DELAWARE RIVERKEEPER®

Edward Hanlon, Designated Federal Officer
SAB Staff Office
Ronald Reagan Building
1300 Pennsylvania Avenue, NW
Suite 31150
Washington, DC 20004

February 25, 2011

Re: Hydraulic Fracturing Study Plan Review Panel

Dear Mr. Hanlon,

I represent the Delaware Riverkeeper Network and the Delaware Riverkeeper, Maya van Rossum. DRN has taken a lead role in protecting the waters of the Delaware River, which supplies drinking water for more than 15 million people. We have taken a keen interest in the issue of hydraulic fracturing for natural gas in shale formations such as the Marcellus Shale because of the potential for severe, if not catastrophic, harm to the Basin's irreplaceable drinking water resources.

Although the EPA Hydraulic Fracturing Study Plan is a good start, its scope has been unduly narrowed to focus only on the deliberate and intentional use of water in the hydraulic fracturing process itself. This study design excludes consideration of impacts to drinking water from critical steps in the natural gas extraction process such as surface level construction, vertical well installation, road and pipeline installation and use, and more. It is simply not the case that the only impacts to drinking water resources will occur from the deliberate use of water in the hydraulic fracturing process itself. The EPA study should not limit consideration only to the intentional use of water in the hydraulic fracturing process alone, but encompass the larger water quality impacts caused by the shale gas well installation and extraction process as a whole.

We intend to submit additional comments on the Environmental Protection Agency's Hydraulic Fracturing Study Plan via fax and email on Monday, February 28, 2011, in time for the Scientific Advisory Board's consideration at the meeting scheduled for March 7-8, 2011. As an initial submission, however, I enclose for the SAB's consideration a number of expert reports that were prepared for the Delaware Riverkeeper Network and the Delaware River Basin

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Commission for a hearing on the impacts to water quality from vertical wells drilled for shale gas exploration in the Delaware River Basin.[1]

Among other issues, these reports specifically address adverse impacts to water quality that are likely to occur specifically because of well pad construction and vertical well installation. Adverse impacts to drinking water quality may occur at many points in the gas development and exploitation process and are not limited to impacts from horizontal drilling and/or hydraulic fracturing.

Actual and potential water quality impacts from vertical well construction and installation identified in these expert reports include:

- Impacts to water quality from sedimentation and erosion as well as stormwater runoff resulting from land disturbance from pad site, entrance road, and pipeline facility construction as well as widening or paving of existing roads and increased road traffic (Adams, O'Dell, Sildorff)

- Chemical and biological contamination to ground water resulting from the chemical products used in both drilling muds and air drilling as well as naturally occurring chemical, biological, and/or radioactive substances mobilized by drilling. Contamination of water may occur either below ground (e.g., through casing or grouting failure or annular channels) or above ground (e.g., from drill cutting pits and waste disposal) (Bishop, Demicco, Harvey, Rubin, O'Dell, Sildorff)

- The water quality impacts of a well blowout, not only from the produced fluids and naturally occurring fluids ejected during the blowout but also from the chemical suppressants and water withdrawals used to cap wells and contain blowouts (Harvey)

- Adverse water quality impacts resulting from stray gas migration when vertical wells are not properly cased and cemented, thus allowing natural gas in subsurface formations to migrate from the wellbore through bedrock and soil, contaminating aquifers and drinking water wells (Harvey, Rubin)

- Adverse water quality impacts resulting from the penetration by vertical wells of bedrock joints that may result in hydrological connections between saline and freshwater horizons by opening inter-formational pathways. (Rubin)

- Clearing and fragmentation of forested areas and degradation of riparian zones related to well pad construction result in adverse impacts to drinking water. Intact forest ecosystems and riparian buffers are critically important to protecting stream water quality from non-point source pollution and nutrient loading, particularly in the headwaters of the Delaware River Basin (Owens, Jackson & Sweeney)

Because surface level construction, site use, and vertical well installation are prerequisites to any horizontal drilling and hydraulic fracturing processes, EPA should address the impacts of these activities in its study design to fulfill Congress' mandate and ensure a complete picture of the impacts to drinking water.

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[1] Five of the reports (Anderson & Kreeger, O'Dell, Sildorff, Jackson & Sweeney, Volz) were produced at the request of the Delaware River Basin Commission, which has no affiliation with the Delaware Riverkeeper Network. These reports are publicly available documents.

More generally, these expert reports highlight some of the shortcomings of the current scope of the proposed EPA study and illustrate how the study, as proposed, will not fulfill Congress' mandate to study the cumulative effects of shale gas extraction on drinking water quality. Many additional elements of the shale gas extraction process need to be studied for their potential impacts to drinking water quality. For example:

- It is inappropriate to exclude consideration of air quality impacts resulting from natural gas production wells from the EPA study, because air quality impacts can cause water quality impacts, as air pollutants precipitate and deposit both on ground surfaces and water surfaces (Harvey).

- Seismic activity in areas of vertical well installation and hydraulic fracturing has significant implications for impacts to drinking water quality. Seismically active regions such as the Marcellus Shale have a high likelihood over time of significant ground motion that may instantly shear multiple well casings, opening connections between formerly separated freshwater and saline horizons and permitting natural gas migration as well as contamination from produced waters. (Rubin)

- Multiple pathways of water quality degradation from surface and subsurface activities relating to well pad construction and shale gas extraction may result in impacts to aquatic biota such as freshwater mussels. In the Delaware River, large assemblages of these filter feeders play a critical role in maintaining the drinking water quality of the River. Yet these species are highly susceptible to the impacts that natural gas well construction and hydraulic fracturing may inflict, such as increased sedimentation, increases in suspended sediments, water quality degradation from brines and other contaminants, inadequate flows and dewatering, invasive species, and forest fragmentation. (Anderson & Kreeger, Sildorff)

- It is also incumbent on the EPA not merely to identify possible contaminants (whether natural or manmade) that may affect drinking water quality but also to examine the potential health impacts of drinking water contamination on human populations. I draw your attention to the Teitelbaum paper and its appendices on this issue.

- EPA should examine the interactions between naturally occurring and manmade chemicals introduced through the drilling and fracturing processes. Biochemist Ron Bishop, whose report is attached, has, identified 4 Nitroquinoline 1-oxide (4NQO), a powerful carcinogen, in the wastewater produced by natural gas drilling. He has informed DRN that this chemical compound is not a drilling or hydraulic fracturing additive and it is also not found naturally in the geologic formations that produce flowback water during the stimulation process. Apparently, it is formed through interaction of the chemicals that are present in these fluids.

- The presence of this extremely powerful carcinogenic compound is a serious health concern and immediately requires further investigation since it is being found in currently produced gas drilling wastewater in New York State and perhaps in Pennsylvania as well. 4NQO is used in cancer research to induce cancerous tumors in animals for study. It is one of the most potent of all cancer causing chemical compounds. (See, e.g., http://bit.ly/gdzwlP).

Thank you for the opportunity to comment on EPA's draft study. For your convenience, I enclose a binder with one paper copy of each of these expert reports (without appendices) as well as twenty-four duplicate copies of all reports plus appendices on CD for the use of the members of the SAB.

Very truly yours,

Jane P. Davenport
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Feb. 28, 2011

Re: Additional Comments on Hydraulic Fracturing Study Plan Review Panel

Dear Mr. Hanlon:

I represent the Delaware Riverkeeper Network and the Delaware Riverkeeper, Maya van Rossum. We submitted a comment letter dated February 25, 2011, as well as eleven expert reports addressing various impacts to water resources implicated by the construction and installation of vertical wells intended for natural gas exploration and production in the Marcellus Shale contained within the Delaware River Basin.

Please accept these additional comments on the Environmental Protection Agency's Hydraulic Fracturing Study for consideration by the Plan Review Panel. In drafting these comments, we have relied heavily on input from Mr. Richard A. Raiders, a law student in our clinical program who has B.S. and M.S. degrees in petroleum engineering and more than twenty-two years of experience working in the field of environmental engineering and compliance.

The Environmental Protection Agency (EPA) Science Advisory Board (SAB) has proposed a draft work plan to study the effect of hydraulic fracturing of gas bearing formations on surface- and groundwater resources through various retrospective, prospective, and research studies. The proposed EPA work plan addresses many important issues. However, EPA must improve the proposed work plan to include and address critical issues related to natural gas development through hydraulic fracturing that have potentially significant deleterious effects on drinking water and the communities that rely on sources of safe drinking water. These effects may stem not only from the deliberate, intentional use of water in the hydraulic fracturing process, as the current study plan focuses on, but also the various impacts on drinking water from well construction and associated infrastructure development and non-intentional contamination through accidents or failure to adhere to appropriate environmental standards.

Radioactive Contamination from Wastewater and Other Drilling-Related Sources

According to the reporting by Ian Urbina in the New York Times dated February 27, 2011, titled Regulation Lax as Gas Wells' Tainted Water Hits Rivers, EPA already has studies or evidence in its possession that demonstrate that wastewater from hydraulic fracturing operations may be highly contaminated with NORM and is being sent to treatment plants that are not equipped to treat such waters to drinking water quality standards. The article also cites information obtained from industry sources concluding that the radioactivity in fracking waste cannot be fully diluted in rivers and other waterways. Moreover, as the article reported, these plants are not being required by the States or by the EPA to test for the presence of such radioactive materials.

See http://www.nytimes.com/2011/02/27/us/27gas.html

and documents cited therein.

The potential for contamination of drinking water with radioactive substances via hydraulic fracturing wastewater is obviously extremely significant. As such, the EPA must expand the focus of the study's section on the treatment and disposal of fracking wastewater to analyze this issue in detail. It is incumbent on the EPA to include, as part of this study, testing of wastewater before and after treatment at water treatment facilities for contamination by radioactive materials.

Radioactive materials present in wastewater also pose the risk of contamination to drinking water sources via accidental spills, leakage from in-ground pits, and injection into underground disposal wells. EPA should ensure that all stages of its analysis take into account the risks that NORM-contaminated wastewater and other materials produced during the natural gas development and extraction processes pose to drinking water quality.

Well Data

EPA appropriately proposed to study production well failures, suspected contamination, and coalbed methane issues. However, well construction and fracture design may affect the impact of the fracturing process on nearby water quality. If an oilfield service company overstimulates a well, either accidentally or by design, the fractures created during the hydraulic fracturing project could propagate beyond the target formation. If the service company fractures the cap formation, and possibly other formations preventing fracturing or production fluids from entering potable water supplies, these oilfield activities could cause indirect long-term water supply problems.

Likewise, EPA should collect any available recompletion data for any shale gas wells. Second attempts to fracture a well rely on the original fractures to provide avenues for produced gas to be captured by a production well. Because the formation is already fractured, the service company performing the fracture may have less control over

where a refracture may spread. Recompletion procedures could also weaken wellbore cement, potentially causing unwanted fluids to travel through the well annular space and possibly into potable water formations. EPA should understand, using actual well data or simulation models, how contemporary refracture and/or recompletion practices may breach either cap rock formations or the wellbore.

EPA should also collect any historic or contemporary cement bond log information, especially for surface casing intended to protect potable water supplies. EPA should inquire if cement bond log data is available for shale gas wells, especially wells known or suspected to have failed and wells in the vicinity of known or anticipated potable water supply problems. In addition, EPA should collect data concerning the use (or lack of use) of centralizers in surface casing. If operators are not collecting cement bond log data from current wells, EPA should request that operators begin to log shale gas wells right after the operator sets the surface casing. Centralizer use and application data would allow EPA to evaluate the relationship between casing position, cement integrity, and well failure in the fate of potable groundwater supplies. Such data would allow EPA to understand if and how casing, cement, or centralizing problems affect sources of drinking water either at the surface or below ground.

Water Acquisition

The proposed water acquisition research studies would provide valuable knowledge for decision-makers in upcoming hydraulic fracturing related regulations. EPA's focus on drinking water supply, including cumulative impacts concerning multiple fracturing projects on a single waterway, appropriately captures one of the critical issues in this area. However, EPA should include goals to evaluate not only drinking water quality impacts, but also impacts on the various ecosystems in the affected watersheds. Seemingly insignificant changes in water quality can have a dramatic impact on several sensitive plant and animal species. Specifically, withdrawal of millions of gallons of water per well could cause increases in suspended solids, salinity, color, or temperature that could impact downstream ecosystems.

EPA's water acquisition studies should evaluate the impact of water withdrawals on downstream water quality. A trace constituent in a waterway that may not pose significant risk at current river flows could become a health hazard for downstream users at slightly higher concentrations.

The quality of streams and their ecosystems is directly related to the quality of surface water, affecting drinking water supplies drawn from the waterway. Therefore, EPA should also analyze the impact of water withdrawals from a surface water body on habitat for species dependent on the existing natural flow regime of the stream. As evidenced in the "Rules and Regulations for the Protection from Contamination, Degradation, and Pollution of the New York City Water Supply and its Sources" adopted by New York City for the protection of its source waters in the Delaware River watershed that flows to the City's reservoirs, one of three main causes of degradation and contamination to the City's source waters is "Urban, suburban, rural, mining,

silvicultural and agricultural land use practices that result in nonpoint source runoff of pollution and/or in adverse changes in the natural rate at which water flows into and through a delineated drainage basin". (Final Regulations, page 2)

Therefore, water flows must be analyzed as part of EPA's study. Changes in volume of flow as well as the natural variation and seasonal changes to a stream's regime directly impacts aquatic life - biota, fish, insects, etc. - as well as wildlife and flora and fauna populations that have adapted to natural stream conditions. Additionally, stream morphology is impacted by changes in flow, impacting stream life, downstream volume and rate of flow, and water quality. Withdrawals can also impact groundwater and aquifer recharge and base flow quality conditions of hydrologically connected surface waters and water-dependent features such as wetlands and verbal pools. Streamside shallow groundwater conditions can also be impacted. These hydrologically based and flow regime changes need to be evaluated and considered in water acquisition studies by EPA.

Impacts of Well Construction

As detailed in our letter of February 25, 2011, the impacts of vertical well construction as well as associated infrastructure cannot be discounted as a significant cause of drinking water quality degradation, particularly given the scale on which intensive gas development will alter the natural landscape, causing erosion, sedimentation, and stormwater issues on a large scale.

Best Management Practices for erosion and sedimentation control for pad development should also be reviewed by the EPA, since sediment pollution can severely affect benthic macroinvertebrates living in the stream and eliminate the habitat they need to survive by consolidating riffle habitats. Macroinvertebrates help filter out nutrients and other pollutants that directly affect the drinking water quality downstream. As richness and diversity of EPT (Ephemeroptera-Plecoptera-trichoptera species) are lost within the benthic community, so are the benefits they provide to drinking water downstream. As Dr. David Velinsky of the Academy of Natural Sciences has pointed out, this could create the need for more treatment procedures for drinking water downstream.

In the Delaware River Watershed, drilling is proposed for the most diverse headwater streams that remain in our Watershed and therefore, is a great potential threat to the diversity that sustains our clean drinking water downstream where benthic life may already be less diverse due to historic development and impacts from stormwater and other land use changes.

The EPA should consider and track waivers and exemptions records and the frequency of these exemptions with the state permitting process for Oil & Gas. For example, state regulations may be put in place to include floodplain protections or setbacks from wetlands, but in reality, waivers may be applied for by the industry that would put these industrial activities in sensitive and unstable habitats that could affect drinking water.

Chemical Mixing

EPA appropriately proposes to study the hazards of various materials used, or potentially used, in hydraulic fracturing projects. EPA should expand this study to evaluate the full life cycle of water used at a well: drilling fluids, completion and fracturing fluids, and produced waters. Water used in each step of the process typically contains different added and naturally occurring water pollutants. EPA should attempt to understand the nature of how each fluid changes composition in use. This study would allow EPA to develop or optimize test methods to detect trace concentrations of potentially toxic or other pollutants in these streams. Current SW-846 analytical data may not provide the requisite sensitivity to detect materials known or suspected to be in fracturing or produced water. Matrix interferences from the clays typically found in drilling mud may complicate evaluate of toxic materials in drilling muds.

EPA should consider both acute and chronic risks in each class of aqueous streams generated during well drilling and production. Some of the materials identified in various water studies, including n-hexane, tetracholoroethylene, and naturally occurring radioactive materials (NORM) can exhibit toxic effects at very dilute concentrations. EPA should perform comprehensive analytical evaluations in several samples of produced and generated fluids, using the most sensitive analytical methods available, to determine what trace constituents may cause human health or other pollution harms.

EPA should then take this data and evaluate treatability of all constituents known or suspected to be contained in these fluids. Where current data exists, EPA could rely on such data. However, in some cases trade secret or other trace compounds could cause substantial potable water supply risks should they reach drinking water or surface water supplies.

In this proposed study area, EPA is missing a major opportunity to evaluate the actual need to use many very toxic materials in fracturing water. Some constituents are not expressly needed in this service. Operators, if requested, should be able to identify a variety of less toxic alternatives to the current additives practices.

EPA appropriately proposes to study spills that potentially impact drinking water quality. EPA should also collect data on well construction issues that negatively affect drinking water supplies. EPA should also identify and track best management practices (BMPs) used by drillers and fracturing contractors to determine if truly best practices are routinely being followed. Following existing state law may or may not adequately protect water supplies.

EPA should further evaluate flowback and produced water chemistry to determine if the dissolved materials in such water significantly change based on when the water is produced. Similarly, EPA should consider how to discern what constituents in produced water occur from surface activities, and which constituents naturally occur in-situ. EPA should also integrate information from wellbore and fracturing failure into this study. The

fate and transport of produced water, especially relating to wellbore or formation failure, will provide EPA with critical insight concerning future regulation of this industry.

As stated in our letter of February 25, 2011, EPA's study must also take into account chemicals that are neither naturally occurring nor used in the drilling or fracturing processes but that are created via interactions with these two classes of substances. We point to the example of 4 Nitroquinoline 1-oxide (4NQO), a powerful carcinogen that has been identified in wastewater produced by natural gas drilling. This chemical compound is not a drilling or hydraulic fracturing additive and it is also not found naturally in the geologic formations that produce flowback water during the stimulation process. Apparently, it is formed through interaction of the chemicals that are present in these fluids. This is one example, but there are potentially more such compounds that should be identified and addressed through EPA' study.

Injection

The proposed work plan will identify critical issues associated with fluid injection during fracturing operations. The proposed well failure analysis for known well failures will assist EPA in future rulemaking efforts. However, EPA should also study a control group of wells not believed to have failed to establish both if these wells exhibit adequate structural integrity and to provide as a control basis for the failed well study. The differences between a failed cement job and a successful well job can be subtle, which may only be determined by conducting cement bond logs on failed and control wells. For example, if the surface casing is offset in the wellbore by an inch or less, the cement fastening the surface casing into the wellbore may not adequately isolate potable water supply from fracturing fluids used during well completion. EPA should use statistical control methods to inform this analysis.

EPA should also review other pathways that may cause groundwater contamination. For instance, if a service company overpressures a formation during the fracturing process, the fracture may propagate beyond the design fracture location. EPA should study overfracturing and determine if overfracturing may affect overburden formations, up to and including potable water bearing formations. EPA should also review any relationship between high fracturing pressure and cement stability. EPA should review the cement strength used for surface casing cementing and final production casing cement projects, to determine if the junction between the surface casing and the production casing may be a cause of potential well failure. If fracture injection pressures exceed the maximum compression pressure that the cement may withstand, the cement, properly placed into a well, could still fail.

EPA should also review the presence or absence of coal seams or other soft formations that may occur near potable water formations and/or near the bottom of the surface casing. Soft formations like coal seams may be more difficult to seal during cementing operations than typical sandstones, limestones, and shales. EPA should also review other potential causes of formation breach, such as abandoned or plugged wells or other wells within one to two miles of locations where potable water supplies may have

been compromised. By conducting a comprehensive review of causes of potential drinking water contamination, EPA can advance the understanding of how shale gas drilling relates to groundwater contamination.

In reviewing mechanical integrity, EPA should review all downhole equipment, including casing materials of construction, any plugs used during drilling and casing installation, and any other downhole equipment. EPA should also review how various permitting authorities authorizing drilling determine the lowest potable water bearing formation to validate that current surface casing practices are designed to protect all potable groundwater resources.

EPA appropriately identifies degradation products of fracturing fluid components as a study goal. EPA also appropriately proposes to study the water contaminants carried out of the fractured formation during fracturing. EPA also proposes to begin the study of trace water contaminants in fracture water. However, EPA should review the ability of the current wastewater analytical methods to detect trace amounts of potentially toxic fracturing additives and in-situ contributors to fracturing water contamination. Method development takes significant planning and design time, and EPA should identify method development needs as soon as possible. The sooner EPA evaluates the toxicity of naturally occurring and fracturing additive water contaminants, the more valuable EPA's work will become.

Flowback

EPA appropriately proposes to review spill and pit leakage contributions to water contamination issues associated with hydraulic fracturing. EPA should review all available hydraulic fracturing models, well logs, and seismic data to determine where conduits between well fluids and groundwater resources may exist.

EPA should also evaluate water quality data from direct discharges and from indirect dischargers who route flowback to wastewater treatment facilities. The existence of treatment facilities may not indicate adequate wastewater treatment. Treatability is a critical element of mitigating pollution from flowback waters, especially in areas where operators rely on wastewater treatment plants not necessarily designed to manage these industrial wastewater streams. To better understand this issue, EPA should collect and analyze information concerning how flowback waters may be treated, and how much of the many pollutants are actually removed by wastewater treatment plants currently used to treat flowback water.

EPA has also conducted research that shows that aquatic invertebrates such as mayflies, for example, appear very susceptible to increased total dissolved solids. If gas drilling flowback water reaches streams through accidents and spills, large die offs of benthic macroinvertebrates could occur (US EPA Region 3 Freshwater Biology Team). Even in the absence of other stressors (pH, organic enrichment, habitat quality, metals) TDS/conductivity significantly explains impairment of aquatic life use. As stated above, the impairment of healthy ecosystems with flourishing aquatic invertebrate communities

may degrade drinking water quality and create the need for additional water treatment to bring waters back up to drinking quality standards.

Wastewater Treatment and Disposal

EPA proposes to use a chloride balance to evaluate salinity in produced and flowback waters. EPA should further study related salts, such as bromides, sulfates, fluorides, and other salts that may exhibit effluent toxicity upon discharge. EPA should also propose a study of less toxic alternative materials that operators may use to accomplish well completion goals while minimizing environmental risks. Less toxic drilling fluids, completion fluids, and fracturing fluids are likely available for use in drilling and hydraulic fracturing. EPA should take this opportunity to study the need for toxic additives such as perchloroethylene, n-hexane, and benzene in fracturing fluid systems. Further study will likely identify less toxic suitable additives. By delaying requiring less toxic alternatives in drilling and well completion, EPA unduly risks contaminating groundwater supplies with materials not needed to conduct drilling operations.

EPA also should study the fate of drilling cuttings on water quality. Drilling cuttings may be contaminated with a wide variety of added or naturally occurring wastewater contaminants that may leach out from Subtitle D landfills and onsite burial disposal facilities. EPA should study contamination levels in drilling cuttings and disposed drilling fluids, and evaluate what steps may be needed to isolate potential contaminants from groundwater and surface water supplies.

Finally, as stated at the beginning of this letter, it is critically important that the EPA's study conduct a detailed analysis of all waters produced by drilling and hydraulic fracturing for contamination with NORM and a detailed analysis of the fate of such contaminated waters and their impacts on sources of drinking water.

Thank you for the further opportunity to comment on EPA's draft study.

[signature omitted]

Index to Expert Reports Regarding Water Quality Impacts of Natural Shale Gas Vertical Wells

Note: CDs contain all exhibits cited in the reports; paper copy contains only reports themselves.

Name	Title
Michele C. Adams, P.E. Meliora Environmental Design	Evaluation of Erosion and Sediment Control and Stormwater Management for Gas Exploration and Extraction Facilities in Pennsylvania under Existing Pennsylvania Regulations and Policies to Determine if Existing Safeguards Protect Water Quality in Special Protection Waters of the Delaware Basin
Ronald E. Bishop, Ph.D., CHO	Chemical and Biological Hazards Posed by Drilling Exploratory Shale Gas Wells in Pennsylvania's Delaware River Basin
	Record of Pennsylvania Gas Industry Inspections, Violations and Enforcements
Peter M. Demicco, RPG Demicco & Associates, LLC Ground Water Resource Expertise	Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells
Susan L. Harvey, Harvey Consulting, LLC Oil & Gas, Environmental, Regulatory Compliance, and Training	Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells
Emmet M. Owens, P.E. Senior Research Engineer Upstate Freshwater Institute	Report on Selected Environmental Impacts of Exploratory Gas Drilling in the Delaware River Watershed
Glenn C. Miller, Ph.D. Consulting Environmental Chemist	Risks Associated with Permitting Exploration Wells in the Delaware River Basin
Paul A. Rubin Hydrologist/Hydrogeologist, HydroQuest	Report for the Delaware River Basin Commission Consolidated Administrative Hearing on Grandfathered Exploration Wells
Daniel Thau Teitelbaum, M.D., P.C.	Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells
Robert M. Anderson, Fish & Wildlife Biologist, U.S. Fish & Wildlife Service **Danielle A. Kreeger**, Ph.D., Science Director, Partnership for the Delaware Estuary	Potential for Impairment of Freshwater Mussel Populations in DRBC Special Protection Waters as a Consequence of Natural Gas Exploratory Well Development
Patrick M. O'Dell, P.E. in Petroleum Engineering, National Park Service	Potential for Development of Natural Gas Exploratory Wells to Adversely Affect Water Resources of the Delaware River Basin
Erik Silldorff, Ph.D., Aquatic Biologist, Delaware River Basin Commission	In the Matter of Delaware River Basin Commission Adjudicatory Administrative Hearing on Natural Gas Exploratory Wells

John K. Jackson, Ph.D. and **Bernard W. Sweeney**, Ph.D. Stroud Water Research Center	Expert Report on the Relationship Between Land Use and Stream Condition (as Measured by Water Chemistry and Aquatic Macroinvertebrates) in the Delaware River Basin
Conrad D. Volz, DrPH, MPH	In the Matter of Delaware River Basin Commission Consolidated Administrative Adjudicatory Hearing on Natural Gas Exploratory Wells

Evaluation of Erosion and Sediment Control and Stormwater Management for Gas Exploration and Extraction Facilities in Pennsylvania under Existing Pennsylvania Regulations and Policies to Determine if Existing Safeguards Protect Water Quality in Special Protection Waters of the Delaware Basin

for the Delaware River Basin Commission (DRBC)

Consolidated Administrative Hearing on Grandfathered Exploration Wells

November 15, 2010

Prepared for:

Delaware Riverkeeper Network

Prepared by:

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EXECUTIVE SUMMARY

The construction and operation of Marcellus Shale Gas Extraction facilities, including wells intended for exploratory purposes, can have significant and adverse environmental impacts on the water quality of the Special Protection Waters of the Delaware River Basin. Specifically, impacts associated with erosion and sediment discharge and stormwater discharge during construction, operation, and after well closure can negatively and significantly impact water quality. The existing environmental regulations and policies of the Commonwealth of Pennsylvania, either as enacted by the Commonwealth or implemented by the Pennsylvania Department of Environmental Protection (PaDEP), do not provide adequate performance standards, review, implementation, or enforcement to protect the Commonwealth's water resources, including the Special Protection Waters of the Delaware River Basin. The Delaware River Basin Commission (DRBC) requirements for a Non-Point Source Pollution Control Plan are not sufficient to protect these water resources in lieu of adequate Pennsylvania requirements, leading to the possibility and likelihood of adverse environmental effects on water resources.

Additionally, the Pennsylvania erosion and sedimentation control and stormwater management regulations and policies, as applied to Oil and Gas facilities, are significantly less stringent and comprehensive and are subject to far less regulatory review than virtually any other construction or industrial activity in Pennsylvania. Construction and performance requirements and regulatory review requirements related to sediment control and stormwater management are far more rigorous for schools, highways, homes, and even geothermal energy wells than for Oil and Gas facilities.

By grandfathering the exploratory wells that were permitted by PaDEP prior to the June 14, 2010 and July 23, 2010 Supplemental Determinations of the DRBC, DRBC has effectively held these facilities to a lower environmental standard than that which is applied to other activities within Pennsylvania, as well as a lower standard than that which will presumably be applied to other oil and gas activities within the Delaware River Basin once its regulations are adopted. Since negative water quality impacts related to sediment discharge and stormwater

management from these facilities can and do impact existing water quality, these facilities cannot be exempt from the requirements to protect and maintain Special Protection Waters, or subject to lower regulatory requirements than other construction and industrial activities.

ANALYSIS AND OPINION

My name is Michele C. Adams, I am a professional engineer registered in the state of Pennsylvania and several other states. As indicated in the attached CV, I have twenty-six years of experience specializing in water resources, stormwater management, and site design engineering. I am one of the primary authors of the Pennsylvania Stormwater Best Management Practices Manual, and currently chair the calculations sub-committee for the Manual update. To form the opinions in this report, I reviewed the available Well Drilling Permit applications and supporting information for several of the exploratory wells in question, including but not limited to Davidson 1V, Woodland Management Partners 1 1, DL Teeple 1 1 and 1 2H, Geuther 1. I also reviewed a number of documents and reports that are listed at the end of this report as references.

It is my opinion, given with a reasonable degree of scientific certainty, that gas exploratory and extraction facilities can adversely impact water quality as a result of inadequate erosion and sedimentation control during construction and operation, and inadequate stormwater management for rate, volume, and discharge of pollutants. As discussed in this report, the current regulatory process for review, approval, and operation of these facilities, as administered by the Pennsylvania Department of Environmental Protection, fails to ensure design and implementation of both erosion control and stormwater management measures that are sufficient to protect water quality. The exploratory wells that have been permitted prior to the June 14, 2010 and July 23, 2010 Supplemental Determinations of the DRBC should not be held to lower standards than facilities that will be subject to the anticipated DRBC regulations.

Construction of Gas Exporatory and Extraction Facilities and Impacts to Water Quality as a Result of Inadequate Erosion and Sediment Control Measures

Impacts to water quality from the Gas Exploratory and Extraction facilities can occur during the construction of the facility, the operation of the facility, and as a result of inadequate restoration of the facility after operations have ceased.

During construction, the water quality impacts are related to the discharge of sediment-laden waters from disturbed areas and the increased amount and rate of runoff from disturbed areas. Disturbance is a result of:

- Construction of the pad site
- Construction of the entrance road
- Widening or paving of existing roads for access to the site
- Construction of pipeline facilities

The amount and type of area disturbed directly impacts the potential for erosive conditions and sediment discharge. Little specific information regarding the disturbed area is available in the permit application materials, for the specific wells in question as part of this Hearing that are less than five (5) acres in disturbance. However, 8-1/2" by 11" Well Location Plat diagrams provided within the PaDEP Well Permit applications (for two wells) indicate approximate areas of pad and entrance drive that can be measured from the diagrams. Based on these diagrams, the well pad and entrance driveway area are shown as 1.80 acres for the Teeple 1 1 well and 2.4 acres for the Woodland Management 1 1 well. In contrast, a page-sized copy of the Woodland Erosion & Sediment Control Plan (included as part of the "Preparedness, Prevention, and Contingency Plan") indicates approximately 4.7 acres of disturbance when this area is measured from the plan, significantly more than 2.4 acres. Approximately 1 acre of disturbance appears to be related to the entrance driveway. Because the Well Location Plat does not indicate the full area of disturbance, it provides virtually no information on the project's disturbance footprint. There is no information on the PaDEP "Permit Application for Drilling or Altering a Well" or available Well Location Plats regarding total acreage of disturbance. PaDEP would not have an estimate of the Total Area of Disturbance from the Well Location Plat. Facilities with less than 5 acres disturbance must prepare an

Erosion and Sediment Control Plan, but are not required to submit the Plan to PaDEP for review.

Information from the New York State Department of Environmental Conservation (NYSDEC), which regulates gas drilling in Marcellus Shale formations in New York State, (NY DEP) indicates that well sites generally involve two to five acres of disturbance per site, not including access roads. The area of disturbance is significant because it directly affects the potential amount of sediment-laden water that can occur if erosion and sediment control measures are not adequate.

In 2005, the U.S. Environmental Protection Agency (U.S. EPA) awarded a grant to the City of Denton, Texas, to monitor and assess the impact of gas well drilling on stormwater runoff. The results of this effort were published in December 2007 in a report titled "Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize These Impacts Through Targeted Monitoring Activities and Local Ordinances". With regards to the discharge of sediment during construction, this study determined that:

> Gas well sites have the potential to produce sediment loads comparable to traditional construction sites.
>
> - Total suspended solids (TSS) and turbidity event mean concentrations (EMC = pollutant mass / runoff volume) at gas sites were significantly greater than at reference sites (the median TSS EMC at gas sites was 136 times greater than reference sites).
> - Compared to the median EMCs of storms sampled by Denton near one of their outfalls, the gas well site median EMC was 36 times greater.
> - Gas site TSS EMCs ranged from 394 to 9898 mg/l and annual sediment loadings ranged from 21.4 to 40.0 tonnes/hectare/year (tonne = 1000 Kg; hectare = 10,000 square meters), and were comparable to previous studies of construction site sedimentation.

This study concludes that "Gas well sites have the potential to negatively impact surface waters due to increased sedimentation rates." (US EPA ID No. CP-83207101-1, page 2).

In addition to the well pad site, roads that are constructed, widened, or altered for vehicle access to and from the well pad site can be a source of sediment and pollutants during both construction and operation. The U.S. EPA Publication

“Erosion, Sediment and Runoff Control for Roads and Highways” (EPA-841-F-95-008d) states that:

> Runoff controls are essential to preventing polluted runoff from roads, highways, and bridges from reaching surface waters. Erosion during and after construction of roads, highways, and bridges can contribute large amounts of sediment and silt to runoff waters, which can deteriorate water quality and lead to fish kills and other ecological problems.
>
> Heavy metals, oils, other toxic substances, and debris from construction traffic and spillage can be absorbed by soil at construction sites and carried with runoff water to lakes, rivers, and bays. Runoff control measures can be installed at the time of road, highway, and bridge construction to reduce runoff pollution both during and after construction. Such measures can effectively limit the entry of pollutants into surface waters and ground waters and protect their quality, fish habitats, and public health.

This publication (EPA-841-F-95-008d) identifies a number of pollutant types and sources related to Roads and Highways, as identified in Table 1.

Table 1. Typical pollutants found in runoff from roads and highways.

Erosion, Sediment and Runoff Control for Roads and Highways | Polluted Runoff | US EPA

	Pollutant	**Source**
Sedimentation	Particulates	Pavement wear, vehicles, the atmosphere and maintenance activities
Nutrients	Nitrogen & Phosphorus	Atmosphere and fertilizer application
Heavy Metals	Lead	Leaded gasoline from auto exhausts and tire wear
	Zinc	Tire wear, motor oil and grease
	Iron	Auto body rust, steel highway structures such as bridges and guardrails, and moving engine parts
	Copper	Metal plating, bearing and brushing wear, moving engine parts, brake lining wear, fungicides & insecticides
	Cadmium	Tire wear and insecticide application
	Chromium	Metal plating, moving engine parts and brake lining wear

	Nickel	Diesel fuel and gasoline, lubricating oil, metal plating, bushing wear, brake lining wear and asphalt paving
	Manganese	Moving engine parts
	Cyanide	Anti-caking compounds used to keep deicing salt granular
	Sodium, calcium & chloride	Deicing salts
	Sulphates	Roadway beds, fuel and deicing salts
Hydrocarbons	Petroleum	Spills, leaks, antifreeze and hydraulic fluids and asphalt surface leachate

Based on these two studies, the construction of Gas Exploration and Extraction facilities and associated construction and/or improvement of roads can negatively impact water quality, and these facilities have the same potential as other construction activities to degrade water quality. However, Pennsylvania does not apply the same standards of performance or regulatory oversight to Gas Exploration and Extraction facilities as is applied to other construction activities, and therefore the DRBC's Supplemental Determination of June 14, 2010 is incorrect in determining that the "existing safeguards" applied to "wells subject to state regulation as to their construction and operation" is sufficient to prevent water quality impacts from construction.

Specifically, the "safeguards" applied in the Pennsylvania regulatory process for Gas Exploration and Extraction facilities fail to address a number of concerns, and this can be seen in the application requirements for Erosion and Sediment Control Permits.

Gas Exploration and Extraction facilities that result in disturbance of fewer than five (5) acres are not required to obtain an Erosion and Sediment Control Permit. For these facilities, a Permit Application for Drilling or Altering a Well (5500-PM-OG0001) is sufficient. An Erosion and Sediment Control Plan must be developed, but is not subject to regulatory review and approval before construction. This is in contrast to most other construction activities, which are subject to erosion and sediment control requirements at 1 acre under the Pennsylvania Chapter 102 requirements and NPDES requirements. For Oil and Gas facilities that are fewer than 5 acres in disturbance, an Erosion & Sediment

Control plan is required, but it is not subject to regulatory review prior to construction.

Significantly, the permit application requirements in the PaDEP "Application for an Erosion and Sediment Control Permit (ESCP)" for projects that are not already addressed under an NPDES permit, are different than the PaDEP application for Oil and Gas Facilities (Notice of Intent for Coverage under the Erosion & Sediment Control General Permit for Earth Disturbance Associated with Oil and Gas Exploration, Production, Processing or Treatment Operations or Transmission Facilities ESCGP-1). This is significant because the permit application is essentially for the same item, namely, an Erosion and Sediment Control Permit. There are also significant differences between the application for coverage under the General (PAG-02) NPDES Permit or Individual NPDES Permit for Stormwater Discharges Associated with Construction Activities. There is only a General Permit option for Oil and Gas facilities, regardless of whether or not the facility is located in Special Protection Waters. Other construction activities require an Individual Permit within Special Protection Waters.

A comparison of permit application requirements for non-oil and gas facilities, as compared to the permit application requirements for Oil and Gas facilities, is provided in Table 2. This table also indicates the comparable requirements for the permit application for Drilling or Altering a Well (for oil and gas projects disturbing fewer than 5 acres).

As can be seen from this table, the requirements for a "standard" ESCP REVIEW THIS application are significantly more stringent than the requirements for an Oil and Gas facility ESCP application for coverage under a general permit. For oil and gas facilities with fewer than five acres of disturbance, virtually no information is required related to the amount of area disturbed and erosion control measures.

Table 2. Comparison of Erosion and Sediment Control Permit Application Requirements for "Non" Oil and Gas Facilities, Oil and Gas Facilities, and Oil and Gas Facilities under 5 acres disturbance.

	NOI for Coverage under the General (PAG-02) NPDES Permit or Application for an Individual NPDES Permit for Stormwater Discharges Associated with Construction Activities	Application for Erosion & Sediment Control Permit	NOI for Coverage under the Erosion & Sediment Control General Permit for Earth Disturbance Associated with Oil and Gas Exploration, Production, Processing or Treatment Operations or Transmission facilities	Permit application for Drilling or Altering a well
Required Information		**ESCP**	**ESCGP-1**	**5500-PM-OG001**
Project Description	yes	yes	yes	no
Project Area	yes	yes	yes	no
Total Disturbed Area	yes	yes	yes	no
Timetable for Phases (with acreage disturbed by phase)	yes	yes	yes	no
Description of Site	yes	yes	no	no
Explanation of consideration of site's Natural Resources in Location and Design of the project, E&S Plan, PCSM Plan)	yes	no	no	no
Identification of geologic formations or soil conditions that may cause pollution and description of BMPs to minimize its impact	yes	no	no	no
Identification of Pollutants other than sediment in stormwater	yes	yes	yes	no
PPC Plan required for use or storage of chemicals, solvents, hazardous wastes or material with potential to cause accidental pollution during earth disturbance	no	yes	yes	no
Explain whether fill will be imported, exported or if the site will balance	yes	no	no	no
Site Contact information (name, firm, title, etc.)	yes	yes	yes	no
Consultant for Project (name, address, etc.)	yes	yes	no	no
Compliance Review - Listing by permit number of other environmental permits issued by Department	yes	yes	no	no
Narrative to address existing or past violations of any environmental regulations or permits	yes, within last 5 years	yes, current and past violations	yes, within last 5 years	no
Post Construction Stormwater Management (PCSM) Plan required	yes	yes	No calculations or measurements required if Section D, 2e indicated as yes to both questions	no
Consistency letters required for ACT 167 and Municipal Ordinances	yes	no	no	no
Off-Site Discharge Analysis	yes	no	no	no
PCSM BMPs must be consistent with…	Act 167 OR PA Stormwater Manual and/or Other Design Standard		Act 167, local ordinances, or BMPs will manage net increase in runoff volume resulting from 2-year/24-hour frequency storm	

There are a number of site-specific conditions that can directly affect the potential for erosion and pollutant discharge during construction activity, including the total area of disturbance, the soil type and potential for erosion, the topographic slopes, and the proximity to surface waters. None of this information is available for regulatory review before construction for Oil and Gas facilities of fewer than 5 acres. Additionally, there is no opportunity for regulatory reviewers to determine if measures such as reducing the area of disturbance and restoring disturbed areas promptly will be implemented.

The potential impacts to water quality can be seen in the existing D.L. Teeple 1 1 well, located in Manchester Township, Wayne County and owned by Newfield Appalachia PA LLC (permit # 37-127-20013, issued on April 23, 2010), shown as Figure 1. This well is located in the Shehawken Rattlesnake Creek, designated in Pennsylvania as High Quality (HQ). The permit application for this well indicates under Item 8 of the "Permit Application for Drilling or Altering a Well" that the well site is not within 100 feet (horizontally) of a stream, spring, or water body of water delineated on the most current 7-1/2 minute topographic map. As can be seen by the overlay of the Well Location Plat onto a USGS 7-1/2 minute quadrangle map, the well pad is not within 100 feet of a body of water as indicated on the USGS 7-1/2 minute quad, but it is situated at the top of a hill surrounded on three sides by streams and wetlands that are delineated on the quad map. The site is bordered on the western side by S.R. 191, and a wetland can be seen just over 100 feet downhill from the construction entrance.

Given the topography and surrounding surface waters at the Teeple 1 1 site, there is significant potential for discharge of sediment and other pollutants to surface waters if erosion and sediment control measures are not actively maintained and implemented.

This well location was cited on 5/26/2010 for a violation of Chapter 102. 4 for "Failure to minimize accelerated erosion, implement E&S Plan, maintain E&S controls. Failure to stabilize site until total restoration under OGA Sec 206(c)(d)." This violation was issued just over one month after the permit was issued. A second violation was also issued on 5/26/2010 under Pa Code 78 for an improperly lined pit.

The Pennsylvania Oil and Gas Act (58 P. S.§ 601.205(b)) states that "no well site may be prepared or well drilled within 100 feet measured horizontally from any stream, spring, or body of water as identified on the most current 7-1/2 minute topographical quadrangle map of the United States geological survey or within 100 feet of any wetlands greater than one acre in size". This question is asked in Item 8 of the PaDEP Permit Application for Drilling or Altering a Well. However, surface waters are defined in Chapter 93 as "Perennial and intermittent streams, rivers, lakes, reservoirs, ponds, wetlands, springs, natural seeps and estuaries…". Many of these features will NOT be mapped on a USGS quad as blue lines, or they will not be mapped adequately. Luna B. Leopold, former Chief Hydrologist for the U.S. Geological Survey, writes in his book A View of the River (Harvard University Press, 1994) that the USGS instructions regarding blue lines on quad maps "do not reflect any statistical characteristic of streamflow occurrence. The specifications that the blue line terminate no higher than about 1,000 feet from the watershed divide does not reflect differences in hydrologic performance among various combinations of climate, topography, and geology" and "blue lines on a map are drawn by non-professional, low-salaried personnel …they are drawn to fit a rather personalized aesthetic." (page 228). In other words, blue lines on 7-1/2 minute USGS quads are not scientific representations of surface waters or even perennial or intermittent streams. Therefore, reliance of these "blue lines" does not represent adequate identification and setback from surface waters as defined under Pa Code Chapter 93. The current Pennsylvania permitting process for Oil and Gas facilities is not sufficiently protective of surface waters.

The preparation of an Erosion and Sediment Control Plan under the requirements for Oil and Gas facilities also does not guarantee that the measures represented on the plan will be adequate to protect water quality. For example, on the Erosion and Sediment Control permit application for Oil and Gas facilities (ESCGP-1), Section E: Special Protection Waters lists "cost effective best management practices (BMPs) that will be used to meet the requirements of Pa Code Chapter 93. Under this list is included "Roads stabilized with crushed rock and/or vegetation." In other words, roads constructed of crushed rock are considered to be a "best management practice" adequate for protection of

Special Protection Waters. In virtually all other construction projects that are subject to Chapter 102 requirements, the construction of roads – including crushed rock roads – is considered earth disturbance that requires its own erosion and sediment control measures (as well as stormwater management measures).

The Pennsylvania Center for Dirt and Gravel Road Studies provides information on measures to maintain gravel roads in a manner to reduce the discharge of pollutants and protect water quality. Penn State's Center for Dirt and Gravel Road Studies (Center) recently completed a research project for the Chesapeake Bay Commission (Sheetz, Summary Statement) that begins to quantify sediment production from gravel roads and sediment reductions from several commonly used practices. This study found that:

> **Runoff Rates from Existing Roads:**
> The five "existing condition" tests done for this study found sediment production rates ranging from 0.7-12.2 pounds of sediment runoff in a single 30 minute, 0.55 inches simulated rainfall. The 0.7 pound event was generated from a flat narrow farm lane with grass growing between the wheel tracks. The 12.2 pound event was generated from a wider, mixed limestone/clay road at a 4-5% slope. This highlights the great variability in erosion rates based on specific site conditions. Using the average sediment runoff rate of 5.6 pounds per event, a single 30 minute 0.55 inch rain event moving across Pennsylvania can be conservatively expected to generate over 3,000 tons* of sediment form the State's 20,000+ miles of public unpaved roads.

In other words, gravel roads are a source of sediment pollution, rather than a "best management practice" for Special Protection Waters as listed on the ESCGP-1 application.

Review of the page-sized copy of the "Woodland Management Partners Well Pad Erosion & Sediment Control Plan" indicates that, for the approximately 850 linear feet of new entrance driveway to the well pad, there are no erosion and sediment control measures, i.e., no silt fence, compost sock, etc. Roads for other construction projects are subject to management requirements for erosion and sediment control, but under ESCGP-1, gravel roads are considered a "best management practice".

Roads and gravel roads for gas exploration and extraction facilities are not the only construction items that are regulated differently for oil and gas facilities than they are for other construction sites, and that have significant potential to adversely impact water quality. Recently, PaDEP began imposing requirements on the construction of geothermal energy wells. Geothermal wells are generally not more than several hundred feet deep. PaDEP has begun imposing requirements for separate Erosion and Sediment Control Plans specific to the construction of geothermal wells and the handling of material from these wells. This includes requirements for dewatering material from the wells, protecting the water resources from discharge of pollutants, and reducing site disturbance. Gravel roads for geothermal well construction must also include measures such as silt fence or compost sock (and are not considered a best management practice). Detailed guidance for E&S measures related to the construction of geothermal wells will be included in the updated Erosion and Sediment Control Manual, and reflect that both well construction and gravel road construction and use are significant sources of nonpoint source pollutants. This is in stark contrast to the ESCGP-1 representation of gravel roads as a best management practice.

In summary, the current state regulations under which the wells in question were permitted do not guarantee that the measures designed or implemented are sufficient to protect water quality from construction-related impacts due to erosion and sedimentation. These wells should not be excluded under the June 14, 2010 and July 23, 2010 Supplemental Determinations.

Gas Extraction Facilities and Impacts to Water Quality as a Result of Inadequate Stormwater Management

The discharge of stormwater runoff and the pollutants conveyed in stormwater runoff also negatively impact surface water quality. Stormwater impacts at Oil and Gas facilities, including both exploratory and extraction well sites, are a result of:

- Increased runoff (volume and rate) from roads
- Increased runoff (volume and rate) from pad site areas
- Increased pollutants from truck movement
- Pollutants from pad materials

- Air deposition of pollutants
- Inadequate handing of drilling materials
- Decreased stormwater recharge
- Decline of adjacent vegetation
- Degradation of roads
- Erosion of pad
- Failure to restore site to natural conditions

The stormwater impacts on water quality and stream health include:

- Increased flooding as a result of increased stormwater flow rates and volumes of runoff
- Increased frequency of runoff discharges
- Thermal impacts from disturbed surfaces and removal of vegetation
- Changes in receiving water stream channel geometry, and corresponding increases in sediment loads
- Discharge of pollutants
- Decreased stream baseflow as a result of reduced recharge

In addition to sediment discharges, the December 2007 U.S. EPA report "Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize These Impacts Through Targeted Monitoring Activities and Local Ordinances," noted that discharges of stormwater from oil and gas facilities include a number of pollutants. The Summary Document for this report states:

> Other pollutants in gas well runoff were found in high concentrations:
>
> - EMCs of total dissolved solids, conductivity, calcium, chlorides, hardness, alkalinity and pH were higher at gas well sites compared to reference sites, and differences were statistically significant for all parameters except conductivity.
>
> - Generally, the presence of metals was higher at gas well sites compared to reference sites and EMCs were statistically significantly greater for Fe, Mn and Ni.
>
> - Overall, the concentrations of metals tend to be higher at gas well sites compared to both nearby reference sites and as measured in runoff from local mixed-use watersheds (EMCs were statistically significantly greater for Fe, Mn and Ni).
>
> - Total petroleum hydrocarbons (TPH) were not detected in any of the samples collected at gas well sites or reference sites.

The Summary Document for this study further concluded that:

- Gas well sites have the potential to negatively impact surface waters due to increased sedimentation rates and an increase in the presence of metals in stormwater runoff.

- Pad sites also have the potential to produce other contaminants associated with equipment and general site operations.
- Gas wells do not appear to result in high concentrations of petroleum hydrocarbons in runoff, but accidental spills and leaks are still a potential source of impact.

Furthermore, the Summary Document noted that:

> The proximity to surface water conveyances is an important consideration for minimizing water impacts, i.e., flat, heavily vegetated areas distant from surface waters are usually less of a concern than those areas close to waters that have highly erodible soils, steeper slopes and little vegetation.

Given the potential for stormwater impacts to water quality from Oil and Gas exploratory and extraction facilities, the requirements for stormwater management and water quality protection should be at least as rigorous as the requirements for other land development and industrial activities.

However, the Erosion and Sediment Control General Permit for Oil and Gas facilities (ESCGP-1) essentially provides these facilities with a waiver from providing stormwater management calculations and data. Specifically, Section D.2.e of ESCGP-1, titled "Site Restoration Plan and Post Construction Stormwater BMPs", requires the applicant to answer yes or no to two questions:

1. The approximate original contours of the project site will be maintained or replicated and the disturbed areas will be revegetated or otherwise stabilized with pervious material.
2. PCSM BMPs which: use natural measures to eliminate pollution, do not require extensive construction efforts, promote pollution reduction, and are capable of controlling the net increase in the volume and rate of stormwater runoff from a 2-year/24-hour storm event will be employed and the net increase in the volume of post construction runoff is infiltrated and/or dissipated away from surface waters of the Commonwealth.

If the answer to both of these questions is "yes," the applicant does not need to provide supporting calculations and data, essentially receiving a waiver of the

requirements for detailed stormwater management calculations and implementation of adequate stormwater management measures. Such waivers are not available for other industrial and commercial projects, which must design PCSM measures based on factors such as disturbed area, slopes, soil types, etc., and which must provide detailed calculations to determine that stormwater BMPs are correctly sized and located.

Even if one of these questions is answered as “no” and post construction stormwater calculations and data are required, that is not an assurance that the calculations and stormwater plan will protect water quality, or be subject to the same level of regulatory review as other construction projects.

For example, the permit application for the Davidson 1V Well Pad Site indicates that the site will NOT be returned to the original contours and revegetated with pervious material, and therefore, stormwater calculations are required. However, the accompanying stormwater calculations indicate that there will be less stormwater runoff after well pad construction than before. This is not a result of BMPs, but rather a result of applying engineering coefficients (Cover Complex values) that indicate that the site will be more pervious. It is shown in Figure 1 that Essentially, areas that are to be revegetated are calculated as “brush” that produces less runoff than woods in good condition. However, the “Brush Seed Mixture” that is specified is primarily a grass and groundcover seed mix, and does not represent established “brush”, which is shown in Figure 1. A more appropriate runoff coefficient that represents lawn and soils that have been graded would indicate a much greater volume of runoff than is presented. This is shown in Figure 2.

SITE STABILIZATION CHART:

BRUSH SEED MIXTURE			
BOTANICAL NAME	COMMON NAME	PERCENTAGE OF MIXTURE	APPLICATION RATE
LOLIUM MULTIFLORUM	ANNUAL RYEGRASS	35	20 LBS / ACRE
PHLEUM PRATENSE	TIMOTHY	25	
ANDROPOGON GERARDII	BIG BLUESTEM	10	
ELYMUS VIRGINICUS	VIRGINIA WILD RYE	10	
LESPEDEZA BICOLOR	BICOLOR LESPEDEZA	5	
HELIANTHUS ANNUS	COMMON SUNFLOWER	5	
LATHYRUS SYLVESTRIS	LATHCO FLAT PEA	5	
VIBURNUM DENTATUM	ARROW WOOD	3	
SAMBUCUS CANADENSIS	ELDERBERRY	2	

* SEEDING DATES: APRIL 1--JUNE 15 & AUGUST 16--SEPTEMBER 15

Figure 1. Brush Seed Mixture that is primarily grasses

POI #1: Pre-Development

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
Woods (Good)	72	2.250			72.00
Gravel Road	89	.230			89.00
Brush	65	5.800			65.00
Gravel Pad	74	.920			74.00
COMPOSITE AREA & WEIGHTED CN --->		9.200			68.21 (68)

POI #2: Pre-Development

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
Woods (Good)	72	16.880			72.00
Gravel Road	89	.250			89.00
Impervious	98	.040			98.00
COMPOSITE AREA & WEIGHTED CN --->		17.170			72.31 (72)

POI #1: Post-Development

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
Woods (Good)	72	9.100			72.00
Gravel Road	89	.100			89.00
COMPOSITE AREA & WEIGHTED CN --->		9.200			72.18 (72)

* Runoff coefficient before development is less than runoff coefficient after well pad construction.

POI #2: Post-Development

Soil/Surface Description	CN	Area acres	Impervious Adjustment %C	%UC	Adjusted CN
Woods (Good)	72	15.930			72.00
Gravel Road	89	.380			89.00
Brush	65	.820			65.00
Gravel Pad	74	.040			74.00
COMPOSITE AREA & WEIGHTED CN --->		17.170			72.05 (72)

Figure 2: Runoff Curve Number for pre and post-development conditions exhibiting increased runoff after construction

Similarly, the well pad itself is given a very low runoff value, presumably since it is paved with a stone bed. However, the detail provided for the Davidson 1V Well Pad indicates that the stone is not appropriate for a stormwater bed as described in the Pennsylvania Stormwater Best Management Practices Manual, and additionally that the bed will be built partially on fill material, which is also not an acceptable technique in the Manual. The designs documented in the Post-Construction Stormwater Management Plan for Davidson 1V do not support the engineering calculations and assumptions that have been submitted. Therefore, the estimates of stormwater runoff rate and volume will be greater than documented within the Plan.

In addition, Section E of ESCGP-1, titled "Special Protection Waters" lists fourteen "cost effective best management practices that will be used to meet the requirements of 25 Pa Code Chapter 93." These include:

1. Minimize earth disturbance
2. Earth moving activities limited during rainstorms and spring thaw
3. No direct discharge to surface water
4. Designed temporary and permanent BMPs for surface water diversion
5. Other
6. Alternative site analysis
7. Roads stabilized with crushed rock and/or vegetation
8. Immediate stabilization
9. Prompt site restoration
10. Stabilized upslope diversion
11. Permanently stabilized ditches and channels
12. Rock lined culvert inlets and outlets
13. Proper vegetative cover techniques
14. 100 ft riparian buffer

None of these measures are sufficient to provide stormwater management and protect water quality for sites that have 5 acres or more of disturbance, and as discussed earlier, measures such as stabilizing roads with gravel can create, rather than mitigate, pollution and increased runoff. The net effect of Section E

and Section D.2.e of ESCGP-1 is to waive stormwater management requirements for these facilities, or approve calculations that are technically incorrect. "Restoration" activities are not required to restore site soils to pre-construction levels of performance, and as a result of disturbance, altered vegetation, and soil compaction, "restored" sites will continue to generate increased volumes and rates of stormwater runoff.

Oil and Gas facilities are given a further exemption from environmental standards applied to other facilities under Pa 25 Code Chapter 102.14, which requires a 150 foot riparian buffer in Special Protection Waters. Oil and gas activities are given an exemption "so long as any existing riparian buffer is undisturbed to the greatest extent possible."

For Oil and Gas facilities with fewer than five acres of disturbance (and not required to apply for permit coverage with ESCGP-1), there are essentially no regulatory processes or safeguards in place to assure that stormwater management measures are adequate, and essentially no safeguards or consideration of factors such as slopes, soil types, amount of vegetation and protection of existing vegetation.

Conclusion

The Supplemental Determination of June 14, 2010 stated that:

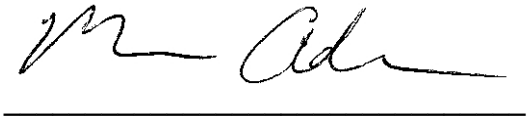
> [T]hese wells are subject to state regulations as to their construction and operation…In light of these existing safeguards…this Supplemental Determination does not prohibit any natural gas well project from proceeding if the applicant has obtained a state natural gas well permit for the project on or before the date of issuance set below.

A review of the regulatory safeguards applied to these wells, specifically the existing Pennsylvania regulations and PaDEP policies, indicates that the safeguards do not guarantee protection of the water quality of Special Protection Waters with regards to Erosion and Sediment Control and Stormwater Management. As such, these wells should have been <u>included</u> in the May 19, 2010 Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters.

The December 2007 EPA report “Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize These Impacts Through Targeted Monitoring Activities and Local Ordinances” specifically recommended that “States or local governments should consider regulating sediment and associated pollutants in stormwater runoff” and suggested as a Recommended Approach to “develop regulations similar to current NDPES requirements for construction sites” for Oil and Gas facilities.

To the extent that the Executive Director’s decision making process relied upon the adequacy of Pennsylvania regulations to protect the water quality of the Basin, it was based upon a mistaken premise of fact.

The opinions expressed in this report are stated to a reasonable degree of scientific and professional certainty.



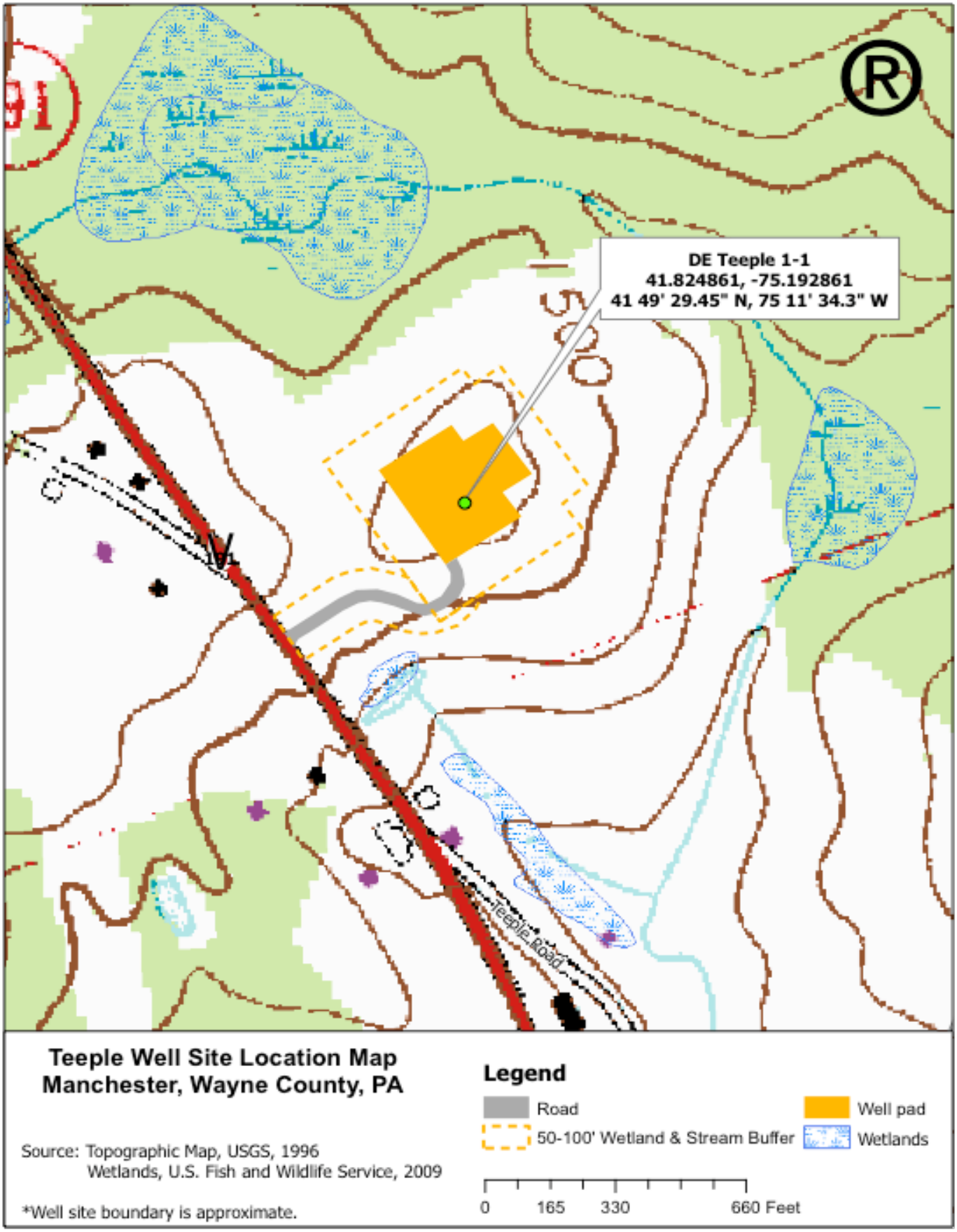
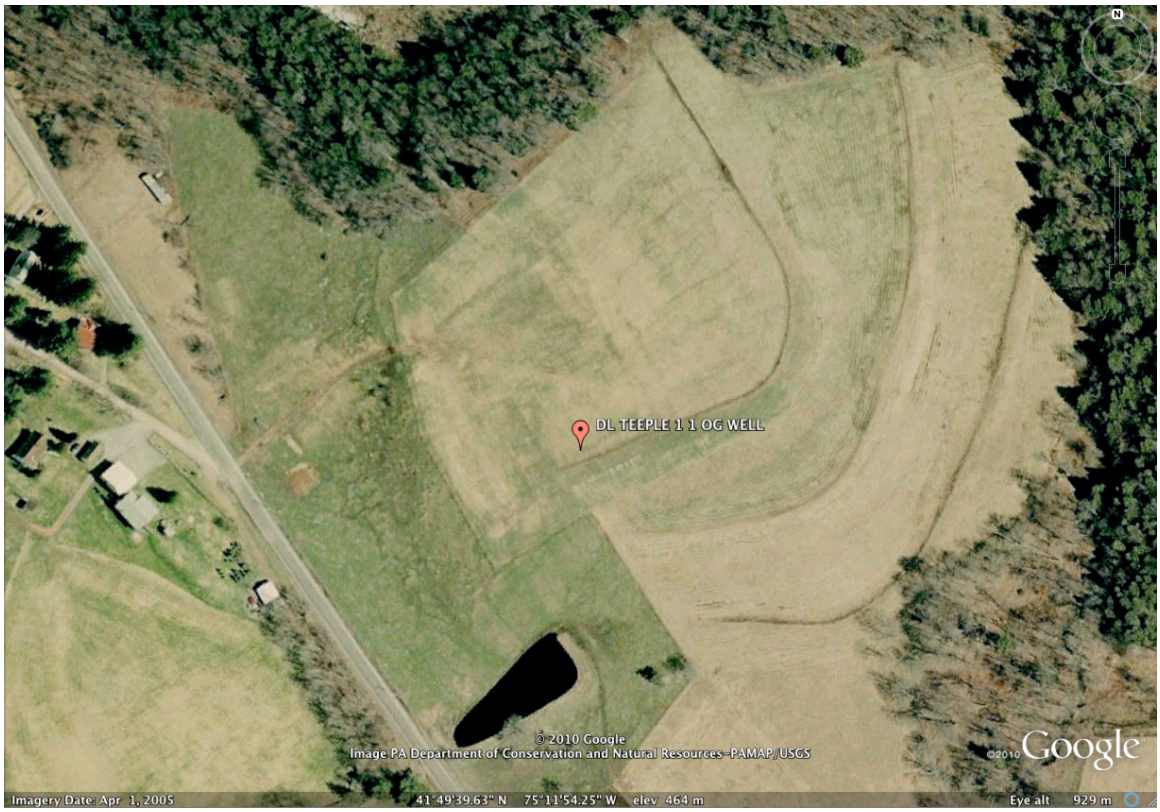


Figure 3. D.L. Teeple 1 1 well, located in Manchester Township, Wayne

County


DL TEEPLE 1 1 OG WELL
© 2010 Google
Image PA Department of Conservation and Natural Resources-PAMAP, USGS
©2010 Google
Imagery Date: Apr 1, 2005
41°49'39.63" N 75°11'54.25" W elev 464 m
Eye alt 929 m

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2009-2010
STUDY GUIDE V

REGULATION AND PERMITTING OF MARCELLUS SHALE DRILLING

OVERVIEW

Regulation of Marcellus Shale drilling operations is complex. It involves authorities at federal, state, and municipal levels. The regulatory enigma is perhaps best summed up by Dr. Roxana Witter of the Colorado School of Public Health, Denver, Colorado:

> Natural gas is such a unique industry in that there are tens of thousands of point sources, hundreds of thousands across the country. They are essentially hundreds of thousands of factories. The industry is completely different in terms of monitoring or regulating it because it is not like a single, stationary factory or refinery. I don't think public-health researchers or the regulatory agencies have gotten their hands around that problem. (Vaughn, 2009, October 4)

Because of the rapid push to develop natural gas from Marcellus Shale, various authorities and agencies have been forced to balance significant, long-term concerns with industry demands for expedient reviews and acceptance of drilling permits. Economic concerns, coupled with imperatives to reduce carbon dioxide and promote energy independence, accelerate the timelines required to achieve the essential goals of clear parameters and failsafe enforcement.

In Pennsylvania, the main regulatory entities include, but are not necessarily limited to:

Federal:

U.S. Environmental Protection Agency (EPA)
U.S. Fish and Wildlife Service
U.S. Forest Service
U.S. Department of Interior - Bureau of Land Management
Occupational and Safety Health Administration (OSHA)

State:

PA Department of Environmental Protection (DEP) - Bureau of Oil and Gas Management, Bureau of Air Quality
PA Department of Conservation and Natural Resources (DCNR)
PA Fish and Boat Commission
PA Emergency Management Agency (PEMA)
PA Department of Labor and Industry
PA Department of Transportation (PennDOT)

Municipal/Regional:

Susquehanna River Basin Commission (SRBC)

Delaware River Basin Commission (DRBC)
PA Municipalities
PA County Courts
PA County Conservation Districts (Note: DEP withdrew the involvement of Conservation Districts in the permitting and review process as of April 2009.)

The above agencies uphold numerous laws and regulations pertinent to Marcellus Shale gas operations including the following:

Federal

Clean Water Act (CWA) - regulates surface water quality, pollutant discharges, and storm water runoff; implements National Pollutant Discharge Elimination System (NPDES) permitting

Safe Drinking Water Act (SDWA) - regulates supply of public drinking water (but does not regulate private wells serving under 25 people); authorizes EPA to determine national standards for maximum allowed contaminant levels; regulates Underground Injection Control (UIC) program to protect ground water from injected contaminants; grants states authority ("primacy") to implement the SDWA within their boundaries; provides funding for water system improvements

Energy Policy Act of 2005 - includes two exemptions relevant to shale gas drilling: (1) amended the SDWA by clearly excluding hydraulic fracturing from the definition of "underground injection" and (2) amended the CWA to effectively exempt "uncontaminated storm water discharges from oil and gas field activities" from federal NPDES permits (*U.S. Storm water rules*, 2006, January 4)

Clean Air Act - authorizes EPA to set limits on particular air pollutants; authorizes EPA to limit air pollutant emissions from point sources

Endangered Species Act - supports the conservation of threatened and/or endangered plants, animals, and their respective habitats

Resource Conservation and Recovery Act (RCRA) - authorizes EPA to manage the generation, transportation, treatment, storage, and disposal of hazardous waste
(Certain oil and gas exploration and production wastes are exempt from Subtitle C of RCRA, but may be covered under Subtitle D or regulations other than RCRA.) (Ground Water Protection . . . ,2009, April, p. 38)

Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA, also known as Superfund) - taxes chemical and petroleum industries; authorizes direct federal response in the event of releases or threatened releases of hazardous substances that may pose a danger to public health or the environment

Emergency Planning and Community Right to Know Act (EPCRA) - protects public health, safety, and the environment from chemical hazards through requirements for planning and reporting

Occupational Safety and Health Act - requires employers to maintain a safe and healthy work environment; administered by the Occupational Safety and Health Administration (OSHA)

Note: Some federal laws (including the SDWA, RCRA, and CERCLA) contain exemptions relevant to Marcellus Shale operations. These are usually very specific in nature and do not necessarily exempt

the industry from complying with other sections of the same law or act, nor do they preclude the states' rights to regulate the same.

Pennsylvania

Oil and Gas Act - regulates oil and gas exploration and production, including permitting, drilling, operating, casing, plugging, reporting, financial responsibility, registration, restoration, and gas storage

Oil and Gas Conservation Law – includes special regulations for "conservation wells" that are wells at least 3,800 feet deep and penetrate the Onondaga formation

Coal and Gas Resource Coordination Act - sets forth means of coordinating activities of coalmine and non-conservation gas well operators

Clean Streams Law - authorizes DEP to control water pollution, especially through regulation of discharges to state waters; provides for DEP's implementation of the federal NPDES program in the state; sets forth enforcement policies and penalties for violations

Solid Waste Management Act - authorizes DEP to regulate solid wastes, including municipal, residual (non-hazardous industrial), and hazardous wastes

Dam Safety and Encroachment Act - regulates activities in, along, or across bodies of water

Safe Drinking Water Act - authorizes DEP to enact the federal SDWA within Pennsylvania; authorizes DEP to set maximum allowable levels for contaminants which the EPA has not yet addressed; does not give the state authority to regulate underground injection wells as PA has opted for a direct federally implemented program (Pennsylvania Department of Environmental Protection, n.d., Ch. 2, p. 12)

Water Resources Planning Act – establishes a state water plan that periodically compiles data on how much water is available, how much is currently being used, how much will be used in the future, and where water use will exceed the available water supply (Swistock, B. & Blanchet, H., n.d.)

Worker and Community Right to Know Act - mandates that employers and chemical suppliers provide identification and hazard data for substances used in any workplace

Vehicle Code - sets forth weight restrictions on vehicles and roadways, as well as posting and bonding requirements

Municipalities Planning Code - addresses zoning, subdivision, and land development at the local level

The Role of the Pennsylvania Department of Environmental Protection

The bulk of Marcellus Shale gas regulatory authority in Pennsylvania falls on the State's Department of Environmental Protection and its Bureau of Oil and Gas Management. DEP's website describes this bureau as:

> . . . responsible for the statewide oil and gas conservation and environmental programs to facilitate the safe exploration, development, and recovery of Pennsylvania's oil and gas reservoirs in a manner that will protect the Commonwealth's natural resources and the environment. The bureau develops policy . . . and programs for the regulation of oil and gas development and production, . . . oversees the oil and gas permitting and inspection programs; develops statewide regulation and standards; conducts training programs for industry; and works with the Interstate Oil & Gas Compact Commission and the Technical Advisory Board. (Pennsylvania Department of Environmental Protection, 2009, October 23)

In this capacity, DEP reviews and approves bond and well permits; inspects drilling operations, wells, and environmental controls; permits and inspects waste management; enforces state laws pertaining to resource management, well construction, and waste management; responds to complaints concerning water quality issues; and provides industry-relevant training programs.

To better guide operators in the state's requirements, DEP has created the *Oil and Gas Operators Manual*. This handbook summarizes statutes, regulations, DEP assistance, and procedures relevant to oil and gas operations. It contains information on permitting, drilling, best management practices (BMPs) for erosion and sediment control, environmental controls, waste management practices, plugging of wells, and associated activities. Copies of laws and regulations, forms, bonding guidelines, and information on oil and gas wastewater permitting are included as appendices (Pennsylvania Department of Environmental Protection, n.d.).

