Memorandum

To: Jim Neumann, Industrial Economics Inc.

From: Leland Deck, Stratus Consulting Inc.

Date: 3/9/10

Subject: MATS estimates of $PM_{2.5}$ estimates for the §812 scenarios.

This memorandum documents the methods and materials Stratus Consulting (Stratus) used to create fine particulate matter ($PM_{2.5}$) air quality estimates for the §812 second prospective project. Stratus prepared $PM_{2.5}$ air quality estimates for each of the six §812 scenarios:

- 2000 with the Clean Air Act Amendments (CAAA)
- 2000 without the CAAA
- 2010 with the CAAA
- 2010 without the CAAA
- 2020 with the CAAA
- 2020 without the CAAA

Some of the $PM_{2.5}$ estimates described in this memorandum were based on Community Multiscale Air Quality (CMAQ Version 4.6) model estimates for the six §812 second prospective scenarios prepared by ICF/SAI (Douglas et al., 2008). Rather than using the direct CMAQ results as the basis for the §812 health analysis, Stratus conducted additional analyses using a speciated monitor and model relative technique to prepare $PM_{2.5}$ air quality estimates used in the §812 analysis.

$PM_{2.5}$ Air Quality Estimates

The $PM_{2.5}$ estimates used in the §812 second prospective health analysis were prepared using EPA's Modeled Attainment Test Software (MATS, Version 2.1.1, Build 807). MATS estimates quarterly mean $PM_{2.5}$ chemical component concentrations at monitor locations (point estimates) by conducting a Speciated Modeled Attainment Test (SMAT) analysis. MATS can also estimate quarterly mean concentration estimates for each $PM_{2.5}$ chemical component concentrations at all grid cells in an Eulerian grid model such as CMAQ using a spatial field gradient interpolation procedure. The analysis for the §812 health analysis used MATS' spatial field gradient interpolation procedure to prepare the $PM_{2.5}$ estimates for the CMAQ 36km x 36km national grid.

Five of the six MATS $PM_{2.5}$ concentration estimates for the §812 scenarios were prepared using the MATS' spatial and temporal relative adjustment method ("Forecast – interpolated monitor

data to spatial field. Temporally adjust"). The MATS estimates for the 2000 with Clean Air Act Amendments scenario used a spatial only relative adjustment method, which relies on only monitor data and a single year of CMAQ modeling.

MATS estimates the $PM_{2.5}$ concentrations in CMAQ grid cells by interpolating values from nearby monitors using the inverse distance squared weighting option in the Voronoi Neighbor Averaging (VNA) procedure in MATS.

The spatial MATS analysis conducted for the $PM_{2.5}$ used the following input information;

- observed quarterly $PM_{2.5}$ data from 1,336 Federal Reference Method (FRM) monitors with sufficient data in at least one year from 2002 to 2004 (file "24-hr-official-FRM-99-06-v2.csv, as provided with the MATS Ver 2.1.1 installation package);
- observed daily chemically speciated fine particle mass data from both the $PM_{2.5}$ Speciated Trends Network (STN) and the Interagency Monitoring of Protected Visual Environments (IMPROVE), a total of 420 monitors with sufficient data in as least one year from 2002 to 2004 (file "24-hr-official-FRM-99-06-v2.csv", as provided with the MATS Ver 2.1.1 installation package; there is no speciated data in this dataset prior to 2002);
- speciated CMAQ estimates for 6 $PM_{2.5}$ species (SO_4, NO_3, elemental carbon, organic carbon, NH_4, and crustal material) at the 36 kilometer $PM_{2.5}$ CMAQ grid cell level for each of the §812 scenarios (from CMAQ speciated output data files provided by ICF/SAI).

An example configuration file (configuration.cfg) created by MATS is included in this memorandum as Appendix A. The sample configuration is from the 2010 With Clean Air Act scenario. Configuration files for all the other MATS analyses are identical except for:

- the Forecast Model Data File (identified on line 141) containing the speciated estimates from CMAQ, and
- the output file (*.asr) identified on line 14.
- The MATS spatial only adjustment procedure for the 2000 with Clean Air Act scenario uses the same CMAQ input file (from the 2000 with CAAA scenario) for both the baseline and control scenarios (lines 63 and 63). This allows MATS to conduct the relative spatial interpolation without a temporal component.

Additional details on the MATS procedures are available in the MATS User Manual (Abt Associates, 2009).

MATS produced estimated average quarterly concentrations for each of the CMAQ 36 km grid cells. These quarterly estimates were subsequently rewritten to the format required for inputting

daily $PM_{2.5}$ data into EPA's BenMAP software. Stratus used the rewritten MATS estimates to create a BenMAP air quality file (*.aqg) for each of the §812 scenarios.

Comparisons of FRM $PM_{2.}$ Monitor Data and Direct CMAQ $PM_{2.5}$ Estimates for the Year 2000 With Clean Air Act Amendments Scenario

In this analysis we compared EPA monitor data with the direct CMAQ $PM_{2.5}$ estimates for the year 2000, with Clean Air Act Amendments (2000 w CAAA) scenario (file pm_2000w.txt). We averaged the daily CMAQ $PM_{2.5}$ estimates in each CMAQ grid cell to estimate the annual mean $PM_{2.5}$ for each CMAQ cell.

We obtained monitor data for the years 2000, 2001 and 2002 from EPA's AirData system. In this analysis we selected only the Federal Reference Method (FRM) $PM_{2.5}$ monitors that had sufficient observations in each of the three years. The monitor data was considered sufficient if it had at least 45 days of valid data (i.e., met an annual 75% criteria for a monitor operating every six days) in each of the three years. We identified 1,012 $PM_{2.5}$ monitors in the CMAQ $PM_{2.5}$ domain that meet our sufficiency criteria, and calculated the average annual mean for each monitor. We also identified which CMAQ grid cell contained each monitor by using the latitude and longitude information for the monitors obtained from the AirData system.

The results of the comparisons between the 2000 with CAAA analysis are shown on two maps. Figure 1 shows the differences between the direct CMAQ estimates and the 2000-2002 average FRM monitor values. A positive value (measured in $\mu g/m^3$) occurs when the monitor value is greater than the direct CMAQ estimate. The range of differences between the monitor data and CMAQ estimates is from -18.1 $\mu g/m^3$ (CMAQ exceeding monitor) to +16.5 $\mu g/m^3$.

Figure 2 shows the differences between the MATS estimates and the 2000-2002 average FRM monitor values. The range of differences in Figure 2 is -3.9 1 $\mu g/m^3$ (MATS exceeding monitor) to +8.65 $\mu g/m^3$.

