CALPUFF MODELING RESULTS FOR THE

RAY D. NIXON POWER PLANT'S "SUBJECT TO BART" DETERMINATION

By: Dale Adams, P.E.

Reviewed By: Mike Brady, P.E.

Colorado Springs Utilities
It's how we're all connected

CALPUFF MODELING RESULTS FOR THE RAY D. NIXON POWER PLANT

Introduction

The Colorado Department of Health and Environment's (CDPHE) "Subject-to-BART" modeling showed that the Ray D. Nixon Power Plant (Nixon Power Plant) would be "subject to BART" due to impacts above the 0.500 deciview threshold at the 98th percentile at the Rocky Mountain National Park and the Eagles Nest Wilderness Area. The CDPHE guidance allows facilities to conduct their own refined modeling that is consistent with the CDPHE's modeling protocol and subject to CDPHE review. Colorado Springs Utilities has conducted refined CALPUFF modeling for the Nixon Power Plant.

The main focus of the refined modeling work is the visibility impacts at the Rocky Mountain National Park and the Eagles Nest Wilderness Area. However, the CDPHE's work indicated that the next highest impacts occurred at the Great Sand Dunes National Park and the Rawah Wilderness Area. It makes sense to quantify the impacts at these additional parks from the refined modeling to ensure that changes made to the model do not adversely impact these two additional Class I Areas. However, the impacts that the Nixon Power Plant had at the remaining Class I Areas in the CDPHE's analysis were small enough to eliminate them from this refined modeling study. The four Class I Areas with the highest impacts are the focus of this study.

Colorado Springs Utilities set up and ran the CALPUFF model to obtain the visibility impact results at the four Class I Areas mentioned above. A key part of the refined analysis involved analyzing the effects that some of the wind field parameters in the CALMET input files have on the wind field. An air quality consulting firm, ENSR was retained to analyze the wind field parameters for use by the Colorado Springs Utilities. ENSR's report detailing the recommended changes to several CALMET parameters is contained in Appendix A. These CALMET parameters were used in the CALMET runs performed by the Colorado Springs Utilities.

This report provides a brief description of the modeling domain, the emissions rates entered into the model, and then mainly focuses on the results obtained from the model runs. The CALMET parameter changes are detailed in the ENSR report in Appendix A.

The model results indicate that with this refined modeling, the Nixon Power Plant does not cause visibility impacts at any of the four Class I areas above the 0.500 deciview threshold at the 98th percentile.

Modeling Domain

A fine grid domain was set up with a 50 kilometer buffer around these four Class I Areas and the Nixon Power Plant consistent with the IWAQM – Phase 2 Summary Report[1]. The grid size was set to one kilometer. The number of one kilometer cells in the *x* direction was 270 and in the *y* direction it was 450. The modeling domain is shown in Figure 2-1 in ENSR's report in Appendix A.

Emission Rates

In the CDPHE's BART Protocol, one of the acceptable methods of estimating emissions is,

> "Peak 24-hour actual emission rates (or calculated emission rates) from the most recent 3 to 5 years of operation that account for "high capacity utilization" during normal operating conditions and fuel/material flexibility allowed under a source's permit. In situations where a unit is allowed to use more than one fuel, the fuel resulting in the highest emission rates should be used for the modeling, even if that fuel has not been used in the last 3 to 5 years."

Emissions from 2003, 2004 and 2005 were analyzed to determine the peak 24-hour average maximums for SO_2 and NO_x. These emissions are expected to adequately represent future operations at Nixon Power Plant, because this time period includes operations with two types of coal. These emission rates are higher than those used by CDPHE in their Individual Source Attribution Analysis; because no data has been excluded for upset conditions. The maximum 24-hour averages for SO_2 and NO_x are given in Table 1.

Table 1 – Maximum 24 Hour Average Emission Rates

Pollutant	24-Hour Max (lbs/hr)	24 Hour Max (g/s)	Year of Occurrence
SO_2	1,889	238.0	2004
NO_x	1,199	151.1	2004

Particulate emissions need to be speciated for input to the model. The total filterable emissions were determined in a stack test for Nixon on March 21, 2003. The average filterable emission rate from three runs was 0.0105 lbs/mmBtu. The CDPHE provided a letter from Howard Gebhart to Don Shepherd that estimated fine particle emissions (PMF) to be 45% of the filterable emissions. The same letter estimated that the coarse particulate fraction (PMC) would be 55% of the total filterable emissions. It has been assumed that elemental carbon (EC) emissions are correlated with LOI (loss on ignition) measurements. The LOI at Nixon is

[1] Environmental Protection Agency, *Interagency Workgroup on Air Quality Modeling (IWAQM) Phase 2 Summary Report and Recommendations for Modeling Long Range Transport Impacts*, EPA-454-98-019, December 1998, p. 10.

typically between 2% and 3%, so the EC emissions are assumed to be 3% of the filterable emissions.

EC is calculated by: 3% x 0.0105 lbs/mmBtu = 0.0003 lbs/mmBtu
PMF is calculated by: 97% x 45% x 0.0105 lbs/mmBtu = 0.0046 lbs/mmBtu
PMC is calculated by: 97% x 55% x 0.0105 lbs/mmBtu = 0.0056 lbs/mmBtu
(Note: To convert to lbs/hr – the heat input rate used for Nixon was 2250 mmBtu/hr).

