

**Scope of Work**

**Project #22-010**

**Dallas Field Study (DFS); Ozone Precursors, Local Sources and  
Remote Transport Including Biomass Burning**

Prepared for

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

By

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Aerodyne Research Incorporated

08/30/22  
Version #2

QA Requirements: Audits of Data Quality: 10% Required  
Report of QA Findings: Required in Final Report

## **Approvals**

This Scope of Work was approved electronically on **8/30/2022** by Vincent Torres, The University of Texas at Austin

AQRP PROJECT MANAGER  
Project Manager, Texas Air Quality Research Program

This Scope of Work was approved electronically on **9/2/2022** by David Westenbarger, Texas Commission on Environmental Quality

TCEQ LIAISON  
Project Liaison, Texas Commission on Environmental Quality

# Scope of Work

## ***Introduction***

The Dallas-Fort Worth-Arlington (DFW) Metropolitan Statistical Area (MSA) is the most populated MSA in the state of Texas and the fourth largest MSA in the United States. It is also experiencing a high rate of growth and is located along the Interstate 35 (I-35) corridor which in general is an area of rapid growth. The most recent population estimate from [www.census.gov](http://www.census.gov) of the DFW MSA is 7,759,615 people with a one-year growth of 97,290 people, which equates to a growth rate of 1.02% from June 2020 to June 2021. Despite the very large size and growing population the MSA has been under sampled with respect to air quality measurements relative to other MSA's within the state of Texas and across the country as a whole. The DFW MSA is a good candidate for study under the Texas Air Quality Research Program (AQRP) indicated desire to focus on rapidly growing areas along the Interstate 35 corridor.

The AQRP has also indicated an interest in obtaining information relating to the impact of domestic wildfires and fires at the wildland-urban interface on particulate matter, particulate matter precursors, ozone, and ozone precursors. It is difficult to plan a campaign around this because of the variability of wildfires, however there are certain seasons and locations which provide the greatest possibility of successfully measuring these events should they occur. With this in mind, we propose to conduct our measurements of the DFW MSA during the Spring (March-April) of 2023 which will overlap with the agricultural crop burning season in the Yucatan (March-May) [Yokelson *et al.* 2009]. Yucatan crop burning has been studied to some extent in the past [Peppler *et al.* 1999; van der Werf *et al.* 2006; Dominguez-Martinez and Rodriguez, 2008; Yokelson *et al.* 2009, 2011] however the Aerodyne Mobile Lab (AML) measurement platform will provide more complete characterization than previous studies while focusing on the DFW MSA interaction with the plume. If biomass burning influenced airmasses from the Western United States appear in the DFW MSA during the intensive, we will be equipped to measure their composition and evolution within the DFW MSA. Finally, due to the flexibility the AML offers, if wildfires become prevalent anywhere in Texas during the March-April 2023 campaign intensive we will have the ability to drive towards the fire-impacted area and conduct transect measurements downwind to investigate the fire plume evolution as it ages and, if applicable, enters any metropolitan area in Texas.

In summary, Aerodyne proposes to deploy our mobile laboratory for 3 weeks during the Spring of 2023 (March-April). Our primary emphasis will be on conducting ozone precursor source measurements and ambient measurements of inflow, evolution within the metro area and egress

downwind of the metro area. Our secondary mission not to exceed a maximum of 35% of total campaign time will be mobile measurements of wildfires in Texas as conditions warrant.

### ***Connecting Science Questions to Work Plan***

How do local sources of industrial based Volatile Organic Compounds (VOCs) impact photochemistry particularly Ozone (O<sub>3</sub>) formation in the DFW Metropolitan area?

What is the typical upwind input value of both primary VOC and particulate as well as secondary gas and particle phase species into the DFW metropolitan area?

What impact do biomass burning plumes upwind of the metropolitan area have on the daily photochemistry within the DFW metropolitan area?

How do locally produced biomass burning plumes evolve upwind of DFW and the I-35 corridor?

