5.0 $PM_{2.5}$ 2009 AND 2012 PROJECTIONS

This chapter presents the 2009 and 2012 future-year $PM_{2.5}$ Design Values projections for $PM_{2.5}$ Federal Reference Method (FRM) monitoring sites within the St. Louis nonattainment area (NAA) and their comparison with the 2002 annual $PM_{2.5}$ National Ambient Air Quality Standard (NAAQS).

The 2009 future-year $PM_{2.5}$ Design Value projections for $PM_{2.5}$ at the Granite City monitoring site using the CMAQ 2009 Base 5a modeling results as shown in Table 5-3 is 15.53 $\mu g/m^3$, which is just at the highest value allowed for a weight of evidence (WOE) attainment demonstration.

Reducing the concentration at Granite City monitor from 15.53 to achieve compliance with the annual NAAQS will entail additional control measures targeting direct $PM_{2.5}$ sources. Therefore, in accordance with section 172(a)(2)(A) of the CAA which states that EPA may grant an area an extension of the initial attainment date for a period of one to 5 years for an area showing that attaining the NAAQS by 2010 was impracticable, the States of Missouri and Illinois requested that the attainment date be extended to 2012. This date extension was essential since more time was needed to implement the new RACT rules for SO2 and NOx. Moreover, other important federal/states rules will not be effective until after 2010. For example, CAIR-Phase I SO2 control from power utilities will cover the years 2010-2014 and IEPA's multi-pollutant utility controls will be in place in 2011.

It is important to note that the primary regional modeling system for the development of the St. Louis annual $PM_{2.5}$ attainment demonstration was the CMAQ model. This is due to better overall model performance in the 2002 base year and a need to minimize the overall resources necessary to complete the modeling analyses.

5.1 GUIDANCE FOR $PM_{2.5}$ PROJECTIONS

EPA has published final modeling guidance that includes recommendations on how modeling results should be used to project future-year $PM_{2.5}$ levels:

> "Guidance on the Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$ and Regional Haze" (EPA, 2007a).

EPA recommends that the modeling results be used in a relative fashion to scale the observed current-year $PM_{2.5}$ Design Value (DVC) to project a future-year $PM_{2.5}$ Design Value (DVF). As described in Section 5.3, the DVC specified in the guidance is actually the average of the three design values containing the base year (e.g. 2000-02, 2001-03, and 2002-04) The model derived scaling factors are called Relative Response Factors (RRFs) and are defined as the ratio of the future-year to current-year modeling results. The $PM_{2.5}$ DVF is obtained from the $PM_{2.5}$ DVC by applying the RRF:

$$DVF = DVC \times RRF$$

Separate RRFs are applied for each major component of $PM_{2.5}$ using a procedure called the Speciated Modeled Attainment Test (SMAT). The RRFs are monitoring site-specific PM species and are derived using modeling results "near" each monitor. The SMAT procedure applies the PM species-specific RRFs to the major components that make up the $PM_{2.5}$ DVC to obtain future-year $PM_{2.5}$ species estimates that are summed to obtain the DVF that is compared with the $PM_{2.5}$ NAAQS. The major components of $PM_{2.5}$ that are projected from the current to future-year are:

- Sulfate (SO_4);
- Nitrate (NO_3);
- Ammonium (NH_4);
- Elemental Carbon (EC);
- Organic Carbon Mass (OCM); and
- Other $PM_{2.5}$ or Fine Crustal Matter (SOIL).

Also included in the current- and future-year $PM_{2.5}$ concentrations are particle bound water (PBW) that is associated with the hygroscopic species (SO_4 and NO_3); a blank correction measurement artifact that is assumed to be 0.5 $\mu g/m^3$; and sea salt. Both the artifact and sea salt remain constant from the current- to future-year.

The current $PM_{2.5}$ SIP which was due April 2008 addresses the 15.0 $\mu g/m^3$ annual $PM_{2.5}$ NAAQS. All FRM monitors in the St. Louis NAA continue to attain the 65 $\mu g/m^3$ 24-hour $PM_{2.5}$ NAAQS so projections are only made for the annual $PM_{2.5}$ NAAQS. NOTE: In 2006, the EPA revised the 24-hour $PM_{2.5}$ NAAQS with a new threshold 35 $\mu g/m^3$. The revised 24-hour $PM_{2.5}$ NAAQS will be addressed in a future $PM_{2.5}$ SIP if the area is formally designated as nonattainment.

$PM_{2.5}$ attainment is based on $PM_{2.5}$ mass measurements collected at FRM monitoring sites. In order to apply the $PM_{2.5}$ species-specific RRFs, the FRM $PM_{2.5}$ mass measurements must be speciated into the individual PM species components of $PM_{2.5}$. There are two routine $PM_{2.5}$ speciation networks being operated in the U.S.: STN and IMPROVE networks. Thus, the $PM_{2.5}$ speciation data from these two networks need to be mapped to the FRM $PM_{2.5}$ mass measurements in order to apply the RRFs to project $PM_{2.5}$ DVFs. This results in two main components for using modeling results to project $PM_{2.5}$ DVFs:

<u>Speciation of Measured FRM $PM_{2.5}$ Mass using the SANDWICH Method</u>: The FRM $PM_{2.5}$ mass and STN/IMPROVE $PM_{2.5}$ speciation measurements have positive and negative artifacts that need to be accounted for when mapping observed $PM_{2.5}$ speciation data to the FRM mass measurements. As $PM_{2.5}$ attainment is based solely on the FRM $PM_{2.5}$ mass measurements, then the STN/IMPROVE $PM_{2.5}$ speciation measurements must be adjusted to mimic the FRM $PM_{2.5}$ mass measurements. EPA has developed the **S**ulfate **A**djusted **N**itrate, **D**erived **W**ater **I**nferred **C**arbon **H**ybrid material balance approach (SANDWICH) for estimating $PM_{2.5}$ mass composition produced by the FRM $PM_{2.5}$ mass measurements to account for measurements artifacts (Frank, 2006a,b).

<u>Projection of Current-Year $PM_{2.5}$ Components to Future-Year using SMAT</u>: (SMAT) (EPA, 2007a; Timin, 2007) uses the relative changes in modeled concentrations to project observed $PM_{2.5}$ DVC to the future.

EPA has codified the SMAT recommended procedures (EPA, 2007a) for projecting future-year 8-hour ozone and $PM_{2.5}$ Design Values and regional haze in MATS. The latest version of MATS at this writing (Version 1.3.1; January 2008) includes procedures for projecting 8-hour ozone, annual $PM_{2.5}$ and regional haze, but not 24-hour $PM_{2.5}$. Previous versions of MATS, before January 2008, did not have a capability for making annual $PM_{2.5}$ projections. Thus, the St. Louis study team developed $PM_{2.5}$ projection software using Excel spreadsheets. In this Chapter we present the 2009 $PM_{2.5}$ projections using the Excel spreadsheet projection and the CMAQ 2009 Base 5a modeling results. Additional $PM_{2.5}$ DVF projections using the Excel spreadsheet projection software and MATS are presented as Additional Analyses in Chapter 6.

The SMAT procedure RRFs are applied separately to the quarterly average components of the $PM_{2.5}$ DVC. When developing the quarterly PM species components of the monitor DVCs from the FRM $PM_{2.5}$ mass and SANDWICH $PM_{2.5}$ speciation, the 24-hour average concentrations from each sample day are averaged across each quarter with quarters defined in 3-month increments (e.g., Quarter 1 is January-February-March). The FRM and STN networks typically use a 1:3 day sampling frequency, which results in approximately 30 days per quarter used in the averaging assuming complete data capture. For the quarterly averaged modeled RRFs, the quarterly averages are obtained by averaging across every modeled day in each quarter of 2002. Thus, modeled RRFs for Quarters 1 through 4 are based on modeled averages across 90, 91, 91 and 91 days, respectively. The full day of December 31, 2002 was not simulated by the model because the MM5 meteorological data stops at midnight GMT so the conversion to local standard time loses the end of the day. No attempt was made to develop modeled quarterly average RRFs based on the 1:3 day FRM/STN monitoring site sampling frequency. Although the FRM/STN 1:3 sampling frequency protocol specifies the same 1:3 days for sampling, in practice samples at some sites may be missed. Also, if a sampling day is missed, there may be a make up day outside of the standard 1:3 day protocol. In addition, some samples may be invalid, and so will be missing. Finally, some sites use a 1:6 day sampling frequency.