With regard to Secondary Organic Aerosols (SOA), it has been assumed that the condensable portion of the stack gas is equivalent to the filterable portion. SOA emissions are assumed to be 30% of the condensable emissions. The balance is made up of HCl, HF, SO4 and other compounds.

Sulfuric acid gas emissions were measured in a stack test in 2005. The test result showed an emission rate of 1.47 E-05 lbs/mmBtu.

Table 2 present a summary of the above information. These PM emissions rates are identical to those used by CDPHE in the Individual Source Attribution Analysis to two or more significant figures.

Table 2 – Speciated PM Emissions Used in the CALPUFF Model

Pollutant	lbs/mmBtu	g/s	Lbs/hr
PMF	0.0046	1.2993	10.3122
PMC	0.0056	1.5881	12.6038
EC	0.0003	0.0893	0.7087
SOA	0.0032	0.8930	7.0874
SO4	1.47E-05	0.0042	0.0331
TOTAL	0.0137	3.8739	30.7452

Due to the fact that assumptions had to be made for SOA and EC emissions, additional stack testing has recently been conducted. The results are not yet final, but indicate that the values used for SOA and EC are reasonable.

Changes to CALMET Parameter Settings

An air quality consulting firm, ENSR, was retained by the Colorado Springs Utilities to evaluate the wind fields generated by CALMET. ENSR evaluated several parameter settings in the CALMET input files to determine the settings that produced the best wind fields. The parameter settings recommended by ENSR were used in this analysis.

ENSR's report, entitled *Refined CALMET Wind Field Analysis for the Colorado Springs Utilities' Ray D. Nixon Power Plant* can be found in Appendix A. ENSR's report supports the limited number of parameters that were changed in the CALMET input files (R1, R2, RMAX1, RMAX2, and TERRAD).

CALPUFF, POSTUTIL, and CALPOST

The CDPHE provided CALPUFF, POSTUTIL and CALPOST input files to each facility that requested them. The expectation of the CDPHE is that few changes would be made to these portions of the model. The Colorado Springs Utilities did not make any changes to the parameter settings in any of the three portions of the model. In addition, all model versions used were the ones specified by the CDPHE in their modeling protocol.

Results

Nixon's impacts at the four Class I Areas identified above are shown in Figure 1. All of the impacts at the 98th percentile are below the 0.500 deciview threshold.

