Revised Quality Assurance Project Plan Southeastern VISTAS II Regional Haze Analysis Project

Prepared for:

Southeastern States Air Resource Managers, Inc. (SESARM)
205 Corporate Center Drive, Suite D
Stockbridge, GA 30281-7383

ERG Contract No. V-2018-03-01
SESARM Grant No. XA-00D53517

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April 3, 2018

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TITLE and APPROVAL SHEET (A1)

Quality Assurance Project Plan for
Southeastern VISTAS II Regional Haze Analysis Project for
SESARM (Revision No. 3)

This QAPP is approved by the undersigned and effective on the latest date signed by any party. The organizations implementing the project are Eastern Research Group, Inc. (ERG) and Alpine Geophysics, LLC (Alpine).

Regi Oommen – ERG Program Manager and Technical Project Coordinator — April 3, 2018 (Date)

Darcy Wilson – ERG Deputy Program Manager and Project QA Coordinator — April 3, 2018 (Date)

Gregory Stella – Alpine Subcontract Manager — April 3, 2018 (Date)

John E. Hornback, SESARM Executive Director — April 3, 2018 (Date)

Rick Gillam – U.S. EPA, Region 4 APTMD, Senior Modeler — April 4 2018 (Date)

Gregg Worley – U.S. EPA, Region 4 APTMD, Branch Chief — APRIL 4, 2018 (Date)

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Abbreviations / Acronym List

Alpine	Alpine Geophysics, LLC
AMET	Atmospheric Evaluation Tool
APC	Administrative Project Coordinator
AQS	Air Quality System
ASOS	Automated Surface Observing System
AWOS	Automated Weather Observing System
BNDEXTR	Program used to extract boundary conditions
CAMx	Comprehensive Air Quality Model with Extensions
CASTNET	Clean Air Status and Trends Network
CC	Coordinating Committee
CEM	Continuous Emissions Monitoring
CONUS	Continental United States
DIAG/DIAG2	Diagnostic output files from the boundary condition extraction program
DQOs	Data Quality Objectives
EGU	Electric generating unit
EPA	United States Environmental Protection Agency
ERG	Eastern Research Group, Inc.
FAA	Federal Aviation Administration
FLM	Federal Land Manager
FR	Federal Register
FTP	File Transfer Protocol
GB	Gigabtye
GIS	Geographic Information System
HYSPLIT	Hybrid Single Particle Lagrangian Integrated Trajectory
IC/BC	Initial conditions and boundary conditions
IMPROVE	Interagency Monitoring of Protected Visual Environments
MAR	Marine/aircraft/rail
MB	Mean Bias
MDA8	Daily maximum 8-hour average
ME	Mean Error
MFB	Mean Fractional Bias
MFE	Mean Fractional Error
Modeled	Mean Modeled value
MPE	Model performance evaluation
NAAQS	National Ambient Air Quality Standards
NADP	National Acid Deposition Program
NAM-12	North American Mesoscale forecast data at the 12-km level
NCEI	National Centers for Environmental Information
NMB	Normalized Mean Bias
NME	Normalized Mean Error
NO_x	Oxides of Nitrogen
NWS	National Weather Service
Observed	Mean Observed value
PM	Particulate matter

$PM_{2.5}$	Fine particle; primary particulate matter less than or equal to 2.5 microns in aerodynamic diameter
PSAT	Particulate Matter Source Apportionment Technology
PSD	Prevention of Significant Deterioration
QA	Quality Assurance
QA/G-5	Guidance for Quality Assurance Project Plans
QA/G-5M	Guidance for Quality Assurance Project Plans for Modeling
QA/QC	Quality assurance/quality control
QA/R-5	EPA Requirements for Quality Assurance Project Plans
QAPP	Quality Assurance Project Plan
QMP	Quality Management Plan
R^2	Coefficient of Determination
RAID	Redundant Array of Independent Disks
RHR	Regional Haze Rule
RMSE	Root Mean Squared Error
RRFs	Relative response factors
SESARM	Southeastern States Air Resources Managers, Inc.
SIP	State Implementation Plan
SMOKE	Sparse Matrix Operator Kernel Emissions
SO_2	Sulfur dioxide
SOP	Standard Operating Procedure
SOW	Scope of Work
TAWG	Technical Analysis Work Group
VISTAS	Visibility Improvement - State and Tribal Association of the Southeast
VISTAS_12	12-km modeling domain for the VISTAS study area
WBAN	Weather Bureau Army-Navy

Document Control Table

Revision No.	Date	Comments
0	March 15, 2018	Draft QAPP submitted to SESARM
1	March 16, 2018	Revised QAPP submitted to SESARM
2	March 27, 2018	Revised QAPP submitted to SESARM based on SESARM comments
3	April 3, 2018	Revised QAPP submitted to SESARM based on EPA comments

DISTRIBUTION LIST (A3)

The approved version of this Quality Assurance Project Plan (QAPP) will be distributed to the staff listed in Table 1. The approved QAPP will be provided to all ERG and Alpine staff involved in the project, including those who join the project after initial distribution of the QAPP. SESARM will distribute the QAPP to the appropriate contacts on the Coordinating Committee and Technical Analysis Work Group.

Table 1. QAPP Distribution to Staff

Name Title	Contact Information	Mailing Address
SESARM		
John Hornback SESARM Executive Director	404.361.4000 hornback@metro4-sesarm.org	Southeastern States Air Resource Managers, Inc. 205 Corporate Center Drive, Suite D Stockbridge, GA 30281-7383
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1 INTRODUCTION

This Quality Assurance Project Plan (QAPP) addresses quality requirements for modeling projects and is responsive to all applicable elements specified by the United States Environmental Protection Agency (EPA)[1,2,3] in *EPA Requirements for Quality Assurance Project Plans* (EPA QA/R-5), EPA's *Guidance for Quality Assurance Project Plans* (EPA QA/G-5), and EPA's *Guidance for Quality Assurance Project Plans for Modeling* (EPA QA/G-5M). In development of this QAPP, ERG also reviewed SESARM's Quality Management Plan (QMP)[4] to ensure this QAPP meets the specifications in the QMP.

QAPP Approval and Distribution. This QAPP is approved and effective on the latest date the Approval Sheet is signed by any party. The ERG Program Manager or Alpine Subcontract Manager will provide the approved QAPP to all staff listed in the Distribution List and any other staff who work on the project. During the course of the project, the ERG Program Manager will also circulate any revision of the approved QAPP to all staff listed in the Distribution List. ERG will document the circulation of the original approved QAPP and any revised QAPP to project staff by maintaining the transmittal email message(s).

QAPP Organization. This QAPP is structured according to the outline in EPA document QA/G-5M. The remaining organization of this QAPP is:

- Section 2 Project Organization (A4);
- Section 3 Problem Definition and Background (A5);
- Section 4 Project Description and Schedule (A6);
- Section 5 Quality Objectives and Criteria for Model Inputs/Outputs (A7);
- Section 6 Special Training Requirements/Certifications (A8);
- Section 7 Documentation and Records (A9);
- Section 8 Measurement and Data Acquisition (Group B);
- Section 9 Assessments and Oversight (Group C); and
- Section 10 Data Validation and Usability (Group D).

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[1] U.S. Environmental Protection Agency, "EPA Requirements for Quality Assurance Project Plans, EPA QA/R-5", Office of Environmental Information, Washington, DC, EPA/240/B-01/003, March 2001. Reissued May 2006.

[2] U.S. Environmental Protection Agency, "Guidance for Quality Assurance Project Plans, EPA QA/G-5", Office of Environmental Information, Washington, DC, EPA/240/R-02/009, December 2002.

[3] U.S. Environmental Protection Agency, "Guidance for Quality Assurance Project Plans for Modeling, EPA QA/G-5M", Office of Environmental Information, Washington, DC, EPA/240/R-02/007, December 2002.

[4] Southeastern States Air Resource Managers, Inc., "Quality Management Plan", March 2014.

1.1 Assessment of QAPP Implementation

ERG will conduct several stages of review during the planning and execution of this project to assure that the procedures outlined in this QAPP are followed. All tasks conducted and products generated receive (1) a conceptual review, (2) a developmental review, and (3) a final technical product review.

A **conceptual review** is performed during the initial stages of work development and ensures that the final product and associated documentation address the needs set forth by the SESARM Administrative Project Coordinator (APC), the Contract, and this QAPP.

The quality of intermediate deliverables and final products is also evaluated as these work products evolve. This **developmental review** includes, for example, (1) checks on calculations and data quality and (2) reviews of draft deliverables to ensure that the direction of work is consistent with the conceptual review outline.

Final product technical review is conducted on all deliverables prior to submittal to SESARM. Technical review is a documented critical review of work that has been performed. All deliverables will subsequently be reviewed by the SESARM APC, which may then be distributed to the Coordinating Committee (CC) and the Technical Analysis Work Group (TAWG). Reviewer comments in tracked changes will be stored on ERG's network in the same directory as the final document with the reviewer's initials and date in the file name. This provides a review history of the deliverable and documents reviewer comments. In addition, as specified in our contract-level QMP, we will employ our *Email Review Tracking System*. Our project team will maintain an internal quality assurance (QA) email mailbox to track team correspondence pertaining to deliverable reviews. This mailbox provides an auditable trail of the sequence and nature of deliverable reviews. The document author emails a review request to the reviewer and copies the QA email mailbox. The review request includes information to identify the document reviewed and the level of review (e.g., calculation review, technical review, senior review). Upon completion of the review, the reviewer responds to the author's email request and copies the QA email mailbox, adding "COMPLETED" to the subject heading.