5.2 PROCEDURES FOR SANDWICH SPECIATION OF STN $PM_{2.5}$ COMPONENTS

The SANDWICH procedure is designed to map the STN/IMPROVE $PM_{2.5}$ speciation measurements to the FRM $PM_{2.5}$ mass measurements accounting for the artifacts and sampling protocols of both sampling devices. $PM_{2.5}$ attainment is based solely on the FRM $PM_{2.5}$ mass measurements, which were developed by design to emulate the $PM_{2.5}$ mass measurements from the epidemiological studies that formed the basis for the $PM_{2.5}$ NAAQS (CFR, 1997). The FRM mass sampling procedures include a specific sampling protocol that involves sampling PM at a 2.5 μm cut point with filter temperature control, rapid sample retrieval, and cold filter shipping. The $PM_{2.5}$ mass is determined by gravimetrically weighing the pre- and post-sampling Teflon filters that have been equilibrated for a minimum of 24 hours at standardized conditions of 25-30 degrees C temperature and 30-40% relative humidity (Rh). This results in the FRM $PM_{2.5}$ mass measurements not capturing all particles and reflects loss of volatile species including ammonium nitrate [NH_4NO_3] and semi-volatile organic compounds (SVOC), which are negative artifacts in the FRM sampling. The FRM measurements also include PBW associated with hygroscopic species, which is a positive artifact.

The SANDWICH uses a mass balance approach to adjust the STN and IMPROVE speciated $PM_{2.5}$ measurements to characterize the FRM $PM_{2.5}$ mass. In addition to addressing the artifacts

of the FRM sampling procedures, it also addresses the artifacts and sampling protocol of the STN filter measurements accounting for blank correction and inaccuracies in the STN organic carbon measurements. In particular the SANDWICH approach uses the STN measured sulfate, adjusted nitrate, derived PBW and inferred organic carbon. The SANDWICH assumes that the FRM $PM_{2.5}$ mass consists of the following components:

$$\text{FRM } PM_{2.5} \text{ Mass} = [SO_4] + [EC] + [NO_{3\ FRM}] + [NH_{4\ FRM}] + [OCM_{mb}] + [PBW] + [SOIL] + [\text{blank correction}] + [\text{Sea Salt}]$$

where,

$[SO_4]$ is the measured sulfate ion;

[EC] is the measured elemental carbon;

$[NO_{3\ FRM}]$ is the NO_3 ion retained on the FRM filter after a portion as been volatilized in the FRM measurement process;

$[NH_{4\ FRM}]$ is the NH_4 cation retained on the FRM filter after partial volatilization;

$[OCM_{mb}]$ is the organic carbon material that is obtained as the difference between the FRM $PM_{2.5}$ mass measurements and the remainder of the $PM_{2.5}$ components;

[PBW] is particle bound water to the hygroscopic PM components;

[SOIL] is soil and other inorganic fine particulate matter;

[blank correction] is the passively collected PM material in the STN measurement process that is assumed to be 0.5 $\mu g/m^3$; and

[Sea Salt] is the measured Sea Salt concentration.

Note that the concentration due to Sea Salt is not always included in the SANDWICH FRM $PM_{2.5}$ mass balance approach. For example, it was not included in the EPA modeling guidance (EPA, 2007) so was not implemented in the St. Louis Excel spreadsheet projection software. On the other hand, it is included in the MATS tool that was used to make projections in this chapter. In the future year $PM_{2.5}$ projections, Sea Salt is assumed to remain constant from the current to future year, so is treated in a similar manner to the blank correction.

5.2.1 Retained Particulate Nitrate [$NO_{3\ FRM}$]

The first step in the SANDWICH procedure for identifying mass components was to estimate the retained nitrate mass on the FRM filters. The FRM does not capture all of the semi-volatile components of the ambient air, such as ammonium nitrate. The retained amount of nitrate ion, however, can be reasonably estimated by a simple thermodynamic model that uses 24-hour ambient nitrate speciation concentrations (as measured by a standard speciation sampler using a nylon filter preceded by a HNO_3 denuder) together with hourly ambient temperature and humidity. Atmospheric nitrates are higher during the cooler months. Retention on the FRM is

also higher during the cooler months and essentially all the nitrates are lost during the summer due to volatilization. The retention does not appear to depend on ambient NH_3 or HNO_3. More NO_3 is retained at low temperatures and high Rh which varies by sampling location and time of year.

Because nitrate retention varies by site and season, the Aerosol Inorganic Model (AIM) ammonium nitrate equilibrium model is used to predict the amount of nitrates retained on the FRM Teflon filter under the FRM sampling conditions (35% RH and 21 C). As used by Hering and Cass (Hering and Cass, 1999; Zhang and McMurry, 1992) the amount of volatilized nitrate (Δ NO_3) is defined by:

$$\Delta NO_3\ (\mu g/m^3) = 745.7/T_R * 1/24 * \sum_{i=1}^{24} (\mathbf{K}_i^{1/2})$$

where, T_R is the reference temperature for the sampled air volume in degrees Kelvin and **Ki** is the dissociation constant for ammonium nitrate evaluated at the ambient temperature for hour i. This volatilization prediction characterizes depletion of some or all of the HNO_3 and ammonia vapors ahead of the filter and specifies a 3-5 degree Kelvin increase in the filtration temperature above ambient.

This model is used to adjust 24-hour STN nitrate ion (NO_3-) concentrations [$NO_{3\ STN}$] to estimate FRM NO_3 [$NO_{3\ FRM}$] as follows:

$$NO_{3\ FRM} = NO_{3\ STN} - \Delta NO_3\ (\mu g/m^3)$$

For each hour of the day, the equilibrium dissociation constant for ammonium nitrate, Ki, was calculated from hourly ambient temperature and hourly ambient Rh based on formulas developed by Mozurkewich (1993) and as applied by Chang and co-workers (2000).

When Rh is less than deliquescence point of ammonium nitrate (61%), then:

$$\ln(K) = 118.87 - (24084/T) - 6.025 \ln(T)$$, where K is in nanobars and T is in Kelvins

When Rh is higher than 61%, K is replaced by

$$K' = [P_1 - P_2(1-a) + P_3(1-a)^2]\ (1-a)^{1.75} * K$$

where ln(P1), ln(P2) and ln(P3) are specified as:

$$\ln(P_1) = -135.94 + 8763/T + 19.12\ln(T)$$
$$\ln(P_2) = -122.65 + 9969/T + 16.22\ln(T)$$
$$\ln(P_3) = -182.61 + 13875/T + 24.46\ln(T)$$

The above equation for K' assumes crystallization of ammonium nitrate when Rh is less than 61%. Thus, predicted NO_3 loss may be underestimated for situations where solids do not form on the filter. For supersaturated solutions with lower RH, the estimated dissociation for the

solution will be larger than K for the solid. However, there is little or no data that can be used to give a reliable result for how much larger.

