Future Year Emission Inventory Development to Support Fine Particulate Mass and Visibility Modeling in the VISTAS Region

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ABSTRACT

The United States Environmental Protection Agency (EPA) has issued regulations to improve visibility, or visual air quality, in 156 national parks and wilderness areas across the country. The regulations require States to develop long-term strategies including enforceable measures designed to meet reasonable progress goals. The first long-term strategy will cover 10 to 15 years, with reassessment and revision of those goals and strategies in 2018 and every 10 years thereafter. States strategies should address their contribution to visibility problems in Class I areas both within and outside the State. Through a memorandum of understanding the eight SESARM states (Alabama, Florida, Kentucky, Georgia, Mississippi, North Carolina, South Carolina and Tennessee) plus Virginia, West Virginia, and participating Tribes have agreed to collaborate in planning activities associated with the management of regional haze, visibility, and other air quality issues. This collaboration is known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS).

The purpose of this paper is to describe the production of a set of comprehensive future year annual emission inventories for the VISTAS States to support the modeling and assessment of speciated particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM-2.5). We briefly describe the VISTAS 2002 inventory, assumptions for 2018 projections, similarity of VISTAS projections to EPA's recent projections, and our procedures for collecting and manipulating inventories for other regions.

INTRODUCTION

The United States Environmental Protection Agency (EPA) has issued regulations to improve visibility, or visual air quality, in 156 national parks and wilderness areas across the country. These areas include many of our best known and most treasured natural areas, such as the Grand Canyon, Yosemite, Yellowstone, Mount Rainier, Shenandoah, the Great Smoky Mountains, Acadia, and the Everglades. More than 280 million visitors come to enjoy the scenic vistas and unique natural features in these and other park and wilderness areas each year.

The regulations require States to develop long-term strategies including enforceable measures designed to meet reasonable progress goals. The first long-term strategy will cover 10 to 15 years, with reassessment and revision of those goals and strategies in 2018 and every 10 years thereafter. States strategies should address their contribution to visibility problems in Class I areas both within and outside the State. Through a memorandum of understanding the eight SESARM states (Alabama, Florida, Kentucky, Georgia, Mississippi, North Carolina, South Carolina and Tennessee) plus Virginia, West Virginia, and participating Tribes have agreed to collaborate in planning activities associated with the management of regional haze, visibility, and other air quality issues. This collaboration is known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS). Figure 1 represents the ten VISTAS States and identifies the Class I areas within the domain.

In identifying the emission reduction measures to be included in the long-term strategy, States should address all types of manmade emissions contributing to impairment in Class I areas, including those from mobile sources, stationary point sources (such as factories and electric generating units (EGUs)), area sources (such as residential wood combustion, gas stations, and agriculture), and fires. Emissions from these activities generally span broad geographic areas and can be transported great distances, sometimes hundreds or thousands of miles. Consequently, haze occurs regionally throughout the nation.

Figure 1. Class I areas within VISTAS domain.

The Technical Analysis Workgroup (TAWG) of VISTAS is charged with overseeing the regional haze and fine particulate modeling that will be required for developing State Implementation Plans (SIPs). These plans are in response to the federal regional haze rules promulgated by the EPA. Through work conducted by VISTAS and its contractors, we generated a comprehensive set of future year emissions inventories for the VISTAS States to support the modeling and assessment of the atmosphere processes that result in particulate matter in air and its effect on visibility. Additionally, as our modeling domain covers all of the continental U.S. and much of Canada and Mexico, future scenario emission inventories for these domains were obtained or prepared for our modeling.

The purpose of this paper is to describe the production of a set of comprehensive future year emission inventories for the VISTAS States to support the modeling and assessment of speciated particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM-2.5). We have included a brief discussion of the VISTAS 2002 inventory with a focus on assumptions for its projection to 2018, how similar or dissimilar our results are from EPA's recent projection assumptions, and our procedures for collecting and manipulating inventories for other regions.

BASE YEAR 2002 EMISSION INVENTORY

Through other contracts, VISTAS had previously funded the development of base year 2002 emission inventories for all anthropogenic sources. In early 2004, these annual inventories of VOC, NOX, CO, SO2, PM-10, PM-2.5, and NH3 were completed and delivered to VISTAS for the categories EGU, non-EGU point, stationary area, onroad and nonroad mobile, and fires (MACTEC 2004a, 2004b; Pechan 2004).

The data sets used to develop these initial base year inventories originated from the U.S. EPA's 1999 National Emission Inventory and were augmented and updated with State, local and Tribal (SLT) agency emissions from the 1999 through 2002 time period (where available). Included with these submissions were recommendations and input on how to utilize non-2002 data to make them representative of the 2002 calendar year. The VISTAS base year contractors then reviewed the methods and data as collected and provided recommendations on how to integrate these data into a single comprehensive 2002 inventory.

Part of these recommendations included the augmentation of emissions and sources using the latest versions of emission factors, models, and methods. Examples include missing PM emissions (for sources previously only required to submit ozone precursors), ammonia (where coverage from the Carnegie Mellon University (CMU) ammonia model was now available), and attainment area emissions (where States previously did not have to submit inventories). Additional recommendations involved the forecasting of emissions from a historical year (e.g., 1999 or 2000) to the current year of study (2002) using SLT activity data or growth rates, U.S. EPA changes in emissions, or alternate methods of projection.