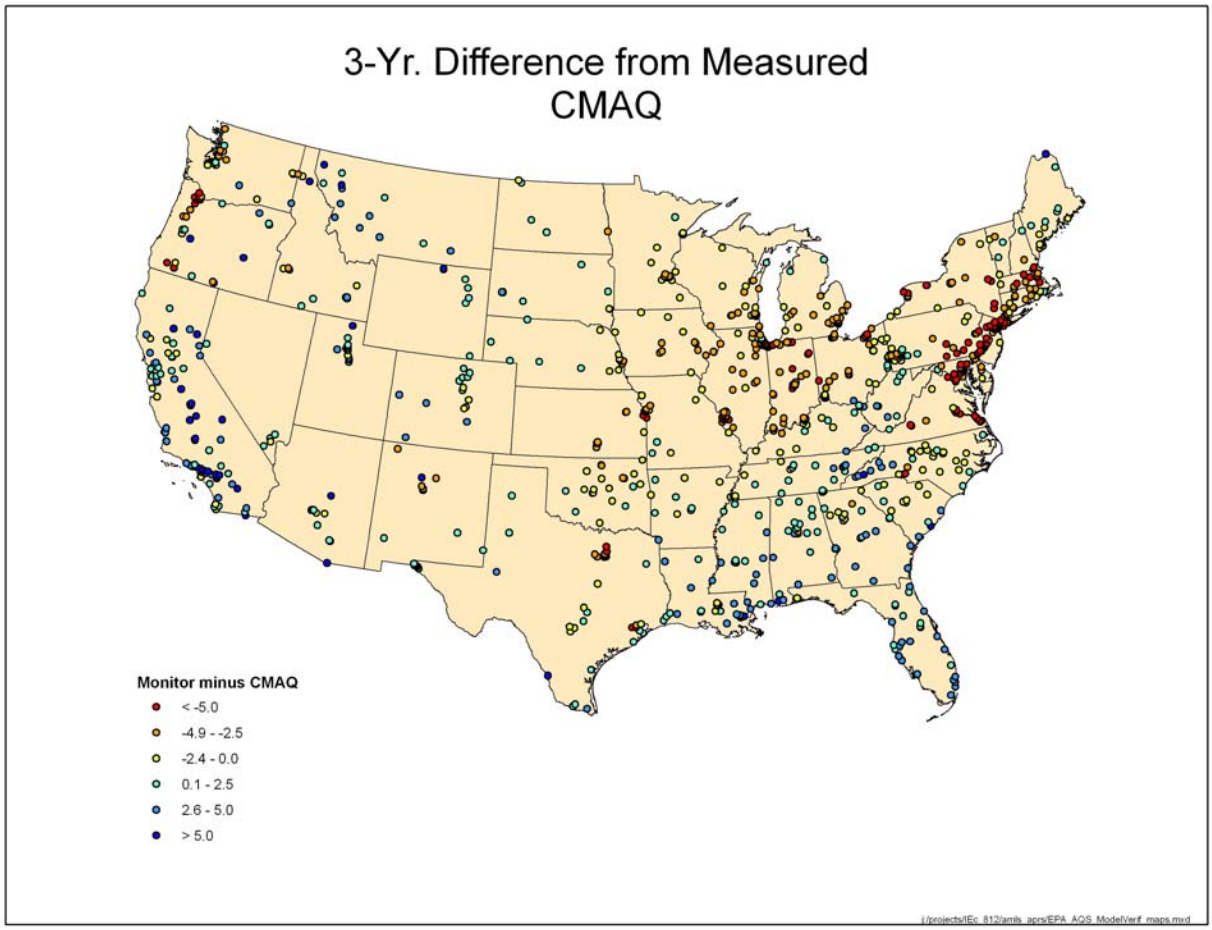

Figure 1 Differences between 2000-2002 average FRM $PM_{2.5}$ monitors and CMAQ estimates

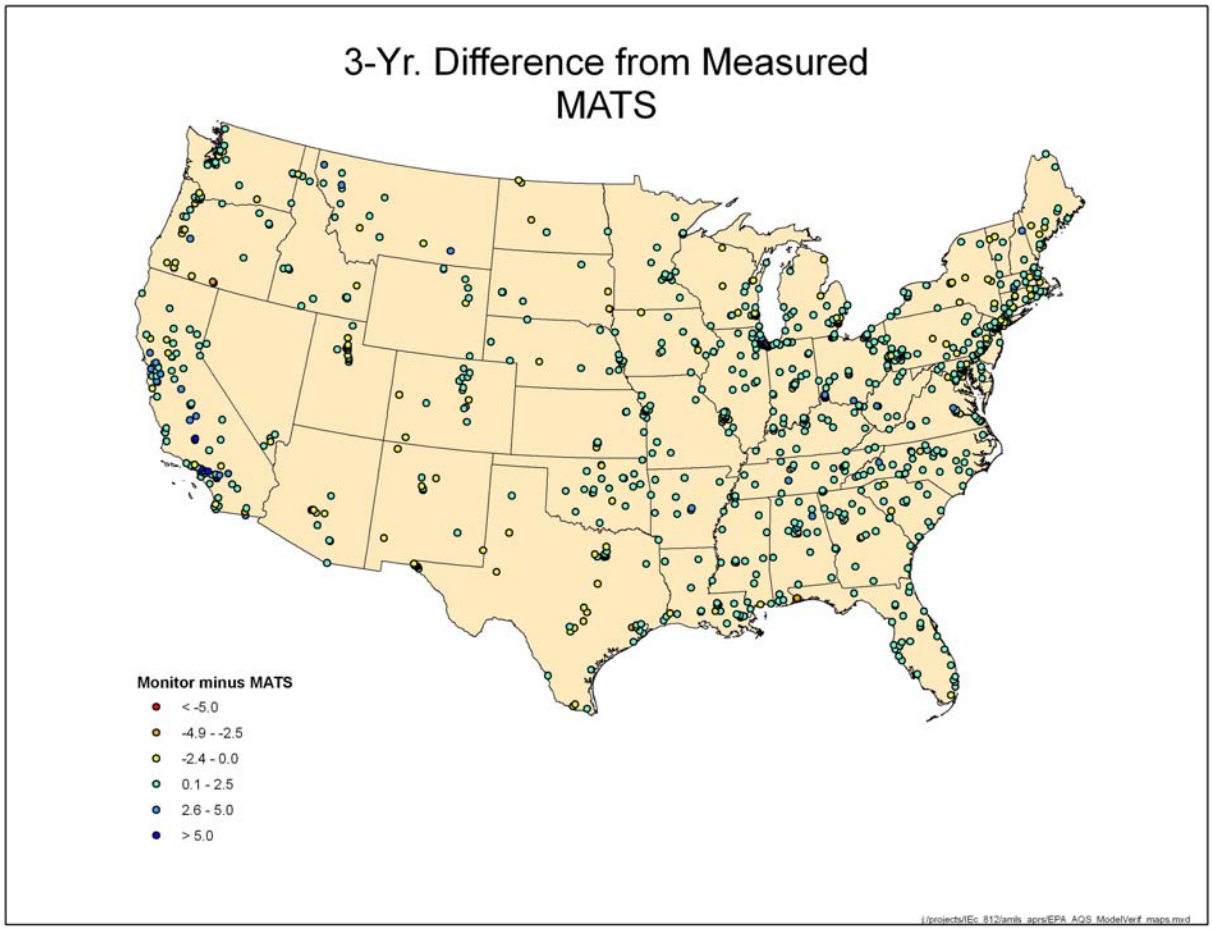

Figure 2 Differences between 2000-2002 average FRM PM2.5 monitors and MATS estimates

