Scope of Work For

Project 16-008
High Background Ozone Events in the Houston-Galveston-Brazoria Area: Causes, Effects, and Case Studies of Central American Fires

Prepared for

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

By

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August 17, 2016
Version #3

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 August 29, 2016 by Elena McDonald-Buller, The University of Texas at Austin

Elena McDonald-Buller
Project Manager, Texas Air Quality Research Program

This Scope of Work was recommended electronically on September 1, 2016 by Doug Boyer, Texas Commission on Environmental Quality

Doug Boyer
Project Liaison, Texas Commission on Environmental Quality

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1.0 Abstract

A significant fraction of surface ozone in Texas comes from regional background originating from outside the state. Background ozone is particularly variable over the Houston-Galveston-Brazoria (HGB) region due to its unique geographical location and meteorology. Prior analyses of the HGB background ozone have focused predominantly upon averages, not high concentration days or extreme events. To bridge this gap, the objectives of this project are to identify high background ozone events across the HGB area over the past 16 years (2000-2015), characterize meteorological conditions and anomalous emissions that cause these events, and understand their effects on ozone exceedances. With regard to emission anomalies, the focus will be on fire events from Mexico and Central America, a large fire region globally of unique importance to Texas air quality in springtime and summer whose impact on Texas background ozone has not been quantified.

Integrated analyses of observations and modeling will be conducted to achieve the project objectives. Daily HGB background ozone estimated by researchers at the Texas Commission on Environmental Quality (TCEQ) will be used as the data source to identify high background ozone days. Different types of meteorological events which may be potentially associated with high background ozone (e.g., cold fronts and thunderstorms) or high local photochemical production (e.g., heat waves and stagnation) will be identified based on the analysis of meteorology data. The relationship between high background ozone days and the meteorological 'event days' will be characterized, e.g., in terms of their overlapping (or the lack of it), and background ozone difference between meteorological 'event days' and 'non-event days' will be evaluated. Anomalies in fire emissions leading to high background ozone will be mapped through spatiotemporal sampling of the Fire INventory from NCAR (FINN) along background trajectories of air masses affecting the HGB area prior to and during the selected high background ozone days. The GEOS-Chem global chemistry transport model, with the FINN inventory implemented, will be used to simulate a number of case studies of large Central American fires and estimate the perturbations caused by ozone precursor emissions from those fires on background ozone concentrations in Texas and HGB area. Finally, we will develop a quantitative estimate of the effects of background ozone versus local production on ozone exceedance cases in the HGB area and the dependence of such effects on meteorology and Central America fire emissions.

This project targets the second area of the AQRP priorities: "Investigating global, international, and regional transport of pollutants (both inter- and intra-state) using data and modeling analysis". The specific focus of the proposal is to examine the causes and effects of high background events in the HGB area with an emphasis on the impact of Central American fires. This is highly relevant to the topic of examining "deviations" and "high concentration events originating outside of Texas (e.g., wildfires)" listed in the second priority area.

2.0 Background

A significant fraction of surface ozone in Texas comes from regional background originating from outside of Texas, with an estimated range of 20 ~ 50 ppbv (Zhang et al., 2011; McDonald-Buller et al., 2011; Fiore et al., 2014). Background ozone is particularly variable over the Houston-Galveston-Brazoria (HGB) region - the largest metropolis in Texas and a marginal ozone nonattainment area - because of this region's unique geographical location and meteorology (Nielsen-Gammon et al., 2005). Observation-based estimates have suggested a decreasing trend of the HGB background ozone during periods of northerly winds, presumably driven by the decreasing trend of U.S. anthropogenic emissions; no trend is evident in background ozone associated with maritime inflow from the Gulf of Mexico (Berlin et al., 2013). This maritime inflow shows substantial year-to-year variability driven by the change in the Bermuda High synoptic system (Wang, 2015), and the frequency of the maritime inflow has been increasing during recent years (Liu et al., 2015). However, all these prior analyses of HGB background ozone focus upon averages, not high concentration days or extreme events.

