Scope of Work For

Project # 20-004
Galveston Offshore Ozone Observations (GO_3)

Prepared for

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

By

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

NOTE: The workplan package consists of three independent documents: Scope of Work, Quality Assurance Project Plan (QAPP), and budget and justification. The QAPP and Budget/Budget Justification were submitted as separate documents.

Approvals

This Scope of Work was approved electronically on **12/8/2020** by

Vincent M. Torres
Project Manager, Texas Air Quality Research Program
The University of Texas at Austin

This Scope of Work was approved electronically on **12/11/2020** by

Doug Boyer
Project Liaison, Texas Commission on Environmental Quality

Contents

1. Abstract

This project addresses the 2020-2021 Texas Air Quality Research Program Priority Area of Monitoring Ozone in Galveston Bay and Offshore. The project aims to deploy two small automated sampling systems on commercial boats operating in Galveston Bay (Larry Willis, commercial shrimper) and the offshore waters adjacent to Galveston Island (Ryan Marine Services, crew launch boat operator) to collect routine measurements of O_3, O_X ($O_X = O_3 + NO_2$) and meteorology, including boundary layer height, during April-August 2021 through a collaboration with the University of Houston (UH) and St. Edward's University (SEU). A third boat, owned and operated by UH, will be utilized for special studies in Galveston Bay as well as for launches of up to 20 ozonesondes to examine vertical profiles of O_3 and confirm ceilometer measurements of boundary layer height. Coupled with 3-D chemical transport modeling, this study will shed light on the conditions and processes that may result in high O_3 over the water and subsequent impacts on the HGB urban area.

The study is designed to focus on the following primary science questions:

1. How frequently does high ozone reside over the water during the ozone season, and how does the observed frequency compared to that simulated by photochemical models?
2. How does O_3 and O_X over water compare with O_3 and O_X ($O_X = O_3 + NO_2$) over adjacent land?
3. How is O_3 formation over the water impacted by local circulation patterns?
4. What are the characteristics of the boundary layer over the water during high O_3 events, and how do the observed boundary layer heights compare to model predicted heights?
5. How do small O_3, O_X, and meteorology sampling systems installed on commercial vessels help us better understand O_3 in Galveston Bay and the Gulf of Mexico?

The proposed instrumentation packages will include an O3 monitor, UV-LED NO2 photocell, Global Positioning System (GPS) receiver, all-in-one weather station, and a ruggedized PC with a cellular data connection. The package will operate autonomously when power is available. A ceilometer will be installed on one of the vessels to measure boundary layer height over the water, which is often parameterized in photochemical models and can have a significant impact on model results. The data, which are logged locally, will be sent to servers at UH when within cellular coverage.

Modeling activities will utilize the Weather Research and Forecasting (WRF) driven GEOS-Chem (WRF-GC). The model will simulate ozone distributions in the HGB region during the measurement periods with a focus on ozone over the water and land-water ozone gradient. WRF has a powerful and flexible grid system, including multiple nested grids and moving nested grids. For the proposed work, the inner-most model domain of WRF-GC will be set over the sampling areas as well as the area surrounding the bay which will include the monitors used for comparisons at a resolution of 1 km x 1 km, allowing replications of fine-scale temporal and spatial dynamics specific to coastal regions such as sea/bay breeze. In addition to confirming the presence or absence of high O_3 over the water and the conditions which occur during high O_3 events, the results from this project are expected to provide more accurate parameterizations for future modeling studies and to identify partners and methodologies for additional studies.