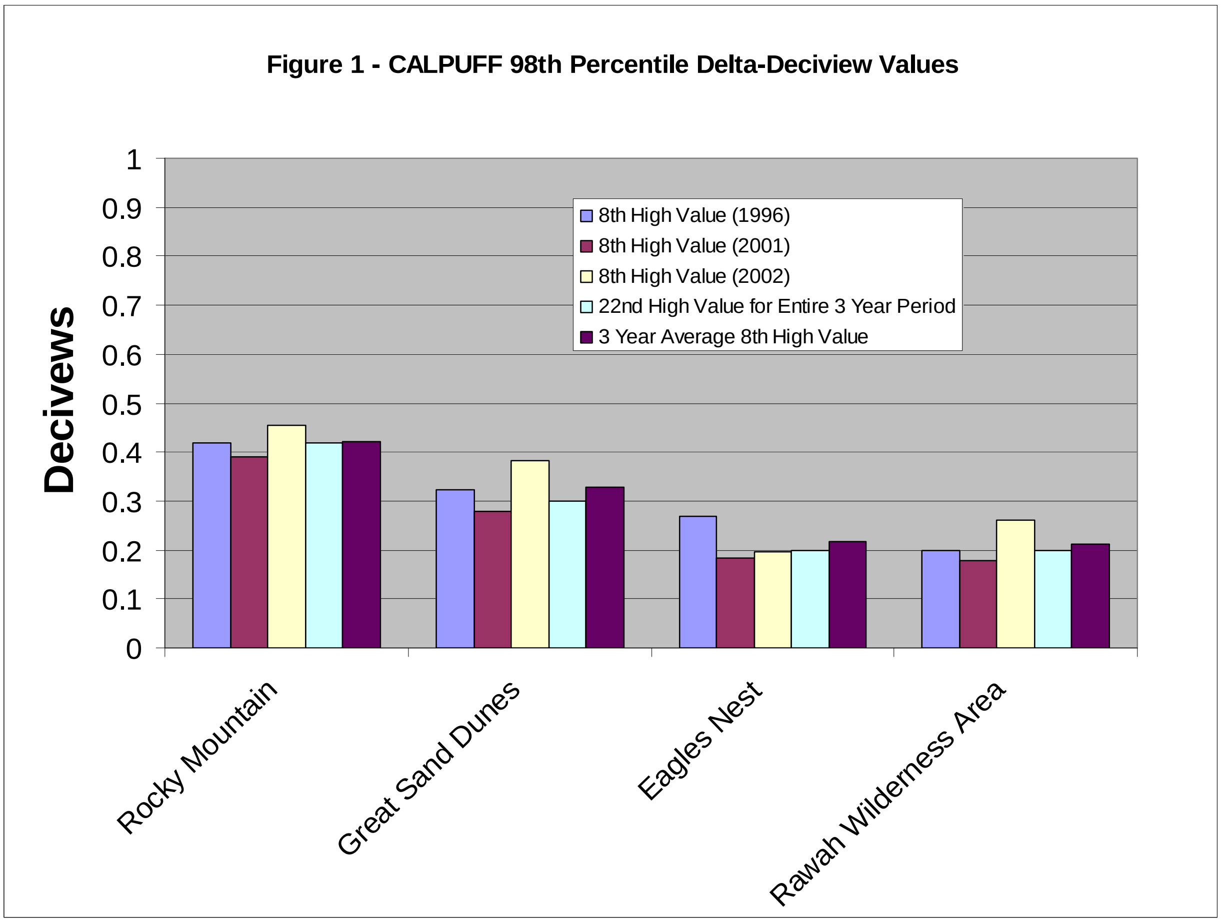


Table 3 contains the top eight deciview impacts at each of the parks for the three years that were modeled. Again, all of the impacts at the 09th percentile are below the 0.500 deciview threshold.

Table 3 - Results for Four Park Areas for 1996, 2001, and 2002

For 1996

Rocky Mtn. Nat. Park			Great Sand Dunes			Eagle's Nest			Rawah Wild. Area		
Day	dV	Rank	Day	dV	Rank	Day	dV	Rank	Day	dV	Rank
306	1.113	1	67	0.924	1	34	1.060	1	306	0.703	1
34	1.021	2	332	0.693	2	33	0.799	2	34	0.566	2
145	0.828	3	239	0.688	3	255	0.395	3	322	0.518	3
60	0.640	4	296	0.459	4	96	0.364	4	145	0.383	4
322	0.455	5	271	0.452	5	60	0.354	5	238	0.342	5
222	0.434	6	33	0.359	6	97	0.336	6	60	0.316	6
96	0.432	7	226	0.332	7	59	0.296	7	146	0.215	7
238	0.418	8	160	0.324	8	237	0.268	8	33	0.199	8
4 Days > 0.5 dV			3 Days > 0.5 dV			2 Days > 0.5 dV			3 Days > 0.5 dV		

For 2001

Rocky Mtn. Nat. Park			Great Sand Dunes			Eagle's Nest			Rawah Wild. Area		
Day	dV	Rank	Day	dV	Rank	Day	dV	Rank	Day	dV	Rank
60	0.734	1	125	0.784	1	40	0.458	1	60	0.326	1
171	0.620	2	332	0.404	2	173	0.420	2	191	0.314	2
173	0.529	3	243	0.381	3	24	0.319	3	67	0.31	3
108	0.500	4	275	0.354	4	77	0.303	4	171	0.31	4
59	0.444	5	222	0.314	5	16	0.279	5	173	0.276	5
86	0.437	6	274	0.299	6	68	0.216	6	59	0.24	6
40	0.402	7	41	0.284	7	123	0.211	7	68	0.198	7
67	0.390	8	252	0.278	8	60	0.183	8	172	0.178	8
4 Days > 0.5 dV			1 Days > 0.5 dV			0 Days > 0.5 dV			0 Days > 0.5 dV		

For 2002

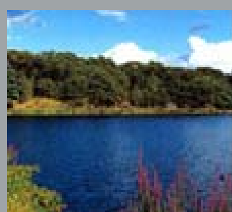
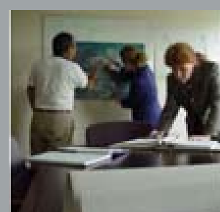
Rocky Mtn. Nat. Park			Great Sand Dunes			Eagle's Nest			Rawah Wild. Area		
Day	dV	Rank	Day	dV	Rank	Day	dV	Rank	Day	dV	Rank
306	1.510	1	61	1.332	1	306	0.660	1	31	1.131	1
305	0.947	2	308	0.735	2	305	0.547	2	306	1.079	2
31	0.931	3	339	0.608	3	85	0.270	3	141	0.652	3
75	0.819	4	303	0.541	4	358	0.261	4	305	0.436	4
141	0.778	5	193	0.498	5	200	0.228	5	75	0.382	5
298	0.532	6	62	0.436	6	198	0.203	6	201	0.299	6
85	0.483	7	165	0.385	7	31	0.200	7	276	0.272	7
201	0.456	8	331	0.382	8	201	0.197	8	199	0.261	8
6 Days > 0.5 dV			4 Days > 0.5 dV			2 Days > 0.5 dV			3 Days > 0.5 dV		

Conclusions

Refined modeling was carried out by Colorado Springs Utilities. The only changes made to the CDPHE model setup was to five parameters in the CALMET input files based on ENSR's work. These changes improved the wind field generated by the model. In addition, a fine grid of one kilometer cells was set up with a 50 kilometer buffer around the four Class I Areas of interest and the Nixon Power Plant. The results clearly indicate that Nixon's maximum historical emissions in the time period from 2003-2005 do not cause or contribute to visibility impairment at the four closest Class 1 areas using the "subject-to-BART" threshold of 0.500 deciviews. Therefore, the Ray D. Nixon Power Plant should not be "Subject-to-BART".

