

Quality Assurance Project Plan

Project 17-053

Spatial Mapping of Ozone Formation near San Antonio

Prepared for Texas Air Quality Research Program (AQRP) The University of Texas at Austin

Prepared by

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Tara Yacovitch and Scott Herndon have prepared this QAPP following EPA guidelines for a Quality Assurance (QA) Category III Project: Measurement. It is submitted to the Texas Air Quality Research Program (AQRP) as required in the Work Plan requirements.

QAPP Requirements: Project Description and Objectives, Organization and Responsibilities, Scientific Approach, Quality Metrics, Data Analysis, Interpretation and Management, Reporting and References

QA Requirements: Technical Systems Audits - Not Required for the Project
 Audits of Data Quality – 10% Required
 Report of Findings – Required in Final Report

Approvals Sheet

This document is a Category III Quality Assurance Project Plan for Project 17-053, "Identifying and Apportioning Ozone Producing Volatile Organic Compounds in Central Texas". The Principal Investigator for the project is Scott Herndon.

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LIST OF ACRONYMS

AML – Aerodyne Mobile Laboratory, includes potential additional vehicle(s)

AMS – Aerosol Mass Spectrometry, includes conventional quadrupole and time of flight methods

ARI - Aerodyne Research, Inc.

CE - Collection Efficiency

BTEX - Benzene, Toluene, Ethyl-benzene, and Xylenes

DVA - Vacuum aerodynamic diameter

GHGs - Greenhouse Gases

HAPs - Hazardous Air Pollutants

NAAQS - National Ambient Air Quality Standards

PTR-MS - Proton Transfer Reaction Mass Spectrometer

QAPP – Quality Assurance Project Plan

QCL - Quantum Cascade Laser, includes “pulsed” and “continuous-wave” methods

SCIPUFF - Second-order Closure Integrated PUFF Model

SIP - State Implementation Plan

USEPA - United States Environmental Protection Agency

VOCs - Volatile Organic Compounds

1. PROJECT DESCRIPTION AND OBJECTIVES

The overall objectives of this project are to elucidate the cause of high ozone concentrations in San Antonio and to inform regulatory decisions regarding mitigation procedures using analysis of data from an air quality study in and around San Antonio during May and June of 2017. More detailed objectives are to answer the following science questions:

The work plan describes a field deployment to central Texas in May/June of 2017. The instrument manifest, described elsewhere, has been selected to allow the comprehensive suite to address the following scientific questions:

Individual VOC emission sources (for example, oil production vs biogenic emissions) all participate in ozone production in central Texas. Can examination of the oxidation products and radical termination species (e.g. butanone and alkyl nitrates) that still retain specific parent VOC information be used to apportion the VOC component of regional ozone production?

What is the instantaneous rate of ozone production in central Texas and is it occurring under NO_x-limited or VOC-limited conditions? Coupled with question one, how does this answer and inform potential mitigation strategies?

Can improved characterization of specific industry sector emissions offer insight into the ozone and air quality impact? Do flares, specifically medium- to large- volume process flares in the Eagle Ford, constitute an emission source type not well represented in emission inventories?

2. PROJECT SCHEDULE AND KEY MILESTONES

Task 1: Project Design and site selection (November 2016 – January 2017)

The PI and measurement team will work with TCEQ to select sites in the region. We seek to select locations from Corpus Christi to Carrizo Springs to San Antonio that will enable the observation of emissions signatures and photochemically processed air. The outcome of this task will be a power point file with sites, goals and action items associated with the logistic preparation tasks.

Task 2: Mobile Laboratory preparation (January 2017 – April 2017)

The GC-MS will be prepared for integration into the Aerodyne mobile laboratory. The instrument designs and operation will be modified as needed due to space constraints. Instrumentation for the measurement of alkyl nitrates and other photochemical products will be adapted for mobile applications taking into account both mounting, and inlet considerations. Finally, the analytical instrumentation will be integrated into the Aerodyne Mobile laboratory. The outcome of this task will be successful integration of field-ready instruments into the Aerodyne mobile laboratory.

Task 3: Field deployment (May 2017 – June 2017)

The three-week field project is planned for May and June in the greater San Antonio area. Measurements of photo-oxidants, NO_x, selected hydrocarbons, aerosol size and composition will be made on board the Aerodyne mobile laboratory in central Texas. This includes the Gulf Coast (e.g., Corpus Christi), northwest of San Antonio (usually a downwind high O₃ site), and in between in locations with suspected biogenic, oil and gas producing areas in both the 'wet' and 'dry' gas regions. This task will be conducted by the Aerodyne Research, Inc team in conjunction with collaborators (Drexel University, Montana State University and others). The outcome of this task will be the raw data collected during the field deployment.

Task 4: Follow-up laboratory work (June 2017 – August 2017)

Following the completion of the field measurements, additional laboratory work will be conducted if necessary as part of the data quality assurance procedure. This would likely involve additional instrumental calibrations and diagnostic tests to ensure the accuracy of the data collected. This task will be conducted by the research team. The outcome of this task is a fuller understanding of the performance of the instruments during the field deployment.

Task 5: Data work-up and analysis (August 2017)

The raw data collected during the field deployment will be processed to produce the final time series data set as well as photochemical production rates as a function of location. Apportionment of the ozone formation based on likely VOC emission sources and intra-urban sources will be analyzed. The deliverable resulting from this task will be the quality-assured dataset and the project final report which summarizes the preliminary analysis performed.

Task 6. Project Reporting and Presentation (September 2016 – August 2017)

AQRP requires the regular and timely submission of monthly technical, monthly financial status and quarterly reports as well as an abstract at project initiation and, near the end of the project, submission of the draft final and final reports. Additionally, members of the research team will attend and present at the AQRP data workshop. For each reporting deliverable, one report per project will be submitted (collaborators will not submit separate reports), with the exception of the Financial Status Reports (FSRs). The lead PI (or their designee) will electronically submit each report to both the AQRP and TCEQ liaisons and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. The report templates and accessibility guidelines found on the AQRP website at <http://aqrp.ceer.utexas.edu/> will be followed. Draft copies of any planned presentations (such as at technical conferences) or manuscripts to be submitted for publication resulting from this project will be provided to both the AQRP and TCEQ liaisons per the Publication/Publicity Guidelines included in Attachment G of the subaward. Finally, our team will prepare and submit our final project data and associated metadata to the AQRP archive.

