

Section 9 – Recommendations and limitations

A. Recommendations

After reviewing other studies and experiences in oil and gas-producing states, DENR has concluded that information available to date suggests that production of natural gas by means of hydraulic fracturing can be done safely as long as the right protections are in place. Production of natural gas by means of hydraulic fracturing can only be done safely in North Carolina if the state adopts adequate safeguards in the form of regulatory standards specifically adapted to conditions in the state and invests sufficient resources in compliance and enforcement. Development of appropriate standards will require additional information on North Carolina's geology and hydrogeology to identify conditions under which hydraulic fracturing can be done without putting the state's water resources at risk. The ban on hydraulic fracturing and horizontal drilling should remain in effect until both standards and a strong compliance and enforcement program are in place. Both of these are needed before issuing permits for horizontal drilling and hydraulic fracturing in North Carolina's shale formations. A number of states have experienced problems associated with natural gas exploration and development because the appropriate measures were not in place from the beginning – forcing both the state and the industry to react after damage had already been done.

DENR has identified a number of immediate recommendations for management of natural gas exploration and development activities. A complete oil and gas permitting program will require more detailed standards than it is possible to provide in this report and those standards should be based on conditions in North Carolina. Conditions in the Triassic Basins of North Carolina are not identical to those found in Pennsylvania or other gas-producing states. For example, we need to understand the depth of usable groundwater in the Triassic Basin in order to set well construction standards that will protect our drinking water resources.

Based on the research and analysis in this report, the Department of Environment and Natural Resources, in consultation with the Department of Commerce, developed the following recommendations for the General Assembly. These recommendations have been revised based on public comment. It should be noted that these recommendations do not take into account information from the Department of Justice's section on consumer protection, because DENR had not received that section of the report in time for preparation of the recommendations. These recommendations have been revised based on public comment.

A brief description of each recommendation is listed, followed by a more detailed explanation of each recommendation below. The recommendations are grouped by subject matter but are not listed by priority.

Funding recommendations

1. Provide funding for any continued work on the development of a North Carolina regulatory program for the natural gas industry.
2. Address the distribution of revenues from oil and gas excise taxes and fees to support the oil and gas regulatory program, fund environmental initiatives, and support local governments impacted by the industry.

Water and air quality recommendations

3. Collect baseline environmental quality data including groundwater, surface water and air quality information.
4. Require oil and gas operators to operate in compliance with a DENR-approved Water and Wastewater Management Plan. The Water Management Plan should limit water withdrawals to 20 percent of the 7Q10 stream flow and prohibit withdrawals during times of drought and periods of low flows.
5. Develop a state stormwater regulatory program for oil and gas drilling sites.

Hydraulic fracturing fluids recommendations

6. Require full disclosure of all hydraulic fracturing chemicals and constituents to regulatory agencies and to local government emergency response officials prior to drilling. The state should encourage the industry to fully disclose that same information to the public and require public disclosure of hydraulic fracturing chemicals and constituents with the exception of trade secrets already protected under state law.
7. Prohibit the use of diesel fuel in hydraulic fracturing fluids

Waste management standards

8. Develop specific transportation, storage and disposal standards for management of oil and gas wastes.

Regulatory program recommendations

9. Develop a modern oil and gas regulatory program, taking into consideration the processes involved in hydraulic fracturing and horizontal drilling technologies, and long-term prevention of physical or economic waste in developing oil and gas resources.
10. Enhance existing oil and gas well construction standards to address the additional pressures of horizontal drilling and hydraulic fracturing.
11. Develop setback requirements and identify areas (such as floodplains) where oil and gas exploration and production activities should be prohibited.

12. Close the gaps in regulatory authority over the siting, construction and operation of gathering pipelines
13. Identify a source of funding for repair of roads damaged by truck traffic and heavy equipment.

Permitting recommendations

14. Keep the environmental permitting program for oil and gas activities in DENR where it will benefit from the expertise of state geological staff and the ability to coordinate air, land and water permitting.
15. Develop a coordinated permitting process.

Data management recommendations

16. Improve data management capabilities and develop an e-permitting program that is easily accessible by the public

Emergency response recommendations

17. Ensure that state agencies, local first responders and industry are prepared to respond to a well blowout, chemical spill or other emergency.

