582-14-40051-FY14-01
Task 3.1.1

Oil and Gas Emission Inventory, Eagle Ford Shale

QUALITY ASSURANCE PROJECT PLAN (QAPP)

Level III

March 20th, 2014

Prepared by:

Alamo Area Council of Governments

Prepared in Cooperation with the
Texas Commission on Environmental Quality

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APPROVAL SHEET

This document is a Quality Assurance Project Plan (QAPP) for the Oil and Gas Emission Inventory of the Eagle Ford Shale.

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During the course of the project, any revision to the QAPP will be circulated to everyone on the distribution list. Paper copies need not be provided to individuals if equivalent electronic information systems can be used.

1 PROJECT DESCRIPTION AND OBJECTIVES

AACOG has prepared this Level III Quality Assurance Project Plan (QAPP) for the Texas Commission on Environmental Quality (TCEQ) following EPA guidelines. The nature of the technical analysis and tasks to be conducted as part of this project are consistent with quality assurance (QA) Category III – National Risk Management Research Laboratory (NRMRL) QAPP requirements for secondary data projects. This QAPP is in effect for the duration of this project, March 1st, 2014 through August 14th, 2015. All calculations and results in this project will be completed with new production data, new emission factors, new methodologies, and/or new survey results.

1.1 Purpose of Study

The Clean Air Act (CAA) is the comprehensive federal law that regulates airborne emissions across the United States.[1] This law authorizes the U.S. Environmental Protection Agency (EPA) to establish National Ambient Air Quality Standards (NAAQS) to protect public health and the environment. Of the many air pollutants commonly found throughout the country, EPA has recognized six "criteria" pollutants that can injure health, harm the environment, and/or cause property damage. Air quality monitors measure concentrations of these pollutants throughout the country. Although the San Antonio area has recorded ozone concentrations in violation of the 2008 ozone standard since August 2012, the timing of the violations was late enough in the NAAQS review cycle that the area was not included in EPA's designation process and the region avoided a non-attainment designation. Ozone is produced when volatile organic compounds (VOC) and nitrogen oxides (NO_X) react in the presence of sunlight, especially during the summer time.[2] These ozone precursors can be generated by natural processes, but the majority of chemicals that form ground-level ozone originate from anthropogenic sources.

To conduct analysis that determines the emission reductions required to bring the area into compliance with the standards, local and state air quality planners need an accurate temporal and spatial account of emissions and their sources in the region. The compilation of the Eagle Ford emissions inventory (EI) requires extensive research and analysis. By understanding these varied sources that create ozone precursor pollutants, planners, political leaders, and citizens can work together to protect heath and the environment. This assessment provides key information on the impact of increased oil and gas production in the Eagle Ford Shale. The project will update the previous Eagle Ford emission inventory completed under 582-11-11219 contract Amendment Number 5, Task 2, Project II delivered to TCEQ on December 19th, 2013.

1.2 Project Objectives

"The Eagle Ford Shale is a hydrocarbon producing formation of significant importance due to its capability of producing both gas and more oil than other traditional shale plays. It contains a much higher carbonate shale percentage, upwards to 70% in south Texas, and becomes shallower and the shale content increases as it moves to the northwest. The high

[1] US Congress, 1990. "Clean Air Act". Available online: http://www.epa.gov/air/caa/. Accessed: 07/19/2010.
[2] EPA, Sept. 23, 2011, "Ground-level Ozone". Available online: http://www.epa.gov/air/ozonepollution/. Accessed: 10/31/2011.

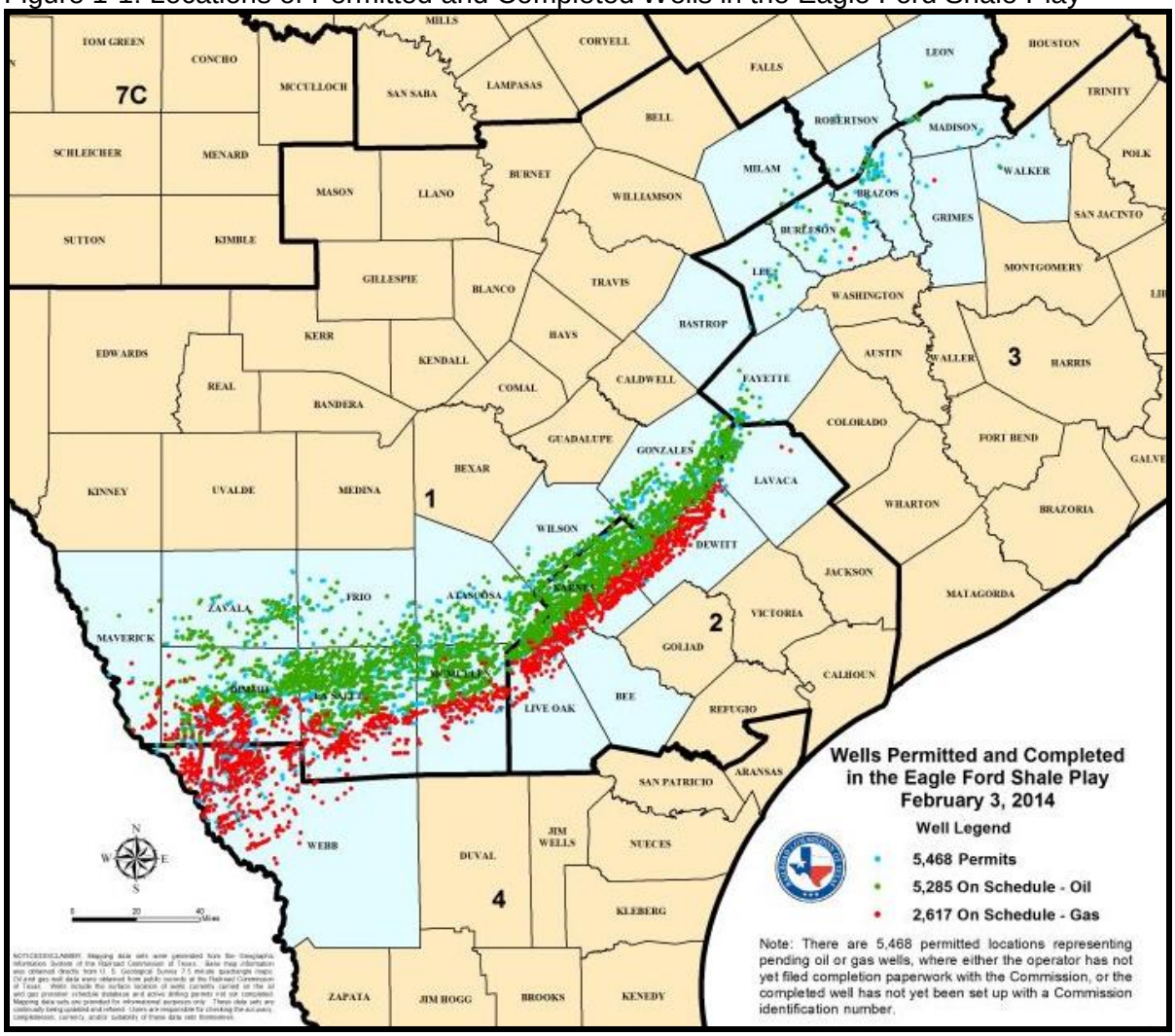
percentage of carbonate makes it more brittle and 'fracable'."[3] Hydraulic fracturing is a technological advancement which allows producers to recover natural gas and oil resources from these shale formations. Today, significant amounts of natural gas and oil from deep shale formations across the United States are being produced through the use of horizontal drilling and hydraulic fracturing.[4]