In its enforcement capacity, DEP has several tools at its disposal. For example, recently DEP has taken the following actions: issued a cease and desist order to U.S. Energy Development Corporation for numerous repeat violations; fined Gas Field Specialist Inc. for residual wastewater violations; and imposed a temporary stop order on all hydraulic fracturing operations by Cabot Oil and Gas in Susquehanna County after three spills occurred within one week. In each of these instances, accountability was clear-cut. However, this is not always the case. Whether from negligence or accident, violations will occur and, most likely, increase with the expansion of natural gas production. As in the case of Pennsylvania's coal legacy, circumstances can become aggravated over time or responsibility cannot easily be determined. Companies come and go, landowners sell their property, corporate officers transfer, and bankruptcies occur. These events make DEP's enforcement role most challenging.

PERMITS AND APPROVALS

Before drilling a Marcellus Shale well, an operator must obtain several permits and approvals. As of October 2009, these include:

- Well Drilling Application
- Water Management Plan (This supersedes former Application Addendum)
- Erosion, Sediment and Storm Water Control Plan or Permit
  - (A plan is allowable when earth disturbance occurs on fewer than five acres; permit is required if earth disturbance occurs on five or more acres.)
- Preparedness, Prevention and Contingency Plan
- Water Withdrawal Permits
- Obstruction and Encroachment Permit
- Water Quality Management Permit (This is for pit impoundments of a treatment facility.)
- Air Quality Permits (Depending on scope of project, separate permits may be needed for generators, compressors, gas flaring, and diesel trucks.)

In addition, a well site bond must be posted before any drilling activity occurs. This is one way "to ensure that the operator will adequately perform the drilling operations, address any water supply problems the drilling activity may cause, reclaim the well site, and properly plug the well upon abandonment" (Pennsylvania Department of Environmental Protection, 2009, October). To comply with state Vehicle Code regulations a roadway bond is usually required as well.

As interest in Marcellus Shale gas exploration and drilling has steadily climbed, so too has the DEP's related workload. Through August 2009, the number of Marcellus Shale drilling permits granted by the DEP showed a 45 percent gain over the total number of similar permits issued for the

entire 2008 year (Stouffer, 2009, September 1). A new fee structure took effect in April 2009. It raises the initial permit cost for a Marcellus Shale well from a flat $100 to $900. There is also a sliding scale surcharge based on well bore type and length. The higher fees help provide funding not only for the increased volume of permit reviews and site inspections but also for the addition of more than 30 new staff members to perform related duties.

Although the DEP handles most shale gas regulatory issues, two federal-interstate compact government agencies also have jurisdiction: The Susquehanna River Basin Commission (SRBC) and the Delaware River Basin Commission (DRBC) have legal authority over water quality and quantity regulation in their respective areas. Because of the large amount of water required for hydraulic fracturing and the equally high volume of industrial-classified wastewater resulting from drilling activities, these commissions are very concerned about natural gas extraction operations. As a result, to drill within SRBC or DRBC areas, operators must apply for and obtain additional approvals from these respective commissions and submit them to the DEP.

The Water Management Plan (listed above) is another important component of the permitting process. Developed through the cooperative efforts of the DEP, SRBC, and DRBC, this plan helps address the high volume of water necessary for drilling, particularly in areas that are not covered by the SRBC and DRBC, i.e., in the Ohio, Potomac, Erie, and Genesee Basins. It contains a set of statewide permitting rules for water withdrawal, usage, treatment, and disposal. Additionally, it requires operators to provide a description of anticipated impacts of drilling and water withdrawals on water resources.

The Role of Municipalities

Municipal regulation of shale gas drilling is extremely limited due to preemption by the Pennsylvania Oil and Gas Act. Aside from road bonding and maintenance agreements, local officials have very little control over the location of wells, on-site safety, water supply protection, permit notification, and well-site bonding. While zoning, subdivision, and/or land development ordinances may be used “to guide growth and development that results from the gas boom and to protect community assets” (Pennsylvania Department of Conservation and Economic Development, n.d.), they cannot be used to regulate gas operations already covered by the Oil and Gas Act. Attempts to clarify their authority, or lack thereof, have left municipalities without recourse except through court action.

For example, local officials have gone to court to reconcile their legislative powers as set forth in the state’s Municipal Planning Code with the largely preemptive state Oil and Gas Act. In February 2009, the Pennsylvania Supreme Court handed down decisions in two pivotal cases, Huntley & Huntley v. Borough Council of the Borough of Oakmont and Range Resources-Appalachia, LLC v. Salem Township. Although far from identical, both rulings validate some degree of municipal authority through traditional zoning ordinances that designate particular land uses. Not surprisingly, the rulings also leave room for interpretation. But, Holly M. Fishel of the Pennsylvania State Association of Township Supervisors (PSATS) pointed out, “These are important rulings for local government because oil and gas well drilling is now treated like every other use and subject to reasonable land use regulations” (2009, August 19). Elam Herr, a director of the same association further said, “We are not asking to regulate drilling, which would duplicate state regulations, but to have oversight of well locations, like other uses” (Hawbaker, 2009, January).

The PSATS has identified several other salient issues. These include: road damage caused by extensive heavy truck use and 30-year-old road bonding limits far below current repair costs; the lack of notification requirements to the appropriate municipalities and counties once DEP has granted a permit; possible contamination of private water wells; insufficient number of treatment facilities for wastewater; limited resources and expertise available to local and volunteer fire departments for handling well fires; and the current exclusion of oil and gas reserves from property tax assessment (coal and other minerals are allowed to be assessed with a property tax).

The Role of Conservation Districts

Pennsylvania's County Conservation Districts, dedicated to conserving the state's natural resources, are involved at the regional level. These districts are designated "to work in close cooperation with landowners and occupiers, agencies of Federal and State Government, other local and county government units and other entities . . ." Conservation District Law, n.d., Section 2, "Declaration of Policy"). Until April 2009, these well-informed agencies served an important role as part of the review and permitting process with oversight over erosion, sedimentation, and storm water control. As of that date, with virtually no advanced notice, DEP rescinded the involvement of conservation districts by creating a more "efficient" centralized system. Now all reviews are performed by one of DEP's own regional offices. Some question these revised procedures and believe that each conservation district had the local expertise needed for protecting public health and the environment. Others wonder if DEP's staff understands the limitation of the local areas and if recent staff increases are sufficient to manage the ever-increasing workload.

ISSUES AND CONCERNS

Federal Water Issues

Federal regulations address pertinent water issues involved in natural gas extraction from Marcellus Shale. Currently, Congress is considering two bills that address hydraulic fracturing. One is in the Senate (S. 1215) and the other is in the House (H.R. 2766). This Fracturing Responsibility and Awareness of Chemicals (FRAC) Act seeks, among other things, to require drilling companies to fully disclose all chemicals used in their hydraulic fracturing operations and places hydraulic fracturing under the jurisdiction of the federal government. It would remove an exemption from the federal Safe Drinking Water Act (SDWA) for hydraulic fracturing which was inserted in the Energy Policy Act of 2005. Currently, "the EPA does not have authority to investigate the fracturing process under the Safe Drinking Water Act" (Lustgarten, 2009, August 25). Opponents of the FRAC Act maintain that the states already adequately regulate hydraulic fracturing. Proponents argue that federal oversight is imperative to protecting the nation's water supply, especially as it will facilitate broad EPA impact studies. On October 29, 2009, the House approved an appropriations bill that provides for a new EPA study on hydraulic fracturing and its impacts on drinking water supplies. The bill is pending Senate approval and signature by President Obama.

State Water Issues

Compared to some states, Pennsylvania has relatively comprehensive hydraulic fracturing regulations (Wiseman, 2009, Spring) that require full chemical disclosure. A summary of Marcellus Shale fracturing solutions is available at the DEP's website. The specific quantities used in any given solution, however, are still considered proprietary information.

Despite the state regulations already in place, there is "one critical yet overlooked aspect in Pennsylvania, the lack of a requirement to monitor groundwater quality in a drilling zone" (McConnell, 2009, June 10). Testing for water quality before, during, and after drilling is voluntary. Although the state's Clean Streams Law would cover groundwater if pollution did occur, "this state law . . . does not require proactive water quality testing, including aquifers, making pollution detection difficult" (McConnell, 2009, June 10). Compounding the issue is the fact that groundwater contamination by hydraulic fracturing has not been definitively confirmed nor disproved (Gjelten, 2009, September 23).

Another area of growing concern is the elevated level of total dissolved solids (TDS**)** polluting Pennsylvania's waterways. Sources of TDS range from storm water runoff to sewage and industrial discharges, including gas well drilling. Pennsylvania's water systems are even less able to handle TDS

due to the chronic discharges from abandoned coal mines. Starting in the fall of 2008, samples taken at the Monongahela River exceeded water quality limits for TDS. Although remedial steps have been taken, the problem persists.

In April 2009, the DEP proposed new limits for high TDS wastewater discharges to be in place by January 2011. Until that date, the DEP plans to follow an interim Permitting Strategy that "will focus on those new sources that have the greatest potential to adversely affect the quality of Pennsylvania's receiving streams. Currently, those sources are wastewaters generated from fracturing and production of oil and gas wells in the Marcellus Shale formation" (Pennsylvania Department of Environmental Protection, 2009, April 11, p.4). This plan addresses the important issue of cumulative effects:

> . . . a strategy for permitting these discharges also must involve an allocation strategy to address those situations in which multiple discharges cause or contribute to downstream water quality standards violations, even if only predicted through modeling. An allocation strategy is the plan to allocate the assimilative capacity of the watershed (the acceptable loading in lbs/d of TDS and/or chlorides) among multiple sources. (Pennsylvania Department of Environmental Protection, 2009, April 11, p. 4)

If implemented, this provision would be a significant, new direction for state regulations. As Jan Jarrett, president and CEO of PennFuture testified, "Neither the Oil and Gas Act nor the Oil and Gas regulations in Chapter 78 require, or even contemplate, that DEP will assess the probable cumulative impacts of gas drilling on the natural resources . . ." (2009, March 31, p. 12). This DEP proposal for new limits on high TDS wastewater discharges is being studied and evaluated by the Chapter 95 Task Force. This special group, composed of representatives of industry, environmental, and state agencies, was formed under the guidance of the Water Resources Advisory Committee (one of several DEP advisory groups). Another joint effort is embodied in the Marcellus Shale Wastewater Partnership, a collaborative venture between the DEP and natural gas industry. However, unlike the Chapter 95 Task Force, no members from the environmental sector are involved in this partnership that primarily focuses on wastewater and new technologies designed for its treatment. With regard to erosion, sediment control and storm water management, the DEP has submitted relevant proposed changes. According to Acting Secretary of the DEP John Hanger, "We are shifting the focus of water quality protection from reviewing paperwork to holding permittees more accountable, conducting more on-the-ground inspections to verify that best management practices are being implemented and maintained, and increasing protections for our waterways" (Pennsylvania Department of Environmental Protection, 2009, August 31). One aspect of the proposal is a permit-by-rule option aimed at shortening the permit processing time for "eligible low-risk construction projects" (Pennsylvania Department of Environmental Protection, 2009, August 31). The 90-day public comment period on this particular proposal is scheduled to close November 30, 2009.

Air Quality Issues

Wells drilled after 1980 have been exempted from the National Emission Standards for Hazardous Air Pollutants (NESHAP), which falls under the Clean Air Act. NESHAP regulates small sources of toxic air pollution grouped in close proximity. With this exemption, natural gas and oil drill sites are not treated as an aggregated unit if they are located outside of areas with a population of one million or more (Horwitt, 2009, March; Mall, Buccino, & Nichols, 2007, October; Legal Information Institute, n.d.*).* Since most Marcellus Shale natural gas wells will not occur in urban areas of this population density, air quality permits will be granted per "point source," e.g., a compressor engine, a dehydrator. Each of these point sources, basically pieces of mechanical equipment, typically meets the DEP administrative and technology standards. Permits are thus granted routinely within 30 days (Barbara

Hatch, personal communication, August 5, 2009). However, with multiple Marcellus wells likely being drilled in a restricted geographic area, the aggregate pollution of the many small sources of air pollution could become problematic. This has been the experience in Colorado (Earthworks, 2006). To underscore the importance of this issue, the National Park Service has warned its employees of this potential source of air pollution in the Eastern United States (National Park Service, 2008).

To determine the nature and extent of air pollution, air quality monitors are needed. Providing air quality monitors involves both the Federal EPA and the Commonwealth DEP. EPA sets the criteria for air quality monitor placement and the Commonwealth has the ability to place additional monitors in specific places. Currently, many of the counties in which natural gas is being extracted from Marcellus Shale have few, if any, such monitoring devises. As a result, there is no data regarding the nature of air quality prior to drilling, during drilling, and/or during production.

Streamlining the Process

Numerous application forms, coupled with long lead times, have become costly and frustrating to both companies and authorities alike leading to pressure to streamline the process. But streamlining only makes sense if it can be done without sacrificing regulatory integrity. A case in point occurred in August and September 2009 when the Chesapeake Bay Foundation filed appeals with the PA Environmental Hearing Board. The charges assert that the DEP granted drilling permits (for Fortuna Energy Inc. and Ultra Resources, Inc.) without adequately evaluating erosion and sediment control ramifications. The Foundation specifically cited an expedited permitting option implemented by the DEP in April 2009. Matt Royer, an attorney for the Chesapeake Bay Foundation, pointed out that this procedure does not require the DEP to do a technical review concerning “the environmental impacts on wetlands or streams . . . which is illegal under state and federal clean streams law” (Hopey, 2009, September 10). In response to the Chesapeake Bay Foundation's action, the DEP re-evaluated the questionable permits. Its investigation found enough deficiencies to warrant revocation of the permits. As a result of this action by a “watchdog” group, DEP also issued violation notices to several licensed professionals responsible for upholding regulations.

Within its jurisdiction, the SRBC has also addressed the need for expediency. One of its main objectives has been "to streamline the approval process for consumptive use, yet simultaneously require all consumptive water users in the basin to comply with monitoring, reporting, and mitigation requirements. This allows the SRBC to better manage the cumulative impact of such consumptive use" (Susquehanna River Basin Commission, 2009, January, p. 3).

CLOSING

Owing in part to its multi-tiered framework, Marcellus Shale gas drilling regulation is inherently problematic. On an extremely simplified level, much of the confusion and debate revolves around at least one of the following:

- the scope and content of the regulations themselves;
- the process creating the regulations;
- the enforcement of the regulations; and
- accountability for violations.

In addition to vigilant oversight and related enforcement, the nature of regulation and monitoring of natural gas extraction from Marcellus Shale will determine its legacy. It is imperative that all agencies – municipal, regional, state, and federal – work together to preserve the public good and provide clear guidance to the natural gas industry.

Reference 2

This DRAFT Docket has been prepared for the purposes of the scheduled public hearing and may be substantially modified as a result of the public hearing process prior to Commission action.
2/9/2010

DOCKET NO. D-2009-18-1

DELAWARE RIVER BASIN COMMISSION

Special Protection Waters

Stone Energy Corporation, Matoushek 1 Well Site
Shale Gas Exploration and Development Project
Clinton Township, Wayne County, Pennsylvania

PROCEEDINGS

This docket is issued in response to an Application submitted to the Delaware River Basin Commission (DRBC or Commission) by Stone Energy Corporation (Stone) on February 13, 2009 for review and approval of a Marcellus Shale natural gas exploration and development project referred to as the Stone-Matoushek Site (Well Site or Well Pad) which contains a single vertical shale gas well referred to as the Matoushek 1 Well (M1) in Clinton Township, Wayne County, Pennsylvania. On March 14, 2008, the Pennsylvania Department of Environmental Protection (PADEP) Oil and Gas Management Program approved its oil and gas Well Permit for the well (Well Permit No. 37-127-20006-00).

The Application was reviewed for approval under Section 3.8 of the *Delaware River Basin Compact*. The Wayne County Planning Commission and Clinton Township have been notified of pending action on this docket. A public hearing on this project was held by the DRBC on February 24, 2010.

A. DESCRIPTION

1. Purpose. The purpose of this project is for the approval of natural gas exploration and development activities of the M1 well from the Marcellus Shale Formation.

2. Natural Gas Well Location. The existing M1 well is located at latitude 41° 41' 6.39" North and longitude 75 ^{o} 21' 58.21" West on the north central portion of an approximate 116-acre parcel (Tax Map Parcel Number 06-1-0212-0016) in Clinton Township, Wayne County, Pennsylvania. The M1 well is situated in the central portion of an approximate 250 foot by 300 foot existing well pad constructed in an agricultural

field between Bethany Turnpike (SR 670) to the north, Johnson Creek Road to the west, and Creamton Drive (SR 247) to the east and the south in Clinton Township, Wayne County, Pennsylvania. The well site is located approximately 0.8 miles southwest of Red Schoolhouse Corner (the intersection of Bethany Turnpike and Creamton Drive).

The M1 well is located in the outcrop area of the Upper Devonian-age Catskill Formation in the Johnson Creek and West Branch Lackawaxen River watersheds in Clinton Township, Wayne County, Pennsylvania. The surficial material at the site is mapped as Wisconsin Till.

3. **Area Served.** This Docket applies to natural gas exploration and development activities only to the M1 well located on the Well Site. For the purpose of this docket, natural gas exploration and development activities include or are associated with: Well site and associated access road construction, air rotary/mud rotary natural gas well drilling, natural gas well construction and testing, support vehicle tire cleaning, dust control on access roads, storage of fresh water, hydraulic fracturing well stimulation, hydraulic fracturing chemical storage, flow-back water storage, transport and disposal of all domestic and non-domestic wastewaters and site reclamation on the well pad surrounding the M1 well. Any additional wells proposed at the M1 well site or any property leased by Stone requires separate DRBC docket approval.

4. **Definitions**.

Conductor casing- A short length of large-diameter pipe used to stabilize the upper portion of the borehole.

Domestic wastewater- Sanitary waste collected in portable self-contained toilets.

Drill cuttings- Rock cuttings and related mineral residues generated during the drilling of an oil or gas well.

Flowback- Return of fluids used in the stimulation process to the surface. While a large proportion of flowback returns to the surface shortly after hydraulically fracturing a well, flowback may return to the surface along with produced water over the production life of the well.

Natural gas exploration and development activities- All activities necessary for the development of and extraction of natural gas including but not limited to well pad and associated access road construction, air rotary/mud rotary natural gas well drilling, natural gas well construction and testing, support vehicle tire cleaning, dust control on access roads, storage of fresh water, hydraulic fracturing well stimulation, hydraulic fracturing chemical storage, flow-back water storage, transport and disposal of all domestic and non-domestic wastewaters, and site reclamation.

DRAFT

Non-Domestic wastewater- Brines, produced water, hydraulic fracturing flowback and any water containing brines, drilling muds, stimulation fluids, well servicing fluids, oil, production fluids or drilling fluids, and cement mixer or cement truck washout water.

Produced water- Water and other fluids brought to the surface during production of oil or gas.

Production casing- A string of pipe other than surface casing and coal protective casing which is run for the purpose of confining or conducting hydrocarbons and associated fluids from one or more producing horizons to the surface.

Surface casing- A string of pipe which extends from the surface and that segregates and protects fresh groundwater and stabilizes the hole.

Tophole water- Water that is brought to the surface while drilling through the strata containing fresh groundwater and water that is fresh groundwater or water that is from a body of surface water. Tophole water may contain drill cuttings typical of the formation being penetrated but is not polluted or contaminated by additives, brine, oil or man induced conditions.

Well site- The area occupied by the equipment or facilities necessary for or incidental to the drilling, production or plugging of a well.

5. Physical Features.

a. Site Description. The M1 well site is located in the Glaciated Low Plateau Section of the Appalachian Plateaus Physiographic Province. This area is characterized by rounded hills and valleys of low to moderate relief. The well pad is located in the northern portion of an open field with wooded areas to the north and west of the drilling site. Access to the drilling site is provided by an improved existing farm road located along the perimeter of the open area with an entrance to Creamton Road.

The drilling site is located on a crest of a low-relief ridge at an approximate elevation of 1,545 feet above mean sea level (MSL). Drainage at the drilling site slopes west toward Johnson Creek, located approximately 3,000 feet from the drilling site, and south toward an unnamed tributary of the West Branch Lackawaxen River, located approximately 1,400 feet from the drilling site. Slopes in the immediate area surrounding the drilling site range from approximately 2 to 4 percent. Based on U.S. Fish and Wildlife Service (FWS) National Wetlands Inventory database, the closest mapped wetlands are located at the headwaters of the unnamed tributary of West Branch Lackawaxen River, approximately ¼ mile east of the well location. The well location conforms to the setback limitations from existing buildings, water wells, streams, springs, bodies of water, and wetlands greater than 1 acre in size as required by Pennsylvania Oil and Gas Act Chapter 2 Section 601.205 *Well Location Restrictions*.

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b. <u>Well Pad and Well Description.</u> The existing well pad is an approximate 250 foot by 300 foot level area containing an existing well and a lined fresh water impoundment. The perimeter of the well pad contains an earthen berm. The pad area and access roads were first stripped of topsoil to expose firm sub-base material. The topsoil has been stockpiled around the well pad. Coarse aggregate was used where additional stabilization was necessary. In order to control runoff and minimize soil erosion, a diversion swale was constructed on the upslope (north) side of the drilling pad and filter fabric fencing was used on the down-slope sides of the well pad. The docket holder indicated that design and construction of the drilling pad incorporated non-structural and structural best management practices (BMPs). BMP's utilized at the site included siting the well/disturbed area outside of sensitive and special value features and minimizing total disturbed area during clearing, grading, and grubbing. Structural BMP's included, silt fencing, road stabilization with geosynthetics and coarse aggregate, seeding and mulching, straw bail barriers, and temporary drains and swales. The Erosion and Sediment Control Plan was posted at the entrance of the site during well construction.

The M1 well is a vertical well drilled between May 9, 2008 and June 2, 2008 to a total depth of 8,350 feet below ground surface for the purpose of natural gas extraction. The well was air drilled from the ground surface to a depth just above the Marcellus Shale. The Marcellus Shale was cored with 3 % potassium chloride (KCl) water. Drilling muds were not used in the construction of the well. The deepest freshwater was encountered in the Devonian-age Catskill Formation at a depth of approximately 665 feet. Drill cuttings and fluids were captured in a lined drill pit excavated in the drilling pad in proximity to the well. Tanks were used to store tophole water during the drilling of the gas well. After drilling, the cuttings were solidified by mixing with cement and disposed of in the lined drill pit in accordance with PA Code § 78.61.

The M1 well log included as part of the Application indicates that the well was constructed in accordance with PADEP Chapter 78 Subchapter D regulations. The well contains a total of three (3) strings of nested casing (conductor casing, surface casing, and production casing). The conductor casing (13 3/8-inch diameter) was installed in a 17 ½ inch borehole and extends from the ground surface to a depth of 710 feet. The entire annular space was filled with cement. The surface casing (9 5/8-inch diameter) was placed in a 12 ¼-inch diameter borehole and extends from the ground surface to a depth of 1,964 feet. The entire length of the annular space was filled with cement. The surface casing was pressure tested to a maximum pressure of 1,500 pounds per square inch (psi) for 5 minutes. The purpose of the pressure test is to ensure the integrity of the cemented surface casing to effectively isolate fresh water bearing zones from the wellbore prior to drilling through deeper, non-fresh water or other fluid-bearing zones. The production casing (5 ½-inch diameter) was placed in an approximate 8-inch diameter borehole from the ground surface to a depth of 8,350 feet (bottom of the drilled well). The annular space was filled with cement from the production casing seat at 8,350 feet up to a depth of 5,500 feet.

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The M1 well and well site were constructed in accordance with PA Chapter 78 and PADEP Permit No. 37-127-20006-00.

c. **Access Roads.** An improved existing farm road was used to access the well site containing M1. The improved access road is approximately 30 feet in width and 1,200 feet in length and stabilized with compacted crushed stone aggregate. Silt fencing was installed along the length of the road. The total acreage of the access road is approximately 0.8 acres.

d. **Drill Cuttings and Water Containment/Disposal.** During drilling, drilling fluids and cuttings were contained in a drill pit excavated and maintained in accordance with PA Chapter 78 Subchapter C. The water generated during drilling was removed from the drill pit and disposed of at Valley Joint Sewer Authority in Athens, PA. The drill cuttings were solidified and disposed of in the M1 Well drilling pit in accordance with the requirements of PA Chapter 78 Subchapter C.

e. **Water Source/Water Storage Facility.** The docket holder will only utilize water from the DRBC approved surface water withdrawal located on the West Branch Lackawaxen River (WBLR) to support the natural gas exploration and development project at the M1 well. The surface water withdrawal project (Docket No. D-2009-13-1) is being processed concurrently with the M1 Well docket. Fresh water used for site activities will be stored in a 0.8 million gallon capacity, lined, earthen impoundment constructed and maintained in accordance with PA Chapter 78.

f. **Onsite Chemical Storage Facilities.** All chemicals, fuels, lubricants, etc. required for natural gas exploration and development at the site will be properly stored on the well pad in accordance with the Preparedness Prevention and Contingency Plan (PPC Plan) as required by 25 PA Code Chapters 91.34 and 78.55.

g. **Wastewater Containment, Sampling, Transport, Treatment and Disposal.**

i. Non-Domestic Wastewater. Non-domestic wastewater shall be stored on site in a manner to prevent its release except in accordance with this docket. Approximately 6,200 barrels of non-domestic wastewater and top-hole water generated during the drilling of the well was removed from the drill pit via vacuum-truck and transported to a disposal facility. Stone informed the Commission that hydraulic fracturing flowback generated from additional work at the site shall be transferred to steel tanks for storage, reuse, or disposal. As such, the use of steel tanks for non-domestic wastewater storage is required at the M1 Well Site as stated in Condition No II.u. in the Decision Section of this docket. The docket holder is encouraged to reuse the flow-back water for well stimulation in accordance with Condition II.m. in the Decision section of this docket. Non-domestic wastewater that cannot be reused for well stimulation will be removed from the site via tanker truck and conveyed to treatment and disposal facilities approved by the DRBC (if in the DRB and subject to Commission approval) as

well as by the applicable state/Federal agency (if inside or outside of the DRB). No on-site discharge of such non-domestic wastewaters, other than as allowed in this docket is permitted.

ii. Domestic Wastewater. Domestic wastewater shall be stored on site in portable self-contained toilets and in a manner to prevent its release onsite. All domestic wastewater shall be conveyed to treatment and disposal facilities approved by the DRBC (if in the DRB and subject to Commission approval) as well as by the applicable state/Federal agency (if inside or outside of the DRB).

iii. Sampling and Record Keeping. Prior to removal from the M1 Well Site, all non-domestic wastewater shall be sampled and the results recorded in accordance with the Operation Plan required by Condition No. II.e. in the Decision section of this docket. Samples shall be representative of the non-domestic wastewater that shall be transported to the DRBC and State-approved off-site treatment and disposal facility. The chemical analysis of non-domestic wastewater must include the following: acidity, alkalinity (total as $CaCO_3$), aluminum, ammonia nitrogen, arsenic, barium, benzene, beryllium, biochemical oxygen demand, boron, bromide, cadmium, calcium, chemical oxygen demand, chlorides, chromium, cobalt, copper, ethylene glycol, gross alpha, gross beta, hardness (total as $CaCO_3$), iron-dissolved, iron-total, lead, lithium, magnesium, manganese, MBAS (surfactants), mercury, molybdenum, nickel, nitrite-nitrate nitrogen, oil & grease, pH, phenolics (total), radium-226, radium-228, selenium, silver, sodium, specific conductance, strontium, sulfates, thorium, toluene, total dissolved solids, total kjeldahl nitrogen, total suspended solids, uranium, and zinc. Domestic wastewater can be transported offsite without sampling; however, it may be subject to sampling at or by the treatment facility.

iv. Wastewater Treatment and Disposal. All wastewater, domestic and non- domestic shall be conveyed to the treatment facility designated in the M1 Well Site Operation Plan or as otherwise approved in writing by the DRBC Water Resource Branch Manager as well as by the applicable state/Federal agency (if inside or outside of the DRB).

h. **<u>Supporting Ancillary Facilities</u>.** The proposed ancillary facilities include Stone's WBLR surface water withdrawal point and the off-site wastewater treatment facilities that will accept the domestic and non-domestic wastewater. Additional facilities will be required to convey and process the natural gas from M1 Well Site including pipelines, compressor stations, separators/liquid storage tanks, etc, however, the locations of these facilities have not been specified.

i. **<u>Cost.</u>** The overall cost of this project is estimated to be $3,000,000.00.

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B. FINDINGS

This docket is issued in response to an Application submitted to the Delaware River Basin Commission (DRBC or Commission) by Stone Energy Corporation (Stone) for review and approval of a natural gas exploration and development project at its M1 Well site in Clinton Township, Wayne County, Pennsylvania. The Commission recognizes that each natural gas well also will be subject to the review of the environmental agency of a signatory state in which the project is located. The Commission staff coordinates with and, where feasible, will utilize the review process and approvals of the applicable state or federal agency to minimize duplication of effort and redundant requirements imposed on project sponsors.

On June 6, 2008 the Executive Director of the DRBC issued a determination to Stone by certified letter that natural gas exploration and development at the M1 Well site may have substantial impacts on the water resources of the Delaware River Basin (DRB). As such, the DRBC requested that an Application for the M1 Well Site be submitted to the Commission for review and approval.

Stone drilled and cased the M1 well without Commission approval. On December 10, 2008, a settlement agreement between Stone and the Commission required Stone to submit an application to the DRBC for review and approval of the well and to pay a fine as specified in the settlement agreement.

On February 13, 2009, Stone submitted an application to the Commission for approval of the M1 Well. Additional information pertaining to the Application was submitted to the Commission on June 11, 2009.

On May 19, 2009, the Executive Director issued the "*Determination of the Executive Director Concerning Natural Gas Extraction Activities In Shale Formations Within The Drainage Area of Special Protection Waters*" that clarified which natural gas related activities require Commission review and approval (EDD).

SPECIAL PROTECTION WATERS

The project is located in the area of the Delaware River Basin that is designated by the Commission as Special Protection Waters (SPW) as set forth in the DRBC *Water Quality Regulations* (WQR). The SPW designation and associated regulations are designed to protect waters with exceptional value including without limitations existing high water quality in applicable areas of the Delaware River Basin. Article 3.10.3A.2.e.1). and 2). of the *WQR, Administrative Manual - Part III,* requires that projects subject to review under Section 3.8 of the Compact that are located in the drainage area of Special Protection Waters must submit for approval a Non-Point Source Pollution Control Plan (NPSPCP) that controls the new or increased non-point source loads generated within the portion of the docket holder's service area which is also located within the drainage area of Special Protection Waters.

The M1 Well Site is located within the drainage area to SPW. Therefore, the NPSPCP plan requirement is applicable to this project. This project includes the constructed well pad (completed), well drilling (completed), and well stimulation through hydraulic fracturing. Water necessary for the well stimulation at the M1 Well Site is being processed concurrently with this docket (Docket No. D-2009-013-1). The docket holder submitted a general NPSPCP with the Application. However, no additional site construction activities, well stimulation, or water staging approved by this docket shall take place at the M1 Well Site until a site specific NPSPCP including measures to control stormwater both during and post construction on the site has been submitted to the Commission and approved by the Executive Director and any other necessary federal, state, and local authorizations have been issued.

WATER STORAGE

Water brought to the M1 Well Site from the Commission-approved West Branch Lackawaxen River site will be stored in a lined impoundment constructed and maintained in accordance with PADEP Chapter 78. Under no circumstances shall any material other than surface water originating from a Commission-approved source or precipitation be stored or be allowed to enter the impoundment. If water in this storage facility or the storage facility comes into contact with hydraulic fracturing chemicals, flow back water, or other chemicals and contaminants, all water in the storage facility shall be considered non-domestic wastewater and handled as discussed below.

Unused water from any of the docket holder's Commission approved M1 well natural gas development and extraction site activities in the DRB may be transported to and used at other Commission-approved well pads targeting shale formations controlled by the docket holder in the DRB, with the written approval of the Executive Director. Such transfers shall also be reported to the Commission.

No water, fracturing fluids, flowback water, or otherwise (e.g. cement mixer wash-out, truck wash water, etc.) shall be discharged to waters of the DRB except in accordance with written approvals from the Executive Director and/or the appropriate state agency (Condition II.g. in the Decision section of this docket).

WELL STIMULATION

The docket holder has indicated that the vertical Marcellus shale gas well at the M1 Well Site will be stimulated for production through slick-water hydraulic fracturing. The docket holder has advised the Commission that the well stimulation will involve the injection of approximately 1.0 million gallons (mg) of water with propping agents (i.e. sand of various grain sizes) and hydraulic fracturing additives through the steel production casing into the Marcellus Shale formation underlying the lease holding(s) at approximately 8,200 feet below land surface (elevation 6,655 feet below mean sea level).

The injection will occur at the M1 Well over a period of approximately three days at injection pressures from 5,500 pounds per square inch (psi) to 7,000 psi. Injection of the hydraulic fracturing additives and solutions detailed in the Application into the target formation is acceptable to the Commission as the M1 well was installed by the docket holder in accordance with PA Chapter 78 Subsection D, and approved by the PADEP in Permit No. 37-127-20006-00.

WASTEWATER

Flowback Water

Following well stimulation, Stone estimates that approximately 30% of the estimated 1.0 million gallons of water used for hydraulic fracturing will be returned to the surface as flowback. Flowback from the M1 Well will be piped from the wellhead directly into steel frac tanks for temporary storage on the M1 Well Site, in accordance with Condition II.u. in the Decision Section of this docket.

Treatment and Reuse of On-site Generated Wastewaters

Treatment and reuse of onsite generated non-domestic wastewaters is not proposed at this site. However, the docket holder is encouraged to use the flowback water for well stimulation in accordance with Condition II.m. in the Decision section of this docket.

Recovered fracturing fluids may be recycled for use in natural gas well stimulation activities at the docket holder's Commission-approved natural gas well pads in the DRB with written approval of the Executive Director. Any reuse shall also be reported to the Commission in accordance with the reporting requirements in the Decision Section of this docket. Otherwise, no recovered fracturing fluids shall be used for any purpose other than hydraulic fracturing at natural gas wells targeting shale formations.

Wastewater Disposal

The docket holder has indicated that all non-domestic wastewater including flowback water will be removed from the site via tanker truck and conveyed to treatment and disposal facilities located outside of the DRB. Such disposal is an exportation of wastewater subject to review and approval under Article 2.3 of the Commission's Water Code. Currently, there are no wastewater treatment and disposal facilities within the DRB that are approved to accept these non-domestic wastewaters. In addition docket Condition No. II.m. in the Decision section of this docket requires the docket holder to implement a continuous program to encourage water conservation in all types of use within the facilities served by this docket including the reuse and recycling of flowback waters. The Decision section of this docket also contains conditions concerning the offsite disposal location and the tracking and reporting of non-domestic wastewaters transported from the project site. Therefore, the Commission staff recommends approval of the proposed exportation of non-domestic wastewater. No on-site discharge of such non-domestic wastewaters, other than as allowed in this docket is permitted. Any such

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discharge shall be reported to the Project Review Section of the DRBC in accordance with Condition No. II.q. in the Decision Section of this docket.

The docket holder has indicated that domestic wastewater shall be collected in portable, self-contained toilets. When necessary, the toilets will be transported to the sewage treatment facility approved in the Operation Plan (described below). No on-site discharge of such domestic wastewaters is permitted.

The project is designed to conform to the requirements of the *Water Code* and *Water Quality Regulations* of the DRBC.

The natural gas well associated with this project was designed and constructed to conform to the casing and cementing requirements of Sections 78.81-.87 of the PADEP Oil and Gas Regulations. It has been determined by the Commission that these casing and cementing requirements satisfy the Basinwide Groundwater Requirements located in Section 3.40 of the Commission's Water Quality Regulations. These casing construction requirements are designed to sufficiently protect the designated uses of the ground waters of the Delaware River Basin.

The cuttings generated during drilling of the M1 well were solidified and buried in a lined pit on-site in accordance with PA Chapter 78 regulations. Non-domestic wastewater generated during drilling of the M1 well was removed from the site and disposed of at Valley Joint Sewer Authority in Athens, PA.

The DRBC estimates that the well stimulation through hydraulic fracturing, results in a consumptive water use of 100 percent of the total water used. The DRBC definition of consumptive use is defined in Article 5.5.1.D of the *Administrative Manual – Part III – Basin Regulations – Water Supply Charges.*

M1 WELL SITE OPERATION PLAN

In accordance with Condition II.e. of the Decision section of the docket, at least 45 days prior to the scheduled initiation of any activity at the M1 Well Site, the docket holder shall submit an Operation Plan (OP) for the M1 Well Site to the Executive Director. The OP shall include the specifics of the site operations, detailing at a minimum, the procedures necessary to comply with the conditions in the Decision section of this docket. In accordance with Condition II.e., no additional construction or natural gas development and extraction activities at the M1 Well Site is permitted until the OP is approved in writing by the Executive Director. The following shall also be included in the M1 Well Site Operations Plan:

Pre-Alteration Groundwater Quality Survey Plan. Prior to initiation of hydraulic fracturing at the M1 Well, the docket holder will submit a pre-hydraulic fracturing groundwater quality survey plan, receive Executive Director approval, and conduct the groundwater quality survey. The plan shall include an inventory and the locations of any

artificial penetrations including groundwater wells within a 1,000 ft radius of the project well. If no existing wells are identified within this distance, the search radius should be extended up to 2,000 feet from the gas well. The plan shall indicate the proposed sampling procedures to be conducted at a representative number of identified wells spaced around the proposed natural gas well. Prior to hydraulic fracturing at the M1 Well, water samples shall be collected and the samples submitted to a PADEP-certified laboratory for analysis of the following parameters: acidity, alkalinity (total as CaCO3), aluminum, ammonia nitrogen, arsenic, barium, benzene, beryllium, boron, bromide, cadmium, calcium, chlorides, chromium, cobalt, copper, ethylene glycol, gross alpha, gross beta, hardness (total as CaCO3), iron-dissolved, iron-total, lead, lithium, magnesium, manganese, MBAS (surfactants), mercury, molybdenum, nickel, nitrite-nitrate nitrogen, oil & grease, pH, phenolics (total), radium-226, radium-228, selenium, silver, sodium, specific conductance, strontium, sulfates, thorium, toluene, total dissolved solids, total kjeldahl nitrogen, total suspended solids, uranium, and zinc.

Wastewater Storage and Handling Details. The OP shall include the details of how domestic and non-domestic wastewater will be stored and handled on the project site.

Wastewater Disposal Locations. The OP shall include a list of the treatment sites where these domestic and non-domestic wastewaters will be disposed. The facility locations, state permit numbers, and acceptance agreements shall be included in the OP.

Measuring, Recording, and Records Maintenance System. The docket holder shall develop and submit with the OP a measuring, recording, and records maintenance system. The measuring, recording, and records maintenance system will include the proposed means with which to measure and record the amount of all water transported to the site by truck or any other means, the amount of water used at the site, the amount of water and fracturing fluids/ chemicals used in the natural gas well stimulation process, the amount of flowback recovered after stimulation, the amount and chemical composition of non-domestic wastewaters produced and stored at the site, and the amount and chemical composition of non-domestic wastewaters transported off-site for treatment and disposal. The method of sampling and analysis of non-domestic wastewater shall also be detailed in this plan. Measuring and record keeping activities shall be required for all non-domestic wastewater including produced water and flowback separated from the natural gas during the operational life of the natural gas well. The system will also record the truck number, license plate number and disposal location for each truck load of non-domestic wastewater transported off site.

Reporting System. The docket holder shall include in the OP the method for complying with the reporting requirements in accordance with docket conditions II.k. and II.l. in the decision section of the docket.

Preparedness Prevention and Contingency Plan (PPC Plan). The docket holder shall submit with the OP the PPC Plan that is required for Oil & Gas Wells as outlined in 25 PA Code Chapters 91.34 and 78.55.

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The project does not conflict with the Comprehensive Plan and is designed to prevent substantial adverse impact on the water resources related environment, while sustaining the current and future water uses and development of the water resources of the Basin.

C. DECISION

I. Effective on the approval date for Docket No. D-2009-18-1 the project and the appurtenant facilities described in the Section A "Description" shall be added to the Natural Gas Database maintained by the DRBC.

II. The project and appurtenant facilities as described in the Section A "Description" are approved pursuant to Section 3.8 of the *Compact*, subject to the following conditions:

a. Docket approval is subject to all conditions, requirements, and limitations imposed by the PADEP in Well Drilling Permit No. 37-127-20006-00, and such conditions, requirements, and limitations are incorporated herein, unless they are less stringent than the Commission's.

b. The lease holding, well pad site, and natural gas well, and operational records shall be available at all times for inspection by the DRBC.

c. The docket holder shall submit a Non-Point Source Pollution Control Plan (NPSPCP) for the M1 Well Site in accordance with Section 3.10.3.A.2.e, of the DRBC Water Quality Regulations to the Executive Director of the DRBC at least 45 working days prior to the scheduled initiation of any additional site clearing or construction at the well pad site. The NPSPCP and erosion and sedimentation control plan shall be designed in accordance with the more stringent of Commission and PADEP requirements. Prior to commencing any site clearing or construction work at the M1 Well Site, the docket holder shall obtain Executive Director's written approval for the NPSPCP, as well as, any other necessary federal, state, and local authorizations. The NPSPCP shall describe erosion and sedimentation controls to be implemented at the site and shall include measures to control stormwater both during and post construction. The post-construction portion of the plan shall describe the final site conditions including a pre- and post-construction project hydrograph analysis, permanent facilities, equipment, access roads, and all sediment and erosion and stormwater control structures necessary after final site restoration has been achieved.

d. Sound practices of excavation, backfill and reseeding shall be followed at the well pad site and any associated appurtenances to minimize erosion and prevent non-point source pollutants from leaving the site. The docket holder shall abide by all state and local erosion and sediment control and storm water management control legislation.

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e. **M1 WELL SITE OPERATION PLAN (OP).** As described in the Findings section of this docket, the docket holder shall submit the OP for approval in writing by the Executive Director. No activities other than those required to maintain or correct existing erosion and sedimentation controls shall be conducted at the M1 Well Site until the OP plan has been approved. The OP plan shall include the following:

i. Pre-alteration groundwater quality survey plan.

ii. Wastewater storage and handling details.

iii. Wastewater disposal locations.

iv. Measuring, Recording, and Records Maintenance System.

v. Reporting system.

vi. Preparedness Prevention and Contingency Plan (PPC Plan).

f. The docket holder shall demonstrate to the satisfaction of the Commission that all surface waters that are withdrawn for the purposes of hydraulic fracturing this well including, but not limited to flow-back fluids, produced brines, and drilling fluids have been treated and disposed of in accordance with applicable state and federal law.

g. No unused water withdrawn from the source approved for use at this well site, fresh or otherwise shall be discharged to waters of the DRB without the written approval of the DRBC and the appropriate state agency. All domestic and non-domestic wastewaters shall be treated at an approved treatment and discharge facility as provided for in the OP in Condition II.e. above.

h. Nothing herein shall be construed to exempt the docket holder from obtaining all necessary permits and/or approvals from other State, Federal or local government agencies having jurisdiction over this project or activities conducted under this project.

i. Upon completion of construction of the approved project, the docket holder shall submit a statement to the DRBC, signed by the docket holder's engineer or other responsible agent, advising the Commission that the construction has been completed in compliance with the approved plans, giving the final construction cost of the approved project and the date the project is placed in operation.

j. This docket approval shall expire three years from date below unless prior thereto the docket holder has commenced operation of the subject project or has expended substantial funds (in relation to the cost of the project) in reliance upon this docket approval.

k. The project natural gas well hydraulic fracturing volume and flow-back discharge volume shall be metered with an automatic continuous recording device

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or equivalent that measures to within 5 percent of actual flow. An exception to the 5 percent performance standard, but no greater than 10 percent, may be granted if maintenance of the 5 percent performance is not technically feasible or economically practicable. A record of hydraulic fracturing stimulation volume and flow-back discharge volume from the project natural gas well shall be maintained, and monthly totals shall be reported to the DRBC after completion of natural gas well stimulation activities and shall be available at any time to the Commission if requested by the Executive Director.

l. The volume of all non-domestic wastewaters removed from the M1 Well Site shall be recorded and maintained and monthly totals shall be reported to the DRBC in accordance with the approved OP.

m. The docket holder shall implement to the satisfaction of the Commission, the continuous program to encourage water conservation in all types of use within the facilities served by this docket approval. This includes the reuse and recycling of flow-back waters to the greatest extent possible at the site. The docket holder will report to the Commission on the actions taken pursuant to this program and the impact of those actions as requested by the Commission.

n. No brines, flowback, produced waters or any other waste shall be used for any well, well pad site, or lease area not contained within this docket unless approved in writing by the Executive Director.

o. A complete application for the renewal of this docket, or a notice of intent to cease the operations (withdrawal, discharge, etc.) approved by this docket by the expiration date, must be submitted to the DRBC at least 12 months prior to the expiration date below (unless permission has been granted by the DRBC for submission at a later date), using the appropriate DRBC application form. In the event that a timely and complete application for renewal has been submitted and the DRBC is unable, through no fault of the docket holder, to reissue the docket before the expiration date below, the terms and conditions of this docket will remain fully effective and enforceable against the docket holder pending the grant or denial of the application for docket approval.

p. The issuance of this docket approval shall not create any private or proprietary rights in the water of the Basin, and the Commission reserves the rights to amend, alter or rescind any actions taken hereunder in order to insure the proper control, use and management of the water resources of the Basin.

q. The docket holder shall report to the Commission Project Review Section Supervisor any violation of the docket conditions within 48-hours of the occurrence or upon the docket holder becoming aware of the violation. In addition, the docket holder shall report in writing any violations of the approved operations plan or any other docket conditions to the DRBC Project Review Section Supervisor within three days of reporting the incident. The docket holder shall also provide a written explanation of the causes of the violation within 30 days of the violation and shall set forth the

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action(s) the docket holder has taken to correct the violation and protect against a future violation.

r. If the monitoring required herein, or any other data or information demonstrates that the operation of this project significantly affects or interferes with any designated uses of ground or surface water, or if the docket holder receives a complaint regarding this project, the docket holder shall immediately notify the Executive Director of any complaints and unless excused by the Executive Director, shall investigate such complaints. The docket holder shall direct phone call notifications of complaints involving water resources to the DRBC Project Review Section at 609-883-9500, extension 216. Oral notification must always be followed up in writing directed to the Executive Director. In addition, the docket holder shall provide written notification to all potentially impacted users of wells or surface water users of the docket holder's responsibilities under this condition. Any ground or surface water user which is substantially adversely affected, rendered dry or otherwise diminished as a result of the docket holder’s project withdrawal, shall be repaired, replaced or otherwise mitigated at the expense of the docket holder. A report of investigation and/or mitigation plan prepared by a hydrologist shall be submitted to the Executive Director as soon as practicable or within the time frame directed by the Executive Director. The Executive Director shall make the final determination regarding the validity of such complaints, the scope or sufficiency of such investigations, and the extent of appropriate mitigation measures, if required.

s. The Executive Director may modify or suspend this approval or any condition thereof, or require mitigating measures pending additional review, if in the Executive Director's judgment such modification or suspension is required to protect the water resources of the Basin.

t. For the duration of any drought emergency declared by either Pennsylvania or the Commission, water service or use by the docket holder pursuant to this approval shall be subject to the prohibition of those nonessential uses specified by the Governor of Pennsylvania, the Pennsylvania Emergency Management Council, PADEP, or the Commonwealth Drought Coordinator to the extent that they may be applicable, and to any other emergency resolutions or orders adopted hereafter by the Commission.

u. All non-domestic wastewaters including, but not limited to, brines, flow-back water, produced waters, etc. must be temporarily stored on-site in steel, water-tight tanks at a minimum unless the docket holder has received written approval from the Executive Director to use an alternative method of storage. All wastewaters will be removed from the site in accordance with the approved OP.

v. The Commission has determined that the review of the reports and requests for modifications and approvals developed under the above docket and any amendments or changes thereto will continue to cause the Commission to expend exceptional efforts and costs. As such, Commission staff will continue to maintain a record of all time and expenses associated with the post-docket approval reviews of the project and associated deliverables. A fee in the amount of 100% of these costs will be

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assessed on a quarterly basis. In the event of a docket amendment or renewal, the larger of actual project review costs or the calculated project review fee will be charged.

w. The docket holder and any other person aggrieved by a reviewable action or decision taken by the Executive Director or Commission pursuant to this docket may seek an administrative hearing pursuant to Articles 5 and 6 of the Commission's *Rules of Practice and Procedure*, and after exhausting all administrative remedies may seek judicial review pursuant to Article 6, section 2.6.10 of the *Rules of Practice and Procedure* and section 15.1(p) of the Commission's *Compac*t.

BY THE COMMISSION

APPROVAL DATE: , 2010

EXPIRATION DATE: , 2020

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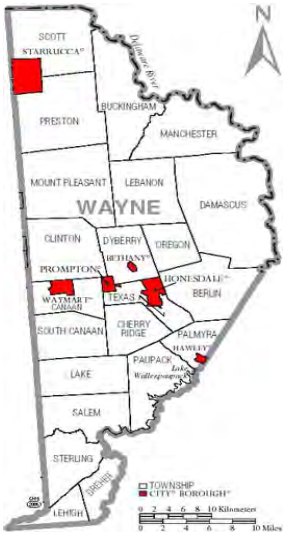
Reference 3

Robson 1 Gas Well Chesapeake Appalachia, LLC
Pennsylvania State Department of Environmental Protection
Permit 37-127-20008-00, Issued 2/26/09

March 15, 2009

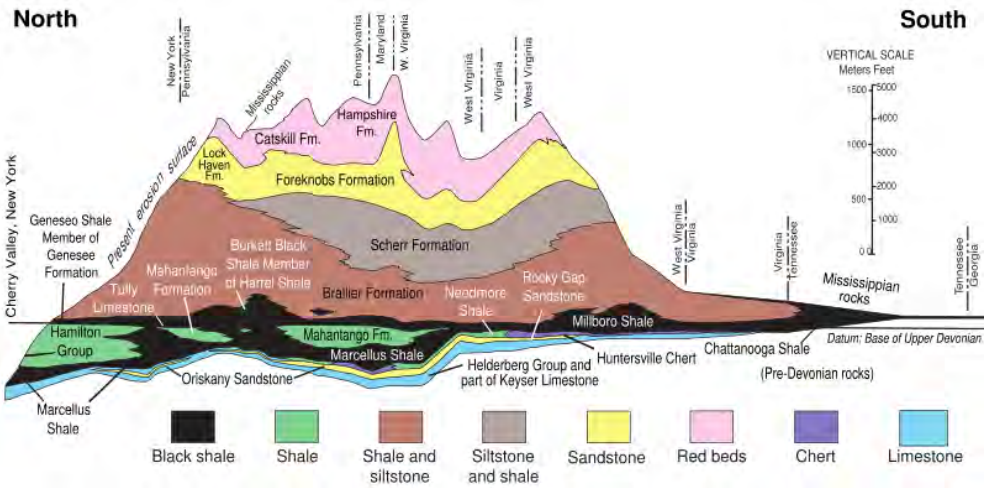
1. **At the particular GIS location of the Robson well, at what depth (top and bottom) is the Marcellus? At what depth (top and bottom) is the Oriskany?**

Well Location: Chesapeake Appalachia, LLC's permit application requested to drill a 8898 ft. True Vertical Depth (TVD) well into the Oriskany formation at latitude 41^0 37' 39.52" N, and longitude 75^0 12' 11.68" W, in Wayne County, Oregon Municipality, Pennsylvania. See attached Google Earth Maps that show the actual well location. The well is proposed to be drilled 4.55 miles NE of Honesdale, Pennsylvania.



The application provided no information on geologic formation depths, well design or wellbore construction path. This lease was unitized, and in doing so, geologic information would have been submitted to the State of Pennsylvania. I was not able to locate the unit application on the web (if needed this could be requested and would likely provide more detailed, site specific geologic information).

However, general geologic stratigraphy is available for this region from the State of Pennsylvania and the USGS, showing the Oriskany Sandstone lies beneath the Marcellus Shale in Wayne County.



The Oriskany Sandstone and the Marcellus Shale are both Devonian aged formations. The Marcellus Shale lies above the Oriskany Sandstone and is believed to be the source rock for the Oriskany Sandstone gas accumulations in places where the Oriskany Sandstone geology created a good structural trap such an anticline to contain the gas. In general, shales are believed to be a common source rock for gas. Gas from shale accumulations may migrate in the subsurface and be stored in more porous sandstone formations, if a structural trap is available in the sandstone formation to contain the gas. The Needmore Shale (which lies above the Oriskany Sandstone, and below the Marcellus Shale) is also believed to be a potential gas source rock (see USGS Figure 47).

This area of Wayne County is known to be Oriskany structural play (see USGS Figure 48). Although the Oriskany Sandstone is known to be present in Wayne County, whether it contains gas is not well known. Most of the Oriskany gas fields developed to date are located several hundred miles to the west.

The bottom of the Devonian Formation at the Robson 1 Well area is approximately 10,000' deep (see USGS Figure 4). In this area, the USGS predicts the Marcellus Shale to be a mature gas source rock (see USGS Figure 31), rather than a gas development source itself (see USGS Figure 13). While Marcellus Shale in Wayne County may provide the source rock for gas stored in the Oriskany Sandstone, it is not predicted by the USGS to be a good area shale gas recovery itself (see USGS Figure 15).

The State of Pennsylvania oil and gas field map of 2007 (see Map 10) shows no known deep gas fields in the Wayne County area. Thus, I assume this well must be an exploratory well, seeking to determine if the Oriskany deep gas play extends east of known western gas fields in Pennsylvania.

I was not able to locate any maps showing the exact depth of the Oriskany or Marcellus formations, but the Devonian formation is believed to be at least 10,000 feet deep. The Oriskany is not the deepest formation in the Devonian. There are other shale and limestone formations in the Devonian that underlie the Oriskany. Thus, if the Devonian is at least 10,000 feet deep in Wayne County, it would make sense that the Oriskany would be shallower at a depth of 8898' TVD.

The State of Pennsylvania maps show the Marcellus Shale is approximately 150-250 thick and overlies the Oriskany sandstone formation in the Wayne County area.[1]

2. **Description of the Oriskany as a porous sandstone layer - is this an accurate description for it wherever the Oriskany label is applied? Is this an accurate description for it at the Robson site?**

   Yes. The USGS characterizes the Oriskany as a lower Devonian sandstone formation.

   > *The Oriskany Sandstone is a white to light gray, texturally mature, coarse-grained to medium-grained quartz sandstone (Edmunds and Berg, 1971; Patchen and Harper, 1996), whose type section is located at Oriskany Falls, New York (Vanuxem, 1839). The*

[1] *Pennsylvania* Geology, Bureau of Topographic and Geologic Survey, Pennsylvania Department of Conservation and Natural Resources, Vol. 38, No. 1, Spring 2008

Oriskany Sandstone and equivalent stratigraphic units are more quartz-rich and coarser-grained to the east, and intergranular cement is more abundant to the east (Patchen and Harper, 1996). In most places, the sandstones are cemented by calcite, and silica cement is common near the top of the formation at some locations (Edmunds and Berg, 1971; Patchen and Harper, 1996).[2]

The State of Pennsylvania reports that the Oriskany Sandstone was a significant source of commercial natural gas in New York and Pennsylvania in the 1930s.[3] The Oriskany gas was typically developed several hundred miles west of Wayne County.

The U.S. Geological Survey (USGS) recently completed an assessment of the technically recoverable undiscovered hydrocarbon resources of the Appalachian Basin Province. The assessment province includes parts of New York, Pennsylvania, Ohio, Maryland, West Virginia, Virginia, Kentucky, Tennessee, Georgia and Alabama. The assessment was based on six major petroleum systems, which include strata that range in age from Cambrian to Pennsylvanian. The USGS reports that Devonian Shale-Middle and Upper Paleozoic TPS contains some of the more productive source rocks and reservoirs for hydrocarbons in the Appalachian Basin Assessment Province. USGS notes that Devonian shale (such as the Marcellus Shale) may contain gas in the eastern part of Pennsylvania because they are autogenic (self-sourced) gas reservoirs, however, the gas may have migrated and been stored in sandstone formations such as the Oriskany Sandstone, a mature, quartzose sandstone, which is known to be up to 360' thick. The USGS characterizes the Oriskany formation as a sandstone formation that collected gas in structural traps located along the crests of anticlines.[4]

[2] U.S. Department of the Interior, U.S. Geological Survey, Open-File Report Series 2006-1237, Assessment of Appalachian Basin Oil and Gas Resources: Devonian Shale–Middle and Upper Paleozoic Total Petroleum System, by Robert C. Milici and Christopher S. Swezey. 2006.

[3] *Pennsylvania* Geology, Bureau of Topographic and Geologic Survey, Pennsylvania Department of Conservation and Natural Resources, Vol. 38, No. 1, Spring 2008

[4] U.S. Department of the Interior, U.S. Geological Survey, Open-File Report Series 2006-1237, Assessment of Appalachian Basin Oil and Gas Resources: Devonian Shale–Middle and Upper Paleozoic Total Petroleum System, by Robert C. Milici and Christopher S. Swezey. 2006.

Reference 4
(Excerpt)

The Oil and Gas Industry's Exclusions and Exemptions to Major Environmental Statutes

EARTHWORKS™

Oil and Gas Accountability Project

EARTHWORKS • www.earthworksaction.org
OIL & GAS ACCOUNTABILITY PROJECT • www.ogap.org

The Oil and Gas Industry's Exclusions and Exemptions to Major Environmental Statutes

Renee Lewis Kosnik, MSEL, JD
Research Director, Oil and Gas Accountability Project

OIL & GAS ACCOUNTABILITY PROJECT,
A PROJECT OF EARTHWORKS
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OGAP P.O. Box 1102 ■ Durango, CO 81302 ■ www.ogap.org
Earthworks 1612 K St. N.W., #808 ■ Washington DC 20006
www.earthworksaction.org

Executive Summary

The oil and gas industry enjoys sweeping exemptions from provisions in the major federal environmental statutes intended to protect human health and the environment. These statutes include the:

- **Comprehensive Environmental Response, Compensation, and Liability Act**
- **Resource Conservation and Recovery Act**
- **Safe Drinking Water Act**
- **Clean Water Act**
- **Clean Air Act**
- **National Environmental Policy Act**
- **Toxic Release Inventory under the Emergency Planning and Community Right-to-Know Act**

This lack of regulatory oversight can be traced to many illnesses and even deaths for people and wildlife across the country. There are a variety of chemicals used during the many phases of oil and gas development. These chemicals also produce varying types of waste throughout these processes. Because of the exemptions and exclusions, toxic chemicals and hazardous wastes are permeating the soil, water sources and the air threatening human health to an alarming extent. In order to adequately remedy the negative impacts on human health and the environment, the following recommendations must be addressed:

1) Crude oil and petroleum must be covered under the *Comprehensive Environmental Response, Compensation, and Liability Act* in order to protect human health and the environment from spills and leaks of hazardous and carcinogenic materials on well sites. This is the only way to currently assist overburdened federal and state programs in light of the exponential growth of oil and gas development in the United States.
2) To protect human health and the environment, oil field wastes must be regulated under the *Resource Conservation and Recovery Act* in order to ensure the proper handling and disposal of hazardous and carcinogenic wastes generated by oil and gas development. Otherwise, the petroleum industry will continue to dispose of oil field waste in ways that can pollute soil, surface and groundwater.
3) Hydraulic fracturing must be regulated by the Environmental Protection Agency under the *Safe Drinking Water Act* in order to adequately protect the United State's drinking water supply from the harmful chemicals used during this process. This recommendation includes a total ban on the use of diesel fuel as one of the additives in the hydraulic fracturing process.
4) Stormwater discharges from all oil and gas development must be regulated under the *Clean Water Act* by the federal government in

order to provide the states with a proper foundation from which to build adequate stormwater programs that will protect human health and the environment from expanding oil and gas development.

Emissions from all oil and gas facilities must be aggregated under the *Clean Air Act* in order to ascertain the true hazardous effect on air quality. Also, hydrogen sulfide must be re-established as a hazardous air emission under the Clean Air Act in light of the current available data regarding its negative impacts on human health and the environment.

Because of the disruptive nature of oil and gas activities on human health and the environment, none of these activities ought to qualify for the categorical exclusion under the *National Environmental Policy Act.* All oil and gas activities must be assessed for impacts on the environment under the more comprehensive environmental assessment and environment impact statement in order to properly fulfill the intentions of the statute.

The petroleum industry must be made to disclose the chemicals used during the development stages under the *Toxic Release Inventory within the Emergency Planning and Community Right-to-Know Act,* in order to ensure that human health and the environment can be protected from these often-hazardous and carcinogenic substances.

One of the goals for the Oil and Gas Accountability Project is to help communities and citizens better understand and protect themselves from the health and environmental impacts associated with toxic oil and gas chemicals and wastes. The following report explains these exemptions, how they apply to oil and gas development, and the consequences to human health and the environment that are left behind. To learn more about the devastating impacts of oil and gas development, read *Oil and Gas at Your Door? A Landowner's Guide to Oil and Gas Development* and *Our Drinking Water At Risk: What EPA and the Oil And Gas Industry Don't Want Us to Know About Hydraulic Fracturing*, available at: www.ogap.org.

Reference 5

Subject: Cabot #2 Well
From: David Kovach <David.Kovach@drbc.state.nj.us>
Date: Tue, 04 Aug 2009 17:05:30 -0400
To: jimmy@arbor-resources.com

Dear Mr. Eichstadt,
I am writing concerning the application for the Cabot #2 well submitted to the Commission by Arbor Operating, LLC (Arbor) on April 16, 2009. As you are aware, on May 19, 2009, the Executive Director of the DRBC issued a determination concerning proposed and existing natural gas wells and associated appurtenances completed in the Marcellus Shale and other shale formations in the drainage area of Special Protection Waters in the Delaware River Basin. As the Cabot #2 natural gas well that Arbor has proposed lies within the drainage area to the special protection waters known as the Lower Delaware and is proposed to be drilled into a shale formation, it is covered under the Executive Director determination. As Arbor has stated that they propose to develop the well if a viable quantity of natural gas is discovered, the well is not therefore being drilled solely for exploratory purposes and is again covered under the Executive Directors Determination. The well may not be covered under the determination if a cap and plug plan is submitted to the Commission and it is affirmed that the well will be properly abandoned upon completion and collection of necessary exploratory data. The groundwater withdrawal rate of significantly less than 100,000 gpd during any consecutive 30-day period detailed in the application is not specifically covered by DRBC regulations, but all water supplies, no matter what the withdrawal volume, will be considered from a potential impact/interference standpoint when an application for a natural gas well in Marcellus or other shale proposed in special protection waters is being reviewed.

The application for the Cabot #2 well as submitted requires additional information if natural gas development at the well is to be considered for DRBC approval. These include, but are not necessarily limited to the following:

1) A revised applicant statement and appropriate fee, related to the actual total project costs that would include the drilling and construction of the Cabot #2 well.

2) The necessary information included in the attached draft natural gas project submission requirements word document.

If the well will be used solely for exploratory purposes, then an appropriate cap and plug plan must be submitted to the Commission affirming that the well will be properly abandoned upon completion and collection of necessary scientific data.

Please contact me if you have any further questions,
Dave

--
David Kovach, P.G.
Geologist, Project Review Section
Delaware River Basin Commission
(p) 609-883-9500 ext 264
(f) 609-883-9522
(e) david.kovach@drbc.state.nj.us

Shale gas drilling project submission requirements.doc	**Content-Type:** application/msword **Content-Encoding:** base64

Reference 6
(Excerpt)

A View of the River

Luna B. Leopold

Harvard University Press
Cambridge, Massachusetts
London, England

of the stream systems throughout the year. The most useful supporting evidence is the information obtained from local residents.

. . . All perennial streams are published regardless of length.

All intermittent streams are published that are longer than 2,000 feet. . . . In applying these rules they should be modified where necessary to produce a consistent portrayal, especially in the extension of streams in headwater drainage.

. . . Streams at the source and upper part of a drainage system are an integral and important part of a complete drainage system. In general, headwater drainage shown on the published map should terminate no higher than about 1,000 feet from the divide, or at the upper confluence of streams, whichever appears most appropriate.

These instructions to the staff preparing a topographic map show that the headward limits of the blue lines do not reflect any statistical characteristic of streamflow occurrence. The specification that the blue line terminate no higher than about 1,000 feet from the watershed divide does not reflect differences in hydrologic performance among various combinations of climate, topography, and geology. Rather, the choice of what is to be shown as an interrupted blue line is based on "consistent portrayal," as the instructions state. The geomorphologist must provide a personal rationale and evidence for designation of first-order tributaries in any given area.

It would be desirable to have some criteria resulting from field studies that would give specific statistical or physical significance to the type of line used on a topographic map. The criteria might stem from a study on the frequency or duration of flow in channels of different sizes or drainage areas. For example, it would be useful if one knew that the solid blue line became dash-dot where a streamflow changed from 90 percent of the time to 80 percent. This change might be a function of drainage area within a given physiographic or lithologic unit. The determination would have to be specific, but also easy in mapmaking practice.

I tried to devise a way of defining hydrologic criteria for the channels shown on topographic maps and developed some promising procedures. None were acceptable to the topographers, however. I learned that the blue lines on a map are drawn by nonprofessional, low-salaried personnel. In actual fact, they are drawn to fit a rather personalized aesthetic. It is surprising that geographers, long interested in mapmaking, have not considered this problem and devised some useful and simple rules based on generalizations from field facts.

In Figure 12.6 appear three versions of the drainage network of Watts Branch above Viers Pasture near Rockville, Maryland. The first map

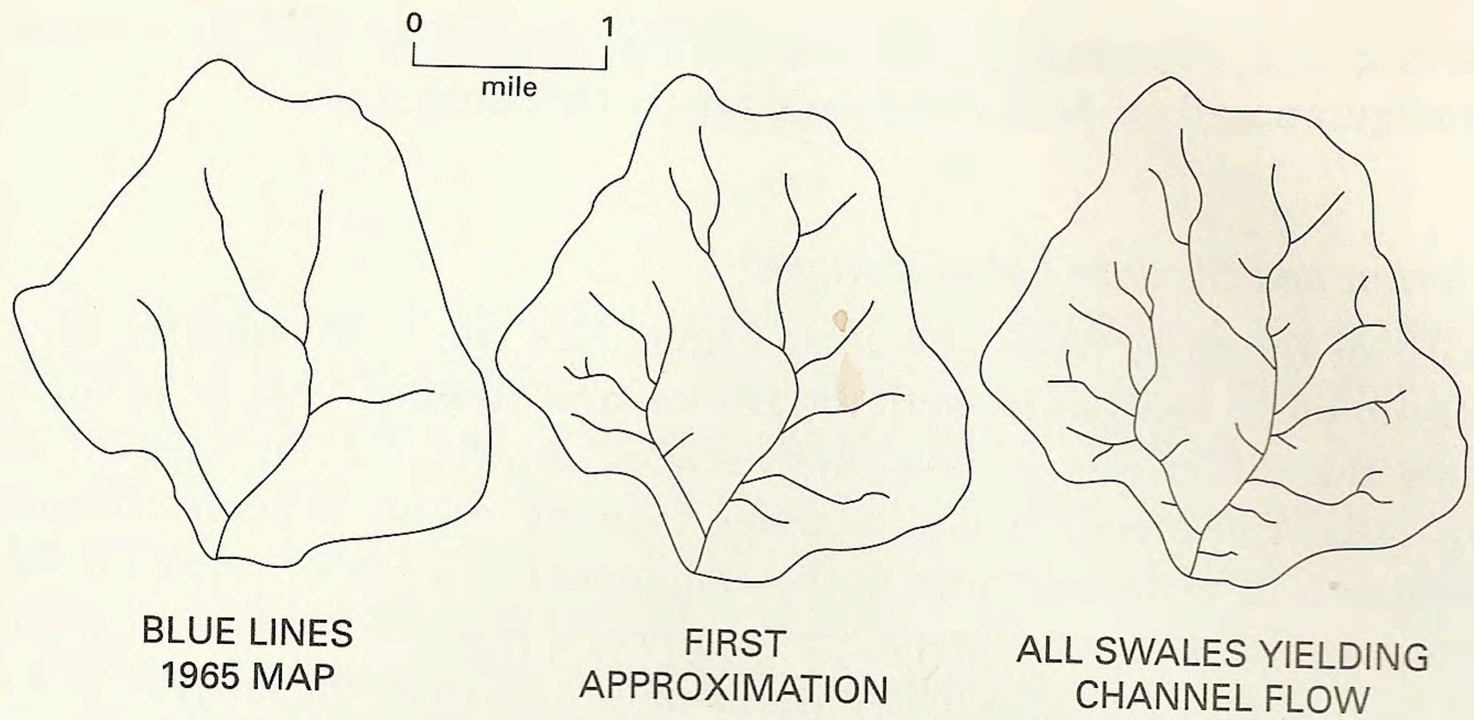


Figure 12.6 Three versions of the channel network. At left, blue lines printed on a 1965 topographic map; at center, a more detailed net; at right, careful analysis of the contour pattern to include all significant swales or draws. Watts Branch, Maryland; drainage area 3.7 square miles.

shows the drainage net depicted by blue lines on the 1965 edition of the topographic map. This net includes both solid blue and dot-dash blue lines, indicating streams as depicted on the published quadrangle map.

The middle version is the drainage net derived from study of the contour lines of the topographic map, in an effort to draw a stream channel in the principal contour reentrants. The channels are drawn in a consistent manner, so that the same contour configuration applies to each draw or swale considered important enough to be represented as a channel.

Finally, the third version is an attempt to add to the drainage net all swales considered prominent enough to yield channel flow during storms, an admittedly subjective choice. For consistency, headwater tips of tributaries shown in the second version are extended headward to be comparable in drainage area and distance from divide to the smallest newly added channels.

The three maps show the differences in drainage network that might logically be derived from the same topographic map. From both field experience and network analysis, preference would be for the third or most detailed version. To construct such a complete map, however, requires considerable time in excess of what is needed for the second, intermediate version. Such extra effort may be precluded if a network map is required for a large area. Either the second or the third version is preferable for nearly all purposes to the first. Comparable maps for some European countries, especially Belgium, are close to the second version,

Reference 7

5500-PM-OG0005 Rev. 12/2009
Application

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT
BUREAU OF OIL AND GAS MANAGEMENT

OFFICIAL USE ONLY
ID #_____
Date Received _____

NOTICE OF INTENT FOR COVERAGE UNDER THE EROSION AND SEDIMENT CONTROL GENERAL PERMIT (ESCGP-1) FOR EARTH DISTURBANCE ASSOCIATED WITH OIL AND GAS EXPLORATION, PRODUCTION, PROCESSING OR TREATMENT OPERATIONS OR TRANSMISSION FACILITIES

READ THE STEP-BY-STEP INSTRUCTIONS PROVIDED IN THIS PERMIT APPLICATION PACKAGE BEFORE COMPLETING THIS FORM.

PLEASE PRINT OR TYPE INFORMATION IN BLACK OR BLUE INK.

APPLICATION TYPE **NEW** ☐ **RENEWAL** ☐ **REVISED** ☐ **EXPEDITED** ☐

SECTION A. E&S PLANNING REQUIREMENTS

1. Total Project Area (Acres): _____ Total Disturbed Area (Acres): _____

2. Project Name

3. Project Type

☐ Oil/Gas Well ☐ Pipeline/Transmission Facility ☐ Processing Facility ☐ Treatment Facility

Project Description

_____

_____

_____

_____

4. Please provide the latitude and longitude coordinates for the center of the project. The coordinates should be in degrees, minutes and seconds (dd mm ss.ss)

Latitude _____degrees _____minutes _____seconds Longitude _____ degrees _____ minutes _____ seconds

Reference Datum: ☐ North American Datum 1983 ☐ North American Datum 1927 ☐ World Geodetic System 1984

Horizontal Collection Method: ☐ GPS ☐ Interpolated from U.S.G.S. topo map ☐ DEP's eMAP

5. U.S.G.S. 7.5 min. Quad Map Name _____

6. Will the project be conducted as a phased permit project? ☐ Yes ☐ No If Yes, Include Master Site Plan

Estimated Timetable for Phased Projects ☐ Additional sheet(s) attached

Phase No. or Name	Description	Total Area	Disturbed Area	Start Date	End Date

7. Existing and previous land use

8. Other Pollutants: Will the stormwater discharge contain pollutional substances other than sediment? ☐ Yes ☐ No If yes, explain and provide any available quantitative data.