We respectfully request the Division to review the modeling input files and results. We will be ready to provide any further clarifications that may be needed.

Prepared for:
Colorado Springs Utilities – Ray D. Nixon Power Plant
Colorado Springs, Colorado

APPENDIX A: Refined CALMET Wind Field Analysis for Colorado Springs Utilities' Ray D. Nixon Power Plant

ENSR Corporation
May 2006
Document No.: 01559-004

ENSR | AECOM

Prepared for:
Colorado Springs Utilities – Ray D. Nixon Power Plant
Colorado Springs, Colorado

Appendix A: Refined CALMET Wind Field Analysis for Colorado Springs Utilities' Ray D. Nixon Power Plant

Prepared By: Jeff Connors

Reviewed By: Robert J. Paine

ENSR Corporation
April 2006
Document No.: 01559-004

ENSR | AECOM

Contents

List of Tables

List of Figures

1.0 Introduction

1.1 Background

The Air Pollution Control Division (APCD) of the Colorado Department of Public Health & Environment (CDPHE) has conducted CALPUFF modeling for BART-eligible facilities in Colorado. This study focuses upon CALPUFF modeling for one of these facilities, Colorado Springs Utilities' Ray D. Nixon Power Plant (Nixon Power Plant). This facility has one BART-eligible source (Unit 1) that fires primarily low-sulfur coal.

In a report dated November 1, 2005, the CDPHE provided information regarding CALPUFF modeling they conducted to determine whether the BART-eligible unit at the Nixon Power Plant is subject to BART. The CDPHE report concluded that emissions from Nixon would cause a 0.570 deciview (dV) impact at the 98th percentile at the Rocky Mountain National Park during 2002. This is the maximum value from the three years modeled, 1996, 2001, and 2002. This exceeds the 0.5 dv threshold for "contributing to impairment" as noted in EPA's final BART rule published on July 6, 2005. In addition to RMNP, there was also a maximum (over three years) 98th percentile impact of 0.535 dv at Eagles Nest Wilderness (EANE) during 1996.

The CDPHE report noted in the Executive Summary that:

"While the modeling results in this report may be used to support regulatory decision making, additional modeling performed by the Division or source operator may supersede the results. If additional modeling is performed, it should be consistent with recommendations in the Division's modeling protocol. Subsequent modeling performed by the source operator will be subject to Division review and approval. Moreover, the contribution threshold and other criteria used for this modeling demonstration have not been finalized and may change in the final rule adopted by the Commission. Therefore, the results in this report are not a final agency action."

The purpose of this report is to summarize modifications made to the wind field to be used in a refined BART analysis. The analysis will primarily focus upon those impacts at RMNP and EANE for which the modeled source has been shown, through modeling conducted by CDPHE, to contribute to a visibility impairment. Refinements to the wind field generated by the CDPHE are warranted in this situation due to the significant amounts of intervening terrain.

In accordance with this agency policy and with frequent communication with the CDPHE dispersion modeler, Mr. Charles Machovec, ENSR has been asked by CSU to assist in making some refinements to the meteorological wind field that will be used for the subsequent refined BART analysis. It is our contention that the refinements to the wind field are warranted. The following sections will provide documentation and justification for the proposed changes to the wind field generated by CALMET. The Colorado Springs Utilities will provide a report that documents the results obtained from using the modified CALMET wind fields. The Utiliities' report will not only examine the effects the refined wind field will have at RMNP and EANE, but also at the Rawah Wilderness Area (RAWA) and Great Sand Dunes National Park (GRSA) because of the potential for significant changes in trajectories with a finer terrain and model grid resolution.

1.2 Elements of the Refined Analysis

The refinements that ENSR has proposed to the wind field are summarized below.

- Increase the model grid density and thus terrain resolution by a factor of 4 in the x and y directions by reducing the grid size from 4 km to 1.0 km.
- Modifiy some of the CALMET Step 2 weighting factors to retain the Step 1 terrain adjustments from being eliminated by the undue influence of a local meteorological station.

2.0 BART Analysis Refinements

Several refinements have been made to CALMET wind fields used by CDPHE for the BART determination at the Nixon Power Plant. Unless otherwise noted in this report, the CALMET setting and inputs will be identical to those used by CDPHE. Additionally, the same CALMET executable file was used to derive the refined CALMET wind fields.

2.1 Meteorological Processing with CALMET

The wind field produced by CDPHE was graphically reviewed using CalDESK. It is our opinion that the wind field would serve as a good screening tool to estimate impacts from all sources within Colorado at each Class I area. However, there appears to be a possibility for improvements in looking at a more refined area. Several changes to the CALMET settings have been made in an effort to refine the wind field around the Nixon Power Plant along with RMNP and EANE. Other than those noted below, no other changes to the CALMET wind fields were made. Those changes include the following (all of which are discussed in more detail below):

(1) CALMET's planimetric grid resolution

(2) CALMET's domain boundaries, and

(3) CALMET settings - RMAX1, RMAX2, R1, R2, and TERRAD.