Figure 3 is a scatter plot comparing the direct CMAQ results with the 1,012 $PM_{2.5}$ monitors for 2000-2002. Figure 4 is a similar scatter plot, comparing the MATS results to the same set of $PM_{2.5}$ monitors.

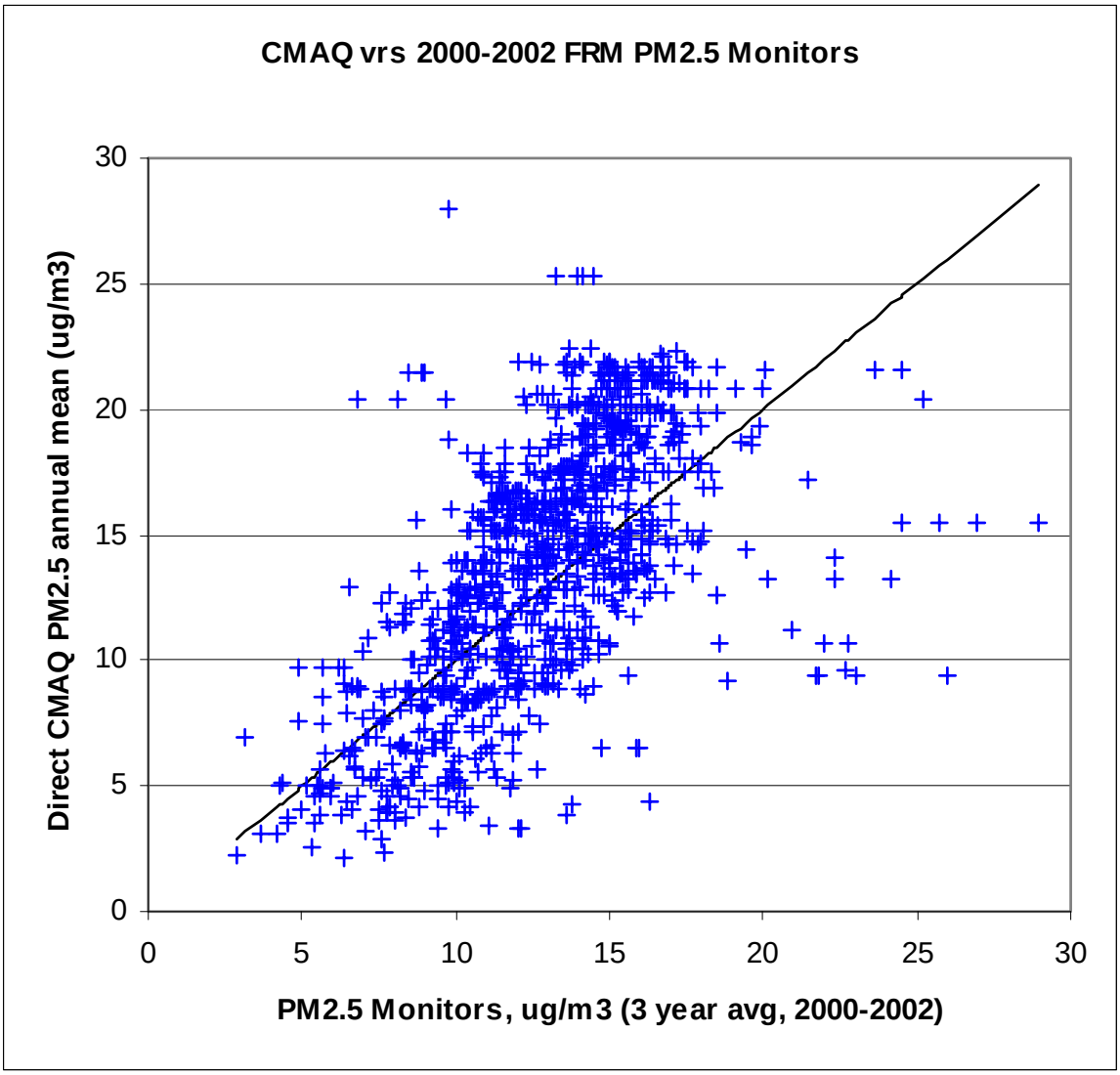

Figure 3 Scatter Plot of Direct CMAQ estimates and 2000-2002 $PM_{2.5}$ monitors

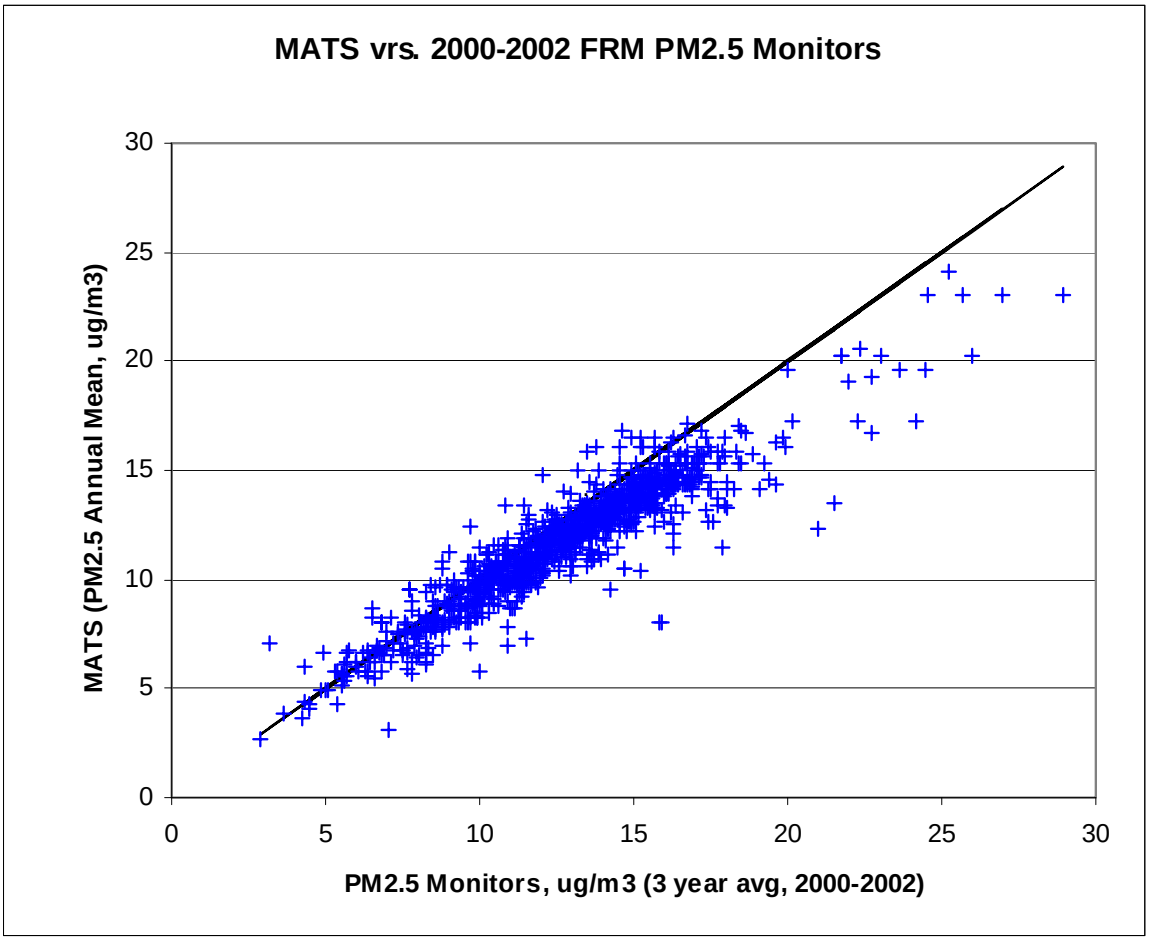

Figure 4 Scatter Plot of MATS estimates and 2000-2002 $PM_{2.5}$ monitors

Comparisons of 2002 $PM_{2.}$ Monitor Data With CMAQ and MATS $PM_{2.5}$ Estimates for the Year 2000 With Clean Air Act Amendments Scenario

In order to more clearly assess the performance of MATS we conducted a separate analysis to examine the performance of MATS using only the 2002 monitors, with a particular focus on the monitors Species Trends Network (STN) monitors. This permits a more direct comparison of a CMAQ and MATS results with the monitor values from that a single year.