3. SCIENTIFIC APPROACH

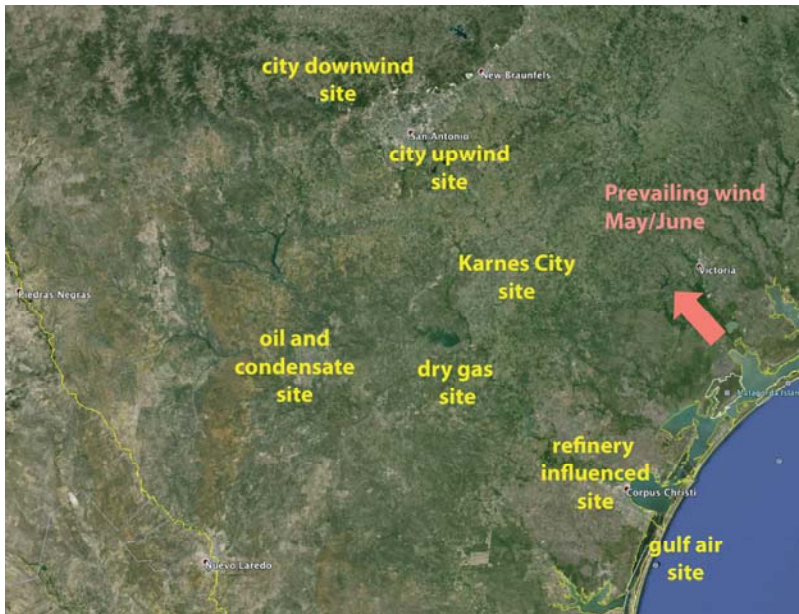


Figure 2. Map of notional sites for photochemical portion of the project.

Data will be collected during drives in the AML over periods of several hours across a range of geographic areas that will be recorded with the AML's on-board GPS system. We will operate the mobile laboratory at various sites between Corpus Christi and San Antonio. The strategy will be to move the portable

supersite to a location that is forecast (based on meteorology) to have needed characteristics to meet the science objectives for 1-3 days into the future. Though forecast conditions will always be changing, the idea is to fully characterize the incoming Gulf air: through the refinery complex, as it passes through the Eagle Ford, into, and out of San Antonio. The mobile laboratory has the capacity and capability to address the science questions with this strategy. With the assistance of collaborators and the TCEQ, specific locations and logistics will be chosen during the planning stages. It is anticipated, however that some sites with high scientific value, identified either during planning or during the course of the study will not have plug-in power or security available. The mobile laboratory can operate for 48-72 hours using its generators for electrical power.

4. SAMPLING PROCEDURES

The AML is generally outfitted with instrumentation that sample the local air and characterize it for a specific chemical or class of chemicals. The majority run pseudo continuously, with a constant intake flow that is processed to produce 1 second data. Other instrumentation do sample collection, such as the gas-chromatography based instruments that sample for a discreet period of time, concentrating sample that is released onto the column during a measurement phase. Still other instrumentation

considered integral to the AML's functionality do not fit into these categories such as the anemometers and global positioning system devices.

Once the campaign begins, the instrumentation suite will be operated continuously, switching between pre-arranged "shore" power and the on-board generator. The procedures and protocols for the switch are described in the mobile laboratory manual. *Approximately 3 minutes are required to re-establish quality assured data following the power switches.*

We plan to operate, measure and stage from more than three but fewer than six sites in central Texas. We will plan to move the AML lab based on prevailing and forecast meteorological conditions. The goal of changing sampling positions will be to measure air representative of regional conditions. When wind advection is strong, we will plan to be 'downwind' at relevant photochemistry sites. When wind advection is weak, or the weather overcast, we may opt to move closer to source VOC regions.

The factors that will influence when the mobile laboratory is taken on the mobile sorties to emission regions and downwind to photochemical regions are:

- predicted wind direction and speed,
- atmospheric mixing layer depth estimates and
- solar insolation.

There is a challenge implicit in measuring this scale of 'photo chemical impact' on a region and the representativeness of the result. The mixing layer depth and local emission strengths are potentially coupled. The mixing layer height can increase rapidly and dominate a change in mixing ratio at the surface. Therefore, in this study it will be important to collect both source and photochemically processed air. We may normalize some data to mixing layer height in an effort to mitigate the influence of the mixing layer height on precursor pollutant levels as well as quantify what is coming from sources. The proposed use of chemical clocks, looking in detail at the unique photochemical products, will allow us to sidestep some of these challenges that result when looking at mixing ratio magnitudes alone.

The campaign will be conducted during a three-week interval. Aerodyne scientists will be attempting to analyze the data while in the field and will regularly update the TCEQ in order to get feedback about which of the modes described above are producing data that addresses the project questions.

5. MEASUREMENT PROCEDURES

The radical termination hydrocarbons that contain a signature of their source and ozone are the highest priority measurements in this project. In order to properly evaluate the photochemical environment, speciated NO_x and photochemical precursors must also be quantified. The measurements of CO and selected hazardous air pollutant hydrocarbon compounds will also be performed. The core suite of species chosen in the deployment package will enable an understanding of the photo-chemical and radical environment.

The measurement system will include:

- Fast (1s time resolution) combustion tracer species, CO₂, CO, NO, NO₂;
- Rapid measurements of particulate quantities, particulate black carbon mass, particulate sulfate, nitrate and organic matter, total number density (count), particulate size distribution spectra;
- Selected ozone precursors and hazardous air pollutant (HAP) measurements such as, benzene, toluene, other aromatics compounds (BTEX), acetaldehyde and other oxygenated hydrocarbons;
- Meteorological instrumentation to monitor wind speed and direction;
- Laboratory Global Positioning System (GPS) data as well as on-road video with time codes to enable random access to the video record.
- Augmented portable wind direction and wind speed monitors that can be arrayed near the AML in order to collect data that would be used to verify local transport;

The measurements described above are tabulated in Table 5-1 with an indication of the anticipated reporting time interval as well as the instrument model or description.

Table 5-1 Measurements to be conducted during the mobile monitoring campaign

Measurement	Rate	Instrument
Carbon Dioxide (CO ₂)	0.9 s	Licor 6262 (2) and Licor 820
Carbon Monoxide (CO)	1 s	Quantum Cascade Laser System (2230 cm ⁻¹)
Nitric Oxide (NO)	1 s	Thermo 42i Chemiluminescence
Nitrogen Dioxide (NO ₂)	5 s	Cavity Enhanced Phase Shift
Oxides of Nitrogen (NO _y)	1.4 s	Thermo 42i with external inlet-tip Mo Converter
Black Carbon PM (70 nm -1.5 μm)	1 s (variable)	SP-AMS with laser-on mode
Non-refractory PM coating on Black Carbon (70 nm - 1.5 μm)	1 s (variable)	SP-AMS with laser-on mode;
Particle Extinction	3 s	Cavity Enhanced Phase Shift
Particle Number Density	1.8 s	Condensation Particle Counter
Number based Size Distribution	2 minutes	Differential Mobility Analyzer with Condensation Particle Counter
Various Aromatics and Oxygenates such as: Benzene, Toluene, Xylene, Acetone, Acetaldehyde	1.4 seconds	Proton Transfer Reaction Mass Spectrometer
Alkanes, Selected Alkenes and Aromatics, including alkyl nitrates	30 mins	Gas Chromatogram with Mass Spec. detection

The mobile laboratory suite includes sampling instrumentation, ambient meteorological measurements, global positioning system and visual record of the front view out of the mobile lab.

The following general tasks will be completed as part of the daily deployment activity. The manual for the mobile laboratory is included as Appendix 1 and contains much more specific instructions for the operational procedures.