Local government authority recommendations

18. Clarify the extent of local government regulatory authority over oil and gas exploration and production activities.

Address liability

19. Address the natural gas industry's liability for environmental contamination caused by exploration and development, particularly for groundwater contamination.

Public participation

20. Provide additional opportunities for the public to participate in development of detailed standards to govern gas exploration and development.

Additional research recommendations

21. Complete additional research on impacts to local governments and local infrastructure.

- 22. Complete additional research on potential economic impacts.**
- 23. Complete additional research on closed-loop systems and the potential for prohibiting open wastewater pits.**
- 24. Complete additional research on the ability of the air toxics program to protect landowners who lease their land for natural gas extraction and production activities.**
- 25. Complete additional research on air emissions from hydraulic fracturing operations.**
- 26. Complete additional research on the shale gas resource.**
- 27. Complete additional research on groundwater resources in the Triassic Basins.**

Funding recommendations

- 1. Provide funding for any continued work on the development of a North Carolina regulatory program for the natural gas industry.**
 - Over the past year, staff in DENR and to a lesser extent the Department of Commerce have worked on this report while also trying to meet their normal job responsibilities. Employees have worked on their “regular” jobs during the day, while researching and writing this report on nights, weekends and holidays. The additional workload was necessary to develop the most robust report possible given the resources and time available. However, this double duty has inevitably detracted from the ability of DENR staff in particular to meet all of the conflicting demands on their time. For example, during one of the public meetings held for this report, two senior DENR staff members were forced to leave the meeting temporarily to respond to a dam safety emergency. State staff members cannot continue to do two jobs at once without sacrificing the quality of their work. If the General Assembly chooses to pursue the development of a regulatory program for shale gas, significant additional work on these issues will need to be done in the next two years to research and draft appropriate regulatory standards.
 - DENR recommends that the General Assembly begin to provide funding for additional positions in DENR to develop and later implement this regulatory program. Program funding should be adequate to provide a strong compliance program.
- 2. Address the distribution of revenues from oil and gas excise taxes and fees to support the oil and gas regulatory program, fund environmental initiatives, and support local governments impacted by the industry.**
 - In other oil- and gas-producing states, revenues from oil and gas fees and taxes are used to support conservation initiatives, offset costs to local governments impacted by the industry and for reclamation and remediation of lands impacted by oil and gas drilling. We recommend that in North Carolina, revenues collected from severance taxes and program fees should fund:

- the administration of the oil and gas program;
- conservation initiatives, including land and water conservation and the improvement of water and wastewater infrastructure;
- reclamation and remediation of any lands adversely impacted by oil and gas exploration and production;
- Repair, maintenance and improvement of local government infrastructure impacted by gas development activities; and
- Support for community services impacted by the industry.

Further study is needed to determine the distribution amounts for each of these needs.

- North Carolina's current severance tax rate is lower than that of any other state that charges a severance tax. Further study is needed to determine an appropriate severance tax rate.
- In addition to a permit fee, an annual fee is needed to support annual inspections of oil and gas sites. Permit fees are collected once and are designed to pay for the cost of reviewing applications for permission to drill. Effective oil and gas programs conduct inspections at various stages throughout the well development process, such as cementing and casing of the well, drilling the well and hydraulic fracturing. Inspections must also occur yearly or at some other regular interval. Ensuring that drilling operations meet regulatory requirements at each stage in the production process is critical to the protection of public health, groundwater resources, surface water resources, and land resources. Severance taxes can be a volatile revenue source, increasing or decreasing based on the natural gas market. However, the need to inspect oil and gas sites exists whether or not the market is booming. Since the costs for administering the regulatory program are annual and ongoing, we recommend that any North Carolina oil and gas regulatory program should assess an annual fee to recover the costs of inspections and data collection related to those inspections, rather than depending on severance tax revenue to pay for this set of program costs.

Water and air quality recommendations

3. Collect baseline environmental quality data including groundwater, surface water and air quality information.

We recommend that:

- a. The General Assembly should require each oil and gas operator to obtain background groundwater quality data including water levels from existing water supply wells near the proposed drill site before drilling begins and to share this data with the regulatory agency. Each water supply well located within a distance determined by the horizontal extent of the hydraulically fractured well should be sampled and analyzed for dissolved

methane, volatile and semi-volatile organic compounds, chloride, total dissolved solids, bromide and dissolved metals.

