Ambient Air Quality Modeling Protocol and Impact Analysis

Dewey-Burdock Project

Powertech (USA) Inc.

Edgemont, South Dakota

February 25, 2013

Prepared by:

IML Air Science

a division of Inter-Mountain Laboratories, Inc.

555 Absaraka

Sheridan, Wyoming 82801

(307) 674-7506

www.imlairscience.com

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

1 INTRODUCTION

Powertech (USA) Inc. (Powertech) has proposed to construct an in-situ recovery (ISR) uranium facility at the Dewey-Burdock site in southwestern South Dakota. An assessment of the air quality impacts of the proposed facility is required as part of the NRC license application and Supplemental Environmental Impact Study (SEIS). Powertech enlisted IML Air Science to develop a project emissions inventory and to model the impacts of these emissions on ambient air quality. IML was also asked to assess potential project impacts on Air Quality Related Values (AQRV's) at the nearby Wind Cave National Park, a Class I area.

The air quality modeling protocol is presented in Sections 2 through 5. It addresses the approach for assessing the ambient air quality impacts from the proposed source emissions for comparison with the National Ambient Air Quality Standards (NAAQS) for PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_2. It also addresses the approach for determining project impacts on the allowable Prevention of Significant Deterioration (PSD) increments for PM_{10}, $PM_{2.5}$, SO_2 and NO_2. Finally, the protocol establishes the methods and assumptions used to model impacts on AQRV's, including visibility and deposition impacts, at Wind Cave National Park.

The modeling results and analysis are presented in Sections 6 and 7. Section 6 contains the ambient air quality impact analysis and Section 7 contains the AQRV analysis. Details concerning potential project emissions, modeling parameter settings, and model outputs appear in Appendix A through Appendix E to this document.

1.1. Project Overview

The proposed Dewey-Burdock Project is a uranium in-situ recovery (ISR) facility in Custer and Fall River counties, South Dakota. The facility is composed of well fields, a central processing plant, and a satellite processing plant. The project will entail four phases: construction, operation, aquifer restoration and decommissioning. Fugitive emission sources of particulate matter (PM_{10}, $PM_{2.5}$) include construction and drilling activities, wind erosion, product transport, pickup traffic, delivery trucks, and passenger vehicles. Particulates (PM_{10}, $PM_{2.5}$), carbon monoxide (CO), and oxides of nitrogen and sulfur (NO_x and SO_2) will be emitted by mobile equipment engine exhaust and by stationary sources such as heaters, pumps, emergency generators and thermal dryers.

1.2. Document Overview

This document addresses two separate modeling scenarios: (1) modeling for ambient air quality impacts at the project boundary, at locations within 50 km of the project, and at Wind Cave National Park (a Class I area), and (2) modeling for AQRV impacts, including visibility and atmospheric deposition impacts, at Wind Cave National Park. Since these two scenarios utilize different modeling assumptions, domains, software models, and meteorological data sets, they are addressed separately.

Ambient air quality impact analysis will be performed using the AERMOD dispersion model. Sections 3 and 4 of this document apply to the AERMOD modeling protocol. AQRV impact analysis will be performed using the CALPUFF model. Section 5 applies to the CALMET/CALPUFF modeling protocol. Section 2 discusses project related emissions and modeled emission sources, which apply equally to AERMOD and CALPUFF.

1.3. Pollutants of Concern

Both combustion emissions and fugitive dust emissions will be modeled in the air quality and AQRV impact analyses. The stationary and fugitive emission sources at the Dewey-Burdock Project will produce particulate matter smaller than ten microns in size (PM_{10}) and particulate matter smaller than 2.5 microns in size ($PM_{2.5}$). Stationary and mobile sources will emit PM_{10}, $PM_{2.5}$, carbon monoxide (CO), sulfur dioxide (SO_2) and oxides of nitrogen (NO_x). It is assumed that 75% of NO_x emissions will be converted to NO_2. Thus, five criteria pollutants (PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_2) will be analyzed for compliance with the NAAQS. Four of these pollutants, PM_{10}, $PM_{2.5}$, SO_2 and NO_2 will be further analyzed for compliance with the maximum allowable PSD increments in Class I and Class II areas.

Both the NAAQS and the PSD analyses will be conducted using the AERMOD software. The modeling domain for AERMOD will extend roughly 50 km in all directions from the Dewey-Burdock Project. Modeled impacts within this domain will be compared to the NAAQS and Class II PSD increments. Since Wind Cave National Park is roughly 50 km from the project site, the Wind Cave park boundary will be included in the air quality impact analysis. Modeled impacts at Wind Cave will be compared to the NAAQS and PSD Class I increments.

These same pollutants have the potential to impact visibility at Wind Cave National Park. Moreover, SO_2 and NO_2 emissions may affect atmospheric deposition. For these reasons an AQRV analysis will be conducted using the CALMET/CALPUFF software. The modeling domain for CALPUFF will extend 100 km in all directions from the Dewey-Burdock Project to provide a 50-km buffer for the Wind Cave Class I area AQRV impact analysis.

1.4. Regulatory Status

The Dewey-Burdock Project will be a non-categorical stationary source. Criteria pollutant emissions from the facility will be below the New Source Review major source threshold of 250 tons/year. Therefore, the facility will not be subject to PSD permitting regulations. The potential to emit hazardous air pollutants (HAPs) will be less than 10 tons/year for any individual HAP, and less than 25 tons/year for all HAPs combined. Therefore, the facility will not be a major HAP source. Point source emissions of criteria pollutants from the facility will be less than the Title V source threshold of 100 tons per year.

1.5. Results Summary

The final modeling results showed compliance with all NAAQS levels, with the following exceptions: (1) Three model receptors along the Dewey-Burdock Project boundary exceeded the NO_2 1-hr standard, (2) three model receptors very near the project boundary and the public road exceeded the PM_{10} 24-hr standard, and (3) six model receptors on the project boundary or very near the public road exceeded the $PM_{2.5}$ 24-hr standard. Since Dewey-Burdock is the first ISR project for which such extensive modeling has been required, there is no basis for direct comparison of the modeling results obtained through this study. It is well documented, however, that modeling fugitive dust for short-term ambient PM_{10} and $PM_{2.5}$ impacts is unreliable. A case is made that the predominant model, which was used for this analysis, tends to over-predict such impacts by a substantial margin.

With the exception of these short-term particulate concentrations, the final modeling results showed compliance with all PSD Class I and Class II increments. They also demonstrated no significant impact on AQRV's at Wind Cave National Park.

2 EMISSION AND SOURCE DATA

2.1. Facility Processes and Emission Controls Affected

The nature of the proposed facility is to extract uranium oxide in solution from uranium bearing formations using in-situ recovery. The solution is processed at on-site facilities to recover yellow cake for transport to an off-site refining facility. Facility processes and emission controls planned for the Dewey-Burdock Project include the use of a dust suppressant to control fugitive dust emissions from unpaved roads, a vacuum dryer to eliminate yellow cake dust generation, and standard diesel engine controls to minimize tailpipe emissions.

2.2. Emission Factors Used to Calculate Potential Emissions

The Dewey-Burdock Project will generate both on-site and off-site emissions. On-site emissions will include stationary source, fugitive dust and tailpipe emissions occurring within the project boundary. Off-site emissions related to the project will be associated with vehicle traffic accessing the project by an unpaved county road. The off-site emissions inventory will include fugitive dust from the road and combustion emissions from vehicle tailpipes. Both on-site and off-site sources will be modeled for ambient air quality and AQRV impacts.

In general, fugitive dust emissions from the Dewey-Burdock Project will include traffic on unpaved roads, drilling and earth moving activities, road maintenance, topsoil stripping and reclamation, and wind erosion on disturbed areas. Emission factors for these sources are provided in EPA's AP-42, Compilation of Air Pollutant Emission Factors as listed below (EPA 1995):

- Unpaved roads — Chapter 13, Section 13.2.2
- Drilling and earth moving — Chapter 11, Section 11.9, Table 11.9-4
- Topsoil stripping and reclamation — Chapter 11, Section 11.9, Table 11.9-4
- Wind erosion — Chapter 11, Section 11.9, Table 11.9-4

In some cases fugitive $PM_{2.5}$ emission factors were not available in AP-42. For wind erosion, a $PM_{2.5}$/ PM_{10} ratio of 15% was applied to the respective PM_{10} emission factor. For unpaved road dust, a $PM_{2.5}$/ PM_{10} ratio of 10% was applied to the respective PM_{10}

emission factor. These ratios follow recommendations in a study performed for the Western Regional Air Partnership (WRAP) by Midwest Research Institute (MRI 2006).

Gasoline and diesel equipment tailpipe emissions were calculated using emission factors from several sources. THC, SO_2, CO_2 and aldehyde emission factors were taken from AP-42 Chapter 3, Table 3.3-1. NO_x, CO, and PM_{10} emission factors for diesel engines are based on EPA standards for various engine tier ratings (EPA 1998). Drill rigs were assumed to have Tier 1 engines, while all other mobile diesel equipment was assumed to conform to Tier 3 standards. The THC emission factor for Tier 1 diesel engines was used for drill rigs, in place of AP-42. $PM_{2.5}$ emissions from equipment tailpipes were assumed to be 97% of PM_{10} emissions (EPA 2004). Emission factors for propane fired heaters and emergency generators were obtained from AP-42, Table 1.5-1 (EPA 1995). Emission factors for diesel pumps were taken from AP-42, Table 3.3-1 (EPA 1995).

2.3. Schedule of Fugitive Particulate Emissions

The potential fugitive emission rates from the Dewey-Burdock Project are summarized in Table 2-1. Detailed emission calculations for the proposed project have been provided in Appendix A. The basis for timing and the source apportionment of equipment-generated fugitive emissions are presented in Appendix B. Year 7 will be modeled since it shows the highest total for fugitive dust emissions. Both on-site and off-site, project related fugitive dust emissions will be modeled for NAAQS, PSD and AQRV impacts.

Table 2-1: Potential Fugitive Emissions by Year (tons/year)

SCHEDULE		ON-SITE FUGITIVE EMISSIONS (INCLUDING WIND EROSION)		OFF-SITE FUGITIVE EMISSIONS	
Year	Phases	PM_{10}	$PM_{2.5}$	PM_{10}	$PM_{2.5}$
1	CF	346.12	36.17	98.88	9.89
2	CW, O	445.79	46.13	121.24	12.12
3	CW, O	446.19	46.19	121.24	12.12
4	CW, O, R	459.40	47.53	132.27	13.23
5	CW, O, R	459.80	47.59	132.27	13.23
6	CW, O, R	460.14	47.64	132.27	13.23
7	CW, O, R, D	555.60	57.20	181.31	18.13
8	CW, O, R, D	553.80	56.93	181.31	18.13
9	O, R, D	304.46	31.96	133.54	13.35
10	R, D	138.11	15.32	60.07	6.01
11	D	125.23	14.03	49.04	4.90
12	D	125.15	14.02	49.04	4.90
13	D	125.12	14.01	49.04	4.90
14	D	125.11	14.01	49.04	4.90

CF = Construction of Facilities
CW = Construction of Wellfields
O = Operation
R = Restoration
D = Decommissioning and Reclamation

2.4. Schedule of Tailpipe Emissions

Table 2-2 summarizes potential combustion emissions from equipment tailpipes. As with fugitive emissions, the highest annual tailpipe emissions of PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_x are projected for year 7. Detailed emission calculations for the proposed project have been provided in Appendix A. The basis for timing of tailpipe emissions is presented in Appendix B. Year 7 will be modeled since it shows the highest total emissions. Both on-site and off-site, project related tailpipe emissions are represented in Table 2-2 and will be modeled for NAAQS, PSD and AQRV impacts.

Table 2-2: Potential Tailpipe Emissions by Year

Mobile Engine Combustion Emissions (tons/year)					
	NO_x	PM_{10}	$PM_{2.5}$	SO_2	CO
Year 1	70.72	4.13	4.00	11.25	73.39
Year 2	76.49	4.44	4.31	11.97	77.87
Year 3	76.49	4.44	4.31	11.97	77.87
Year 4	77.72	4.52	4.39	12.04	78.64
Year 5	77.72	4.52	4.39	12.04	78.64
Year 6	77.72	4.52	4.39	12.04	78.64
Year 7	90.13	5.14	4.99	14.25	85.75
Year 8	90.13	5.14	4.99	14.25	85.75
Year 9	27.54	1.51	1.47	4.26	17.20
Year 10	13.64	0.70	0.68	2.27	7.89
Year 11	12.41	0.62	0.60	2.21	7.11
Year 12	12.41	0.62	0.60	2.21	7.11
Year 13	12.41	0.62	0.60	2.21	7.11
Year 14	12.41	0.62	0.60	2.21	7.11

For modeling purposes, NO_x emissions will be multiplied by 0.75 to estimate NO_2 emissions. NO_2 is the regulated pollutant, with associated NAAQS and PSD increments, per Section 6.2.3 of EPA's Guideline on Air Quality Models (40 CFR 51 Appendix W).

2.5. Stationary Equipment Emissions

Table 2-3 summarizes stationary equipment emissions. With the exception of startup construction, these emissions are assumed to be constant from year to year.

Table 2-3: Potential Stationary Equipment Emissions per Year

Stationary Equipment Emissions (tons/yr)					
Pollutant	**Space Heater**	**Dryer Thermal Fluid Heater**	**Emergency Generator**	**Pump**	**Total**
NO_x	0.74	0.91	0.00	0.04	1.69
PM10/PM2.5	0.040	0.049	0.000	0.003	0.092
SO_2	0.001	0.001	0.000	0.003	0.005
CO	0.43	0.52	0.00	0.01	0.96

2.6. Source Parameters

The modeled emission sources in AERMOD will include area sources, line sources and point sources. The line sources include the haul road, access roads and public road. Area sources include disturbed acreage, well fields, reclamation areas, and plant facilities. Release heights for area and line sources of fugitive dust are assumed to be zero, while release heights for area and line sources of equipment tailpipe emissions are assumed to be 1 meter. For CALPUFF modeling, the area and line sources will be identical to those used for AERMOD.

Appendix B details the apportionment of equipment and fugitive emissions among these sources. Based on this apportionment process, Table 2-4 summarizes area and line source emissions (tons/year) for the modeled year.

Table 2-4: Year 7 Area and Line Source Emission Totals (includes on-site and off-site fugitive dust and tailpipe emissions)

Area/Line Source Totals	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO
Disturbed	257.78	27.81	16.62	2.15	11.67
AccessRdSat	17.44	1.78	0.72	0.21	0.61
AccessRdCPP	34.99	3.56	1.45	0.43	1.24
NewWells	115.04	14.10	51.85	8.11	61.71
FacilitiesCPP	9.00	1.18	4.62	0.36	1.27
FacilitiesSat	4.50	0.59	2.24	0.17	0.55
HaulRd	10.10	1.04	0.59	0.18	0.51
OperWells	32.30	3.32	1.96	0.61	1.70
DecomWells	69.50	7.18	7.30	1.59	4.49
LandAPDewey	5.35	0.80			
LandAPBurdock	4.57	0.68			
AccessRdPublic	181.48	18.29	2.78	0.42	2.00
Year 7 Totals (tpy)	**742.05**	**80.32**	**90.13**	**14.25**	**85.75**

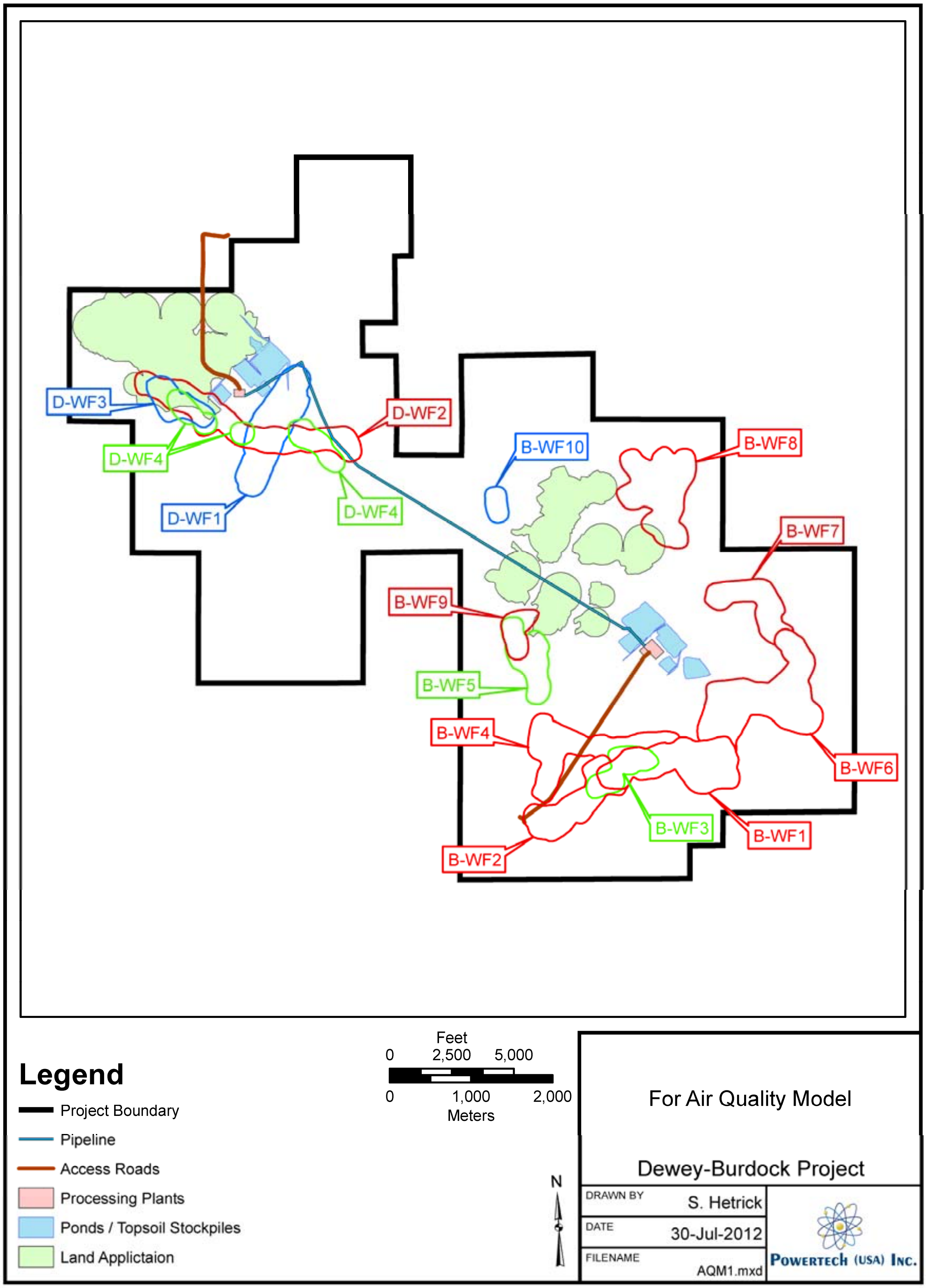
Table 2-5 summarizes point source emission rates (tons/year) and associated stack parameters for the modeled year. All modeled point sources have a vertical discharge. The modeled CPP heater source includes multiple space heaters located within the main facility.

Table 2-5: Point Source Emission Totals and Stack Parameters

	Emissions (tons/year)					**Stack**	**Temp**	**Velocity**
Point Source Totals	PM_{10}	$PM_{2.5}$	NO_x	SO_2	CO	Diam (in)	(Deg F)	(ft/sec)
CPP_Point_Dryer	0.049	0.049	0.909	0.001	0.524	9.0	200	17.4
CPP_Point_Heater	0.020	0.020	0.369	0.000	0.213	5.0	160	5.4
CPP_Point_Pump	0.001	0.001	0.020	0.001	0.004	4.0	240	27.2
Sat_Point_Heater	0.020	0.020	0.369	0.000	0.213	5.0	160	5.4
Sat_Point_Pump	0.001	0.001	0.020	0.001	0.004	4.0	240	27.2
Year 7 totals (tpy)	**0.092**	**0.092**	**1.687**	**0.005**	**0.959**			

Figure 2-1 shows the locations and orientations of modeled area and line sources for the Dewey-Burdock Project. Area sources will be digitized as rectangles and polygons to reduce model complexity and execution time. Modeled point sources reside at the processing plants, which include a satellite plant in the northwestern portion of the project area, and the central processing plant in the southeastern portion of the project area. Roads will be modeled as area/line sources. Not shown in Figure 2-1 is the unpaved section of county road providing access to the project site. Fugitive dust and tailpipe emissions from this road will also be modeled.

Figure 2-1: Dewey-Burdock Project Emission Source Locations



Source emission rates will be assumed to be uniform during the time each source is active, but variable throughout the modeled year based on equipment duty cycles (see Appendix B). For point sources, average emission rates in tons/year will be converted to lbs/hour for the hours each source is operated. For area and line sources, average emission rates of tons/year will be converted to lbs/hour/ft^2 for the hours each source is active and the area over which the source emissions are distributed. Line sources in AERMOD and CALPUFF are actually rectangular areas chained together in a prescribed line.

3 AMBIENT AIR QUALITY IMPACT MODELING METHODOLOGY

3.1. Model Selection and Justification

The proposed facility includes multiple sources, including point, line and area sources that have a wide range of parameters that are too complex to merge into a single emission point. Therefore, criteria pollutant emissions will be modeled with the American Meteorological Society (AMS) and EPA Regulatory model (AERMOD) Version 07026 to evaluate air dispersion from multiple sources. AERMOD was chosen over the Industrial Source Complex (ISC3) model since it has been promulgated by the EPA as the preferred air dispersion model in the Agency's "Guideline on Air Quality Models" (40 CFR 51 Appendix W). AERMOD officially replaced the ISC3 air dispersion model effective December 9, 2006 (one year after rule promulgation) as published in the Federal Register on November 9, 2005. The Lakes Environmental software will be used to implement the AERMOD model (Lakes Version 8.1.0).

3.2. Model Options

The AERMOD regulatory settings will be left in the default settings, except that for modeling short-term PM_{10} and $PM_{2.5}$ impacts, the dry depletion option will be evaluated and compared to the default setting (no dry depletion).

3.3. Averaging Periods

For the purpose of this modeling analysis, the annual and 24-hour averaging periods will be utilized for PM_{10} and $PM_{2.5}$ modeling. The 8-hour and 1-hour averaging periods will be used for CO modeling. The annual and 1-hour averaging periods will be used for NO_2 while the annual, 24-hour, 3-hour and 1-hour averaging periods will be used for SO_2 modeling. These averaging periods are consistent with the NAAQS primary and secondary standards and the PSD increment standards.

3.4. Building Downwash

Based on the proposed facility design, buildings and/or structures will cause negligible influences on normal atmospheric flow in the immediate vicinity of the emission sources. Therefore building downwash will not be modeled.

3.5. Elevation Data

The terrain surrounding the Dewey-Burdock Project is relatively flat. However, the terrain encompassing model receptors includes hills and valleys. Therefore, the Elevated Terrain mode will be used. Receptor elevations will be entered based on elevations obtained from USGS digital elevation model (DEM) files.

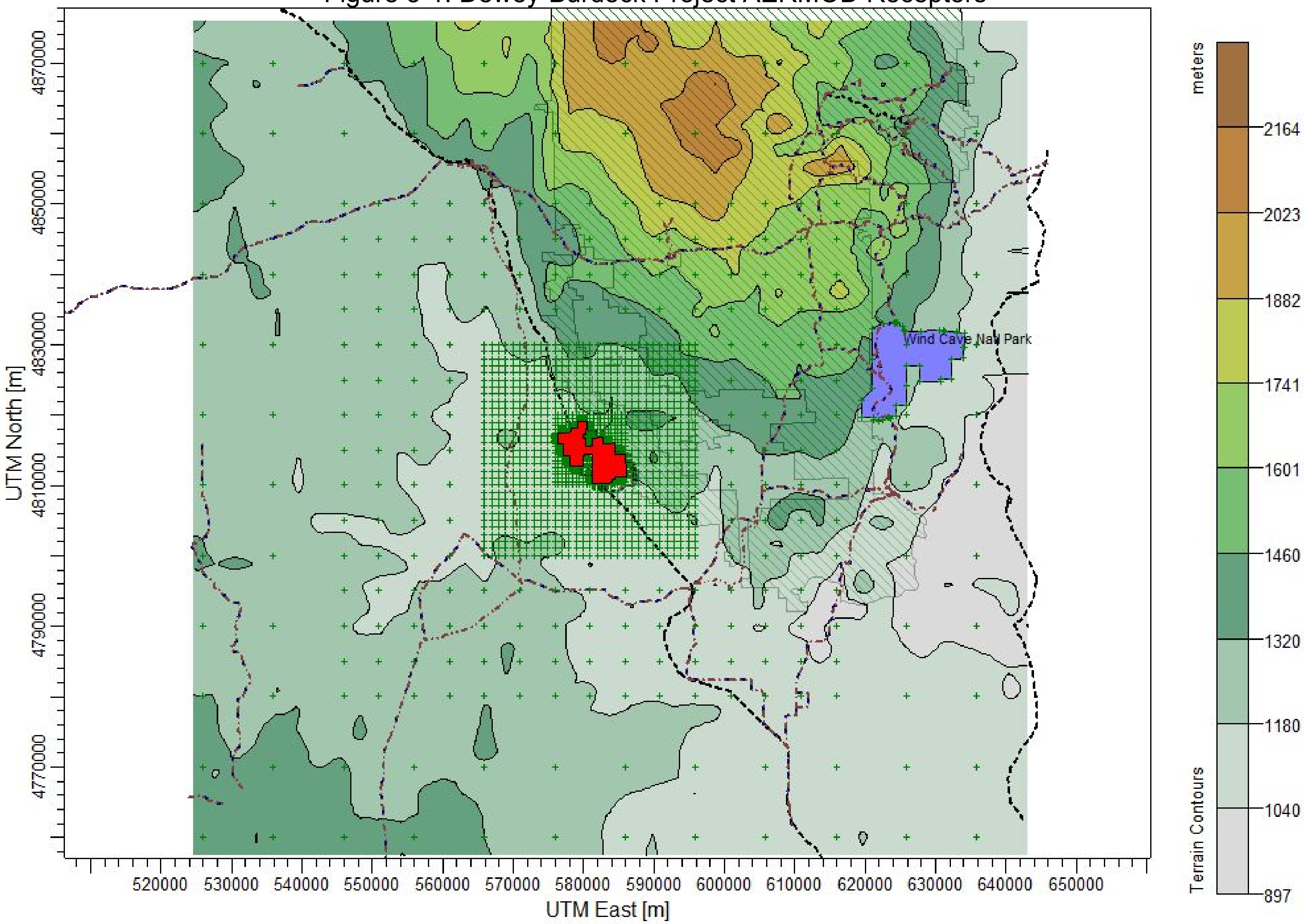
3.6. Receptor Network

Figure 3-1 displays the AERMOD receptor placement (designated as green crosses on the map). The receptor grid extends in all directions from the project site to fully encompass the nearest Class I area, Wind Cave National Park, roughly 50 km from the project site. The following grid resolutions are proposed to sufficiently demonstrate that areas of maximum impact of the source remain below the applicable standards:

3.6.1. Fenceline Receptors

Fenceline receptors will be placed along the project boundary at least every 250 meters in linear fenceline distance, with a receptor placed at each boundary corner. In addition, 44 receptors will be placed at roughly uniform spacing around the Wind Cave National Park boundary, approximately 50 kilometers from the project site. Areas inside the project boundary will not be analyzed.