Hydraulic fracturing is the process of creating fissures, or fractures, in underground formations to allow natural gas and oil to flow up the wellbore to a pipeline or tank battery. In the Eagle Ford Shale, product is extracted by pumping "water, sand and other additives under high pressure into the formation to create fractures. The fluid is approximately 98% water and sand, along with a small amount of special-purpose additives. The newly created fractures are "propped" open by the sand, which allows the natural gas and oil to flow into the wellbore and be collected at the surface. Variables such as surrounding rock formations and thickness of the targeted shale formation are studied by scientists before fracking is conducted."[5]

Eagle Ford counties and the location of permitted wells are provided in Figure 1-1. Oil wells on schedule are marked in green, gas wells on schedule are marked in red, and permits are highlighted in blue. Most of the wells are concentrated in the core area. There are also a significant number of wells in the southwest section of the Eagle Ford, while there are very few wells in the northern counties of the Eagle Ford. The project objective is to develop an oil and gas emission inventory of hydraulic fracture activities and wells in the counties highlighted on the map.

[3] Railroad Commission of Texas, May 22, 2012. "Eagle Ford Information". Austin, Texas. Available online: http://www.rrc.state.tx.us/eagleford/index.php. Accessed 05/30/2012.
[4] *Ibid*.
[5] *Ibid*.

Figure 1-1: Locations of Permitted and Completed Wells in the Eagle Ford Shale Play[6]



[6] Railroad Commission of Texas, February 3rd, 2014. "Wells Permitted and Completed in the Eagle Ford Shale Play". Austin, Texas. Available online: http://www.rrc.state.tx.us/eagleford/images/EagleFordShalePlay021214-lg.jpg. Accessed: 02/13/2014.

2 PROJECT ORGANIZATION AND RESPONSIBILITIES

2.1 Responsibilities of Project Participants

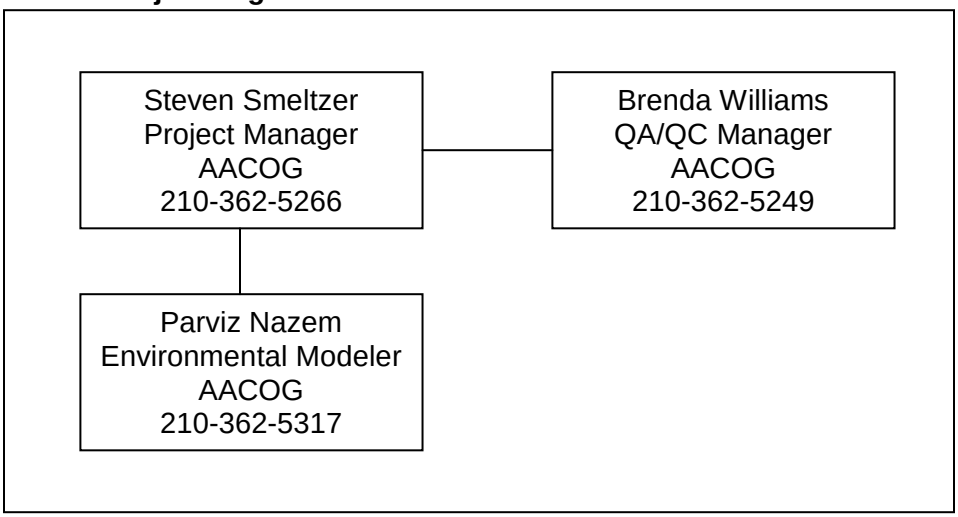
This study will be conducted by Alamo Area Council of Governments (AACOG) under 582-14-40051-FY14-01 contract to the Texas Commission on Environmental Quality (TCEQ). Staff working on this project and their specific responsibilities are listed below. "The project manager is ultimately responsible for assessing whether the performance and acceptance criteria for the intended modeling use were met and works iteratively with the intended users of the results."[7]

Figure 2-1: AACOG's project team participants and their responsibilities.

Participant	Project Responsibility
Steven Smeltzer	Project manager and expert on developing emission inventories including previous Eagle Ford emission inventory. He will ensure the project implementation follows all contract requirements and that project quality standards are met on all deliverables. He will assist in interactions with TCEQ as required.
Parviz Nazem	Expert on developing emission inventory and will be responsible for collecting and analyzing raw production data
Brenda Williams	Expert on emission inventory and will be responsible for implementing project review and quality assurance

In addition, TCEQ staff will participate in the review of the technical documentation generated during this project.

2.2 Project Organization Chart



[7] EPA, December, 2002. "Guidance for Quality Assurance Project Plans for Modeling EPA QA/G-5M". EPA/240/R-02/007. Washington, DC. Available online: http://www.epa.gov/quality/qs-docs/g5m-final.pdf. Accessed 02/13/2014.