2. Background

Studies have observed high ozone periods in the HGB area driven by large circulation patterns and mesoscale land-sea breeze circulations (Berlin et al., 2013; Caicedo et al., 2019; Langford et al., 2009; Wang et al., 2016). Regional background (non-locally produced) O_3 transported into the area by large-scale winds, is significantly correlated with peak O_3 levels in the HGB region (Berlin et al., 2013; Langford et al., 2009; Nielsen-Gammon et al., 2005). High O_3 events in the HGB were most associated with continental outflow, while the lowest O_3 levels were from onshore winds (Berlin et al., 2013). However, the onshore bay breeze which passes over the industrial regions (e.g. HSC) had significantly elevated regional background O_3 levels than the stronger onshore sea breeze which passes through the Caribbean before entering the Gulf of Mexico (Berlin et al., 2013; Langford et al., 2009). Though episodic, the bay and sea breeze circulation patterns are also found to be important causes for high O_3 events in urban/industrial coastal sites in the U.S. (Banta et al., 2005; Caicedo et al., 2019; Loughner et al., 2011; Mazzuca et al., 2017; Stauffer and Thompson, 2015).

The land/bay/sea breeze phenomenon occurs under weak synoptic forcing when offshore winds sweep urban/industrial pollutants onto open waters, before later reversing as an onshore breeze and bringing the photochemically aged air, which can be high in O_3, back on shore. There is great interest in understanding the O_3 levels in these open waters (i.e. Galveston Bay) which is exposed to a combination of land-based urban and industrial emissions (Wallace et al., 2018), ship emissions (Schulze et al., 2018; Williams et al., 2009), and complex marine O_3 chemistry (i.e. halogen) (Tuite, et al., 2018; Osthoff et al., 2008; Tanaka et al., 2003). Previous studies have observed elevated O_3 levels in these open waters relative to land-based sites (Sullivan et al., 2018; Goldberg et al., 2014). However, unlike land-based measurements, historical records and/or routine measurement of O_3 levels over these waters (i.e. areas where measurement can be difficult) are limited. Available measurements in these regions are generally from ship or airborne measurements during short-intensive sampling campaigns, which were not designed with a focus on O_3 over the water (Mazzuca et al., 2017; Parrish et al., 2009).

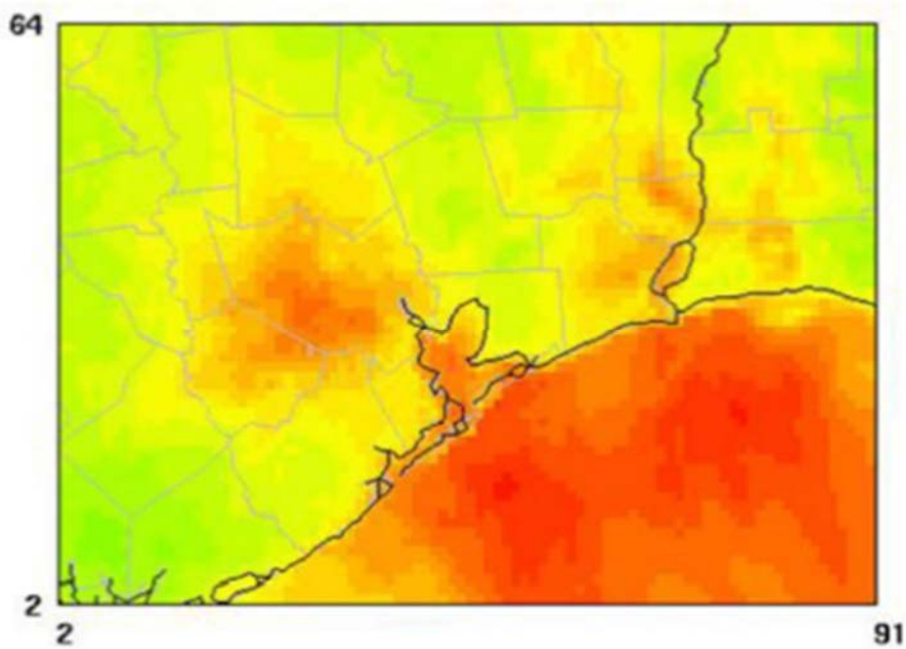

Figure 1. Future case simulation showing high O_3 over water, from Dunker, et al. (2019).

