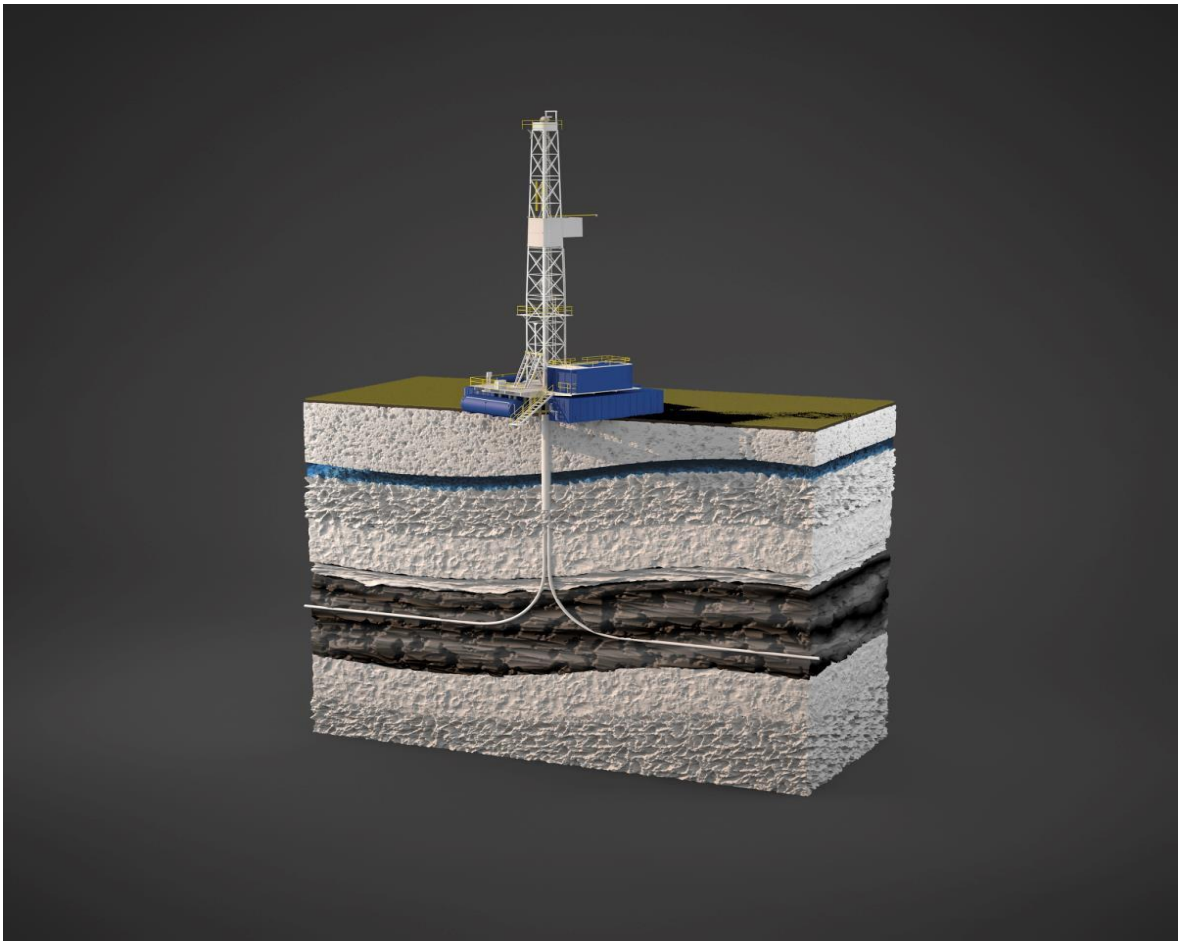
Chatham County North Carolina
Hydraulic Fracturing Background Assessment



October 2017

Submitted to Chatham County Board of Commissioners

Submitted by: Charles Yuill Environmental Consultant

Morgantown West Virginia

Preface

This report summarizes aspects of hydraulic fracturing, which is a technology for extracting natural gas from tight or non-fractured shale formations. The report is presented in terms of potential impacts and issues for Chatham County, North Carolina. The report is not intended to be an all-inclusive review of hydraulic fracturing's or fracturing issues and impacts. Such summaries are well presented in numerous other publications. The reader is referred to the following documents that do provide such detailed assessments:

1. Physicians for Social Responsibility. Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking Unconventional Gas and Oil Extraction. November 2016.
2. Resources for the Future. The State of State Natural Gas Regulation. June 2013. (now may be a little out of date).
3. State of North Carolina. North Carolina Oil and Gas Study. 2012.
4. United States Environmental Protection Agency. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. December 2016.

Table of Contents

Chatham County North Carolina

Hydraulic Fracturing Background Assessment

A. Introduction

This summary report has been prepared to provide background information for Chatham County, North Carolina with regards to the potentials for hydraulic fracturing for natural gas recovery in the County. This report considers the County's geologic, land use / land cover, hydrologic, and cultural resource environments, as well as the regulatory environment in North Carolina and the Federal government. The report also briefly reviews the major environmental, fiscal, and human health issues associated with hydraulic fracturing or fracking. The report does not provide an in-depth review of fracking's associated human health, environmental, fiscal, and community impacts as such reviews.

Chatham County is located in central North Carolina southwest of the Raleigh / Durham metropolitan area. The County is primarily rural agriculture and forestland with a number of small towns and villages, in addition to dispersed rural development and significant natural and recreational resources. The County is on the eastern edge of the Piedmont Plateau consisting mostly of gently rolling hills, V shaped river valleys, and a number of monadnocks (which are steep isolated hillsides) – located mostly in the western higher elevation portions of the County. Natural gas exploration and development became a topic of interest in 2009 when the North Carolina Geologic Survey began studying shale formations in the Deep River rift basin – a narrow sedimentary basin running through the southern portion of the County. At that time the NCGS estimated that there are 700 acres in the county suited to natural gas development utilizing hydraulic fracturing, though it was anticipated that this estimate could be enlarged with additional investigations.

To establish a working definition for this report, hydraulic fracturing ("fracking") is drilling into geologic formations, specifically tight shale gas or oil bearing formations, and then directing a high-pressure water mixture at the rock to release the gas or oil inside by creating fractures and other openings in the rock where previously such openings did not exist. Water, sand or fine granular ceramic materials, and chemicals are injected into the rock at very high pressures allowing the gas to flow through the formation out to the head of the well. Fracking has now become a dominant technology for the recovery of natural gas in the United States, as well as around the world, primarily due to the large reserves of natural gas in geologic basins and formations that are recoverable only applying such technologies.

The organization of the report is as follows:

1. A brief history of fracking.
2. The current state of fracking technologies and practices
3. Fracking and Chatham County
4. Fracking and North Carolina
5. Observations / Recommendations / Suggestions

6. Appendices
    a. Major environmental, health and safety, and community infrastructure issues associated with fracking.
    b. Summary of public meeting questions / comments from the public meeting held on June 13 in Pittsboro, North Carolina.
    c. Copy of the presentation from the June 13 Commission public meeting.

B. A Brief History of Fracking

One of the current myths regarding fracking is that it was developed relatively recently. In fact, fracking can trace its roots to the American Civil War. During the war a Union artillery officer observed the increased explosive power associated with firing explosive artillery shells into narrow trenches and surmised that firing such shells into vertical or horizontal tunnels would result in even greater explosive results. After the war in 1865, the officer patented his "explosive torpedo" as a way to free captured underground oil, and eventually water, from tight geologic formations. He initially used black powder and then nitroglycerin to charge these "explosions." The use of "nitro" continued until the 1930's when drillers began to use what they referred to as acid, which was an early mixture of non-explosive materials providing drillers far more control with casing design and maintenance and eventual well closure. It was during this time that drillers began to apply this "acid" under significant pressures to improve the results of the injections.

Modern commercial fracking began during the 1940s when geologists from the Stanolind Oil Company attempted pressurized fracking in the Hugaton Gas Field in Kansas using 1,000 gallons of gelled gasoline per "frack." Though these experiments failed, they were noticed by Halliburton geologists in Oklahoma and Texas, who in 1947 – 1948, began their own experiments in various gas fields utilizing a range of liquid mixtures often under very high pressure. Their results were more successful and the technology became to be widely used in a number of oil and gas basins in Oklahoma, Texas, Colorado and Wyoming. As a matter of fact, fracking (though not using the specific term) was mentioned by President Ford in his 1975 state-of-the-union address as a potential future contributor to future American energy independence. Modern day fracking, using the methods we describe today, did not really begin until the 1990s, with accompanying significant increases in oil prices, without which the high investments required to undertake fracking activities would not have been possible. Geologist George Mitchell helped usher in modern fracking when he took hydraulic fracturing and combined it with horizontal drilling. A couple of other important fracking "milestones" include:

1. 1986 – The US Department of Energy drills a horizontal fracking well In Wayne County, West Virginia ushering in the era of eastern fracking.
2. 1999 – Very high-pressure injections are initially used in Texas and this practice soon spreads throughout the industry.
3. 2004 – Initial EPA report indicates that numerous fluids utilized in fracking are potentially toxic for humans.
4. 2005 – A number of exemptions for fracking from the Clean Water Act, Clean Air Act and Safe Drinking Water Act are put in place with the Energy Policy Act of 2005. Today,

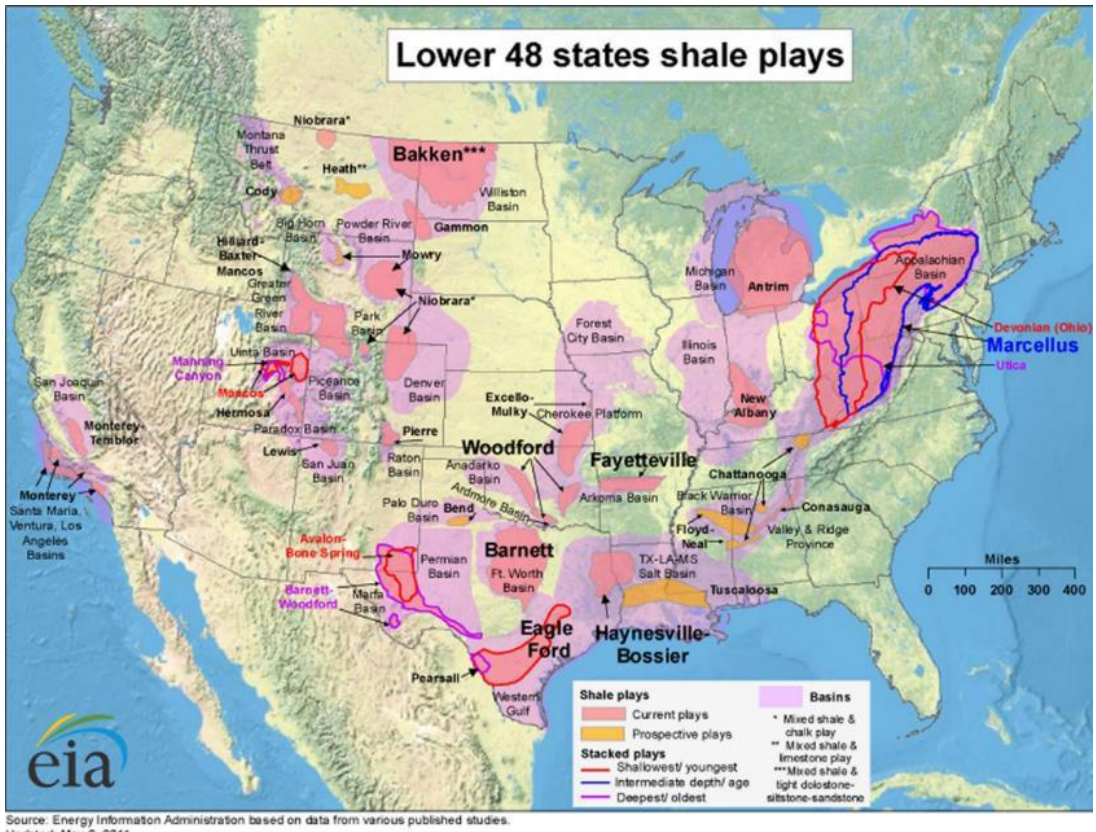
fracking regulations are basically set by the states.

5. 2011 – EPA initiates a long-term comprehensive study on the impacts of fracking on drinking water resources, which was completed in 2016.

Today, fracking occurs throughout the United States, with active operations now in 21 states. In addition,

1. 34 states have laws and regulations on the books to facilitate fracking.
2. Three states have bans or moratoriums – Vermont, Maryland, and New York.
3. One multi-state region has a fracking moratorium – The Delaware River Basin (a primary water supply watershed for New York City). However, that moratorium is expected to be lifted.
4. Michigan, another state with significant fracking activity (12,000 wells), will likely have a fracking moratorium, on the ballot in 2018.

The following map outlines the major basins of the United States in which the majority of fracking activity is occurring.



Source: Energy Information Administration based on data from various published studies.
Updated: May 9, 2011

Figure 1. Major shale / fracking basins in the United States.

C. Fracking – A General Description

Fracking is actually a small (in terms of duration), but very significant, part of the broader natural gas drilling, recovery, operations, environmental controls, site closure and restoration

activities that may be required in the overall development of a gas well. Once mineral rights have been obtained or are available, fracking activities can be initiated. A simple description of fracking operations includes:

1. Developing new access roads (typically heavy duty unpaved roads). The roads are constructed during prospecting, which generally requires drilling and testing utilizing a range of seismic experiments.
2. Exploration sites can become drill/well pads when the site is deemed to be suitable and available for well development based on legal, regulatory, production and environmental characteristics. In larger production areas, numerous wells are often drilled, ideally on relatively even spacing, allowing for logical units for development (40- to 240-acre spacing is typical). Often, well pads are 8 to 15 acres in total area. Typically, about 40% of the land is disturbed.
    a. Well pads: 25% of area will remain disturbed due to continued activity at the well.
    b. Pipelines: 4% typically remains disturbed after revegetation. Pipelines are often hundreds of yards in length for each well. Pipelines are typically ten yards or more in width. There will be pipelines for natural gas transport and there may be pipelines for water to support water recycling.
    c. Ponds: 5% of total disturbed area. Pond sizes are being reduced with newer operations now using water storage tanks.
    d. Roads: typically 7% of the total area. Roads that are constructed for well pad access are often 100 to 300 yards in length and are developed for moving equipment and water / chemicals between paved roads and the well pads.

    Re-vegetation, water control, and other mitigation can be restored to 60% of that area soon after construction and well development.
3. Well pads will contain a well or multiple wells, as well as supporting technology and environmental control features in the case of horizontal fracking. Examples of these environmental control features include storage and treatment ponds and other excavated areas for storage / evaporation of return and produced water. Ponds are used for water storage and as evaporation ponds. On-site removal of potentially toxic solids is required. The resulting residuals are transported offsite for landfilling or other disposal. New methods for water re-use permits for the size of these water storage ponds to be greatly reduced and if some cases eliminated. In addition, well pads are used for:
    a. Fluid mixing, storage and warming equipment;
    b. Non-target gas control and measurement equipment – primarily methane; and
    c. Storage of equipment;
4. The operation may have on-site or nearby injection wells. However, injection wells are being utilized less frequently due to the requirements and economics of water reuse in some fracking operations that may be in close proximity to a given well.
5. Pipelines are developed for natural gas transport and in some cases for water recycling.
6. Pipeline lengths can vary from a few hundred yards per well pad to miles.
7. Compressor stations and gathering compressors are developed for gas transport. Compressor stations may be attached to well pads or be developed separately. There also may be two different stages of compressor stations – compressors in close proximity to wells to the collected gas along gathering pipelines and second stage compressors that are utilized to move the gas to major transmission pipelines.

8. Existing infrastructure – roads and water – are critical to successful fracking operations.

Figure 2. Typical water retention pond and well pad for fracking.

A brief description of the fracking process. Once a suitable well location has been established, drilling the well can begin utilizing standard deep drilling drill pipe hardware and methods. As the drill bit descends into the ground, air is forced down the borehole flushing rock cuttings to the surface of the ground. These cuttings return with water from the drilling operation and often contain highly toxic materials. The hole should be initially drilled to below the elevation of the deepest freshwater aquifer. At this point, a surface casing is inserted into the well borehole to separate subsequent activities from the freshwater source aquifer. This surface casing also anchors a blowout preventer, which is a safety device that protects workers and equipment at the well location. Then cement is pumped into the borehole filling and sealing the area between the casing and the outer edges of the borehole.

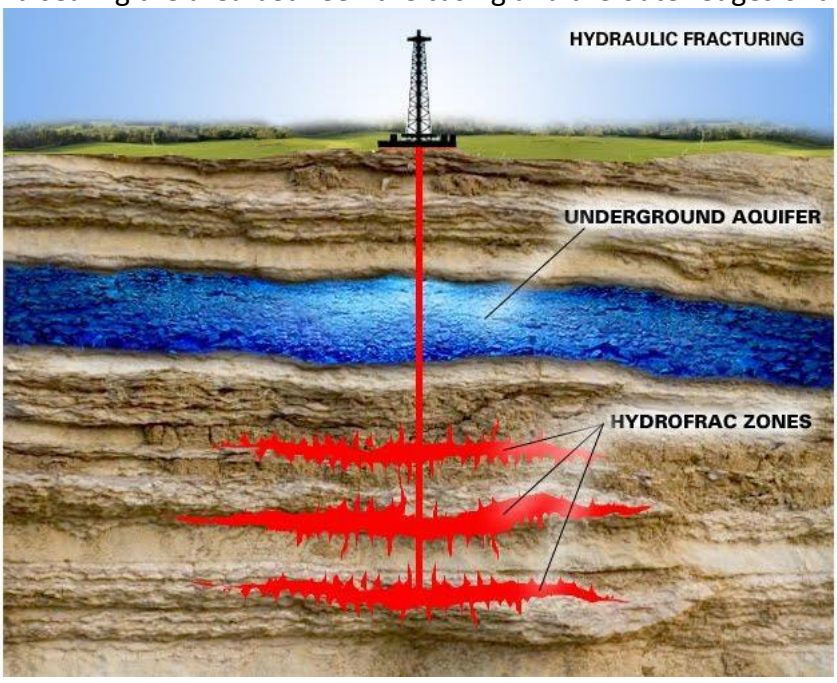


Figure 3. Illustration of the basic process of fracking for natural gas.