For the 2002-only analysis we reran MATS in the same basic configuration as was used to prepare the MATS estimated §812 air quality for the 2000 with CAAA scenario, except only 2002 monitors in the MATS data sets were used. The MATS monitor input file includes 1,058 FRM $PM_{2.5}$ monitors with complete $PM_{2.5}$ data in 2002. The MATS speciated monitor input files include 2002 data from 183 STN monitors and 155 IMPROVE monitors.

Figure 5 is a scatter plot of the direct CMAQ 2000 with CAAA annual mean estimates and the 1,058 FRM $PM_{2.5}$ monitors from 2002. Figure 6 is a scatter plot of the MATS results (using only the 2002 monitor data) with the same set of 2002 $PM_{2.5}$ FRM monitors.

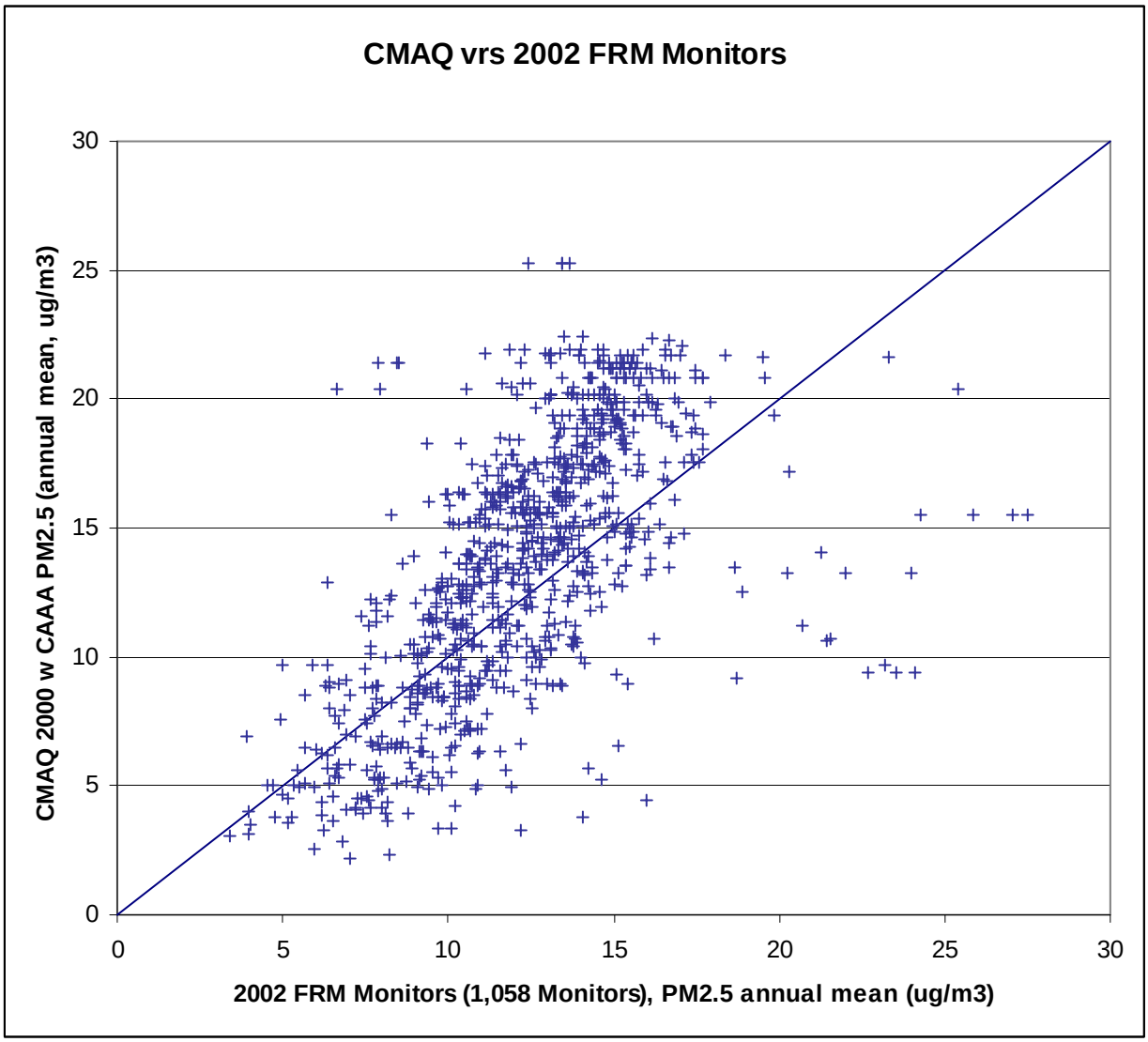

Figure 5 Scatter plot of direct CMAQ $PM_{2.5}$ estimates and 2002 FRM $PM_{2.5}$ monitors