Figure 3-1: Dewey-Burdock Project AERMOD Receptors



3.6.2. Fine Grid

A fine grid of receptors will be placed at 500-meter spacing, from the project fenceline outward to 5 kilometers (km) in all directions.

3.6.3. Intermediate Grid

An intermediate grid will be placed at 1-km spacing, from the outer edge of the fine grid outward to 10 km in all directions.

3.6.4. Coarse Grid

A coarse grid will be placed at 5-km spacing, from the outer edge of the intermediate grid outward to 20 km in all directions. A grid will also be placed at 10-km spacing, from the outer edge of the 5-km grid to an additional 20 km in all directions.

3.7. Meteorological Data

The baseline meteorological data collected from the Dewey-Burdock site represents only one year (July 2007 to July 2008). EPA recommends that AERMOD be run with a minimum of three years of meteorological data. Therefore the model will use three years of hourly data from the meteorological station at Newcastle, Wyoming (2009 through 2011). Hourly data from a nearby station are needed for AERMOD in order to simulate wind speeds and directions synchronous with hourly emissions data. Newcastle is approximately 30 miles north-northwest of the Dewey-Burdock Project site and provides a better comparison to the Dewey-Burdock project area than the nearest National Weather Service (NWS) station (Chadron, NE) in terms of elevation, surrounding topography and proximity to the southwestern flank of the Black Hills. The station meets EPA's Meteorological Monitoring Guidance for Regulatory Modeling Applications (EPA, 2000). The Newcastle station has been accepted by NRC in conjunction with the Dewey-Burdock Project, as suitable for conducting the regional weather analysis.

No upper air data are available at the Dewey-Burdock or Newcastle sites. The upper air data will be obtained from the nearest available (and only reasonable) source, the Rapid City, South Dakota National Weather Service upper air site. This data set will be processed using the AERMET program. The surface characteristics (albedo, bowen ratio and roughness) representative of the land type surrounding the meteorological station location are required by the AERMET data processing procedures.

AERSURFACE will be used to estimate the surface characteristics at the site based on land use/type files generated by the USGS. The AERMET program will combine the on-site meteorological data with the upper air data to create the AERMOD meteorological data files.

3.8. Background Concentrations

For this ambient air quality impact analysis, only the project impacts will be modeled. Background concentrations and regional source emissions for each pollutant will not be included in the AERMOD analysis. Note that for the AQRV impact analysis, certain background constituents will be incorporated into the model (see Section 5 below) and the modeled results will be compared to background conditions.

4 APPLICABLE REGULATORY LIMITS FOR CITERIA POLLUTANTS

4.1. Methodology for Evaluation of Compliance with Standards

The modeled concentration of the five criteria pollutants will be compared to the National Ambient Air Quality Standards to demonstrate that the facility impacts will not cause or contribute to an exceedance of the NAAQS. PM_{10}, $PM_{2.5}$, SO_2, and NO_2 concentrations will also be compared to the allowable Prevention of Significant Deterioration increments for Class I and Class II airsheds.

4.2. NAAQS and PSD Standards

The applicable standards and associated averaging intervals to be used in the modeling analysis are summarized in Table 4-1. Primary standards provide public health protection. Secondary standards provide public welfare protection, including protection against decreased visibility and damage to animals, crops, vegetation, and buildings. Prevention of Significant Deterioration (PSD) increments protect air quality in Class I and Class II areas from significant deterioration.

Table 4-1: National Ambient Air Quality Standards (μg/m^3)

Criteria Pollutant	Averaging Time	Primary NAAQS	Secondary NAAQS	PSD Class I Increments	PSD Class II Increments
Nitrogen Dioxide	Annual	100	100	2.5	25
	1-hour	187	---	---	---
PM_{10}	24-hour	150	150	8	30
	Annual	---	---	4	17
$PM_{2.5}$	24-hour	35	35	2	9
	Annual	12	12	1	4
SO_2	1-hour	200	---	---	---
	3-hour	---	1,300	25	512
	24-hour	---	---	5	91
	Annual	---	---	2	20
CO	1-hour	40,000	---	---	---
	8-hour	10,000	---	---	---

The purpose of PSD increments is to protect public health and welfare, and to preserve, protect, and enhance the air quality in national parks, national wilderness areas, national monuments, national seashores, and other areas of special national or regional natural, recreational, scenic, or historic value. The goal of this program is to prevent significant deterioration of air quality in areas that meet the NAAQS. Areas in the U.S. have been classified in two categories for the purpose of this program. Class I areas include national wilderness areas, parks and memorial parks of a certain size, and international parks. In these areas, which include Wind Cave National Park, the maximum allowable increase of any criteria pollutant is significantly lower than in Class II areas, which includes most of the country.

4.3. Presentation of Modeling Results

The purpose of the dispersion modeling outlined in this protocol is to demonstrate that emissions from the Dewey-Burdock Project will not cause exceedances of the applicable NAAQS and PSD standards, either in the Class II area surrounding the project site or at the nearby Class I area, Wind Cave National Park. The final impact analysis will include all the information necessary for this demonstration including: (a) levels of maximum impacts for each pollutant and averaging period, and corresponding locations; (b) an emission source location map; (c) a complete list of source parameters; (d) complete modeling input and output files; and (e) graphic presentations of the modeling results for each pollutant, showing concentration isopleths attributable to project impacts.

4.4. Summary

The AERMOD model with on-site meteorological data and maximum potential emissions will be used to assess the ambient air quality impact of the criteria pollutants associated with the Dewey-Burdock Project. The model will be run with regulatory default options. Emissions of PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_x associated with the proposed emission sources will be modeled. NO_x impacts will be converted to NO_2 impacts and maximum modeled concentrations of all five pollutants will be compared to NAAQS and (where applicable) PSD standards.

5 AIR QUALITY RELATED VALUES (AQRV) MODELING METHODOLOGY

5.1. Introduction

The purpose of AQRV modeling is to ensure that Class I area resources (i.e., visibility, flora, fauna, etc.) are not adversely affected by the projected emissions from a proposed project. AQRV's are resources which may be adversely affected by a change in air quality. Based on its proximity to the Wind Cave National Park, a federally mandated Class I area, the Dewey-Burdock Project will be modeled to determine its potential AQRV impacts at Wind Cave. Species to be modeled are PM_{10}, $PM_{2.5}$, SO_2, SO_4, NO_x, $NHNO_3$ and NO_3. Elemental carbon (EC) and Organic Carbon (SOA) will also be enabled in the model, but with zero project-related emissions. This is needed for background visibility calculations and to comply with the latest Federal Land Manager protocol (FLAG 2010).

Figure 5-1 depicts the Dewey-Burdock Project boundary and the Wind Cave National Park, approximately 50 km to the east-northeast of the project. Badlands National Park lies approximately 120 km to the east of the project. Based on projected emission levels and the fact that the predominant pollutant is filterable particulate matter (i.e., PM_{10}), the Dewey-Burdock Project is not expected to impact AQRV's at Badlands National Park.

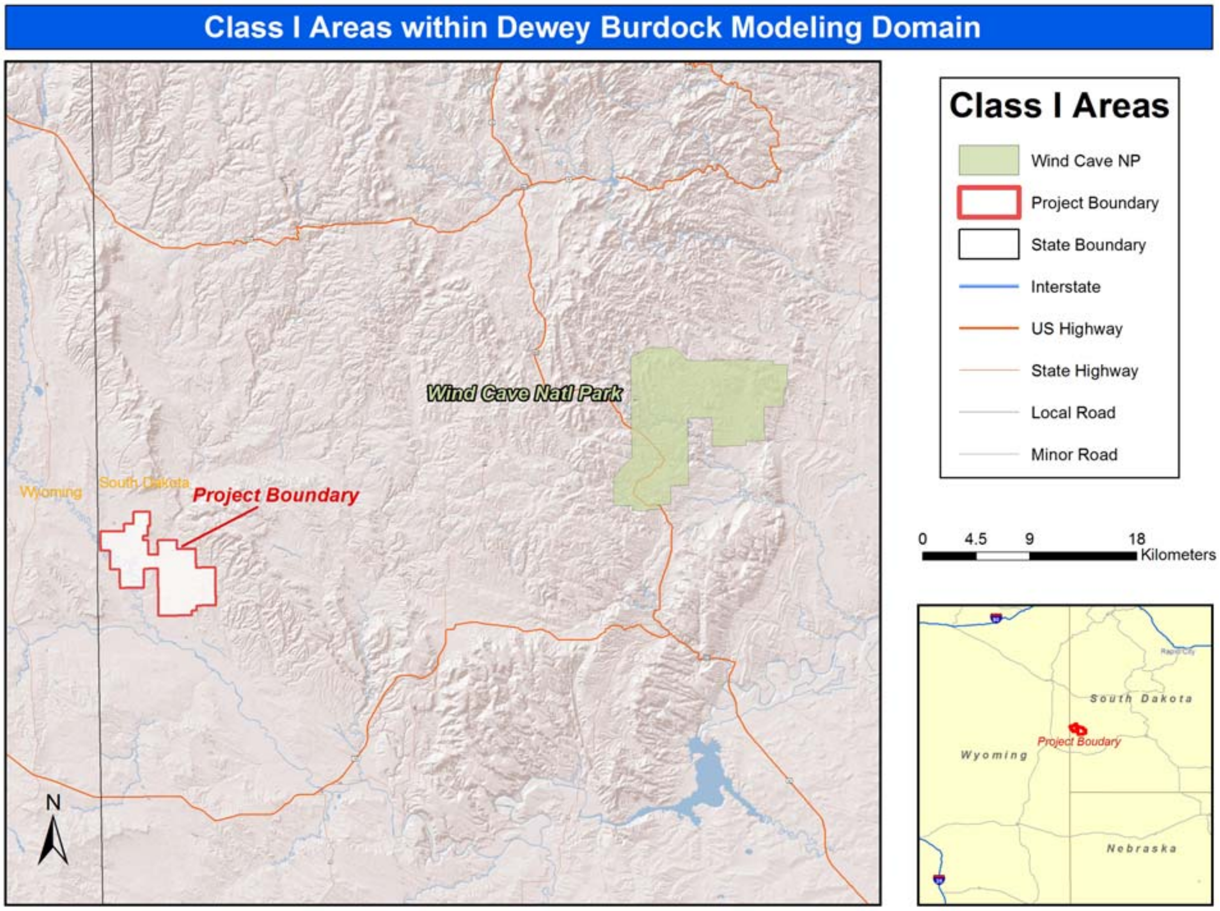
This protocol has been developed following applicable portions of the U.S. Environmental Protection Agency (EPA) guidance document: Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report And Recommendations for Modeling Long Range Transport Impacts, December 1998 (IWAQM 1998). It makes adjustments based on the findings of EPA's draft Reassessment of the Phase 2 Summary Report published in May 2009 (EPA 2009). It also reflects certain elements of the Western Regional Air Partnership BART protocol (WRAP 2006).

AQRVs that are generally evaluated for the federal mandatory Class I areas include:

- Visibility – Visual Plume
- Visibility – Regional Haze
- Acid Deposition

Visibility can be affected by plume impairment or regional haze. Plume impairment results from a contrast or color difference between a plume and a viewed background such as the sky or a terrain feature. Regional haze occurs at distances where the plume has become evenly dispersed in the atmosphere and is not definable. The primary causes of regional haze are sulfates and nitrates, which are formed from SO_2 and NO_X through chemical reactions in the atmosphere. Impacts at distances greater than 30 to 50 km are generally referred to as regional haze. Given that Wind Cave National Park is roughly 50 km from Dewey-Burdock and the project will not generate a single plume of emissions, it is assumed that any visibility impacts at Wind Cave National Park will be in the form of regional haze.

Figure 5-1: Dewey-Burdock Project and Nearest Class I Area



5.2. Model Selection and Justification

Evaluation of the impacts on Air Quality Related Values (AQRVs) from the proposed Dewey-Burdock Project at Wind Cave will be conducted using CALPUFF, which is the recommended model for long range transport applications (EPA 2005). CALPUFF is also recommended by the Federal Land Managers (FLM) for AQRV analyses, to simulate visibility and deposition impacts on a Class I area (FLAG 2010). The most recent, EPA-approved model of CALPUFF is Version 5.8. IML Air Science will use the commercial version of CALPUFF 5.8 from Lakes Environmental, supplemented with CALPOST Version 6.4 to take advantage of recent visibility post-processing improvements.

CALPUFF is a non-steady-state puff dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollution transport, transformation, and removal. CALPUFF can be applied for long-range transport and for complex terrain. The

CALPUFF model calculates the change in light extinction caused by a source (or group of sources) as part of the regional haze calculations. The EPA has proposed the use of CALPUFF for applications involving long-range transport, which is typically defined as transport over distances beyond 50 km (IWAQM 1998).

The CALPUFF model accounts for chemical transformations that occur during plume transport using algorithms to calculate the conversion of SO_2 to sulfates and NO_x to nitrates. The IWAQM Phase 2 report (IWAQM 1998) recommended the use of the MESOPUFF II scheme, which requires the user to select additional species to be modeled, e.g., sulfates (SO_4), nitrates (NO_3) and nitric acid (HNO_3). It also requires the input of background ozone and ammonia concentrations. Although the CALPUFF model provides default values for background concentrations, values specific to the Class I area being modeled are recommended given the sensitivity of the model to these parameters. For visibility calculations, site-specific relative humidity data are also recommended in the post processing step. Monthly average relative humidity values from Wind Cave National Park will be used for the Dewey-Burdock Project modeling.

The CALPUFF Modeling System includes three main components: CALMET, CALPUFF, CALPOST, and a large set of preprocessing and postprocessing programs designed to interface the model with standard, routinely available meteorological and geophysical datasets.

5.2.1. CALMET

CALMET is a meteorological model that develops hourly wind and temperature fields on a three-dimensional gridded modeling domain. Associated two-dimensional fields such as mixing heights, surface characteristics, and dispersion properties are also included in the file produced by CALMET.

5.2.2. CALPUFF

CALPUFF is a transport and dispersion model that advects “puffs” of material emitted from modeled sources, simulating dispersion and transformation processes along the way. In doing so it typically uses the fields generated by CALMET, or as an option, it may use simpler non-gridded meteorological fields explicitly incorporated in the resulting distribution of puffs throughout a simulation period. The primary output files from CALPUFF contain either hourly concentrations or hourly deposition fluxes evaluated at selected receptor locations.

5.2.3. CALPOST

CALPOST is used to process these files, producing tabulations that summarize the results of the simulation (concentrations at each receptor, for example). When performing visibility related modeling, CALPOST uses concentrations from CALPUFF to compute extinction coefficients and related measures of visibility, reporting these for selected averaging times and locations.

5.3. Meteorological, Terrain and Land Use Data

Preprocessed data will be acquired for incorporation into CALMET. This will include three dimensional mesoscale data (MM5), hourly surface observations from weather stations in the modeling domain, upper air data from the National Weather Service (NWS) station at Rapid City, precipitation data, terrain elevations, and land use classifications.

5.3.1. Time Period

According to 40 CFR Part 51 Appendix W, the length of the modeled meteorological period should be long enough to ensure that the worst-case meteorological conditions are adequately represented in the model results. EPA recommends that consecutive years from the most recent, readily available 5-year period are preferred, but when mesoscale meteorological data are used (i.e., MM5) three years of modeling is acceptable (WRAP BART Modeling Protocol).These mesoscale meteorological fields should be used in conjunction with available standard NWS or comparable meteorological observations within and near the modeling domain. Therefore this modeling analysis will be conducted using 3 years (2009, 2010, 2011) of mesoscale meteorological model output data coupled with observational data from nearby surface, upper air and precipitation stations.

5.3.2. Prognostic Meteorological Data

The CALMET/CALPUFF modeling system currently includes the capability to incorporate 3-dimensional prognostic meteorological data from a mesoscale wind field model (MM5) into the processing of meteorological data through the CALMET Diagnostic Wind Model (DWM). This is most commonly accomplished by using the MM5 data as the initial guess for the wind field in CALMET. The MM5 data used in this modeling effort will span a 200 km by 200 km modeling domain centered at the Dewey-Burdock Project site, with 12-km horizontal resolution and 18 vertical layers. This data set will be obtained from Lakes Environmental.

5.3.3. CALMET Diagnostic Meteorological Data

EPA recommends using a “hybrid” CALMET, to include MM5 and weather station data (EPA 2009). EPA recommends against the use of the “no-observation” methods for CALMET (NOOBS=1, 2). The CALMET NOOBS mode is less conservative, therefore meteorological observations will be blended with the MM5 data as input to the CALMET/CALPUFF modeling system. These will include three years of hourly meteorological data from the Dewey-Burdock on-site station, the Newcastle station, and the NWS station at Chadron, NE. Three years of upper air data will be obtained from Rapid City, the only upper air station in the region. Precipitation data will be supplied by a collection of 18 weather stations in the modeling domain. Traditionally, the FLMs have recommended a CALMET grid resolution of approximately 4 km. There is concern that the increased structural detail in the horizontal wind fields resulting from application of CALMET at higher grid resolutions may lead to spurious effects on plume dispersion which may not be obvious (WRAP 2006). EPA studies show little, if any, sensitivity to the increase in grid resolution within CALMET relative to the MM5 grid resolution (EPA 2009). Therefore, a 4 km grid resolution will be used for CALMET.

5.3.4. CALMET Approach

CALMET uses a two-step approach to calculate wind fields. In the first step, an initial guess field is adjusted for slope flows and terrain blocking effects, for example, to produce a step 1 wind field. In the second step, an objective analysis is performed to introduce observational data into the Step 1 wind field. EPA recommends elimination of CALMET diagnostic adjustments to first-guess wind field (EPA 2009). EPA recommends continuation of incorporation of surface observations for radii of influence (RMAX1, RMAX2, RMAX3, R1, R2, R3) set to minimal value to preserve the integrity of prognostic meteorological data used as the first-guess wind field. These recommendations will be followed in modeling the Dewey-Burdock Project.

5.3.5. CALMET Parameter Settings

The maximum mixing height (ZIMAX) has an EPA default value of 3000 m AGL. All the other parameters are set on a case by case basis taking the terrain surrounding the observation stations into consideration.

5.3.6. Terrain Data

Gridded terrain elevations for the modeling domain are derived from 3 arc-second digital elevation models (DEMs) produced by the United States Geological Survey (USGS).

The files cover 1-degree by 1-degree blocks of latitude and longitude. The elevations are in meters relative to mean sea level and have a resolution of about 90 meters. These data will be processed to generate 4 km average terrain heights that will be input into CALMET.

5.3.7. Land Use Data

Surface properties such as albedo, Bowen ratio, roughness length and leaf area index are computed proportionally to the fractional land use. The land use data is based on the Composite Theme Grid format (CTG) using Level I USGS land use categories. The 4 km land use grid will be mapped into the 14 primary CALMET land use categories.

5.3.8. CALMET Switch Settings

Most of the default switch settings for CALMET will be used. Table 5-1 lists some of the key parameter settings as proposed, and as implemented in the WRAP Protocol (WRAP 2006). The proposed reductions in some of the distances are based on recent modeling protocol for the Rosemont Copper Mine in Arizona (Rosemont 2009).

Table 5-1: CALMET Switch Settings

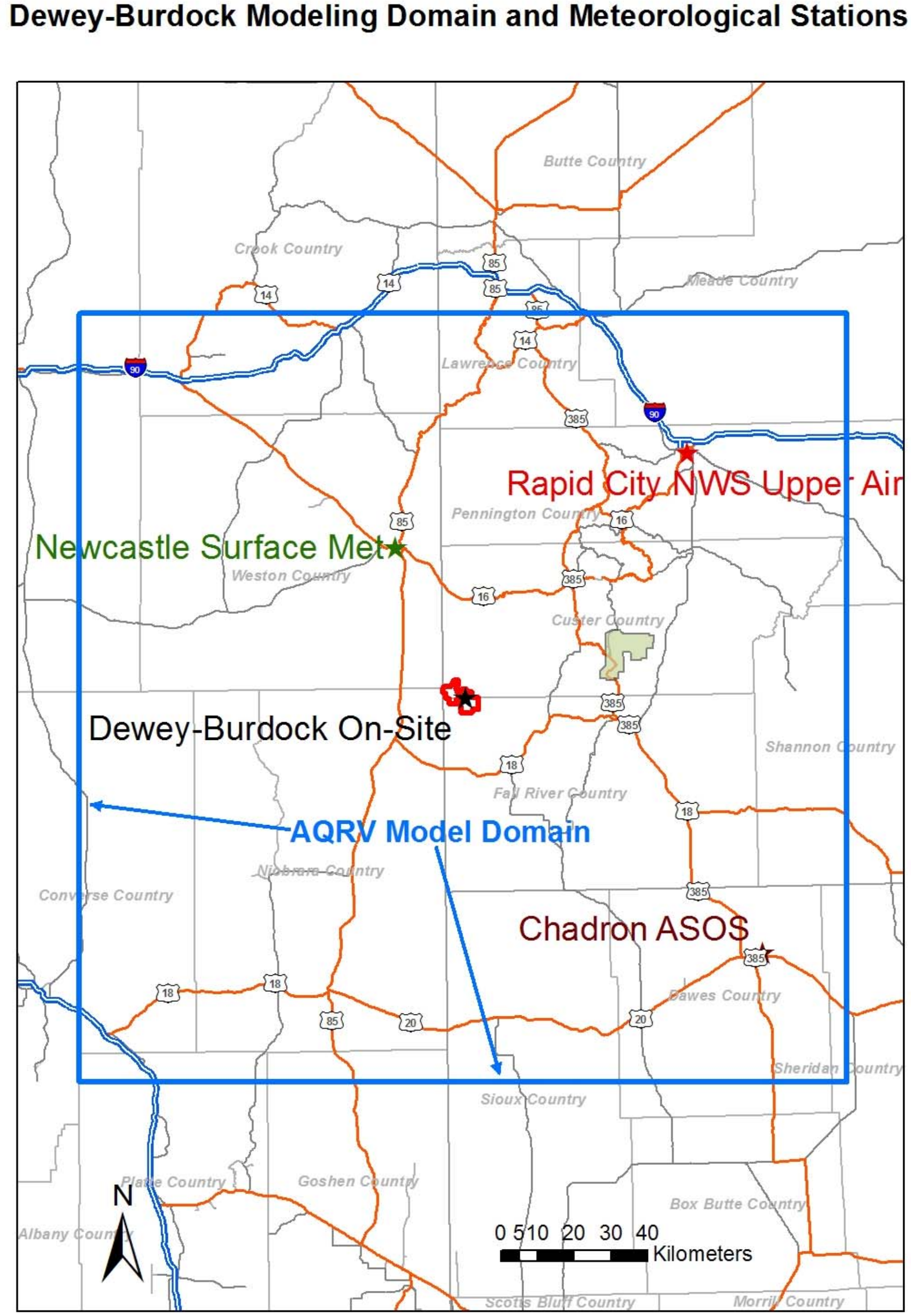
Parameter	WRAP Setting	Proposed Setting
R1MAX	50 KM	20 KM
R2MAX	100 KM	30 KM
R3MAX	100 KM	100 KM
R1	100 KM	18 KM
R2	200 KM	20 KM
ZIMAX	4500 m AGL	3000 m AGL
TERRAD	10 KM	10 KM

5.4. Modeling Domain and Receptors

Figure 5-2 shows the proposed AQRV modeling domain. In order to adequately characterize potential AQRV impacts to Wind Cave National Park, the modeling domain will extend 100 km in all directions from the Dewey-Burdock Project (200 km by 200 km grid). IWAQM recommends modeling 50 km beyond the relevant Class I boundary to provide a buffer and to account for any potential wind circulation. For Dewey-Burdock, the proposed buffer width meets this criterion.

Receptor locations and elevations for the Wind Cave National Park Class I area will be obtained from the National Park Service database in order to generate visibility data compatible with and comparable to previous modeling exercises.

Figure 5-2: Dewey-Burdock Project CALPUFF Modeling Domain and Surface Meteorological Stations



5.5. CALPUFF Model Inputs

5.5.1. Background Concentrations

CALPUFF requires ozone and ammonia background concentrations in order to characterize atmospheric chemistry. These species influence the rates of formation of sulfates and nitrates, aerosols that affect visibility.

Although a uniform background value for ozone may be adequate for small modeling domains, this modeling exercise will incorporate a time varying background. Accordingly, monthly ozone concentrations will be calculated using data from the Clean Air Status and Trends Network, or CASTNet. If values are missing CALPUFF will impose a default of 80 ppb.

For ammonia background, IWAQM recommends 1 ppb for forested lands, 10 ppb for grasslands, and 0.5 ppb for arid lands (IWAQM 1998). The relevant ammonia background is at Wind Cave National Park, not the entire modeling domain. Since the predominant land use at Wind Cave is forest, a conservative value of 1 ppb will be used in the model.

5.5.2. Chemistry Modeling

The MESOPUFF II pseudo-first-order chemical reaction mechanism (MCHEM=1) will be used for the conversion of SO_2 to sulfate (SO_4) and NO_x to nitrate (NO_3) as recommended by EPA (WRAP 2006). MESOPUFF II is a 5-species scheme in which all emissions of nitrogen oxides are simply input as NO_x. In the MESOPUFF II scheme, the conversion of SO_2 to sulfates and NO_x to nitrates is dependent on relative humidity (RH), with an enhanced conversion rate at high RH. This modeling exercise will therefore incorporate an adjustment factor for RH. Aqueous phase oxidation is currently not modeled, leading to an underestimation of sulfate formation in clouds or fog.

5.5.3. Particle Size Distribution

The dominant pollutant emitted from the Dewey-Burdock Project will be fugitive PM_{10}. Calpuff models the atmospheric dispersion and attempts to model the settling of particulate matter based on an input particle size distribution. This modeling exercise will use a PM_{10} size distribution for haul road dust based on AP-42 Section 13.2.2, emission factors for unpaved roads (EPA 1995). Table 5-2 lists the corresponding size distribution.

Table 5-2: Fugitive PM_{10} Particle Size Distribution

Particle Size (µm)	Fraction
2.2	0.069
3.17	0.128
6.1	0.385
7.82	0.224
9.32	0.194

All tailpipe particulate emissions will be modeled as $PM_{2.5}$.

5.5.4. CALPUFF Switch Settings

Most of the default switch settings for CALPUFF will be used. Table 5-3 lists the default values and proposed values for some of the key parameter settings. The increase in number of species emitted accounts for NO_x, SO_2, PM_{10} and $PM_{2.5}$ emissions.