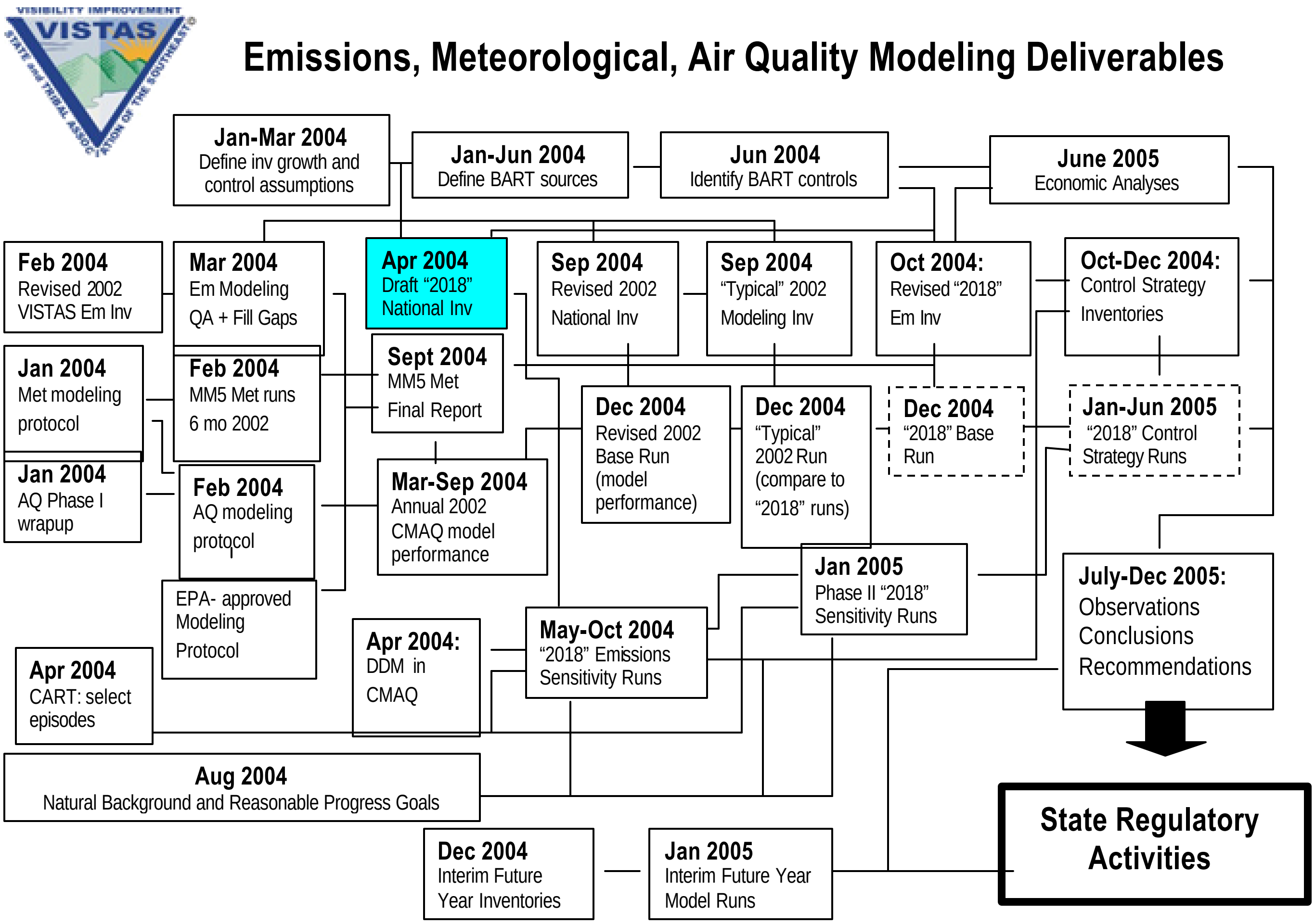
Each step of the process was quality assured by VISTAS stakeholder workgroups and State emission inventory developers. These emissions data are intended to both support the regional modeling exercises planned by VISTAS and its States, and to serve as the starting point for State, and local inventory submittals under the EPA's Consolidated Emission Reporting Rule (CERR). As such, the data were prepared in a form (NIF 3.0) and a time period (annual) necessary to fulfill this reporting obligation. It is anticipated that much of the data prepared for this 2002 base year inventory will be submitted to EPA for the CERR requirements, particularly for area and non-road sectors. Some states will incorporate data unavailable by January 2004 (e.g. 2002 point source surveys and 2002 highway activity data) prior to the CERR submittal.

The remainder of this paper references the early 2004 base year inventories when mentioning "base year" or "2002" emissions and not to any improvements made by VISTAS or it's State, local and Tribal agencies for CERR submittal purposes.

EMISSION PROJECTION PROCESS

Because the VISTAS domain contains two States (North Carolina and Virginia) who have regulatory approval processes of two years, VISTAS is in a position where recommendations to participating States need to be finalized by December 2005. This date would allow these States the full two years necessary to complete a formal SIP submittal to EPA. Figure 2 represents the current schedule of deliverables for the air quality-related technical aspects of VISTAS work. As can be seen in this figure, in order to meet a December 2005 recommendations deadline, VISTAS requires a final future year emission inventory and control strategy assumptions to be developed and processed through air quality models no later than

Figure 2. VISTAS Emissions, Meteorological, and Air Quality Modeling Deliverables Flowchart.



