BART Exemption Modeling Analysis

Sid Richardson Carbon Company

Borger, TX

TCEQ Account No. HW-0017-R

April 2007

Environmental Resources Management
350 Eagleview Blvd
Exton, Pennsylvania 19341

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PROFESSIONAL ENGINEER CERTIFICATION

I am certify that the information presented in this Best Available Retrofit Technology Exemption Modeling Analysis was prepared in accordance with good engineering practice and to the best of my knowledge and based on my review of the project details, in accordance with the requirements of the applicable rules.

____

Signature   Date

Paul D. Despres, P.E. Texas Professional Engineer No. 83907
Environmental Resources Management

1.0 BACKGROUND AND OVERVIEW

This report presents the results of a refined Best Available Retrofit Technology (BART) exemption modeling analysis that was conducted for the Sid Richardson Carbon Company (Sid) facility located in Borger, TX. A screening CALPUFF analysis conducted for the Sid facility indicated that modeled maximum 24-hr impacts greater than the BART significance threshold of 0.5 deciview (dv) occurred in some Class I areas. Due to the results of the screening analysis, the refined analysis was needed to determine if the facility can be considered exempt from requirements of the BART rule. An individual BART eligible facility can be considered exempt from BART requirements if the impacts of visibility impairing pollutants (VIP) from the facility's BART eligible emissions units are less than the BART significance threshold of 0.5 deciviews (dv) on a 98^{th} percentile basis for each modeled year, based on a refined meteorological grid.

1.1 The Regional Haze Rule and BART

On 6 July 2005 a final rule regarding Regional Haze Regulations and BART Determinations was published in the federal register. The final rule requires certain sources affected by the rule to install and operate BART controls. The BART provision of the rule affects sources which were installed and commenced operation between 1962 and 1977 belonging to one of the 28 source categories defined in the Clean Air Act (CAA) and emitting greater than 250 tons per year of VIP which include nitrogen dioxide (NOx), sulfur dioxide (SO2), and particulate matter (PM10). The BART guidelines specify a step-wise approach for the states and other regulatory agencies to determine and establish emission limits for affected sources. For sources located in the Central United States, the Central Region Air Planning Association (CENRAP) provides guidelines for BART affected sources. The individual states, however, are responsible for regulating the BART-subject sources and establishing source-specific emission limits.

The first step in the BART process is identifying sources which are subject to the rule. TCEQ identified sources which might be subject to the rule. These "BART-eligible" sources are responsible for demonstrating if they qualify for an exemption from the rule based on estimates of visibility impacts in Class I areas. CENRAP has provided BART modeling guidelines which specify the requirements for individual sources to qualify for an exemption by conducting a visibility modeling analysis. The sources can conduct the analysis using the regulatory model

CALPUFF to show that the impacts on visibility at Class I areas potentially affected by the source are less than the significant levels established in the guidelines and adopted by the State. TCEQ has developed Texas-specific guidelines for BART screening modeling (final version dated January 2007) which were followed in the screening analysis conducted for the Sid Borger facility.

2.0 REFINED MODELING METHODOLOGY

The CENRAP and TCEQ modeling guidelines describe two categories of dispersion modeling for BART: screening and refined. Both of these analyses utilize the CALPUFF modeling system; however, in the refined mode a more focused domain, consideration of observations in the meteorological processing step, and additional refinements such as puff splitting can be accomplished. The results from a refined application of CALPUFF can be used to assess BART applicability by comparing the 98th percentile 24-hr average impact per Class I area on an annual basis to the 0.5 deciview significance threshold. This differs significantly from the interpretation of the screening results, where the highest overall impact per Class I area was used for comparison to the threshold.

The guidelines also discuss the use of the CAMx photochemical model to evaluate visibility impacts at Class I areas more than 300 km from a source. CALPUFF can be used, at the source's discretion, for analyses greater than 300 km, since it is acknowledged to be conservative at greater distances.

2.1 BART Eligible Sources and Emissions Modeled

Sid operates a carbon black production facility (the Borger plant) located in Borger, Texas (TCEQ Account No. HW-0017-R). The Borger plant produces carbon black using the thermal method. Off-gas from the carbon black process is controlled in combustion devices in accordance with TCEQ Permit Number 1876A/PSD-TX-1032. The Borger plant operates two sources that are BART-eligible: waste heat boilers no. 1 and 2 (FINs: B119N, B119S; EPN: 119). These sources emit greater than 250 tons per year of visibility impairing pollutants and do not meet the model plant exemption; therefore, these sources are subject to BART. Table 1 shows the stack characteristics and emission rates that were modeled in the refined analysis for these sources. The emission rates were determined from emission factors and actual production data.

Table 1: Stack Characteristics and Emission Rates

(a) English Units

EPN	Height ft	Diameter ft	Temp F	Exit Flow acfm	Exit Velocity fps
119	160.00	9.94	550.0	477,017	102.50

(b) Metric Units

EPN	Height m	Diameter m	Temp K		Exit Velocity m/s
119	48.77	3.03	560.9		31.24

(c) Emissions - Maximum Actual 24-hour average

EPN	Emissions (lbs/hr)			Emissions (g/s)		
	SO2	NOx	PM2.5 [1]	SO2	NOx	PM2.5 [1]
119	2089.00	219.70	38.28	263.21	27.68	4.82

Notes:
[1] All PM is conservatively modeled as PM2.5, per TCEQ guidance.

2.2 *Summary of Screening Modeling Results*

Screening modeling was conducted in accordance with CENRAP and TCEQ guidance for the Sid Borger facility BART sources at the 20 Class I areas identified in the TCEQ guidance. A summary of the results of the screening modeling is presented in Table 2, expressed as the deciview (dv) change in visibility from natural background conditions (24-hour averages). Electronic copies of screening modeling files are included in Appendix A.