Based on the equations above, Figure 5-1 illustrates the potential nitrate loss as a function of temperature and Rh. Temperature is presented as degrees Fahrenheit (F) for more convenient interpretation. It shows that at 50 deg F and Rh of 80%, approximately 1.6 $\mu g/m^3$ nitrate would be lost. At Rh less < 61% an additional 0.4 ug/m3 could be lost. In both cases, the loss cannot exceed the amount of ambient NO_3, as depicted by the STN NO_3. When these predictions are compared with measured FRM nitrates at six eastern US monitoring locations, the annual average prediction errors are less than -0.3 to +0.1 $\mu g/m^3$ (Frank, 2006a).

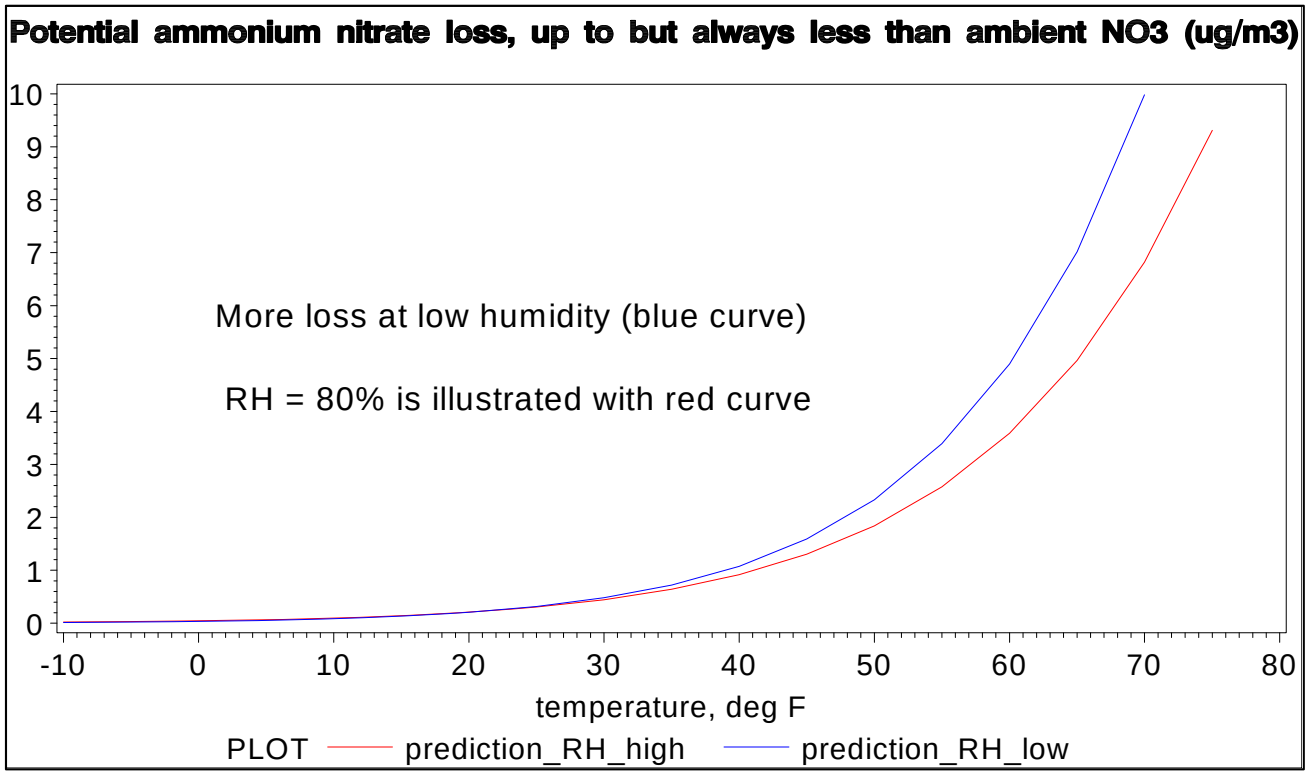

Figure 5-1. Potential NO_3 loss (Δ NO_3) as a function of temperature and Rh.

5.2.2. Estimated Ammonium Associated with Sulfate and Retained Nitrates and Sulfates

To determine the mass associated with nitrates, the SANDWICH approach assumes that all retained nitrate is in the form of ammonium nitrate, which is likely an accurate assumption over the St. Louis area, which is not impacted by sea salt from a coastline or dust from alkali soils. In coastal areas, nitrate may also be neutralized by sodium. However, sodium nitrate concentrations would mainly be in the PMC mode and would not be collected on the FRM or STN $PM_{2.5}$ samplers. Assuming that all of the particulate nitrate is in the form of ammonium nitrate, the ammonium associated with nitrates can be derived directly from the FRM retained $NO_{3\ FRM}$ as:

$$NH_{4\ NO3} = 0.29 * NO_{3\ FRM}$$

Similarly, the dry $PM_{2.5}$ mass associated with $NH_{4\ NO3}$ is:

$$[\text{Retained dry FRM } NH_{4\ NO3}] = 1.29 * NO_{3\ FRM}$$

5.2.3 Ammoniated Sulfate Mass

The mass associated with sulfates is first estimated as its dry mass. All estimated sulfates are assumed to be associated with ammonium, but the form of the sulfate compound and the amount of ammonium must be estimated. The form of the ammoniated sulfate compound(s) and the amount of associated ammonium, however, is somewhat uncertain.

Sulfates may not be fully neutralized in all geographic areas or seasons of the year. During winter-time conditions, when nitrates are prevalent in the ambient aerosol, sulfates tend to be fully neutralized and exist as ammonium sulfate [$(NH_4)_2SO_4$]. During the summer, when sulfates are higher and nitrates are lower and ammonia is less available for reaction with sulfuric Acid H_2SO_4, the resulting aerosol can be acidic and the form of sulfates can include ammonium bisulfate [NH_4SO_4] or even H_2SO_4.

The amount of ammonium associated with the sulfate ion can be estimated as:

$$NH_{4\ (SO4)} = NH_{4\ adj} - 0.29 * NO_{3\ FRM},$$

where, 0.29 is the molar ratio of NH_4 to NO_3 and
$NH_{4\ FRM}$ and $NO_{3\ FRM}$ reflect the amounts retained on the FRM filter.

The amount of $NH_{4\ (SO4)}$ is not allowed to exceed the fully neutralized amount of 0.375 multiplied by the estimated sulfate ion concentration.

Because of uncertainties in NH_4 speciation measurements and the fact that the IMPROVE monitoring network does not measure NH_4, NH_4 is calculated by deriving the degree of SO_4 neutralization (DON) from the estimated $NH_{4\ (SO4)}$ as:

$$DON = NH_{4\ (SO4)} / SO_4$$

The DON is assumed to remain constant from the current-year to future-year. Values of DON, sulfate and estimated FRM nitrate (adjusted nitrate) are used to estimate the adjusted ammonium at each FRM site as follows:

$$NH_{4\ FRM} = DON * SO_4 + 0.29*NO_{3\ FRM}$$

where, DON, SO_4 and NO_3FRM are the quarterly average values at each FRM site.

Thus, in the standard SANDWICH SMAT application $NH_{4\ FRM}$ is not a direct measured value, but is derived from the DON, SO_4, and $NO_{3\ adj}$ values. In the default EPA $PM_{2.5}$ Design Value projection approach, interpolated DON values are used to estimate ammonium, this is due to uncertainties in the ammonium measurements and the lack of NH_4 measurements at IMPROVE sites.

5.2.4 Particle Bound Water

Because ammoniated sulfate and ammonium nitrate are hygroscopic, the retained sulfate and nitrate mass will include water[1]. PBW is estimated using the Aerosol Inorganic Model (AIM) (Clegg, 1998). PBW was derived from quarterly average FRM concentrations of SO_4, NH_4, and NO_3 as describe above. Estimated hydronium ion (H+) needed to achieve ionic balance was derived from the latter values. The model enables the distribution of water and ions to be calculated between liquid, solid and vapor phases for specific temperature and Rh conditions. Typical filter equilibration conditions of 35% Rh and 22 deg C (295 deg K) temperature are used.