June 2005. Prior to this deadline, sensitivity runs, updates to base year and projection year inventories, control strategies, and other assumptions need to be processed and finalized during the remainder of 2004 and early 2005. The projections in this paper are identified by the highlighted box from Figure 2 titled "Apr 2004 Draft '2018' National Inv" and are the first of a series of planned emission projection activities.

Emission Projection Methodology

The initial 2018 projections will be used in emissions sensitivity modeling in the summer of 2004 to provide guidance to VISTAS' Planning Workgroup for emissions control strategy design. Because the schedule to draft the initial 2018 emission projections was relatively short, VISTAS used interim assumptions to prepare this initial set of projection data. For this application, ultimate accuracy of the inventory was not required. Instead, VISTAS' initial focus was to prepare these emissions to closely represent what a subsequent, more thorough emission projection process might produce. For this reason, existing information (growth rates, control factors, modeling parameters) that was available in early 2004 was used. The EPA's Interstate Air Quality Rule (IAQR) future year forecasts had recently been released and after review of these data, VISTAS decided that these files were the most relevant available in the required timeframe. Since VISTAS state and stakeholder review teams were to review and comment on the appropriateness of these factors, there was little concern that the recycled data would generate unsuitable emission estimates.

To completely fulfill the requirements of the projection and to define the basis of the sensitivity runs, the VISTAS Planning Workgroup developed a list of "Base Case" assumptions to be included in the future year inventories. These cases would be based on recently promulgated emission reduction strategies and would include Federal, State, local, and site-specific emission control information. The final list of cases defined by the Planning Workgroup is presented in Table 1.

Table 1. Control Programs Included in Emission Projection Inventories.

Base 1 (As of January 1, 2004)

- Atlanta / Northern Kentucky / Birmingham 1-hr SIPs
- Gulf Power (Crist 7) SCR application
- Heavy Duty Diesel (2007) Engine Standard (HDD)
- Large Spark Ignition and Recreational Vehicle Rule
- North Carolina Clean Smokestacks Act
- NOx RACT in 1-hr NAA SIPs
- NOx SIP Call (Phase I- except where states have adopted II already e.g. NC)
- Petroleum Refinery Initiative (October 1, 2003 notice; MS & WV)
- RFP 3% Plans where in place for one hour plans
- TECO & VEPCO Consent Agreements
- Tier 2 Tailpipe
- Title IV for Phase I and II EGUs
- VOC 2-, 4-, 7-, and 10-year MACT Standards
- Combustion Turbine MACT

Base 2a

- 8-hr attainment plans (e.g., NOx RACT)
- Industrial Boiler/Process Heater/RICE MACT
- Nonroad Diesel Rule (Tier 4)
- NOx SIP Call (Phase II – remaining States & IC engines)
- TVA scrubber application
- Interstate Air Quality Rule (IAQR)

Base 2b

- Base 2a assumptions
- Excludes Interstate Air Quality Rule

Beyond Base (Not included in any projection)

- Clear Skies Act (Phase I implementation through 2009)
- Clear Skies Act (Phase II implementation through 2018)
- Early Action Compact Plans
- PM SIPs
- Best Available Retrofit Technology (BART) Guidelines
- Utility Mercury MACT

VISTAS Base 1 was designed to represent control strategies that were known to exist and had been promulgated as of January 1, 2004. Included in this list of programs are the federally promulgated CAAA regulations (Title I and IV, NOx SIP Call Phase I, Heavy Duty Diesel (HDD) and Tier-2

Tailpipe onroad rules, and 2-, 4-, 7-., and 10-year MACT standards) and VISTAS-specific State (North Carolina Clean Smokestacks Act) and facility plans (e.g. Southern Company's Crist plant) and consent agreements (e.g. Tampa Electric, VEPCO). Base 2a closely resembles the U.S. EPA IAQR inventory assumptions and includes additional MACTs, Nonroad Diesel Rule (Tier 4), Phase II of the NOx SIP Call, and IAQR as proposed by EPA, as well as VISTAS-specific facility plans (e.g., TVA scrubbers). Base 2b reflects all Base 2a programs with the exception of the IAQR. Table 1 also presents those strategies that VISTAS is currently considering beyond our base case. These have not been included in any of the 2018 initial projection calculations and are listed for reference purposes only.

Because of the source specific nature of the planned base cases, a few of the major source categories required multiple base case inventories. Examples include both a Base 1 and Base 2 nonroad mobile source inventory to account for the inclusion of Tier 4 reductions, a Base 1 and Base 2 for non-EGU sources to account for MACTs and additional IC engine reduction from Phase II of the NOx SIP Call, and a Base 1, Base 2a, and Base 2b for EGUs to account for the application of NOx SIP Call, and forecasts with and without the IAQR. Stationary area and highway mobile sources required only a single forecasted inventory as the control programs applicable to these categories did not change from scenario to scenario.

Additionally, as two exclusive methods were chosen by VISTAS for forecasting EGU emissions, two sets of emissions for each strategy were developed to account for each individual technique. These are described in more detail in following section.