At this point, drilling continues below the casing, utilizing a downhole drilling motor, which can continue with vertical drilling or begin turning for horizontal drilling. When the target locations are reached, the drilling motor is removed and production casings are inserted for the entire length of thee borehole. Again, cement is pumped into the hole filling the voids between the casing and the walls of the hole. Once this effort is completed, the lower casing is perforated using a perforating gun or "perf" creating thousands of holes in the casing. Electric currents are used to shoot small holes through the casing and cement. Plugs are sometimes placed into the borehole to facilitate fracking at different depths. Depending on the depth of the target shale formation, total fracking well depths can range from three or four thousand feet to over eight or nine thousand feet.

The well is now set for fracking with water, sand or ceramic particles. Fracking fluids are sent into the borehole at pressures often exceeding 10,000 pounds per square inch (psi). Fracking can continue to different stages or depths and the entire well borehole can be re-fracked multiple times as needed – either initially or over the life of the well. Fracking can require up to five million gallons of water per frack event. Such amounts of water, sand, and chemicals can require over 1,000 round trips from water sources and chemical storage areas to the well(s) in what may be a concerted two-week length of time. Once fracking is completed, any well plugs are removed and gas typically begins flowing up the borehole and into on-site pipelines moving the gas to adjacent compressors and eventually into gas transmission lines in the region.

Regulatory components and associated fracking components. Fracking is an extremely complex process that requires detailed logistics planning, numerous different activities, complex equipment, significant amounts of chemicals, complex environmental protection management activities, and a variety of skillsets. A 2013 report by Resources for the Future (RFF 2013) provides a detailed summary of these components.

1. **Site Components**
    a. Well spacing is generally a function of shale formation geology
    b. Well setbacks from surface water and development such as buildings
    c. Water testing

2. **Well Drilling**
    a. Casing / cementing regulations
    b. Cement preparation and circulation

3. **Fracturing Regulations**
    a. Water withdrawal limits
    b. Fracking fluid limits and disclosure

4. **Wastewater Storage**
    a. Fracking fluid storage
    b. Pit liner requirements
    c. Pit freeboard requirements

d. Underground injection regulations
e. Fluid disposal
f. Fluid transportation

5. Excess / fugitive gas disposal
a. Venting
b. Flaring

6. Production
a. Severance taxes

7. Well abandonment
a. Idle time limits
b. Temporary abandonment
c. Final restoration and stabilization

8. Other considerations
a. Accident reporting
b. Regulatory agencies

States have applied a number of different approaches to regulating the aspects above, but typically, states are adopting combinations of approaches such as basic command and control (setting minimum requirements for parameters such as distance and storage volumes); case by case permitting; and allowances for special case variances. States are also beginning to utilize performance standards. This means well developers are given flexibility in selecting their various methods (such as for water storage or reuse) so long as certain performance metrics are met (such as water quality measures).

<u>Site development regulations</u>. States regulate shale gas development from the very beginning of the process – before fracking activities are initiated. The following graphic illustrates a timeline showing the various aspects of gas well development and operation through the life of the well – which in some cases can extend decades with multiple fracks.

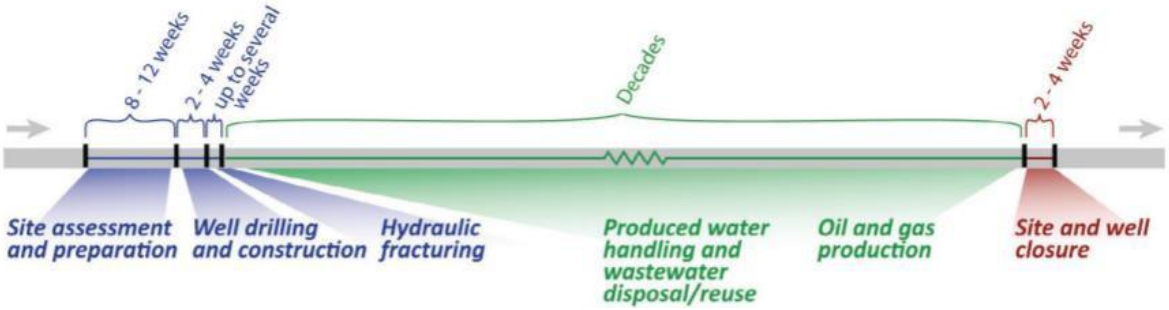


Figure 4. Summary of a timeline and activities for a typical hydraulic fracture well (source USEPA 2016).

Typically the states, and therefore operators, must document the suitability of a proposed well site for development including meeting relevant setback requirements (typically from occupied structures). These setbacks can also include: public and private drinking water sources including both wells and public water intakes; riparian zones and other sensitive landscapes; and any other landscape features deemed appropriate and allowable with state regulations. In viewing a number of states, setbacks requirements for occupied structures range from 100 to 1,000 feet. There is also a tremendous range for setbacks from various water features – from 50 to 500 feet – though setbacks from public water sources (surface intakes and wells) are typically greater (often up to 2,000 feet). Over the last couple of years, States have been expanding required setbacks, particularly for public water sources. A number of states actually do not regulate minimum distances for gas wells from private drinking water wells, though minimum distances of 100 feet are typical.

Pre-drilling water testing is required in nearly all states, with the distances required for water testing often based on estimated fracking distances and characteristics. When actual minimum distances are mentioned, they range from .09 miles to one mile. Where states require testing "near to the proposed well," the definition of "near" is often left to the operator and / or regulatory agency to determine.

Typically, other aspects such as suitability of local roads and infrastructure, as well as proximity to schools and healthcare (except for occupied building minimums), are not considered in well siting decisions or regulations.

Water quality liabilities. Operators are generally liable for pollution problems originating from their wells for distances in excess of the minimum distances for required water testing. Liability distances can range from 1,500 feet - 2,500 feet for a number of eastern states to over a half of a mile in Colorado.

Well casing and cementing requirements. In general, states require the extension of well casings and cementing to extend below the lowest or base levels / zones containing any freshwater that is utilized (drinking water aquifers). These distances, however, are relatively short, ranging between 30 and 120 feet below the lowest or base elevations (often determined by monitoring existing wells in the area), with an average of 60 feet. Typically, casings and cementing must also be able to meet performance standards, such as the ability to withstand the pressures associated with multiple fracking events over various durations of time. Cementing performance minimums are also typically dealt with – particularly to insure that cementing from different cementing injections are fully joined to minimize potentials for subsequent leakage through cement seams. Cementing in all cases is completed from the lowest required elevations in the borehole to the surface of the ground. Methods for insuring well casing and cementing performance are variable from operator to operator and from state to state. Well casing and cementing longevity are also not typically / systematically addressed by operators or state regulations except in general qualitative terms.

Hydraulic fracturing. The actual fracturing involves high-pressure injection of a mixture of water, sand or pulverized ceramic materials, and fracking fluid, which is composed of what is

often a very complex mixture of chemicals that are combined to meet very specific objectives in the fracking process. These objectives can include:

1. Biocides to reduce bacteria and other living organisms that can impact the durability of the well casing and cement.
2. Corrosion inhibitors to protect the well casing.
3. Friction reducers to improve the slick water / gas performance of the process.
4. Iron control to minimize iron armoring which can reduce the porosity of the shale fractures.
5. PH adjusting compounds to reduce potential damage to the well casing and cement collars.

Water is the dominant ingredient in this mixture with often millions of gallons of water required per fracking episode. This water is typically withdrawn from local surface and groundwater sources. However, water recycling is becoming far more prevalent in fracking with water reuse typically providing the majority of the water being used in many gas-producing areas. States typically require permits for industrial operations that withdraw significant amounts of water, such as those required with fracking. Operators also must typically report on the amounts and source locations for the water they are using. Trucks are typically used to transport the water to well sites, though areas that utilize recycled water often install piping systems to move frack water to where it may be needed. As mentioned above, individual frack events can involve hundreds of round-trip truck trips from water sources or storage areas to the individual well.

Fracking fluids. Fracking fluid components have historically been regarded as trade secrets, so many of the components included in the fluids are not fully regulated and are not always fully disclosed. Partial disclosure is generally mandated by states and the amount of disclosure is often left to the discretion of the well operators by determining what chemicals are in fact "trade secrets." States that require full disclosure often hold those disclosures as confidential, free from the potential reporting requirements of the Freedom of Information Act. FracFocus, a database initially developed by the US Department of Energy, is perhaps the best source of information about fracking chemicals – state-to-state and operator-to-operator. The Occupational Safety and Health Administration also require the disclosure of all hazardous chemicals – however there are storage minimum amounts and levels of required reporting that do not always result in full disclosure of chemicals and associated concentrations or amounts. This is because well operator methods often do not align with OSHA requirements for chemical reporting.

Wastewater and flow back water storage and disposal. Typically, almost half of the water that is fracked returns to the surface as flow back or produced water, depending on the characteristics of the well and the shale formation being fracked. This water also returns with many of the fracking chemicals, as well as carrying materials from the formation itself, which many times includes toxic or at least environmentally problematic materials. In the past, this water has typically been stored for recycling (reuse in additional fracking) or disposed of by utilizing deep injection wells. In many areas of the eastern United States, injection well usage has slowed due to injected water being lost for subsequent fracking activities because

operator access to public water sources is now being permitted and in some cases, limited.

The storage, disposal, and recycling of such water is extremely complex with opportunities for spills and / or leaks that can lead to shallow groundwater or surface water pollution events. This flow back or produced water is most common immediately after a fracking event, and will be minimized or eliminated once the well is producing gas. As the economics and technologies of fracking are changing, so are the ways the industry is dealing with the resulting wastewater. On-site lined storage ponds/pits are being replaced with enclosed storage tanks improving environmental protection. This also improves operational aspects of fracking with improved control over storage and management of the produced water. The volumes of water being stored are being reduced significantly as the industry develops improved methods for water reuse in the fracking process. In addition, water treatment technologies are being developed and improved to facilitate increased and continued utilization of produced water for continued fracking, reducing operational demands for new water. For example, a billion dollar treatment facility is being developed in central West Virginia to potentially handle water from hundreds of wells. Well-to-well and operator-to-operator networks are being established to move produced water from where it is being produced to where it might be needed. New pipeline systems may be above ground or underground. These new water pipelines often use the same pipeline alignments as already in-place natural gas pipelines. However, much of the produced water also continues to be trucked, often severely impacting rural / local road networks in terms of road damage and maintenance, as well as road crowding and safety.

For operations utilizing pits and impoundments for water storage, the operators must typically adhere to state impoundment design and operation regulations, often with increased design requirements due to the potentially toxic nature of the water mixtures being stored. State impoundment freeboard design requirements (additional depth of the pit or impoundment above the design water level), emergency storage in the event of unexpected water volumes; pit liner materials, and site / landform slope guidelines are all aspects regulating water storage in pits for fracking operations. Pit failures of one form or another (sloughing sidewalls, tears, etc.) are often the source of significant surface and shallow groundwater pollution events associated with frack wells. Pit liners are regulated in every state and typically address liner thickness, materials, maintenance, and monitoring of liner degradation, failure, and requirements and methods for replacement.

Underground injection wells. Injection wells are permitted in all of the states with active fracking and the associated regulatory programs. However, there are tremendous variations in the required design and operation of the wells. Currently, Ohio, Arkansas and portions of Texas have moratoria due the increased seismic activities linked to shale gas fluid disposal in such wells and the expansion of such moratoria to other states is likely to continue. These concerns over seismic activity are driving the industry towards improved water treatment for greater reuse of produced water in other fracking operations and decreased reliance on deep well injection. There are a variety of other water disposal methods being utilized in different fracking states and the following is a list of these technologies / methods moving from most widely used to least used:

1. Underground injection (though use is being reduced)

2. Disposal facilities
3. Evaporation ponds / disposal pits
4. Land application – for certain uses only
5. Discharge into surface water bodies – under very limited conditions

Drilling wastes such as drill lubrication fluids, muds and well cuttings must be similarly disposed of.

Wastewater transportation and tracking. Wastewater that is not utilized, stored on-site, or in adjacent fracking operations must be transported using either trucks or pipelines. Truck transport generally requires permitting for transport of hazardous materials that is typical for other hazardous materials. Trucks have traditionally been the primary method for wastewater transportation though pipelines are now becoming more prevalent.

Excess gas disposal. Typically, excess gases, often methane, that are not to be captured are either vented or flared. It is now recognized, that these practices have had serious environmental consequences. Venting and flaring are regulated by all of the states with active fracking, at least in terms of setting limitations on their usage. Venting is more widely regulated than flaring, which is still relatively widely used in many fracking states. However, when the Obama Administration sought to regulate excess and fugitive gases (primarily methane), the majority of operators responded by installing equipment for the capture of these gases for transport for downstream processing and utilization. This has resulted in decreased use of both flaring and venting.

Production of gas from the well. Well production is regulated similarly to traditional gas and oil well regulation. There is often less governmental oversight of traditional gas producing wells. These wells may be essentially static and low maintenance for many years. However, producing wells may periodically produce water and fugitive methane, which will be dealt with as discussed above. However, it must be noted that periodic methane escapes are relatively common in producing wells, particularly in the early stages of production.

Site downtime, abandonment and environmental restoration. Typically, site abandonment and restoration regulations come in to play at the end of the well life. When wells are no longer producing they are typically plugged and abandoned. However, wells are often temporarily abandoned or "shut down," as is currently the case with many wells, due to the relatively low cost of natural gas. Operators and the states have a variety of mechanisms for the continued inspection and maintenance of such inactive wells. The time over which wells can remain idle varies significantly from state to state – ranging from 1 to 300 months, but typically 12 months. After such periods the well must be "permanently plugged".

Once a well is abandoned a range of state regulations that address erosion and sedimentation control, road abandonment, revegetation, regrading and land reshaping, and the restoration of natural surface water flow patterns come into play.

There are numerous other regulatory / legal aspects that can impact frack well development

and operation. These can include environmental accident reporting, health and safety reporting, production reporting for taxation purposes, unannounced inspections, etc.

D. Fracking and Chatham County

The geology of North Carolina includes four "Triassic Rift Basins" that contain sedimentary shale formations, some of which could be natural gas sources using fracking technologies. Rift basins are typically sedimentary areas that are narrow and bounded by other large metamorphic or igneous formations that are the result of tectonic activities that occurred over millions of years. The major basins are the Wadesboro, Sanford, and Durham sub-basins of the Deep River Basin and the Dan River Basin. The Davie County and Ellerbe Basins are two additional much smaller basins. A 2012 USGS / North Carolina Geology Survey identified the Deep River Basin as the most promising for containing recoverable natural gas.

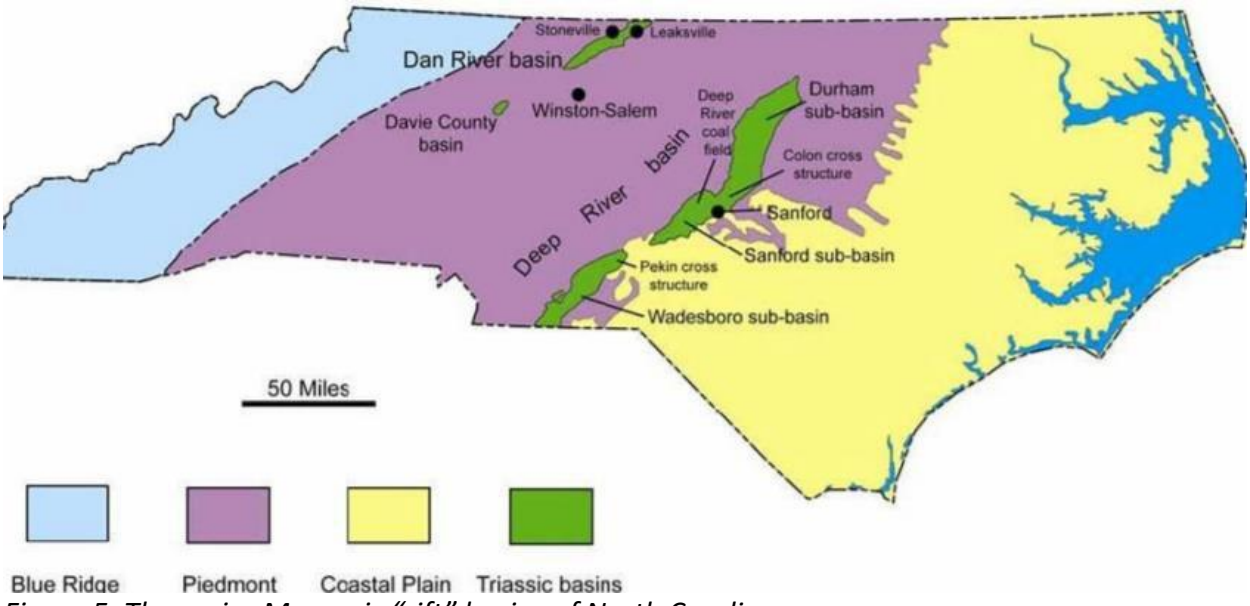


Figure 5. The major Mesozoic "rift" basins of North Carolina.

The Deep River Basin can be divided into the three sub-basins – Durham, Sanford, and Wadesboro. It is the Sanford sub-basin that is present in the southeastern corner of Chatham County and actually covers most of adjacent Lee County. The following graphic provides a more detailed view of the Deep River Basin in the Chatham County region.