Ms. Darcy Wilson, ERG's Project QA Coordinator, will assess the implementation of quality assurance/quality control (QA/QC) procedures on this project as follows:

- Review the QAPP (this document) for completeness and applicability, and
- Audit project files to ensure and verify the following:
    - That project staff have developed QC procedures and that these procedures are used; and
    - That project staff are documenting their use of these QC procedures by completing checklists, review spreadsheets, workflows, and other project-specific tracking methods.

Any quality deficiencies detected by technical reviewers or the Project QA Coordinator will be communicated, in writing, to the ERG Program Manager. The ERG Program Manager is responsible for ensuring that appropriate corrective action is taken. The Project QA Coordinator

will notify the ERG Program Manager if, at any time, she considers the project to have quality deficiencies and they are not being remedied in a timely manner. Upon notification, the ERG Program Manager will conduct a project review. If he concurs that the work is deficient, he may issue a stop work order until the deficiencies are remedied. ERG will provide notifications to the SESARM APC when any significant quality deficiencies are identified that would potentially impact the acceptability of deliverables, the project schedule, project costs, and/or any other significant project criteria.

ERG will include any reports of corrective actions in the project QA files. At any time or at the end of the project, the Program Manager or the Project QA Coordinator may inspect the project QA files.

2 PROJECT ORGANIZATION (A4)

This section identifies project personnel and defines the project organization, roles, and responsibilities. The project organization structure is depicted in Figure 2-1 for staff with program management, technical support, or QA/QC roles. It shows the relationship and lines of authority, reporting, and communication among key ERG and Alpine project participants.

Mr. Regi Oommen, the ERG Program Manager and Technical Project Coordinator, will be the principal contact for SESARM on project issues, deliverables, and schedule. As Program Manager, Mr. Oommen has overall responsibility for planning and executing all work performed by ERG and Alpine under the contract and will:

- Ensure that the quality of work, schedule, and budget meet the requirements of the project;
- Provide technical direction to ERG staff and manage the daily activities on the project;
- Maintain the official, approved QAPP;
- Obtain appropriate technical review of all deliverables and ensure deliverables conform to ERG technical review requirements; and
- Keep the Project QA Coordinator advised of any quality problems that arise.

Mr. Oommen has the support of Ms. Darcy Wilson, the ERG Deputy Program Manager, for any issues that warrant elevation to develop strategies for mitigation and resolution. Ms. Wilson will provide senior level review, as needed. Ms. Wilson will also serve as ERG Project QA Coordinator. She is responsible for ensuring that the requirements of this QAPP are implemented and documented and may conduct an audit at any time to ensure quality review has occurred and been documented.

Mr. Oommen will be a principal investigator, leading Tasks 1 (Project Management), 2 (Emission Inventory Development), and 11 (Other Potential Tasks). Ms. Bebhinn Do, the ERG Data Librarian, will lead Tasks 4 (Data Acquisition and Preparation) and 5 (Area of Influence). Mr. Adam Langmaid, the ERG Digital Solutions Manager, will lead Task 10 (Data Handling and Sharing).

Mr. Gregory Stella, the Alpine Subcontract Manager, will be the principal contact for ERG on project deliverables and schedule. In addition, Mr. Stella will be a principal investigator, leading Tasks 3 (Emissions Processing), 8 (Model Performance Evaluation), and 9 (Future Year Model Projections). Mr. Stella will be supported by Mr. Dennis McNally of Alpine, who will lead Tasks 6 (Air Quality Modeling) and 7 (Source Apportionment Tagging).

Each Task Leader will draw upon all qualified personnel and equipment resources available at ERG and Alpine, to assemble the optimum skill sets for achieving each of the Tasks.

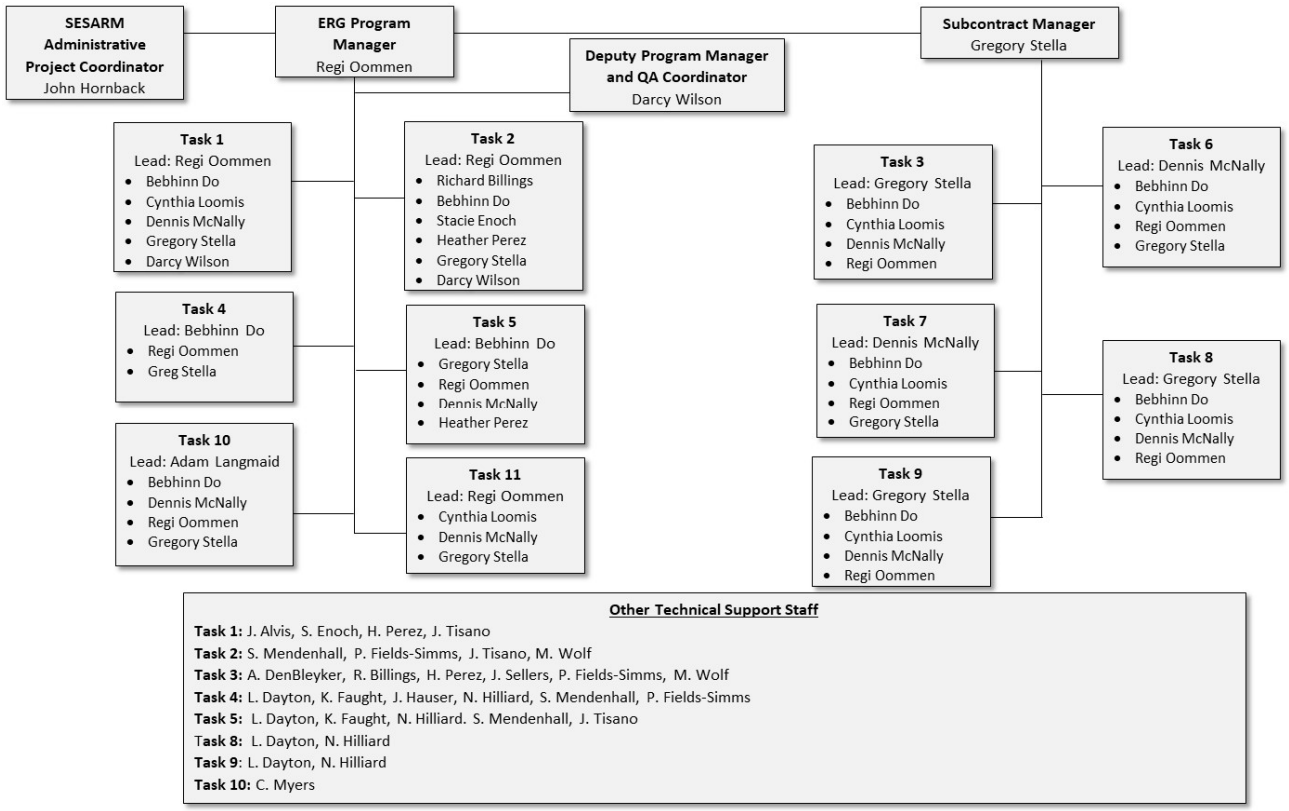

Figure 2-1. Project Organization Structure

The ERG Program Manager will be in regular communication with the SESARM APC (and/or the CC or TAWG) through periodic e-mails and telephone calls. The purpose of these communications will be to provide updates on progress, identify areas of technical concern, propose solutions to challenges where applicable, and discuss any preliminary results and/or data. ERG will provide a bulleted agenda to SESARM via email prior to each status meeting that will facilitate the discussion of progress and related issues. After each meeting, ERG will summarize the discussion for SESARM, including issue resolutions, action items, and responsible team members.

The ERG Program Manager and Alpine Subcontract Manager will prepare Project Instructions for the ERG/Alpine team, describing in detail the tasks and subtasks that are to be accomplished, milestone and deliverable schedules, and allocated resources per staff member. After the work plan and this QAPP are approved and notice to proceed is issued, ERG and Alpine Task Leaders

will meet weekly or bi-weekly to monitor the technical activities of the team and ensure adherence to project budget, schedule, and quality specifications for deliverables.

3 PROBLEM DEFINITION AND BACKGROUND (A5)

The purpose of this project is to assist SESARM in evaluating current and projected future visibility in ten southeastern states: Alabama, Florida, Georgia, Kentucky, Mississippi, North Carolina, South Carolina, Tennessee, Virginia, and West Virginia. The Eastern Band of Cherokee Indians and the Knox County, Tennessee local air pollution control agency are also participating agencies. These parties are collaborating through the Regional Planning Organization known as Visibility Improvement - State and Tribal Association of the Southeast (VISTAS) in the technical analyses and planning activities associated with visibility and related regional air quality issues. VISTAS Project analyses will support the states in their responsibilities to develop, adopt, and implement their State Implementation Plans (SIPs) for regional haze.