SPECIAL INTEREST WORKGROUP PROCESS

Special Interest Workgroups (SIWG) were assembled to review and assess initial emission forecast data and were presented with as much of the existing forecasting information as possible during the timeframe available for review. These data included growth rates, control technologies, reduction potential, and affected sources. The fundamental purpose of these Workgroups during the initial emission projection process was to assess, review, and modify "base case" assumptions that would allow VISTAS contractors to provide timely files for air quality modeling sensitivity runs.

Throughout the emission projection process, VISTAS emission projection contractors provided the Workgroups with these data in user-friendly or other Workgroup defined formats. These data and the initial emission projections were then refined with stakeholder input. Upon completed review of the projections, final emission inventories were provided with emission summaries for one final examination. The results of these final reviews are presented in this paper.

Each Workgroup also identified a list of issues which it would attempt to address during the initial emission forecast development process taking notice of the fact that the largest issues may have to wait for resolution during the final forecast process.

Common Forecast Issues

While each Workgroup developed a unique list of concerns, each one had to deal with a common set of issues before beginning the projection process. These issues involved the methods for projection, growth data and control assumptions, model specific input data, and other source specific data applicable to the emissions categories.

The method for projecting emissions can be as important as the projections themselves. For a number of major source categories, models are readily available to project emissions to a future year. However, equally viable ad hoc methods lend themselves to the preparation of these inventories. VISTAS Workgroups reviewed each available method or model and made determinations based on existing data, available time, and historical performance.

The availability of recent and timely growth factors and control information was reviewed by the VISTAS emission projection contractors and proposals were made to each Workgroup for their approval. These factors included federal, state, or local regulatory reductions and domain-specific growth rates and methods. Where factors were identified which were not yet available, these data were tabled for future review and possible inclusion in the longer term forecasts.

Model specific data were identified for the Integrated Planning Model (IPM®), MOBILE6, NONROAD, and the CMU ammonia models. Data for each model were reviewed and updated by the Workgroups prior to application. Similarly, source specific data and projections were submitted to the Workgroups for review and upon approval were included in the forecasted emissions.

Source Specific Forecast Issues

Complementing the common issues identified by each Workgroup, the individual SIWGs also identified source specific issues related to projecting emissions from their categories. These issues are presented in Table 2 and are discussed in more detail in the following sections.

EGU

Two options for developing the three base case inventories were approved by the EGU SIWG and provided complementary data to refine the final "Base Case" decision making process. These options were modifying EPA's IAQR IPM® runs and projections calculated from VISTAS 2002 base year inventories.

Under Option 1, VISTAS contractors reviewed data and documentation (EPA, 2004a) of the development of the IAQR projection inventories. Although the inventories were generated using the proprietary IPM®, we were able to extract VISTAS sources from the final parsed files and integrate data modifications provided and approved by VISTAS States and EGU SIWG. Additionally, although these files were identified as 2015, EPA documentation on the development of these projections indicate that they are representative for a range of years around 2015 and therefore for purposes of our initial projections were considered applicable for 2018.

Since multiple base cases were identified for the EGU sector by the VISTAS Planning Committee, we needed to analyze and modify multiple IAQR files (base and control cases) with stakeholder provided data. After providing the EGU SIWG with the data files and summaries created with EPA's IAQR projections, participating stakeholders provided comment on revisions or refinements to these forecasts.

Included in these comments were planned emission rates and emissions for sources covered by North Carolina's Clean Smokestacks Act, scrubber application for a number of sources at TVA operated facilities, SCR application at Florida Power's Crist 7 unit and hour specific emissions, heat input, and stack flow and temperature data for many sources owned and operated by Southern Company. Upon State and/or SIWG approval of these submitted data, they were incorporated into the Base 1, 2a, and 2b estimates.

Option 2 involved the use of VISTAS 2002 planning year inventory (e.g., "typical") as the basis of its emission projections. These files were generated through the application of growth factors from the EPA's Economic Growth Analysis System (EGAS) 4.0 or the Energy Information Administration (EIA), estimates of reduction percentages as calculated from EPA's IAQR files, and refined future emission rates from stakeholder input regarding utilization rates, capacity, retirements, and new unit information.

Table 2. VISTAS Special Interest Workgroup source specific issues.

EGU
- method for projection
- growth rates / energy efficiency
- assumed control programs / emission rates
  - base and future year
  - BART identification
- shared generation demands
- planned units / capacity / retirements
- utilization rates
- "typical" operation for base & projection year
- usage of CEM
- stack parameters
  - hourly stack parameters
  - changes in stack parameters due to scrubber application

Mobile (Onroad and Offroad)
- VMT or engine growth
- control programs
  - I/M, LEV, RFP, fuel characteristics
- Vehicle/fleet mix
  - Hybrid introduction
- Speed data
- Temperature application
- 3-D aircraft emissions
- nonroad distribution issues
- shipping lane information

Non-EGU Point
- growth rates / energy efficiency
- assumed control programs
  - base and future year
  - BART identification
- stack parameters
- planned units / retirements

Fires (Wild, Managed, Rx, and Agricultural)
- temporal and spatial distribution in base year
- "typical" fire inventory for use in base and projection year
- changes in fuel loadings / forest types

Agriculture
- improved NH3 estimates from animal / crop operations
- growth rates / moratoriums
- temporal schedule for SE states
- CAFOs

Stationary Area
- growth rates / energy efficiency
- assumed control programs
  - base and future year
- PM transport factor application
- Paved / unpaved road estimate improvements
- Urban sprawl

Because of anomalous operating conditions during any single year of operation, it was determined that instead of utilizing actual 2002 emissions from EGU sources in the projection process, we would first estimate a planning base year inventory. This inventory is also sometimes referred to as a "typical" year inventory and is a normalized version of historical activity at sources in the domain. In 2002 a number of VISTAS EGU sources were not in operation for part or all of the year due to regular maintenance, equipment failure, or control technology installation.