9. Will fuels, chemicals, solvents, other hazardous waste or materials be used or stored on site during earth disturbance activities?
Yes ☐ No ☐ **(If yes, a PPC Plan is required)**

10. Receiving Water/Watershed Name	Name of Municipal or Private Separate Storm Sewer Operator
Chapter 93 Designated Use or Existing Use Stream Classification ☐ High Quality ☐ Exceptional Value ☐ Other Secondary Water	

SECTION B. APPLICANT INFORMATION

Applicant's Last Name	First Name	MI	Phone FAX	
Organization Name or Registered Fictitious Name			Phone FAX	
Mailing Address	City		State	ZIP + 4
Co-Applicant's Last Name	First Name	MI	Phone FAX	
Organization Name or Registered Fictitious Name			Phone FAX	
Mailing Address	City		State	ZIP + 4

SECTION C. SITE INFORMATION

Site Name			
Site Location			
Site Location -- City	State	ZIP+4	
Detailed Written Directions to Site			

County	Municipality	City ☐	Boro ☐	Twp ☐

SECTION D. SITE RESTORATION PLAN AND POST CONSTRUCTION STORMWATER BMPS
See the Attached Instructions on how to Complete This Section

1. Site restoration should be designed to use natural measures to eliminate pollution, infiltrate runoff, not require extensive construction and maintenance efforts, promote pollutant reduction, preserve the integrity of stream channels, and protect the physical, chemical and biological qualities of the receiving water.

Check those that apply:

☐ The Site Restoration Plan and PCSM BMPS are developed to be consistent with an Act 167 Stormwater Management Plan approved by the Department after January 2005.

☐ The Site Restoration Plan and PCSM BMPs are developed to be consistent with existing local ordinances.

☐ The Site Restoration Plan and PCSM BMPs were developed to employ water quality design features and the PCSM BMPs will manage any net increase in stormwater runoff volume resulting from the 2-year/24-hour frequency storm.

2. Site Restoration Plan Contents

a. Written narrative ☐ Yes ☐ No

b. Plan drawings ☐ Yes ☐ No

c. Identification and location of PCSM BMPs. Such PCSM BMPs should address: (1) infiltration; (2) volume and rate control; and (3) water quality treatment ☐ Yes ☐ No

d. Operation and maintenance procedures ☐ Yes ☐ No

e. Supporting calculations and measurements (when necessary): ☐ Yes ☐ No

Supporting calculations and measurements are required only if the answers to both questions 1 and 2 below are NO.

1) The approximate original contours of the project site will be maintained or replicated insuring the preservation of the pre-construction drainage pattern and features; and the disturbed areas will be re-vegetated or otherwise stabilized with pervious material. ☐ Yes ☐ No

2) PCSM BMPs will be employed which: use natural measures to eliminate pollution, do not require extensive construction and maintenance efforts, promote pollutant reduction, and are capable of controlling the net increase in the volume and rate of stormwater runoff from a 2-year/24-hour storm event, and the net increase in the volume of post construction runoff is infiltrated and/or dissipated away from surface waters of the Commonwealth. ☐ Yes ☐ No

If the responses to both questions 1 and 2, above are NO, please provide the requested post construction stormwater information in the Data Table for Supporting Calculations and Measurements below:

3. Explain how post construction stormwater runoff volume will be managed if BMPs will not infiltrate the total net increase in stormwater runoff volume. (Net increase volume = Post construction runoff volume minus Pre-construction runoff volume):

☐ N/A (check N/A only if BMPs **will** infiltrate all of the Net Change in Runoff)

4. Are there existing post construction stormwater management BMPs at this Location/Site? ☐ Yes ☐ No

Do you plan to use and/or expand these existing post construction stormwater management BMPs? ☐ Yes ☐ No ☐ N/A

5. **SUMMARY TABLE FOR SUPPORTING CALCULATION AND MEASUREMENT DATA**
See the Instructions on how to Complete This Section

☐ Check this box if supporting calculations and measurements are NOT required in accordance with Section D.2.e on the preceding page.

Design storm frequency _____ Rainfall amount _____ inches	Pre-construction	Post Construction	Net Change
Impervious area (acres)			
Volume of stormwater runoff (acre-feet) without planned stormwater BMPs			
Volume of stormwater runoff (acre-feet) with planned stormwater BMPs			
Stormwater discharge rate for the design frequency storm			

SUMMARY DESCRIPTION OF POST CONSTRUCTION STORMWATER BMPs

6. In the lists below, check the BMPs identified in the Site Restoration Plan. The primary function(s) of the BMP listed in the functions column (infiltration/recharge; detention/retention; water quality). Additional functions may be added if applicable to that BMP. List the stormwater volume and area of runoff to be treated by each BMP type when calculations are required. If any BMP in the Site Restoration Plan is not listed below, describe it in the space provided after "Other".

BMP	Function(s)	Volume of stormwater treated	Acres treated
Bio-infiltration areas	Infiltration/Recharge		
☐ Infiltration Trench		_____	_____
☐ Infiltration Bed		_____	_____
☐ Infiltrated Basin		_____	_____
Natural Area Conservation	Infiltration/Recharge		
☐ Streamside Buffer Zone		_____	_____
☐ Wetland Buffer Zone		_____	_____
☐ Sensitive Area Buffer Zone		_____	_____
☐ Pre-Construction Drainage Pattern Intact		_____	_____
Stormwater Retention	Detention/Retention		
☐ Constructed Wetlands		_____	_____
☐ Wet Ponds		_____	_____
☐ Retention Basin		_____	_____
Sediment and Pollutant Removal	Water Quality Treatment		
☐ Vegetated Filter Strips		_____	_____
☐ Brush Barriers		_____	_____
☐ Detention Basins		_____	_____
Access Road Design	Infiltration/Recharge		
☐ Road Crowning		_____	_____
☐ Ditches		_____	_____
☐ Turnouts		_____	_____
☐ Culverts		_____	_____
☐ Roadside Vegetated Filter Strips		_____	_____
Stormwater Energy Dissipaters	Infiltration/Recharge		
☐ Level Spreaders		_____	_____
☐ Riprap Aprons		_____	_____
☐ Upslope Diversions		_____	_____
☐ _____		_____	_____
		_____	_____

SECTION E: SPECIAL PROTECTION WATERS

List the reasonable and cost effective best management practices (BMPs) that will be used to meet the requirements of 25 Pa. Code Chapter 93. Recommended Special Protection Watershed BMPs are found in the Oil and Gas Operators Manual.

☐ Minimize disturbed area	☐ Alternative Site Analysis	☐ Permanently stabilized ditches and Channels
☐ Earth Moving activities limited during rainstorms and spring thaw	☐ Roads stabilized with crushed rock and/or vegetation	☐ Rock lined culvert inlets and outlets
☐ No direct discharge to surface water	☐ Immediate Stabilization	☐ Proper vegetative cover techniques
☐ Designed temporary and permanent BMPs for surface water diversion	☐ Prompt site restoration	☐ 100 ft. vegetated riparian buffer
☐ Other	☐ Stabilized Upslope Diversion	

SECTION F: COMPLIANCE REVIEW

☐ Yes ☐ No

Is the applicant in violation of any existing permit, regulation, order, or schedule of compliance issued by the Department within the last 5 years? If yes, provide the permit number or facility name, a brief description of the violation, the compliance schedule (including dates and steps to achieve compliance) and the current compliance status. (Attach additional information on a separate sheets, when necessary)

SECTION G. CERTIFICATION BY PERSON PREPARING APPLICATION

I do hereby certify to the best of my knowledge, information, and belief, that the Erosion and Sediment Control and PCSM/Site Restoration Plan are true and correct, represent actual field conditions, and are in accordance with the 25 Pa. Code Chapters 78 and 102 of the Department's rules and regulations. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Print Name	Signature	Professional Seal
Company		
Address		
Phone		
Most Recent DEP Training Attended Location _____ Date _____		

EXPEDITED REVIEW PROCESS

In addition to the certification required above applicants using the expedited permit review process must attach an E&S and PCSM/Site Restoration Plan developed and sealed by a licensed professional engineer, surveyor or professional geologist. The plans shall contain the following certification:

> *I do hereby certify to the best of my knowledge, information, and belief, that the Erosion and Sediment Control and PCSM/Site Restoration Plan and Post Construction BMPs are true and correct, represent actual field conditions and are in accordance with the 25 Pa. Code Chapters 78 and 102 of the Department's rules and regulations. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.*

SECTION H. APPLICANT CERTIFICATION

Applicant Certification. I certify under penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. The responsible official's signature also verifies that the activity is eligible to participate in the permit, and that the applicant agrees to abide by the terms and conditions of the permit. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Print Name and Title of Applicant	Print Name and Title of Co-Applicant (if applicable)
Signature of Applicant	Signature of Co-Applicant
Date Application Signed	Date Application Signed

Notarization

Sworn to and subscribed to before me this

_____ day of _____, 20_____

Commonwealth of Pennsylvania

County of _____

_____

Notary Public

My Commission expires _____

AFFIX SEAL

NAME, ADDRESS AND PHONE NUMBER OF INDIVIDUAL TO BE CONTACTED IF ADDITIONAL INFORMATION IS REQUIRED

Name	
Address	Phone

Reference 8

5500-PM-OG0002-DXF Rev. 11/2003

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking # 395#634450 Permit # 127-21006 Project #	Rev. 3/11/08

Denotes location of well on topo map.

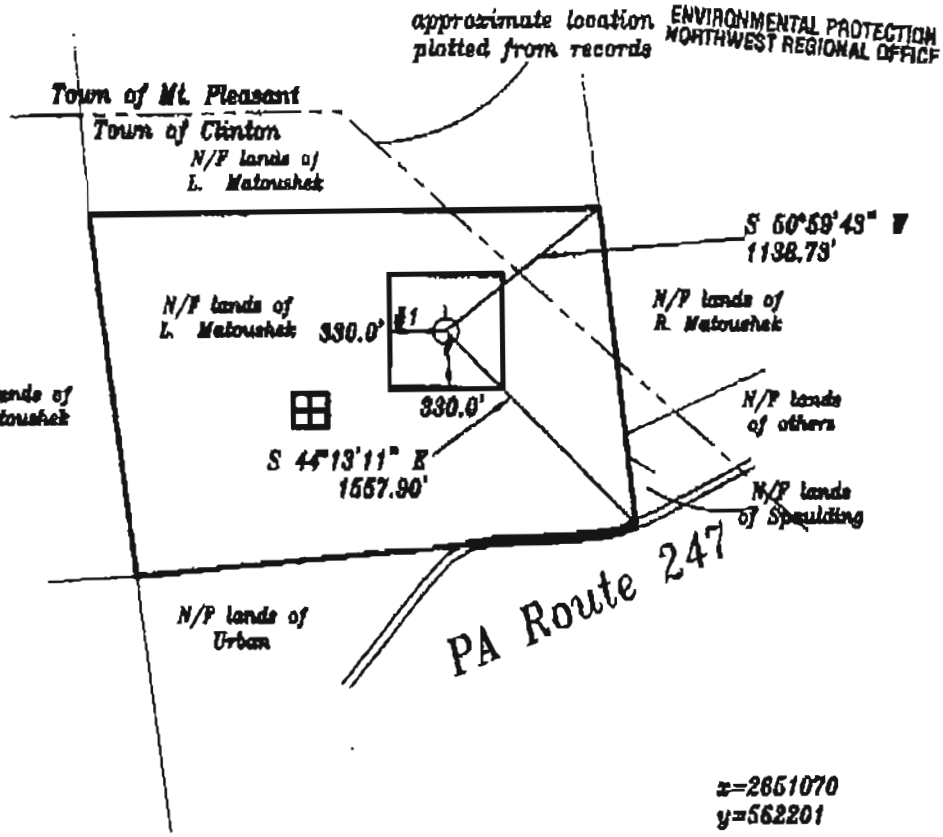
True Latitude: NORTH
41° 41' 06.39"

True Longitude: WEST
75° 21' 58.21"

Well is located on topo map 8496 feet south of latitude 41 ° 42 ' 30 "

Well is located on topo map 8968 feet west of longitude 75 ° 20 ' 00 "

RECEIVED
MAR 06 2008
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE



Surveyor or Engineer: D. Michael Cavada, Pa. Lic. # 029272 E	Phone #: (716) 379-7915	Dwg. #: 6669	Date: Rev. 3/3/08 December 12, 2007	Scale: 1" = 1000'
Tract Acreage: 133.45 AC				
Lat. & Long Metadata: Method: Static GPS Accuracy: ± 10 ft. Datum: NAD 27			Elevation Metadata: Method: Scaled Accuracy: ± 10 ft. Datum: USGS Quad	Survey Date: Dec. 11, 2007
Applicant / Well Operator Name: Stone Energy Corporation			Well(Farm) Name: Matoushek	Well #: # 1
Serial #:				
Address: PO Box 5280 Lafayette, LA. 70506			County - Code: Wayne	Municipality: Clinton / Mt. Pleasant
Surface Landowner: Louis Matoushek			USGS 7½ Quadrangle Map Name: Aldenville	Map Section: 4
Surface Lessor:			Angle & Course of Deviation (Drilling):	Surface Elevation: 1545 ±
Anticipated Total Depth: 8150' ±				

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated

Reference 9

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 826657
Watershed Name: Shehawken Rattlesnake Creek	Quality: HQ

Permittee: NEWFIELD APPALACHIA PA LLC	OGO.#: OGO-67425	Permit Number: 37-127-20013-	Date Issued: 04/23/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020		Farm Name & Well Number: DL TEEPLE 1 1	Well Serial #:
		Municipality: Manchester	County: Wayne
HOUSTON, TX 770602424		7½' Quadrangle Name: Long Eddy	Map Section #: 1
Phone: (281) 847-6031	Project #:	Latitude: 41-49-39.9000	Longitude: -75-11-53.3300
Surf Elev at Site: 1516 feet	Anticipated Total Depth: 8350 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 2304 feet West 8580 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/23/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Stan Gustafson for S. Craig Lobins
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

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OIL & GAS

5500-PM-OG0001 Rev. 10/2009

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 1063245	Amount $ 1500.00

#1250 + 250 #1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes			
Vertical Test Well	OGO # 67425	Objection Date - Do not issue before: 4/5/10	Well Permit # 127-20013
	Bond # 12382		Special Cond. A B C D E F
	C: 3/11/10 G: 4/5/10 INV: 4-22-10	Date Approved: 4/20/10	Watershed Name: Shehawken Rattlesnake Creek
			Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
D.L. Teeple	1-1	

County	Municipality	Project # (from DEP)
WAYNE	MANCHESTER	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled***, check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled**, if known:_____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL
Check one.
- ☐ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☒ Other (specify)

vertical test well

APPLICATION FEE
Check applicable.
- ☐ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☒ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☐ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☒ Vertical: Length 8350 ft.
- ☐ Marcellus: Length _____ ft.
- ☐ Non-Vertical: Length _____ ft.

Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, Is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," Is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

DEP USE ONLY
Date Stamps/Notes
Auth 826659
Site 731937
Clnt 277879
APS 715262
Acct 674710
PF 728625
SF 1010226

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the **"Coordination of a Well Location with Public Resources"** form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. _____	☐	☒

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date
Donald F. Sleeth II			3-5-10

Application Preparer/Contact: BETSY COLLINS Phone: 412-921-8250

5500-PM-OG0002-DWG Rev. 09/2008

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: ACO 4/19/10
	Permit # 127-20013	C:
	Project #	

Denotes location of well on topo map.

True Latitude: NORTH
41 ° 49 ' 39.90 "

True Longitude: WEST
75 ° 11 ' 53.33 "

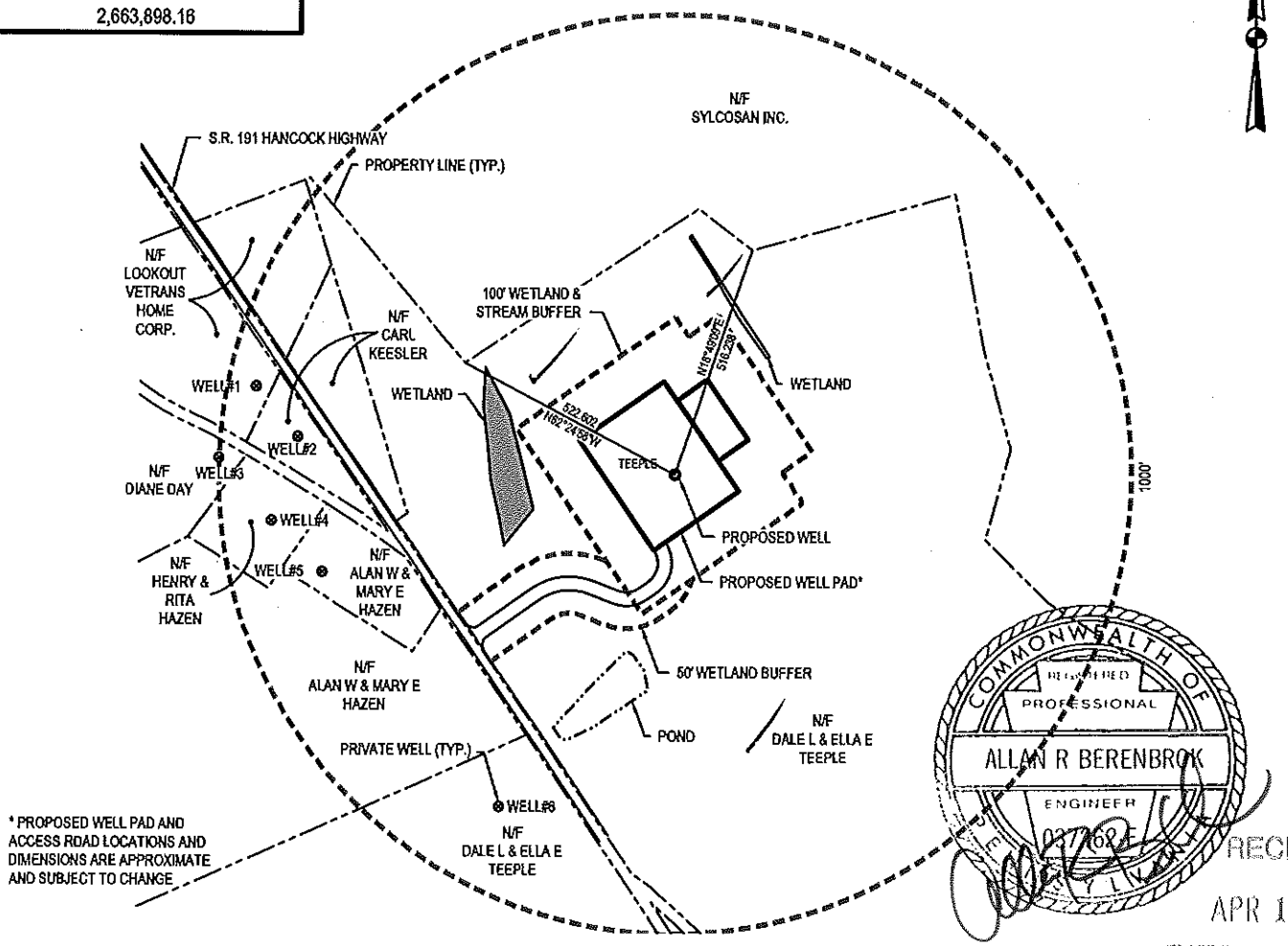
WELL NORTHING - Y
615,470.64

WELL EASTING - X
2,663,898.16

Well is located on topo map 2,034 feet south of latitude 41 ° 50 ' 00 "

Well is located on topo map 8,580 feet west of longitude 75 ° 10 ' 00 "

HQ WATERSHED Shehawken Rattlesnake Creek



COMMONWEALTH OF PENNSYLVANIA REGISTERED PROFESSIONAL ALLAN R BERENBROK ENGINEER

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Surveyor or Engineer TETRA TECH Phone # (412) 921-8873 Dwg. # 1 Date 4/16/2010 Scale 1" = 400' Tract Acreage

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83		Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Survey Date Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC		Well(Farm) Name: D.L. Teeple	Well # 1-1 / Serial #
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code: Wayne / Municipality: Manchester	Well Type: Vertical Test
Surface Landowner / Lessor: Dale and Ella Teeple		USGS 71/2 Quadrangle Map Name: Long Eddy, NY 0444	Map Section: 5 / Surface Elevation: 1516 ft.
Target Formation(s): Onondaga		Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth: TVD 8,350 TMD 8,350

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Lookout Veterans Home Corp.	N78d 20' 44"W 938'	N/A	N/A
Carl Keesler	N84d 27' 43"W 832'	N/A	N/A
Dale L & Ella E Teeple	S27d 51' 49"W 818'	N/A	N/A
Alan W Mary E Hazen	S74d 33' 6"W 802'	N/A	N/A

R:_Marcellus Shale Projects\Newfield\2679 - Newfield Wells\Well Plat Permits\Permit Drawings\Teeple Well Pad Plat Exhibit A.dwg PIT BEN.HOPPE 4/16/2010 12:43:02 PM

Reference 10

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 830993
Watershed Name: Salt River Brook	Quality: HQ

Permittee: NEWFIELD APPALACHIA PA LLC	OGO.#: OGO-67425	Permit Number: 37-127-20018-00	Date Issued: 05/25/2010
Address: 363 N SAM HOUSTON PKWY E		Farm Name & Well Number: DL TEEPLE 1 2H	Well Serial #:
SUITE 2020		Municipality: Manchester	County: Wayne
HOUSTON, TX 77060-2424		7½' Quadrangle Name: Long Eddy	Map Section #: 5
Phone: (281) 674-2501	Project #:	Latitude: 41-49-23.1900	Longitude: -75-11-39.3900
Surf Elev at Site: 1438 feet	Anticipated Total Depth: 8140 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 3725 feet West 7525 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

The permittee shall not withdraw or use water from water sources within the Commonwealth of Pennsylvania, for well fracing activities, unless the permittee does so in accordance with a Water Management Plan approved by the Department.

Permittee shall obtain a permit or Environmental Assessment approval from the Department prior to the construction of any dam, reservoir, water obstruction, and/or encroachment for which a permit or Environmental Assessment approval is required by 25 Pa. Code Chapter 105. Any dam embankment including centralized dam embankments utilized to impound freshwater or frac water associated with well fracing not requiring a permit pursuant to 25 Pa. Code Chapter 105 will be constructed in accordance with requirements of 25 Pa. Code §§ 78.56-78.63 and Department guidelines 5500-PM-OG0085 entitled, Design, construction and maintenance standards for dam embankments associated with impoundments for oil and gas wells.

Prior to fracturing the well, as part of its Preparedness, Prevention and Contingency Plan the permittee shall implement a Control and Disposal Plan for the control and disposal of fluids and residual wastes in accordance with 25 Pa. Code § 78.55. The Control and Disposal Plan shall identify the control and disposal methods and practices utilized to prevent pollutants from directly or indirectly reaching waters of the Commonwealth during the impoundment, production, processing and transportation of pollutants, including identification of the permitted processing or disposal facilities where residual wastes will be processed or disposed, in accordance with 25 Pa. Code §§ 78.55 and 91.34.

Prior to transport of the residual wastewater off site, chemical analysis and characterization of the waste shall be conducted and provided to the processing or disposal facility intended for acceptance of the waste in accordance with 25 Pa. Code § 287.54.

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OIL & GAS

The Operator shall run a complete angular deviation survey of the intentionally deviated well. The deviation survey is to be obtained by a responsible well surveying company and shall be filed with the Department within thirty (30) days after well drilling together with other regularly required reports.

This permit expires **05/25/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Regional Oil and Gas Program Manager

Stephen Watson	2 Public Square	570-826-2320
Oil & Gas Inspector	Wilkes-Barre, PA 18711-0790	Telephone

5500-PM-OG0001 Rev. 10/2009

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

ESM10-127-0001

DEP USE ONLY	
AUTH #	NC
Check # 1067827	Amount $ 3650.00

1067826 $500.00

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY

Notes	OGO # 67425	Objection Date - Do not issue before: 4/26/10	Well Permit # 127-20018 NC
	Bond # 12382		Special Cond. A B C D (E) F
	C: 4/13/10 mm G: 4/26/10	Date Approved: 5/21/10	Watershed Name: SALT RIVER BROOK
	INV: 5-24-10		Designation: (HQ) EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	
Newfield Appalachia PA LLC	277879	281-674-2501	281-674-2902	Check if new address. ☐
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
D.L. Teeple	1-2H	

County	Municipality	Project # (from DEP)
WAYNE	MANCHESTER	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled**, if known:_____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE
Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☒ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL
Check one.
- ☒ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☐ Other (specify)

APPLICATION FEE
Check applicable.
- ☒ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☐ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☒ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☐ Vertical: Length ____ ft.
- ☒ Marcellus: Length 13,548.8 ft.
- ☐ Non-Vertical: Length ____ ft.

Total Application Fee $ 4,150

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☐	☒
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☐	☐
b. Does the location fall within an area covered by a spacing order?	☐	☐
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

DEP USE ONLY
Date Stamps/Notes
Auth 830993
Site 733332
Clnt 277879
APS 717984
Acct 1676740
PF 729789
SF 1012170

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "**Coordination of a Well Location with Public Resources**" form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. See Attached Module	☒	☐

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date 4-12-10

Application Preparer/Contact: ANDREW STRASSNER Phone: 412-862-7963

5500-PM-OG0001 Rev. 10/2009

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple 1-2H	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

Name	Address	Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification (Note the means and attach proof.) Certified Mail Dates: Sent	Certified Mail Dates: Return Receipt	Address Affidavit	Written Consent
Dale L & Ella E Teeple	13 Teeple Road Equinunk, Pa 18417-3514	X					X						X
Roger D & Patricia A Hazen	3697 Hancock Hwy Equinunk , Pa 18417-3164						X						X
Granville W & Charlene Teeple	24 Sault River Road Equinunk, Pa 18417-3501						X			3-25-10	3-29-10		
Cynthia F Rowe	3743 Hancock Hwy Equinunk, Pa 18417-3166						X			3-25-10	3-27-10		

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APR 13 2010
ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☑ Water Purveyor or ☑ Landowner with water supply within 1,000 ft.	Date 3-31-10	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location: Dale L Teeple	Date 3-31-10	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location: Ella E. Teeple	Date 3-31-10	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

Dale L Teeple Ella E. Teeple

8100E-L61

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple 1-2H	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 — Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification (Note the means and attach proof.) Certified Mail Dates: Sent	Certified Mail Dates: Return Receipt	Address Affidavit	Written Consent
Name: Dale L & Ella E Teeple	Address: 13 Teeple Road Equinunk, Pa 18417-3514	X					X						X
Name: Roger D & Patricia A Hazen	Address: 3697 Hancock Hwy Equinunk , Pa 18417-3164						X						X
Name: Granville W & Charlene Teeple	Address: 24 Sault River Road Equinunk, Pa 18417-3501						X			3-25-10	3-29-10		
Name: Cynthia F Rowe	Address: 3743 Hancock Hwy Equinunk, Pa 18417-3166						X			3-25-10	3-27-10		
Name:	Address:												
Name:	Address:												
Name:	Address:												

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Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☑ Landowner with water supply within 1,000 ft. Roger D. Hazen	Date 03/30/2010	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☑ Landowner with water supply within 1,000 ft. Patricia A. Hazen	Date 3/30/2010	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

1871-2201 8

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
D.L. Teeple 1-2H	
Applicant Name	DEP ID#:
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification (Note the means and attach proof.) Certified Mail Dates: Sent	Certified Mail Dates: Return Receipt	Address Affidavit	Written Consent
Name: Dale L & Ella E Teeple	Address: 13 Teeple Road Equinunk, Pa 18417-3514	X					X						X
Name: Roger D & Patricia A Hazen	Address: 3697 Hancock Hwy Equinunk , Pa 18417-3164						X						X
Name: Granville W & Charlene Teeple	Address: 24 Sault River Road Equinunk, Pa 18417-3501						X			3-25-10	3-29-10		
Name: Cynthia F Rowe	Address: 3743 Hancock Hwy Equinunk, Pa 18417-3166						X			3-25-10	3-27-10		
Name:	Address:												
Name:	Address:												
Name:	Address:												

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Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

8100C-LG1

Acct-676742

5500-PM-OG0001a 3/2009
Application

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF OIL AND GAS MANAGEMENT

DEP USE ONLY	
APS # 717984	Site # 733332
Permit # 127-20018	Auth ID # 830995

Erosion, Sediment and Stormwater Control MODULE

ESM10-127-0001

Please complete this section if your earth disturbance activities will disturb 5 acres or greater.

1. Project Site Information.

   a. Attach topographic map of proposed location.

   b. Location of surface waters which may receive runoff and the waters classification, pursuant to Chapter 93 and the "statewide existing use listing":

   Receiving Waters/Watershed Name
   Salt River Brook / Little Equinunk Creek

   Chapter 93 Designated Use or Existing Use Stream Classification
   (High Quality) Exceptional Value Other _____

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2. Erosion and Sediment Control authorization for Earth Disturbance Associated with Oil and Gas Activities filing fee of $500 payable to: Commonwealth of Pennsylvania, Clean Water Fund.

3. **Compliance History**

   Is the applicant in violation of any existing permit, regulation, order or schedule of compliance issued by the Department? If yes, provide the permit number or facility name, a brief description of the violation, the compliance schedule (including dates and steps to achieve compliance) and the current compliance status.

   Yes (No)

   (Attach on a separate sheet, if needed)

4. **Erosion & Sediment Control and Site Restoration Plan**

   At least fourteen days before the commencement of earth disturbance activities, or earlier in accordance with applicable Chapter 105 permitting requirements, the applicant shall provide the appropriate DEP Regional Oil and Gas Program Office with the following:

   A. An Erosion and Sediment Control and Site Restoration Plan that meets the requirements of 25 Pa. Code Chapters 78 and102, and in the Department's *Erosion and Sediment Pollution Control Manual*, No. 363-2134-008, as amended and updated and the Department's *Oil and Gas Operator's Manual*, No. 550-0300-001.

   B. The Site Restoration Plan shall include PCSM BMPs designed and implemented to meet the requirements of 25 Pa. Code Chapter 93, and consistent with the *Pennsylvania Stormwater Best Management Practices Manual*, No. 363-0300-002, as amended and updated.

   Both the E&S and Site Restoration Plan shall minimize the accelerated erosion and sedimentation and shall eliminate the net change in post construction stormwater runoff as compared to the amount of preconstruction stormwater runoff. This shall be accomplished first through the use of site design and nonstructural BMP approaches, and if necessary structural filtration, infiltration, and runoff control BMPs in accordance with *Erosion and Sediment Pollution Control Manual*, No. 363-2134-008, *Oil and Gas Operator's Manual*, No. 550-0300-001and *Stormwater Best Management Practices Manual*, No. 363-0300-002, as amended and updated. Supporting calculations and measurements for PCSM BMPs are not required unless there will be permanent impervious paved surfaces or above-ground structures or facilities (excluding well-heads and brine storage tanks and other such ancillary equipment. See model plan for further guidance). Crushed rock or gravel roads are not considered impervious.

   Both the E&S and Site Restoration Plan shall be developed and sealed by a licensed professional engineer, surveyor or professional geologist, and shall contain the following certification:

   I do hereby certify to the best of my knowledge, information and belief, that the Erosion and Sediment Control and Site Restoration Plan are true and correct, represent actual field conditions and are in accordance with the 25 Pa. Code Chapters 78 and 102 of the Department's rules and regulations. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

   Print Name: _____ Signature: _____

   Company: _____

   Address: _____

   Phone: _____

5. **Area Wide or Phased E&S and Stormwater Management**

   List the well permit numbers for any other well permit that is or will be included in the E&S and/or Site Reclamation Plan for this project:

   _____

5500-PM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: JR 4/26/10
	Permit # 127-20018	C:
	Project #	

Denotes location of well on topo map.

True Latitude: NORTH
41 ° 49 ' 23.19 "

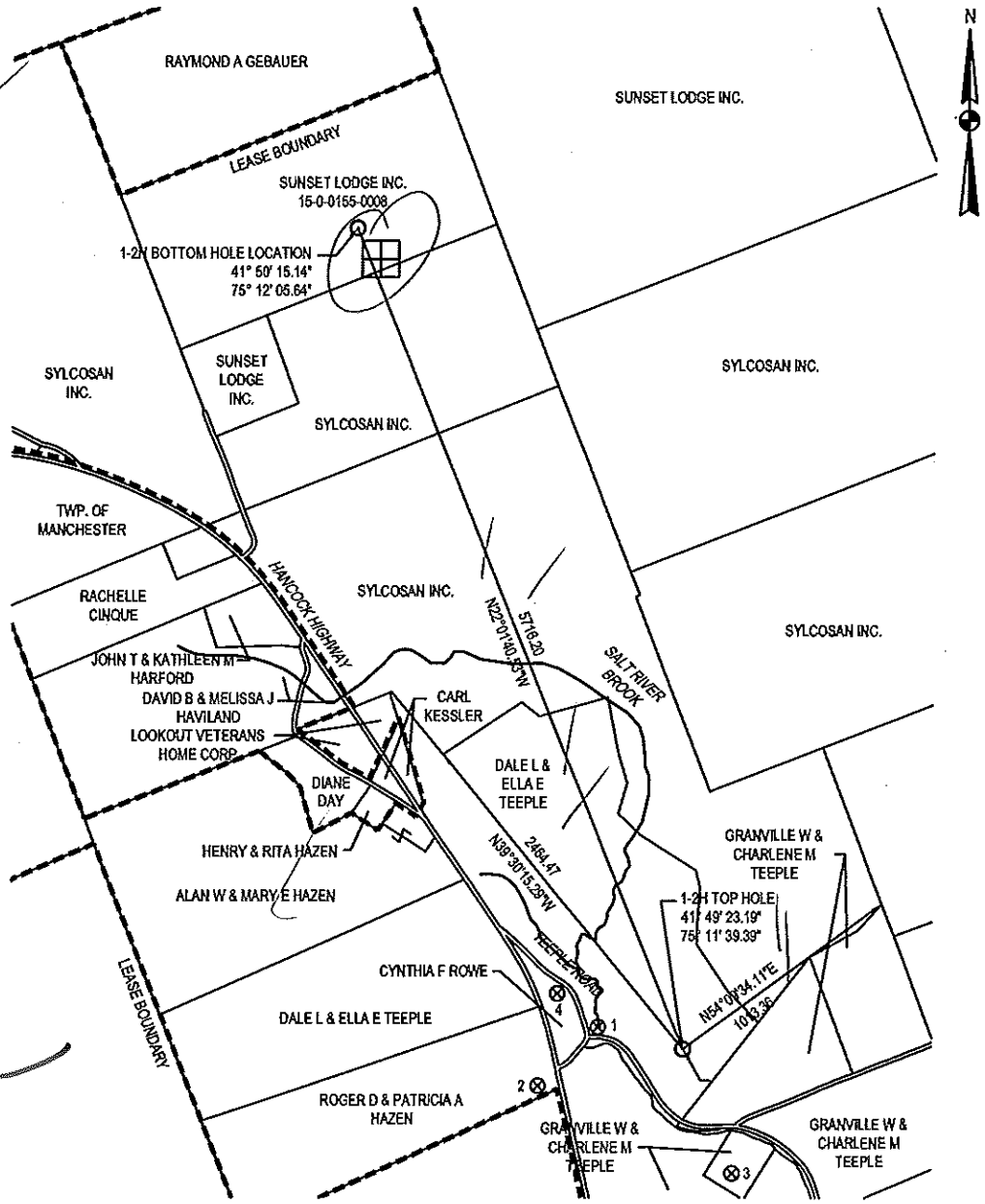
True Longitude: WEST
75 ° 11 ' 39.39 "

WELL NORTHING - Y
613,811.1

WELL EASTING - X
2,665,002.7

Well is located on topo map 3,725 feet south of latitude 41 ° 50 ' 00 "

Well is located on topo map 7,525 feet west of longitude 75 ° 10 ' 00 "



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COMMONWEALTH OF PENNSYLVANIA
REGISTERED PROFESSIONAL
ALLAN R BERENBROK
ENGINEER
037263-E

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1-2H | Date: 4/7/2010 | Scale: 1"= 1200' | Tract Acreage:

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83		Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Survey Date Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC		Well(Farm) Name: D.L. Teeple	Well #: 1-2H / Serial #:
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code: Wayne / Municipality: Manchester	Well Type: Gas
Surface Landowner / Lessor: Dale and Ella Teeple		USGS 7½ Quadrangle Map Name: Long Eddy, NY	Map Section: 5 / Surface Elevation: 1438 ft.
Target Formation(s): Marcellus Shale		Angle & Course of Deviation (Drilling): N22D 01' 40.53"W 5,716.20'	Anticipated Total Depth: TVD 8,140 ft. TMD 13,548.80 ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated
Dale L. and Ella E. Teeple	N75D 34' 24.47"W 568'	N/A	N/A
Roger D. and Patricia A. Hazen	S75d 45' 16.93"W 967'	N/A	N/A
Granville W. and Charlene M. Teeple	S21d 53' 56.41"E 864'	N/A	N/A
Cynthia F. Rowe	N66d 11' 03.82"W 887'	N/A	N/A

WATERSHED SALT RIVER 31000IC

Reference 11

5500-FM-OG0001 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 261535	Auth ID: 715410
Watershed Name	Quality

Permittee: STONE ENERGY CORPORATION	OGO.#: OGO-66630	Permit Number: 37-127-20007-00	Date Issued: 04/28/2008
Address: PO BOX 5280		Farm Name & Well Number: GEUTHER 1	Well Serial #
LAFAYETTE, LA 70506		Municipality: Clinton	County: Wayne
Phone: (337) 237-0410	Project #	7½' Quadrangle Name: Forest City	Map Section #: 5
Surf Elev at Site: 2210 feet	Anticipated Total Depth: 8150 feet	Latitude: 41-41-3.7400	Longitude: -75-26-10.8600
	Well Type: GS	Offset distances referenced to NE corner of map section. South 8,703 feet	West 5377 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires 04/28/2009 unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

RB KARLINSEY
and Gas Inspector

P O Box 673, Coudersport, PA 16915-0673
Address

814-274-3611
Telephone

5500-PM-OG0001 Rev. 9/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 1198	Amount $ 350.00

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY			
Notes	OGO # 666630	Objection Date - Do not issue before: 4-17-08	Well Permit # 127-20007
	Bond # 11503		Special Cond. A B C D E F
	C: 3/10/08	Date Approved:	Watershed Name:
	INV: 4-28-08		Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
STONE ENERGY CORPORATION		337-237-0410	337-237-0426	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
P.O. Box 5280	Lafayette	LA	70506	

(Well) Farm Name	Well #	Serial #
Geuther	1	

County	Municipality	Project # (from DEP)
WAYNE	CLINTON	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, ***or for a well site that was previously permitted but not drilled,*** check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and **enter date drilled,** if known:_____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE Check one.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ Other (specify)

TYPE OF WELL Check one.
- ☒ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☐ Other (specify)

APPLICATION FEE Check one.
- ☒ $ 350 (Gas; Comb.; Coal Meth; Storage)
- ☐ $ 250 (Oil; Inj– Rec)
- ☐ $ 150 (Injection – Waste Disposal)
- ☐ $ 100 (Redrill, Drill Deeper, Alter a Well, or Change Use)
- ☐ $ 0 (Rehab orphan)

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the **Oil and Gas Conservation Law**? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a **workable coal seam**? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a **workable coal seam**, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the **coal** has been removed?	☐	☒
5. Will the well be drilled through an **active (operating or projected) coalmine**, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: Operator:		
6. Will the well penetrate or be within 2,000 feet of an active **gas storage reservoir** boundary?	☐	☒
a. If Yes, print the names of: Storage Field: Operator:		
7. Is the proposed well location within the permitted area of a **landfill**?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a **stream, spring or body of water** identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a **wetland** or in a **wetland**?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing **building** or an existing **water supply**?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

DEP USE ONLY	
Date Stamps/Notes	
Auth	715410
Site	702466
Clnt	261535
APS	639350
Acct	614142

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the **"Coordination of a Well Location with Public Resources"** form 5500-PM-OG0076? If yes, attach a competed copy of the form.	☐	☒
12. Is the well site in a **Special Protection** High Quality (HQ) or Exceptional Value (EV) watershed?	☐	☒
13. Is this well part of a development where you need an **Earth Disturbance Permit** for Oil and Gas Activities disturbing more than 5 acres?	☐	☒

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Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: Eric W. Rankinen	Date
Eric W. Rankinen		Title: Regional Landman	2/13/2008

Application Preparer/Contact: FOX AND FOX, INC. Phone: 814-745-2861

Forest City

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP Application Tracking # 2081639350 4-18-08
Permit # 127-20007
Project #
C:

Denotes location of well on topo map.

True Latitude: NORTH
41° 41' 03.74"

True Longitude: WEST
75° 26' 10.86"

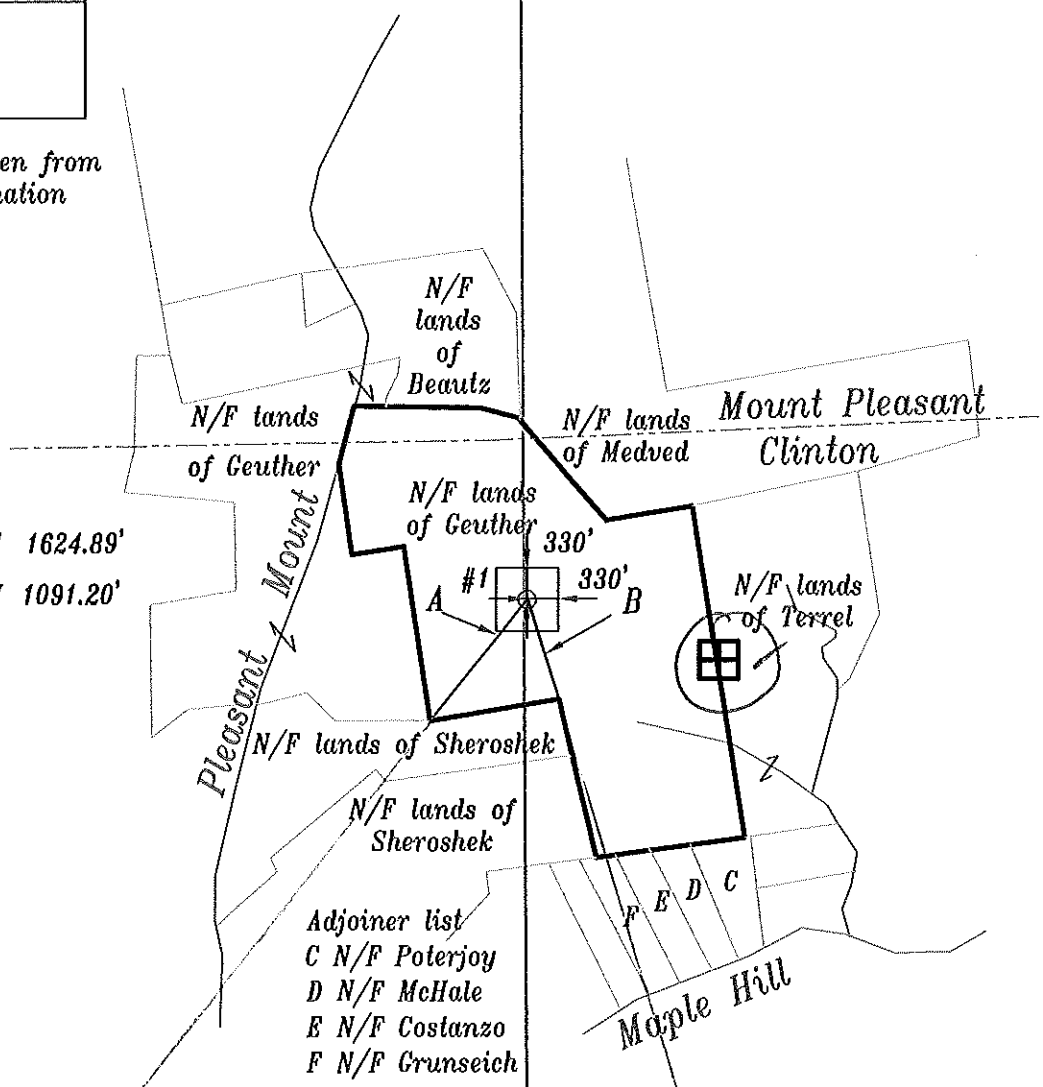
Well is located on topo map 8703 feet south of latitude 41 ° 42 ' 30 "

Well is located on topo map 5377 feet west of longitude 75 ° 25 ' 00 "

parcel lines taken from tax map information

x 561411.86
y 2631916

A N 38°52'59" E 1624.89'
B N 17°59'20" W 1091.20'



D. Michael Canada

Surveyor or Engineer	D. Michael Canada Pa. Lic. # 029272 E	Phone # (716) 379-7918	Dwg. # 6669	Date Rev. Mar. 3, 2008 January 30, 2008	Scale 1" = 2000'	Tract Acreage 261

Lat. & Long Metadata Method Static GPS Accuracy ± 10 ft. Datum NAD 27		Elevation Metadata Method Scaled Accuracy ± 10 ft. Datum USGS Quad	Survey Date 1/30/2008
Applicant / Well Operator Name Stone Energy Corporation		Well (Farm) Name Geuther	Well # #1 / Serial #
Address PO Box 5280 Lafayette, LA 70506		County - Code Wayne	Municipality Clinton
Surface Landowner Robert Geuther		USGS 7 1/2 Quadrangle Map Name Forest City	Map Section 5
Surface Lessor		Angle & Course of Deviation (Drilling) Vertical 0	Surface Elevation 2210 ft. / Anticipated Total Depth 8150 ft.

Surface Owner or Water Purveyor with a Water Supply within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner, Lessee, or Operator of Workable Coal Seam	Name of Coal Seam Owned, Leased, or Operated

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NORTHWEST REGIONAL OFFICE

Reference 12

5500-FM-OG0001A Rev. 11/2007

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 825419
Watershed Name: N. Branch Culkins Creek	Quality HQ

Permittee: NEWFIELD APPALACHIA PA LLC	OGO #: OGO-67425	Permit Number: 37-127-20012-	Date Issued: 04/29/2010
Address: 363 N SAM HOUSTON PKWY E STE 2020		Farm Name & Well Number: HL RUTLEDGE 1 1	Well Serial #:
		Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424		7½' Quadrangle Name: Galilee	Map Section #: 2
Phone: (281) 847-6031	Project #:	Latitude: 41-43-43.2000	Longitude: -75-11-32.1000
Surf Elev at Site: 1440 feet	Anticipated Total Depth: 8350 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 7820 feet West 6983 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires **04/29/2011** unless drilling is commenced on or before that date and prosecuted with due diligence.

Stacie Gustafson for Craig Lobins
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

5500-FM-OG0004 Rev. 1/2010

pennsylvania
DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

DEP USE ONLY	
Site ID	Primary Fac ID 728266
Client Id 277879	Subfacility Id

Well Record and Completion Report

Ii Operator NEWFIELD APPALACHIA PA LLC	DEP ID# 277879	Well API # (Permit / Reg) 37-127-20012-	Project Number	Acres
Address 363 N SAM HOUSTON PKWY E STE 2020,		Well Farm Name & Well # HL RUTLEDGE 1 1		Serial #
City HOUSTON	State TX / Zip Code 77060-2424	County Wayne	Municipality Damascus	
Phone (281) 847-6031	Fax	USGS 7.5 min. quadrangle map Galilee		

Check all that apply: ☐ Original Well Record ☐ Original Completion Report ☐ Amended Well Record ☐ Amended Completion Report

WELL RECORD

Also complete the Log of Formations on back (page 2)

Well Type ☐ Gas ☐ Oil ☐ Combination Oil & Gas ☐ Injection ☐ Storage ☐ Disposal

Drilling Method ☐ Rotary – Air ☐ Rotary – Mud ☐ Cable Tool

Date Drilling Started	Date Drilling Completed	Surface Elevation ft.	Total Depth – Driller ft.	Total Depth – Logger ft.

Casing and Tubing

Cement returned on surface casing? ☐ Yes ☐ No
Cement returned on coal protective casing? ☐ Yes ☐ No ☐ N/A

Hole Size	Pipe Size	Wt.	Thread / Weld	Amount in Well (ft)	*Material Behind Pipe* Type and Amount	*Packer / Hardware / Centralizers* Type	Size	Depth	Date Run

COMPLETION REPORT

Perforation Record

Date	Interval Perforated From	To

Stimulation Record

Date	Interval Treated	*Fluid* Type	Amount	*Propping Agent* Type	Amount	Average Injection

Natural Open Flow	Natural Rock Pressure	Hours	Days
After Treatment Open Flow	After Treatment Rock Pressure	Hours	Days

Well Service Companies -- Provide the name, address, and phone number of all well service companies involved.

Name	Name	Name
Address	Address	Address
City - State – Zip	City - State – Zip	City - State – Zip
Phone	Phone	Phone

5500-FM-OG0004 Rev. 1/2010

LOG OF FORMATIONS

Well API#: 37-127-20012--

(If you will need more space than this page, please photocopy the blank form before filling it in.)

Formation Name or Type	Top (feet)	Bottom (feet)	Gas at (feet)	Oil at (feet)	Water at (fresh / brine: ft.)	Source of Data

I do hereby certify to the best of my knowledge, information and belief that the well identified on this Well Record and Completion Report has been properly cased and cemented in accordance with the requirements of 25 Pa. Code Chapter 78 and any conditions contained in the permit for this well. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

5500-FM-OG0075 Rev. 8/2001

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

Well Site Restoration Report

DEP USE ONLY	
Site ID	Primary Fac ID 728266
Client Id 277879	Subfacility Id

A. Operator and Well Information

Please read instructions on back before completing this form.

Well Operator: NEWFIELD APPALACHIA PA LLC	DEP ID#: 277879
Address: 363 N SAM HOUSTON PKWY E STE 2020,	
City: HOUSTON	State: TX; Zip Code: 77060-2424
Phone: (281) 847-6031	Fax:
Well API # (Permit / Reg): 37-127-20012-	
Well Farm Name & Well #: HL RUTLEDGE 1 1	Serial #:
County: Wayne	Municipality: Damascus

B. Land Application of Tophole Water

Date applied: | pH:

Volume (bbls): | Spec. cond. (µmhos/cm):

C. Off-site Waste Disposal

Type: ☐ Driling Fluid (803) **Amount:** bbls

☐ Fracing Fluid (804) bbls

☐ Other, specify: **Qty:** bbls or tons

Method of disposal or reuse

☐ Sewage Treatment Plant (10)
☐ Disposal Well (04)
☐ Brine Treatment Plant (12)
☐ Landfill (05)
☐ Other (08)

Facility Information

Name: | Permit #:

Hauler Information

Name:

Address:

City: | State: | Zip Code:

D. On-site Disposal – Drill Cuttings or Waste

Location of center of disposal area in relation to the well:

Course: degrees | Distance: feet

Describe the **material disposed**, including additives.

Specify disposal method

☐ Unlined pit, complete Section E.
☐ Lined pit, complete Section E.
☐ Land application, complete Section F.
☐ Dusting
☐ Solidification
☐ Other

E. Pit Disposal

Describe pit closure procedures.

Subbase, material: Thickness: inches

Pit liner, material: Thickness: mils

Pit dimensions (feet) Length: Width: Depth:

F. Land Application

Area: Length: feet Width: feet

Waste-to-soil ratio (by volume):

Chemical analysis of waste

Cadmium (Cd)	ppm	Nickel (Ni)	ppm
Copper (Cu)	ppm	Zinc (Zn)	ppm
Chromium (Cr)	ppm	Oil and Grease	%
Lead (Pb)	ppm	Spec. Cond.	µmhos/cm
Mercury (Hg)	ppm		

Well Operator's Signature

Title: Date:

DEP USE ONLY

Reviewed by: Date:

Comments:

Reference 13

COPY

5500-FM-OG0001A Rev. 11/2007

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL AND GAS MANAGEMENT PROGRAM

WELL PERMIT

DEP USE ONLY	
Permittee's eFACTS ID: 277879	Auth ID: 830957
Watershed Name: Hollister Creek	Quality HQ

Permittee: NEWFIELD APPALACHIA PA LLC	OGO.#: OGO-67425	Permit Number: 37-127-20017-00	Date Issued: 05/27/2010
Address: 363 N SAN HOUSTON PKWY E		Farm Name & Well Number: WOODLAND MGMT PARTNERS 1 1	Well Serial #
SUITE 2020		Municipality: Damascus	County: Wayne
HOUSTON, TX 77060-2424		7½' Quadrangle Name: Callicoon	Map Section #: 7
Phone: (281) 847-6031	Project #:	Latitude: 41-45-57.2000	Longitude: -75-6-33.8000
Surf Elev at Site: 1193 feet	Anticipated Total Depth: 8350 feet	Well Type: GS	Offset distances referenced to NE corner of map section. South 9393 feet West 7108 feet

This permit covering the well operator and well location shown above is evidence of permission granted to conduct activities in accordance with the Oil and Gas Act and the Oil and Gas Conservation Law, if the well is subject to that act and any rules and regulations promulgated thereunder, subject to the conditions contained herein and in accordance with the application submitted for this permit. This permit does not convey any property rights.

This permit and the permittee's authority to conduct the activities authorized by this permit are conditioned upon operator's compliance with applicable law and regulations.

Notification must be given to the district oil and gas inspector, the surface landowner and political subdivision of the date well drilling will begin at least 24 hours prior to commencement of drilling activities.

The permittee hereby authorizes and consents to allow, without delay, employees or agents of the Department to have access to and to inspect all areas upon presentation of appropriate credentials, without advance notice or a search warrant. This includes any property, facility, operation or activity governed by the Oil and Gas Act, the Oil and Gas Conservation Law, the Coal and Gas Resource Coordination Act and other statutes applicable to oil and gas activities administered by the Department. The authorization and consent shall include consent to the Department to collect samples of wastewaters or gases, to take photographs, to perform measurements, surveys, and other tests, to inspect any monitoring equipment, to inspect the methods of operation and disposal, and to inspect and copy documents required by the Department to be maintained. The authorization and consent includes consent to the Department to examine books, papers, and records pertinent to any matter under investigation pursuant to the Oil and Gas Act or pertinent to a determination of whether the operator is in compliance with the above referenced statutes. This condition in no way limits any other powers granted to the Department under the Oil and Gas Act and other statutes, rules and regulations applicable to these activities as administered by the Department.

This permit does not relieve the operator from the obligation to comply with the Clean Streams Law and all statutes, rules and regulations administered by the Department.

Special Permit Conditions:

This permit expires 05/27/2011 unless drilling is commenced on or before that date and prosecuted with due diligence.

S. Craig Lobb
Regional Oil and Gas Program Manager

Stephen Watson
Oil & Gas Inspector

2 Public Square
Wilkes-Barre, PA 18711-0790

570-826-2320
Telephone

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OIL & GAS MANAGEMENT PROGRAM

DEP USE ONLY	
AUTH #	CNC
Check # 1064287	Amount $ 1500

1250
200
50
$1500

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

DEP USE ONLY			
Notes	OGO # 674425	Objection Date - Do not issue before: 5/3/10	Well Permit # 127-20017
	Bond # 12382		Special Cond. A B C D E F
	C: 4/13/10 n&m 5/3/10 JC	Date Approved: 5/11/10	Watershed Name: HOLLISTER CREEK
	INV: 5-27-10		Designation: HQ EV

Please read instructions before you begin filling in this form.

Applicant (Operator) Name	DEP Client ID#	Phone	FAX	Check if new address. ☐
Newfield Appalachia PA LLC	277879	281-847-6031	281-847-6160	
Mailing Address (Street or PO Box)	**City**	**State**	**Zip +4**	**Country (if not USA)**
363 N. Sam Houston Pkwy E. Suite 2020	Houston	TX	77060-2424	

(Well) Farm Name	Well #	Serial #
Woodland Management Partners	1-1	

County	Municipality	Project # (from DEP)
WAYNE	DAMASCUS	

If you are applying for a permit to redrill, drill deeper, or alter a well that was previously permitted or registered, *or for a well site that was previously permitted but not drilled*, check this box ☐ and enter the permit or registration number here:

If applying for a permit to rework an existing well not registered or permitted, check this box ☐ and enter date drilled, if known: _____ (see instructions)

PNDI Attached: ☒ Any "hit" must include accepted mitigation plan from applicable agency.

PERMIT TYPE Check applicable.
Application is to:
- ☒ Drill a new well
- ☐ Deepen a well
- ☐ Redrill a well
- ☐ Alter a well
- ☐ E&S Control Module
- ☐ Other (specify)

TYPE OF WELL Check one.
- ☐ Gas
- ☐ Oil
- ☐ Comb. (gas & oil)
- ☐ Injection, recovery
- ☐ Injection, disposal
- ☐ Coalbed Methane
- ☐ Gas Storage
- ☒ Other (specify)

vertical test well

APPLICATION FEE Check applicable.
- ☐ Marcellus Well: Non-Vertical
- ☐ Marcellus Well: Vertical
- ☐ Non-Marcellus Well: Non-Vertical
- ☒ Non-Marcellus Well: Vertical
- ☐ $200 (Home Use Well)
- ☐ $500 E&S Fee
- ☐ $ 0 (Rehab orphan)
- ☒ Vertical: Length 8350 ft.
- ☐ Marcellus: Length _____ ft.
- ☐ Non-Vertical: Length _____ ft.

Total Application Fee $ 1500

COORDINATION WITH REGULATIONS AND OTHER PERMITS	Yes	No
1. Will the well be subject to the Oil and Gas Conservation Law? If "No," go to 2).	☒	☐
a. If "Yes" to #1, is the well at least 330 feet from outside lease or unit boundary?	☒	☐
b. Does the location fall within an area covered by a spacing order?	☐	☒
2. Will the well penetrate a workable coal seam? If "No," include justification and supporting documentation.	☐	☒
3. If the well will penetrate a workable coal seam, and the well is a "non-conservation" gas well, does the location comply with the distance requirements of Section 7 of the Coal and Gas Resource Coordination Act? (At least 1,000 feet from all existing wells).	☐	☐
a. If "No," is the required exception request attached? (Check here if re-working an existing well: ☐ N/A)	☐	☐
4. Will the well be drilled at a location where the coal has been removed?	☐	☒
5. Will the well be drilled through an active (operating or projected) coalmine, or within 1,000 feet of the boundary?	☐	☒
a. If "Yes," print the names of: Mine: _____ Operator: _____		
6. Will the well penetrate or be within 2,000 feet of an active gas storage reservoir boundary?	☐	☒
a. If Yes, print the names of: Storage Field: _____ Operator: _____		
7. Is the proposed well location within the permitted area of a landfill?	☐	☒
8. Will the well site be within 100 feet (measured horizontally) of a stream, spring or body of water identified on the most current 7½' topographic map?	☐	☒
a. If "Yes," is a request for a waiver (form 5500-FM-OG0057), and E&S control plan attached?	☐	☐
9. Will the well site be within 100 feet of a wetland or in a wetland?	☐	☒
a. Is the well site within 100 feet of a wetland greater than one acre in size?	☐	☐
If yes, is a waiver request (form 5500-FM-OG0057) and E&S control plan attached?	☐	☐
10. Will the well be drilled within 200 feet (horizontally) from any existing building or an existing water supply?	☐	☒
a. If "Yes," is written consent from the owner attached?	☐	☐
b. If written consent is not attached, is a variance request (form 5500-FM-OG0058) attached?	☐	☐

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NORTHWEST REGIONAL OFFICE

DEP USE ONLY	
Date Stamps/Notes	
Auth	830957
Site	733315
Clnt	277879
APS	717958
Acct	676721
PF	729777
SF	1012151

	Yes	No
11. Will the well be located where it may impact a public resource as outlined in the "Coordination of a Well Location with Public Resources" form 5500-PM-OG0076? If yes, attach a completed copy of the form.	☐	☒
12. Is the well site in a Special Protection High Quality (HQ) or Exceptional Value (EV) watershed?	☒	☐
13. Is this well part of a development where you need an Earth Disturbance Permit for Oil and Gas Activities disturbing more than 5 acres? If yes, attach a completed Erosion Sediment and Stormwater Control Module or list the number and date of the ESCGP-1 Approval. _____	☐	☒

Signature of Applicant The person signing this form attests that they have the authority to submit this application on behalf of the applicant, and that the information, including all related submissions, is true and accurate to the best of their knowledge.

Signature of Person Authorized to Submit Application	(Print or Type)	Name of Signer: DONALD F. SLEETH Title: Drilling Manager	Date 4-6-10
Application Preparer/Contact: BETSY COLLINS		Phone: 412-921-8250	

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Woodland Management Partners-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 --- Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.

Name	Address	Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification (Note the means and attach proof.) Certified Mail Dates: Sent	Certified Mail Dates: Return Receipt	Address Affidavit	Written Consent
Donald and Marie Hartnett	841A Calicoon Rd. Damascus, PA 18415-3514						X			3/25/10	3/29/10		
Woodland Management Partners	308 Egypt Rd. Tafton, PA 18464	X											X
Alfred Cimino	124 Monroe St, Apt. 1 Archibald, PA 18403-1818						X			3/25/10	4/1/10		
Leon N Clouse, Sr.	PO Box 241 Stanhope, NJ 07874-0241						X						X

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Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.

☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date
Surface Landowner at proposed location	Date	Coal Operator within 1,000 feet of proposed location	Date
Surface Landowner at proposed location	Date	Gas Storage Operator within 2,000 feet	Date

Signature below indicates written consent. Check applicable box.

Owner of: ☑ water supply, or ☐ building within 200 feet	Date 3/6/10
Address (of above) Leon n Clouse	
Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Address (of above)	

02-27-2010

5500-PM-OG0001 Rev. 10/2009

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DEPARTMENT OF ENVIRONMENTAL PROTECTION
OIL & GAS MANAGEMENT PROGRAM

Farm Name - Well #	
Woodland Management Partners-Well #1-1	
Applicant Name	DEP ID#
Newfield Appalachia PA LLC	277879
DEP USE ONLY	APS #

PERMIT APPLICATION FOR DRILLING OR ALTERING A WELL

Page 2 — Record of Notification / Written Consent

List the following: surface landowner; all landowners or water purveyors whose water supplies are within 1,000 feet of this proposed well location; gas storage operator if within 2000 feet; all coal owners and lessees of all underlying workable coal seams; operators of underground coal mines at the proposed location; and coal operators with a deep mine within 1,000 feet. Mark the boxes, "X," which show the parties' interests. Use additional forms if you need more space. You are required to notify each of these parties.		Surface Landowner	Coal Owner	Coal Lessee	Coal Mine Operator	Gas Storage Operator	Within 1,000 feet: Surf Owner with Water	Within 1,000 feet: Water Purveyor	Within 1,000 feet: Coal Mine Operator	Notification (Note the means and attach proof.) Certified Mail Dates: Sent	Certified Mail Dates: Return Receipt	Address Affidavit	Written Consent
Name: Donald and Marie Hartnett	Address: 841A Calicoon Rd. Damascus, PA 18415-3514						X			3/25/10	3/29/10		
Name: Woodland Management Partners	Address: 308 Egypt Rd. Tafton, PA 18464	X											X
Name: Alfred Cimino	Address: 124 Monroe St, Apt. 1 Archibald, PA 18403-1818						X			3/25/10	4/1/10		
Name: Leon N Clouse, Sr.	Address: PO Box 241 Stanhope, NJ 07874-0241						X						X
Name:	Address:												
Name:	Address:												
Name:	Address:												

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NORTHWEST REGIONAL OFFICE

Optional: Signature below indicates the party's approval of the well location, and waives the 15-day objection period. Check applicable box.				Signature below indicates written consent. Check applicable box.	
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date	Owner of: ☐ water supply, or ☐ building within 200 feet	Date
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date	Address (of above)	
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date		
☐ Water Purveyor or ☐ Landowner with water supply within 1,000 ft.	Date	Coal ☐ Operator, ☐ Owner, or ☐ Lessee	Date	Owner of: ☐ water supply, or ☐ building within 200 feet	Date
Surface Landowner at proposed location WOODLAND MANAGEMENT PARTNERS LP	Date 3/4/2010	Coal Operator within 1,000 feet of proposed location	Date	Address (of above)	
Surface Landowner at proposed location WOODLAND MGT SERVICES, INC General Partner PRESIDENT	Date	Gas Storage Operator within 2,000 feet	Date		

1877-2001

5500-PM-OG0002-DWG Rev. 09/2008

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DEPARTMENT OF ENVIRONMENTAL PROTECTION

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
Oil and Gas Management Program
WELL LOCATION PLAT

DEP USE ONLY	DEP Application Tracking #	G: JC 5/3/10
	Permit # 127-20017	C:
	Project #	

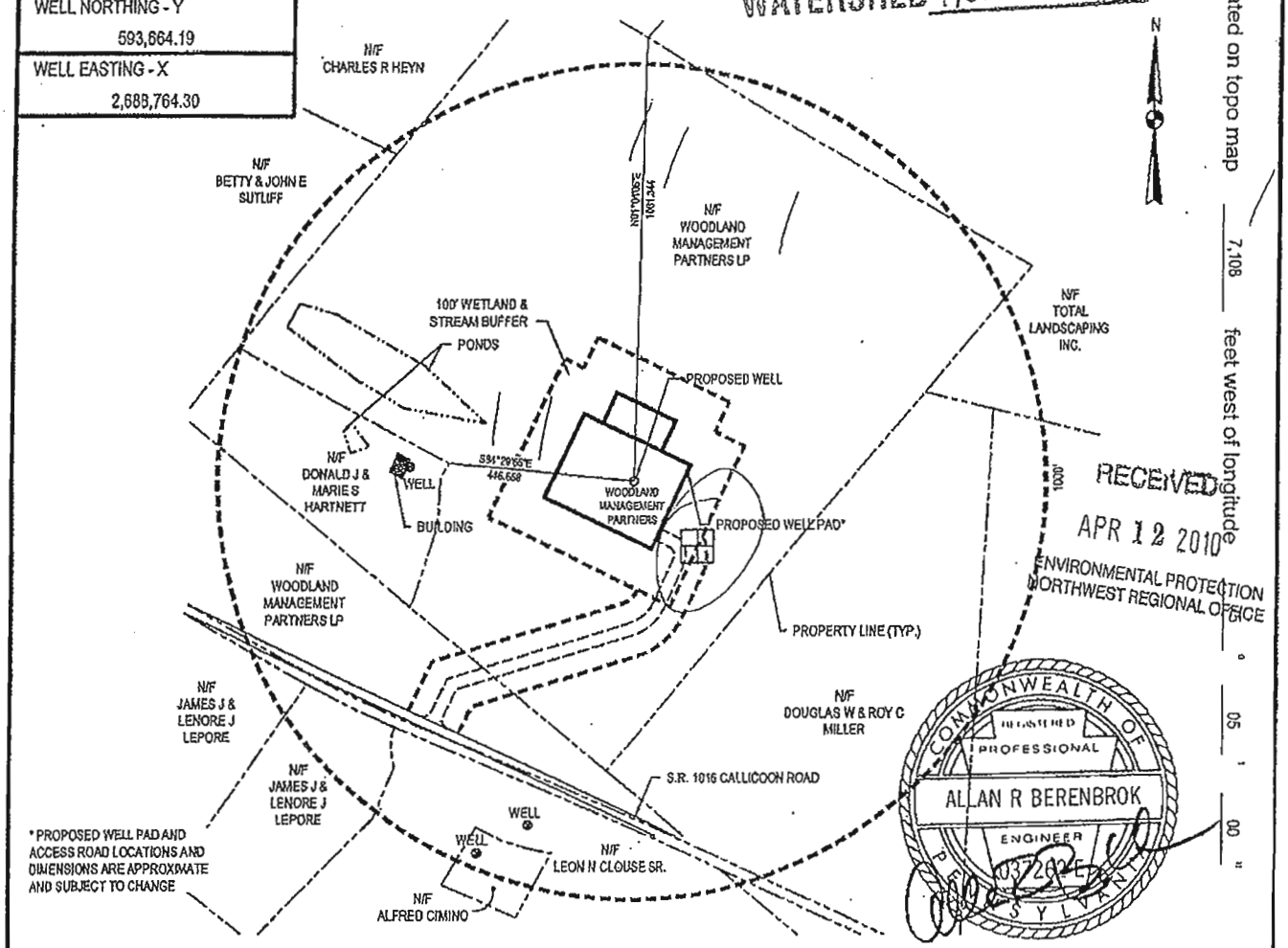
Denotes location of well on topo map.

Well is located on topo map 9,393 feet south of latitude 41 ° 37 ' 30 "

Well is located on topo map 7,108 feet west of longitude 75 ° 05 ' 00 "

True Latitude: NORTH	41 ° 45 ' 57.2 "
True Longitude: WEST	75 ° 06 ' 33.8 "
WELL NORTHING - Y	593,664.19
WELL EASTING - X	2,688,764.30

HQ
WATERSHED Hollister Creek



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ENVIRONMENTAL PROTECTION
NORTHWEST REGIONAL OFFICE

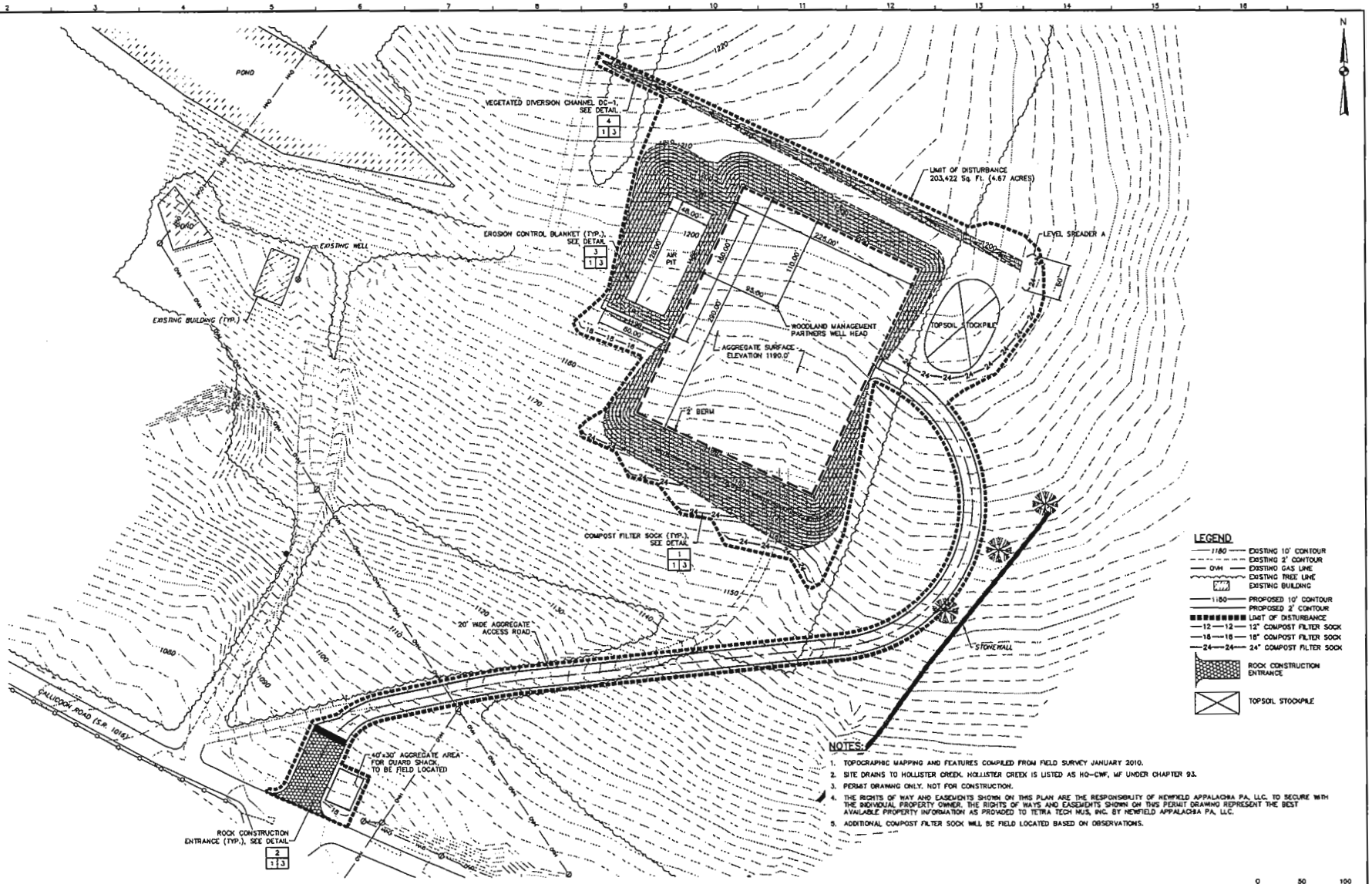
*PROPOSED WELL PAD AND ACCESS ROAD LOCATIONS AND DIMENSIONS ARE APPROXIMATE AND SUBJECT TO CHANGE

Surveyor or Engineer: TETRA TECH | Phone #: (412) 921-8873 | Dwg. #: 1 | Date: 4/6/2010 | Scale: 1" = 400' | Tract Acreage:

Lat. & Long Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83		Elevation Metadata Method GPS Accuracy +/- 1 ft. Datum NAD83	Survey Date Jan. 2010
Applicant / Well Operator Name: Newfield Appalachia PA LLC		Well(Farm) Name: Woodland Management Partners	Well # 1-1 / Serial #
Address: 363 N. Sam Houston Parkway E., Suite 2020, Houston, TX 77060		County - Code: Wayne / Municipality: Damascus	Well Type: Vertical Test
Surface Landowner / Lessor: Woodland Management Partners		USGS 7 1/2 Quadrangle Map Name: Callicoon, PA	Map Section: 7 / Surface Elevation: 1193 ft.
Target Formation(s): Onondaga		Angle & Course of Deviation (Drilling): N/A	Anticipated Total Depth: TVD 8,350 ft. / TMD 8,350 ft.