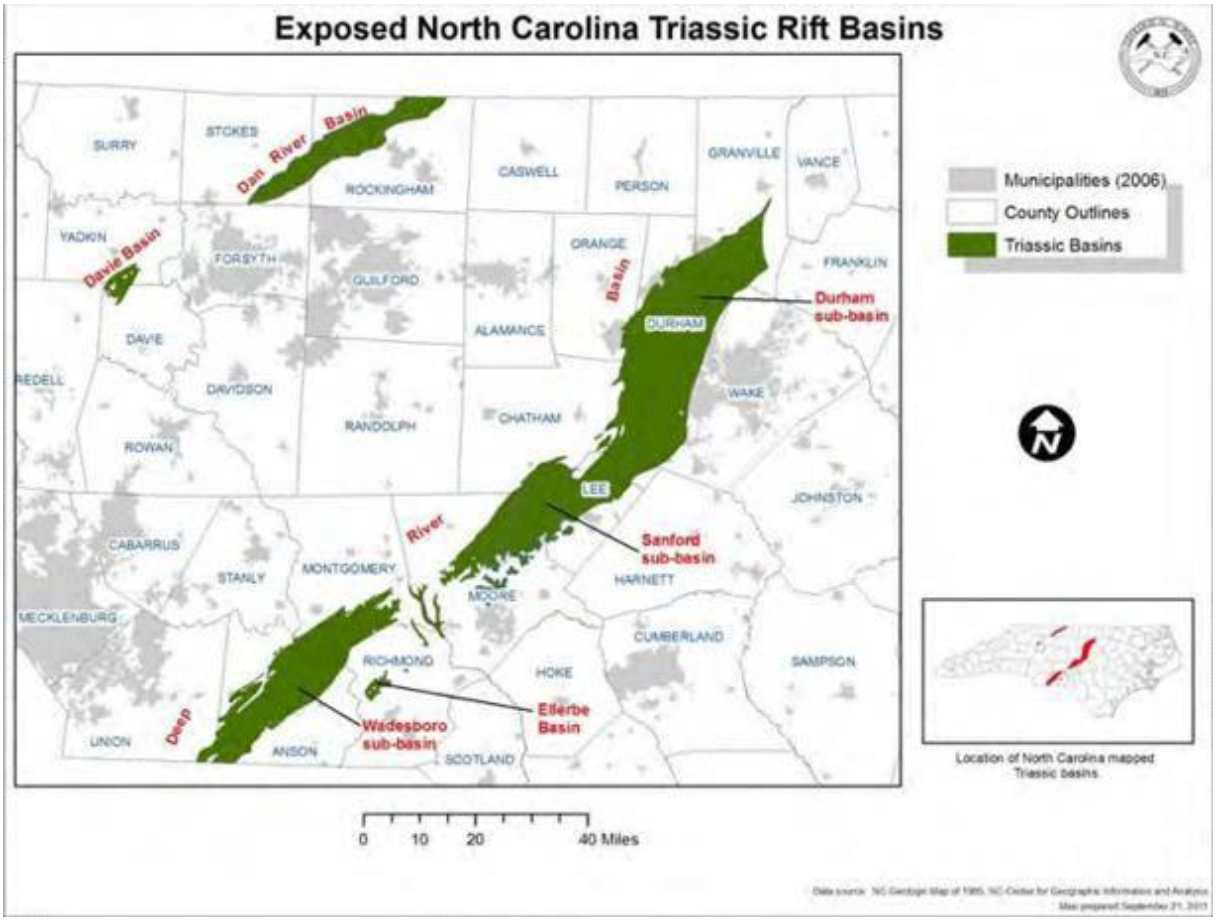


Figure 6. Exposed basins in the Chatham County region.

According to a number of USGS / NCGS investigations within the Sanford sub-basin, only the Cumnock shale formation provides the opportunity for recoverable natural gas. The Cumnock formation only occurs in the southeastern portion of Chatham County. The formation actually daylights / outcrops at the earth's surface in the County. This is according to the 2012 USGS / NCGS study (USGS 2012) and confirmed with a recent May 2017 map compilation for the County. The earlier study, as well as current mapping, indicates that there are between 700 and 1,000 acres of Cumnock Formation in the County. Additional estimates seem to indicate that this area could be slightly over 3,000 acres. However, much of this area is unavailable for natural gas development due to the presence of an "exclusion zone" for the Harris nuclear power plant located adjacent to the southeastern corner of the Chatham County. Though fracking is not specifically controlled in this zone, the Utility operating the plant has significant input into activities that are allowed / controlled in proximity to the plant (Haven 2017 unpublished, CFR 100.11 NRC). In addition, the floodplain / riparian zone of the Deep River excludes additional areas. In summary, the very shallow depths of the Cumnock Formation potentially results in only 500 to 700 acres available for development in the County. This area may be reduced further as it may be subject to other constraints such as existing building and well setbacks, surface water setbacks, and protection zones around a significant public water intake.

Early estimates indicated that gas volumes in the entire Deep River were in the range of 1,660 billion cubic feet of gas but more recent estimates put the total volume in the basin around 1.7 trillion cubic feet, much of which is not recoverable. The Cumnock Formation typically ranges in thickness between 200 and 600 feet with localized maximum thicknesses in excess of 800 feet. Following is a generalized geology compilation map of Chatham County showing the outcrop areas of the Cumnock Formation. The potential area for fracking in Chatham County is the southern portion of the County – often in relatively close proximity to the Deep River floodplain and riparian zone.

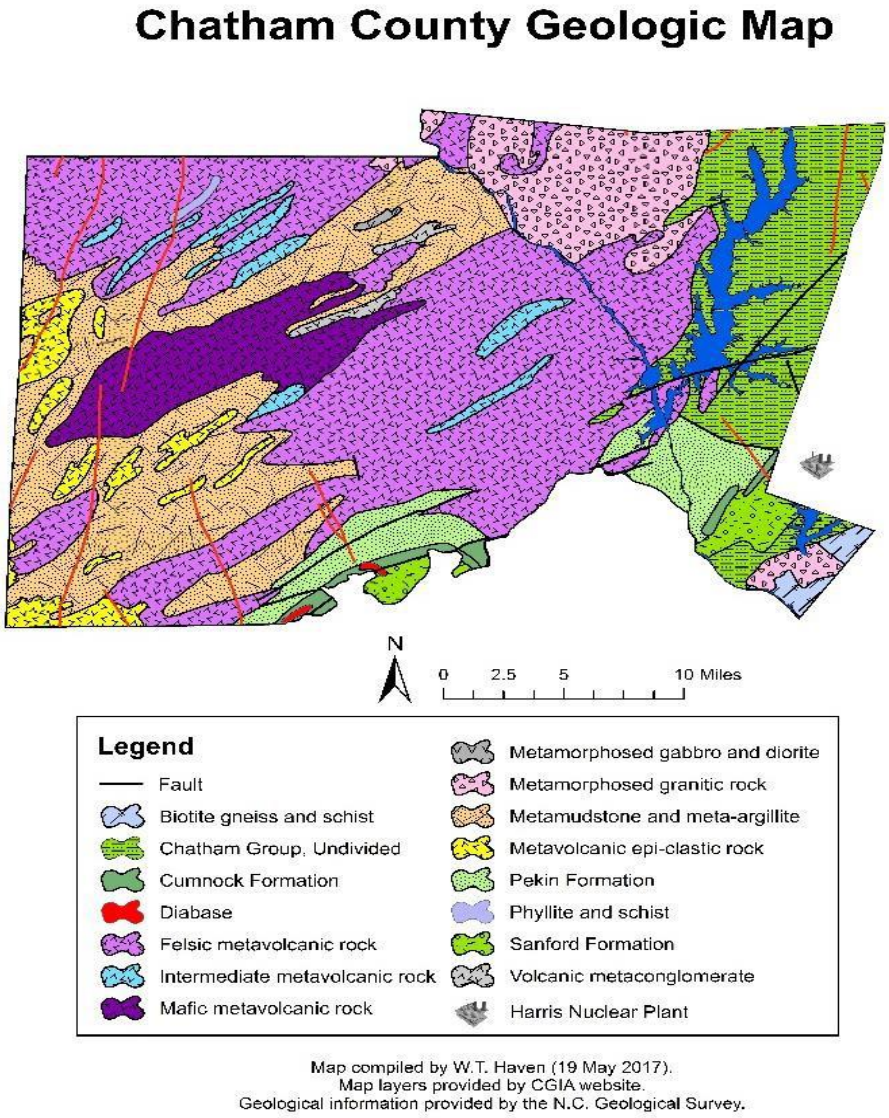


Figure 7. Geologic Map showing the outcrop of the Cumnock Formation in Chatham County in dark green.

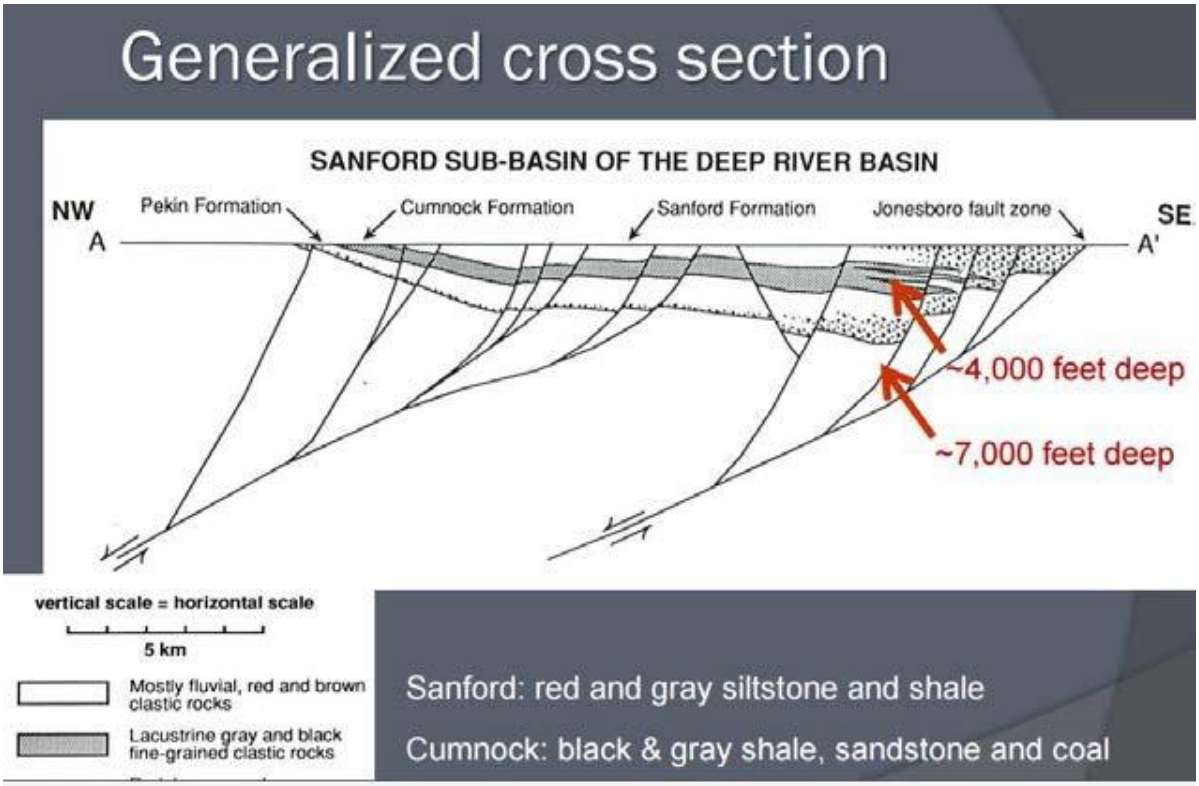


Figure 8. Geologic cross-section highlighting the Cumnock formation with the outcrop of the formation shown in the northwestern edge of the section. The section also illustrates the gradually increasing depth of the formation, as the formation extends into Lee County. Gas from these greater depths are more suited to recovery using fracking well technologies.

The result of these conditions is that much of the Cumnock Formation area in Chatham County includes areas of irregular formation outcrops where no gas recovery is possible because of the inconsistent presence / absence pattern of the shale. In addition, much of the remainder of the formation is at relatively shallow depths. This can result in significant cost increases due to technical difficulties with shale recovery at shallow depths, as well as increased potentials for the environmental damages that are often associated with “shallow fracking”.

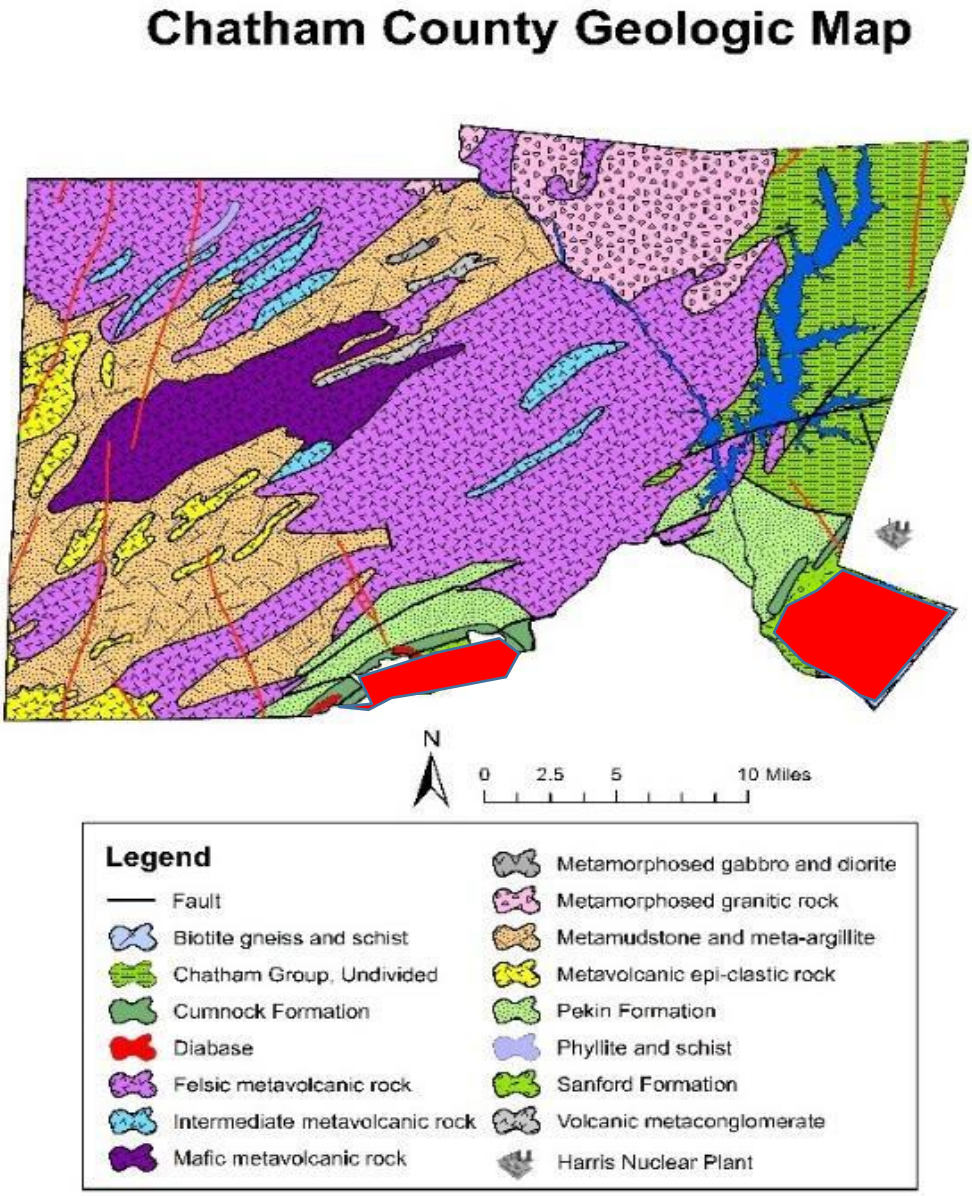


Figure 9. Chatham County geologic map with Cumnock Formation coverage in Chatham County illustrated in red.

Though countywide zoning regulation has recently been extended cover previously unzoned areas of Chatham County, the County does have a history of land use and environmental planning spanning back a number of years. This includes moving forward with the current countywide comprehensive planning effort that is underway. The recently released comprehensive plan draft summarizes some of these milestones.

1. County land conservation and development plan – 2001.
2. Chatham County housing needs assessment – 2006.
3. Farmland Preservation Plan – 2009.
4. Parks and Recreation Master Plan 2011.
5. Conceptual Land Use Plan – 2013.
6. Comprehensive Transportation Plan – 2016.

The portion of Chatham County that overlays the Cumnock Formation can be characterized as an agricultural area with numerous farms, significant forest patches, small village centers, dispersed development, and an employment zone or area with dispersed commercial and industrial facilities in the eastern portion of the County.