To prevent these abnormal activities from being carried into the future year, the EGU SIWG decided that a historical average of operations at each unit would be used instead. After obtaining, reviewing and processing historical operational data from EPA's Clean Air Markets Division, VISTAS contractors developed NOx, SO2, and heat input average profiles using data from 2000, 2001, and 2002. Additional reconciliation was completed with the VISTAS 2002 base year inventory to identify units that operated in 2000 or 2001 but did not operate in 2002. These profiles and resulting emissions were reviewed by the EGU SIWG and after approval were incorporated as the planning base year inventory.

Using input provided by the EGU SIWG and other participating stakeholders, we then incorporated known facility shutdowns, outages, and other relevant data to generate a future year forecasted inventory. These data were integrated with electric generation demand projections prepared by the Energy Information Administration (EIA) in their 2004 Annual Energy Outlook (DOE, 2004) and energy efficiency factors developed by EPA and used for the IAQR (EPA, 2002) to complete the emission forecast steps. These energy efficiency factors account for the CCAP programs, like EPA's Energy Star and U.S. Department of Energy's Motor Challenge Programs, which EPA estimates will effectively lower the reference case projections by 6.7% and 10.3% for the years 2010 and 2020, respectively. Unlike the IPM®-based Option 1, Option 2 does not account for any trading program within the VISTAS domain.

Source classification codes (SCCs) for the industrial sector were identified from the Tier categories and each SCC was assigned to one of the fuel categories. Appropriate energy adjustment factors were applied to growth-factor based emissions projections for all pollutants for each SCC to develop the revised emissions projections. Similar adjustments were made to the projected emissions for combustion sources in the commercial/institutional sector included in the inventories by assuming increases in fuel efficiencies for future years.

Non-EGU Point and Stationary Area

The EPA's EGAS Version 4.0 was used to develop projection factors by county and 2-digit SIC or 8- or 10-digit SCC. These factors were then applied to the VISTAS 2002 inventory to estimate changes in activity between 2002 and 2018 for the non-EGU point and stationary area source sectors. For each record in the VISTAS 2002 non-EGU inventory, a link was established between the State and county FIPS code, the standard industrial classification (SIC) or SCC code, and the applicable growth factor to be used for projecting emissions.

The adjustments made to account for energy efficiency increases in the industrial sector assume increases in fuel efficiencies for future years. Efficiency adjustment factors were developed from data on energy consumption per unit output from the EIA in their 2004 Annual Energy Outlook (DOE, 2004). Using 2002 as the base year, these factors were calculated for each fuel (e.g., natural gas, steam coal, residual fuel, etc.) as the ratio between the base year consumption per unit output and the projection year consumption per unit output, as shown in Equation 1.

Equation (1) $EAF_{2018} = C18 / C02$

where

EAF_{2018} = efficiency adjustment factor for 2018
C18 = consumption per unit output for projection year 2018
C02 = consumption per unit output for base year 2002

Although not reflected in the mass emission inventories prepared for the 2018 cases, the application of a fugitive dust transport fraction is recommended by EPA to account for the amount of fugitive dust matter which enters a transport layer and disbursed within the domain. For the modeling file preparation, county-specific fugitive dust emission adjustment factors based on land-use categories were applied to the fugitive dust emissions within the area source inventories (EPA, 2003a).

The initial intent of the agricultural SIWG was to collect readily available information on animal and crop operations which would have an impact on future year estimates of ammonia emissions. However, due to the shortened timeline for the preparation of these initial estimates, no new information was collected on control strategies or technologies which were appropriate to these calculations. For growth factors, in addition to EGAS-based rates, where non-matching SCCs or more current data were available, factors generated from U.S. Department of Agriculture sources or interpolated from EPA projections in recent publications (EPA, 2004b) or the IAQR inventories were utilized.

Onroad Mobile

For purposes of estimating onroad mobile source emissions in the 2018 forecast year, we are running the MOBILE6 module of the SMOKE emissions processor. Relevant to the development of these emissions using this module are the projected vehicle miles traveled (VMT) and MOBILE model input files by county.

Initial 2018 VMT estimates were developed at the vehicle class (i.e., LDGV, LDGT1, LDGT2, etc.) level of detail since the base 2002 VMT were provided at that level of resolution. In effect, the county and vehicle class specific growth factors derived from linear growth estimates of VMT from EPA's Heavy Duty-Diesel Engine Rulemaking inventories (EPA, 2000) were applied to the 2002 VMT estimates for each vehicle and road class.

Overall county-specific VMT estimates for 2018 (developed by summing the vehicle and road class specific forecasts) were then compared to the overall county-specific growth targets from the previously estimated growth factors. Since overall county growth is a more appropriate controlling factor as it includes the combined impacts of all vehicle classes, the initial 2018 vehicle and road class specific VMT forecasts were normalized so that the overall county VMT growth matched that of the previously provided growth spreadsheet using Equation 2.