Table 2: Screening Modeling Results Summary

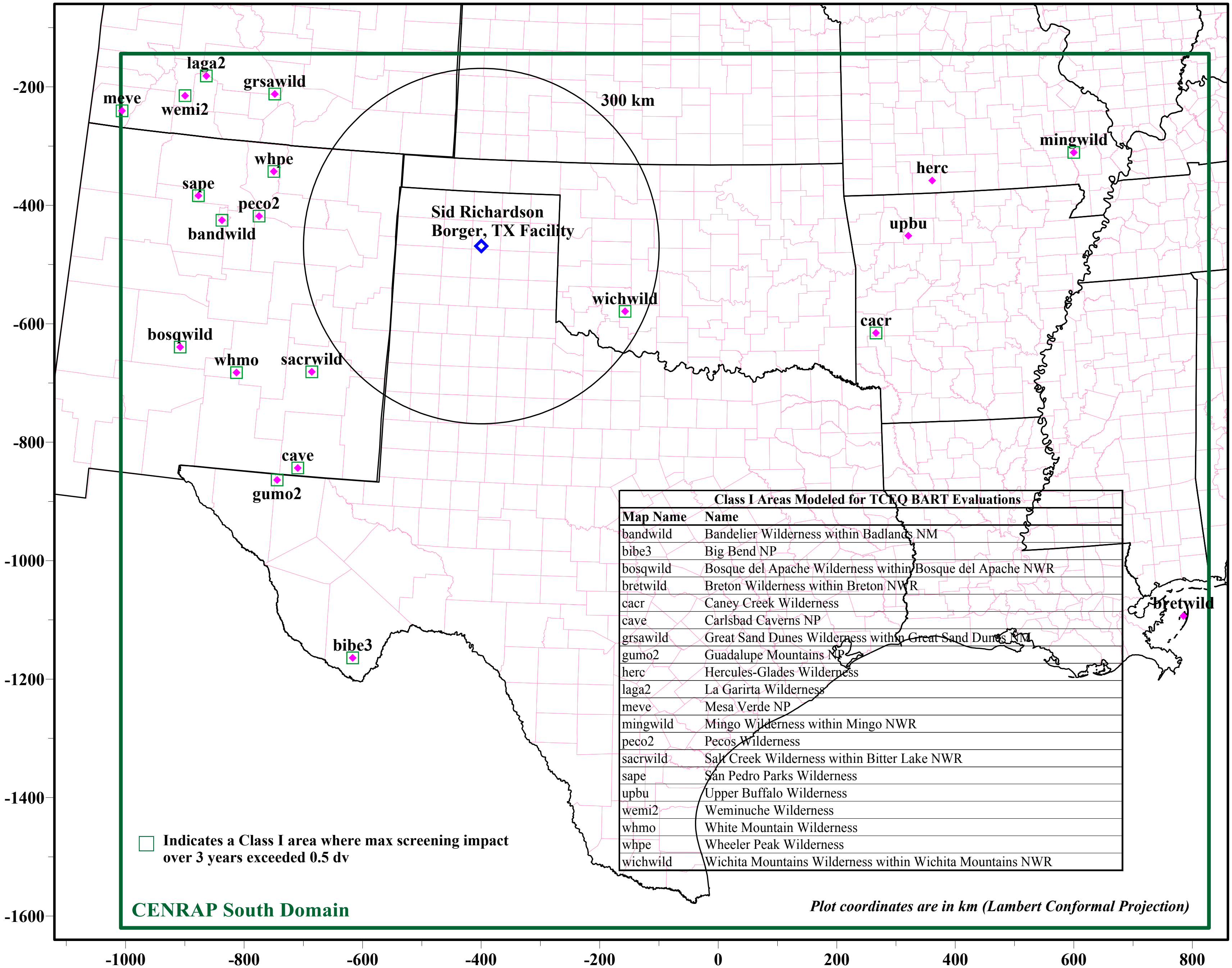
Class I Area	# of Days > 0.5 dv			Largest Impact (dv)			Rank of 1st Impact < 0.5 dv		
	Year			Year			Year		
	2001	2002	2003	2001	2002	2003	2001	2002	2003
Bandelier Wilderness	1	0	0	0.809	0.392	0.261	2	1	1
Big Bend	0	1	0	0.279	1.080	0.423	1	2	1
Bosque del Apache	0	1	0	0.214	0.505	0.354	1	2	1
Breton Wilderness	0	0	0	0.098	0.150	0.175	1	1	1
Caney Creek	1	1	0	0.666	0.685	0.327	2	2	1
Carlsbad Caverns	0	3	0	0.496	0.542	0.308	1	4	1
Great Sand Dunes	0	2	0	0.200	1.292	0.417	1	3	1
Guadalupe Mountains	0	2	0	0.366	0.607	0.288	1	3	1
Hercules-Glades	0	0	0	0.315	0.425	0.376	1	1	1
La Garita	1	0	0	0.595	0.314	0.089	2	1	1
Mesa Verde	1	0	0	1.160	0.182	0.068	2	1	1
Mingo Wilderness	1	0	0	0.959	0.473	0.182	2	1	1
Pecos Wilderness	1	1	1	0.869	0.524	0.567	2	2	2
Salt Creek Wildlife	3	5	1	0.589	0.995	0.534	4	6	2
San Pedro Parks	1	0	0	0.887	0.312	0.160	2	1	1
Upper Buffalo	0	0	0	0.418	0.372	0.270	1	1	1
Weminuche Wilderness	1	0	0	1.164	0.258	0.093	2	1	1
Wheeler Peak	0	1	0	0.495	0.572	0.373	1	2	1
White Mountain	0	2	0	0.400	0.565	0.419	1	3	1
Wichita Mountains	3	3	3	0.641	1.005	0.559	4	4	4

For 17 Class I areas, at least one day out of three years modeled exceeded the BART threshold of 0.5. Most of the Class I areas were impacts exceeded 0.5 dv for at least one day are located in either Oklahoma, New Mexico, or Colorado.

Three Class I areas with impacts greater than 0.5 dv are located at a significant distance from the Sid facility. Caney Creek Wilderness is located over 600 km to the east in Arkansas, Mingo Wilderness is located nearly 1000 km to the east-northeast in Missouri, and Big Bend National Park is located nearly 800 km to the south-southwest near the Texas border with Mexico. It should be noted that the facility only caused one modeled impact over 0.5 dv in each of these three Class I areas over the three year modeled period. It should also be noted that the single high impacts over 0.5 dv in each Class I area were at least twice as high as the next highest impact for all three Class I areas.

