SHALE GAS DEVELOPMENT AND AIR QUALITY: PROPOSED PILOT PROJECT IN THE GREATER TRIANGLE AREA OF NORTH CAROLINA THAT EXPLORES JOINT EDUCATIONAL COLLABORATIONS AND A BUSINESS MODEL FOR INNOVATIVE SMALL SCALE AIR QUALITY SERVICES

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Project Summary

Overview

The FLARE activity described in this research sketch anticipates energy and health information gaps in North Carolina, takes advantage of an opportunity to fill those gaps over the course of the next 6 to 12 months by undertaking a baseline local air quality assessment before the onset of shale gas development, and establishes a research infrastructure for the analysis of those data and for their use in developing future research proposals. Collection of proper baseline data is important for accurate measurement of the potential future air quality impacts from shale gas development; without it one cannot, for example, credibly measure impacts on health outcomes and housing values. Creating a baseline air quality data set will provide us with information that is both crucial for the accurate measurement of the air quality impacts of shale development and unique amongst research in this area. Once collected, the data and research infrastructure will be used for the development of policy-relevant research and scientific publications.

Expected Outcomes

Our specific goal is to create a structure for air quality data collection and analysis that exploits the combined strengths of Duke and RTI. The collaboration will establish a research infrastructure for collection and analysis of baseline air quality data in locations where shale gas development is imminent. This will allow for data visualization and exploration of correlations with identifiable sources of local air pollution and characteristics of local populations. Documenting the ambient concentrations of pollutants (in particular, toxics, VOC's and particulates) before the advent of shale gas development is critical to accurately measuring changes in concentrations attributable to that activity. The data we collect, merged with birth records, hospital records and schooling data, will have independent value, allowing for analysis of impacts of air toxics and particulate matter on fetal and child health.

Period of Monitoring: June 1, 2015 – May 30, 2016

1. Background

The expansion of shale gas operations in the US has brought with it a national debate over economic, environmental, health, and social implications. Although shale gas may provide an energy source that yields fewer emissions of select pollutants (e.g., carbon dioxide, sulfur dioxide, nitrogen oxides, carbon monoxide and particulate matter) compared to other fossil-fuel energy sources, significant public health concerns remain as this process results in potential occupational and community exposures to multiple contaminants used and/or emitted by gas operations[1, 2]. Recent studies indicate that shale gas development may produce waste that could contaminate the air, aquifers, waterways, and ecosystems that surround drilling sites or areas where water treatment facilities treat the wastewater from shale gas operations [3, 4]. A few studies have reported contamination of drinking water wells in northeastern Pennsylvania with hydrocarbons including ethane, propane, and methane [4, 5]. Air pollution resulting from all phases of shale gas development has been reported in several shale gas sites [3, 6]. Still, much remains to be learned about the local and global environmental impacts of shale gas operations and their implications for public health outcomes.

Hazardous air pollutants related to shale gas development include (i) diesel emissions from trucks, compressor stations, power generators, and drilling rigs; (ii) volatile organic compounds, which mix with NOx to produce ground level ozone; (iii) silica dust from handling, transport, and use of sand; and (iv) fugitive gas emissions that escape during the production phase [3, 6-12]. Increased local and regional ambient air pollution has been associated with intensive gas extraction areas [11], and studies have documented emissions of several air pollutants resulting from shale gas operations including volatile organic compounds (VOCs), nitrogen dioxide, sulfur dioxide, particulate matter (PM), fugitive

methane gas mixed with nitrogen oxides (NOx) and polycyclic aromatic hydrocarbons (PAHs) [6, 9, 12]. However, the proximity of well pads, produced-water evaporation ponds, and compressor stations to affected communities is not well-characterized [2]. In particular, air quality is currently monitored in states with shale gas development, but that monitoring did not begin until after development was undertaken, making it impossible to determine how much of the emissions were caused by the development.

The goal of the proposed research is to collect baseline air quality information. North Carolina provides a unique opportunity to collect true baseline air quality readings *before* shale gas development has begun. In this study, we propose to collect baseline air quality measurements of VOCs, toxics and black carbon particulates in the greater Research Triangle area of North Carolina prior to the introduction of shale gas wells on the Triassic Basin. Baseline data will allow us to uniquely determine the contribution of shale gas development to local air quality and to follow up with health measurements after shale gas development begins.