Background ozone is expected to vary substantially from day to day as a result of meteorological variability and emissions (e.g., wildfires, and lightning). There are only a few case studies of high background ozone events in Texas, mostly focusing on short periods of aircraft campaigns (e.g., Langford et al., 2009) and single episode (e.g., Morris et al., 2006). Through simple statistical correlation, Berlin et al. (2013) found that background ozone contributes more than 50% to the HGB MDA8 ozone and explains 63-83% of the MDA8 ozone variability during the ozone season. Given this substantial contribution, it is important to identify extreme events of high background ozone over the HGB area over a longer time period, plus characterize common features and drivers of these events, and understand their effects on ozone exceedance. This project is directed at addressing these questions.

Episodic emissions such as wildfires are important drivers of short-term enhancement in background ozone (Morris et al., 2006). Significant progress has been made in the past to improve emission estimates from wildfires and quantify the impacts of these emissions on Texas air quality, with a focus on fires from the continental U.S. (Kemball-Cook et al., 2014; McDonald-Buller et al., 2015). Internationally, Mexico and Central America is a large fire region of unique importance to Texas air quality and its background ozone. The Central America fire season peaks in spring (Apr-May), coincident with the start of the ozone season in Texas. Satellite and in situ measurements have documented several cases of long-range transport of fire smokes and gaseous emissions from the Yucatan Peninsula and Central America across the Gulf of Mexico into Texas and other parts of the southern U.S. (Wang et al., 2006; Alvarez, 2009), as illustrated in Figure 1. The transport of Central American wildfire emissions into Texas is largely steered by the Bermuda High (Wang et al., 2009), the same large-scale circulation pattern controlling the maritime background ozone into the HGB area. The implication of this linkage on HGB background ozone has not been investigated in prior analyses. Here we hypothesize that wildfire emissions originating from Central America can cause significant perturbations to chemical composition of the otherwise clean maritime air masses flowing into the HGB area, resulting in short-term enhancements in background ozone. This project will test this hypothesis by quantifying the contribution of Central American fires to background ozone in the HGB area.

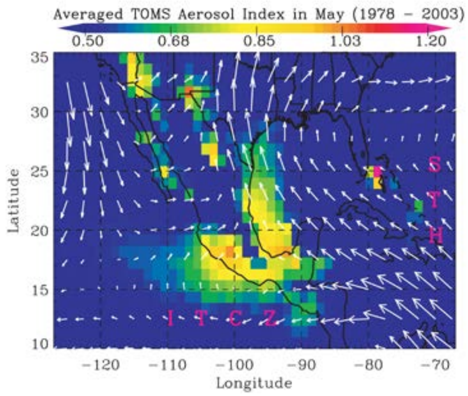

Figure 1. Long-term (1978-2003) mean aerosol index in May (filled colors) from the Total Ozone Mapping Spectrometer (TOMS) and 700 hPa wind vectors (white arrows). STH denote the subtropical high pressure system (i.e., the Bermuda High) and ITCZ denotes intertropical convergence zone. Adopted from Wang et al. (2009).

3.0 Objectives

Through integrated analyses of observations and modeling, the project aims to improving current understanding of the causes and effects of high background ozone events in the HGB area. The specific objectives are:

1) To identify days/events of high background ozone in the HGB region and characterize meteorological conditions and emission anomalies for those cases;
2) To distinguish the effect of high background ozone versus local ozone production on daily MDA8 ozone concentration and exceedances; and
3) To quantify the contribution of wildfires emissions from Central America on background ozone in Texas and the HGB area.

The time periods that this project will be focused on are from April to October (ozone season) over the period 2000 to 2015 when routine surface measurements of ozone, aircraft, and satellite remote sensing data are available and well maintained.

4.0 Task Descriptions

Task 4.1. Identify high background ozone days and other relevant 'event days'

Researchers from the Texas Commission on Environmental Quality (TCEQ) and the National Oceanic and Atmospheric Administration (NOAA) have developed independent methods to estimate HGB background ozone concentrations through detailed analysis of ozone measurements at surface monitoring sites around the region (Estes et al., 2014; Berlin et al., 2013). Background ozone concentrations derived by the two methods are largely consistent, with a high temporal correlation (r^2 = 0.8) and a small mean difference of 7.3 ppbv. While TCEQ and NOAA methods provide a rich dataset of background ozone concentrations on daily scales, previous analyses have predominantly focused on monthly or ozone-season mean scales, not high concentration days or extreme events. To fill the gap, in this task we will investigate high background ozone days and extreme events.