Going back to earlier work completed by the State Natural Heritage Program, what emerges is a recognition of the importance of the ecological, water resource, cultural, and recreational resources from the Deep River floodplain and riparian zone. Following is the proposed plan for parks, recreation, and open space from the County Comprehensive Plan. The plan illustrates the Deep River riparian zone containing:

1. Blue ways and water trails
2. Recreational trails
3. Historic areas and districts
4. A conservation design zone for residential development
5. Two designated village centers
6. River access recreation nodes

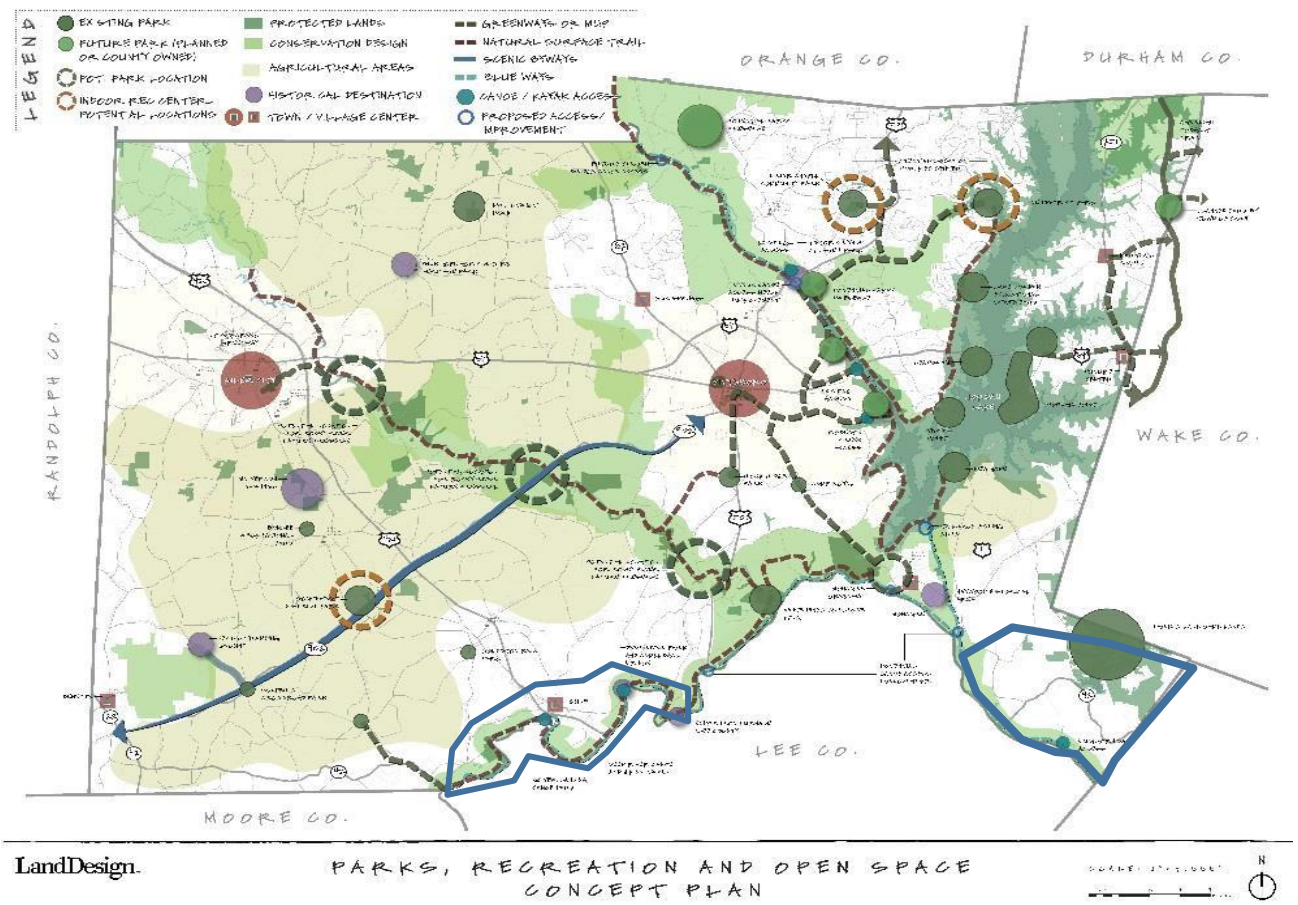


Figure 10. Proposed Chatham County open space and recreation plan. Cumnock Formation areas are outlined in blue.

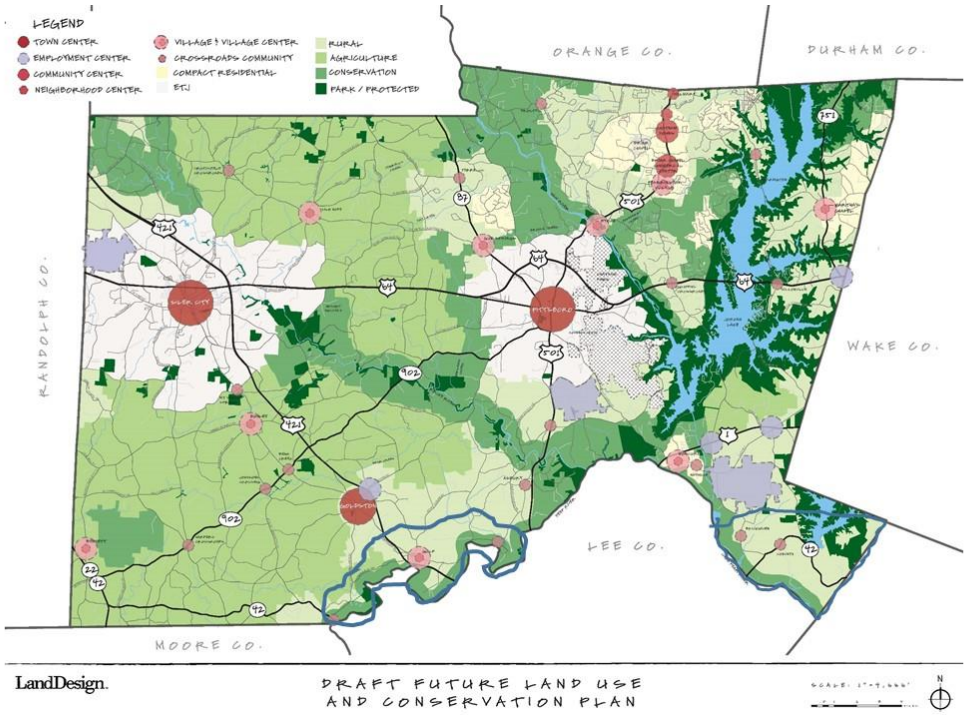


Figure 11. Proposed general land use concept plan for Chatham County with areas overlaying the Cumnock Formation outlined in blue.

Chatham County and "shallow fracking." What is known as "shallow fracking" nationally occurs in roughly 15% of fracking wells. Shallow fracking is where well depths are generally less than 3,000 feet. This often results in reduced vertical distances between drinking water groundwater formations and the shale formations being fracked. These short distances would be found with any fracking operation that would occur in Chatham County due to the relatively shallow depths of the Cumnock Formation. Significantly higher risks of groundwater pollution are present with shallow fracking because of the relatively short distances between the bottom elevations of zones of concern (such as with groundwater aquifers) and the top elevation of the formations to be fracked. States such as Arkansas and Texas that have a majority of existing shallow wells require specialized casing / cementing methods to offset the relatively short distances between groundwater and the fracking activity. However, even with such specialized well construction higher numbers of groundwater pollution incidents are observable.

Chatham County and the regulation of fracking. North Carolina's counties and municipalities operate under "Dillon's Rule" in which local government authority is restricted to areas specifically outlined in state laws and regulations. Counties and municipalities are granted zoning and developmental regulations powers and those powers can be relevant for fracking. A 2014 Mining and Energy Commission study (Cary community study 2014.) researched whether local government can apply these powers to aspects of fracking. This study's results appear to be integrated into the 2015 state regulations that will be implemented once the state regulatory program is operational. Important among these provisions are:

1. Local ordinances should only apply to surface land and water issues;
2. Local governments should be able to apply zoning and land use authorities to the oil and gas industry;
3. Local governments cannot develop and apply ordinances / regulations exclusively to prohibit oil and gas operations including fracking;
4. Special use permit programs can be developed that specifically address oil and gas operations allowing such operations with special use permitted areas;
5. The ability to appeal all decisions concerning implementation of local regulations to oil and gas operations need to be included in local regulatory programs.

E. Fracking and North Carolina

North Carolina developed and passed a comprehensive oil and gas exploration bill in 2011 – Session Law 201-143 / Senate Bill 820 that included authorization for fracking. Among other aspects, the legislation addressed the following;

1. Reconstituting the State Mining Commission as a Mining and Energy Commission.
2. Authorized development of a modern regulatory program – resulting in the 2015 regulations.
3. Provided for allowing hydraulic fracturing and horizontal drilling pending additional legislative actions.
4. Enhanced protections for surface owners and public bodies.
5. Established a legislative committee for energy policy.
6. Forced pooling of gas leases was not implemented in North Carolina.

The legislation also authorized the development of a comprehensive study of the issues associated with hydraulic fracturing in North Carolina. The resulting study titled, “North Carolina Oil and Gas Study”, is an exhaustive 500+ page document which examines numerous aspects of hydraulic fracturing, including: regulatory program development and funding, permitting and inspection program development, program management and potential enforcement methods and associated penalties, the surface and underground environmental impacts of fracturing, and potential community and health and safety issues.

Additional legislation was passed in 2013, and 2015 regulations (Subchapter 05H- Oil and Gas Conservation) were put in place with implementation to be activated with full appointment of a new Oil and Gas Commission. Once fully operational, the Commission will have regulatory and rule development responsibilities. The North Carolina Department of Environmental Quality will have responsibilities for technical support and providing technical guidance to the Commission. The 2015 regulations encompass the full range of administrative and technical issues associated with operation of the State’s regulatory program and the oil and gas operators addressing those regulations.

The following is not going to provide an exhaustive review of those regulations. These regulations, as well as the 500-page background report, can be downloaded from online sources. This report summarizes the regulations, as they address surface land and water aspects, air and groundwater pollution, land use and location siting issues, impacts on

community infrastructure, and issues related to hearings and appeals and the disposition of "confidential information as well as public notification requirements.

1. Public notification requirements.
    a. 30 calendar day public notifications prior to any drilling activity.
    b. Specific notices to surface and mineral owners within a proposed "drilling unit."
2. Oil and gas permit applications.
    a. Activities that require permits – full life cycle of a potential gas well from drilling to plugging and location re-entry and plan revisions.
    b. Map submission requirements – including detailed, map scale, well data, and environmental / community context mapping.
    c. Detailed well technical characteristics.
3. Well site development plans.
    a. Sedimentation and erosion control plans.
    b. Water management plans.
    c. Well site reclamation plans.
    d. Plans for emergency management.
    e. Plans for fugitive methane control.
4. Permit review, appeal, timing and denial procedures.
5. Bonding – required for well plugging and abandonment, a disturbed land bond (amount calculated for each well) and a one million dollar environmental damage bond. Criteria for eventual bond release are also detailed.
6. Well site construction standards.
    a. Well construction – not reviewed here.
    b. Leak detection system – must be detailed.
    c. Well pad and site must be developed according to the North Carolina Erosion and Sedimentation Control Design Manual.
    d. Stormwater management using the BMP's of the North Carolina Division of Water Quality.
    e. Spill containment systems must be designed and fully detailed.
    f. Storage pit and tank construction standards.
        i. Location setbacks
        ii. Impoundment design standards
        iii. Locations – in cut rather than fill areas
        iv. Adherence to relevant standards – ASSHTO and ASTM among others
7. Setback requirements for wells and other production equipment and facilities.
    a. 650 feet from all occupied buildings
    b. 100 feet from paved public roads
    c. 200 feet from perennial streams, lakes and wetlands
    d. 100 feet from intermittent streams
    e. 650 feet from public and private water wells
    f. 100 feet to the edges of mapped floodplains
    g. 1,500 feet setback from any public water intakes or the edges of rivers that drain more than 140 square miles (such as the Deep River).
    h. Criteria for granting variances to setbacks and prohibited setbacks. Criteria address reducing setback requirements with no specific guidelines for increasing setbacks.

8. Casing and cementing standards – not summarized here.
9. Well stimulation methods – not summarized here.
10. Wellhead requirements.
    a. Wellhead equipment must withstand 100% above the anticipated well operating pressures.
    b. Check-valves to prevent unintended gas or fluids flows.
11. Well maintenance, blowout, and control measures (not reviewed here)
12. Visual impact mitigation.
    a. Well operators must use visual screening including vegetation, berms, and new vegetation planting.
    b. Operators may request variances based on;
        i. Zoning.
        ii. Surface use agreements.
        iii. Land use compatibility.
        iv. Topography and / or design of the well pad.
13. Well closure – not reviewed here.
    a. Permanent closure.
    b. Well shutting in
    c. Well temporary abandonment
14. Closure requirements for the site and water handling and safety and security at well sites.
15. Reclamation plan requirements.
    a. Future land use plans.
    b. A plan for revegetation and / or reforestation (if site was previously forested).
    c. Requirements for plan review.
        i. Consultation with different organizations and agencies
        ii. Professional background of persons preparing reclamation plans.
16. Requirements for continued well operations.
    a. Testing and additionally required testing.
    b. Requirements for inspections and inspection reporting.

F. Observations / Recommendations / Suggestions

Observations

1. Hydraulic fracturing is unlikely to occur in Chatham County. This is due to the relatively small acreage of the Cumnock Formation present in the County, which is really the only candidate shale formation for fracking in the County. The relatively small acreage present is further reduced with the exclusion zone for Harris nuclear power station, publicly managed lands, and the various setback distances included in the proposed regulatory program for occupied buildings, streams and wetlands, public water intakes, public and private drinking water wells, and the Deep River floodplain / riparian zone. Any fracking that may occur in the County will likely be peripheral to fracking that may occur to the south of Chatham County in Lee County. Such limited potentials could include a very small number of wellpads that are extensions of more intensive development in Lee County.

2. The relatively shallow depths of the Cumnock Formation in Chatham County would create conditions for what is known as "shallow fracking," in which the distances between groundwater aquifers (with drinking water wells in the County sometimes driven to 1,000 foot depths). The Cumnock Formation which may be right around 1,000 feet in parts of the County, with those depths increasing as the formation moves southward towards Lee County. Such conditions increase the potentials for fracking related ground water pollution due to the close proximity of the fracking activity and groundwater wells and the associated aquifer depths, which are typically variable in rift basins.

3. The Deep River riparian zone has been recognized as a nationally significant ecological and natural resource asset in previous environmental studies completed by the North Carolina Natural Heritage Program. The Deep River is also central to the Chatham County cultural and recreational resource plans and open space development.

4. The State has designated a number of significant natural / cultural / recreational areas that have a variety of special land use performance and management measures associated with these areas; Jordan Lake is one of the designated areas. The County could explore having the Deep River floodplain / riparian zone designated as one of these areas to provide a greater degree of environmental protection in an area that may suitable for fracking.

5. There are a number of avenues for the County to integrate aspects of county zoning with standards from the State's fracking regulations – such as for visual impact standards.

Recommendations

1. Formation of a multi-county working group focusing on larger geographic issues regarding unconventional shale development

2. Develop voluntary guidelines for shale gas development in the County similar to those developed by the working group in the Marcellus region.

   http://marcelluscoalition.org/wp-content/uploads/2013/03/RP_Site_Planning.pdf

3. Develop formal guidelines / standards with potential amendment of the county regulations (such as zoning and subdivision regulations) to exert additional controls over any fracking that may occur. Such guidelines / standards are allowable with the 2011 law and associated 2015 regulations so long as the guidelines / standards do not eliminate the possibility for hydraulic fracturing or overly restrict fracking activities to make such activities essentially unfeasible.

Suggestion

1. Chatham and Lee Counties could undertake a detailed spatial study to examine specific

extents and patterns for potential fracking and the potential relationships between the two counties and eventual development of a fracking industry. Such a study could rely on data that for the most part are available in the two counties, including:

a. Lidar data for precise elevation modeling.
b. Geology data developed by NC Geologic Survey and USGS for the Triassic Basin.
c. Land use / land cover.
d. Plans and ordinance restrictions.
e. Structures – building footprints are available for Lee County and could be developed for Chatham County.
f. Public and private drinking water wells and water intake locations.
g. Natural and cultural resource locations.
h. Streams, wetlands and floodplains.

Appendices

Some key legal / regulatory aspects of hydraulic fracturing in North Carolina

Use of injection wells for disposal of produced water from fracking. Injection wells are prohibited in North Carolina. The result is that produced water would likely be recycled for reuse in fracking or disposed of utilizing surface disposal.

North Carolina Oil and Gas Commission regulations. Current proposed of the regulations covers most but not all aspects of fracking. Regulations will need to be reviewed and revised to address all critical aspects of hydraulic fracturing operations – from exploration to restoration and site abandonment and to comprehensive record keeping and reporting.

Most aspects of the proposed regulations for North Carolina do reflect current science and practice. However, the utility of many of the regulations (such as borehole cementing and surface will site water control measures) require rigorous inspection and enforcement to be effective.

Local regulation of hydraulic fracturing. Generally applicable local regulations can be applied to hydraulic fracturing as authorized in state laws. Typically, local regulations cannot address any aspects regulated by state law. Zoning, subdivision regulations, and other design review / siting ordinances may address aspects of fracking operations so long as such ordinances do not preclude or severely limit the development of hydraulic fracturing operations.

However, it must be noted that the application of local ordinances can be appealed to the Oil and Gas Commission to determine whether such regulation is overly restrictive or unnecessary.

Surface owner property rights. Deference is given to the mineral owner such that the surface owner(s) cannot diminish the value of the mineral resource. This applies to all surface aspects of fracking operations except for thru pipelines and roadways. Right-of-ways for thru pipelines and roadways (not directly required for on-site development) must be negotiated separately.

Forced or mandatory pooling of mineral leases. North Carolina does not have forced or mandatory pooling of mineral leases. Eastern states, in which surface and mineral ownership patterns typically do not have forced pooling due to complex surface and mineral ownership patterns.

Hydraulic fracturing moratoriums. Moratoriums can be enacted, if such moratoriums are: of fixed duration; and relate to specific goals and objectives, such as the need for additional study and not simply as a "delaying tactic."

State regulations and conditions found specifically in Chatham County. Proposed state regulations (primarily setback requirements) potentially do not adequately address a number of critical environmental conditions found in Chatham County. These include: igneous and metamorphic geologic features such as dikes which are often sites susceptible to groundwater

pollution from surface sources; proximity to the Deep River main-stem and riparian zone and the ecological importance of the Deep River; and the shallow depths of the Cumnock Formation in the County and the resulting close proximity of groundwater source formations to the formation suitable for natural gas development. This close proximity potentially increases the likelihood of groundwater pollution of fracturing activities.

Major environmental, health and safety, and community infrastructure issues associated with fracking

Water Quality. The impacts of fracking activity on surface and groundwater resources are perhaps the most well-known and documented. These impacts relate to groundwater water quality degradation that is often due to leaking of fracking chemicals because of surface accidents or well casing and cementing failures, water well failures due to drilling altering shallow aquifers, and surface water features such as streams and wetlands that can be impacted by surface accidents and equipment failures.