Figure 1 provides a map of the main shale plays in North Carolina. Of particular interest are the Sanford and Durham sub-basins of the Deep River basin, where development is expected to occur first. The Sanford sub-basin begins in Moore County and extends northward through Lee County into Chatham and Wake Counties, where it transitions into the Durham sub-basin. The Durham sub-basin extends northward into Granville County. The heavily populated Research Triangle area of North Carolina extends from Orange County (Chapel Hill) through Durham County (Durham) and into Wake County (RTP and Raleigh). Smaller towns are scattered outside of this metropolitan area, southward to Sanford in Lee County.

Figure 2 illustrates the Deep River basin and an area delineated as having the most potential to develop shale gas based on available core and test drilling data and associated oil and gas "shows" (i.e., an indication of oil or gas noted while drilling a borehole or well). The total area defined by that delineated boundary is about 79 square miles, including the northwestern quarter of Lee County and extreme southeastern Chatham County along the Deep River; U.S. Census indicates that 14,903 people lived there in 2010.[1]

Given the high-quality shale around the town of Sanford in Lee County, this area was the first to see leasing activity. Figure 3 describes the mineral leases and reserved mineral rights in this area. Based on leasing activity, the map indicates that shale development will most likely occur west and northwest of the town of Sanford, but the potential for development exists anywhere along the course of the Sanford and Durham sub-basins.

2. Research Plan and Methods

With the preceding information in mind, our goal is to expand baseline air quality monitoring in this area in order to provide the information required to accurately evaluate the air quality impacts of shale gas development. We will focus much of our attention on the area around Sanford, as this is where initial development is most likely to occur, but will expand data collection to encompass a larger area that might eventually be developed. The area where we intend to collect baseline data is described in Figure 4, along with the locations of existing TRI facilities taken from the US EPA's Toxic Release Information.[2] It is clear from this figure that there are significant baseline sources of toxics in this area, and some of the largest are in Lee County. Documenting the ambient concentrations of pollutants (in particular, toxics, VOC's and particulates) before the advent of shale gas development will be critical to accurately measuring changes in concentrations attributable to that development.

[1] http://www.census.gov/geo/reference/ua/urban-rural-2010.html; accessed January 2014.
[2] http://www2.epa.gov/toxics-release-inventory-tri-program

Monitoring Technology

We plan to deploy four types of devices for our monitoring activities. The first two are "passive" monitors for (i) aldehydes (e.g., formaldehyde and acetaldehyde), and (ii) volatile aromatic compounds or BTEX (benzene, toluene, ethylbenzene, xylenes). The third device is the RTI MicroPEM. This instrument measures particulate matter (PM2.5 or PM10) concentrations and black carbon concentrations, another pollutant produced by diesel engines. Finally, we will exploit existing capacities at RTI to also employ an additional active, real-time monitor for black carbon (i.e., microAethalometer AE 51).

Study Area

We plan to focus much of our attention on the area surrounding Sanford, where initial development is most likely to occur. Approximately 15,000 people live in this area; the payoff to a rich characterization of baseline pollution in this area will likely be great.

While current leasing activity provides some indication, we do not know exactly where shale gas development will occur in the greater Research Triangle area (this is a largely unavoidable aspect of baseline data collection). As such, we plan to collect information over the broad area defined by Figure 4. The goal will be to achieve both breadth of coverage and high geographic frequency, but the specifics of how we achieve these two goals will largely be determined by the budget that we have to work with.

To give a rough sense of the area we are considering, we use Heron's Formula to calculate the area of the triangle formed by cities of Sanford, Durham, and Raleigh (taking the distances between Sanford and Durham and Sanford and Raleigh to both be 45 miles, and the distance between Durham and Raleigh to be 25 miles). This yields an area of 540 mi^2. If we expand this area on either side (to include, for instance, Chapel Hill and Fuquay-Varina), we could consider the area to be approximately 600 mi^2.