While photochemical models can be powerful tools in detecting and forecasting O_3 levels in these maritime environments (Figure 1), the models are typically built upon parameterizations or simple assumptions to represent small-scale meteorological and chemical processes over the waters. These assumptions/parameterizations need suitable measurements for validation and/or tuning. In addition, current models may not include all important processes, and to identify which processes are missing and their impacts will also require extensive measurements. But routine observations over the waters have been lacking. Due to this, model performance over the marine environments has been largely unconstrained and thus highly uncertain. Previous studies have observed both positive and negative biases of modeled O_3 concentration in these coastal, transitional regions (Caicedo et al., 2019; Dunker et al. 2019; Sullivan et al., 2018; Goldberg et al., 2014; Li et al., 2012; Yerramilli et al., 2012). A recent study of the HGB region and the Galveston Bay compared observation and modeled planetary boundary layer (PBL), wind direction and speed, and O_3 concentrations during a high O_3 event in Houston (Caicedo et al., 2019). They observed a lower correlation between observations and models over bodies of water and coastal regions compared to measurements closer inland (Caicedo et al., 2019). For that study, the discrepancy observed in the coastal and land-water regions was due to a delay in the simulation of onset bay and sea breezes, which are important factors for modeling O_3 (Caicedo et al., 2019). A recent O_3 model study accounted for the changes in local and regional background O_3 levels and found that similar to previous studies, the model performed well for inland sites but overestimated O_3 at the coastal sites, specifically for days with lower O_3 levels (less than 60 ppbv) (Dunker et al. 2019). These model studies incorporated the halogen chemistry proposed by Tuite et al. (2018). However, the chemistry alone was insufficient to match observations, leading the authors to suspect inaccurate emissions in the Gulf of Mexico or incorrect meteorology with respect to the marine boundary layer height and residual layer mixing. Further measurement of O_3 and meteorological conditions directly on Galveston Bay are necessary to understand the high O_3 events in the HGB region and also to improve and refine models.

3. Objectives

The goals for this project are described by the science questions below:

1. How frequently does high O3 reside over the water during the O3 season, and how does the observed frequency compare to that simulated by photochemical models? Under what conditions do the modeled and measured O3 agree or disagree? Is O3 consistently elevated over water relative to over land, or is there a spatial variability in O3 over water?

2. How does O_3 and O_X over water compare with O_3 and O_X over adjacent land? Are there indications that O_3 is higher over water due to a lack of titration from point and mobile sources? Are the offshore O_3 values consistent with the findings from previous studies, including the coastal measurements at San Luis Pass in 2016 (Tuite et al., 2018)?

3. How is O_3 formation over the water impacted by local circulation patterns? How does the diurnal pattern over water differ from over land and from coastal measurement locations, such as Smith Point? How frequently does the bay breeze result in a local circulation that brings urban plumes into Galveston Bay? What effect does this circulation have on O_3 in the Houston area in an era of reduced VOC emissions from the Houston Ship Channel area?

4. What are the characteristics of the boundary layer over the water during high O_3 events, and how to the observed boundary layer heights compare to model predicted values? Boundary layer heights over water are often parameterized and may not accurately represent reality, especially in areas with complex land-water interaction and circulation patterns, such as in Galveston Bay and the offshore waters (Dunker et al., 2019). How do the measured boundary layer heights compare to other land-based coastal measurements, such as those from Smith Point during DISCOVER-AQ Houston or from the Galveston 99^{th} St. site (C1034)?

5. How do small O_3, O_X, and meteorology sampling systems installed on commercial vessels help us better understand O_3 and O_X in Galveston Bay and the Gulf of Mexico? Measurements of O_3 and meteorological parameters have been installed on commercial aircraft, such as in the MOZAIC project (Marenco et al., 1998). Do the vessels operating in Galveston Bay and the offshore coastal areas provide appropriate spatial coverage to investigate O_3 over water under a variety of weather conditions? Can a small sampling system be designed such that it operates with little to no impact on the routine vessel operations?