### ***Project Strategy***

The AML [*Herndon et al., 2005; Kolb et al., 2004; Yacovitch et al., 2015*] will host a suite of research-grade instruments, shown in Figure 1. The Vocus [*Krechmer et al., 2018*] is a high-resolution chemical ionization time-of-flight (ToF) mass spectrometer (MS) typically run as a proton-transfer reaction mass spectrometer (PTR-MS). The Vocus has higher resolving power and an improved inlet design over standard PTR-ToF-MS instruments [*Riva et al., 2019*]. To increase the range of VOC and hazardous air pollutant (HAP) species that can be measured beyond the Vocus capability, the AML will also deploy a gas chromatograph (GC) coupled to an electron ionization (EI) ToF-MS [*Claflin et al., 2021*] to separate isomers, such as ethyl benzene/xylenes, and to provide more detailed chemical fingerprints, including an expanded volatility range (e.g., C<sub>3</sub> – C<sub>12</sub> hydrocarbons, C<sub>2</sub> – C<sub>10</sub> oxygenates). A Soot-Particle Aerosol Mass Spectrometer (SP-AMS) [*Onasch et al., 2012*] will provide total particulate matter (PM) loading (PM<sub>2.5</sub>) as well as chemical speciation: PM nitrate, sulfate, ammonia, organics (fresh and aged), chloride, black carbon, and select metals. The instrument manifest will be filled out with state-of-the art trace gas measurements including carbon monoxide (CO), nitrous oxide (N<sub>2</sub>O), hydrogen cyanide (HCN), water vapor (H<sub>2</sub>O), carbon dioxide (CO<sub>2</sub>), O<sub>3</sub>, nitrogen oxides (NO<sub>x</sub>) (including nitric oxide (NO) vs nitrogen dioxide (NO<sub>2</sub>), formaldehyde (HCHO), methane (CH<sub>4</sub>) and ethane (C<sub>2</sub>H<sub>6</sub>) (Figure 1).