Table 5-3: CALPUFF Switch Settings

Parameter	Description	Default Value	Proposed Value	Notes
Group 1 – General Options				
NSPEC	Number of chemical species	5	9	
NSE	Number of species emitted	3	4	
METFM	Meteorological data format	1	1	1 = CALMET file
PGTIME	Pasquill-Gifford (PG)	60	60	Minutes
MGAUSS	Near-field vertical distribution	1	1	1 = Gaussian
MCTADJ	Terrain adjustments to plume path	3	3	3 = Partial plume path adjustment
MCHEM	Chemical mechanism	1	1	1 = MESOPUFF II chemistry
MDISP	Method for dispersion coefficients	3	3	3 = PG for rural and McElroy-Pooler (MP) for urban
MREG	Regulatory default checks	1	1	1 = Technical options must conform to EPA Long Range Transport guidance
SYTDEP	Equations used to determine sigma-y and -z	550	550	Puff size (m) beyond which equations (Heffter) are used to determine sigma y and z
MHFTSZ	Heffter equation for sigma z	0	0	0 = Not use Heffter

5.6. CALPUFF Model Outputs, Calculations and Evaluation Methods

5.6.1. CALPOST and POSTUTIL

The CALPUFF results will be post-processed using the CALPOST and POSTUTIL processors. POSTUTIL is a post processing program used to process the concentrations generated by CALPUFF. POSTUTIL occurs prior to the visibility processing in CALPOST and allows the user to sum the contributions of sources from

different CALPUFF simulations into a total concentration file. Monthly RH adjustment factors will be applied directly to the background and modeled sulfate and nitrate concentrations in CALPOST.

5.6.2. Visibility Impact Determination

The general theory for performing visibility calculations with the CALPUFF modeling system is described in the Interagency Workgroup on Air Quality Modeling Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts (IWAQM 1998). The theory is also summarized in Section 5.6.4 below. Change of light extinction is the preferred metric for assessing visibility impairment. Visibility impact on a Class I area is considered significant if the source's contribution to visibility impairment, modeled as the 98th percentile of the daily (24-hour) changes in deciviews (dv), is equal to or greater than the contribution threshold of 0.5 dv (FLAG 2010). Stated differently, a source can be reasonably anticipated to cause or contribute to an impairment of visibility if the 98th percentile of the distribution of modeled changes in light extinction is greater than 0.5 dv. The EPA lists three types of natural background conditions in their guidance document: (1) Annual Average, (2) Best 20% Days and (3) Worst 20% Days (WRAP 2006). Changes in visibility at Wind Cave National Park will be calculated from the Dewey-Burdock Project model outputs and reported in terms of the 98th percentile change in dv at each modeled receptor, as well as the total light extinction at each receptor.

5.6.3. Comparison to Existing AQRV Status

Assessing some Air Quality Related Values (e.g., crop injury, or visibility effects) is fundamentally tied to knowing the current stress being exerted on the system. This is reflected in the current background visibility. Assessing the response of a resource is related to the cumulative effects of all the current existing stresses (IWAQM 1998). The evaluation of the Dewey-Burdock modeling results will therefore consider the current visual resource and visibility impairment at Wind Cave National Park. Studies conducted by the National Park Service and the Western Regional Air Partnership (WRAP) will provide references for current conditions.

5.6.4. Calculation of Light Extinctions

The calculation of regional visibility impacts in CALPUFF takes into account the scattering of light caused by several particulate matter (PM) constituents in the atmosphere. This scattering of light is referred to as extinction. The PM constituents that are accounted for in the visibility calculations include ammonium sulfate, ammonium

nitrate, organic carbon, elemental carbon, soil, and coarse and fine PM. The CALPUFF model calculates the light extinction attributable to a source's emissions and compares it to the extinction caused by the background constituents to estimate a change in extinction.

The extinction caused by a source's emissions is affected by several factors. One such factor is the formation of light scattering constituents by chemical transformation during plume transport, e.g., conversion of SO_2 to sulfates and NO_x to nitrates. These chemical transformations are dependent on the level of available gaseous ammonia and ozone in the atmosphere, i.e., the higher the ammonia and ozone concentration in the air, the greater the transformation, and hence the greater the light extinction. Since sulfates and nitrates are hygroscopic in nature, the light extinction caused by these constituents is also affected by relative humidity (RH). The other PM constituents are considered to be non-hygroscopic. The visibility analysis will be conducted using monthly average relative humidity adjustment factors, or f(RH) values.

The CALPOST postprocessor will be used for the calculation of the impact from the modeled source’s primary and secondary particulate matter concentrations on light extinction. The formula that is used is the existing IMPROVE/EPA formula, which is applied to determine a change in light extinction due to increases in the particulate matter component concentrations. Using the notation of CALPOST, the formula is the following:

B_{ext} = 2.2 x fS(RH) x [Small Sulfates] + 4.8 x fL(RH) x [Large Sulfate]
+ 2.4 x fS(RH) x [Small Nitrates] + 5.1 x fL(RH) x [Large Nitrates]
+ 2.8 x [Small Organic Mass] + 6.1 x [Large Organic Mass]
+ 10 x [Elemental Carbon]
+ 1 x [Fine Soil]
+ 0.6 x [Coarse Mass]
+ 1.7 x fSS(RH) x [Sea Salt]
+ [Rayleigh Scattering]
+ 0.33 x [NO2 (ppb)]

The concentrations, in square brackets, are in $\mu g/m^3$ and b_{ext} is in units of inverse megameters or Mm-1. The Rayleigh scattering term will be set to the value of 10 Mm-1,

the default value recommended in EPA guidance for tracking reasonable progress (WRAP 2006).

Each hour's source-caused extinction is calculated by first using the hygroscopic components of the source caused concentrations, due to ammonium sulfate and nitrate, and monthly f(RH) values specific to Wind Cave National Park. The contribution to the total source-caused extinction from ammonium sulfate and nitrate is then added to the other, non-hygroscopic components of the particulate concentration to yield the total hourly source caused extinction. The terms fS(RH), fL(RH) and fSS(RH) are relative humidity adjustment factors for small particles, large particles and sea salts respectively. These values will be taken from the Federal Land Managers Air Quality Related Values Workgroup Phase 1 Report Revised Draft Table V.1-2, V.1-3 and V1.-4 (FLAG 2008) which list f(RH) values for each Class I area.

5.6.5. Deposition Analysis

Atmospheric deposition includes wet and dry fluxes of the pollutants modeled ($g/m^2/sec$), represented as sulfur and nitrogen calculated in pollutant-specific runs of CALPOST. Modeled fluxes are for the modeled species and do not directly represent the mass flux of either sulfur or nitrogen. Adjustments are therefore made for the ratio of molecular weight of S and N vs. the molecular weight of the species modeled (SO_2, SO_4, NO_x, HNO_3, NO_3). The deposition flux of sulfur includes contributions from any modeled sulfur compounds. The deposition flux of nitrogen includes contributions from any modeled nitrogen compounds.

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 to sum the wet and dry fluxes, and to compute the total sulfur and nitrogen contributed by the modeled species for subsequent CALPOST processing.

5.6.6. CALPOST Switch Settings

Table 5-4 lists default and proposed values for key parameters for CALPOST. The maximum relative humidity will be lowered from 98% to 95% based on recent FLM guidance (FLAG 2008).

5.7. Presentation of Modeling Results

The purpose of the AQRV modeling outlined in this protocol is to demonstrate that emissions from the Dewey-Burdock Project will not cause a significant reduction in Air Quality Related Values (AQRV) at the nearby Class I area, Wind Cave National Park. The final impact analysis will present all the information necessary for this demonstration, by comparing project-related impacts to background conditions. This will include the 98th percentile of the 24-hour changes in haze index (deciviews), and an isopleth map of the total light extinction (background plus project-induced) at Wind Cave. It will also include an isopleth map showing maximum nitrogen and sulfur deposition at Wind Cave, with a table comparing modeled deposition rates to monitored conditions, significance thresholds and critical loads.

Table 5-4: CALPOST Switch Settings

Parameter	Description	Default Value	Proposed Value	Notes
Group 1				
ASPEC	Species to process	No Default	VISIB	Visibility processing
Group 2				
MFRH	Particle growth curve f(RH)	4	4	4 = IMPROVE (2006) f(RH) tabulations for sea salt and for sulfate and nitrate
RHMAX	Maximum relative humidity (%) in growth curve	98	95	FLAG (2008) guidance
Modeled Species				
LVSO4	Include sulfate	T	T	
LVNO3	Include nitrate	T	T	
LVNO2	Include nitrogen dioxide absorption	T	T	
LVOC	Include organic carbon	T	T	
LVPMC	Include coarse particulates	T	T	
LVPMF	Include fine particulates	T	T	
LVEC	Include elemental carbon	T	T	
Extinction Efficiency				
EEPMC	Particulate matter coarse	0.6	0.6	
EEPMF	Particulate matter fine	1.0	1.0	
EEPMCBK	Particulate matter coarse background	0.6	0.6	Background particulate species
EESO4	Ammonium sulfate	3.0	3.0	
EENO3	Ammonium nitrate	3.0	3.0	
EEOC	Organic carbon	4.0	4.0	
EESOIL	Soil	1.0	1.0	
EEEC	Elemental carbon	10.0	10.0	

6 AERMOD MODELING RESULTS AND ANALYSIS

6.1. Introduction

The stationary and fugitive emission sources at the Dewey-Burdock Project will produce particulate matter smaller than ten microns in size (PM_{10}) and particulate matter smaller than 2.5 microns in size ($PM_{2.5}$). Stationary and mobile sources will emit PM_{10}, $PM_{2.5}$, carbon monoxide (CO), sulfur dioxide (SO_2) and oxides of nitrogen (NO_x). It was assumed that 75% of NO_x emissions will be converted to NO_2. Thus, five criteria pollutants (PM_{10}, $PM_{2.5}$, CO, SO_2 and NO_2) were analyzed for compliance with the NAAQS using the AERMOD dispersion modeling software. Four of these pollutants, PM_{10}, $PM_{2.5}$, SO_2 and NO_2 were further analyzed for compliance with the maximum allowable PSD increments in Class I and Class II areas. For each scenario, emissions from all 34 on-site and off-site emission sources identified and quantified in the Dewey-Burdock Project emissions inventory (Figures 6-2 and 6-3), were modeled. Each model run, with the exception of a “plume depletion” run discussed in Section 6.2 below, produced maximum pollutant concentrations and related statistics at all 1,609 receptors in the 110-km by 110-km modeling domain (Figure 6-1).

Table 6-1 summarizes the results of the AERMOD model runs for all pollutants and relevant averaging intervals. Sections 6.2 through 6.6 discuss these results in detail for each of the five criteria pollutants.

As discussed in Section 6.4, the NO_2 model results predicted that three receptors along the project boundary would exceed the 1-hr National Ambient Air Quality Standard (NAAQS). This standard has been defined by EPA as the three-year average of the 98^{th} percentile of annual distributions of daily 1-hour highs. All other receptors were in compliance with all standards as reflected in Table 6-1. Sections 6.5 and 6.6 present the SO_2 and CO modeling results. Both pollutants showed compliance with all standards.

Section 6.2 discusses the initial PM_{10} modeling results, which showed 64 receptors with maximum daily concentrations in excess of the 24-hr NAAQS. Section 6.2 evaluates the accuracy and sensitivity of AERMOD when modeling particulate emissions from fugitive dust sources, and documents the case that AERMOD over-predicts short-term, ambient PM_{10} and $PM_{2.5}$ impacts from fugitive dust sources. Section 6.2 describes a refined

model run that was completed for critical receptors only, using a “plume depletion” option to lessen the model’s tendency to over-predict. Under this scenario, three receptors – all within a few hundred meters of fugitive dust sources – were predicted to exceed the PM_{10} 24-hr NAAQS. Unlike the initial modeling run, these results showed compliance with the 24-hr PSD Class I increment at Wind Cave National Park.

Section 6.3 discusses $PM_{2.5}$ modeling results. Many of the documented problems with over-prediction of short-term PM_{10} concentrations also apply to $PM_{2.5}$ concentrations. The model results showed $PM_{2.5}$ compliance with all applicable standards except the 24-hr NAAQS at six receptors near the project and three receptors at Wind Cave that slightly exceeded the Class I PSD increment. Re-running the model with dry plume depletion had only a minor effect; the same six receptors still exceeded the NAAQS, and one of the three Wind Cave receptors remained above the Class I PSD increment.

Table 6-1: Modeled Pollutant Concentration Summary (AERMOD)

Regulated Pollutant		Concentrations (µg/m³)					
Pollutant	**Statistic**	**Modeled Near Project**	**NAAQS Limit**	**Location of Modeled Exceedances**	**PSD Class II Increment**	**Modeled at Wind Cave NP**	**PSD Class I Increment**
PM_{10} (Modeled without Plume Depletion)	Annual Average	17.9	--	--	17	0.1	4
	24-Hr High	385.5	150	< 1 mile from Project Boundary or Public Road	30	32.7	8
PM_{10} (Modeled with Plume Depletion)	Annual Average	17.2	--	--	17	0.03	4
	24-Hr High	290	150	< 150 meters from Project Boundary or Public Road	30	2.5	8
$PM_{2.5}$ (Modeled without Plume Depletion)	Annual Average	1.9	12	--	4	0.01	1
	24-Hr High	41.7	35	On Project Boundary or < 150 meters from Public Road	9	3.3	2
$PM_{2.5}$ (Modeled with Plume Depletion)	Annual Average	1.5	12	--	4	0.01	1
	24-Hr High	40.6	35	--	9	3.0	2
NO_2	Annual Average	1.6	100	--	25	0.01	2.5
	98th Percentile of Daily 1-Hr Highs	243.8	187	On Project Boundary	--	1.7	--
SO_2	Annual Average	0.3	--	--	20	0.002	2
	24-Hr	14.9	--	--	91	0.3	5
	3-Hr	118.7	1300	--	512	2	25
	99th Percentile of Daily 1-Hr Highs	69.8	200	--	--	2.4	--
CO	8-Hr High	352.6	10000	--	--	6.3	--
	1-Hr High	2820.6	40000	--	--	30.5	--

Figure 6-1: AERMOD Modeling Domain and Receptors

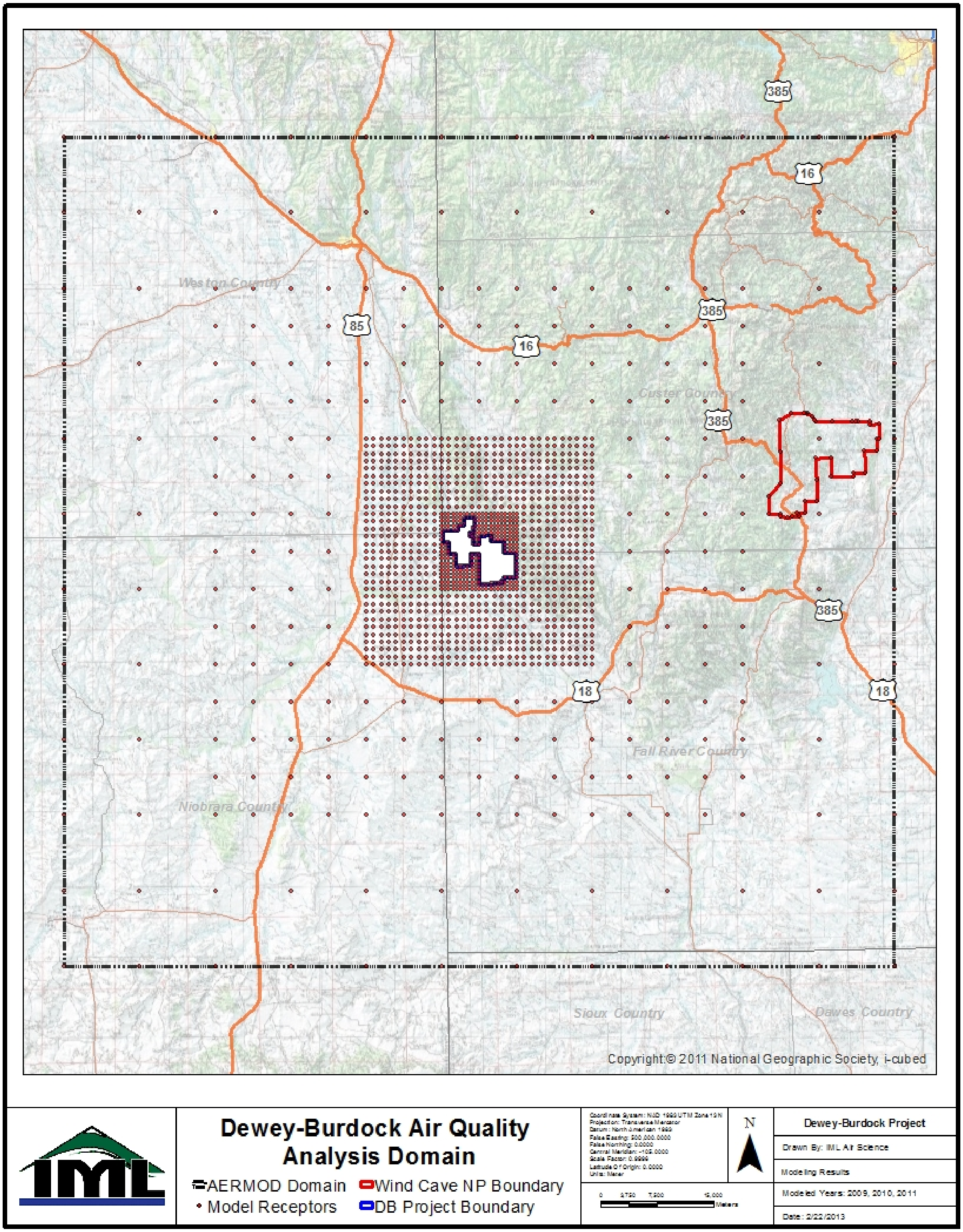


Figure 6-2: Dewey-Burdock Project Modeled Emission Sources

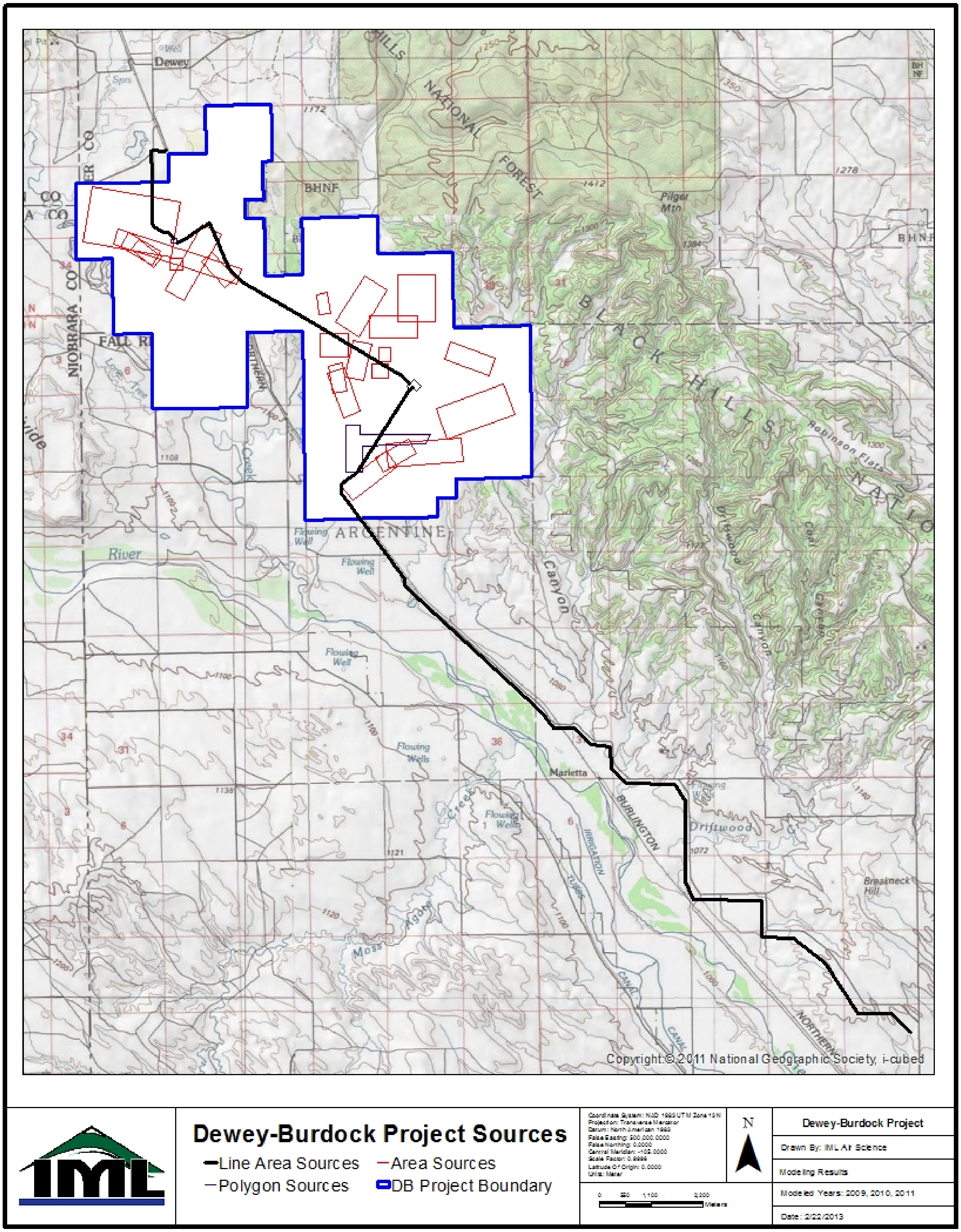
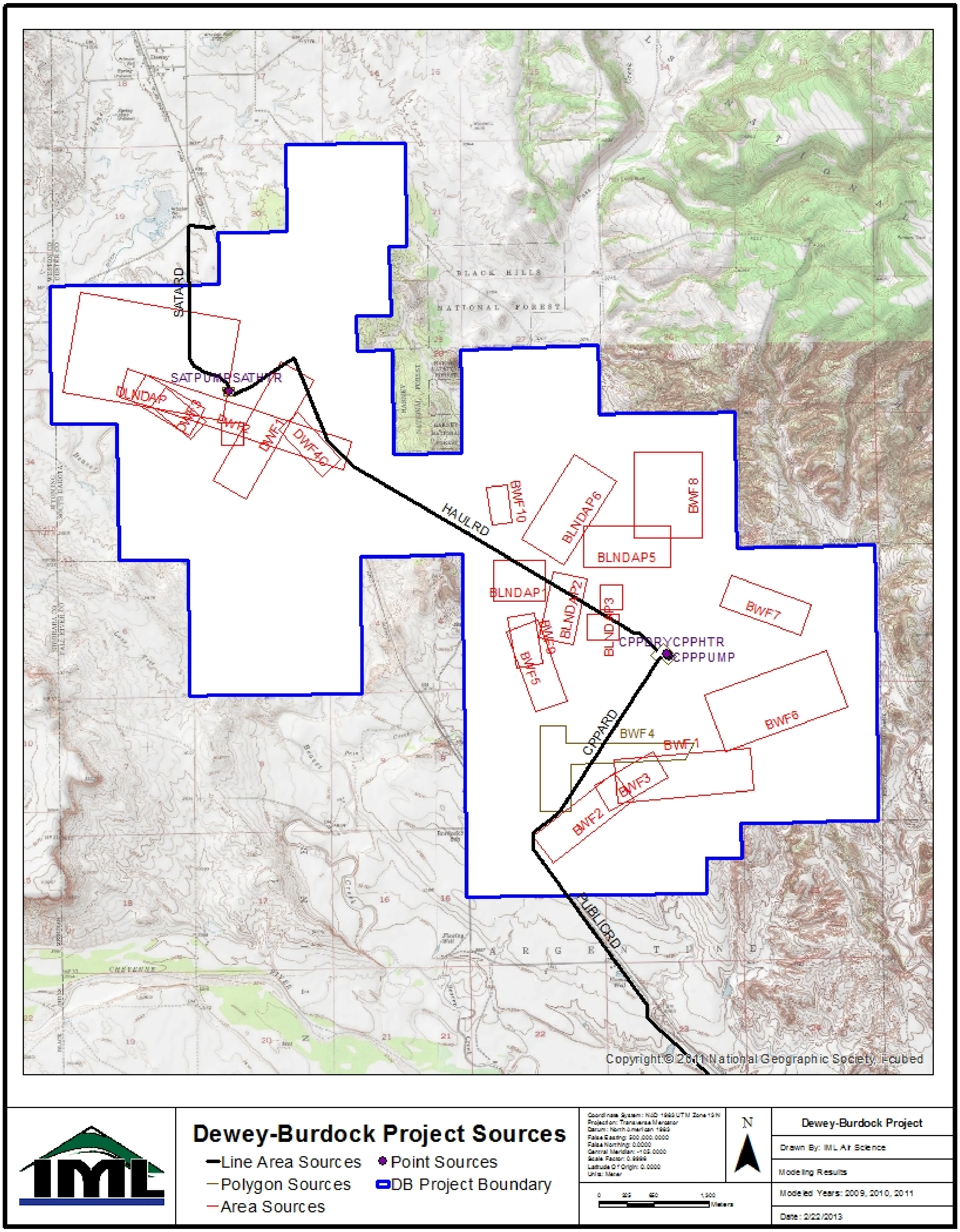


Figure 6-3: Dewey-Burdock Project Modeled Emission Source Detail



6.2. PM_{10} Modeling Analysis

Particulate matter in the form of PM_{10} emissions will constitute the single largest air pollutant from the proposed Dewey-Burdock Project. The primary source of PM_{10} emissions will be fugitive dust generated by traffic on unpaved roads, road maintenance, drilling and construction activities, and wind erosion on disturbed areas. A small fraction of the total PM_{10} emissions will be generated by internal engine fuel combustion. Nearly all of these combustion emissions will also qualify as $PM_{2.5}$ (particles with aerodynamic diameter less than 2.5 microns). Accordingly, the outcome of this PM_{10} modeling study is driven by ground-level sources of fugitive dust.

The maximum yearly PM_{10} emissions from the Dewey-Burdock Project were modeled for potential impacts on ambient air quality at all receptors in the modeling domain. Both on-site and off-site, project-related emission sources were included in the model. Variable emission rates were used, based on month, day and hour. The model produced maximum receptor concentrations for any calendar day (24-hr average) and for the entire modeling period (annual average). In order to characterize worst-case, short-term impacts, the modeling period spanned three years of hourly meteorological conditions.

6.2.1. Initial PM_{10} Modeling Results

Results from the initial AERMOD run are presented below. Table 6-2 lists the top 20 receptors ranked by annual average concentrations. Table 6-3 lists the top 50 receptors ranked by 24-hour maximum concentrations. Figure 6-4 is an isopleth, or contour plot of the annual impacts from the Dewey-Burdock Project. Figure 6-5 is an isopleth map of the maximum 24-hr impacts from the Dewey-Burdock Project.

Table 6-2 shows all receptors were well below the previous annual NAAQS of 50 $\mu g/m^3$ (standard no longer exists). One of the 1,609 receptors barely exceeded the annual, Class II PSD increment. None of the Wind Cave receptors exceeded the annual Class I PSD increment (Table 6-1). Table 6-3 shows all of the top 50 receptors exceeding the 24-hr NAAQS. In total, the initial PM_{10} model run predicted 64 receptors exceeding the NAAQS at least one day during the 3-year modeling period. Figure 6-6 illustrates the proximity of these modeled exceedances to the fugitive PM_{10} emission sources. All of the modeled exceedances occur at receptors within approximately one mile of the

Dewey-Burdock Project boundary and the public road over which commuter traffic would access the project. All receptor concentrations at Wind Cave National Park were in compliance with the 24-hr NAAQS, but the highest modeled value exceeded the 24-hr, Class I PSD increment (Table 6-1).