Figure 1 displays the locations of these Class I areas, the location of the Sid Borger facility and the Class I areas where impacts were predicted in screening modeling. The CENRAP modeling guidelines define three separate slightly overlapping CALMET domains - north, central, and south - each of which have a grid resolution of 6 km. The CENRAP south domain is shown on this figure – the south domain meteorological data files were used to conduct the screening modeling.

Figure 1: Location of Sid Borger Facility and Class I Areas



2.3 *Refined Meteorological and Modeling Domain*

The modeling methodology used for the refined analysis was similar to the CENRAP and TCEQ BART screening modeling guidelines, but with added refinements. A refined modeling protocol was submitted to the TCEQ on 14 March 2007. An electronic copy of the protocol is included in Appendix A.

The refined meteorological and modeling domain is shown in Figure 2. Figure 2 also depicts terrain features within the CENRAP southern domain. The western portion of the refined domain is in complex terrain. Therefore, a grid spacing of 4 km was used to better simulate wind flow within the domain. The refined domain extends further to the north and west than the CENRAP southern domain to ensure adequate coverage of the Class I areas in that part of the domain.

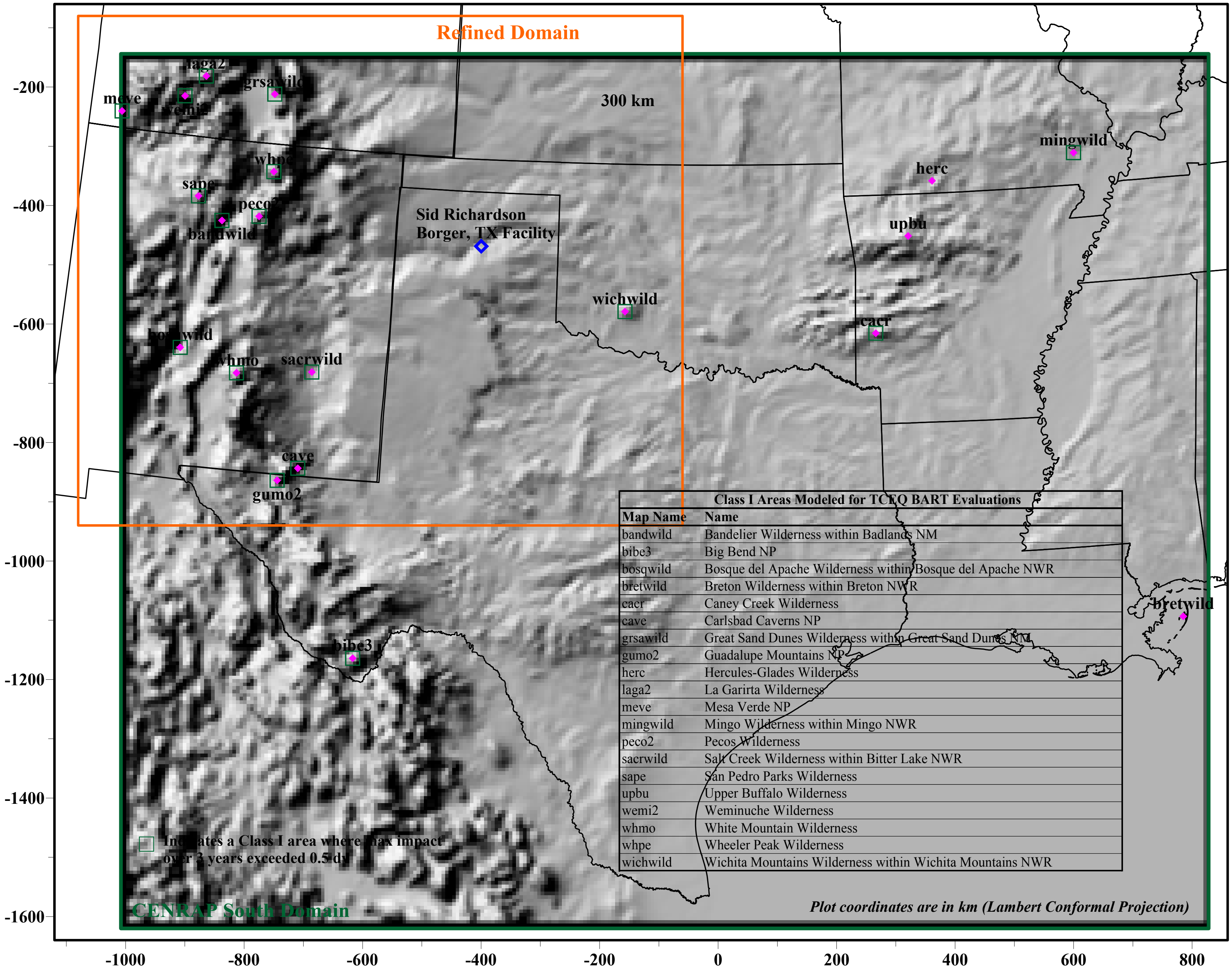
All Class I areas within the domain were included in the refined modeling analysis. The Class I areas within the refined domain include the most heavily impacted Class I area, Wichita Mountains Wilderness in Oklahoma, and several Class I areas to the west of the facility in New Mexico and Colorado. The following Class I areas in the CENRAP southern domain were not included in the refined modeling analysis:

- Mingo Wilderness – Missouri
- Hercules-Glades Wilderness – Missouri
- Upper Buffalo Wilderness – Arkansas
- Caney Creek Wilderness – Arkansas
- Breton Wildlife Refuge – Louisiana
- Big Bend National Park – Texas

As shown in Table 2, the screening modeling indicated three of the excluded Class I areas, Mingo Wilderness, Big Bend National Park, and Caney Creek Wilderness, each had one 24-hr impact greater than 0.5 dv over the three-year modeling period. These Class I areas are located at considerable distances from the facility, and are geographically isolated from the other eight Class I areas where 24-hr screening impacts were above 0.5 dv.