4. Task Descriptions

The following tasks describe the work to be performed and specify the scope of the tasks, due dates, responsible organization(s), and deliverable(s) to successfully complete this project.

4.1. Develop Work Plan – A Scope of Work (this document), detailed budget and justification, and Quality Assurance Project Plan (QAPP) will be developed and delivered to the AQRP. The QAPP will be a composite of a measurement and research model development and application type of QAPP.

Due date: May 11, 2020.
Responsible organization: University of Houston with assistance from St. Edward's University
Deliverables: Approvable Work Plan

4.2. Purchase equipment and major components – Orders for all major components, such as the ceilometer, data acquisition computers and software, GPS sensors, weather stations and equipment enclosures will be purchased by University of Houston. Ozonesondes and the associated radiosondes and balloon train components as well as helium will be purchased by St. Edward's University.

Due date: Within 30 days of receiving AQRP issued start date.
Responsible organization: University of Houston and St. Edward's University
Deliverables: Confirmation of order placement and updates of expected delivery times in the subsequent MTR.

4.3. Prepare instrument packages – Assemble the sampling systems into the instrument enclosures, including data acquisition system. The sampling systems will be comprised of a 2BTechnology Model 205 dual-beam ozone monitor, a UV-LED NO_2 photocell, ruggedized industrial fanless PC with integrated 4G cellular modem, all-in-one GPS-weather station, and cooling components. One system may also have the ceilometer installed, provided the boat operator can provide a suitable space and an appropriate mounting system can be fabricated for the location. If it is not feasible to install the ceilometer onto one of the vessels, the ceilometer will be integrated into the UH monitoring trailer at Smith Point.

Due date: February 28, 2021
Responsible organization: University of Houston with assistance from St. Edward's University
Deliverables: Updates and documentation of completed instrument packages in MTRs.

4.4. Install instrument packages on commercial vessels and begin collecting data – Install instrument packages aboard the two boats and collect ambient O_3, weather, position, and boundary layer height information. Maintain instruments with scheduled and unscheduled visits for filter changes, preventative maintenance, and repairs.

Automatically backup data to multiple systems on the UH campus for archival and data processing, display, editing, and validation.

Due date: within 14 days of completing instrument package preparation through August 31, 2021.
Responsible organization: University of Houston with assistance from St. Edward's University
Deliverables: Documentation of instrument package installation and preliminary data plots of field data in MTRs.

4.5. R/V Mishepeshu operations – Prepare the UH-owned R/V Mishepeshu, a pontoon boat, for launching O_3 sondes in Galveston Bay. This will include a complete inspection and tune-up by a professional boat service company as well as a refurbishment of needed components since this boat has been stored outside. The addition of lights, electrical power, helium cylinder storage, and other sonde launching and tracking updates will also be included in this task. Safety equipment for all personnel on the boat as well as Texas Parks and Wildlife Boater education courses for faculty and staff in charge of leading boat operations will be provided. Pre-launch approvals from the FAA will also be acquired, and notifications will be provided to appropriate agencies based on FAA procedures. During April-August 2021 morning and afternoon ozonesonde launches will be conducted on high O_3 days, days when local bay breeze circulations are expected to impact local O_3 levels, and on days which may aid in data analysis and modeling studies.

Due date: All preparations completed by March 31, 2021; Operational window April-August 2021.
Responsible organization: University of Houston and St. Edward's University
Deliverables: Documentation of instrument R/V Mishepeshu status and preliminary data plots of field data in MTRs.