6.2.2. PM_{10} Model Over-Prediction Problems

These modeling results must be qualified by noting an inherent bias in the AERMOD model. Several studies and regulatory actions have recognized AERMOD's tendency to over-predict 24-hr impacts from ground-level, fugitive PM_{10} emissions. It has been widely documented that atmospheric dispersion models used for predicting impacts from non-Gaussian fugitive sources lead to over-prediction of transportability and the resultant air quality impacts of fugitive dust emissions (Cliffs 2011).

Table 6-2: Top 20 Receptors, Annual Average PM10 Concentrations

UTM Easting	UTM Northing	Maximum Modeled Concentration (μg/m^3)	PSD Class II Standard (μg/m^3)
578158	4818210	17.9	17
582172	4810421	14.0	17
589158	4803710	13.1	17
582658	4809710	12.6	17
589158	4802710	12.6	17
593158	4799710	11.6	17
577137	4815932	11.4	17
582658	4810210	10.8	17
581937	4810416	10.1	17
582158	4810210	10.0	17
592158	4800710	9.7	17
576945	4815934	9.5	17
577141	4815703	9.3	17
581702	4810411	9.1	17
583158	4808710	8.8	17
581228	4810638	8.2	17
581466	4810407	8.1	17
586158	4805710	8.0	17
581225	4810873	7.9	17
581158	4810710	7.8	17

This tendency was exposed in ISCST3, the regulatory model that preceded AERMOD. Although AERMOD improved on many of ISCST3's features, these improvements were confined primarily to stationary sources and buoyant plumes. According to EPA, AERMOD is a better regulatory model than ISCST3 for a number of reasons. For example, AERMOD has better treatment of vertical plume dispersion. For point and volume sources, the accounting for plume meander is a significant improvement. However, for low-level emission plumes, AERMOD has not been evaluated extensively by EPA for performance against measured data, nor compared to ISCST3 modeling results. While the plume transport equations have been improved, modeling source parameter input requirements for fugitive (non-point) sources have changed little. Even with the improvements to AERMOD, the problem of over-predicting 24-hr PM_{10} impacts from fugitive dust persists (Sullivan 2006).

Despite selecting AERMOD as "the best state-of-the-practice Gaussian plume dispersion model," EPA has acknowledged some if its limitations. Section 234 of the Clean Air Act recognized that as of 1990, the U.S. Environmental Protection Agency lacked adequate air quality modeling tools to accurately predict short-term concentrations of PM_{10} from surface coal mines. More recently, EPA stated, "Due to the difficult nature of characterizing and modeling fugitive dust and fugitive emissions, it is recommended that the proposed procedure be cleared by the Regional Office for each specific situation before the modeling exercise is begun" (EPA 2005).

Table 6-3: Top 50 Receptors, 24-Hr Maximum PM_{10} Concentrations

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m^3)	NAAQS Concentration (µg/m^3)
591158	4801710	385.5	150
589158	4802710	370.1	150
576361	4816399	358.5	150
576358	4816629	357.0	150
593158	4799710	355.1	150
582172	4810421	352.5	150
581937	4810416	317.8	150
576158	4816710	293.8	150
584158	4807710	293.6	150
582158	4810210	289.0	150
586158	4806710	285.0	150
581225	4810873	281.7	150
589158	4803710	277.7	150
582658	4810210	277.1	150
581158	4810710	263.9	150
576158	4817210	250.3	150
576349	4817319	249.8	150
577137	4815932	247.3	150
581658	4809710	242.1	150
576945	4815934	238.7	150
583158	4809710	228.2	150
576346	4817549	226.9	150
581228	4810638	224.4	150
592158	4800710	224.1	150
582658	4809710	223.5	150
582158	4809710	219.8	150
590158	4801710	219.3	150
583158	4808710	219.0	150
590158	4802710	215.9	150
581658	4810210	213.0	150
577141	4815703	212.8	150
576594	4817552	212.4	150
576158	4817710	208.7	150
581222	4811109	201.0	150
581205	4812522	200.3	150

582643	4810430	199.8	150
576752	4815936	196.3	150
581220	4811344	191.9	150
588158	4803710	191.3	150
580658	4810710	186.3	150
581702	4810411	186.3	150
577088	4817559	183.4	150
576658	4818210	183.2	150
580658	4812710	178.4	150
580158	4810210	178.2	150
581158	4811210	176.9	150
578158	4818210	175.3	150
581231	4810402	173.5	150
588158	4802710	168.5	150
581208	4812286	167.9	150

Figure 6-4. Annual Average PM_{10} Concentrations

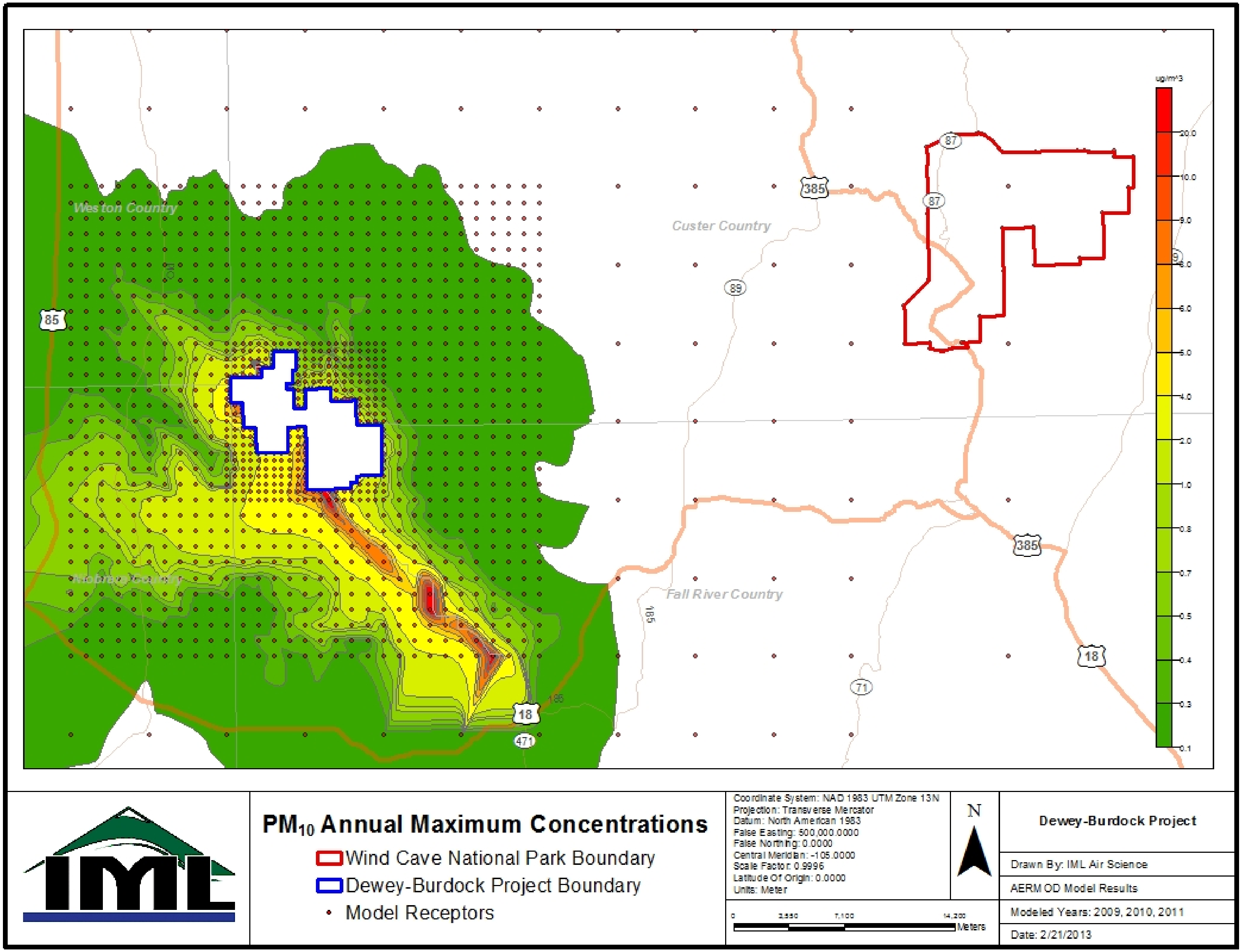


Figure 6-5. Maximum 24-Hour Average PM_{10} Concentrations

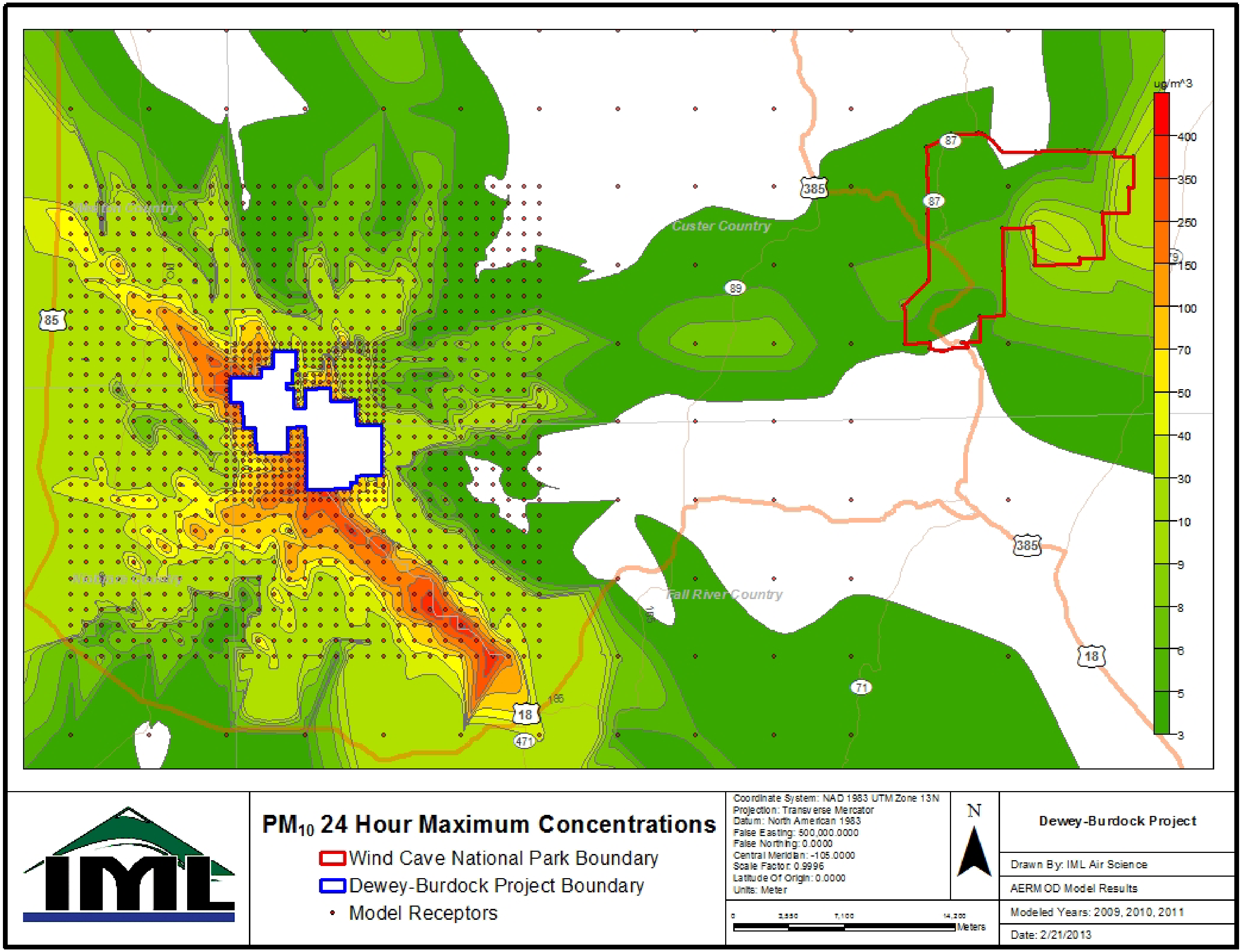
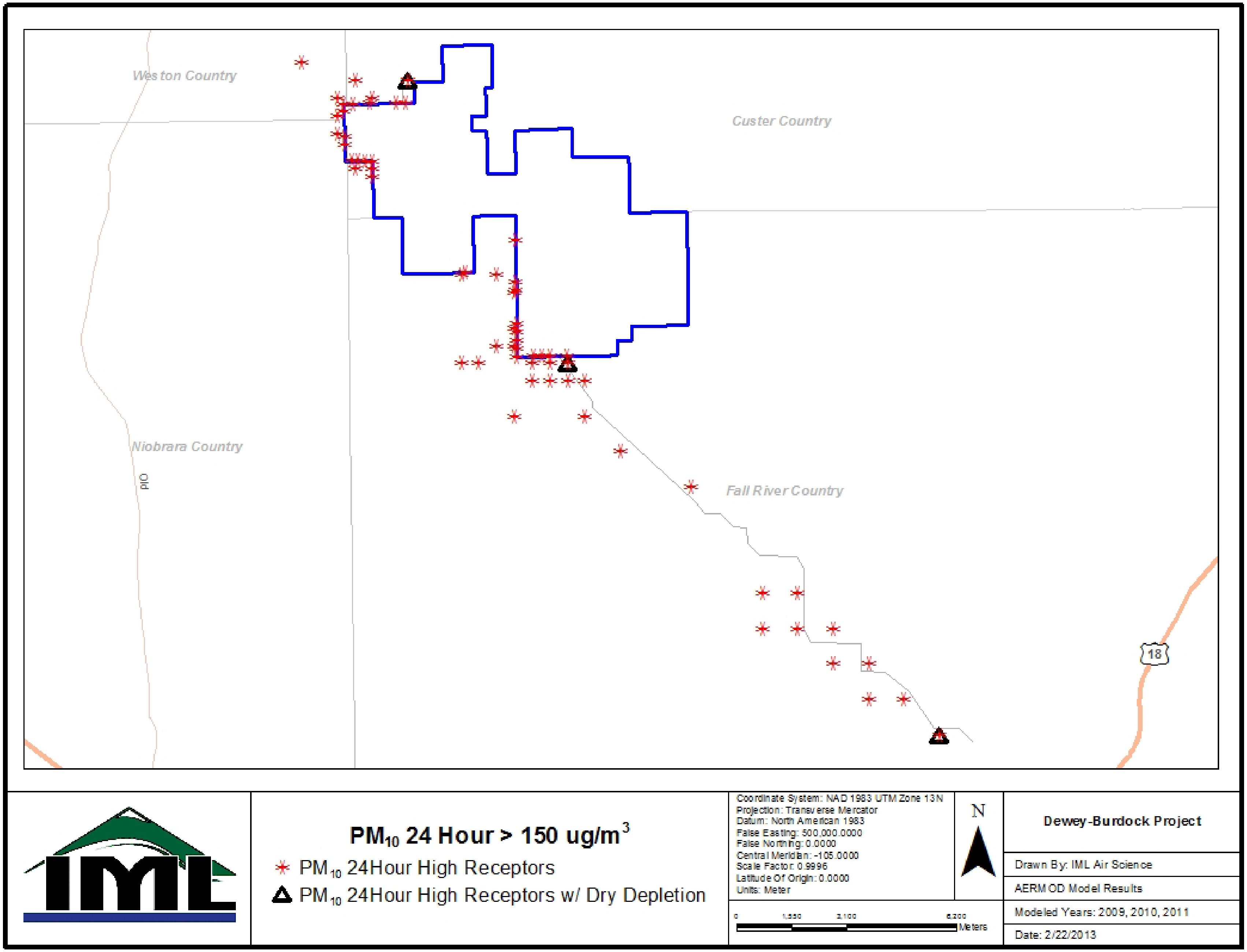


Figure 6-6. Modeled 24-Hour PM_{10} NAAQS Exceedances (With and Without Dry Depletion)



Based on comparisons of modeled vs. measured concentrations of PM_{10} and $PM_{2.5}$, a recent study estimated that the cumulative effects of AERMOD deficiencies lead to over-prediction of ambient dust concentrations by a factor of four (Cliffs 2011). Chatten Cowherd of Midwest Research Institute also estimated an over-prediction factor of at least four (Sullivan 2006). AECOM documented over-predictions by factors of 6 to 20. AECOM reduced this to a factor of 2 by doubling the minimum horizontal plume spread in AERMOD and by including direct turbulence observations. The results were documented, and the entire database was provided to EPA in the Spring of 2010 (AECOM 2012). To date, however, these improvements have not been implemented.

Experts have speculated as to possible causes of AERMOD's over-prediction of short-term fugitive dust impacts. First, model formulation problems cause underestimates of turbulent mixing in stable conditions. Second, predicted concentrations do not account for particle electrostatic agglomeration, enhanced gravitational settling and deposition near the point of release (AECOM 2012). Third, vehicular traffic is not continuous. Aside from their non-point release characteristics, the unsteady state nature of most fugitive emitting activities is what makes them particularly problematic when simulated by steady-state dispersion models (Trinity 2009). Fourth, AERMOD meteorological profiling is designed to be conservative without the use of multiple-level meteorological data.

The issue of over-prediction is not only of academic interest, but also of regulatory concern. The Texas Commission on Environmental Quality (TCEQ) Modeling Guidelines specifically state that road emissions should not be included in permit modeling analyses for short-term averaging periods, that is, less than the annual averaging period. TCEQ states, "combined with worst-case operating scenarios, the modeling tool [referring to ISCST3] will overpredict concentrations, particularly in the vicinity of the source…" (TCEQ 1999). The Wyoming DEQ maintains that AERMOD still produces a high degree of uncertainty in modeling short-term fugitive impacts. As a result (and with EPA authorization), DEQ requires annual, but not short-term modeling of PM_{10} and $PM_{2.5}$ impacts from fugitive sources. Instead it relies on ambient monitoring to demonstrate compliance.

A cooperative study initiated in 1991 by EPA, the State of Wyoming, and the Wyoming Mining Association evaluated improvements to the then preferred model, ISCST3 (MMA 2011). These improvements included a deposition model that was intended to improve

its performance in predicting fugitive dust impacts. According to MMA, one of the conclusions of the study was, “In spite of the improved performance of the ISC3 model, the model significantly overpredicts (as defined in the protocol) for PM_{10} but not for TSP.”

EPA followed this study with a letter dated June 26, 1996 from John Sietz of EPA to Senator Alan Simpson, Wyoming, acknowledging that the model still over-predicts for PM_{10}. The concluding paragraph of the Sietz letter states:

> “Since the model still appears to overpredict the impacts of surface coal mines, the Agency does not plan to use it for regulatory applications involving these sources. As a consequence, the regulatory procedures currently in place will remain in effect. These procedures are contained in the January 24, 1994 Memorandum of Agreement (MOA) between EPA Region VIII and the State (copy enclosed) and were summarized in the Federal Register on September 12, 1995 (60 FR 47290). The MOA allows the State to conduct monitoring in lieu of short term modeling for assessing coal mining-related impacts in the Powder River Basin. We believe that these procedures provide adequate protection for the environment and are also acceptable to the stakeholders. At this time, we and the various stakeholders believe that the interim procedures work well, and therefore we do not currently plan any further analyses. If in the future EPA is able to correct the model’s tendency to overpredict as described above, it may, of course, review these regulatory procedures.”

In the migration from ISC3 to AERMOD, EPA has still not corrected the over-prediction (MMA 2011), which may explain why it continues to endorse the above-stated policy. In 2011 MMA conducted a modeling analysis to determine whether EPA’s current model (AERMOD) would yield significant improvements over the ISC3 Short Term model in the prediction of short-term particulate concentrations for surface mining operations. The study found that AERMOD still over-predicts short-term PM_{10} concentrations, and even exceeds the predictions of ISCST3 at model receptors positioned from 100 to 500 meters from the sources of fugitive emissions (MMA 2011). The study concludes that AERMOD “consistently predicts concentrations higher than ISCST in the range of concentrations that would be critical decision points in the permitting process.”

6.2.3. *Final PM_{10} Modeling Results*

In an attempt to at least partially address the problem of over-predicting impacts from fugitive dust at the Dewey-Burdock project, AERMOD was re-run for impacts at select receptors using the plume depletion option. This option, also available with ISCST3, seeks to account for particulate deposition near the source. It requires the user to input particle densities (assumed to be 2.65 g/cm^2) and size distributions (mass fractions for each particle size category). The particle size distribution for fugitive PM_{10} from unpaved roads was obtained from AP-42 Section 13.2.2 and input to AERMOD using Method 2. The receptors modeled with dry plume depletion included all 64 receptors that exceeded the 24-hr PM_{10} NAAQS in the initial model run, as well as 24 receptors at Wind Cave National Park that initially exceeded the Class I PSD increment. It was not realistic to use this option for the initial run, as modeling impacts on all receptors in the modeling domain would have required several hundred hours to execute.

It was presumed that the plume depletion option would not cause any receptor concentration to increase, so that modeling only those receptors with exceedances in the initial model run should exhaust any potential exceedances in the second model run. This partial-receptor run predicted annual PM_{10} impacts only marginally lower than those in the initial model run. The predicted 24-hr PM_{10} impacts, however, were significantly lower as summarized in Table 6-4. The highest concentration was reduced from 385.5 to 290.0, but more importantly, the partial model run lowered the number of receptors exceeding the 24-hr NAAQS from 64 to three. All three of these receptors fall within 150 meters of the project boundary or the public road (Figure 6-6).

Perhaps most significantly, the highest 24-hr PM_{10} concentration at Wind Cave dropped from 32.7 without dry depletion to 2.5 µg/m^3 with dry depletion (see Table 6-1), well below the Class I PSD increment. This seems to corroborate other evidence that PM_{10} particles will settle out within a few kilometers of a ground-level, fugitive dust source.

The contrast between AERMOD results with and without dry depletion exposes some of the model uncertainty discussed above. EPA has not designated plume depletion as the regulatory default option as it has not been thoroughly validated and it increases model execution time by an order of magnitude. At the same time, EPA sanctioned the use of dry deposition (roughly equivalent to dry depletion) with the ISC model under certain conditions, all of which apply to the present Dewey-Burdock case (Trinity 2007).

> “Furthermore, although the EPA currently does not require the use of the settling and deposition algorithm, the Agency considered making its use a requirement. In 1995, the EPA promulgated Supplement C to its Guideline on Air Quality Models (Appendix W to Part 51). In the preamble that accompanied that rulemaking, the EPA stated it had considered requiring “the dry deposition algorithm be used for all ISC analyses involving particulate matter in any of the programs for which guideline usage is required under 40 CFR Parts 51 and 52.”

Although EPA decided to not make the dry deposition algorithm a regulatory default modeling option, it recommended its use in appropriate instances as enumerated below:

1. Large number of PM_{10} fugitive sources
2. Source emissions can be quantified
3. Settling and deposition are anticipated to occur
4. A refined modeling analysis is being conducted

A recent study of fugitive dust modeling with AERMOD concluded that even with dry plume depletion enabled, the model still over-predicts receptor concentrations. “The author's experience is that only marginal concentration reduction will result from using dry deposition when sources are close to receptors” (Sullivan 2006). It has been suggested by an EPA scientist that “any removal that may occur near the source (on a scale of 10’s to100’s of meters) is beyond the capability of current grid models, which are intended for use in regional scale analyses” (PACE 2005). “The recognition that vegetation captures some of this dust has led to a useful, albeit emerging methodology to account for the near source removal of particles in regional and urban scale analyses. This method is an improvement upon the national divide-by-four adjustment that has been used for about ten years. It may be applied in regional scale analyses where fugitive dust is emitted from paved and unpaved roads, construction, agricultural tilling, quarrying and earthmoving.” The Dewey-Burdock modeling results substantiate these assertions: using dry plume depletion lowered the close-in receptor concentrations (local scale) incrementally, but the most dramatic impact was observed at Wind Cave (regional scale).

Notwithstanding the uncertainties in modeling short-term impacts from fugitive dust sources, Powertech intends to adopt several control strategies to reduce actual impacts:

1. Apply water spray to project-area roads and exposed areas

2. Reduce commuter traffic over the unpaved county road by providing company vans and incentivizing carpool arrangements
3. Install particulate monitors as needed to determine background ambient air quality and downwind impacts from the project
4. Assist Fall River County with maintenance and the application of dust suppressant on the unpaved public road

The modeling results reported here already incorporate the first two strategies. The third strategy will eventually enable the evaluation of short-term dispersion model performance. The fourth strategy has been initiated under a cooperative agreement between Powertech and the County.

Table 6-4: Top 50 Receptors, 24-Hr Maximum PM_{10} Values With Dry Depletion

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m^3)	NAAQS Concentration (µg/m^3)
582658	4810210	290.0	150
578158	4818210	199.5	150
593158	4799710	150.9	150
591158	4801710	128.4	150
583158	4809710	127.3	150
589158	4802710	124.7	150
582643	4810430	111.8	150
586158	4806710	103.6	150
582658	4809710	101.7	150
582172	4810421	100.1	150
577137	4815932	92.1	150
589158	4803710	92.1	150
592158	4800710	88.3	150
581228	4810638	72.2	150
576945	4815934	70.4	150
581158	4810710	70.2	150
577829	4817570	70.1	150
578077	4817573	68.2	150
577141	4815703	67.3	150
576358	4816629	66.8	150
581702	4810411	64.2	150
581937	4810416	62.5	150
582158	4810210	62.3	150
576752	4815936	60.6	150

581225	4810873	57.9	150
581231	4810402	57.7	150
581222	4811109	55.4	150
576158	4816710	55.2	150
590158	4802710	54.8	150
576361	4816399	53.4	150
583158	4808710	53.4	150
576658	4815710	52.0	150
581658	4810210	51.6	150
576560	4815937	50.8	150
581220	4811344	50.8	150
581158	4811210	49.9	150
577145	4815474	48.1	150
590158	4801710	48.0	150
580658	4810710	44.0	150
584158	4807710	42.1	150
581208	4812286	41.4	150
582158	4809710	40.4	150
581191	4813699	39.6	150
581205	4812522	37.5	150
581158	4812210	36.4	150
576349	4817319	36.3	150
580158	4810210	35.1	150
576158	4817210	34.8	150
580658	4812710	32.1	150
588158	4802710	31.0	150

6.3. $PM_{2.5}$ Modeling Analysis

Particulate matter in the form of $PM_{2.5}$ emissions were modeled in a similar fashion to PM_{10} emissions. The primary source of $PM_{2.5}$ emissions will be the smaller fugitive dust particles generated by traffic on unpaved roads, road maintenance, drilling and construction activities, and wind erosion on disturbed areas. A small fraction of the total $PM_{2.5}$ emissions will be generated by internal engine fuel combustion.

The maximum yearly $PM_{2.5}$ emissions from the Dewey-Burdock Project were modeled for potential impacts on ambient air quality at all receptors in the modeling domain. Both on-site and off-site, project-related emission sources were included in the model. Variable emission rates were used, based on month, day and hour. The model produced maximum receptor concentrations for any calendar day (24-hr average) and for the entire modeling period (annual average). In order to characterize worst-case, short-term impacts, the modeling period spanned three years of hourly meteorological conditions.