3. Timeline and Data Use

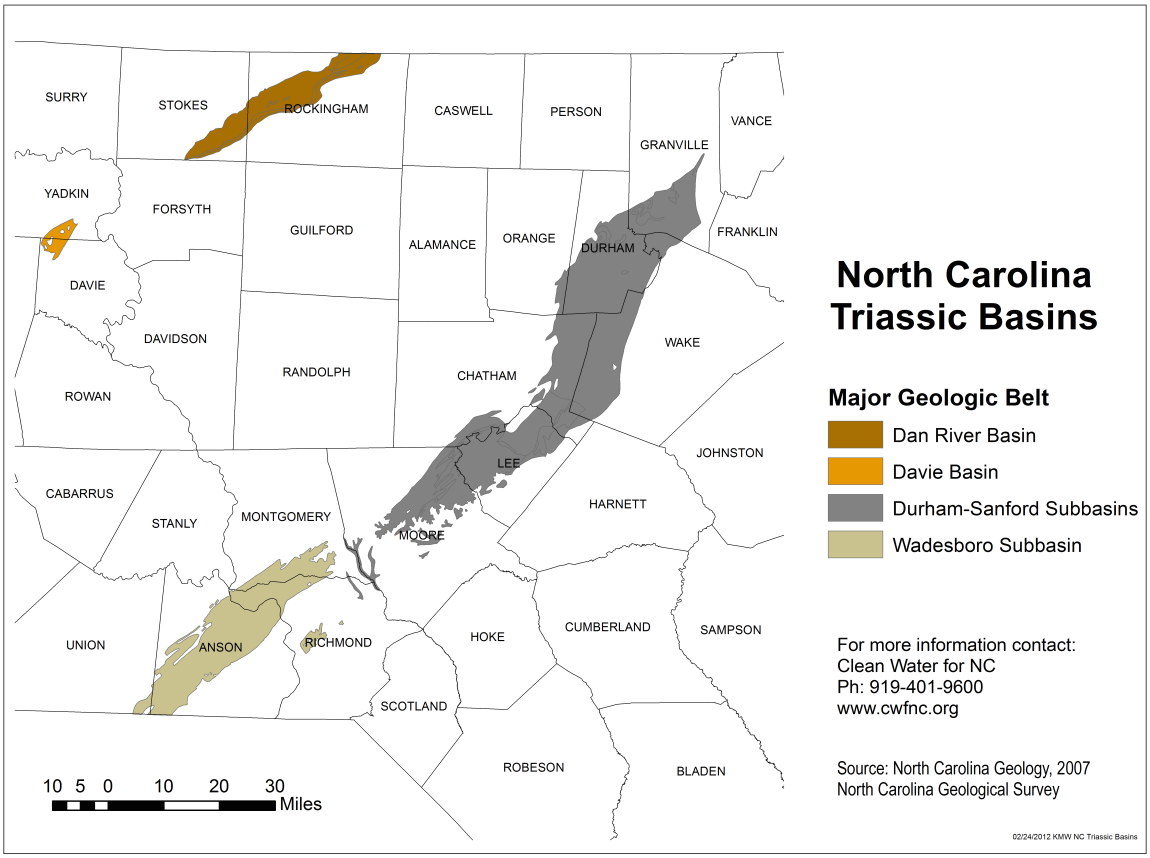
Time is of the essence, as North Carolina is slated to begin issuing permits for shale gas development in the spring of 2015. The lack of shale gas infrastructure will likely delay the onset of development, which is fortuitous from the point of view of baseline data collection. However, our goal is to begin collecting data by June 1, 2015 and to continue until one year of baseline data have been collected.

The data collected through the proposed project will serve as the basis for a longer-term effort directed at measuring the air quality impacts and subsequent health effects of shale gas development in the Durham and Sanford sub-basins. Our baseline air pollution measurements will, however, be used for more than just assessing the effects of shale gas development on air emissions in the Triangle area once development begins. There are a few promising research efforts that we, as well as students, can use these data for. First, we will link the data to birth certificate records (already available at Duke) and assess the effects of black carbon and VOCs on pregnancy outcomes in the region. Our data will allow us to assign relatively refined measures of air quality at the residential level, as well as temporally using monthly measures during pregnancy. Second, we can assign our air pollution measurements to schools in the region and assess any effects of these pollutants on school test scores. Third, the pollutants we are measuring have been associated with acute health events, such as heart attacks or asthma emergencies. We will be able to use our data to study these and other acute health events using inpatient hospital discharge data. Finally, the environmental health literature suggests that measuring black carbon is an important air quality indicator that can be used to assess mortality risks from air pollution, can be used in climate change modeling, and can be used to assess any benefits from traffic related abatement efforts. The use of these data could have far-reaching public health benefits for the region.