Surface Owners Within 1,000 ft.	Approximate Course and Distance to Water Supply	Owner of Mineable Coal Seam	Name of Coal Seam Owner Operator
Donald and Marie Hartnett	N86d 22' 34"W 537'	N/A	N/A
Leon N. Clouse Sr.	S16d 46' 23"W 862'	N/A	N/A
Alfred Cimino	S22d 36' 51"W 965'	N/A	N/A
		N/A	N/A

R:_Marcellus State Projects\Newfield\20673 - Newfield Wells\Well Pad Permits\Permit Drawings\WUP Well Pad Plat Exhibit A.dwg PIT BENJHOPPE 4/6/2010 10:54:34 AM



NOTES:

1. TOPOGRAPHIC MAPPING AND FEATURES COMPILED FROM FIELD SURVEY JANUARY 2010.
2. SITE DRAINS TO HOLLISTER CREEK. HOLLISTER CREEK IS LISTED AS HQ-CWF, MF UNDER CHAPTER 93.
3. PERMIT DRAWING ONLY. NOT FOR CONSTRUCTION.
4. THE RIGHTS OF WAY AND EASEMENTS SHOWN ON THIS PLAN ARE THE RESPONSIBILITY OF NEWFIELD APPALACHIA PA, LLC. TO SECURE WITH THE INDIVIDUAL PROPERTY OWNER. THE RIGHTS OF WAYS AND EASEMENTS SHOWN ON THIS PERMIT DRAWING REPRESENT THE BEST AVAILABLE PROPERTY INFORMATION AS PROVIDED TO TETRA TECH NUS, INC. BY NEWFIELD APPALACHIA PA, LLC.
5. ADDITIONAL COMPOST FILTER SOCK WILL BE FIELD LOCATED BASED ON OBSERVATIONS.

TETRA TECH
www.tetratech.com
661 ANDERSEN DRIVE - FOSTER PLAZA 7
PITTSBURGH, PA 15220
T: (412) 921-7090 | F: (412) 921-4040

MARK	DATE	DESCRIPTION	BY

NEWFIELD APPALACHIA PA LLC.
WAYNE COUNTY, PENNSYLVANIA

WOODLAND MANAGEMENT PARTNERS WELL PAD
EROSION & SEDIMENT CONTROL PLAN

SCALE: 1" = 50'

DATE:	5/6/10
PROJECT NO.:	112C02879
DESIGNED BY:	RL
DRAWN BY:	BH
CHECKED BY:	RL
SHEET:	1 OF 7

COPYRIGHT TETRA TECH INC.

FIGURE 3

Reference 14

Erosion and Sediment Control General Permit For Earth Disturbance Associated With Oil & Gas Exploration, Processing or Treatment Operations or Transmission Facilities

(take a deep breath)

Otherwise known as…

ESCGP-1

HISTORY

- E&S Controls Required since 1972.
- E&S Control Manual published in 1981
- E&S Control Manual incorporated into the Oil and Gas Operator's Manual.
- NPDES Phase I Stormwater Rule in 1990
- Oil and Gas Stormwater Policy was issued in 2001. Reissued in 2003

ENERGY POLICY ACT OF 2005

- Defined Oil and Gas Activities in the Clean Water Act
- Identified Oil and Gas Activities that do not require an NPDES Permit.
- Made certain Oil and Gas activities eligible for exemption from Stormwater NPDES permits associated with Construction Activities.

July 2006

EPA amended the NPDES regulations for stormwater discharges associated with oil and gas exploration, production, processing or treatment operations or transmission facilities **exempting them from the NPDES Stormwater Permit requirements.**

The EPA rulemaking does not affect the authority of the Department to regulate earthmoving activities under Chapter 102

The Department's Plan

- Continue Enforcement of Chapter 102
- Issue a General Permit for Erosion and Sediment Control.
- Revise Existing Oil & Gas Stormwater Policy.
- Revise Regulations.

Why Do We Need This Permit?

- **Restore disturbed areas promptly**
- **Minimize earth disturbance**
- **Ensure proper oversight by DEP**

ESCGP – 1

(the permit)

- Specific to Oil and Gas Activities
- disturb 5 acres or greater **at one time over the life of the project**
- Encourages prompt stabilization
- Ensure proper design and use of Erosion & Sediment BMPs and Post Construction Stormwater BMPs

•Encourages Operators to complete site restoration promptly

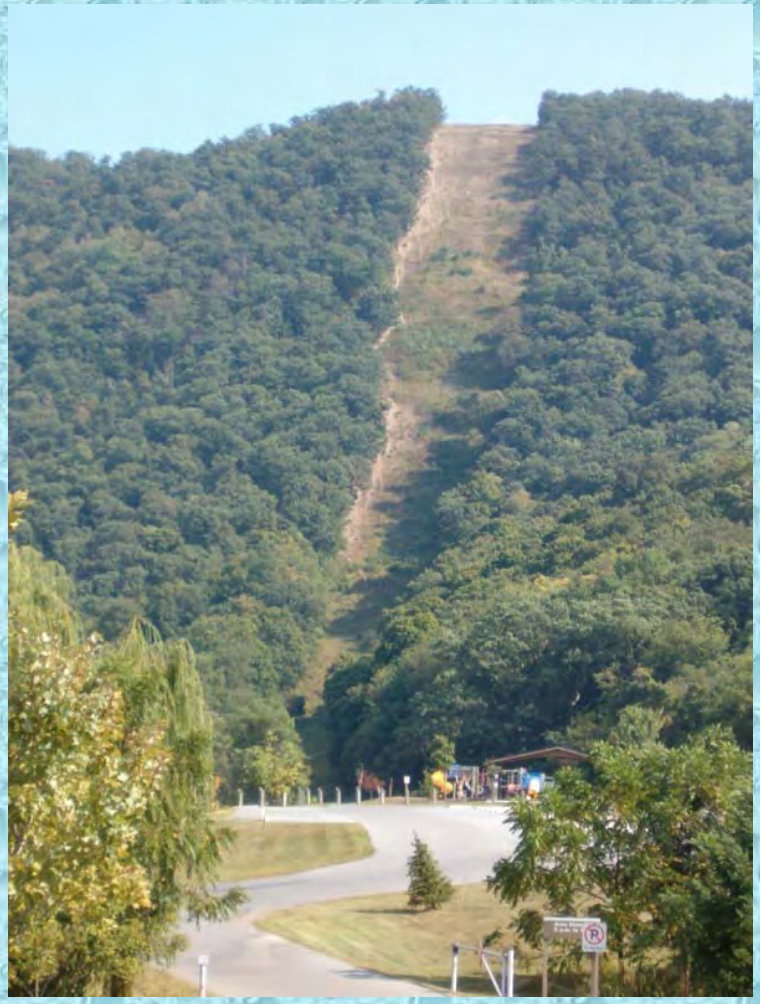
•Incentive for Operators to minimize disturbed areas

What Activities Might Need This Permit?

- **Deep well drilling**

- **Projects with multiple, closely spaced and interconnected wells**

Multiple wells that are interconnected by a common access road and pipeline



•**Transmission Pipelines**

Who Issues What?

County Conservation Districts

- **Chapter 102 Delegated**
- **can issue the ESCGP-1**

Non-Delegated Counties

Bureau of Oil & Gas Management Regional Office (SWRO or NWRO)

- Projects that include well sites, access roads, flow linesand gathering lines

Bureau of Watershed Management Regional Office

- **Transmission Line Projects**

Where Are We in the Process?

November 18, 2006 – The Dept. announced it's intent to develop an Erosion & Sediment Control Permit for Oil and Gas Activities in the PA Bulletin.

The intent to issue ESCGP-1 was published in the PA Bulletin on **May 5, 2007** and the public comment period ended on **June 4, 2007**.

Draft Permit, Application, Checklist and Instructions have been prepared.

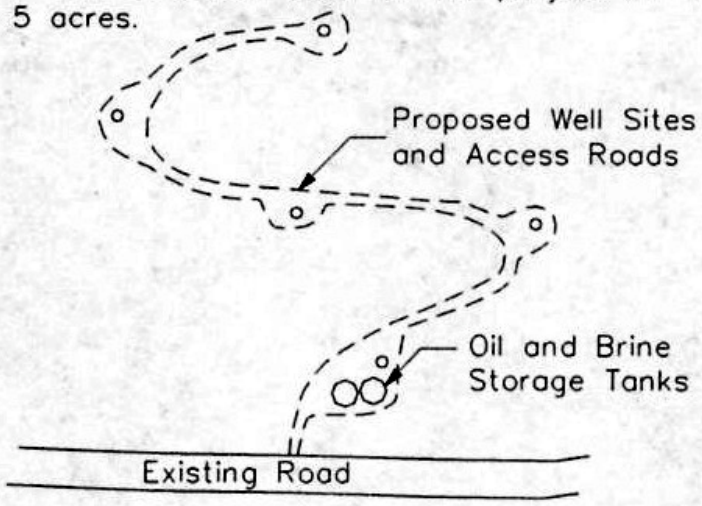
Oil and Gas Earth Disturbance Examples

Example No. 1 – To construct the well sites and access roads for five oil wells on 660 ft. spacing. Pipelines and power lines will be buried along the access road.

Disturbed Area

Access Road 3,400 ft. x 16 ft.	=	54,400 Sq. Ft.
5 Well Sites 75 ft. x 60 ft. x 5	=	22,500 Sq. Ft.
Total	=	76,900 Sq. Ft.
	=	1.8 Acres

Comment – The disturbed area for the project will be less than 5 acres.

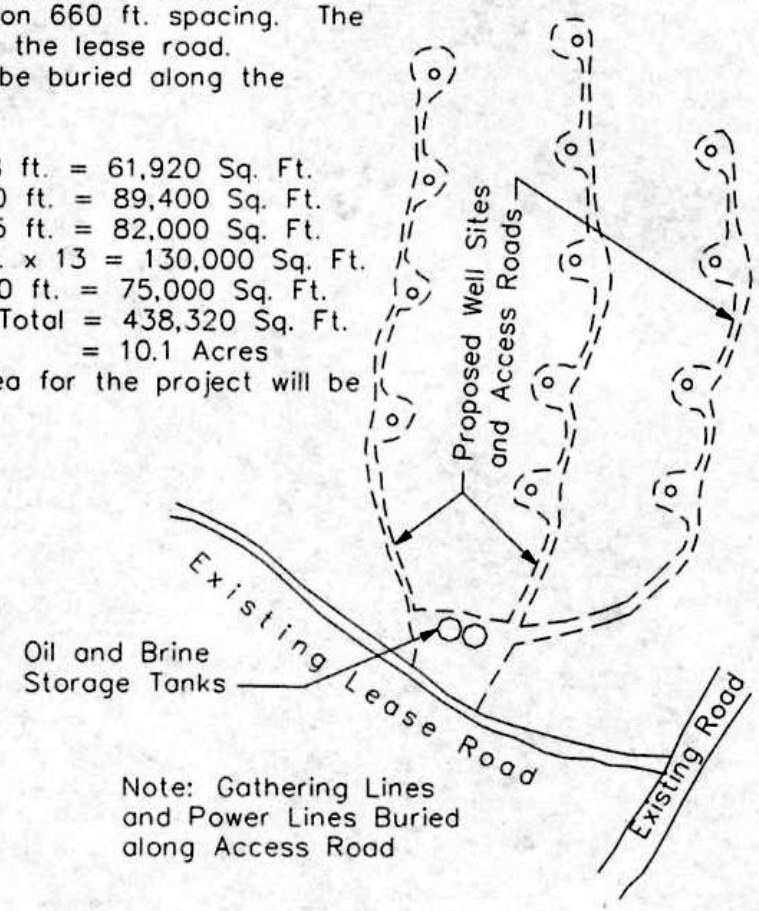


Example No. 2 – To construct the well sites and access roads for 13 oil wells on 660 ft. spacing. The tank battery will be set along the lease road. Pipelines and power lines will be buried along the access road.

Disturbed Area

Access Road	3,440 ft. x 18 ft.	= 61,920 Sq. Ft.
	2,980 ft. x 30 ft.	= 89,400 Sq. Ft.
	3,280 ft. x 25 ft.	= 82,000 Sq. Ft.
13 Well Sites	100 ft. x 100 ft. x 13	= 130,000 Sq. Ft.
Tank Battery	300 ft. x 250 ft.	= 75,000 Sq. Ft.
	Total	= 438,320 Sq. Ft.
		= 10.1 Acres

Comment – The disturbed area for the project will be greater than 5 acres.



Example No. 3 – To construct the well sites and access roads for four new oil wells at an existing operation. Wells are placed on 660 ft. spacing. Pipelines and power lines will be buried in the access road.

Disturbed Area

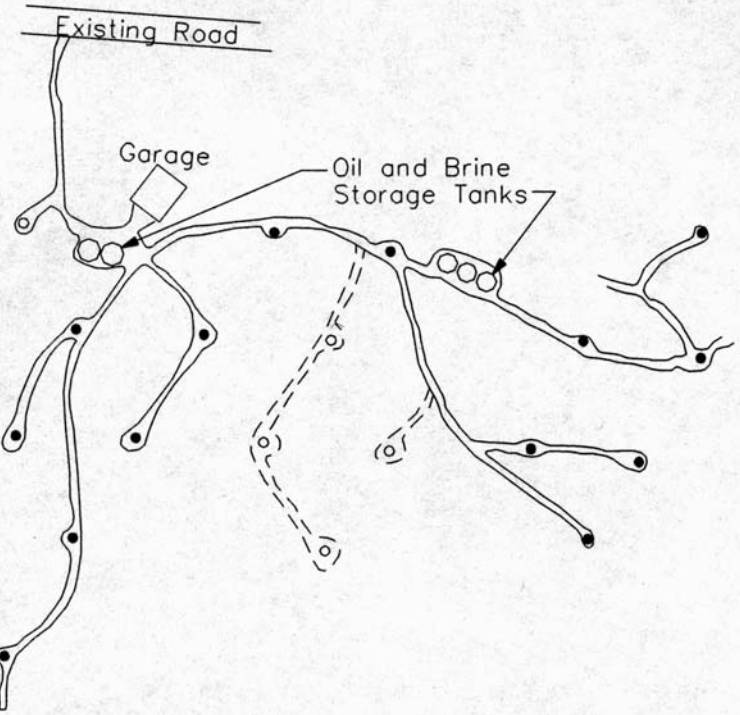
Access Road 2,700 ft. x 16 ft. = 43,200 Sq. Ft.
4 Well Sites 50 ft. x 60 ft. x 4 = 12,000 Sq. Ft.
Total = 55,200 Sq. Ft.
= 1.3 Acres

Comment – The disturbed area for the project will be less than 5 acres.

Note: Proposed Gathering Lines and Power Lines to be Buried along Road

• Existing Well
o Proposed Well

Existing Lease Road
Proposed Road and Well Site

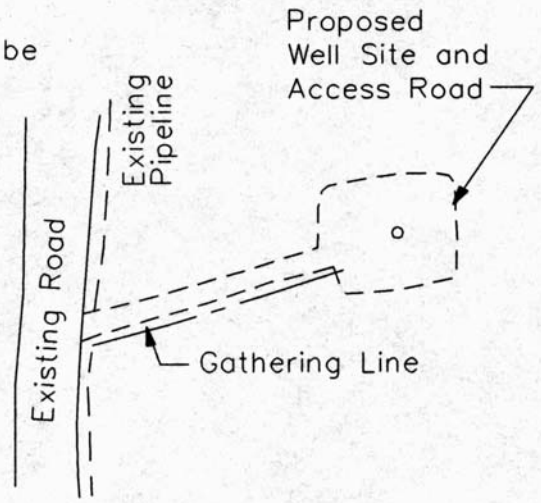


Example No. 4 – To construct the well site and access road and install the gathering line for a gas well on 1,000 ft. or 1,320 ft. spacing.

Disturbed Area

Access Road 900 ft. x 20 ft. = 18,000 Sq. Ft.
1 Well Site 220 ft. x 220 ft. = 48,400 Sq. Ft.
Gathering Line 900 ft. x 10 ft. = 9,000 Sq. Ft.
Total = 75,400 Sq. Ft.
= 1.7 Acres

Comment – The disturbed area for the project will be less than 5 acres

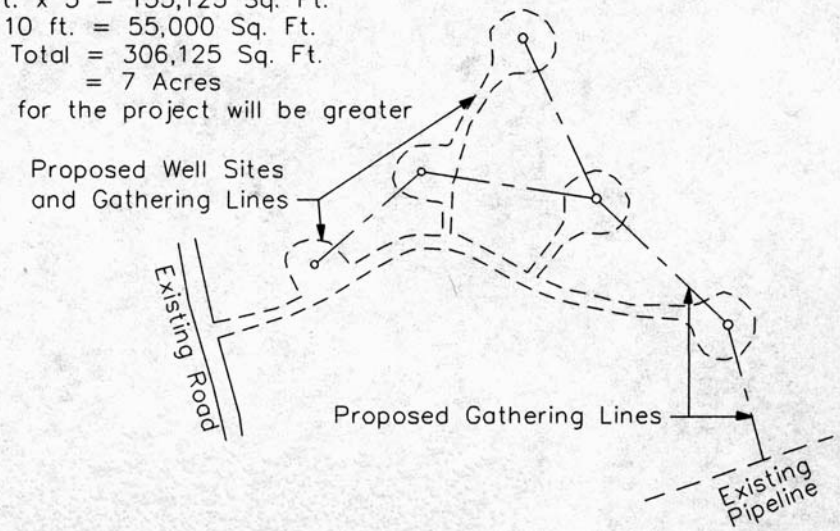


Example No. 5 – To construct well sites and access roads and install the gathering line for five gas wells on 1,200 ft. spacing.

Disturbed Area

Access Road	4,900 ft. x 20 ft. =	98,000 Sq. Ft.
5 Well Sites	175 ft. x 175 ft. x 5 =	153,125 Sq. Ft.
Gathering Line	5,500 ft. x 10 ft. =	55,000 Sq. Ft.
	Total =	306,125 Sq. Ft.
	=	7 Acres

Comment – The disturbed area for the project will be greater than 5 acres.



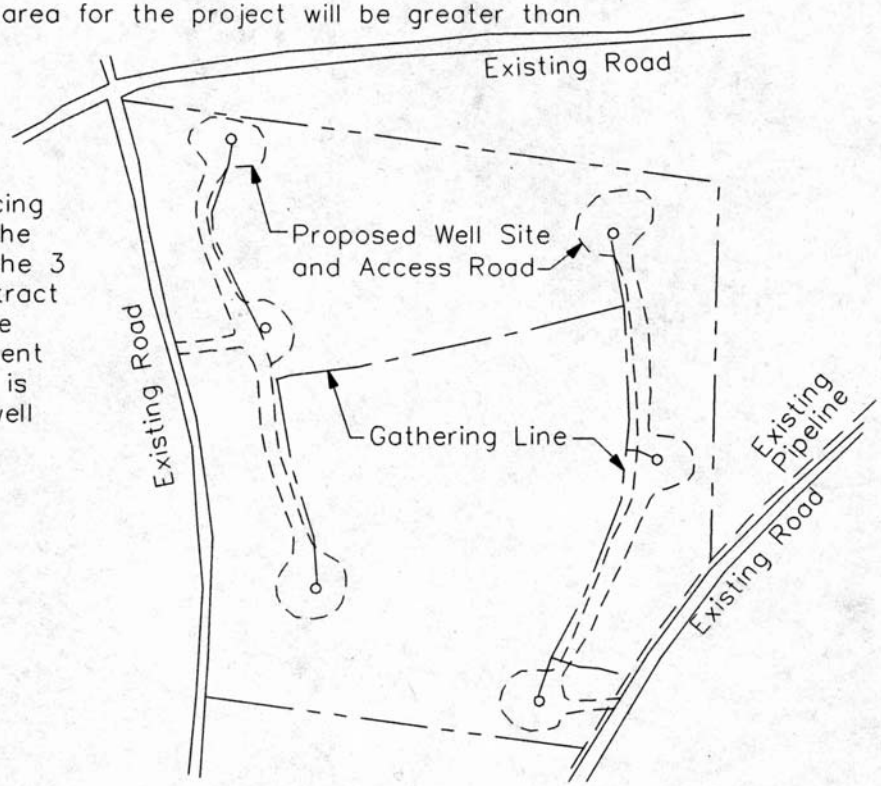
Example No. 6 – To construct well sites and access roads and install the gathering line for six gas wells (1000 ft. well spacing). Access for three wells is from the existing road on the west and access for the other 3 wells is from the existing road on the east. The installation of the gathering line connects the two areas.

Disturbed Area

Access Road 3,850 ft. x 22 ft. = 84,700 Sq. Ft.
Well Site 190 ft. x 190 ft. x 6 = 216,600 Sq. Ft.
Gathering Line 2100 ft. x 10 ft. = 21,000 Sq. Ft.
Total = 322,300 Sq. Ft.
= 7.4 Acres

Comment – The disturbed area for the project will be greater than 5 acres.

Note – Since the well spacing is greater than 900 feet, the construction activities for the 3 wells on each side of the tract may be treated as separate common plans of development provided the gathering line is not constructed until the well site and access roads are permanently stabilized.



In Summary

- Conservation District with 102 delegation can process the ESCGP-1 permit for O & G well sites, access roads, flow lines and gathering lines as well as transmission lines

- Non Delegated counties, in the case of O & G covered activities, the ESCGP-1 permit would go to the appropriate O & G REGIONAL OFFICE. (NWRO or the SWRO)

- For Transmission lines in non-delegated counties the permit would be reviewed by the appropriate Regional Watershed Management program for that county.

- **Transmission lines are exempt from the NPDES Stormwater Permit process.**

- **They are not exempt from the state permit ESCGP-1**

- **O & G doesn't do transmission lines. They will be covered, as always, by Watershed Management**

- **O & G covers well sites, access roads, flow lines and gathering lines**

- **Distribution lines are not exempt from the federal NPDES permit process. These are also the responsibility of Watershed Management.**

The Permit Application and Checklist

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT
BUREAU OF OIL AND GAS MANAGEMENT

OFFICIAL USE ONLY
ID #_____
Date Received _____

NOTICE OF INTENT FOR COVERAGE UNDER THE EROSION AND SEDIMENT CONTROLGENERAL PERMIT (ESCGP-1) FOR EARTH DISTURBANCE ASSOCIATED WITH OIL AND GAS EXPLORATION, PRODUCTION, PROCESSING OR TREATMENT OPERATIONS OR TRANSMISSION FACILITIES (ESCGP-1)

READ THE STEP-BY-STEP INSTRUCTIONS PROVIDED IN THIS PERMIT APPLICATION PACKAGE BEFORE COMPLETING THIS FORM.

PLEASE PRINT OR TYPE INFORMATION IN BLACK OR BLUE INK.

APPLICATION TYPE NEW ☐ RENEWAL ☐ REVISED ☐

SECTION A. E&S PLANNING REQUIREMENTS

1. Total Project Area (Acres): _____ Total Disturbed Area (Acres): _____

2. Project Name

3. Project Description

☐ Oil/Gas Well ☐ Pipeline/Transmission Facility ☐ Processing Facility ☐ Treatment Facility

____Number of wells to be drilled ☐ Installation of injection lines
☐ Construction of access road ☐ Construction and restoration of well site ☐ Installation of pipeline
☐ Installation of tank battery ☐ Installation of gathering/production line ☐ Other (list) _____

4. Please provide the latitude and longitude coordinates for the center of the project. The coordinates should be in degrees, minutes and seconds (dd mm ss.ss)

Latitude _____degrees _____minutes _____seconds Longitude _____ degrees _____ minutes _____ seconds

Reference Datum: ☐ North American Datum 1983 ☐ North American Datum 1927 ☐ World Geodetic System 1984

Horizontal Collection Method: ☐ GPS ☐ Interpolated from U.S.G.S. topo map ☐ DEP's eMAP

5. U.S.G.S. 7.5 min. Quad Map Name _____

6. Estimated Timetable for Phased Projects

Phase No. or Name	Description	Total Area	Disturbed Area	Start Date	End Date

7. Existing and previous land use

8. Other Pollutants: Will the stormwater discharge contain pollutional substances other than sediment? Yes ☐ No ☐ If yes, explain and provide any available quantitative data.

9. Receiving Water/Watershed Name

_____

Chapter 93 Designated Use or Existing Use Stream Classification

☐ High Quality ☐ Exceptional Value
☐ Other

Secondary Water

Name of Municipal or Private Separate Storm Sewer Operator

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SECTION B. PERMIT COORDINATION

In addition to well permits, are other DEP environmental permits required for this project (check the type of permit needed)?

- ☐ Encroachment permit — ☐ √ if the application has been submitted
- ☐ Air Quality permit for compressor station — ☐ √ if the application has been submitted
- ☐ Other (list) — ☐ √ if the application has been submitted

SECTION C. APPLICANT INFORMATION

Applicant's Last Name	First Name	MI	Phone FAX
Organization Name or Registered Fictitious Name			Phone FAX
Mailing Address	City		State ZIP + 4
Co-Applicant's Last Name	First Name	MI	Phone FAX
Organization Name or Registered Fictitious Name			Phone FAX
Mailing Address	City		State ZIP + 4

SECTION D. SITE INFORMATION

Site Name			
Site Location			
Site Location -- City	State	ZIP+4	
Detailed Written Directions to Site			
County	Municipality		City ☐ Boro ☐ Twp ☐

SECTION E. POST CONSTRUCTION STORMWATER MANAGEMENT (PCSM) PLAN
See the Attached Instructions on how to Complete This Section

All PCSM plans should be designed to maximize infiltration technology, eliminate or minimize point source discharges to surface waters, preserve the integrity of stream channels, and protect the physical, chemical and biological qualities of the receiving water. In addition to these water quality design features, all PCSM plans must comply with local water quantity or flood control requirements.

Check those that apply:

- ☐ The attached PCSM plan was developed to be consistent with an Act 167 Stormwater Management Plan approved by the Department after July 2001.
- ☐ The attached PCSM plan was developed to be consistent with existing local ordinances
- ☐ The attached PCSM plan was developed to employ water quality design features and BMPs that will manage any net increase in stormwater runoff volume resulting from the DEP recommended 2-year/24-hour frequency storm.

Draft

a. Written narrative ☐ Yes ☐ No

b. Plan drawings ☐ Yes ☐ No

c. Identification and location of post construction stormwater management BMPs. Such BMPs should address: (1) infiltration; (2) volume and rate control; and (3) water quality treatment ☐ Yes ☐ No

d. Operation and maintenance procedures ☐ Yes ☐ No

e. Supporting calculations and measurements: ☐ Yes ☐ No

Supporting calculations and measurements are required only if the answers to both questions 1 and 2 below are NO.

1) The approximate original contours of the project site will be maintained or replicated and the disturbed areas will be revegetated or otherwise stabilized with pervious material. ☐ Yes ☐ No

2) PCSM BMPs which: use natural measures to eliminate pollution, do not require extensive construction efforts, promote pollutant reduction, and are capable of controlling the net increase in the volume and rate of stormwater runoff from a 2-year/24-hour storm event will be employed, and the net increase in the volume of post construction runoff is infiltrated and/or dissipated away from surface waters of the Commonwealth. ☐ Yes ☐ No

If the responses to both questions 1 and 2, above are NO, please provide the requested post construction stormwater information in the Data Table for Supporting Calculations and Measurements below:

2. Explain how post construction stormwater runoff volume will be managed if BMPs will not infiltrate the total net increase in stormwater runoff volume. (Net increase volume = Post construction runoff volume minus Pre-construction runoff volume):

Supporting calculations and measurements are required only if the answers to both questions 1 and 2 below are NO.

1) The approximate original contours of the project site will be maintained or replicated and the disturbed areas will be revegetated or otherwise stabilized with pervious material. ☐ Yes ☐ No

2) PCSM BMPs which: use natural measures to eliminate pollution, do not require extensive construction efforts, promote pollutant reduction, and are capable of controlling the net increase in the volume and rate of stormwater runoff from a 2-year/24-hour storm event will be employed, and the net increase in the volume of post construction runoff is infiltrated and/or dissipated away from surface waters of the Commonwealth.

☐ Check this box if supporting calculations and measurements are NOT required in accordance with Section E.1.e on the preceding page.

Design storm frequency _____	Pre-construction	Post Construction	Net Change

If the responses to both questions 1 and 2, above are NO, please provide the requested post construction stormwater information in the Data Table for Supporting Calculations and Measurements below:

2. Explain how post construction stormwater runoff volume will be managed if BMPs will not infiltrate the total net increase in stormwater runoff volume. (Net increase volume = Post construction runoff volume minus Pre-construction runoff volume):

☐ N/A (check N/A only if BMPs **will** infiltrate all of the Net Change in Runoff)

SECTION H. CERTIFICATION BY PERSON PREPARING APPLICATION

I do hereby certify to the best of my knowledge, information and belief, that the Erosion and Sediment Control Plan and Post Construction Stormwater Management Plan are true and correct, represent actual field conditions and are in accordance with the 25 Pa. Code Chapters 78 and 102 of the Department's rules and regulations. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment.

Print Name	Signature
Company	
Address	
Phone	

SECTION I. APPLICANT CERTIFICATION

Applicant Certification. I certify under penalty of law that this document and all attachments were prepared by me or under my direction or supervision in accordance with a system designed to assure that qualified personnel properly gathered and evaluated the information submitted. Based on my inquiry of the person or persons who manage the system, or those persons directly responsible for gathering the information, the information submitted is, to the best of my knowledge and belief, true, accurate, and complete. The responsible official's signature also verifies that the activity is eligible to participate in the permit, and that the applicant agrees to abide by the terms and conditions of the permit. I am aware that there are significant penalties for submitting false information, including the possibility of fine and imprisonment for knowing violations.

Print Name and Title of Applicant	Print Name and Title of Co-Applicant (if applicable)
Signature of Applicant	Signature of Co-Applicant
Date Application Signed	Date Application Signed

Notarization

Sworn to and subscribed to before me this

_____ day of _____, 20_____

Commonwealth of Pennsylvania

County of _____

_____
Notary Public

My Commission expires _____

NAME, ADDRESS AND PHONE NUMBER OF INDIVIDUAL TO BE CONTACTED IF ADDITIONAL INFORMATION IS REQUIRED

Name	
Address	Phone

Draft

5500-PM-OG0005 Rev. 3/2007
Checklist

COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL PROTECTION
BUREAU OF WATERSHED MANAGEMENT
BUREAU OF OIL AND GAS MANAGEMENT

NOTICE OF INTENT (NOI) CHECKLIST
EROSION AND SEDIMENT CONTROL GENERAL PERMIT FOR EARTH DISTURBANCE ASSOCIATED WITH OIL AND GAS EXPLORATION, PRODUCTION, PROCESSING, OR TREATMENT OPERATIONS OR TRANSMISSION FACILITIES (ESCGP-1)

Please check the following list to make sure that you have included all the required information. Place a check mark in the column provided for all items completed and/or provided. Failure to provide all of the requested information will delay the processing of the application and may result in the application being placed ON HOLD with NO ACTION, or being considered withdrawn and the application file closed.

THIS CHECKLIST MUST BE COMPLETED AND ENCLOSED WITH YOUR GENERAL PERMIT NOI

	✓CHECKLIST FOR EROSION AND SEDIMENT CONTROL GENERAL PERMIT NOI			Applicant Check √ If Included	Official Use Only
1.	Fully completed, properly signed and notarized Notice of Intent form (1 original and 2 copies).			☐	☐
2.	Complete Erosion and Sediment Control Plans. (3 copies)			☐	☐
	a. Topographic features	Location:_____	Page:_____	☐	☐
	b. Soils information	Location:_____	Page:_____	☐	☐
	c. Proposed alteration	Location:_____	Page:_____	☐	☐
	d. Amount of runoff	Location:_____	Page:_____	☐	☐
	e. Location of water which may receive runoff and receiving water classification, pursuant to Chapter 93 and the "statewide existing use listing".	Location:_____	Page:_____	☐	☐
	f. Supporting calculations	Location:_____	Page:_____	☐	☐
	g. BMPs used before, during, and after earth disturbance, including special protection BMPs.	Location:_____	Page:_____	☐	☐
	h. Maintenance program	Location:_____	Page:_____	☐	☐
	i. Plan drawings and narratives	Location:_____	Page:_____	☐	☐
	j. Sequence of BMP installation and removal	Location:_____	Page:_____	☐	☐
	k. Recycling and disposal methods	Location:_____	Page:_____	☐	☐
3.	Permit filing fee of $500 payable to the appropriate Clean Water Fund.			☐	☐
4.	Location map: USGS of scale 1:24,000 indicating project location and boundaries. (3 copies)			☐	☐

	✓CHECKLIST FOR ESCGP-1			Applicant Check √ If Included	Official Use Only
5.	Notifications to the local municipality and county governments that specify Acts 67 and 68 Coordination, and that the application is for a Erosion and Sediment Control General permit for Earth Disturbance Associated with Oil and Gas Activities. (3 copies) A "sample" notification letter is provided as Appendix A of the instructions.			☐	☐
6.	Proof of receipt of municipal notifications; copies of certified mail receipts or acknowledgment letters from the local municipality and county government. (3 copies)			☐	☐
7.	The PNDI Review receipt for the project area. Include impact clearance letters if proof of agency coordination is required. (3 copies)			☐	☐
8.	PPC Plan: Include a current Preparedness, Prevention and Contingency Plan (3 copies)			☐	☐
9.	Complete Post Construction Stormwater Management Plan. (3 copies) Location: Drawings (D), Narrative (N).			☐	☐
	a. Written Narrative	Location _____	Page _____	☐	☐
	b. Location of BMPs showing final contours	Location _____	Page _____	☐	☐
	c. Plan drawings of permanent stabilization	Location _____	Page _____	☐	☐
	d. Plan drawings of BMPs	Location _____	Page _____	☐	☐
	e. Operation and maintenance procedure	Location _____	Page _____	☐	☐
	f. Supporting calculations or measurements	Location _____	Page _____	☐	☐
	g. Design frequency storm rainfall amount	Location _____	Page _____	☐	☐
	h. Area of impervious surface	Location _____	Page _____	☐	☐
	i. Curve Number or Runoff Coefficient	Location _____	Page _____	☐	☐
	j. Runoff from the design frequency storm	Location _____	Page _____	☐	☐
	k. Volume of water infiltrated through BMPs	Location _____	Page _____	☐	☐
	l. Peak discharge rate from the design frequency storm	Location _____	Page _____	☐	☐

Draft

Umholtz's Corollaries to Murphy's Law of BMP Entrophy

1. All BMPs work if it's not raining.

2. BMPs and PMS sound alike for a reason.

3. All BMPs will eventually fail.
   The question is, will they last until you retire?

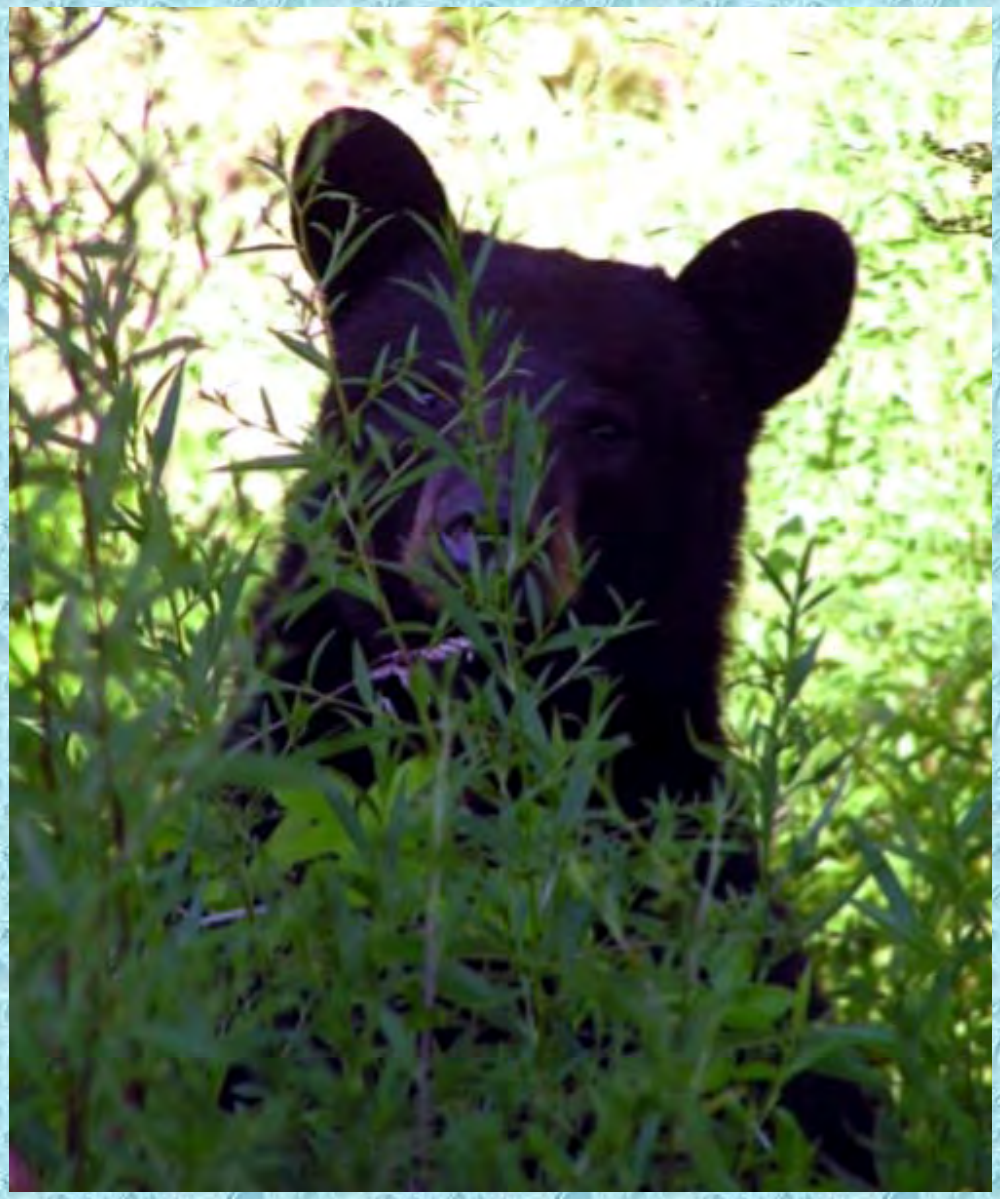
4. You can get grass to grow on the side of a tree.
   The question is, for how long? (See 3 above.)

5. Water flows downhill, unless you're looking at the
   Erosion and Sedimentation Plan upside down..

6.. All filter fence and hay bales are installed correctly, and yes, Virginia, there is a Santa Claus.

7. Snow is not an effective sediment filter BMP.

8. Erosion is a natural process, but then again, so is death.
   It is not in your best interest to accelerate either.



Questions?

Reference 15

Pennsylvania's Environment Facility Application Compliance Tracking System

eFACTS

Last update 8/26/2010 12:58:04 PM

Site Details

North Central Regional Office | Site Search | Sites by County/Muni Search

Site ID:	721137
Site Name:	PRESTON 38 LLC OG WELL
Address:	ORSON,
Status:	Active

Clients

Client List
PENNSWOOD OIL & GAS LLC (272597)

Programs

DEP Programs
Oil & Gas

PA Municipalities

Municipalities/Counties
Preston Twp, Wayne County

Site Permits

No records matched the criteria.

Facility Permits

Authorization Id	Authorization Type	Date Received	Status/Date
792478	Drill & Operate Well Permit	05/15/2009	Issued 07/29/2009
841478	Drill & Operate Well Permit	07/06/2010	Issued 07/20/2010

Site-Level and Primary Facility-Level Inspections

No records matched the criteria.

Licensing, Permits, and Certification

http://www.ahs2.dep.state.pa.us/eFACTSWeb/searchResults_singleClient.aspx?ClientID=272597

Reference 16

EPA Envirofacts

The PA Code

Last update 8/26/2010 12:58:04 PM

Site Details	North Central Regional Office	Site Search	Sites by County/Muni Search	[no paging]

Site ID:	722440
Site Name:	STOCKPORT ASSN 1
Address:	HANCOCK,
Status:	Active

Clients

Client List
PENNSWOOD OIL & GAS LLC (272597)

Programs

DEP Programs
Oil & Gas

PA Municipalities

Municipalities/Counties
Buckingham Twp, Wayne County

Site Permits

No records matched the criteria.

Facility Permits

Authorization Id	Authorization Type	Date Received	Status/Date
796670	Drill & Operate Well Permit	06/15/2009	Issued 07/22/2009
841481	Drill & Operate Well Permit	07/06/2010	Issued 07/20/2010

Site-Level and Primary Facility-Level Inspections

No records matched the criteria.

Licensing, Permits, and Certification

Reference 17
(Excerpt)

Environmentally Sensitive Maintenance Practices for Unpaved Roads: Sediment Reduction Study

Prepared for

Chesapeake Bay Commission

c/o Senate of Pennsylvania
G-05 North Office Building
Harrisburg, PA 17120

By

Dr. Barry E. Scheetz
Steven M. Bloser

Center for Dirt and Gravel Road Studies

The Pennsylvania State University
University Park, PA 16802

FINAL REPORT
June 30, 2008
Revised August 29, 2008

Research Summary

Center for Dirt and Gravel Road Studies

Sediment Reductions from Environmentally Sensitive Maintenance Practices on Unpaved Roads

8/2008

Research Overview:

Pennsylvania's Dirt and Gravel Road Maintenance Program has long advocated Environmentally Sensitive Maintenance (ESM) Practices to reduce stream pollution from unpaved roads. Penn State's Center for Dirt and Gravel Road Studies (Center) has recently completed a research project with funding from the Chesapeake Bay Commission that begins to quantify sediment reductions from several commonly used ESM practices.

This document is a summary only, full report is available at www.dirtandgravelroads.org under "research".

research funded by…

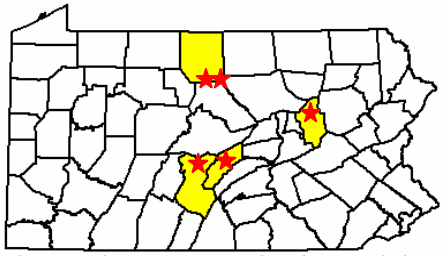
ESM Practices Tested:

Five Environmentally Sensitive Maintenance Practices were tested in this study:

- **Driving Surface Aggregate**: a specific aggregate mixture designed as a wearing course for unpaved roads;
- **Raising the Road Profile**: raising road elevation to eliminate lower ditch & restore sheet flow;
- **Grade Breaks**: elongated humps in the road surface designed to shed water to each side of the road;
- **Additional Drainage Outlets**: creating new outlets in ditchline to reduce channelized flow; and
- **Berm Removal**: removing unnecessary berm and ditch on down slope side of road to encourage sheet flow.

Methods:

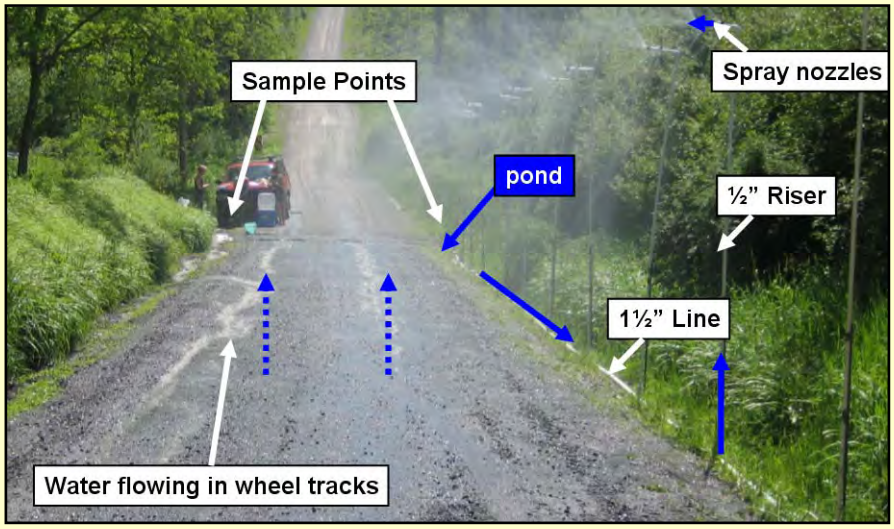
In order to determine sediment reductions of the five practices, it was necessary to collect sediment data both before and after each practice was implemented. The Rainmaker (see description below) was used to create a controlled and repeatable rainfall event on a 100' section of road. Each test consisted of three 30-minute runs of the rainmaker, both before and after ESM practice implementation. Flow and sediment samples were taken at regular intervals to determine the total sediment loss for each section of road. The three test runs were combined for each section of road to determine the average sediment loss for one 30 minute event. By comparing the flow and sediment differences from before and after ESM practice implementation, the sediment reduction from each practice can be determined.



These projects were completed on roads in Potter, Columbia, Huntingdon, and Mifflin Counties as illustrated by the stars above.

Meet the Rainmaker, a Rainfall Simulator for Roadways…

The "rainmaker" is a rainfall simulator developed by the Center that creates a 0.55" rainfall event in 30 minutes over a 100' length of road. This is equivalent to a 1-month return interval for a 30 minute storm for most of Pennsylvania. The rainmaker creates a controlled, repeatable rainfall event that is run both before and after ESM practices are installed on the road. By comparing runoff and sediment concentrations, sediment reductions can be calculated for the various ESM practices. Rainmaker layout and components are illustrated to the right.



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Center for Dirt and Gravel Road Studies

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Results

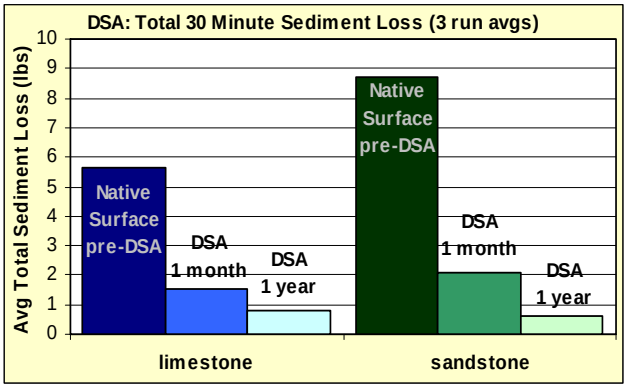
***Special Note**: This study provides a valuable initial look at sediment reductions from ESM practices. However, due to the limited number of sample points, and the infinite variability of road conditions in the field, sediment reductions for specific practices found in this study should NOT be considered blanket or universal reductions for each practice.*

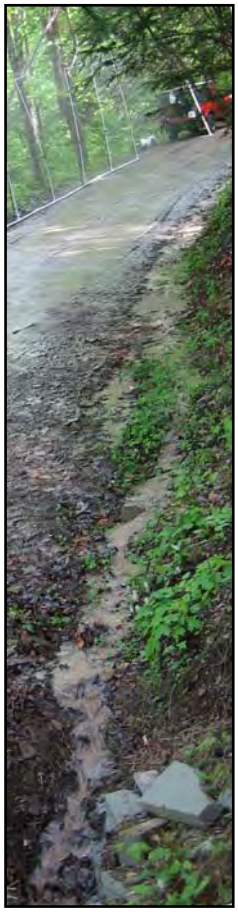
Runoff Rates from Existing Roads:

The five "existing condition" tests done for this study found sediment production rates ranging from 0.7-12.2 pounds of sediment runoff in a single 30 minute, 0.55 inches simulated rainfall. The 0.7 pound event was generated from a flat narrow farm lane with grass growing between the wheel tracks. The 12.2 pound event was generated from a wider, mixed limestone/clay road at a 4-5% slope. This highlights the great variability in erosion rates based on specific site conditions. Using the average sediment runoff rate of 5.6 pounds per event, a single 30 minute 0.55 inch rain event moving across Pennsylvania can be conservatively expected to generate over 3,000 tons* of sediment form the State's 20,000+ miles of public unpaved roads. **For illustrative purposes only, more testing on varied roads is needed to substantiate this extrapolation.*

Driving Surface Aggregate:

Two separate DSA placements were tested on Lebo Road in Potter County. The aggregates, one limestone and one sandstone, were placed according to Dirt and Gravel Road Program standards (one 8" lift, placed using a paver, compacted to 6"). Rainfall simulations were run before placement, and at intervals of 1 month and one year after placement. The graph to the right summarizes the results in total sediment loss per 30 minute rainfall simulation. Compared to their respective native surfaces, Limestone DSA reduce sediment by 73% after one month and 86% after one year, while Sandstone DSA reduced sediment by 76% after one month and 93% after one year. Parent material did not significantly affect sediment generation rates.





Drainage Control Practices:

Unlike DSA which reduces sediment generation from the road surface, the four remaining practices reduce sediment by reducing and controlling the volume of road runoff.

Raising the Road Profile:

Diehl Road in Columbia County was filled approximately 5 feet in order to completely eliminate the ditch on the down slope side of the road. Sheet flow into a vegetative filter was achieved off the down slope side of the road after it was filled. This practice reduced the amount of sediment entering the stream by 82% after one month, and 87% after one year. Some infiltration of runoff into the new road fill may have accounted for the higher than expected sediment reductions on Diehl Road.

Grade Break:

Two grade breaks were tested in this study, one in Huntingdon County, and one in Mifflin County. The grade breaks showed sediment reductions of 57% and 43% respectively. *Note that the grade breaks were placed in the middle of the 100' test section, therefore sediment reductions of 50% indicate the gradebreak was 100% effective in eliminating upslope sediment.*

Additional Drainage Outlets:

The effect of adding a turnout was tested on Pine Swamp Road in Huntingdon County. The new turnout discharged into a vegetative filter and did not affect the stream. A turnout was used instead of a culvert for cost effectiveness and simplicity. The turnout showed sediment reductions of 48% for the down slope ditch alone, or 31% when factoring in the up slope ditch that was unaffected by the turnout. *Note that, as with the "grade-break", the turnout was placed in the middle of the 100' test section, so a 50% sediment reduction indicates a 100% efficiency.*

Berm Removal:

The effect of berm removal was tested on Pine Swamp Road in Huntingdon County. Removing the berm effectively eliminated the down slope ditch and allowed water to sheet flow into a vegetative filter area. Berm removal showed sediment reductions of 94% for the down slope ditch alone, or 59% when factoring in the up slope ditch that was unaffected by the practice.

This is a summary only, full report available at www.dirtandgravelroads.org under "research".

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Reference 18
(Excerpt)

PREPAREDNESS, PREVENTION, AND CONTINGENCY PLAN
WAYNE COUNTY FIELD
WAYNE COUNTY, PENNSYLVANIA

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May 2010

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1.0 DESCRIPTION OF FACILITY

1.1 DESCRIPTION OF THE INDUSTRIAL OR COMMERCIAL ACTIVITY

Newfield Appalachia PA LLC (Newfield) is a natural gas exploration company with operations planned for Wayne County, Pennsylvania. Operations will involve natural gas exploration of the Marcellus Shale formation, which will include site preparation, drilling, and well development and production activities. Wastes generated during these activities will be typical for gas drilling operations and will include drill cuttings, produced water, drilling and frac fluids, waste oil, municipal waste and trash. No hazardous waste is expected to be generated at the Newfield sites.

Newfield is currently in the exploratory phase of operations, which will require construction activities for new natural gas well pads and access roads.

This Prevention, Preparedness and Control (PPC) Plan applies to all well sites in Wayne County, Pa.

The attached map (Figure 1) in Appendix B shows the area covered under this PPC Plan Figure 2 is the required 7.5 topographic map of the specific well site. The proposed Site Plan (Figure 3) shows the site layout, the well site boundaries, material storage areas, waste storage areas, dike drains and drainage that leads away from the well site, and the entrances and exits to the well site.

During the different stages of site preparation, construction, drilling, well development and production, the site will store various fuels, oils and chemicals on-site. A chemical and container inventory for the specific well site is located in Table 1 of Appendix C.

1.2 DESCRIPTION OF EXISTING EMERGENCY RESPONSE PLANS

This is a new facility and this plan has been prepared prior to construction of the well pad. There are no previous emergency response plans.

A separate Spill Prevention Control and Countermeasure (SPCC) Plan will be prepared for each facility meeting the requirements defined in 40 CFR§112.

1.3 MATERIAL AND WASTE INVENTORY

Information in this section is used to evaluate the prevention, containment, mitigation, cleanup, and disposal measures which would be used in the event of a spill, discharge, explosion, or fire. Oils, chemicals and other hazardous materials anticipated to be used and stored at the facility during site preparation and construction, drilling, well development and production are listed in Table 1.

MSDS's will be maintained onsite for chemicals and compounds used at the facility in accordance with the Occupational Safety and Health Administration (OSHA) worker right-to-know requirements, as appropriate.

1.4 POLLUTION INCIDENT HISTORY

Newfield has not had any reportable incidents for this facility.

1.5 IMPLEMENTATION SCHEDULE FOR PLAN ELEMENTS NOT CURRENTLY IN PLACE

All plan elements are in place.

1.6 PURPOSE AND IMPLEMENTATION OF PPC PLAN

Newfield has developed and will implement this PPC Plan for effective action to minimize and abate hazards to human health and the environment from fire, explosion, and emission or discharge of pollutants to air, soil, surface water or groundwater. This plan was prepared to satisfy the requirements set forth in 25 PA Code Section 78.

The Drilling Manager serves as the Primary Emergency Coordinator and is responsible for the preparation and implementation of the PPC Plan. The PPC Plan has been prepared and implemented in general accordance with Pennsylvania Department of Environmental Protection (PADEP) guidelines, and will be submitted to PADEP for approval at such time as the PADEP may prescribe.

This PPC Plan identifies and describes any arrangements with police departments, fire departments, hospitals, contractors, and state, county, and local emergency response teams to coordinate emergency services.

The PPC Plan lists names, addresses and phone numbers of all persons identified to act as Emergency Coordinator. One person is named as the Primary Emergency Coordinator and others are listed in the order in which they will assume responsibility as alternates. The PPC Plan also includes a list of emergency equipment at the facility, the location and a physical description of emergency equipment, and a brief outline of emergency equipment capabilities.

1.7 PLAN REVISIONS

This PPC Plan will be reviewed and amended, annually, or whenever:

- Applicable PADEP regulations are revised;
- The plan fails in an emergency;
- The list of Emergency Coordinators changes;
- The list of emergency equipment changes; and
- Construction, operation, maintenance, or other circumstances change in a manner that materially increases the potential for fires, explosions, or releases of toxic or hazardous constituents; or which changes the response necessary in an emergency.

Reference 19

http://water.epa.gov/polwaste/nps/runoff.cfm

Polluted Runoff

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Erosion, Sediment and Runoff Control for Roads and Highways

United States Environmental Protection Agency | Office of Water (4503F) | EPA-841-F-95-008d December 1995

The Coastal Zone Management Act of 1972 established a program for states to voluntarily develop comprehensive programs to protect and manage coastal water resources. There are now 29 coastal states and territories with federally approved coastal management programs.

The Coastal Zone Act Reauthorization Amendments (CZARA) of 1990 specifically charged coastal states and territories with upgrading their runoff pollution control programs to protect coastal waters. The Environmental Protection Agency (EPA) and the National Oceanic and Atmospheric Administration (NOAA) jointly oversee the development and implementation of these *Coastal Nonpoint Pollution Control Programs*, or CNPCPs.

EPA published *Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters* to be used by states to implement management measures - economically achievable measures that reflect the greatest degree of runoff pollution control - to control the addition of runoff pollutants to coastal waters.

The *Guidance* also includes best management practices, technologies, processes, siting criteria, and operating methods for roads, highways, and bridges that states can use to implement the management measures. States can use alternative management measures if they provide the same or a greater degree of pollutant control as the management measures in the *Guidance*. States will begin implementing their CNPCPs in 1996 and achieve full implementation by 2004.

CZARA applies to site development and land disturbing activities in the coastal management area of each State with an approved coastal management program. Certain road, highway and bridge related activities are excluded from this program due to coverage under the National Pollutant Discharge Elimination System (NPDES) permitting program. These activities include construction activities where 5 or more acres (2.02 ha) are disturbed, and activities within municipalities with municipal separate storm sewer systems that have populations of 100,000 or more.

Why Runoff Control is Needed

Runoff controls are essential to preventing polluted runoff from roads, highways, and bridges from reaching surface waters. Erosion during and after construction of roads, highways, and bridges can contribute large amounts of sediment and silt to runoff waters, which can deteriorate water quality and lead to fish kills and other ecological problems.

Heavy metals, oils, other toxic substances, and debris from construction traffic and spillage can be absorbed by soil at construction sites and carried with runoff water to lakes, rivers, and bays. Runoff control measures can be installed at the time of road, highway, and bridge construction to reduce runoff pollution both during and after construction. Such measures can effectively limit the entry of pollutants into surface waters and ground waters and protect their quality, fish habitats, and public health.

Pesticides and fertilizers used along roadway rights-of-way and adjoining land can pollute surface waters and ground water when they filter into the soil or are blown by wind from the area where they are applied. Table 1 shows typical pollutants in runoff waters that can be traced to the operation of roads and highways.

Principles of Runoff Control for Roads, Highways, and Bridges

Preventing runoff pollution from road, highway, and bridge construction in coastal areas requires planning, education, inspection,

and maintenance. An erosion and sediment control (ESC) plan that incorporates the most appropriate and cost-effective best management practices (BMPs) is essential to effective pollution control. Affected highway personnel must be educated about the requirements of the ESC plan. Inspection and enforcement authority are necessary to ensure awareness of and compliance with the adopted practices. Finally, BMPs require regular maintenance to ensure that they perform optimally. The following principles apply to an effective erosion and runoff control program.

- **Develop a comprehensive erosion and sediment control (ESC) plan prior to earth-moving activities.** Write ESC requirements into plans, specifications, and cost estimates for highway and bridge projects.
  Four key factors affect the potential for soil erosion from a site: soil characteristics, vegetative cover, topography, and climate. Take all of these factors into consideration to develop an ESC plan that will minimize soil loss, limit the area exposed to construction, maximize the vegetative cover, use natural topographic features to the best advantage, and include BMPs suitable to the regional climate.

  The Federal Highway Administration Local Transportation Assistance Program, the Association of American State Highway and Transportation Officials, and many state highway departments can provide ESC guidelines.

- **Apply ESC practices to prevent excessive onsite damage.** Use ESC BMPs to control the flow of runoff water and thereby prevent or lessen soil erosion. Limiting land disturbance and preserving natural vegetation are excellent ESC practices.
- **Apply perimeter control practices to protect the disturbed area from offsite runoff and to prevent sedimentation damage to areas below the construction site.** A sediment and runoff barrier surrounding the disturbed area prevents construction site runoff from moving offsite and fouling surface waters downstream.
- **Keep runoff velocities low and retain runoff on the site.** The erosive power of runoff increases dramatically as distance and slope increase. BMPs can be used to effectively control runoff velocity and detain it to remove 80 to 90 percent of the sediment from runoff.
- **Stabilize disturbed areas immediately after final grade has been attained.** Any exposed soil is subject to erosion from rainfall, wind, and vehicles. BMPs to stabilize soil should be applied as quickly as possible after the land is disturbed. Temporary stabilization practices include seeding, mulching, and erosion control blankets or mats.
- **Develop a schedule and implement a comprehensive inspection and maintenance program.** This principle is vital to the success of erosion control. BMPs must receive regular inspection and maintenance to ensure that they are operating effectively and optimally, both during and after construction.

Best Management Practices

CZARA defines management measures as economically achievable measures to control the addition of pollutants to our coastal waters. Management measures are achieved by the application of one or more BMPs. The BMPs described below are especially useful for erosion and runoff control for roads, highways, and bridges.

Best management practices can be organized by the function they perform. General maintenance BMPs (listed below) are usually vegetative practices used to contain polluted runoff from the operation of highways or from erosion and sedimentation generated at small construction sites. A variety of practices are used at construction sites to control both erosion and polluted runoff. These are identified as Construction Site BMPs. Practices developed as permanent erosion and sediment control devices are both structural and nonstructural. Several of these BMPs are listed below as long-term or Permanent Control BMPs.

Construction Site BMPs

- **Straw bale barriers** should be bound, entrenched, and securely anchored to prevent deterioration. A row of straw bales slows runoff flow and creates a pond behind the barrier where sediment can settle out. Straw bale barriers are most effective for filtering low to moderate storm flows, where structural strength is not required.
- **Filter fabrics** are engineering fabrics designed to retain sediment particles larger than a certain size and allow water to pass through. Filter fabrics can be used in silt fences (see below) or erosion control mats. Erosion control mats protect soil and seed from erosion and can be designed to allow vegetation to grow through the material.
- **Silt fences** are vertical fences of filter fabric that are stretched across and attached to support poles. The fabric retains sediment on the construction site and allows relatively sediment-free water to pass through. Silt fences are placed to protect streams and surrounding property from sediment-laden runoff.
- **Sediment basins** are ponds created by excavation or the construction of a dam or barrier. Sediment basins primarily serve to retain or detain runoff to allow excessive sediment to settle out during construction. Sediment basins can be converted into permanent detention ponds or wetlands after construction.
- **Stabilized entrances** reduce the amount of sediment carried off a construction site by vehicles when pressure-washed on-site. These entrances are designed to include stabilized pads of aggregate underlain with a filter fabric. Stabilized construction site entrances should be located at any point in the construction zone where vehicles enter and leave. Wheels and undercarriages of vehicles should be washed before leaving the site.

Operation and Maintenance

Inspection and maintenance of erosion and sediment control BMPs after construction has been completed is important to ensure that the BMPs are operating properly and effectively. Some key operation and maintenance procedures include:

- **Prepare and adhere to a schedule of regular maintenance for temporary erosion and runoff control BMPs.** Two critical maintenance operations that must be performed regularly are cleaning out accumulated sediment and replacing worn-out or deteriorated materials, such as silt fence fabrics, so that the effectiveness of the controls is maintained. Maintenance can include dredging and reshaping sediment basins and revegetating the slopes of grassed swales.
- **Remove temporary BMPs from construction areas when they are no longer needed and replace them, where appropriate, with permanent BMPs.**
- **Schedule and periodically inspect and maintain permanent erosion and runoff controls.** This should include a periodic visual inspection of permanent BMPs during runoff conditions to ensure that the controls are operating properly. Clean, repair, and replace permanent erosion and runoff control BMPs when necessary.

General Maintenance BMPs

- **Seeding with grass and fertilizing** to promote strong growth provide long-term stabilization of exposed surfaces. Disturbed areas can be seeded and fertilized during construction and after it is completed. Sufficient watering and refertilizing 30 to 40 days after the seeds germinate help establish dense growth.
- **Seeding with grass and overlaying with mulch or mats** is done to stabilize cleared or freshly seeded areas. Types of mulches include organic materials, straw, wood chips, bark or other wood fibers, or decomposed granite and gravel. Mats are made of natural or synthetic material and are used to temporarily or permanently stabilize soil.
- **Wildflower cover** has been successfully used by many state and county highway departments to provide attractive vegetation along roadways and erosion control. Careful consideration must be given to visibility, access, soil condition, climate, and maintenance when choosing sites for wildflower cover.
- **Sodding** with established grass blankets on prepared soil provides a quick vegetative cover to lessen erosion. Proper watering and fertilizing are important to ensure the vitality of newly placed sod.

Permanent Control BMPs

- **Grassed swales** are shallow, channeled grassed depressions through which runoff is conveyed. The grass in swales slows the flow of runoff water, which allows sediment to settle out and water to infiltrate into the soil. Grassed swales can remove small amounts of pollutants such as nutrients and heavy metals. Check dams (see below) can be added to grassed swales to further reduce flow velocity and promote infiltration and pollutant removal.
- **Filter strips** are wide strips of vegetation located to intercept overland sheet flows of runoff. They can remove organic material, sediment, and heavy metals from runoff. Filter strips can consist of any type of dense vegetation from woods to grass but they cannot effectively treat high-velocity flows. They are therefore best suited to low-density developments.
- **Terracing** breaks a long slope into many flat surfaces where vegetation can become established. Small furrows are often placed at the edge of each terraced step to prevent runoff from eroding the edge. Terracing reduces runoff velocity and increases infiltration.
- **Check dams** are small temporary dams made of rock, logs, brush, limbs, or another durable material, placed across a swale or drainage ditch. By reducing the velocity of storm flows, sediment in runoff can settle out and erosion in the swale or ditch is reduced.
- **Detention ponds or basins** temporarily store runoff from a site and release it at a controlled rate to minimize downstream flooding. Pollutant removal effectiveness is quite good for well-designed basins. Effectiveness is greatest for suspended sediments (80 percent or more removal) and related pollutants such as heavy metals.
- **Infiltration trenches** are shallow, three to eight feet deep (.91 to 2.44 m), excavated trenches that are backfilled with stone to create underground reservoirs. Runoff is diverted into the trenches, from which it percolates into the subsoil. Properly designed infiltration trenches effectively remove sediment from runoff and can remove some other runoff pollutants.
- **Infiltration basins** are relatively large, open depressions produced by either natural site topography or excavation. When runoff enters an infiltration basin, the water percolates through the bottom or the sides and the sediment is trapped in the basin. The soil where an infiltration basin is built must be permeable enough to provide adequate infiltration. Some pollutants other than sediment are also removed in infiltration basins.
- **Constructed wetlands** are areas inundated by water for a sufficient time to support vegetation adaped for life in saturated soil conditions. Wetlands effectively filter sediment, nutrients, and some heavy metals from runoff waters.

Table 1. Typical pollutants found in runoff from roads and highways.

Sources of Pollution in Highway Runoff

	Pollutant	Source
Sedimentation	Particulates	Pavement wear, vehicles, the atmosphere and maintenance activities
Nutrients	Nitrogen & phosphorus	Atmosphere and fertilizer application
Heavy Metals	Lead	Leaded gasoline from auto exhausts and tire wear
	Zinc	Tire wear, motor oil and grease
	Iron	Auto body rust, steel highway structures such as bridges and guardrails, and moving engine parts
	Copper	Metal plating, bearing and brushing wear, moving engine parts, brake lining wear, fungicides & insecticides
	Cadmium	Tire wear and insecticide application
	Chromium	Metal plating, moving engine parts and brake lining wear
	Nickel	Diesel fuel and gasoline, lubricating oil, metal plating, bushing wear, brake lining wear and asphalt paving
	Manganese	Moving engine parts
	Cyanide	Anti-caking compounds used to keep deicing salt granular
	Sodium, calcium & chloride	Deicing salts
	Sulphates	Roadway beds, fuel and deicing salts
Hydrocarbons	Petroleum	Spills, leaks, antifreeze and hydraulic fluids and asphalt surface leachate

Adapted from Guidance Specifying Management Measures for Sources of Nonpoint Pollution in Coastal Waters

Last updated on Wednesday, April 21, 2010.

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United States Environmental Protection Agency
Final Report for Catalog of Federal Domestic Assistance Grant Assistance Number 66.463 Water Quality Cooperative Agreement for Project Entitled "Demonstrating the Impacts of Oil and Gas Exploration on Water Quality and How to Minimize these Impacts Through Targeted Monitoring Activities and Local Ordinances"

ID No. CP-83207101-1

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Summary of the Results of the Investigation Regarding Gas Well Site Surface Water Impacts

In 2005, the Environmental Protection Agency awarded a grant to the City of Denton, Texas, to monitor and assess the impact of gas well drilling on stormwater runoff, and to provide, if necessary, regulatory and management strategies for these activities. This unique study focused on three nearby gas well sites where pad construction and drilling were occurring. Runoff, primarily from the sites' well pad areas, was monitored and analyzed, as were the contents of on-site drilling mud pits.

There is presently no regulatory oversight of oil and gas-related construction or operations under the National Pollutant Discharge Elimination System (NPDES) permit program, except in very limited circumstances. While NPDES stormwater regulations cover a large amount of the construction and industrial activity in the US, Congress mandated that oil and gas construction is specifically exempt from stormwater regulations in the Energy Policy Act of 2005 (the act encourages oil and gas operators to voluntarily implement best management practices to minimize erosion and control sediment). To help local governments decide whether drilling activities do, in fact, have impacts on their water resources, and how to minimize those impacts, the Agency awarded this research grant.

Findings

Gas well sites have the potential to produce sediment loads comparable to traditional construction sites.

- Total suspended solids (TSS) and turbidity event mean concentrations (EMC = pollutant mass / runoff volume) at gas sites were significantly greater than at reference sites (the median TSS EMC at gas sites was 136 times greater than reference sites).

- Compared to the median EMCs of storms sampled by Denton near one of their outfalls, the gas well site median EMC was 36 times greater.

- Gas site TSS EMCs ranged from 394 to 9898 mg/l and annual sediment loadings ranged from 21.4 to 40.0 tonnes/hectare/year (tonne = 1000 Kg; hectare = 10,000 square meters), and were comparable to previous studies of construction site sedimentation.

Other pollutants in gas well runoff were found in high concentrations.

- EMCs of total dissolved solids, conductivity, calcium, chlorides, hardness, alkalinity and pH were higher at gas well sites compared to reference sites, and differences were statistically significant for all parameters except conductivity.

- Generally, the presence of metals was higher at gas well sites compared to reference sites and EMCs were statistically significantly greater for Fe, Mn and Ni.

- Overall, the concentrations of metals tend to be higher at gas well sites compared to both nearby reference sites and as measured in runoff from local mixed-use watersheds (EMCs were statistically significantly greater for Fe, Mn and Ni).

- Total petroleum hydrocarbons (TPH) were not detected in any of the samples collected at gas well sites or reference sites.

Conclusions based on runoff sampling results.

- Gas well sites have the potential to negatively impact surface waters due to increased sedimentation rates and an increase in the presence of metals in stormwater runoff.
- Pad sites also have the potential to produce other contaminants associated with equipment and general site operations.
- Gas wells do not appear to result in high concentrations of petroleum hydrocarbons in runoff, but accidental spills and leaks are still a potential source of impact.

Runoff monitoring from gas well sites can be difficult.

- Requires complex equipment to do the volume-based sampling needed.
- Municipal inspections by trained individuals are important.
- In most cases, sediment impacts are visually apparent.

States or local governments should consider regulating sediment and associated pollutants in stormwater runoff.

- Recommended approach: develop regulations similar to current NDPES requirements for construction sites.
- Requirement options: stormwater pollution prevention plans, erosion and sediment control BMPs, provisions for containing spills and leaks, procedures for site inspections and enforcement of control measures, sanctions to ensure compliance.
- Require installation of berms around the down slope portion of gas well pad sites (regular compost can be used but newer, better technologies such as compost "socks" offer more stability, durability and ease of installation).

Models and other predictive tools can help with gas site management decisions.

- The Water Erosion Prediction Project (WEPP) and the Revised Universal Soil Loss Equation (RUSLE 2.0) can be used to model runoff and sediment yields from gas well sites, and to evaluate sediment impacts and control options
- Modeling indicated that using both erosion and sediment controls at sites tended to give the best combination of protection and cost, but the optimum combination is dependent on soil type and slope.
- Modeling showed that using BMPs reduced sediment from 52% to 93%.
- Generally, mulching and erosion control blankets produced the best results; however, in most cases, silt fences or filter strips were shown to be less expensive and still effective.
- The approach used can be applied to complex or simple slopes, can evaluate a wide variety of BMPs, and can be easily customized for specific site characteristics or geographical regions.

Regulating gas well drilling and production operations is needed, but can be complex.

- In addition to erosion and sediment control requirements, institute regulations for site locations and tree preservation.

- Requirements are needed for proper site management, equipment maintenance, and hazardous materials management and containment.

- Subchapter 22 of the Denton Development Code (www.cityofdenton.com) has information municipalities can use to establish gas well regulations.

- Regular monitoring of receiving waters using specific conductance (conductivity) can, under the right circumstances, offer a relatively inexpensive and rapid method for detecting contaminant discharges and tracing these discharges back to the well site source.

Regulating site activities (i.e., site management).

.

- Place drip pans or oil absorbing materials underneath all tanks, containers and other equipment with a potential to leak.

- Store chemical materials on pallets or other devices to raise containers off the ground, and shelter the materials from stormwater and wind.

- Depending on the type and quantity of materials, use secondary containment and other similar strategies.

- Institute a hazardous materials management plan, including adequate labeling and containment, and having material safety data sheets on hand.