6.3.1. Initial $PM_{2.5}$ Modeling Results

Results from the initial AERMOD run are presented below. Table 6-5 lists the top 20 receptors ranked by annual average concentrations. Table 6-6 lists the top 50 receptors ranked by 24-hour maximum concentrations. Figure 6-7 is an isopleth, or contour plot of the annual impacts from the Dewey-Burdock Project. Figure 6-8 is an isopleth map of the maximum 24-hr impacts from the Dewey-Burdock Project.

Table 6-5: Top 20 Receptors, Annual Average $PM_{2.5}$ Values (No Dry Depletion)

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m³)	PSD Class II Standard (µg/m³)
578158	4818210	1.9	4
582172	4810421	1.5	4
577137	4815932	1.4	4
589158	4803710	1.3	4
582658	4809710	1.3	4
589158	4802710	1.3	4
576945	4815934	1.2	4
593158	4799710	1.2	4
577141	4815703	1.2	4
582658	4810210	1.1	4

581937	4810416	1.1	4
582158	4810210	1.1	4
581702	4810411	1.0	4
592158	4800710	1.0	4
576752	4815936	1.0	4
577145	4815474	0.9	4
581228	4810638	0.9	4
583158	4808710	0.9	4
581466	4810407	0.9	4
581225	4810873	0.9	4

Table 6-6: Top 50 Receptors, 24-Hr Maximum $PM_{2.5}$ Values (No Dry Depletion)

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m^3)	NAAQS Concentration (µg/m^3)
576361	4816399	41.7	35
576358	4816629	41.6	35
591158	4801710	38.9	35
589158	4802710	37.3	35
582172	4810421	36.3	35
593158	4799710	35.8	35
576158	4816710	34.1	35
581937	4810416	33.0	35
582158	4810210	29.9	35
584158	4807710	29.6	35
581225	4810873	29.2	35
576158	4817210	28.7	35
586158	4806710	28.7	35
577137	4815932	28.7	35
576349	4817319	28.5	35
589158	4803710	28.0	35
582658	4810210	27.9	35
576945	4815934	27.7	35
581158	4810710	27.4	35
576346	4817549	25.7	35
581658	4809710	25.2	35
577141	4815703	25.0	35
576594	4817552	24.1	35
576158	4817710	23.6	35

581228	4810638	23.2	35
583158	4809710	23.0	35
582158	4809710	23.0	35
576752	4815936	22.8	35
592158	4800710	22.6	35
582658	4809710	22.5	35
581658	4810210	22.3	35
583158	4808710	22.3	35
590158	4801710	22.1	35
590158	4802710	21.8	35
581222	4811109	21.0	35
581205	4812522	21.0	35
581220	4811344	20.3	35
576658	4818210	20.2	35
582643	4810430	20.2	35
577088	4817559	20.0	35
581702	4810411	19.7	35
580658	4810710	19.4	35
588158	4803710	19.3	35
580658	4812710	18.9	35
576560	4815937	18.5	35
581158	4811210	18.5	35
580158	4810210	18.5	35
575158	4818710	18.5	35
577145	4815474	18.4	35
581231	4810402	18.2	35

Table 6-6 shows six receptors with maximum 24-hr concentrations in excess of the NAAQS. AERMOD also predicted three receptors at Wind Cave National Park with 24-hr high values slightly above the Class I PSD increment of 2 μg/m^3. The predicted values were 3.3, 2.2 and 2.2 μg/m^3. Section 6.2 above discusses in detail the model weaknesses that lead to probable over-prediction of short-term impacts from fugitive dust. Despite this tendency, all modeled $PM_{2.5}$ exceedances in the vicinity of the project and at Wind Cave were near the respective standards.

6.3.2. *Final $PM_{2.5}$ Modeling Results*

As with 24-hr PM_{10} impacts from the Dewey-Burdock Project, AERMOD was re-run for 24-hr $PM_{2.5}$ impacts at select receptors using the dry plume depletion option. In this case, AERMOD Method 2 was used to characterize particle size. For all fugitive sources, a mass mean particle diameter of 1.0 µm was assumed. The receptors modeled with plume depletion included all six receptors that exceeded the 24-hr $PM_{2.5}$ NAAQS in the initial model run (plus two more), as well as all three receptors at Wind Cave National Park that exceeded the Class I PSD increment in the initial model run. It was not realistic to use plume depletion for all receptors in the modeling domain as this would have required several hundred hours to execute.

For the six model receptors originally above the NAAQS, the plume depletion run predicted 24-hr PM_{10} impacts only slightly lower. The highest concentration was reduced from 41.7 µg/m^3 to 40.6 µg/m^3, and all six receptors still exceeded the NAAQS of 35 µg/m^3 as shown in Table 6-7. This result was not unexpected, given the much smaller particle size for $PM_{2.5}$. The highest 24-hr $PM_{2.5}$ concentration at Wind Cave dropped from 3.3 to 3.0 µg/m^3, and the number of receptors exceeding the Class I PSD increment dropped from three to one. It is worth noting that the CALPUFF model predicted a maximum 24-hr $PM_{2.5}$ concentration at Wind Cave of 0.44 µg/m^3, or 22% of the PSD Class I increment.

Table 6-7: Modeled Receptors, 24-Hr Maximum $PM_{2.5}$ Comparison

UTM Easting	UTM Northing	Maximum Without Plume Depletion (µg/m^3)	Maximum With Plume Depletion (µg/m^3)
576361	4816399	41.7	40.6
576358	4816629	41.6	40.8
591158	4801710	38.9	40.6
589158	4802710	37.3	38.2
582172	4810421	36.3	37.6
593158	4799710	35.8	38.6
576158	4816710	34.1	33.7
581937	4810416	33.0	33.4
606158	4784710	3.3	3.0
611158	4779710	2.2	2.0
616158	4779710	2.2	1.9

Section 6.2 discusses mitigation measures incorporated into the modeling of Dewey-Burdock Project PM_{10} emission sources. Since $PM_{2.5}$ emission factors for fugitive dust sources are derived from PM_{10} emission factors, these mitigation measures will apply equally to $PM_{2.5}$ impacts.

Figure 6-7. Annual $PM_{2.5}$ Concentrations

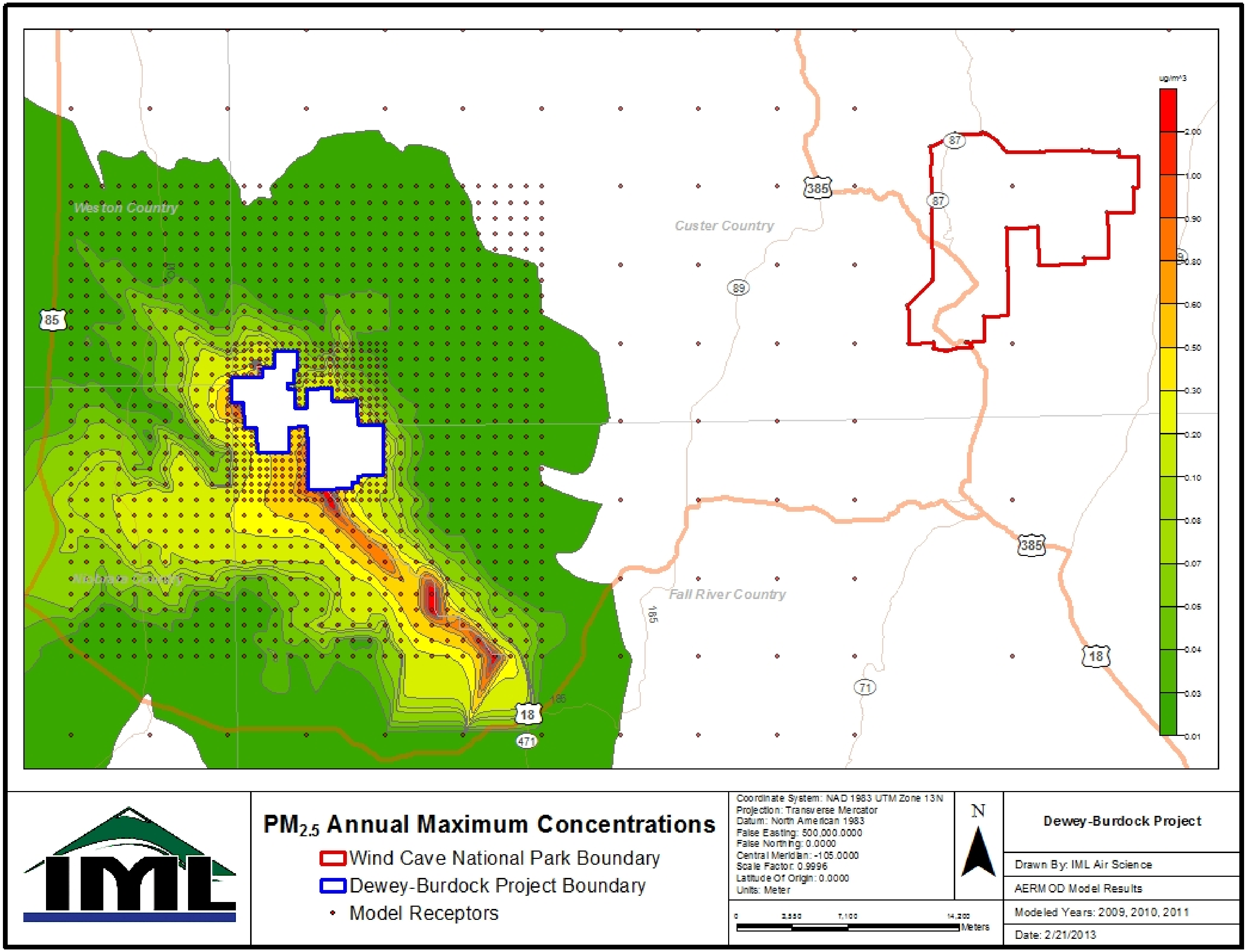


Figure 6-8. Maximum 24-Hour $PM_{2.5}$ Concentrations

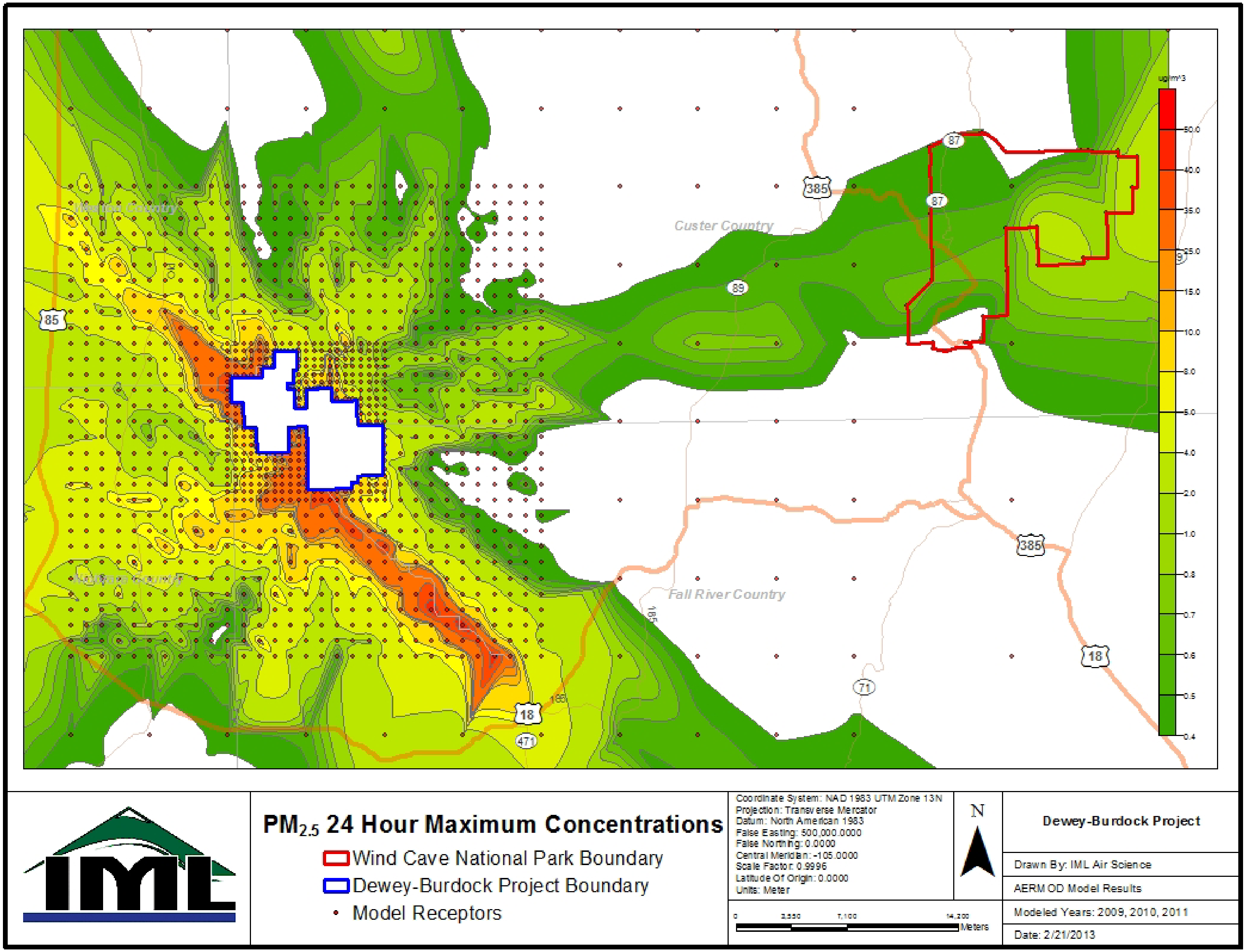
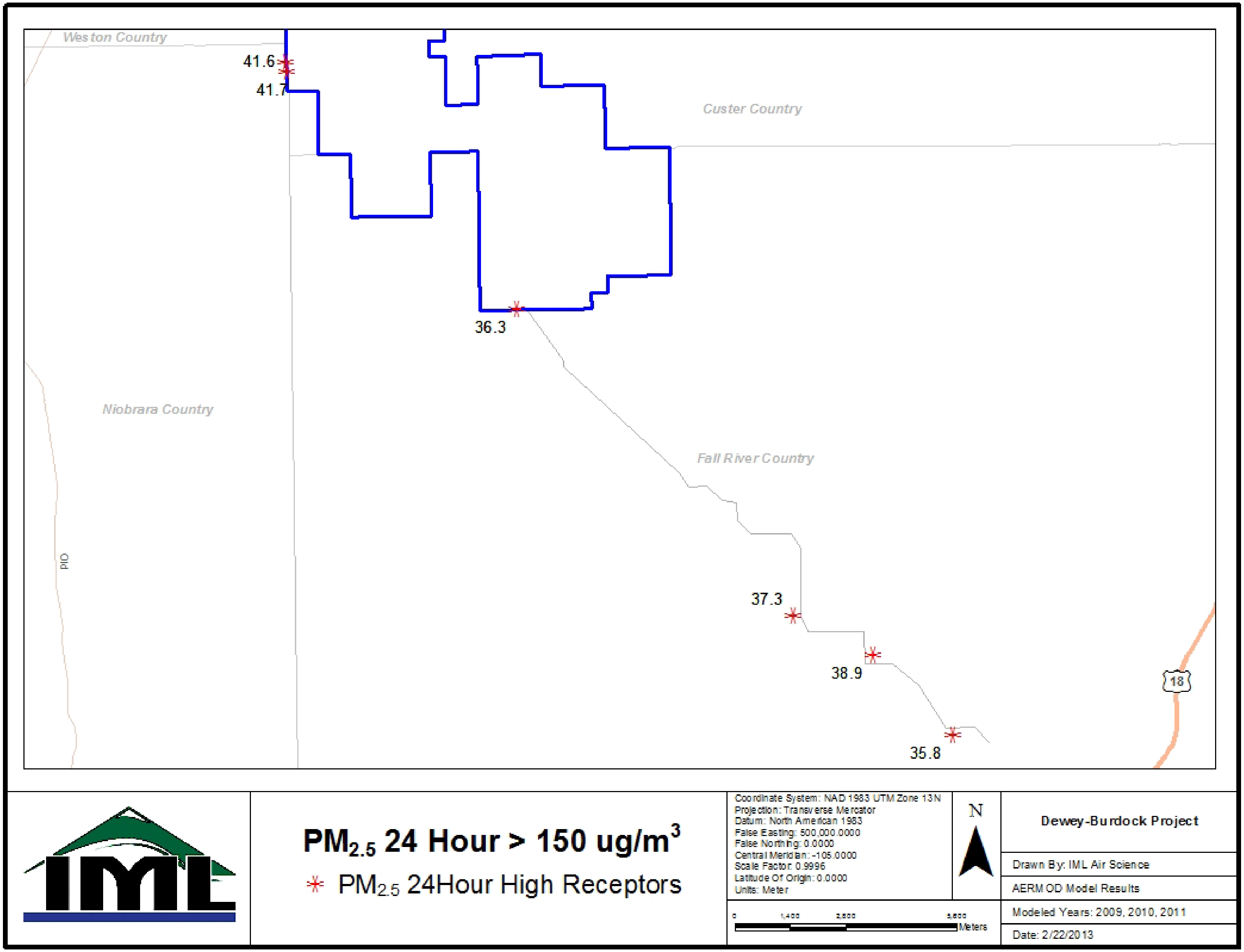


Figure 6-9. Modeled 24-Hour $PM_{2.5}$ NAAQS Exceedances (With or Without Dry Depletion)



6.4. NO_2 Modeling Analysis

NO_2 emissions are derived from oxides of nitrogen (NO_x), at an assumed conversion ratio of 75%. The primary source of NO_x emissions will be internal engine fuel combustion from mobile and stationary sources.

The maximum yearly NO_x emissions from the Dewey-Burdock Project were modeled for potential impacts on ambient air quality at all receptors in the modeling domain. Both on-site and off-site, project-related emission sources were included in the model. Variable emission rates were used, based on month, day and hour. The model produced maximum hourly receptor concentrations by calendar day, the 98th percentile of these daily maxima for each year, and the three-year average of the 98th percentiles. It also produced the average receptor concentrations for the entire modeling period (annual average). In order to characterize worst-case, short-term impacts, the modeling period spanned three years of hourly meteorological conditions.

Results from the initial AERMOD run are presented below. Table 6-8 lists the top 20 receptors ranked by annual average concentrations. Table 6-9 lists the top 50 receptors ranked according to the 1-hr NAAQS. Figure 6-10 is an isopleth, or contour plot of the annual impacts from the Dewey-Burdock Project. Figure 6-11 is an isopleth map of the 98th percentile 1-hr impacts from the Dewey-Burdock Project.

Table 6-8: Top 20 Receptors, Annual Average NO_2

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m^3)	PSD Class II Standard (µg/m^3)
577137	4815932	1.59	25
577141	4815703	1.30	25
576945	4815934	1.26	25
577145	4815474	1.03	25
576752	4815936	0.95	25
576658	4815710	0.87	25
577149	4815245	0.79	25
576658	4815210	0.73	25
578158	4818210	0.70	25
576560	4815937	0.69	25
577153	4815016	0.65	25
581200	4812993	0.61	25
576158	4815210	0.58	25

581197	4813228	0.57	25
581158	4813210	0.54	25
581202	4812757	0.54	25
577157	4814787	0.54	25
576367	4815939	0.52	25
581158	4812710	0.52	25
576358	4816629	0.51	25

Table 6-9: Top 50 Receptors, 98th percentile of Daily Maximum 1-Hr NO_2 Values

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m³)	NAAQS Concentration (µg/m³)
577137	4815932	243.8	187
577141	4815703	208.2	187
576945	4815934	195.6	187
577145	4815474	163.3	187
576752	4815936	152.1	187
576361	4816399	142.9	187
577149	4815245	132.2	187
576560	4815937	131.4	187
576364	4816169	125.9	187
576658	4815210	122.3	187
576658	4815710	121.3	187
576358	4816629	111.9	187
576158	4816210	110.8	187
576367	4815939	110.6	187
577153	4815016	102.4	187
576658	4814710	95.3	187
581202	4812757	94.2	187
576158	4816710	94.2	187
581158	4812710	91.5	187
581200	4812993	90.6	187
576158	4815210	87.2	187
577161	4814558	87.1	187
576355	4816859	85.5	187
576158	4815710	84.5	187
577158	4814710	83.3	187
581197	4813228	81.8	187
581205	4812522	80.1	187

577157	4814787	79.8	187
581158	4813210	79.0	187
581194	4813464	77.0	187
577571	4814329	76.4	187
581191	4813699	67.9	187
577774	4814329	67.5	187
584395	4814482	64.8	187
581158	4813710	64.1	187
581182	4814406	61.0	187
581188	4813935	60.8	187
580658	4812210	60.1	187
577368	4814329	57.5	187
580233	4814383	57.0	187
580658	4812710	56.8	187
580158	4814210	56.5	187
580471	4814389	56.3	187
581231	4810402	55.9	187
577658	4814210	55.5	187
581208	4812286	55.2	187
582778	4816050	54.7	187
579999	4814150	54.3	187
581158	4812210	53.8	187
577977	4814329	52.4	187

All but three receptors were in compliance with all relevant NAAQS and PSD standards. The three receptors which AERMOD predicted would exceed the 1-hr NO_2 standard (Table 6-9) lie on the Dewey-Burdock Project boundary as shown in Figure 6-12. This portion of the boundary is very close to planned well field development activities. Principal among the equipment involved in these activities are the drill rigs, which will generate over half the total annual NO_x emissions.

Powertech considered several measures to mitigate short-term NO_2 impacts from diesel powered equipment:

1. Reduce drill rig engine horsepower to 300 hp
2. Commit to Tier 1 engine emission standards for drill rigs
3. Commit to Tier 3 engine emission standards for mobile equipment fleets

4. Evaluate Tier 3 engine availability for drill rigs
5. Model well field progression as strictly sequential

Measures 1, 2 and 3 are reflected in the emissions inventory and model results presented here. Measures 4 and 5 were modeled to assess their effectiveness. Modeling results for measure #4 showed compliance with the NO_2 1-hr NAAQS at all receptors. The highest modeled receptor concentration for this scenario was 139 μg/m^3, compared to the NAAQS of 187 μg/m^3. However, Powertech consulted prospective drilling contractors and determined that drill rig fleets with Tier 3 engines would not be readily available. Therefore, this measure was eliminated from further consideration.

Measure #5 involved the sequencing of well field development such that construction activites were confined to a single well field at any given time. The rationale for this was to avoid area emission sources that overlapped in time. This merely intensified emission rates for each well field, resulting in modeled concentrations that were virtually the same as for the base case. Therefore, this measure was eliminated from further consideration.