1. The truck infrastructure instrumentation, GPS, clock synchronization software, time coded webcam functionality and time stamped notes stations are verified.
2. Quality Control checks are performed on all analyzers. The real-time display of all measured vectors is used to verify that all instruments are recording data with the predicted time response and they are all responding to on-board inlet based zero air or particle free air events.
3. Ambient monitoring analysis will be performed depending on the wind condition and total status of the truck. For any instrumentation requiring corrective actions, a judgment will be made regarding the instrument priority within the study objectives and the current sampling condition.
4. When not driving, the mobile lab will be docked to shore power and sampling will continue. At this time, detailed calibration and QA procedures are performed according to specific instrument demands.

The manuals or documents describing the various operational procedures are attached as appendices.

- Appendix 1: Mobile Laboratory
- Appendix 2: Proton Transfer Reaction Mass Spectrometer (PTRMS)
- Appendix 3: Licor 6262 (CO₂ analyzer)
- Appendix 4: TDLWintel Manual (TILDAS/QCL instruments)
- Appendix 5: Thermo NO Chemiluminescence Manual
- Appendix 6: CAPS NO₂ Manual
- Appendix 7: CAPS Particle Extinction Manual
- Appendix 8: General Aerosol Mass Spectrometer Manual
- Appendix 9: High Resolution Time of Flight Mass Spectrometer (for GC-MS and Iodide CIMS)

The main truck notes log is similar to a chat system, where notes entered at any terminal are time stamped and recorded in a centralized file. Specific calibration procedures and instrument evaluation notes are recorded on the computer that is responsible for acquiring or logging the data from that instrument.

Quality Control in Sample Analysis

The mobile laboratory in this deployment will not collect physical samples for subsequent analysis. It is anticipated that the GC-MS instrumentation that should be available does in-line pre-concentration methods using a cryogenic and/or TENAX trap.

Sample Preservation

No preserved, physical sampling substrates will be collected during this deployment.

Sample Numbering

The mobile laboratory data collection scheme is a continuous measurement system. The various instrument computers each use an archival method specific to that instrument (described elsewhere). On board the mobile laboratory, the main computer server maintains a mirrored drive for all project data files. The project folder ("2017_05_AQRP") will contain several sub-folders. The folder structure is derived by the name of the computer collecting the data. The various instrument and data logging computer files (described below) are synchronized to this server location, which accomplishes two things. First, it is an initial backup of the data and second, it produces a unified data source that can be copied to removable thumb drives or laptops for daily in-field analysis. Additionally, this produces a gateway to the data that does not interfere with continued data collection.

The specific data files produced vary depending on which instrument system is producing the data. The AMS instrument produces .hdf files that are synchronized to the server. Due to the complexity of the data collected by the high resolution time of flight mass spectrometer, all quantitative analysis is performed off line using the

analysis software maintained by the AMS users group. The data files are named according to the data and stored in a folder entitled SP-AMS.

The QCL instruments log data into time stamped files (date and time) that are stored on the local machine (e.g. "120429_134500.stc" is the file that was initiated in the software on 4/29/2012 at 1:45 pm). The entire TDLWintel directory is synchronized to the network server location into its own named folder. This keeps the dataset distinct from other QCL laser instrument data and facilitates post processing by keeping all of the specific spectral files (species.hit) together. The "live" RS-232 feature is also employed (described below).

There are numerous instruments that are date and time stamped using an RS-232 data stream. DataLogger and VoltLogger write files to the \results\ directory according to name of the instrument channel. Datalogger date and time stamps the incoming data according to the computer clock. A server document entitled COMKEY.rtf contains the description of which instrument, channel name, COM port number, RS-232 line label text and any other notes about the data source. The computers, "Rhenium", "Osmium" and "Tungsten" are all capable of running data logger and during integration the COMKEY file is kept up-to-date. All data produced is copied to the server into folders organized by the name of the computer that did the logging. In some cases, because DataLogger is running on more than one machine, it is possible to use a generic data channel (e.g. "Log-A") twice. By keeping the data separated by computer name, this practice prevents "cross-threading" data from two different instruments.

All computers run the Net-Time software which keeps the time synchronized to the clock of the dedicated GPS time server appliance. This software also produces a log of all time settings. Typically, the differences in clock settings are less than 50 ms after an initial time set. Generally, the data collected on a particular sampling line is logged into a common instance of data logger. For example, on the main gas phase inlet, the measurements, CO₂, CO, NO and NO₂, measured using four different instruments are all being logged by the same computer so that the only differences in the time/signal relationship are due to lag times along the sampling inlet.

For the purposes of this deployment, universal coordinated time (UTC) will be the official mission time. Daylight savings switches will not occur mid-campaign causing a duplicate hour or hour gas in a "local time" vector. A time-coded notes system is in use on the mobile laboratory that either time stamps the initial keystroke or the final entry return key depending on the user preference. The notes are used to describe both the running tally of activity taking place local to the mobile lab as well as any measurement phase or experiment. Customizable event buttons are built into the "QAQC" software that can be used dynamically to produce a digital record of a defined lab or air mass state. This process facilitates semi-real time analysis of measurement vectors and generates cues for subsequent analysis. These notes are valuable data and will be reported as such.

Sample Chain of Custody

The data files managed in the mobile laboratory computer system are backed up and archived daily. All data from all machines are collected and organized with specialized synchronization software to a central location on the server computer. The folder structure is based on named instruments and computers. Portable back ups to various researchers of the raw data are made daily for on-going in-field analysis.

At the conclusion of the project, the collected data and any additional files produced in data analysis that has been performed will be transmitted to UT and TCEQ. The analysis products will be updated as a result of post campaign quality assurance and detailed analysis of the high-resolution mass spectrometry data.

Raw data and analysis products will be archived at ARI for 5 years following completion of the fieldwork. This data archive is maintained by Scott Herndon.

6. QUALITY METRICS (QA/QC CHECKS)

QC metrics are listed below:

The QC checks used in the field to assess the QA Objectives for this mission are tabulated in three tables. They have been divided into the following categories: a) core gas phase measurements, b) core particulate measurements and c) truck infrastructure data and additional measurements.

The core gas phase measurement assessment notes are tabulated in Table 6-1a.

The core particulate measurement assessment notes are tabulated in Table 6-1b.

The truck infrastructure measurement and additional measurement assessment notes are tabulated in Table 6-1c.

