Project Plan
for
Baseline Ambient Air Monitoring near Potential Shale Gas Development Zones in Lee County, NC

Updated November 8, 2013

Department of Environment and Natural Resources

Division of Air Quality

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Executive Summary

The North Carolina Division of Air Quality (DAQ) has assessed its air quality monitoring network and developed a plan to better characterize baseline air quality in the area that may hold potential for shale gas production. Based on a review of available literature, the predominant air pollutants from hydraulic fracturing operations are speciated volatile organic compounds (benzene, tolene, ethyl benzene, xylenes, hexanes, 2,2,4-trimethylpentane, styrene), adehydes (formaldehyde, acetaldehyde), criteria air pollutants (sulfur dioxide, nitrogen oxides, ozone, particulate matter) and reduced sulfur compounds.

An analysis of the existing air quality monitoring network indicates well-placed upwind and downwind multi-pollutant air monitoring locations in Candor (Montgomery County) and Raleigh (Wake County). These sites are near the Triassic Basin, but not within the area that may be considered most promising for shale gas production – the Sanford sub-basin located in Lee County. The DAQ does not currently operate any air quality monitors in Lee County. This project plan recommends establishing a multi-pollutant air monitoring site in Lee County that will employ identical monitoring methods and equipment as is used at all other monitoring sites.

The DAQ will leverage existing resources to the extent possible in implementing this project plan. However, it is estimated that $158,000 of additional equipment will need to be purchased. Ongoing operating costs are projected to be approximately $163,000 annually, including staff time for site maintenance and data analysis.

1.0 Introduction

North Carolina General Assembly Session Law 2011-276 directed the Department of Environment and Natural Resources (DENR), in conjunction with other agencies *"to study the issue of oil and gas exploration in the State and the use of horizontal drilling and hydraulic fracturing."* The study recommended, among other things, the collection of baseline air quality information. Following that study, Session Law 2012-143, Section 2(c), requires rules related to collection of baseline data in areas where oil and gas exploration and development activities are proposed.[1] While the session law requires rules, the Division of Air Quality (DAQ) has the authority and expertise to accomplish baseline air monitoring objectives without additional rule making. This document contains an assessment of the DAQ ambient monitoring network and a project plan to better characterize air quality in the areas where the shale gas deposits are located.

The geologic formation of interest for hydraulic fracturing (HF) is the Triassic Basin, a discontinuous feature composed of sedimentary rock that lies on a generally southwest to northeast axis through 14 counties in the middle of the state. Several sub-basins in the Triassic Basin may hold potential for shale gas production, but the area considered most promising is the Sanford sub-basin of the Deep River geologic basin. This area of interest consists of approximately 59,000 acres north-northwest of the city of Sanford.

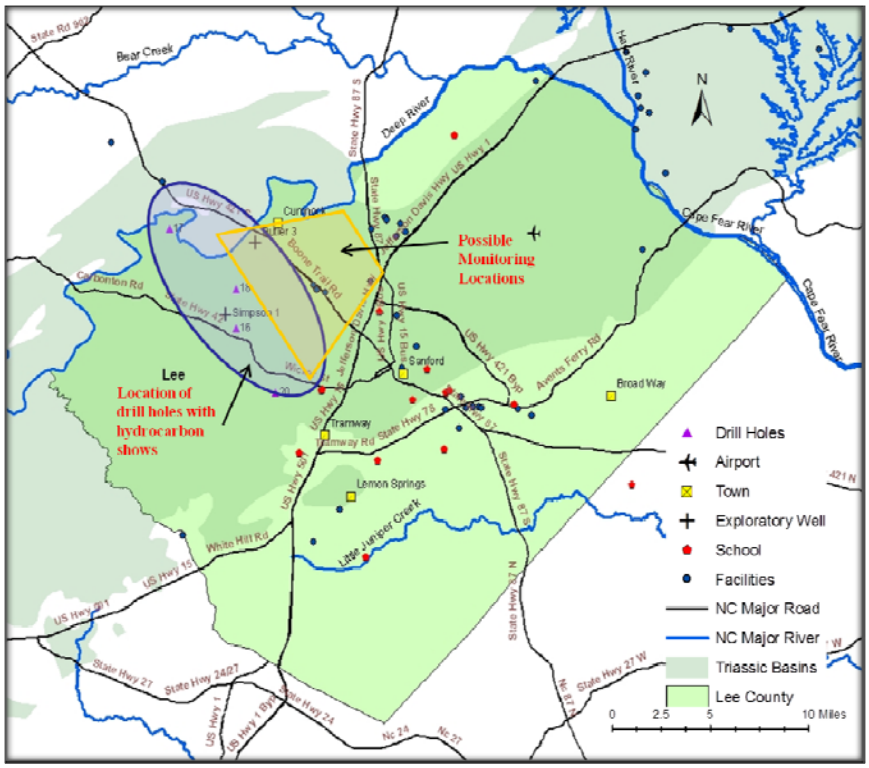
Recommendations for an ambient air monitoring program would necessarily need to be based on the HF process, the geochemical profile of the potential reserve, and probable well-pad and drilling configuration. Preliminary geochemical assessments indicate a potential for 'wet-gas' reserves, the more commercially preferred resource due to the presence of value-adding natural gas liquids (condensates) such as pentane, butane, hexane and ethane. Not all 'wet-gas' reserves are identical and definitive characterization of the deposits in the Sanford sub-basin are incomplete. In light of this weakly characterized shale gas deposit, and no prior ambient air monitoring for this purpose, this air monitoring plan heavily relies on the experiences of published studies from Arkansas, Colorado, Pennsylvania, New York, Texas, Wyoming, and United States Environmental Protection Agency (EPA). Those experiences have shown that unconventional natural gas development such as exists with HF results in direct and fugitive air emissions of a complex mixture of pollutants from the natural gas resource itself as well as from diesel engines, tanks, impoundment ponds and on-site materials used in production. The DAQ has used this information to identify target air pollutants most frequently described from monitoring and emission measurements, as well as those expected from HF production.