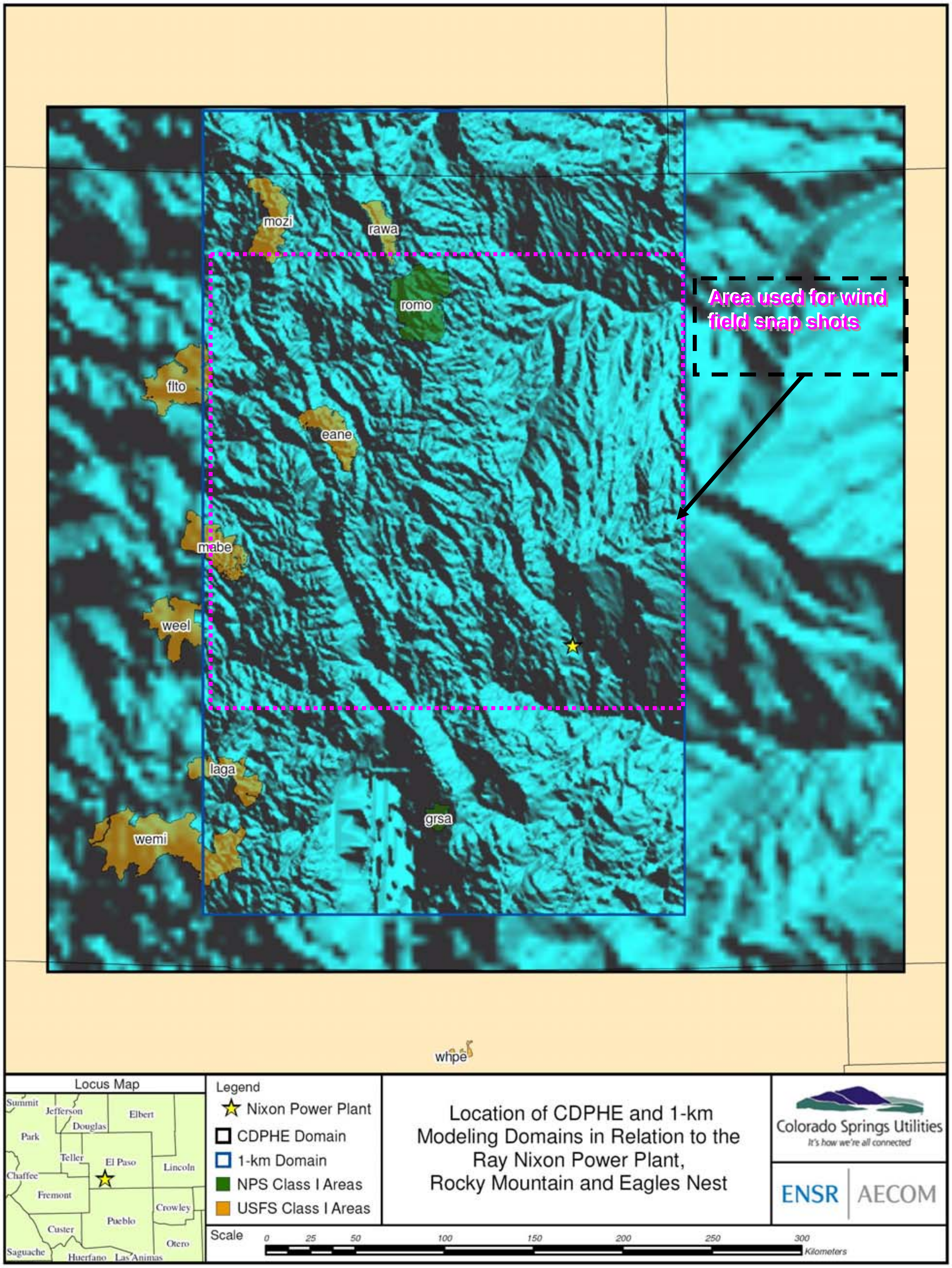
CALMET's Horizontal Grid Resolution

The grid resolution of the BART modeling conducted by CDPHE was 4 kilometers. The resolution was reduced to 1 kilometer for this refined analysis. It appears this refinement provides a much better representation of the intervening terrain relief between the Nixon Power Plant and RMNP and EANE, as well as throughout the entire modeling domain and within the RMNP and EANE. The better the terrain depiction, the more realistic the wind field will appear in complex terrain after CALMET incorporates the terrain adjustments in the Step 1 wind field. Figure 2-1 depicts the different terrain resolutions between the 4-km and the 1-km grid spacing.

CALMET's Domain Extents

In the refined BART analysis, the wind field was generated on a smaller modeling domain. The extent of modeling domain was limited to the Nixon Power Plant, RMNP, EANE, RAWA, GRSA and a ~50-km buffer north of RAWA, west of EANE, south of GRSA, and east of the Nixon Power Plant. Figure 2-1 shows a depiction of the domain used by for the BART modeling conducted by the CDPHE overlaid on 4-km resolution terrain along with the domain that was used for the refined BART analysis overlaid on the 1-km resolution terrain. The boundaries of the domain were modified to save on disk space as CALMET output is proportional the number of grid cells. However, a 50-km buffer should be sufficient to allow puffs to recirculate. Based on the area covered by the 1-km grid resolution domain, the domain contained 121,500 Cartesian grid cells as opposed to 14,520 Cartesian grid cells for the 4-km domain used by CDPHE.