2.3 Project Schedule

Emission inventory development will be performed in three steps: (1) Update of a 2012 Eagle Ford emission inventory for Texas, (2) Update of 2018 Eagle Ford emission inventory for Texas, and (3) Update of input files in EPS3 format for the 2012 and 2018 Eagle Ford emission inventory. The table below shows the overall schedule for completion of this project.

Figure 2-2. Summary of project schedule and milestones.

Work Element	Deliverable Date
Deliverable 3.1.1: QAPP	
Drafts submitted to TCEQ for review and approval	March 31st, 2014
Deliverable 3.1.2: Final Report	
Draft Report	June 31st, 2015
Final Report and EPS3 emission files	August 14th, 2015

3 SCIENTIFIC APPROACH

3.1 Data Needed

Data used for this project will be comprehensive and scientific significant surveys, reports, or data that can be used to determine emissions from oil and gas activities in the Eagle Ford. For the purposes of this study, the emission inventory will be developed for the five main phases of activity.

- Exploration and Pad Construction: During exploration, vibrator trucks produce sound waves beneath the surface to help determine subsurface geologic features. Construction of the drill pad requires clearing, grubbing, and grading, followed by placement of a base material by construction equipment and trucks. Reserve pits are also usually required at each well pad because the drilling and hydraulic fracturing process uses a large volume of fluid that is circulated through the well and back to the surface.
- Drilling Operation: "Drilling of a new well is typically a two to three week process from start to finish and involves several large diesel-fueled generators."[8] Other emission sources related to drilling operations include construction equipment and trucks to haul supplies, equipment, fluids, and employees.
- Hydraulic Fracturing and Completion Operation: Hydraulic fracturing "is the high pressure injection of water mixed with sand and a variety of chemical additives into the well to fracture the shale and stimulate natural gas production from the well. Fracking operations can last for several weeks and involve many large diesel-fueled generators"[9] "Once drilling and other well construction activities are finished, a well must be completed in order to begin producing. The completion process requires venting of the well for a sustained period of time to remove mud and other solid debris in the well, to remove any inert gas used to stimulate the well (such as CO_2 and/or N_2) and to bring the gas composition to pipeline grade".[10] In the Eagle Ford, gas vented during the completion process is usually flared.
- Production: Once the product is collected from the well, emissions might be released at well sites from compressors, flares, heaters, and pneumatic devices. There can also be significant emissions from equipment leaks, storage tanks, and loading operations fugitives. Trucks are often used to transport product to processing facilities and refineries.
- Midstream Sources: Midstream sources in the Eagle Ford consist mostly of compressor stations and processing facilities, but other facilities can include cryogenic plants, saltwater disposal facilities, tank batteries, and other facilities. "The most significant emissions from compressors stations are usually from combustion at the compressor engines or turbines. Other emissions sources may include equipment leaks, storage tanks, glycol dehydrators, flares, and condensate and/or wastewater loading. Processing facilities generally remove impurities from

[8] University of Arkansas and Argonne National Laboratory. "Fayetteville Shale Natural Gas: Reducing Environmental Impacts: Site Preparation". Available online: http://lingo.cast.uark.edu/LINGOPUBLIC/natgas/siteprep/index.htm. Accessed: 04/20/2012.

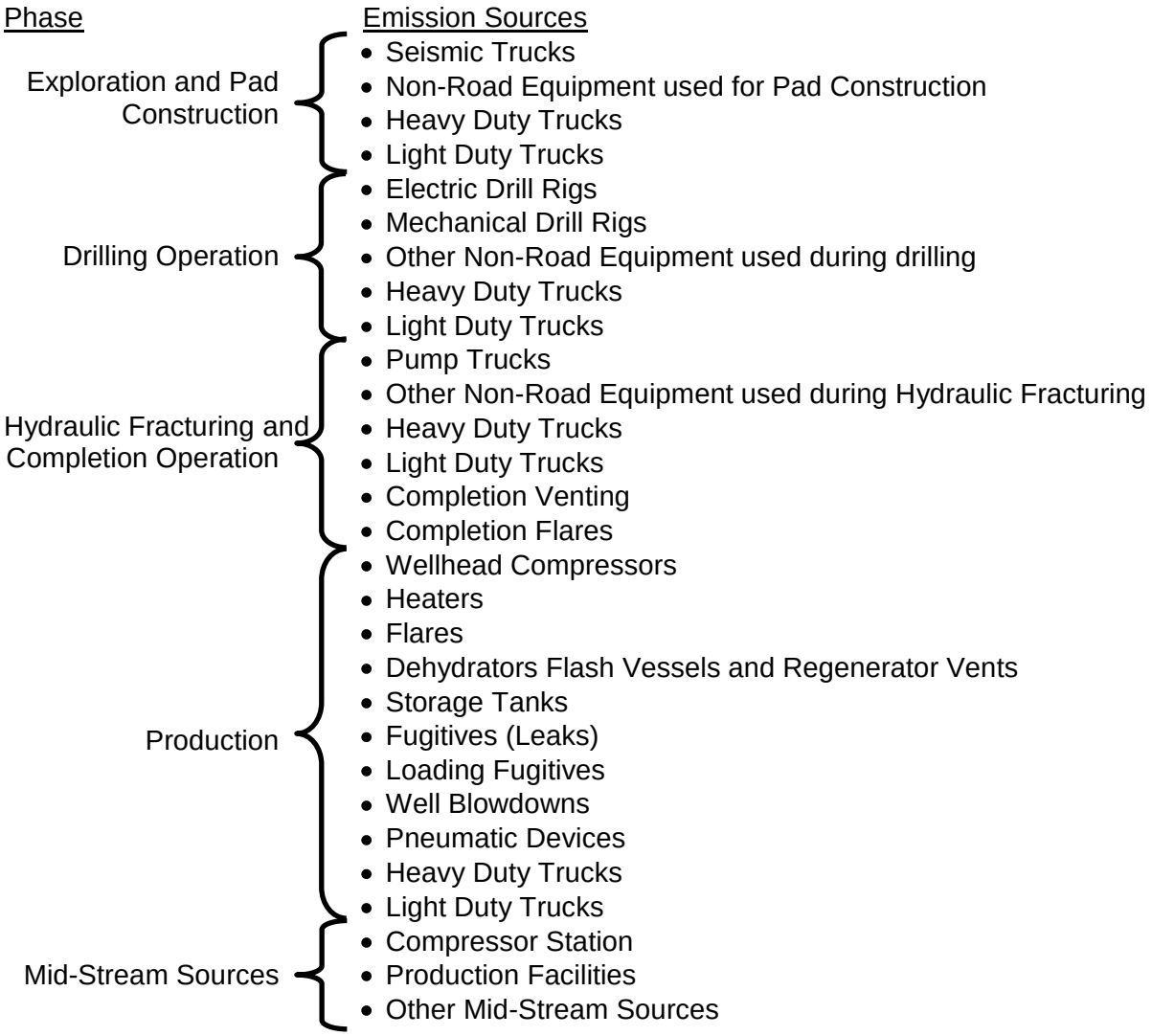
[9] *Ibid*.