Table 6-1a Procedures to Assess QA Objectives for Core Gas Phase Measurements

Measurement Parameter	Analysis Method	Assessment Method
Carbon Dioxide	Nondispersive IR	Flow check[1] Zero, Span1 and Span2 prior Span1 checks semi-daily Zero checks semi-hourly
Carbon Monoxide	Fingerprint IR/TILDAS	Zero, Span1, High Concentration Span diluted. Calibrations described in 6.2 semi-daily
Nitrous Oxide	Fingerprint IR/TILDAS	Span1 - Zero checks are semi-daily when using N2 overblow
Nitrogen Dioxide	Cavity Enhanced Phase Shift (CAPS)	Regular Zero (5 mins) with humidity matched, VOC free, CO free, NOx free air. Formal signal calibrations performed prior to campaign with permeation sources. In-field NO/O ₃ /NO ₂ calibrations described in section 6.2 TILDAS instruments in series with own flow check. CAPS flow check described in Table Note[1]
Nitric Oxide	Chemiluminescence detection of NO ₂ *	Instrument pump is used, flow check Calibration described in Section 6.2 Time response with CO/CO ₂ used to diagnose real time performance
Oxides of Nitrogen (NOy)	Molybdenum Conversion of NO _z and NO ₂ into NO Chemiluminescence detection of NO ₂ *	Instrument pump is used, flow check Calibration described in Section 6.2 Time response with CO/CO ₂ used to diagnose real time performance

Table Notes

[1] Sample Flow Rates Designated with this note entry are set using critical apertures that are protected by a high surface area particle filter. The aperture is chosen according to its size designation, however all flow rates are measured using a certified mass flow meter to quantify the actual flow rate. Note that the total 'ganged' flow where multiple instruments are joined to the same sample trunk line is also measured. The small disparities (<10%) between the measured total and sum of the Individual flow are due to small pressure drop along the truck sample line. Whenever possible, the calibrations, zeros or instrument span checks are all performed at the inlet tip to ensure the instrument operating pressure and flows are as similar as possible. None of the instruments used in the truck show a systematic dependence on the flow rate and thus, the flow checks are generally performed during the common inlet synthesis. The total flow rate is checked semi-daily along with the examination of the common time response to 'zero' gas overblow. Only if there is an inconsistency or a change of the internal plumbing are the individual instrument flows re-measured.

Table 6-1b Procedures to Assess QA Objectives involving Particulate Measurement

Measurement Parameter	Analysis Method	Assessment Method
Particle Number Density	Optical Particle Count Condensation Particle Counter (CPC)	Flow Check 300 sccm or 1.5 slpm semi-daily HEPA filter to zero time response comparison with PM CO ₂ (Licor 6262b or 820) as overall performance check
Number Based Particle Size Distribution	Differential Mobility Analyzer with CPC	Precampaign assessment of the delay parameter. Additional DMA comparison to size selected ammonium nitrate aerosol
Black Carbon	SP-AMS	Flow rate checked continuously by pressure and instrument air beam signal. Ion Signal to mass loading performed with classified ammonium nitrate aerosol (<i>nitrate equivalent loading</i>); Black carbon detection sensitivity (ionization efficiency) determined using Regal Black.
Total Particle Extinction	Cavity Enhanced Phase Shift (CAPS)	Pre-campaign calibration using PSL Sample Flow Check, mirror purge flow verified. 630 nm to compare with MAAP. Time response check with particle line CO ₂ measurement to verify flow response

Table 6-1c Procedures to Assess QA objective for Additional Measurements

Measurement Parameter	Analysis Method	Assessment Method
Mass to charge ratios in the PTR-MS	Sample reaction with proton hydrates	Hourly dedicated sampling of the VOC free air with matched humidity. Daily calibration using standards to determine instrument response.
Volatile organic compounds	Gas Chromatogram with Mass Spectrometer Detector	Continuous quantitation of relatively invariant ambient halocarbon species (e.g. CCl ₄) to track detector sensitivity. Daily measurements of VOC-free UHP N ₂ to evaluate instrument background. Daily calibration standards to track retention times and instrument sensitivities of select reported species. Pre-campaign determination of the instrument sensitivities for all reported species using three different standard tanks.
Webcam Image	NA	As the measurement sortie is begun, the frequency of image capture is increased and verified. Images saved as Jyyyymmdd_hhmmss.jpg and later organized via igor script into hourly folders to keep limit each folders file count to 3600 files. An index is also constructed for random access during data analysis and playback.
Wind Speed and Direction	3 axis sonic anemometer	The anemometer direction is checked against a coordinated manual fan blowing on the anemometer along the four quadrants (ahead, driver, passenger, rear). Wind speed calibration is compared by looking at the GPS velocity signal during a mobile condition with light ambient wind.
Position	Global Position System (GPS)	Examining the output from the GPS compared to an online source such as google maps verifies the function. All mobile ground tracks are mapped into the UTM coordinate space to put traces onto a georeferenced image of the roadway, terrain, facility boundaries
Ozone	UV absorption	Frequent zeros to test response and noise performance. Factory calibration is used without adjustment. Consistency is checked during the NO calibration process described in Table Note [1] to part a of this Table series.

Gas Phase Measurement Instrument Assessment

Generally, the combustion tracer compounds described in table 6-1a are evaluated in real time by examining the implications these species point to in the ensemble time series analysis. In other words, when a transient enhancement of NO+NO₂ (interpreted as NO_x) to the enhancement of CO₂ evaluated as an short duration emission ratio for a plume event is observed to be between 4 and 12 ppbv per ppmv, this is a typical emission ratio for diesel plumes – particularly if the ratio between CO and CO₂ is less than 20 ppbv per ppmv [*Burgard et al., 2006*]. When an emission plume consists of relatively high NO_x and high CO, it is generally associated with gasoline engine out (cold start catalyst or malfunctioning catalyst). This is typically corroborated with a high NO₂/NO_x ratio. When there is a problem with any of these combustion vectors, these analyses are not possible and this is a primary assessment technique used on the mobile laboratory. By engaging in cursory real time analysis of the enhancement ratios for these combustion tracer species, the scientist in the mobile lab stays connected to the nature of the transient plumes being sampled and the merit of the instrument output. Problems with the instrument response time (flow) or in typical enhancement ratios immediately signal the need to move to instrument by instrument assessments of performance.

Each real-time instrument operates on different physical principles; however, they all require established baselines for quantitative measurements. True “no signal” baselines are established periodically during mobile lab operation by introducing zero air into the mobile laboratory-sampling manifold, exposing all instruments to a “no pollutant” stable air sample. Background ambient air and plume pollutant levels are measured from the zero air baseline. Each instrument can then be calibrated by introducing known levels of gaseous or PM species into the sampling manifold. In the case of the major trace gases (NO, CO and CO₂), calibration gas cylinders with known trace gas levels, traceable to National Institute of Standards and Technology (NIST) standards or other analytical lab verifications, are used for absolute calibration. Calibrations are periodically performed using calibration gas cylinders carried onboard the mobile laboratory. Some of the standards that will be carried require quantitative dilution using two flow controllers (1 for standard and 1 for diluent). Other cal tanks operate as a single point ‘overblow’. In all cases, the continuous sampling gas phase instruments are calibrated by introducing the standard at the inlet tip. Instruments are never removed from the sample line and calibrated at different pressures of flows.