Application of AIM at the specified FRM filter equilibration conditions show that PBW is much more dependent on sulfate concentration compared to nitrate and that the relationship varies somewhat by season to differentiate the relative amounts of sulfate and nitrate aerosol. There is proportionally less estimated PBW water for wintertime aerosol which has higher NH_4 and NO_3 and lower SO_4.

For computational convenience, a polynomial regression equation was fit to the calculated water mass from AIM under the FRM equilibration conditions and the three input values that fed into AIM (sulfate, nitrate and ammonium). The polynomial equation was used in all SMAT analyses to estimate water. Due to the non-linear nature of the water calculation, the measurements were divided into 2 regimes: all measurements (site-days) where DON > 0.225 and all measurements where DON ≤ 0.225. A separate equation was developed to represent each regime.

The equations are as follows:

$$S = SO_4 / (SO_4 + NO_{3\,FRM} + NH_{4\,FRM})$$
$$N = NO_{3\,FRM} / (SO_4 + NO_{3\,FRM} + NH_{4\,FRM})$$
$$A = NH_{4\,FRM} / (SO_4 + NO_{3\,FRM} + NH_{4\,FRM})$$

If DON ≤ 0.225 then:

$$\begin{aligned} PBW = \; & 595.56 \\ & - 1440.58*S \\ & - 1126.49*N \\ & + 283.91*(S^{1.5}) \\ & - 13.38*(N^{1.5}) \\ & - 1486.71*(A^{1.5}) \\ & + 764.23*(S^{2}) \\ & + 1502.00*(N*S) \\ & + 451.87*(N^{2}) \\ & - 185.18*(S^{2.5}) \\ & - 375.98*(S^{1.5})*N \\ & - 16.90*(S^{3}) \\ & - 65.81*(N^{1.5})*S \\ & + 96.83*(N^{2.5}) \end{aligned}$$

[1] Note that some organic carbon (OC) species are also likely hygroscopic but due to uncertainties the PBW associated with hygroscopic OC species it is not accounted for in SANDWICH.

$$
\begin{aligned}
&+ 83.04*(N^{1.5})*(S^{1.5}) \\
&- \ \ 4.42*(N^{3}) \\
&+ 1720.82*(A^{1.5})*S \\
&+ 1220.38*(A^{1.5})*N \\
&- \ 311.50*(A^{1.5})*(S^{1.5}) \\
&+ 148.77*(A^{1.5})*(N^{1.5}) \\
&+ 1151.65*(A^{3})) * (SO_4 + NO_{3\ FRM} + NH_{4\ FRM})
\end{aligned}
$$

If DON > 0.225 then:

$$
\begin{aligned}
PBW = \ & 202049.0 \\
&- 391494.6*S \\
&- 390912.1*N \\
&+ 442.4*(S^{1.5}) \\
&- 155.3*(N^{1.5}) \\
&- 293406.8*(A^{1.5}) \\
&+ 189277.5*(S^{2}) \\
&+ 377992.6*N*S \\
&+ 188636.8*(N^{2}) \\
&- \ 447.1*(S^{2.5}) \\
&- \ 507.2*(S^{1.5})*N \\
&- \ 12.8*(S^{3}) \\
&+ 146.2*(N^{1.5})*S \\
&+ 217.2*(N^{2.5}) \\
&+ 30.0*(N^{1.5})*(S^{1.5}) \\
&- \ 18.6*(N^{3}) \\
&+ 216267.0*(A^{1.5})*S \\
&+ 215419.9*(A^{1.5})*N \\
&- \ 621.8*(A^{1.5})*(S^{1.5}) \\
&+ 239.1*(A^{1.5})*(N^{1.5}) \\
&+ 95413.1*(A^{3})) * (SO_4 + NO_{3\ FRM} + NH_{4\ FRM})
\end{aligned}
$$

5.2.5 Passively Collected $PM_{2.5}$ Components (Blank Correction)

The other quantifiable components of $PM_{2.5}$ mass include passively collected mass, represented by the field blank concentration that is typically 0.3-0.5 μg/m^3 (EPA, 2002). This appears to constitute a contamination of the filter resulting from handling or contact with the FRM cassette. This value is deemed to be an important constituent of $PM_{2.5}$ mass and is assumed not to be dependent on pollutant emissions. A nominal blank mass value of 0.5 μg/m^3 is assumed in mass construction computations. This value is assumed to remain constant from the current-year to future-year.

5.2.6 Calculation of Carbonaceous Mass

Carbonaceous mass is estimated from blank corrected $PM_{2.5}$ speciation data, where OCM is first estimated by multiplying the organic OC concentrations by 1.4 (OCM = 1.4 x OC) to account for the oxygen, hydrogen and other elements associated with ambient carbon particles. Note that the

1.4 OCM/OC ratio was based on limited organic compound speciation data in Los Angeles (Watson, 2002). More recent analyses by Turpin and Lim (2001) have found OCM/OC ratios that vary from 1.6±0.2 for urban areas to 2.4±0.2 for rural areas. However, since the SANDWICH derivation of the initial OCM is just used as a "floor' for the OCM calculation, the lower OCM/OC ratio of 1.4 is used. To that amount is added the EC concentration. An alternative approach to estimate carbon contribution to $PM_{2.5}$ mass is used for SMAT because of many uncertainties in estimating carbonaceous mass from carbon measurements (Turpin and Lim, 2001; Chow et al., 2004), differences in carbon measurement protocol between urban and rural monitoring locations, a relatively "bumpy" surface of urban carbon concentrations as derived from these urban and rural organic carbon measurements, and lack of carbon measurements at all FRM locations. The SANDWICH approach estimates carbon by mass balance comparing precisely measured FRM $PM_{2.5}$ mass (EPA, 2003) with the sum of its non-carbon components. The latter are sulfates, ammonium, nitrates, estimated particle bound water, estimated SOIL, and 0.5 $\mu g/m^3$ passively collected mass blank correction as discussed earlier.

This approach estimates retained carbonaceous FRM mass and explicitly accounts for the following important and difficult to estimate carbon mass properties: regional and urban-rural differences in the mix of carbonaceous aerosols (i.e. the amount of oxygen, hydrogen, etc that is associated with the organic carbon); retained water associated with hygroscopic carbon compounds (Saxena, 1996; Yua, 2004*)*; volatile carbonaceous material measured by speciation samplers, but not retained in FRM mass; and uncertainties associated with blank corrections of measured organic and elemental carbon.

Total Carbonaceous Mass by mass balance (TCM_{mb}) is defined as:

$$TCM_{mb} = FRM\ PM_{2.5} - \{[SO_4] + [NO_{3\ FRM}] + [NH_{4\ FRM}] + [PBW] + [SOIL] + [0.5]\}$$

In this expression, all of the above quarterly average components represent the mass retained on FRM Teflon filters.

The mass associated with organic compounds is defined as:

$$OCM_{mb} = TCM_{mb} - [EC_{STN}]$$

where, EC_{STN} is STN measured elemental carbon.

This approach completely accounts for FRM mass and OCM_{mb} is often greater than the amount that would be derived directly from speciation measurements. Because of uncertainties in speciation measurements and their estimates from interpolated surfaces, a lower limit (floor) for OCM_{mb} was set so that the OCM_{mb} was not unreasonably low. The floor was set so that OCM_{mb} could not be more than 30% lower than measured OCM. For the St. Louis projections, the STN measured OCM was used to calculate the floor assuming a 1.4 OCM/OC ratio. The lower limit is equal to interpolated (measured) OC * 1.4 * 0.7. If the OCM_{mb} concentration was less than the lower limit, it was set equal to the lower limit.