The potential issues associated with fracking and water quality are only likely to worsen. For example, during 2015, 300,000 wells in the United States were producing 53 billion cubic feet of gas per day and utilizing over 150 billion gallons of water per year – some of this water is recycled from previous fracking but much of it is from ongoing water supply withdrawals.

Fracking chemicals. Fracking chemical use is not regulated by the Clean Energy Act of 2005 and limitations on fracking chemical disclosure to the public are regulated by the same law. However, states are not precluded from regulating fracking chemicals and chemical disclosures. Twenty-eight states require disclosure of some, but not all, chemicals used in fracking, and in fact, no state requires the reporting of all frack constituent chemicals in the interest of "trade secrets". Twenty-three states actually rely on FracFocus (a USDOE initiated effort) for chemical review and reporting. Following are some of the chemicals and their purposes in fracking. Such chemicals typically make up .5% to 2% of the total volumes of typical fracking fluid mixtures.

Category	Purposes	Examples
Diluted acids	improve injection and penetration	Hydrochloric acid
Biocide	minimizes bacterial contamination of	Glutaraldehyde
Breaker	used to break down gels that form	Ammonium
Clay stabilizer	prevents clays from forming in open	Potassium chloride
Corrosion inhibitors	maintaining integrity of the metal	Dimethylformamide
Crosslinker	thickens fluids to hold proppants	Borate salts
Defoamer	lowers tension and allows gas to escape	Polyglycol

Foamers	reduces fluid volumes	Acetic acid
Friction reduces	improves fluid flow efficiencies	Polyacrylamide
Gels	thicken fluids	Guar gum
Iron control	prevents materials from hardening	Citric acid
Oxygen scavenger	maintaining integrity of steel casing	Ammonium
pH adjustor	controls pH in the solution	Sodium carbonate
Proppant	holds fractures open	silica – sand
Scale control	prevents mineral scale formation	Ethylene glycol
Solvents	improves wettability	Stoddard solvent
Surfactant	improves fluid flows	Isopropanol

Numerous past and on-going studies have indicated that many of the chemicals being utilized are toxic to humans, wildlife, and insect populations. In addition to utilization of potentially toxic chemicals, other water resource related fracking aspects include: water usage, and surface and groundwater contamination. Several of the chemicals that are used are also known to cause cancer.

Water usage. Typical fracking wells utilize between two and ten million gallons of water for a single frack. A single five million gallon frack using water removed from the natural sources would require 1,400 truck trips. The extraction of so much water has raised issues concerning water availability for human use, agriculture, and the ecology of aquatic and terrestrial wildlife. In the past, fracking operators were generating excesses of water, which were being stored or injected. The industry is moving towards recycling water from fracking wells, often after being re-processed in industrial water treatment facilities.

Aquatic ecology. Water withdrawals can impact aquatic habitat quality, as well as water temperature in surface water streams and wetlands that can degrade habitat values for water temperature sensitive species. Chemical spills will certainly have potentially drastic, but often short-term impacts on aquatic wildlife in proximity to wells and pipelines.

Sources of water pollution. Storage basin leaks, fracking fluid leakage from well casing and cementing discontinuities, and fracking fluid migration from fracked shales to adjacent aquifers have all occurred in other fracking operations are certainly potentials for future operations. There are inconsistences in different scientific studies on the contributions of fracking to groundwater pollution with geologic and operational differences being significant variables. An additional issue may relate to the long-term resiliency of the steel casings and cement linings that may be present and operating in wells for many years and will remain after wells are abandoned and plugged. This is somewhat due to the very slow rates that

water and therefore, fracking fluids can move through subsurface formations – often groundwater pollution impacts may not be felt in areas from such pollution sources for decades. However, studies are finding increases in surface pollution events from accidents and equipment failures at the well pads that are potentially the issues of greatest concern. Little is actually known about the very long term pollution potentials of abandoned wells.

Air quality including methane. Air pollution associated with fracking operations typically exerts a number of negative impacts. Dozens of pollutants are associated with drilling and fracking operations that do pose serious health impacts. The two main sources of air quality problems are excess gas escapes and operational impacts such as pollutant discharges from compressors and other mechanized equipment such as trucks and drill rigs. In the past, gases were flared or vented if the gas could not be stored or used commercially. Venting is the release of gas from the well borehole into the atmosphere. Borehole gases are often produced during initial drill and fracking operations. Flaring is a process in which gas is burned off in stacks or flairs. When burned, methane produces carbon dioxide – a greenhouse gas. Such practices have environmental consequences – primarily the release of greenhouse gas emissions. The Obama Administration implemented rules in 2016 to control greenhouse gases produced by fracking operations; however, those regulations were recently deactivated. Methane also has developing markets so it is now being captured as a commercially viable product, which it has been in the west for a number of years where there is a lucrative coalbed methane industry. However, widespread operational returns to flaring and venting are not anticipated as many gas operations put significant hardware investments in place, given that fugitive gas control measures were going to be critical in the expected regulatory program of EPA which has since been reversed.

Fugitive methane releases have proven to be significant and continue to be problematic during actual well operation. Methane releases often continue after well abandonment, pointing to the importance of well abandonment and well plugging regulations. Continued methane releases have been noted in traditional gas wells that have often been abandoned decades ago.

There are many sources of air pollutants along the shale gas development chain. Other activities associated with shale gas development are often significant sources of air pollutants. Example of other important sources include:

1. ***site preparation***, including building roads and clearing pads,
2. ***drilling*** the well,
3. ***truck traffic*** to deliver and remove materials and wastes to and from the site,
4. ***separation and treatment operations*** (remove acid gases, remove water from natural gas and *separation* of natural gas from other hydrocarbons),
5. ***compressor stations*** that pressurize natural gas in gathering and transport pipelines, and
6. ***fugitive emissions*** that escape unintentionally from cracks or leaks.

Natural gas development and production emits criteria pollutants as defined by the Clean Air Act. Nitrogen oxides (NO_X) and volatile organic compounds (VOCs) are associated with oil

and gas development. In the presence of sunlight, these may react to form ozone and contribute to regional air problems. Regional chemical transport modeling has predicted that ozone may be of particular concern (EPA 2012) in heavy fracking regions. Nitrogen dioxide and particulate matter ($PM_{2.5}$) emissions are also potentially significant but may be more of a local than a regional issue.

Hazardous air pollutants or air toxics are another category of pollutant that is emitted with shale gas development and production. Many operations necessary for oil and gas development use diesel-powered engines, which emit diesel particulate matter. In addition, natural gas-fired engines can be significant sources of formaldehyde, a secondary pollutant. Aromatics (e.g., benzene and toluene) and other volatile chemicals can be and are often released during shale gas production.

Noise and light pollution. Fracking operations do produce noise levels that increase risks on human health, cardiovascular disease, and other conditions that may relate to increased stress. A number of studies have noted that people living near fracking operations bring up issues like air pollution, traffic and groundwater issues, but also regularly complain about noise. In fact, environmental noise is a well-known public health issue. Excess noise can actually link to adverse health issues such as depression, diabetes, birth complications and cognitive impairments in children. Noises can be constant or variable ranging from drilling, which results in loud continuous noises, to compressor stations that produce continuous low rumbles. The greatest noise levels in fracking are associated with site development, drilling, and fracking – typically over a period of a month or two per well. Compressor noise will be present throughout the life of the well(s), which can extend decades. The major sources of noise during development of a fracking well pad including:

1. excavators, graders, bulldozers, compactors and loaders associated with site and pipeline development,
2. drilling equipment including drill rigs, tubular preparation, and drill pipe connections,
3. trucks and other large vehicles to supply the well site with raw materials and water during,
4. well development, and
5. gas compressors – which actually generate the greatest noise actually during natural gas production once well development and fracking activities have ceased.

Field studies of people living in proximity to fracking in West Virginia and Pennsylvania have yielded the following general results:

1. Sound levels, even at their most extreme do not typically have enough intensity to cause hearing loss in humans.
2. Sound monitoring indicates continuous low-level noise with intermittent changes in intensity, which causes annoyance, anxiety, and stress over long periods of time in residents living nearby – typically less than ¼ mile.
3. Residents continue to indicate that sound impacts are of greater concern than the 24 hour a day lighting that is typically associated with frack wells during development.

In addition, noise exposure like other health issues, may disproportionately impact vulnerable populations such as the elderly, children, and people with chronic illnesses.

Health effects. Potential health issues can be present for workers, as well as resident / adjacent populations. Shale gas workers face chronic morbidity concerns similar to most oil and gas workers from silicosis and cancers, respiratory, and dermal diseases. People living near fracking operations report noticeable odors, and in smaller numbers – respiratory and dermatological problems.

Ecosystem, wildlife, and other exposures. Pet and livestock illness and mortality rate increases have been reported near drilling sites, in Pennsylvania, West Virginia, and Texas. In addition, to impacts on ecological health indicator species such as mussels, amphibians, and benthic macroinvertebrates, studies have noted impacts on endemic species such as small and large mammals in terms of decreased populations and increased offspring mortality. Direct chemical exposures, noise, and habitat disturbances are all potential wildlife impacts that can be significant. In addition, larger landscape impacts that relate to potential wildlife issues include:

1. Well pads, roads, and pipelines result in significant landscape fragmentation.
    a. Loss of quality forests that support wildlife diversity.
    b. Loss of interior forests that are habitat to interior species such as songbirds.
    c. Loss of quality forest edges which are critical to songbird and insect pollinator populations as well as bats.
    d. Loss of forested stream buffers and riparian zone quality that contribute to habitat quality for many wildlife species.
    e. Fragmentation of agricultural fields that are utilized as habitat and food sources for many species.

Road safety and maintenance costs. Fracking activities, over the life of a typical well, will require thousands of truck trips to and from well sites. Rural paved roads are typically constructed as light-duty roads that are not designed to handle such traffic loads and levels. Paved road quality rapidly degrades when designed capacities are exceeded. Road damage repair and ongoing maintenance costs can exert significant financial burdens on local and state agencies.

Other community impacts. A range of community impacts can be felt in areas such as emergency services, social services, and law enforcement. At least, during the early stages of fracking operation development, the majority of workers employed are typically from outside of the region as workers are often required to have specialized expertise and training, creating a transitory workforce for the period of well development, drilling, and fracking. Once wells begin production, industry worker requirements are greatly reduced, relying on a much smaller resident workforce.

Land use and land use planning impacts. With the Federal government deferring nearly all of the regulation of fracking to the states, the states in turn do provide local governments with some ability to regulate aspects of fracking with the tools readily at their disposal – primarily planning, zoning, and subdivision regulations. However, local governments typically are only

able to regulate the surface impacts of fracking with no real authority to regulate sub-surface or operational aspects of fracking operations. Typically, local governments, when considering aspects such as required setbacks and siting standards, cannot exceed state regulatory requirements. However, local governments are generally able to interpret such state regulations adapting those regulations to the context of local land use and other environmental conditions as expressed in community land use plans and regulations – so long as those regulations do not appear to have been developed to preclude fracking as a potential activity.

Questions, Comments And Observations

Summary of Public and Officials' Comments Regarding Fracking in Chatham County.

Key Concerns – written and oral comments summary of all community inputs – June 2017 comment period.

1. Potential human health effects of exposure to fracking fluids from groundwater / well pollution and/or surface sources.
2. Potential human health from accidents and other unplanned surface events.
3. Noise and air pollution of from various components of the operations.
4. Community impacts on infrastructure, community services and general community health.
5. Environmental / ecological impacts of groundwater pollution and surface accidents.
6. Impacts of methane releases through flaring and leakage on air quality.
7. Impacts on general community quality and health.
8. Long-term durability and maintenance of wells and other equipment.
9. Traffic, congestion and roadway safety.

Natural Gas Study Meeting – June 13, 2017 Questions and comments received after the meeting

<u>Questions</u>

1. The rules/regulations developed by the NC Mining & Energy Commission (now in "limbo" due to litigation) dealt only with horizontal fracking. Will a new set of regulations/rules be needed to address shallow and vertical fracking?

   The 2015 regulations will form the basis for the regulatory programs – those regulations are also currently under review. North Carolina DEQ is operating on the assumption that these regulations will the core of the eventual regulatory program.

   What are the possible taxes that local government can impose on fracking or fracking infrastructure? If there are restrictions on county taxation, where in the NC regulations/statutes are these restrictions stated?

   Development impact fees and special use fees are possible (such as for road maintenance) – taxation would be difficult. There are no state restrictions but there are also no state allowances for such taxation– which is more important. Local governments can only engage in activities that are explicitly allowed.

2. Estimate costs for crime, schools, medical care, housing etc. for fracking workforce and their families. How could the county increase resiliency in anticipation of these costs to County infrastructure and budget? The workers and families do not pay local or state taxes, but they need health and social services--how does our county manage these costs?

   It is highly unlikely that there will be a significant in-county transient workforce to support fracking in the County. If there is one there are a number of options, counties in Pennsylvania and West Virginia levy local employment fees to capture some of these costs – for workers not living in the area of work. Infrastructure impact fees can be significant – high impact roads in Pennsylvania are now typically repaved every four to five years with

these fees.

Example of well development to worker ratios, if ten new wells in Chatham County, the transient workforce would be fifty to seventy workers for a period of six months to one year. Then a local workforce would like assume responsibility for well operation and maintenance.

3. If vertical fracking occurs, how will gas be gathered? Currently there is no infrastructure for this process.

   All natural gas wells require pipelines – which typically move gas from an individual well to a compressor station. Compressors are typically sited to process gas from multiple wells. From a local compressor location additional pipeline will move gas to an additional compressor and then into the larger gas transmission system.

4. Are drilling units formed for vertical fracking?

   Yes. Any fracking that would occur in Chatham County would likely be vertical frack wells – due to the shallow depth of the Cumnock Formation in the County. Geology and lease availability are the determinants of spacing and not an arbitrary well spacing. The often seen spacings in the literature, that are on spacing variants of 40 acres, are artifacts of gas development in the Midwest and Upper Great Plains where subsurface ownership is often on 40 acre increments due to the Public Land Survey. Drilling units can be complex particularly in eastern states where mineral ownership patterns may be very complex. For example, an area in Greene County Pennsylvania has three different gas producers operating three adjacent wells within an area less than one square mile. Gas production is measured at the well head. Complex and uneven well spacings are typical in eastern states.

5. At the meeting it was discussed that fracking is suspended during droughts. However, what sort of legislation/ordinances are needed to assure that agricultural and residential water needs are assured before any water is used for fracking during a drought?

   These cases are typical for states that require water use permits. North Carolina does not have general requirements for water use. Water use from wells does require permitting.

6. When shallow fracking is done, will the gas and fracking fluid flow into our aquifers? Case studies/references?

   That is difficult to assess ahead of time but with the reduced distances between aquifers and frack shale formations the likelihood is increased – though there are different studies showing different results. For the best review see work by Robert Johnson at Stanford – http://pubs.acs.org/doi/full/10.1021/acs.est.5b01228.

   See also Climate Change News – 02/15/2016. "Shallow fracking wells contaminate drinking water wells – scientist warns."

7. Will shallow fracking have detectable and significant effects on our aquifer and on natural and built surface structures?

   See above. There should be no impacts on structures. No impacts on structures have been noted in any studies. Shallow fracking is generally undertaken at significant depths – any fracking less than a mile in depth is referred to as shallow fracking.

8. In our local geology we have diabase sills and dikes that extend to the surface. How will shallow fracking blasts interact with these unique, shallow features? Will the blasts cause severe impacts on our aquifers? Documentation/ references?

   Sills and dikes, which typically occur in igneous / metamorphic environments are often very sensitive to potential water movement and water pollution. Fracking has not regularly occurred in such environments so little is known about fracking in close proximity to such features. The Mining and Energy Commission potentially should develop setbacks and / or operational standards for well development in proximity to these features. The features are not specifically addressed in the 2015 regulations.

9. Next to diabase dikes there are often "pocket aquifers" formed by the pooling of water around dikes. Is it known if water contamination is a greater risk with shallow fracking since the dikes can act as conduits for water? Documentation/references?

   There are no references addressing the relationships between dikes and sills and fracking outside of papers developed in North Carolina which would indicate that the associated issues are specific to rift basins. As such the issue potentially demands greater study by DEQ and the Mining and Energy Commission.

10. Will flaring come under our county's noise and light ordinances?

    Unknown. Typically flaring has not been addressed in local ordinances.

11. Can Chatham/Lee Counties develop a ballot initiative to ban fracking? Have other local bans been effective?

    In North Carolina, local governments cannot ban fracking but can impose moratoria. Ballot initiatives have not always proven to be effective in other states due to state regulations. Ballot initiatives did lead to the banning of fracking in Maryland and New York and a ballot initiative will be on the ballot to limit fracking in Michigan in 2018 – which already has over 10,000 wells.

12. Could additional information be provided about the new system for cleaning fracking wastewater that Dr. Yuill described?

    Antero Resources facility in Doddridge County WV. Water will only be suitable for re-fracking at the present time.

13. Dr. Yuill indicated that casing failures have decreased since 2015. What improvements have been made to reduce casing failures? Are these improved methods being adopted by most fracking companies? Given that well casings can crack anytime and that the likelihood of cracks increases after repeated fracking of a well, what is the likelihood that even these new well casings will eventually leak?

    Improved monitoring in-well.

    Based on current knowledge it is anticipated significant percentage of wells that are fracked multiple times will leak.

    Ten years of data in the Marcellus Region indicated a casing failure rate of 7% with single or repeated frackings.

    Newer technology long-term durability is presently unknown.

14. What local strategies, policies and regulations have been most effective in decreasing the negative impacts of fracking?

    Zoning is primary source of regulation – siting limitations. Development impact fees are typically the only avenue to local governments to exert control over potential infrastructure damage costs.

15. If fracking occurs in Lee County, do you expect it to be vertical or horizontal fracking?

    Potentially both technologies are feasible in Lee County. Where feasible, horizontal fracking may be preferred as surface disturbances are greatly reduced (with multiple wells on one well pad) as well as secondary impacts from road construction and other infrastructure features.