The Clean Air Act established a visibility protection goal to prevent future and remedy existing impairment of visibility resulting from manmade pollution in certain national parks and wilderness areas. The 1999 Regional Haze Rule (RHR) (64 FR 35714) identified 156 parks and natural areas as "mandatory Class I Federal areas" for which goals would be established to improve visibility to natural conditions. There are 18 Class I areas located in the VISTAS region.

The 1999 RHR required states to define long-term strategies to improve visibility in Federal Class I national parks and wilderness areas. States were required to establish baseline visibility conditions for the period 2000-2004, natural visibility conditions in the absence of anthropogenic influences, and an expected rate of progress to reduce emissions and improve visibility systematically to reach natural visibility conditions by 2064. The original RHR required states to improve visibility on the 20% worst days and protect visibility on the 20% least impaired days. States were required to submit SIPs by December 17, 2007 demonstrating reasonable progress to achieve incremental visibility improvements for the 2008-2018 planning period. The original RHR required states to evaluate progress toward visibility improvement goals every five years and submit revised SIPs every ten years.

EPA finalized revisions to various requirements of the RHR in January 2017 (82 FR 3078) that were designed to strengthen, streamline, and clarify certain aspects of the agency's regional haze program including:

A. Strengthening the Federal Land Manager (FLM) consultation requirements to ensure that issues and concerns are brought forward early in the planning process.
B. Updating the SIP submittal deadlines for the second planning period from July 31, 2018 to July 31, 2021 to ensure that they align where applicable with other state obligations under the Clean Air Act. The end date for the second planning period remains 2028; that is, the focus of state planning will be emission reduction measures that should be achieved by 2028, as was required by the original RHR. This extension will allow states to incorporate planning for other federal programs while conducting their regional haze planning. These other federal programs include: the Mercury and Air Toxics Standards, the 2010 1-hour SO_2 National Ambient Air Quality Standards

(NAAQS); the 2012 annual fine particle ($PM_{2.5}$) NAAQS; and the 2008 and 2015 ozone NAAQS.

C. Adjusting interim progress report submission deadlines so that second and subsequent progress reports will be due by: January 31, 2025; July 31, 2033; and every ten years thereafter. This means that one progress report will be required midway through each planning period.

D. Removing the requirement for progress reports to take the form of SIP revisions. States will be required to consult with FLMs and obtain public comment on their progress reports before submission to the EPA. EPA will be reviewing but not formally approving or disapproving these progress reports.

The regional haze rule as amended defines "clearest days" as the 20% of monitored days in a calendar year with the lowest deciview index values. "Most impaired days" are defined as the 20% of monitored days in a calendar year with the highest amounts of anthropogenic visibility impairment. The long-term strategy and the reasonable progress goals must provide for an improvement in visibility for the most impaired days since the baseline period and ensure no degradation in visibility for the clearest days since the baseline period.

The SESARM member agencies are mandated to protect human health and the environment from the impacts of air pollutants. They are responsible for air quality planning and management efforts including development, adoption, and implementation of strategies controlling and managing all air pollutants including fine particles, ozone, and regional haze. This project will focus on regional haze and regional haze precursor emissions. Control of regional haze precursor emissions will have the additional benefit of reducing criteria pollutants as well.

The objectives of the VISTAS II Project include updating the Environmental Protection Agency's (EPA's) emission inventories for 2028, conducting a model performance evaluation (MPE) and air quality modeling, projecting potential 2028 visibility impacts in mandatory Class I Federal areas, conducting source apportionment analyses of results, providing presentations of results, producing project reports, and archiving support information and final conclusions. This project will mainly focus on emissions inventory development and emissions/air quality modeling. The work products resulting from this project will be used by the states to develop SIPs that are due to EPA by July 31, 2021.

This project is being funded under SESARM Grant # XA-00D53517. A project contract has been executed between SESARM and ERG, designated as Contract # V-2018-03-01.

This QAPP is one of several important project documents including the December 21, 2017 Request for Proposals, ERG's January 26, 2018 proposal, the referenced project contract executed on March 1, 2018, the project work plan, and numerous EPA quality assurance guidance and policy documents described in Section 1. Introduction of this QAPP. The content of this QAPP should be considered with other supporting, companion, and guidance documents in mind. Together, they constitute a comprehensive plan to produce necessary deliverables that are of acceptably high quality.

4 PROJECT DESCRIPTION AND SCHEDULE (A6)

4.1 Project Deliverables and Milestones

4.1.1 Task 1: Project Management

ERG will work closely with the SESARM APC to determine the number and size of the interim draft and interim final reports, which may be as frequent as the completion of each task or subtask. Each interim report will document the methodologies, data, and QA activities, and will act as stand-alone documents for their respective tasks. The interim reports from each task will serve as the basis of the final report. In preparation of the final report, ERG will prepare a detailed outline that will be provided to SESARM for review and comment. The final report will contain, at a minimum:

- An executive summary that provides a brief overview and summary of the modeling effort, emissions and air quality models used, model configuration, MPE overview and results, and rationale for the selected configuration;
- Summaries of QA procedures completed for the project;
- Technical details for all technical work performed as part of this project including:
  - Area of influence analysis,
  - Emissions inventory updates,
  - Emissions and air quality models used,
  - Model configuration and rationale, and
  - Model performance evaluation;
- Summaries and conclusions;
- A list of all final work products being delivered; and
- A discussion of data accessibility and availability for review by SESARM, stakeholders, and the public.

ERG will prepare a draft final report for SESARM review, and a final report will be prepared after receiving final comments from SESARM. ERG will submit two hard copies of the final report to SESARM for its files and for transmittal to EPA. An electronic copy of the report in Microsoft Word (.docx) format will be submitted to SESARM and will be made available in Adobe (.pdf) format on the Technical Website developed in Task 10 (Section 4.1.10).

Finally, ERG will provide project summaries in the form of slide presentations that can be distributed to VISTAS agencies and stakeholders to inform them of progress and findings. Each slide deck will contain the appropriate SESARM/VISTAS logo as prescribed by SESARM.

ERG will participate in up to two face-to-face meetings with the VISTAS agencies and any other invited guests.

4.1.2 Task 2: Emission Inventory Development

ERG will prepare EPA's 2011v6.3el base year and EPA's 2028v6.3el[5] and VISTAS' 2028 projected emission inventory files and ensure the data are in the proper formats for emissions modeling. Upon completion of the updates to the 2028 emissions as agreed upon, ERG will prepare state-specific final 2011 and 2028 emissions summaries for electric generating unit (EGU), non-EGU point, area, onroad, nonroad, fire, and marine/aircraft/rail (MAR) source categories. ERG will work with SESARM to determine the final format of the emission summaries which shall be compiled in separate Excel files for each SESARM state. The draft emission inventory comparisons will be prepared for VISTAS states review and finalized after comments are received.

4.1.3 Task 3: Emissions Processing

Alpine will prepare SMOKE-ready input files from the mass emissions data prepared in Task 2 (Section 4.1.2 of the QAPP).

4.1.4 Task 4: Data Acquisition and Preparation

The ERG/Alpine team will develop a database with Interagency Monitoring of Protected Visual Environments (IMPROVE), EPA's Air Quality System (AQS), National Atmospheric Deposition Program (NADP) deposition data, and meteorological data for use on this project. This database will provide a permanent record of the data used to support the MPE and the regional haze calculations. A final Microsoft Access Database (.accdb) will be provided that contains the observed data, station metadata, and data definitions table that documents each field in the database.

4.1.5 Task 5: Area of Influence

The ERG/Alpine team will use the IMPROVE data to identify upwind source regions contributing to the 20% most impaired days for each Class I area over the 2011-2016 period. The Hybrid Single Particle Lagrangian Integrated Trajectory (HYSPLIT) model will be run for each of these days to identify areas most likely influencing visibility. The NAM-12 hybrid meteorology file will be used to run HYSPLIT. The ERG/Alpine team will use a combination of geographic information system (GIS) and *R* to analyze the trajectories and develop the gridded residence time plots and pollutant weight residence time plots. The ERG/Alpine team will include any *R* code, with documentation, as part of the project deliverables to provide a transparent analysis process, as well as the final shapefiles of the trajectories and gridded residence time analysis. The GIS or *R* generated gridded pollutant weighted residence time will then be linked with the 2011 and 2028 point source inventories to calculate the emission contribution from each source. This information will be summarized in separate Microsoft Excel

[5] The 2011v6.3el base year and 2028v6.3el data files are posted at: ftp://newftp.epa.gov/air/emismod/2011/v3platform/.

(.xlsx) format spreadsheets for each Class I area. A technical memorandum/interim report describing the area of influence calculations, and the results, will be prepared for SESARM.

4.1.6 Task 6: Air Quality Modeling

Alpine will use Version 6.40 of the Comprehensive Air Quality Model with Extensions (CAMx) and Particulate Matter Source Apportionment Technology (PSAT) to generate files and concentration data necessary to support air quality modeling to project visibility levels at individual Class I areas to 2028 and to estimate emissions sector contributions to 2028 PM concentrations and visibility. The ERG/Alpine team will document the modeling procedure in a draft protocol document and submit to SESARM for EPA review. Upon receipt of comments and revision requests by EPA and approved by SESARM, the ERG/Alpine team will make appropriate revisions to the document with plans to incorporate any revised direction into the air quality modeling itself.

