6.02
4	6.89	5.76	4.19	4.71
5	8.55	4.97	4.19	5.15
6	9.60	4.80	5.41	5.85
7	9.60	6.28	5.50	6.63
8	8.99	5.24	6.11	6.54
9	7.50	6.46	7.68	7.85
10	8.38	8.20	7.42	9.07
11	9.16	8.46	9.95	8.20
12	10.73	15.09	10.38	9.34
13	9.69	11.08	10.91	11.17
14	10.56	9.34	9.86	9.51
15	10.03	8.20	13.18	9.95
16	9.42	7.94	9.34	10.47
17	7.15	9.86	11.08	9.16
18	7.50	7.42	9.69	7.24
19	9.25	6.37	9.86	6.98
20	12.30	6.54	8.73	5.93
21	9.07	6.02	6.19	6.28
22	6.11	8.99	5.76	5.67
23	6.46	7.07	5.67	5.85
24	7.24	6.81	5.41	6.11

1. Hours in AERMOD are defined as hour-ending. i.e., Hour 1 is the period from midnight through 1 AM, etc.

Figure 3-1 Relative Location of Facility, Airport, and Ambient Monitor

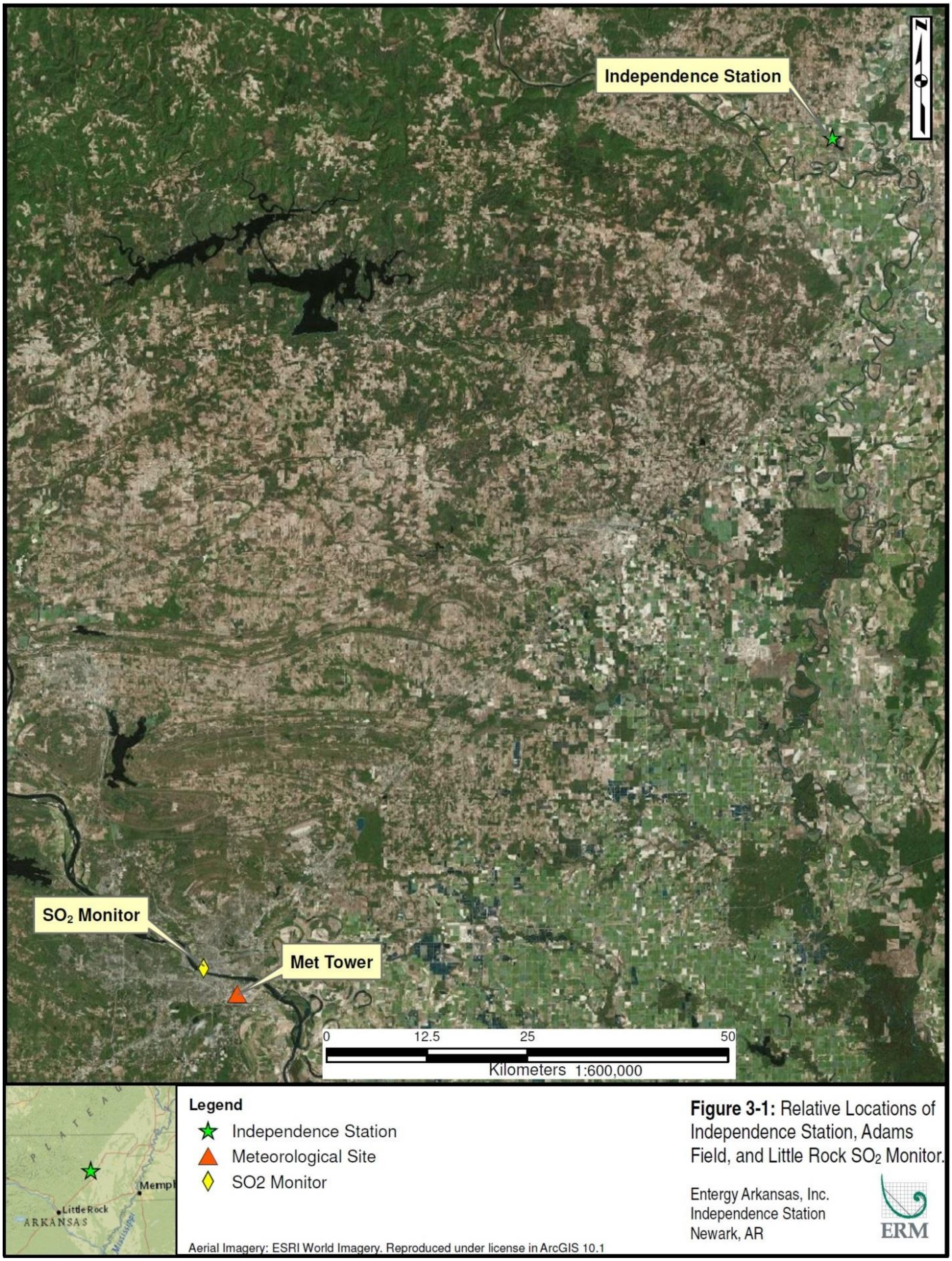


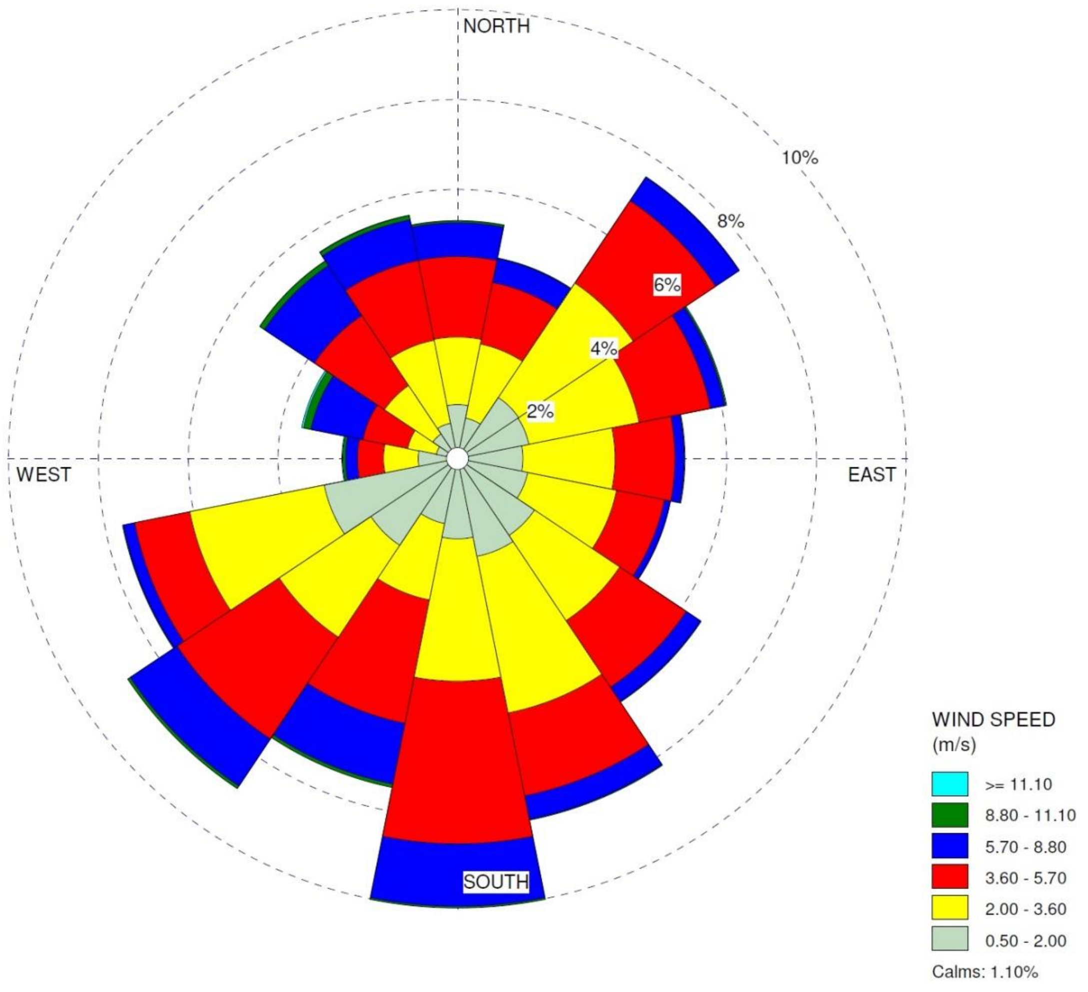
Figure 3-2 Three-year Wind Rose (2012-2014): Little Rock – Adams Field