4.6. Data analysis and modeling - Data analysis will include statistical and correlation as well as an assessment of spatial and diurnal trends. Geospatial tools will be used to assess whether certain areas exhibit consistent patterns of high ozone or large variability. Data will also be separated by area, such as within Galveston Bay or in the Gulf of Mexico, over open water or near shore, and proximity to shipping lanes. Meteorological conditions will also be considered when analyzing this data set. Back trajectories will be used to determine the source and of the air mass with open water, land, or areas of known or suspected emissions. Data will be binned by days dominated by local circulation and days dominated by synoptic flows, as well as photochemically active vs. low O_3 days. Ozonesonde analysis will use same-day morning and afternoon launches to examine how residual layer ozone correlates with the boundary layer ozone for select days in Galveston Bay, with a focus on high ozone episodes. Our expectation is that the morning/afternoon profile comparison in Galveston Bay will be rather different than what is often observed from inland locations.

Additional sources of data will likely include analysis of winds aloft from the radar wind profiler and boundary layer heights at La Porte (Questions 3, 4). Trace gases such as O_3 and NO_X from land-based sites including Smith Point (C1606), Seabrook Friendship Park (C45), and La Porte Sylvan Beach (C556, O_3 only), and Galveston 99th St. (C1034) will be used to assess the relative difference between O_3 over the bay and coastal waters and whether the differences observed between measurements on water and land may be due to titration from NO_X emissions (Questions 1, 2).

An assessment of the suitability for installing small sampling packages aboard commercial vessels will also be provided. This assessment will consider the area of operations, access, cost, utility of the data generated, and specific challenges that were encountered as a result of the sampling approach (Question 5). This assessment will help guide future experiments that may take place in Galveston Bay, the Gulf of Mexico, or other coastal areas that may experience similar conditions. Suggestions for potential improvements and/or changes in operations will also be included.

All the observational data collected (chemical and meteorological) will be compared to the corresponding outputs from a 3-D chemical transport model, Weather Research and Forecasting (WRF) - driven GEOS-Chem (WRF-GC) (Lin et al., 2020). The model will simulate ozone distributions in the HGB region during the measurement periods with a focus on ozone over the water and land-water ozone gradient. WRF has a powerful and flexible grid system, including multiple nested grids and moving nested grids. For the proposed work, the inner-most model domain of WRF-GC will be set over the sampling areas (i.e. the Galveston Bay) at a resolution of 1 km x 1 km. The advantage of fine-resolution meteorology that comes with WRF will allow replications of fine-scale temporal and spatial dynamics specific to coastal regions such as sea/bay breeze. The GEOS-Chem model has a state-of-the-science, well-documented, and benchmarked chemical module that fully couples gaseous and aerosol chemistry, including the recent development of halogen chemistry, which is of particular utility for coastal environments. Combining the advantages of the two models, WRF-GC will allow us to simulate the chemical and dynamical complexity of the proposed field measurements.

The WRF-GC modeling analysis will address Questions 1-4. Specifically, we will analyze the spatiotemporal consistency (or inconsistency) between simulated and observed ozone patterns and high ozone events over Galveston Bay and GOM (Question 1) and between simulated and observed boundary layer heights and other meteorological parameters such as winds (Question 3). The model-to-observation differences will be binned by sampling locations (over waters vs. on the coast), weather conditions (e.g. high vs. low temperature), circulation patterns (sea breeze days vs. synoptic flow days), NO_X levels, and other factors that will emerge from the analysis. These composite comparisons will reveal possible drivers of model biases and help answer Questions 2 and 3.

After we have a good understanding of model performance and biases under different conditions, we will select different ozone cases (e.g. high ozone over water and high ozone over land) to better identify and attribute the gaps within the models that need to be improved. The focus of this analysis will be on ozonesonde measurements that capture the vertical structure of coastal environments (over land and over water). We will add tagged tracers in the model to represent different air masses and conduct perturbation simulations to probe the impact of different processes (or key parameters for a given process) on model performance such as but not limited to PBL height, ozone deposition over water, halogen chemistry, and shipping emissions.