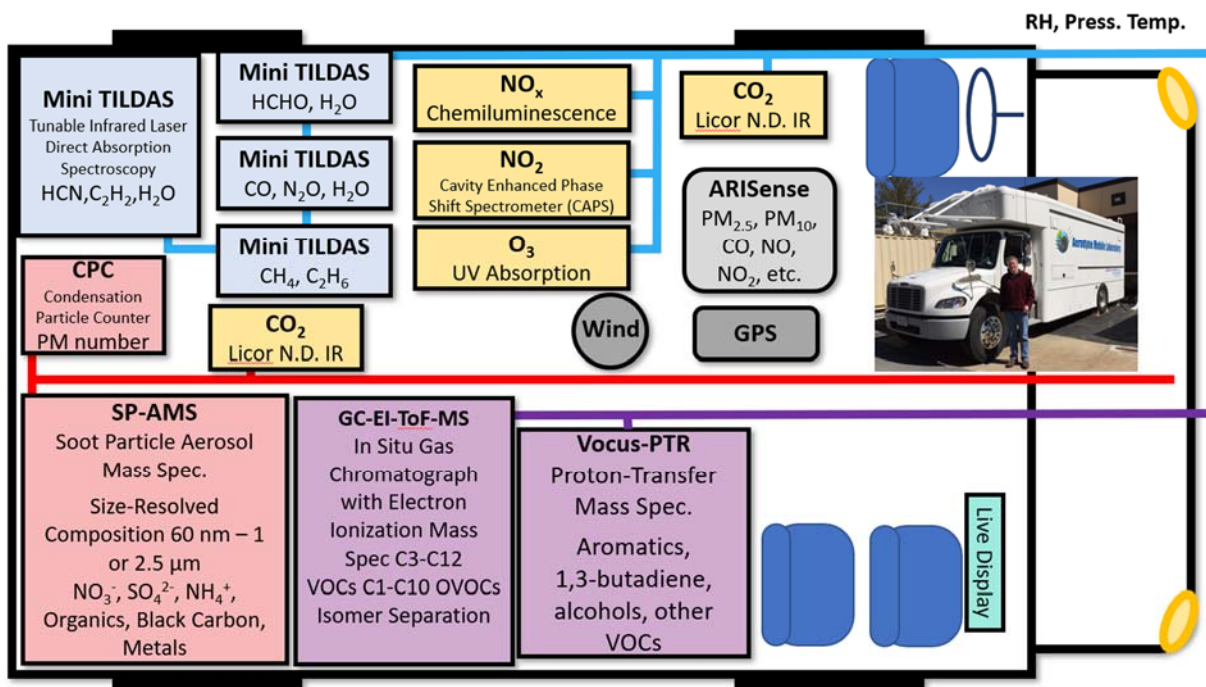


Figure 1. The instrumentation suite for the Aerodyne Mobile Laboratory (AML) proposed for the 2023 Dallas Field Study (Dallas FS) intensive

## Relevant Campaign Experience

### 2017 San Antonio Field Study (SAFS)

During the 2017 San Antonio Field Study (SAFS) [Anderson et al. 2019] The AML was located in 3 different locations (San Antonio, Floresville, Lake Corpus Christi) during the month of May 2017 conducting a full suite of measurements to examine ozone precursors in the San Antonio Metropolitan Area. This campaign had an instrument manifest similar to the proposed manifest for DallasFS including the Vocus-PTRMS, numerous Tunable Infrared Laser Direct Absorption Spectroscopy (TILDAS) instruments for gas phase measurements and the SP-AMS for particulate measurements. A prototype version of the GC-EI-ToF-MS was also operated during the 2017 SAFS Study.

One of the key findings of that study related to determining which VOCs play an important role in net ozone production in San Antonio. The hydroxyl radical (OH) reactivity of various VOC source categories was examined using a time dependent(0D) photochemical model leading to the conclusion that biogenic VOCs played the most significant role in this area at that time. Additional findings included that when the production of ozone ( $p(O_3)$ ) was between 5 – 15 parts per billion per hour (ppb hr<sup>-1</sup>), the chemical regime was NO<sub>x</sub>-limited and when  $p(O_3)$ , was less than 5 ppb hr<sup>-1</sup> and the radical pool (e.g., hydrogen oxide radicals (HO<sub>x</sub>)) was lower, either chemical regime was possible (NO<sub>x</sub>-limited or NO<sub>x</sub>-saturated). Despite the proximity to city and oil and gas

sources, biogenic VOCs were found to dominate OH reactivity in the SAFS study area. We also determined that at one downwind site alkanes and non-biogenic alkenes represented less than 10% of OH reactivity. Source-signatures were identified with varying contributions during the campaign, including oil and gas emissions and oxidation products, urban VOCs and oxidation products biogenic VOCs, and auto emissions. We intend to conduct intensive measurements in the DFW area to gain an understanding of ozone precursors in that area, with an added emphasis on specific source characterization.

One of the instruments which provided key results during the SAFS study and has undergone considerable development since that study is the GC-EI-ToF-MS. The GC-EI-ToF-MS is now capable of parallel sample collection of two atmospheric samples with subsequent separation via two chromatographs, with complimentary volatility ranges. This system allows for expansion of the GC analytical range to nominal C<sub>3</sub>-C<sub>12</sub> or C<sub>5</sub>-C<sub>20</sub> alkane equivalents. The Aerodyne Research Incorporated (ARI) GC system has been deployed as part of multiple field campaigns to characterize VOC background and emission sources (e.g. 2019 National Oceanic and Atmospheric Administration (NOAA)- National Aeronautic and Space Administration (NASA) Fire Influence on Regional To Global Environments Experiment – Air Quality (FIREX-AQ) [<https://csl.noaa.gov/projects/firex-aq/>], 2020 Oliktok [<https://prattlab.chem.lsa.umich.edu/campaigns.php>], 2021 Michigan-Ontario Ozone Source Experiment (MOOSE) [<https://www-air.larc.nasa.gov/missions/moose/>]) as well as characterizing biogenic emissions from a controlled drought experiment (2019 Biosphere, Werner et al. [2021]) and indoor air quality Clafin et al. [2021]. Results from these campaigns have already been published (e.g. Clafin et al., 2021) or are currently in preparation for submittal.