- Remediate as quickly and safely as possible any accidental spills, leaks or discharges of materials.

Regulating well drilling locations.

- Typically, consists of site "setback" requirements from residential structures and places of assemblage (e.g., schools, churches).

- The proximity to surface water conveyances is an important consideration for minimizing water impacts, i.e., flat, heavily vegetated areas distant from surface waters are usually less of a concern than those areas close to waters that have highly erodible soils, steeper slopes and little vegetation.

- In floodplains or other environmentally sensitive areas, Denton requires a Watershed Protection Permit (WPP), which contains extra environmental regulations plus a fee to cover site assessments, additional regulatory oversight, and water quality testing.

- Denton's WPP requirements highlights:

  - Must take a tree survey of the site and effect a 1:1 replacement for trees removed from the site.

  - Storage tanks and separation facilities allowed only if they are at least 18 in above the established base flood elevation, plus an extra depth for encroachment to the limits of the floodway

- Must show via an engineering study that the proposed activity will have no adverse impact on the carrying capacity of the adjacent waterway, and will not cause any increase in the elevations established for the floodplain.

Regulating tree preservation (Denton's program).

- All construction activities associated with gas wells, roads, pipelines, etc., must be considered.
- In non-WDD areas, must mitigate at a rate of 25% for all trees removed from the property in the form of payments to Denton's tree fund (not on-site planting).
- Removal of trees in WDD areas may cause a loss of critical habitat and harm waters, thus the 1:1 replanting requirement (or a very high payment into tree fund).

Well drilling mud pits merit attention and management.

- Mud pits exceeded the regulatory standard for total petroleum hydrocarbons (TPH) of 15 mg/L in approximately 46% of samples (there were also a few instances of very high concentrations, with a max of 25,590 mg/l).
- Based on the diesel and hydraulic equipment used at gas well sites, and the type of hydrocarbons found, contamination was likely due at least in part to such things as maintenance activities, fuel / hydraulic fluid leaks and spills, or similar sources.
- To a lesser extent, this also applies to fracture water pits.
- Municipalities may want to consider sampling and setting standards for pits, but mud pit contents are complex and appeared not amenable to analyses via rapid field-based methods or rapid laboratory methods.
- Although a regular monitoring program coupled with associated regulatory standards may be the best way to minimize the pollution potential for these pits, municipalities may not have the staff, resources or expertise to implement such a program.

Regulating mud pits.

- Enforceable standards for pit contents are not generally viable; instead, consider pit design standards that minimize the chances of releases.
- Restrict pits to areas with relatively flat slopes and design them to not capture much stormwater so the pits do not overflow.
- Use pit liners.
- Use freshwater-based muds only.
- Maintain a minimum freeboard distance between the elevation of the pit contents and the elevation of the top of the mud pit dam.
- Remove mud pits as soon as possible after drilling.
- Eliminate open mud pits altogether (e.g., use closed loop drilling).

Placement of drip pans or oil absorbing materials underneath all tanks, containers and other equipment with a potential to leak.

Safely store chemical materials on pallets or other devices to raise containers off the ground and, and sheltering them from stormwater and weather elements.

Depending on the type and quantity of materials, secondary containment and other similar strategies may be appropriate.

Institute a hazardous materials management plan including adequate labeling and containment, and have material safety data sheets available.

Remediate as quickly and safely as possible any accidental spills, leaks or discharges of materials.

Reference 21
(Excerpt)

EROSION AND SEDIMENT CONTROL PLAN

FOR THE PROPOSED
DAVIDSON 1V WELL SITE
SCOTT TOWNSHIP
WAYNE COUNTY, PENNSYLVANIA
APRIL 2010

Submitted for:
Hess Corporation
500 Dallas Street
Houston, TX 77002

Statement of Limitations: This report is intended for the sole use of Hess Corporation. The scope of services performed may not be appropriate to satisfy the need of other users, and an use or re-use of this document or of the findings, conclusions, or recommendations presented herein is at the sole risk of said user. Background information, design bases, and other data have been furnished to URS by Hess Corporation and/or third parties, which URS has used in preparing this report. URS has relied on this information as furnished, and is neither responsible for nor has confirmed the accuracy of this information.

I do hereby certify to the best of my knowledge, information and belief, that the Erosion and Sediment Control and Site Restoration Plan are true and correct, represent actual field conditions and are in accordance with 25 PA. Code Chapters 78 and 102 of the Department's rules and regulations. I am aware that there are significant penalties for submitting false information, including the possibility of imprisonment.

Prepared By:

URS

335 COMMERCE DRIVE, SUITE 300
FORT WASHINGTON, PA 19034
Job # 19998479.00010

IMPORTANT
A COPY OF THIS EROSION AND SEDIMENT CONTROL PLAN NARRATIVE AND COMPANION DRAWINGS MUST BE PRESENT ON SITE AT ALL TIMES DURING CONSTRUCTION.

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ATTACHMENTS

Attachment A.	PNDI Search
Attachment B.	Design Calculations
Attachment C.	Soil Survey Report
Attachment D.	Form 5500-FM-OG0111
Attachment E.	Act 14 Notification Letters and Proof of Receipt
Attachment F.	Erosion and Sediment Control Plan Drawings

INTRODUCTION

The Erosion and Sediment Control (E&SC) Plan for well pad installation associated natural gas exploration (Project) includes this narrative, appended supporting information and drawings. The E&SC Plan described in this narrative was developed to comply with the requirements of Chapter 102, Title 25 of the Pennsylvania Administrative Code created under the Clean Streams Law. The Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Pollution Control Program Manual, dated April 2000, was used as a primary reference for the design and selection of erosion and sediment control Best Management Practices (BMPs).

1.0.0 Project Description

This project is located on an unused, forested area accessed from Harris Road in Scott Township, Wayne County, Pennsylvania. The proposed work includes grading and construction of approximately 2,600 feet (ft) of access road and a one (1) 300 ft x 300 ft gravel drilling pad. Once drilling has been completed, the gravel pad will be reduced in size to 200 ft x 200 ft. The resulting disturbed area will be stabilized with grass seed.

1.1.0 Stormwater Handling

1.1.1 Existing Site Drainage Characteristics

The site currently does not have a drainage system in place. The project is located on a gently sloping hillside. Stormwater from the existing project area generally drains in sheet-flow and/or concentrated overland flow conditions from north to south. Runoff from the site drains to an unnamed tributary to Sherman Creek which is classified as high quality – cold water fishes (HQ-CWF).

1.1.2 Proposed Site Drainage Characteristics

The proposed drainage will closely match that of the existing drainage characteristics. Due to the location of the well pad, stormwater runoff will generally flow from north to south following the same general pattern as under existing conditions. Diversion channels will be constructed at the base of the well pad cut slope which will divert up-gradient stormwater runoff around the pad to stabilized outlets (i.e., riprap aprons). Roadside ditches will be constructed on the upslope side of the access road. Cross drain culverts will be placed along the access road to convey stormwater under the roads to stabilized outlets (i.e., riprap aprons). Stormwater flowing across the well pad will drain to a sump located in a topographical low corner. The sump will be drained during rain events and discharged through a stabilized outlet (riprap apron) to areas with stable ground cover.

1.2.0 Project Schedule

The project construction is anticipated to begin in May of 2010 and be concluded in February 2011.

Reference 22
(Excerpt)

POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN

HESS MARCELLUS SHALE SITE - DAVIDSON 1V

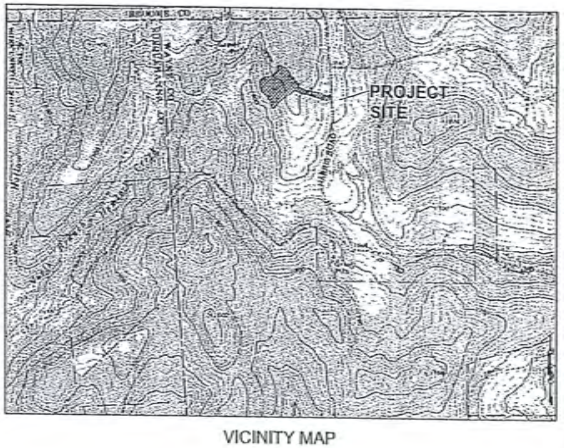
149 HARRIS ROAD
SCOTT TOWNSHIP, WAYNE COUNTY
PENNSYLVANIA

Prepared for:

HESS CORPORATION

REGIONAL LOCATION MAP
PENNSYLVANIA STATE
N.T.S.

DRAWING SCHEDULE		
DRAWING NUMBER	DRAWING TITLE	DRAWING SCALE
PCSM-01	COVER SHEET	AS SHOWN
PCSM-02	EXISTING CONDITIONS PLAN	1"=100'
PCSM-03	POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN	1"=100'
PCSM-04	DETAILS (SHEET 1 OF 2)	NTS
PCSM-05	DETAILS (SHEET 2 OF 2)	NTS



VICINITY MAP
N.T.S.

OWNER:
HESS CORPORATION
500 DALLAS STREET
HOUSTON, TX 77002
(570) 253-7801

SITE LOCATION:
149 HARRIS ROAD
SUSQUEHANNA, PA 18847

ENGINEER:
URS CORPORATION
335 COMMERCE DRIVE, STE. 300
FORT WASHINGTON, PA 19034
PH: (215) 367-2500 FAX: (215) 367-1000

REVISIONS				
NO.	BY	CHKD	DATE	DESCRIPTION
0	SVB	NCW	4/23/10	SUBMITTED TO FUGRO FOR EXPEDITED REVIEW

NOTES:

1. SCALE NOTED APPLIES TO 22" x 34" SHEET SIZE. FOR SHEET SIZES OTHR THAN 22"X34", REFER TO GRAPHIC SCALE.
2. EXISTING CONTOURS SHOWN ARE BASED ON NGVD88 DATUM.
3. HORIZONTAL DATUM IS TIED TO THE NORTH AMERICAN DATUM (NAD) OF 1983.

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FAX: (215) 367-1000

HESS MARCELLUS SHALE WELL SITES
DAVIDSON 1V
SCOTT TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA
POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN
COVER SHEET

JOB NO. 10998479 SCALE: NTS
ORIGINAL DATE: 04/23/10 LAST REVISED: 04/23/10 REV: 0
DRAWING NO. PCSM-01

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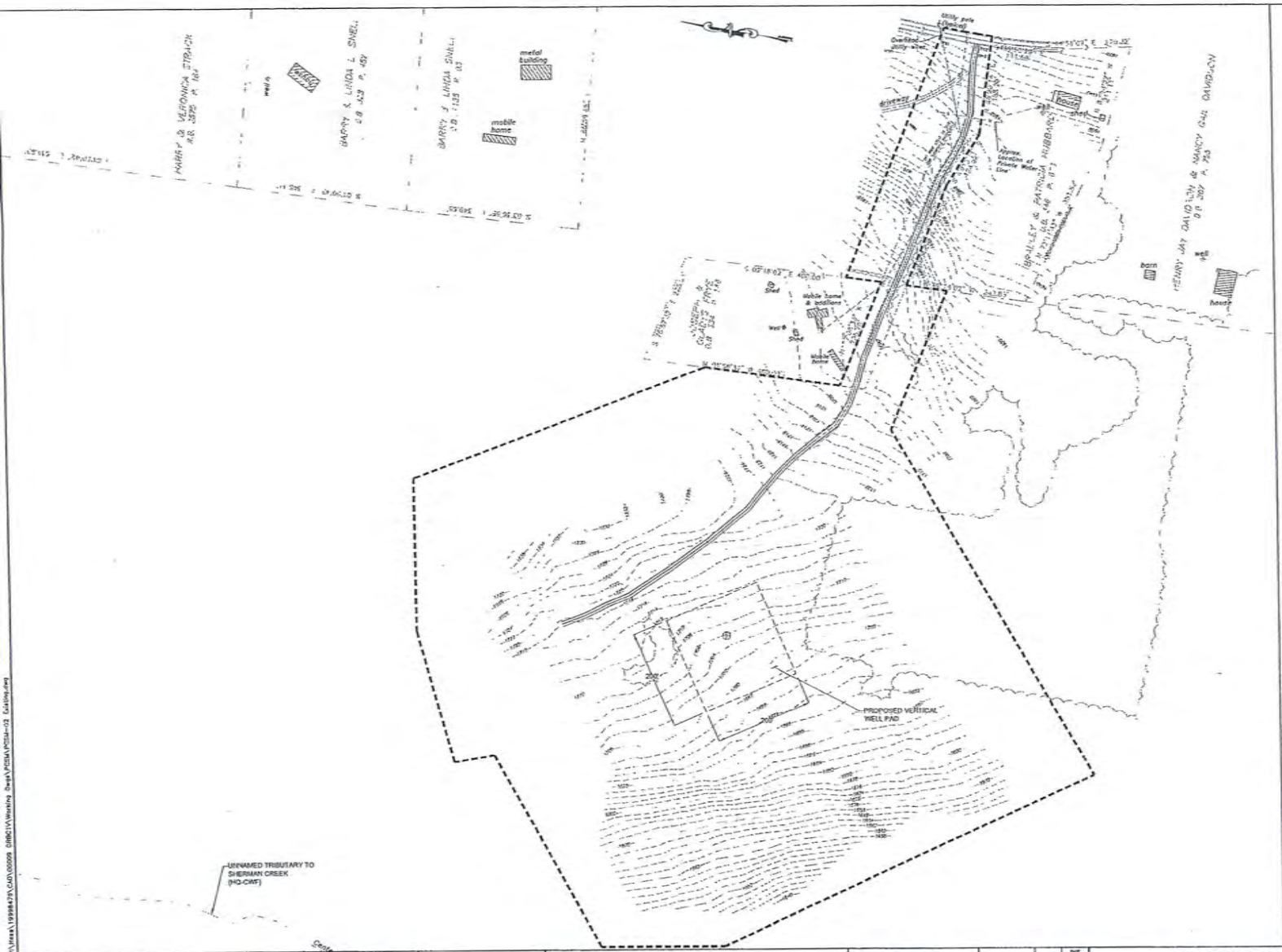

LEGEND:

—1640—	MAJOR CONTOUR (10' INTERVAL)
	MINOR CONTOUR (2' INTERVAL)
·243.2	EXISTING SPOT ELEVATION
LdC2	SOIL CLASSIFICATION
	SOIL BOUNDARY
	PROPERTY LINE
	EDGE OF TREES
	PROPERTY LINE
⊕	VERTICAL GAS WELL
	PROJECT BOUNDARY
	EXISTING STONE WALL

NOTES:

1. EXISTING FEATURES, 2-FOOT CONTOURS, AND PROPERTY LINES SHOWN HEREON ARE FROM A FIELD SURVEY PERFORMED BY FACHER ASSOCIATES, INC., 146 HOLGATE ROAD, HONESDALE, PA 18431, (570) 224-4300 DURING MARCH 2010.
2. THIS TOPOGRAPHIC MAP DOES NOT REPRESENT A PROPERTY BOUNDARY SURVEY.
3. HORIZONTAL DATUM IS TIED TO THE NORTH AMERICAN DATUM (NAD) OF 1983.
4. VERTICAL DATUM IS TIED TO THE NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1988.
5. THE RECEIVING WATERCOURSE, LOCATED WEST OF THE PROJECT AREA, IS AN UNNAMED TRIBUTARY TO SHERMAN CREEK. THE CHAPTER 93 CLASSIFICATION IS HIGH QUALITY-COLDWATER FISHES (HQ-CWF).

100 0 100 200
SCALE IN FEET

REVISIONS				
NO.	BY	CHKD	DATE	DESCRIPTION
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NOTES:

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DAVIDSON 1V
SCOTT TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA
POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN
EXISTING CONDITIONS PLAN

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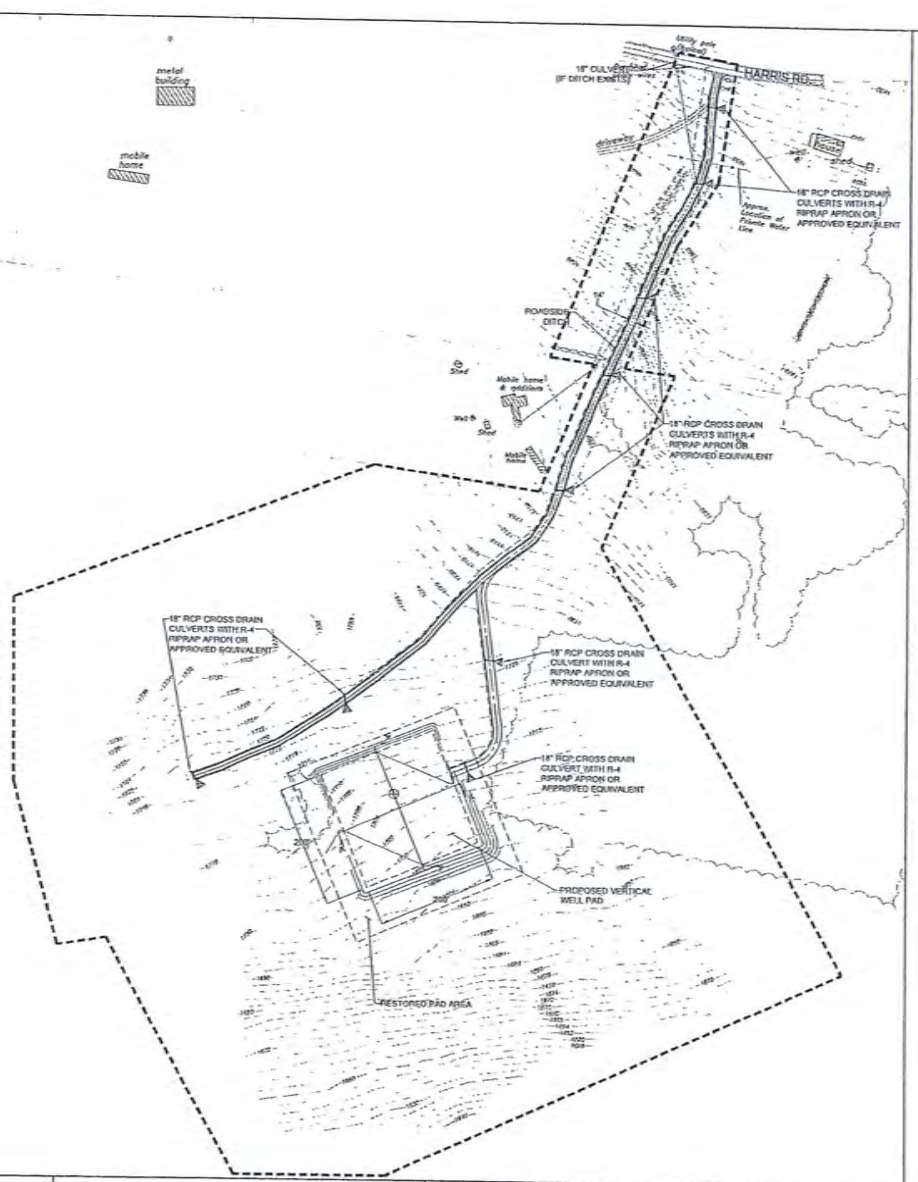

LEGEND:

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	MINOR CONTOUR (2' INTERVAL)
-243.2	EXISTING SPOT ELEVATION
LdC2	SOIL CLASSIFICATION
	SOIL BOUNDARY
	PROPERTY LINE
	EDGE OF TREES
	VERTICAL GAS WELL
	PROPOSED MAJOR CONTOUR (5' INTERVAL)
	PROPOSED MINOR CONTOUR (1' INTERVAL)
	PROPOSED DRIVE
	ROADSIDE DITCH
	CROSS DRAIN
	RIPRAP APRON
	PROJECT BOUNDARY

NOTES:

1. EXISTING FEATURES SHOWN HEREON ARE FROM A FIELD SURVEY PERFORMED BY PACKER ASSOCIATES, INC., 148 HOLGATE ROAD, HONESDALE, PA 18431, (570) 224-4300 DURING MARCH 2010.
2. HORIZONTAL DATUM IS TIED TO THE NORTH AMERICAN DATUM (NAD) OF 1983.
3. VERTICAL DATUM IS TIED TO THE NATIONAL GEODETIC VERTICAL DATUM (NGVD) OF 1988.
4. THE RECEIVING WATERCOURSE, LOCATED WEST OF THE PROJECT AREA, IS AN UNNAMED TRIBUTARY TO SHERMAN CREEK. THE CHAPTER 93 CLASSIFICATION IS HIGH QUALITY-COLDWATER FISHES (HQ-CWF).

100 0 100 200
SCALE IN FEET

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1				
2				
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6				
7				
8	BVK	PEW	04-23-10	SUBMITTED TO PADEP FOR REVIEW AND REVIEW

COMMONWEALTH OF PENNSYLVANIA REGISTERED PROFESSIONAL ENGINEER

NOTES:

1. SCALE NOTED APPLIES TO 22" x 34" SHEET SIZE. FOR SHEET SIZES OTHER THAN 22"X34", REFER TO GRAPHIC SCALE.
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URS

335 COMMERCE DRIVE STE 300
FORT WASHINGTON, PA 19034
TEL: (215) 367-2500
FAX: (215) 367-1000

		DATE
DESIGNED BY:	TPF	04/23/10
DRAWN BY:	BVK	04/23/10
CHECKED BY:	PEW	04/23/10
APPROVED BY:		
QUALITY APPROVED BY:		

0 0.5 1.0
IF THIS BAR DOES NOT MEASURE 1" THEN DRAWING IS NOT TO SCALE

HESS MARCELLUS SHALE WELL SITES
DAVIDSON 1V
SCOTT TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA

POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN

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ORIGINAL DATE: 04/23/10	LAST REVISION: 04/23/10	REV. 0

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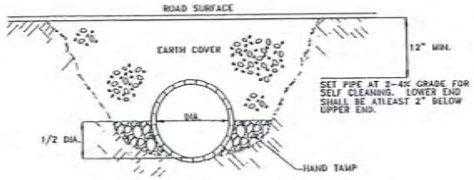

TYPICAL CROSS DRAIN CULVERT
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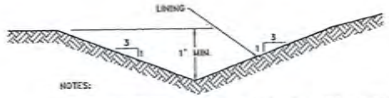
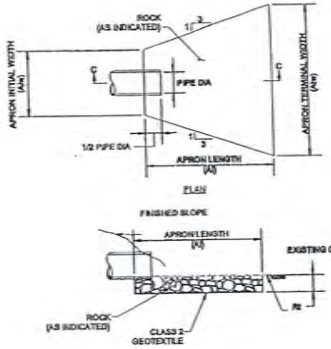


NOTES:

1. SEE MANUFACTURER'S INSTALLATION DETAIL FOR STAPLE PATTERNS, AND VEGETATION STABILIZATION SPECIFICATIONS FOR SOIL AMENDMENTS, SEED MIXTURES, AND MULCHING INFORMATION.

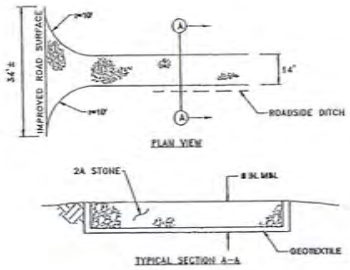
SLOPE (H:)	LINING
1 – 5	NAG - S75BN
5 – 10	NAG - P300

TYPICAL ROADSIDE DITCH SECTION
N.T.S.

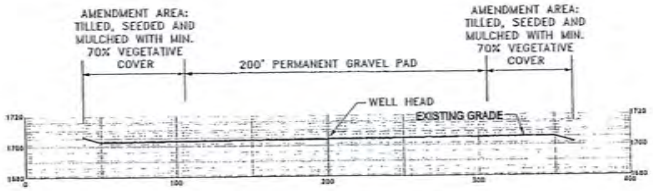


OUTLET NO.	PIPE DIA. Pd (IN)	RIPRAP		APRON		
		SIZE	THICK. Rt (IN)	LENGTH Al (FT)	INITIAL WIDTH Aiw (FT)	TERMINAL WIDTH Atw (FT)
TYPICAL	18	R-4	18	10	4.5	13

RIPRAP APRON
N.T.S.



PERMANENT ACCESS ROAD
N.T.S.



PERMANENT WELL PAD CROSS-SECTION B-B'
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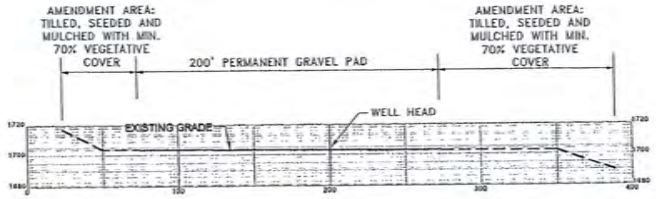

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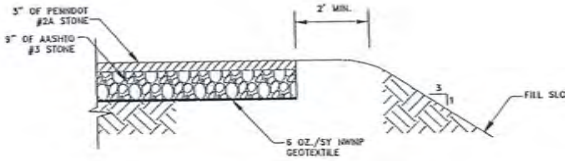

PERMANENT WELL PAD - SURFACING DETAIL
N.T.S.

REVISIONS				
NO.	BY	CHKD	DATE	DESCRIPTION

NOTES:

1. SCALE NOTED APPLIES TO 22" x 34" SHEET SIZE. FOR SHEET SIZES OTHR THAN 22"X34", REFER TO GRAPHIC SCALE.
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SCOTT TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA

POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN DETAILS (SHEET 1 OF 2)

04/23/10

PCSM-0

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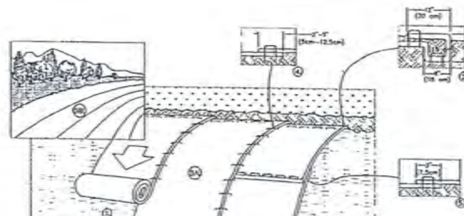


NOTES:

1. PLACE EROSION CONTROL MATTING (NAG P-300 OR APPROVED EQUAL) ON SLOPES AT OR STEEPER THAN 3:1.
2. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED.
3. BEGIN AT THE TOP OF THE SLOPE BY ANCHORING THE BLANKET IN A 6" (15cm) DEEP X 6" (15cm) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30cm) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30cm) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30cm) APART ACROSS THE WIDTH OF THE BLANKET.
4. ROLL THE BLANKETS (A.) DOWN OR (B.) HORIZONTALLY ACROSS THE SLOPE. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE STAPLE PATTERN GUIDE. WHEN USING OPTIONAL DOT SYSTEM*, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
5. THE EDGES OF PARALLEL BLANKETS MUST BE STAPLED WITH APPROXIMATELY 2"-5" (5cm-12.5cm) OVERLAP DEPENDING ON BLANKET TYPE. TO ENSURE PROPER SEAM ALIGNMENT, PLACE THE EDGE OF THE OVERLAPPING BLANKET (BLANKET BEING INSTALLED ON TOP) EVEN WITH THE COLORED SEAM STITCH ON THE PREVIOUSLY INSTALLED BLANKET.
6. CONSECUTIVE BLANKETS SPLICED DOWN THE SLOPE MUST BE PLACED END OVER END (SHINGLE STYLE) WITH AN APPROXIMATE 3" (7.5cm) OVERLAP. STAPLE THROUGH OVERLAPPED AREA, APPROXIMATELY 12" (30cm) APART ACROSS ENTIRE BLANKET WIDTH.

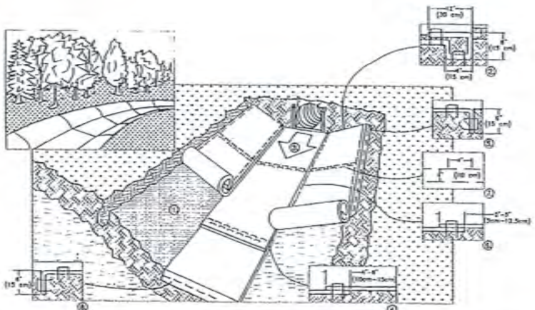
SUPPLEMENTAL NOTES:

*IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15cm) MAY BE NECESSARY TO PROPERLY SECURE THE BLANKETS.

** STAPLE PATTERNS AND APPLICATIONS VARY BETWEEN MANUFACTURERS AND MATTING TYPES. THE CONTRACTOR IS ENCOURAGED TO CONSULT SPECIFIC MANUFACTURER INSTALLATION PROCEDURES FOR STAPLE SPACING AND CONSTRUCTION.

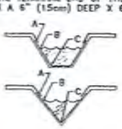
INSTALLATION OF EROSION CONTROL MATS FOR SLOPE STABILIZATION

N.T.S.



NOTES:

1. PREPARE SOIL BEFORE INSTALLING BLANKETS, INCLUDING ANY NECESSARY APPLICATION OF LIME, FERTILIZER, AND SEED. NOTE: WHEN USING CELL-O-SEED DO NOT SEED PREPARED AREA. CELL-O-SEED MUST BE INSTALLED WITH PAPER SIDE DOWN.
2. BEGIN AT THE TOP OF THE CHANNEL BY ANCHORING THE BLANKET IN A 6" (15cm) DEEP X 6" (15cm) WIDE TRENCH WITH APPROXIMATELY 12" (30cm) OF BLANKET EXTENDED BEYOND THE UP-SLOPE PORTION OF THE TRENCH. ANCHOR THE BLANKET WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30cm) APART IN THE BOTTOM OF THE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING. APPLY SEED TO COMPACTED SOIL AND FOLD REMAINING 12" (30cm) PORTION OF BLANKET BACK OVER SEED AND COMPACTED SOIL. SECURE BLANKET OVER COMPACTED SOIL WITH A ROW OF STAPLES/STAKES SPACED APPROXIMATELY 12" (30cm) APART ACROSS THE WIDTH OF THE BLANKET.
3. ROLL CENTER BLANKET IN DIRECTION OF WATER FLOW IN BOTTOM OF CHANNEL. BLANKETS WILL UNROLL WITH APPROPRIATE SIDE AGAINST THE SOIL SURFACE. ALL BLANKETS MUST BE SECURELY FASTENED TO SOIL SURFACE BY PLACING STAPLES/STAKES IN APPROPRIATE LOCATIONS AS SHOWN IN THE MANUFACTURER'S STAPLE PATTERN GUIDE. WHEN USING OPTIONAL DOT SYSTEM, STAPLES/STAKES SHOULD BE PLACED THROUGH EACH OF THE COLORED DOTS CORRESPONDING TO THE APPROPRIATE STAPLE PATTERN.
4. PLACE CONSECUTIVE BLANKETS END OVER END (SHINGLE STYLE) WITH A 4"-6" (10cm-15cm) OVERLAP. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10cm) APART AND 4" (10cm) ON CENTER TO SECURE BLANKETS.
5. FULL LENGTH EDGE OF BLANKETS AT TOP OF SIDE SLOPES MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30cm) APART IN A 6" (15cm) DEEP X 6" (15cm) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.
6. ADJACENT BLANKETS MUST BE OVERLAPPED APPROXIMATELY 2"-5" (5cm-12.5cm) (DEPENDING ON BLANKET TYPE) AND STAPLED. TO ENSURE PROPER SEAM ALIGNMENT, PLACE THE EDGE OF THE OVERLAPPING BLANKET (BLANKET BEING INSTALLED ON TOP) EVEN WITH THE COLORED SEAM STITCH ON THE BLANKET BEING OVERLAPPED.
7. IN HIGH FLOW CHANNEL APPLICATIONS, A STAPLE CHECK SLOT IS RECOMMENDED AT 30 TO 40 FOOT (9m-12m) INTERVALS. USE A DOUBLE ROW OF STAPLES STAGGERED 4" (10cm) APART AND 4" (10cm) ON CENTER OVER ENTIRE WIDTH OF THE CHANNEL.
8. THE TERMINAL END OF THE BLANKETS MUST BE ANCHORED WITH A ROW OF STAPLES/STAKES APPROXIMATELY 12" (30cm) APART IN A 6" (15cm) DEEP X 6" (15cm) WIDE TRENCH. BACKFILL AND COMPACT THE TRENCH AFTER STAPLING.



CRITICAL POINTS

A. OVERLAPS AND SEAMS
B. PROJECTED WATER LINE
C. CHANNEL BOTTOM/SIDE SLOPE VERTICES

SUPPLEMENTAL NOTES:

* HORIZONTAL STAPLE SPACING SHOULD BE ALTERED IF NECESSARY TO ALLOW STAPLES TO SECURE THE CRITICAL POINTS ALONG THE CHANNEL SURFACE.

** IN LOOSE SOIL CONDITIONS, THE USE OF STAPLE OR STAKE LENGTHS GREATER THAN 6" (15 cm) MAY BE NECESSARY TO PROPERLY ANCHOR THE BLANKETS.

*** STAPLE PATTERNS AND APPLICATIONS VARY BETWEEN MANUFACTURERS AND MATTING TYPES. THE CONTRACTOR IS ENCOURAGED TO CONSULT SPECIFIC MANUFACTURER INSTALLATION PROCEDURES FOR STAPLE SPACING AND CONSTRUCTION.

INSTALLATION OF EROSION CONTROL MATS IN CHANNELS

N.T.S.

SEEDING PROCEDURES:

SEEDING PREPARATION WILL BE ACCOMPLISHED BY TRACKING THE AREAS TO BE SEEDED WITH A SMALL BULLDOZER OR OTHER COMPARABLE DEVICE IN AN UP AND DOWN PATTERN TO CREATE TINY CONTOURS ALONG THE SLOPE. THESE TINY DEPRESSIONS HELP REDUCE EROSION AND PROVIDE A POCKET FOR PROPER GERMINATION OF THE SEEDS. SOIL SUPPLEMENTS, AS SHOWN BELOW IN THE "SITE STABILIZATION CHART" WILL BE REQUIRED TO PREPARE THE AREA TO BE SEEDED.

MULCHING AS LISTED BELOW WILL BE PERFORMED IMMEDIATELY AFTER THE ADMINISTRATION OF THE LIME, FERTILIZER AND SEDING MATERIALS.

THE MOST EFFECTIVE PERIODS FOR VEGETATION ESTABLISHMENT ARE EARLY SPRING TO EARLY SUMMER AND LATE SUMMER TO MID FALL. SEEDING AND MULCHING CAN BE PERFORMED DURING OTHER PERIODS AS WEATHER CONDITIONS PERMIT. MAJOR ACTIVITIES OF DEVELOPMENT SHALL BE PLANNED TO COINCIDE WITH THESE PRIME GROWING SEASONS.

IF OUT-OF-SEASON SEEDING IS NECESSARY, APPLY EITHER THE FULL-SPECIFIED QUANTITIES FOR SUPPLEMENTS, SEED AND MULCH OR APPLY FULL SUPPLEMENTS AND 50% OF THE SEED APPLICATION RATE TO BE FOLLOWED BY THE REMAINING 50% WITHIN THE NEXT SEEDING DATES. FULL MULCH RATE APPLICATIONS WILL BE REQUIRED FOR EACH SEEDING APPLICATION TO PREVENT SOIL EROSION UNTIL SEED GERMINATES.

TEMPORARY STABILIZATION:

ANNUAL RYE OR OATS SHALL BE USED AT A RATE OF 40 LBS. PER ACRE. STRAW AT A RATE OF 3 TONS PER ACRE SHALL BE USED AS MULCH. STRAW SHALL BE APPLIED IN LONG STRANDS, NOT CHOPPED OR FINELY BROKEN.

IN WETLAND AREAS, ANNUAL RYE SHALL BE USED AT A RATE OF 48 LBS. PER ACRE, CLEAN STRAW WITHOUT BINDERS AT A RATE OF 3 TONS PER ACRE SHALL BE USED.

SITE STABILIZATION CHART:

BRUSH SEED MIXTURE			
BOTANICAL NAME	COMMON NAME	PERCENTAGE OF MIXTURE	APPLICATION RATE
LOLIUM MULTIFLORUM	ANNUAL RYEGRASS	35	20 LBS / ACRE
PHLEUM PRATENSE	TIMOTHY	25	
ANDROPOGON GERARDII	BIG BLUESTEM	10	
ELYMUS VIRGINICUS	VIRGINIA WILD RYE	10	
LESPEDEZA BICOLOR	BICOLOR LESPEDEZA	5	
HELIANTHUS ANNUS	COMMON SUNFLOWER	5	
LATHYRUS SYLVESTRIS	LATHCO FLAT PEA	5	
VIBURNUM DENTATUM	ARROW WOOD	3	
SAMBUCUS CANADENSIS	ELDERBERRY	2	

* SEEDING DATES: APRIL 1-JUNE 15 & AUGUST 16-SEPTEMBER 15

SOIL SUPPLEMENT RATES:

SUPPLEMENTS	RATES
PULVERIZED AGRICULTURAL LIMESTONE	435 KG PER 1000 M² (800 LBS PER 1,000 SY)
10-20-20 ANALYSIS COMMERCIAL FERTILIZER	80 KG PER 1000 M² (140 LBS PER 1,000 SY)
38-0-0 UREAFORM FERTILIZER	30 KG PER 1000 M² (50 LBS PER 1,000 SY)
32-0-0 TO 38-0-0 SULFUR COATED UREA FERTILIZER	35 KG TO 30 KG PER 1000 M² (59 TO 50 LBS PER 1,000 SY)
31-0-0 IBDU FERTILIZER	35 KG PER 1000 M² (61 LBS PER 1,000 SY)

MULCHING:

SUPPLEMENTS	RATES
CLEAN STRAW	3 TONS PER ACRE

NOTES:

WITHIN SEVEN DAYS OF AN EARTH DISTURBANCE ACTIVITY OR ANY STAGE OR PHASE OF AN ACTIVITY, THE SITE SHALL BE SEEDED, MULCHED, OR OTHERWISE PROTECTED FROM ACCELERATED EROSION AND SEDIMENTATION. (SECTION 102.22 (A)).

CLEAN STRAW MULCHING MAY BE USED AT A RATE OF 3 TONS PER ACRE AS TEMPORARY STABILIZATION DURING TIMES OF NON-GERMINATING.

EROSION CONTROL MATTING MUST BE USED ON ANY SLOPE STEEPER THAN 3:1. PLEASE SEE DETAIL ON SHEET ES-007.

THE SITE RESTORATION WILL BE IMPLEMENTED AND COMPLETED WITHIN 9 MONTHS AFTER THE LAST DRILLING AND FRACING ACTIVITIES.

EROSION CONTROL MATTING FOR STEEP SLOPES:

STEEP SLOPES THAT ARE DISTURBED FOR CONSTRUCTION SUCH AS ROADWAY CUT OR EMBANKMENT SLOPES 3 HORIZONTAL TO 1 VERTICAL OR STEEPER SHALL BE PROTECTED AGAINST EROSION WITH EROSION CONTROL MATTING (NAG P-300 OR APPROVED EQUAL) OR MATS SUITABLE FOR THE ESTABLISHMENT OF VEGETATION. THE EROSION CONTROL MATTING SHOULD BE INSTALLED IMMEDIATELY AFTER THE SOIL AMENDMENTS AND THE SEED ARE APPLIED. EROSION CONTROL MATTING SHOULD ALSO BE INSTALLED ON OTHER STEEP SLOPES WHERE EROSION WILL BE A PROBLEM UNTIL VEGETATION IS ESTABLISHED. THE INSTALLATION PROCEDURE SHOULD COMPLY WITH THE RECOMMENDATIONS OF THE MANUFACTURER, INCLUDING SLOPE PREPARATION, ORIENTATION, TRENCHING, OVERLAP AND SPACING OF STAPLES.

STABILIZATION DURING NON-GROWING SEASONS:

ALL CONSTRUCTION SHOULD BE PLANNED FOR COMPLETION WITHIN THE RECOMMENDED DATES FOR THE APPLICATION OF PERMANENT SEEDING AND ESTABLISHMENT OF A PERMANENT VEGETATIVE COVER, HOWEVER, WHEN CONSTRUCTION MUST BE DONE AND IS COMPLETED DURING A NON-GROWING SEASON (WINTERTIME, ETC.), INTERIM STABILIZATION BMPS MUST BE IMPLEMENTED AND ADEQUATELY MAINTAINED. THE APPLICATION OF STRAW MULCH AT THE RATE OF THREE TONS PER ACRE IS RECOMMENDED. THE BMPS SHOULD BE CHECKED WEEKLY (UNLESS SNOW COVERED) TO IDENTIFY AREAS THAT BECOME BARE. THESE BARE AREAS SHOULD BE COVERED WITH A PROPERLY INSTALLED EROSION CONTROL MATTING.

ALL TEMPORARY EROSION AND SEDIMENT POLLUTION CONTROLS MUST BE MAINTAINED UNTIL PERENNIAL VEGETATION IS ESTABLISHED.

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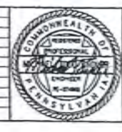

NOTES:

1. SCALE NOTED APPLIES TO 22" x 34" SHEET SIZE. FOR SHEET SIZES OTHR THAN 22"X34", REFER TO GRAPHIC SCALE.
2. EXISTING CONTOURS SHOWN ARE BASED ON NGVD88 DATUM.
3. HORIZONTAL DATUM IS TIED TO THE NORTH AMERICAN DATUM (NAD) OF 1983.

URS

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HESS MARCELLUS SHALE WELL SITES
DAVIDSON 1V
SCOTT TOWNSHIP, WAYNE COUNTY, PENNSYLVANIA

POST-CONSTRUCTION STORMWATER MANAGEMENT PLAN DETAILS (SHEET 2 OF 2)

JOB NO. 19998479 | SCALE NTS
ORIGINAL DATE 04/22/10 | LAST REVISED 04/22/10 | REV 0

DRAWING NO. PCSM-05

Chemical and Biological Hazards Posed by Drilling Exploratory Shale Gas Wells in Pennsylvania's Delaware River Basin

Report for the Delaware River Basin Commission Exploratory Well Hearing

to

Delaware Riverkeeper Network

and

Damascus Citizens for Sustainability

November 16, 2010

Ronald E. Bishop, Ph.D., CHO

s/ Ronald E. Bishop

_____

Ronald E. Bishop

Summary:

Over the last decade, operators in the natural gas industry have developed highly sophisticated methods and materials for the exploration and production of methane from black shale. In spite of the technological advances made to date, these activities carried out on <u>any</u> <u>scale</u> pose significant chemical and biological hazards to human health and ecosystem stability. In brief:

- The probability that shale gas well projects will impact local groundwater ranges from 4.0 to 5.7% over the short term, *i.e.* while the wells are in development.
- The probability that shale gas wells will degrade local water quality over the long term (50 years) exceeds 16%; a project scope of as few as ten wells practically guarantees long-term groundwater contamination.
- Some chemicals in ubiquitous use for shale gas well drilling constitute human health and environmental hazards even where they are extremely diluted. For example, the biocide DBNPA is lethal to Chesapeake Bay oysters at parts-per-trillion concentrations, below its chemical detection limit.
- Some constituents of flowback fluids from shale gas wells are hazardous to human health at extreme dilutions; potential exposure effects include tissue poisoning and cancer.
- The risks of exposing workers and neighbors to toxic chemicals and harmful bacteria are exacerbated by certain common practices in Pennsylvania, such as air-lubricated drilling and the use of impoundments for flowback fluids; these are not regarded as best practices from a national perspective.

Overall, proceeding with any shale gas projects in the Delaware River Basin by current practices is highly likely to degrade surface water and groundwater quality, to harm humans, and to negatively impact aquatic ecosystems.

Background:

Natural gas production from hydrocarbon-rich shale formations is probably the most rapidly developing trend in onshore oil and gas exploration and production today. "In some areas, this has included bringing drilling and production to regions of the country

that have seen little or no activity in the past. New oil and gas developments bring changes to the environmental and socio-economic landscape, particularly in those areas where gas development is a new activity. With these changes have come questions about the nature of shale gas development, the potential environmental impacts, and the ability of the current regulatory structure to deal with this development." (1)

The major features of shale gas development, which distinguish it from conventional gas extraction activity, are the use of horizontal drilling and high-volume hydraulic fracturing. While these technologies certainly lead to well projects which are larger than traditional gas wells by fifty-fold or more, and enable energy development companies to pursue projects in places which historically weren't commercially viable (such as the Delaware River Basin), gas exploration and production have never been free of risk. Toxics Targeting, Inc., using data compiled by the New York State Department of Environmental Conservation (NYS DEC), brought to light 270 gas drilling-related contamination incidents which had occurred in New York State since 1979 (2). This value, compared with a total of 6,680 active gas wells (3), points to a serious incident rate of 4.0%. These were in addition to incidents which were not reported to the DEC, such as the "wildcat" operation by which the U.S. Gypsum Company of Batavia, NY contaminated its own water well while drilling for natural gas on company property (4).

Data from Colorado indicated that 1549 spill incidents related to natural gas extraction activities occurred in the period from January 2003 to March 2008; the Congressional Sportsmen's Foundation estimated that 20% of these (310) impacted groundwater (5). The New Mexico Oil Conservation Division recorded 705 groundwater-contaminating incidents caused between 1990 and 2005 by the oil and gas industry (6). And the Pennsylvania Land Trust reported 1610 DEP violations in the Commonwealth between January 2008 nd late August 2010, 1052 of them likely to impact the environment (7). Compared with totals of 25,716, 40,157 and 55,631 producing gas wells in Colorado, New Mexico and Pennsylvania, respectively (3), these data suggest that natural gas development in a region degrades groundwater quality at a rate of 1.2 to 1.9 incidents per 100 gas wells. However, not all producing gas wells pose equal risk; new construction

accounts for most spills and other mishaps. Interpreted in the context of new gas (and only gas) wells, (18,554 in Pennsylvania for the period January 2008 through August 2010 – mostly non-Marcellus projects) (8), the data suggest that we may reasonably anticipate a violations rate of 8.7% (one citation for every 11 – 12 gas wells) and a groundwater contamination rate of 5.7% (one incident for every 17 – 18 wells).

Short-term collateral damage from gas well development is only part of this industry's hazard profile. In 1992, the US Environmental Protection Agency (EPA) estimated that of 1.2 million abandoned oil and gas wells in the U.S., 200,000 were leaking (9). This represents a 16.7% failure rate; one of every six abandoned wells is releasing its contents to the surrounding area, including the surface. A Canadian research team investigated the mechanisms for these failures, and determined that concrete shrinkage which leads to well casing fissures is essentially inevitable in a fifty-year time frame. They found that this cracking was especially severe at maximum depth, and exposure of steel casings to the hot (140 – 180 °F) brines there accelerated their breakdown, permitting subterranean gases and other fluids to re-pressurize the deteriorating wells (10). Wells in regions containing mobile geological faults (such as eastern Pennsylvania) are also subject to casing deformation and shear (11). Therefore, we may reasonably expect higher percentages of gas well casings to fail over time, especially longer than fifty years. The probability that a project scope of as few as ten gas wells will impact ground water within a century approaches 100%; ground water will be contaminated.

In view of the risks, summarized above, for gas wells to engender spills and leaks, a discussion of the chemicals involved with these projects is in order.

Drilling Additives:

Many chemical products are used in the development of a gas well. Some examples, along with their most common applications, are shown in **Table 1**. Individual additives are typically used in multiple stages of the drilling process ; most hydraulic fracturing additives are also used in drilling fluids (or "muds") (12). Two rare exceptions are bentonite and barium sulfate, which are used almost exclusively in drilling muds and packer slurries, and hemicellulase enzyme, used solely in post-fracturing fluids. Even the chemicals used for post-production purification may also be used as solvents in drilling muds.

The majority of chemical products used by the gas industry have not been fully tested for human or environmental toxicity (13, 14). Of those which have, a minority (*e.g.,* bentonite, guar gum, hemicellulase, citric acid, acetic acid, potassium carbonate, sodium chloride, limonene, polyethylene glycol and mineral oil) pose no significant hazards to humans or other organisms as utilized in gas extraction processes.

Table 1: Additive Functions in Shale Gas Extraction

Additive Type	Examples	Purpose	Used In
Friction Reducer	heavy naphtha, polymer microemulsion	lubricate drill head, penetrate fissures	drilling muds, fracturing fluids
Biocide	glutaraldehyde, DBNPA, dibromoacetonitrile	prevent biofilm formation	drilling muds, fracturing fluids
Scale Inhibitor	ethylene glycol, EDTA, citric acid	prevent scale buildup	drilling muds, fracturing fluids
Corrosion Inhibitor	propargyl alcohol, *N*,*N*-dimethylformamide	prevent corrosion of metal parts	drilling muds, fracturing fluids
Clay Stabilizer	tetramethylammonium chloride	prevent clay swelling	drilling muds, fracturing fluids
Gelling Agent	bentonite, guar gum, "gemini quat" amine	prevent slumping of solids	drilling muds, fracturing fluids
Conditioner	ammonium chloride, potassium carbonate, isopropyl alcohol	adjust pH, adjust additive solubility	drilling muds, fracturing fluids
Surfactant	2-butoxyethanol, ethoxylated octylphenol	promote fracture penetration	drilling fluids, fracturing fluids
Cross-Linker	sodium perborate, acetic anhydride	promote gelling	fracturing fluids
Breaker	hemicellulase, ammonium persulfate, quebracho	"breaks" gel to promote flow-back of fluid	post-fracturing fluids
Cleaner	hydrochloric acid	dissolve debris	stimulation fluid, pre-fracture fluid
Processor	ethylene glycol, propylene glycol	strip impurities from produced gas	post-production processing fluids

Several other additive chemicals, including ammonia, methanol, ethanol, 2-propanol, 1-butanol, thioglycolic acid, acetophenone, sodium perborate tetrahydrate, diammonium peroxydisulfate and hydrochloric acid, are moderately or acutely toxic to humans or aquatic organisms when encountered in concentrated forms (15 – 24), but as used by the natural gas industry, they end up greatly diluted, and so impose relatively modest hazards (13). More significant issues with these chemicals would be anticipated from storage sites, trucking accidents while they are being transported to remote well sites via rural roads, and stagingat well sites.

However, a few chemical products in widespread use, including in exploratory wells, pose significant hazards to humans or other organisms, because they remain dangerous even at concentrations near or below their chemical detection limits. These include the biocides glutaraldehyde, 2,2-dibromo-3-nitrilopropionamide (DBNPA) and 2,2-dibromoacetonitrile (DBAN), the corrosion inhibitor propargyl alcohol, the surfactant 2-butoxyethanol (2-BE), and lubricants containing heavy naphtha. (Note: CAS No. refers to a unique identifier assigned to every known substance by the Chemical Abstracts Service Registry.)

Glutaraldehyde:

Glutaraldehyde (CAS No. 111-30-8) is a biocide used widely in drilling and fracturing fluids. Along with its antimicrobial effects, it is a potent respiratory toxin effective at parts-per-billion (ppb) concentrations (24); a sensitizer in susceptible people, it has induced occupational asthma and/or contact dermatitis in workers exposed to it, and is a known mutagen (i.e., a substance that may induce or increase the frequency of genetic mutations) (25, 26). It is readily inhaled or absorbed through the skin. In the environment, algae, zooplankton and steelhead trout were found to be dramatically harmed by glutaraldehyde at very low (1 – 5 ppb) concentrations (27).

DBNPA:

2,2-Dibromo-3-nitrilopropionamide (DBNPA) (CAS No. 10222-01-2) is a biocide finding increasing use in drilling and fracturing fluids. It is a sensitizer, respiratory and skin toxin, and is especially corrosive to the eyes (28). In the environment, it is very toxic to a wide variety of freshwater, estuarine and marine organisms, where it induces developmental defects throughout the life cycle. In particular, it is lethal to "water fleas" (*Daphnia magna*), rainbow trout and mysid shrimp at low (40 to 50 ppb) concentrations, and is especially dangerous to Eastern oysters (29). Chesapeake Bay oysters are killed by extremely low (parts-per-trillion, ppt) concentrations of DBNPA, well below the limit at which this chemical can be detected.

DBAN:

Dibromoacetonitrile (DBAN) (CAS No. 3252-43-5) is a biocide often used in combination with DBNPA, from which it is a metabolic product (with the release of cyanide). Its human and environmental toxicity profiles are similar to that of DBNPA, except that DBAN is also carcinogenic (30). DBNPA and DBAN appear to work synergistically. In combination, the doses at which these biocides become toxic are significantly lower than when they are used separately. In other words, it takes much less of these chemicals to exert toxic effects when they are used together.

Propargyl Alcohol:

Propargyl alcohol (CAS No. 107-19-7) is a corrosion inhibitor that is very commonly used in gas well construction and completion. This chemical causes burns to tissues in skin, eyes, nose, mouth, esophagus and stomach; in humans it is selectively toxic to the liver and kidneys (31). Propargyl alcohol is a sensitizer in susceptible individuals, who may experience chronic effects months to years after exposure, including rare multi-organ failure (32). It is harmful to a variety of aquatic organisms, especially fathead minnows, which are killed by doses near 1 ppm (33).

2-BE:

2-Butoxyethanol (2-BE), also known as ethylene glycol monobutyl ether (EGBE) (CAS No. 111-76-2), is a surfactant used in many phases of gas exploration and extraction. It comprises a considerable percentage of Airfoam HD, which Newfield is using to drill some of the wells grandfathered by the SEDD (34). Easily absorbed through the skin, this chemical has long been known to be selectively toxic to red blood cells; it causes them to rupture, leading to hemorrhaging (35). More recently, the ability of EGBE at extremely low levels (ppt) to cause endocrine disruption, with effects on ovaries and adrenal glands, is emerging in the medical literature (36). This chemical is only moderately toxic to aquatic organisms, with harm to algae and test fish observed with doses over 500 ppm (35).

Heavy Naphtha:

Heavy naphtha (CAS No. 64741-68-0) refers to a mixture of petroleum products composed of, among other compounds, the aromatic molecules benzene, toluene, xylene, 1,2,4-trimethylbenzene and polycyclic aromatic hydrocarbons including naphthalene. It is

used by the gas industry as a lubricant, especially in drilling muds. This material is hazardous to a host of microbes, plants and animals (37). Several of the mixture's components are known to cause or promote cancer. If released to soil or groundwater, several components are toxic to terrestrial and aquatic organisms, especially amphibians, in which it impedes air transport through the skin.

Flowback Fluids:

Irrespective of chemical additives used for drilling, Marcellus shale contains several toxic substances which can be mobilized by drilling. These include lead, arsenic, barium, chromium, uranium, radium, radon and benzene, along with high levels of sodium chloride (38). These components make flowback fluids hazardous without any added chemicals, and are often among the analytes most easily measured by potential waste fluid treatment plant operators (**Figure 1**).

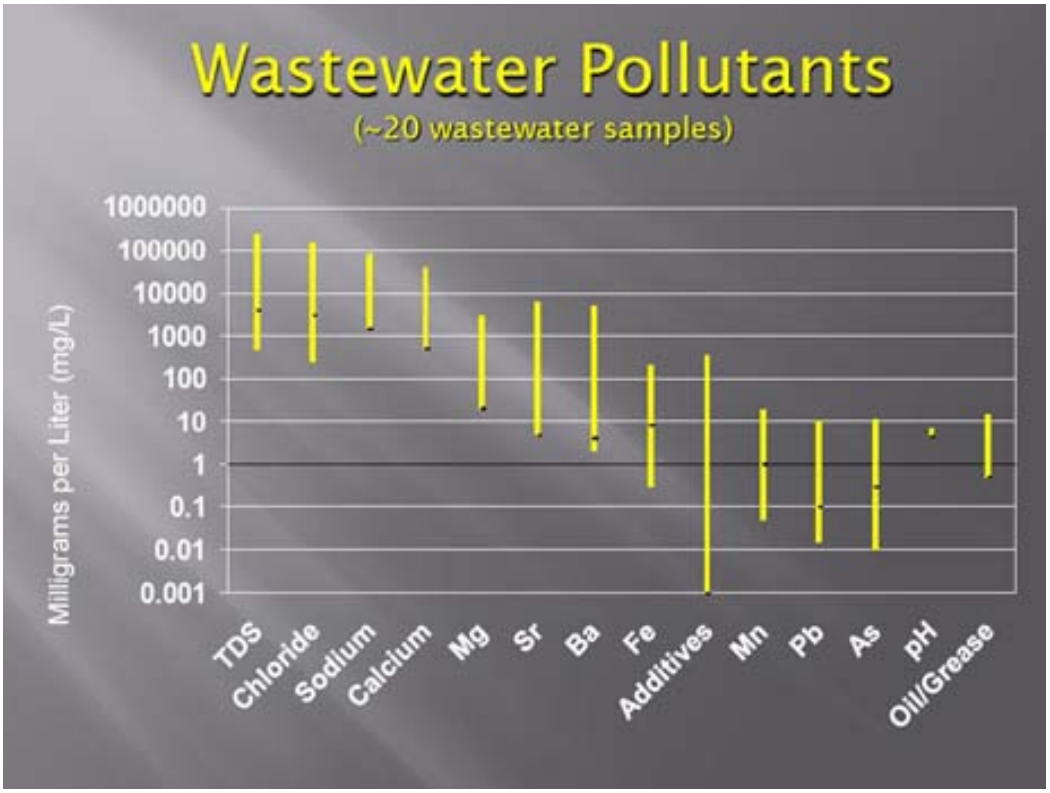

Figure 1: Wastewater Pollutants (39)

Because of their significant toxicity at low (ppb) concentrations, and the fact that drill cuttings are often not removed, but rather are buried on-site, several of these flowback fluid and cuttings components (40) are discussed below, including barium, lead, arsenic, chromium and benzene:

Barium (Ba):

Barium is a toxic heavy metal commonly found in Marcellus shale well flowback fluids (39). Exposure to soluble salts (not the sulfate), which may occur by ingestion, absorption or inhalation, may induce drops in tissue potassium levels, and by this mechanism it is selectively toxic to the heart and kidneys (41). Further, barite (barium sulfate), used as a weighting agent in drilling muds, reacts with radium salts in shale, forming radioactive scale on metal parts (such as the drill "string") which then are subsequently brought to the surface (13); in these reactions, barite is converted to more soluble (i.e. more toxic) barium salts.

Lead (Pb):

The poisonous nature of lead has been known for centuries, but its ability to impair neurological development in children at very low (1 ppb) concentrations makes it a toxicant of special concern. The most sensitive targets for lead toxicity are the developing nervous system, the blood and cardiovascular systems, and the kidney. However, due to the multiple modes of action of lead in biological systems, and its tendency to bio-accumulate, it could potentially affect any system or organs in the body. It has also been associated with high blood pressure (42).

Arsenic (As):

Arsenic, another component of black shale (38), has also been known as a poison for hundreds if not thousands of years. The most sensitive target tissue appears to be skin, but arsenic produces adverse effects in every tissue against which it has been tested, especially

brain, heart, lung, the peripheral vascular system, and kidney (43). Arsenic is harmful below one part per trillion (ppt) in water, and is a confirmed carcinogen.

Chromium (Cr):

Chromium, also found in Marcellus shale (44), may be an essential nutrient required in extremely small doses (μg per day), but the biological system it supports is not currently known. Exposure to elevated doses by inhalation, ingestion, skin or eye contact may lead to respiratory, gastrointestinal, reproductive, developmental and neurological symptoms (45). Sensitization-induced asthma and allergy have also been reported. However, at very low concentrations, particularly of potassium dichromate or strontium chromate (the hexavalent form, as found in shale rock) (46), the major hazard posed by chromium is as a carcinogen, especially in stomach and lung tissues (45).

Benzene:

Benzene, a known shale constituent (38), was briefly considered above as a component of heavy naphtha. In ppb concentrations, the primary hazard from this compound is due to its proven ability to cause acute non-lymphocytic leukemia (47).

4-NQO:

In addition to the above shale constituents, one chemical compound was consistently encountered in flowback fluids from Marcellus gas wells in Pennsylvania and West Virginia: 4-nitroquinoline-1-oxide (4-NQO) (48). This is one of the most potent carcinogens known, particularly for inducing cancer of the mouth (49). It is not used as a drilling additive and is not known to occur naturally in black shale; no studies have been published to date with respect to what chemical interactions account for its consistent presence in flowback fluids. However, it is dangerous at parts-per-trillion (ppt) concentrations, well below its levels reported in gas well flowback fluids (48).

Biological Contamination:

Rock strata beneath the earth's surface are populated by bacteria, and the advent of air-lubricated drilling (without biocides) has introduced a risk of contaminatingsurface (fresh) water zones with bacteria and other microbes from deeper (brine) layers, where they often flourish. Of particular concern are sulfate-reducing bacteria, especially *Desulfovibrio desulfuricans*, an organism that thrives in fresh water where some sulfate (such as is present in pyrite or hematite) is available (50), (**Figure 2)** (51). In fact, these bacteria are especially prevalent and aggressive in oil and gas producing regions, where they avidly form living black, sticky films in water wells and other structures (52). There they produce hydrogen sulfide (H_2S), characterized by a "rotten eggs" smell. Rock strata rich in gas are often also rich in this bacterium, and exposure to hydrogen sulfide along with methane raises significant health concerns –neurological syndromes in humans and, in livestock, elevated birth defect rates and diminished herd health. At high concentrations, hydrogen sulfate is lethal (53).

The now-common use of air-lubrication (without biocides) while drilling the top one- to three thousand feet of gas wells (54) risks contaminating fresh water aquifers with sulfate-reducing bacteria from the deeper strata, but there is no clear evidence that this well-fouling mechanism is recognized by Pennsylvania DEP regulators.

Figure 2: Biofilm of *Desulfovibrio desulfuricans* Growing on a Hematite Surface

Cumulative Effects:

Hazards that accompany the above chemicals and microbes have to this point been considered individually. It is clear that they don't occur individually. No investigations of interactions among these materials have been reported to date. However, the author has been contacted by officials with the National Institute of Safety and Occupational Health, Centers for Disease Control (NIOSH/CDC), who requested any information that might shed light on a group of symptoms presented by clinical patients in southwestern Pennsylvania and the state of West Virginia which is tentatively identified as "downwinder's syndrome" (55). These symptoms, including irritated eyes, sore throat, frequent headaches and nosebleeds, skin rashes, peripheral neuropathy, lethargy, nausea, reduced appetite and mental confusion, were also reported in a Texas gas-field study conducted by Wilma Subra (56). These disparate observations are supported by a literature review of potential human health effects from gas drilling activities (57).

The practice in Pennsylvania of using open impoundments for capture of flowback fluids from gas wells may exacerbate the risk of this syndrome. Although most additives are greatly diluted in the drilling process, organic compounds (with the exceptions of DBNPA and DBAN) tend to be lighter than water; therefore they float to the surface of holding pits, where they concentrate to essentially 100% of the surface. From there they volatilize or aerosolize into the air, from which they may be inhaled by neighbors and on-site industry workers. Partly for this reason, the states of Colorado (58) and New Mexico (59) have prohibited the use of impoundments for flowback fluids.

As a case in point, at 7:00 AM on September 5, 2010, Greg Swartz and Tannis Kowalchuk, who live 0.3 miles from the Woodland Management Partners 11 exploratory gas well in Damascus Township, Wayne County, PA (developed by Newfield Appalachia PA, LLC), smelled a "chemical sulfuric odor". They put up with this odor for three days before the flowback fluids pit (evidently the source of the chemical smell) was pumped out and the odor subsided. Neither the fire department chief nor the DEP inspector indicated concern about the hydrogen sulfide being generated by bacteria living in the pit. However, Mr. Swartz and Ms. Kowalchuk were concerned, particularly for the health of their 2-year-old son (60).

The DEP inspection summary indicated that on September 2, three days prior to the sulfur odor complaint, workers were observed skimming an "oil sheen" from the pit fluids, and the odors detected then were typical of "drilling fluids and/or cuttings". On September 8, the hydrogen sulfide exposure grew worse for several hours, because the pit's contents were stirred as they were pumped out. Finally, the inspector noted that the sub-contractor planned to solidify the residual pit contents, fold them into the plastic liner and bury them in place (60).

Well permit data indicate that 2-butoxyethanol (2-BE) was used in the drilling fluids (61). Results from early ("tophole") analysis of the pit's contents (62) indicated the presence of high levels of barium, lead, arsenic and chromium (discussed above). No test

for 4-nitroquinoline-1-oxide (4-NQO) was performed. However, a very high concentration of lithium (more than 600 times the reporting limit) was present. This is significant because lithium is psychoactive in humans at concentrations down to 1 part per billion (ppb) (63).

Therefore, the neighbors to this gas well were subjected to fumes from drilling fluids and cuttings, whether or not they identified those odors as nuisances. Then they were exposed to nuisance (and possibly greater) levels of hydrogen sulfide, which DEP reports to be common with gas drilling operations (60). Now, this family lives less than 600 yards from a buried repository of toxic solid waste, for which no long-term monitoring is planned (54). They were potentially exposed to chemicals known to cause disorders of the skin, eyes, mucous membranes, the gastrointestinal tract, kidneys, heart and brain. Threshold doses for some of these adverse health effects were realistically achievable, given the extreme potency of the agents involved. A slightly elevated risk of cancer for these people cannot be ruled out.

All this was the outcome of just one nearby "exploratory" gas well project where, from developers' and regulators' perspectives, nothing unusual happened.

If a spill, pit overflow, seepage from a defective plastic liner, or a tank leak had occurred, this family's exposures to noxious chemicals would have increased, possibly without their knowledge. Further, harm to sensitive environmental receptors, such as amphibians and aquatic organisms, would also have ensued. As discussed above, such incidents are unavoidable where any gas wells – including exploratory projects – are developed on a broad scale. When allowed to contaminate groundwater, the toxins and/or bacteria discussed above can persist at hazardous levels for years. Therefore, inevitable environmental damage extends to wherever gas well projects are developed, including the Delaware River Basin.

The opinions expressed in this report are stated to a reasonable degree of scientific and professional certainty.

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Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells

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November 15, 2010

1. Executive Summary

Demicco & Associates, LLC has been retained by the Delaware Riverkeeper Network and Damascus Citizens for Sustainability to provide expert review and opinion on the Delaware River Basin Commission's (DRBC) decision to exclude 11 Pennsylvania state permitted wells from DRBC review of exploratory wells under its June 12, 2010 and July 23, 2010 Supplemental Determinations. The decision to exclude the 11 wells has resulted in the Consolidated Administrative Hearings on actions of the DRBC relative to exploration wells being drilled into the Marcellus Shale. Specifically the Hearing will address DRBC decisions to:

- Regulate so-called "exploratory wells" and subject them to DRBC's temporary moratorium (challenge brought by Northern Wayne County Property Owners' Alliance, joined by Newfield and Hess Corporation as interested parties)
- Exclude certain state-permitted wells from DRBC review of exploratory wells, (challenge brought by the Delaware Riverkeeper Network (DRN) and the Damascus Citizens for Sustainability (DCS))

The findings in this report are based on the material provided by DRN and DCS included within the references presented at the end of the report. Should additional materials and reports be disclosed as part of the Hearing process the findings and conclusions in this report are subject to revision.

Conclusion 1 - Grandfathering

In our opinion, the 11 wells listed as grandfathered exploration wells do not meet the DRBC criteria of exploration well due to the lack of an appropriate certification of Intent by Well Operator to Plug the Well. The Marcellus Shale in sections of Wayne County,

PA may exceed the average thickness of the shale unit throughout much of the rest of the state and vertical wells can expose a significant volume of Marcellus shale for gas production. True exploration wells would be sealed and decommissioned immediately upon completion.

Conclusion 2 – Exploratory Drilling Impacts

Drilling of exploratory holes can, with lack of regulatory oversight, cause as much if not more harm to the water resources of the Delaware River Basin than a properly permitted and installed nontraditional horizontal well. Specific problems with exploratory drilling are the apparent dominance of air rotary drilling techniques to increase speed of drilling and decrease the cost of drilling. Air rotary drilling uses generally uses either naturally occurring ground water or a source of potable water and compressed air to remove the rock cuttings from the borehole as well as cooling the compression air hammer drill bit. When extensive fractures are encountered during air rotary drilling, large volumes of ground water approaching 1000 gpm can be blown from the borehole. Extensive fracturing will also cause problems with borehole stability and resulting problems with achieving a proper grout seal. Grout seals are the single most important element to protecting ground water resources from contamination as presented within this report.

Conclusion 3 – Water Resource Impacts

Damage to ground water resources can occur through both negative impacts on quantity and quality. The month long process of drilling may exceed the 100,000 gallons per day (gpd), 3.1 million gallon per month (mgm) threshold for an allocation permit if numerous fractures are encountered during air rotary drilling. Again, adequate and complete grouting of the gas well from the principal fresh water aquifers is critical to protect the water resources. Leakage along the grout wall can promote vertical upward movement of low quality water if over pressure from deeper zones in the well creates an upward gradient. Large movement of gas and deep brine fluids into shallow zones will have

negative water quality impacts on both water resource wells and streams. However, vertical downward leakage of freshwater into newly exposed and opened fracture zones from air rotary drilling can remove fresh water from the shallow aquifer zones. Loss of fresh water to deeper portions of the aquifer would diminish summer base flow to headwater streams. The increased runoff from site construction and road construction will also have a negative impact on the quantity summer base flow by decreasing the amount of rainfall that would normally reach the ground water.

Conclusion 4 – Exploratory Well and Grouting Efficiency

The drilling of the stated "exploratory" hole is done predominantly by air rotary methods based on the examined documents obtained to date. This results in an underbalanced borehole at depth where formation pressure exceeds borehole pressure. When formation pressure exceeds borehole pressure water, petroleum and gas, if present in the formation enter into the borehole and are brought up to the surface. The result is even greater strain on the borehole increasing the importance of properly grouting the well. Regulatory changes are currently being proposed in Pennsylvania indicating the inadequacies of the current regulatory procedures. Air rotary drilled wells, if drilled quicklywithout maintaining directionality, will potentially drift off vertical. The rapidly varying rock types encountered in Pennsylvania will create an uneven borehole with a wide borehole where soft shale is easily removed and a narrower borehole when passing through hard sandstones. Both the verticality (i.e. deviations from a purely vertical bore) and uneven borehole width will have negative impacts on the efficiency of the grout installation. It should be noted that State of Pennsylvania requires only a 1 inch grout diameter, whereas the State of New Jersey, where gas wells are not being drilled, requires a two inch diameter grout seal on any borehole annulus (eg. water, oil, geothermal, water, etc.).

The four issues described above result in an overall summary conclusion. It is my opinion, given with a reasonable degree of scientific certainty, that the grandfathering of these so-called exploratory wells is not protective of the Special Protection Waters of the

Delaware River Basin due to lack of regulatory review by DRBC, reliance on outdated and inadequate drilling regulations that are currently undergoing modification, and uncertainty in proper development of grout seals with the use of air rotary exploration drilling into an over-pressurized geologic zone.

2. Introduction

The primary topic of this expert report focuses on water resource issues, specifically possible water usage and water resource contamination which can occur during exploratory drilling operations. Mr. Peter Demicco is the author of this report and has over 28 years in ground water resource development including water well design, water resource and allocation permitting, ground water recharge wells, and deep geothermal wells. Part of his experience includes several years of appointment to the New Jersey Well Drillers Licensing Board for the New Jersey Department of Environmental Protection. Mr. Demicco is also a registered geologist in the State Of Pennsylvania. His curriculum vita is attached to this report (Exhibit 1).

2.1 Discussion of Drilling Techniques

The first topic of the presentation will include a discussion of drilling techniques including background experience in both mud and air rotary drilling. Volumes of water needed vary based on drilling techniques and conditions encountered during drilling. In addition, air rotary drilling can result in large volumes of water production when fracture zones are encountered along with borehole stability issues. The quality of this water will vary with depth of materials encountered with naturally occurring contaminants and radionuclides increasing with depth.

2.2 Discussion of Well Grouting

The second topic is the potential long term impacts that can occur if casing or grout failure occurs from unexpected drilling conditions or improper grouting. Grout and casing failure are jointly caused by rock shearing and pressure changes in the formation. These impacts range from casing deformation to breakdown of the grout

seal, both often occur together. The breakdown of the grout seal potentially leads to migration of water from one aquifer zone to another, vertical upward movement of naturally occurring non-potable water into potable zones and vertical downward movement of aquifer water into a non-potable zone. The latter condition would potentially result in diminished aquifer resources and potentially have a negative effect on stream base flow. In addition, migration of water even within potable aquifer zones can have negative consequences. The most common example of this is migration of water with dissolved oxygen into an anoxic zone containing specific minerals, most notably pyrite. With the introduction of oxygen into such zones, dissolution of pyrite will result in water with low pH and high iron and either elevated sulfate or sulfide concentrations. Arsenic contamination can occur as arsenic is known to be a secondary element in iron pyrite.