Daily HGB background ozone estimates from the TCEQ (Estes et al., 2014) will be used as the data source to identify high background ozone days and extreme events (described below). The TCEQ data of HGB background ozone concentrations span from 2000 to 2013 at the time of writing this proposal. We will extend the data record to 2015 with the same methodology. The selection of high and extreme background ozone days will be conducted by month, as opposed by the ozone-season as a whole, because of the large month-by-month variability of background ozone in HGB area (Nielsen-Gammon et al., 2005). These cases are defined as follows:

(1) High background ozone days: defined as the highest 15% of daily background ozone concentrations for each calendar month (Apr-Oct), corresponding to a total of 72 days per month over the 16-year period (2000-2015);
(2) Extreme background ozone days: defined as the highest 6% concentrations by month, about 29 days per calendar month. Please note the use of 'extreme' here is for its generic meaning, which does not connect with extreme events defined by US EPA or other agencies.

The 6% threshold tentatively chosen for the identification of extreme background ozone days is based on preliminary assessment of background ozone distributions. Figure 2 shows the 2000-2013 mean frequency distribution of HGB background ozone and MDA8 ozone for the month of April (left) and May (right), the months of highest background ozone. The right tail of the background ozone distribution intercepts with the left tail of the MDA8 total ozone distribution at approximately the upper 6 percentile.

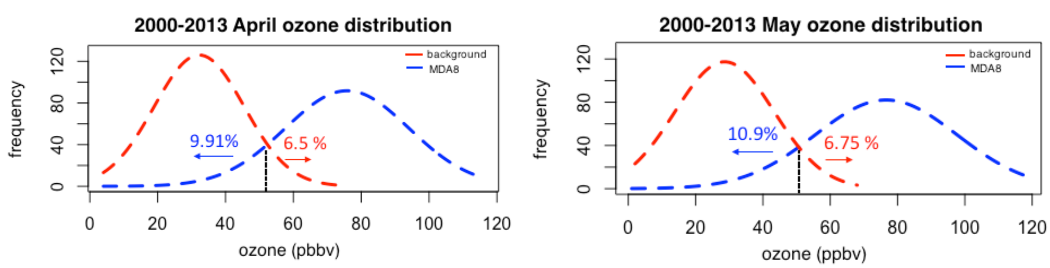

Figure 2. The 2000-2013 mean distribution of background ozone (red) and surface MDA8 ozone (blue) in the HGB region in April (left) and May (right).

In addition, we will label other types of 'event days' that include both high surface ozone days and extreme meteorological events in HGB which may be potentially associated with high background ozone (e.g., cold front passing and thunderstorms) or high local photochemical production (e.g., heat waves and stagnation). These relevant 'event days' include:

(3) High MDA8 ozone days, defined as the highest 15% of daily MDA8 ozone for each calendar month, corresponding to a total of 72 days per month over the 16-year period (2000-2015);

(4) Ozone exceedance days, defined as the days when at least two surface monitors in HGB exceeded 70 ppbv; the definition of exceedance based on two monitors reduces the influence of local emissions specific to any single site on the analysis.
(5) Heat wave, defined when the daily maximum temperature in HGB exceeds the "climatological" daily maximum temperature (averaged over the reference period of 1961-1990) by at least 5º K for more than two consecutive days (Frich et al., 2002);
(6) Stagnation, defined when the 10 m wind speed, 500 hPa wind speed, and precipitation in the HGB area are all less than their climatological values for the reference period (1961-1990) by at least 20% (Frich et al., 2002);
(7) Cold front, defined when a cold front passes over the HGB from the north and cold fronts are tracked by the method of Wang et al. (2006);
(8) Lightning and thunderstorm, identified from the Houston lightning detection and ranging network (LDAR) (http://atmo.tamu.edu/ciams/lma/network_loop.html; Orville et al., 2001).