4.1.7 Task 7: Source Apportionment Tagging

Alpine will tag 2028 emissions using CAMx PSAT modeling and using SESARM identified combinations of regions, facilities, and/or source categories. For this task, only sulfate and nitrate will be tracked using PSAT. During analysis for the initial regional haze SIPs, analysis found that in the southeast ammonium sulfate ($(NH_4)_2SO_4$), predominantly from sulfur dioxide (SO_2) emissions from EGUs and industrial sources, contributes 60 –70% of the light extinction on the 20% haziest days.[6] Current analysis of IMPROVE measurements continue to confirm the important of sulfate to visibility impairment on the 20% worst days though the southeast.[7] In addition to sulfate, nitrate is relatively high contributor at sites from Oklahoma thru Kentucky and is generally of concern with respect to transport from VISTAS states Class I areas outside VISTAS. The initial VISTAS analysis showed that the impacts from elemental carbon are minimal on the 20% worst days, and higher impacts from organic carbon. However, the impacts from organic carbon are dominated by biogenic emissions, not anthropogenic emissions, which can be controlled. Tracking of these and other PM species (i.e., elemental carbon, organic carbon, etc.) that contribute to visibility impairment may of some use, but has not been requested in this analysis.

4.1.8 Task 8: Model Performance Evaluation

Alpine will review EPA's current operational MPE for particulate matter ($PM_{2.5}$ species components and coarse PM) and regional haze to compare the ability of the CAMx v6.40 modeling system to simulate 2011 measured concentrations. Alpine will prepare comprehensive MPE statistics and graphics from the 2011 CAMx simulation using data from the IMPROVE

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[6] Patricia Brewer & Tom Moore (2009) Source Contributions to Visibility Impairment in the Southeastern and Western United States, Journal of the Air & Waste Management Association, 59:9, 1070-1081, DOI: 10.3155/1047-3289.59.9.1070.

[7] U.S. Environmental Protection Agency. 2016. Technical Support Document (TSD) Revised Recommendations for Visibility Progress Tracking Metrics for the Regional Haze Program U.S. Environmental Protection Agency Office of Air Quality Planning and Standards Air Quality Assessment Division Research Triangle Park, NC 27711. July 2016.

network. A technical document describing the performance evaluation and results will be prepared for SESARM.

The ERG/Alpine team include MPE for weekly wet deposition and weekly dry deposition species. For the model performance evaluation, VISTAS CAMx results will be aggregated to appropriate time periods to match the various NADP monitoring network's collection times. To prevent confounding the MPE, the networks with different collection time (i.e., biweekly versus weekly) will be examined separately. Annual mean MPE statistics, similar to the statistics for the base year MPE, will be developed for wet deposition and dry deposition species available. Analysis will also include scatter plots of NADP observations versus CAMx predictions, and their correlation (r), both annually and by season. Statistics and scatter plots will also be examined by VISTAS state to provide more refined MPE information to facilitate further use by the states.

4.1.9 Task 9: Future Year Model Projections

The ERG/Alpine team will calculate relative response factors (RRFs) for each IMPROVE monitor in the VISTAS_12 modeling domain and prepare/update related graphics and charts. A technical memorandum/interim report describing the projections, methods, and results will be prepared for SESARM. Upon completion of this task, Alpine will work with ERG to develop procedures necessary to upload all future year regional haze visibility projections and supporting data on the website or dedicated file transfer protocol (FTP) site to be developed in Task 10 (Section 4.1.10 of the QAPP).

The ERG/Alpine team will also calculate the RRFs and future year projections of weekly wet deposition and weekly dry deposition species. RRFs for each deposition site will be calculated consistent with EPA guidance for calculating RRFs Ozone and $PM_{2.5}$ species. Future year projections will be developed for each site by multiplying the RRF by monitored values. The ERG/Alpine team will consult with SESARM on the averaging time used for the development of the RRFs. At a minimum, we would produce annual and maximum weekly RRFs and future projections to provide an estimate of annual and short-term loading changes.

4.1.10 Task 10: Data Handling and Sharing

The ERG/Alpine team will develop and implement a solution for the distribution and archival of project assets (emissions and air quality modeling output, summaries, and other project documentation). The ERG/Alpine team will work with SESARM to develop an effective data handling and sharing scheme.

The ERG/Alpine team will also develop a Standard Operating Procedure (SOP) for uploading files to sites such as SharePoint and the Metro 4/SESARM Drupal website. The SOP will address:

- File formats for all project asset types (e.g., model outputs);
- The review/approval process for publishing files and updates to either or both of the websites;

- Routines for publishing the model outputs after each run is complete, allowing SESARM to review the results in a timely manner; and

- Instructions for downloading content for offline access.

4.1.11 Task 11: Other Potential Tasks

ERG will provide support to SESARM for additional work not included in the original Scope of Work (SOW) in the Request for Proposals. Such support may involve assisting the member states in developing regional haze SIPs. Prior to contract execution, SESARM determined that subtasks would be required for data extractions of initial conditions and boundary conditions (IC/BC) and state-specific meteorological data files for up to five states. An additional five states may be requested by SESARM for each of the subtasks.

4.1.12 Task Deliverable Summary and Schedule

The ERG Program Manager and Alpine Subcontract Manager will work with each of the Task Leaders to ensure that the deliverables listed in Table 4-1 are met.

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
Contract Award	Notification of award	February 20, 2018
Task 1: Project Management [Responsible Person: Regi Oommen]		
Contract Management	Project Milestone	Ongoing
Contract Development	Completed March 1, 2018	March 1, 2018
Work Plan Development	Draft delivered March 13, 2018	March 16, 2018
QAPP Development	Draft delivered March 15, 2018	March 16, 2018
Communications and Presentations		Ongoing
Reporting – Progress Reports	Deliverable	Monthly, within two weeks after the end of the month.
Reporting – Draft Interim Reports	Deliverable	Completion of tasks or subtasks
Reporting – Final Interim Reports	Deliverable	Within 2 weeks of receiving comments
Reporting – Draft Final Report	Milestone	May 8, 2019
Reporting – Final Report	Deliverable	July 1, 2019

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
Reporting – Presentation Slides	Deliverable	Ongoing, as-needed
Invoicing	Deliverable	Monthly, within two weeks after the end of the month.
Task 2: Emission Inventory Development [Responsible Person: Regi Oommen]		
2011 Base Year Emissions Inventories	Deliverable	June 1, 2018
Projection Year Emissions Inventory Comparisons, draft	Draft Deliverable	May 18, 2018
Projection Year Emissions Inventory Comparisons, final	Deliverable	Within one week of receiving comments
Revisions to 2028 Projection Year Emissions Inventories, draft	Draft Deliverable	May 18, 2018
Revisions to 2028 Projection Year Emissions Inventories, final	Deliverable	Within one week of receiving comments
2028 EGU Point Source Emissions, draft	Draft Deliverable	May 18, 2018
2028 EGU Point Source Emissions, final	Deliverable	Within one week of receiving comments
2028 Non-EGU Point Source Emissions, draft	Draft Deliverable	May 18, 2018
2028 Non-EGU Point Source Emissions, final	Deliverable	Within one week of receiving comments
2028 Emissions for Other Categories, draft	Draft Deliverable	May 18, 2018
2028 Emissions for Other Categories, final	Deliverable	Within one week of receiving comments
Emission Comparisons from 2028v6.3el and 2023v6.3en, draft	Draft Deliverable	May 18, 2018
Emission Comparisons from 2028v6.3el and 2023v6.3en, final	Deliverable	Within one week of receiving comments
Documentation for Emission Comparisons from 2028v6.3el and 2023v6.3en, draft	Draft Deliverable	May 18, 2018
Documentation for Emission Comparisons from 2028v6.3el and 2023v6.3en, final	Deliverable	Within one week of receiving comments
2028 Documentation, draft	Draft Deliverable	May 18, 2018

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
2028 Documentation, final	Deliverable	Within one week of receiving comments
Emission Summaries and QA	Deliverable	June 1, 2018
Task 3: Emissions Processing [Responsible Person: Gregory Stella]		
Create Photochemical Model Ready-EGU Emission Files for 2028	Deliverable	July 1, 2018
Full EGU Emissions Replacement	Not applicable	Task not funded
Scale Hourly EGU SMOKE to Match Annual 2028 Emissions	Deliverable	July 1, 2018
Create photochemical Model-Ready Non-EGU Emission Files for 2028	Deliverable	July 1, 2018
Merge EGU and non-EGU Data from Subtasks 3.1 and 3.2 for CAMx Modeling	Deliverable	July 1, 2018
Merge area/MAR data from Subtasks 3.1 and 3.2 for CAMx Model	Deliverable	July 1, 2018
Task 4: Data Acquisition and Preparation [Responsible Person: Bebhinn Do]		
Data Acquisition and Preparation	Deliverable	June 1, 2018
Collecting Additional Data (weekly wet deposition and weekly dry deposition)	Deliverable	Not specified, but would have to be completed by June 1, 2018.
Task 5: Area of Influence [Responsible Person: Bebhinn Do]		
Area of Influence Analysis	Deliverable	September 1, 2018
SO_2 and NO_x Emissions Contributions Rankings	Deliverable	Not specified, but would have to be completed by September 1, 2018.
Task 6: Air Quality Modeling [Responsible Person: Dennis McNally]		
Modeling Protocol, draft	Draft Deliverable	May 2, 2018
Modeling Protocol, final	Deliverable	Within 2 weeks of receiving comments
2011 Base Year Air Quality Modeling	Deliverable	September 1, 2018
2028 Projection Year Air Quality Modeling	Deliverable	December 1, 2018