[10] Amnon Bar-Ilan, Rajashi Parikh, John Grant, Tejas Shah, Alison K. Pollack, ENVIRON International Corporation. Nov. 13, 2008. "Recommendations for Improvements to the CENRAP States' Oil and Gas Emissions Inventories". Novato, CA. p. 48. Available online: http://www.wrapair.org/forums/ogwg/documents/2008-11_CENRAP_O&G_Report_11-13.pdf. Accessed: 04/30/2012.

> the natural gas, such as carbon dioxide, water, and hydrogen sulfide. These facilities may also be designed to remove ethane, propane, and butane fractions from the natural gas for downstream marketing. Processing facilities are usually the largest emitting natural gas-related point sources including multiple emission sources such as, but not limited to equipment leaks, storage tanks, separator vents, glycol dehydrators, flares, condensate and wastewater loading, compressors, amine treatment and sulfur recovery units."[11]

Below is a list of emission sources for each phase of operation. Emission sources include non-road equipment, generators, drill rigs, on-road vehicles, compressors, fugitive emissions, and flare combustion. TCEQ's point source database will be checked to avoid double counting emissions from mid-stream sources or large wellhead compressor facilities, All other area and non-road emissions will be calculated only at the well head site. Data on the area and non-road sources are based on data from the Barnett Special Inventory at wellhead sites and does not include Barnett Special Inventory activity data at mid-stream sources. TCEQ point source database only include emissions at some mid-stream sources.

[11] Eastern Research Group Inc. July 13, 2011. "Fort Worth Natural Gas Air Quality Study Final Report". Prepared for: City of Fort Worth, Fort Worth, Texas. p. 3-2. Available online: http://fortworthtexas.gov/gaswells/?id=87074. Accessed: 04/09/2012.



AACOG's Eagle Ford emissions inventory will omit some infrequent, ancillary, and indirect sources. Non-routine emissions, such as those generated during upsets or from maintenance, startup, and shutdown activities, will be excluded from the emission inventory, with the exception of blowdowns from gas wells. The emission inventory will not include construction of mid-stream facilities, building offices, quarrying of fracturing sands, pipeline construction, etc. Generators and other equipment at camp houses and offices used by oil field workers are not part of the emission inventory. Emission sources outside of the Eagle Ford shale region that are directly or indirectly affected by the shale development are not included. The emission inventory does not include trucks that bring supplies to mid stream sources, worker camps, and other facilities not located at the well head. Emissions from the production of cement, steel pipes, and other non-recycled material are not included in the emission inventory. The emission inventory excludes emissions from railroad activity related to Eagle Ford development. Railroads carry fracturing sands, pipelines, petroleum products, equipment, building materials, and other supplies to production sites in the Eagle Ford.

3.2 Sources of Data to be Used

A variety of data sources will be used to estimate emissions from Eagle Ford oil and gas production. Whenever possible, local data will be used to calculate emissions and project future production. The data and methods used in developing the emission inventory should be peer-reviewed and should be consistent with best current scientific practices. Any industry data will be well documented including the results from any surveys. Well characteristics and production amounts will be collected from Schlumberger and the Railroad Commission of Texas. Non-road equipment emissions will be calculated using local industry data, emission factors from ERG's Statewide Drilling Rigs Emission Inventories for the Years 1990, 1993, 1996, and 1999 through 2040,[12] latest version of TexN model, equipment manufacturers, TCEQ, and the results from Texas Center for Applied Technology (TCAT) at Texas A&M University System surveys.[13] Compressor engine emissions will be based on TCEQ's Barnett Shale Special Inventory (Table 3-1). Compressor engines emissions factors will be updated with the latest production data from the Railroad Commission of Texas and any updates from final results from the Barnett special. All emissions source calculations will include updated production data. Calculations will also include any updated activity data including horsepower, fuel usage, and fugitive emissions from surveys. As part of this process, spatial allocation factors will also be updated with new well data location from the Railroad Commission of Texas. Calculations will not repeat what was perform during the previous Eagle Ford Emission Inventory,

Production emission calculations will be based on data produced from TCEQ's Barnett Shale special inventory. Other sources for production emissions included local industry data, ERG's Texas emission inventory, ENVIRON's CENRAP emission inventory, Railroad Commission of Texas, and AP42 emission factors for flares (Table 3-2). On-road data sources, as listed in Table 3-3, are from NCTCOG's study in the Barnett Shale, TxDOT's study also in the Barnett Shale, and ENVIRON's Colorado report. Emission factors for heavy duty and light duty trucks will be produced by the MOVES model and from EPA. All emission calculations will be updated with new activity data from the Railroad Commission of Texas, and surveys conducted by AACOG. The Eagle Ford activity and production is changing rapidly because the field is new and technology is changing rapidly. The final results from the Barnett Special inventory, TCEQ pneumatic survey, drill rigs and pump engine surveys can change the emission factors for compressor engines, pneumatic devices, heaters, fugitives, drill rigs, hydraulic pump engines, non-road equipment used at drilling sites, and mid-stream sources.

[12] Eastern Research Group, Inc., August 15, 2011. "Development of Texas Statewide Drilling Rigs Emission Inventories for the Years 1990, 1993, 1996, and 1999 through 2040". TCEQ Contract No. 582-11-99776. Austin, Texas. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821199776FY1105-20110815-ergi-drilling_rig_ei.pdf. Accessed 10/24/2013.