In an effort to develop the most efficient refined analysis possible, Sid has elected to use the screening results as evidence that the facility does not cause or contribute to visibility impairment in the Mingo Wilderness, Big Bend National Park, or Caney Creek Wilderness. The screening results for these three Class I areas showed only one day per year where the facility caused a modeled impact greater than 0.5 dv in each Class I area. In Mingo and Big Bend, the facility only had one modeled impact over 0.5 over the entire three year modeling period. The highest modeled day for all three of these Class I areas is markedly higher than the next highest modeled day. The second highest modeled day in 2001 in Mingo is nearly six times less than the highest day. Similarly, the second highest modeled day in 2001 and 2002 in Caney Creek is two times less than the highest day. The second highest modeled day in 2002 in Big Bend is also two times less than the highest day. The refined modeling results, presented in Section 3 of this report, indicate that the refined modeling does not significantly alter the visibility impacts when compared to the screening results. The inclusion of these distant Class I areas would require additional refined domains to properly model the visibility impacts. Sid asserts that this level of effort is unwarranted, and that the screening results are adequate to demonstrate that the facility does not cause or contribute to visibility impairment in the Mingo Wilderness, Big Bend National Park, or Caney Creek Class I areas. This overall approach was outlined in the Modeling Protocol that was submitted to the TCEQ on 14 March 2007, and the TCEQ found this approach to be acceptable.

Figure 2: Refined Domain



Class I Areas Modeled for TCEQ BART Evaluations	
Map Name	**Name**
bandwild	Bandelier Wilderness within Badlands NM
bibe3	Big Bend NP
bosqwild	Bosque del Apache Wilderness within Bosque del Apache NWR
bretwild	Breton Wilderness within Breton NWR
cacr	Caney Creek Wilderness
cave	Carlsbad Caverns NP
grsawild	Great Sand Dunes Wilderness within Great Sand Dunes NM
gumo2	Guadalupe Mountains NP
herc	Hercules-Glades Wilderness
laga2	La Garita Wilderness
meve	Mesa Verde NP
mingwild	Mingo Wilderness within Mingo NWR
peco2	Pecos Wilderness
sacrwild	Salt Creek Wilderness within Bitter Lake NWR
sape	San Pedro Parks Wilderness
upbu	Upper Buffalo Wilderness
wemi2	Weminuche Wilderness
whmo	White Mountain Wilderness
whpe	Wheeler Peak Wilderness
wichwild	Wichita Mountains Wilderness within Wichita Mountains NWR

2.4 *Receptors and Class I Area Specific Variables*

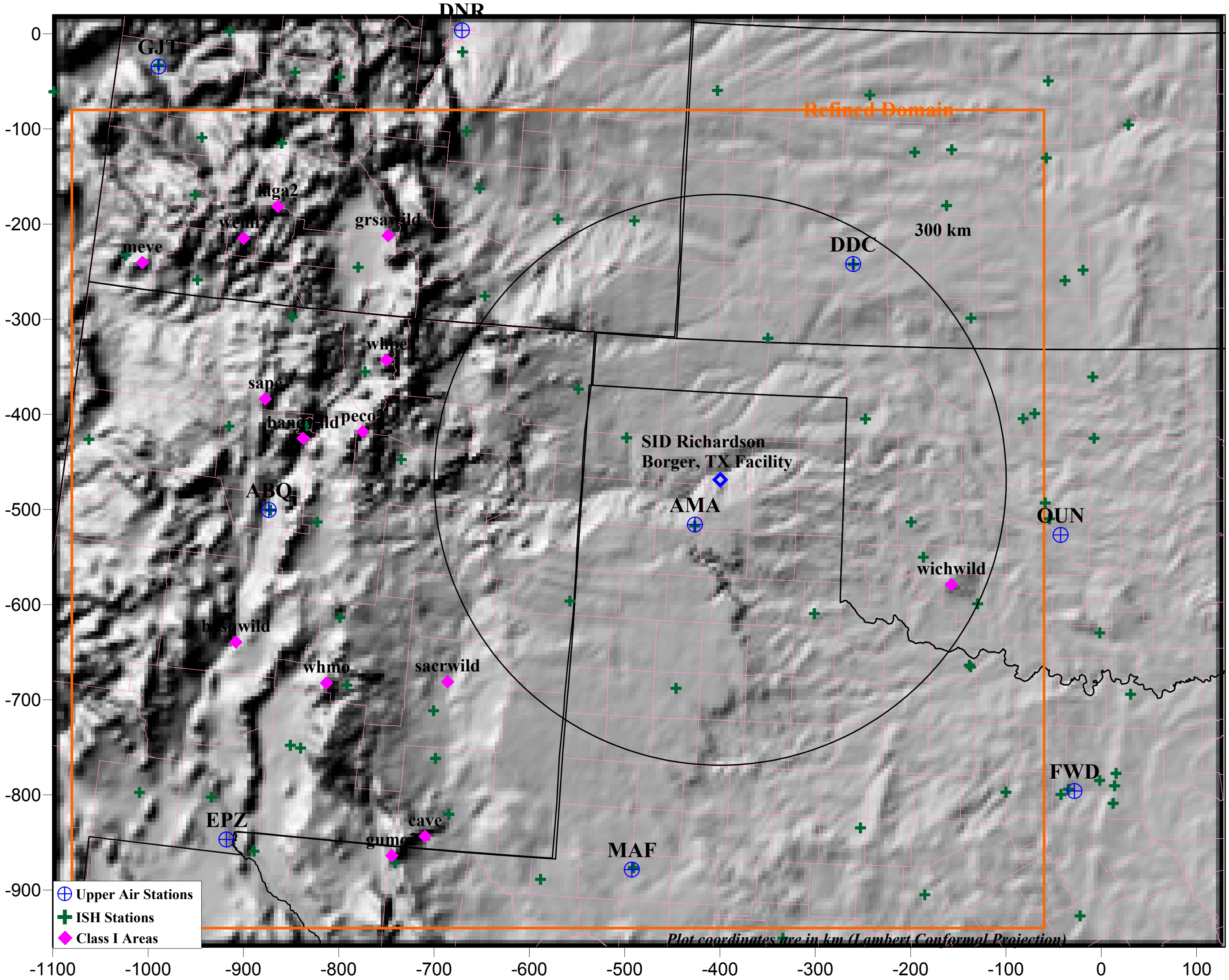
For each Class I area, receptor locations and elevations were developed based on the National Park Service receptor files. The aerosol concentrations used to estimate natural background visibility conditions are defined in the TCEQ modeling guidelines (Table 5) for each Class I area. Table 4 in the TCEQ modeling guidelines specify the monthly average relative humidity adjustment factors to use in calculating visibility impairment for hygroscopic species. These values were used in the post-processing to determine visibility impacts.