Table 4-1. Task Deliverable Summary and Schedule

Task/Subtask	Deliverable to SESARM or Internal Project Milestone	Deliverable or Milestone Date
Task 7: Source Apportionment Tagging [Responsible Person: Dennis McNally]		
Source Apportionment Tagging*	Deliverable	April 1, 2019
Task 8: Model Performance Evaluation [Responsible Person: Gregory Stella]		
Model Performance Evaluation of 2011 Modeling	Deliverable	October 1, 2018
Model Performance Evaluation Related to Optional Subtask 4.1	Deliverable	October 1, 2018
Task 9: Future Year Projections [Responsible Person: Gregory Stella]		
Future Year Model Projections (minus PSAT runs)	Deliverable	December 31, 2018
Future Year Model Projection (with PSAT runs)	Deliverable	April 19, 2019
Calculate Relative Response Factors related to Optional Subtask 4.1	Deliverable	May 3, 2019
Task 10: Data Handling and Sharing [Responsible Person: Adam Langmaid]		
Website/FTP Site Development; Data Transfer and Archival	Deliverable	Ongoing, but to be completed by July 1, 2019
Task 11: Other Potential Tasks [Responsible Person: Regi Oommen]		
Other Potential Tasks (Not Defined)	Deliverable	Not specified, but to be completed by July 1, 2019
Other Potential Tasks (Defined): Extraction – IC/BC Data	Deliverable	Within 1 week after completion of Task 6.1 and 6.2 activities
Other Potential Tasks (Defined): Extraction – Meteorological Data	Deliverable	Within 1 week after regions are defined by the time the meteorological data is windowed for the VISTAS_12 domain

*250 tags – final number to be determined.

5 QUALITY OBJECTIVES AND CRITERIA FOR MODEL INPUTS/OUTPUTS (A7)

5.1 Data Quality Objectives, Performance Criteria, and Acceptance Criteria

This QAPP was prepared to ensure that (1) modeling input data are valid and defensible, (2) CAMx model set up is adequately documented in the protocol and final report, (3) model output data are reviewed and evaluated in a consistent manner and (4) that any analysis based on any of the modeling (e.g., RRFs) is reviewed and evaluated in a consistent manner.

The Data Quality Objectives (DQOs) specify the acceptance criteria for existing model input, and validation of data. DQOs identify the (1) type and quality of data that will be appropriate for use in the modeling project, (2) spatial and temporal input data coverage requirements, (3) data quality, and (4) technical soundness of the collection methodology. A list of related requirements is shown below.

- All input data for the model will be of known and documented quality.
- Meteorological and ambient monitoring data will be collected from as many sources as available and provide the maximum temporal and spatial coverage of the modeling domain.
- Modeling data will be representative of the parameters being measured with respect to time, location, and the conditions from which the data are obtained.

DQOs for the air quality modeling specifically include the ability to:

- Replicate base case air quality conditions.
- Estimate future air quality conditions, both spatially and temporally.
- Evaluate relative contributions of various pollutants to visibility impairment in the Class I areas.
- Identify the source(s) most likely influencing visibility in the Class I areas.

This project primarily uses data that were previously collected for a different intended use. For example, the emissions inventories for the base case modeling were developed by EPA for NAAQS regulatory purposes. The main objective is to evaluate the data quality to ensure that it meets the project's needs to generate reproducible and defensible modeling results to support VISTAS states' Regional Haze SIP submittals. Data used for this objective will be screened for the following:

- Completeness – All publicly-available data available will be collected and catalogued. At the onset of collection, the datasets will be assessed for missing data, including full documentation of collection and QA procedures. Datasets falling below certain completion thresholds will not be used in the analysis, and those completion thresholds are dependent upon the type of data used. For example:

- Time-period averaging. If annual average concentrations are to be developed, then ERG will require temporal completeness of 75% completeness for an entire year. This is consistent with averaging schemes used for criteria pollutants.[8]

- Meteorological measurements. For any observed data collected for the study, each measure will be subjected to the same completeness criteria as the Prevention of Significant Deterioration (PSD) program.[9] Any measurement failing to meet this criterion will be flagged. All meteorology modeling files used in this project were generated by EPA and will be checked to ensure all files needed have been obtained and contain all hours and parameters need for modeling.

- Emissions. Completeness checks for emissions include evaluating PM species, such as complete reporting of the filterable and condensable portions, as well as expected pollutants from source categories. Additionally, emission totals for 2011 will be compared to EPA-published Tier-level emissions.[10] Finally, ERG will check for stack parameter completeness for point sources that are necessary for emissions modeling.

Datasets below the prescribed completeness will not be used in any analysis, but will be retained and flagged as failing to meet completeness criteria. If analysis is performed for smaller time intervals (e.g., seasonal), completeness criteria will be reevaluated and data meeting completeness criteria for the smaller time intervals may be used.

- Representativeness – Collected data will be assessed for representativeness against similar datasets. For example, data distribution statistics will be calculated once the data has been collected, and those statistics will be compared to similar datasets. Statistics include minimum value, maximum value, and percentiles (5^{th}, 10^{th}, 25^{th}, 50^{th}, 75^{th}, 90^{th}, and 95^{th}). ERG will only compare datasets that are representative to one another, such as $PM_{2.5}$ measurements from the IMPROVE network being compared to other rural $PM_{2.5}$ monitoring sites. Representativeness is also evaluated for identifying data from other sources that can be used as surrogates. For example, if meteorological observations may be incomplete or not taken at a particular monitoring site, ERG would identify the closest, most representative meteorological station and use the data as a surrogate.

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[8] 40 CFR Part 50.

[9] Bailey, D. T., 2000: Meteorological monitoring guidance for regulatory modeling applications. Environmental Protection Agency Rep. EPA-454/R-99-005, 168 pp. [available at http://www.epa.gov/scram001/guidance/met/mmgrma.pdf.]

[10] US Environmental Protection Agency. 2011el_cb6v2v6_11g_state_sector_totals. ftp://ftp.epa.gov/EmisInventory/2011v6/v3platform/reports/2011el_and_2023el/2011el_cb6v2_v6_11g_state_sector_totals.xlsx (accessed on March 29,2018).

- Compatibility – Compare compatible versions of emission inventory data—for example, base year emissions compared to the projected emissions—to characterize differences and evaluate significant differences, if found. This include keeping records of how the future year emission estimates have been adjusted and the justification for those adjustments.

- Accuracy – Verify all calculations and revisions based on the data received. This includes verifying and changes to emissions based on a percent reduction, and assuring any values transcribed from one data source to another were not erroneously copied. These verifications will be performed by a staff member who was not involved in the initial identification and collection of the data.

5.2 Task Description and Intended Uses of Output

The project will utilize previously collected meteorological, ambient monitoring data, meteorological modeling, and emission inventories. As recommended in current EPA regional haze modeling guidance, the use of monitoring data will help ensure that the modeling effort yields accurate predictions with an acceptable level of model uncertainty as compared to other, similar modeling exercises.[11] Calculation to this end will only use monitoring data sources with a QAPP in place. That is, only data from reputable sources that follow standardized and quality-controlled data collection procedures will be used. Data with unknown quality (i.e., collected without a documented QAPP or using unapproved SOPs) will not be acceptable for use.

For the existing emission inventories, ERG will verify the emission totals in the files received match the total emissions in EPA published summaries for the 2011 and 2028v6.3el model platform. ERG will independently check each data point to verify the correct value and units.

The existing EPA 2011 WRF meteorological modeling files will be used without modification. EPA has already conducted a thorough review of the modeling, including quantitative review of the 2-meter temperature and mixing ratio, 10-meter wind speed and direction, and shortwave radiation and a qualitative evaluation of precipitation. The quantitative metrics used in model performance included: mean bias, mean (gross) error, fractional bias, and fractional error.[12] Overall, the WRF modeling was deemed acceptable for use by EPA.

For the modeling platform, Alpine will replicate EPA base year modeling to ensure that all modeling options have been applied correctly, thus ensuring the ability to compare SESARM future year estimates to EPA's efforts. The modeling output will be evaluated against the collected ambient monitoring data, to ensure replication of the base year conditions. The comparison will be performed using the Atmospheric Evaluation Tool (AMET) and custom

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[11] Wayland, R. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Memorandum. http://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance2014.pdf

[12] U.S. Environmental Protection Agency. 2014. Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation. (available at: https://www3.epa.gov/scram001/reports/MET_TSD_2011_final_11-26-14.pdf)

scripts developed by Alpine, which have been thoroughly vetted on previous projects. The modeling protocol developed under Task 6.1 will outline the graphics and statistics to be used in evaluating model performance, as does Section 10.2 of this QAPP.