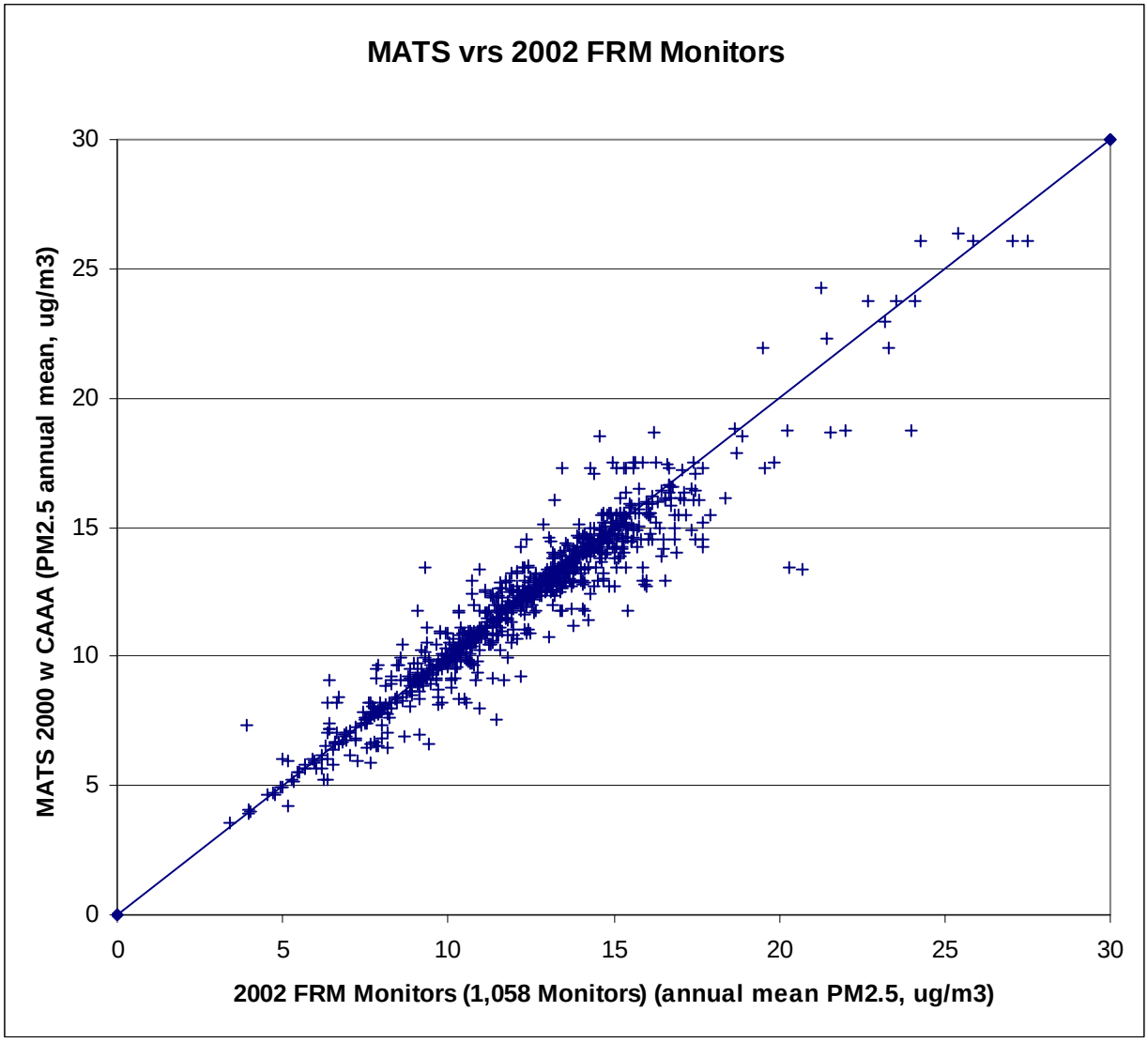

Figure 6 Scatter plot of MATS estimates and 2002 $PM_{2.5}$ FRM monitors.

While Figure 6 shows marked improvement over the direct CMAQ results shown in Figure 5, there is not perfect correlation. There are several reasons for this, including

- MATS estimates $PM_{2.5}$ levels at the center of each CMAQ grid cell, and uses an inverse distance weighting algorithm that uses data from neighboring monitors. Hence even when there is a monitor (or multiple monitors) within a grid cell, the estimated values at the center of the grid cell will combine data from multiple monitors.

- Figures 5 and 6 are scatter plots comparing the CMAQ or MATS estimates with observed data from 1,058 $PM_{2.5}$ monitors. MATS, however, uses speciated data from only 338 monitors (183 STN and 155 IMPROVE monitors) to use in combination with the 1,058 FRM monitors to calculate the estimated PM2.5 levels.

In order to examine the performance of MATS in finer detail, we looked at only the grid cells containing one of the 183 STN monitor locations. This analysis examines only the STN monitors because the IMPROVE monitors do not have FRM mass data in the MATS dataset. Figure 7 is the scatter plot comparing the direct CMAQ estimates with the 2002 FRM mass measured at the 183 STN monitors. Figure 8 is the scatter plot comparing the MATS estimates with same STN monitor data.