WIND ROSE PLOT:

3-Year Wind Rose: Little Rock / Adams Field
2012-2014

DISPLAY:

Wind Speed
Direction (blowing from)



COMMENTS:	DATA PERIOD: **Start Date: 1/1/2012 - 00:00** **End Date: 12/31/2014 - 23:00**	COMPANY NAME: **ERM**	
		MODELER: **R. Hamel**	ERM
	CALM WINDS: **1.10%**	TOTAL COUNT: **26290 hrs.**	
	AVG. WIND SPEED: **3.42 m/s**	DATE: **8/3/2015**	PROJECT NO.:

WRPLOT View - Lakes Environmental Software

Figure 3-3 Near-Field Model Receptors

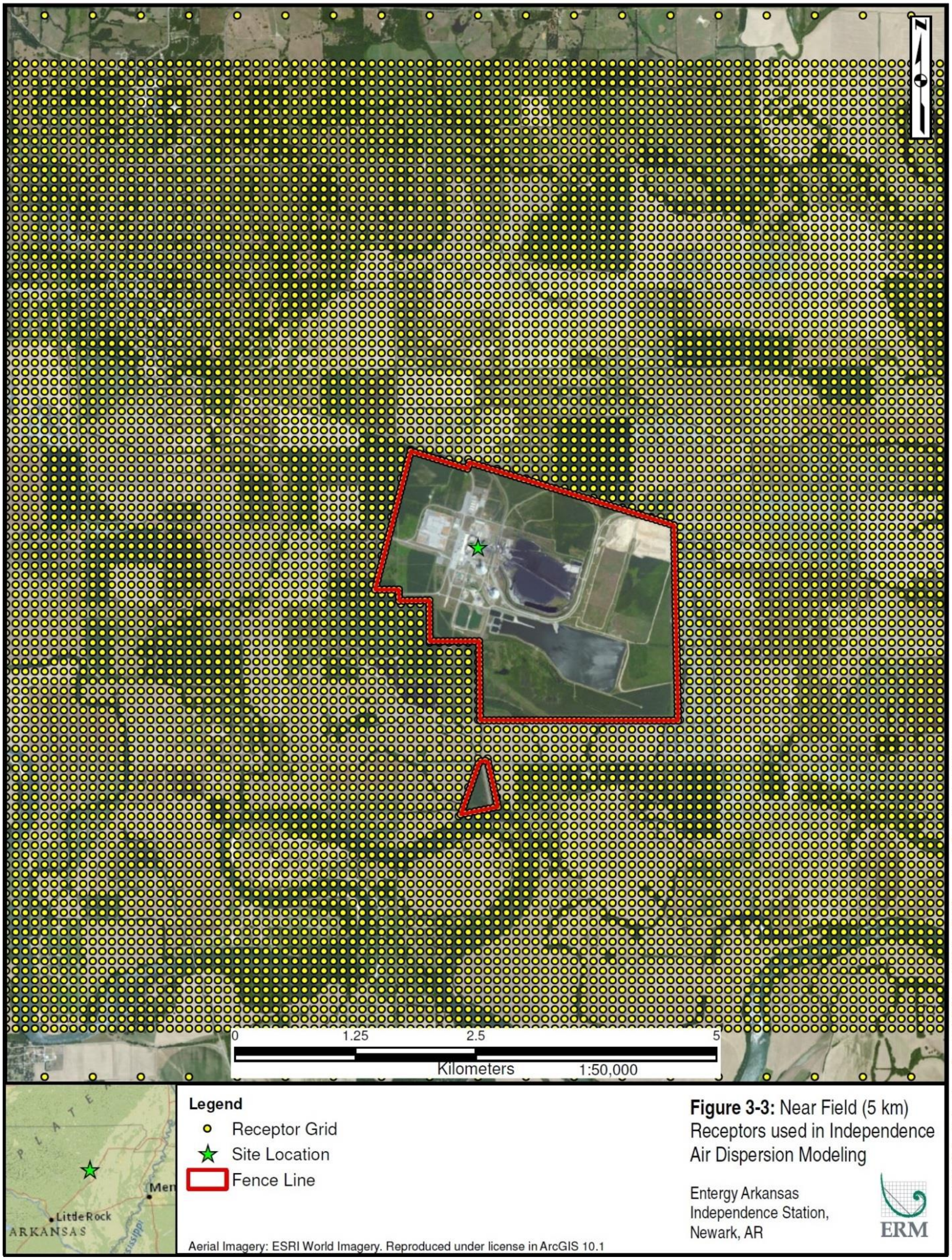
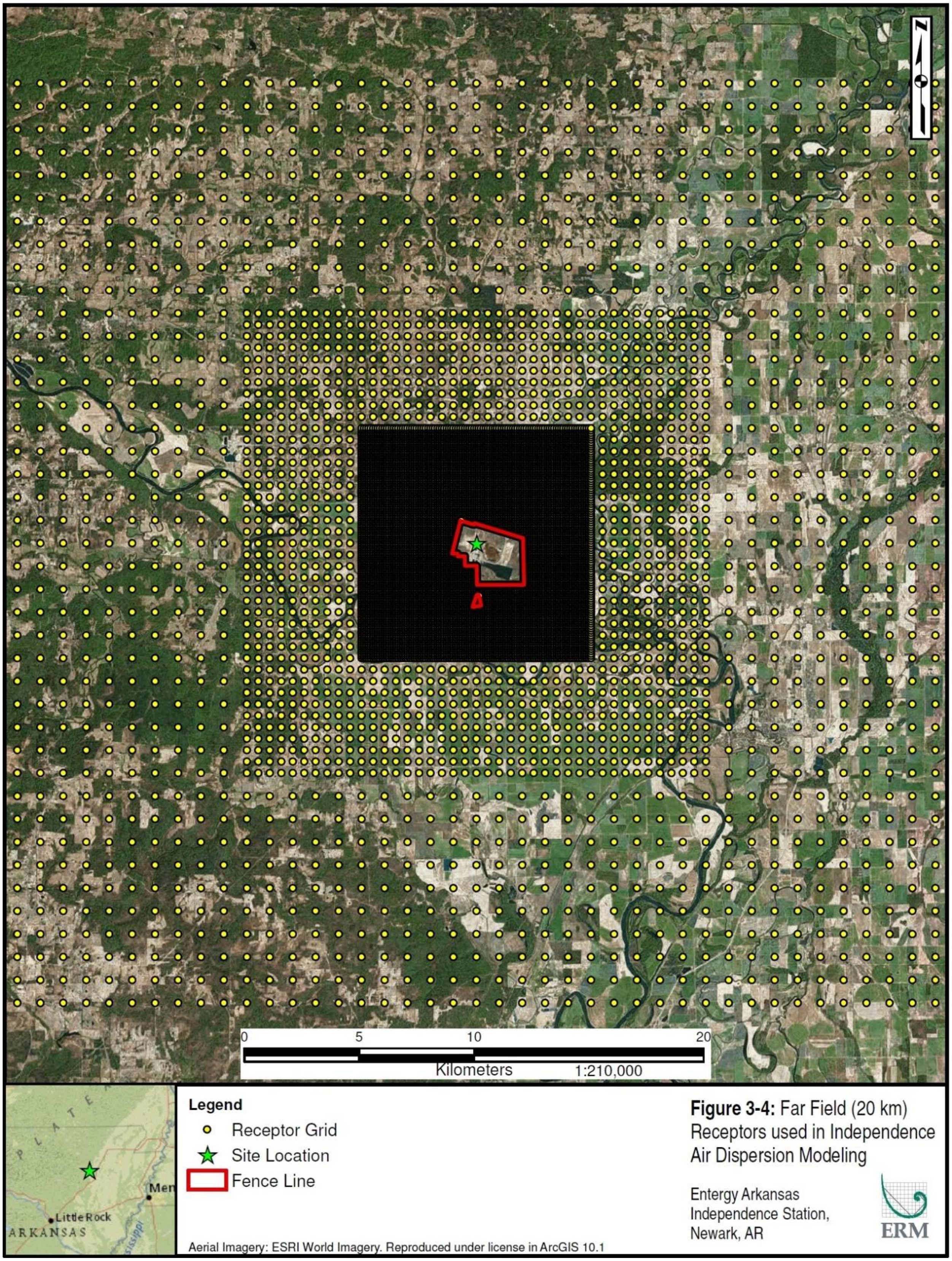