5.3 Requirements for Hardware/Software Configuration

For hardware, ERG and Alpine periodically review their equipment inventory to ensure that they are adequate for the needs of the project. For example, ERG rotates computer resources to each staff member every three years, and high-end users receive the more powerful computers in terms of processing speed and storage. All computers and laptops are currently equipped with the Windows10 operating software and the Microsoft Office Professional 2016 Suite. Recently, ERG built a state-of-the-art server farm at its Corporate headquarters that will house the meteorological, ambient, and emissions data to be used for this project. Similarly for software, ERG and Alpine often customize their networks to optimize performance and speed for data-intensive projects. Specific details on Alpine's high-performance computing cluster is in Section 8.10.2 of this QAPP. All software is licensed such that the latest security patches and updates are automatically updated by the vendor. In terms of modeling, Alpine has configured its powerful computing system using the latest modeling software versions prior to project initiation.

6 SPECIAL TRAINING REQUIREMENTS/CERTIFICATION (A8)

As the tasks evolve and new technologies are deployed, we will ensure that staff members are trained internally on software upgrades, new packages that are being applied, and other areas requiring proficiency.

6.1 Types of Required Training and Certification

No additional training or certification is required for this project.

6.2 Plan for Obtaining Training and Certification

No additional training or certification is required for this project.

6.3 Documentation of Training and Certification

All personnel working on any element of this project have had their qualifications reviewed and have been determined by the Program Manager to have sufficient experience and knowledge to participate on this project. The only requirement is that project personnel are expected to read and observe the QAPP and the project instructions developed by the Program Manager/Technical Project Coordinator and task leads. The Project QA Coordinator will collect a written acknowledgement, via email, from each staff member that they have received and read the QAPP. The emails will be retained as part of the project record.

The Program Manager is responsible for overseeing internal training, should it become necessary. If any training or certifications are deemed necessary for any staff member working on this project to for the advancement of this project, it will be recorded in the company-wide training log. The log will note the name of the training course or certification, when it was taken, the name of entity that provided the training, short course description, and which staff completed

the training or certification. Proof of satisfactory training completion and certification numbers will also be logged, with scanned copies of any certificates or course completion certificates retained with the project files.

7 DOCUMENTATION AND RECORDS (A9)

All project team members will have the approved work plan and approved QAPP for use during the project. It is the responsibility of the Program Manager and Subcontract Manager to ensure that each staff member receives each document, including any amended versions.

This project will generate the reports noted in Table 4-1 in Section 4.1 of the QAPP. All reports will either be emailed directly to SESARM, posted to the project website as described in Section 4.1.10 of the QAPP, or by both means. Reports that use or develop specific data sets will include descriptions of data source(s) and methodologies used in their preparations, and any other information that might be critical to their use in the project. To the extent possible, the documentation of the data will also include references that may have further information on the data validity and usability. Copies of all project reports will be retained in electronic format through the duration of the project and archived following its completion. Additional information on project retention and backup policies is noted in Section 8.10.1 of the QAPP.

8 MEASUREMENT AND DATA ACQUISITION (GROUP B)

This section of the QAPP describes the data generation and acquisition management activities of the project team. The QAPP elements in this group are intended to address all aspects of data generation and acquisition to ensure that appropriate methods for sampling, measurements and analysis, and QC activities are employed and documented. Data generation and acquisition group elements that are not applicable to specific project tasks are not discussed. Because the SESARM project does not involve the sampling, handling, or analysis of primary data, the first eight elements of Group B described in EPA document QA/R-5 are not applicable for QA/G-5M to this project.

8.1 Sampling Process Design (Experimental Design) (B1)

This element is not applicable to this project.

8.2 Sampling Methods (B2)

This element is not applicable to this project.

8.3 Sample Handling and Custody (B3)

This element is not applicable to this project.

8.4 Analytical Methods (B4)

This element is not applicable to this project.

8.5 Quality Control (B5)

This element is not applicable to this project.

8.6 Instrument/Equipment Testing, Inspection, and Maintenance (B6)

This element is not applicable to this project.

8.7 Calibration (B7)

This element is not applicable to this project.

8.8 Inspection/Acceptance of Supplies and Consumables (B8)

This element is not applicable to this project.

8.9 Non-direct Measurements (Data Acquisition Requirements) (B9)

The proposed modeling and data analysis study will utilize data from emissions inventories and models, meteorological models, and air quality models as well as data from air quality monitoring networks and meteorological observations in the Southeastern United States.

8.9.1 Emissions inventories, and ancillary data for emissions processing including chemical speciation profiles, temporal profiles and spatial surrogates

Base year 2011 and projected 2028 emissions inventory data will be obtained from EPA's Air Emissions Modeling website. The 2011 emissions inventory has undergone thorough review by EPA and state/local/tribal air agencies. The 2028 projected emissions inventory is projected from the base year 2011 emissions inventory, with growth and control packets applied, as well as incorporation of emissions from new sources, and retirements of other sources. To facilitate ERG and SESARM review, county-level emissions density plots and/or tables will be developed to show the 2011 emissions, 2028 emissions, absolute difference, and percent difference. Significant differences that are identified will be documented and checked for reasonableness against what future changes that may occur by 2028. Data entered for these two emissions inventories have passed QA/QC procedures employed by EPA and documented in the technical support document.[13] If revisions are directed for the 2028 emissions inventories by the states, then those changes will be documented, and double-checked to ensure that they were processed correctly. As part of this QA, ERG would prepare a tabular revisions summary for 2028, comparing the original 2028 vs. the revised 2028 that can be shared with SESARM. Comparisons would include absolute differences and percentage differences, along with comments about sizable changes.

[13] U.S. Environmental Protection Agency. 2016. Technical Support Document (TSD), Preparation of Emissions Inventories for the Version 6.3, 2011 Emissions Modeling Platform. https://www.epa.gov/sites/production/files/2016-09/documents/2011v6_3_2017_emismod_tsd_aug2016_final.pdf

8.9.2 Initial and boundary conditions

Alpine will extract the initial and boundary conditions for the VISTAS_12 domain from the EPA CONUS 12km domain simulation. This simulation will be performed using the EPA platform and CAMx v6.40 on the Alpine computer cluster. The most recently released version of the standard CAMx BNDEXTR processor will be used and the DIAG and DIAG2 BNDEXTR outputs will be examined for reasonableness as compared to similar data from the EPA CONUS 12km domain simulation. If any major differences are noted between the modeling results from this study's 2011 and EPA's 2011 modeling runs, a call will be convened between ERG, Alpine, SESARM, and the appropriate EPA staff to identify any inconsistencies in model data input, output, and/or model options procedures and come to consensus on appropriate corrective actions.

8.9.3 Ambient air quality data

ERG will obtain ambient air quality monitoring data from the IMPROVE website and EPA's AQS for all IMPROVE pollutants for 2011 through 2016. These data will be a mix of sub-daily (e.g., hourly) and daily measurements. Each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries. Data entered into these systems have passed QA/QC procedures employed by EPA and the data owners. For AQS data, most monitors are run by state and local agencies that operate under monitoring plans,[14] which include QA/QC procedures, and are approved by their respective EPA Regional Offices. Other monitoring networks, like IMPROVE[15] and the Clean Air Status and Trends Network (CASTNET),[16] have quality assurance and standard operating procedures that are produced by the EPA contractor.

Wet and dry deposition data will be collected from the various NADP networks to supplement the project ambient air quality database. Monitor observation and station metadata will be obtained and preserved in the project database. Just like the ambient data obtained from EPA, each data record has primary keys assigned to ensure that no duplication of data is permissible or that record growth occurs when running queries. NADP[17] data have passed QA/QC procedures, all data flags added by NADP will be retained in the dataset.

8.9.4 Meteorological data

ERG will obtain observed meteorological data from three primary data sources:

- The National Centers for Environmental Information (NCEI)[18] for the Weather Bureau Army-Navy (WBAN) sites, which includes:

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[14] State monitoring plans are available at: https://www.epa.gov/amtic/state-and-local-monitoring-plans

[15] IMPROVE quality assurance documents (QAPP and QMP) are available at: http://vista.cira.colostate.edu/Improve/quality-assurance/

[16] CASTNET Quality Assurance Project Plan is available at: https://www3.epa.gov/castnet/docs/qapp_v9-0_Main_body.pdf

[17] NADP quality documentation is available at: http://nadp.slh.wisc.edu/lib/qaPlans.aspx

[18] NCEI quality documentation is available at: http://www.cio.noaa.gov/services_programs/info_quality.html

- National Weather Service (NWS) Automated Weather Observing System (ASOS),[19] and
- Federal Aviation Administration (FAA) Automated Surface Observing System (AWOS),[20] and

- Ambient meteorological measurements from EPA's AQS; and
- Ambient meteorological measurements from the IMPROVE website.

Data entered into these systems have passed QA/QC procedures employed by EPA and the data owners. Data will be collected for 2011 through 2016 for all parameters available to facilitate any additional analysis state may want to conduct. Documentation of the database will note the varying quality of the meteorological data sets, and make suggestion as to appropriate site substitutions, when possible.