- b. Where the use of groundwater is proposed for use in hydraulic fracturing, DENR should monitor groundwater levels for all wells in the vicinity of the lateral extent of the hydraulically fractured well, at a distance to be determined based on future research. Drillers should be required to conduct a pump test prior to using their well.
- c. DENR should collect pre-drilling surface water monitoring data for areas proposed for drilling to establish baseline water quality information. The extent and location of data collection should be determined as drilling blocks are established.
- d. DENR should collect pre-drilling air emissions data for areas proposed for drilling, at a distance determined through additional research.

Part of this additional research should involve evaluation of the existing state air toxics program and its ability to protect landowners who lease to oil and gas operators. North Carolina's air toxics program currently requires a source of state-regulated toxic air pollutants to demonstrate compliance with health-based pollution standards at the property boundary. The program has assumed that measuring toxic air pollutants at the boundary of an industrial facility adequately protects nearby residents who may have long-term exposure to the pollutants. Shale gas production often occurs under a lease of property that may be owned and in some cases occupied by another person. In that case, the property owner may be exposed to unhealthy concentrations of toxic pollutants associated with gas production. The existing air toxics program should be evaluated to determine whether it provides adequate protection when natural gas production occurs on residential properties or farms.

4. Require oil and gas operators to operate in compliance with a DENR-approved Water and Wastewater Management Plan. The Water Management Plan should limit water withdrawals to 20 percent of the 7Q10 stream flow and prohibit withdrawals during times of drought and periods of low flows.

- We recommend that the General Assembly require oil and gas operators to have a water and wastewater management plan that has been approved by DENR for any new water withdrawals for use in hydraulic fracturing and for the disposal of wastewater generated by hydraulic fracturing.
- The water management portion of the plan should be similar to plans required by the Delaware and Susquehanna River Basin Commissions. Any new surface water withdrawals for gas well development should be limited such that the cumulative instantaneous withdrawals for all hydraulic fracturing operations in the vicinity of the intake do not exceed 20 percent of the 7Q10 stream flow. Instantaneous withdrawals greater than 20 percent of the 7Q10 stream flow should require site-specific evaluation of potential impacts. The 7Q10 threshold has been used for many years to manage impacts to stream flows and has been shown to be protective of other water users and

the environment. This approach would be naturally protective during low-flow conditions and droughts (which is particularly important in small watersheds); prevent excessive withdrawals during periods of peak usage; and prevent any surface water in North Carolina from drying up due to natural gas withdrawals.

- As a further precaution, water withdrawals for hydraulic fracturing should be prohibited during times of drought and during low-flow periods. The development of the specific low-flow threshold for the cessation of water withdrawals for hydraulic fracturing would be determined as part of the regulatory development process.
- For approval of the water and wastewater management plan, operators should be required to demonstrate that wastewater will be reused or recycled to the maximum extent feasible and that remaining wastewater will be treated in a way that protects receiving wastewater treatment plants, receiving waters and downstream water users.
- Operators should be encouraged to use reclaimed water as an initial source of water to further reduce the need for withdrawal of surface water or groundwater.
- Because of their variability in the Triassic basins, DENR cautions that groundwater resources may not be adequate to meet water needs for hydraulic fracturing operations. However, if operators choose to use groundwater as a source, DENR recommends documentation and monitoring of water levels in wells within a distance of the wellhead to be determined based on future research and conducting a 24-hour pump test prior to use of new wells to evaluate aquifer conditions and potential impacts to neighboring wells.
- We recommend that the gas industry and public water utilities work together to meet water needs for gas exploration while protecting water quality and the rights of other water users. We encourage the investigation of options to satisfy water needs by recycling to the extent practical and taking advantage of unused capacity in existing water systems.

5. Develop a state stormwater regulatory program for oil and gas drilling sites.

The impacts of stormwater discharges from oil and gas exploration and production are substantially similar to the impacts from the construction and industrial activities that occur in North Carolina today. Oil and gas exploration and production can disturb large areas of land to develop impervious well pad sites, creating significant impacts related to sedimentation and erosion, water quality pollution, increased peak discharges, increased frequency and severity of flooding, and other stormwater concerns.