The MDA8 ozone concentrations (i.e., total ozone) over the HGB region will be downloaded in ASCII format from the EPA AirData website (https://www3.epa.gov/airquality/airdata/) with additional observations at supplementary sites from the TCEQ. Meteorological data will be adopted from National Centers for Environmental Prediction (NCEP) North America Regional Reanalysis (spatial resolution of ~32 km) and the selection of meteorological events will be corroborated by other meteorological databases such as the NCEP global reanalysis and European Centre for Medium Range Forecast Re-analysis Interim (ERA-Interim).

Deliverables: Monthly reports describing selected background ozone and MDA8 ozone 'event days' and meteorological 'event days'.

Schedule: The schedule for Task 4.1 Deliverables is shown in Section 7.

Task 4.2. Characterize meteorological conditions during high background ozone cases

Since high background ozone events are expected to result from the right combination of regional transport and out-of-state emissions, the objective of this task is to characterize meteorological conditions that are associated with high background ozone days (including extreme background ozone days) identified in Task 4.1 (anomalies in out-of-state emissions will be investigated in Task 3). We will first investigate the relationship between high background ozone days and the meteorological 'event days' identified in Task 4.1. The extent and statistical significance of high background ozone days overlapping with the selected meteorological event days, or the lack of this overlap, will be calculated by month, season, and year during the 16-year period (2000-2015). Average background ozone concentrations on meteorological 'event days' will be compared with those on 'non-event days'. The significance of such difference will be assessed and its variability characterized, e.g., in terms of its dependence on season/month or change with time. The possible interactions between different types of meteorological events will be considered in assessing their association with high background ozone. For example, background ozone on days when multiple meteorological events occur simultaneously will be compared with background ozone on days with only one type of meteorological event.

Since the meteorological ‘events’ defined above are mostly local scale (except for cold fronts), it is likely that a fraction of high background ozone days will occur outside of the selected ‘events’ when high background ozone is caused by synoptic scale circulation patterns other than cold front passage or by local-scale meteorological conditions not identified yet. We will investigate these ‘outside’ cases in detail to identify if they are influenced by certain meteorological conditions in common which are not considered above through cluster analysis (Ngan and Byun, 2011) or principle component analysis (PCA) of the corresponding meteorological fields.

Deliverables: Monthly reports describing meteorological conditions causing high background ozone days and extreme background ozone events in the HGB area; statistics of the occurrences of those conditions by month, season, and year; and quantitative analyses of background ozone characteristics under different types of meteorological events.

Schedule: The schedule for Task 4.2 Deliverables is shown in Section 7.

Task 4.3. Analyze emissions anomalies and case studies of Central American fires on HGB background ozone

The most likely candidates of emissions anomalies responsible for the short-term (i.e., days) enhancement of background ozone in the HGB area are episodic emissions, such as fires and lightning. The lightning-thunderstorm case is treated as a type of meteorological ‘event’ (Case 8 in Task 1), the analysis of which will be conducted in Task 4.2. The effects of fire emissions will be investigated in this task separately from the meteorological analysis. We will use the Fire INventory from NCAR (FINN) complied by Wiedinmyer et al. (2011) that is based on MODIS fire products. The FINN inventory provides daily, 1 km resolution, global estimates of the trace gas and particle emissions from open burning of biomass, which includes wildfire, agricultural fires, and prescribed burning.

In order to map regions of fire emissions that can potentially affect the HGB area, 3-day background trajectories will be calculated at each of the high background ozone days using the Hybrid Single-Particle Lagrangian Integrated Trajectory (HYSPLIT) model (Draxler and Hess, 1998) driven by the NCEP reanalysis fields. The FINN fire emissions inventory will be sampled by those back trajectories on daily scales to calculate fire emissions along each trajectory. The distribution of fire emissions sampled by the background trajectories will be mapped and compared with the distribution of fire emissions outside the sampling days. For back trajectories across the Gulf of Mexico toward the Yucatan Peninsula and Central America in general, we will test if 3 days are sufficiently long to trace back the origin of the fires and if not, more days will be added to back trajectory calculations.