4. Scientific Impact

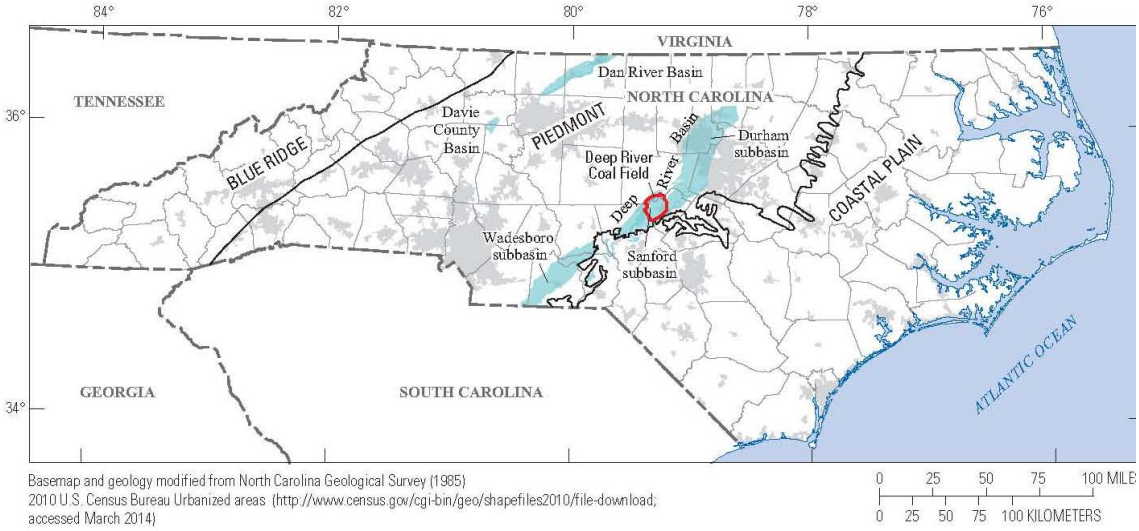
Air quality is currently monitored in states with shale gas development, but that monitoring did not begin until after development was undertaken, making it impossible to determine how much of the emissions were caused by the development. North Carolina provides a unique opportunity to collect true baseline air quality readings before shale gas development has begun. This project will yield the first data set describing baseline air quality in anticipation of impending shale gas development. This will provide an important opportunity for a "before-and-after" comparison of the effects of shale gas on an air shed, avoiding the effects of potential unobservable factors that might confound a cross-sectional analysis. A recent commentary from NIH funded Environmental Health Science Centers recommended that ambient and occupational air-quality should be measured at active drilling sites and be compared with baseline measurements in adjacent areas without shale gas development [2]. A more ideal research strategy is to compare active drilling sites before and after development with baseline ambient air quality measurements. Baseline data will allow us to uniquely determine the contribution of shale gas development to local air quality and to follow up with health measurements after shale gas development begins.

Figure 1: North Carolina Shale Plays (Durham and Sanford Sub-Basins)



Source: http://www.cwfnc.org/documents/Shale-Gas_basemap2.png

Figure 2: USGS Study Area for Baseline Water Measurements [13]