### **2018 WE-CAN; 2019 FIREX Campaigns**

During August of 2018 and 2019 the AML conducted measurements of wildfires in the Western United States while based out of McCall Idaho in support of the Western Wildfire Experiments for Cloud Chemistry, Aerosol Absorption and Nitrogen (WE-CAN) campaign (2018) and FIREX (2019) [*Majluf et al.* 2022]. In both instances, the AML staged at the McCall Activity Barn and sampled there between mobile excursions. In both campaigns the AML drove to regions with wildfires of interest and, coordinating with the local fire authorities, conducted measurements close to the wildfire, including transects that moved further downwind of the fire to measure the evolution of the plume as it aged. These trips were planned dynamically as fire conditions evolved, ensuring that there was no interference with the firefighting and public safety priority and that our own crew maintained appropriate rest.

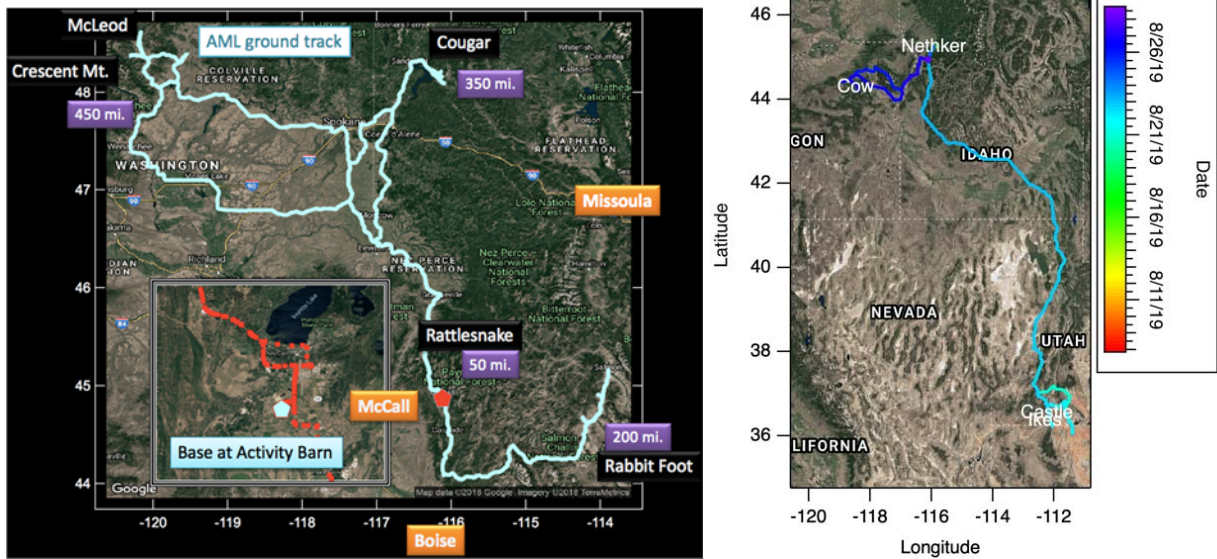


Figure 2. Maps of the AML routes driven to sample wildfires during the WECAN 2018 study (left) and FIREX2019 (right)

An example of mobile measurements conducted in one afternoon, providing observation of the evolution of a biomass burning plume is depicted in Figure 3. This fire plume propagated from West to East and the plume was traversed at three different distances by the AML. Plume HCN levels measured by TILDAS dropped and the SP-AMS measured Organics became more oxidized as is shown by the steady increase in oxygen:carbon (O:C) ratio as transects move farther away from the fire source.