Some commercial instruments (LI-COR CO₂, Thermo Environmental NO) have standard calibration procedures prescribed by their manufacturers that will be implemented during the field campaign. For example, the carbon dioxide measurements are made by two LI-COR model LI-6262 detectors and by a higher range model 840 detector. The accuracy and linearity of the LI-COR detectors are periodically checked by overflowing the inlet with gas directly from one of two standard calibration tanks (400 ppm and 803 ppm, ± 1%, Scott Specialty Gases) or

with CO₂-free nitrogen. The NO chemiluminescence analyzer is calibrated by dynamic dilution of a standard tank concentration using a two Alicat mass flow controllers. This procedure mixes quantitative flows of NO in nitrogen (99.3 ± 2 ppm, Scott Specialty Gases) with a known flow of dry “ultra-zero” air in order to create gas with concentrations ranging from ~20 ppb up to 120 ppb. The stated accuracy and precision of the calibrator’s mass flow controllers is ± 1.2%. The accuracy and reproducibility of the readings is thus calculated, at the 2 sigma level (95%), to be ±6%. The calibration NO tank is purged several times prior to calibration and all calibration points are allowed to flow for several minutes through the chemiluminescence analyzer before a reading is taken in order to allow for passivation and settling time. Readings are taken at 4-6 different concentrations ranging between 20 and 120 ppb. These readings are plotted versus calculated concentrations and fit with a linear least squares routine. The instrumental zero level is periodically measured by overflowing the inlet with zero air or nitrogen.

Once the essential performance of the NO measurement is established, the procedure described in Table Note [1] to Table 6-1a can be used to perform the in-field check of the two NO₂ instrument performances.

Particle Measurement Instrument Assessment

The commercial TSI CPC and Thermo Environmental MAAP instruments are factory calibrated and are periodically returned for refurbishment and recalibration.

The Aerodyne PM extinction monitor uses Cavity Attenuated Phase Shift (CAPS) spectroscopy to measure radiative properties (extinction) of tunnel aerosol particles with high precision and accuracy at 1 Hz. The measurement principles are described in detail in the literature [*Kebabian et al., 2007; Massoli et al., 2010*]. This system utilizes a LED light source rather than more expensive and difficult to maintain laser light sources. The amount of phase shift is a function of fixed instrument properties—cell length, mirror reflectivity, and modulation frequency—and of the presence of a scatterer or absorber (air, particles, trace gases, etc.) within the cell. Small purge flows are used to keep the mirrors particle free. The system has a detection limit of 0.7 Mm⁻¹ (2σ) in 10 s integration time and a base line drift of less than ±1 Mm⁻¹ over a 24 h period. Operating with a sample flow rate of ~1 L min⁻¹, the system can readily achieve 1 second sampling rates due to small sample volume (25 cm length cell) and near plug flow conditions. The instrument will have a wavelength of 630nm (matched with the absorption measurement of the MAAP). Particle extinction (PM_{2.5}) is determined by the measured light loss for particle laden air in the cell. Rayleigh scattering and changes in the baseline (e.g. mirrors getting dirty) will be subtracted using a baseline measurement every 120 minutes.

The calibration of the ARI AMS is a more complex procedure. In order to minimize uncertainties in the reported mass concentrations, it is desirable that the fluctuations of the detection efficiency of the AMS are closely monitored and properly corrected throughout the whole campaign. The parameters that capture

the AMS detection efficiency are $IE_{NO_3^-}$, which is the ionization efficiency of a reference compound— NO_3^- , and the air beam signal (AB), which is the ion rate (Hz) detected for a major air signal, e.g. N_2^+ in this study [Allan *et al.*, 2003; Jiménez *et al.*, 2003]. While AB can be monitored continuously during instrument operation, the determination of $IE_{NO_3^-}$ requires interruption of sampling to perform a calibration experiment (typically 1 – 2 hrs). Given this restriction and the expectation (based on previous experience) that IE would not be highly variable, periodic $IE_{NO_3^-}$ calibrations will be conducted during this study. Because the ratios of $IE_{NO_3^-}$ to AB remains remarkably constant (r.s.d. < 1%) the continuous AB signal can be used to correct for the variations in the AMS detection efficiencies to a very good approximation.

Two other AMS parameters significantly influence the absolute values of its PM measurements: the collection efficiency (CE) and relative ionization efficiency (RIE). CE is introduced to correct for incomplete detection of nonrefractory particles, NR-PM, by the AMS, e.g., due to irregularly shaped particles that do not completely reach the vaporizer [Jayne *et al.*, 2000; Tobias *et al.*, 2000]. Although strictly speaking CE should be a function of particle size and shape, at present it is defined as the correction factor for the bulk mass concentrations, i.e., the fraction of the particle mass that is measured by the AMS. A CE value of 0.5 is assigned to sulfate, based on extensive observations from several laboratory and field tests for sulfate aerosols. The same CE value (i.e., 0.5) is applied to particles containing nitrate and ammonium, because they appear to be internally mixed with sulfate particles most of the time.

The CE value for total NR-PM₁ organics is estimated based on their size distributions, which often show two modes – a larger accumulation mode of ambient background particles that appears to be internally mixed with SO_4^{2-} , NO_3^- and NH_4^+ , and a smaller ultra-fine mode that seems to be mainly emitted from combustion-related sources. A CE value of 0.5 is thus applied to the accumulation mode organics (due to the internal mixing with SO_4^{2-}) and CE for the smaller mode is assumed to be 1.0 because laboratory studies have shown close to 100 % AMS transmission for sooty combustion particles. By studying the size distributions of total organics, as well as individual organics mass fragments averaged over the whole sampling period, we have found that these two modes can be best separated at $D_{va} = 160$ nm and that the mass ratio of the smaller ($D_{va} < 160$ nm) to the larger mode ($D_{va} > 160$ nm) is roughly 2/3. The CE value of the bulk organics is therefore set at 0.7.

Relative ionization efficiency (RIE) is the ratio of the electron impact ionization efficiency of a given species to $IE_{NO_3^-}$ on a per unit mass basis. Note that $IE_{NO_3^-}$ is the IE of NO_3^- measured based on two major ions, m/z's 30 and 46, instead of all the mass fragments. RIE values of individual species representative have been determined in a range of laboratory measurements and tabulated [Zhang *et al.*, 2006].

Finally, two other key AMS parameters require calibration. The AMS volumetric sampling flow rate and the particle velocity. The sample flow rate will be determined using a Gilibrator (bubble flowmeter). The particle aerodynamic size reported by the AMS is based on measured particle velocities. The size – velocity calibration is performed using NIST traceable polystyrene latex spheres (PSLs) in the size range 50 – 1000 nm. Particles generated from an atomizer and differential mobility analyzer combination will also be used to validate the AMS particle size calibration.

PTR-MS Instrument Assessment

The PTR-MS instrument provides a measurement of a selected set of organic gases possessing proton affinities greater than water. Most non-alkane organics possessing more than 2 carbons can be detected using the PTR-MS. This instrument is located on the floor on the passenger side of the mobile laboratory between the QCLs and rear wheel well.

Specific step-by-step instructions for bringing this instrument on-line and a copy of the instrument manual on are available elsewhere (Appendix 2 in the context of this QAPP). The description provided in this document pertains to the normal operation of instrument.

The PTR-MS draws sample from the main gas phase sample inlet through a short length, ~ 2 feet, of 1/8" OD PFA tubing. The PTR-MS sample flow is adjustable from 50 – 400 ml/min via the metering valve located on the back panel of the instrument, but is normally set around 250 ml/min.