5.2.7 Summary of $PM_{2.5}$ Composition Calculations

As presented in the beginning of this Chapter, the application of the SANDWICH speciated STN/IMPROVE data to the FRM $PM_{2.5}$ mass produces the following composition of PM species as they relate to the measured FRM values for each quarter of 2002. Quarterly average FRM mass is equal to the sum of the seven species plus blank mass and, under some circumstances, Sea Salt, which is treated like blank mass.

$$PM2.5_{FRM} = \{ [OCM_{mb}] + [EC] + [SO_4] + [NO_{3\ FRM}] + [NH_{4\ FRM}] + [PBW] + [SOIL] + [0.5] + [\text{Sea Salt}]\}$$

The SANDWICH species data is generated in the following order:

1. Adjusted nitrate is calculated using hourly meteorology and 24-hour average nitrate measurements.
2. Quarterly averages are calculated for adjusted NO_3, SO_4, EC, DON, SOIL, and measured OCM.
3. Quarterly average ammonium is calculated from the adjusted nitrate, sulfate, and DON values.
4. Calculated ammonium, sulfate, and nitrate values are input into the water equation to derive PBW concentrations.
5. Carbon mass by difference (OMC_{mb}) is calculated from the $PM_{2.5}$ mass, adjusted nitrate, ammonium, sulfate, water, elemental carbon, crustal, and blank mass values.
6. The sum of the 7 species plus blank mass is equal to the FRM mass.

5.3 DEFINING CURRENT-YEAR $PM_{2.5}$ DESIGN VALUES (DVC)

The $PM_{2.5}$ component species fractions are applied to $PM_{2.5}$ DVC that are then projected to the future using the model derived RRFs. EPA's $PM_{2.5}$ modeling guidance recommends using the average of the 3 years of $PM_{2.5}$ Design Value periods that straddle the emissions year. The average of the 3 design values is not a straight five year average. It is, in effect, a weighted average of the annual averages. The base year inventory and modeling year for the St. Louis $PM_{2.5}$ modeling is 2002. Therefore, the design value period is from 2000-2004. In the average of 2000-2002, 2001-2003, and 2002-2004 $PM_{2.5}$ Design Values for the DVC, the annual average $PM_{2.5}$ concentrations for 2002 is "weighted" 3 times, 2001 and 2003 are weighted twice, and 2000 and 2004 are weighted once. EPA notes that this has the desired effect of weighting the projected $PM_{2.5}$ values towards the middle year of the five year period, which is the emissions and meteorology year for the St. Louis modeling (i.e., 2002).

There are several steps in the derivation of the average $PM_{2.5}$ design values for projections to the future. Quarterly average values are needed for each FRM site. The following steps were used to derive the quarterly average FRM values. Table 5-1 shows calculations of 2002 design values using MATS for Granite City, East St. Louis and 2nd & Mound monitoring sites. The remaining monitoring sites' design values calculations and MATS input file are shown in Appendix D.

1. The analysis began with quarterly average FRM data for all quarters from 2000-2004.

2. A quarterly average 3 year design value was calculated for each design value period in which a site had at least one of three quarters complete data (2000-2002, 2001-2003, and 2002-2004). This results in four quarterly averages for up to three design value periods for each FRM site. For example, if a site had complete data for 1st Quarter from 2000, 2001, and 2002, those three quarterly averages were averaged together to represent the 1st Quarter in the 2000-2 period.
3. The (up to) 3 quarterly design value periods were averaged together to get a single quarterly average design value for each site.

Table 5-1: 2002 Design Values for three Monitoring Sites Using MATS

Quarter	Granite City			East St. Louis			2nd & Mound		
	00-02	**01-03**	**02-04**	**00-02**	**01-03**	**02-04**	**00-02**	**01-03**	**02-04**
20000101	18.26			16.86			15.73		
20000401	15.24			14.04			12.87		
20000701	18.22			19.99			18.04		
20001001	17.69			18.79			17.39		
20010101	20.36	20.36		21.22	21.22		18.09	18.09	
20010401	14.80	14.80		15.98	15.98		14.48	14.48	
20010701	16.91	16.91		17.15	17.15		16.34	16.34	
20011001	17.08	17.08		13.67	13.67		12.77	12.77	
20020101	16.49	16.49	16.49	13.93	13.93	13.93	12.97	12.97	12.97
20020401	16.56	16.56	16.56	15.01	15.01	15.01	13.96	13.96	13.96
20020701	21.66	21.66	21.66	21.68	21.68	21.68	20.54	20.54	20.54
20021001	16.13	16.13	16.13	15.98	15.98	15.98	14.83	14.83	14.83
20030101		16.03	16.03		14.24	14.24		15.44	15.44
20030401		15.75	15.75		14.59	14.59		14.71	14.71
20030701		20.93	20.93		18.23	18.23		16.49	16.49
20031001		17.34	17.34		12.34	12.34		12.02	12.02
20040101			14.29			14.52			13.93
20040401			14.93			13.92			12.57
20040701			18.60			16.98			16.28
20041001			13.71			13.36			11.50
Average	**17.45**	**17.50**	**16.87**	**17.03**	**16.17**	**15.40**	**15.67**	**15.22**	**14.60**
Weighted Average	**17.27**			**16.19**			**15.16**		

5.4 SPECIATED MODEL ATTAINMENT TEST (SMAT)

The EPA default procedure for projecting $PM_{2.5}$ DVF using SMAT is as follows:

1. The current quarterly mean concentrations for each of the major components of $PM_{2.5}$ is derived by multiplying the monitored quarterly mean concentration of FRM-derived $PM_{2.5}$ mass by the monitored fractional composition of $PM_{2.5}$ species, measured at nearby speciation monitor sites, for each quarter. In the case of the St. Louis projections, the $PM_{2.5}$ composition at each FRM site is defined from a SANDWICH speciation of an assigned nearby STN or the StL-SS site.
2. The St. Louis 2002 Typical Base Case and 2009 and 2012 Base Case CMAQ modeling results are used to estimate current and future quarterly average concentrations for each of the components of $PM_{2.5}$ near the FRM monitor by using the ratio of future to current

predictions for each component. The result is a component-specific quarterly average RRF.

3. For each quarter, the current quarterly mean component concentration from Step 1 is multiplied by the component-specific RRF obtained in Step 2. This leads to an estimated future quarterly mean concentration for each $PM_{2.5}$ component.
4. The future-year ammonium concentrations are derived assuming the future-year nitrate is completely neutralized and that the DON stays constant from the current- to future-year. PBW concentrations are derived from the future-year $PM_{2.5}$ components (SO_4 and NO_3) and atmospheric conditions for the FRM monitor. The blank correction is assumed to stay constant from the current- to future-year.
5. The four quarterly mean future concentrations are averaged to obtain an estimated future annual mean concentration for each $PM_{2.5}$ component. The annual mean concentrations of the $PM_{2.5}$ components are summed to obtain an estimated future annual concentration for $PM_{2.5}$.

The FRM data is used for nonattainment designations. Therefore it is important that the SMAT procedures described above use the FRM data as the base value for projecting future $PM_{2.5}$ concentrations. As can be seen from the list of steps, the modeled attainment test is dependent on the availability of species component mass representative of the FRM sites.

5.5 ESTIMATING FUTURE YEAR $PM_{2.5}$ DESIGN VALUES

Future-year concentrations of $PM_{2.5}$ component species are estimated by assuming that the quarterly average component concentration will change in the same proportion as the model predicted change. Model predicted changes in species concentrations (from a current-year to a future-year) are used to calculate RRFs. RRFs are calculated for each grid cell and species as the ratio of the quarterly average future-year (2009 & 2012) model predictions to the current-year (2002) base case model predictions "near" the FRM monitor. The RRF for each $PM_{2.5}$ species is then multiplied by the estimated base year ambient $PM_{2.5}$ species mass for the site to estimate future species concentrations.