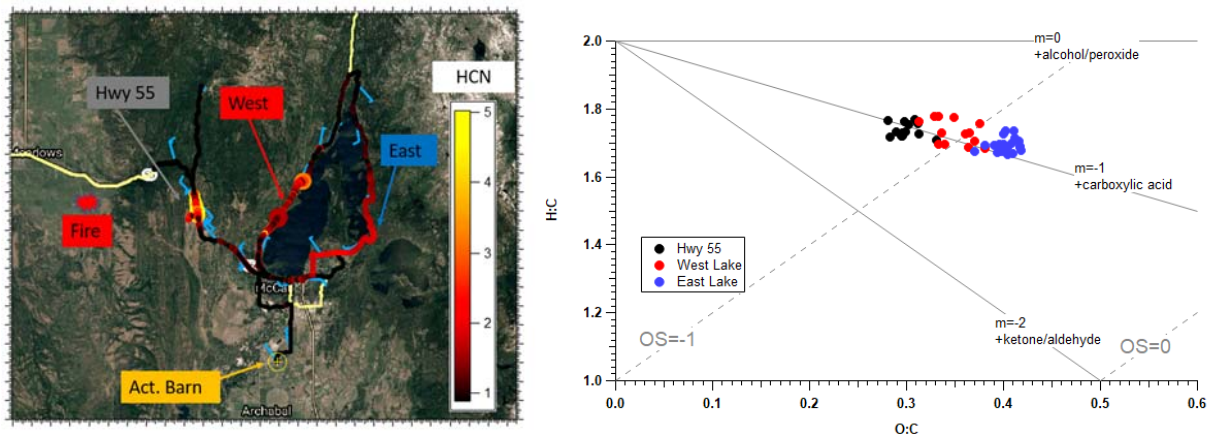


Figure 3. The propagation of a biomass burning plume from West to East was measured by AML conducting transects ; HCN TILDAS measurements are depicted on the left and SP-AMS measurements of Organic hydrogen:carbon(H:C) and oxygen:carbon (O:C) ratios are depicted on the right

## ***Key Personnel***

### ***Dr. Edward Fortner***

Dr. Edward Fortner has been the lead particle measurement scientist on the majority of AML campaigns over the last 12 years. In collaboration with others at Aerodyne he has conducted urban source measurement campaigns in Houston (Study of Houston Radical Atmospheric Precursors (SHARP), Deriving Information on Surface conditions from Column and Vertically Resolved Observations Relevant to Air Quality (DiscoverAQ)), San Antonio (SAFS), Los Angeles (South Coast Air Quality Management District (SCAQMD) studies), Detroit (MOOSE) and Philadelphia Chester Hazardous Air Pollutant Monitoring and Assessment Project (HAP-MAP) ) all of which focused at least to some degree on ozone precursors. He has also conducted biomass burning measurements with the SP-AMS on the AML during FIREX 2017, WE-CAN 2018 and FIREX 2019 as well as conducting Smoke Chamber measurements of biomass burning with the SP-AMS during the third Fire Lab at Missoula Experiment (FLAMEIII 2009) and the FIREX 2016 campaigns at the Fire Laboratory in Missoula MT. He is the lead trainer for SP-AMS systems at Aerodyne.

### ***Dr. Megan Claflin***

Dr. Megan Claflin is an analytical chemist with extensive experience in instrument construction, method development, and data analysis for environmental applications with a focus on field-deployable instrumentation. At Aerodyne Research, Dr. Claflin has been integral in the design, build, characterization, and successful deployment of the Aerodyne GC with in situ thermal desorption preconcentration paired with both electron ionization (EI) and chemical ionization (CI) time-of-flight mass spectrometric detection (TOF-MS). Recent deployments of the Aerodyne GC with EI-TOF-MS detection include the 2019 FIREX-AQ campaign in the Western US, the 2021 NASA Michigan-Ontario Ozone Source Experiment (MOOSE), and the 2021 Chester Hazardous Air Pollutant Monitoring and Assessment Project (HAP-MAP). For these campaigns the Aerodyne GC-EI-TOF-MS quantified hydrocarbon, halocarbon, and oxygenated volatile organic compounds (VOCs), including those classified as hazardous air pollutants (HAPs) and tropospheric ozone precursors.