For the modeling, EPA's 2011 WRF runs will be obtained from EPA. These modeling files have already had their mode performance scrutinized and accepted for as sufficient.[21] To assure that the meteorological data are accurately converted (windowed) from the EPA CONUS domain to the VISTAS 12km domains, the meteorological fields all the domains will be compared both graphically and by examining specific grid values.

8.9.5 Air quality modeling and analysis

Each step of the air quality modeling will include verification of model configurations, confirmation that the correct data were used and were processed correctly, and other procedures. Alpine will compare al l configuration and processing streams with EPA obtained files and protocol to ensure consistent modeling with EPA's 2011 platform methods. A comprehensive MPE of the predicted output concentrations will be conducted and compared with observational data to ensure representativeness, and to calculate bias and error margins, temporal accuracy, and dynamic response to emissions and meteorology ensuring that the modeled predictions demonstrate adequate confidence in the application of the model for this analysis. Consistent with most current EPA modeling guidance,[22,23] these results will be compared to other peer-reviewed applications of a similar nature to determine adequate representation of observed

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[19] Quality control procedures for ASOS sites are laid out in the ASOS User's Guide (https://www.weather.gov/media/asos/aum-toc.pdf), standard operating procedure documents (https://www.weather.gov/asos/ASOSImplementation), and Observation quality control document (http://www.nws.noaa.gov/directives/sym/pd01013005curr.pdf)

[20] For non-federal AWOS are subject to certification and review by the FAA as outlined in: (https://www.faa.gov/documentLibrary/media/Advisory_Circular/AC_150_5220-16E.pdf)

[21] U.S. Environmental Protection Agency. 2014. Meteorological Model Performance for Annual 2011 WRF v3.4 Simulation. (available at: https://www3.epa.gov/scram001/reports/MET_TSD_2011_final_11-26-14.pdf)

[22] Simon, H., Baker, K.R., Phillips, S., 2012. Compilation and interpretation of photochemical model performance statistics published between 2006 and 2012. Atmospheric Environment 61, 124-139.

[23] Wayland, R. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Memorandum. http://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance2014.pdf

conditions. Additionally, the simulations of the EPA platform performed on the Alpine cluster will be compared with the simulation results supplied by EPA with the original platform release (see Section 8.9.5.2 for more information). If significant differences between the SESARM 2028 run and EPA run that cannot be explained due to emission changes are found, the deltas will be explored with ERG, SESARM, and EPA.

8.9.5.1 SMOKE Emissions Processing QA/QC and Emissions Merging

EPA processed the emissions by major source category in several different "streams", including area sources, on-road mobile sources, non-road mobile sources, biogenic sources, non-CEM point sources, CEM point sources using day-specific hourly emissions, and emissions from fires. Separate QA/QC will be performed for each stream of emissions processing and in each step following the procedures utilized by EPA in their recent regional haze modeling. SMOKE includes advanced quality assurance features that include error logs when emissions are dropped or added. In addition, we will generate visual displays that include:

- Spatial plots of the hourly emissions for each major species.
- Summary tables of emissions for major species for each grid and by major source category.
- This QA information will be examined against the original source data and summarized in an overall QA/QC assessment.

Scripts to perform the emissions merging of the appropriate biogenic, on-road, non-road, area, low-level release point sources, fire, and elevated release point emission files will be written to generate the CAMx-ready two-dimensional day and domain-specific hourly speciated gridded emission inputs. The point source and, as available elevated fire, emissions would be processed into the day-specific hourly speciated emissions in the CAMx-ready point source format.

The resultant CAMx model-ready emissions will be subjected to a final QA using spatial maps to assure that: (1) the emissions were merged properly; (2) CAMx inputs contain the same total emissions; and (3) to provide additional QA/QC information.

Similar QA/QC will be conducted on both the base year and projection year modeling platform.

8.9.5.2 CAMx Model Confirmation

To insure the data transfer integrity of the EPA CAMx platform being used in this study, the results of the EPA 2028el and 2011el CONUS 12km CAMx 6.32 model simulations will be compared to the simulations performed on the Alpine Geophysics computer system.

For the 2028el simulation EPA has provided the hourly average model outputs for all species. Model comparisons will be performed for ozone, sulfate, nitrate, organic carbon, and $PM_{2.5}$. Comparisons products will include tables of the hourly maximum positive and negative differences, and production of animations of hourly spatial difference plots.

For 2011el EPA has supplied daily maximum 8-hour average (MDA8) ozone results. These values will be compared with the Alpine simulation by producing tables of the maximum and minimum daily differences and production of an animation of the daily spatial differences. Should EPA be able to supply the daily "average" model outputs, the additional comparisons for the 2028el simulation will be performed.

The numerics of the CAMx model are quite complex, and it is typical to get small differences between simulations on different computer systems. The maximum ozone differences are typically less than 0.01 ppb. For PM species the differences can be larger do to different paths in the PM chemistry that are concentration dependent, so a small difference can lead to a different path through the chemistry that can increase the difference. In general, should a difference of 2% be seen in the replication of the 2011 base year photochemical modeling a call will be convened between ERG, Alpine, SESARM, and the appropriate EPA staff to identify any inconsistencies and come to consensus on appropriate corrective actions.

8.9.5.3 PSAT Tagging QA

The tagged modeling results will be qualitatively evaluated to better understand the individual source sector and species contributions and spatial distributions relative to regional haze at Class I areas. We will examine the tagged results by looking at spatial maps of the raw source apportionment outputs in modeled concentration units.

8.9.5.4 Area of Influence Analysis

For the area of influence analysis, all model execution code will be reviewed for accuracy by a second modeler. HYSPLIT output will be reviewed and all trajectories will be plotted to verify proper HYSPLIT model execution. Reviewer will ensure the proper origin of the trajectories, all levels are present, all trajectories are for the 72-hour timeframe. As possible, modelers will assess the reasonableness of the trajectories, noting any particularly long or short trajectories or divergent patterns that would need further review. Residency time plots will be compared back to the trajectory plots to qualitatively verify the highest regency corresponds to the highest density of trajectories. Final spreadsheets of ranked emission sources will be reviewed by a second analyst to ensure proper data transfer and calculation of facility specific values.

8.10 Data Management and Hardware/Software Configuration (B10)

The proper management of all data associated with this project is critical to assuring the quality and usability of the modeling results. As such, procedures will be implemented to ensure adequate data acquisition, validation, transmission, and storage of electronic and hard copy data.

8.10.1 Data Management

All original files (i.e., data obtained from external sources) will be kept separate from project working files. The data librarian will preserve backup copies of these files for record keeping and dissemination purposes.

All final project documentation, records, data, and reports will be maintained at ERG for a period of at least five years from the completion of the project. Data will be backed up periodically to alternate storage locations to prevent data loss. ERG's current back up practice is to perform a full back up every week, with daily backups of files alternated that day. After five years, the project documentation, records, data, and reports will be archived to tape storage and retained for another five years. Modeling files will be retained by ERG and duplicate copies of the modeling files will be retained by Alpine. All files will be retained in readily-accessible format for at least five years after project completion, and as an archive copy (i.e., tape storage) for five years after that. Original data files and final files, particularly input files, will be restricted to read-only access to order to avoid possible overwriting the files and unintentional editing.

Data will not be released without the expressed approval of the SESARM APC or previously identified surrogate. All outside requests for the data will go through the data librarian. The data librarian will arrange the dissemination of copies of the requested files. As part of the project deliverables, the data librarian will arrange to send hard drives with copies of the project files (e.g., modeling inputs, modeling outputs) to designated state and federal representatives. A list of all SESARM stakeholders and approved federal entities will be developed for disk dissemination two weeks prior to shipping the drives to ensure correct contact information. The data librarian will send the drives to the first representative, who will copy the contents of the drive to their own system and then forward the drive to the representative on the list. SESARM may elect to have two separate copies of the files developed, to expedite the process (i.e., two distinct copies sent to different representatives at a time). After the final representative copies the data, the drive will be returned to the data librarian. At that time, the drive's integrity will be checked, and after finding no errors, will be sent on the SESARM headquarters where it will remain.

8.10.2 Hardware/Software Configuration

In all tasks, the latest versions of the models and analysis software will be used, unless otherwise explicitly requested by SESARM. Alpine will use CAMx v6.40 with PSAT to generate the files and concentration data necessary to support this and additional tasks. All software version numbers and special configuration settings will be documented in the task protocols and reports.

A high-performance computing cluster is required to accomplish photochemical modeling in a reasonable timeframe. Alpine's computing facilities consist of a very powerful array of 32 multiprocessor Linux-based workstations. The aggregate network has 192 Processor Cores; 4688 gigabyte (GB) of memory and 96,000 GB of aggregate disk space with over 70,000 GB of RAID protected space. Alpine scientists have been using Linux and Unix for emissions, meteorological, and air quality modeling and data analysis for over twenty years. Alpine's computing system and knowledge base, in conjunction with existing relationships with hardware vendors, software vendors, and system specialists, enable Alpine to meet the computational requirements of this projects.