Multiple reports and publications were reviewed for this opinion. The documents most germane to this report are presented as exhibits attached to this report. Several background documents also reviewed for this report include the followings:

- PaDEP's existing Chapter 78 Oil and Gas Well Regulations
- PaDEP's proposed amendments to Chapter 78 Oil and Gas Regulations in the Pa Bulletin (July 10, 2010)
- DRBC's May 19, 2009 Executive Director Determination (EDD)
- DRBC's June 14, 2010 Supplemental Executive Director Determination (SEDD)
- DRBC's July 23,2010 Amendment to Supplemental Executive Director Determination
- DRBC's Delaware River Basin Code: 18 CFR Part 410

3.0 Background Geology

A cursory overview of the geology of Wayne County is needed in the context of drilling. The background overview of the geology has been obtained from "Ground water in Northeastern Pennsylvania" by S. W. Lohman. (1937; 2nd printing, 1957). Exhibit 2 presents an updated review of the stratigraphy of northeastern Pennsylvania from Frank Fletcher. Generally, the Upper Devonian rocks of the Catskill Continental Group are the dominant bedrock unit below any glacial deposits. The Catskill Group consists of various non-marine sandstone, shale and conglomerate units. These rock units were largely deposited in fluvial (i.e. riverine) environments. The rocks exhibit the fining upward characteristics of the classic fluvial sequence. The fining upward sequence starts with coarse sandstones and some conglomerates channel deposits at the base with finer grained river overbank siltstone and shale at the top of the sequence. These cycles repeat throughout most of the sequence of unit.

Wells drilled into the Catskill Group produces abundant water for nearly all domestic needs (Lohman, 1957). This geologic group is the most important water bearing unit in Wayne County and provides not only domestic and other human needs, but provides a large part of the base flow to local surface waters along with flows from surficial glacial deposits. The sandstones form the largest water bearing group of sediments. The Catskill Group can range in thickness from 1,800 feet thick in Susquehanna County in the north to over 6,000 feet in Carbon County (see Lohman, 1957).

Beneath the Catskill Group non-marine units are marginal marine units of the Portage Group dominated in this area by the Trimmers Rock Formation. These marine units contain typically coarsening upward deposits of off shore deltaic deposition. Soft shale from deep water environments forms the basal units and, as the delta builds out into the shallow seas, coarser and cleaner sandstones are deposited near the top of the

sequence. This Group is not considered an aquifer in Wayne County due to depth, probable salt and hydrogen sulfate concentrations. This Group, as with the Catskill Group will exhibit rapidly varying drilling conditions. The unit is roughly 1,500 feet thick in the eastern part of northeast Pennsylvania thickening to 3,000 feet westward into Luzerne County (see Lohman, 1957).

The Hamilton Group, which includes the upper Hamilton Formation (see Lohman, 1957 for an in depth discussion of stratigraphy) and lower Marcellus Shale, underlies the Portage Group. The Hamilton Formation represents shallower marine waters than the depositional environment of the Marcellus Shale. In the Hamilton Formation, beds of fossiliferous olive-gray to dark grey sandy shale and sandstone with locally thin beds of calcareous shale to coral limestone and coquinite can be found (see Lohman, 1957). This unit is on the order of 1,100 to 1,600 feet thick (see Lohman, 1957). The Marcellus Shale is a gray to black shale with some fine sand in locations and contains pyrite indicative of the anoxic environment that resulted in the formation of natural gas. The thickness of the Marcellus Shale is on the order of 700 to 900 feet in the eastern counties of northeast Pennsylvania, including Wayne County) decreasing to 400 feet in the western counties of northeastern Pennsylvania (see Lohman, 1957).

The Onondaga Formation, a cherty limestone, underlies the Marcellus Shale in the northeastern portion of Pennsylvania. This formation has been listed as the target formation by some drilling operations presumably to ensure that the full thickness of the Marcellus Shale has been penetrated.

Each of the 11 grandfathered wells will have to be drilled through this highly variable geologic column. The amount of the Catskill Group penetrated will vary the most depending on location of the well.

4.0 Well Permits

Several well permits and related documents were reviewed including the Docket NO. D-2009-18-1 on the Stone Energy Corporation Matoushek 1 Well (Exhibit 3). Only this Docket provided any details on the actual drilling of an gas well into the Marcellus Shale. The other exploratory well permits reviewed had some details on specific aspects of the drilling including the MSDS sheets for material to be brought on-site, the "Preparedness, Prevention, and Contingency Plan, Wayne County Field, Wayne County, Pennsylvania" report, and site construction details. (see Exhibit 4, Woodland Mgmt Partners 11: Exhibit, 5 HL Rutledge 11; and Exhibit 6, VE Crum 11). However, the permits were completely silent on the actual drilling methods, well construction methods and the critically important grouting methods. It is important to note that the materials and grouting techniques will not vary greatly from an exploratory hole to a production well.

The Stone Energy Corporation, Matoushek 1 well was reported in the Docket (Exhibit 3) to be drilled by air rotary methods to the top of the Marcellus Shale, and then the Marcellus Shale was cored using a 3 percent potassium chloride solution. Air rotary drilling is different than mud rotary drilling in that air and chemicals are used as the fluid to cool the drilling bit, lift the cuttings from the hole, and lubricate the drill column. Usually foaming agents are used with air rotary drilling. The borehole should be underbalanced in this process, in other words the pressure of water and gas in the formation should be greater than the pressure created by the air compressor. As a result, oil, gas and brine ground waters will be pulled up to the ground surface during this type of drilling. Air drilling should be significantly faster than mud rotary through the use of air hammer drilling bits and with less deterioration and damage to the drill bit. However, there is a greater risk of well blowout if overpressurized (i.e. greater than atmospheric pressure at the depth of the overpressure area) zones are encountered as the borehole is advanced.

As stated above, the other permits (the grandfathered exploratory well permits) were silent on drilling method(s), so there is no information available to evaluate the risks associated with the drilling technique that will be used on these wells. A discussion of drilling methods should be mandatory in these permits. -. Typically, mud rotary drilling would be used to drill through the gas producing Marcellus shale.

Several other significant differences with air rotary drilling versus mud rotary exist. The compressed air injected during drilling also lifts the water encountered in borehole and surrounding fractures to the surface. Air drilled wells can remove significant volumes of water during the drilling process. Exhibit 7 presents a set of e-mails discussing the volume of discharge to the Valley Joint Sewerage Authority. Significant volumes of water are reported to have been removed during drilling of the Matoushek well.

Where large fractures are encountered, borehole collapse can occur further enhancing the water flow and slowing drilling. A mud cake is not formed on the borehole of an air drilled well to diminish water movement into or out of fracture zones. As a result air drilling allows for greater movement of water between fracture zones during drilling. On occasion, I have observed drillers of geothermal wells stop and grout up sections of failing rock before drilling deeper. Conventional wisdom was that very few high water yielding fractures existed below 500 feet. Again, I have seen yields close to 800 gpm being blown from fractures zones below 1000 feet deep. Bottom line, during the month long drilling process using air rotary, the potential exists to withdraw more than 100,000 gallons per day on average, or 3.1 million gallons for the month.

It is not unusual for air drilled wells to have significant deviation from the vertical in areas of nearly flat lying to slightly dipping bedrock (Dr. Greg Herman, New Jersey Geological Survey, 2005). Dip is the angle from the horizontal of the bedding plane of the rock. Typically, the drill bit may follow the near vertical (but not completely

vertical) fractures in the rock mass. This is also a concern when rocks of very different characteristics are adjacent to one another as is the case in Wayne County, PA. Typically, a very ragged borehole will result with zones of collapsed fractured sandstone.

Problems with the verticality and variability of the borehole will potentially result in grouting difficulties. Questions on the integrity of the grout seal arise when the casing to be grouted may lie up against one side of the borehole. Centralizers may not align the well properly in a rough borehole. In addition, Pennsylvania requires only 1 inch diameter of grout whereas New Jersey requires 2 inches of grout. Since details on well drilling and construction are absent in the permit papers, how is the issue of the casing grout going to be reviewed and documented during drilling? The PaDEP regulations do not appear to require disclosure of drilling method on the permit application. However, DRBC has not required this information on any of the 11 exploratory well sites to know potential drilling risks at the 11 sites and have a better inventory of chemicals stored at these sites to conduct mud rotary drilling before allowing these 11 "grandfathered" wells to proceed. In my opinion, these data are necessary to evaluate potential impacts to the water resources of the basin.

Grouting at the depth of the production casing occurs with only 1¼ inch of grout on either side of the casing. This assumes that the casing is centered, the hole is truly vertical and the drill bit drilling the 8-inch borehole had not been worn down significantly. The potentially rapidly varying casing pressures that occur if test fracking or test gas production occurs may shear the grout and even the casing (Dusseault, et al, 2001). If grout failure occurs at this interval, high pressure gas and fluids could reach up to the surface and conductor casings via the ungrouted portion of the borehole. At the shallower depths, the higher pressures could damage the surface and conductor casings allowing further upward migration of gas and fluids into the aquifer zones above.

The significant issue with these wells is the pressures placed on the grout seals and casings. Experience even in the water industry has led to field observations of grout mixtures that have excess water to improve pumping characteristics. The result is a grout subject to shrinkage, a situation that could prove disastrous in high and overpressured environments such as the Marcellus shale in the Delaware River Basin. Skimping on the grout seal may be an inevitable problem that has been the cause of well blowouts. Again, the result is vertical upward migration of gas and fluids into the area of the surface and conductor casings and eventually into the aquifers above.

The PaDEP regulations do not appear to require disclosure of drilling method on the permit application. However, DRBC has not required this information on any of the 11 exploratory well sites to know potential drilling risks at the 11 sites and have a better inventory of chemicals stored at these sites to conduct mud rotary drilling before allowing these 11 "grandfathered" wells to proceed. In my opinion, these data are necessary to evaluate potential impacts to the water resources of the basin.

In summary, in my opinion, water use and resource losses can be an issue with exploratory wells. Drilling and grouting plans for any well must be fully developed prior to any drilling activities and, because these 11 exploratory wells are going unregulated by the DRBC, there is no review of these plans and procedures and no basis for any conclusion by the executive director of DRBC that the drilling of these exploratory wells will not have a substantial effect on the water resources in the Special Protection Waters of the Delaware River Basin.

The opinions expressed in this report are stated to a reasonable degree of scientific and professional certainty.

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Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells

Report to:

Delaware Riverkeeper Network
and
Damascus Citizens for Sustainability, Inc.

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A. Executive Summary

This report responds to the Delaware Riverkeeper Network's (DRN) and Damascus Citizens for Sustainability's (DCS) request to provide expert review and opinion on the Delaware River Basin Commission's (DRBC) decision to exclude 11 Pennsylvania state permitted wells in Wayne County from DRBC review of exploration wells under its June 14, 2010 and July 23, 2010 Supplemental Determinations. The findings contained in this report are based on the material provided by DRN and DCS, as shown in the attached exhibits. The opinions stated here are stated to a reasonable degree of scientific and professional certainty.

This report provides my opinion in response to five (5) questions. Each question is responded to more fully in Sections D1 through D5 of this report. An executive summary of each response is provided below:

(1) Do the wells listed by DRBC as grandfathered wells meet DRBC's definition of an exploration well eligible for grandfathered status?

It is my opinion that the 11 wells listed by DRBC as grandfathered wells, covered under its June 14, 2010 and July 23, 2010 Supplemental Determinations, do not meet DRBC's definition of an exploration well eligible for grandfathered status. DRBC defined a grandfathered exploration well as a well intended solely for exploratory purposes and one that is plugged and capped at the conclusion of exploratory activities, without future use for production. No information was provided for my review to show that the grandfathered wells were drilled exclusively for exploratory purposes and will be permanently plugged and abandoned after the wells are drilled. None of the grandfathered well permits specify the completion method or the final disposition of the wells, nor were the 30 day well completion reports available. None of the grandfathered wells appear to have submitted a Notice of Intent by Well Operator to Plug a Well, and/or a Certificate of Well Plugging. Instead, several of the grandfathered well documents confirm alternative plans for these wells, including gas production. Approval of an exploration well destined for production is in essence production well approval.

Well density and drilling pace are strong indicators of well type. True exploration wells are drilled on large spacing intervals to test hydrocarbon trap theories. The pace is slower than production well drilling, so data from preceding exploration wells can be used to avoid the economic risk of drilling several dry-holes in rapid succession. The density and pace of some of the grandfathered wells, especially Newfield's wells, are inconsistent with exploration well classification.

Most companies have exploration departments that are separate and distinct from production drilling departments. Exploration departments typically have higher levels of data security, dedicated exploratory budgets, and staff that specialize in finding new hydrocarbon sources. Very small companies may combine exploration and production drilling staff, however, funding documents for each well will clearly delineate the nature of the well and whether it was funded and located as a true exploration well and whether the well was planned to be a test well only, destined for plugging and abandonment.

(2) Do exploration wells pose lower risk than production wells?

It is my opinion that exploration wells are riskier than production wells, because drilling hazards are unknown. The risk of a well blowout or well control situation occurring is higher due to the increased difficulty in designing and constructing a well based on unknown data. DRBC's decision to forego

regulation of the grandfathered wells, because they are "exploration wells" and thereby "lower risk," is inconsistent with the known higher risk profile for an exploration well. The risk of an exploration well blowout is approximately 7 wells in every 1000 drilled.

True exploration wells, by definition, explore into previously unknown and unmapped hydrocarbon formations; therefore, an exploration well drilling Operator must be prepared to encounter both oil and gas. The grandfathered wells should have been equipped to deal with either a gas and/or oil well blowout. While an exploration well Operator may target gas, as is the stated intent in these grandfathered wells, it cannot rule out the potential to encounter oil enroute to the gas target, or instead of hitting a gas target. In a true exploration well, the type of hydrocarbons, depth of burial and whether they are present in commercial quantities are all unknown.

There was no material provided for my review to show that the risk of drilling an exploration well in the Delaware River Basin is less than that of a production well, nor that the possibility of oil being encountered during exploration drilling can be completely ruled out.

(3) Did DRBC's decision to grandfather 11 wells create the potential for increased risk to water quality and water resources of the Delaware River Basin?

It is my opinion that DRBC's decision to forego regulation of the grandfathered wells resulted in increased risk to water quality and water resources of the Delaware River Basin. This increased risk was created by:

- not stipulating additional site-specific mitigation measures to reduce environmental impacts above the minimum statewide standards required by PADEP to protect the waters of the Delaware River Basin;
- allowing wells to be drilled and sited in environmentally sensitive areas within the Delaware River Basin without adequate DRBC siting review;
- not requiring appropriate setbacks from sensitive locations; and
- creating a situation whereby an exploration well must be drilled and plugged (even if successful), such that drilling impacts are duplicated when a production well is re-drilled at the same or another location at a later date.

The DRBC's definition of an exploration well is inconsistent with industry practice. It is industry practice to convert successful exploration wells into production wells, if commercial quantities of hydrocarbons are found. DRBC's decision to forego review of the grandfathered wells if they are drilled solely to collect data, and then immediately plugged and abandoned, could result in two wells being drilled in the same area (first the exploration well and then later a production well). Drilling a well twice results in economic waste and increased impacts to air, land and water in the Delaware River Basin. Instead, the DRBC should have reviewed each exploration well to ensure it was properly sited and environmental impacts were mitigated. In this way, if Operators make a commercial find, DRBC would have already ensured the well was positioned at a low impact surface location and was drilled using the lowest impact methods. It is important to properly site and assess the impacts of any proposed exploration well in as much detail as is necessary for a production well, because a successful exploration well is in essence the first production well in the field.

DRBC should carefully examine the grandfathered wells that have been drilled to determine if they were properly sited and completed using technically sound well construction practices. Wells that were not properly sited or constructed should be plugged and abandoned.

DRBC grandfathered 11 wells based on economic and risk considerations, with no publicly available economic or risk assessments to support this decision. This decision appears to conflict with DRBC's mission to protect water resources in the Delaware River Basin. There is no evidence that the permit applications for each of the grandfathered wells confirm that they are in fact shale gas "exploration" wells or that the risk of these wells to the Delaware River Basin is low.

(4) Are there sufficient plans and protections included in PADEP's approval to mitigate and respond to the risks associated with exploration wells?

It is my opinion that the Pennsylvania Department of Environmental Protection (PADEP) permit materials and Preparedness, Prevention and Contingency Plans (PPC) provided for my review do not include sufficient plans and protections to mitigate and respond to the risks associated with exploration wells.

There are a number of risks posed by exploration wells, including air, water and land pollution, resulting from fuel and chemical spills, stray gas, well blowouts, water use, waste disposal, and other aspects of drilling operations. The most significant and potentially catastrophic risk of those listed is an uncontrolled blowout. An uncontrolled blowout must be considered when planning an exploration well. There is insufficient evidence to show that the grandfathered exploration wells are equipped to deal with either a gas and/or oil well blowout. Well permit applications filed with PADEP for the grandfathered wells do not include any explanation or evidence of blowout prevention or control capability.

While blowouts are very infrequent, they do occur, and are a reasonably foreseeable consequence of exploratory drilling operations. Blowouts can last for days, weeks, or months until well control is finally achieved. The most common method, and best technology, to control an on-land blowout is well capping, requiring large volumes of water to deluge the rig, allowing well control experts to work near a blowout. Water requirements can range from 500,000 to 6,000,000 gallons of water per day. Well control experts also use foam and dry chemicals to respond to blowouts. Deluge operations create large pools of water on the surface that drain away from the well blowout. This can transport oil, chemicals, fuels, and any other materials released during a blowout toward lower elevation drainage areas.

Newfield's PPC for the proposed Newfield grandfathered wells does not meet PADEP's requirements; the adequacy of the other grandfathered wells' PPCs is not known, because they were not provided for review. Exploration well operations require fuel to operate drilling and completion equipment, and the process of drilling a well requires numerous chemicals. Newfield's PPC lists the potential for both fuel and chemical storage tanks to leak and contaminate the nearby environment, water supplies or water resources. However, Newfield's PPC lists insufficient onsite resources to respond to the potential fuel and chemical spills it lists.

The PPC Plans provided for my review did not adequately identify the environmentally sensitive areas within the Delaware River Basin that should be protected during exploration drilling, and did not include adequate tactics and strategies to protect those areas.

Pennsylvania only requires a bond of $2,500 per well, or a blanket bond of $25,000 for all wells drilled in Pennsylvania by a single Operator. Neither amount would provide sufficient funds to control, clean up,

and/or remediate the damage caused by a well blowout, chemical spill or large fuel spill from an exploration well operation.

(5) Was DRBC's assumption the risk of the grandfathered wells was small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania well-founded?

It is my opinion that DRBC's assumption that the risks associated with the grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania is not well founded for the following reasons:

- PADEP's existing Chapter 78 Oil and Gas Well Regulations are known to be deficient;
- Grandfathered wells are not required to be constructed to industry best practices for shale gas wells in Pennsylvania;
- PADEP did not apply "Special Permit Conditions," requiring a Water Management Plan, to most of the grandfathered wells;
- Fracture treatment operations are planned for the B&E well;
- Drilling waste can result in environmental harm if not properly managed, and some waste has already been buried on-site and not transported out of the Basin;
- Stray gas migration associated with oil and gas wells can impact water supplies, if wells are not properly constructed and operated;
- PADEP's well siting criteria allows wells to be placed very close to water resources; and
- Air pollution impacts, and corresponding impacts to water resources, are not well understood or mitigated.

B. Introduction

This report responds to the Delaware Riverkeeper Network's (DRN) and Damascus Citizens for Sustainability's (DCS) request to provide expert review and opinion on the Delaware River Basin Commission's (DRBC's) decision to exclude 11 Pennsylvania state permitted wells in Wayne County from DRBC review of exploration wells under its June 14, 2010 and July 23, 2010 Supplemental Determinations. The opinions stated here are stated to a reasonable degree of scientific and professional certainty.

C. DRBC's Contested Decisions and Chronology

On May 19, 2009, the DRBC issued a "Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 1**), directing natural gas extraction projects located in shale formations within the drainage area of Special Protection Waters to obtain DRBC approval for:

> "*…the drilling pad upon which a well intended for eventual production is located, all appurtenant facilities and activities related thereto and all locations of water withdrawals used or to be used to supply water to the project*."

The May 19, 2009 determination exempted "wells intended solely for exploratory purposes."

On May 5, 2010, the DRBC issued a decision to finalize natural gas regulations before considering project approvals (**Exhibit 2**).

On June 14, 2010, the DRBC issued a "Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 3**), directing **all** natural gas extraction projects located in shale formations within the drainage area of Special Protection Waters to obtain DRBC approval. This determination withdrew the May 19, 2009 decision to exclude exploration wells. The DRBC wanted to remove:

> "*…any regulatory incentive for project sponsors to classify their wells as exploratory wells and install them without Commission review before the Commission's natural gas regulations are in place*."

However, the DRBC decided that:

> "*…where entities have invested in exploration well projects in reliance on [the] May 2009 Determination and information from staff, there are countervailing considerations that favor allowing these projects to move ahead*."

The DRBC determined that:

> "*[i]n contrast to the thousands of wells projected to be installed in the Basin over the next several years, the risk to Basin waters posed by only the wells approved by PADEP since May are comparatively small. Not only are these wells subject to state regulation as to their construction and operation, but they continue to require Commission approval before they can be fractured or otherwise modified for natural gas production*."

In other words, the DRBC determined that any exploration well that obtained a state natural gas well permit on or before June 14, 2010 was grandfathered, meaning DRBC review and approval was not required.

According to the DRBC's June 14, 2010 decision, there were no permits issued by the New York State Department of Environmental Conservation as of June 14, 2010, but there were a "limited" number of permits issued by the Pennsylvania Department of Environmental Protection (PADEP). The number and name of the PADEP permits issued were not listed in the DRBC decision. Later a spreadsheet was provided by DRBC listing the wells that DRBC thought qualified for "grandfather" status. According to the DRBC spreadsheet, 13 wells were approved by PADEP prior to June 14, 2010 (**Exhibit 4 and 4A**).

The notes that accompany DRBC's spreadsheet (**Exhibit 4**) state that three (3) wells of these 13 wells are not pertinent to the issue of grandfathered wells, because two wells were already drilled (Matoushek #1 OG Well, Stone Energy Corp and Robson 627528 #1 OG Well, Chesapeake Appalachia LLC) and the DL Teeple #1-2H OG Well, Newfield Appalachia PA LLC was designed as a horizontal well and does not meet the exploration well criteria. This left 10 wells subject to the June 14, 2010 grandfather provision.

1. HL Rutledge #1-1 OG well, Newfield Appalachia PA LLC, April 29, 2010, ("**Rutledge**");
2. VE Crum #1-1 OG Well, Newfield Appalachia PA LLC, April 30, 2010, ("**Crum**");
3. EM Schweighofer #1-1 OG Well, Newfield Appalachia PA LLC, May 7, 2010, ("**Schweighofer**");
4. Woodland Mgmt Partners #1-1 OG Well, Newfield Appalachia PA LLC, May 27, 2010, ("**Woodland**");
5. DL Teeple #1-1 OG Well, Newfield Appalachia PA LLC, April 23, 2010, ("**Teeple**");
6. Stockport Assn 1; Pennswood Oil & Gas LLC, July 22, 2009, ("**Stockport**");
7. Preston 38 LLC OG Well; Pennswood Oil & Gas LLC, July 22, 2009,("**Preston**");
8. Geuther #1 OG Well, Stone Energy Corp, April 28, 2008, ("**Geuther**");
9. Cabot #2 OG Well, Arbor Operating, LLC, April 13, 2010, ("**Cabot**"); and,
10. B&E Well #1 OG Well; Schrader Kevin E, March 5, 2009, ("**B&E**").

On July 23, 2010, the DRBC issued an "Amendment to Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 5**), allowing two additional Hess Corporation wells to be drilled that had not yet received PADEP permits, but had obtained Pennsylvania Erosion and Sediment Control General Permits (ESCGP-1). Hess argued that because these wells were in the final PADEP permit approval process, the wells represented a level of investment equivalent to the natural gas exploratory wells that were grandfathered by the DRBC June 14, 2010 decision. DRBC based its decision on economics and the need to obtain scientific data from the two exploration wells to plan future wells in the Delaware River Basin. DRBC noted in its decision that none of the other grandfathered wells had obtained Pennsylvania Erosion and Sediment Control General Permits, because the well pads fell below the five-acre threshold. Therefore, a total of 12 wells were grandfathered by DRBC, including:

11. Davidson 1V Well; Hess Corporation, July 13, 2010, ("**Davidson**"); and
12. Hammond 1V Well; Hess Corporation, July 20, 2010, ("**Hammond**").

On October 14, 2010, Arbor Operating, LLC withdrew its Cabot well permit (**Exhibit 6**), leaving 11 grandfathered wells that remain at issue in the Hearing.

According to DRBC's records, as of mid-October 2010, three (3) of the 11 grandfathered wells have been drilled:

1. Crum well (**Exhibit 7 and 7A**)[1];
2. Woodland well (**Exhibit 8 and 8A**)[2];
3. Teeple well (**Exhibit 9 and 9A**)[3];

[1] VE Crum# 1-1 OG Well, Newfield Appalachia PA LLC, permit documents, produced by Damascus Township pursuant to a subpoena issued in a federal court proceeding by the Damascus Citizens for Sustainability, et al v. Newfield Appalachia, LLC & Damascus Township, USDC, M.Pa., Civil Action No. 10-CV-1604 on August 9, 2010.
[2] Woodland Mgmt Partners #1-1 OG Well, Newfield Appalachia PA LLC, permit documents, produced by Damascus Township pursuant to a subpoena issued in a federal court proceeding by the Damascus Citizens for Sustainability, et al v. Newfield Appalachia, LLC & Damascus Township, USDC, M.Pa., Civil Action No. 10-CV-1604 on August 9, 2010.

As of mid-October, DRBC reports that eight (8) of the 11 grandfathered wells have not been drilled, but work has commenced on some wells, as noted below:

4. Rutledge well (**Exhibit 10 and 10A**)[4] – pad construction completed;
5. Schweighofer well (**Exhibit 11 and 11A**)[5];
6. Stockport well (**Exhibit 12**)[6];
7. Preston well (**Exhibit 13**)[7];
8. Geuther well (**Exhibit 14**)[8];
9. B&E well (**Exhibit 15**)[9];
10. Davidson well (**Exhibit 16**)[10] – site preparation underway; and
11. Hammond well (**Exhibit 17**)[11] – site preparation underway.

The Matoushek and Robson wells were drilled prior to the grandfathering decision. DRBC's information on these wells shows that the Matoushek well was "TAed" (presumably the code for temporary abandonment) and the Robson well was "PAed" (plugged and abandoned). Materials were provided for review on both the:

- Matoushek #1 OG Well, Stone Energy Corp, March 14, 2008, (**Exhibit 18 and 18A**)[12] ("**Matoushek**"); and,
- Robson #1 OG Well, Chesapeake Appalachia LLC, February 26, 2009, (**Exhibit 19**), ("**Robson**").

DRN explained that the DL Teeple #1-2H OG well application was determined to be a production well, and is pending DRBC production well review; therefore, it is not a grandfathered exploration well.

- DL Teeple #1-2H OG Well, Newfield Appalachia PA LLC, May 25, 2010, (**Exhibit 20**) [13], ("**Teeple 2H**").

D. Questions Responded to in this Report

This report provides my expert opinion on five (5) questions:

[3] Woodland Mgmt Partners #1-1 OG Well, Newfield Appalachia PA LLC, permit documents, provided by DRN on October 23, 2010.
[4] HL Rutledge #1-1 OG well, Newfield Appalachia PA LLC, permit documents, produced by Damascus Township pursuant to a subpoena issued in a federal court proceeding by the Damascus Citizens for Sustainability, et al v. Newfield Appalachia, LLC & Damascus Township, USDC, M.Pa., Civil Action No. 10-CV-1604 on August 9, 2010.
[5] EM Schweighofer #1-1 OG Well, Newfield Appalachia PA LLC, permit documents, provided by DRN on October 23, 2010.
[6] PADEP eFacts Information on Stockport Assn#1 well, retrieved October 23, 2010.
[7] PADEP eFacts Information on Preston 38 LLC OG Well, retrieved October 23, 2010.
[8] Geuther # 1 OG Well, Stone Energy Corp, permit documents, provided by DRN on October 20, 2010, only including two pages of the PADEP well permit application.
[9] B&E Wells #1 OG Well; Schrader Kevin E, permit documents, provided by DRN on October 20, 2010.
[10] Map of Davidson 1V Well Site.
[11] **Exhibit 17** is a map of the well location only. As of October 23, 2010 DRN confirmed that only E&S permits had been obtained for this well.
[12] Matoushek #1 OG Well, Stone Energy Corp, permit documents, provided by DRN on October 20, 2010.
[13] Robson 627528 1 OG Well, Chesapeake Appalachia LLC, permit documents, provided by DRN on October 23, 2010.

D.1 Do the wells listed by DRBC as grandfathered wells meet DRBC's definition of an exploration well eligible for grandfathered status?

D.2 Do exploration wells pose lower risk than production wells?

D.3 Did DRBC's decision to grandfather 11 wells create the potential for increased risk to water quality and water resources of the Delaware River Basin?

D.4 Are there sufficient plans and protections included in PADEP's approval to mitigate and respond to the risk associated with exploration wells?

D.5 Was DRBC's assumption that the risk associated with the grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania well founded?

D.1 Do the Grandfathered Wells Meet the Definition of Exploration Well?

The DRBC does not define the term "exploration well" in its regulations,[14] but uses the term "exploratory well" in its decisions to make a distinction between "exploration" and wells used for "production." DRBC clarified its definition of an exploration well in a May 19, 2009 news release that stated:

> *"Wells intended solely for exploratory purposes are not covered by this determination.* ***An exploratory well is one that the project sponsor intends to plug and cap at the conclusion of exploratory activities without use for production or fracking*** *[emphasis added]."* [15]

Later in August 2009, the DRBC wrote Arbor Operating, LLC regarding its Cabot #2 well further affirming that its exploration well definition included the requirement to be drilling the well "solely" for exploration purposes and the requirement for a "cap and plug plan."

> *"As Arbor has stated that they* ***propose to develop the well if a viable quantity of natural gas is discovered,*** *the* ***well is not therefore being drilled solely for exploratory purposes*** *and is again covered under the Executive Director's Determination. The well may not be covered under the determination* ***if a cap and plug plan is submitted to the Commission*** *and* ***it is affirmed that the well will be properly abandoned upon completion and collection of necessary exploratory data*** *[emphasis added]."*[16]

The Pennsylvania Code does not make a distinction between exploration and production wells. The Pennsylvania Code requires an Operator to obtain a permit for a well, but does not make a distinction between an exploration well and a production well for purposes of that application.[17] The Pennsylvania Code does define a Marcellus Shale Well as:

> *"A well that when drilled or altered produces gas or is anticipated to produce gas from the Marcellus Shale geologic formation."* [18]

[14] For example, DRBC, Ground Water Protected Area Regulations for Southeastern Pennsylvania, 1999.
[15] DRBC May 19, 2009 Press Release, "DRBC Eliminates Review Thresholds for Gas Extraction Projects in Shale Formations in Delaware's Basin's Special Protection Waters, (**Exhibit 26**).
[16] DRBC letter to Arbor Operating LLC, August 4, 2009, (**Exhibit 25**).
[17] 25 Pa.Code 78.11 Permit Requirements
[18] 25 Pa.Code 78.1 Definitions

The Pennsylvania Oil and Gas Act defines an "operating well" as any well not plugged and abandoned. Because there do not appear to be any plug and abandonment plans (P&A) for the grandfathered wells, these wells are "operating wells" under the Pennsylvania Oil and Gas Act.

The US Securities and Exchange Commission (SEC) governs oil and gas reserve reporting in the US. The SEC defines an exploratory well as:

> "*An exploratory well is a well drilled to find a new field or to find a new reservoir in a field previously found to be productive of oil or gas in another reservoir. Generally,* ***an exploratory well*** *is any well that* ***is not a development well, an extension well, a service well, or a stratigraphic test well*** *as those items are defined in this section [emphasis added].*"[19]

The SEC defines stratigraphic test wells as those wells that collect geologic data such as coring and expendable exploration holes, but this definition does not customarily include wells being drilled for hydrocarbon production:

> *"Stratigraphic test well is a drilling effort, geologically directed, to obtain information pertaining to a specific geologic condition.* ***Such wells customarily are drilled without the intent of being completed for hydrocarbon production****. The classification also includes tests identified as core tests and all types of expendable holes related to hydrocarbon exploration.* ***Stratigraphic tests are classified as ''exploratory type'' if not drilled in a known area or ''development type'' if drilled in a known area****.*[20]

The SEC also requires Operators to disclose the number of net productive and dry exploration wells drilled.[21] Therefore the Operator must identify the type of well that is being drilled as exploration or production for federal reporting purposes.

Therefore, both the DRBC definition and SEC definition of exploration well make it very clear that an exploration well is not a production well. The DRBC takes its exploratory well definition one step further by clearly articulating that an exploration well drilled in the Delaware River Basin, under grandfathered status, must be plugged and capped.

If DRBC's definition of an exploration well is applied to each of the 11 wells listed by DRBC as grandfathered, none of these wells would qualify as true "exploration wells" because none appear to be drilled "solely for exploration" and none appear to have a plug and cap plan.

For the three (3) wells already drilled (Crum, Woodland, and Teeple #1), there were no Well Records or Completion Reports[22] provided for my review to show the final well disposition, no Application for Inactive Well Status,[23] no Notice of Intent by Well Operator to Plug a Well,[24] and no Certificate of Well Plugging.[25] If those records exist they should be obtained and provided for review.

[19] 17 CFR Parts 210.4-10(a)(13); (**Exhibit 24**)
[20] 17 CFR Parts 210.4-10(a)(30); (**Exhibit 24**)
[21] 17 CFR Part 229.1205; (**Exhibit 25**)
[22] PADEP Form 5500-FM-0G0001
[23] PADEP Form 5500-FM-0G0056.
[24] PADEP Form 5500-FM-OG0005 or 5500-FM-OG0005A
[25] PADEP Form 5500-FM-0G0006.

For the remaining eight (8) wells that have not yet been drilled (Rutledge, Schweighofer, Stockport, Preston, Geuther, B&E, Davidson, and Hammond), there is no Notice of Intent by Well Operator to Plug a Well.[26] If these records exist they should be disclosed.

Absent documentation showing intent to plug the well, the well applications and supporting materials provided for my review were examined for Operator intent.

Newfield Appalachia PA, LLC is the Operator for a majority of the grandfathered wells. Newfield's permit application materials propose to explore for natural gas in the Marcellus Shale in Wayne County. Yet, the application also includes well **production** activities under the umbrella of exploration operations. Newfield's Preparedness, Prevention and Contingency (PPC) Plan states:

> *"Newfield Appalachia PA, LLC (Newfield) is a natural gas exploration company with operations planned for Wayne County, Pennsylvania. Operations will **involve natural gas exploration** of the Marcellus Shale formation, **which will include** site preparation, drilling and **well development and production activities** [emphasis added]."* [27]

Exploration and Production (E&P) operations are two separate and distinct activities. Production operations do not fall under exploration. The manner in which Newfield has blurred the line between exploration and production operations supports a reasonable assumption that their intent is to convert successful exploration wells into production wells. Unless Newfield submitted Notices of Intent to plug the grandfathered wells, Newfield's wells do not meet DRBC's definition of exploration wells.

April 1, 2010 letters from Newfield to PADEP explained the purpose of two wells, Teeple #1[28] and Schweighofer.[29] The same language was used in both letters:

> *"This permit [D.L. Teeple Well #1-1] is to develop a well which is **intended solely for exploration purposes**. A core is to be taken from several formations throughout the drilling process of this well and additional scientific study is to be performed on multiple formations including, but not limited to, geophysical logs, micro-seismic studies and fluid sampling. As permitted and configured, this well is not to be complete for production, not to be hydraulically fractured and is not to produce gas. **In the future, this wellbore will either** be plugged and abandoned per PADEP regulations, converted to inactive status and utilized as a monitoring well, **or reconfigured and converted to a production well**. Prior to either plugging and abandonment, conversion to inactive status **or reconfiguration and conversion to production**, we acknowledge that additional permitting will be necessary with approvals from the PADEP and other regulatory bodies with jurisdiction [emphasis added]."*

Both of Newfield's letters start off by stating that the Teeple #1 and Schweighofer wells are intended only for exploration purposes, yet leave the future utilization of the wells open, with a possibility to convert each well to a production well. Therefore, approval of these wells is de facto approval of production wells in the same location, because Newfield has not met DRBC's definition of an exploration well.

[26] PADEP Form 5500-FM-OG0005 or 5500-FM-OG0005A
[27] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency (PPC) Plan, May 2010, submitted with all its grandfathered wells.
[28] Newfield Appalachia PA, LLC, letter to PADEP, April 1, 2010 regarding D.L. Teeple Well #1-1, in **Exhibit 9**.
[29] Newfield Appalachia PA, LLC, letter to PADEP, April 1, 2010 regarding EM Schweighofer Well #1-1, in **Exhibit 11**.

Based on the data provided for my review, it is unclear how DRBC decided to include the 11 wells in its spreadsheet as grandfathered exploration wells (**Exhibit 4**), especially when these wells do not meet DRBC's own definition for an exploration well.

It is also unclear why DRBC included the Stockport and Preston wells in the list of grandfathered wells, because the renewal applications for the Stockport and Preston wells were not submitted until after June 14, 2010, and the renewal permits were not approved until July 20, 2010.[30] In other words, the currently approved permits were approved by PADEP after the June 14, 2010 DRBC cut-off date for grandfathered wells.

The main difference between an exploration well and a production well is that exploratory drilling, by definition, seeks to locate unknown subsurface hydrocarbons to determine if they exist and can be produced in commercial quantities. Most companies have exploration departments that are separate and distinct from production drilling departments. Exploration departments typically have higher levels of data security, designated exploratory budgets, and dedicated staff that specialize in finding new hydrocarbon sources. Very small companies may combine exploration and production drilling staff, however, funding documents for each well will clearly delineate the nature of the well and whether it was funded and located as a true exploration well. Additionally, as explained above, the Operator also has to designate the exploration well type and track findings in its SEC reporting. The organizational structure of each company, funding documents for each well, and any SEC reporting data that has been developed were not available for review.

Exploration wells are typically drilled on low density spacing to cover large areas, especially when drilled by a single Operator. True exploration wells test geologic hydrocarbon trap theories, attempting to locate hydrocarbons that have been trapped in commercial quantities. Typically a team of geologists, geophysicists and reservoir engineers select an exploration well location based on seismic data, geologic information in the region, offset well data and other information that may be available. Financially it is too risky for a single Operator to drill multiple exploration wells in rapid succession in a small area, testing the same hydrocarbon trap theory. Typically, a single Operator would spread its exploration budget and risk, testing several hydrocarbon trap theories in different exploration areas and carefully examining the data from each exploration well to determine if an additional well in that same geologic trend is a worthwhile investment. Data collected from one exploration well is used to pin-point future exploratory well targets. A successful exploration well in one area may lead to a recommendation for subsequent appraisal wells around the original exploration well to further delineate the size of a hydrocarbon reservoir, so that engineers can properly size surface production facilities and pipeline needs. Later, production wells are drilled on a more dense spacing around the successful exploration wells.

Newfield received permits for five (5) wells in a 6 by 10 mile area. This is unusually dense spacing for a single Operator to be drilling exploratory wells in rapid succession, with little or no opportunity to inform future exploration well locations (**Exhibit 29** provides a map showing the well density). The pace of Newfield's drilling program strongly indicates that several of these wells are akin to production wells, rather than true exploration wells.

[30] The original permits expired in July 2010. The July 20, 2010 permit renewal post-dates the June 14, 2010 grandfather cut-off date (**Exhibits 12 and 13**). The original Stockport and Preston well applications were approved by PADEP prior to June 14, 2010 but the Operator Pennswood Oil & Gas LLC did not act on either well.

Findings:

- DRBC defined a grandfathered exploration well as a well intended solely for exploratory purposes and one that is plugged and capped at the conclusion of exploratory activities without future use for production.
- No information was provided for my review to show that the grandfathered wells will be permanently plugged and abandoned after the wells are drilled.
- The grandfathered well permits do not specify the completion method, and the 30 day completion reports showing the final disposition of each well were not available for review.
- A Notice of Intent by Well Operator to Plug a Well and/or a Certificate of Well Plugging do not appear to have been submitted for any of the grandfathered wells.
- Absent any new data showing that the Operators of the "grandfathered" wells listed in Exhibit 4 provided clear written evidence that they meet DRBC's exploration well standard, these wells do not meet DRBC's grandfathered exploration well definition.
- Newfield's application data and supporting information confirms it has alternative plans for these wells, including gas production.
- Newfield's 2010 PPC Plan shows clear intent to produce successful exploration wells. Approval of an exploration well destined for production is in essence production well approval.
- The Stockport and Preston well permits were renewed July 20, 2010, after the cut-off date for grandfathered wells.
- Well density and drilling pace are strong indicators of well type. The density and pace of some of the exploration wells, especially Newfield's wells, are inconsistent with exploration well classification.
- Funding documents for each well will clearly delineate the nature of the well and whether it was funded and located as a true exploration well. Funding documents have not been available for review.

D.2 Do Exploration Wells Pose a Lower Risk Than Production Wells?

Exploration wells are riskier than production wells because factors such as pressures, temperatures and drilling hazards are not known or are uncertain. On average 7 out of every 1000 onshore exploration wells will result in a blowout. [31,32] Blowouts can eject drilling mud, gas, oil and/or formation water from the well and onto waters and lands adjacent to the well, within the radius of the blowout plume. Depending on the reservoir pressure, blowout circumstances, and wind speed these pollutants can be distributed hundreds to thousands of feet away from the well.[33] Pollutants that reach a water systems can be carried

[31] Rana, S., Environmental Risks- Oil and Gas Operations Reducing Compliance Cost Using Smarter Technologies, Society of Petroleum Engineering Paper 121595-MS, Asia Pacific Health, Safety, Security and Environment Conference, 4-6 August 2009, Jakarta, Indonesia, 2009.
[32] Rana, S., Facts and Data on Environmental Risks- Oil and Gas Drilling Operations, Society of Petroleum Engineering Paper 114993, October 2008.
[33] S.L. Ross Environmental Research Limited, Oil Deposition Modeling For Surface Oil Well Blowouts, 1998.

downstream and contaminate even larger areas. Pollutants that reach lands can migrate into groundwater resources.

The lack of information available to an exploration well driller increases the risk profile of a well. Exploration well design and planning is more difficult and typically requires more materials to be brought to the site, to deal with unknown pressures, depths, temperatures, casing needs, cementing needs, drilling mud needs, and other unknowns. Proper engineering design of drilling fluid and blowout preventer systems is critical to reducing the risk of a blowout. The inability to accurately predict pressures in an exploration well requires that mud and blowout prevention systems be designed with an adequate safety factor, to ensure unexpected pressures can be controlled while drilling.

> *"The uncontrolled eruption of a well is one of the most critical accidents that can occur both during exploration and exploitation of hydrocarbon fields. Significant HSE [health, safety and environmental] issues are associated to this event that introduces safety risks for the field operators, potential health injury for the population living in the area and impacts, mainly associated to the hydrocarbon contamination, on the environment."*[34]

Because true exploration wells, by definition, are exploring into previously unknown and unmapped hydrocarbon formations, an exploration Operator must be prepared to encounter both oil and gas. While an exploration Operator may seek gas, as is the stated intent in these grandfathered wells, it cannot rule out the potential to encounter oil enroute to the gas target, or instead of hitting a gas target. Exploration in other areas of Pennsylvania has resulted in finds of both oil and gas, therefore this is a reasonable assumption, unless the Operator has information to prove that no oil exists from offset well data. In that case, if there is sufficient information to rule out the presence of oil, there is likely sufficient information to make the case that the well is not a true exploration well.

In both Pennsylvania[35] and New York[36]oil has been found in the Upper Devonian Formations above the Marcellus Shale Therefore, the grandfathered exploration wells should have been equipped with detailed plans to prevent and respond to a gas and/or oil well blowout.

> *"Oil deposition in the area surrounding a blowout is one of the most visible consequences of the loss of control over well flow. Less visible, but equally serious, are the short- to medium-term effects of oil coverage on the environment… Apart from the **direct damage to** capital goods, crops, and **water basins** and the cost of subsequent cleanup operations, there are medium- to long-term effects, such as reduced tree growth over a period of many years following the incident…Hence, oil fallout, in the case of loss of well control, is a factor to be taken into account in decisions on well locations, emergency procedures, contingency planning, etc. **This requires an estimate of the area around the well likely to be affected by oil fallout, given the geomorphology of the terrain, prevailing winds, and expected outflow** conditions [emphasis added]."*[37]

[34] Blotto, P., ENI- Exploration & Production, Development of an Integrated Approach to the Risk Analysis of a Blow-out Accident, Society of Petroleum Engineers Paper 86704-MS, SPE International Conference on Health, Safety, and Environment in Oil and Gas Exploration and Production, 29-31 March 2004, Calgary, Alberta, Canada, 2004.
[35] Pennsylvania Department of Conservation and Natural Resources, Pennsylvania Geology, Vol 29, No.1, Spring 1998.
[36] New York State, Draft Supplemental Generic Environmental Impact Statement (DSGEIS) on the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, September 2009, Figure 4.2.
[37] Oudeman, P., Shell International E&P, Oil Fallout in the Vicinity of An Onshore Blowout: Observations on A Field Case, Society of Petroleum Engineers, Facilities & Construction Journal, Volume 1, Number 4, December 2006.

The Woodland, Teeple and Crum wells are all located very near designated High Quality tributaries of the Delaware River. For example, the Woodland well, is adjacent to Hollister Creek and is less than half a mile from the Delaware River itself. Hollister Creek flows into the River approximately 0.7 mile above a colony of Dwarf Wedge Mussels, a federally protected endangered species. Teeple is located adjacent to Shehawken/Rattlesnake Creek, and is approximately two miles from the River. The location of these wells in such sensitive areas increases the harms that might flow from these risks should a blowout occur. Instead, the surface location for these wells should have been sited in less sensitive locations with careful evaluation and planning.

DRBC's decision to forego regulation of these exploration wells because they are "lower risk" is inconsistent with the known higher risk profile for an exploration well. There was no data provided for this review to show that DRBC supported its lower risk finding with a written technical document.

Findings:

- Exploration wells are riskier than production wells, because drilling hazards are unknown. The risk of a well blowout or well control situation occurring is higher due to the increased difficulty in designing and constructing a well based on unknown data.
- DRBC's decision to forego regulation of these exploration wells because they are "lower risk" is inconsistent with the known higher risk profile for an exploration well.
- The grandfathered exploration wells should have been equipped to deal with a gas and/or oil well blowout.

D.3 Did DRBC's decision to grandfather 11 wells create the potential for increased risk to water quality and water resources of the Delaware River Basin?

DRBC's primary responsibility is to protect water resources in the Delaware River Basin. DRBC reports to the public that its mission is one of: "providing comprehensive watershed management; acting as a steward of the Basin's water resources particularly with respect to: surface water quality, including both point and nonpoint sources of pollution; ground and surface water quantity, including water demands, water withdrawals, water allocations, water conservation, and protected areas; drought management; and in-stream flow management; promoting effective inter-agency coordination to prevent duplication of efforts and seeking increased public involvement" (**Exhibit 22**).[38]

Shale gas drilling operations use water and create wastewater. The amount of water that is used and waste that is generated depends on the well construction technique used, the depth of the well, formations encountered while drilling, well control incidents and other factors.

This report does not examine the exact amounts of water use or waste from a shale gas well drilling operation because **DRBC determined that all shale gas wells, regardless of water use or waste amounts, are subject to DRBC review**. However, Chesapeake Energy reports that a Marcellus Shale gas well can require 100,000 gallons[39] of water to drill a well, even if fracturing operations are not planned. This water is used for mixing cement, drilling mud, dust control and other routine uses.

[38] DRBC Vision Statement, http://www.state.nj.us/drbc/vision.htm, retrieved October 24, 2010.
[39] Chesapeake Energy, Water Use in Marcellus Deep Shale Gas Exploration, March 2010 (**Exhibit 31**).

On June 14, 2010, DRBC determined that all shale gas wells, regardless of water use or waste amounts, are subject to DRBC review. The DRBC issued a "Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters" (**Exhibit 3**), eliminating any water or wastewater threshold for DRBC review of shale gas extraction projects, and requiring all shale gas wells to obtain DRBC review.

> *In my Determination of May 2009, I exercised the authority conferred on the Executive Director by section 2.3.5 B.18 of the Commission's Rules of Practice and Procedure (RPP) by directing* ***all sponsors of natural gas extraction projects in shale formations within the drainage area of Special Protection Waters to obtain Commission approval*** *before commencing such projects,* ***notwithstanding that the thresholds for review established by the RPP were not exceeded*** *[emphasis added].*

DRBC's decision to eliminate any review threshold was reconfirmed in a January 19, 2010 DRBC Presentation (**Exhibit 21**)[40] that stated:

> ***Natural gas well activities*** *(NGWA)* ***[are] covered regardless of DRBC thresholds*** *in RPP[41] and Water Code [emphasis added].[42]*

In this finding, DRBC concluded that shale gas well drilling warranted DRBC review; it did not provide any technical or scientific support for exempting review of the grandfathered shale gas wells, except to say companies would suffer economic harm if the projects were delayed, and the risk was "comparatively small."[43] DRBC reasoned that the number of grandfathered wells constituted a small risk compared to the thousands of wells projected to be installed in the Basin over the next several years.

There does not appear to be any written economic assessment supporting the claim that the grandfathered well Operators would suffer economic harm or weighing the economic harm against the potential harm to the watershed from the proposed drilling operations.

There does not appear to be any written risk assessment to support the claim that the risk of drilling the grandfathered wells was small. Likewise, there does not appear to be any evidence to show that the 11 wells listed in DRBC's spreadsheet of "grandfathered wells" (**Exhibit 4**) meet DRBC's definition of an "**exploration**" well.

Exploration wells that find commercial hydrocarbons are typically converted into the first production wells of a commercial hydrocarbon reservoir development, once surface production facilities are installed. Additionally PADEP has no requirement to plug and abandon successful exploration wells.

DRBC's definition for an exploration well, which requires the well to be solely used for exploration data gathering and immediately plugged and abandoned, (per the May 2009 EDD and accompanying press release), does not reflect typical industry practice or state approval processes. Furthermore, DRBC's decision to allow unregulated drilling impacts in sensitive watershed areas sets an unfavorable precedent

[40] Muszynski, W.J., DRBC Manager Water Resources Management Branch, Presentation, DRBC Engagement in Natural Gas Exploration and Development, Marcellus Shale Meeting, January 19, 2010.
[41] DRBC's Rules of Practice and Procedure (RPP), Section 2.3.5.B.6.
[42] DRBC's Water Code Section 3.40.
[43] DRBC, Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters, June 14, 2010.

by potentially doubling drilling impacts. There will be the initial impacts of the exploration well drilling, followed by repeated impacts when a production well is drilled to replace the plugged exploration well.

The more prudent approach would be for DRBC to review exploration wells to ensure they are properly sited, drilled, completed, tested, and suspended, using the best well construction and environmental practices, for potential later conversion to a production well.

The conversion of properly sited and robustly constructed exploration wells to production wells ensures the well is placed in the lowest environmental impact area, and eliminates the environmental impact of drilling a well into the same hydrocarbon target twice. For these reasons, it is important to properly site and assess the impacts of proposed exploration wells in as much detail as is needed for production wells. A successful exploration well is in essence the first production well in the field.

There are limited cases where exploration wells are drilled solely to obtain subsurface data (e.g. cores, well logs, drill stem tests), and in these cases the well is immediately and permanently plugged and abandoned after drilling. This approach is not common. Most Operators will convert a successful exploration well to a production well, unless there are unique circumstances preventing this from occurring. It is not economically attractive for an Operator to drill a well twice.

When an exploration well is destined to be a production well, it is cased and completed with production tubing and a producing wellhead. The well permits for the 11 grandfathered wells do not specify the completion method or the final disposition of the wells and the required 30 day well completion reports were not available for my review.

Findings:

- DRBC grandfathered wells based on economic and risk considerations, without the Operators providing any apparent written economic or risk assessments to support this decision, nor any analysis showing that these considerations trump DRBC's watershed protection obligations.
- There does not appear to be any evidence to show that the permit applications for each of the grandfathered wells are in fact shale gas "exploration" wells.
- DRBC's decision to forego regulation of the grandfathered wells resulted in greater harm to the Delaware River Basin. This harm was created by: allowing wells to be drilled without evaluating whether they are sited in environmentally sensitive areas within the Delaware River Basin; not requiring appropriate setbacks from sensitive locations; and creating a situation whereby an exploration well must be drilled and plugged (even if successful), such that drilling impacts are duplicated when a production well is re-drilled at the same or another location at a later date.
- The DRBC's definition of an exploration well is inconsistent with industry practice, because it is industry practice to convert successful exploration wells into production wells, if commercial quantities of hydrocarbons are found.
- DRBC's decision to forego review of the grandfathered wells, if they are drilled solely to collect data and immediately plugged and abandoned, does not provide the opportunity for DRBC to mitigate the impacts of exploratory operations on the Delaware River Basin. This decision also results in economic waste and creates increased impacts, by requiring successful wells to be drilled twice.

- DRBC should have reviewed each exploration well to ensure it was properly sited and environmental impacts were mitigated. In this way, if Operators make a commercial find, DRBC would have already ensured the well was positioned at a low impact surface location.
- It is important to properly site and assess the impacts of any proposed exploration well in as much detail as is necessary for a production well, because a successful exploration well is in essence the first production well in the field.

D.4 Are There Sufficient Plans and Protections Included in PADEP's Approval to Mitigate and Respond to the Risks Associated with an Exploration Well?

There are a number of risks posed by exploration wells, including air, water and land pollution, resulting from fuel and chemical spills, stray gas migration, well blowouts, water use, waste disposal, and other aspects of drilling operations. One of the most significant and potentially catastrophic risks posed by drilling is an uncontrolled blowout.

An uncontrolled blowout must be considered when planning an exploration well. The grandfathered wells should have been equipped to deal with a gas and/or oil well blowout. Well blowouts can release substantial amounts of oil, gas, drilling mud, and formation water, resulting in significant environmental damage to the surrounding air, water and land. Methods to control a well blowout can require significant water withdrawals and can create large volumes of waste. Well permit applications filed with the PADEP for these grandfathered wells do not include any explanation or evidence of blowout prevention or control capability.

The Pennsylvania Oil & Gas Act at § 601.209 requires a drilling Operator to use safety devices[44] and the 25 PA Code § 78.72 requires the use of blowout prevention equipment and trained personnel. The PA Code focuses on the testing and inspection of blowout preventers, and requires at least one person certified in well control to be on the drill floor. However, neither Pennsylvania law nor regulation requires Operators to demonstrate that they have the expertise, equipment and capability to actually control a blowout and minimize environmental damage, if one occurs.

While Pennsylvania currently requires a Pollution Prevention and Contingency (PPC) Plan to be submitted as part of a drilling application, that plan is inadequate for response to a blowout. PADEP's PCC Guidance[45] (**Exhibit 27**) does not specifically require a well control plan, a written well control barrier policy, a well blowout response plan, or well control experts on contract. This is in sharp contrast to other state and federal agencies, which do currently require response plans to deal with a worst-case blowout scenario. Additionally, the World Bank's Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development recommend comprehensive blowout planning, training and equipment as well as blowout modeling to ensure a well blowout plume radius is understood.[46]

To compound the problem, the Pennsylvania Oil & Gas Act at § 601.215 only requires a bond of $2,500 per well, or a blanket bond of $25,000 for all wells drilled in Pennsylvania by a single Operator. Neither

[44] Section 601.209 requires: "Any person engaged in drilling any oil or gas well shall equip the well with casings of sufficient strength and with such other safety devices, as may be necessary in a manner as prescribed by regulation of the department, and shall use every effort and endeavor effectively to prevent blowouts, explosions and fires."
[45] PADEP's PCC Guidance Document 400-220-001.
[46] World Bank's Environmental, Health, and Safety Guidelines for Onshore Oil and Gas Development, 2007.

amount would provide sufficient funds to control, clean up and/or remediate the damage caused by a well blowout. Nor would $2,500 go very far to meet PADEP's stated uses for the bond which is to:

> *…act as a penalty for failure to comply with the drilling, water supply replacement, restoration and plugging requirements of the Act.*[47]

Blowout response and control plans should not only include methods for controlling the well, but identify environmentally sensitive areas, and list tactics and strategies for protecting those areas during a response. For example, a plan should provide for special protection of waters in the Delaware River Basin. Absent these plans, the Delaware River Basin is at increased risk in the event of an uncontrolled blowout.

Newfield's PPC lists the potential for a fire or explosion from its well drilling operations,[48] but provides no blowout prevention or response plan to address an oil and /or gas well blowout, if it were to occur. Newfield's PPC provides no information on blowout preventer sizing, testing methods, or maintenance programs; it provides no information on methods to control a blowout or tactics, strategies or equipment to respond to a blowout.

By comparison, other state and federal agencies require much more detailed Preparedness, Prevention and Contingency Plans, defining the worst-case blowout scenario, a well control response plan, and well control experts and equipment. Most companies have a separate written well control and blowout response plan that is referenced as part of their emergency plan, but there is no evidence of such a plan in the Newfield PPC. The PPCs from other companies with grandfathered wells were not available for review.

A well-thought-out, written blowout prevention and response plan, with trained and experienced drilling staff able to rapidly identify well control problems and control them, has proven critical in reducing the number and severity of well control incidents across the US. Additionally, plans should be in place to immediately access well control experts and equipment, preferably staging well control equipment nearby, in the event a well control situation exceeds a drilling company's capacity or expertise. Access to well control experts is especially critical for small companies that may have little or no well control experience.

While, PADEP has made some attempt at improving Pennsylvania's blowout control capability by partnering with CUDD Well Control to locate a new facility in Canton Township in Bradford County in response to "recent high-profile accidents at nature gas wells in Pennsylvania"[49] the type of equipment located in Pennsylvania is still insufficient to cap a well. Equipment at CUDD's new Bradford County facility will include: a 2,000-gallon-per-minute pump; heat shields; pneumatic cutting devices; trained crews, and a "hot tap," but does not include an athey wagon or a well capping stack. An athey wagon and well capping stack are both large and critical pieces of equipment used in well control. Because this equipment must still be brought in from the Gulf of Mexico, Houston, Canada or Alaska, places where much of the North America well control equipment is located, this will delay well control, increasing a blowout's impacts.

The potential spill volume from a blowout is equal to the volume of the reservoir contents (gas, oil, and/or formation water) that can flow to the surface, plus the discharge of the drilling mud that is in the hole at

[47] PADEP, Oil and Gas Manual, Chapter 3, October 2001.
[48] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.
[49] PADEP, DEP Says Specialized Natural Gas Emergency Responders Locating in PA, Improving Response Times, PADEP News Bureau Press Release, August 9, 2010.

the time of a blowout. Hydrocarbon reservoirs can contain large quantities of gas, oil and/or formation water, which could continue to be released into the environment until the well naturally bridges on its own (e.g. plugged with sand or debris), is controlled by human/mechanical intervention (e.g. well capping, drilling a relief well, well ignition), or the subsurface reservoir pressure finally drops to a level that the well stops flowing. While blowouts are very infrequent, they do occur, and are a reasonably foreseeable consequence of exploratory drilling operations. Blowouts can last for days, weeks, or months until well control is finally achieved. A blowout in the Delaware River Basin could have significant and irreversible environmental impacts.

The most common method, and best technology, to control an on-land blowout is typically well capping. However, well ignition or drilling a relief well could be alternatives. Well capping requires large volumes of water to allow well control experts to work near the fire with dozers, wagons, and well capping equipment. Water requirements to cap a well depend greatly on the nature of the well blowout, and whether it has ignited.

Surface (lakes, rivers and streams) or subsurface (water wells) water supplies may be tapped to draw the large volumes of water needed for well capping operations, or water may be trucked in, if no nearby surface water or supply well is available. Well control experts use high volume pumps to deluge the rig. Well control experts recommend water supply sourcing and deluging equipment be incorporated in drilling plans. Water requirements can range from 9 barrels of water per minute (9 bpm) [50] to upwards of 100 bpm.[51] This equates to 500,000 to 6,000,000 gallons of water per day, with the average blowout taking days to weeks to control. Deluge operations create large pools of water on the surface that drain away from the well blowout. Deluge fluids can transport oil, chemicals, fuels, and other materials released during the blowout toward lower elevation drainage areas.

Well control experts also use foam and dry chemicals to respond to blowouts. John Wright Co., a well control expert company, explains:

> *Foam consists of water, foam concentrate and air. It is used on liquid hydrocarbon fires to smother the fuel surface (excludes oxygen), suppress vapor emissions (explosive vapor release is restricted), generate steam (removes heat and displaces oxygen), cool surface (heat absorption) and reflect radiant heat. Use on blowouts is restricted to gas condensate fires and oil wells where lateral flow has led to a large fire surface area. Foam can help contain fire near the source and allow work near the flow source. Generally, water alone is adequate for this, but with large, low velocity, lateral oil flow, foam may be required. Modern firefighting foam such as 3M Lightwater ATC is commonly used… Nozzles are available to handle up to 6,000 gpm, but the 2,000-bpm nozzle is most used on oil well fires. Dry chemical extinguishers work like water, but principally act as a smothering agent. Common compounds used are sodium bicarbonate, Purple K (potassium bicarbonate base) and Monnex (highest efficiency rating). Use is generally on methane well fires where explosives cannot be used and water supply is inadequate.*[52]

Additionally, deliberate well ignition or spontaneous combustion can result in large amounts of local air pollution, which can distribute particulate matter and other airborne combustion materials that will eventually deposit on downstream waters, and lands.

[50] John Wright Co., well control expert, http://www.jwco.com/technical-litterature/p09.htm, and (**Exhibit 28**)
[51] Grace, R. d., Blowout and Well Control Handbook, Gulf Professional Publishing, 2003.
[52] John Wright Co., well control expert, http://www.jwco.com/technical-litterature/p09.htm, and (**Exhibit 28**)

PADEP's PPC Guidance[53] (**Exhibit 27**) does require a PPC to include: maps showing the well site layout, boundaries, storage locations, high risk areas, drainage, and topography; location of stored chemicals at wellsite; drawings and plot plans showing sources and quantities of materials and wastes; specific countermeasures to be taken in the event of a spill, including strategies and tactics for responders to follow to contain and control the spill to prevent it reaching water sources, or environmentally sensitive areas; inspection and monitoring programs; security plans; and external factor planning. Yet, many PPCs in Pennsylvania that I have reviewed[54] do not include these components in practice. PADEP has on occasion required PPC Plans to be revised after large spills to remedy plan deficiencies, but this is of little assistance for the damaged environment, especially damaged water resources that are not easily remediated. A more thorough review of these plans prior to drilling is needed to ensure that they are adequate.

For example,[55] Newfield's May 2010 PPC (the only PPC available for this review) did not include many of the elements required by PADEP's PPC Guidance Document 400-220-001. These required elements are critical to preventing and responding to spills in areas and waters of concern to DRBC. Missing plan elements include:

- Drawings showing high-risk areas where spills and leaks most likely would occur;
- Drawings showing drains, pipes, and channels that lead away from potential leak or spill areas;
- Drawings showing outfall pipes that discharge to surface streams or drainage channels;
- Locations of surface drainage courses leading away from the site, and major surface streams and tributaries near the site;
- Locations of any known public and private surface water intakes downstream from the site;
- Descriptions of any existing plans previously developed for the project for the purpose of pollution incident prevention or emergency response preparedness;
- Descriptions of the sources and areas where potential spills and leaks may occur, the direction of flow of spilled materials, and the pollution incident prevention practices specific to the source or area;
- Separate drawings, showing sources and quantities of materials and wastes, sources and areas where potential spills may occur, and pollution incident prevention practices, including a prediction of the direction of the flow of materials spilled as a result of equipment failure, accident, or human error;
- Summary of the engineering practices followed with regard to material compatibility, such as the materials of tanks, piping and other equipment, including their contents and the reaction of materials or wastes when intentionally or inadvertently mixed or combined;
- Summary of the compatibility of a container such as a storage tank or pipeline with its environment;
- A preventive maintenance program for equipment and systems relating to conditions that could cause environmental degradation or endangerment of public health and safety;

[53] PADEP's PCC Guidance Document 400-220-001.
[54] In 2010, I completed a technical review of the Atlas Energy Inc., Cabot Oil & Gas Corporation, EOG Resources, Inc., Newfield Appalachia, and Range Resources PPC, none of which met the PADEP PPC guidelines requirements.
[55] Additional information on the other grandfathered wells PPC plans would be needed to determine the adequacy of the other plans.

- Detailed explanation of the employee training program to ensure that personnel are able to respond effectively to emergencies, by familiarizing them with emergency procedures and emergency equipment systems, including, where applicable: procedures for using, inspecting, repairing, and replacing emergency and monitoring equipment; key parameters for automatic cut-off systems; communications and alarm systems; response to fires and explosions; site evacuation procedures; and shut down of operations procedures;
- Specific countermeasures which will be undertaken by facility personnel in the event of a release, including: valve activations, equipment isolations, flow diversions, boom deployment, and any other activities that will be undertaken to halt the migration of the contaminant off site and to mitigate the consequences of the release;
- A summary of the services of nearby contractors and pre-made arrangements for contractual services on short notice. (PADEP requires equipment suppliers to be contacted to determine the availability and delivery means of equipment needed for removing pollution or hazards to public health and safety).
- A list of available emergency equipment.[56] The list should include the location, a physical description, and a description of the intended use and capabilities of each item on the list. All installations should have equipment available to allow personnel to respond safely and quickly to emergency situations. Some examples of emergency equipment are portable fire extinguishers, fire control equipment (including special extinguishing equipment such as that using foam, inert gas, or dry chemicals), spill control equipment, decontamination equipment, self-contained breathing apparatus, gas masks, and emergency tool and patching kits.

Both exploration and production well operations require fuel to operate drilling and completion equipment and the process of drilling a well requires chemicals. Newfield's PPC lists the potential for both fuel and chemical storage tanks to leak and contaminate the nearby environment, water supplies, or water resources.[57] Newfield's PPCP states:

> *"**For large spills or spills of oils or hazardous materials which may reach surface water or impact the environment**, the employee who first discovers the spill should contact the Emergency Coordinator [emphasis added]."*[58]

TABLE 4

On-Site Emergency Response Equipment

On-Site Emergency Response Equipment
Fire Extinguishers
Tyvek Suits
Nitrile Gloves
Hearing Protection
Particulate Adsorbent
Absorbent Pads
Shovels
Earth Moving Equipment
Decontamination Equipment

Yet Newfield's PPC lists insufficient onsite resources to respond to the potential fuel and chemical spills it lists. Newfield's onsite resources are listed in Table 4[59] as shown to the right.

[56] Newfield's PPC lists spill response equipment but the type and amount is insufficient, and there is no explanation of its intended use or capability as required.
[57] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, included in **Exhibit 7**.
[58] http://www.epa.gov/radiation/tenorm/oilandgas.html#disposalpast.
[59] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.

Newfield's PPC, at Table 1, shown below, provides a list of materials that it plans to use at its exploratory drilling operations. This list shows there is a potential for hazardous materials to spill, including fuels, lubricants, drilling mud, and cement additives. To minimize environmental hazards, production chemicals should be selected carefully by taking into account their volume, toxicity, bioavailability, and bioaccumulation potential. There is no indication in the PPC that this work was completed.

The list provided by Newfield does not make a distinction between exploration or production drilling operations. And, Newfield's PPC does not contain sufficient information to verify whether it has trained and qualified staff able to respond to the potential fuel and chemical spills it lists in Table 1 of its PPC Plan.

TABLE 1

LIST OF MATERIALS & WASTES

CONSTUCTION

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	250 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	180 gallons	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

DRILLING

POLLUTIONAL MATERIAL	VOLUME OR QUANTITY	LOCATION ONSITE	SPILL CONTAINMENT MATERIALS ONSITE/LOCATION
Diesel Fuel	2000 gallons	Well Pad	Sorbent pads; shovels/Gang box
Lubricants	320 gallons	Well Pad	Sorbent pads; shovels/Gang box
DURATONE HT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
GELTONE V	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Lime	7,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
OIL ABSORBANT	2,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
Base Fluid	300 bbl	Well Pad	Sorbent pads; shovels/Gang box
Rig Wash	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Calcium Chloride (CaCl-)	4,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
RHEMOD L	1,770 lbs	Well Pad	Sorbent pads; shovels/Gang box
LE SUPERMUL	8,500 lbs	Well Pad	Sorbent pads; shovels/Gang box
BARACARB 25, 50 (2 pallets each)	12,600 lbs	Well Pad	Sorbent pads; shovels/Gang box
WALNUT	2,400 lbs	Well Pad	Sorbent pads; shovels/Gang box
DRILTREAT	1,900 lbs	Well Pad	Sorbent pads; shovels/Gang box
Liquid Mud	1,500 bbl	Well Pad	Sorbent pads; shovels/Gang box
BAROID REGULAR / **BAROID BULK (barite)	125,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Trash & Debris	2,000 lbs	Well Pad	Sorbent pads; shovels/Gang box
Drill Cuttings	100,000 lbs	Air Pit	Sorbent pads; shovels/Gang box
Cement	130,000 lbs	Well Pad	Sorbent pads; shovels/Gang box

Findings:

- An uncontrolled blowout is a catastrophic risk, but one that must be considered when planning an exploration well. The grandfathered wells should have been equipped to deal with a gas and/or oil well blowout.
- Well blowouts and spills can release substantial amounts of oil, gas, drilling mud, and formation water, resulting in significant environmental damage to the surrounding air, water, and land.
- Well permit applications filed with the PADEP for these grandfathered wells do not include any explanation or evidence of blowout prevention or control capability.
- Pennsylvania requires a Preparedness, Prevention and Contingency (PPC) Plan but that plan does not require a written blowout control plan. Nor does the plan require evidence of trained and qualified personnel to respond to well control situations or evidence of contracts with experts to control well blowouts. In contrast, other state and federal agencies require response plans to deal with worst-case blowout scenarios.
- Pennsylvania only requires a bond of $2,500 per well, or a blanket bond of $25,000 for all wells drilled in Pennsylvania by a single Operator; neither amount would provide sufficient funds to control, clean up and/or remediate the damage caused by a well blowout.
- There are inadequate plans in place to identify environmentally sensitive areas, such as special protection waters of the Delaware River Basin. Tactics and strategies for protecting those areas during a spill response are also inadequate.
- The most common method, and best technology, to control an on-land blowout is typically well capping. Well capping requires large volumes of water to allow well control experts to work near the blowout. Water requirements can range from 500,000 to 6,000,000 gallons per day. Deluge operations create large pools of water on the surface that drain away from the well blowout. This water can transport oil, chemicals, fuels, and any other materials released during the blowout toward lower elevation drainage areas.
- Exploration well operations require fuel to operate drilling and completion equipment and the process of drilling a well requires chemicals.
- Newfield's PPC lists the potential for both fuel and chemical storage tanks to leak and contaminate the nearby environment, water supplies, or water resources; yet lists insufficient onsite resources to respond to the potential fuel and chemical spills it lists.

D.5 Was DRBC's assumption that the risk associated with the grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania well-founded?

DRBC's assumption that the risk associated with grandfathered wells is small because PADEP has sufficient human health, environmental and safety protections in place for exploration drilling projects in Pennsylvania is not well founded for the following reasons:

- PADEP's Chapter 78 Oil and Gas Well Regulations are known to be deficient;
- Grandfathered wells are not required to be constructed to industry best practices for shale gas wells in Pennsylvania;
- PADEP did not apply "Special Permit Conditions," requiring a Water Management Plan, to most of the grandfathered wells;
- Fracture treatment operations are planned for the B&E well;
- Drilling waste can result in environmental harm if not properly managed, and some drilling waste has already been buried on-site and not transported out of the Basin;
- Stray gas migration associated with oil and gas wells can impact water supplies, if wells are not properly constructed and operated;
- PADEP's well siting criteria allows wells to be placed very close to water resources; and
- Air pollution impacts are not well understood or mitigated.

D.5.1 PADEP's Chapter 78 Oil and Gas Well Regulations are known to be deficient

DRBC's June 14, 2010 decision to grandfather wells was based, in part, on the "existing safeguards" offered by PADEP permits issued under Chapter 78. DRBC concluded:

> *In contrast to the thousands of wells projected to be installed in the Basin over the next several years, **the risk to Basin waters posed by only the wells approved by PADEP since May 2009 are comparatively small**. **Not only are these wells subject to state regulation as to their construction and operation**, but they continue to require Commission approval before they can be fractured or otherwise modified for natural gas production. **In light of these existing safeguards** and the investment-backed expectations of the sponsors of these projects, this Supplemental Determination does not prohibit any exploratory natural gas well project from proceeding if the applicant has obtained a state natural gas well permit for the project on or before the date of issuance set forth below [emphasis added].*[60]

Yet PADEP's current regulatory initiative to substantially revise the Pennsylvania regulations at 25 PA Code Ch. 78 (Chapter 78) for Oil and Gas Wells is evidence that Pennsylvania itself acknowledges that the existing Chapter 78 regulations are not currently reflective of best practices, and do not go far enough to protect human health and the environment, especially for sensitive resources.