[1] Session Law 2012-143 Section 2.(c)(a)(5)(b)

2.0 Project Description

The DAQ will coordinate this baseline air monitoring program that is intended to characterize targeted air pollutants and establish ambient air conditions prior to start-up of possible emission sources from HF processes. Implicit in 'baseline monitoring' is that monitoring occurs before and during well development, production and gas treatment, thus making possible a "before-during-after" comparison necessary to characterize possible air quality impacts. Non-HF source impacted baseline air monitoring is planned for at least one year to account for fluctuations due to any seasonal, weekly and daily variations.

Additionally, national quality assurance documents recommend that ambient baseline sites be situated at a spatial scale defined as "urban" or "regional".[2,3]



Approximate Monitoring Location
Figure 1

Figure 1 shows the targeted monitoring area within Lee County with respect to the locations of the Triassic Basin, exploratory wells, and facilities, all of which are necessary to consider when selecting a monitoring site. This monitoring plan anticipates that one site in Lee County will be suitable for comparison to other air monitoring data collected in North Carolina.

2.1 Target Air Pollutants

Based on a review of available literature the predominant air pollutants (other than methane) from HF operations are listed below and are target air

[2] Quality Assurance Handbook for Air Pollution Measurement Systems Vol II Ambient Air Quality Monitoring Program, December 2008

[3] It should be noted that using these spatial scales are not typically used with monitoring objectives for characterizing community situations.

pollutants for baseline monitoring:

Air Pollutant Category	Typically Monitored Pollutants
Speciated volatile organic compounds (VOCs)	benzene, toluene, ethyl benzene, xylenes, hexanes, 2,2,4-trimethylpentane, styrene
Aldehydes	formaldehyde, acetaldehyde
Criteria Air Pollutants	Sulfur dioxide, nitrogen oxides, ozone, particulate matter (PM 2.5)
Reduced sulfur compounds (RSC)*	hydrogen sulfide

*the presence of reduced sulfur compounds is dependent upon the type of shale gas ("wet" or "dry") found, but is typical of "wet" gas. Until the composition of the deposit in the Deep River geologic basin is fully characterized, baseline monitoring for RSC is deferred.

2.2 Study Objectives

The baseline study objectives are intended to:

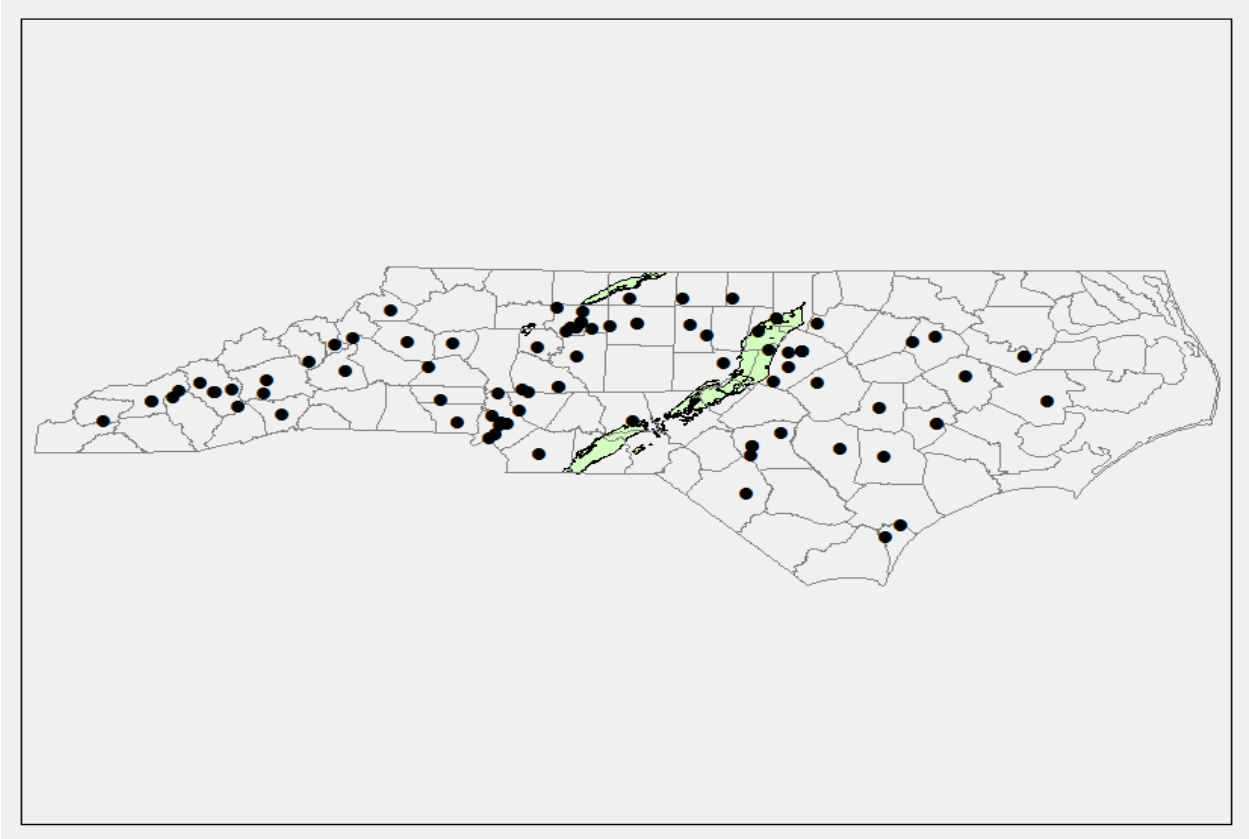
1. Measure target pollutant concentrations over a minimum one-year period to characterize baseline ambient conditions.
2. Collect a sufficient amount of data to estimate annual average concentrations
3. Implement monitoring consistent with existing State monitoring for ease of data comparability.
4. Use standard monitoring protocols to ensure consistent data of high quality.
5. Use conventional data reduction, data summary and analysis techniques to characterize the data

2.3 Assessment of Existing Monitoring Network

Since 2002, the DAQ has operated ambient air monitoring sites in five urban areas (Asheville, Winston-Salem, Charlotte, Raleigh, and Wilmington) and one rural area (Candor) under the federal Urban Air Toxics Monitoring Program (UAT). In addition to the six UAT sites, the Division has operated numerous monitoring sites across the state since the 1970s to monitor criteria air pollutants required by various federal regulations. Figure 2 shows the locations of all air quality monitoring sites in NC respective to where there is a potential for shale gas deposits to be located.

The multi-pollutant air quality monitoring sites nearest to the location where DENR has the most data on potential shale gas deposits (Lee County) include the Candor (Montgomery County) site and the Raleigh Millbrook (Wake

County) site. These sites are near the Triassic Basin, but not within the Sanford sub-basin located in Lee County. The DAQ does not currently operate any air quality monitors in Lee County. This project plan recommends establishing a Lee County air monitoring site that will employ identical monitoring methods and equipment as is used at all other monitoring sites.



North Carolina's Ambient Air Quality Monitoring Sites and the Triassic Basin
Figure 2

Thus, data collected could be directly comparable between the Lee County air monitoring sites and DAQ's existing air monitoring sites. The new Lee County site, along with the two existing sites in Candor and Raleigh, will help characterize air quality within, upwind and downwind of the Sanford sub-basin. The orientation of these three monitors will be aligned with the axis of the Triassic Basin, southwest to northeast, and with climatological wind directions in central North Carolina.

The Candor site will be considered the "upwind" site. An "upwind" site is needed to serve as a reference location to characterize ambient air typical to North Carolina. The Raleigh Millbrook site will be the "downwind" site. A "downwind" site is used for characterizing the possible influence of emission sources located downwind from the reference site. The proposed Lee County site is located between them.

While the sites at Candor and Raleigh Millbrook are already established, a few additions are proposed to those sites to ensure adequate coverage for the

pollutants of interest related to HF. The "upwind" site at Candor already monitors VOC, ozone and fine particles. The changes at Candor would be to install an aldehyde sampler and replace the existing every-third-day particle sampler with a continuous monitor. No sulfur dioxide (SO_2) or nitrogen dioxide (NO_2) monitoring is expected at Candor. Ozone is already monitored through EPA's Clean Air Status and Trends Network or CASTNET[4] and these data are publically available. No additional ozone equipment is expected to be needed at this site. The "downwind" site at Millbrook (Raleigh) already measures VOC, ozone, fine particles, and sulfur dioxide. Monitoring will soon begin for nitrogen dioxide. No additional criteria monitors are necessary at the Millbrook site, but the installation of an aldehyde sampler is necessary. The new Lee County site would be fitted with monitors for VOC, aldehydes, ozone, fine particles, and sulfur dioxide (first year only), and possibly nitrogen dioxide.