All databases developed to disseminate data will include a data dictionary that provides the field name, a clear description of the field contents, unit information, and data source for all

tables included. For the data collected under Task 4, Data Acquisition and Preparation, databases will include the metadata for each monitoring/observation site, including locational information, site duration, site identifier, and network identifier. Any code generated to analyze data for the project will be provided to SESARM with adequate inline documentation to facilitate execution of the code by any member state.

9 ASSESSMENTS AND OVERSIGHT (GROUP C)

The purpose of this section is to describe the internal and external checks and activities necessary to assess the effectiveness of the modeling project implementation and associated QA/QC activities.

9.1 Assessment and Response Actions (C1)

Although the primary stakeholder providing oversight is SESARM, several other stakeholders will also provide some level oversight, including:

- The CC;
- The TAWG; and
- Representatives of EPA and EPA Regional Offices (3 and/or 4).

While some stakeholders may have more oversight than others, all of the above have oversight in the approval of this QAPP. As such, no technical work is to be authorized or commence until this QAPP is approved by the above-mentioned parties and formally authorized by the SESARM APC.

ERG's Program Manager will have oversight on all technical and administrative aspects for this contract. He will receive substantial support from the Deputy Program Manager, as well as contracts and clerical staff at ERG. For financial information, ERG uses the Deltek Timesheet program for accurate tracking of project charges and IBM Cognos Connection, which provides weekly financial information to be monitored by the ERG Program Manager.

Along with the ERG Program Manager, the ERG Project QA Coordinator will review all deliverables, and ensure that the required elements are met. Additionally, ERG and Alpine staff will employ the QA/QC checks that are described in this document and that have been developed and scripted over decades of experience, in reviewing the data for this project. As such, ERG and Alpine staff will serve as an extra level of review for each other within the tasks and subtasks.

9.1.1 Hardware/Software Assessments and Configurations

As part of its business practice, ERG and Alpine regularly evaluate their software and hardware needs for complex air quality projects. Such evaluations include: installation of the most recent versions of software such as Microsoft Office's Professional Suite; updates of vendor security patches and software updates; computer and hard drives upgrades; and increased network capacity for performance improvements and data archival backups.

ERG and Alpine also ensure that staff have redundant capabilities, such that code and scripts developed can be evaluated by another team member. When a new code or script is developed for the project, it will be tested, and quality assured by others on the team.

9.1.2 Plans for Science and Product Peer Review

There are no plans for science and product peer review for this project.

9.2 Reports to Management (C2)

Reports from ERG to SESARM will be frequent, through the use of Monthly Progress Reports, regular phone calls, e-mails, and interim project deliverables. The assessment reports described in Section 4.1 of the QAPP will describe our reporting procedures on the status of various elements of the project, including results, QA procedures, and any QA problems and suggested remedies. ERG is committed to the schedule, as described in Table 4-1.

Monthly Progress Reports will be submitted within two weeks of the end of each calendar month and will be electronically submitted to the SESARM APC. The monthly progress report will contain information about:

- Administrative items;
- Technical progress achieved by task and subtask;
- Any significant QA efforts and progress, as described in the QAPP;
- Work and deliverables to be accomplished the next month;
- Meetings and deliverables that took place;
- Problems that need to be addressed; and
- Financial information about resources spent and remaining.

If problems arise during the course of the project, then ERG will inform SESARM immediately describing the problem, and providing recommendations for corrective action. If such actions require updates in the approved QAPP, then ERG will initiate those discussions with SESARM, and make adjustments accordingly.

10 DATA VALIDATION AND USABILITY (GROUP D)

The primary purpose of this group of elements is to describe the process to assess the usability of the modeling results. Many of these procedures will occur during and/or near the end of each Task.

10.1 Departures from Validation Criteria (D1)

All data received or created during the project will undergo a verification procedure to ensure that the data are identical to their original sources (for example, checking on file names, format, and file sizes). Further, it is important to validate the names of parameters included and the units of such parameters.

10.2 Validation Methods (D2)

The AMET Tool and other statistical and graphical tools will be used to verify the meteorological and air quality modeling inputs/outputs. Graphical plots for variables will include:

- Overlaying observational and model data
- Graphical statistical plots for various meteorological and air quality variables including:
  - Time series of ambient and modeled concentrations
  - Stacked bar charts
  - Scatter plots
  - Bugle plots
  - Soccer plots
- Tabular statistical parameters

Calculated model performance statistics will be include to the following values:

- Mean Observed monitored concentration (Observed)
- Mean Modeled concentration (Modeled)
- Mean Bias (MB)

$$MB = \frac{1}{N}\sum_{1}^{N}(Modeled - Observed)$$

- Mean Error (ME)

$$ME = \frac{1}{N}\sum_{1}^{N}|Modeled - Observed|$$

- Normalized Mean Bias (NMB)

$$NMB = \frac{\sum_1^N(Modeled - Observed)}{\sum_1^N Observed} \times 100\%$$

- Normalized Mean Error (NME)

$$NME = \frac{\sum_1^N(|Modeled - Observed|)}{\sum_1^N Observed} \times 100$$

- Mean Fractional Bias (MFB)

$$MFB = \frac{2}{N}\sum_{1}^{N}\left(\frac{Modeled - Observed}{Modeled + Observed}\right) \times 100$$

- Mean Fractional Error (MFE)

$$MFE = \frac{2}{N}\sum_{1}^{N}\left(\frac{|Modeled - Observed|}{Modeled + Observed}\right) \times 100$$

- Root Mean Squared Error (RMSE)

$$RMSE = \sqrt{\frac{\sum_1^N(Modeled - Observed)^2}{N}}$$

- Pearson Correlation Coefficient (r)

$$r = \frac{\sum_1^N \left((Modeled - \overline{Modeled}) \times (Observed - \overline{Observed}) \right)}{\sqrt{\sum_1^N (Modeled - \overline{Modeled})^2 \sum_1^N (Observed - \overline{Observed})^2}}$$

Additional statistical analysis may also be performed, as determined necessary. All statistics will be calculated consistent with the respective pollutants NAAQS averaging time. EPA has recently moved away from numeric "acceptable ranges" in lieu of using comparisons to other similar, modeling studies. This is outlined in the most current modeling guidance and will be the methods utilized here.[24] Additional studies[25,26] have suggested, at a minimum, the following performance criteria:

- Total $PM_{2.5}$ and SO_4: NMB <±30% and NME <50%
- NO_3: NMB <±65% and NME <115%.
- Major component species (i.e., ≥30% of total $PM_{2.5}$): MFE ≤75% and MFB ≤ ±60%.

ERG/Alpine expects the model performance of the replicated 2011 CAMx run to the be slightly different from EPA published MPE metrics[27] due to the differences in the version of CAMx being used and domain. If performance is not comparable to EPA's MPE, then data files will be reviewed to determine the cause. If the difference is not explainable by the changes in domain or model version, a call will be convened between ERG, Alpine, SESARM, and the appropriate EPA staff to identify any inconsistencies and come to consensus on appropriate corrective actions. Any of the metrics outside published proposed criteria levels will be noted as part of the uncertainty associated with the modeling.

10.3 Reconciliation with User Requirements (D3)

The results of this project are intended to provide SESARM scientific-based information for its member states to update their Regional Haze SIPs. Representatives from each member state will be important stakeholders throughout the project reviewing emissions data, ambient monitoring data, and modeling results prior to the completion of interim and final reports. Should any concerns about quality of products arise, a call will be convened between contractors and stakeholders to determine the most appropriate corrective action. The ERG Program Manager will document all action and assure their completion.

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[24] Wayland, R. 2014. Draft Modeling Guidance for Demonstrating Attainment of Air Quality Goals for Ozone, $PM_{2.5}$, and Regional Haze. Memorandum. Available at: http://www3.epa.gov/scram001/guidance/guide/Draft_O3-PM-RH_Modeling_Guidance2014.pdf

[25] Emery, C., Liu, Z., Russell, A. G., Odman, M. T., Yarwood, G., & Kumar, N. (2017). Recommendations on statistics and benchmarks to assess photochemical model performance. Journal of the Air & Waste Management Association, 67(5), 582-598. doi:10.1080/10962247.2016.1265027

[26] Boylan, J.W. and Russell, A.G. (2006). PM and Light Extinction Model Performance Metrics, Goals, and Criteria for Three-Dimensional Air Quality Models; Atmos. Environ., Volume 40, pp. 4946-4959.

[27] US Environmental Protection Agency. 2017. Documentation for the EPA's Preliminary 2028 Regional Haze Modeling. October 2017. Available at: https://www3.epa.gov/ttn/scram/reports/2028_Regional_Haze_Modeling-TSD.pdf.

ERG will report to SESARM any departures from the assumptions set in the planning phase of the project, should they arise. Such departures will be documented in the Monthly Progress Reports and the interim and final reports.

All output data used by the member states will also contain the applicable data limitations to help inform decision makers about the appropriateness of using the data. Such limitations include the facts that all data was generated for this project for the explicit use in regional haze analysis and evaluation. As such, model performance, at all levels, has been tuned to the needs of regional haze evaluation and generally do not extend beyond regional haze pollutants. Any use outside of this purpose does so at their own risk. It is solely the data user's responsibility to ensure the data is applied appropriately. Detailed Metadata files and documentation will accompany all data outputs to encourage the appropriate use of the files.