Prior investigations have identified several large events of Central American fires that adversely affected air quality in Texas, including late Apr – May 2003 (Levinson and Waple, 2004; Wang et al., 2006), Apr 2011 (Saide et al., 2015), Apr 2013, and Apr 2015 (http://www.nasa.gov/mission_pages/fires/main/world/20130412-centralamerica.html; http://www.nasa.gov/image-feature/fires-in-the-yucatan-peninsula-april-2015). The impact of those fire cases on background ozone in Texas can be potentially large and has yet to be quantified. These previously identified fire events, with additional events identified from the back trajectory analysis described above, will be chosen as case studies for in-depth data and modeling analyses. We will first check whether any high background ozone days (identified in Task 1) occur within 3 days after the fire events. We will then compare background ozone levels in the HGB area within 3 days of individual fire events with the corresponding monthly mean background ozone.

The GEOS-Chem global chemical transport model and its nested-grid version over North America will be used to simulate the periods of the selected case studies of Central American fires. The model will be driven by the GEOS-5 assimilated meteorology and uses the FINN inventory for biomass burning emissions. Long-range transport of gaseous emissions (NO_x, VOCs, and CO) from Central American fires will be simulated and perturbations of these fire events to background ozone concentrations in Texas will be quantified through the difference in model results with and without fire emissions in Central America.

Deliverables: Distribution maps of anomalous fire emissions during high background ozone days; Monthly reports describing emissions and meteorological conditions for each of the case studies of large fire events from Central America; GEOS-Chem simulation results of the selected case studies of Central American fires on background ozone in Texas and the HGB area; and one or two manuscripts in draft form for publication in peer-reviewed journals.

Schedule: The schedule for Task 4.3 Deliverables is shown in Section 7.

Task 4.4. Quantify the effects of background ozone versus local ozone production on ozone exceedances

The objective of this task is to quantify the effects of high background ozone events versus local ozone production on surface ozone concentrations in the HGB region, focusing on their respective impacts on high MDA8 ozone days and ozone exceedances identified in Task 4.1 (Case 3 and 4). Local ozone production is approximated as the difference between observed surface ozone and background ozone estimated by the TCEQ.

Several indicators will be used to quantify the effects of background ozone versus local ozone production on total MDA8 ozone and ozone exceedances. First, the fractional contribution of background ozone to total MDA8 ozone will be calculated and compared with that of local ozone production for high MDA8 ozone days, ozone exceedance days, and all other days. The resulting differences will be analyzed to understand the extent to which they are affected by occurrences of certain meteorological 'event days' identified in Task 4.1 or Central American fire emissions identified in Task 4.3. For example, local production of ozone is expected to increase during heat wave days and stagnation, while background ozone contribution is expected to be higher during cold front passages. We will examine the difference in the relative contribution of local production and background ozone to total MDA8 ozone under these meteorological events, in comparison with their difference under other meteorological conditions.

Second, the percentages of high MDA8 ozone days and ozone exceedance days that are labeled simultaneously as high (or extreme) background ozone days will be calculated by month. The percentage occurrences of meteorological 'event days' during the high MDA8 ozone days and ozone exceedance days will also be labeled. We will examine the variability and trend of those percentages and investigate if they exhibit certain association with the variability and trend of MDA8 ozone and ozone exceedance days during the period 2000-2015.

Third, we will examine if the distribution and magnitude of background ozone concentrations during the high MDA8 ozone days and ozone exceedance days are different from the mean characteristics of background ozone outside of those days. All the assessments described here will be conducted by month rather than the ozone season as a whole in order to account for intra-seasonal variability of total ozone, background ozone, and meteorology.

As a further illustration, we will answer the following hypothetical question: How many days of ozone exceedances in the HGB area can be avoided during the past 16 years (2000-2015) if background ozone concentrations had been 10% lower during the days of exceedances? We will address the same question but with a 10% reduction in local ozone production. The answers to the two questions are expected to be different and such differences will be used to further illustrate the different roles of background ozone and local production of ozone on exceedances.

Deliverables: Monthly reports presenting quantitative estimates of the effects of background ozone versus local production on ozone exceedance cases in the HGB area; the dependence of such effects on meteorology and fire emissions; publication of the manuscripts presenting project results in high-impact journals.