Figure 6-10. Annual NO_2 Concentrations

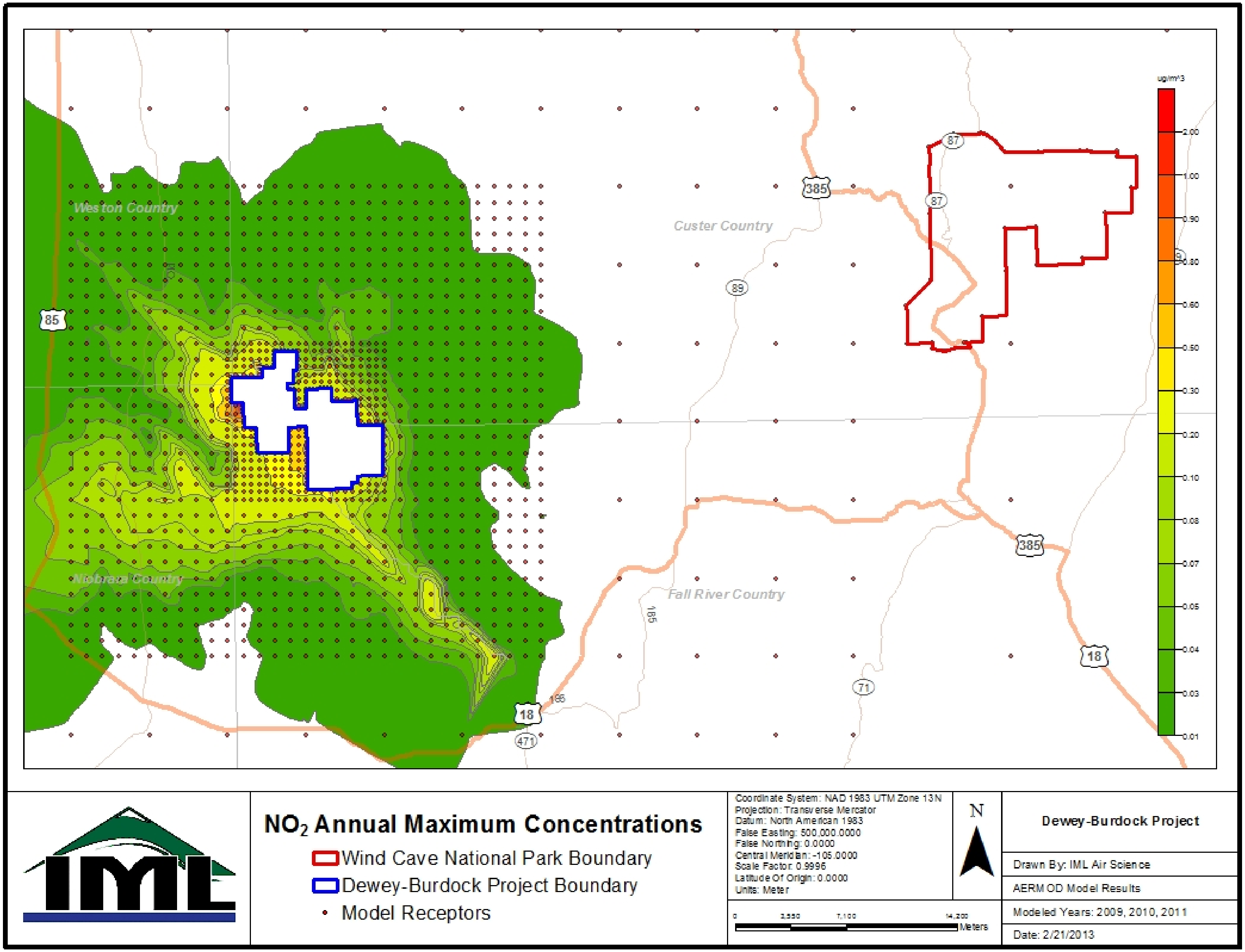


Figure 6-11. Modeled 98th Percentile 1-Hr NO_2 Concentrations

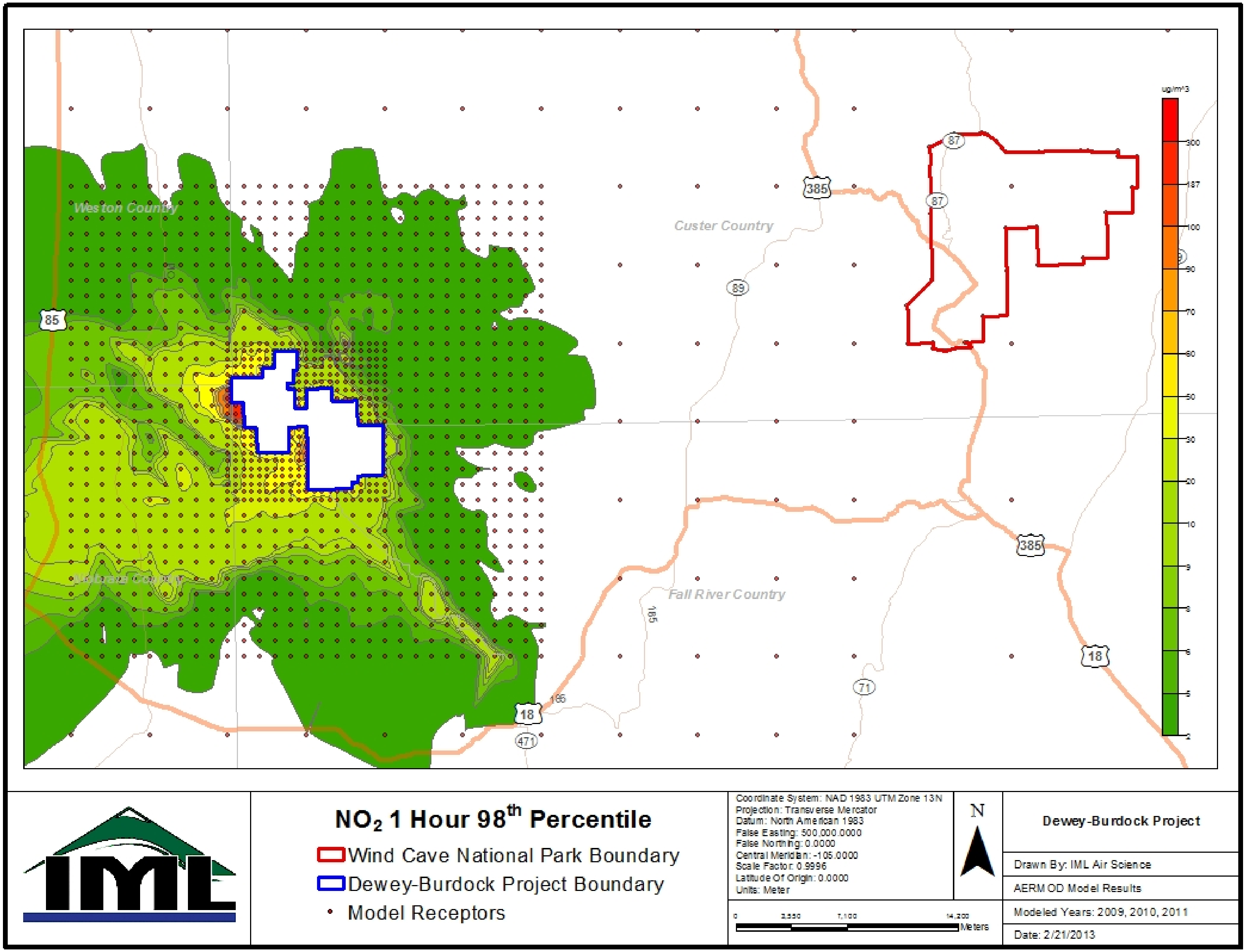
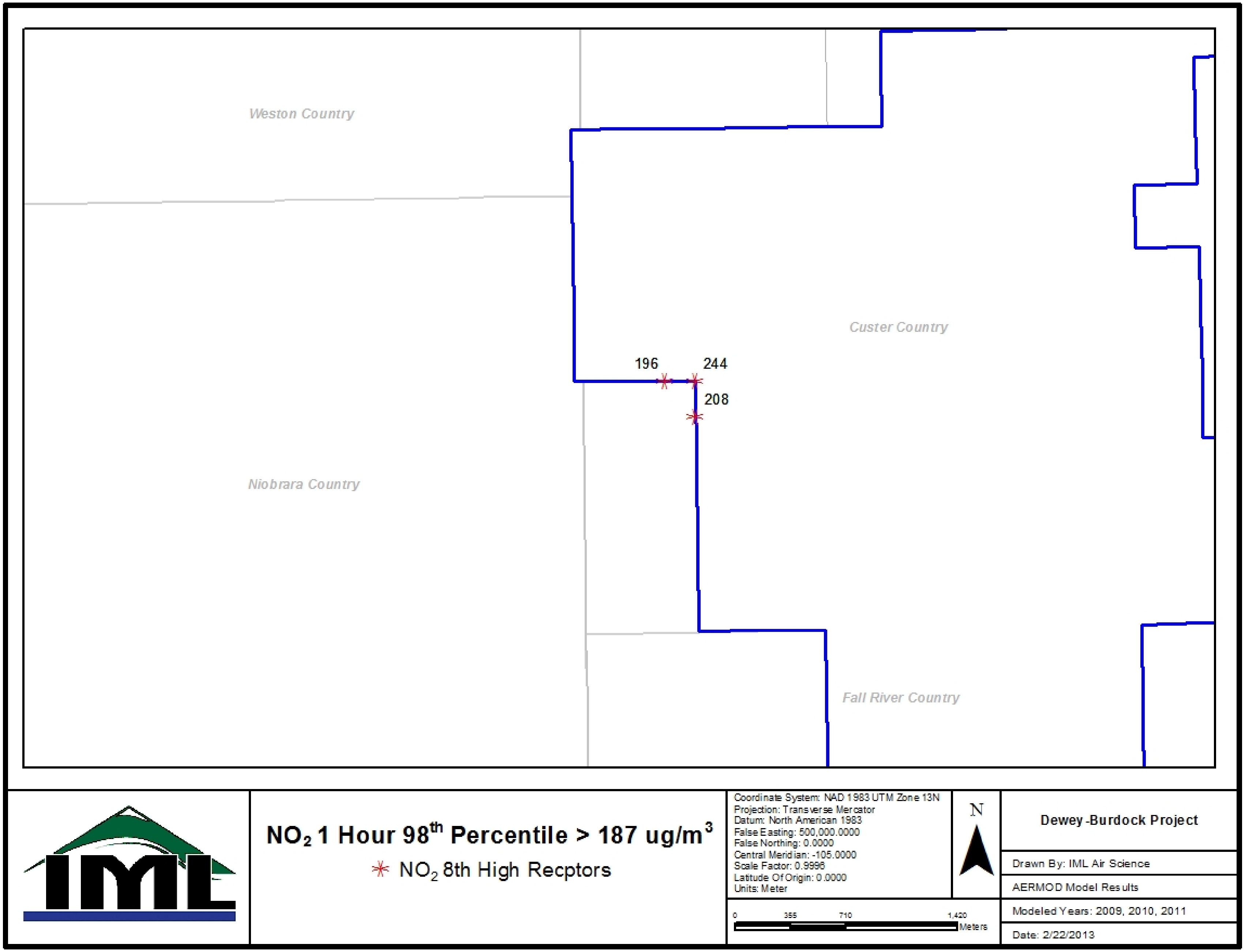


Figure 6-12. Modeled 1-Hour NO_2 NAAQS Exceedances



6.5. SO_2 Modeling Analysis

The primary source of SO_2 emissions from the Dewey-Burdock project will be internal engine fuel combustion from mobile and stationary sources.

The maximum yearly SO_2 emissions from the Dewey-Burdock Project were modeled for potential impacts on ambient air quality at all receptors in the modeling domain. Both on-site and off-site, project-related emission sources were included in the model. Variable emission rates were used, based on month, day and hour. The model produced maximum hourly receptor concentrations by calendar day, the 99^{th} percentile of these daily maxima by year, and the three-year average of the 99^{th} percentiles. It also produced 3-hr maxima, 24-hr maxima, and the average receptor concentrations for the entire modeling period (annual average). In order to characterize worst-case, short-term impacts, the modeling period spanned three years of hourly meteorological conditions.

Results from the initial AERMOD run are presented below. All receptors, including those at Wind Cave National Park, were compliant with the appropriate standards. The 24-hr and annual average values were all very near zero. Table 6-10 lists the top 20 receptors ranked by 3-hr average concentrations. Table 6-11 lists the top 50 receptors ranked by 3-year average of the 1-hour maximum (99^{th} percentile) concentrations. Figure 6-13 is an isopleth, or contour plot of the annual impacts from the Dewey-Burdock Project. Figure 6-14 is an isopleth map of the maximum 24-hr impacts. Figure 6-15 is an isopleth map of the maximum 3-hr impacts. Figure 6-16 is an isopleth map of the 99^{th} percentile 1-hr impacts.

Table 6-10: Top 20 Receptors, 3-Hr Maximum SO_2

UTM Easting	UTM Northing	Maximum Modeled Concentration (μg/m^3)	PSD Class II Standard (μg/m^3)
576361	4816399	118.70	1300
576358	4816629	118.52	1300
576158	4816710	96.66	1300
576158	4817210	72.17	1300
581158	4810710	69.43	1300
577137	4815932	66.69	1300
581228	4810638	64.72	1300
576945	4815934	62.48	1300
581225	4810873	57.03	1300
576349	4817319	55.81	1300

577141	4815703	55.26	1300
576752	4815936	50.43	1300
580158	4810210	49.28	1300
576346	4817549	48.42	1300
576658	4815710	46.84	1300
576594	4817552	44.73	1300
576158	4817710	43.98	1300
576560	4815937	43.92	1300
575158	4816710	42.56	1300
576367	4815939	42.33	1300

Table 6-11: Top 50 Receptors, 99th percentile of Daily Maximum 1-Hr SO_2 Values

UTM Easting	UTM Northing	Maximum Modeled Concentration (µg/m^3)	NAAQS Concentration (µg/m^3)
577137	4815932	69.80	200
577141	4815703	59.98	200
576945	4815934	57.65	200
576358	4816629	53.96	200
577145	4815474	48.94	200
576752	4815936	46.97	200
576158	4816710	41.82	200
577149	4815245	41.60	200
576364	4816169	41.60	200
576361	4816399	40.65	200
576658	4815710	38.04	200
576158	4816210	37.69	200
576560	4815937	36.85	200
576355	4816859	35.65	200
576658	4815210	35.41	200
581202	4812757	34.02	200
577153	4815016	32.48	200
576367	4815939	31.07	200
576349	4817319	30.95	200
581158	4812710	30.16	200
581200	4812993	29.98	200
576594	4817552	29.92	200
581205	4812522	29.88	200
576352	4817089	29.38	200
576158	4817210	29.23	200
581191	4813699	28.57	200
576658	4814710	27.62	200
576658	4817710	27.33	200

581158	4812210	26.95	200
581208	4812286	26.91	200
576158	4815710	26.15	200
581158	4813710	25.98	200
582778	4816050	25.85	200
581197	4813228	25.83	200
576158	4815210	25.21	200
581158	4813210	24.99	200
581220	4811344	24.76	200
581211	4812051	24.55	200
577157	4814787	24.15	200
576841	4817556	24.13	200
581194	4813464	24.12	200
577158	4814710	23.48	200
580658	4812210	23.48	200
581466	4810407	23.02	200
580658	4812710	22.84	200
581158	4811210	22.74	200
581188	4813935	22.72	200
581214	4811815	22.62	200
584395	4814482	22.39	200
583007	4816054	22.23	200

Figure 6-13. Modeled Annual SO_2 Concentrations

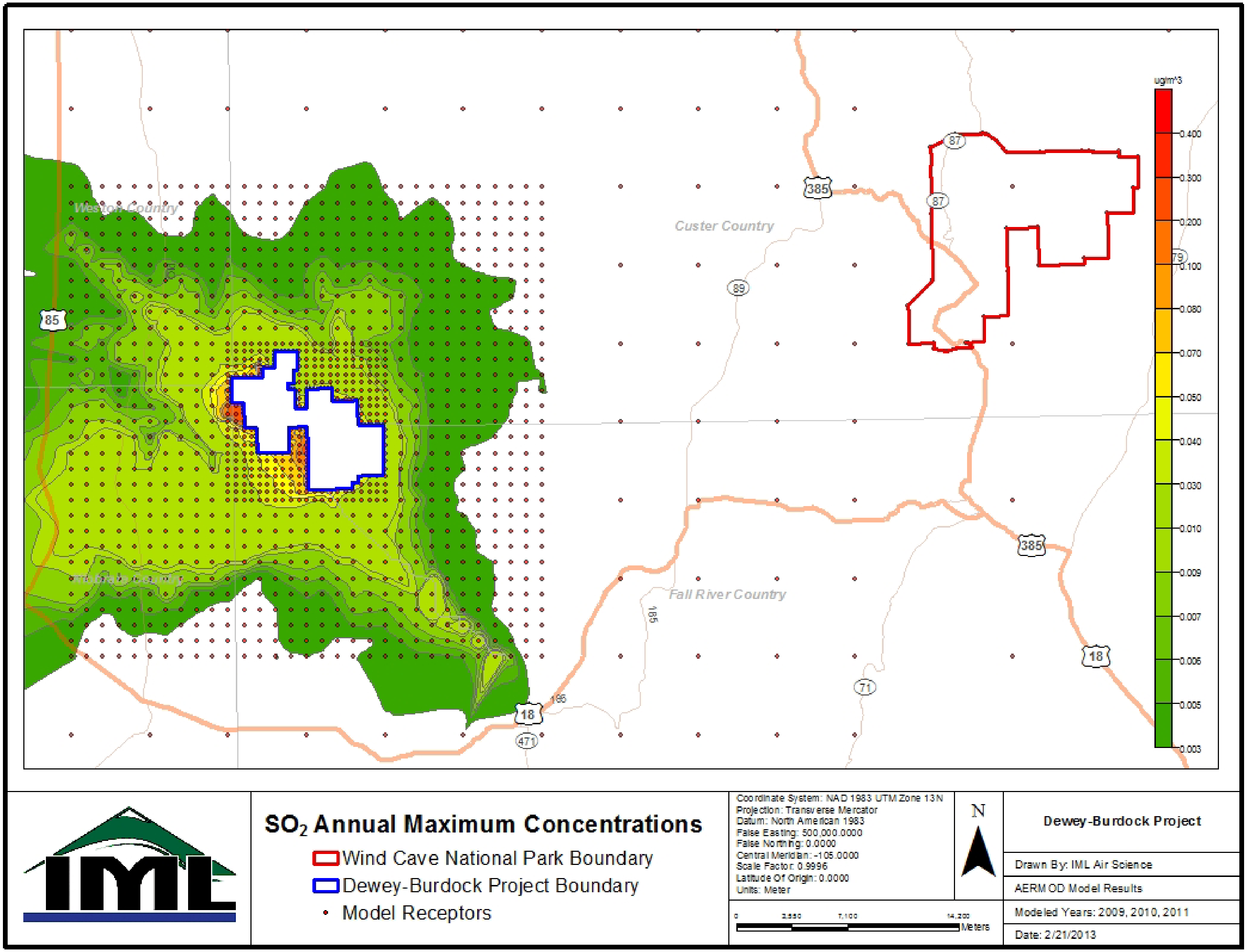


Figure 6-14. Modeled Maximum 24-Hour SO_2 Concentrations

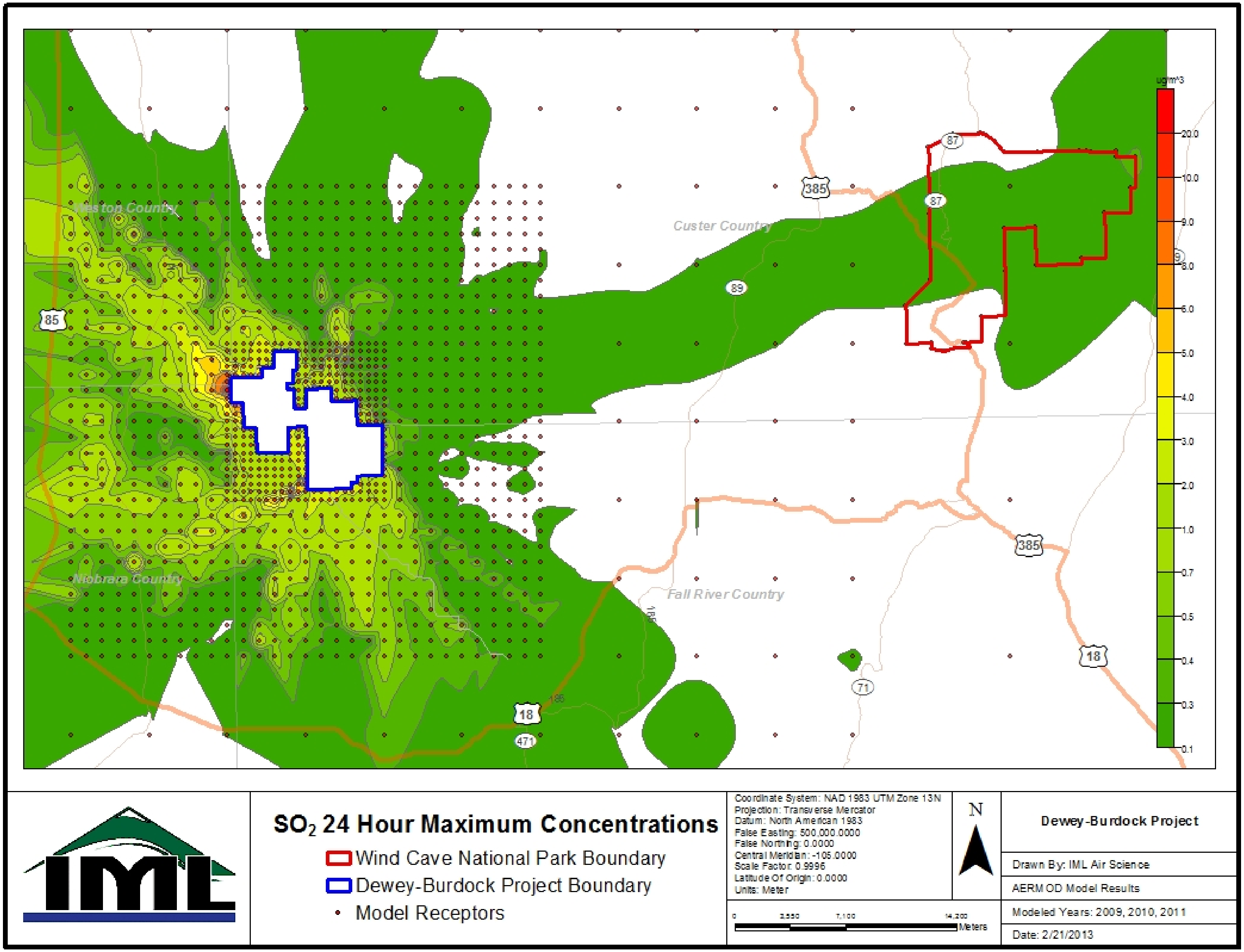


Figure 6-15. Modeled Maximum 3-Hour SO_2 Concentrations

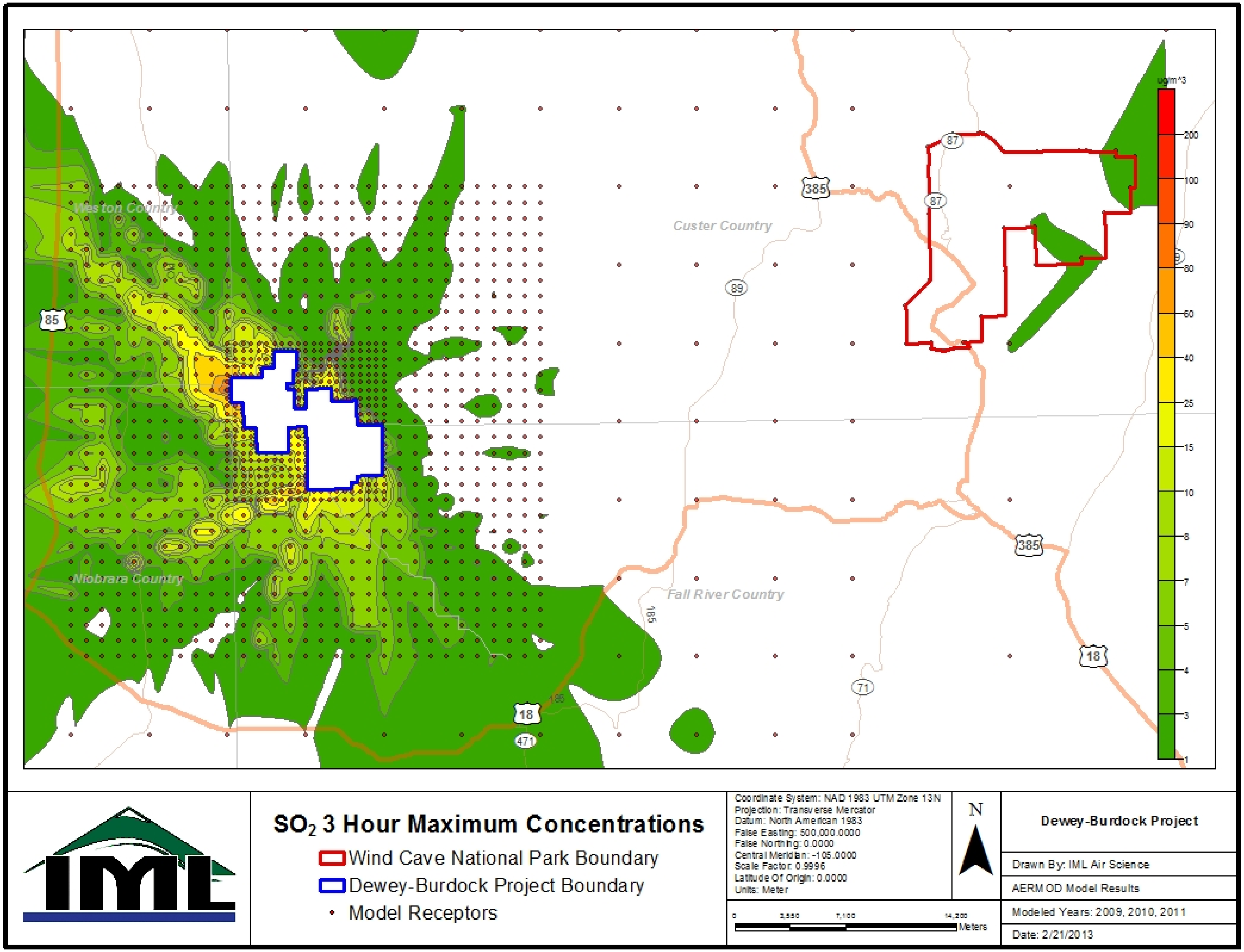
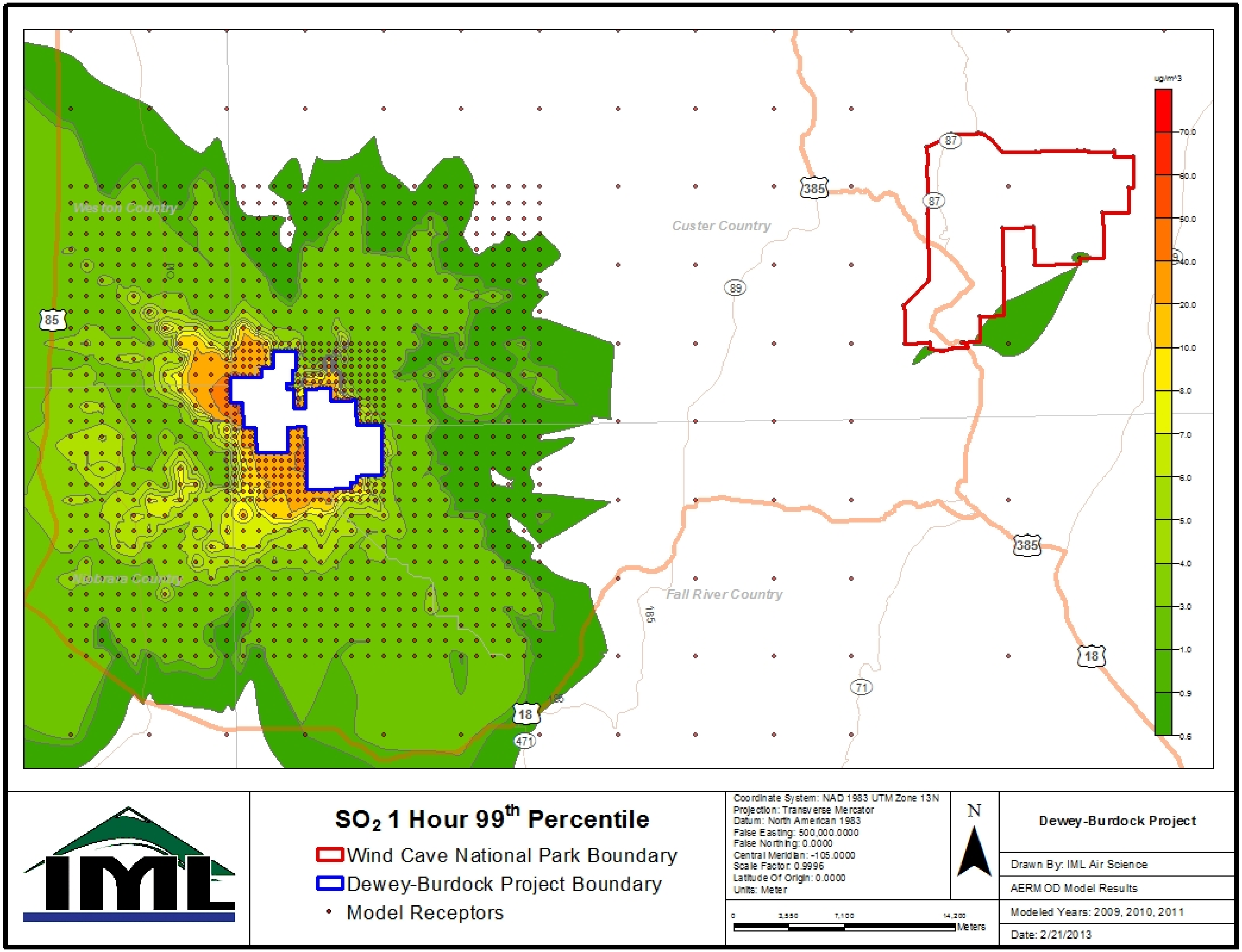


Figure 6-16. Modeled 99th Percentile 1-Hour SO_2 Concentrations



6.6. CO Modeling Analysis

The primary source of CO emissions from the Dewey-Burdock project will be internal engine fuel combustion from mobile and stationary sources.

The maximum yearly CO emissions from the Dewey-Burdock Project were modeled for potential impacts on ambient air quality at all receptors in the modeling domain. Both on-site and off-site, project-related emission sources were included in the model. Variable emission rates were used, based on month, day and hour. The model produced maximum 1-hr and 8-hr receptor concentrations over the modeling period. In order to characterize worst-case, short-term impacts, the modeling period spanned three years of hourly meteorological conditions.

Results from the initial AERMOD run are illustrated below. All receptors, including those at Wind Cave National Park, were compliant with the applicable standards. As shown in Table 6-1, all modeled concentrations of CO constituted a small fraction of the NAAQS, and are therefore not tabulated separately. Figure 6-17 is an isopleth, or contour plot of the maximum 8-hr impacts from the Dewey-Burdock Project. Figure 6-18 is an isopleth map of the maximum 1-hr impacts.