Equipment and operational costs are in Section 4.0 of this document.

2.4 Methods

A Quality Assurance Project Plan (QAPP) will be written to specify performance objectives and measures.

Field practices:

All air monitoring sampling and analysis methods follow reference or compendium methodologies published by the EPA. Equipment manufacturers' operating manuals and agency standard operating procedures and preventative maintenance procedures will be followed. Samples will be managed under chain of custody procedures. The VOC samples will be collected once every six days and aldehyde samples will be collected once every 6 days throughout the duration of the baseline monitoring. Criteria air pollutants will be measured using continuous monitors. All sampling will occur on a schedule consistent with the national air monitoring schedule. Equipment typically used for monitoring air pollutants are listed below.

Field Monitoring Equipment*:

Make	Model	Description
Teledyne - Advanced Pollution Instrumentation, Inc.	T700U	NO_2 Analyzer
Thermo Environmental Instruments, Inc.	43C	SO_2 Analyzer
Thermo Environmental Instruments, Inc.	49C	Ozone Analyzer
Met One Instruments, Inc.	BAM-1020	$PM_{2.5}$ Sampler
In House	--	Zero Air Generator
ESC	8832	Datalogger

[4] CASTNET is a national air quality monitoring network designed to provide data to assess trends in air quality due to changes in air pollutant emissions. http://epa.gov/castnet/javaweb/index.html

Make	Model	Description
Thermo Environmental Instruments, Inc.	146C	Calibrator
Thermo Environmental Instruments, Inc.	49CPS	Ozone Calibrator
Teledyne - Advanced Pollution Instrumentation, Inc.		Calibrator
ATEC	2200	Aldehyde Sampler
Xontech	911	VOC Canister Sampler
ECTO	8' x 8'	Monitoring shelter
Campbell Scientific	CS800L	Meteorological Tower
Campbell Scientific	CR10X	Meteorological Sensors

*Equipment makes and models may change depending upon availability

Laboratory Practices:

The DAQ laboratory will analyze the canister (VOC) and cartridge (aldehyde) samples using standard operating procedures implementing EPA Compendium Method TO-15 (VOC), EPA PAMS Method, and TO-11A (aldehydes). Note that these analytical methods quantify a larger set of air pollutants than just those specifically targeted for this study. All data obtained will be reported and compared with monitoring results from the existing monitoring network. (See Monitoring Objectives.)

Laboratory Equipment*:

Make	Model	Description
Dionex/Thermo-Fisher		High Pressure Liquid Chromatograph
Agilent Technologies	7890A/240	GC/MS
Entech	3000	Canister Cleaning System
Entech	4600A	Dynamic Dilution System
Perkin Elmer	TurboMatrix TD	Thermal Desorber
Perkin Elmer	AutoSystem	GC/FID

*Equipment makes and models may change depending upon availability

3.0 Data Analysis and Results

The immediate outcome from reviewing sample results includes the identification of any elevated concentrations of air pollutants. The monitoring study will test the working hypothesis that pre-HF air quality at a specific location in Lee County is similar to air quality monitored at the upwind and downwind sites or across the state, hence establishing a baseline in Lee County.

To make this comparison, a database of long-term, historical, quality-assured air monitoring data acquired by ongoing state monitoring activities will be used in the final assessment(s). These data establish the long-term air pollutant characteristics, statewide, or of the general region where the baseline monitoring will occur. If there is a difference at the Lee County site, then data

obtained during the baseline period will establish a local, pre-HF air quality baseline.

The monitoring data can be used to provide estimates of exposure and create a valuable database for any future analysis of long-term health impacts or changes in air quality conditions.

4.0 Cost Estimates

Costs were estimated for site installation, equipment, operations, maintenance and labor. The cost estimate is for a one-year monitoring period at a new Lee County site and the Candor and Raleigh Millbrook sites to ensure adequate monitoring coverage for the pollutants of interest related to HF. Additionally, the DAQ will redirect available air monitoring equipment for use in this baseline monitoring project.

Item	Year 1	Year 2 and Beyond
Equipment	$157,790	----------
Operation & Maintenance	$ 13,122	$ 32,862
Initial set-up labor	$ 44,736	----------
Ongoing operation labor	$130,800	$ 130,800
Total Cost	$346,448	$ 163,662
Labor Hours	4267	3255
FTE	2.6	2.0

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