[60] DRBC, Supplemental Determination of the Executive Director Concerning Natural Gas Extraction Activities in Shale Formations within the Drainage Area of Special Protection Waters, June 14, 2010 (**Exhibit 3**).

The majority of PADEP's well construction and water supply replacement regulations were promulgated in July 1989 and remained largely unchanged until PADEP proposed revisions to Chapter 78 in 2009. Therefore, Pennsylvania's existing well construction standards are more than 20 years old and do not reflect best technology or practice. Several of the grandfathered wells have already been constructed using these out-dated rules.

PADEP summarizes the problems with the existing Chapter 78 regulations:

> *Many of the regulations governing well construction and water supply replacement were promulgated in July 1989 and remained largely unchanged until this rulemaking. Since that time, recent advances in drilling technology have attracted interest in producing natural gas from the Marcellus Shale, a rock formation that underlies approximately two-thirds of Pennsylvania. New well drilling and completion practices now employed to extract natural gas from the Marcellus Shale and other similar shale formations in Pennsylvania, as well as* ***several recent incidents of contaminated drinking water caused by traditional and Marcellus Shale wells resulted in the Department's decision to re-evaluate the existing well construction requirements.***
>
> ***It was determined that the existing regulations were not specific enough in detailing the Department's expectations of a properly cased and cemented well****, especially in light of the new techniques used by Marcellus Shale operators. The Department also determined that the* ***existing regulations did not address the need for an immediate response by operators to a gas migration complaint and did not require routine inspection of existing wells by the operator***
>
> *The final rulemaking contains* ***revised design, construction, operational, monitoring, plugging, water supply replacement, and hydraulic fracturing reporting requirements****. The final rulemaking also provides material specifications and performance testing to ensure the proper casing, cementing and operation of a well. Additionally, the final rulemaking contains new provisions that require routine inspection of wells and outline the actions an operator and the Department must take in the event of a gas migration incident [emphasis added].*[61]

Therefore, DRBC's lack of review of the grandfathered exploratory wells, as well as any other drilling that DRBC allows before the new PADEP Chapter 78 regulations are in place, will allow the current well construction deficiencies, known to be a problem in Pennsylvania, to be repeated in the DRBC watershed.

In 2009 PADEP proposed numerous revisions to Chapter 78 and sought industry and public comment to improve the regulations consistent with PADEP's stated goals of: minimizing public concerns associated with gas migration into public drinking water supplies; updating material specifications and performance testing requirements; and revising design, construction, operations, monitoring, plugging, water supply replacement, and gas migration reporting requirements.

The fact that Pennsylvania has acknowledged deficiencies in its own regulations, and the fact that the current, unimproved Chapter 78 regulations were used as criteria for review and approval of the grandfathered wells is evidence that the grandfathered wells do not have sufficient protections in place.

PADEP received more than 2,000 comments from industry and the public recommending Chapter 78 improvements, including comments written by HCLLC (**Exhibit 23)**.[62] PADEP has developed final

[61] PADEP Notice of Final Rulemaking, Department of Environmental Protection Environmental Quality Board, 25 Pa. Code, Chapter 78 Oil and Gas Well Cementing and Casing, 2010 (**Exhibit 30A**).
[62] Harvey Consulting, LLC, Recommendations for Pennsylvania's Proposed Changes to Oil and Gas Well Construction Regulations, Report to Earthjustice and Sierra Club, March 2010.

revisions to Chapter 78 (**Exhibit 30 and 30A**), but these changes will not be codified until early 2011. Chapter 78 regulatory changes still must undergo review by the Independent Regulatory Review Commission (planned for November 18, 2010) and then must be published in the *Pennsylvania Bulletin* as final rulemaking (planned for early 2011).[63]

Proposed Chapter 78 improvements that do not apply to the grandfathered wells include:

- Additional protections for water supplies (§ 78.51) including improvements to restoration or replacement of impaired water supplies due to oil and gas well operations;
- Additional requirements for waste control and disposal plans (§ 78.55);
- Improved instructions on when a blowout preventer and other well control safety control devices are required (§ 78.72);
- Improved well construction and operational standards (§ 78.73), including standards to ensure that: oil, brine, completion and well servicing fluids do not pollute groundwater; annular overpressuring does not cause gas migration into subsurface water supplies; and gas is safely flared, captured or diverted during well drilling operations;
- Improved well cementing and casing standards (§ 78.83-78.85) to: prevent subsurface infiltration of surface waters; establish more rigorous requirements to centralize casing, install cement, and verify the cement integrity to protect ground water; require the Operator to prepare and maintain a casing and cementing plan; and require use of new pipe and pressure testing and quality standards for that pipe;
- Improved mechanical integrity standards for operating wells (§ 78.88);
- Gas migration response (§ 78.89);
- Improved well plugging standards (§ 78.92-78.95); and
- A requirement for the Operator to certify that the well has been constructed to Pennsylvania's well construction standards (§ 78.122).

Three (3) of the eleven (11) grandfathered wells were drilled under the existing regulatory structure that is known to be inadequate. The remaining eight (8) grandfathered wells were permitted under the existing Chapter 78 regulatory scheme, and may not be required to comply with the new Chapter 78 regulatory requirements, depending on when the wells are actually drilled and when the Chapter 78 revisions are codified.

Findings:

- Existing PADEP oil and gas well regulations at Chapter 78 are known by PADEP to be inadequate to protect human health and the environment.
- PADEP is in the process of revising Chapter 78 with the stated goals of minimizing public concerns associated with gas migration into public drinking water supplies; updating material specifications and performance testing requirements; and revising design, construction, operations, monitoring, plugging, water supply replacement, and gas migration reporting requirements.

[63] November 3, 2010 phone conversation with Scott Perry, Director of Pennsylvania Bureau of Oil and Gas Management.

- PADEP has not yet promulgated Chapter 78 regulations that are adequate to protect human health and the environment; grandfathered wells are being drilled under regulations known to be deficient.

D.5.2. Grandfathered wells are not required to be constructed to industry best practices for shale gas wells in Pennsylvania

Because PADEP does not require well casing and cementing plans to be submitted, reviewed, and approved as part of a well permit application, there is insufficient information available on the grandfathered wells to verify the integrity of the planned or installed casing and cementing configuration. This problem will not be resolved as part of the proposed Part 78 revisions, because the proposed Part 78 rules still do not require a well construction plan to be submitted and approved as part of the permit to drill.

The permit to drill issued by PADEP approves the well location and directs the applicant to follow PADEP regulations, but does not include any PADEP engineering review of the proposed well construction plans.[64] Because there is no engineering review of the permit application prior to drilling, PADEP's process does not ensure that the well will be constructed to best industry/best technology practices at the time the well is drilled. Therefore, the grandfathered well applications at issue here did not include well construction plans, nor was there any engineering review completed by PADEP.

PADEP's proposed Chapter 78 regulations do include an improvement that requires an Operator to certify that the well has been constructed to Pennsylvania's well construction standards (§ 78.122) after the well has been drilled. However, major casing and cement design flaws are difficult to remedy once the well has been drilled.

Recognizing the importance of proper wellbore design prior to construction, the federal government and many states require wellbore construction plans as part of the permit application, subject to agency engineering review and approval prior to well construction.

PADEP does currently require an after-the-fact drilling completion report to be submitted providing information on the final well construction configuration. However, the well completion reports for the three grandfathered wells that have been drilled were not available for my review. Therefore, there was insufficient information available on the well construction method used for these wells to verify if the wells were drilled to best industry practice using best technology standards.

Wells being drilled in the Delaware River Basin, that may be later used as production wells, and subject to high-volume, high-pressure fracturing should be designed and constructed using best industry practice to protect ground water resources.

[64] November 3, 2010 phone conversation with Scott Perry, Director of Pennsylvania Bureau of Oil and Gas Management

Findings:

- PADEP's rules do not require mandatory use of robust well construction practices and designs for Marcellus Shale wells.
- PADEP's well permit application process does not include any engineering review of the proposed well construction plans. Because there is no engineering review of the permit application prior to drilling, PADEP's process does not ensure that the well will be constructed to best industry/best technology practices at the time the well is drilled.
- There is insufficient information available on the grandfathered wells to verify the planned or installed casing and cementing configurations and whether they have a robust design.

D.5.3 PADEP did not apply "Special Permit Conditions," requiring a Water Management Plan, to most of the grandfathered wells

Recognizing the increased water use associated with shale gas drilling and completions, PADEP typically adds a Special Permit Condition to shale gas wells requiring a Water Management Plan to be submitted. The Water Management Plan must describe water sources that will be used for the drilling operation, including safe yield calculations for surface water withdrawals for each new well. The Water Management Plan must include Best Management Practices (BMPs) and must verify that anti-degradation requirements are met and that designated uses of surface waters are protected.

PADEP required a Water Management Plan be submitted as a Special Permit Condition for the B&E well, but did not require a Water Management Plan be submitted for the Crum, Woodland, Teeple #1, Rutledge, Schweighofer, Geuther, and Robson wells. There was insufficient information available on the permit history for the remaining grandfathered wells to determine if Special Permit Conditions had or had not been applied to them.

Because the Crum, Woodland, Teeple #1, Rutledge, Schweighofer, Geuther, and Robson permits did not include a Water Management Plan Special Permit Condition, and there were no documents provided for my review showing that the Operators of these wells prepared a Water Management Plan, it appears that PADEP did not approve the method of water withdrawal, use, storage, or distribution for these wells. There is a lack of consistency in permit conditions applied to the grandfathered wells and a lack of Water Management Plans for many of the grandfathered wells.

Findings:

- PADEP did not require a Water Management Plan for the Crum, Woodland, Teeple #1, Rutledge, Schweighofer, Geuther, and Robson wells.
- There is a lack of consistency in permit conditions applied to the grandfathered wells and a lack of Water Management Plans for many of the grandfathered wells.

D.5.4. Fracture treatment operations are planned for the B&E well.

DRBC lists the B&E Well #1 as one of the 11 grandfathered wells. DRBC maintains that the grandfathered wells are limited to exploration shale gas wells that will not undergo fracture stimulation treatments; however, the B&E Well #1 permit issued by PADEP on March 5, 2009 includes a "Special Permit" condition that requires the Operator to:

> *…not drill the well until the permittee submits to the Department and the Department has approved the method by which the permittee will withdraw, use, store, distribute, process and dispose of water* ***for well drilling and hydraulic fracturing purposes*** *("Water Management Plan").*[65]

The fact that PADEP included a Water Management Plan requirement on the B&E Well #1 well is noteworthy because it must have had a reason to believe that the Operator, Kevin E. Schrader, was planning fracturing operations for this well, which are clearly prohibited under the grandfathering provisions.

Findings:

- PADEP permit indicates fracturing treatments are planned for the B&E Well #1 well. Fracture treatments are not allowed under the grandfathered well provisions.

D.5.5. Drilling waste can result in environmental harm if not properly managed

There is no assurance that a driller's waste management plan will meet DRBC's water protection requirements, because PADEP allows waste disposal methods that DRBC does not. For example, PADEP allows drill cuttings and residual waste to be disposed onsite, under certain circumstances (§ 78.61 disposal of drill cuttings, § 78.62 disposal of residual waste-pits, § 78.61 disposal of residual waste-land application and § 78.60 disposal of tophole water by land application).

For example, a September 8, 2010 PADEP inspection report at the Matoushek wellsite shows that drilling waste was left on-site and buried there. The Matoushek inspection report states that: drilling fluids were being removed from the drilling reserve pit; two workers were observed skimming an oil sheen off of the pit; and the pit's solid wastes would be encapsulated within liner and buried on site. Onsite waste burial within Delaware River Basin is inconsistent with DRBC's requirement to collect drilling waste to be treated at an approved DRBC facility, or transported out of the Delaware River Basin. Produced water from the Matoushek well was transported to a sewage treatment facility that was not approved for drilling waste.[66]

[65] B&E Well #1, PADEP Permit, March 5, 2009, in **Exhibit 15.**

[66] **Exhibit 18B** shows an email exchange between Stone Energy (Woodland Well Operator), DRBC and PADEP. This information was obtained from DRBC through a DRN March 15, 2010 FOIA request. This email exchange questioned whether Valley Joint Sewer Authority had accepted 270,000 gallons of Woodland produced water waste. PADEP confirmed with Valley Joint Sewer Authority that they had stopped taking drilling waste as of April 2009, but DRBC later confirmed that the drilling waste was sent to Valley Joint Sewer Authority prior to April 2009. This series of events was confirmed on November 4, 2010 via a phone call between DRN and DRBC staff.

Because the PPCs for some of the grandfathered wells were not available for my review, it is unclear what the waste management plan is/was for all of the wells. There was also no information provided for my review showing that DRBC had reviewed the waste management plans for the grandfathered wells to ensure that the waste management plans met the DRBC's water protection requirements.

Best waste management practices in other states do not allow onsite burial of drilling waste. For example, New Mexico requires all fluids be removed from the reserve pit and recycled or disposed of in accordance with state regulations.[67] New Mexico also requires the drill cuttings and reserve pit liners be sent to a disposal facility in accordance with state regulations, and the soil under the reserve pit be tested for benzene, total BTEX[68], TPH[69], the GRO,[70] and DRO[71] combined fraction, and chlorides.[72] If contamination is found, it must be excavated and remediated. If the soil is clean it can be backfilled. The City of Fort Worth, Texas, prohibits onsite burial of drilling muds and cuttings.[73] The reserve pits are temporary and all muds and cuttings must be removed and handled at an approved waste management facility.

Although large-volume, high pressure fracture treatments are not currently permitted for the grandfathered wells, in the future there will be requirements for very large impoundments that warrant careful design and limits.

The use of closed loop tank systems, instead of reserve pits and impoundment, is best practice. The Bureau of Land Management (BLM) recommends the use of closed loop tank systems as a best practice instead of reserve pits and impoundments, whenever technically feasible.[74] Texas requires closed looped mud systems with steel tanks. [75] It is much more efficient (from an energy standpoint) to collect waste in the container that will be used to transport it offsite to a waste disposal facility than it is to create an intermediate storage pit. The use of temporary reserve pits and impoundments results in surface disturbance. It also has the potential for leakage to occur through the liner, impacting groundwater. Impoundments also generate air pollution.

None of the other grandfathered wells include the Special Permit Condition applied to the Teeple #1-2H production well,[76] which requires an environmental assessment from PADEP for any impoundments and chemical analysis and characterization of drilling waste prior to processing or disposal. It is not clear why PADEP would have required a more stringent Special Permit Condition for the Teeple #1-2H production well than the other grandfathered exploration wells. There is inconsistency in permit conditions applied to wells subject to this Hearing.

Reported waste handling concerns at the Teeple[77] and Mastoushek[78] wells are strong indications that additional waste management oversight is needed.

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[67] Alpha Environmental Consultants, Inc., Report for NYS on DSGEIS, September 2009
[68] BTEX= benzene, toluene, ethylbenzene, and xylene.
[69] THP= total petroleum hydrocarbons.
[70] GRO= gasoline range organics.
[71] DRO= diesel range organics.
[72] Alpha Environmental Consultants, Inc., Report for NYS on DSGEIS, September 2009.
[73] Alpha Environmental Consultants, Inc., Report for NYS on DSGEIS, September 2009.
[74] Bureau of Land Management, Surface Operating Standards and Guidelines for Oil and Gas Exploration and Development, The Gold Book, 2007.
[75] Fort Worth Texas, Ordinance No. 18449-02-2009.
[76] See **Exhibit 20**, PADEP well permit for DL Teeple 1 2H for Special Permit Conditions.
[77] **Exhibit 9B** shows a May 26, 2020 violation at the Teeple well for an improperly lined pit.
[78] **Exhibit 18B**

The amount and type of waste generated during the drilling and completion of an exploration well varies based on: the drilling method (air or a drilling mud system), the completion and stimulation method, and the amount of well testing that is conducted.

Typical waste streams from an exploration drilling operation can include: domestic wastewater from on-site septic tanks and portable toilets; produced formation water during well drilling, testing, and stimulation; solids waste including drill cuttings, scrap metal, and debris; waste chemicals; waste oils; and materials associated with chemical and fuel spills. Newfield's PPC lists its expected waste streams from its "natural gas exploration of the Marcellus Shale formation" to include:

> *Wastes generated during these activities will be typical for gas drilling operations and will include* ***drill cuttings***, ***produced water***, ***drilling and frac fluids***, ***waste oil*** *and* ***municipal waste*** *and* ***trash*** *[emphasis added].*[79]

According to the DRBC, there are no DRBC approved non-domestic wastewater treatment facilities in the Delaware River Basin at this time (**Exhibit 21**).[80] Absent DRBC review of exploration well permit applications, there is no process to limit the amount and type of waste generated at exploration wells in the Delaware River Basin, and there is no method to ensure that it is collected and shipped to a state approved waste treatment and storage facility outside of the Delaware River Basin, because PADEP is not providing this additional level of oversight and assurance. PADEP only assures that PADEP's standards are met, not incremental local standards.

Examples of significant wastes that could be generated by an exploration well includes drilling mud, cuttings and produced water. This is not an exhaustive list, but rather these drilling wastes are described in more detail below to highlight some of the more significant environmental concerns.

Drilling Muds & Drill Cuttings: Drilling muds are used to control the hydrostatic pressure in a wellbore.[81] The most common weighting agent used is barite. Barite can contain mercury and other heavy metals.

Drilling muds are not used in air drilling techniques; however, it must be assumed that drilling muds will be used, because there is no state statute in Pennsylvania limiting shale gas drilling to air drilling methods only, [82] and the PPCs provided for review include drilling mud.

U.S. Department of Energy studies show that barite contains mercury (1ppm-10ppm Hg, depending on its origin).[83] Mercury concentrations can be reduced by using thermal methods, leaching with dilute acids, or selecting barite with naturally occurring lower concentration levels of mercury.[84]

The U.S. Department of Interior estimates that 0.8 metric tons of mercury is discharged into the Gulf of Mexico (GOM) annually (1839 lb Hg/yr) from mud disposed from drilling operations.[85] This equates to approximately 1.69 lbs[86] of mercury per well for wells drilled to a total depth of approximately 12,000'.

[79] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.
[80] Muszynski, W.J., DRBC Manager Water Resources Management Branch, Presentation, DRBC Engagement in Natural Gas Exploration and Development, Marcellus Shale Meeting, January 19, 2010.
[81] DRN communication with HCLLC on October 23, 2010.
[82] While DRN reports that Newfield stated publically at a September 15, 2010 meeting that its wells use air drilling methods, Newfield's PPC documents plan for use of drilling muds, not air drilling. DRN reports that the top-hole section of some wells may be drilled with air, and the remaining section of the well drilled with mud.
[83] http://www.fossil.energy.gov, "Mercury Removal from Barite for the Oil Industry."
[84] http://www.fossil.energy.gov, "Mercury Removal from Barite for the Oil Industry."

Assuming that the top-hole of some of these wells is drilled using air drilling methods, an average wellbore length of 5,000' for the remaining section of the well is drilled with mud, and there is a lower barite use rate of 100 lbs/ft, to account for lower expected pressures, the mercury content in drilling mud is estimated at 0.5- 5.0 lbs[87] per well, depending on barite quality.

Drilling muds may also contain the heavy metal cadmium, leading the EPA to establish cadmium concentration limits in drilling muds.[88]

Drill cuttings can also contain Naturally Occurring Radioactive Material (NORM). Absent data to support otherwise, there is the potential for NORM content in drill cuttings in the Delaware River Basin. Gas shales are known to contain NORM in some regions. Shales can be heterogeneous and the NORM compositions can vary substantially. Recent studies on the Marcellus Shale in New York State acknowledge that drilling and production waste and equipment may contain NORM. The New York State Department of Environmental Conservation (NYSDEC) reports that the Marcellus Shale contains Uranium-238 and Radium-226, and that this NORM may be present in drill cuttings, produced water and stimulation treatment waste.[89] NYSDEC identified Radium-226 as the most significant NORM of concern, because it is water soluble and has a half-life of 1,600 years.[90] Radiation pathways can include external gamma radiation, injection, inhalation of particulates, and radon gas.[91] Therefore, exploration drill cuttings should be tested to determine NORM content and be disposed of accordingly at a licensed radioactive waste disposal facility. Other oil and gas states, such as Texas and Louisiana, have adopted stringent NORM regulations for E&P operations, including: occupational dose control, surveys, testing and monitoring, record keeping, signs and labeling, and treatment and disposal methods.

Best practice for managing drilling muds and cuttings includes the use of "closed loop tank systems," instead of a reserve pit, and transportation to an approved waste disposal facility. This avoids the impact of constructing a reserve pit and the potential for leakage into the environment.

Yet PADEP did not require the best practice of closed loop tank systems for these grandfathered wells. Instead, PADEP allows drilling muds and cuttings in Pennsylvania to be disposed of in a variety of methods, including subsurface injection into a disposal well, annular injection into the annulus[92] of a previously drilled well, burial on site in pits, or transportation to an offsite waste treatment and disposal facility. There is no assurance that exploration well waste handling will meet DRBC water protection standards. Because PADEP allows onsite burial of drilling cuttings and land spreading of other E&P wastes, we must assume that onsite burial may occur.

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[85] http://www.gomr.mms.gov/homepg/regulate/environ/Hg%20discharge%20estimate.pdf.

[86] (1,091 wells/yr drilled in GOM))* (12,038 ft/well)*(140 lbs barite/ft)*(1x10^{-6} Hg/g barite)= 1,839 lb Hg/yr. (1,839 lb/Hg)/(1,091 wells) = 1.69 lbs of mercury per well.

[87] 1ppm Hg in barite= (1 Marcellus well)* (5,000 ft/well)*(100 lbs barite/ft)*(1x10^{-6} Hg/g barite) = 0.5 lb Hg/well
10ppm Hg in barite= (1 Marcellus well)* (5,000 ft/well)*(100 lbs barite/ft)*(10x10^{-6} Hg/g barite) = 5.0 lb Hg/well

[88] U.S. Environmental Protection Agency, Development Document for Effluent Limitation Guidelines and New Source Performance Standards for the Offshore Subcategory of the Oil and Gas Extraction Point Source Category, EPA 821-R-93-003, 1993.

[89] New York State, 2009 Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, DSGEIS, p. 4-36.

[90] New York State, 2009 Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, DSGEIS, p. 6-129.

[91] US Department of Interior, Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment- an Issue for the Energy Industry, USGS Fact Sheet FS-142-99.

[92] Annulus is the space between the wellbore and the casing.

The drilling permits issued by PADEP for the 11 grandfathered wells do not limit drilling method, do not set limits on drilling mud composition, and do not specify waste disposal method.

Produced Water Waste: Formation water (commonly referred to as "produced water") can be generated as a waste during exploration drilling and well testing operations. PADEP reports that air drilling operations can produce larger quantities of produced water than those wells drilled with mud.[93] Produced waters that are discharged to surface waters or lands of the US are regulated under the federal Clean Water Act, under a National Pollutant Discharge Elimination System (NPDES) permit. PADEP administers the NPDES program in Pennsylvania.[94]

The primary method for disposal of oil field wastewater in Pennsylvania is through pre-treatment facilities that clarify and filter the waste and dispose of it to surface water or sewage treatment plants.[95] A smaller amount of wastewater is disposed of into Class II injection wells.[96] Absent waste management plans for most of the grandfathered wells, it is unclear what the waste management plan is for produced water, because PADEP also allows produced water to be disposed of by land or road spreading, under some circumstances.

Produced water is typically rich in chloride, which enhances the solubility of other elements, including the radioactive element radium. This often makes produced water unsuitable for land application or surface water disposal, especially in sensitive areas such as the Delaware River Basin.[97]

Other states, such as Texas, require extensive produced water testing and specifically prohibit road spreading of waste containing NORM.[98] A study conducted by Argonne National Lab for the US Department of Interior (DOI) concluded that land spreading of diluted NORM waste presented the highest potential dose of exposure to the general public of all waste disposal methods studied.[99]

Furthermore, EPA identified produced water pits as an outdated practice if produced water contains NORM. EPA reports that:

> *Lined and/or earthen pits were previously used for storing produced water and other nonhazardous oil field wastes, hydrocarbon storage brine, or mining wastes. In this case, TENORM[100] in the water will concentrate in the bottom sludges or residual salts of the ponds.* ***Thus the pond sediments pose a potential radiological health risk****….produced waters are now generally reinjected into deep wells…No added radiological risks appear to be associated with this disposal method as long as the radioactive material carried by the produced water is*

[93] PADEP Oil and Gas Manual Chapter 4, October 2001.
[94] PADEP Oil and Gas Manual Chapter 2, October 2001.
[95] Gaudlio, A.W., Paugh, L.O. (Range Resources) and Hayes, T.D. (Gas Technology Institute), Marcellus Shale Water Management Challenges in Pennsylvania, 2008.
[96] The Underground Injection Control Program (UIC) of the federal Safe Drinking Water Act governs control of the injection of flowback and produced waters to ensure that injected waste is confined to the injection zone in a manner that does not contaminate fresh water bearing formations that may serve as Underground Sources of Drinking Water (USDW).
[97] US Department of Interior, Naturally Occurring Radioactive Materials (NORM) in Produced Water and Oil-Field Equipment-an Issue for the Energy Industry, USGS Fact Sheet FS-142-99.
[98] Texas Railroad Commission (TXRRC), 16 Texas Administrative Code, Title 16, Part 1, Chapter 4, Subchapter F, §4.601 - 4.632. "Disposal of Oil and Gas NORM Waste". The TCEQ has jurisdiction over the disposal of other NORM wastes.
[99] Argonne National Laboratory, Radiological Dose Assessment Related to Management of Naturally Occurring Radioactive Materials Generated by the Petroleum Industry, Publication ANL/EAD-2, 1996.
[100] TENORM is Technologically Enhanced Natural Occurring Radioactive Material.

returned in the same or lower concentration to the formations from which it was derived [emphasis added].[101]

Newfield's Preparedness, Prevention and Contingency (PPC) Plan states:

Produced water will be removed periodically from the tanks at each wellsite and transported by a licensed residual waste hauler to a permitted disposal facility *[emphasis added].* [102]

Newfield does not specify who the waste hauler is, nor does it name the permitted disposal facility. Therefore, it is not possible to confirm whether this waste handling plan conforms to DRBC's requirements for waste from industrial operations in the Delaware River Basin.

Findings:

- Drilling waste can result in environmental harm if not properly managed.
- Because waste management plans were not available, it is unclear what the waste management plan is/was for most of the grandfathered wells.
- Reported waste handling concern at the Teeple and Mastoushek wells are strong indications that additional waste management oversight is needed.
- There is no assurance that a driller's waste management plan will meet DRBC's water protection requirements, because PADEP allows waste disposal methods that DRBC does not.
- Best waste management practices in other states do not allow onsite burial of drilling waste.
- The used of closed loop tank systems is a best practice, preferred over reserve pits and impoundments.
- Drilling waste can include Naturally Occurring Radioactive Material (NORM), mercury, cadmium and other heavy metals.

D.5.6. Stray gas migration associated with oil and gas wells can impact water supplies

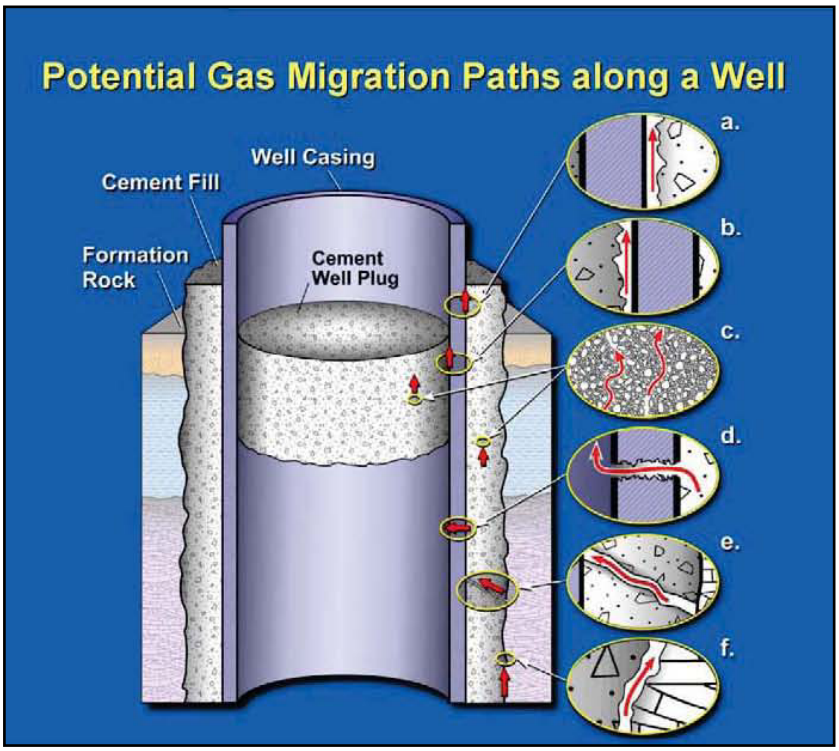
PADEP stresses the importance of proper well construction to mitigate stray gas, noting that these protections are not currently found in PADEP's regulations at Chapter 78, but will be when the rulemaking is finalized in 2011:

Properly constructed and operated oil and gas wells are critical to protecting water supplies *and public safety.* ***If a well is not properly cased and cemented, natural gas in subsurface formations may potentially migrate from the wellbore through bedrock and soil. This stray gas may adversely affect water supplies****, as well as accumulate in or adjacent to structures such as residences and water wells. Under certain conditions,* ***stray gas has the potential to cause a fire or explosion. These situations present a serious threat to public health and safety as well as the***

[101] http://www.epa.gov/radiation/tenorm/oilandgas.html#disposalpast.
[102] Newfield Appalachia PA, LLC, Preparedness, Prevention and Contingency Plan (PPCP), May 2010, submitted with all its grandfathered wells.

> ***environment.*** *The purpose of this final rulemaking is to improve drilling, casing, cement, testing, monitoring and plugging requirements for oil and gas wells to minimize gas migration and protect water supplies [emphasis added].*[103]

In October 2009, PADEP released a draft report summarizing 65 cases of stray natural gas migration associated with oil and gas wells (**Exhibit 32**), where improperly constructed and operated oil and gas wells have reportedly introduced gas into drinking water wells, aquifers, top soils, and structures. Most of these cases were attributed to inadequate well design and construction, improper well operation, poor well abandonment procedures, or a failure to abandon a well that is no longer in use.



The risks associated with well annulus over-pressuring, well casing failure, improperly constructed wells, and improperly abandoned wells could result in stray natural gas migration in the Delaware River Basin, if these risks are not mitigated.

There is insufficient information available on the grandfathered wells to verify whether the planned or installed casing and cementing configuration is a robust design. Therefore, it is not possible to verify whether stray gas problems associated with well construction practices have been mitigated in the grandfathered wells. Because there are no plug and abandonment applications or approvals for the grandfathered wells, it is not possible to verify whether the wells have been plugged or will be plugged in a manner that mitigates stray gas. Stray gas mitigation is a design concern for all types of well construction, including vertical and horizontal wells.

As shown in the figure above,[104] there are a number of ways that gas can migrate in a wellbore through failed piping (e.g. casing damage, corrosion, erosion) or through poor quality or improperly placed cement.

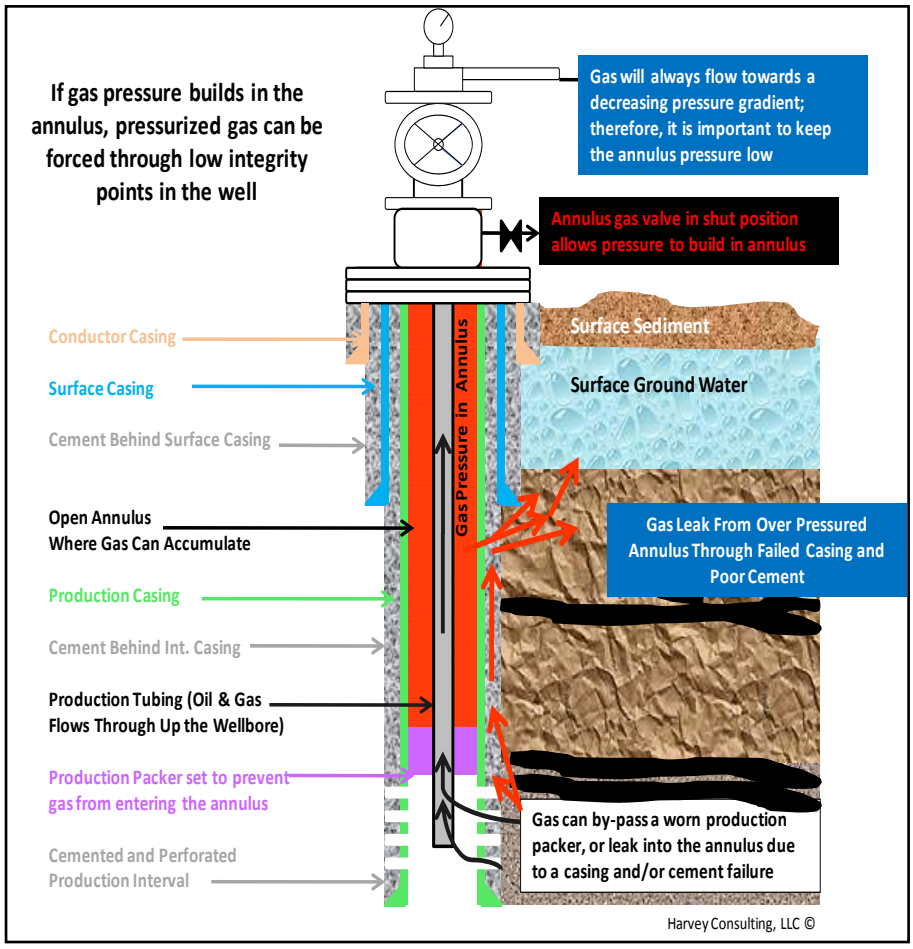
Open hole completions, where no cement or casing is installed across hydrocarbon bearing intervals, can increase the likelihood of gas migration.

[103] PADEP Notice of Final Rulemaking, Department of Environmental Protection Environmental Quality Board, 25 Pa. Code, Chapter 78 Oil and Gas Well Cementing and Casing, 2010 (**Exhibit 30A**).
[104] Potential Gas Migration Pathways Diagram, Alberta Energy Utilities Board.

Unmonitored annulus pressure in completed, temporarily suspended wells can also provide opportunities for stray gas problems. Over pressured well annulus (see diagrams on next pages) can force gas through low integrity points in the well.

For the grandfathered wells that have been drilled, but not yet plugged, it is important that the well is monitored to ensure that the annulus does not over-pressure, forcing high pressure gas from the well annulus into lower pressure ground water zones. This happens under certain circumstances, such as when a wellbore is not cased and cemented; casing failure occurs; cement is poorly bonded; or a production packer fails.

The diagrams shown in this report are simplified schematics showing the risk posed by gas migration due to annular over-pressuring (in a completed well) or a well that is left open hole (uncased) and uncompleted. These diagrams are not intended to show how the grandfathered wells may have been constructed, because those construction diagrams were not available for my review. Rather these diagrams are intended to show the types of stray gas problems that can occur in cased and completed wells, and in open hole completions.

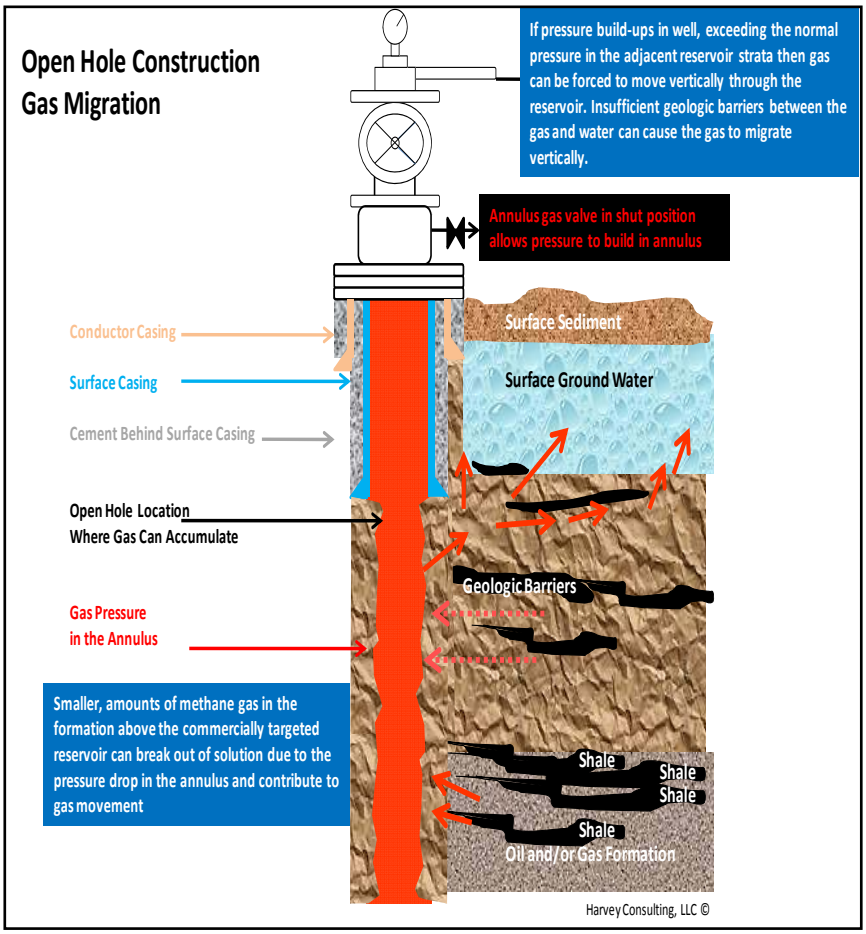


New construction practices do not guarantee stray gas migration will not occur, but these practices do significantly reduce risk. Over time production packers can wear out or casing can fail due to corrosive and erosive conditions in the wellbore, resulting in gas leaks into the annular space. Poor cementing practices can also result in gas movement.

Proper monitoring of the annulus pressure can help prevent gas migration. Even in wells constructed with more modern well construction techniques, gas pressure can build in the annulus. For example, gas can bypass a worn out production packer or leak into the annulus due to a casing and/or cement failure. Gas from a higher pressure oil and gas formation will move into the annulus through a leak because the annulus is of lower pressure. By the laws of physics, gas will always flow toward a decreasing pressure gradient. Therefore, the higher pressure gas will move from the oil and gas reservoir into the lower pressure annulus. As long as the annulus is not over pressured, this gas can be extracted at the surface. However,

if the annulus becomes over pressured, formation gas will take the path of least resistance, which may cause it to migrate into shallower formations.

An open-hole provides several pathways for gas to migrate from deeper, higher pressure formations to shallower, lower pressure formations. Gas can leak though poor cement placed at the bottom of the production casing. Smaller amounts of methane gas in the formation above the commercially targeted reservoir can break out of solution, and move toward the lower pressure open-annulus. An over-pressured annulus can cause gas to move from the higher pressure annulus into lower pressure, shallower zones.



The problem of ground water contamination by open-hole completions in Pennsylvania is well documented in two articles published in the Ground Water Journal by Samuel Harrison, a Professor of Geology and Environmental Science from Allegheny College, Meadville, Pennsylvania.[105,106]

Dr. Harrison concluded:

> *This annulus is a potential avenue of migration of contaminants from strata of higher hydrodynamic pressure into formations of lower hydrodynamic pressure.* ***If gas from the strata exposed to the annulus is not permitted to escape to the atmosphere, the annulus may become pressurized and a hydraulic gradient may be created between the potential contaminants in the annulus (e.g. brine and/or natural gas) and the overlying fresh-water aquifers.*** *If a permeability pathway exists between the pressurized annulus and an overlying fresh-water aquifer,* ***contamination of the aquifer will result*** *[emphasis added].*"[107]

Of note, Dr. Harrison's article from 1985 stated that gas should be vented to atmosphere to relieve pressure on the annulus. However, best practices to mitigate greenhouse gas emissions, such as methane,

[105] Harrison, S.S., Evaluating System for Ground-Water Contamination Hazards Due to Gas-Well Drilling on Glaciated Appalachian Plateau, Groundwater, November-December 1983, Vol. 21, No.6.
[106] Harrison, S.S., Contamination of Aquifers by Overpressuring the Annulus of Oil and Gas Wells, Groundwater, May-June 1985, Vol. 23, No.3.
[107] Harrison, S.S., Evaluating System for Ground-Water Contamination Hazards Due to Gas-Well Drilling on Glaciated Appalachian Plateau, Groundwater, November-December 1983, Vol. 21, No.6.

now recommend collecting this gas in a low pressure gas system or using it as fuel at the well site, rather than venting it to atmosphere, where technically feasible.

Dr. Harrison goes on to write:

> *The risk of contaminating fresh ground water with the contents of a gas- or oil-well annulus could be greatly reduced by filling the annulus with cement.*

The oil and gas industry has learned from experience that casing and cementing the wells along the entire length of the hole provides added protection to ground water resources, as shown in the more current wellbore construction approaches used today.

Gas pressure buildup in the annulus can cause gas to move vertically in the reservoir toward the lower pressure ground water aquifer. This problem can be mitigated by opening the annulus valve and producing the gas to the surface, thereby decreasing the pressure in the annulus ("gas annulus de-pressuring"). An open-hole design does not guarantee that gas will migrate vertically to the lower pressure groundwater aquifer. It is just more likely to occur than in a more robust well construction design, with multiple barriers of cement and casing.

Geologic barriers to vertical flow, such as thick continuous shale layers, can trap gas and prevent vertical migration. Sealed faults and other sealed geologic unconformities can also provide barriers to vertical flow. Moreover, the pressure of the gas in the annulus must exceed the normal hydrostatic pressure gradient for it to flow vertically. Higher pressure gas will naturally seek equilibrium pressure and flow toward areas of lower pressure. If the gas pressure is sufficient enough to overcome the natural hydrostatic pressure gradient, and there are insufficient geologic barriers to prevent vertical gas migration, then gas may reach the ground water reservoir.

Pennsylvania has casing pressure regulations at Subchapter D, § 78.73 requiring Operators to monitor and prevent gas well annulus over-pressuring. The fact that gas well annulus over-pressuring is occurring, despite this rule being in place points to the need for additional agency monitoring and oversight to ensure the regulation is being complied with in the field.

Findings:

- Stray gas migration associated with oil and gas wells can impact water supplies.
- Well construction improvements to mitigate stray gas problems associated with oil and gas drilling have been proposed by PADEP for adoption in 2011, but will not apply to most of the grandfathered wells.
- Risks associated with well annulus over-pressuring, well casing failure, improperly constructed wells and improperly abandoned wells could result in stray natural gas migration in the Delaware River Basin, if these risks are not mitigated.
- Because there are no plug and abandonment applications or approvals for the grandfathered wells, it is not possible to verify whether the wells have been plugged or will be plugged in a manner that mitigates stray gas.
- Open hole completions and/or unmonitored annulus pressure in completed, temporarily suspended wells can provide opportunities for stray gas problems.

D.5.7. PADEP's well siting criteria allow wells to be placed very close to water resources

The Oil and Gas Act, §601.205(a) only requires oil and gas wells be located at least 200 feet from existing buildings and existing water wells, and allows for granting a variance[108] to place the well even closer.

The Oil and Gas Act, §601.205(b) only requires oil and gas wells be located at least 100 feet from any stream, spring or body of water, as identified on the most current 7½ minute topographic map, and at least 100 feet from any wetland greater than one acre in size, and allows for granting a variance[109] to place the well even closer.

These surface siting criteria do not provide sufficient setbacks from sensitive water resources in the Delaware River Basin. For example, blowouts can eject drilling mud, gas, oil and/or formation water from the well and onto waters and lands adjacent to the well, within the radius of the blowout plume. Depending on the reservoir pressure, blowout circumstances, and wind speed these pollutants can be distributed hundreds to thousands of feet away from the well.[110] Pressurized fluids can spray hundreds of feet, and spilled fluids can travel across surface terrain, or seep into the ground and travel towards water resources though the soil. For example, in September 2009 well chemicals spilled at the Cabot Heitsman 4H well flowed to the nearby Steven's Creeks located more than 100' away.[111]

The Crum well site is on the North Branch of Calkins Creek, a "High Quality" Creek, as classified by PADEP. It has high quality biota in the stream that will be impacted by influxes of sediment and pollution, and changes in stream flow. Calkins Creek supports brook trout, brown trout (both are temperature sensitive), merganser ducks, and great blue herons. It is also habitat for black bear and bald eagles that fish the river and roost the forest in this sub-watershed.[112] The Woodland well site is less than one-half mile from the river, on Hollister Creek, a "High Quality" stream, as classified by PADEP. Black bear and bald eagles use this area for hunting, foraging and nesting.

Findings:

- PADEP's setback requirements of 100' from a water body or 200' from a well are not sufficient to protect high-value water resources.

D.5.8 Air pollution impacts are not well understood or mitigated.

The 25 PA Code § 127.14 (38) exempts oil and gas drilling operations from air quality control requirements (**Exhibit 33**).

[108] Where the restriction would deprive the owner of the oil and gas rights, the right to produce or share in production, the Department may grant a variance upon submission and approval of form 5500-FM-OG0058, Request for Variance From Distance Restriction From Existing Building or Water Supply.
[109] The Department may waive distance requirements upon submission and approval of form 5500-FM-OG0057, Request for Waiver for Distance Requirements From Springs, Streams, Body of Water or Wetland.
[110] S.L. Ross Environmental Research Limited, Oil Deposition Modeling For Surface Oil Well Blowouts, 1998.
[111] Cabot Oil & Gas Corporation, Engineering Study, Prepared for PADEP, In Response to Order Dated September 24, 2009, prepared by URS Corporation for Cabot, October 9, 2009.
[112]Biological Information provided by DRN November 1, 2010.

> *"38. Oil and gas exploration and production facilities and operations that include wells and associated equipment and processes used either to: a) drill or alter oil and gas wells; b) extract, process and deliver crude oil and natural gas to the point of lease custody transfer; c) plug abandoned wells and restore well sites, or d) treat and dispose of associated wastes. This includes petroleum liquid storage tanks which are used to store produced crude oil and condensate prior to lease custody transfer."*

This exemption includes shale gas drilling; therefore, air pollution impacts from the grandfathered wells are currently unregulated and unmitigated.

PADEP is in the process of determining whether this air permitting exemption is warranted for Marcellus Shale Drilling Operations. PADEP is currently studying short-term air quality impacts and is expected to complete these studies in early 2011 (**Exhibit 33** includes a news report summarizing PADEP's study).

PADEP's study does not examine combined and cumulative impacts of multiple drilling operations, nor does PADEP's study examine the impacts of air pollutant transport and deposition on waters and lands downwind of drilling operations.

Components of atmosphere pollution caused by exploration drilling includes gaseous products of hydrocarbon evaporation and burning as well as aerosol particles of unburned fuel, including nitrogen oxide, sulfur oxides, carbon monoxide, particulate matter, and hazardous air pollutants. These airborne pollutants interact with atmospheric moisture, and transform in the presence of solar radiation and precipitate onto land and water surfaces causing both local and regional pollution.[113]

There are a number of potential air emission sources from drilling operations, including combustion source emissions (drilling engines and flares), direct venting of gas, and fugitive emissions from pits, impoundments and other leaks.

Since PADEP does not require a permit and there is no list of emission sources, or any assessment of the air pollution impact, it is not clear whether air pollution impacts from the grandfathered wells are significant and warrant mitigation to protect the Delaware River Basin airshed and associated waters. Air pollution can transport airborne pollutants downwind, depositing pollutants to water and land surfaces. These impacts are not well understood or mitigated for the grandfathered wells.

EPA explains the direct relationship between air pollution and water quality impacts:

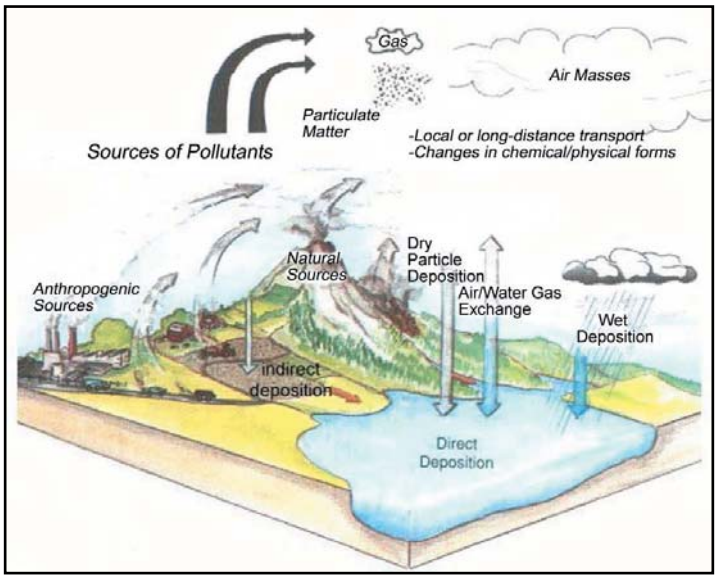
> ***Airborne pollutants*** *from human and natural sources* ***can deposit back onto*** *land and* ***water bodies, sometimes at great distances from the source, and can be an important contributor to declining water quality.*** *Pollutants in waterbodies that may originate in part from atmospheric sources include nitrogen compounds, sulfur compounds, mercury, pesticides, and other toxics [emphasis added]."*[114]
>
> *Airborne pollution can fall to the ground in precipitation, in dust, or simply due to gravity. This type of pollution is called "atmospheric deposition" or "air deposition." Pollution deposited from the air can reach water bodies in two ways. It can either be deposited directly onto the surface of the water (direct deposition) or be deposited onto land and be carried to water bodies*

[113] Rana, S., Facts and Data on Environmental Risks- Oil and Gas Drilling Operations, Society of Petroleum Engineering Paper 114993, October 2008.
[114] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/airdeposition_index.cfm

through run off (indirect deposition). ***Once these pollutants are in the water, they can have undesirable health and environmental impacts, such as contaminated fish, harmful algal blooms, and unsafe drinking water*** *[emphasis added].*[115]

The diagram below shows the air pollution pathway from industrial sources to water resources. [116]

EPA explains that there are several pathways for air pollution to contaminate water resources, including:



- Direct deposition where air pollutants are directly deposited to the water resource;
- Indirect deposition where the air pollutant is deposited to the water resource, initially only impacting one part of the water resource, but later those pollutants are transported through runoff, rivers, streams and groundwater contaminating larger areas;
- Wet deposition where pollutants are deposited in rain, snow clouds or fog. Acid rain is an example of wet deposition of sulfur and nitrogen compounds associated with fossil fuel combustion;
- Dry deposition where air pollutant particles settle on water surfaces via gravity.

In many states, drilling equipment has been exempt from air permitting requirements because of its mobile, short-term nature, but upon further study regulators are finding that the air pollution impacts are more substantial than initially expected especially the amount of hazardous air pollution that is emitted, when large open-air impoundments are used to store fracture fluids and drilling chemicals.

A recent Environmental Impact Statement completed for Marcellus Shale drilling in New York State identified the potential for large amounts of hazardous air pollution (methanol[117]) may be present at central impoundments (32.5 tons per year).[118] A major source of hazardous air pollution is one that emits more than 10 tons/yr of any single hazardous air pollutant, or 25 tons/yr of multiple hazardous air pollutants, therefore New York's study found that shale drilling operations exceeded the hazardous pollutant threshold by more than three times.

[115] http://water.epa.gov/lawsregs/lawsguidance/cwa/tmdl/airdeposition_index.cfm
[116] EPA's Office of Air and Radiation (OAR) and Office of Water (OW), Frequently Asked Questions about Atmospheric Deposition Handbook: A Handbook for Watershed Managers, EPA-453/R-01-009, September 2001.
[117] EPA lists methanol as a hazardous air pollutant, but has not yet classified methanol with respect to carcinogenicity. http://www.epa.gov/ttn/atw/hlthef/methanol.html. Chronic inhalation or oral exposure may result in headache, dizziness, giddiness, insomnia, nausea, gastric disturbances, conjunctivitis, blurred vision, and blindness in humans. Neurological damage, specifically permanent motor dysfunction, may also result. The Merck Index. An Encyclopedia of Chemicals, Drugs, and Biologicals. 11th ed. Ed. S. Budavari. Merck and Co. Inc., Rahway, NJ. 1989.
[118] New York State, 2009 Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program Well Permit Issuance for Horizontal Drilling and High-Volume Hydraulic Fracturing to Develop the Marcellus Shale and Other Low-Permeability Gas Reservoirs, DSGEIS, p. 6-57.

The New York State Environmental Impact Statement did not estimate significant amounts of benzene emissions; however, recent reports indicate the Texas Commission on Environmental Quality is finding surprisingly high levels of benzene emitted from Barnett Gas Shale activities in Texas.[119] Benzene is a known, EPA-listed human carcinogen.

Air toxics do not just remain airborne when emitted from industrial operations, these toxins can deposit onto soils or surface waters where they are taken up by plants and ingested by animals and can be magnified through the food chain.[120]

Findings:

- PADEP exempts oil shale gas drilling operations from air quality control requirements, but has yet to complete a study to verify that short and long-term (cumulative impacts) meet the Clean Air Act requirements and are protective of human health and the environment.
- PADEP is in the process of determining whether this air permitting exemption is warranted for Marcellus Shale Drilling Operations. PADEP is currently studying short-term air quality impacts and is expected to complete these studies in early 2011.
- PADEP's study does not examine combined and cumulative impacts of multiple drilling operations, nor does it examine the impacts of air pollutant transport and deposition on waters and lands downwind of drilling operations.
- Shale gas drilling operations, when combined with use of fracture and drilling chemical impoundments, can be major sources of hazardous air pollutants.
- The use of closed looped collection and tank systems can mitigate water, land and air pollution impacts and are best pollution mitigation practices for shale gas drilling.
- Fuel and power selection options can also be considered to reduce air pollution impacts.

[119] Dr. Michael Honeycutt, Head of TCEQ's Toxicology Division, quoted in WFAA-TV new report, November 20, 2009. Dr. Michael Honeycutt "was shocked to see air sampling revealed high levels of benzene, a cancer-causing toxin, near some natural gas facilities."
[120] http://www.epa.gov/oar/toxicair/newtoxics.html

Report on Selected Environmental Impacts of Exploratory Gas Drilling in the Delaware River Watershed

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Executive Summary

This report is concerned with the construction and operation of exploratory vertical gas wells in the Special Protection Waters portion of the Delaware River watershed.

Current well drilling technologies, as applied in practice, do not guarantee that surrounding groundwater and surface water will be protected from the effects of exploratory well drilling. Regulators should proceed with caution in evaluating the impact of exploratory gas wells on surrounding surface waters. Current regulations in Pennsylvania do not require analysis of surrounding surface waters and there is no evidence that the well operators will perform or have performed any surface water analysis prior to, during or after drilling of these wells.

Stream buffer strips have proven to be an effective means of reducing the effect of land development on surface waters, both in general land development and in the particular case of drilling for oil and gas exploration and extraction. Pennsylvania regulations only require a 100 foot separation distance between a gas well and a surface water body. This is wholly inadequate as a stream buffer and will not provide needed protection to the Special Protection Waters of the Delaware River.

The loss of intact forest land and the increase of forest fragmentation associated with oil and gas development is well documented. In this Special Protection Waters area, development that results in such changes to the land should be carefully evaluated. Where such development is approved, mitigating steps or measures should be implemented in order to preserve water quality. Pennsylvania regulations do not provide adequate protection of forest and does not prevent or reduce forest fragmentation leading to inadequate protection of forest cover required to protect the Special protection Waters of the Delaware River Basin.

At issue here is the impact of multiple exploratory wells. It is important that, in evaluating the environmental impact of these wells, the evaluation consider not only the impact of each individual well site, but also of the cumulative impact of all sites operating together and simultaneously. When viewed in this manner, the impact of the exploratory wells in question is amplified. There is no evidence that any cumulative impact analysis of the potential impacts of and risks posed by the multiple exploratory wells on receiving water bodies, particularly the main stem Delaware River, has been done.

It has been found (The Nature Conservancy and Pennsylvania Audubon, 2010) (Exhibit 1) that, with proper planning in advance of well construction, integration of conservation features into the development of well sites can lead to significantly reduced impacts on surface waters. However, there is no evidence that such planning has occurred in the development of the exploratory well sites that are of interest here. As a result, it is prudent that the procedures used in selecting the sites for the exploratory sites, and the activities on these sites, be carefully reviewed. This is particularly important given the Special Protection Waters status of the watershed.

The opinions provided in this report are stated to a reasonable degree of scientific and professional certainty

Introduction

Exploratory gas wells have been or are permitted to be drilled in northeastern Pennsylvania as a part of a project to extract natural gas from the Marcellus shale formation. This gas extraction will use the process of hydraulic fracturing in the future to extract the gas from this deep geologic formation. The portions of the Delaware River watershed where the exploratory wells grandfathered under the Supplemental Executive Director Determination (SEDD) at issue in this hearing are located have been designated as Special Protection Waters (SPW) by the Delaware River Basin Commission (DRBC). Waters receiving this designation have been found to have exceptionally high scenic, recreational, ecological and/or water supply values. The regulations establishing SPW significantly restrict new and increased discharges of wastewater directly to the designated waterways by prohibiting discharges that create any measurable change in water quality.

Groundwater Contamination

An important issue in evaluating potential pollution pathways from exploratory gas wells is groundwater contamination from poorly constructed water wells. Generally, drinking water wells are shallower than natural gas wells, and their casing may not extend their entire depth. This is particularly the case for domestic water wells that may not be subject to the same level of oversight and scrutiny as municipal or privately owned water supply facilities. This is particularly true for older water wells and for spring wells, which are used in the regions of the Delaware River watershed that are underlain by Marcellus shale, including Wayne County, and the local areas immediately adjacent or quite close to where these grandfathered exploratory wells are located. A water well that is not cased from the surface, or is not constructed and cased properly, might allow contaminated water to flow from the ground surface and enter the water well, possibly compromising the quality of drinking water in the well, as well as the drinking water aquifer itself.

In such instances, and particularly where natural gas drilling activities are nearby, leaky surface impoundments or careless surface disposal of drilling fluids at the natural gas operation could increase the risk of contaminating the nearby water well. While the quantity of chemicals used in the installation of exploratory wells may be less than for production wells, the potential for this type of contamination is significant. The grandfathered wells under the SEDD are each located close to groundwater wells or springs providing potable water to residents in, adjacent to, and downgradient from these exploratory well sites.

Surface Water Impacts of Well Drilling

The Pennsylvania Academy of Natural Sciences has called for a comprehensive research plan that would result in guidelines and an assessment tool for regulators and managers in order to minimize the environmental impact of Marcellus Shale gas drilling. Dr. David Velinsky Testimony (Exhibit 2) (available at http://www.ansp.org/about/news/marcellus-shale.php)

The research described by Dr. Velinsky found that there is very little information available as to the impacts of long-term exposure of a watershed to Marcellus Shale drilling activities. It is unknown if there is a cumulative impact of drilling activity on a small watershed. Initial research by Academy scientists shows the environmental impact of drilling may be directly related to the density of drilling in a specific area. This research has pointed out that a question that needs to be addressed is whether there is a threshold point past which a certain amount of drilling activity has an impact on the ecological health and services of the watershed, regardless of how carefully drilling is conducted. This is very important in regards to the exploratory wells that are being drilled in the Basin under the grandfathered wells provision of the SEDD. Three of the grandfathered wells in southern Wayne County drain over a short distance to a relatively small stretch of the Delaware River that influences vulnerable species such as dwarf wedge mussel, a federally listed endangered species, and other fish, wildlife and aquatic species that are sensitive to water quality and flow changes.

The Academy scientists examined small watersheds in northeastern Pennsylvania—three in which there had been no drilling, three in which there had been some drilling and three in which there had been a high density of drilling. At each site, they tested the water, the abundance of certain sensitive insects, and the abundance of salamanders. The presence of salamanders is particularly important because amphibians are especially vulnerable to changes in the environment. The absence of amphibians is often an ecological early-warning system. For each of the measures, there was a significant difference between high-density drilling locations and locations with no drilling or less drilling. The studies showed that water conductivity (which indicates the level of contamination) was almost twice as high in the high density sites as the other sites, and the number of both sensitive insects and salamanders were reduced by 25 percent.

Site preparation on the surface at the well site is likely to cause increased erosion and runoff into surrounding streams. For both exploratory and production wells, the wellbore acts as a conduit between adjoining geologic formations, which can allow contaminants to flow into shallow groundwater or surface waters.

It has been reported (DRBC 2009) that wastewater generated during the drilling of the Matoushek well (which was completed as a future production well but has not gone into production and therefore is similar to an exploratory well) was stored on site and then trucked to a municipal wastewater treatment plant in Athens, PA. It is known that the wastewater treatment processes used at municipal treatment plants, including the plant at Athens, are not capable of removing the industrial pollutants (organic chemicals, heavy metals, etc.) that are present in the wastewater that is generated by well drilling operations. As a result, it is likely that these pollutants were discharged into either surface or groundwater without treatment. The

grandfathered exploratory wells at issue here either have already generated wastewaters or will generate them when they are drilled and such wastewaters will most likely be transported from the well site to another treatment or disposal location that has not been identified by DRBC because it is not exercising any regulatory control over these wells.

Land Disturbance - General

Drill sites involve land disturbance, making sites susceptible to runoff during storm events that can cause pollution of streams, lakes, ponds, etc. downstream from the site. Construction of drill pads as a surface for operations and storage of large equipment/containers is completed prior to the commencement of drilling and can be as large as five acres. Roads may also need to be built for access to the site. Phase II Stormwater Regulations require that construction activities disturbing one or more acres of land must have a stormwater discharge permit. In New York such permits are issued by NYS DEC under its State Pollutant Discharge Elimination System (SPDES) General Permit for construction activities. As part of this permit, a Stormwater Pollution and Prevention Plan (SWPPP) would be required, with NYS DEC charged with ensuring the SWPPP is met. Apparently no such permitting of this type is required in Pennsylvania for oil and gas projects less than 5 acres. Stormwater runoff from the grandfathered exploratory well sites is a source of pollutants to the Special Protection Waters.

With regard to land disturbance, the grandfathered exploratory wells that are at issue here are generally the same as production wells. This includes disturbance on the well site itself, placement of well facilities such as the well pad and pit, and in the construction of access roads to the site, and traffic on such roads.

It should be noted that the Marcellus shale formation underlies a significant portion of the watershed of the New York City water supply system in southeastern New York State and the watershed for water supply to Philadelphia, central and southern New Jersey, and all of the communities along the Delaware River. The New York City public water supply is unusual in that there is no filtration applied to the water diverted from the Delaware River Basin before delivery to the public. New York City has been granted a waiver from federal regulations that require such filtration. The granting of this waiver is dependent on enforcement of various regulations in the watershed that are designed to maintain water quality. The goals and associated requirements of the Special Protection Waters status of the portion of the Delaware River watershed where the grandfathered exploratory wells are located are applicable to protect the downstream water users and are similar in many ways to the requirements that exist in the watershed of the New York City water supply system.

The entire New York City watershed located west of the Hudson River (the Catskill and Delaware portions of the watershed) is underlain by Marcellus shale, and gas development has been proposed in this area. In response to this potential gas development, the New York City Dept. of Environmental Protection completed a study to evaluate the impact of gas development on general water quality in the watershed, and specifically on the risk to the federal filtration waiver (Hazen and Sawyer 2009)(Exhibit 3).

While this study was concerned with both gas exploration and production, many of the findings and recommendations apply to the grandfathered exploratory wells in question here, because, as reported by Dr. Rubin in recent comments to the U.S. Environmental Protection Agency (Exhibit 4), the geology of the Delaware River Basin watershed below the New York City reservoirs is the same as the geology of the areas of New York state addressed by Hazen and Sawyer. Among other conclusions, the Hazen and Sawyer study found that land disturbance associated with gas exploration and development would lead to increased risk to the water supply. With regard to land disturbance, these conclusions also apply to the Special Protection Waters of the Delaware River watershed. The Hazen and Sawyer study more generally documented the problems that may be associated with well drilling (exploratory or production), such as migration of drilling muds, hydrocarbons, and naturally occurring radioactive compounds into surface and groundwater.

Projects that involve only exploratory wells have been found to result in problems affecting surrounding land and water resources (U.S. Forest Service, 2005). Monitoring of the Gunnison Energy Exploratory Gas Drilling Project in the Grand Mesa/Uncompahgre/Gunnison (GMUG) National Forest and the Willsource Exploratory Project in the White River National Forest demonstrated unexpected negative environmental impacts after exploration began. Gunnison Energy Corp., the developer at the GMUG National Forest, experienced the movement of significant quantities of sediment from well sites into nearby streams. Measures that were designed to prevent an increase in runoff from well sites were found to not be effective. At the Willsource Exploratory Project, sediment from access roads was deposited in nearby stream channels, and runoff from well sites was not properly controlled. The grandfathered well sites at issue here present similar runoff pollution risks.

Land Disturbance - Buffer Zones

A riparian forest buffer is a streamside forest composed of native trees, shrubs and herbaceous plants (Lee et al. 2004). Use of such buffer areas provides various benefits. Buffers are natural filters. Leaf litter on the forest floor traps sediments before they can enter the stream. In addition, the presence of trees and shrubs along a stream's banks minimizes erosion and the effects of flooding. Buffers also encourage groundwater infiltration. Trees convert the excess nutrients in stormwater runoff into a form that actually sustains the growth of the forest. In addition, buffers provide shade necessary to maintain cool water temperatures and higher dissolved oxygen levels. Native trout, for example, require water temperatures below 68°F to survive, and forested streams are as much as 10 degrees cooler than streams that flow through meadows (Lee et al. 2004). In addition, insects, the primary food for trout, are abundant both above and in wooded streams and cannot survive in water temperatures that exceed 68°F.

The results demonstrate the positive impact of forest buffer zones in reducing the influence of agricultural nutrients and chemicals on surface stream waters (Anbumozhi et al. 2005).
Some of the adverse effects of impervious surfaces (such as paved roads, parking lots, and manmade structures) and agricultural areas can be mitigated by tree cover and streamside vegetation buffers, which reduce the force of overland flows, uptake excess nutrients, maintain stream bank integrity, and provide shade that reduces solar warming of waterways (Goetz et al.

2004). In addition, it has been found that forest cover provides more optimal land cover for protecting water quality than many of the potential uses to which that land may be converted (Hall et al. 2008).

There is solid evidence that providing riparian buffers of sufficient width protects and improves water quality by intercepting nonpoint source pollution (NPSP) in surface and shallow subsurface water flow (Lowrance et al. 1984; Pinay and Decamps 1988). The spatial placement of buffer strips within a watershed can have profound effects on water quality. Riparian buffers in headwater streams (i.e., those adjacent to first-, second-, and third-order systems) have much greater influences on overall water quality within a watershed than those buffers occurring in downstream reaches. Downstream buffers have proportionally less impact on polluted water already in the stream (Fischer and Fischenich, 2000).

The areas that have been or will be disturbed by the construction of the grandfathered well sites at issue here include forested and other land areas that will be or have been disturbed. This will compromise buffer zones to streams and creeks in close proximity to the well sites. These streams and creeks are mostly classified as high value or exceptional value streams and provide spawning habitat for native trout, among other important aquatic species.

It has been found that species richness was positively correlated with wetland area, forest cover, and the amount of wetlands on adjacent lands and negatively correlated with road density (Houlahan and Findlay, 2003). Lowrance et al. (1997) found that riparian forest buffers retain 50%–90% of the total loading of nitrate in shallow groundwater, sediment in surface runoff, and total nitrogen in both surface runoff and groundwater, thereby reducing the loading of these nutrients to downstream waters.

In a study of Pennsylvania streams by Brenner et al. (1991), riparian woodlands were effective in reducing fecal coliform, suspended solids, and total phosphorus. The establishment and maintenance of wetlands and riparian vegetation were determined to be a cost effective means of non-point source pollution abatement. Stormwater treatment strategies that focus on infiltration and take advantage of trees and intact forest buffers can counter the unhealthy effects of development. The areas surrounding the grandfathered well sites generally provide all or most of these land features.

Pennsylvania's Independent Regulatory Review Commission (IRRC) recently passed two new regulations that provide protections for water resources and for drinking water and watersheds from the impacts of natural gas drilling pollution as well as other new development projects. The rules fall under Title 25, in the PA code, Chapter 95, Wastewater Treatment Requirements, and Chapter 102, Erosion and Sedimentation Control. Changes to Chapter 102 state regulations approved by the IRRC will require some developers to maintain or create a 150-foot natural vegetative buffer beside Pennsylvania's best rivers and streams. These rules affect so-called E&S permitting or Erosion and Sedimentation Control measures implemented with construction projects to reduce impact on streams and rivers. Streams in the top 20% statewide for water quality will be subject to the increased protections. This would presumably include streams designated as Special Protection Waters. Unfortunately, natural gas projects are exempted from the additional buffer width requirements that are being adopted for Pennsylvania's best streams.

The subject exploratory wells will not employ these extra buffer protections, exposing the high and exceptional water quality of the tributaries and main stem Delaware River in the Wayne County region to degradation in proximity to the places where the grandfathered wells have been or will be located.

Streamside buffers are widely considered to be the best and most effective long-term solution for protection water quality. Buffers help filter water, reduce the impacts of flooding, shade and reduce water temperatures creating better habitat for fish and aquatic species. Over 200 municipalities within Pennsylvania require streamside buffers for such development projects. Again, no natural gas well, exploratory or production well, will be required to follow this rule to which all other development projects are now subject.

Land Disturbance - Intact Forest Land Cover and Forest Fragmentation

Ecosystem fragmentation generally causes large changes in the physical environment as well as biogeographic changes (Saunders et al. 1991). The exchange of solar radiation, water, and nutrients across the land surface and landscape are altered significantly. These in turn can have important influences on the biota within remnant areas, especially at or near the edge of the remnant. It has generally been found that intact forests that have not been subject to fragmentation by construction of roads and pipelines support more diverse and healthier ecosystems (Spellerberg 1998).

Areas of high ecological integrity that may serve as core refugia include: intact old growth forests, native forest ecosystems operating within the bounds of historic disturbance regimes, intact watersheds and large roadless areas (DellaSala et al. 2003). Intact natural vegetation helps to reduce or control floods and retain moisture in the soils (O'Neill et al. 1997; Hunsaker and Levine. 1995). Construction of logging and other roads in forested areas has been correlated with decrease in the acreage of intact forest (Heilman et al. 2002).

For gas well drilling in forested areas, trees and vegetation are removed for the well pad, access roads, and pipelines (Woodring 2009). This habitat destruction and forest fragmentation has the potential to seriously disrupt and endanger flora and fauna. Furthermore, noise from traffic could have a negative effect on local wildlife and clearings for pipelines may present an opportunity for increased traffic from off-road vehicles (Woodring 2009). Indirect impacts include road-building and pipeline development, which may result in habitat fragmentation and increased access to remote areas. While larger intact forest ecosystems may withstand the impacts of mining and oil development, smaller fragments are likely to be particularly sensitive to clearing (Mooney et al. 1995). Several of the sites where grandfathered wells have been or will be located will suffer forest fragmentation from the construction of these well sites.

General decline in the diversity of animal populations has been observed as a result of forest fragmentation in Pennsylvania (Yahner 1996). One potential repercussion of forest fragmentation is a decline in migratory bird populations, which become more vulnerable without continuous forest cover (Robinson et al. 1995). It has been found that maintenance of intact forests encourages the vitality of bird populations in Pennsylvania (Porneluzi et al. 1993). Food

supply for various bird species in Pennsylvania has been found to be reduced as a result of forest fragmentation (Robinson 1998).

Forest fragmentation has been found to increase the susceptibility of forests to damage from unusual weather events. For example, in the first autumn after fragmentation, a period with high winds caused severe blowdown and other forest damage in all five fragments of a previously intact forest. Total tree mortality after 67 months showed a steep increase with decreasing area of contiguous forest areas (Esseen 1994). Because the Executive Director of the Delaware River Basin Commission decided in the SEDD not to exercise the Commission's review jurisdiction over the grandfathered sites, there is no assessment from the Commission staff whether the cumulative effect of these grandfathered projects could result in similar forest fragmentation and its consequences.

Conclusions

Current well drilling technologies, as applied in practice, do not guarantee that surrounding groundwater and surface water will be protected from the effects of drilling the grandfathered exploratory wells.
The loss of intact forest land and the increase of forest fragmentation associated with grandfathered exploratory gas wells can be expected to have measurable impact in the Special Protection Waters area. Mitigating steps or measures, such as the provision of stream buffers, will not be required by the Commission because it is not exercising jurisdiction over the grandfathered wells. Such mitigation measure should be taken in order to preserve water quality.