5.5.1 Projecting $PM_{2.5}$ Component Species

In the SMAT methodology, RRFs are calculated for five of the $PM_{2.5}$ component species: SO_4, $NO_{3\ adj}$, OCM_{mb}, EC, and SOIL. Note that future-year values for the other four $PM_{2.5}$ component species are either derived from the projections of these five $PM_{2.5}$ component species (i.e., NH_4 and PBW) or held constant (i.e., blank correction and Sea Salt). The future year concentrations of the five $PM_{2.5}$ components are calculated for each site and each quarter. The future-year ammonium concentrations are calculated from the future-year sulfate, nitrate, and (current-year) DON values. Assuming that the DON is unchanged from the current year, the ammonium is calculated using the following formula:

$$NH_{4\ future} = DON * SO_{4\ future} + 0.29*NO_{3\ future},$$

The $NH_{4\ future}$, $SO_{4\ future,}$ and $NO_{3\ future}$ concentrations are then run through the water equation to predict a future-year PBW concentration. The future-year $PM_{2.5}$ species concentrations at each FRM site are then summed over the seven species plus blank mass and Sea Salt (if used) to

estimate the future quarterly average $PM_{2.5}$ concentration. The four quarterly values are then averaged to obtain the estimated future annual average $PM_{2.5}$ for each FRM site.

5.6 DEFINING RRFS BASED ON MODELING RESULTS "NEAR" THE MONITOR

When defining the model derived RRFs, EPA recommends using current- and future-year modeling results "near" the monitor. By "near," EPA recommends using spatially averaged modeling results for a grid resolution X by Y array of grid cells centered on the FRM monitor. In the St. Louis modeling a grid resolutions of 12 km is being used for which EPA recommends that X=Y=3. Thus, for the St. Louis 2009 and 2012 $PM_{2.5}$ Design Value projections, RRFs were based on the modeling results within the 9 grid cells centered on the FRM monitor from the CMAQ 12 km modeling results.

5.7 2009 $PM_{2.5}$ DESIGN VALUE PROJECTIONS

The 2000-2004 current-year $PM_{2.5}$ Design Values at FRM sites within the St. Louis NAA were projected to 2009 using the SMAT/SANDWICH procedures described above that were implemented in the Excel spreadsheet projection tool and the 2002 Typical and 2009 Base 5a CMAQ simulations. A modeled attainment demonstration of the annual $PM_{2.5}$ NAAQS is achieved when all of the projected $PM_{2.5}$ DVFs are less than 15.0 $\mu g/m^3$ rounded (i.e., DVF<l5.05$\mu g/m^3$). However, EPA requires a supplemental weight of evidence analysis to demonstrate attainment if the DVF lies between 14.5 and 15.5$\mu g/m^3$.

The 2009 Base 5a emissions scenario consists of emissions projected from 2002 to 2009 with OTB control measures. The 2009 Base 5a OTB controls include:

- CAIR;
- NOx SIP Call;
- MACT Standards;
- Tier 2 Rule – Light-Duty Vehicle Standards and Low-Sulfur Gasoline;
- Heavy-Duty Diesel Engine Standards and Low-Sulfur Diesel;
- Tier 4 Rule – Off-Road Mobile Engine Standards; and
- Vehicle Emission Controls.

Tables 5-2 and 5-3 display the 2009 $PM_{2.5}$ RRF and DVFs, respectively, using the Excel spreadsheet tool and the CMAQ Base 5a 12 km modeling results. The starting point for these projections is the $PM_{2.5}$ DVC that is based on the average of three $PM_{2.5}$ Design Values ending in 2002, 2003, and 2004. There are three FRM monitoring sites with DVCs that exceed the annual $PM_{2.5}$ NAAQS. Using the Excel tool and the 2009 Base 5a 12 km CMAQ modeling results, there is one site, Granite City, that is projected to be above the annual $PM_{2.5}$ NAAQS with a value of 15.53 $\mu g/m^3$. With this high value, it is evident that the St. Louis area can not attain the $PM_{2.5}$ NAAQS by the deadline of 2010. Reducing the concentration at The Granite City monitor from 15.53 to 15.00 will entail additional control measures for the area, including RACT controls for SO2 and NOx in Missouri/Illinois and targeting direct $PM_{2.5}$ sources near the monitoring site in Illinois. Therefore, the department requested that the attainment date to be extended to 2012. This date extension was essential since more time was needed to implement the RACT requirements for SO2 and NOx. Moreover, other important federal/states rules will not be

effective until after 2010. For example, CAIR-Phase I SO2 control from power utilities will cover the years 2010-2014 and IEPA's multi-pollutant utility controls will be in place in 2011.

Table 5-2. 2009 Quarterly Relative Response Factor Values Based on Spreadsheet for Base 5a 12 km CMAQ modeling results.

FRM Site ID	Site Name	Period	SOIL	EC	OC	SO_4	NO_3	NH_4
17_119_1007	Granite City	Q1	1.09	0.74	0.98	1.01	0.74	0.86
		Q2	1.14	0.74	0.99	0.86	0.29	0.64
		Q3	1.18	0.72	0.99	0.76	0.25	0.62
		Q4	1.11	0.74	1.00	0.93	0.70	0.80
17_119_2009	Alton	Q1	1.08	0.75	0.99	0.99	0.74	0.84
		Q2	1.14	0.76	1.00	0.83	0.23	0.58
		Q3	1.20	0.73	1.00	0.74	0.14	0.55
		Q4	1.11	0.75	1.01	0.91	0.66	0.76
17_119_3007	Wood River	Q1	1.08	0.75	0.99	0.99	0.74	0.84
		Q2	1.14	0.76	1.00	0.83	0.23	0.58
		Q3	1.20	0.73	1.00	0.74	0.14	0.55
		Q4	1.11	0.75	1.01	0.91	0.66	0.76
17_157_0001	Tilden City	Q1	1.10	0.77	0.99	1.00	0.65	0.78
		Q2	1.15	0.77	0.98	0.81	0.16	0.48
		Q3	1.25	0.72	0.99	0.73	0.10	0.46
		Q4	1.14	0.77	1.01	0.89	0.57	0.68
17_163_0010	Eest St. Louis	Q1	1.09	0.74	0.98	1.01	0.74	0.86
		Q2	1.14	0.74	0.99	0.86	0.29	0.64
		Q3	1.18	0.72	0.99	0.76	0.25	0.62
		Q4	1.11	0.74	1.00	0.93	0.70	0.80
17_163_4001	Swansea	Q1	1.10	0.76	0.99	1.00	0.70	0.82
		Q2	1.15	0.76	0.99	0.83	0.23	0.56
		Q3	1.22	0.72	0.99	0.75	0.20	0.55
		Q4	1.13	0.76	1.01	0.91	0.66	0.75
29_099_0012	Arnold	Q1	1.05	0.74	0.97	1.02	0.72	0.85
		Q2	1.09	0.77	0.99	0.87	0.33	0.63
		Q3	1.12	0.74	1.00	0.78	0.30	0.61
		Q4	1.07	0.74	0.99	0.94	0.70	0.80
29_183_1002	West Alton	Q1	1.06	0.74	0.98	0.99	0.75	0.85
		Q2	1.10	0.76	1.00	0.84	0.27	0.61
		Q3	1.16	0.74	1.01	0.74	0.16	0.56
		Q4	1.09	0.75	1.00	0.91	0.67	0.77
29_189_0004	Sunset Hills	Q1	1.05	0.73	0.97	1.02	0.75	0.87
		Q2	1.09	0.75	0.99	0.88	0.38	0.69
		Q3	1.12	0.74	1.00	0.78	0.36	0.66
		Q4	1.08	0.73	0.99	0.95	0.73	0.82
29_189_2003	Clayton	Q1	1.06	0.72	0.97	1.01	0.76	0.87
		Q2	1.09	0.75	0.99	0.88	0.39	0.71
		Q3	1.12	0.74	1.00	0.77	0.35	0.66
		Q4	1.08	0.73	0.99	0.94	0.74	0.83
29_189_5001	Ferguson	Q1	1.06	0.73	0.98	1.00	0.76	0.86
		Q2	1.10	0.75	0.99	0.86	0.34	0.67
		Q3	1.14	0.73	1.00	0.76	0.27	0.63
		Q4	1.09	0.74	1.00	0.92	0.71	0.80
29_510_0007	S. Broadway	Q1	1.07	0.73	0.97	1.02	0.74	0.86
		Q2	1.11	0.75	0.99	0.87	0.35	0.67
		Q3	1.15	0.73	0.99	0.78	0.35	0.65
		Q4	1.09	0.73	0.99	0.94	0.72	0.81
29_510_0085	Blair St.	Q1	1.09	0.74	0.98	1.01	0.74	0.86