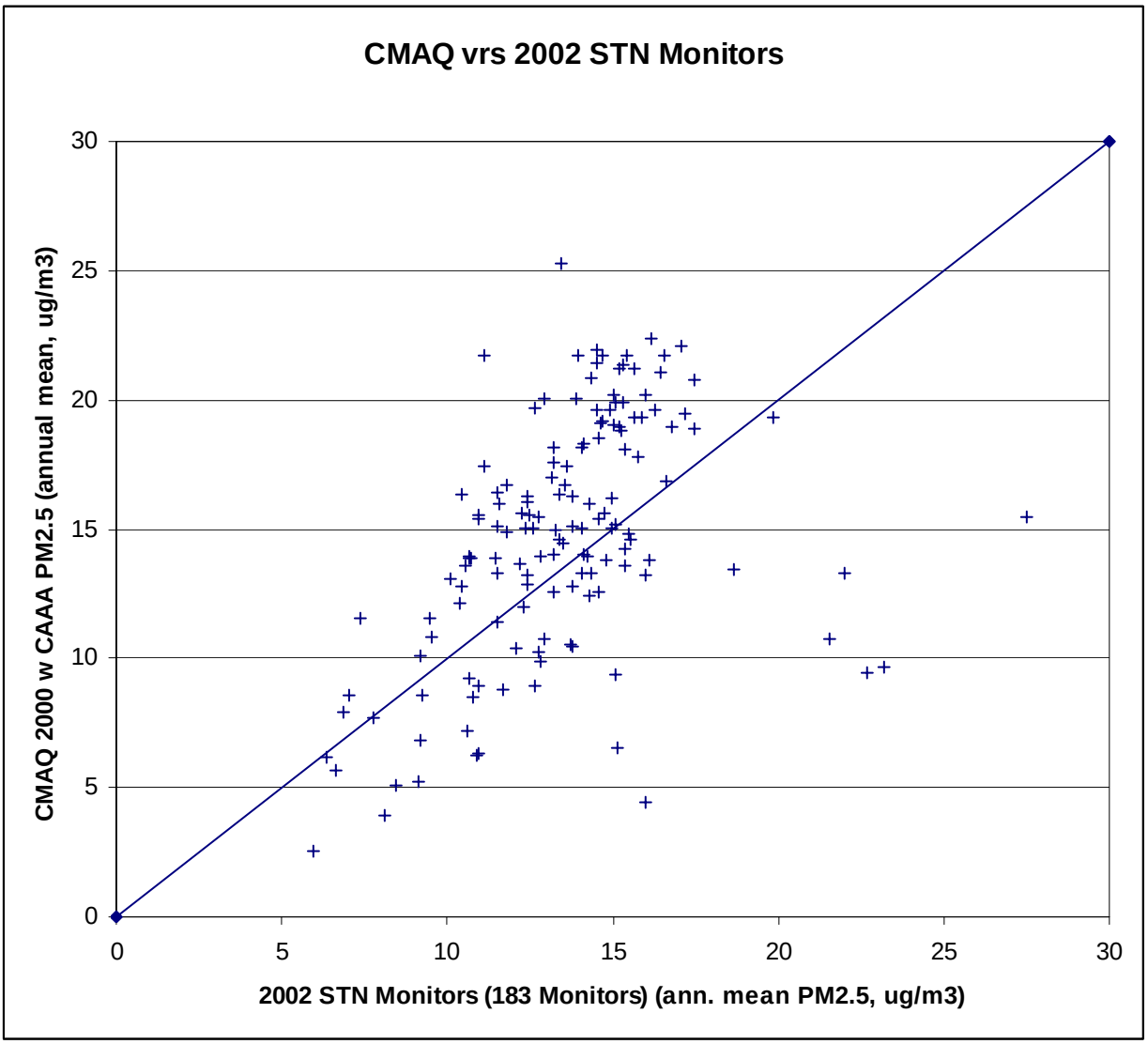

Figure 7 Scatter plot of direct CMAQ $PM_{2.5}$ estimates and 2002 STN $PM_{2.5}$ monitors

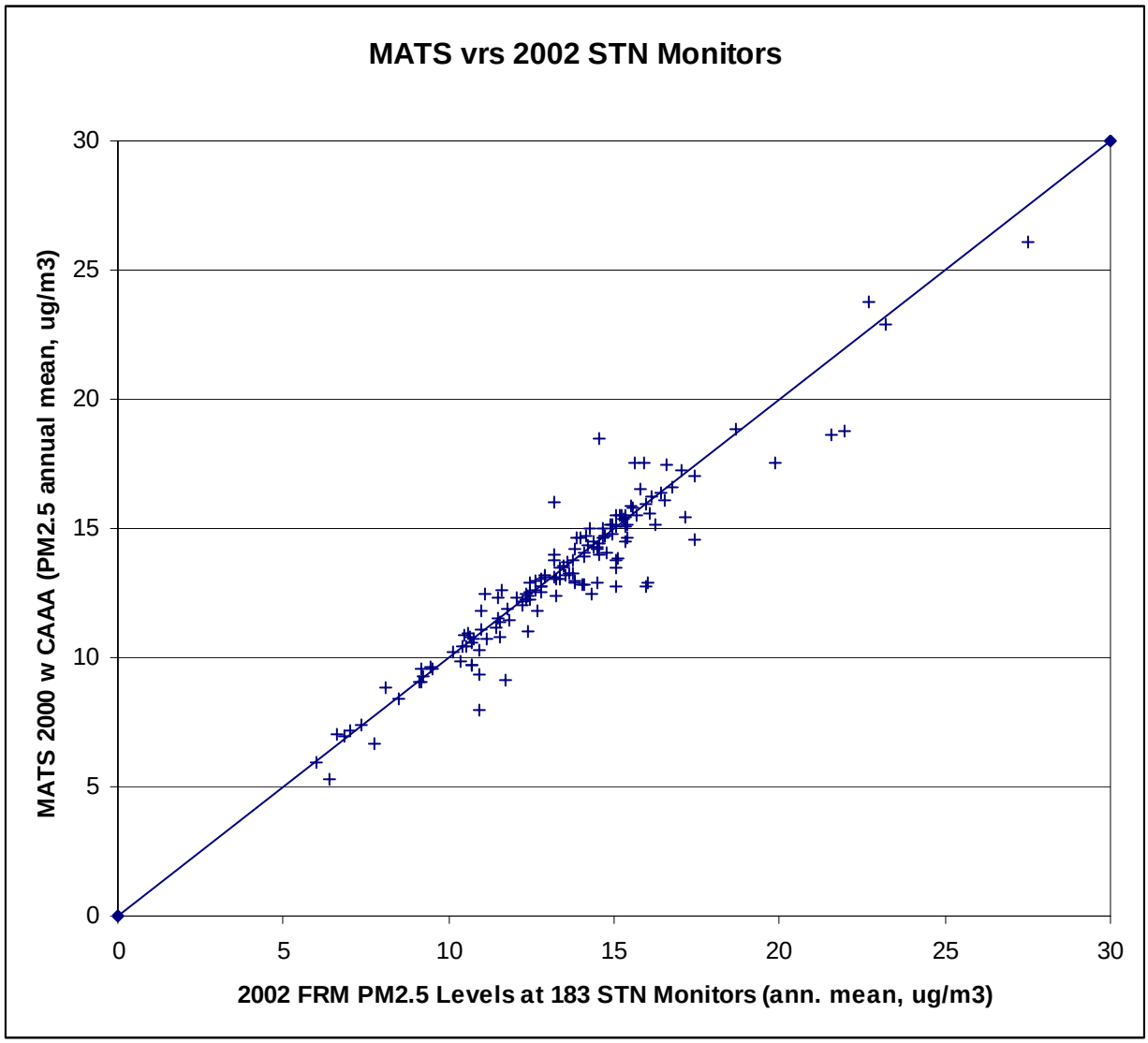

Figure 8 Scatter plot of MATS $PM_{2.5}$ estimates and 2002 STN $PM_{2.5}$ monitors

These scatter plots from the more detailed 2002-only monitor analysis indicate that the use of the multiyear monitor data used to prepare the §812 results in a wider spread in the MATS-and-monitor comparison.