Figure 3-4 Far-Field Model Receptors



4.0 *MODELING RESULTS*

The modeling results are shown in Table 4-1 below. The modeled design value represents the modeled 3-year average of the 99th percentile, maximum daily 1-hour average impact for Independence, which is then added to the ambient background concentration and the total impact compared to the NAAQS to demonstrate attainment.

Contours of the predicted impacts, as well as the location of the maximum predicted impact of 131.3 $\mu g/m^3$, are shown in Figure 4-1. The table shows that model predicted impacts from Independence, when modeled using the most recent three years of actual emissions data and added to a representative ambient background concentration, are below the level of the 1-hour SO_2 NAAQS.

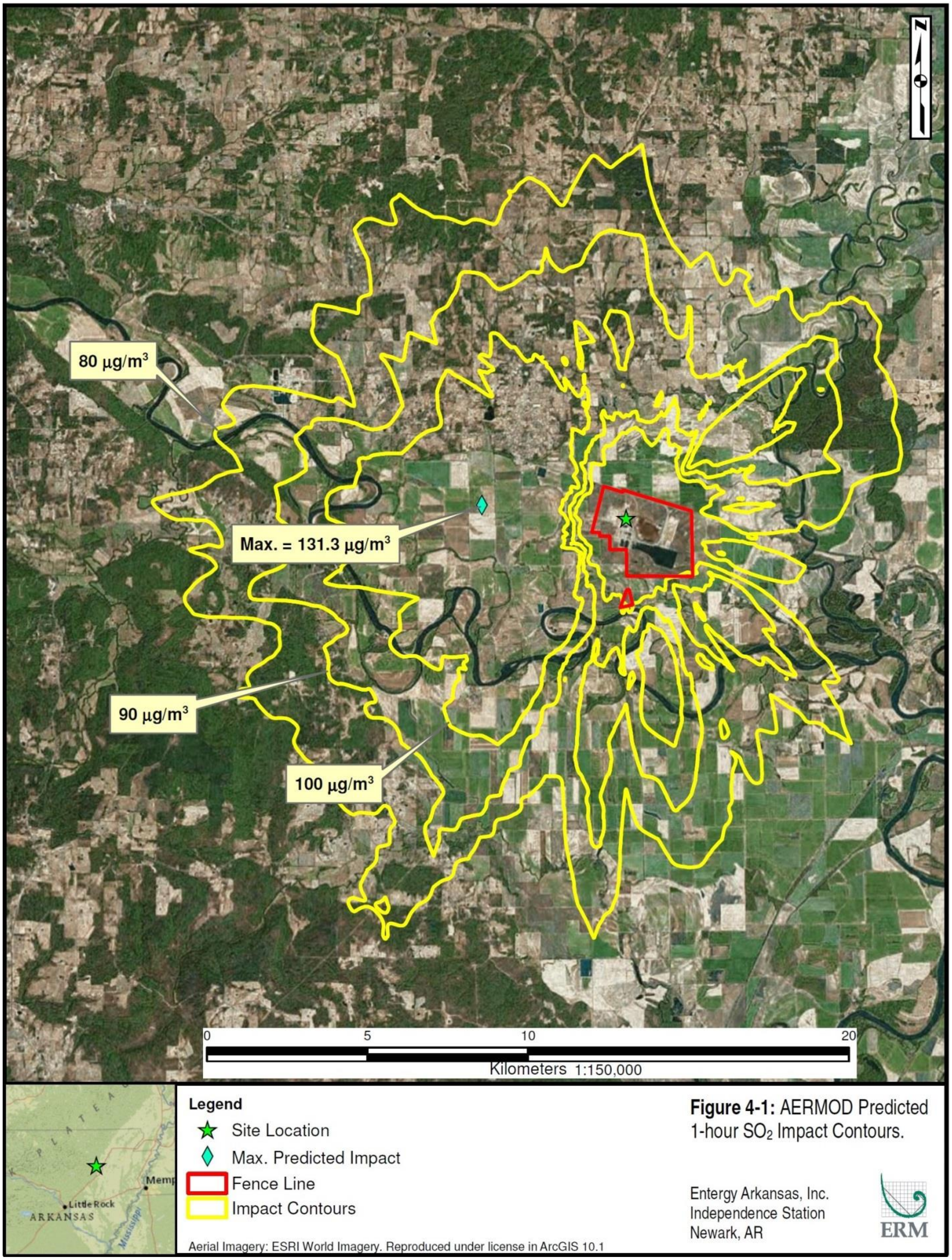
Table 4-1 1-hour SO_2 Modeling Results for Independence Station

Source	*Independence Only*	*Independence and Background*	*1-hr. SO_2 NAAQS*	*Below NAAQS?*
Independence Station	122.2	131.3	196.5	Yes

4.1 *Conclusions*

The air dispersion modeling performed as described in this report shows that the SO_2 emissions from **Independence Station result in maximum predicted impacts below the 1-hour SO_2 National Ambient Air Quality Standard.** Therefore, an attainment designation for Independence County is recommended.

Figure 4-1 Independence Station 1-hour SO_2 Impact Contours



5.0 *REFERENCES*

U.S. Environmental Protection Agency. (USEPA 2005) Guideline on Air Quality Models (GAQM, 40CFR Appendix W), November, 2005

U.S. Environmental Protection Agency. (USEPA 2009) AERMOD Implementation Guide, AERMOD Implementation Workgroup. March 19, 2009.

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

U.S. Environmental Protection Agency. (USEPA 2014) "SO_2 NAAQS Designations Modeling Technical Assistance Document (Draft)," December 2013;

U.S. Environmental Protection Agency. (USEPA 2014) "SO_2 NAAQS Designations Monitoring Technical Assistance Document (Draft)," December 2013;

U.S. Environmental Protection Agency. (USEPA 2014) "Data Requirements Rule for the 2010 1-Hour Sulfur Dioxide (SO_2) Primary National Ambient Air Quality Standard (NAAQS)," Final rule submitted August 10, 2015; and

U.S. Environmental Protection Agency. (USEPA 2014) "Guidance for 1-hour SO_2 Nonattainment Area SIP Submissions," April 23, 2014.

Appendix A

Electronic Modeling Archive