FRM Site ID	Site Name	Period	SOIL	EC	OC	SO_4	NO_3	NH_4
		Q2	1.14	0.74	0.99	0.86	0.29	0.64
		Q3	1.18	0.72	0.99	0.76	0.25	0.62
		Q4	1.11	0.74	1.00	0.93	0.70	0.80
29_510_0086	Margaretta	Q1	1.07	0.73	0.98	1.01	0.76	0.87
		Q2	1.11	0.74	0.99	0.87	0.36	0.69
		Q3	1.15	0.73	1.00	0.77	0.32	0.66
		Q4	1.09	0.73	0.99	0.94	0.72	0.82
29_510_0087	2nd & Mound	Q1	1.09	0.74	0.98	1.01	0.74	0.86
		Q2	1.14	0.74	0.99	0.86	0.29	0.64
		Q3	1.18	0.72	0.99	0.76	0.25	0.62
		Q4	1.11	0.74	1.00	0.93	0.70	0.80

Table 5-3. Projected 2009 $PM_{2.5}$ Design Values using the Excel spreadsheet tool and the 2009 Base 5a 12 km CMAQ modeling results.

FRM Site ID	Site Name		Excel
		(2002) $PM_{2.5}$ DVC Observed	(2009) $PM_{2.5}$ DVF CMAQ Base 5a
17_119_0023	Washington Ave.	N/A	N/A
17_119_1007	Granite City	17.27	15.53
17_119_2009	Alton	14.58	12.99
17_119_3007	Wood River	14.70	13.09
17_157_0001	Tilden City	12.41	10.94
17_163_0010	East St. Louis	16.19	14.54
17_163_4001	Swansea	14.68	13.10
29_099_0012	Arnold	14.43	12.91
29_183_1002	West Alton	14.08	12.54
29_189_0004	Sunset Hills	12.52	11.36
29_189_2003	Clayton	14.02	12.70
29_189_5001	Ferguson	13.77	12.16
29_510_0007	S. Broadway	14.55	13.29
29_510_0085	Blair St.	14.93	13.42
29_510_0086	Margaretta	13.93	12.59
29_510_0087	2nd & Mound	15.16	13.62

5.8 2012 $PM_{2.5}$ DESIGN VALUE PROJECTIONS

Since the 2009 projected design value at Granite City monitoring site was 15.53 µg/m^3, the two states requested that the attainment year to be extended to 2012 for reason sighted above and in the Attainment Extension Letter. The 2000-2004 current-year $PM_{2.5}$ Design Values at FRM sites within the St. Louis NAA were projected to 2012 using the SMAT/SANDWICH procedures described above that were implemented in EPA MATS tool and the 2002 Typical and 2012 Base 5b12 CMAQ simulations (additional future year projections are presented in Chapter 6). A modeled attainment demonstration of the annual $PM_{2.5}$ NAAQS is achieved when all of the projected $PM_{2.5}$ DVFs are less than 15.0 µg/m^3 rounded (i.e., DVF<l5.05µg/m^3). However, EPA requires a supplemental weight of evidence analysis to demonstrate attainment if the DVF lies between 14.5 and 15.5µg/m^3.

The 2012 Base 5b12 emissions scenario consists of emissions projected from 2002 to 2012 with on-the-books (OTB) control measures, some additional control measures and one ethanol plant in the NAA Permitted by IEPA. The 2012 Base 5b12 OTB controls include:

- CAIR;
- NOx SIP Call;
- MACT Standards;
- Tier 2 Rule – Light-Duty Vehicle Standards and Low-Sulfur Gasoline;
- Heavy-Duty Diesel Engine Standards and Low-Sulfur Diesel;
- Tier 4 Rule – Off-Road Mobile Engine Standards;
- Illinois' Multi-pollutant Utility Rule (pre-2012 requirements);
- Vehicle Emission Controls with 90% Inspection and Maintenance Program Control Efficiency; and
- Missouri SO_2 and NOx RACT requirements.

The 2012 Base 5b12 boundary conditions (BCs) were based on a linear interpolation of the BCs from the VISTAS/ASIP 2009 and 2012 CMAQ simulations.

Tables 5-4 and 5-5 display the RRF and projected 2012 $PM_{2.5}$ Design Values using the MATS tool and the CMAQ Base 5b12 12 km modeling results. The starting point for these projections is the current-year Design Value (DVC) that is based on the average of three $PM_{2.5}$ Design Values ending in 2002, 2003 and 2004. There are three FRM monitoring sites with DVCs that exceed the annual $PM_{2.5}$ NAAQS. Using the EPA MATS tool and the 2012 Base 5b12 12 km CMAQ modeling results, there is one site (Granite City) that is still projected to be above the annual $PM_{2.5}$ NAAQS. Note that MATS does not provide any projection for the Washington Ave. site as it is not a compliance monitor for the annual $PM_{2.5}$ NAAQS. The projected 2012 $PM_{2.5}$ Design Value at Granite City is 15.28 $\mu g/m^3$ (15.3 rounded) which is above the annual $PM_{2.5}$ NAAQS (15.0 $\mu g/m^3$).

The projected 2012 $PM_{2.5}$ Design Value at Granite City is within the range where supplemental analysis may be included in a Weight of Evidence (WOE) attainment demonstration. Chapter 6 provides some additional analyses to support a WOE attainment demonstration. However, the main facts in the WOE attainment demonstration are as follows:

- The Conceptual Model for $PM_{2.5}$ nonattainment in the St. Louis area has identified local sources as contributing a significant fraction (2 - 3$\mu g/m^3$) of the annual $PM_{2.5}$ concentrations at the Granite City FRM monitor (See Chapter 2).
- The impact of sulfate and nitrate on the violating monitor is primarily composed on regionally transported pollution with a smaller component from sources within the nonattainment area. The control of nonattainment area SO2 sources has some impact on the monitor and the overall reduction in the 2012 future year design value (~2.0 $\mu g/m^3$) is directly related to the overall reduction in SO2 and NOx emissions from the base-year.
- As the local sources contributing to $PM_{2.5}$ at Granite City monitor are on the Illinois side of St. Louis, they are in the jurisdiction of the state of Illinois. Therefore, the IEPA is performing local-scale analysis using the regional CMAQ modeling detailed here and the AERMOD modeling system for "local sources" to identify the level of control needed to attain the annual $PM_{2.5}$ NAAQS. The department fully supports this effort by IEPA and will continue to provide necessary information to the project.