[13] Texas Center for Applied Technology (TCAT), Nov. 2011. "Environmentally Friendly Drilling Systems Program Hydraulic Fracturing Phase Emissions Profile (Air Emissions Field Survey No. 1)". San Antonio, Texas. p. 2.

Table 3-1: Data Sources for Non-Road Equipment Emissions

Source Category	Population	Horsepower	Hours/Fuel Usage	Load Factor (LF)	Emission Factors
Seismic Trucks	Local Industry Data	Equipment Manufactures	Local Industry Data	TexN Model	TexN Model
Pad Construction Eq.	San Juan Inventory[14] (Colorado)	San Juan Inventory (Colorado)	San Juan Inventory (Colorado)	TexN Model	TexN Model
Electric Drill Rigs	Local Industry Data	Survey Results	Survey Results	Local Industry Data/ TexN Model	TCEQ
Mechanical Drill Rigs	Local Industry Data	Local Industry Data	Local Industry Data	ERG Drill Rig EI	ERG Drill Rig EI
Other Non-Road Eq. used during Drilling	Local Industry Data	Local Industry Data	Based on Time to Drill a well	TexN Model	TexN Model
Pump Trucks	TCAT Survey, Survey Results, and Ariel Imagery	Survey Results	Survey Results	Local Industry Data	TCEQ
Other Non-Road Eq. used during Fracturing	TCAT Survey	TCAT Survey, Local Industry Data, & TexN Model	Based on Time to Fracture a well	TexN Model	TexN Model
Wellhead Compressors	Barnett Shale Special Inventory	Barnett Shale Special Inventory	Barnett Shale Special Inventory	Barnett Shale Special Inventory	Barnett Shale Special Inventory, ENVIRON CENRAP EI (Western Gulf)[15], and TexN Model
Compressor Stations, Production facilities, Cryogenic Plants, etc.	Emissions from TCEQ Permit Data[16] and Barnett Shale Special Inventory				

[14] BLM National Operations Center, Division of Resource Services, December, 2007. "San Juan Public Lands Center Draft Land Management Plan & Draft Environmental Impact Statement: Air Quality Impact Assessment Technical Support Document". Bureau of Land Management, San Juan Public Lands Center, Durango, Colorado. Available online: http://ocs.fortlewis.edu/forestplan/DEIS/pdf/120507_TSD&App%20A.pdf. Accessed: 04/03/2012.
[15] Amnon Bar-Ilan, Rajashi Parikh, John Grant, Tejas Shah, Alison K. Pollack, ENVIRON International Corporation. Nov. 13, 2008. "Recommendations for Improvements to the CENRAP States' Oil and Gas Emissions Inventories". Novato, CA. Available online: http://www.wrapair.org/forums/ogwg/documents/2008-11_CENRAP_O&G_Report_11-13.pdf. Accessed: 04/30/2012.
[16] TCEQ. "TCEQ Document Search". Available online: https://webmail.tceq.state.tx.us/gw/webpub. Accessed 06/08/2012.

Table 3-2: Data Sources for Fugitives, Flaring, Breathing Loss, and Loading Emissions

Source Category	Amount and Heat Content	Activity/Population	Emission Factors
Completion Venting	ERG's Texas EI (Western Gulf)[17]	Local Industry Data	ERG's Texas EI (Western Gulf)
Flaring	ENVIRON CENRAP EI (Western Gulf)	ENVIRON CENRAP EI (Western Gulf) and Local Industry Data	AP-42 Section 13.5[18]
Heaters	ERG Texas EI and ENVIRON CENRAP EI (Western Gulf)	Barnett Shale Special Inventory	Barnett Shale Special Inventory and ENVIRON CENRAP EI (Western Gulf)
Dehydrators	-	-	ERG Texas EI
Storage Tanks	-	-	ERG Texas EI and ERG's condensate tank study[19]
Fugitives from Natural Gas Wells	-	-	Barnett Shale Special Inventory
Fugitives from Oil Wells		-	ERG Texas EI
Loading Loss	-	-	AP42[20] and Local Meteorological Data[21]
Blowdowns	ENVIRON CENRAP EI (Western Gulf)	ENVIRON CENRAP EI (Western Gulf)	ERG's Texas EI (Western Gulf)
Pneumatic Devices	-	TCEQ Pneumatic Survey	TCEQ Pneumatic Survey

[17] Mike Pring, Daryl Hudson, Jason Renzaglia, Brandon Smith, and Stephen Treimel, Eastern Research Group, Inc. Nov. 24, 2010. "Characterization of Oil and Gas Production Equipment and Develop a Methodology to Estimate Statewide Emissions". Prepared for: Texas Commission on Environmental Quality Air Quality Division. Austin, Texas. p. 4-36. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820784003FY1026-20101124-ergi-oilGasEmissionsInventory.pdf. Accessed: 04/10/2012.

[18] EPA, Sept. 1991. "AP 42: Section 13.5 Industrial Flares". Available online: http://www.epa.gov/ttnchie1/ap42/ch13/final/c13s05.pdf. Accessed 05/20/2012.

[19] Eastern Research Group, Inc. Oct. 10, 2012. "Condensate Tank Oil and Gas Activities". Morrisville, NC. prepared for Texas Commission on Environmental Quality. p. 2-25. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5821199776FY1211-20121031-ergi-condensate_tank.pdf. Accessed 03/12/2013.

[20] EPA, June 2008. "AP42 - 5.2 Transportation And Marketing Of Petroleum Liquids". Available online: http://www.epa.gov/ttn/chief/ap42/ch05/final/c05s02.pdf. Accessed: 05/12/2012.

[21] National Oceanic and Atmospheric Administration (NOAA), National Climatic Data Center. July 1, 2011. "NOAA's 1981-2010 Climate Normals". Available online: http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html. Accessed: 04/30/2012.