16. While the shale layer in Lee County may be thicker and therefore extend deeper than the shale layer in Chatham County, all of the diagrams I have seen depicting the shale in Chatham & Lee counties show the shale very close to the surface, regardless of how deep the shale goes. Will this extension of the shale near to the surface make Lee County susceptible to groundwater contamination just like Chatham County? In the Marcellus the upper layer of the shale is a mile from the water table—but in Lee and Chatham the shale extends upwards very close to the water table (and in at least one place extends through the water table to the ground surface!)

    The Shale may extend to depths of 8,000 feet in portions of Lee County. Shallow fracking issues are of concern where shale depths are less than 3,000 feet and horizontal fracking is unfeasible in such conditions.

17. What steps could Chatham County take to gain control over the location of fracking infrastructure, surface water & groundwater withdrawals and flow of truck traffic as a result of fracking in Lee County?

    Location – can and has been regulated with zoning and special use zoning / permitting.
    Groundwater withdraws are permitted. Regulations that preclude fracking are not permitted.
    Surface water not regulated.
    Truck traffic not regulated but noise and braking system restrictions for trucks may be applied.
    Road impact fees may be applied but fees do not limit usage.

18. The report indicates that much of Chatham's shale area lies under public lands and is therefore off limits to fracking. However, public lands across our country are being fracked. Could public lands in Chatham County eventually be opened to fracking?

    Most public land fracking is under Federal land – Federal agencies are precluded from limiting fracking by current USDI and USDA directives. State land decisions are the responsibility of the state agencies. However, agency limits may be difficult to enforce if the mineral rights have been severed from the agency

owning the surface.

19. I would like clarification on the issue of high-level technology for "reclaiming" the fracking solution. Water treatment technology including membrane and adsorption for contaminant separation is my area of expertise in my career as a researcher and teacher at the Univ. of North Carolina and before that at the Univ. of Mass.

    First I am not a research chemist so the expertise of the questioner probably exceeds mine.

20. Would it ever make economic sense to transport reclaimed fracking solution to a public water treatment plant to augment the supply even if the treatment technology at the fracking site was producing excellent quality water? I would think in general that the fracking sites are too far removed from water treatment plants to make this viable.

    In an area such as North Carolina – the simple answer is water transport costs would make this unfeasible. In the arid west the answer is quite possibly.

21. What are the specifics to the example given where fracking solution was shipped to a water treatment plant resulting in "killing" the plant operation? I am assuming that Dr. Yuill did mean delivery to a water treatment plant and NOT to a publicly owned wastewater treatment plant. The term "killing" could be misinterpreted by the public. Water treatment plants rely on physical and chemical methods of purification. The only interference that I could imagine is that the salt concentration had not been sufficiently lowered and interfered with the chemical coagulation process but I'd like Dr. Yuill to clarify.

    Killing is perhaps an unfortunate term. Prior to 2009 there were a number of attempts in Pennsylvania, West Virginia and Ohio to treat fracked water in municipal water treatment plants using standard municipal treatment technologies. Damage was incurred at a number of these plants. So, in 2011 the USEPA issued regulations against such plants accepting fracking water. The jurisdiction of EPA in such matters was due to the EPA grants that often funded construction and ongoing operation of the plants. In 2012-2013 the industry began to explore development of frack water specific treatment plants because the expansion of natural gas production was slowing and as such the industry was dealing with excess water with no disposal options. Water disposal is problematic if the industry is not expanding creating new demands for recycled frack water.

22. Would not the most logical reuse of the fracking solution be directly on site? For instance, given multiple wells, what about sequencing the fracking such that the reclaimed fracking solution from the first well could be used over and over?

    What is mentioned is always the idealized plan but many times sequencing does not always work. Truck haulage and new pipelines are now being constructed to move frack water around heavy production areas – from well to well. Many of these pipelines are above ground so that they may be readily disassembled and reassembled as needed.

23. What is the likelihood that locations for fracking in Chatham and Lee counties would coincide with areas interested in reuse of irrigation?

    In an area such as the two counties, irrigation would not be recommended as the technologies are still somewhat unproven and although the two counties are rural, there are still populations that could be in close proximity to any irrigation activities. Irrigation has been implemented mostly in the unpopulated arid Great Plains of Wyoming and Montana.

24. What is best way to explain to the public why reclaimed fracking solution is Ok for non-potable but not Ok for potable reuse? I think the public is getting unnecessarily scared when presented with this seeming contradiction. While I question the circumstances where reclaimed fracking solution could be added to the raw water supply of a community, the public here needs to understand water reclamation practices. In California, reclaimed wastewater is injected into the groundwater and withdrawn at another location, allowing for a natural process to occur in between injection and POTABLE reuse. Nonpotable resuse has been practiced for decades and California is the leader in setting regulations, including inorganics like NaCl applied to crops.

    Though not a question directly for Dr. Yuill, why not educate the public a little about the nature of raw water supplies in the U.S.? A woman at the presentation raised concerns about any chemical being in a public water supply giving the example of a chemical (this is 1,4 dioxane used in manufacturing upstream) found in the Pittsboro water supply by Dr. Knappe at NCSU. While we surely want a raw water supply of the highest quality, the public fails to understand the regulatory process that leads to list of Maximum Contaminant Levels (MCLs) that recognizes the presence of synthetic chemicals from upstream sources and requires removal at water treatment plants. There is not yet an MCL for the chemical she was concerned about. It is currently on the Unregulated Contaminant Monitoring Rule list. It is above Surface Water Quality standard and above the NC Groundwater Standard. But there is NO Federal or NC standard. I don't condone the presence of synthetic chemicals in drinking water supplies. Nevertheless, the public needs to understand the regulation process for control and the role of water treatment processes to remove these chemicals. In western European countries, the *precautionary principle* has been promoted as a way to take control steps in the absence of health risk information. In the U.S., a water utility can on its own decide to add more protection for the public absent regulations by installing more technology such as carbon adsorption or membrane separation. But it is balancing act between cost and risk reduction.
    Comments noted for the record.

(Note: This email was submitted by two people)

I am responding to your request that attendees submit their comments and questions by email to you in a timely manner.
I am totally against the possibility that Chatham County pursue a program of natural gas

extraction from our county... or any county in NC.
After listening to Mr. Yuill's presentation it was clear to me and all those around me at the meeting that this would be a foolhardy endeavor.
Examples:

1. 1-4 (actually up to 16) MILLION gallons of fresh water combined with possible 750 SECRET toxic chemicals pumped under great pressure into the earth.
    a. This alone is shocking. However this water becomes toxic, stored in ponds 20 ft. DEEP and the size of a few football fields, lined for safety to protect the ground under, and surrounded with barbed around to prevent poisoning of drinkers of this water. When the water evaporates in the air, the sludge is then rolled up and BURIED in special hazardous materials landfills specifically built for these materials.
2. In the PA study, from 1200 wells, over 100 documented cases were confirmed about compromised water systems.
    a. One community lose their water supply for two years.... still ongoing. (East Findlay Township where Charles Yuill has 24 acres of land so I know firsthand.)
3. Much loss of forest, wildlife habitat
4. Much loss of farmland.
5. Many documented cases of urban loss of water potability.
6. Many accidental spills of gas and oil and chemicals.

Note: The above are comments and observations that stand for themselves. Yuill agrees with the sentiments expressed above. One additional point worth mentioning is that even when an operator is doing things correctly, significant problems can still occur due to the unpredictability of many aspects of subsurface geology as well as drill and hardware performance at great depths.

I hope you can answer my concerns. Plus, why defend an old technology. Unsure of point but C.Yuill is commenting on what has occurred and not defending technology – as the technology is complex and often very problematic.

Comments are noted for the record.

(Note: the breaks in numbering are from the submittal) Review of Fracking Report for Chatham Co. 6/13/17 Unconventional NG Resource Considerations and Conditions for Chatham County, NC

Dr. Yuill, thank you for this brief review of some of the issues around fracking in Chatham County. I understand this work is preliminary. Governor Cooper has just signed NC onto "We Are Still In" referring to the Paris Climate Accord. Adding fracking during this time of rapid global warming is irrational and immoral since we have sustainable energy alternatives and methane is 86X more potent greenhouse gas than carbon dioxide. (**Methane continues to be an issue at all stages of natural gas development – particularly with recent relaxation of methane control regulations by the USEPA.).** Every step of natural gas production releases methane! Frack Free NC is a coalition of many grassroots

organizations that organized years ago to resist fracking and the build-up of gas infrastructure and to promote sustainable (non-nuclear) energies for our future. These groups and others spoke at hearings and wrote thousands of responses opposing and criticizing the weak oil and gas regulations passed last year. These comments may be useful in your research.

In my opinion some subjects that should be researched and covered sufficiently in your final report and presentation are the following:

1. Human, animal and wildlife health risks and injuries from chemical exposures downwind or adjacent to frack pads and near trucking accidents. I would like you to include the types of chemicals used in fracking—carcinogens, petroleum products, endocrine disruptor chemicals, acids, bases etc. There are dangers from acidizing and from sand inhalation.;
2. Deliberate and unlawful releases of waste water; for example bad practices like spreading waste waters on road for deicing and illegal dumping;
3. The amount of methane released from fracking and gas infrastructure—this is considerable according to my reading in the Compendium;
4. The social changes and costs brought on by fracking—for example drugs and crime;
5. How diabase dikes which are numerous through the Triassic shale deposits will impact drilling and casement success. Could dikes limit where fracking occurs and provide a path of groundwater contamination? ;
6. The incredible daily number of chemical and oil spills that are routine for the oil and gas industry as monitored by Sky Truth Alerts and other watchdogs. ;
7. How will wildcatters potentially create more environmental, property and financial damage for NC? What can be done about this?
8. Although no local government can ban or regulate fracking there is the qualification that “generally-applicable requirements, restrictions or conditions are OK”. This will continue to be fought in court. Case law will have a bearing on how fracking can be managed. Fracking moratoria can be renewed for valid reasons.
9. North Carolina has no cheap methods or facilities for disposal of hazardous fracking liquids and solids. I am fearful that sanitary waste water treatment systems will be forced to “treat “liquid wastes causing contamination of our rivers and sludges for field application. Solid wastes—toxicity ignored — could be disposed in our solid waste landfills. How effective are “treatment” facilities and where are these used?
10. What is the status of recycling waste water in the fracking industry? What equipment is needed?

Recycling is becoming significant for reuse for fracking not for general purpose water usage.

Here are some notes by page from your presentation:

Page 2.

Working Definition: I like it that you don't play games with the definition of HF like the O and Gindustry does. But your definition should include the fact that shale rock is blasted to pieces with explosives and cracks opened with pressure. Review of Fracking Report for Chatham Co. M. Girolami 6/13/17 Unconventional NG Resource Considerations and Conditions for Chatham County, NC

I really object in the second paragraph calling natural gas the "preferred fuel". By Whom???The oil and gas industry of course. For those of us who want a livable earth and rejoice in the Paris Climate Accord, we say the excellent fuels for Planet Earth are solar and wind.

Page 5.

"Fracking has been around since 1947.

Fracking in 1947 was baby fracking. It did not use the range of toxic chemicals and the quantities of water in use today. Nor were frack pad density of any consequence at that time. Fracking was done out west where few humans lived. Not the same beast as today. So since by your phrasing it is so old, does that give it prestige or make it safer? Very doubtful.

The answer is not it does not and as fracking has moved to more populated areas the impacts on human health have increased simply due to increased exposures.

Page 8.

You note that "process complexity is the source of many potential problems". Dr. A. Ingraffea states that 5 % of wells fail right away and all wells fail eventually especially if fracked repeatedly. My reading in the Compendium is that the "process" involves extensive well failure, no real solution to waste water disposal, extravagant wastage of clean water, major methane leaks and losses, toxic chemicals released to groundwater contaminating wells and surface water etc. The process itself is no good! It does not protect the environment or human health.https://www.epa.gov/sites/production/files/documents/ingraffea.pdf

Page 12.

Type of chemicals? Endocrine disruptor chemicals, carcinogens, petroleum products, metals, waste products from other industries, etc. No limit on the chemicals used…even radioactive chemicals.

Page 18.
I would like to hear what forced pooling has meant to the unwilling landowner.NC does not have mandatory pooling …yet.
Mandatory pooling is unlikely in North Carolina as logical gas units can be developed in North Carolina without it – see Pennsylvania and West Virginia.

Page 19.
How do you protect surface owners when mineral rights are severed?
Enforcement of environmental regulations is perhaps the only recourse. As well as enforcement of all required setbacks.

Page 20.
The Duke University Law Center says that "Generally Applicable requirements, restrictions or conditions are OK, although a fracking operator may petition the O & G Commission for preemption review". Moratoria can be renewed.

Page 21.
What is a toxic solid settling from a toxic liquid? There is no separation of toxins…only sediment. Injection wells are not legal in NC. What landfills are you thinking about? No natural gas infrastructure in Chatham.

This is why fracking is unlikely in Chatham County.

Page 22.
Repeated fracs. That is a sure way of destroying the casing and contaminating groundwater.

Page 23.
How many wells drilled per pad? Please cover pad density. And well density.

Where horizontal drilling is suitable there can be up to six wells per well pad with each horizontal extent on a 60 degree offset. At this density there would likely be less than one well pad per square mile and more than likely less dense than that.

Page 26. There are no methods for permanent disposal of produced and flow back water in NC. There are no treatment facilities and deep well injection is not feasible or legal. Flaring is not restricted in NC regs. Noise and pollution from flares is major. Well failure is chronic. (Ingraffea) Review of Fracking Report for Chatham Co. Girolami 6/13/17 Unconventional NG Resource Considerations and Conditions for Chatham County, NC.

Page 28.
Fracking over a fault that is also near a nuclear plant may be a grave risk. Is 5 miles adequate? Methane escaping from fracking is considerable not negligible. See Compendium.

In 2017 methane from fracking did become negligible (due to Obama era regulations and operator compliance). By this I mean actually the one week of fracking and not the complete well development and operation, as methane escapes during well operation do continue to be a serious problem – much of the data in the compendium is seriously out of date and actually a bit questionable. However, methane control reversals will result in methane levels rising in all aspects of natural gas production. Methane escape has always been a problem in all aspects of natural gas production. 29.
"Perceptions of community health, perceptions about environmental quality and health" Perceptions is the wrong word here. There are real impacts to public health immediately from traffic danger, diesel, sand, chemical emissions, chemical spills, noise and social degradation from drugs, crime, man camps etc. But perception alone can have a grave impact as well. There is no plan to do health monitoring etc. Many have no health care or limited access.

Page 30.
Fracking 2017Unreal that flaring would continue for up to 30 days a year. That gas should be captured at once. But NC has no infrastructure. Very likely a wildcatter would just frack to show we have gas but have no way of capturing the gas. What are specialized treatments that can remove 700 plus chemicals? NC has no specialized landfills for hazardous waste solids.

Page 37.
Consider long term open waste pits and damage to birds and other wild things. Evaporation during some months. We have hurricanes and frequent heavy rain events that would keep these filled.

Page 38.
Damage to drinking water appears to be extensive. Loss of trust in water will ruin the economy as well as harm community health.

Page 44.
Good treatment of shallow fracking. What are some sources of information? Pavilion is a shallow shale deposit that had extensive groundwater and well contamination. Consider the diabase dykes that an extremely common throughout the Triassic.

Page 45.
Damage from high density vertical wells. Out west sometimes the spacing is much less than 40 acres.
Typically for coal bed methane – very rare for hydraulic fracturing for natural gas – I work in the Powder River Basin.

Page 54.
I think that Chatham's shallow shale, diabase dikes, Jonesboro fault running along shale deposits and under nearby Sharon Harris Nuclear Power Plant, lack of gas infrastructure, there is an excellent case for no fracking in Chatham. Your recommendations are very weak and not relevant to your content.
I agree totally that fracking in Chatham County is highly unlikely for the above reasons – the County needs to build this case as only the State can declare the County unsuited for fracking. Though I could readily make that case.

Above comments are noted for the record.
Comments

- Attached is a 2013 NC DOT study of the projected impact of fracking on our transportation infrastructure and the anticipated costs to repair the damage. The study was presented to the NC Mining & Energy Commission's Funding Levels & Potential Funding Sources Study
Group. The study gives a great overview of the amount of truck traffic required to frack a well, along with estimates of the cost to repair the transportation infrastructure damage that will occur. This study includes bridge damage, which was not detailed in Dr. Yuill's study. While presenting this PowerPoint, the DOT representatives pointed out that while the fracking companies sometimes help finance road repairs, they usually do not pay for bridge repairs which can be very expensive.
In Pennsylvania they do pay for bridge repairs.

  I am sending this study because I think it provides valuable information that will support and extend Dr. Yuill's information on road/travel impacts from fracking. (Note: See attachment labelled "2013-Feb 20-H – Infrastructure Impacts & Associated Costs …")

- Having been a resident of Chatham County since 1974, I would like to go on record as being totally opposed to fracking in our (or any) area. Realizing you may be inundated with scientific information and facts, I will just say: ditto! And register my total opposition. Thank you for your consideration.

- My husband and I moved to NC about 3 years ago and had not heard about the issues related to fracking until now. We understand that a fracking moratorium was in place but has lapsed and could or could not be reinstated. Please put us in the group of those who oppose fracking—and we are glad to bring a much longer list of Chatham Co. folks who are too, if necessary. We can think of no faster way to stop development and lower home and business values in Chatham County than by making it a fracking area. We will be out in force if this looks like a possibility. Chatham has a lot of near term potential for prosperity. Fracking is a desperate activity for areas that have no pathway to prosperity and thus

dynamite the area surrounding homes and pollute the water for a short term injection of meagre funds.

- I was present at last night's talk on the possibility of natural gas extraction (aka fracking) in Chatham County. I am absolutely against a program which would enrich big business and deplete, in many ways, the residents of our county – or any NC county.