However, unlike existing construction and industrial activities, oil and gas exploration and production activities are exempt from the requirements of the National Pollutant Discharge Elimination System (NPDES) stormwater permit program under the federal Clean Water Act unless there has been a documented water quality standard violation, or release of a reportable quantity of oil or hazardous substance. Since North Carolina has relied on the

federal stormwater permitting programs to manage industrial stormwater impacts, the state is not prepared to effectively manage stormwater impacts associated with oil and gas production.

We recommend that the General Assembly authorize a state stormwater regulatory program for oil and gas activities, including requirements for stormwater permitting, inspections and compliance activities.

Hydraulic fracturing fluids recommendations

- 6. Require full disclosure of all hydraulic fracturing chemicals and constituents to regulatory agencies and to local government emergency response officials prior to drilling. The state should encourage the industry to fully disclose that same information to the public and require public disclosure of hydraulic fracturing chemicals and constituents with the exception of trade secrets already protected under state law.**

We recommend that the General Assembly require full disclosure of all hydraulic fracturing chemicals and constituents, not just those reported on MSDSs, to the state regulatory agency and to local government emergency response officials and medical facilities before each operator begins hydraulic fracturing on a particular site. We also recommend that the General Assembly should encourage full public disclosure and require the industry to disclose all hydraulic fracturing chemicals and constituents – except for information protected under North Carolina law as a trade secret – to the public through the FracFocus website or a state agency website. The General Assembly should encourage the use of environmentally friendly and non-toxic hydraulic fracturing fluids where feasible as well as the use of tracers.

- 7. Prohibit the use of diesel fuel in hydraulic fracturing fluids**

The use of diesel fuel in fracturing fluid is a concern because it contains toxic constituents, including the BTEX compounds benzene, toluene, ethylbenzene and xylenes. Benzene is a human carcinogen, while chronic exposure to toluene, ethylbenzene or xylenes can damage the central nervous system, liver and kidneys. We recommend that its use as a hydraulic fracturing constituent be completely prohibited.

Waste management standards

- 8. Develop specific transportation, storage and disposal standards for management of oil and gas wastes.**

- a. *Solid Waste.* Many of the waste products of the oil and gas industry are exempt from federal hazardous waste rules, but some have the characteristics of hazardous wastes. As a result, oil and gas-producing states generally have specific standards for wastes generated by oil and gas production. Since those wastes are not specifically addressed by North Carolina's waste manage program, we recommend the development of a

regulatory program to address the unique characteristics of solid wastes associated with oil and gas during transportation, on-site storage and final disposal.

Recommended requirements include:

- Industrial and MSW landfills' operational plans should be required to include radiation monitoring at the working face of the landfill when exploration and production waste is being accepted.
 - Exploration and production waste should only be allowed in a landfill with a liner and leachate system design that is equivalent to the design requirements for an MSW landfill. Current standards for construction of a MSW landfill allow use of one of four liner systems. These same liner alternatives exist for industrial landfills. Prohibiting oil and gas waste from unlined landfills will require a change in existing rules.
 - Industrial landfills (in the event that the shale gas industry will choose to site and can permit a landfill in North Carolina) do not at this time receive disposal fees. It is recommended that fees be assessed for this type of waste at industrial landfills.
 - All exploration and production industrial wastes accepted into MSW landfills, including those allowed by permit to be used as alternative daily cover, should always be considered waste and must be assessed appropriate fees. We recommend that these types of waste not be excluded from fee assessments at an industrial landfill.
 - There has not been research on the possible interaction between chemicals used in industrial processes and wastes in MSW landfills and possible impacts on the liner or leachate systems. The possibility that chemicals solutions used in hydraulic fracturing may compromise landfill integrity must be thoroughly assessed before these exploration and production wastes are allowed into existing or new MSW landfills. We recommend a comprehensive study to determine if design or operation should be changed for this particular waste stream.
- b. *Solid waste and wastewater.* Prohibit land application of solid waste and wastewater from oil and gas activities because of environmental impacts and the lack of sufficient capability to dispose of all waste generated.
- c. *Wastewater.* Maintain the state's prohibition on underground injection of wastewater due to North Carolina's unsuitable geology and seismic risks.
- d. *Wastewater.* Encourage a wastewater management hierarchy in which recycling and reuse of hydraulic fracturing fluids is used to the maximum extent feasible. The preferred order of disposal options for oil and gas wastewater is 1) recycling and reuse of hydraulic fracturing fluids and produced water, 2) on-site treatment or pretreatment at a centralized waste treatment facility with ultimate disposal to a publicly-owned treatment works (POTW), and 3) centralized waste treatment facility with a direct discharge permit under the NDPES program. Pretreatment and wastewater treatment plant protocols should be adequate to meet applicable water quality standards and

sufficient to prevent the introduction of chemical components into any receiving waters that would compromise downstream water treatment plants.