2.5 *CALMET Setup*

CALMET was configured as outlined in the TCEQ guidance for screening level analyses, except for the following refinements:

- All available surface and upper air stations within the meteorological domain that have valid data from 2001-2003 were used as observational data to refine the initial guess wind field. Any valid surface or upper air data within 100 km of the edge of the meteorological domain (outside of the domain) was used as observations to enhance the wind fields within the domain. Surface data were obtained from the Integrated Surface Hourly (ISH) CD-ROMs; upper air data were obtained from NOAA's rawinsonde web site. Six upper air stations were used in 2001, and nine upper air stations were used for 2002 and 2003. 83 surface stations were used in 2001, 81 in 2002, and 85 in 2003. Figure 3 displays the location of upper air and ISH stations in and near the refined grid, and also displays terrain features at a 4 km resolution.
- All valid, readily available precipitation observations within the meteorological domain were used in the analysis. 246 precipitation stations were used for each modeled year.
- Grid resolution of 4-km was used, with the 10 layer vertical structure recommended by CENRAP.
- The same 1-km resolution terrain and land use data used by CENRAP to develop the 6-km CALMET domains were used in the refined analysis. Other terrain and land use data are available at resolutions less than 1-km, however the 1-km data is adequate to characterize geographical data at a 4-km resolution. Since this refined analysis is being designed to model very long range transport of pollutants, refining the geographical data is not of utmost importance.
- The EPA approved version of CALMET (version 5.53a) was used.

Figure 3: Meteorological Stations and Terrain in the Refined Grid



Additional CALMET refinements include:

- Use surface and upper air observations (NOOBS = 0);
- Use the diagnostic wind module (IWFCOD=1);
- Use MM5 winds as the initial guess field (IPROG=14);
- Relative weighting of initial guess vs. observations at surface (R1): 5 km
- Relative weighting of initial guess vs. observations aloft (R2): 5 km
- Maximum radius of influence of observations at surface (RMAX1): 40 km
- Maximum radius of influence of observations aloft (RMAX2): 40 km
- Radius of influence of terrain features (TERRAD): 15 km.

The CALPUFF meteorological preprocessor, CALMET, was run with both observational data and data derived from the MM5 mesoscale meteorological model as provided by CENRAP. The MM5 data posed an operational issue with the EPA versions of CALMET. CENRAP ran the MM5 processor, CALMM5, for each month's worth of MM5 data, and defined the monthly start and end times for each CALMM5 run based on UTC time, rather than UTC-6 (US central time). This caused considerable difficulty in running CALMET with both MM5 and observational data combined. The problem arises due to the fact that the EPA version of CALMET can only process one MM5 file per run. To run the first hours of each MM5 file, the CALMET run would need to be started on hour 18 local time due to the time difference between US central time and UTC time. Due to CALMET's mixing height algorithms, CALMET must be started prior to hour 5 local time. Because of this constraint, conducting sequential EPA CALMET runs would result in data gaps between months. CALPUFF can not accept gaps in meteorological data. Therefore, the EPA version of CALMET was modified to allow multiple MM5 data files per run. A detailed description of the CALMET code modification is included in Appendix B, and the modified code and all parameter files are included on the accompanying CD-ROM (Appendix A). None of the modifications affected any underlying algorithms in CALMET.

2.6 Meteorological Data Evaluation

The CALMET meteorological data fields were evaluated for reasonableness using the PRTMET post processor in conjunction with the CALVIEW Graphical User Interface (GUI). Not all modeled days were examined using the GUI. An effort was made to identify days where high modeled impacts were occurring, and to select those days for display in the CALVIEW GUI. This qualitative review did not reveal any data flaws or inaccuracies. In addition to the review of the wind fields, the CALMET binary files were processed to summarize minimum, maximum, and averages of various derived parameters and wind speed and direction at various heights in the modeled domain. The summaries are presented, along with a brief discussion, in Appendix C of this report.

2.7 *CALPUFF Setup*

This section describes the input parameters and the setup used for conducting the CALPUFF modeling analysis. Emissions of NOx, SO2, PM10, and PM2.5 from the BART eligible sources at the facility were modeled at the emission rates shown in Table 1. The following are the CALPUFF options that were used in the refined analysis:

- The Pasquill-Gifford stability class-based dispersion methodology is the regulatory default setting for CALPUFF, and was used in this analysis.
- In addition to the VIP emitted from the facility, SO4, HNO3, and NO3 were included in the modeling analysis. The MESOPUFF chemical mechanism module was used to generate formation of these pollutants from the emitted pollutants.
- Hourly background ozone data from all ambient monitors in the domain were used.
- An ammonia concentration of 3 ppb was used.

A modification to the CALPUFF code was made after encountering an unexpected error in the model runs. This error was due to a calculation that resulted in a slightly negative value of incremental travel time and incremental distance traveled in the subroutines SIGTY and SIGTZ. Later versions of CALPUFF, including the version described in Model Change Bulletin B, recognized this problem and included a fix to the model code. In order to complete the processing for each of three full years, modifications to the CALPUFF code were made to prevent the model from stopping when this situation is encountered. A detailed description of the CALPUFF code modification is included in Appendix B, and the modified code and all parameter files are included on the accompanying CD-ROM (Appendix A). None of the modifications affected any underlying algorithms in CALPUFF.

2.8 *CALPOST Post Processing*

The CENRAP and TCEQ BART guidance recommends that visibility impacts be evaluated against natural background conditions. Visibility impairment can be expressed in a number of different ways; the most common and relevant to BART determinations include light extinction, deciviews, and visual range.

Light extinction (Bext) is a measure of light scattered from the line of sight; this is related to visual range by:

$$VR\ (km) = 3912/Bext\ (Mm^{-1})$$

e.g. Bext of 20 (good visibility) corresponds to a visual range of about 200 km; Bext of 200 (poor visibility), about 20 km

Deciviews provide a scale where equal changes in the numerical value represent equal changes in perception; deciviews are related to light extinction as follows:

$$dv=10*\ln(Bext/10)$$

e.g. Bext of 20 (good visibility) corresponds to a dv of 6.9; Bext of 200 (poor visibility), about 29.2

Light extinction can be calculated from predicted or measured concentrations of visibility impairing pollutants. The calculation is carried out as follows:

$$Bext = [chi] \times [fRH) \times [EE]$$

where

Bext: is the light extinction;
chi: is the 24-hr average compound concentration;
fRH: is the growth factor for hygroscopic compounds (e.g. sulfates and nitrates);
EE: is the extinction efficiency of the compound.