- Mr. Yuill's presentation made clear to me, and to the residents seated around me at the meeting, that this would be a shortsighted and foolhardy endeavor, in short because:

    1. 1-4 million (more like 16 million) gallons of fresh water, mixed with a possible 750 secret and toxic chemicals are to be pumped under great pressure into the earth. I find this shocking and unacceptable.
    2. As this water becomes toxic, it is to be stored in ponds the size of several football fields, and 20 feet deep, lined for safety and ostensibly to protect the environment. These immense ponds are to be surrounded with barbed wire to prevent wildlife from drinking this poisonous brew, but not the avian population.

    3. After an extended time of evaporation (and odor?), the remaining sludge is to be rolled up in the pond liners and buried in special *hazardous materials landfills specifically built to hold these materials.* We have enough of these death sites and do not need more.

    4. Over 100 documented cases of compromised water systems was confirmed in a study of 1200 PA wells. One community, after two years, is still waiting to again enjoy drinkable water in its homes. Chatham County has its share of water problems, and does not need this additional concern.

  Additionally: Much loss of forest, of wildlife habitat, of farmland, and many other documented cases of loss of potable water, left unmentioned, plus many accidental spills of gas, of oil and chemicals.

  Why defend a technology with all these well-known drawbacks?

  I have deep concerns about the possibility of fracking in Chatham.

- The information Mr. Yuill presented on fracking seems compelling. Given North Carolina's worship of business and run-away legislature, I have little confidence in any "ameliorating" measures with which the state may develop. Stopping fracking appears to be the only safe way to prevent the resulting harm.

- As a native of Pennsylvania, a state with some of the highest rates of fracking in the country, I have seen first-hand how fracking can affect a community. In addition to the noise and pollution of trucks and heavy industry, fracking divides people in a variety of ways. The problems aren't only political. Fracking salaries create an inflation in rental costs and other living expenses. It exaggerates differences between the haves and haves nots. One of the reasons I chose to live in Chatham County is that it did not have the extreme economic differences as I had seen elsewhere. Nor did I encounter the tensions, the casually snide remarks, the inflated fears for safer and other marks of a divided society. I hope that the county's final report on fracking takes into account these social concerns.

- I was unable to attend the recent meeting on the possibility of natural gas extraction in Chatham County but I wanted to submit my concerns. Fracking in Chatham County or anywhere in North Carolina is a terrible idea for many reasons.

  Clean, renewable energy is on the ascendency and on a remarkable downward trend in cost. This is where the future is, this is where the jobs are. And these technologies, plus new innovations, will help our efforts to slow climate change and prevent a catastrophic future for our children and grandchildren.

  Methane, produced through leakage and general maintenance, is an extremely potent greenhouse gas. We need to be taking every possible greenhouse gas OUT of the environment, not putting more in.
  In addition, there are real health concerns about the chemicals used in fracking and the risk of contamination for drinking water. We don't need to be taking these risks for a dying industry. Instead we should be doing all we can to keep fossil fuels in the ground.
  I am totally against the possibility that Chatham County pursue a program of natural gas extraction from our county. Instead, let Chatham County lead the way in pursuing clean, renewable energy.

- Comments from the Chatham County Climate Change Committee

  The Natural Gas Study (NGS) is being conducted pursuant to the "*ORDINANCE OF THE CHATHAM COUNTY BOARD OF COMMISSIONERS INSTITUTING A TEMPORARY MORATORIUM ON OIL AND GAS DEVELOPMENT ACTIVITIES WITHIN CHATHAM COUNTY, NORTH CAROLINA*", dated August 17, 2015.

  At that time, the Commissioners noted, among other findings, that:

  "(20) Existing state statutes and regulatory programs for oil and gas development do not yet constitute the best management practices necessary to adequately ensure such activities will not negatively impact the air, soil, water, environment, and health of residents within

Chatham County; and therefore do not adequately protect the health and welfare of the County's residents …" and

"(21) The Board finds it necessary to provide for additional time to study the impact of fracking and other oil and gas development activities that has been experienced in other states and to determine the adequacy of applicable State and federal regulatory programs in regulating and mitigating such impacts
…"

- CCAC Comments and Suggestions:
  To provide the information the Commissioners sought, as noted above, the study must

  1. Examine the potential negative impacts of oil and gas development activities on air, soil, water, environment, and health, should those activities be conducted in Chatham County.
  2. Examine adequacy of existing state statutes and regulatory programs to determine the adequacy of those programs in mitigating the potential negative impacts associated with oil and gas development.

     Potential Negative Impacts. To ensure technical credibility, the study must address the full range of potential environmental risks that may result from fracking in Chatham County. A major study by Resources for the Future (RFF) found that there were at least 12 pathways in which air, land, or water could be impacted by fracking.[1]

- The NSG should evaluate all of the risk pathways and the possible implications for environmental, health, and infrastructure in Chatham County. Where possible the NSG should identify best practices to mitigate risks.

- NSG should clarify whether it is likely that an oil and gas development site would also include storage of produced waters onsite, and whether disposal wells would be drilled at the site or nearby.

- It is well documented that the "produced waters" from fracking contain high concentrations of salt, and may contain a suite of chemicals added during the fracking process. It is unclear what facilities exist in Chatham County to manage this type of wastewater. The NSG should address the likely management pathway for these waters, and assess accompanying risks.

- It is also unclear what chemicals exist in fracking water. EPA reviewed data that had been

[1] "Pathways to Dialogue - What the Experts Say about the Environmental Risks of Shale Gas Development", by Alan Krupnick, Hal Gordon, and Sheila Olmstead. February 2013.

submitted voluntarily to the website, "FracFocus".[2] EPA found toxic chemicals such as Methanol, Hydrochloric Acid, and Ethylene Glycol, to name a few.[3] There may be additional chemicals. Companies are not required to submit data to FracFocus.

- The NSG should identify the types of chemicals that could be expected to be used here in Chatham County, or if that is not possible, acknowledge that we don't know, and identify a best practice approach to obtain chemical information.

  A pathway of serious concern from a climate perspective is the release of methane to the air. EPA has stated: *"…Methane's lifetime in the atmosphere is much shorter than carbon dioxide (CO_2), but CH_4 is more efficient at trapping radiation than CO_2. Pound for pound, the comparative impact of CH_4 is more than 25 times greater than CO_2 over a 100-year period."*[4] Other sources have argued that impact of methane is even greater.[5] Some estimates were to 50-90% higher.

  Chatham County is seeking to be a "*Become a Carbon Negative County*".[6] At this time we do not have major sources emitting methane in Chatham.

- The NGS should estimate the potential methane emissions of potential fracking in Chatham County, and determine the potential contribution of carbon equivalent emissions (CO2e) to the environment that could result. This may require development of one or more "model" facilities based in information from other states. If possible, the NSG should identify best practices to control and minimize methane emissions.

  It should be noted that methane risk pathways include contamination of groundwater. Methane can contaminate drinking water sources. The Extension Service of the Pennsylvania State University (Penn State) cautions: *"… Escaping gas may seep into confined areas of your home, where it may reach dangerous concentrations. There have been cases in Pennsylvania where houses, camps, or wells have exploded due to methane accumulation*."[7] Penn State's Extension Services also suggests homeowners may want to install gas monitors.[8] In fact, the issue of methane contamination has become so widespread in Pennsylvania that state's Department of Environmental Protection (DEP)

---

[2] EPA Report, "Analysis of Hydraulic Fracturing Fluid Data from the FracFocus Chemical Disclosure Registry 1.0", March 2015. The three chemicals cited as listed in EPA's Toxics Release Inventory, and so by definition are toxic.
[3] Ibid., p. 4.
[4] See https://www.epa.gov/ghgemissions/overview-greenhouse-gases#methane
[5] "Using Multi-Scale Measurements to Improve Methane Emission Estimates from Oil and Gas Operations in the Barnett Shale Region, Texas", published in Environmental Science and Technology, Robert Harriss, Ramon A. Alvarez, David Lyon, Daniel Zavala-Araiza, Drew Nelson, and Steven P. Hamburg. July 7, 2015.
[6] Draft Chatham County Comprehensive Plan, p. 109.
[7] Pennsylvania State University http://extension.psu.edu/natural-resources/water/drinking-water/water-testing/pollutants/methane-gas-and-its-removal-from-wells-in-pennsylvania.
[8] Ibid

maintains a list of accredited labs so property owners can have their wells tested.[9]

- The NSG should evaluate whether methane could contaminate groundwater in Chatham based on experiences in other states. If possible the NSG should recommend best practice to minimize groundwater contamination.

  Unfortunately, methane emissions can continue and even increase if wells are not closed properly.[10] Abandoned wells in Pennsylvania "…keep emitting for years, even decades".[11]

  Finally, the disposal of produced water is another issue with serious implications for Chatham County. The water is contaminated with salt and other chemicals, many of which are unknown. The State of Ohio had over 200 disposal wells active in 2014.[12] Some counties in Ohio had 10 or more disposal wells.

- The NSG should estimate the amount of produced waters that may be associated with oil and gas development in Chatham County, the capacity for wastewater treatment that may be needed, and whether the burden of providing the waste water capacity may fall upon the County.

  In summary, the NSG must evaluate at least a dozen exposure pathways. The chemicals used are only partially known. There are major implications for Chatham County residents and infrastructure. The NSG must address these points to provide the Commissioners the information cited in the Moratorium notice.

  Adequacy of NC laws. To address the information cited by the Commissioners, the NSG should address NC or other applicable laws and programs. Some questions would include:

- Regulations or laws in place to control the venting or discharge of methane to the atmosphere?
- Regulations to control leakage of methane to groundwater?
- Requirements to disclose chemicals used in fracking injection water?
- Requirements for storage, use, and disposal of produced fracking waters?
- Requirements such as bonding, to ensure proper closure of fracking facilities?

  Other impacts on Chatham County government may include having to conduct inspections, providing monitoring and analysis of well water, facilities to allow shipment and management of wastewater, and air monitoring.

- The NSG should address what a best practice approach to controlling fracking would

[9] http://extension.psu.edu/natural-resources/water/drinking-water/water-testing/testing
[10] University of Stanford News Service, 11/14/2016, study by Jackson and Kang.
[11] Ibid.
[12] State of Ohio "Class II Brine Injection Wells in Ohio" map, 07/11/2014.

look like here in Chatham County.

- Best practices would include legislation, regulations, and permitting and other activities needed to ensure compliance.
- The goal of laws and regulations would be to reduce any releases or emissions from fracking to negligible amounts, to protect the health of Chatham residents, and the County's environment.

Above comments are noted for the record.

Legal Questions – presented here for the record but summarized beginning on page 28 of the report.

1. Legal Framework for Fracking: The Scope of Study states that a summary of the current status of the legal framework for regulation these activities (natural gas development) will be included in the report. This is quite important since the Mining and Energy Commission has been replaced by the Oil and Gas Commission, which has not yet had a majority of appointees seated yet. No fracking permits have been issues in NC to date.
   What is the status of the rules governing fracking in NC and the legal challenges to them?
2. What controls do landowners have over the use of the surface of their property for natural gas development if...
   A). the property owner does not own the mineral rights under their property?, or
   Deference given to mineral owner over the surface owner. Surface owner cannot diminish value of mineral rights. Pipelines and transportation are negotiated separately.
   B). their property is included in a development through forced pooling?
   NC Does not have mandatory pooling.
3. With the control of oil and gas production allocated to the State, how much can the County do to change the answers to the questions above?
   The County can regulate everything the state provides for – with county ordinances such as zoning and subdivision regulations, special use zones as wells as additional standards for siting, location, road layout etc.
4. Most (all?) of the incidents where gas drilling has resulted in migration of natural gas to surrounding water wells have been caused by faulty cementing around the well casing in the zone adjacent to producible groundwater. How good are the State regulations governing cementing of wells and how effective is the State oversight of drilling operations?

State regulations reflect current practice. Note: regulations have not really "gone live" as the Commission has not been fully staffed. However, there are conditions in Chatham County that potentially require special consideration – primarily related to dikes and other igneous and metamorphic features that can be areas with significant groundwater problems due to the complexity of the geology.

Other Questions:

5. How much geologic separation is there between the gas-producing shale deposits in Chatham County and the groundwater used for domestic and agricultural uses? I.e. How deep are the shale deposits compared to the depth of groundwater produced for domestic uses and how effective is the intervening rock in isolating the shale deposits?

Shale depths range from 0 to greater than 1,000 feet. Groundwater wells have gone to those depths in the County.

6. The report should look at the most current data and studies. There is considerable new information regarding impacts of fracking since the Chatham County moratorium was enacted in 2015. An excellent source of documents on a wide variety of health and other impacts can be found in the "The Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking" which brings together findings and studies from the scientific and medical literature, government and industry reports, and journalistic investigation. The Compendium demonstrates scientific evidence of risks and harms, health impacts and water contamination, and climate impacts of fracking. There are now over 900 peer-reviewed studies on the impacts of fracking, the vast majority of which indicate risks and adverse impacts. The report can be found at http://concernedhealthny.org/compendium/

Study was reviewed – as have all of the annual updates.

7. Also of importance is the report released on 12/13/2016 by the EPA on "Impacts from Hydraulic Fracturing Activities on Drinking Water". EPA's report concludes that hydraulic fracturing activities can impact drinking water resources under some circumstances and identifies factors that influence these impacts. The report can be found at https://www.epa.gov/hfstudy.

8. Will the report look at studies from other areas where fracking has taken place in addition to the Marcellus shale regions of Pennsylvania and WVA, as mentioned in the Scope of Services? The shale basins in NC are quite shallow compared to the Marcellus shales, which could create much larger threats to contamination of ground water and drinking water wells. This link is to an illustration of the NC Deep River shale basin and the distance between ground water and shale depths. The studies of drinking water contamination in the shallower Pavillion Wyoming fracking, may be relevant for Chatham County.
New studies on the connection between induced earthquakes and fracking (not just injection of fracking wastewater into deep wells) must also be considered since Chatham County's underlying geology may be particularly unsuited for fracking, especially with the presence of the Shearon Harris nuclear power plant within the shale region.

EPA study was reviewed. Duke Power can extend the exclusion zone.

9. Will the report look at methane releases during fracking operations that contribute to climate change? This is another area where more studies and data have been done since 2015.

Actually methane control was to be implemented in fracking operations during Fall 2016 and a number of operators have already installed hardware to begin to do this. Methane is actually a commercially viable product that is captured with thousands of methane wells in Wyoming, Colorado and Montana. However, the USEPA recently reversed those regulations so methane will continue to be dealt with with flaring and release.

From Emails

Brian,
Here are some concerns and questions I would like addressed in the report being developed by the consultant,

Charles Yuill, concerning expected impacts from fracking. As stated earlier I regret that I cannot be at the meeting on June 13, but look forward to reading, and commenting on, the presentation once it is available online.

1. The report should look at the most current data and studies. There is considerable new information regarding impacts of fracking since the Chatham County moratorium was enacted in 2015. An excellent source of documents on a wide variety of health and other impacts can be found in the "The Compendium of Scientific,
Medical, and Media Findings Demonstrating Risks and Harms of Fracking" which brings together findings and studies from the scientific and medical literature, government and industry reports, and journalistic investigation. The Compendium demonstrates scientific evidence of risks and harms, health impacts and water contamination, and climate impacts of fracking. There are now over 900 peer-reviewed studies on the impacts of fracking, the vast majority of which indicate risks and adverse impacts. The report can be found at http://concernedhealthny.org/compendium/
Also of importance is the report released on 12/13/2016 by the EPA on "Impacts from Hydraulic Fracturing Activities on Drinking Water". EPA's report concludes that hydraulic fracturing activities can impact drinking water resources under some circumstances and identifies factors that influence these impacts. The report can be
found at https://www.epa.gov/hfstudy.
2. Will the report look at studies from other areas where fracking has taken place in addition to the Marcellus shale regions of Pennsylvania and WVA, as mentioned in the Scope of Services? The shale basins in NC are quite shallow compared to the Marcellus shales, which could create much larger threats to contamination of ground water and drinking water wells. This link is to an illustration of the NC Deep River shale basin and the

distance between ground water and shale depths. The studies of drinking water contamination in the shallower Pavillion Wyoming fracking, may be relevant for Chatham County. 3 New studies on the connection between induced earthquakes and fracking (not just injection of fracking wastewater into deep wells) must also be considered since Chatham County's underlying geology may be particularly unsuited for fracking, especially with the presence of the Shearon Harris nuclear power plant within the shale region.

The Scope of Study states that a summary of the current status of the legal framework for regulation these activities (natural gas development) will be included in the report. This is quite important since the Mining and Energy Commission has been replaced by the Oil and Gas Commission, which has not yet had a majority of appointees seated yet. No fracking permits have been issues in NC to date. What is the status of the rules governing fracking in NC and the legal challenges to them?