References

Abt Associates. Modeled Attainment Test Software User's Manual. Report prepared for Brian Timmon, US EPA Office of Air Quality Planning and Standards, Research Triangle Park, NC. March, 2009.

Douglas, S.G., Haney, J.L, Hudischewskyj, A. B., Myers, T.C., and Wei, Y. "Draft Report. SECOND PROSPECTIVE ANALYSIS OF AIR QUALITY IN THE U.S.: AIR QUALITY MODELING". Report prepared for Jim DeMocker, US EPA by ICF International. September 30, 2008.

Appendix A: MATS Configuration.cfg file for 2010 With Clean Air Act Scenario

```
RunPM25=0
RunPM25Quarterly=1
RunPM25Daily=0
RunVisibility=0
RunOzone=0
o3UseBackStop=0
UseDefMaxDist_o3=0
o3UseHighDayPairs=0
MonitoredSpeciatedData=C:\Program Files\Abt Associates\MATS\SampleData\Timin_sandwich_all.csv
FRMSiteData=C:\Program Files\Abt Associates\MATS\SampleData\FRM_ASIP_input.csv
TargetPointDataCount=0
ModelFutureYearDataCount=1
ModelFutureYearData1=C:\Program Files\Abt Associates\MATS\SampleData\pm_model_2015.csv
OutputFileName=C:\Program Files\Abt Associates\MATS\output\812 2010 CAAA.asr
WindRecords=C:\Program Files\Abt Associates\MATS\SampleData\SimpleWind.csv
InterpolationsFile=C:\Program Files\Abt Associates\MATS\SampleData\Interpolations.csv
DefaultGeoMembership=C:\Program Files\Abt Associates\MATS\SampleData\GeoMembership.csv
ModelBaseYearData=C:\Program Files\Abt Associates\MATS\SampleData\pm_model_2001.csv
FRMDataBaseYear=2002
FRMDataBaseYearWindow=3
RunOutputForDefMesh=1
UseNH4AltCalc=0
AddDefMeshDataToTargets=1
TrackPctsCount=5
TrackPcts1=0.1
TrackPcts2=0.25
TrackPcts3=0.5
TrackPcts4=0.75
TrackPcts5=0.9
DefInterp=1
DefMaxDist=9000000000
FloorOCMValue=0.7
BCMFactor=1.4
NH4assNH3=0
BlankMass=0.5
ImgWidth=500
ImgHeight=400
outMonitorLocations=1
outNationalWalkView=0
NoGraphicalOutput=1
SIStartYear=2002
```

```
SIEndYear=2004
SIMinDays=11
SIMinQtr=1
SIMinYear=1
FRMStartYear=2002
FRMEndYear=2004
FRMMinDays=11
FRMMinDV=12
FRMMinDVC=10
FRMMinDVT=1
SIDayChecks=",,,,",",,,,",",,,,",",,,,"
SIQtrChecks=",,,,",",,,,"
opMonSpatial=0
opGradAdjSpatial=0
opMonSpatialFore=0
opToFRMGradAdjFore=0
opToFRMGradAdj=0
opToFRMFore=1
opToFRM=0
opGradAdjSpatialFore=0
ModelFutureYearData_O3Count=1
ModelFutureYearData_O31=C:\Program Files\Abt Associates\MATS\SampleData\ozone_model_data_2015.csv
ModelBaseYearData_O3=C:\Program Files\Abt Associates\MATS\SampleData\ozone_model_data_2001.csv
O3MonData=C:\Program Files\Abt Associates\MATS\SampleData\OZONE_MATS_input_9906.csv
DefInterp_o3=1
DefMaxDist_o3=100
O3StartYear=2002
O3EndYear=2004
O3MinDV=1
MaxDomainDist=25
MaxDomainDistVis=25
o3InitT=85
o3BackStop=60
O3MDBT=10
o3MinT=70
O3MDMT=5
o3TAG=1
o3GAG=0
```

```
o3TAS=0
o3TAG_s=1
o3GAG_s=1
o3TAS_s=1
opo3MonSpatial=0
opo3MonGASpatial=0
opo3MonSpatialTemp=0
opo3MonGASpatialTemp=0
opo3MonTemp=1
o3startrfday=1
o3endrfday=153
o3RRFAvg=5
o3SRFAvg=5
o3SRFStart=1
o3SRFEnd=5
ModelBaseYearData_vis=C:\Program Files\Abt Associates\MATS\SampleData\2002cc_EUS_PM25_sub.csv
ModelFutureYearData_visCount=1
ModelFutureYearData_vis1=C:\Program Files\Abt Associates\MATS\SampleData\2020cc_EUS_PM25_sub.csv
VisMonData=C:\Program Files\Abt Associates\MATS\SampleData\visibility_monitor_data_old_improve.csv
VisMonDataNew=C:\Program Files\Abt Associates\MATS\SampleData\2000-2004-daily IMPROVE-all data-new equation.csv
VisStartYear=2000
VisEndYear=2004
VisMinYear=3
VisBaseYear=0
visTAG=1
visTAG_s=0
visAttrFile=C:\Program Files\Abt Associates\MATS\SampleData\156-Class1-coordinates-all site names.csv
DefInterp_vis=1
DefMaxDist_vis=9000000000
opVisMon=0
opVisMonTemp=1
opUseAltLL=0
visAlgorithmVersion=1
qpm_doOutput_PeakData=1
qpm_doOutput_Standard=0
qpm_doOutput_QuarterlyModelData=1
qpm_doOutput_UsedQuarterlyModelData=0
qpm_doOutput_SpeciesFractions=0
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qpm_doOutput_ForecastPointEstimates=0
qpm_doOutput_GradientAdjustedSpeciesFractions=0
qpm_doOutput_InterpolatedSFE_TempAdj=0
qpm_doOutput_InterpolatedSFE_TempAdj_GradAdj=1
qpm_doOutput_QAF_Point=0
qpm_doOutput_QAF_Point_GradAdj=0
qpm_doOutput_QAF_SpatialField=0
qpm_doOutput_QAF_SpatialField_GradAdj=1
qpm_doOutput_HighCountySites=0
qpm_doOutput_SpeciesFractionsField_SpatialField=0
qpm_doOutput_SpeciesFractionsField_SpatialField_GradAdj=1
qpm_doOutput_QuarterlyAverageSpeciatedMonitors=0
qpm_doOutput_NeighborFiles_Point=0
qpm_doOutput_NeighborFiles_SpatialField=0
qpm_doInput_SpeciesMonitorDataFile=1
qpm_File_SpeciesMonitorDataFile=C:\Program Files\Abt Associates\MATS\SampleData\Species-for-fractions-0205-v2.csv
qpm_doInput_SpeciesFractionsFile=0
qpm_File_SpeciesFractionsFileModePoint=0
qpm_File_SpeciesFractionsFileModeSpatial=0
qpm_File_Unofficial_FRMDailyDataFile=C:\Program Files\Abt Associates\MATS\SampleData\PM25-for-fractions-0005-
v2.csv
qpm_File_Official_FRMQuarterlyAverageDataFile=C:\Program Files\Abt Associates\MATS\SampleData\Annual-official-FRM-
99-06-v2.csv
qpm_choice_UseQuarterlyModelData=0
qpm_BaselineModelDataFile=D:\EPA Projects\812\MATS\Make MATS Input\2000 CAAA\2000 CAAA 4 MATS.csv
qpm_ForecastModelDataFile=D:\EPA Projects\812\MATS\Make MATS Input\2010 CAAA\2010 CAAA 4 MATS.csv
qpm_IMPROVESTN_StartYear=2002
qpm_IMPROVESTN_EndYear=2004
qpm_IMPROVESTN_EPA_Deletions=1
qpm_IMPROVESTN_User_Deletions=0
qpm_IMPROVESTN_MinNumberOfValidDaysPerQuarter=11
qpm_IMPROVESTN_MinNumberOfValidQuartersPerYearForMonitor=1
qpm_IMPROVESTN_MinNumberOfValidYearsForMonitor=1
qpm_UnOfficialPM25_StartYear=2002
qpm_UnOfficialPM25_EndYear=2004
qpm_UnOfficialPM25_EPA_Deletions=1
qpm_UnOfficialPM25_User_Deletions=0
qpm_UnOfficialPM25_MinNumberOfValidDaysPerQuarter=11
```