Table 3-3: Data Sources for On-Road Vehicles Emissions

Vehicle Type	Process	Number of Vehicles	Distance Traveled or Hours Idling	Emission Factors
Heavy Duty Trucks	On-Road	NCTCOG (Barnett)[22]	Railroad Commission of Texas	MOVES Model[23]
	Idling	NCTCOG (Barnett)	ENVIRON Colorado Report[24]	MOVES Model
Light Duty Trucks	On-Road	ENVIRON Colorado Report	Railroad Commission of Texas	MOVES Model
	Idling	ENVIRON Colorado Report	ENVIRON Colorado Report	EPA based on MOVES model

NO_X emission estimates for all diesel equipment will be reduced to account for Texas Low Emission Diesel (TxLED) supplied in the following 19 counties included in the Eagle Ford[25].

- Atascosa
- Bee
- Brazos
- Burleson
- De Witt
- Fayette
- Goliad
- Gonzales
- Grimes
- Houston
- Karnes
- Lavaca
- Lee
- Leon
- Live Oak
- Madison
- Milam
- Washington
- Wilson

When the Eagle Ford emission inventory is completed, a number of improvements will be incorporated that were not included in the previous Eagle Ford emission inventory. All calculations and results in this project will be completed with new production data, new emission factors, new methodologies, and/or new survey results.

Drill Rig and Hydraulic Pump Survey

In the summer of 2013, AACOG conducted surveys of drill rigs and well pad hydraulic pump engines from oil and gas activity in the Eagle Ford. The surveys requested 2012 data on number of engines, hours of use, fuel consumption, controls on engines, total annual depth that drills rigs drilled, average percentage of time ancillary equipment was operated at drill sites, and the replacement rate of engines to meet Tier 4 standards. As part of the survey process, AACOG requested the drill rig and well pad hydraulic pump engines inventory from each company. The survey forms represented collaboration between AACOG and oil and gas industry representatives from the Eagle Ford emission inventory working group. New activity data will be from surveys conducted on oil and gas producers by AACOG and TCEQ, and new production data from the Texas Railroad Commission. No additional surveys are planned as part of this emission inventory update.

[22] Lori Clark, Shannon Stevenson, and Chris Klaus North Central Texas Council of Governments, August 2012. "Development of Oil and Gas Mobile Source Inventory in the Barnett Shale in the 12-County Dallas-Fort Worth Area". Arlington, Texas. Texas Commission on Environmental Quality Grant Number: 582-11-13174. pp. 11, 13. Available online: http://www.nctcog.org/trans/air/barnettshale.asp. Accessed 01/23/2013.

[23] Office of Transportation and Air Quality, August 2010. "MOVES". U.S. Environmental Protection Agency, Washington, DC. Available online: http://www.epa.gov/otaq/models/moves/index.htm. Accessed: 04/02/2012.

[24] Amnon Bar-Ilan, John Grant, Rajashi Parikh, Ralph Morris, ENVIRON International Corporation, July 2011. "Oil and Gas Mobile Sources Pilot Study". Novato, California. pp. 11-12. Available online: http://www.wrapair2.org/documents/2011-07_P3%20Study%20Report%20(Final%20July-2011).pdf. Accessed: 04/12/2012.

[25] Eastern Research Group, Inc. July 15, 2009. "Drilling Rig Emission Inventory for the State of Texas". Prepared for: Texas Commission on Environmental Quality. Austin, Texas. p. 6-18. Available online: http://www.tceq.texas.gov/assets/public/implementation/air/am/contracts/reports/ei/5820783985FY0901-20090715-ergi-Drilling_Rig_EI.pdf. Accessed: 04/09/2012.

A total of 9 companies responded to the survey including most of the major operators in the Eagle Ford. These companies reported on 94 drill rigs that represented 48 percent of the drill rigs operating in the Eagle Ford. For the questions about well pad hydraulic pump engines, the survey results included data on 340 engines that hydraulically fractured 1,289 wells in the Eagle Ford in 2012 (37 percent of the wells drilled).

Projection of Mid-Stream Sources

The projections of mid-stream sources for 2018 will be revised with updated equipment counts from TCEQ's permit database.[26] The previous Eagle Ford emission inventory projections are based on all permitted mid-stream sources between 2008 and April 2012. Mid-stream sources continue to expand rapidly in the Eagle Ford and may represent a larger emission source then what is reported in the previous emission inventory.

Stack Parameters of Mid Stream Sources

Stack parameters used in the June 2006 photochemical modeling episode for previous Eagle Ford mid-stream sources were based on similar facilities in TCEQ's point source emission inventory.[27] Eagle Ford mid-stream sources were split into crude petroleum and natural gas, natural gas liquids, natural gas transmission, and petroleum bulk stations and terminals. For each type, average stack height, stack diameter, temperature, and velocity were calculated from TCEQ's existing point source database. The updated Eagle Ford emissions inventory will have separate parameters for each process at an individual facility instead of average stack parameters for all processes at the facility.

TCEQ's Pneumatic Survey

As part of TCEQ's ongoing efforts to improve the area source oil and gas emissions inventory, the TCEQ requested "data associated with pneumatic devices operating at active gas well sites outside of the 23-county Barnett Shale area for calendar year 2011."[28] TCEQ requested "information regarding the total component count of pneumatic devices categorized according to type and bleed rate. This data will be used to evaluate volatile organic compounds (VOC) emissions estimates from pneumatic devices on the county-level."[29] TCEQ categorized component count of pneumatic devices according to type and bleed rate.[30] Since AACOG has not yet received a copy of the pneumatic survey results from TCEQ, it has not been determine how to incorporate the results in update Eagle Ford Emission Inventory.

TxDOT On-Road Traffic Counts

TxDOT collected short term traffic count data for 2012 in districts that are being impacted by oil, gas, and wind energy expansion activities.[31] Traffic count data was collected for 26 sites in the Eagle Ford from the TxDOT districts of Corpus, Laredo, Pharr, San Antonio, and Yoakum. Most of the 15 minute traffic counts were collected over one or two days. The data collected included data counts by vehicle classification for each traffic lane. By using this data, future inventories will account for temporal profiles collected by TXDOT for traffic in the Eagle Ford for each

[26] TCEQ, Jan. 2012. "Detailed Data from the Point Source Emissions Inventory". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/point-source-ei/psei.html. Accessed 06/01/2012.
[27] TCEQ, Nov. 28, 2012. "afs.osd_2006_STARS_extract_for_CB06_cat_so2_lcpRPO.v2.gz". Available online: ftp://amdaftp.tceq.texas.gov/pub/Rider8/ei/basecase/point/AFS/. Accessed 03/08/2013.
[28] TCEQ. "Area Source Emissions: Statewide Pneumatic Devices Survey". Austin, Texas. Available online: http://www.tceq.texas.gov/airquality/areasource/ASEI.html. Accessed 10/22/2013.
[29] *Ibid*.
[30] Keith Sheedy, P.E. Technical Advisor, Office of Air , TCEQ. "Statewide Update 2012". Austin, Texas. p.
[31]. Available online: www.tceq.texas.gov/assets/public/permitting/air/info/statewide-update.pptx. Accessed: 10/22/2013.
[31] Lorri Pavliska, Texas Department of Transportation, SAT District. San Antonio, Texas.

vehicle classification. Additional traffic count data will be researched and if available included in the Eagle Ford emission inventory.