The local scale analysis is detailed here and a status is provided as of the publication of the St. Louis plan. Regional $PM_{2.5}$ chemical transport modeling for the Metro-East/St. Louis domain (containing nested grids with 36 kilometer and 12 kilometer grid spacing) did not fully "capture"

local source contributions in the Granite City, Illinois area. A hybrid modeling approach that integrates fine-scale Gaussian dispersion modeling results (AERMOD) with those of the grid-based chemical transport models (CAMx/CMAQ) was implemented to resolve local culpability and develop appropriate control strategies. Facilities whose direct $PM_{2.5}$ emissions were discretely modeled using AERMOD had these same $PM_{2.5}$ emissions "zeroed out" of the chemical transport model simulations. AERMOD, using base year (2002) and future year (2012) inventories of local sources potentially contributing to elevated $PM_{2.5}$ levels, predicted a concentration for the Federal Reference Monitor (FRM) location in Granite City and concentrations for a receptor grid with 100-meter spacing immediately surrounding the FRM. Model results were applied in a relative sense against a base year design value to develop a future year design value. Local speciated $PM_{2.5}$ monitoring data that has been evaluated for a "local" component and a "regional" component provides the necessary separation for applying the AERMOD results and the chemical transport model results. Demonstrating modeled attainment of the annual $PM_{2.5}$ NAAQS is accomplished by implementing the Speciated Modeled Attainment Test (SMAT), using the same concentration differences as described for the regional modeling. The SMAT is a future year design value extrapolation from "local" and "regional" components of a FRM-derived base design value. It integrates model-predicted relative changes, assesses quarterly contributions of individual $PM_{2.5}$ species, and ultimately reflects any control strategies needed to meet the annual $PM_{2.5}$ NAAQS. The IEPA is near completion of the SMAT for Granite City and is also preparing a rule for submittal to the Illinois Pollution Control Board that will reduce emissions from culpable sources.

Table 5-4. 2012 Quarterly Relative Response Factor Values Based on MATS for Base 5b12 12 km CMAQ modeling results.

FRM Site ID	Site Name	Period	SOIL	EC	OC	SO_4	NO_3	NH_4
17_119_1007	Granite City	Q1	1.11	0.67	0.99	1.01	0.78	0.90
		Q2	1.14	0.67	0.99	0.81	0.28	0.65
		Q3	1.16	0.67	0.99	0.69	0.25	0.61
		Q4	1.12	0.64	1.00	0.94	0.68	0.81
17_119_2009	Alton	Q1	1.07	0.69	0.99	0.98	0.77	0.87
		Q2	1.10	0.68	0.99	0.77	0.23	0.58
		Q3	1.13	0.69	0.99	0.65	0.16	0.53
		Q4	1.09	0.66	1.00	0.90	0.66	0.77
17_119_3007	Wood River	Q1	1.07	0.69	0.99	0.98	0.77	0.87
		Q2	1.10	0.68	0.99	0.77	0.23	0.58
		Q3	1.13	0.69	0.99	0.65	0.16	0.53
		Q4	1.09	0.66	1.00	0.90	0.66	0.77
17_157_0001	Tilden City	Q1	1.11	0.72	1.00	0.98	0.71	0.82
		Q2	1.18	0.72	0.99	0.74	0.14	0.48
		Q3	1.24	0.72	0.99	0.61	0.11	0.44
		Q4	1.13	0.68	1.02	0.86	0.57	0.69
17_163_0010	Eest St. Louis	Q1	1.11	0.67	0.99	1.01	0.78	0.90
		Q2	1.14	0.67	0.99	0.81	0.28	0.65
		Q3	1.16	0.67	0.99	0.69	0.25	0.61
		Q4	1.12	0.64	1.00	0.94	0.68	0.81
17_163_4001	Swansea	Q1	1.11	0.69	0.99	1.00	0.76	0.88
		Q2	1.16	0.70	0.99	0.78	0.22	0.57
		Q3	1.19	0.70	0.99	0.66	0.20	0.54
		Q4	1.13	0.66	1.00	0.91	0.64	0.78
29_099_0012	Arnold	Q1	1.05	0.71	0.98	1.00	0.77	0.88
		Q2	1.08	0.68	0.98	0.79	0.34	0.64
		Q3	1.10	0.67	0.98	0.67	0.33	0.59

FRM Site ID	Site Name	Period	SOIL	EC	OC	SO_4	NO_3	NH_4
		Q4	1.07	0.66	0.99	0.91	0.70	0.80
29_183_1002	West Alton	Q1	1.06	0.69	0.98	0.99	0.77	0.87
		Q2	1.08	0.68	0.99	0.78	0.26	0.61
		Q3	1.10	0.69	0.99	0.66	0.18	0.55
		Q4	1.08	0.66	1.00	0.90	0.67	0.78
29_189_0004	Sunset Hills	Q1	1.06	0.68	0.98	1.00	0.78	0.88
		Q2	1.09	0.66	0.98	0.80	0.38	0.68
		Q3	1.11	0.65	0.98	0.68	0.36	0.63
		Q4	1.07	0.64	0.99	0.92	0.71	0.82
29_189_2003	Clayton	Q1	1.06	0.67	0.98	1.00	0.78	0.88
		Q2	1.09	0.65	0.98	0.81	0.38	0.69
		Q3	1.10	0.65	0.98	0.68	0.34	0.63
		Q4	1.07	0.64	0.99	0.92	0.71	0.82
29_189_5001	Ferguson	Q1	1.08	0.67	0.99	1.01	0.78	0.90
		Q2	1.11	0.66	0.99	0.82	0.31	0.67
		Q3	1.12	0.67	0.99	0.69	0.26	0.61
		Q4	1.09	0.65	1.00	0.94	0.69	0.82
29_510_0007	S. Broadway	Q1	1.09	0.67	0.98	1.01	0.78	0.90
		Q2	1.12	0.66	0.99	0.82	0.35	0.67
		Q3	1.14	0.66	0.99	0.70	0.34	0.63
		Q4	1.10	0.64	1.00	0.94	0.70	0.82
29_510_0085	Blair St.	Q1	1.09	0.66	0.98	1.01	0.78	0.90
		Q2	1.12	0.66	0.99	0.82	0.34	0.69
		Q3	1.14	0.66	0.99	0.70	0.31	0.63
		Q4	1.10	0.64	0.99	0.94	0.70	0.83
29_510_0086	Margaretta	Q1	1.09	0.66	0.98	1.01	0.78	0.90
		Q2	1.12	0.66	0.99	0.82	0.34	0.69
		Q3	1.14	0.66	0.99	0.70	0.31	0.63
		Q4	1.10	0.64	0.99	0.94	0.70	0.83
29_510_0087	2nd & Mound	Q1	1.11	0.67	0.99	1.01	0.78	0.90
		Q2	1.14	0.67	0.99	0.81	0.28	0.65
		Q3	1.16	0.67	0.99	0.69	0.25	0.61
		Q4	1.12	0.64	1.00	0.94	0.68	0.81

Table 5-5. Projected 2012 $PM_{2.5}$ Design Values using the EPA MATS tool and 2012 Base 5b12 12 km CMAQ modeling results.

FRM Site ID	Site Name		MATS v1.3.1
		(2002) $PM_{2.5}$ DVC Observed	(2012) $PM_{2.5}$ DVF CMAQ Base 5b12
17_119_0023	Washington Ave.	N/A	N/A
17_119_1007	Granite City	17.27	15.28
17_119_2009	Alton	14.58	12.29
17_119_3007	Wood River	14.70	12.51
17_157_0001	Tilden City	12.41	10.31
17_163_0010	East St. Louis	16.19	14.13
17_163_4001	Swansea	14.68	12.58
29_099_0012	Arnold	14.43	12.27
29_183_1002	West Alton	14.08	11.93
29_189_0004	Sunset Hills	12.52	10.76
29_189_2003	Clayton	14.02	12.02
29_189_5001	Ferguson	13.77	11.93
29_510_0007	S. Broadway	14.55	12.70
29_510_0085	Blair St.	14.93	13.12
29_510_0086	Margaretta	13.93	12.07

FRM Site ID	Site Name		MATS v1.3.1
		(2002) $PM_{2.5}$ DVC Observed	(2012) $PM_{2.5}$ DVF CMAQ Base 5b12
29_510_0087	2nd & Mound	15.16	13.10