Figure 2-1 Modeling Domain used in the CDPHE BART Analysis and in the Refined Analysis



CALMET settings - RMAX1, RMAX2, R1, R2, and TERRAD

Considering the focused study area with new domain boundaries and model grid resolution, it was determined that some modifications to the CALMET wind field were warranted, over what was used by CDPHE. The modifications to the CALMET settings were designed to create a more realistic looking wind field throughout the modeling domain and especially within the two Class I areas of interest: RMNP and EANE. One drawback of CALMET is that separate radius of influence values (RMAX1, RMAX2, R1, and R2, which express the radius of influence of station wind observations within the CALMET grid) cannot be specified for each surface and/or upper air station. It can likely be agreed on that the radius of influence of surface weather stations within terrain enhanced regions, such as the Rocky Mountains, should be more limited than for those in areas that are more open such as the Great Plains. Table 2-1 lists the CALMET settings used for the CDPHE's BART modeling and those used in the refined modeling analysis. If the CDPHE CALMET settings are used on a finer scale for the 1-km domain depicted in Figure 2-1; the wind fields appear rather unrealistic in some places.

Since there is not a meteorological station near or within EANE, the change in radius of influence values should not have a drastic affect on the wind field within the park, however it could have an affect on the wind field as the plume travels to the park. Therefore, as depicted in Figures 2-2 and 2-3, the wind field produced using the CDPHE and Refined CALMET settings does not differ significantly. The major change in the wind field within EANE incorporated into the refined modeling is due to the model's increased grid resolution that allows CALMET to see more of the significant terrain features within and as the plume travels to EANE.

For RMNP, there is a surface station within the park, so the change in radius of influence values does have more of an impact on the wind field both within the park and as the plume travels to RMNP. For the wind field within RMNP, the main reason for the unrealistic appearance in the CDPHE wind field is that the RMNP CASTNET surface station has a radius of influence of 30 km, which removes the beneficial terrain adjustments performed by CALMET in the Step 1 wind field. This radius of influence value creates a situation where the drainage flow and complex wind flows that we would expect in RMNP do not exist after the Step 2 wind field is completed. ENSR conducted several CALMET iterations with multiple settings and found that the settings listed in Table 2-1 appear to produce the most realistic looking wind field. As with the wind field within and along the way to EANE, the wind field within and along the way to RMNP is also aided by the model's increased grid resolution.

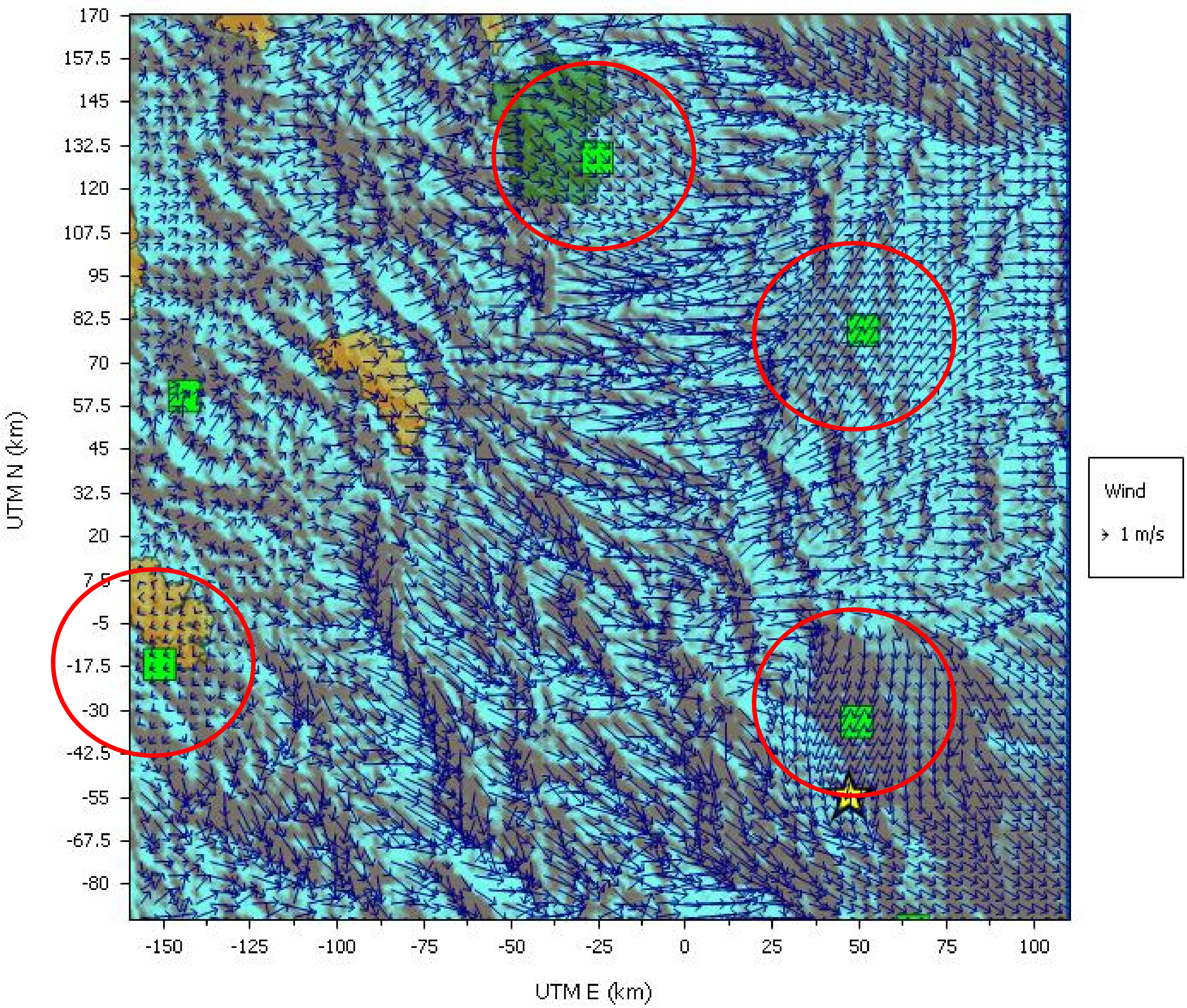
The enhanced model grid resolution also impacts the wind field throughout the entire modeling domain and in RAWA and GRSA, but like EANE, since there are no surface stations nearby either of these parks, the modifications to the radius of influence CALMET settings should not have a significant affect. This assumption is fairly well documented in Figures 2-2 and 2-3. However the change in the model grid resolution has the potential to change the plume's trajectory for other Class I areas. Therefore the supplemental CSU report will document the impacts at RAWA and GRSA.