Regulatory program recommendations

9. Develop a modern oil and gas regulatory program, taking into consideration the processes involved in hydraulic fracturing and horizontal drilling technologies, and long-term prevention of physical or economic waste in developing oil and gas resources.

- We recommend that the General Assembly authorize DENR to establish a complete regulatory program for oil and gas management, including oversight, compliance, inspections, recordkeeping and notice provisions that will complement the existing regulatory framework for regulation of the oil and gas industry
- In addition, we recommend several specific items below:
 - Establish well pad density requirements, to limit surface disturbance from well pads and pipelines
 - Develop requirements for minimization of secondary and cumulative impacts, such as forest fragmentation and damage to important natural areas. Require oil and gas operators to present a drilling unit management plan to the regulatory agency; the plan should demonstrate minimization of secondary and cumulative impacts through site design and construction techniques.
 - Require the regulatory agency to be on site during gas well cementing
 - Provide non-recurring funding to DENR for the first few years of the regulatory program
 - Fund a regulatory program that is sufficient to provide rigorous oversight and regular inspections
 - Under the existing statute, bonds collected for oil and gas wells can only be used to plug abandon wells. We recommend broadening this authority to include using bonds for reclamation and remediation of sites contaminated by oil and gas activities.
 - Develop defensible and enforceable state water quality standards for constituents used in hydraulic fracturing to address potential adverse effects to public health and the environment
 - Develop standards for well abandonment and site reclamation and remediation

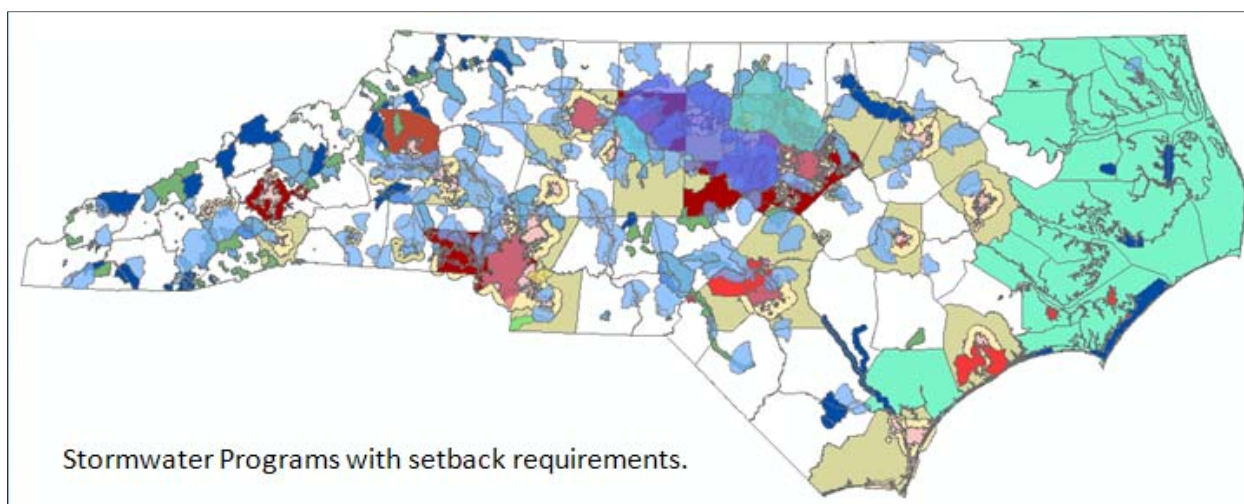
10. Enhance existing oil and gas well construction standards to address the additional pressures of horizontal drilling and hydraulic fracturing.

North Carolina's oil and gas well construction standards haven't changed over the last couple of decades. The standards should be revised, relying on the best guidance currently

available, to establish well construction standards appropriate for modern oil and gas production methods, including horizontal drilling and hydraulic fracturing.