All project participants fully intend to complete all project activities and expend all funds by August 31, 2021. Under the current federal, state, local, and university guidelines in place with respect to COVID-19, we do not anticipate difficulties in successfully completing the project. During the previous "stay-at-home" order the UH field team was designated as essential personnel and allowed to continue operations. Likewise, our commercial operators are commercial operators producing food and providing logistical support to international commerce and are unlikely to be significantly affected as essential operations. All work will be performed in compliance with all federal, state, local, and university safety guidelines. In the event conditions beyond our control change and we are required by federal, state, local, or university guidelines to adjust our operations, the AQRP program manager will be notified immediately.

Due date: August 31, 2021
Responsible organization: University of Houston and St. Edward's University
Deliverable: Final Report and associated data, per Section 4.7 below.

4.7. Project reporting and presentation – As specified in Section 0 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 Project 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.

Due Date: The schedule for Task 4.7 Deliverables are shown in Section 0.
Responsible organization: University of Houston with assistance from St. Edward's University

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

5. Project Participants and Responsibilities

Below is a bulleted list that summarizes the individual participants and their responsibilities.

University of Houston

- James Flynn, Project PI – Responsible for overall project management and reporting as well as providing oversight for instrument preparation and deployment. Will coordinate all team efforts as well as interfacing with boat operators and ensuring the UH boat is maintained and operated in a responsible manner.
- Yuxuan Wang, Co-PI – Oversight of the modeling and analysis portion of the project, which will be led by a graduate student. Incorporates measurements from the project and supporting sources into model analysis. Assists in project management and reporting.

St. Edward's University

- Paul Walter, Co-PI – Responsible for training of UH and SEU personnel for ozonesonde preparation and launch procedures, ozonesonde preparation, launch, and decision making for days to launch, in consultation with project team members. Will lead SEU portion of the project including reporting to UH and assists in instrument package development and deployment.
- Gary Morris, Co-PI – Responsible for obtaining FAA approvals for ozonesonde launches. Leads ozonesonde data processing and analysis. Assists with project management and reporting.

6. Timeline

Task and description	Timeline
4.1 Develop Work Plan	April 27 – May 11, 2020
4.2 Purchase equipment and major components	Within 30 days of receiving AQRP issued start date
4.3 Prepare instrument packages	To begin with Notice to Commence and completed by February 28, 2021.
4.4 Install instrument packages on commercial vessels and begin collecting data	Within in 14 days of completion of instrument package preparation through August 31, 2021
4.5 R/V Mishepeshu operations	Preparations to begin with AQRP issued start date and be completed by March 31, 2021. Ozonesonde launches to be conducted April-August 2021.
4.6 Data analysis and modeling	Data analysis to begin as the observational data come in. 3-D modeling setup to begin in April 2021 after the first month's observational data are collected.
4.7 Project reporting and presentation	Continuous from Notice to Commence through October 29, 2021 (Quarterly Report #6). Draft Final Report due August 2, 2021, AQRP presentations in August 2021, Final Report due August 31, 2021. Additional details on specific project reporting can be found in Section 0.

7. 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 Project 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: Friday, July 31, 2020

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.

Quarterly Report Due Dates:

Report	Period Covered	Due Date
Quarterly Report #1	May, June, July 2020	Friday, July 31, 2020
Quarterly Report #2	August, September, October 2020	Friday, October 30, 2020
Quarterly Report #3	November, December 2020, January 2021	Friday, January 29, 2021
Quarterly Report #4	February, March, April 2021	Friday, April 30, 2021
Quarterly Report #5	May, June, July 2021	Friday, July 30, 2021

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.