Figure 6-17. Modeled Maximum 8-Hr CO Concentrations

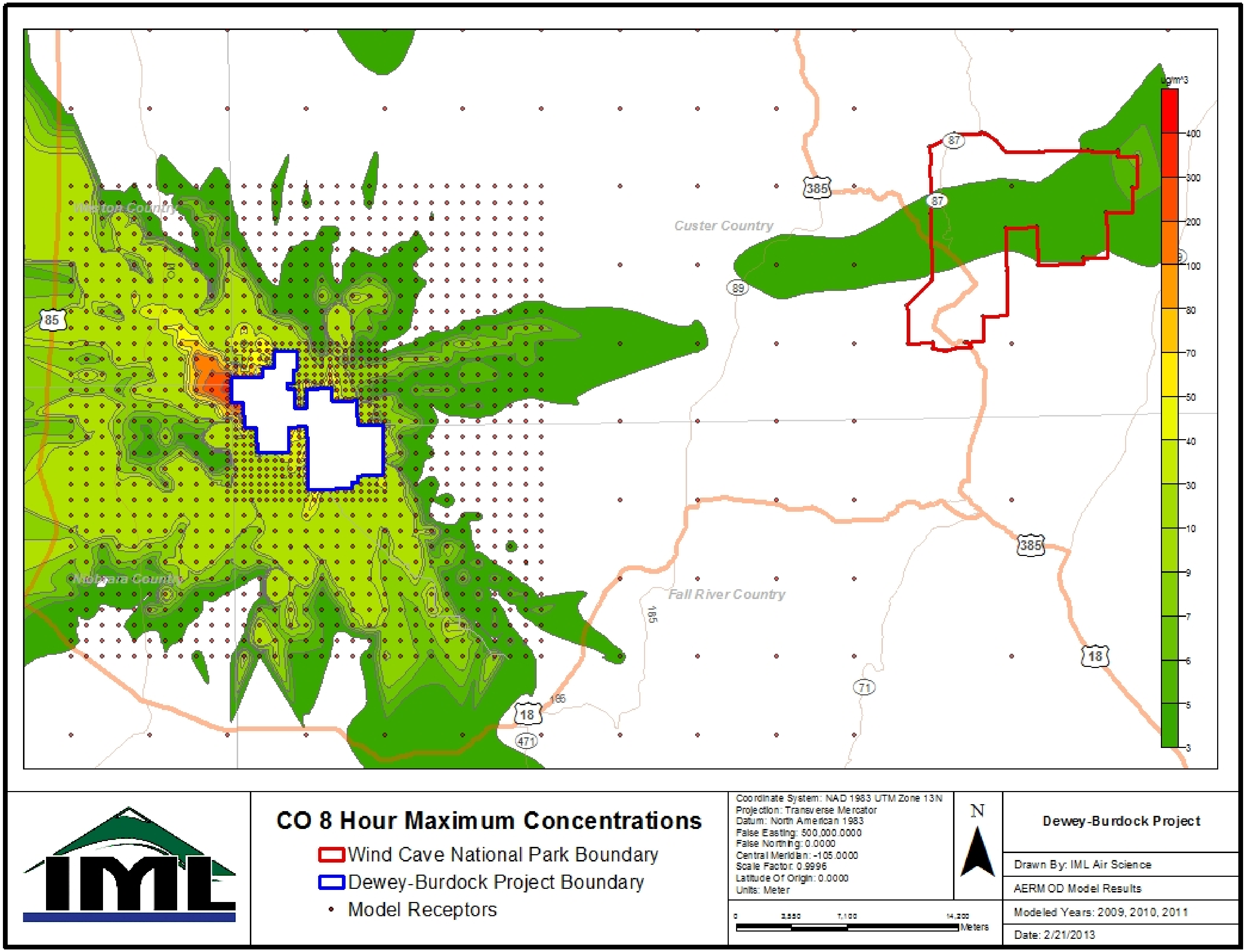
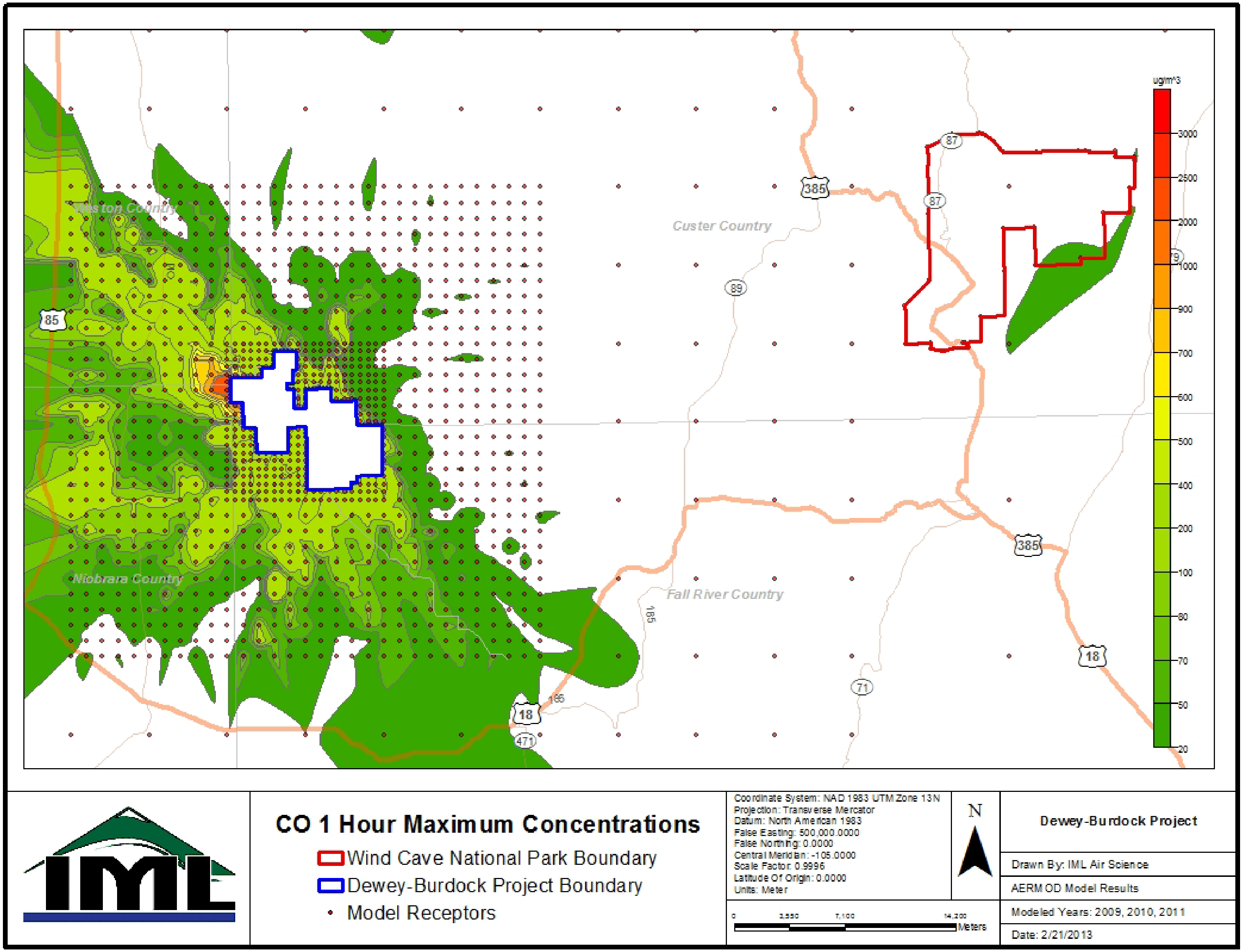
1. 

Figure 6-18. Modeled Maximum 1-Hr CO Concentrations



7 CALPUFF MODELING RESULTS AND ANALYSIS

7.1. Introduction

The purpose of AQRV modeling is to ensure that Class I area resources (i.e., visibility, flora, fauna, etc.) are not adversely affected by the projected emissions from a proposed project. AQRV's are resources which may be adversely affected by a change in air quality. Based on its proximity to the Wind Cave National Park, a federally mandated Class I area, the Dewey-Burdock Project was modeled to determine its potential AQRV impacts at Wind Cave. Species modeled included PM_{10}, $PM_{2.5}$, SO_2, NO_x, SO_4, $NHNO_3$ and NO_3. The first four of these would be emitted by the project, while the other three were based on reaction chemistry in the atmosphere.

The model selected for AQRV impact analysis (recommended by EPA and the Federal Land Managers) is CALPUFF, along with its companion models CALMET and CALPOST. In addition to the above seven species, elemental carbon (EC) and organic carbon (SOA) were enabled in the model to accommodate Visibilty Method 8.1. Visibility model outputs included daily background light extinction at receptors in Wind Cave National Park, to which the project impacts were added. By contrast, the modeled atmospheric deposition rates were attributable only to project emissons. Background deposition rates and significance thresholds were obtained from sources outside the model.

The CALPUFF modeling domain was selected to include the project area, Wind Cave National Park, and a 50-km buffer to provide meteorological model continuity. This resulted in a 200-km by 200-km modeling grid (Figure 7-1). A total of 192 model receptor locations were obtained for Wind Cave from the National Park Service (Figure 7-2). Modeled emission sources and emission rates were identical to those configured in the AERMOD model (Figure 7-3).

Visibility impacts from the Dewey-Burdock Project at Wind Cave were modeled under two scenarios. The first one included coarse particulate matter (PM_{10}) in computing total light extinction, which resulted in a 98^{th} percentile of 24-hour changes in visibility (relative to background) of just over 5%. This level of change in visibility is considered barely perceptible by 50% of the viewers. Thus, the result of the first scenario was barely over the significance threshold. The second scenario excluded PM_{10} from this

computation, resulting in a 98th percentile of 24-hour changes in visibility of less than 2%, well below the significance threshold. Section 7.2 presents evidence and precedent for the validity of the second scenario, due to CALPUFF's lack of accounting for deposition of most PM_{10} particles within a short distance of the emission source.

Atmospheric deposition (also known as acid deposition), another measure of AQRV impact, is modeled by CALPUFF as the deposition of a variety of species containing nitrogen and sulfur. SO_2 and NO_x emissions from the Dewey-Burdock Project constitute potential sources of acid deposition at Wind Cave National Park. The modeled deposition rates predicted by CALPUFF were first compared to measured deposition rates at Wind Cave. Second, the modeled deposition rates were compared to estimated critical loads at Wind Cave, below which no harmful impacts to the ecosystem would be expected to occur. Third, the modeled deposition rates were compared to the deposition analysis thresholds established by the U.S. Forest Service, below which deposition impacts are considered negligible. Section 7.3 presents these comparisons and demonstrates that modeled annual deposition impacts from the Dewey-Burdock Project are less than the deposition analysis thresholds for nitrogen and sulfur by an order of magnitude. Given these results and the fact that measured deposition rates are substantially lower than the estimated critical loads for both sulfur and nitrogen, deposition impacts from the Dewey-Burdock Project at Wind Cave will be insignificant.

Ambient concentrations of all modeled pollutants at each receptor were also output from CALPOST. Appendix C contains a report summarizing the maximum modeled 24-hr PM_{10} and $PM_{2.5}$ concentrations, maximum 24-hr total light extinction and maximum 24-hr atmospheric deposition rates at Wind Cave National Park. None of the modeled species showed concentrations exceeding any applicable standards. The maximum 24-hr $PM_{2.5}$ concentration from CALPUFF was 0.4 $\mu g/m^3$. This was considerably less than the maximum 24-hr $PM_{2.5}$ concentration of 3 $\mu g/m^3$ from AERMOD (see Section 6 above), and well under the PSD Class I increment of 2 $\mu g/m^3$.

Figure 7-1. CALPUFF Modeling Domain

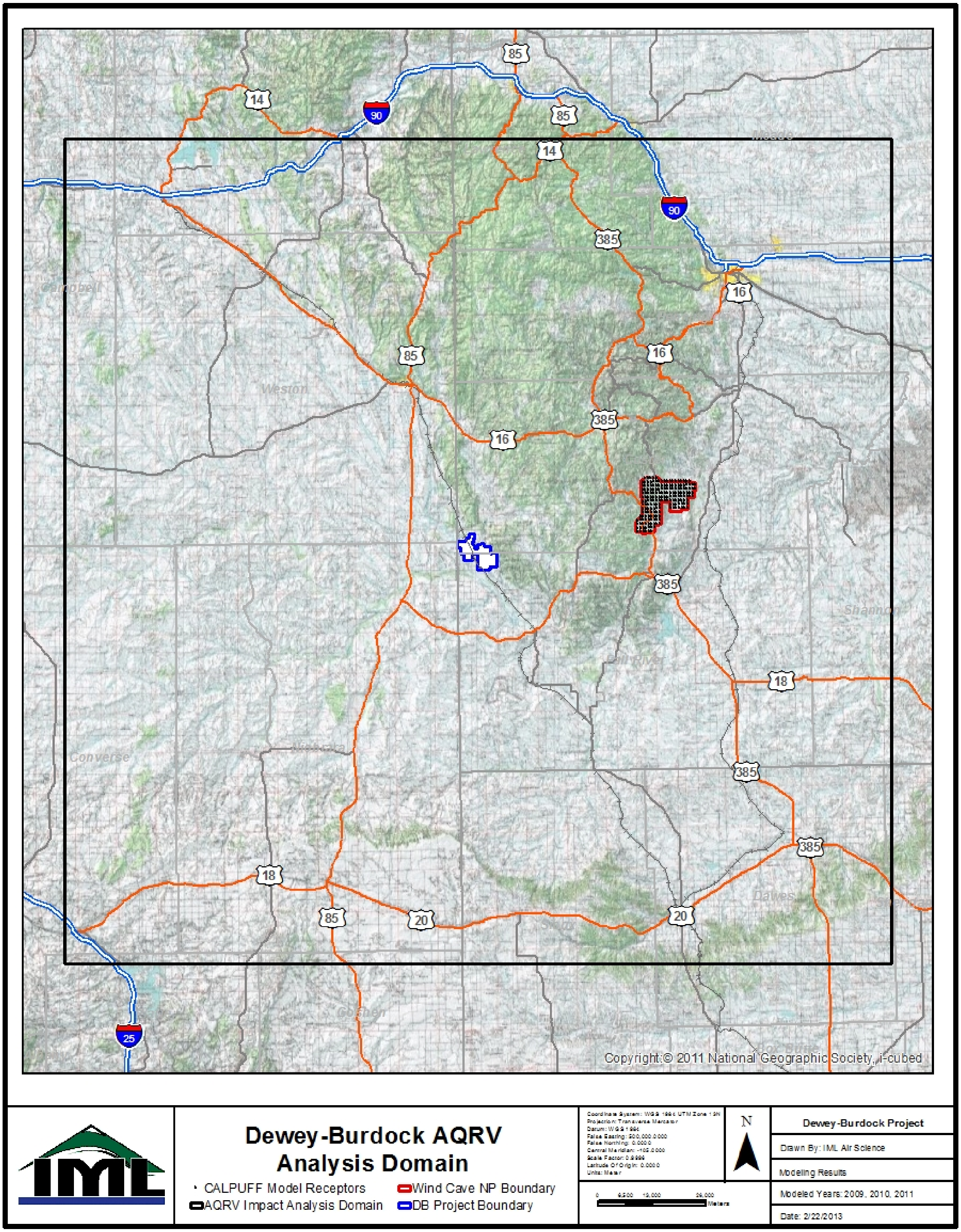


Figure 7-2. CALPUFF Model Receptors

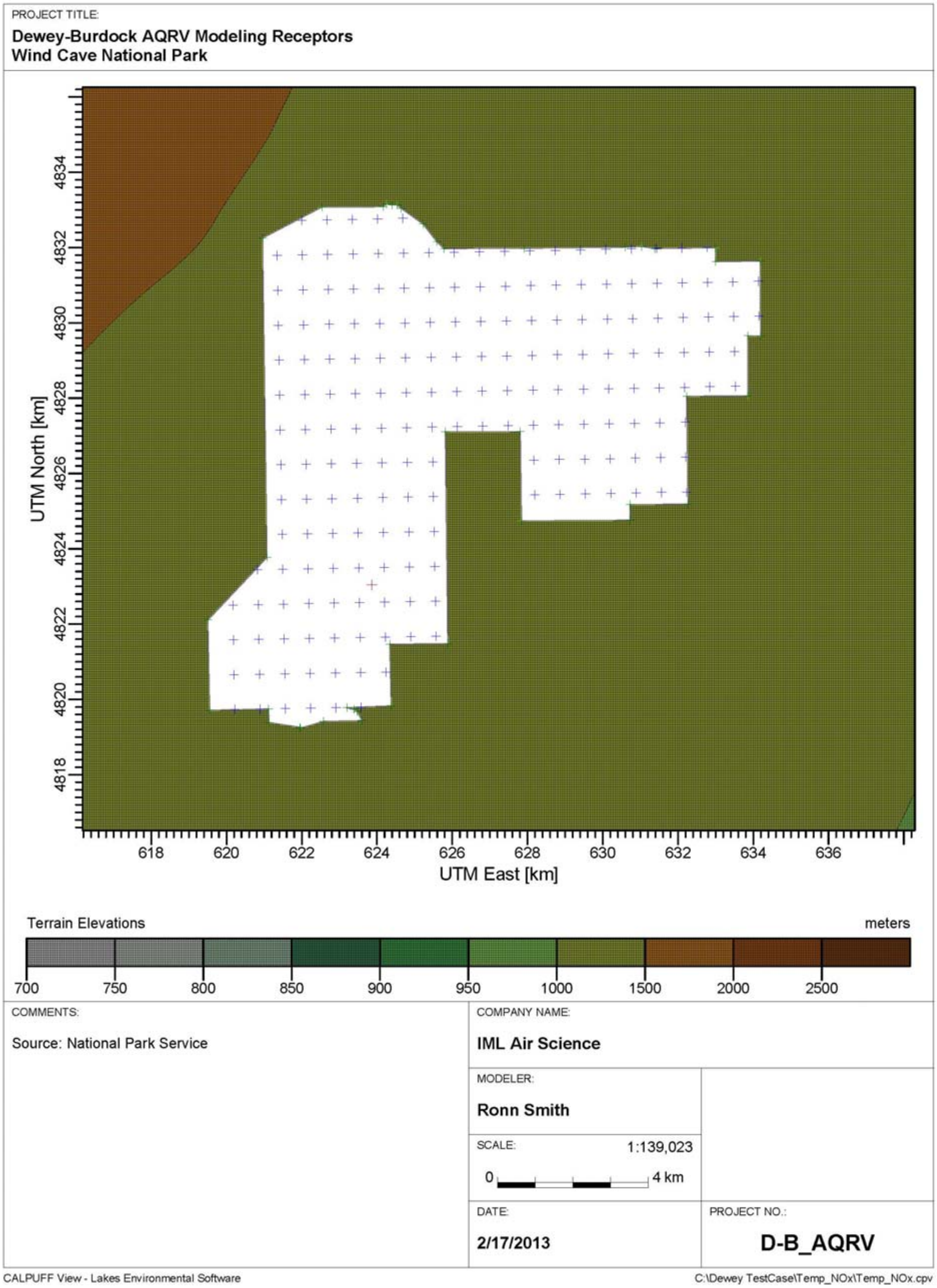
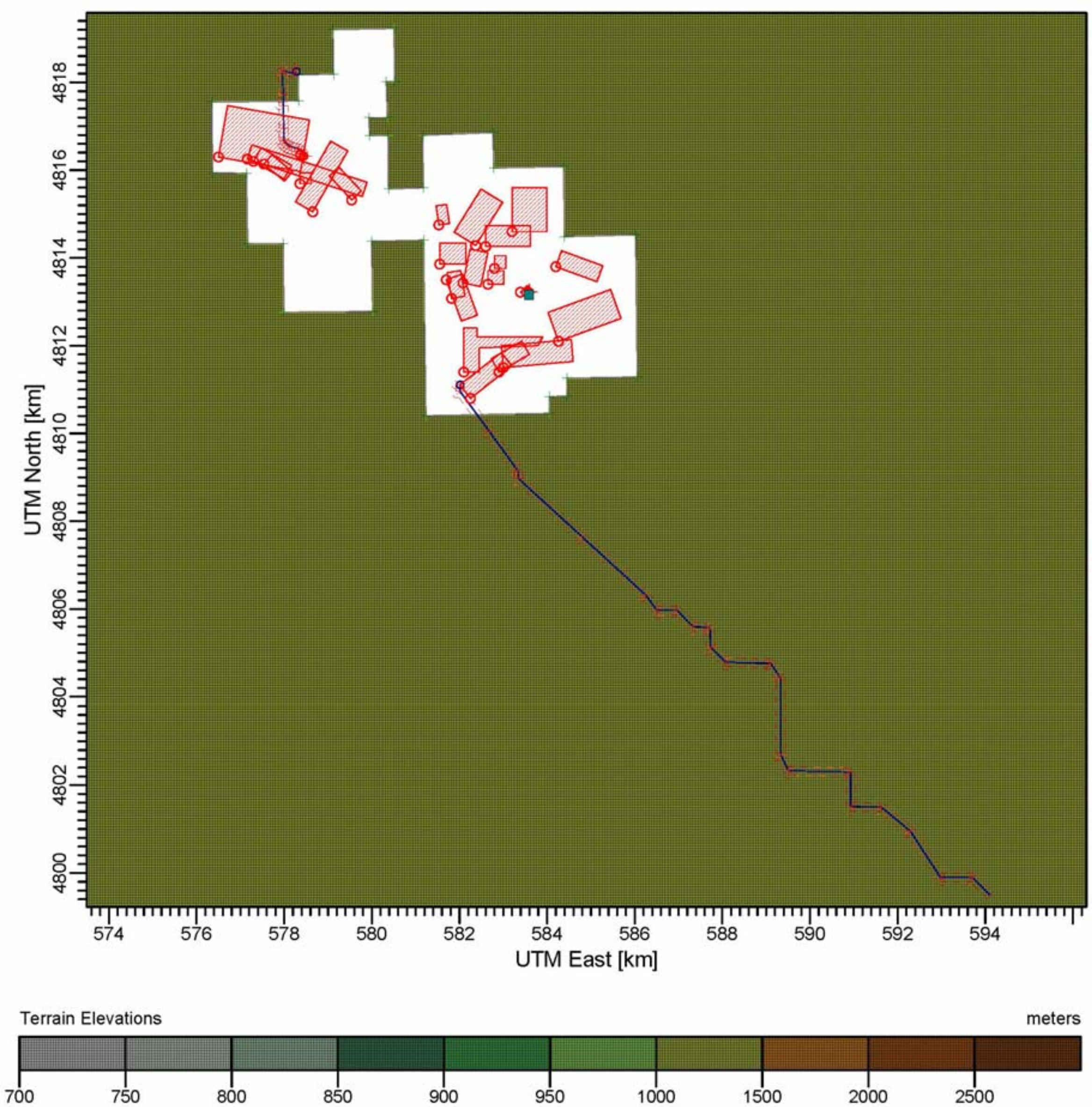


Figure 7-3. CALPUFF Modeled Emission Sources

PROJECT TITLE:

Dewey-Burdock AQRV Modeling
Emission Source Locations



COMMENTS:

Source: Dewey-Burdock Emissions Inventory

COMPANY NAME:

IML Air Science

MODELER:

Ronn Smith

SCALE: 1:143,415

0 4 km

DATE:

2/17/2013

PROJECT NO.:

D-B_AQRV

CALPUFF View - Lakes Environmental Software

C:\Dewey TestCase\Temp_NOx\Temp_NOx.cpv

7.2. Visibility Analysis

7.2.1. Basis for Analysis

In August 1977, the federal Clean Air Act was amended by Congress to establish the following national goal for visibility protection:

> "Congress hereby declares as a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory class I Federal areas which impairment results from man-made air pollution."

To address this goal for each of the 156 mandatory federal Class I areas across the nation, the federal Environmental Protection Agency (EPA) developed regulations to reduce the impact of large industrial sources on nearby Class I areas. It was recognized at the time that regional haze, which comes from a wide variety of sources that may be located far from a Class I area, was also a part of the visibility problem.

The 1977 Clean Air Act Amendments also established the Prevention of Significant Deterioration (PSD) permit program, which included consultation with federal land managers on visibility impacts and public participation in permitting decisions. The PSD permit program was delegated to South Dakota on July 6, 1994, and later approved in South Dakota's State Implementation Plan on January 22, 2008.

In 1980, EPA adopted regulations to address "reasonably attributable visibility impairment", or visibility impairment caused by one or a small group of man-made sources generally located in close proximity to a specific Class I area. Most visibility impairment occurs when pollution in the form of small particles scatters or absorbs light. Air pollutants are emitted from a variety of natural and anthropogenic sources. Natural sources can include windblown dust and smoke from wildfires. Anthropogenic sources can include motor vehicles, electric utility and industrial fuel burning, prescribed burning, and mining operations. More pollutants mean more absorption and scattering of light, which reduce the clarity and color of scenery. Some types of particles such as sulfates and nitrates scatter more light, particularly during humid conditions. Other particles like elemental carbon from combustion processes are highly efficient at absorbing light.

Commonly, visibility is observed by the human eye and the object may be a single viewing target or scenery. In the 156 Class I areas across the nation, a person's visual range has been substantially reduced by air pollution over the past few decades. A common measure of visual resources is the haze index, expressed in deciviews (dv). The deciview is a metric used to represent normalized light extinction attributable to visibility-affecting pollutants. A 0.5 dv change equals about a 5% change in visible range and is barely perceptible by about 50% of the observers. A 1.0 dv change is perceptible by almost all observers.

For sources generally further than 50 km from a Class I area, the visibility threshold of concern is not exceeded if the 98th percentile change in light extinction is less than 5% for each year modeled, when compared to the annual average natural condition value for that Class I area (FLAG 2010). A 5% change in light extinction is equivalent to a 0.5 dv change in visibility. When assessing visibility impairment from regional haze, EPA guidelines indicate that for a source whose 98th percentile value of the haze index, evaluated on a 24-hour average basis, is greater than 0.5 dv is considered to contribute to regional haze visibility impairment. Similarly, a source that exceeds 1.0 dv causes visibility impairment (FLAG 2010).

7.2.2. Preliminary Modeled Visibility Impacts

Wind Cave National Park, located approximately 50 km east-northeast of the proposed Dewey-Burdock Project, is the nearest Class I area and the only one in the modeling domain. The maximum potential air emissions from the project were modeled for impacts on visibility at Wind Cave, using the CALPUFF software and modeling protocol discussed in Section 5 of this report. The modeling results, with and without consideration of coarse particulate matter (PM_{10}) emissions from the Dewey-Burdock Project, are summarized in Table 7-1. Project emissions of fine particulate matter ($PM_{2.5}$) were included in both model runs, along with oxides of nitrogen and sulfur. These three species, along with organic carbon, are the primary contributors to visibility impairment in the Wind Cave region (DENR 2010).

Table 7-1: Trial Visibility Analysis

Year	98th Percentile of 24-Hour Changes in Deciviews (Δdv)	
	Modeled with coarse PM_{10}	**Modeled without coarse PM_{10}**
2009	0.53	0.14
2010	0.47	0.17
2011	0.62	0.17
Average	**0.54**	**0.16**

7.2.3. CALPUFF Visibility Model Weakness

There is evidence and precedent that supports excluding ground-level, fugitive PM_{10} emissions from the assessment of project impacts on visibility at Wind Cave (see discussion below). Even without this exclusion, however, Table 7-1 shows the 98th percentile of the annual, 24-hour average changes in haze index to be near the visibility threshold of concern (0.5 dv). With the PM_{10} exclusion, the modeled Δdv values fall well below this threshold.