Sid used CALPOST visibility method 6, with site specific relative humidity factors and background particulate concentrations identified in TCEQ modeling guidelines. All of the control and list files, as well as the executable used for this analysis, are included on the accompanying CD-ROM (Appendix A).

3.0 *REFINED MODELING RESULTS*

The results of the refined visibility modeling analysis are shown in Table 3. The 98th percentile predicted value (corresponding to the 8th high prediction in each year) is less than the BART threshold of 0.5 dv for all of these Class I areas. The emissions of VIP from the BART eligible units at the Sid facility do not contribute to visibility impairment in any Class I area. Sid Richardson Carbon Company requests that TCEQ exempt the Borger, TX facility from any further requirements of the BART rule.

Table 3: Refined Modeling Results Summary

	# of Days > 0.5 dv			Largest Impact (dv)			Rank of 1st Impact < 0.5 dv		
	Year			Year			Year		
Class I Area	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**	**2001**	**2002**	**2003**
Bandelier Wilderness	0	0	0	0.231	0.202	0.362	1	1	1
Bosque del Apache	0	0	0	0.132	0.262	0.261	1	1	1
Carlsbad Caverns	0	0	0	0.415	0.243	0.329	1	1	1
Great Sand Dunes	0	1	1	0.210	2.205	0.734	1	2	2
Guadalupe Mountains	0	0	0	0.246	0.240	0.286	1	1	1
La Garita	0	0	0	0.078	0.318	0.181	1	1	1
Mesa Verde	0	0	0	0.264	0.135	0.048	1	1	1
Pecos Wilderness	0	0	2	0.194	0.349	0.671	1	1	3
Salt Creek Wildlife	0	0	1	0.356	0.387	0.547	1	1	2
San Pedro Parks	0	0	0	0.187	0.169	0.199	1	1	1
Weminuche Wilderness	0	0	0	0.212	0.188	0.156	1	1	1
Wheeler Peak	0	1	0	0.109	0.508	0.497	1	2	1
White Mountain	0	0	0	0.240	0.416	0.352	1	1	1
Wichita Mountains	0	2	2	0.448	0.664	0.708	1	3	3

Modeling Files (CD)
Appendix A

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Description of CALPUFF and CALMET Program Modifications and Recompilation

Appendix B

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CALPUFF

The EPA-approved version of the CALPUFF model (version 5.711a) was used in this BART evaluation. A modification to the CALPUFF code was made after encountering an unexpected error in the model runs. This error was due to a calculation that resulted in a slightly negative value of incremental travel time and incremental distance traveled in the subroutines SIGTY and SIGTZ. Later versions of CALPUFF, including the version described in Model Change Bulletin B, recognized this problem and included a fix to the model code. In order to complete the processing for each of three full years, modifications to the CALPUFF code were made to prevent the model from stopping when this situation is encountered. The later modifications included revised versions of the subroutines SIGTY and SIGTZ, and addition of a new subroutine WARN. In the original version of CALPUFF, if a negative incremental travel time or a negative incremental distance traveled resulted in a fatal error. Recognizing that occasionally a slightly negative value of incremental travel time or travel distance can occasionally occur, the new subroutines established two levels for travel time and distance. If calculated values are greater than the first level (-0.1 second and -0.01 meters), the values are re-set to zero and the model proceeds without stopping. If calculated values are less than the first level but greater than the second level (-1.0 second and -1.0 meters), the values are re-set to zero and a warning is written the list file; again, the model proceeds without stopping. If calculated values are less than the second level, a fatal error occurs and the model stops. The modifications to CALPUFF version 5.711a included substituting newer versions of the subroutines SIGTY and SIGTZ, and adding the new WARN subroutine. Following these substitutions and additions, the model was re-compiled and run on three years of data. The modified code and the relevant subroutines are included on the accompanying CD-ROM. A review of the CALPUFF list files showed that no warning messages were written to this file, which means that any negative values of incremental travel time (that would have stopped the original version of CALPUFF) are very small.

CALMET

The EPA-approved version of the CALMET processor (version 5.53a) was used in this BART evaluation. Because of problems with the start times of the MM5 files, and due to the fact that CALMET v7.53a can only accept one MM5 file, modifications to the code were made to complete the CALMET processing. In this modified version of the code, MM5 file names are listed in an external file, with the number of files included on the first record and then the names following in order. The following changes were made:

- Add an include file with the /meg/ common block “meg.puf”

- Changes to the COMLINE subroutine (in calutils.for) to allow for incorporating the MM5 file names file on the command line; also add the capability to “run” or “not” on the command line;

- Changes to the SETUP subroutine to read MM5 file names and to determine whether the run is a test run; and,

- Changes to the RDMM5 subroutine to allow for opening and reading the next MM5 file when searching for MM5 data.

A listing of the meg.met file follows:

```
      parameter (mx_mm5=32)
      common /meg/ fnm_mm5(mx_mm5),num_mm5,count_mm5
      character*70 fnm_mm5
      integer num_mm5,count_mm5
```