Figures 2-2 and 2-3 show examples of the resultant wind field using the settings used in the CDPHE modeling and those used in the refined analysis. The red circles on the figures are meant to draw attention to the changes the modified radius of influence values have on the wind field. In Figure 2-2 when CALMET is run with the radius of influence settings used by CDPHE, the wind field around each surface station and especially within RMNP is rather uniform out to a fair distance. However, when these radii of influence values are refined to those proposed by ENSR in Table 2-1, the drainage flow that should be apparent within and around RMNP and near some of the other surface stations (i.e. Colorado Springs Airport) is more evident. A comparison of these wind fields should provide justification for refined CALMET settings under this specific situation. Although these figures provide a very limited review of the wind fields, it is representative of a pattern seen throughout all the years modeled. The pattern can be seen more readily with visualization software such as CalDESK.

Table 2-1 Modifications to CALMET Settings

CALMET Setting	CDPHE Value	Refined Value
TERRAD	40 km	20 km
R1	30 km	5 km
R2	50 km	10 km
RMAX1	30 km	20 km
RMAX2	100 km	100 km

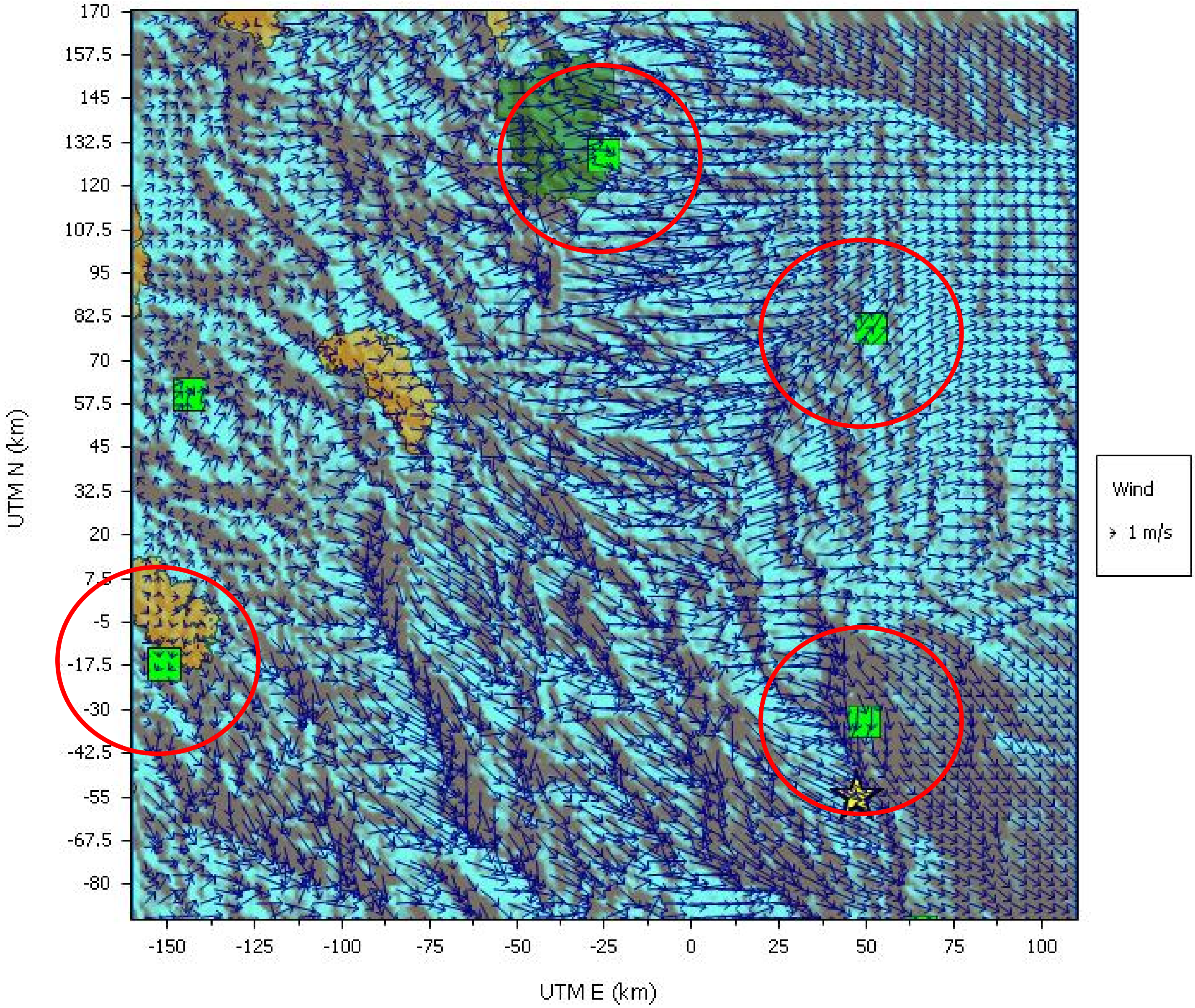
Figure 2-2 CDPHE Model Wind Field with 1-km Grid (subset of 1-km domain shown in Figure 2-1)