MTR Due Dates:

Report	Period Covered	Due Date
Technical Report #1	Project Start - June 30, 2020	Friday, July 10, 2020
Technical Report #2	July 1 - 31, 2020	Monday, August 10, 2020
Technical Report #3	August 1 - 31, 2020	Thursday, September 10, 2020
Technical Report #4	September 1 - 30 2020	Friday, October 9, 2020
Technical Report #5	October 1 - 31, 2020	Tuesday, November 10, 2020
Technical Report #6	November 1 - 30, 2020	Thursday, December 10, 2020
Technical Report #7	December 1 - 31, 2020	Friday, January 8, 2021
Technical Report #8	January 1 - 31, 2021	Wednesday, February 10, 2021
Technical Report #9	February 1 - 28, 2021	Wednesday, March 10, 2021
Technical Report #10	March 1 - 31, 2021	Friday, April 9, 2021
Technical Report #11	April 1 - 30, 2021	Monday, May 10, 2021
Technical Report #12	May 1 - 31, 2021	Thursday, June 10, 2021
Technical Report #13	June 1 - 30, 2021	Friday, July 9, 2021
Technical Report #14	July 1 - 31, 2021	Tuesday, August 10, 2021

DUE TO 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.

FSR Due Dates:

Report	Period Covered	Due Date
FSR #1	Project Start - June 30, 2020	Wednesday, July 15, 2020
FSR #2	July 1 - 31, 2020	Friday, August 14, 2020
FSR #3	August 1 - 31, 2020	Tuesday, September 15, 2020
FSR #4	September 1 - 30 2020	Thursday, October 15, 2020
FSR #5	October 1 - 31, 2020	Friday, November 13, 2020
FSR #6	November 1 - 31, 2020	Tuesday, December 15, 2020
FSR #7	December 1 - 31, 2020	Friday, January 15, 2021
FSR #8	January 1 - 31, 2021	Monday, February 15, 2021
FSR #9	February 1 - 28, 2021	Monday, March 15, 2021
FSR #10	March 1 - 31, 2021	Thursday, April 15, 2021
FSR #11	April 1 - 30, 2021	Friday, May 14, 2021
FSR #12	May 1 - 31, 2021	Tuesday, June 15, 2021
FSR #13	June 1 - 30, 2021	Thursday, July 15, 2021
FSR #14	July 1 - 31, 2021	Friday, August 13, 2021
FSR #15	August 1 - 31, 2021	Wednesday, September 14, 2021
FSR #16	Final FSR	Friday, October 15, 2021

DUE TO GRANT MANAGER

Draft Final Report: A Draft Final Report will be submitted to the AQRP 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: Monday, August 2, 2021

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: Tuesday, August 31, 2021

Project Data: All project data including but not limited to quality assurance (QA) and quality control (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 20, 2021). 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 2021.

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. References

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9. Addendum

In order to more completely quantify the photochemical state over the water, a photolytic NO_2 converter such as the blue light converter (BLC) from Teledyne API (previously produced by Air Quality Design (Wheat Ridge, CO, USA)) can be placed upstream of the ozone instrument sample inlet. While the BLC is typically used for photolysis conversion of NO_2 to NO for chemiluminescent detectors, it can also be used in conjunction with an ozone instrument to measure NO_2. When NO_2 is photolyzed, it forms O_3 in addition to NO. By using the BLC upstream of the O_3 instrument, the enhancement in signal when the BLC lamps are on is proportional to the ambient NO_2. Taking the difference between measured O_3 when the BLC lamps are off and O_X ($NO_2 + O_3$) when the lamps are on, ambient NO_2 can be calculated. This would directly address science questions 1-3. If the budget allows, each automated system installed on the commercial boats could be augmented with a BLC, LabJack U3-HV, and associated plumbing and electrical connectors. Additional calibration and instrument characterization would be required, but can easily be performed in the labs at UH as well as in the field during quarterly calibrations. No additional calibration supplies would be needed for this project. The same equipment would be used to characterize the NO_2 conversion of this system as is used to characterize and standardize the NO_2 measurements as part of the UH HNET system, allowing for direct comparisons to other NO_2 monitors, such as the one deployed during ozone season to Smith Point (C1606).