A complete copy of the modified code is included on the accompanying CD-ROM. All fortran code changes are marked by the character strings “megs” (start of changes) and “mege” (end of changes). A listing of the code changes follows:

```
Changes in CALMET_M.FOR: look for megs and mege

c----------------------------------------------------------------------
      subroutine rdmm5(cellzc,udat,vdat,uprog,vprog,mhr,mjul,myr,
     1                 tprog,vptprog,icloud,ccgrid,iceilg,rho,npsta)
c----------------------------------------------------------------------
c
c --- CALMET   Version: 5.53a     Level: 030528                  RDMM5
c              F.Robe
c ---          Modified by M. Fernau (2/99), F.Robe (09/01)
c ---          Modified by J. Scire (5/03)
.
.
.
c frr (09/01) set the precipitation rate rmm
      include 'metgrd.met'
c megs
      include 'meg.met'
c mege
      COMMON /D4/ EDIT,EDITL,IEDIT,IEDITL
.
.
.
c
       goto 997
c
c --- ran out of data
c
c megs now simply open the next file
c999   if (iskip .eq. 1) then
c        write(io6,*) ' ran out of MM5 data before start!'
c        stop
```

```
c      else
c        write(io6,*) ' ran out of MM5 data during run...'
c        stop
c      end if
999    continue
c megs
      count_mm5=count_mm5+1
      if(count_mm5.gt.1.and.count_mm5.le.num_mm5)then
       close(io20)
       open(io20,file=fnm_mm5(count_mm5),status='old')
c code from rdhd5:
c --- Read first two records to determine whether file is
c     in 3D.DAT format (Data version 3.0)
      read(io20,'(a)')buff
      read(io20,'(a)')buff
      read(buff,'(a12)')cset3d
c
       if(cset3d.eq.'3D.DAT'.or.cset3d.eq.'MM53D.DAT')then
          rewind(io20)
          imm53d=1
          call rdhd52
       else
          rewind(io20)
          imm53d=0
          call rdhd51
       endif
      elseif(count_mm5.gt.num_mm5)then
       write(*,'(a,2i6)')' count_mm5 gt num_mm5: ',count_mm5,num_mm5
       write(io6,'(a,2i6)')' count_mm5 gt num_mm5: ',count_mm5,num_mm5
       if (iskip .eq. 1) then
         write(*  ,*) ' ran out of MM5 data before start!'
         write(io6,*) ' ran out of MM5 data before start!'
         stop
       else
         write(io6,*) ' ran out of MM5 data during run...'
         write(*  ,*) ' ran out of MM5 data during run...'
         stop
       end if
       stop
      endif
      go to 1
c mege


 997   continue
.
.
.
c----------------------------------------------------------------------
      subroutine setup(itest)
c----------------------------------------------------------------------
c
c --- CALMET   Version: 5.53a     Level: 030402                   SETUP
c ---          J. Scire, SRC
c ---          MEF, SRC/ETCO added separate land/water surface sites
c
.
.
```

```
.
c --- include parameters
      include 'params.met'
c megs
      include 'meg.met'
      character mm5f_nm*70
c mege
c
      integer idiopt(5)
      character*80 title(3)
c
      include 'gen.met'
      include 'grid.met'
      include 'met1.met'
      include 'metpac.met'
      include 'geo.met'
      include 'outpt.met'
      include 'qa.met'
      include 'filnam.met'
      include 'flags.met'
      include 'wtgrd.met'
      include 'ovrwat.met'
c
      COMMON /D1/ U(mxnx,mxny,mxnz),V(mxnx,mxny,mxnz),
     1  W(mxnx,mxny,mxnzp1), UB(mxny,2,mxnz), VB(mxnx,2,mxnz),
     1  USLOPE(mxnx,mxny,mxnz),  VSLOPE(mxnx,mxny,mxnz),
     1  UG(mxnx,mxny,mxnz),  VG(mxnx,mxny,mxnz),
     1  HTOPO(mxnx,mxny), HMAX(mxnx,mxny),
     1  UTMXST(mxwnd), UTMYST(mxwnd), WT(mxwnd),
     1  RS(mxwnd), IS(mxwnd), IST(mxwnd), JST(mxwnd),
     1  US(mxnz,mxwnd), VS(mxnz,mxwnd),
     1  CELLZB(mxnzp1), CELLZC(mxnz),
     1  PEXP(7), FEXTRP(mxnz), DIV(mxnx,mxny,mxnz),
     1  NINTRP(mxnz)

c megs
      logical test_meg,run_meg
c mege

c
c --- Get date and time from system
      call datetm(rdate,rtime,rcpu)
c
c --- Get the name of the control file from the command line
c megs
c     call comline(metinp)
      call comline(metinp,mm5f_nm,test_meg,run_meg)
c mege
c
c --- Open the control file
      open(io5,file=metinp,status='old')
c
c --- Read control file inputs
      call readcf(idiopt,title,iprog,itest)
c megs
c  if test_meg,override itest from control file
      if(test_meg)then
       if(run_meg)then
```

```
         itest=2
        else
         itest=1
        endif
       endif
       write(*,'(a,2l4,i4)')
      *' test_meg,run_meg,itest: ',
      *  test_meg,run_meg,itest
c initialize mm5 counter
       count_mm5=1
c mege
c
c --- Pass image of CALMET control file to scratch file
      call TFERCF
c
c --- Write the files used in this run to the list file
      call wrfiles
c megs
      open(42,file=mm5f_nm)
      read(42,*)num_mm5
      do kmm5=1,num_mm5
       read(42,*)fnm_mm5(kmm5)
       write(io6,'(a,i4,1x,a)')
     * ' kmm5,fnm_mm5(kmm5): ',kmm5,fnm_mm5(kmm5)
      end do
      close(42)
      mm4dat=fnm_mm5(1)
c mege
c
c --- Open I/O files other than the control & list files
      call openot
.
.
.
```