Equation (2) $Est\_rv\_f = (Est\_rv\_i) * (C\_2018 / Sum(Est\_rv\_i))$

where

Est_rv_f = the final road/vehicle class-specific estimates,
Est_rv_i = the initial road/vehicle class-specific estimates, and
C_2018 = the county-specific growth target.

Through coordinated efforts and review by the Mobile SIWG, the MOBILE input files for 2002 were revised to reflect appropriate factors (i.e., I/M, fuel programs, etc.) in the forecast year. These input files were then submitted to the modeling contractor and run using episode specific meteorological conditions.

With the exception of the diesel sulfur content, for 2018, all other input parameters were set to MOBILE defaults or retained 2002 values. The sulfur content of diesel fuel was set to 11 ppm, down from the 500 ppm value assumed for 2002 modeling. The 11 ppm value is based on data developed by EPA for the 2007 Heavy Duty-Diesel implementation and includes a small (4 ppm) compliance margin relative to the applicable 15 ppm standard.

Since the initial emission projection data sets generated for the VISTAS domain in this analysis were not required for an entire annual period but only for meteorological episodes in January and July of 2000 and 2001, no annual emissions are available at this time. Future work to support the final regional haze recommendations will be completed by VISTAS in late 2004 and will generate these annual data sets.

Nonroad Mobile

For NONROAD model categories, emission estimates for projection years were developed using a method comparable to that for the base year (Pechan 2004). Four seasonal NONROAD model runs were performed at the county level for each of the scenarios and for each State in the VISTAS domain. Seasonal runs account for differences in average seasonal temperature, as well as RVP.

The NONROAD model actually required three independent sets of runs to properly model the Tier 4 program. Two of the three sets included a diesel fuel sulfur content of 11 ppm (representing a 15 ppm standard and a 4 ppm compliance margin, as compared to a Base 1 sulfur level of 2500 ppm) and applied to all equipment with the exception of recreational marine engines. The first run properly modeled all engines with the exception of diesel engines between 50 and 75 hp, while the second properly modeled all engines except diesel engines between 75 and 100 hp. The two runs were subsequently aggregated using weighting factors of 57 percent 75-100 hp and 43 percent 50-75 hp (EPA, 2003b). The third set of runs applied to recreational marine engines, which are subject to a higher diesel fuel sulfur limit of 500 ppm. However, because a fraction of these engines are assumed to use the lower 11 ppm fuel, the actual modeled sulfur content is 233 ppm. The outputs from this third set of runs (for recreational marine engines only) were subsequently appended to those from the two aggregated runs. All other inputs are retained at their Base 1 inventory values.

The method used to estimate 2018 non-NONROAD model based emissions (locomotives, railroad, commercial marine vessels) was similar to that used to generate VISTAS 2002 emissions (Pechan 2004). We started with the 2002 estimates and forecast those to 2018 using growth rates developed at the county-SCC-pollutant level from EPA's Nonroad Diesel and IAQR modeling inventories. These forecasts are described as already considering economic growth and in-place control measures. In those cases where VISTAS SCCs did not directly match EPA's inventories at the county-10-digit SCC level, State generated values were applied based on the 6-digit SCC (e.g., 227502xxxx for aircraft).

Since the IAQR baseline emissions already include the impacts of the proposed Tier 4 diesel rules, which implement a low fuel sulfur requirement that will affect future NONROAD and non-NONROAD based emissions, a complimentary set of emissions were collected from the pre-controlled inventories of the Nonroad Diesel Engine Rulemaking. These two sets of emissions were required to appropriately model the VISTAS Base 1 and Base 2 forecasts.

Finally, using factors derived from the engine population and horsepower estimates of the NONROAD model, we applied reductions from the Nonroad Diesel Rule Regulatory Impact Analysis (RIA) to calculate emission changes due to the large spark ignition and recreational vehicle (LSIRV) rule. These additional reductions were required as the LSIRV reductions are not currently available for modeling in the latest public version of the NONROAD model. To develop an application factor (similar to rule penetration) for those SCCs which had both large and small engines, we assigned an additional factor based on the average horsepower (HP) from the model's file to determine small vs. large engines (small < 25 hp). We then multiplied the average horsepower for each SCC by the total population in each SCC/HP range bin and came up with a weighted contribution of large to small HP engines. Using this factor, we scaled the percent reduction from the RIA published reductions by this adjustment to account for the small population of engines which did not receive control under this regulation.

Fires

Several unique issues are involved with the forecasting of emissions from the fires categories. Not only is there a level of uncertainty associated with the magnitude of emissions (i.e., acres burned and fuel loading), but associated temporal and spatial uncertainty in predicting where many fires (especially wildfires) might occur. Through consultation with fire experts participating in the VISTAS Fire SIWG, an agreed upon method was developed to generate the initial forecast of fire emissions for 2018.

To comply with the timing of the near-term projections requirements of VISTAS, we based the initial forecast of fire emissions on a planning baseline or "typical year" acreage of fires at the State or county level of aggregation. VISTAS contractors collected these acreage estimates for recent time periods that were thought to be representative of the conditions of the "typical" base year or were readily available to stakeholders participating in the process. The goal was to try and obtain a minimum of five years worth of data where possible in order to develop an average number of acres per State for each fire type. Although this was not always the case, many of the VISTAS States did have data for a number of historical years; some going back as far as 1984. These data were then used to "normalize" the 2002 base year inventory to "typical" conditions. Seven VISTAS States were able to provide a historical set of wildfire data, while six States have prescribed fire data readily available for this purpose.