11. Develop setback requirements and identify areas (such as floodplains) where oil and gas exploration and production activities should be prohibited.

Currently, no uniform setback requirements for oil and gas exploration or production activities exist in North Carolina. The state stormwater and Phase II stormwater programs require a 30-foot setback from streams and wetlands for any impervious surface. The water supply watershed protection program requires impervious surfaces to be located 30-feet away from perennial streams for low-density projects and 100-feet away from perennial streams for high-density projects. Riparian buffer protection rules are in place in the Neuse, Tar-Pamlico and Catawba River basins and the Jordan Lake and Randleman Lake watersheds that require 50-foot protected riparian buffers from streams, lakes and ponds. These existing setback and buffer requirements were designed to manage the impacts of conventional development activities and may not be sufficient for the infrastructure associated with oil and gas development.



Many other states have specific setback requirements in place or proposed for oil and gas exploration or production activities. Pennsylvania regulations require storage or disposal pits for production fluids to be located at least 100 feet away from a stream, wetland or body of water. Land application areas, drill cutting disposal areas and residual waste pits must be at least 200 feet from a water supply and 100 feet away from a stream, wetland or other body of water. New York's existing regulations prohibit an oil or gas well within 50 feet of any water body; however, a 1992 EIS for the New York oil and gas program proposed increasing that distance to 150 feet for the entire well site. The 2011 draft Supplement to that EIS proposes prohibiting high-volume hydraulic fracturing within the 100-year floodplain.

Further work is needed to establish setbacks and areas where oil and gas activities should be prohibited in order to protect public health, public safety and sensitive natural

environments. These setbacks and prohibited areas must be established in collaboration with a number of other partners, including local government, other state and federal agencies, industry representatives, and others with an interest in the region (including agriculture and conservation organizations).

Setbacks may include provisions to:

- Protect neighbors and surface owners from safety hazards, noise or other impacts
- Establish setbacks from property lines
- Protect wetlands and streams
- Protect fish, wildlife and important natural areas

Areas prohibited from oil and gas activity may include:

- 100-year floodplain
- Water supply watersheds
- State parks, state forests, game lands, conservation easements and Significant Natural Heritage Areas

12. Close the gaps in regulatory authority over the siting, construction and operation of gathering pipelines

Based on the lack of an existing regulatory system for gathering lines in North Carolina and gathering line safety issues noted in this report, DENR recommends that the General Assembly direct DENR and the North Carolina Utilities Commission to work together to close the regulatory gaps for gathering lines in North Carolina.

13. Identify a source of funding for repair of roads damaged by truck traffic and heavy equipment.

We recommend that the General Assembly direct the North Carolina Department of Transportation to study the issue of road management and options for mitigating the impacts of increased traffic on roads, such as requiring bonds or road use management agreements.

Permitting recommendations

14. Keep the environmental permitting program for oil and gas activities in DENR where it will benefit from the expertise of state geological staff and the ability to coordinate air, land and water permitting.

Currently the Secretary for the Department of Environment and Natural Resources has authority to adopt rules to administer an oil and gas permitting program. In addition,

existing environmental regulatory programs in DENR have authority (through DENR or a citizen commission) to adopt rules for the aspects of oil and gas production regulated by those programs. We recommend that existing administrative structures and authorities be used to regulate the oil and gas industry, rather than creating a new regulatory agency. The state may rely on the DENR Secretary's existing authority from the Oil and Gas Act or expand the authority of the Mining Commission or the Environmental Management Commission to regulate this industry. Consistent with the STRONGER report, keeping the environmental regulation of the oil and gas industry in DENR will allow coordination of environmental reviews and provide more efficient service delivery for the industry.

15. Develop a coordinated permitting process.

DENR has the ability to develop a permitting process that coordinates among the various agencies that will require environmental permitting for oil and gas activities.