A recent EIS for a gas development in southern Wyoming discussed the exclusion of fugitive PM_{10} emissions from visibility assessment (TRC 2006). Appendix F to the EIS states, "In post-processing the PM_{10} impacts at all far-field receptor locations, the PM_{10} impacts from Project alternative traffic emissions (production and construction) were not included in the total estimated impacts, only the $PM_{2.5}$ impacts were considered. This assumption was based on supporting documentation from the Western Regional Air Partnership (WRAP) analyses of mechanically generated fugitive dust emissions that suggest that particles larger than $PM_{2.5}$ tend to deposit out rapidly near the emissions source and do not transport over long distances (Countess et al. 2001). This phenomenon is not modeled adequately in CALPUFF; therefore, to avoid overestimates of PM_{10} impacts at far-field locations, these sources were not considered in the total modeled impacts. However, the total PM_{10} impacts from traffic emissions were included in all in-field concentration estimates."

Deposition is recognized as an important effect that can lead to rapid concentration depletion in a fugitive PM_{10} emissions plume generated at or near ground level. One researcher claimed that PM_{10} will deposit out of a plume located one meter above ground in about 1 kilometer with a 3 meter/second wind speed (Sullivan 2006).

Physical measurements reported by the South Dakota Department of Natural Resources (DENR) and the Western Regional Air Partnership (WRAP) conclude that coarse mass particulates (i.e., PM_{10} and larger) contribute a small fraction toward visibility impairment at Wind Cave. DENR's Regional Haze State Implementation Plan states, "In the 1st quarter, ammonia sulfate and ammonia nitrate have the greatest impact on visibility impairment in the Wind Cave National Park. In the 2nd quarter, ammonia sulfate has the greatest impact on visibility impairment in the Wind Cave National Park in the last five years. In the 3rd quarter, organic carbon mass has the greatest impact on visibility impairment followed by ammonia sulfate. In the 4th quarter, ammonia sulfates and ammonia nitrate continue to contribute the greatest with one exception in 2005" (DENR 2010). In 2005, organic carbon dominated due to wild fires.

Despite the above findings and the fact that virtually all of the PM_{10} emissions from the Dewey-Burdock Project would be ground-level fugitive dust, initial CALPUFF modeling results showed PM_{10} emissions to be dominant in determining changes in visibility at Wind Cave. On days with non-zero Δdv values, CALPUFF attributed on average 71% of the change in visibility to PM_{10} emissions. Removing PM_{10} from the visibility analysis, as allowed for in the CALPUFF post-processor CALPOST, lowered these Δdv values proportionately.

To confirm the validity of excluding fugitive PM_{10} emissions from the visibility assessment, three test receptors were evaluated with CALPUFF. One was placed 80km east of the Dewey-Burdock Project and another 117 km northeast of the project, both near the edge of the modeling domain. At these large distances one would expect a diminished role for coarse particulate emissions from the project, in affecting overall visibility. A third receptor was placed near Wind Cave National Park as a control. CALPUFF was rerun with these test receptors, followed by post-processing in CALPOST with and without the PM_{10} option enabled. The results allowed the computation of that portion of Δdv attributable to PM_{10}, as shown in Table 7-2.

Table 7-2: Model Comparison Test, Contribution to Δdv

Receptor	Easting	Northing	Average PM_{10} Contribution	Distance from Source (km)
1	660,000	4,815,000	64%	80
2	660,000	4,900,000	75%	117
3	620,000	4,820,000	62%	40

7.2.4. Final Modeled Visibility Impacts

Table 7-2 illustrates that not only is PM_{10} the dominant contributor to modeled changes in visibility even at distant locations, but in this scenario its contribution actually increases with distance from the emission source. This runs counter to common sense, and confirms the inadequacy of CALPUFF's long-range transport model to properly account for PM_{10} deposition near the source. For this reason the visibility modeling results that exclude PM_{10} are presented here as the most representative of potential project impacts.

As shown in Table 7-3, these impacts are approximately one third the 0.5 dv threshold of concern, or significance level. There were no days during the modeled three-year period with Δdv over the significance level. The maximum 24-hr Δdv was 0.29 dv on day 238 of year 2011.

Table 7-3: Final Visibility Analysis

Model Year	98^{th} Percentile Δdv	No. of Days > 0.5 dv	No. of Days > 1.0 dv	Significance Level (Δdv)	FLM Max Δdv Threshold
2009	0.14	0	0	0.5	1.0
2010	0.17	0	0	0.5	1.0
2011	0.17	0	0	0.5	1.0

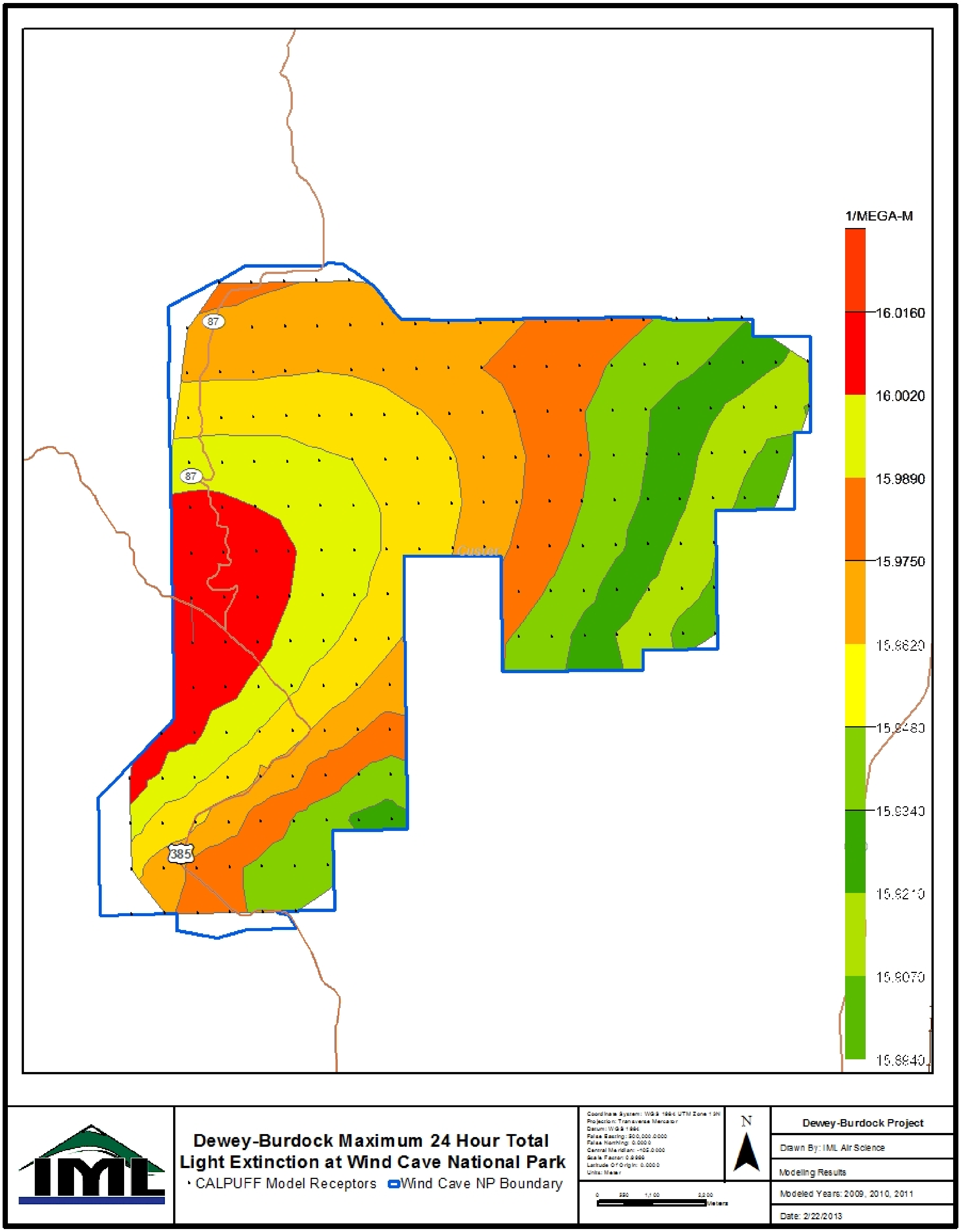
The deciview haze index is derived from calculated light extinction measurements so that uniform changes in haziness correspond to uniform incremental changes in perception across the entire range of conditions, from pristine to highly impaired. The

deciview haze index is calculated directly from the total light extinction coefficient (b_{ext} expressed in inverse megameters [Mm^{-1}]) as follows:

$$dv = 10 \ln (b_{ext}/10\ Mm^{-1})$$

CALPOST produced maximum 24-hour light extinction values for each model receptor at Wind Cave National Park. The highest 24-hr total b_{ext} was 16.0 Mm^{-1}. The corresponding background extinction on that day (without Dewey-Burdock Project impacts) was 15.5 Mm^{-1}, leading to the 0.29 dv change in the haze index reported above. Figure 7-4 is a contour map of maximum total light extinction modeled at all receptors with PM_{10} excluded.

Figure 7-4. Wind Cave 3-Yr Maximum 24-hr Light Extinction



7.3. Deposition Analysis

7.3.1. Basis for Analysis

Air pollution emitted from a variety of sources is deposited from the air into ecosystems. Of particular concern are compounds containing sulfur and nitrogen that deposit from the air into the soil or surface waters. These pollutants may cause ecological changes, such as long-term acidification, soil nutrient imbalances affecting plant growth, and loss of biodiversity.

The term critical load is used to describe the threshold of air pollution deposition that causes harm to sensitive resources in an ecosystem. A critical load is technically defined by the National Atmospheric Deposition Program as “the quantitative estimate of an exposure to one or more pollutants below which significant harmful effects on specified sensitive elements of the environment are not expected to occur according to present knowledge.” Critical loads are typically expressed in terms of kilograms per hectare per year (kg/ha/yr) of wet or total (wet + dry) deposition. Critical loads are widely used to set policy for resource protection in Europe and Canada. They are presently emerging as guidelines to help in the protection of Class I areas in the United States. Recommended critical loads for nitrogen alone range from 1.5 kg/ha/yr at sensitive alpine regions such as Rocky Mountain National Park (Fenn 2003), to 8 kg/ha/yr at Mt. Rainier, to 10-25 kg/ha/yr in mixed and short-grass prairie systems (USFS 2010).

Due to the lower elevation and absence of lakes with low acid buffering capacity at Wind Cave and throughout the northern Great Plains, it is believed that conditions in Wisconsin and Minnesota are more representative than conditions in the Rocky Mountains. Based on the Acid Deposition Control Act passed by Minnesota, the sulfur (S) deposition limit that would protect the most sensitive lakes and streams from acidification was set at 11 kg/ha/yr for the Class I Boundary Waters Canoe Area Wilderness (USFS 2013). Total S plus 20% of nitrogen (N) deposition was set at 12 kg/ha/yr, implying a critical load for N of 5 kg/ha/yr. The Forest Service shows similar thresholds for the Rainbow Lake Wilderness in Wisconsin (7.5 kg/ha/yr each, for S and N). The combined critical loads (S + N) of 17 kg/ha/yr in Minnesota and 15 kg/ha/yr in Wisconsin are consistent with the 10-to-25 kg/hr/yr range cited above for N in mixed and short-grass prairie systems.

Another measure often applied to sulfur and nitrogen deposition is the Deposition Analysis Threshold, or concern threshold, below which estimated impacts from a source are considered negligible. In the Class I areas of Colorado, Wyoming and Montana where high mountain lakes often exhibit low acid neutralization capacity, this threshold has been set by the U.S. Forest Service at 0.005 kg/ha/yr for sulfur and the same for nitrogen. In Wisconsin and Minnesota, the Class I thresholds are 0.010 kg/ha/yr. To date, no concern threshold has been published for Class I areas in South Dakota, but the 0.010 kg/ha/yr value appears representative.

7.3.2. Modeled Deposition Fluxes

In order to assess potential impacts of the Dewey-Burdock Project on atmospheric deposition at Wind Cave National Park, it is necessary to examine current conditions. Table 7-4 summarizes actual measurements of precipitation chemistry at Wind Cave for the modeled years. Samples were collected and analyzed under the National Acid Deposition Program (NADP 2012). The combined (S + N) deposition rate or flux averaged just over 4 kg/ha/yr during the three-year period.

Table 7-4: Current Acid Deposition at Wind Cave National Park (kg/ha/yr)

Year	NH4	NO3	SO4	S (inferred)	N (inferred)	S + N
2009	2.14	4.68	3.00	1.00	2.72	3.72
2010	3.04	5.29	3.48	1.16	3.56	4.72
2011	2.30	4.78	2.70	0.90	2.87	3.77
Average				**1.02**	**3.05**	**4.07**

Source: National Atmospheric Deposition Program/National Trends Network, 2012

Table 7-5 presents the results of wet and dry deposition modeling of the Dewey-Burdock Project emissions using CALPUFF. The table compares these results to measured values, concern thresholds and critical loads.

Table 7-5: Acid Deposition Modeling Analysis at Wind Cave (Wet + Dry, kg/ha/yr)

Parameter	Sulfur	Nitrogen	Sulfur + Nitrogen
Modeled daily maximum µg/m^2/sec	0.0005209	0.0008328	0.0013536
Modeled 3-yr average µg/m^2/sec	0.0000033	0.0000045	0.0000077
Modeled 3-yr average kg/ha/yr	0.0010	0.0014	0.0024
Concern threshold (kg/ha/yr)	0.010	0.010	0.020
Measured 3-yr average kg/ha/yr	1.02	3.05	4.07
Estimated critical load (kg/ha/yr)	12	5	17

First, Table 7-5 demonstrates that measured deposition flux for S and N are below the estimated critical loads, by a significant margin. Second, Table 7-5 demonstrates that the modeled annual deposition impacts from the Dewey-Burdock Project are less than the concern thresholds by an order of magnitude. Also listed are the peak 24-hr deposition rates, in µg/m^2/sec. Figures 7-5 and 7-6 provide contour plots of the modeled maximum 24-hour S deposition and N deposition fluxes, respectively.

Figure 7-5. Maximum 24-hr Sulfur Deposition Rates at Wind Cave National Park

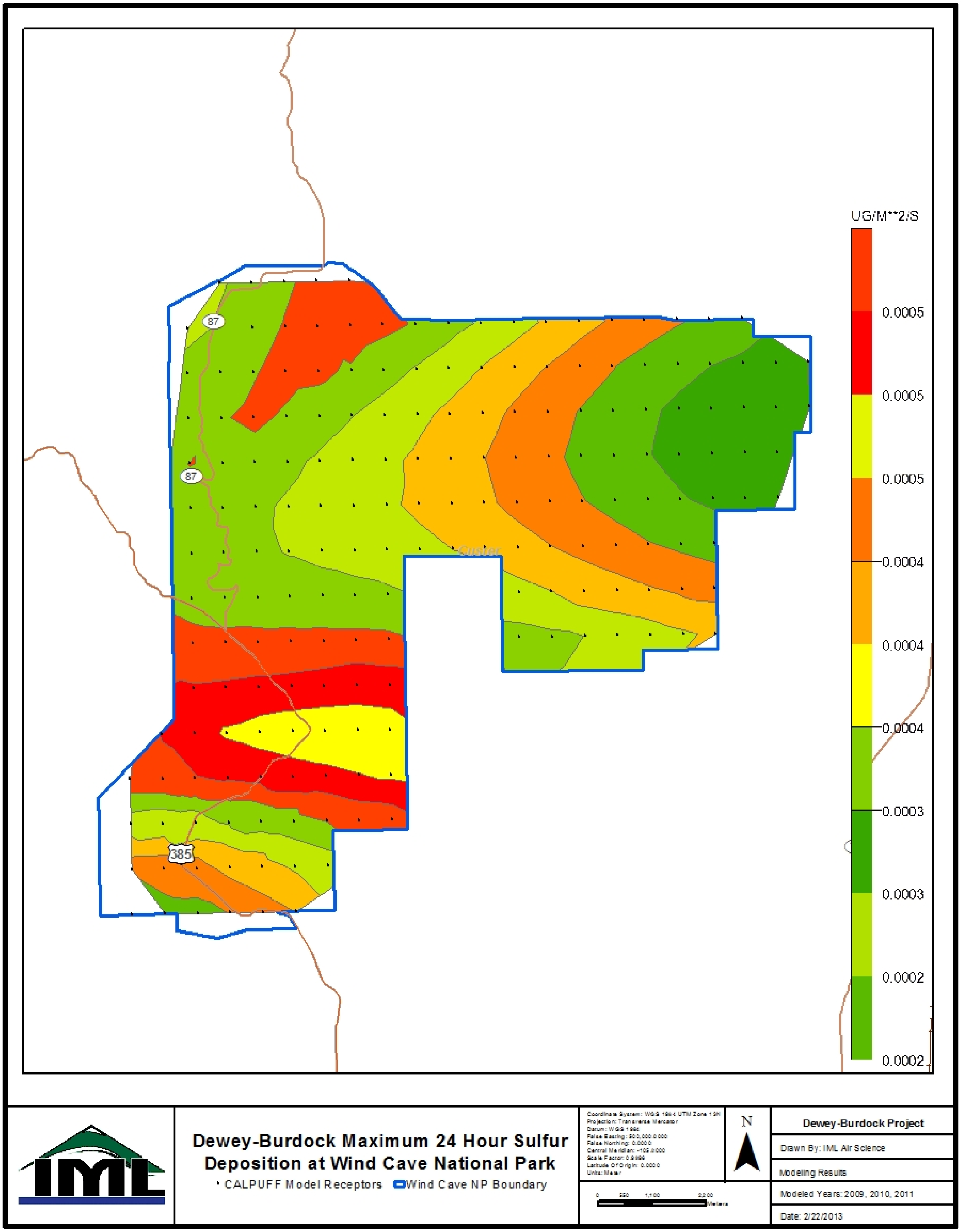
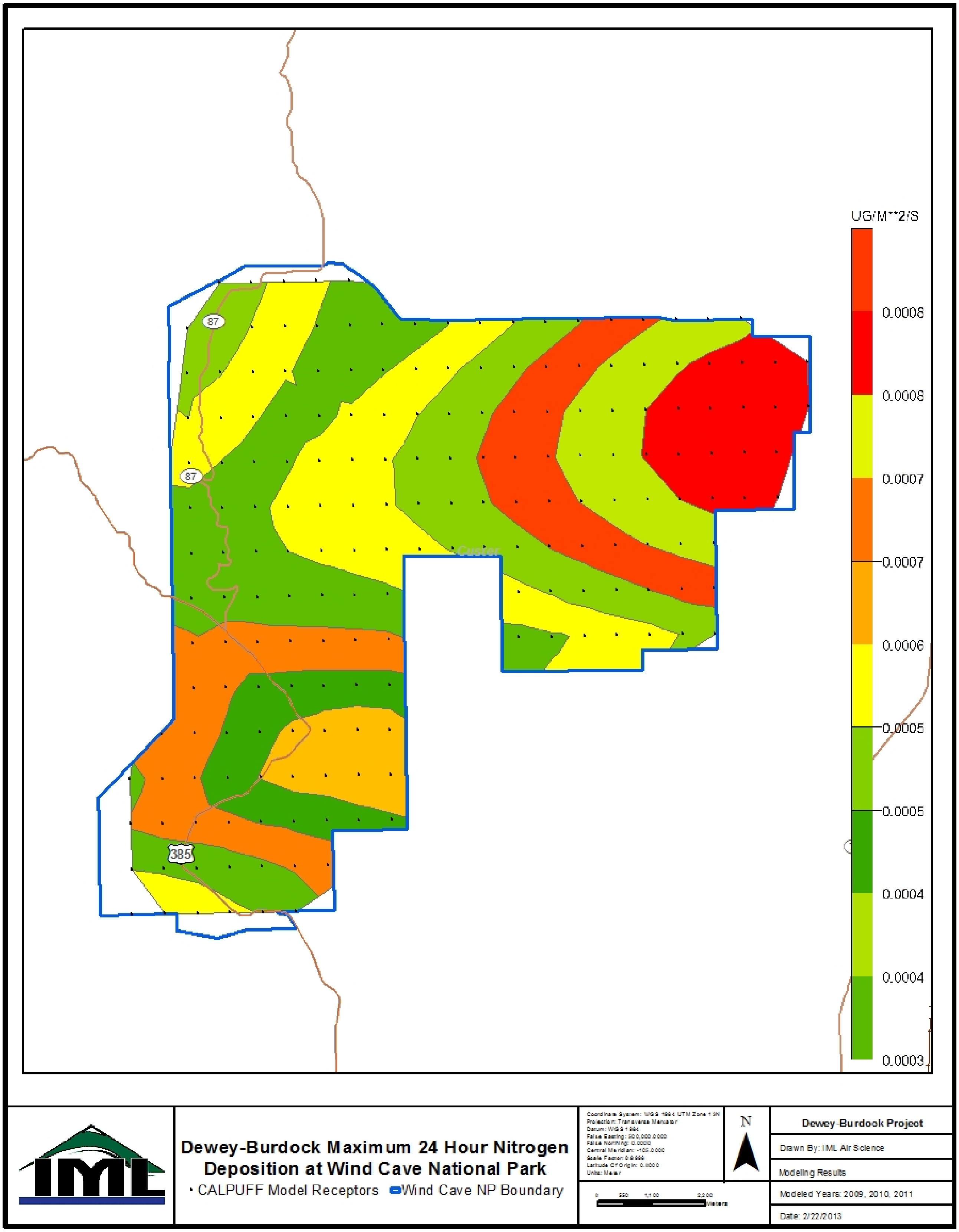


Figure 7-6. Maximum 24-hr Nitrogen Deposition Rates at Wind Cave National Park



8 REFERENCES

1. AECOM 2012, Robert Paine and David Heinold, AECOM, *Modeling Issues for Short-Term SO_2, NO_2, and $PM_{2.5}$ NAAQS Compliance*, Air & Waste Management Association 105th Annual Meeting and Exhibition, June 21, 2012.
2. Cliffs 2011, Michael E. Long, Director Environmental Strategy and Programs, Cliffs Natural Resources, *Air Quality Modeling and Impacts on the Mining Industry: An Overview*, September 26, 2011.
3. DENR 2010, South Dakota Department of Natural Resources, *South Dakota's Regional Haze State Implementation Plan*, January 2010.
4. EPA 2009, *Reassessment of the Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report: Revisions to Phase 2 Recommendations, Draft Report*, May 2009.
5. EPA 2005, USEPA, 40 CFR Part 51, *Revision to the Guideline on Air Quality Models: Adoption of a Preferred General Purpose (Flat and Complex Terrain) Dispersion Model and Other Revisions*, November 9, 2005.
6. EPA 2004, EPA, *Exhaust and Crankcase Emission Factors for Non-Road Engine Modeling - Compression Ignition*, April 2004.
7. EPA 2000, EPA, *Meteorological Monitoring Guidance for Regulatory Modeling Applications*, February 2000.
8. EPA 1998, EPA, *Control of Emissions of Air Pollution from Non-Road Diesel Engines; Final Rule, Subpart 89.112*, October 1998.
9. EPA 1995, AP 42, Fifth Edition, *Compilation of Air Pollutant Emission Factors, Volume 1: Stationary Point and Area Sources*, 1995 (multiple updates through 2012), http://www.epa.gov/ttn/chief/ap42/
10. Fenn 2003, Fenn, Mark E.; Baron, Jill S.; Allen, Edith B.; Rueth, Heather M.; Nydick, Coren R.; Geiser, Linda; Bowman, William D.; Sickman, James O.; Meixner, Thomas; Johnson, Dale W.; Neitlich, Peter, *Ecological Effects of Nitrogen Deposition in the Western United States*, 2003.
11. FLAG 2010, U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service. *Federal land managers' air quality related values work group (FLAG): phase I report—revised (2010)*, October 2010.
12. FLAG 2008, U.S. Forest Service, National Park Service, and U.S. Fish and Wildlife Service. 2008. *Federal Land Managers' Air Quality Related Values Workgroup (FLAG). 2008. Phase I Report—Revised. June 2008*.

13. IWAQM 1998, Interagency Workgroup On Air Quality Modeling, *Phase 2 Summary Report And Recommendations For Modeling Long Range Transport Impacts*, December 1998.
14. MMA 2011, McVehil-Monnett Associates, Inc., *Draft “White Paper,” Status of CAAA Section 234, Regulatory and Technical Issues Update*, May 2011.
15. MRI 2006, Midwest Research Institute. *Background Document for Revisions to Fine Fraction Ratios Used for AP-42 Fugitive Dust Emission Factors*, February 2006.
16. NADP 2012, National Atmospheric Deposition Program, *Annual Data Summary for Site: SD04 (Wind Cave National Park-Elk Mountain)*, 2012. http://nadp.sws.uiuc.edu/nadpdata/ads.asp?site=SD04
17. Pace 2005, Thompson G. Pace, US EPA, *Methodology to Estimate the Transportable Fraction (TF) of Fugitive Dust Emissions for Regional and Urban Scale Air Quality Analyses*, 8/3/2005 Revision.
18. Rosemont 2009, *Calpuff Modeling Protocol For Rosemont Copper Project To Assess Impacts On Class I Areas*, October 30, 2009.
19. Sullivan 2006, Westbrook, J.A., and Sullivan, P.S., *Fugitive Dust Modeling with AERMOD for PM_{10} Emissions from a Municipal Waste Landfill*, Specialty Conference, 2006.
20. TCEQ 1999, Texas Commission on Environmental Quality, *Texas Air Quality Modeling Guidelines*, New Source Review Permits Division, RG-25 (revised), February 1999.
21. Trinity 2009, Trinity Consultants, *Sensitivity of AERMOD in Modeling Fugitive Dust Emission Sources,* October 28, 2009.
22. Trinity 2007, Arron J. Heinerikson, Abby C. Goodman, Divya Harrison, Mary Pham, Trinity Consultants, *Modeling Fugitive Dust Sources With Aermod*, Revised January 2007.
21. TRC 2006, TRC Environmental Corporation, *Air Quality Technical Support Document, Appendix F to the Atlantic Rim Natural Gas Project and the Seminoe Road Gas Development Project, Wyoming*, July 2006.
22. USFS 2013, USDA Forest Service, Air Resource Management, Boundary Waters Canoe Area Wilderness, *Resource Concern Thresholds*, February 2013. http://www.fs.fed.us/air/technical/class_1/wilds.php?recordID=6
23. USFS 2010, U.S. Forest Service, *Assessment of Nitrogen Deposition Effects and Empirical Critical Loads of Nitrogen for Ecoregions of the United States*, L.H. Pardo, M.J. Robin-Abbott, C.T. Driscoll, editors, February 2010.

24. WRAP 2006, *CALMET/CALPUFF Protocol for BART Exemption Screening Analysis for Class I Areas in the Western United States*, Prepared for the Western Regional Air Partnership (WRAP) Air Quality Modeling Forum, by Environ, August 2006.

APPENDIX A

REVISED EMISSION CALCULATIONS

APPENDIX B

SOURCE APPORTIONMENT AND TIMING

APPENDIX C

CALPUFF RESULTS SUMMARY

APPENDIX D

AERMOD LIST FILES

APPENDIX E

CALPUFF LIST FILES