This instrument is controlled via an RS-232 cable using software installed on Electron. The PTR-MS has three modes of operation: measure, zero and calibrate. The measure and zero modes are automated, while the calibrate mode requires the instrument to be taken off-line. The PTR-MS parameters: drift tube pressure, detection region pressure, drift tube temperature and reagent ion intensity should always be within the following specifications:

Drift tube pressure = 2.05 (\pm 0.05) mbar
Detection region pressure < 4×10^{-5} mbar
Drift tube temperature 40 (\pm 1) °C
m/z 21 > 2500 count per second
m/z 32 < 4% of m/z 21*500
m/z 39 > 0.25*m/z 21 but < 0.9*m/z 21

Instrument zeros are software controlled and scheduled to occur at a regular specified interval using an on-board zero air generator. The PTR-MS uses a series of 3-way solenoid valves to redirect the inlet flow from the sample inlet to zero gas inlet. This allows the PTR-MS to evaluate the instrument background independently

without affecting any of the other gas phase measurements. VOC free air is produced by pulling filtered ambient air through a heated oxidation catalyst. A ¾"OD stainless steel tube packed with finely divided Platinum on quartz wool is housed within a small oven that is heated to 400 °C and oxidizes any VOCs to CO₂. Instrument background is mass dependent with some ions having non-zero values. Under most conditions, ion backgrounds should be in the range of 2 – 200 counts per second. Atmospherically persistent compounds such as methanol (m/z 33) and acetone (m/z 59) should exhibit discernable decreases in their ion intensities when the PTR-MS is sampling zero air.

Instrument calibrations are performed at regular intervals (normally daily during the first days of the project) by serially diluting the PTR-MS multi-component calibration gas with VOC free air from the on-board zero air generator. Instrument calibration is accomplished with the PTR-MS operated in the zero-mode so that the calibration procedure does not affect any of the other gas phase measurements. The flows of the calibration gas and the VOC free dilution gas are controlled via mass flow controllers. Serial dilutions are performed by mixing 2-10 ml/min of the calibration gas into a zero gas dilution flow of 400 – 1000 ml/min.

GC-MS Instrument Assessment

The GC-MS instrument provides a measurement of select volatile organic compounds, typically C₅-C₁₀ hydrocarbons (i.e. alkanes, alkenes including isoprene and monoterpenes, aromatics), C₂-C₈ oxygenated species with single oxygen moiety (i.e. alcohols, ketones, aldehydes, ethers) and C₂-C₅ alkyl nitrates. Measurement is made by either cryogenic or adsorbent pre-concentration, followed by thermal desorption to a low- to mid-polarity gas chromatograph column [DB-624: (6%-cyanopropylphenyl)-methylpolysiloxane]. The GC column is programmatically temperature-ramped from 35°C to 225°C during a ~20-minute separation step. The column effluent is analyzed via electron-impact (EI) time-of-flight (TOF) mass spectrometry, using 70 eV potential.

The GC-MS instrument operates on a half-hour sampling and analysis cycle, with sample pre-concentration performed during the first five minutes of each half-hour time period (xx:00-xx:05; xx:30 – xx:35). Ambient air is continuously drawn at 60 ml/min via a short length (~2 ft) of 1/8" OD (1/16" ID) PFA tubing; during sample pre-concentration periods, the air is directed to the sample pre-concentration trap. Sample flow is controlled by mass flow controller (MFC).

Initial calibration of the GC-MS system is performed in the laboratory prior to field deployment. Multiple calibration gases (no less than 3) are evaluated at multiple mixing ratios via dynamic dilution in humidified nitrogen gas (typically LN₂ dewar gas). The dilution system consists of two streams of nitrogen at 500 – 5000 ml/min controlled by MFCs, one of which is directed through a glass bubbler system containing HPLC-grade water. The calibration gases are mixtures of analyte species,

typically at 0.1 – 10 ppmv diluted in nitrogen (e.g. 57-component ozone precursor mixture; Restek p/n 26368); these gases are flowed at constant rate between 0.5 and 5 ml/min via heated critical orifice or crimped capillary. The calibration gas is mixed with the wet and dry nitrogen streams upstream of the instrument inlet, where it is added via overflow. Instrument response during calibration established a retention time, mass spectrum and quantitation ion for each analyte species. Multi-point calibrations (at no less than 7 mixing ratio levels) are performed over three decades of mixing ratio, typically 0.01 to 10 ppbv, to determine instrument response as m/Z Hz-sec / ppbv analyte at the specified quantitation ion. A field calibration standard consisting of calibration gas diluted in UHP nitrogen into a silanized (e.g. Aculife) aluminum gas cylinder is evaluated during the dynamic dilution experiments to establish mixing ratios in this standard (typically 0.5 ppbv).

Acceptable total uncertainty (% RSD) for reported VOCs is species-dependent, but is typically between 5-10%. The minimum detection level (MDL) for each species is determined as 10x the standard deviation of the lowest reported mixing ratio from the multi-point calibration described above.

During field operations, the GC-MS instrument operates in four modes: ambient measurement, instrument blank and calibration measurements, inlet blank measurement. Instrument blanks and calibrations consist of measurement of ultra-high purity (UHP) nitrogen and a nominal 500 part-per-trillion multi-component hydrocarbon in UHP nitrogen standard, respectively. These gases are alternatively added via computer-controlled 3-way solenoid valves just upstream of the pre-concentration system every 5 hours in place of an ambient measurement, so that a calibration and instrument blank is measured every 10 hours. Once per day the blank gas (UHP N₂) is added at the inlet tip in excess of the sampling rate, typically 75 ml/min blank gas, so that the entire inlet sampling system can be evaluated for background.

For most species, instrument response to blank gas should be less than 10 pptv mixing ratio. UHP N₂ typically has contamination from a few species (e.g. acetone, benzene, toluene) at 10s to 100s of pptv. These species will be evaluated for drift, where changes less than 10% of the mean mixing ratio value will be considered acceptable. Measurement of the calibration standard provides replicates of constant mixing ratio across the entire chromatogram; reported mixing ratios for all species in the calibration standard must be within 10% of the nominal value.

QA Objectives and Acceptance Criteria

The data quality indicator goals for accuracy, precision and completeness for this project are listed in Table 6-2. *At the time of this draft, the instrument manifest is not finalized. The noted precisions will be revised based on the pre-deployment precisions of the specific instrument chassis and wavelength selections. The values cited here convey the approximate precision targets.*

During the campaign, any failure of the instrumentation to meet the DQI goals will be reported to Tara Yacovitch, who will be responsible for informing Vince Torres. Data collected during periods in non-attainment with DQI goals will be flagged as questionable, but not necessarily considered invalid. Corrective action will be taken depending on the nature of the problem encountered.