Barnett Shale Special Inventory Final Results

TCEQ conducted a two-phase ozone precursor emission survey of Barnett Shale operations. The inventory collected data on "equipment and production information for emission sources associated with Barnett Shale oil and gas production, transmission, processing and related activities; air emissions authorizations for these sources; coordinates of sources located within one-quarter mile of the nearest receptor; and annual 2009 emissions for nitrogen oxides, volatile organic compounds, and hazardous air pollutants."[32] Through this process, TCEQ collected detailed information on production and midstream emission sources in the Barnett Shale including data on compressors, storage tanks, loading fugitives, production fugitive, heaters, and other sources. The Eagle Ford emission inventory calculations will be updated based on information that reflects the final results from the Barnett Shale special inventory.

Updated Spatial Allocation of Emissions

In the previous Eagle Ford emission inventory, pad construction, drilling operations, and hydraulic fracturing emissions were geo-coded to the location of all permitted Eagle Ford wells. Emissions from natural gas production were geo-coded to the location of natural gas wells in the Eagle Ford, while emissions from oil production were geo-coded to the location of oil wells. Emissions from condensate production were geo-coded to natural gas wells located in the condensate window.[33] The spatial allocation will be updated as new wells are permitted by the Railroad Commission of Texas. The spatial surrogates used for geo-coding all emission sources will be based on well locations by county.

3.3 Industry Involvement

Beginning in May 2012, AACOG convened a group of technical experts representing many of the major oil & natural gas producers in the Eagle Ford shale play in order to improve the Eagle Ford emissions inventory. These experts can assist with acquisition of improved activity data and/or an improved equipment inventory.

In the case that industry data provided to AACOG is judged as being valuable for use in updating data proposed for this deliverable, AACOG's Project Manager will contact TCEQ staff for advisements on including this data in the final deliverable report. If included, the data source will be clearly identified for the corresponding data in a manner that is consistent with all protocols contained in this QAPP.

3.4 Growth Factors

Emissions from Eagle Ford production are projected to continue to grow as oil and gas development increases over the next few years. Projection data will be reviewed for completeness before using the data to develop 2018 emission projections. Three different scenarios will be used to estimate future drill rig counts:

1. Low Development
2. Moderate Development
3. Aggressive Development

Emission factors for electric drill rigs and hydraulic pumps' Tier 2 generators will be based on emission factors for engines ≥ 750 from TCEQ's Texas Emissions Reduction Plan (TERP).[34]

[32] *Ibid*.
[33] Railroad Commission of Texas, 2012. "Digital Map Information". Austin, Texas.
[34] TCEQ, April 24, 2010. "Texas Emissions Reduction Plan (TERP): Emissions Reduction Incentive Grants Program Technical Supplement No. 2, Non-Road Equipment". Austin, Texas. p. 5.

NO_X emission factors for Tier 4 Interim and Tier 4 engines >900 bkW will be based on EPA's emission limit requirements,[35] while VOC and CO emission factors for these engines will be based on certified engine data from Caterpillar.[36]

The estimated activity rates, horsepower, load factors, and equipment populations of other non-road equipment used for pad construction, drilling, and hydraulic fracturing will be kept the same for each projection year. Emission factors for other non-road equipment will be projected using the latest version of the TexN model. To calculate on-road emissions, many parameters, such as number of on-road trips, vehicle speeds, vehicle types, distances travelled, and idling hours per trip during pad construction, and drilling, and hydraulic fracturing, were kept the same for each projection year. The number of vehicles, however, will be determined by multiplying future projections of wells drilled and emission factors were developed from the MOVES model.

To estimate emissions from production sources, future projections of oil, condensate, and natural gas were calculated. Projections of liquid and gas production in the Eagle Ford will be based on three factors,

1. The number of new production wells drilled each year
2. Estimated ultimate recovery (EUR) for each well
3. Decline curve for each well

Future projections of wells will be based on the number of drill rigs operating in the Eagle Ford. The number of new production wells will be based on the average number of days between spud to spud for each drill rig.

All state or federal mandated controls will be included in each projection scenario. Future projections will take into account EPA's amendments to air regulations for the oil and natural gas industry. "On April 17, 2012, the U.S. Environmental Protection Agency (EPA) issued cost-effective regulations to reduce harmful air pollution from the oil and natural gas industry while allowing continued, responsible growth in U.S. oil and natural gas production. The final rules include the first federal air standards for natural gas wells that are hydraulically fractured, along with requirements for several other sources of pollution in the oil and gas industry that currently are not regulated at the federal level."[37]

[35] California Environmental Protection Agency Air Resources Board, March 30, 2011. "New Off-Road Compression-Ignition Engines: Caterpillar Inc.".
[36] Caterpillar, 2011. "TIER 4 Interim EPA Emissions Requirements for Diesel Generator Sets".
[37] EPA, April 17th, 2012. "Overview of Final Amendments to Air Regulations for the Oil and Natural Gas Industry". Available online: http://www.epa.gov/airquality/oilandgas/pdfs/20120417fs.pdf. Accessed 10/21/2013.

4 QUALITY METRICS

In this section, the quality requirements for the data used in this study and the procedures for determining the quality of the data are described. Note that 10% of the data used in this study will be audited. After each section is completed, the QA/QC manager will check the data inputs into the formulas and will check all documentation on methodologies. All formulas will be recalculated by the QA/QC manager to make sure the results can be replicated and are accurate. The QA/QC manager will work closely with the project manager to update the calculations, emission estimates, and documentations. The results of the audit process will be provided in the draft and final emission inventory submitted to TCEQ.