3. Will the report look at methane releases during fracking operations that contribute to climate change? This is another area where more studies and data have been done since 2015. Thank you,

I am not for or against the process to be presented about.
This is only my personal opinion. I believe information about abase dikes should be included. I will not publicly speak on this, but it is disingenuous not to have it included in the presentation in my opinion.I have attached a few pieces of info about them. Thank you,

One of the assumptions that we follow in Chatham County is that diabase dikes, due to their formation, have a greater opportunity to channel ground water and are highly prized by well drillers when siting wells. Being able to channel the groundwater also enables the diabase dikes to act as a channel of contamination as well.
Curious if the below concern is with placing fracking wells or injection wells near diabase dikes and the more direct impact these activities will potentially have on the ground water and drinking water
wells. Just a guessJ

Yes you are correct about ground water movement in those areas and can certainly bring the issue up – the areas around the dikes appear to not be particularly well suited for well development due to shale depth and the probable unfeasibility of fracking in those areas.
Charlie Yuill

I have a question, which is whether NC has any regulations or laws in place to control the venting or discharge of methane to the atmosphere? Methane is almost 100 times more potent than other greenhouse gases so even small discharges are believed to contribute to global warming.
A second question is whether NC has any laws or regulations to require the disclosure of fracking chemicals?
It's hard to evaluate the possible impacts when we don't know what
might be used. 2

- Regarding the treatment of wastewater, where is the nearest specialized water treatment facility that could process fracking wastewater? This seems especially important since wastewater injection is not legal in NC.
- Seismic issues with fracking may be less severe than those encountered with wastewater injection, but when drilling comes close to a fault that runs right under a nuclear rod storage pond and along the edge of a nuclear power plant, any seismic activity becomes potentially lethal
2
- Could a map be developed which identifies the location of the 1,000 acres of non-contiguous land where fracking might be possible? (pg. 53 of draft report.)
- The Triassic basin extends under Jordan Lake. What impact could fracking have on Jordan Lake as a drinking water source?
- What might the impacts be on the Cape Fear River, Haw and Rocky Rivers, all of which serve as drinking water resources?
- What financial impacts would fracking have on Chatham County? Could a comparison be done of **the costs of fracking**-- for additional services (emergency, social services, police, etc.), disruption of travel due to road destruction, loss of agriculture, loss of eco-tourism, decrease of property values, etc. VS. **county income from fracking.**
- What would the impact of fracking be on our roads? In a report done by the NCDOT on fracking impacts, information was included about the low standards of construction used for most rural roads in Chatham County and the NCDOT predicted severe destruction of roads due to these low construction standards. Furthermore, Chatham County is in the same NCDOT funding district as Lee and Moore County, so we would be competing with them for limited funds for road repairs—and their fracking would likely be very destructive on their roads too.
- What impacts of fracking will Chatham County encounter from the fracking done in surrounding counties, even if Chatham itself has no fracking within its borders? For example, will our roads be destroyed by trucks going to Lee County? Will compressors or other infrastructure likely be located in Chatham County? Will water be taken from Chatham for fracking in Lee? Will workers likely live in Chatham and therefore need increased social services, medical care, etc.?

I hope there is still time to submit questions for Dr. Yuill. I am in LA right now, so a little slow on the review!

- Regarding the treatment of wastewater, where is the nearest specialized water treatment facility that could process fracking wastewater? This seems especially important since wastewater injection is not legal in NC.
- Seismic issues with fracking may be less severe than those encountered with wastewater injection, but when drilling comes close to a fault that runs right under a nuclear rod storage pond and along the edge of a nuclear power plant, any seismic activity becomes potentially lethal
- Could a map be developed which identifies the location of the 1,000 acres of non-contiguous land where fracking might be possible? (pg. 53 of draft report.)
- The Triassic basin extends under Jordan Lake. What impact could fracking have on Jordan Lake as a drinking water source?
- What might the impacts be on the Cape Fear River, Haw and Rocky Rivers, all of which serve as drinking water resources?

What financial impacts would fracking have on Chatham County? Could a comparison be done of **the costs of fracking**-- for additional services (emergency, social services, police, etc.), disruption of travel due to road destruction, loss of agriculture, loss of eco-tourism, decrease of property values, etc. VS. **county income from fracking.**

- What would the impact of fracking be on our roads? In a report done by the NCDOT on fracking impacts, information was included about the low standards of construction used for most rural roads in Chatham County and the NCDOT predicted severe destruction of roads due to these low construction standards. Furthermore, Chatham County is in the same NCDOT funding district as Lee and Moore County, so we would be competing with them for limited funds for road repairs—and their fracking would likely be very destructive on their roads too.
- What impacts of fracking will Chatham County encounter from the fracking done in surrounding counties, even if Chatham itself has no fracking within its borders? For example, will our roads be destroyed by trucks going to Lee County? Will compressors or other infrastructure likely be located in Chatham County? Will water be taken from Chatham for fracking in Lee? Will workers likely live in Chatham and therefore need increased social services, medical care, etc.?

Dr. Yuill, thank you for this brief review of some of the issues around fracking in Chatham County. I understand this work is preliminary.
Governor Cooper has just signed NC onto “We Are Still In” referring to the Paris Climate Accord. Adding fracking during this time of rapid global warming is irrational and immoral since we have sustainable energy alternatives and methane is 86X more potent green house gas than carbon dioxide. Every step of natural gas production releases methane!
Frack Free NC is a coalition of many grassroots organizations that organized years ago to resist fracking and the build up of gas infrastructure and to promote

sustainable (non nuclear) energies for our future. These groups and others spoke at hearings and wrote thousands of responses opposing and criticizing the weak oil and gas regulations passed last year. These comments may be useful in your research.

In my opinion some subjects that should be researched and covered sufficiently in your final report and presentation are the following:

(1) Human, animal and wildlife health risks and injuries from chemical exposures downwind or adjacent to frack pads and near trucking accidents. I would like you to include the types of chemicals used in fracking—carcinogens, petroleum products , endocrine disruptor chemicals, acids, bases etc.. There are dangers from acidizing and from sand inhalation.;

(2) Deliberate and unlawful releases of waste water; for example bad practices like spreading waste waters on road for deicing and illegal dumping;

The amount of methane released from fracking and gas infrastructure—this is considerable according to my reading in the Compendium;

(3) The social changes and costs brought on by fracking—for example drugs and crime;

(4) How diabase dikes which are numerous through the Triassic shale deposits will impact drilling and casement success. Could dikes limit where fracking occurs and provide a path of groundwater contamination?;

(5) The incredible daily number of chemical and oil spills that are routine for the oil and gas industry as monitored by Sky Truth Alerts and other watchdogs.;

(6) How will wildcatters potentially create more environmental, property and financial damage for NC?. What can be done about this?;

(7) Although no local government can ban or regulate fracking there is the qualification that “generally-applicable requirements, restrictions or conditions are OK”. This will continue to be fought in court. Case law will have a bearing on how fracking can be managed.

Fracking moratoria can be renewed for valid reasons.;

(8) North Carolina has no cheap methods or facilities for disposal of hazardous fracking liquids and solids. I am fearful that sanitary waste water treatment systems will be forced to “treat” liquid wastes causing contamination of our rivers and sludges for field application. Solid wastes —toxicity ignored — could be disposed in our solid waste landfills. How effective

are “treatment” facilities and where are these used?;

(9) What is the status of recycling waste water in the fracking industry? What equipment is needed?

Here are some notes by page from your presentation:

Page

2.

Working Definition: I like it that you don’t play games with the definition of HF like the O and G industry does. But your definition should include the fact that shale rock is blasted to pieces with explosives and cracks opened with pressure.

Review of Fracking Report for Chatham Co.

Unconventional NG Resource
Considerations and Conditions for
Chatham County, NC

I really object in the second paragraph calling natural gas the "preferred fuel". By Whom??? the oil and gas industry of course. For those of us who want a livable earth and rejoice in the Paris Climate Accord, we say the excellent fuels for Planet Earth are solar and wind.

5.

"Fracking has been around since 1947.

Fracking in 1947 was baby fracking. It did not use the range of toxic chemicals and the quantities of water in use today. Nor were frack pad density of any consequence at that time. Fracking was done out west where few humans lived. Not the same beast as today. So since by your phrasing it is so old, does that give it prestige or make it more safe? Very doubtful.

8.

You note that "process complexity is the source of many potential problems". Dr. A. Ingraffea states that 5 % of wells fail right away and all wells fail eventually especially if fracked repeatedly.

My reading in the Compendium is that the "process" involves extensive well failure, no real solution to waste water disposal, extravagant wastage of clean water, major methane leaks and losses, toxic chemicals released to groundwater contaminating wells and surface water etc.

The process itself is no good!. It does not protect the environment or human health.

https://www.epa.gov/sites/production/files/documents/ingraffea.pdf

Type of chemicals? Endocrine disruptor chemicals, carcinogens, petroleum products, metals, waste products from other industries, etc.

No limit on the chemicals used…even radioactive chemicals.

18.

I would like to hear what forced pooling has meant to the unwilling landowner.

NC does not have mandatory pooling …yet.

19.

How do you protect surface owners when mineral rights are severed?

20.

The Duke University Law Center says that "Generally Applicable requirements, restrictions or conditions are OK, although a fracking operator may petition the O & G Commission for preemption review".

Moratoria can be renewed.

21.

What is a toxic solid settling from a toxic liquid? There is no separation of toxins…only sediment.

Injection wells are not legal in NC. What landfills are you thinking

about? No natural gas infrastructure in Chatham.

22.

Repeated fracs. That is a sure way of destroying the casing and contaminating groundwater.

23.

How many wells drilled per pad? Please cover pad density. And well density.

26.

There are no methods for permanent disposal of produced and flow back water in NC. There are no treatment facilities and deep well injection is not feasible or legal. Flaring is not restricted in NC regs. Noise and pollution from flares is major.

Well failure is chronic. (Ingraffea)

Review of Fracking Report for Chatham Co.

Unconventional NG Resource

Considerations and Conditions for

Chatham County, NC

M. Girolami 6/13/17

28.

Fracking over a fault that is also near a nuclear plant may be a grave risk. Is 5 miles adequate? Methane escaping from fracking is considerable not negligible. See Compendium.

29.

"Perceptions of community health, perceptions about environmental quality and health" Perceptions is the wrong word here. There are real impacts to public health immediately from traffic danger, diesel, sand, chemical emissions, chemical spills, noise and social degradation from drugs, crime, man camps etc. But perception alone can have a grave impact as well. There is no plan to do health monitoring etc. Many have no health care or limited access.

30.

Fracking 2017

Unreal that flaring would continue for up to 30 days a year. That gas should be captured at once. But NC has no infrastructure. Very likely a wildcatter would just frack to show we have gas but have no way of capturing the gas.

What are specialized treatments that can remove 700 plus chemicals? NC has no specialized landfills for hazardous waste solids.

Consider longterm open waste pits and damage to birds and other wild things. Evaporation during some months. We have hurricanes and frequent heavy rain events that would keep these filled.

38.

Damage to drinking water appears to be extensive. Loss of trust in water will ruin the economy as well as harm community health.

44.

Good treatment of shallow fracking. What are some sources of information.
Pavilion is a shallow shale deposit that had extensive groundwater and well contamination. Consider the diabase dykes that a extremely common throughout the Triassic.

45.

Damage from high density vertical wells. Out west sometimes the spacing is much less than 40 acres.

54.

I think that Chatham's shallow shale, diabase dikes, Jonesboro fault running along shale deposits and under nearby Sharon Harris Nuclear Power Plant, lack of gas infrastructure, there is an excellent case for no fracking in Chatham.
Your recommendations are very weak and not relevant to your content.

References

Brady, William J. Hydraulic fracturing regulation in the United States: The laissez-faire approach of the Federal Government and varying state regulations. University of Denver - Sturm College of Law. 2012.

Chatham Conservation Partnership. A comprehensive conservation plan for Chatham County, North Carolina. Pittsboro. March 2011.
Chatham County Planning Commission. Comprehensive Plan 2017. Pittsboro. June 2017.
Clean Water for North Carolina. (flyer). Economic and community impacts of hydraulic fracturing. 2016.

Climate change news. Shallow fracking wells contaminate drinking water, US Scientist warns. 2016.

Costa, Daniele, Jesus Joao, David Brance, et.al., Extensive review of shale gas environmental impacts from scientific literature 2010 – 2015. Environmental Science Pollution Research. Springer Verlag, April 2017.

Duke University. Chronology of hydraulic fracturing in North Carolina. Regulatory oral history hub. April 2016.

Dutzik, Tony and Elizabeth Reddington. The costs of fracking – The price tag of dirty drillings environmental damage. Environment America. 2012.

East Coast Mesozoic Basin Assessment Team – USGS. Assessment of undiscovered oil and gas reserves of the East Coast Mesozoic Basins of the Piedmont, Blue Ridge Thrust Belt, Atlantic Coastal Plain and the New England Provinces. USGS National Assessment of Oil and Gas. June 2012.

Edmondson, Liz. Regulating hydraulic fracturing in the states: trending issues in 2016 and beyond. Energy and Environment. Council of State Governments 2016.

Evans, Jeffrey and Joseph M. Kiesecker. Shale gas, wind and water: assessing the potential cumulative impacts of energy development on ecosystem services within the Marcellus Play. PLOS 1. February 2014.

Feyrer, James, Eri Mansur, and Bruce Sacerdote. The impact of fracking on local economies. VOX – CEPR. November 2015.

Fisher, William. Development of a hydrologic foundation and flow-ecology relationships for monitoring riverine resources in the Marcellus Shale Region. USGS – New York Cooperative Fish and Wildlife Research Unit. June 2013.

Fitzgerald, Rebekah. States, local governments battle for control over fracking. Council of State Governments. April 2017.

Freilich, Robert and Neil M. Popowitz. Oil and gas fracking. State and federal regulation does not preempt needed local government regulation. The Urban Lawyer. Volume 44. No. 3. 2012.

General Assembly of North Carolina. Session Law 2012-143. Senate Bill 820. Session 2011. Goodman, Paul S., Fabio Galatioto, Neil Thorpe, et. al. investigating traffic-related environmental impacts of hydraulic fracturing operations. Environment International. Volume 89-90. 2016.

Hammersley, Ross. A. and Katie Redman. Local government regulation of large scale hydraulic fracturing activities and uses. Michigan bar Journal. June 2014.

Haven, Walt. Chatham County Geologic Map. North Carolina Geologic Survey. May 2017. Hirji, Zahra. Drillers fracking at much shallower depths than widely believed. Inside climate news. July 2015.

Israel, Brett. Noise pollution from fracking may harm human health. Physician's news. 2017. Johnson, Jeff. Shallow fracking wells may threaten aquifers. Chemical and Engineering News. August 2015.

Lallanilla, Marc. Facts about fracking. Live Science January 2015.

Landinfo Line. What types of policies are local governments adopting to respond to fracking? Journal of the American Planning Association, vol. 82 no. 10. October 2016.

Loh, Carolyn and Anna Osland. Local land use planning responses to hydraulic fracturing. Journal of the American Planning Association. May 2016.

Longest, Ryke. Local issues associated with fracking and gas production. Duke University Environmental Policy Clinic. 2015.

Longest, Ryke. Differences between Marcellus and Sanford Sub-basin. Duke University Environmental Policy Clinic. 205.

Manfreda, John. The origin of fracking actually dates back to the Civil War. Business Insider. 4 – 2015.

Marcellus Drilling News. Triassic park: North Carolina becomes 34th state to frack shale. Marcellus Drilling. 2015.

Marcellus Drilling News. Whatever happened to fracking in North Carolina? Marcellus drilling. February 2016.

Margil, Mari. Should your town have the right to ban fracking? These laws will have to change first. Yes Magazine. May 2012.

McMahon, David B. What land/surface owners should know when a landman shows up and wants an easement/ right of way to put a pipeline across your land? Unpublished by the author.

McRae, Sarah. Shale gas resources in the Deep River Triassic Basin. PowerPoint presentation. US Fish and Wildlife Service. January 2011.

Minor, Joel. Local government fracking regulations: A Colorado case study. Stanford Environmental Law Journal. November 2016.

North Carolina Division of Natural Resources. Biogeographic features of Chatham County. Raleigh. 1999.

Philips, Susan. Study: Fracking didn't impact West Virginia's groundwater; but wastewater spills pollute streams. NPR state impact. 2014.

Physicians for Social Responsibility. Compendium of Scientific, Medical, and Media Findings Demonstrating Risks and Harms of Fracking Unconventional Gas and Oil Extraction. November 2016.

Resources for the Future. The State of State Natural Gas Regulation. June 2013. (Now may be a little out of date).

Reid, Jeffrey C. and Robert Millici. Hydrocarbon source rocks in the Deep River and Dan River Triassic Basins, North Carolina. USGS Open file report 2008 – 1108.

Reid, Jeffrey C. and Kenneth Taylor. Shale gas potential of the Deep River Basin, Lee and Chatham Counties, North Carolina, USA. AAPG Eastern Section Meeting. December 2009.

Research Triangle Environmental Health Collaborative. Shale gas extraction in North Carolina: Public Health Implications. October 2012.
Rosenbloom, Sandi. How do planners deal with fracking? American Planning Association. 2016. Sadasivim, Naveena. Gas pipeline boom fragmenting Pennsylvania's forests. Inside climate news. 2013.

Sage Policy Group. The potential economic and fiscal impacts of natural gas production in Western Maryland. Maryland Petroleum Council. March 2012.

Sangaramoorthy, Thurka, Amelia Jackson, Meleah Boyle, et. al. Place-based perceptions of the impacts of fracking along the Marcellus Shale. Social Science and Medicine. Volume 151. 2016.

Schipani, Vanessa. The facts on fracking chemical disclosure. Fact check. The Wire. 2016.

Shale stuff. The process of fracking. May 2016.

Stanford News. Shallow fracking raises questions for water, new Stanford research shows. Stanford News. July 2015.

Slonecker, Terry, L.E. Milheim, C.M. Roig-Silva, et. al. Landscape consequences of natural gas extraction in Bradford and Washington Counties, Pennsylvania. Open file report. 2012.

State of North Carolina. North Carolina Oil and Gas Study. 2012

State of North Carolina. Subchapter 05H – Oil and Gas Conservation. 2015 draft regulatory program.

Town of Cary Shale Gas Development Task Force. Report. May 2014.

Triangle J Council of Governments. Hydraulic Fracturing: Practical Considerations and First-hand experience. Southwestern Pennsylvania Commission. September 2012.

United States Environmental Protection Agency. Hydraulic Fracturing for Oil and Gas: Impacts from the Hydraulic Fracturing Water Cycle on Drinking Water Resources in the United States. December 2016.

USGS. Induced earthquakes; myths and misconceptions. USGS Research. 2016.

West Virginia Surface Rights Organization. Why multiple horizontal wells from centralized well pads should be used for the Marcellus Shale. March 2012.

Whisnant, Richard. Hydraulic Fracturing: Practical Considerations and First-hand Experience – Regulatory and Authority Issues. UNC School of Government. March 2012.

White, Taylor, Caleb Shruggs, Michael Ortiz, et. al. The Fracking Front in North Carolina. East Carolina University. 2016.

Zinkhan, Frederick C. Site characteristics associated with conventional and unconventional petroleum development in West Virginia. Unpublished thesis. 2016.