Table 6-2 QA Objectives and Acceptance Criteria

Measurement Parameter	Analysis Method	Assessment	Criteria Accuracy	Completeness	Precision	Corrective Action Given Failure to meet Criteria
CO ₂ Carbon dioxide Licor 6262 (a)	NDIR	Flow rate measurement Zero check Span Check	Zero Check: ±5 ppmv from zero Span Check: ±3 ppmv of the travel standard tank	90%	130 ppbv at 1s	Flow rate problems, check pumping, check filter Zero problems, check other instruments (is sample line being overblown?); Check internal offset in instrument against lab notebook value Span problems, check sample overblow, leverage reading against Licor 6262 (b) and Licor 840 instruments. Re-calibrate instrument using zero-air and span tank.
CO ₂ Licor 6262 (b)	<i>Same</i>	<i>Same</i>	<i>Same</i>	<i>Same</i>	<i>Same</i>	<i>Same as actions for Licor (a)</i>
CO, carbon monoxide	TILDAS	Flow Rate Measurement Zero measurement check Span check	Zero Check: Performance on zero should be less than 120 pptv 1s RMS Span Check: Cal Standard is within 1%	90%	120 pptv at 1s	Flow rate problems, check pumping, check filter Zero problems, check catalyst function using methane, formaldehyde or PTRMS; Verify that inlet is being overblown Span problems, map pressure dependence of measured CO in the standard as a function of cell pressure; if no dependence found, follow additional instrument troubleshooting.
N ₂ O, nitrous oxide	TILDAS	Same laser as the CO measurement	Zero Check: within ±5 ppb. Span Check: reproducible within 1%.	90%	50 pptv at 1s	N ₂ O is tested against different criteria than the CO instrument, but they are measured in the same spectral window. Zero check requires N ₂ boil-off (this is unsuitable for CO) and will be checked pre- and post-campaign. Zero problems, check interference from ambient high-pressure lines. Span check, N ₂ O measurements are judged by the instruments ability to return the calibration tank value consistently. A span calibration factor is applied to the data in post-analysis.

NO ₂ , nitrogen dioxide	CAPS	Consistent zero value during regular overblow. Evaluate time-response in signals with QCL-NO ₂ , this instrument is slower, but should mimic faster NO ₂ . If not, there is a problem to diagnose.	Within 20% of the in-field ozonized delta NO. See Table Note [a]	90%	50 pptv at 5-s	Flow problems, check pumping, check inlet line Span Problems: See Table Note [a]
NO, nitric oxide	Chemiluminescence	Zero measurement on regular overblow. Check for time response consistency. As operated on truck should be as fast as CO and CO ₂ . Not used in switching mode.	Within 5% of span tank during calibration process described in Table Note [a]	90%	300 pptv at 1s	Flow problems, check pumping, check that overdraw to this inlet is functioning. Internal Alarms: see manual for troubleshooting and diagnosis.
NO _y , oxides of nitrogen	Molybdenum Converter paired with Chemiluminescence	Same as NO CL-instrument	Converter Efficiency is quantified using isopropyl nitrate pre-campaign: 95%. No infield checks other than the NO/NO ₂ /O ₃ are used. Truck implementation requires manual check of the temperature of the Mo converter (embedded in a side tap at the main inlet tip): 285 Celsius. Instrument status checked daily for internal alarms: 0 alarms should be present	90%	300 pptv at 1s	If internal alarms are present: determine which type of alarm is occurring. Refer to manual for troubleshooting. Flow problems, check pumping, check that overdraw to this inlet is functioning. Additional checks of the temperature control system for the Mo converter.

PTR-MS all	Reaction with Proton hydrates and classified by mass to charge ratio (parent and daughter ions)	Reagent ion count Ion molecule region pressure Flow rate to instrument	Response Factors should be within 15% of the running instrument performance	85%	Typically 1 ppbv at 1Hz, depends on specific compound	Flow, reagent ion and pressure problem are corrected using procedure described in the PTRMS manual
SP-AMS	PM focused with aerodynamic lens and 'concentrated' by differential pumping. PM vaporized with laser absorption. Gaseous PM constituents ionized with electron impact and classified by mass to charge ratio	Airbeam signal Flow rate Particle time of flight pressure regime	Calibration of Relative ionization efficiency must match. SP module laser power meets instrumental value	80%	NA	Flow rate restored by cleaning the orifice. Calibration performance of collection efficiency and relative ionization efficiency evaluated. Laser re-aligned according to the established procedure in the manual.
Particle Number Density	CPC	Flow Check Daily zero checks	10% of specified flow rate either 300 sccm or 1.5 slpm zero must be less than 100 particles per cm ³	90%	N/A	Inlet pump is verified to be operational. If it fails, truck 'house' pumping can be used. Failure to Zero mandates instrument optics cleaning

[a] The in-field calibration check of NO, NO₂ and O₃ are performed using dilution of a tank standard containing CO and NO. The CO instrument is used to verify the measured flow rate of the standard and diluent because it is verified in the field using a 673 ppbv standard. The NO instrument is calibrated first. To this sample stream varying (and small) flows of concentrated O₃ are added. The NO₂ instrument response is verified against the NO instrument by computing quantitative difference between NO levels, with and without the added O₃. The resulting time series from the calibration procedure is analyzed for consistency among the signal level. Any discrepancies greater than 8% are investigated by checking the calibration protocol, the specific instrument operation and repeated to deduce the source of the disparity.

As required by this category of QAPP, the data quality manager, Tara Yacovitch, will perform a quality audit of 10% of the data. Days of data to be inspected will be randomly chosen from the measurement periods (e.g. 1 24-hour period from a 10-day total). Instrument performance is assessed based noise during periods of stable ambient concentrations. Lacking such periods due to real variability in the atmosphere, tank air overblows will be sought out within the full dataset. Furthermore, those inspected datasets containing data from routine overblows with zero air will be inspected for problems in the zero levels (these are separate from zero checks, which usually occur prior to calibrations). Relevant notes taken in the field on instrument performance will be reviewed for the audited data, and the issues noted will be checked against the final QA/QC data to make sure they have been corrected, or the affected data excised. Finally, calibration results (which often include zero-checks) will be collected for the whole campaign, and the performance compared to the metrics noted above. A report of the results of the Data Quality Audit will be included in the final report.

7. DATA ANALYSIS, INTERPRETATION, AND MANAGEMENT

7.1 Data processing

The raw data, collected using the protocols described in Sections 5 and 6 will be processed with some initial quality assurance procedures to time align, remove the automatic and manually triggered zeros and store the calibration checks separate from the ambient sample data. A merge is produced combining the GPS data (typically using the UTM north and east coordinate system) with the measurement vectors.

7.2 Data validation procedures.

The data quality indicators in Table 6-1a, b and c are used as the primary validation sources. When the time series analysis of the DQI criteria do not flag problems and the time series vectors are consistent on multiple instruments the inlet is casually validated and all instruments on the manifold are reporting the respective outdoor sampled air. Thereafter, the calibration and performance checks for each instrument (Table 6-2) will be evaluated and data will be validated. *None of the methods used in this project are EPA standard protocol techniques. Each measurement will employ a calibration protocol needed to pass scientific peer-review.*

Verification and validation of the procedures used to collect and analyze data are critical to achieving the project objectives. Data validation for this study will be accomplished through a review of the quality control checks conducted daily for the instrumentation as described in Table 6-2. This review will determine whether or

not instrumentation had acceptable performance. The Aerodyne Research quality assurance officer for this project (Tara Yacovitch) will review and draft a statement for inclusion in the August 2017 report. TCEQ and UT will be able to review any aspect of the data collection, archival or analysis procedures.