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qpm_UnOfficialPM25_MinNumberOfValidQuartersPerYearForMonitor=4
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qpm_UnOfficialPM25_MinNumberOfValidYearsForMonitor=1
qpm_choice_IMPROVESTN_DoUseAlldailyMonitorValuesGreaterThan=1
qpm_IMPROVESTN_UseAlldailyMonitorValuesGreaterThan=0
qpm_IMPROVESTN_MinumumNumberOfDaysRequiredAboveFixedAmount=1
qpm_choice_IMPROVESTN_DoTopXPercent=0
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qpm_Interpolation_PM25=2
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qpm_Interpolation_NOx=2
qpm_Interpolation_EC=2
qpm_Interpolation_Crustal=2
qpm_Interpolation_DON=2
qpm_Interpolation_OC=2
qpm_Interpolation_NH4=2
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qpm_Interpolation_NOx_Distance=9000000000
qpm_Interpolation_EC_Distance=9000000000
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qpm_Interpolation_OC_Distance=9000000000
qpm_Interpolation_NH4_Distance=9000000000
qpm_Interpolation_SALT_Distance=9000000000
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qpm_choice_Misc_DoUseAmmoniumValues=0
qpm_Misc_NH4PercentageEvaporating=0
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qpm_Misc_DefaultBlankMass=0.5
qpm_Misc_OrganicCarbon=1
qpm_OCMMB_ceiling=0.8
qpm_OfficialPM25_StartYear=2002
qpm_OfficialPM25_EndYear=2004
qpm_choice_UseOfficialDesignValues=1
qpm_choice_UseCustonDesignValues=0
qpm_choice_CalcNH4fromDON=1
qpm_ValidFRMQuarters=11
qpm_ValidFRMDesignValues=12
qpm_ValidFRMMonitors_MinimunNumberOfDesignValues=1
qpm_ValidFRMMonitors_RequiredDesignValues=None selected
qpm_TemporalAdjustmentAtMonitorGrid=1
qpm_TemporalAdjustmentType=0
qpm_TemporalAdjustmentAtMonitorGridSpatial=0
qpm_TemporalAdjustmentTypeSpatial=0
qpm_choice_RRF_DoUseAllModelDaysGreaterThan=1
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qpm_RRF_MinumumNumberOfDaysRequiredAboveFixedAmount=1
qpm_choice_RRF_DoTopXPercent=0
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qpm_choice_RRF_DoTopXValues=0
qpm_RRF_TopXValues=25
qpm_choice_Gradient_DoUseAllModelDaysGreaterThan=1
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qpm_Gradient_MinumumNumberOfDaysRequiredAboveFixedAmount=1
qpm_choice_Gradient_DoTopXPercent=0
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qpm_choice_Gradient_DoTopXValues=0
qpm_Gradient_TopXValues=25
qpm_MaxDistCell=25
```

Appendix B: BenMAP Audit Trail file for 2010 With Clean Air Act Scenario (western domain) air quality grid

```
D:\EPA Projects\812\BenMAP\o3_wus_2010 CAAA eVNA 2002 monitors.aqg

      Pollutant: Ozone
      Interpolation Method: Voronoi Neighborhood Averaging
      Library Monitors: True
      Monitor Dataset Name: EPA Standard Monitors PM, O3
      Monitor Year: 2002
      Scaling Type: Both
      Base Year Model File: D:\EPA\812\BenMAP\output files created\o3_wus_2000 CAAA 3metrics.csv
      Base Year Model Table: o3_wus_2000 CAAA 3metrics.csv
      Future Year Model File: D:\EPA\812\BenMAP\output files created\o3_wus_2010 CAAA 3 metrics.csv
      Future Year Model Table: o3_wus_2010 CAAA 3 metrics.csv
      Grid Definition

            Name: CMAQ 812 West US ozone
            ID: 92
            Columns: 213
            Rows: 192
            Grid Type: Shapefile
            Shapefile Name: WUS_polys



            Neighbor Scaling Type: Inverse Distance
Advanced
      Monitor Filtering

            Methods: 3, 11, 14, 19, 47, 53, 55, 56, 78, 87, 91, 103, 112, 134
            Objectives: .
            Maximum POC: 4
            POC Preferences: 1, 2, 3, 4
            Minimum Lat, Long: 20, -130
            Maximum Lat, Long: 55, -65
            Start Hour: 8
            End Hour: 19
            Observations Required Per Day: 9
            Start Day: 120
```

```
End Day: 272
Valid Days Required Per Year: 76
```