### ***Dr. Tara Yacovitch***

Dr. Tara Yacovitch has over 10 years of experience at ARI, including extensive experience in laser-based monitors, and project management. She was key personnel in the AQRP-funded 2017 San Antonio Field Study (SAFS) and served as Principal Investigator (PI) for the follow-on 2018 SAFS analysis project. More recently, she served as ARI PI for the 2021 Michigan-Ontario Ozone Experiment (MOOSE), which completed a 6-week mobile measurement campaign in South-Eastern Michigan. She will participate in field measurements, data analysis and will serve as the project's data quality manager.

### ***Mr. Conner Daube***

Mr. Conner Daube has engaged in field campaigns using Aerodyne instrumentation over the past 7 years. He has developed and demonstrated mobile measurement methods using various platforms with collaborators across academia, industry, and government agencies. He has operated infrared spectrometers during projects measuring small gaseous species, including ozone precursors (i.e., CO, CH<sub>4</sub>, HCHO), in emissions from wildfires (FIREX, 2016 – 2019) and several urban areas (major cities in California and Texas). He has engineered and applied solutions to enable the mobile deployment of sensitive equipment, such as the GC-EI-ToF and Vocus PTRMS models. He is currently the Manager of Field Measurements at Aerodyne.

### Work Schedule

Task	Description	Year	2022				2023									
			Month	9	10	11	12	1	2	3	4	5	6	7	8	
1	Work Plan Including QAPP		█													
2	Base Site Selection		█	█	█	█	█									
3	Campaign Planning		█	█	█	█	█	█								
4	Instrument Integration at ARI							█	█							
5	Campaign Execution									█	█					
6	Data Analysis									█	█	█				
7	Finalized Dataset												█			
8	Monthly Reports		█	█	█	█	█	█	█	█	█	█	█	█	█	█
9	Presentation at AQRP Workshop														█	
10	Draft Final Report															█
11	Final Report															█

Figure 4. Workplan; note that light shading indicates limited preliminary analysis intended to guide the next day’s activity

#### Task 1. Campaign Planning.

A field campaign “home base” will be selected in this task, considering the space and power requirements of the instrumentation. Aerodyne has experience performing measurements using a variety of power setups, including recreational vehicle (RV) power, construction generators, and arranging power directly with the electrical utility company. We will also consider how well potential sites represent the majority of the DFW MSA regarding air pollution and ease of transportation around the site. Additionally, we will investigate staging options for the AML in areas of possible deployment for wildland fires. Equipment will be fully integrated onto the AML at Aerodyne and calibrations of equipment will be conducted at Aerodyne as appropriate prior to deployment.

#### Task 2. Campaign Execution.

We will primarily focus on source measurements of VOCs, including ozone precursors, and particulate matter in the DFW TX MSA. Our base measurement location will have a wealth of measurements conducted whenever the AML is stationary, and we intend to be mobile for at least an 8 hour shift on most days. We will identify specific sites of interest (industrial facilities, chemical storage areas, etc.) and measure downwind of those facilities characterizing their

impact on the DFW TX MSA. Our schedule for mobile measurements will be flexible with the intent of capturing emissions of interest whenever they occur (e.g., day versus nighttime emissions) as well as building some variety into our diurnal sampling statistics.

Our secondary mission will involve measuring biomass burning plumes of interest, which may result in different measurement strategies depending on the source location. For air masses which are impacted by distant biomass burning events entering the DFW area we will position the AML to measure the incoming plume upstream of the city for some period, followed by in-city measurements, and finally measurements downwind of the city to assess the impact of the biomass burning air mass on local ozone production in DFW. Ideally, we will also have a non-biomass burning air mass dataset with similar sampling locations for comparison. The other biomass burning measurement strategy is to drive the AML to a wildfire area in the state of Texas and then conduct transects downwind of the fire to characterize the wildfire plume evolution as it ages. We will be safety conscious in this mission ensuring no interference with firefighting efforts while also maintaining safe operating conditions in the AML as we have done in previous wildfire measurement focused campaigns.