Data management recommendations

16. Improve data management capabilities and develop an e-permitting program that is easily accessible by the public

A robust data management system including GIS tools is needed to:

- Collect baseline water quality and air quality data
- Track production of oil and gas activities for royalties/severance tax
- Facilitate public disclosure of hydraulic fracturing constituent information
- Provide electronic permitting to the industry to allow for efficient and effective collection and distribution of data, particularly when concerns about pollution occur
- Enable the permitting, inspection and enforcement system to be as effective as possible
- Provide accurate information to the public

DENR currently has no computer data management capabilities with respect to oil and gas regulatory activities. The STRONGER review noted this deficiency of North Carolina's programs in comparison to STRONGER's guidelines. In order to effectively manage the large volumes of reporting information associated with baseline sampling, production, drilling logs and hydraulic fracturing, and to make this information available to interested parties in the public, industry and other state agencies, North Carolina will need to make substantial investments in electronic databases and online reporting tools. A sound electronic data management system benefits the public by providing increased, and more timely, public awareness of industry activity and environmental impacts; benefits industry and landowners by making exploration data available to guide additional exploration and leasing

decisions; and benefits the state by allowing for improved tracking of revenue from severance taxes.

Emergency response recommendations

17. Ensure that state agencies, local first responders and industry are prepared to respond to a well blowout, chemical spill or other emergency.

- We recommend that oil and gas operators be required to develop an emergency response plan; state criteria for an acceptable plan should include a requirement that a wild-well qualified person be on the well pad at all times and 911 addressing of all well locations.

If shale gas development occurs in North Carolina, local governments will require additional funds to train their local emergency services providers and to acquire additional or specialized equipment to respond to emergencies related to natural gas drilling and production activities. These providers will need training in responding to a variety of potential emergencies that could occur as a result of large truck accidents, hazardous materials truck accidents and accidents on drilling sites.

- We recommend that the General Assembly encourage the Department of Labor to review its readiness to inspect drilling sites and appropriately enforce the OSHA standards for this industry to prevent worker injuries or death.

Local government authority recommendations

18. Clarify the extent of local government regulatory authority over oil and gas exploration and production activities.

We recommend that the General Assembly address the issue of local zoning preemption and be clear about the authority that remains at the local level with regard to oil and gas exploration and production activities. Several models exist in other oil and gas-producing states for sharing authority between state and local government.

Address liability

19. Address the natural gas industry's liability for environmental contamination caused by exploration and development, particularly for groundwater contamination.

Accidents and equipment failure can cause spills, leaks and other environmental contamination even with the best regulations in place. At the federal level, the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) establishes cleanup standards and liability for hazardous waste contamination. However, CERCLA expressly excludes petroleum and natural gas. As a result, state regulators face the task of assigning financial and cleanup responsibility. Consistent with existing law, DENR believes the oil and gas industry should be held responsible for damages that it causes. We

recommend that the General Assembly further study this issue and develop appropriate provisions addressing liability for environmental damage and for damage to personal or real property.

Public participation

20. Provide additional opportunities for the public to participate in development of detailed standards to govern gas exploration and development.

As noted in the report, a complete oil and gas regulatory program requires a number of very detailed standards; many of those standards, such as development of setback requirements and separation distances between gas production and groundwater, need to be based on North Carolina conditions. Those standards should be developed in an open process that draws on technical advisory groups that include representatives from academia, industry, nonprofit advocacy organizations and other government agencies. The process should also allow for additional public input.

Additional research recommendations

21. Complete additional research on impacts to local governments and local infrastructure.

The state needs a better understanding of the potential impacts of gas production on local government services and infrastructure in North Carolina. We recommend that the General Assembly request assistance from research institutions, the North Carolina League of Municipalities, the North Carolina Association of County Commissioners and other organizations with expertise on local government issues.

22. Complete additional research on potential economic impacts.

Section 5 of this report provides an estimate of economic impacts on the North Carolina economy related to new gas drilling activities, specifically directional drilling of gas wells in the Sanford sub-basin of the Deep River Triassic Basin. The economic impact analysis does not take site preparation, leasing of land, hydraulic fracturing or extraction, production or transmission of gas into consideration. While a review of the natural gas industry was conducted in order to potentially model economic impacts, uncertainty about data quality did not permit further analysis. Data quality issues resulted primarily from a lack of survey-based, real-world industry cost and supply chain relationship data. This survey approach would be necessary due to the absence of well-defined data in the matrix that underlies the modeling tool. Follow-on analysis with better data is recommended.

23. Complete additional research on closed-loop systems and the potential for prohibiting open wastewater pits.

The use of open pits for storing wastewater could pose potential threats to wildlife, could overtop during large storm events, and could emit harmful air pollutants. More research is needed to determine whether closed-loop systems are a better solution and whether open wastewater pits should be prohibited.