4.1 Data

The data for Eagle Ford oil and gas activities must meet a number of requirements and include sufficient data to evaluate those requirements prior to use. The data must be reasonably consistent with other studies and the data must be sufficiently complete to be expected to adequately represent emissions. In addition, collected data will be assessed for missing data and outliers through communications with industry contacts, oil and gas sector experts, and trade group officials. The QA/QC has not been completed on the survey results, but the QA/QC will be included in the Updated Eagle Ford emission inventory.

4.2 Quality Control

The first component is that of quality control (QC), which is a system of routine technical activities implemented by inventory development personnel to measure and control the quality of the inventory as it is being developed. The QC system is designed to:

1. Provide routine and consistent checks and documentation points in the inventory development process to verify data integrity, correctness, and completeness;
2. Identify and reduce errors and omissions;
3. Maximize consistency within the inventory preparation and documentation process; and
4. Facilitate internal and external inventory review processes.

QC activities include technical reviews, accuracy checks, and the use of approved standardized procedures for emission calculations. These activities should be included in inventory development planning, data collection and analysis, emission calculations, and reporting."[38]

Equations, data sources, and methodology were checked throughout the development of the emission inventory. "Simple QA procedures, such as checking calculations and data input, can and should be implemented early and often in the process. More comprehensive procedures should target:

- Critical points in the process;
- Critical components of the inventory; and
- Areas or activities where problems are anticipated"[39]

Special emphases will be put on critical components, such as drill rigs and hydraulic fracturing pumps, for quality checks. Eagle Ford data developed through the emission inventory process will be compared to previous data sets from other shale oil and gas emission inventories. These data sets will be from other oil and gas emission inventories including emission factors and activity data. These reports can include ERG's Texas EI, Barnett Shale Special Inventory, ENVIRON CENRAP EI (Western Gulf), and TCEQ Pneumatic Survey.

[38] Eastern Research Group, Inc, Jan. 1997. "Introduction: The Value of QA/QC'. Quality Assurance Committee Emission Inventory Improvement Program, U.S. Environmental Protection Agency. p. 1.2-1. Available online: http://www.epa.gov/ttn/chief/eiip/techreport/volume06/vi01.pdf. Accessed 06/04/2012.

39 *Ibid*., p. 1.2-2.

Twenty five percent of calculations will be independently replicated to ensure accuracy. The project manager will ensure that all of the QA checks performed are compiled, and maintained in the project archives.

When errors and omissions are identified, they will be corrected and all documentation will be updated with the corrections. All emission inventory calculation methodologies will be documented and described in detail so external officials and other interested parties can replicate the results. For every emission inventory source, documentation will be consistent and contained data sources, methodology, formulas, and results.

Pertinent information and supporting statistics used for developing Eagle Ford emission inventory will be analyzed to ensure that the information and statistics are reasonable (i.e., avoiding extremely low or high values that are indicative of errors). Data that are found to be questionable will be examined in greater detail to determine what errors might be present and what adjustments might be needed. If data are revised, the procedures and assumptions used will be thoroughly documented. The Project Manager will review and approve all data adjustments.

AACOG will use a senior peer reviewer not directly involved in conducting the project to review all methods and results of the work. The senior peer reviewer will be involved in the initial planning stages of this project to ensure the planned approaches are technically sound, and will also provide quality checks and review on all final products prior to submittal to TCEQ to ensure the project procedures were properly implemented. When the emission inventory is completed, documentation and spreadsheets will be sent to TCEQ and other interested parties for review.

5 DATA ANALYSIS, INTERPRETATION AND MANAGEMENT

5.1 Data Reporting Requirements

Primary data on emissions from oil and gas activity in the Eagle Ford that are assembled for this study will be reported electronically and documented in the project final report. Any data that are assembled for this study, well counts and production data, will also be delivered electronically and documented in the final report. Data that are documented elsewhere, such as data on emission factors or data used to calculate emissions, will be documented in the final report by reference to the original data source. Records will be maintained that include sufficient information to reconstruct each emission inventory calculation.

5.2 Data Management Procedures

Hard copy data received during the course of the project will be cataloged into the file index and made available for copying or checkout. Electronic data files will be stored in a specific project directory on AACOG's fileserver network drives. Original data files will be kept in a separate folder and will not be altered or changed. Project staff will make copies of any data files needed and perform their work with the copy. All project staff will have access to these files and all files on the network drive undergo automatic backup each night such that any information can be easily retrieved as necessary. After the final product is completed and approved by TCEQ, all project data will be archived on CD-ROM for storage.

6 DATA REPORTING

6.1 Project Deliverables

The project final delivery will include a report documenting the Eagle Ford oil and gas development emissions inventory improvement project and the information necessary to update TCEQ modeling files. All relevant AQ/QC findings will be included in the final report. The report will describe the steps taken and any background that is relevant to the project. The report shall provide the report in Microsoft Office Word and Adobe Acrobat Reader (*.pdf) formats. The final report will include the following components:

1. An executive summary and abstract.
2. An introduction that discusses background and objectives. Include relationships to other studies if applicable.
3. A discussion of the pertinent accomplishments, shortfalls, and limitations of the work completed.
4. Recommendations, if any, for what should be considered next as a new study.

The Final Report will provide a comprehensive overview of activities undertaken and data collected and analyzed during the Grant Activity. The Final Report must highlight major activities and key findings, provide pertinent analysis, describe encountered problems and associated corrective actions, and detail relevant statistics including data, parameter, or model completeness, accuracy and precision.

Modeling files will be in EPS3 format based on the grid system consistent with EPA's Regional Planning Organizations (RPO) Lambert Conformal Conic map projection with the following parameters:

- First True Latitude (Alpha): 33°N
- Second True Latitude (Beta): 45°N
- Central Longitude (Gamma): 97°W
- Projection Origin: (97°W, 40°N)
- Spheroid: Perfect Sphere, Radius: 6,370 km

All future TCEQ photochemical model emissions processing work, including the Eagle Ford emission inventory, will be based on the grid system listed above.