The process for estimating emissions from these sources in the initial projection is much like that employed in the development of a planning base year for EGU sources. We multiplied the current 2002 base year emissions by the estimated normalization factor to account for deviations from "typical" in the acreage burned for each fire type. This method assumes that:

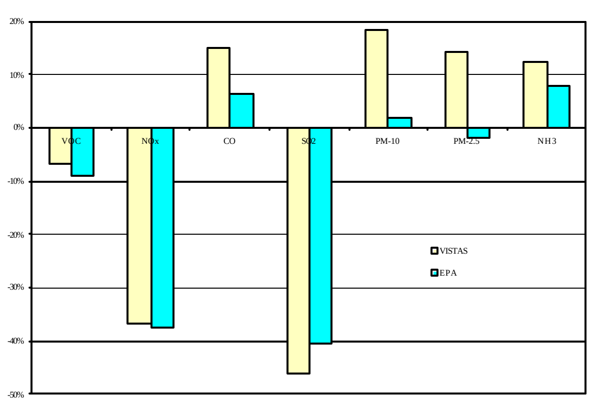
- fuel loading/characteristics of the base year are representative of the "typical" year;
- spatial distribution of the emissions in the base year is representative of a "typical" year and;
- temporal variability of emissions in the base year is representative of a "typical" year.

Although an attempt was made to collect specific information related to easily implemented control or fire management programs that take effect between 2002 and the future base case year, no data were available in time to include in the initial forecast. In particular, we were investigating strategies or changes in prescribed burn programs which may result from smoke management plans or other associated agenda. If significant increases in the acres burned under prescribed burn programs are identified then the "typical" year approach applied above may not be appropriate for that fire category in future work and an alternative approach (perhaps implemented as control program) may be considered. In fact, such a program would effect both prescribed and wildfires since the increase in prescribed burning would potentially effect wildfire emissions in future years. These changes and any associated data will be considered in future forecast analyses.

RESULTS AND COMPARISON TO RECENT EPA PROJECTIONS

It is not expected that this initial emission projection to 2018 should exactly replicate those previously completed by other agencies. In fact, due to the regionally-specific information provided through VISTAS stakeholder groups, this projection should be unique. Not only has VISTAS chosen to use a set of growth factors slightly different that EPA's recent set, we have attempted to incorporate regional, State, local, and facility-based responses to recent Federal, State, and local pollution reduction actions into the forecast.

Figure 3 and Table 3. Relative emission change comparison between VISTAS and EPA reductions.



	Percent Change in Annual Emissions	
Pollutant	**VISTAS**	**EPA**
VOC	-7%	-9%
NOx	-37%	-37%
CO	15%	6%
SO2	-46%	-41%
PM-10	18%	2%
PM-2.5	14%	-2%
NH3	12%	8%

Despite this, the resulting emission changes track very closely on a percentage and tonnage basis to most pollutants and source sectors when compared to recent EPA projections. Figure 3 presents the relative emission change comparison between VISTAS 2002 base year to 2018 Base 2a and EPA's 2001 to 2015 IAQR control case scenario. Exceptions to the nearness of reductions include PM and CO emissions increases in the VISTAS domain which are resultant of the inclusion and change in fire emissions. The EPA assumptions hold fires constant between their base and future year and exclude wildfires altogether. Option 1 generated emissions from the EGU sector are presented in this section. Additionally, as no annual onroad mobile source emissions from the VISTAS projection were available at the time of this publication, emissions and comparisons exclude the contribution from these sources.

Figure 4 presents a comparison of NOx emissions from the ten VISTAS States between the 2002 base year and 2018 Base 2a. Figure 5 represents annual SO2 emissions from these same States and categories during the projection timeframe. As expected and seen in these figures, emissions from EGU sources dominate these pollutants in most States. However, under the strategies applied in Base 2a, they also contribute the majority of the 37 and 46 percent reduction, respectively from all represented categories. These percentages correspond to annual emission reductions of 1,265,000 tons NOx and 2,237,000 tons SO2 in the VISTAS domain and compare to the 37 and 41 percent (1,336,000 tons NOx and 2,141,000 tons SO2) estimated by EPA in the latest IAQR modeling inventories for these same categories.

Figures 4 and 5. NOx and SO2 emission changes resulting from 2018 Base Case 2a in VISTAS States.