01/5/2002 0200 LST - 10 meter level

Locations of surface stations noted by squares
Location of Nixon Plant noted by star
Red circles highlight some areas of interest

Figure 2-3 Refined Wind Field with 1-km Grid (subset of 1-km domain shown in Figure 2-1)



01/5/2002 0200 LST - 10 meter level

Locations of surface stations noted by squares
Location of Nixon Plant noted by star
Red circles highlight some areas of interest

3.0 References

Note: References other than those already included in the CDPHE 2005 report (which is referenced here) are included in this section.

Colorado Department of Public Health & Environment, 2005. BART CALPUFF Class I Federal Area Individual Source Attribution Visibility Impairment Modeling Analysis for Ray Nixon Power Plant Unit 1. Available at http://apcd.state.co.us/documents/BARTCalpuff%20Report-nixon.pdf.

ENSR | AECOM

U.S. Locations

AK, Anchorage
(907) 561-5700

AK, Fairbanks
(907) 452-5700

AL, Birmingham
(205) 980-0054

AL, Florence
(256) 767-1210

CA, Alameda
(510) 748-6700

CA, Camarillo
(805) 388-3775

CA, Orange
(714) 973-9740

CA, Sacramento
(916) 362-7100

CO, Ft. Collins
(970) 493-8878

Ft. Collins Tox Lab
(970) 416-0916

CT, Stamford
(203) 323-6620

CT, Willington
(860) 429-5323

FL. St. Petersburg
(727) 577-5430

FL, Tallahassee
(850) 385-5006

GA, Norcross
(770) 381-1836

IL, Chicago
(630) 836-1700

IL, Collinsville
(618) 344-1545

LA, Baton Rouge
(225) 298-1206

MA, Air Laboratory
(978) 772-2345

MA, Sagamore Beach
(508) 888-3900

MA, Westford
(978) 589-3000

MA, Woods Hole
(508) 457-7900

MD, Columbia
(410) 884-9280

ME, Portland
(207) 773-9501

MI, Detroit
(269) 385-4245

MN, Minneapolis
(952) 924-0117

NC, Charlotte
(704) 529-1755

NC, Raleigh
(919) 872-6600

NH, Gilford
(603) 524-8866

NJ, Piscataway
(732) 981-0200

NY, Albany
(518) 453-6444

NY, Rochester
(585) 381-2210

NY, Syracuse
(315) 432-0506

NY, Syracuse Air Lab
(315) 434-9834

OH, Cincinnati
(513) 772-7800

PA, Langhorne
(215) 757-4900

PA, Pittsburgh
(412) 261-2910

RI, Providence
(401) 274-5685

SC, Columbia
(803) 216-0003

TX, Dallas
(972) 509-2250

TX, Houston
(713) 520-9900

VA, Chesapeake
(757) 312-0063

WA, Redmond
(425) 881-7700

WI, Milwaukee
(262) 523-2040

Headquarters
MA, Westford
(978) 589-3000

Worldwide Locations

Azerbaijan
Belgium
Bolivia
Brazil
Canada
China
France
Germany
Ireland
Italy
Japan
Malaysia
Philippines
Thailand
Turkey
United Kingdom
Venezuela

www.ensr.aecom.com