Changes in CALUTILS.FOR: look for megs and mege

```
c Changes made by Mark Garrison April, 2007
c  add options for command line run or not
c  add name for file containing mm5 file names
c  (comline subroutine only; original comline commented out with "cx")
c  all changes bracketed by megs and mege

c----------------------------------------------------------------------
c megs
c     subroutine comline(ctext)
      subroutine comline(ctext,mm5f_nm,test_meg,run_meg)
c mege
c----------------------------------------------------------------------
c
c --- CALUTILS   Version: 2.2      Level: 960521                COMLINE
c                J. Scire, SRC
c
.
.
.
c                          IARGC, GETARG - HP routines
c----------------------------------------------------------------------
c megs
```

```
      logical test_meg,run_meg
      character*120 chchin
      character*70 dum
      character*70 mm5f_nm
c mege
c
c ------------------------------------
c --- COMPAQ DF compiler library directive
.
.
.
c -----------------
c --- Lahey compiler
c -----------------
c megs
c     call getcl(ctext)
      call getcl(chchin)
      call clxfr(chchin,1,1,xdum,idum,dum)
      ctext=dum
      call clxfr(chchin,2,1,xdum,idum,dum)
      mm5f_nm=dum
      call clxfr(chchin,3,1,xdum,idum,dum)
      test_meg=.false.
      if(dum(1:3).eq.'run'.or.dum(1:3).eq.'RUN')then
       test_meg=.true.
       run_meg=.true.
      elseif(dum(1:3).eq.'not'.or.dum(1:3).eq.'NOT')then
       test_meg=.true.
       run_meg=.false.
      endif
c mege
c
.
.
.
c megs
c
c 96120 (or so...)
c Subroutine to extract information from a string of characters
c string can be up to 120 chars long
c character: up to 70 characters
c   integer: up to 6 digits
c      real: up to 6 digits real
c            implemented 4/22/96
c
c   WARNING! must send a 70-char variable to clxfr or higher bytes
c            will be over-ridden.  If a char string less than 70
c            is desired, must assign after calling clxfr
c

      subroutine clxfr(chin,iwch,itpe,xreal,iint,charo)

      dimension idig(6),ldig(7),irdig(6)
      character*120 chin
      character*70 charo
      character*1  blnk,numc(10),neg,dec
      logical isfld,left,right
      data blnk /' '/, neg /'-'/, dec /'.'/
```

```
      data numc /'0','1','2','3','4','5','6','7','8','9'/
c
c Initialize
c
      charo(1:70)=blnk
      iint=0
c
c Define the beginning and end points of the iwch field...
c
      nfno=0
      isfld=.false.
      do 10 k=1,120
       if(chin(k:k).ne.blnk)then
        if(isfld)then
         go to 10
        else
         isfld=.true.
         nfno=nfno+1
         if(nfno.eq.iwch)ifst=k
        endif
       else
        if(isfld)then
         isfld=.false.
         if(nfno.eq.iwch)ifend=k-1
        else
         go to 10
        endif
       endif
   10 continue

      if(nfno.lt.iwch)return

      if(itpe.eq.1)then
c      assign character field
       do 20 kc=ifst,ifend
       nmch=ifend-ifst+1
       charo(1:nmch)=chin(ifst:ifend)
   20  continue
       return
      elseif(itpe.eq.2)then
c      assign integer field
       ndigs=ifend-ifst+1
       mult=1
       if(chin(ifst:ifst).eq.neg)then
        ndigs=ndigs-1
        ifst=ifst+1
        mult=-1
       endif
       if(ndigs.gt.6)stop ' too many digits in integer field! '
       do 30 ki=ifst,ifend
        do 28 kd=1,10
         if(chin(ki:ki).eq.numc(kd))idig(ki-ifst+1)=kd-1
   28   continue
   30  continue
       iint=0
       do 40 kd=1,ndigs
        iexp=ndigs-kd
        iint=iint+idig(kd)*(10**iexp)
```

```
   40  continue
       iint=iint*mult
       return
      elseif(itpe.eq.3)then
c      real values
       nrtot=ifend-ifst+1
       if(nrtot.gt.16)stop ' too many digits in real field! '
       xmult=1.0
       ks=ifst
       ke=ifend
       if(chin(ifst:ifst).eq.neg)then
        nrtot=nrtot-1
        ifst=ifst+1
        xmult=-1.0
        ks=ifst
        ke=ifend
       endif
c      write(*,'(a,f4.0)')' xmult1 = ',xmult
       nleft=0
       nright=0
       left=.true.
       right=.false.

       do 42 kr=ks,ke
        if(chin(kr:kr).eq.dec)then
         left=.false.
         right=.true.
         iwdec=kr
         go to 42
        endif
        if(left)nleft=nleft+1
        if(right)nright=nright+1
   42  continue
c      write(*,'(a,i4,a,i4)')' nleft = ',nleft,' nright = ',nright
       if(nleft.gt.7)stop ' too many digits to the left! '
       if(nright.gt.6)stop ' too many digits to the right! '

       do 46 ki=ifst,ifst+nleft-1
        do 44 kd=1,10
         if(chin(ki:ki).eq.numc(kd))ldig(ki-ifst+1)=kd-1
   44   continue
   46  continue

       do 50 ki=ifst+nleft+1,ifend
        do 48 kd=1,10
         if(chin(ki:ki).eq.numc(kd))irdig(ki-(ifst+nleft+1)+1)=kd-1
   48   continue
   50  continue
c      write(*,'(a,7i1)') ' ldig: ',ldig
c      write(*,'(a,6i1)') ' irdig: ',irdig

       rval=0.0
       do 60 kd=1,nleft
        iexp=nleft-kd
        rval=rval+ldig(kd)*(10.0**iexp)
c       write(*,'(a,i3,f14.4)')' left: ',kd,rval
   60  continue
       do 70 kd=1,nright
```

```
         iexp=kd
         rval=rval+irdig(kd)*(1.0/(10.0**iexp))
c        write(*,'(a,i3,f14.4)')' right: ',kd,rval
   70   continue
        xreal=rval*xmult
c       write(*,'(a,3f14.4)')' rval,xmult2,xreal = ',rval,xmult,xreal
        return
       endif
       end

c
c "Eat" blanks embedded in character strings
c  ich=0 skip all blanks
c  ich=1 skip only blanks with before or after blank
c  nmnb=number of non-blanks (i.e., width of field)

      subroutine bleat(ich,nc,nmnb,chin)
      character*120 chin,chout

      do 1 k=1,120
       chout(k:k)=' '
    1 continue

      nmnb=0
      ndxo=0
      do 10 kc=1,nc
       if(chin(kc:kc).eq.' ')then
        if(ich.eq.0)then
         go to 10
        else
         if(kc.eq.1.or.kc.eq.nc)then
          go to 10
         else
          if(chin(kc-1:kc-1).eq.' '.or.chin(kc+1:kc+1).eq.' ')go to 10
         endif
        endif
        ndxo=ndxo+1
        chout(ndxo:ndxo)=chin(kc:kc)
       else
        ndxo=ndxo+1
        chout(ndxo:ndxo)=chin(kc:kc)
       endif
       nmnb=nmnb+1
   10 continue
      chin(1:nc)=chout(1:nc)
      return
      end

c mege
```

Diurnal and Monthly Variability of CALMET Meteorological Fields

Appendix C

Sid Richardson Carbon Company
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Environmental Resources Management
350 Eagleview Blvd
Exton, Pennsylvania 19341