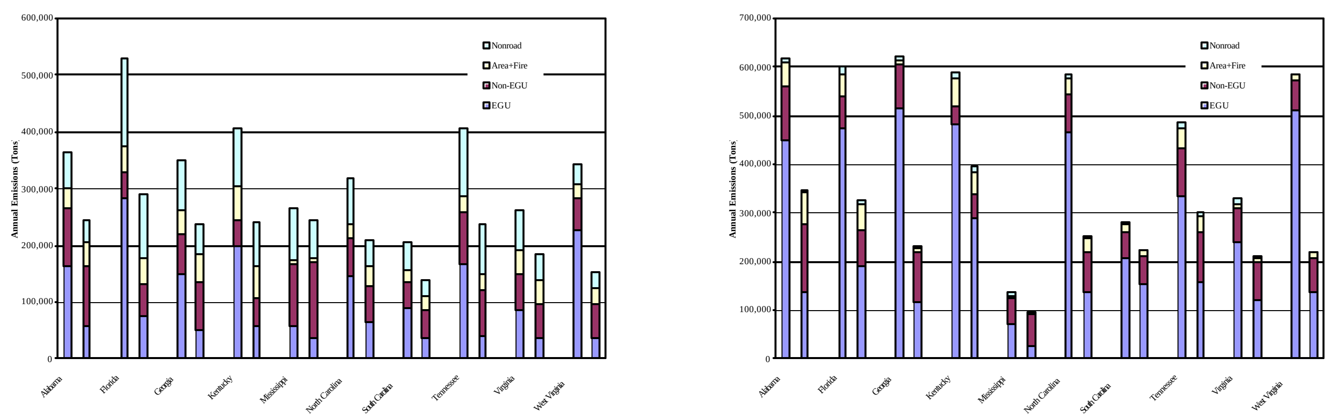
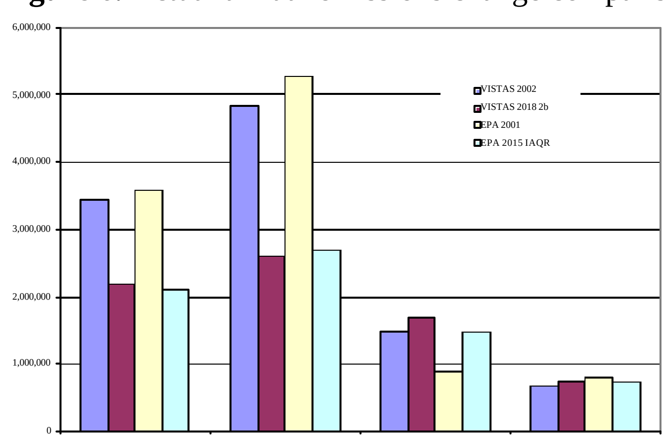


Figure 6 exhibits the actual emission changes for the four major regional haze and visibility inhibiting pollutants (NOx, SO2, PM-2.5, and NH3) as comparisons of VISTAS' 2002-2018 and EPA's 2001-2015 forecasts for the entire 10 State VISTAS domain. As indicated earlier, these reductions track quite closely.

Figure 6. Actual annual emissions change comparison between VISTAS and EPA projections.



NON-VISTAS DOMAIN PROJECTIONS

Since the modeling domain chosen by VISTAS covered an area much larger than the ten States represented by VISTAS, emission inventories for the U.S., Canada, and Mexico were required for each of the future year scenarios. Using emission inventories initially prepared by other RPOs, States, and EPA, VISTAS contractors generated a set of future year emissions used to represent the remaining modeling domain.

Western State base year point and area source emissions for 2002 were provided by the WRAP RPO and forecasted to 2018 using EGAS growth rates and similar control strategies as modeled by EPA in the IAQR rulemaking. Additionally, an inventory of point source resolved agricultural fire emissions were provided by WRAP and utilized in the projection. The CENRAP RPO provided VISTAS with an inventory of 2002 area source ammonia emissions which were also forecasted using EGAS growth rates and EPA control assumptions.

For the remaining U.S. domain, point source projections were based on EPA's 2001 modeling platform inventories and area source and fire emissions were based on EPA's preliminary 2002 NEI. These emissions were forecast to 2018 using EGAS 4.0 growth rates, DOE energy efficiency factors for combustion sources, and other control strategies as modeled by EPA in the IAQR inventories. Onroad and nonroad mobile source emissions were developed using interpolation of annual, county-level inventories developed and made publicly available through the Heavy Duty Diesel and IAQR Rulemakings.

Emission projections for Canadian nonpoint sources were based on interpolated inventories of Canadian area and mobile sources available and modeled by EPA during the Clear Skies Act analyses. Because confidentiality issues involved with Canadian point sources and the lack of Mexican emissions forecasts data, these emissions were held constant from base year to future year.

CONCLUSIONS

The goal of this analysis was to generate a set of comprehensive and complete emission inventories for the VISTAS States to support the modeling and assessment of speciated particulate matter with an aerodynamic diameter less than or equal to a nominal 2.5 micrometers (PM-2.5). To compound the difficulties associated with the generation of these data, VISTAS schedule compressed the analysis to a period of only a few months wherein data collection, review, analysis, comment, revision, and application occurred with the assistance of stakeholder Special Interest Workgroups. The delivery of these projection inventories was met within the timeframes provided and the resulting inventories were of a quality and coverage more than acceptable to meet the needs of the planned sensitivity runs application. In fact, direct comparison to recent EPA projections in support of the IAQR show significant

Continued improvements to the base year, growth rates, and control factors are already underway and are expected to produce more robust future year inventories for control strategy application and air quality modeling runs. These improvements are largely based on the lessons learned from the initial projection and valuable input and data review efforts of the contractor teams and stakeholders. Ultimately those who have contributed to this process will benefit from their contributions in the form of regional haze and visibility recommendations based on the latest state-of-knowledge data, methods, and models.

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KEYWORDS

VISTAS
Emissions
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Regional Planning Organization
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Visibility