7.3 Data analysis.

For this study, data analysis after the simple processing steps describe above will include parallel time series and correlation analysis of the air pollutant measurements (following step 1) as well as geospatial and temporal analysis (following step 2 and/or step 3). These and other analyses may lead to further post-processing of data, dependent on project needs. Additional data used for interpretation will include regional meteorology data and other air pollutants measured at other TCEQ sites in the area.

7.3.1 Statistics and experimental uncertainties.

The uncertainty (accuracy) at the two sigma level of the various mixing ratio and particulate data is expected to be in the range of 5 to 15%. Each of the anticipated precisions is noted in table 6-2. The systematic uncertainty at 95% confidence limits will be the combination of the method uncertainty and the uncertainty of the calibration standard used in-field, pre- and post- campaign. All errors will be accounted for and estimated.

7.4 Data storage requirements.

The digital data chain of custody is discussed in Section 6.6. The digital data storage requirements are modest by current standards. We anticipate a complete raw data footprint of ~ 120 GB. The quality assured measurement data and pre-process dataset to be used for analysis will be less than ~ 5 GB. The largest data source are the AMS high resolution data files and the QCL spectra in binary format. The PI will retain all data, results of measurements and reports, whether in electronic or hard copy format, for a minimum of five years.

8. REPORTING

8.1 Project deliverables

A description of the specific reports to be submitted by the PI and their due dates are outlined below. One report per project will be submitted (collaborators will not submit separate reports), with the exception of the Financial Status Reports (FSRs). The lead PI will submit the reports, unless that responsibility is otherwise delegated with the approval of the Project Manager. All reports will be written in third person

and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. Report templates and accessibility guidelines found on the AQRP website at <http://aqrp.ceer.utexas.edu/> will be followed.

Abstract: At the beginning of the project, an Abstract will be submitted to the Project Manager for use on the AQRP website. The Abstract will provide a brief description of the planned project activities, and will be written for a non-technical audience.

Abstract Due Date: Wednesday, August 31, 2016

Quarterly Reports: Each Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the Project Manager as a Microsoft Word file. It will not exceed 2 pages and will be text only. No cover page is required. This document will be inserted into an AQRP compiled report to the TCEQ.

Quarterly Report Due Dates:

Report	Period Covered	Due Date
Nov2016 Quarterly Report	September, October, November 2016	Wednesday, November 30, 2016
Feb2017 Quarterly Report	December 2016, January & February 2017	Tuesday, February 28, 2017
May2017 Quarterly Report	March, April, May 2017	Friday, May 31, 2017
Aug2017 Quarterly Report	June, July, August 2017	Thursday, August 31, 2017
Nov2017 Quarterly Report	September, October, November 2017	Thursday, November 30, 2017

Monthly Technical Reports (MTRs): Technical Reports will be submitted monthly to the Project Manager and TCEQ Liaison in Microsoft Word format using the AQRP FY16-17 MTR Template found on the AQRP website.

MTR Due Dates:

Report	Period Covered	Due Date
Sep2016 MTR	September 1 - 30, 2016	Monday, October 10, 2016
Oct2016 MTR	October 1 - 31, 2016	Tuesday, November 8, 2016
Nov2016 MTR	November 1 - 30 2016	Thursday, December 8, 2016
Dec2016 MTR	December 1 - 31, 2016	Monday, January 9, 2017
Jan2017 MTR	January 1 - 31, 2017	Wednesday, February 8,

		2017
Feb2017 MTR	February 1 - 28, 2017	Wednesday, March 8, 2017
Mar2017 MTR	March 1 - 31, 2017	Monday, April 10, 2017
Apr2017 MTR	April 1 - 28, 2017	Monday, May 8, 2017
May2017 MTR	May 1 - 31, 2017	Thursday, June 8, 2017
Jun2017 MTR	June 1 - 30, 2017	Monday, July 10, 2017
Jul2017 MTR	July 1 - 31, 2017	Tuesday, August 8, 2017

Financial Status Reports (FSRs): Financial Status Reports will be submitted monthly to the AQR Grant Manager (Maria Stanzione) by each institution on the project using the AQR FY16-17 FSR Template found on the AQR website.

FSR Due Dates:

Report	Period Covered	Due Date
Aug2016 FSR	Project Start - August 31	Thursday, September 15, 2016
Sep2016 FSR	September 1 - 30, 2016	Monday, October 17, 2016
Oct2016 FSR	October 1 - 31, 2016	Tuesday, November 15, 2016
Nov2016 FSR	November 1 - 30 2016	Thursday, December 15, 2016
Dec2016 FSR	December 1 - 31, 2016	Tuesday, January 17, 2017
Jan2017 FSR	January 1 - 31, 2017	Wednesday, February 15, 2017
Feb2017 FSR	February 1 - 28, 2017	Wednesday, March 15, 2017
Mar2017 FSR	March 1 - 31, 2017	Monday, April 17, 2017
Apr2017 FSR	April 1 - 28, 2017	Monday, May 15, 2017
May2017 FSR	May 1 - 31, 2017	Thursday, June 15, 2017
Jun2017 FSR	June 1 - 30, 2017	Monday, July 17, 2017
Jul2017 FSR	July 1 - 31, 2017	Tuesday, August 15, 2017
Aug2017 FSR	August 1 - 31, 2017	Friday, September 15, 2017
FINAL FSR	Final FSR	Monday, October 16, 2017

Draft Final Report: A Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will include an Executive Summary. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources. It will also include a report of the QA findings.

Draft Final Report Due Date: Tuesday, August 1, 2017

Final Report: A Final Report incorporating comments from the AQR and TCEQ review of the Draft Final Report will be submitted to the Project Manager and the TCEQ Liaison. It will be written in third person and will follow the State of Texas accessibility requirements as set forth by the Texas State Department of Information Resources.

Final Report Due Date: Thursday, August 31, 2017

Project Data: All project data including but not limited to QA/QC measurement data, metadata, databases, modeling inputs and outputs, etc., will be submitted to the AQRP Project Manager within 30 days of project completion (September 29, 2017). The data will be submitted in a format that will allow AQRP or TCEQ or other outside parties to utilize the information. It will also include a report of the QA findings.

AQRP Workshop: A representative from the project will present at the AQRP Workshop in the first half of August 2017.

Presentations and Publications/Posters: All data and other information developed under this project which is included in **published papers, symposia, presentations, press releases, websites and/or other publications** shall be submitted to the AQRP Project Manager and the TCEQ Liaison per the Publication/Publicity Guidelines included in Attachment G of the Subaward.

8.2 Expected final product(s) prepared for the project.

We expect that the final products resulting from this project will be the final project report (due 8/31/2017) and at least one journal article that describes the most noteworthy results from this project. The most likely target journals are *Environmental Chemistry and Technology*, *Atmospheric Chemistry and Physics*, and *Journal of the Air and Waste Management Association*. These will be prepared and submitted following the Publication/Publicity Guidelines included in Attachment G of the Subaward.

9. REFERENCES

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