24. Complete additional research on the ability of the air toxics program to protect landowners who lease their land for natural gas extraction and production activities.

The existing procedure for assessing ambient concentrations at the property boundary will need to be evaluated for situations where a well could be located on a piece of property that also contains a home, a farm, etc.

25. Complete additional research on air emissions from hydraulic fracturing operations.

An assessment of the emissions from hydraulic fracturing operations and associated truck traffic needs to be done to understand the impact on ozone in North Carolina. As better emission estimates are developed for potential oil and gas development and production in North Carolina, we recommend that DENR evaluate potential impacts on ozone levels in the region and identify any measures needed to maintain compliance with the federal ozone standard.

26. Complete additional research on the shale gas resource.

An assessment of the potential for shale gas throughout the Triassic Basins but outside the Sanford sub-basin should be completed using 2D or 3D seismic reflection data. This information will be useful in assessing the shale gas resource, but may also be a valuable tool for understanding groundwater resources in the Triassic Basins.

27. Complete additional research on groundwater resources in the Triassic Basins.

The state needs to conduct further study of the routes of possible groundwater contamination resulting from oil and gas operations, including hydraulic fracturing, and the potential role of vertical geological structures such as dikes and faults. Study should include identification of mechanisms for preventing and diagnosing the cause of groundwater contamination, such as tracers. At a minimum, a detailed hydrogeologic investigation should be required at all sites where hydraulic fracturing is proposed to identify the horizontal and vertical extent of all faults and intrusions and their capacity to affect the movement of deep groundwater and hydraulic fracturing fluids in the area to be hydraulically fractured.

B. Limitations

As requested by the General Assembly, this report analyzes the potential environmental, health, economic, social and consumer protection impacts that an oil and gas extraction industry may have in North Carolina. The analysis is constrained by the limited information available at this time. We do not have detailed or comprehensive information on the extent and richness of the shale gas resource in North Carolina. For purposes of this report we have been forced to extrapolate from data gathered from only two wells in the Sanford sub-basin; those well values have been averaged to project an estimate of the natural gas resource potentially available in that sub-basin. Since there are only two data points and the two wells have significantly different values, it is not clear how well the average value represents the resource throughout the Sanford sub-basin. This report generally uses the Sanford sub-basin as the basic unit for analysis of all impacts because the available data came from that sub-basin. The Sanford sub-basin represents only a fraction of the total Triassic Basin formations in the state – approximately 59,000 acres out of a total of 785,000 acres that are estimated to be able to produce hydrocarbons.

These limitations carry over into the assessment of both potential economic and environmental impacts. DENR projected the number of wells and total gas production *for the Sanford sub-basin*, using the limited data derived from averaging the values of two wells. Those projections are used throughout the report as the basis for assessing economic and environmental impacts.

Many impacts of natural gas extraction will vary based on local characteristics, such as water resources and even the weather. For example, the depth and quality of groundwater resources in the Triassic Basins of North Carolina appear to be very different from conditions in the Marcellus shale formations in Pennsylvania. North Carolina does not seem to have as great a separation between potential drinking water resources and the gas-producing zone; understanding the geology and groundwater hydrology of North Carolina's shale formations will be critical to ensuring protection of drinkable groundwater. In terms of infrastructure impacts, weather can be an important factor. A local government official in Pennsylvania told DENR staff that when the natural gas industry first came to Pennsylvania from the South, oil and gas operators were surprised at how the harshness of the winters magnified the road damage caused by heavy oil and gas trucks.

There are some aspects of oil and natural gas extraction for which data is extremely limited even at a national level; the limited time available to prepare this report prevented us from taking into account additional research that is currently underway. This includes EPA's research on potential groundwater impacts in Pavillion, Wyo., and Dimock, Pa. and EPA's study of hydraulic fracturing and its potential impact on drinking water resources. EPA's first report of results related to drinking water is expected in 2012; the final report is not expected until 2014. To our knowledge, no comprehensive studies are currently available on the long-term impacts to health from hydraulic fracturing for natural gas, and DENR is not qualified to conduct such a study. DENR recognizes that questions remain about health impacts. The EPA drinking water study may provide additional insight on health effects.