### ***Task 3. Data Analysis and Reporting.***

During the campaign limited data analysis will be conducted to ensure proper instrument functionality and to help guide the next day's measurement activities. After the campaign, data from the project will be fully analyzed and quality assured. A first-level analysis will focus on quick turnaround for species including trace gases, core VOCs (benzene, toluene, ethylbenzene, xylene (BTEX), isoprene) and basic speciated particulate loading. Meanwhile, a full analysis will be performed, to include high-resolution integration of the mass spectra, calibrations, and estimating response factors for VOCs not in calibration tanks.

### ***Project deliverables***

AQRP requires certain reports to be submitted on a timely basis and at regular intervals. A description of the specific reports to be submitted 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 AQRP 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 AQRP 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:** August 16<sup>th</sup>, 2022

**Quarterly Reports:** Each Quarterly Report will provide a summary of the project status for each reporting period. It will be submitted to the AQRP 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.

Table 1. Quarterly Report Due Dates:

Report	Period Covered	Due Date
Quarterly Report #1	August, September, October 2022	October 31, 2022
Quarterly Report #2	November, December 2022, January 2023	January 31, 2023
Quarterly Report #3	February, March, April 2023	April 30, 2023
Quarterly Report #4	May, June, July 2023	July 31, 2023

**Monthly Technical Reports (MTRs):** Technical Reports will be submitted monthly to the AQRP Project Manager and TCEQ Liaison in Microsoft Word format using the AQRP FY20-21 MTR Template found on the AQRP website.

Table 2. MTR Due Dates:

Report	Period Covered	Due Date
Technical Report #1	Project Start - August 31, 2022	September 10, 2022
Technical Report #2	September 1 - 30, 2022	October 10, 2022
Technical Report #3	October 1 - 31, 2022	November 10, 2022
Technical Report #4	November 1 - 30, 2022	December 10, 2022
Technical Report #5	December 1 - 31, 2022	January 10, 2023
Technical Report #6	January 1 - 31, 2023	February 10, 2023
Technical Report #7	February 1 - 28, 2023	March 10, 2023
Technical Report #8	March 1 - 31, 2023	April 10, 2023

Technical Report #9	April 1 - 30, 2023	May 10, 2023
Technical Report #10	May 1 - 31, 2023	June 10, 2023
Technical Report #11	June 1 - 30, 2023	July 10, 2023
Technical Report #12	July 1 - 31, 2023	August 10, 2023

***DUE TO AQRP PROJECT MANAGER***

**Financial Status Reports (FSRs):** Financial Status Reports will be submitted monthly to the AQRP Grant Manager (RoseAnna Goewey) by each institution on the project using the AQRP 20-21 FSR Template found on the AQRP website.

Table 3. FSR Due Dates:

Report	Period Covered	Due Date
FSR #1	Project Start - August 31, 2022	September 15, 2022
FSR #2	September 1 - 30, 2022	October 15, 2022
FSR #3	October 1 - 31, 2022	November 15, 2022
FSR #4	November 1 - 30, 2022	December 15, 2022
FSR #5	December 1 - 31, 2022	January 15, 2023
FSR #6	January 1 - 31, 2023	February 15, 2023
FSR #7	February 1 - 28, 2023	March 15, 2023
FSR #8	March 1 - 31, 2023	April 15, 2023
FSR #9	April 1 - 30, 2023	May 15, 2023
FSR #10	May 1 - 31, 2023	June 15, 2023
FSR #11	June 1 - 30, 2023	July 15, 2023
FSR #12	July 1 - 31, 2023	August 15, 2023
FSR #13	August 1 -31, 2023	September 15, 2023
FSR #14	Final FSR	October 15, 2023

## ***DUE TO GRANT MANAGER***

**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:** August 1, 2023

**Final Report:** A Final Report incorporating comments from the AQRP and TCEQ review of the Draft Final Report will be submitted to the AQRP 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:** August 31, 2023

**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 30, 2023). 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. All data will be retained by ARI for a minimum of three years following project completion.

**AQRP Workshop:** A representative from the project will present at the AQRP Workshop in the first half of August 2023.

**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.

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