Schedule: The schedule for Task 4.4 Deliverables is shown in Section 7.

Task 4.5. Project Reporting and Presentation

As specified in Section 7.0 "Deliverables" of this Scope of Work, 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, at least one member of the project 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.

Deliverables: Abstract, monthly technical reports, monthly financial status reports, quarterly reports, draft final report, final report, attendance and presentation at AQRP data workshop, submissions of presentations and manuscripts, project data and associated metadata

Schedule: The schedule for Task 4.5 Deliverables is shown in Section 7.

5.0 Project Participants and Responsibilities

The project will be directed by a collaborative team of two PIs: Dr. Yuxuan Wang (PI) and Dr. Robert Talbot (Co-PI) at the University of Houston (UH). The PIs will be supported by a group of graduate students and undergraduate students in the Department of Earth and Atmospheric Sciences at UH. Both PIs and their graduate students will be involved collaboratively in all the tasks and reporting. Specifically, Dr. Wang and her team will lead the analyses of meteorological conditions (Task 4.2) and GEOS-Chem modeling (Task 4.3); Dr. Talbot and his team will lead the analysis of ozone and meteorological data to identify different types of events (Task 4.1) and their respective effects on HGB ozone exceedances (Task 4.4). Project participants and their responsibilities are listed in Table 1.

Table 1. Project participants and key responsibilities

Participant	Project Responsibility
Dr. Yuxuan Wang	Principal investigator (PI). Overseeing all aspects of this project and quality assurance; supervising PhD graduate students and undergraduate research assistants to work on Task 4.2 and 4.3; project reporting and presentation; responsible for quality assurance (QA) of the project deliverables.
Dr. Robert Talbot	Co-PI. Supervising PhD graduate students and undergraduate research assistants to work on Task 4.1 and 4.4; project reporting and presentation; responsible for quality assurance (QA) of the project deliverables.
Sally Sing-Chun Wang	PhD. student working with Dr. Wang on Task 4.2 and 4.3.
Ruixue Lei	PhD. student working with Dr. Talbot on Task 4.1 and 4.4.
Ph.D. Student (TBD)	PhD student working with Dr. Wang on analysis of GEOS-Chem model outputs.
Undergraduate student (TBD)	Undergraduate research assistants working with Dr. Wang and Dr. Talbot on compilation of ozone monitoring data.

Undergraduate student (TBD)	Undergraduate research assistants working with Dr. Wang and Dr. Talbot on compilation of meteorological data.
Undergraduate students (TBD)	Undergraduate research assistants working with Dr. Wang and Dr. Talbot on analysis of fire data and model outputs.

6.0 Timeline

The project is estimated to start September 1, 2016 and end Aug 30, 2017 for a period of 12 months. The overall schedule of the project is presented in the table below.

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<tr><th>Task Months</th><th>2016
9-10</th><th>2016
11-12</th><th>2017
1-2</th><th>2017
3-4</th><th>2017
5-6</th><th>2017
7-8</th></tr>
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<tr><td>Task 4.2. Characterize meteorological conditions during high background ozone cases</td><td></td><td bgcolor="#00B0F0"></td><td bgcolor="#00B0F0"></td><td></td><td></td><td></td></tr>
<tr><td>Task 4.3. Analyze case studies of Central American fires on HGB background ozone</td><td></td><td></td><td></td><td bgcolor="#00B0F0"></td><td bgcolor="#00B0F0"></td><td></td></tr>
<tr><td>Task 4.4. Quantify the effect of background ozone on ozone exceedances</td><td></td><td></td><td></td><td></td><td bgcolor="#00B0F0"></td><td bgcolor="#00B0F0"></td></tr>
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7.0 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 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
Aug2016 Quarterly Report	June, July, August 2016	Wednesday, August 31, 2016
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
Aug2016 MTR	Project Start - August 31, 2016	Thursday, September 8, 2016
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 AQRP Grant Manager (Maria Stanzione) by each institution on the project using the AQRP FY16-17 FSR Template found on the AQRP 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 AQRP 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.

8.0 References

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