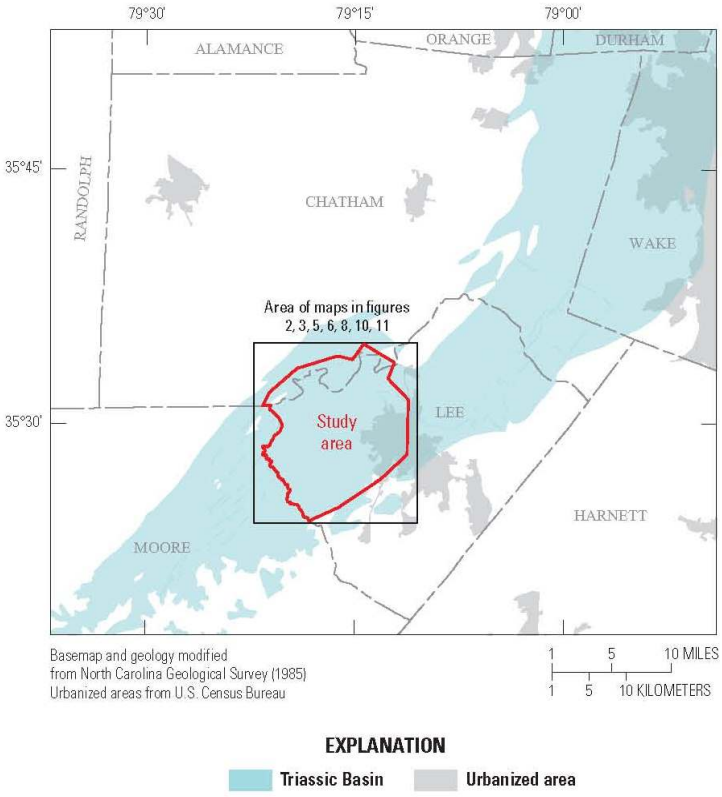
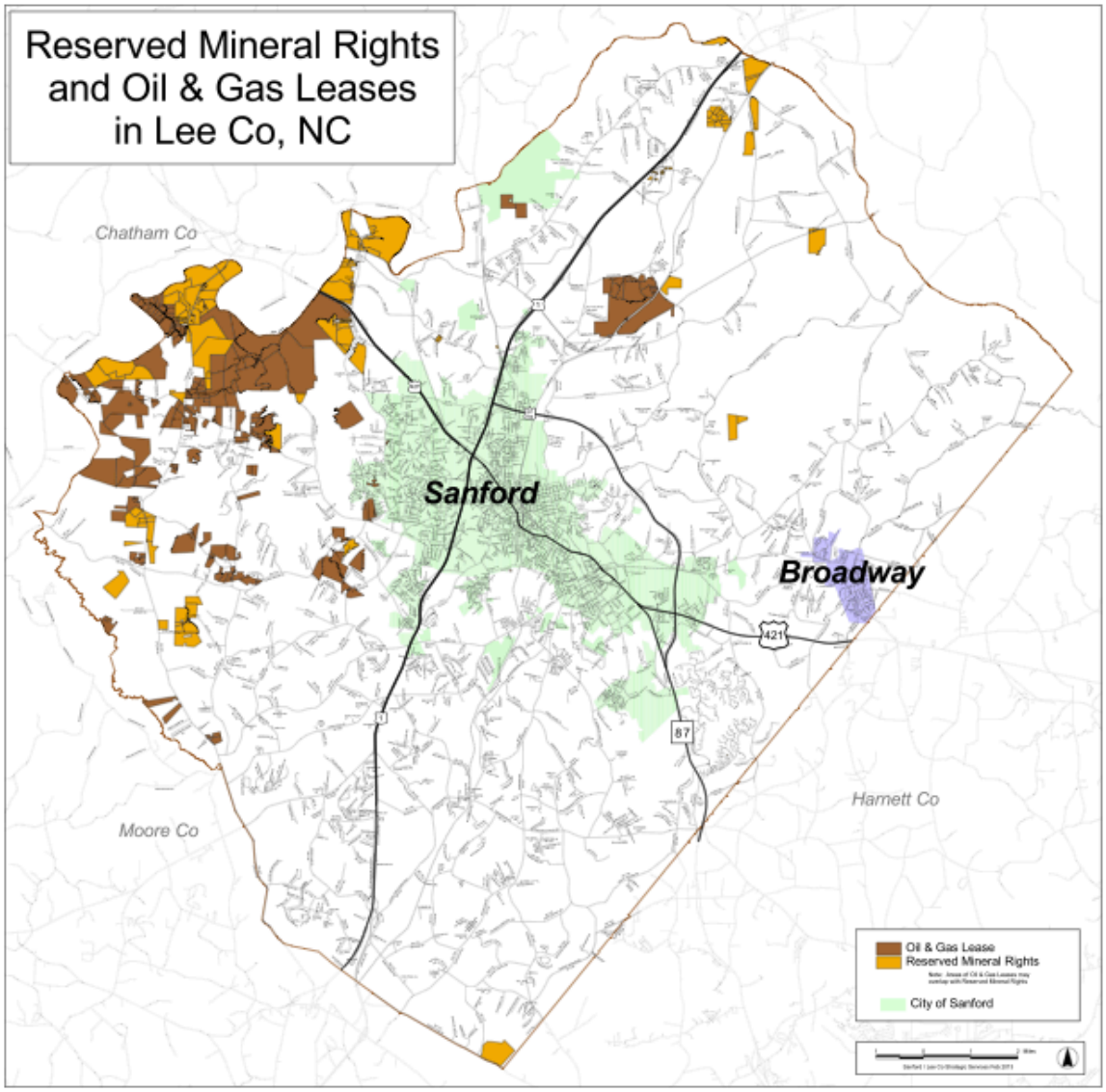
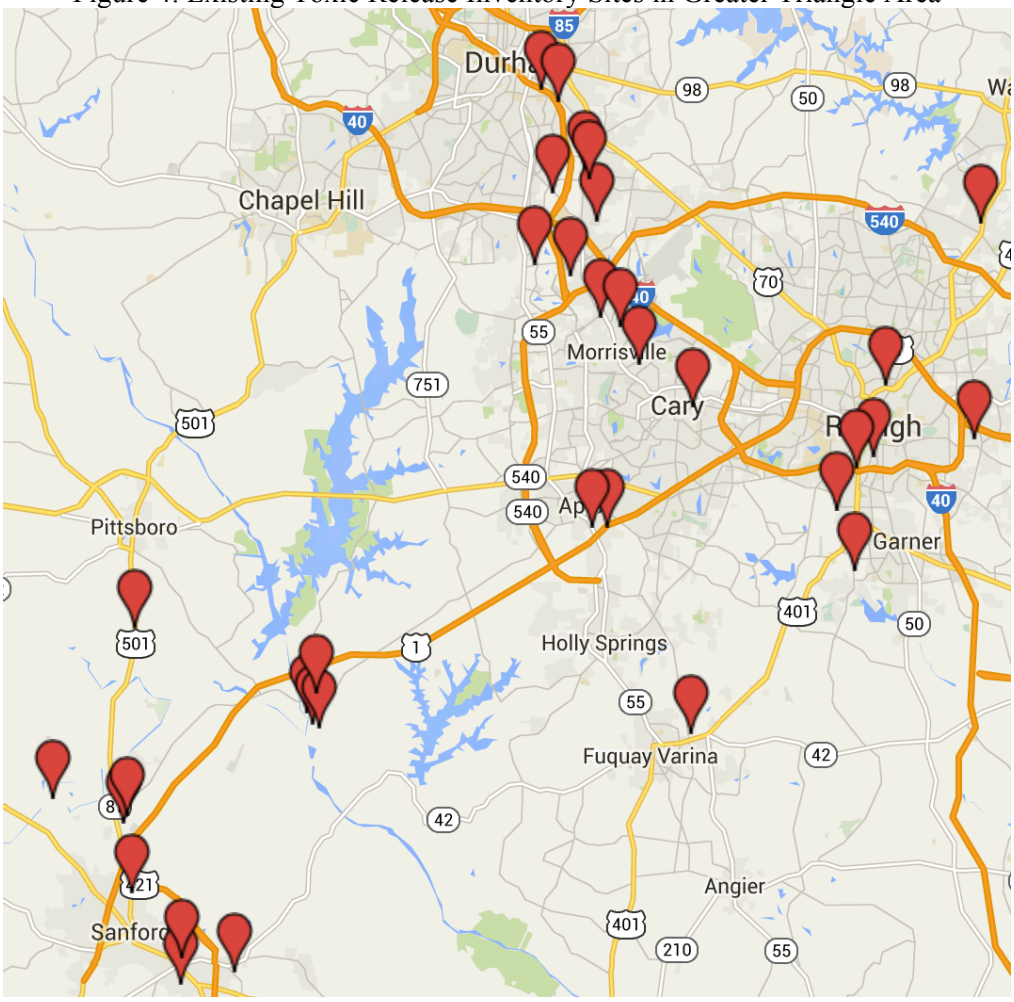


Figure 3: Leases and Reserved Mineral Rights in Lee County, NC



Source: http://www.ces.ncsu.edu/site-lee-naturalgasexploration/

Figure 4: Existing Toxic Release Inventory Sites in Greater Triangle Area



Source: http://www2.epa.gov/toxics-release-inventory-tri-program

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