The multiple exploratory wells that are at issue here should not only be reviewed as to the individual impact of each site, but also the cumulative impact of all exploratory sites in the Special Protection Waters. The surface waters of the Delaware River Basin, in particular the Special Protection Waters are at significant risk of degradation associated with construction and operation of exploratory gas wells. These waters are not protected adequately by present regulations.

The opinions expressed herein are stated to a reasonable degree of scientific and professional certainty.

Signature: Emmet M. Owens

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Date: November 18, 2010

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Risks Associated with Permitting Exploration Wells in the Delaware River Basin
to

Delaware Riverkeeper Network and Damascus Citizens for Sustainability

By

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November 12, 2010

The following comments are a response to a request for a determination of the risk of chemical contamination from exploration gas wells. In my professional opinion, the chemicals introduced into the environment during exploratory well construction, along with the naturally occurring substances that may be introduced to the surface system via drilling, pose a significant threat to ground and surface waters in the Delaware River Basin. Additionally, the Delaware River Basin Commission's lack of oversight with respect to siting of these wells increases the risk of harm from these wells, an issue that will be further exacerbated should they allowed to be converted to production wells.

1. **The 11 wells listed by the Delaware River Basin Commission (DRBC) are not truly exploration wells, since they are not planned to be plugged and capped at the end of the exploratory period.** While others have examined this issue in more detail (see S. Harvey's report), it is reasonably clear that these wells are intended to be used for production, should they tap into a sufficient gas reservoir. However, it is apparent that these wells have not undergone the same level of detailed scrutiny that a normal production well would undergo. Normal siting criteria for an exploratory well would include, at a minimum, the following:

    a. Potential for groundwater contamination from leakage or chemical additive release;
    b. Potential for surface water contamination from migration of gases or drilling additives from the exploration well;
    c. Potential for release of odors that could affect nearby residents;
    d. Potential for impacts on a variety of organisms that may suffer adverse effects from activities associated with the exploration wells; and
    e. Impacts on sensitive ecological areas from activities and releases from drilling the wells.

    Siting characteristics are critical component of protecting human health and the environment from gas wells, and allowing "exploration" well construction

without the rigorous hard look for the potential for water and air contamination is creating an unnecessary increase in risk.

2. **Additives and the quantities of those additives used in drilling of the wells are not specifically indicated, but should be, in order to assess the risk of these wells.** Following review of Material Safety Data Sheet (MSDS) data from several of the PaDEP permits for the 11 well sites grandfathered under the Supplemental Executive Director Determination, it is clear that a variety of chemical additives and cement products are used during the exploratory well construction (Exhibit 1). The amount of each of these substances is not reported and certain of these compounds present an uncertain risk. Some of the chemicals of concern include the following:

    a. Halad 344 Cement additive: This appears to be a modified acrylamide copolymer. No indication is present as to the amount of monomer present in the polymer. The monomer is more chemically active (or "available") to interact with other chemicals and organisms (including aquatic animals and people) and very often provides the primary risk for use of polymers. This is a particular concern due to the carcinogenicity of acrylamide. Also not indicated is how the polymer will be used, or the amount of polymer used.
    b. Ethylene glycol monobutyl ether (EGBE) and diethylene glycol monobutyl ether. These are fairly low toxicity to humans, but can still contribute to water quality degradation, simply by adding in organic carbon that will be a source of microbial reactions. EGBE (also known as 2-butoxyethanol) has been identified as a carcinogen in animals for formation of adrenal tumors, but not in humans, Exposure to EGBE can cause irritation of mucous membranes and other respiratory problems including pulmonary edema and coma at high doses. It is used in more limited quantities
    c. HR-601: Modified lignosulfates. These materials are not well chemically characterized and can add also add organic carbon that can adversely affect water quality.
    d. Cellulose derivative: No information is provided on what type of derivative is used. This material is presumably a modification of cellulose (which is not a risk, when unmodified) but no information is presented on what that modification is.
    e. Diesel and motor oil: Both of these materials, when used in wells, can release organics including benzene, toluene, ethylbenzene and xylene to surface and ground waters. Benzene presents the largest cancer risk, in that it is known human carcinogen. The other compounds, although less toxic, are general indicators of fuel contamination, are flammable, and, at high concentrations are central nervous system depressants (Klaassen, et. al., 1996)
    h. Quaternary ammonium compounds: Essentially no information is provided as to which compounds are being used. The toxicity will vary

with the type of compound. All the structural information that is provided with the term "quaternary ammonium compounds" is that the molecule contains a nitrogen bonded to four carbon atoms, but does not provide information sufficient to even speculate on the risks of this class of compounds.

i. Duratone HT: This additive contains nonylphenol, a compound which is biologically long-lived, slightly bioaccumulative, and is a toxic substance and an endocrine disruptor in aquatic organisms (US EPA, 2010).

3. Gaseous odors from the well sites have been demonstrated, and have the clear potential for release of unknown chemical and unhealthful exposure to chemicals from the wells. Drilling of the Woodland Management Gas Drilling Site near Damascus in September, 2010 (Exhibit 2, statement by Greg Swartz and Tannis Kowalchuk) released a "sulfuric chemical odor." While the source of this odor was unclear, it may have come from the well, the water stored in the pond, or during emptying of the pond. While a limited set of water samples was analyzed, the source of the odor remains unclear. What is concerning is that there was no serious attempt to determine the source of the odor, or the chemical characterization of the odor. If it was from the well, it could represent a serious source of hydrogen sulfide; if it was from biological reduction of sulfate, it would have required carbon sources to reduce sulfate to sulfide. Yet the analysis of the water (WMP-Tophole), did not show hydrocarbons normally present in gas releases from gas wells (e.g. toluene, xylene, ethyl benzene, etc.). It did, however have a high biological oxygen demand (BOD) of 432 mg/L. The source of this biological reduction equivalent was, however, not clear. Whether it was chemical additives used during drilling or organic chemicals from the produced water was unclear. While the source of the water was not described, the water had characteristics that may have indicated that it was produced water, including elevated salinity as well as elevated barium, strontium and iron. The lack of concern of the regulatory agency was noted in a comment regarding hydrogen sulfide that said that "H_2S is primarily an eye irritant", while in fact, hydrogen sulfide is highly toxic, and has a toxic LC_{50} value of 444-585 ppm (ATSDR, 2008). Gases can come from several sources at these wells, and often contain a variety of odorous materials, including hydrogen sulfide, other sulfides, and a variety of malodorous organic compounds. While odors in a completely cased and sealed well may be minimal, these very volatile compounds often find ways to be emitted to the surface air, most commonly from either inadequately sealed wells, or from transport pathways created from the formation during the well construction. These odors can have a serious impact on the quality of life of surrounding residents, since odors are unpredictable and, in my experience with odors, very difficult to regulate.

4. **Exploration gas wells have not gone through the siting analysis that would have been conducted for production wells.** This involves consideration of the receptors, including surface and groundwater, as well as nearby residents, schools and work places that may be affected by proximity to the wells. Natural

gas is not simply methane, and contains a variety of hydrocarbons and contaminants that may present risks to persons and other organisms exposed to these chemicals. These include benzene and a variety of organic small molecules (toluene, xylenes and other alkyl aromatics, alkanes). These will move more slowly in soil and groundwater systems but ultimately can migrate to surface water systems. Benzene in particular is a known carcinogen, and transport to groundwater systems is a serious problem.

Transport mechanisms will vary with the specific conditions of the gas well. Spills can occur at the site, or from the near surface casing that experiences a failure. Contaminating chemicals, including produced water, or additives used in the drilling process, and these chemicals can then be introduced directly into the near-surface aquifers, or in surface water from runoff. Gas pressure that is released during drilling can push natural gas to the surface when a migration pathway is created. This is likely to also carry a variety of volatile hydrocarbon constituents that exist in the formation. Finally, blowouts, although infrequent, can result in uncontrolled release of contaminated water that will result in degradation of water quality in near surface aquifers, and surface water.

Because exploration wells will not undergo any siting analysis by DRBC, the risks from these wells can potentially be larger than from production wells. As has been argued by others, gas producers will likely seek to convert exploration wells into production wells in the Delaware River Basin if they intercept gas reservoirs that are economic. Drilling additional wells under an exploration permit is unwise, and has an increased potential to affect human health and the environment in the Delaware River Basin.

References:

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ATSDR (Agency for Toxic Substances and Disease Registry), (2006). "Toxicological Profile for Hydrogen Sulfide" US Public Health Service. US Dept. of Health and Human Services"

The opinions expressed in this report are stated to a reasonable degree of scientific and professional certainty.

Signature

Date 11-16-2010

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Report for the Delaware River Basin Commission Consolidated Administrative Hearing on Grandfathered Exploration Wells

To
Delaware Riverkeeper Network
and
Damascus Citizens for Sustainability

Prepared by
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November 15, 2010

1) On behalf of the Delaware Riverkeeper, the Delaware Riverkeeper Network, and Damascus Citizens for Sustainability, I have reviewed numerous reports and much material that relates to the practice of developing gas wells in shales. Much of my focus relates to the Appalachian Basin that encompasses portions of New York State, Pennsylvania, New Jersey, and Delaware. While this testimony is oriented to exploration wells in Wayne County, PA and the broader Delaware River Basin, the concepts forwarded are applicable throughout the Appalachian Basin to areas overlying the Marcellus and Utica shales. In my professional opinion, vertical exploratory gas wells, as well as horizontal hydraulically fractured wells, create a high risk of contamination of the water resources of the Delaware River Basin. This risk exists not only at the time of drilling but also increases over time, because of a) the likelihood of failure of the well over time, b) the likelihood of eventual migration of toxic natural and drilling-related substances through extensive natural fractures that exist throughout the region, and c) the exacerbation of a) and b) above by natural or drilling-induced seismic activity. This report also documents significant natural seismic activity in and adjacent to the Delaware River Basin over time. Ground motions from even one significant earthquake, among many that occur over time, may catastrophically shear numerous gas well casings or, at the very least, may result in fracturing and loss of integrity of well casing cement designed to isolate freshwater aquifers from deep saline waters. As such, earthquakes may instantly destroy the integrity of hundreds of gas wells, thereby forever and irreparably compromising the hydrologic integrity of geologic formations that formerly protected freshwater aquifers. Restoration of contaminated freshwater aquifers is probably not possible, thus well failures from any single or combination of mechanisms is likely an irrevocable commitment of natural resources. These points will be discussed in greater detail below.

2) I offer this opinion based on my training as a geologist, hydrogeologist, and hydrologist with more than twenty-nine years of professional environmental experience, which includes work conducted for the New York State Attorney General's Office (Environmental Protection Bureau), Oak Ridge National Laboratory (Environmental Sciences Division), the New York City

Department of Environmental Protection, and as an independent environmental consultant as President of HydroQuest. My educational background and professional experience are more fully set forth in my Curriculum Vitae, attached as Addendum A, attached to my report. I have conducted detailed assessments of streams, wetlands, watersheds, and aquifers for professional characterizations, for clients, and as part of my own personal research. I have authored numerous reports and affidavits related to this work and have made presentations to judges and juries. In addition, I have published papers and led all-day field trips relating to this work at professional conferences.

Location and Bedrock Geology

3) The Delaware River Basin encompasses portions of New York State, Pennsylvania, New Jersey, and Delaware. Figure 1 portrays this large watershed area. The exploratory wells that are the subject of this testimony lie in Wayne County, the furthest northeastern county of Pennsylvania. Immediately north, northeast, and east of Wayne County are three New York State counties: Broome, Delaware, and Sullivan respectively.

4) Geologically, Wayne County, PA is virtually indistinguishable from portions of Broome, Delaware, and Sullivan Counties. Figure 2 depicts similar geologic formations present in Broome, Delaware, Sullivan and other counties throughout New York State that lie in close proximity to Wayne County. Geologically, these units are composed of a series of sedimentary shales, siltstones, sandstones, and some conglomerates layered from the Honesdale Formation downward through and below the Marcellus Formation. These rock units were deposited under the same hydrologic conditions through the widespread area now recognized by geologists as the Catskill Delta. Before the sediments of these rock units were lithified into bedrock, they were shed northwesterly from the ancestral Acadian Mountains.

5) The subcrop of the Marcellus shale underlies portions of these New York State counties and all of Wayne County, PA. Portions of these counties, as well as portions of Schoharie, Greene, and Ulster counties in New York State, lie within the headwater region of the Delaware River Basin. In Figure 2, Wayne County, PA lies in a white area directly southwest of the boxed label titled: Cannonsville Reservoir Delaware R. headwaters.

6) As reflected in Figure 2, it is apparent that erosion has, in places, removed some of the uppermost bedrock units through glaciation and erosion. In places, Wayne County and nearby watershed areas have the same bedrock units exposed at the ground surface. Significantly, geologically and hydrologically, ground and surface water flow in Wayne County and surrounding counties behaves similarly – all potentially being vulnerable to gas field related contaminants from below and above.

7) The Marcellus and Utica shales extend under a large, multi-state, land area. The environmental risks associated with the installation of vertical exploratory wells and hydraulic fracturing are interstate in nature and must be fully evaluated in this manner - not solely state by state or watershed by watershed. The need to comprehensively evaluate and regulate hydrologic and hydrogeologic risks on a gas field basis is paramount.

Joints, -Faults, Methane Presence, and Blowouts

8) Jacobi (2002) documented numerous joints and faults (collectively termed fractures) present throughout the headwaters of the Delaware River Basin, as well as elsewhere throughout portions of New York State overlying the Marcellus and Utica shales (Figure 3). While much of Jacobi's work did not extend into Pennsylvania, the density of these fractures clearly argues that similar joint sets and faults are present in neighboring Wayne County, PA and beyond. Reference to Figure 3 reveals the dominant NW, N-NW, NE, and E-NE fracture orientations. As seen below, these trends coincide with those throughout the broader Appalachian Basin.

9) Exploratory wells may target or have a high likelihood of penetrating vertical bedrock joints that have the potential of hydrologically connecting saline and freshwater horizons. Prominent joint orientations throughout the Appalachian Basin, inclusive of Wayne County Pennsylvania, are well documented by Evans (1994), Engelder et al. (2009), and Lash and Engelder (2009). Figure 4 depicts four figures from Engelder et al. (2009) and Lash and Engelder (2009) that illustrate dominant joint orientations throughout the Appalachian Basin. These geologists determined that most pervasive systematic joints hosted by Devonian black shale strike east-northeast (J_1 joint set) with younger cross-fold joints striking northwest (J_2 joint set). They concluded that "*[B]oth sets were driven exclusively by fluid pressure generated as a consequence of hydrocarbon-related maturation supplemented by subsequent tectonic compaction during the Alleghanian tectonic cycle. In the more deeply buried, proximal region of the Catskill Delta, joints of both sets cross-cut.*" (Lash and Engelder, 2009). Figure 3 confirms this cross-cutting relationship in New York State counties immediately north, northeast, and east of Wayne County. Engelder et al. (2009) confirm that the more permeable J_1 joint sets are found at depth in the Marcellus based on the presence of systematic J_1 joints in Marcellus outcrops on either side of the deep central region of the Appalachian Basin, as well joint appearance in Formation MicroImager images of recent wells. Thus, two regional, well-integrated, perpendicular joint sets exist throughout Wayne County, PA. Exploratory and other wells have a high likelihood of intersecting these interconnected joint sets.

10) Vertical exploration wells, even in the absence of stimulation via hydraulic fracturing, pose similar environmental risks as do horizontal well completions. Natural fractures function as high-permeability gas pathways (Engelder et al., 2009). The greater the fracture interconnectivity, the greater the potential gas production. Recent drilling technology in the Marcellus Shale uses hydraulic fracturing to take advantage (i.e., maximize production) of the more densely spaced and more permeable E-NE oriented J_1 joint sets by interconnecting them via horizontal drilling methods oriented perpendicular to J_1 joints (i.e., N-NW and S-SE). Hydraulic fracture interconnection results in J2 joints draining to J1 joints and gas production wells. In the absence of hydraulic fracturing, vertical exploratory wells have been known to intersect high permeability gas-bearing fractures, sometimes with disastrous results. Engelder et al. (2009) document the presence of unhealed (i.e., methane-filled) joints at depth in the Marcellus shale and major blowouts that occurred when these unhealed joints were encountered (as cited from Bradley and Pepper, 1938 and Taylor, 2009). For example, Taylor (2009) discusses the 1940 Crandell Farm blowout near Independence, New York where massive uncontrolled gas flow occurred from joints intersected by an unstimulated vertical Marcellus well that lacked any evidence of faulting. Engelder et al. (2009) further discuss blowouts in the

Marcellus Shale after the Crandell Farm blowout:

> *"Over the following half century, blowouts were a common consequence of drilling vertical wells penetrating the Marcellus. The low permeability of the Marcellus suggests that many, if not all, blowouts must have tapped a reservoir of interconnected natural fractures. In fact, blowouts were one of the major attractions drawing Range resources to Washington County, Pennsylvania, where Range started targeting the Marcellus gas shale during 2004 (W.A. Zagorski, personal communication)."*

11) Engelder et al. (2009) document that, even in the absence of stimulation, some gas wells that tap unhealed and well-interconnected joint sets at depth are excellent producers. Clearly, preserved unhealed joints are important to gas production because healed fractures and veins would otherwise serve as barriers to gas flow (Engelder et al., 2009). Thus, vertical exploration wells that intersect permeable, gas-rich, interconnected joint sets pose a potential hydraulic pathway (i.e., with a decreasing pressure gradient) for upward migration and release of methane, especially in the event of casing or grout failure or stemming from seismic activity – whether natural or induced at some point later in time by hydraulic fracturing. In the latter case, earthquake or micro-seismicity stemming from future hydraulic fracturing in the area may result in shearing of exploration well casing and the opening of inter-formational pathways. Beyond this, blowouts themselves may pose a means of catastrophically interconnecting brine-rich and freshwater geologic horizons. Therefore, vertical exploration wells bear many of the same potential adverse environmental impacts as hydraulically fractured horizontal wells.

12) Numerous joints in the Appalachian Basin, even in the absence of gas well installations, provide open, functioning, avenues for upward migration of methane. Gas-rich joints encountered by exploration well boreholes may interconnect and enhance preexisting joint pathways for methane, deep-seated saline water, radioactivity and, following development of horizontal gas wells, for contaminated LNAPL (Light Non-Aqueous Phase Liquids; e.g., chemicals with a density less than freshwater, such as benzene) fracture fluids to migrate to aquifers, reservoirs, lakes, rivers, streams, wells, and even homes.

13) Importantly, Figure 3 of New York State counties north, northeast, and east of Wayne County, PA provides a <u>conservative</u> approximation of the actual number of joints and faults present throughout the area. In establishing a relationship between seismicity and faults, Jacobi (2002) examined Fracture Intensification Domains (FIDs: closely spaced fractures commonly with a frequency greater than 2/m and with a fracture frequency an order of magnitude greater than in the region surrounding the FID), E97 lineaments (Fig. 3), topographic lineaments, gradients in gravity and magnetic data, seismic reflections profiles, and well logs. Jacobi states:

> *"In interbedded shales and thin sandstones in NYS, fractures within the FID that parallel the FID characteristically have a fracture frequency greater than 2/m, and commonly the frequency is an order of magnitude greater than in the region surrounding the FID."*

14) Jacobi makes a case for repeated reactivation along faults in the Appalachian Basin. Furthermore, and importantly, Jacobi addresses his and Fountain's identification of FIDs based on soil gas anomalies over open fractures:

> *"Certain sets of FIDs are marked by soil gas anomalies commonly less than 50 m wide (Jacobi and Fountain, 1993, 1996; Fountain and Jacobi, 2000). In NYS, the background methane gas content in soil is on the order of 4 ppm, but over open fractures in NYS, the soil gas content increases to 40-1000+ ppm."*

The fact that Jacobi and Fountain have successfully identified and measured methane seepage from fractures that most likely extend downward to gas producing shales shows that open vertical pathways already exist, confirming the risk of increasing gas excursions as a result of exploratory boreholes penetrating joints or, later in time, as horizontal wells are hydraulically fractured. Clearly, Jacobi and Fountain's work suggests that opening and expanding fractures that now naturally release methane from gas-rich shales will provide even greater gas and contaminant migration pathways if later interconnected and widened via hydraulic fracturing. As with environmental concerns attendant to completing hydrofracked horizontal gas wells, installing vertical exploratory boreholes into gas-rich joint sets should not occur until after full environmental review.

Earthquakes, Seismicity, and Risk of Casing Shearing

15) The installation of exploratory wells that open borehole or nearby joint pathways between formerly separated geologic horizons pose an environmental risk, particularly because the area is seismically active. Ground motion associated with seismic activity has the real potential of instantly shearing multiple well casings, degrading cement grout designed to isolate geologic horizons, and thereby opening vertical joint and borehole vectors between formerly separated geologic horizons. Numerous earthquakes have occurred in Pennsylvania, New York, and adjacent states (see Addendum B and Addendum C), pointing out that the region of the exploratory wells is seismically active. Figure 5 depicts historical earthquake epicenters, documenting that significant portions of the Appalachian Basin are seismically active. Figure 6 portrays USGS seismic hazard maps for Pennsylvania, New York, Delaware, and New Jersey. The Wayne County, PA area shows a peak horizontal ground acceleration of some 6-8% g with a 2% probability of exceedance in 50 years (i.e., earthquake ground motions that have a common given probability of being exceeded in 50 years). The %g relates to the acceleration due to gravity. It is a measure of ground motion that decreases the farther one is from an earthquake epicenter. A 6-8%g roughly correlates with a Modified Mercalli Intensity of VI. This intensity of an earthquake is likely to be felt by everyone, may result in movement of heavy furniture, and may damage house plaster and chimneys (DCNR, 2006). While damage on the ground surface is slight, it is likely that damage to casing grout and possibly well casings may occur – potentially compromising the integrity and physical isolation of different bedrock horizons.

16) Seismic activity in Pennsylvania and nearby states may result in significant ground motions that may compromise the integrity of well grout and casing. This, in turn, may result in interformational mixing of groundwater along exploratory well boreholes or adjacent joints. Earthquakes have occurred in Pennsylvania and elsewhere (DCNR, 2006). One of the largest earthquakes, of unknown magnitude, had an epicenter near Attica, NY and is reported to have cracked walls in Sayre, PA in 1929. Sayre is located in Bradford County, only some 50 miles

from Wayne County. Another nearby New York State earthquake, with a magnitude of 5.5, occurred in New York City in 1884 (only about eighty miles from Wayne County, PA), again documenting that the region is seismically active.

17) Numerous earthquakes have occurred in Pennsylvania, many in recent time, with the largest recorded in 1998 with a magnitude of 5.2. Some of those reasonably close to Wayne County include Berks County (to magnitude 4.0 and 4.6 in 1994), Bucks County (to 2.5), Lancaster County (to 4.4), Lehigh County (to 3.3), Monroe County (immediately south of Wayne County; 3.4, epicenter may have been in NJ), and Montgomery County (3.5). While these earthquakes did not produce substantial damage, there is a reasonable probability that higher magnitude earthquakes, with related damage, may occur. DCNR (2006) details this real possibility:

> *"Earthquakes having magnitudes greater than 5 can occur in Pennsylvania, as demonstrated by the earthquake of September 25, 1998 (Armbruster and others, 1998) (Table 2, Crawford County). Southeastern Pennsylvania, the state's most seismically active region, is not known to have experienced an earthquake with magnitude greater than 4.7, but the historical record goes back only about 200 years. No obvious reason exists to conclude that an earthquake of magnitude between 5 and 6 could not occur there also. An earthquake with magnitude greater than 6 is much less likely, but the fact that such large earthquakes have occurred elsewhere in the East means that this possibility cannot be ruled out entirely for Pennsylvania. … The possibility that a magnitude 7 earthquake could occur having an epicenter near New York City cannot be completely discounted, and such an earthquake could produce significant damage (intensity VIII) in eastern Pennsylvania. … A large local earthquake, one with magnitude greater than 6, though unlikely, is not impossible."*

18) Earthquakes of these magnitudes in Pennsylvania have the real potential of resulting in sufficient ground motion to shear well casings and degrade the integrity of grout designed to physically separate different geologic and hydrologic horizons. For example, earthquakes of magnitude 5.0 to 5.9 on the Richter or moment magnitude scales can cause major damage to poorly constructed buildings. Wikipedia provides an approximate energy equivalent in terms of TNT explosive force for a 5.0 Richter magnitude earthquake as being equivalent to the seismic yield of the Nagasaki atomic bomb. Clearly, the decision to permit installation of exploratory wells, or horizontal wells, should be based on a comprehensive analysis of all environmental risks. It should be noted that the risk to grout and casing integrity exists both from natural earthquake activity and, in the case of hydraulically fractured horizontal wells, from microearthquakes stemming from fluid-induced seismicity (Bame and Fehler, 1986; LI, 1996; Feng and Lees, 1998; Horálek et al., 2009; Shapiro and Dinske, 2009). Therefore, the potential impacts of seismicity, whether from natural or man-induced activities, should be extensively analyzed prior to any deep drilling efforts. Because portions of Pennsylvania are seismically active, a real risk exists that earthquakes might instantly and catastrophically degrade casing grout integrity and shear multiple well casings, resulting in the commingling of formation fluids and release of methane. Unlike the recent British Petroleum disaster in the Gulf of Mexico, once the integrity of bedrock formations is breached, it will not be possible to restore degraded freshwater aquifers.

19) As an example of active seismicity in the Appalachian Basin, Jacobi and Smith (2002) document the epicenters of three seismic events in eastern Otsego County, New York. These seismic events indicate that earth movement occurs from great depth along faults upward to aquifers and near the ground surface. The great lateral extent of these faults, and their visually observable connectivity with other faults, confirms that the process of gas drilling activities, which may interconnect naturally occurring faults and fractures, has a great and very real potential of causing contaminants to migrate to aquifers and surface water from localized zones across and beyond county and watershed boundaries.

Grout and Casing Failure

20) The high risk of compromising the integrity of the physical separation of freshwater aquifers from deeper saline water-bearing bedrock formations may be compounded as a result of well grout and casing failures that occur A) as a result of poor well construction (e.g., as in the BP well failure), B) due to mechanisms including cement shrinkage, or C) due to differences in downhole bedrock conditions (e.g., pressure differentials). Zhou et al. (2010) point out that casing pipes in well construction may suddenly buckle inward as their inside and outside hydrostatic pressure difference increases. Dusseault et al. (2000) document the many reasons why oil and gas wells leak, thus providing important supportive scientific rationale as to why both vertical exploratory wells and horizontal gas wells should not be permitted in advance of extensive environmental risk characterization:

> *"Oil and gas wells can develop gas leaks along the casing years after production has ceased and the well has been plugged and abandoned (P&A). Explanatory mechanisms include channeling, poor cake removal, shrinkage, and high cement permeability. The reason is probably cement shrinkage that leads to circumferential fractures that are propagated upward by the slow accumulation of gas under pressure behind the casing.*
>
> *The consequences of cement shrinkage are non-trivial: in North America, there are literally tens of thousands of abandoned, inactive, or active oil and gas wells, including gas storage wells, that currently leak gas to surface. Much of this enters the atmosphere directly, contributing slightly to greenhouse effects. Some of the gas enters shallow aquifers, where traces of sulfurous compounds can render the water non-potable, or where the methane itself can generate unpleasant effects such as gas locking of household wells, or gas entering household systems to come out when taps are turned on."*

21) Dusseault et al. (2000) detail the underlying causes behind tens of thousands of grout failures in North America that likely compromise environmental security and zonal isolation while leading to contamination of freshwater aquifers. They conclude that:

- Surface casings have little effect on gas migration;
- Water-cement slurries generally placed at low densities will shrink and will be influenced by elevated pressures and temperatures encountered at depth;

- While cement is in an almost liquid, early-set state, massive shrinkage can occur by water expulsion, resulting in shrinkage of the annular cement sheath;
- Portland cements continue to shrink after setting and during hardening;
- Other processes can lead to cement shrinkage. High salt content formation brines and salt beds lead to osmotic dewatering of typical cement slurries during setting and hardening, resulting in substantial shrinkage;
- Dissolved gas, high curing temperatures, and early (flash) set may also lead to shrinkage;
- Initiation and growth of a circumferential fracture ("micro-annulus") at the casing-rock interface will not be substantially impeded because cement shrinks;
- Circumferential fractures develop and gas leakage typically increase over time;
- Wells that experience several pressure cycles are more likely to develop circumferential fractures;
- Circumferential fractures propagate vertically upward because of the imbalance between the pressure gradient in the fracture and the stress gradient in the rock;
- Free gas will serve to further degrade the casing-grout-rock interface, increase gas flow into circumferential fractures, and may lead to continuous gas leakage;
- In turn, differences in pressure favor driving gas, and pressurized fluids present at depth, upward and outward from circumferential fractures back into bedrock formations (including those present in freshwater aquifers) where the pore pressure is less. Over time, the excess pressure is large enough to fracture even excellent cement bonds and force flow outward into surrounding strata;
- Methane from leaking wells into freshwater aquifers is unlikely to attenuate, and the concentration of the gases in shallow aquifers will increase with time;
- Loss of this zonal seal can have negative effects, such as pressurizing higher strata, or leakage of brines and formation fluids into shallower strata causing contamination; and
- Despite our best efforts, the vagaries of nature and human factors will always contribute to grout failures.

22) As detailed above by Dusseault et al. (2000), gas leakage up circumferential fractures at the cement-bedrock interface may also enter and degrade freshwater aquifers. In fact, the greatest risk of this occurring is in vertical wells, not in deep horizontal wells that have not been hydraulically fractured (Dusseault et al., 2000). Thus, unfracked vertical exploratory wells pose a greater environmental risk than do deep, unfracked, horizontal boreholes. When the above issues are considered within the broader context of documented regional seismicity, the real threat to the long-term integrity of our freshwater aquifers and quality of our surface waters is obvious.

Contamination of Freshwater Aquifers and Loss of Aquifer Integrity

23) Contamination of freshwater aquifers via the mechanisms detailed above by Dusseault et al. (2000) (i.e., methane entering formations from leaking circumferential fractures) is likely to be far greater than more limited contamination proximal to well heads. Freshwater aquifers in

Wayne County, PA extend to at least 665 feet, as observed at the Matoushek #1 well (Stiles, 2010). Permitting the installation of vertical exploration wells needs to be considered in the broader environmental setting where these wells may ultimately be completed as hydrofracked horizontal production wells. Should natural ground motion from earthquakes (and possibly from seismically induced earthquakes from future hydrofracked wells) occur, it is likely that alternate groundwater flow paths will develop. These flow paths will then provide avenues for migration of gas well related contaminants, particularly low density or gaseous ones. Pre-existing joint sets that are already open to gas-rich shales (Jacobi, 2002) will provide pathways and release avenues for methane and any Light Non-Aqueous Phase Liquids that may be present. In this way, vertical fractures extending into overlying bedrock formations may result in the disruption and alteration of natural groundwater flow.

24) Understanding the cumulative impacts of natural gas drilling in the Delaware River Watershed is essential in order to determine how this activity should be regulated. By way of analogy, using a somewhat different but worst case example, solution mining in Tully Valley, New York, demonstrates how alteration of a previously isolated and intact freshwater aquifer was compromised via anthropogenic activities. While not physically observable on the ground surface, the adverse environmental impacts of gas production throughout large portions of the Appalachian Basin, may have much broader and far reaching impacts. The Tully Valley example described below demonstrates the nature and consequences of disrupting a previously intact groundwater flow regime. This analogy is especially applicable to adverse environmental impacts likely to occur with additional well drilling.

25) Deep solution mining of salt beds in Tully Valley, conducted under NYSDEC mining permits, regulation, and oversight has resulted in slow and catastrophic collapse of portions of Tully Valley from depths of 1,700 feet (518 m) to the ground surface. Rubin et al. (1992) document the structural failure of portions of the valley overlying and adjacent to brine cavities where salt was removed. The resulting settlement area is in excess of 550 hectares (~1,360 acres; 2.1 mi^2). It continues to expand outward. Upward fracture propagation eventually resulted in open permeable pathways where fresh aquifer and infiltrating meteoric water began to recharge formerly isolated groundwater flow regimes, thereby establishing new deep flow routes that now result in connate, saline, and turbid water discharge to the ground surface, and Onondaga Creek (see Figure 7).

26) As illustrated in the Tully Valley example, once even a few significant fracture interconnections (i.e., planer, laterally extensive, and potentially interconnected with Fracture Intensification Domains) are established between target shale beds and the ground surface, naturally isolated groundwater flow systems then become accessible for commingling of formation waters, for transmission of contaminants, for the unnatural and increased recharge of deeper formations, and for the establishment of new groundwater flow routes. Much as methane can be released upward to lower pressure formations from exploration wells, so will LNAPLs rise upwards along fault and fracture pathways as more wells are drilled and developed, thereby broadly contaminating freshwater aquifers. Then, as new groundwater circulation pathways develop in response to repeated hydro-fracturing and newly available freshwater hydraulic/pressure heads, more and more commingling of freshwater and contaminant-laden, saline, water is likely. Thus, extensive natural fractures present throughout the Delaware River

Basin and broader Appalachian Basin may provide vectors for new interconnected groundwater circulation pathways.

27) With time, methane (and hydro-fracturing chemicals as gas production is permitted) will move with groundwater flow, down valley, toward zones of lower hydraulic head, particularly valley bottoms, major streams, and principal aquifers. Areas with higher groundwater flow velocities are likely to develop groundwater circulation patterns along Fracture Intensification Domains (i.e., high permeability pathways), especially where hydro-fracturing has opened elongate fracture pathways that have high hydraulic gradients between watershed uplands and valleys. To a large degree, these new circulation pathways will resemble those illustrated in the Figure 7 Tully Valley example – albeit fracture aperture width may be narrower and associated catastrophic collapse less likely.

28) While the focus of this testimony does not directly extend to horizontally hydraulically fractured gas production wells, it is not prudent to ignore the overall physical setting within which exploration well installations may ultimately fit. Since it has been shown above that many of the environmental risks normally attributed only to horizontal gas wells directly relate to unfracked vertical exploration wells (e.g., seismic risk, grout shrinkage, vertical flow pathways into freshwater formations), it is prudent to at least cursorily review broader gas production based environmental considerations. While gas field fracture aperture may be narrower than the disrupted Tully Valley example, it is important to recognize that the hydraulic transmissivity of fractures increases by the cube of the effective fracture width, thereby pointing out the likely increased risk associated with repeated hydro-fracturing. The combination of excessive pressure associated with hydro-fracturing and lubricated fault planes may lead to increased faulting and seismicity, followed by increased groundwater circulation between formerly isolated hydrologic horizons. Northrup (2010), for example, references a hydro-fracturing induced earthquake in Cleburne, Texas – the likely tip of the iceberg. Once these new groundwater circulation pathways are established, it will be impossible to restore the integrity of adversely impacted freshwater groundwater flow systems, contaminant migration and dispersal will expand, and plugging and abandonment procedures of gas production wells will have little impact on retarding water quality degradation throughout irreparably compromised aquifer systems.

29) Cumulative impact studies must address potential adverse environmental impacts associated with both exploratory wells and the overall long-term plan for the installation of hundreds or thousands of horizontal hydraulically fractured wells throughout the Delaware River Basin. Naturally occurring excursion of methane gas via faults and fractures has long been recognized. Recent studies are now beginning to confirm that methane, drilling chemicals, and hydro-fracking chemicals are migrating upward along hydro-fractured fracture pathways to freshwater aquifers and homeowner water supplies. For example, Lustgerten (2009) references scientific work conducted on methane gas excursions in Garfield County, Colorado where a three-year study used sophisticated scientific techniques to match methane from water to a deep gas-rich bedrock layer stating:

> *"The Garfield County report is significant because it is among the first to broadly analyze the ability of methane and other contaminants to migrate underground in drilling areas, and to find that such contamination was in fact occurring. It examined more than*

700 methane samples from 292 locations and found that methane, as well as wastewater from the drilling, was making its way into drinking water not as a result of a single accident but on a broader basis. As the number of gas wells in the area increased from 200 to 1,300 in this decade, methane levels in nearby water wells increased too. The study found that natural faults and fractures exist in underground formations in Colorado, and that it may be possible for contaminants to travel through them. Conditions that could be responsible include vertical upward flow along natural open-fracture pathways or pathways such as well-bores or hydraulically-opened fractures …"

30) What we are just beginning to understand is the fact that repeated fracturing at each well will further amplify all of these risks. Reaping maximum gas production from horizontal gas wells commonly requires repeated hydro-fracturing of wells (see discussion by Northrop, 2010). With each successive hydro-fracturing event, more toxic contaminants are introduced into subsurface formations, including those already aggravated and potentially opened in the first fracturing cycle. In addition, as gas companies expand their operations, they may turn to the new, more effective, multilateral drilling technology to selectively tap multiple target zones in adjacent areas. This will necessarily result in multiple wellheads and multiple fracturing operations in close proximity. Through these processes, it is highly likely that new, previously unconnected, fractures will be integrated into the area influenced by each production well.

31) David Kargbo et al. (2010), U.S. EPA Region III, recently cautioned about the particular challenges still unresolved about drilling in tight shale formations:

"The control of well bore trajectory and placement of casing become increasingly difficult with depth…At the Marcellus Shale, temperatures of 35-51°C (120-150°F) can be encountered at depth and formation fluid pressures can reach 410 bar (6000 psi) (8). This can accelerate the impact of saturated brines and acid gases on drilling at greater depths. In addition, the effect of higher temperature on cement setting behavior, poor mud displacement and lost circulation with depth makes cementing the deep exploration and production wells in the Marcellus Shale quite challenging. For example following a recent report by residents of Dimock, PA, of natural gas in their water supplies, inspectors from the Pennsylvania Department of Environment Protection (PADEP) discovered that the casings on some gas wells drilled by Cabot Oil & Gas were improperly cemented, potentially allowing contamination to occur….During drilling into the tight Marcellus Shale, there is a slight risk of hitting permeable gas reservoirs at all levels. This may cause shallow gas blowouts and underground blowouts between subsurface intervals. Other geo-hazards that may pose challenges to drillers in the Marcellus Shale include: (1) disruption and alteration of subsurface hydrological conditions including the disturbance and destruction of aquifers, (2) severe ground subsidence because of extraction, drilling, and unexpected subterranean conditions, and (3) triggering of small scale earthquakes."

32) With each additional well and well activity, all of the "challenges" noted by Kargbo, Wilhelm, and Campbell of necessity multiply and increase. See also the BP internal report reported September 9, 2010, attributing fault for the 2010 Deepwater Horizon oil rig explosion to

unexpected cementing problems at pressures less than those of the average shale gas frack. Studies have not yet been done regarding the effect of depth and pressure on casing failure rates in tight shale formations nor on the repeated fracturing re-pressurization under such temperature and depth conditions on cement casings and joints. Nor have studies or plans been developed for remedial action should the casings and joints fail at extreme depth.

33) Risks of casing failure are further compounded by the frequency (or spacing) of casing couplings which may be on the order of every 100 feet or less. Zhou et al. (2010) assessed casing pipes in oil well construction and the risk that they may suddenly buckle inward as their inside and outside hydrostatic pressure difference increases. They point out the importance of measuring the stress state of casing pipe, complete with real-time monitoring and state-of-the-art warning system installations. Consideration should be given to evaluating cost-effective and reliable sensing technologies and installation techniques for long-term monitoring and evaluation of casing pipe before issuing gas well related regulations. Most deeply buried casings are difficult to repair or replace and, as such, can lead to aquifer contamination. Even a small percent casing or grout failure can be effectively irremediable at deep depths and irreparably harm ground and surface water sources.

34) Repeated hydraulic fracturing may activate pre-existing faults or induce shifting or settlement along lubricated fractures. Parts of Pennsylvania and New York State within and near the Delaware River Basin are seismically active. Excessive lubrication of faults and fractures with highly pressurized hydraulic fracturing fluids, bolstered by repeated hydrofracturing episodes, may result in fault activation and bedrock settlement. This, in turn, may result in catastrophic shearing of production well boreholes and casing strings even in the absence of natural seismic activity. Pre-existing old and poorly abandoned oil and gas wells may also provide additional contaminant migration pathways. Unlike the British Petroleum well that was finally plugged, once the structure of the bedrock has been compromised by faulting and/or hydraulic expansion of joints, and formation waters have commingled, aquifer restoration will not be possible.

35) The risk of ground collapse as a result of repeated fracturing cycles should also be studied prior to issuing regulations. "*Severe ground subsidence*" may occur "*because of extraction, drilling, and unexpected subterranean conditions*", as may "*disruption and alteration of subsurface hydrological conditions including the disturbance and destruction of aquifers*" (Kargbo et al., 2010).

36) Homeowner wells do not need to be near gas production wells to be adversely impacted from the upward migration of methane gas and Light Non-Aqueous Phase Liquid contaminants from gas-rich shales. Neither discussion of known fracture frequency nor existing maps depicting massive fracturing throughout the Delaware River Basin appear to have been incorporated into the well permitting review process. As such, many of the real risks attendant to vertical exploratory well installations, or future horizontal hydraulic fracturing of gas-rich shale beds, have not been addressed. As some vertical fractures are widened and opened via hydrofracturing, they will and most probably have already, in some cases, provided a hydraulic avenue where methane is released upward into and throughout these well-integrated Fracture Intensification Domains. Thus, fractures enlarged by hydrofracturing will provide lower

pressure gas release points or routes. Once vertical and lateral fracture pathways are open, even a limited number, natural gas and LNAPLs will migrate extensively throughout formerly isolated upper bedrock and freshwater aquifer groundwater flow systems. As methane is released upward along vertical borehole pathways, and along future hydrofractured boreholes and their interconnected fractures, homeowner wells will provide a final open fracture and cased pathway to the ground surface from methane contaminated aquifers. Because horizontal components of gas wells extend may thousands of feet and may intersect numerous planar vertical pathways, large-scale aquifer degradation is possible. Initially, aquifer degradation can be expected above and adjacent to boreholes with poor grout seals. With time and successive hydrofracturing episodes conducted in individual wells, methane and LNAPLs that are released upward through fault planes and related fractures will widely contaminate freshwater aquifers and surface water receptors.

37) Some of the contaminated groundwater in areas now undergoing hydraulic fracturing is far removed from gas production wellheads, thus strongly indicating that groundwater contamination is already occurring along vertical fault and fracture pathways, distant from potential poor wellhead grout jobs or casing failures. This topic is discussed here because understanding the cumulative impacts of natural gas drilling in the Delaware River Watershed is essential in order to determine how this activity should be regulated. Fractures extend from gas-rich shales to the ground surface and naturally leak methane gas. Repeated hydraulic fracturing is likely to exacerbate this situation. Repeated hydraulic fracturing within numerous individual wells will serve to expand and extend these existing fractures through freshwater aquifers. This will increase upward migration of methane to aquifers, streams, homes, and wellheads. Dimock, Pennsylvania provides an excellent case in point.

38) It is likely that contaminant dispersal along fault, joint, and fracture pathways will be the more common mechanism whereby natural gas and LNAPL excursions find their way into aquifers, homeowner homes, well houses, and streams – not solely via pathways stemming from poor casing grouting. This mechanism also explains why many of the gas contamination incidents reported to date are far removed from individual gas production wellheads (e.g., up to 1,300 feet in the Dimock, PA area; COP 2009). This contaminant dispersal mechanism also strongly accents why gas companies would much prefer to admit that poor or failed casings or poor grout integrity is the root cause of gas excursion problems. Certainly, in the gas industry, it is far preferable to invoke any gas leak mechanism other than that of widespread, uncontrolled, and undocumented upward and lateral migration of formerly isolated methane gas into and through freshwater aquifers.

39) As in the Tully Valley example above, the loss of natural geologic and hydrologic integrity throughout formerly isolated geologic formations poses an enormous threat to the existing and future way of life in planned gas exploitation areas. However, the disruption of the geologic strata presented in the Tully Valley Figure 7, while having wider fracture apertures and relatively great vertical offset of geologic beds, has occurred in an area far smaller in areal extent than what is planned extensively throughout the Delaware River Basin and much of the Appalachian Basin. Gas excursions are likely to occur throughout the Appalachian Basin, wherever there are mapped and as yet undocumented fractures. Because of the physical nature of existing fractures systems, these excursions, even a few in an area, are likely to degrade freshwater aquifers such that

existing and new homeowner well installations will be degraded.

40) Because permitting of vertical exploration wells may result in numerous adverse environmental impacts (discussed above), it is important to fully consider the broader gas field development picture and related environmental impacts. Radioactive radium present in the Marcellus may also be mobilized in fluids and thus become available for transport in the groundwater flow system. This appears to be particularly true of uranium that University of Buffalo researchers recently determined is released during the hydraulic fracturing process (presented at a GSA meeting on Nov. 2, 2010). Tracy Bank and her colleagues determined that hydrofracking forces toxic uranium into a soluble phase and mobilizes it, along with chemically bound hydrocarbons, thereby making it available for groundwater transport. In addition, uranium tainted flow back water poses the risk of contaminating streams, wetlands, and ecosystems.

41) Fracking contaminants, once mobilized vertically along fault planes and joints, especially under pressurized conditions, can reach freshwater aquifers. Even if all fracking fluids were composed of non-toxic chemicals, the risk of interconnecting deep saline-bearing formations (i.e., connate water) and/or radioactive fluids with freshwater aquifers is great. Any commingling of deep-seated waters, with or without hazardous fracking fluids is unacceptable. Documented gas excursions near existing gas fields demonstrate that vertical pathways are open. If gas can migrate to the surface, it is highly likely that hydrocarbon and contaminant-rich Light Non-Aqueous Phase Liquids will also reach aquifers and surface water resources. These contaminants may then also migrate to down gradient wells, principal aquifers, and waterways.

42) Artificially enlarged and expanded hydrofracked fractures may provide vertical pathways for light, low density, drilling fluid chemicals and radon. Some fracking related contaminants will migrate upwards via fractures into freshwater aquifers - particularly Light Non Aqueous Phase Liquids (i.e., less dense hydrocarbons) inclusive of benzene, a known carcinogen. In addition, increased upward migration of radon is likely to occur. The pathways are already there and functioning, waiting to be further expanded and laced with toxic chemicals.

43) There is a growing catalog of hydro-fracking related accidents in other gas-field plays (see e.g., Hazen and Sawyer, 2009). Accidental spills of fracking fluids and flow-back water has the potential of contaminating ground and surface water. Similarly, lateral and upward migration of hydro-fracturing chemicals pose a real risk to Delaware River Basin aquifers, especially to moderate and high yield unconfined aquifers situated in stream valleys that receive their base flow recharge from up-gradient groundwater aquifers.

44) Excursion of drilling fluids and produced fluids from breached flow-back wastewater containment structures, whether via rupture, leakage, or overflow poses a real threat to surface water quality. Overland flow of flow back fluid chemicals to streams, ponds, wetlands, and waterways poses an immediate water quality and ecosystem concern that should be fully evaluated prior to issuance of draft regulations.

45) In the broader context of fully examining all potential adverse environmental impacts, it is

necessary to not only look at impacts associated with vertical exploration wells, but also planned future horizontal hydrofracked wells. Excursion of frack fluids from breached flow-back wastewater containment structures, whether via rupture, leakage, or overflow, poses a real threat to groundwater quality. Slow infiltration of frack fluid chemicals to groundwater and its potential degradation need to be fully addressed prior to issuance of draft regulations.

46) Poor or failing exploratory and production well construction (e.g., poor grouting, corroded casing) may provide vertical pathways for contaminant excursions from deep shale beds upward into freshwater aquifers. While this has already been documented, increased gas well installations will also increase the number of failed wells and resultant contaminant migration. Apparently, at this time, gas field contaminant excursions are not being treated as outward expanding contaminant plumes that warrant expensive, full-scale, hydrogeologic characterization, groundwater clean-up, and remedial action. The importance of this must be underscored because aquifer restoration on a gas field scale, even if cost were not an issue, may not be possible.

Endangered Species

47) Methane that is released up vertical annular pathways between outer casing walls and bedrock formations almost certainly enters freshwater aquifers. The mechanisms involved are detailed by Dusseault et al. (2000) and pose a risk of groundwater contamination stemming from vertical exploration wells. As methane enters and accumulates in freshwater aquifers, it will move down gradient of its initial release avenues until an open release pathway is encountered (e.g., open joints). A risk that requires further research is that to Dwarf Wedge Mussels and other species present in streamways of the Delaware River Basin. Should methane or other gas field contaminants (e.g., benzene, LNAPLs) bubble up and be released into surface streams, they may compromise surface water quality and jeopardize the survival of an endangered species.

48) Excursions of gas field related contaminants may lead to degradation or loss of endangered and other species. Potential commingling of deep connate waters, hydrofracking fluids, methane, and freshwater aquifers, as a result of disrupted bedrock strata, may lead to new, altered, groundwater flow regimes. Altered flow regimes may, in turn, result in the formation of new aquifer discharge locations that effuse methane and other contaminants to streams, springs, wetlands, or other locations. The potential exists for such contaminants to degrade surface water quality and sensitive ecosystems that support threatened or endangered species (Tzilkowski et al., 2010; NYSDEC and PFBC, 2010), such as the federally endangered Dwarf Wedge Mussel (*Alasmidonta hereroden*). Of the few remaining populations of this species, one is found within the Neversink River, one in the mainstem of the upper Delaware River, and another within a small coldwater tributary of the middle river (Playfoot and Snyder, 2010). Dwarf wedge mussels are protected under the Endangered Species Act. It is critically important that pristine water quality conditions be maintained to protect this species.

49) There are real environmental, water quality, air quality, explosive, health, and endangered species concerns regarding gas exploitation below carbonate beds, inclusive of in caves. Carbonate formations in portions of the Delaware River Basin are recognized among karst

hydrologists as being karstic or cave/conduit bearing in nature. Contaminants that may enter karstic solution conduits, from below or above, would quickly degrade groundwater and surface water quality.

50) Carbonates of the Onondaga Formation and Helderberg group outcrop in portions of the Delaware River Basin (Figure 10; Veni, 2002). These carbonate formations, while stratigraphically lower than the Marcellus shale, overlie other shale beds that are gas rich (e.g., the Utica shale of the Trenton Group). These carbonate formations are recognized among karst hydrologists as being karstic or cave/conduit bearing in nature. An important aspect of karst is its effect on water supply and contaminant transport. Water in solution conduits can travel up to several kilometers per day, and contaminants can move at the same rate. This poses serious problems when monitoring for water quality. Contaminants enter the ground easily through sinkholes and sinking streams, and filtering is virtually non-existent. Even small solution conduits can transmit groundwater and contaminants hundreds of times faster than the typical unenlarged fracture network. Methane or drilling-related contaminants that may enter karstic solution conduits, from below or above, would quickly degrade groundwater and surface water quality. Because karst aquifers are extremely vulnerable, it would be prudent to characterize the environmental risks to them prior to conducting drilling activities.

51) Gas drilling activities may pose a health risk to cave-dwelling species and cavers, including the federally endangered Indiana bat (*Myotis sodalis*). The build up of methane and other toxic chemicals in caves and mines may pose both an explosive and health risk to cavers, cave scientists, and cave-dwelling fauna. People and bats in caves may potentially be overwhelmed by the build up of methane and other toxic chemicals. This could lead to their deaths via inhalation or via explosions similar to those that have occurred at wellheads above gas plays. If methane or LNAPLs were to seep or flow into caves (from below or from leaking surface holding pits) situated above gas-rich shales, caves might in effect become "confined spaces" - toxic to breathe in with great and, possibly, rapid exposure risk. Importantly, cave dwelling animals, such as bats (Figures 8 and 9), might have their already stressed populations (i.e., via White-Nose Syndrome; USGS, 2010) further decimated by gas field related contaminant excursions.

52) The endangered Indiana bat has one or more hibernacula in the Delaware River Basin stratigraphically above the Utica Shale. To protect these bats, the NYS Department of Environmental Conservation (i.e., State of New York) purchased Surprise Cave, located near Mamakating, NY (Sullivan County) some years ago. There may be other bat hibernacula within the Delaware River Basin. Contaminants that may migrate into areas inhabited by the Indiana Bat would constitute unauthorized taking of the bats under the Endangered Species Act.

Conclusions

53) Significant natural seismic activity is well documented in and adjacent to the Delaware River Basin over an extended period of time. Ground motions from even one significant earthquake, among many that occur over time, may catastrophically shear numerous gas exploration and well casings or, at the very least, may result in fracturing and loss of integrity of well casing cement designed to isolate freshwater aquifers from deep saline waters. As such, earthquakes may instantly destroy the integrity of hundreds of gas wells, thereby forever and irreparably compromising the hydrologic integrity of geologic formations that formerly protected freshwater aquifers. Restoration of contaminated freshwater aquifers is probably not possible, thus well failures from any single or combination of mechanisms is likely an irrevocable commitment of natural resources.

54) The installation of exploratory wells that open borehole or nearby joint pathways between formerly separated geologic horizons pose an environmental risk, particularly because the area is seismically active. Ground motion associated with seismic activity has the real potential of instantly shearing multiple well casings throughout gas fields, degrading cement grout designed to isolate geologic horizons (i.e., freshwater aquifers), and thereby opening vertical joint and borehole vectors between formerly separated geologic horizons. Numerous earthquakes have occurred in Pennsylvania, New York, and adjacent states, pointing out that the region of the exploratory wells is seismically active.

55) Vertical exploration wells and related surface activities have the potential to permanently and irreparably harm ground and surface water resources in the Delaware River Basin. Extensive existing fracture and fault networks throughout the Appalachian Basin may provide upward pathways for contaminant and gas migration through geologic zones believed to be physically isolated, based on incomplete data. Although gas producers have asserted publicly that these zones are physically isolated, to date there are no publicly available studies to prove this claim. On the contrary, multiple studies indicate the presence of pervasive natural fracturing that will allow for migration to freshwater aquifers of methane, other hydrocarbons and their constituents, drilling fluids and materials, and naturally occurring hazardous materials including deep saline waters and NORMs. As a result, there are significant health and environmental risks associated with advancing exploratory gas wells in the Delaware River Basin and elsewhere in the Appalachian Basin.

56) The characterization of vertical fractures, faults, seismic hazards, casing and grout failures, contaminant hazards, and methane soil gas in the Delaware River Basin and elsewhere in the Appalachian Basin is not adequate to address potential adverse environmental impacts. Existing information does not sufficiently address pre-existing contaminant (i.e., gas and fluid) pathways that extend from the Marcellus shale to aquifers, surface water bodies, and the ground surface. Vertical exploratory wells, as well as future hydro-fracturing and enhancement of gas-bearing fractures may significantly increase gas excursions to formerly isolated geologic formations. Review of reports and news articles indicate that significant environmental contamination has occurred in geologically similar settings, including explosive hazards and groundwater and surface water contamination. This puts the Delaware River, its tributaries, and watershed at substantial risk of pollution and degradation.

57) Documentation by Jacobi of Fracture Intensification Domains based on methane soil gas anomalies over open fractures reveals evidence that naturally occurring fractures and faults provide upward gaseous migration pathways, even in the absence of deep hydro-fracturing in the Marcellus shale. If fracture and fault networks are intersected by vertical exploratory well completions and/or integrated and enlarged via hydro-fracturing processes, it is likely that methane, LNAPL, and radioactive gas excursions will increase.

58) The reality is that methane gas extraction from tight shale formations, including the Marcellus and similar formations throughout the country, have contaminated ground and surface waters. Reasons for this include poor containment of fracturing fluids, spills of flow-back water, intentional illegal disposal, mixing of different formation waters (e.g., brine and fresh water), inadequately grouted casing, failed grout, spills, and various forms of operator error. Gas production in the Delaware River Basin and elsewhere in the Appalachian Basin would almost certainly result in contaminant excursions, even under the best planned conditions. The presence of confirmed fractures and faults that extend from gas-rich geologic beds to the ground surface, some of which extend laterally for miles and are closely linked with others formed under similar structural conditions, pose potential contaminant pathways to surface waterways, reservoirs, and freshwater aquifers.

59) Because the density, location, aperture width, and length of all fractures (often present and not visible beneath a soil mantle) are not known, it would not be prudent to risk placement of numerous gas wells within sub-basins that contain lakes and reservoirs used for public water supplies. From a water quality standpoint four facts stand out: 1) there is a point at which the actual total number of toxic contaminants introduced into a groundwater flow system no longer matters because the water is unlikely to ever be potable again no matter how much money is spent attempting to remediate it, 2) new groundwater circulation pathways are likely to develop in response to repeated hydro-fracturing and newly available freshwater hydraulic/pressure heads, resulting in commingling of freshwater and contaminant-laden waters, 3) eventually, even deep groundwater flow systems discharge to surface water, albeit it may take many years to occur (i.e., analogous to a slowly ticking time bomb), and 4) it makes little sense to jeopardize the quality of surface and groundwater by intentionally introducing vast quantities of toxic contaminants into the environment, especially where gas-conducting fractures and faults are known to extend from gas-bearing formations to the ground surface.

60) It is important to recognize that once our natural resources have been compromised as a result of an operator error, grout and/or casing failure, a major contaminant excursion, seismic activity, or an unforeseen breaching of geologic beds, that it may be impossible to remediate and restore them to their pre-existing conditions. Failed confining beds and contaminated natural resources often represent an irrevocable commitment of our lands. Our decision to risk natural resources in the Delaware River Basin must weigh all the health and environmental risks against exploitation of relatively short-lived gas reserves and financial gain.

The opinions expressed herein are stated to a reasonable degree of scientific and professional certainty.

Paul A. Rubin

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Available at http://hydroquest.com/Riverkeeper/

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Figure 9: Spread of White-Nose Syndrome in Bats in Eastern US
Figure 10: US Karst Map

Addenda Listing

Available at http://hydroquest.com/Riverkeeper/

Addendum 1: Paul Rubin Resume
Addendum 2: Pennsylvania Earthquake History
Addendum 3: New York Earthquake History

Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells

Report to:

Delaware Riverkeeper Network

And

Damascus Citizens for Sustainability

Prepared by:

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November 19, 2010

As a toxicologist and physician specializing in environmental medicine and public health, I have been asked by the Delaware Riverkeeper Network and Damascus Citizens for Sustainability to provide my professional opinion on the potential toxicological effects that may result from exposure to chemicals and substances that may be released from natural gas wells, including certain "grandfathered" exploratory wells, that have been or may be drilled in the drainage area of the Special Protection Waters of the Delaware River Basin.

In my professional opinion, due to the multiple known risks to human health from exposure to such chemicals and substances, such exploratory well drilling should not be done until the consequences of such exposure are thoroughly examined in a comprehensive health effects study for the Delaware River Basin. The necessity for such a study, before drilling begins, has been established in our research and in that of others in the western United States, especially in the Battlement Mesa area of Garfield County, Colorado. In Garfield County we found in 2008 that there was a total lack of research into the health effects from gas development activities. As a result of this study, a comprehensive Health Impacts Assessment was commissioned by Garfield County and completed in September, 2010. It is imperative that a similar study be performed for the Delaware River Basin before any gas development – including the grandfathered wells – is allowed to proceed.

One of the most glaring omissions of the gas drilling process has been the exclusion of consideration of human health impacts. Only through anecdotal reports can impacts to human health in the Delaware River Basin be presumed as no epidemiological or environmental health studies have been done in the Basin. This is necessary before drilling proceeds in the Basin in part because the Delaware River supplies water to more than 15 million people. In addition to the potential toxicological effects from exposure to water contaminated by pollutants released from gas drilling activities, there are significant air pollution issues which also may become water pollution issues due to downwash. We have studied these potential water and air pollution issues in certain areas in the western United States, but such studies have not been done in the significantly more densely populated northeastern United States.

In preparation for our September 2010 Health Impact Assessment (HIA) report on Battlement Mesa in Garfield County, Colorado (http://www.garfield-

county.com/index.aspx?page=1408 and copy attached), in 2008 my colleagues and I reviewed previously completed studies from the general area of Garfield County and concluded that there were major gaps in public health information. At the request of the Garfield County Board of Commissioners, the Colorado School of Public Health (working in conjunction with the Garfield County Health Department) undertook a public health impacts assessment of the gas development activities underway or planned for this area. We conducted a qualitative and quantitative analysis of existing environmental, exposure, health and safety data for the Battlement Mesa community. We offered specific recommendations and produced a Health Impact Assessment (HIA) which involved several defined steps. The HIA looked at health stressors specific to gas development and rated them. Our results are in the HIA report, a copy of which is being submitted with this report.

The health effects on the Battlement Mesa residents were based on a careful study of the area population and the locations of gas development activity. The general conclusions of this HIA can be extrapolated from the study of the Battlement Mesa area to other areas with similar gas development activity across the county, including the northeastern United States. However, it is necessary to additionally look at the unique characteristics of any particular area, such as the Delaware River Basin including its geology and subsurface faulting and jointing, radioactivity of the underlying layers, water resources in proximity and downstream or down gradient from gas development areas and, of course, the unique population of that area. Therefore a study similar to the HIA should be done for the Delaware River Basin before exploratory drilling and gas development occurs and in preparation for any issuance of regulations. This study must precede permits, not the other way around, including any "test" or "exploratory" wells. These wells will include all the stressors we found, and perhaps additional ones, to a greater or lesser degree, depending on the unique population and geology of the potentially affected areas of the Delaware River Basin. Therefore it is imperative to study these issues before allowing gas drilling and development to proceed.

As part of the 2008 preliminary review that led to the 2010 HIA, my colleagues and I undertook an extensive review of the professional literature on the toxicology of the types of chemicals being used by the gas development industry and the substances being brought to the surface by gas drilling activities. As part of this report and my professional opinion in this matter, I

am incorporating that 2008 literature review, entitled "Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008)," into this report. The toxicology assessment in this literature review is just as relevant for the Delaware River Basin as it is for western Colorado. The same sorts of chemicals and substances are involved in gas drilling and development activities in the Delaware River Basin as are involved in such activities in western Colorado. Moreover, the toxicological effects of exposure to these various chemicals and substances do not change based on the location where the exposure occurs. For this same reason, references throughout the Literature Review to natural gas "exploration," "extraction," or "production" are essentially interchangeable as related to toxicity of chemicals and substances that may be released into the environment anywhere during these activities. The one exception to the applicability of the Literature Review to this hearing is that the portion of that Review related to chemicals used exclusively in fracking operations would not be relevant to this hearing related only to the drilling of exploratory wells. Everything else in the Literature Review is relevant to the issues involved in this hearing.

I have attached as appendices the 2008 White Paper and Literature Review Appendices listing all of the professional publications that were included in the literature review. I have also attached for completeness the 2010 report entitled, "Health Impact Assessment for Battlement Mesa, Garfield County Colorado."

The opinions provided in this report are stated to a reasonable degree of scientific and professional certainty.

/s/ Daniel Thau Teitelbaum

Daniel Thau Teitelbaum, M.D., P.C.

Attachments:

Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003 – 2008)

Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review Appendices

Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper

Health Impact Assessment for Battlement Mesa, Garfield County, Colorado

Potential for Impairment of Freshwater Mussel Populations in DRBC Special Protection Waters as a Consequence of Natural Gas Exploratory Well Development

By

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and

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November 23, 2010

Our testimony addresses the question of whether natural gas exploratory wells have the potential for a substantial effect on the quality of waters classified by the Delaware River Basin Commission (DRBC or "Commission") as Special Protection Waters (SPW), for which the Commission has established a policy of "no measurable change except towards natural conditions . . . ." *DRBC Water Quality Regulations* § 3.10.3 A.2. We focus on the water quality value and susceptibility to impairment of freshwater mussel populations, which both depend upon and contribute to the exceptional water quality of the main stem upper and middle Delaware River. We also highlight characteristics of the dwarf wedgemussel, a federally listed endangered species found in portions of the main stem upper Delaware River and its tributaries underlain by the Marcellus shale. The dwarf wedgemussel is particularly susceptible to siltation, hydrologic changes, exposure to contaminants, and losses of population caused by invasive species, all of which are likely to accompany the development of natural gas in the region, including the construction of exploratory wells. We contend that in light of the potential for adverse effects on water quality and aquatic resources as a result of natural gas exploratory well development, regulation by the Delaware River Basin Commission is warranted. Such regulation may help to prevent impairment, ensure that any water resource impacts, should they occur, are measured, and require that those responsible for causing damage to water quality and aquatic resources have the means and legal obligation to perform restoration.

I. Freshwater Mussel Status and Trends in the Delaware Basin

Freshwater mussels include abundant species that are vital for ecosystem function. These are also the most imperiled of all animals and plants in the Delaware River Basin, as elsewhere in North America (Williams et al. 1993.) This otherwise highly successful and diverse group has specific life history characteristics that contribute to their apparent sensitivity and have resulted in substantial declines in range and abundance of some species. These characteristics include a dependence upon populations of an unrelated species of fish for successful reproduction, low annual recruitment balanced by a long reproductive life-span, relative immobility, and filtering of water to extract food.

II. Mussel Assemblages in the Delaware River System

Population Abundance and Biodiversity

As a result of being undammed and well managed, the upper mainstem Delaware River retains healthy numbers of several native species of freshwater mussels (Lellis 2001, Lellis 2002). Although there are numerous state and federal listed imperiled species in the basin (e.g. dwarf wedgemussels), the numerical health of the collective mussel assemblage is sizeable in the river itself, extending down even into the tidal areas of the Delaware River.

Approximately 60 species of bivalve mollusks live in headwater streams and lakes of the Delaware basin as well as in the non-tidal main stem and other large tributaries, freshwater tidal areas, and in the brackish and saline portions of the Estuary (Kreeger and Kraeuter 2010).

Approximately 12-14 species are native freshwater mussels (Unionidae, Table 1) based on historical accounts (e.g., Ortmann 1919.) Numerous species of special concern to PA and NJ are known to remain in portions of the basin (Table 1) including the Upper Delaware. Although the status terminology varies among states, nine of the twelve remaining native species are deemed imperiled by New York, New Jersey, Pennsylvania, and/or the Federal Government, or are deemed to be globally imperiled (Table 1.)

Scientific Name	**Common Name**	**Conservation Status**			
		NY Status	**NJ Status**	**PA Status**	**Global/ Federal Status**
Alasmidonta heterodon	Dwarf wedgemussel	Critically imperiled/ **Endangered**	Critically imperiled/ **Endangered**	Critically imperiled/ **Endangered**	Critically imperiled/ **Endangered**
Alasmidonta undulata	Triangle floater	Apparently secure	Imperiled/ **Threatened**	Vulnerable	Apparently secure
Alasmidonta varicosa	Brook floater	Critically imperiled/ **Threatened**	Critically imperiled/ **Endangered**	Imperiled	Vulnerable/ **Species of concern**
Anodonta implicata	Alewife floater	Critically imperiled	Secure	Not ranked	Secure
Elliptio complanata	Eastern Elliptio	Secure	Secure	Secure	Secure
Lampsilis cariosa	Yellow lampmussel	Vulnerable	Imperiled/ **Threatened**	Vulnerable	Vulnerable
Lampsilis radiata	Eastern lampmussel	Apparently secure	Imperiled/ **Threatened**	Critically imperiled	Secure
Leptodea ochracea	Tidewater mucket	Critically imperiled	Imperiled/ **Threatened**	Critically imperiled/ extirpated	Vulnerable
Ligumia nasuta	Eastern pondmussel	Vulnerable	Critically imperiled/ **Threatened**	Critically imperiled	Apparently secure
Maragatifera maragatifera	Eastern pearlshell	Imperiled	Not ranked Proposed	Critically imperiled/ **Endangered**	Apparently secure

			Endangered		
Pyganodon cataracta	Eastern floater	Apparently secure	Secure	Vulnerable	Secure
Strophitus undulatus	Creeper	Apparently secure	Vulnerable/ **Species of concern**	Apparently secure	Secure

Table 1. Conservation status of native freshwater mussel species of the Delaware River watershed. Bold text indicates legally protected species status by state. Natural Heritage status accessed on NatureServe (www.natureserve.org) on November 16, 2010.

Within the Delaware basin, colonies of dwarf wedgemussels, a federally listed endangered species, currently are found only in portions of the main stem upper Delaware River and in four tributaries – the Neversink River, within the drainage area of DRBC Special Protection Waters in New York State, and the Flat Brook/Little Flat Brook, Paulins Kill River and Pequest River in New Jersey. The distribution of dwarf wedgemussels was once much wider across the mid-Atlantic watersheds than it is today.

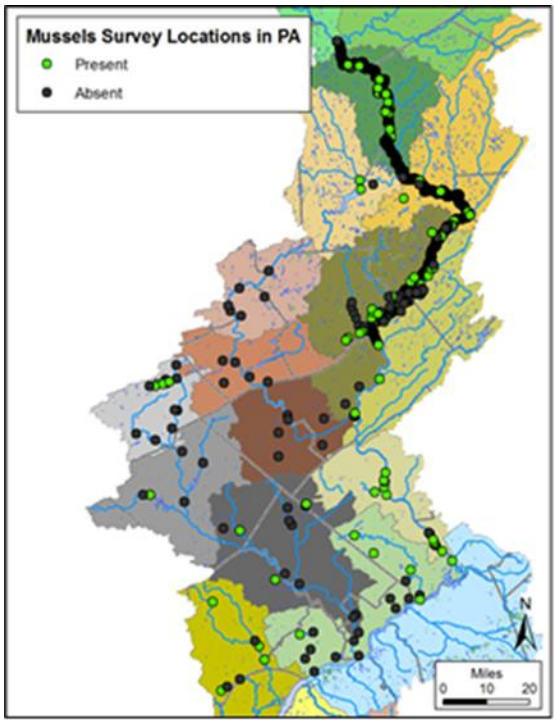

Figure 1. Presence and absence of freshwater mussels in Pennsylvania locations where they were historically reported as surveyed by various researchers since 1980.

The natural mixed-species assemblage of mussels would have consisted of aggregated populations of numerous species, occupying different niches (benthic habitats) within the stream, and collectively filtering a tremendous amount of water. Today, only one of our native 12+ mussel species can be readily found (*Elliptio complanata*). Unfortunately, mussel abundance appears greatly reduced in virtually all tributary streams and rivers in the Delaware River Basin. (PDE 2008.)

Based on the limited current distribution of mussels of any species in tributary streams (<10% in southeast PA, limited surveys elsewhere, Fig. 1), and the patchiness and low mussel abundance (<1 m^2) within streams where they are found (often only in wooded reaches), the healthy assemblages that exist in the main stem and tributaries of the Upper Delaware are particularly valuable and require protection.

Preservation of Existing Colonies is Critical to Stemming Mussel Declines

A number of factors make it critically important that existing colonies be preserved to serve as broodstock for restoring populations to streams from which they have been lost.

Mussels likely become extirpated from streams because of either: 1) general impaired water or habitat quality, 2) specific incidents (i.e. spills) that cause acute mortality in a single event, 3) overharvesting/predation, or 4) loss of fish host species to support larval growth and distribution.

Once extirpated from a stream or reach, mussels are not able to recolonize easily, particularly if there is no longer broodstock nearby. In some tributaries, dams and other impediments to fish passage may block dispersal of juveniles (via fish hosts, see life history below) back into the stream (McMahon 1991). Most mussels have a long lifespan (30-100 years) and don't reproduce until at least 8 years old. Therefore, even if conditions permit redistribution via fish hosts, recolonization and recovery can take decades.

Remaining mussel beds in the Delaware River are vulnerable to spills and land-based development. Protection of the existing metapopulation includes ensuring that it does not become further fragmented, less able to disperse and exchange genes, and as a result, less resilient.

III. Importance of Freshwater Mussels

There are societal and ecological reasons for maintaining large populations of filter feeders in aquatic ecosystems. Where abundant, they help to maintain water quality, stabilize substrates, decrease erosion, and create beneficial habitat complexity. Some species are also commercially and historically important. Filter-feeders are effective at accumulating many classes of contaminants and so are useful in assessing water and sediment contamination in specific areas and for specific time periods. The health of individual bivalves and assemblages of bivalves can directly indicate the health of the aquatic ecosystem.

Ecosystem Function Values

Freshwater mussels, like most bivalves, are considered “ecosystem engineers” because they modify habitat complexity and improve water quality, often dominating the ecology of rivers and streams where they are still abundant. Similar to oyster and coral reefs, these animals form dense assemblages that create habitat conditions beneficial for other organisms. The habitat benefits are myriad, including physical, chemical, and biological modifications. They help to stabilize stream channels and decrease bed transport during high flow events (physical). The vertical structure of large-bodied mussels also furnishes stable microhabitats for benthic macroinvertebrates and fish (physical). Mussel shells protruding from the bottom increase turbulent mixing in the benthic boundary layer and provide refugia for other fauna.

Through their biodeposits (agglutinated mussel feces and pseudofeces), mussels enrich sediments (Vanni 2002, Howard and Cuffey 2005) with organic materials and biochemical compounds (chemical) providing for enhanced benthic algal production and greater food resources for other benthic fauna (biological).

Although mussel beds provide many ecosystem services such as streambed stabilization and enrichment of sediments for other animals and plants, they are most valued for their water

processing ability. Mussels improve water quality by removing suspended particulates through filter-feeding. Each adult mussel filters liters of water per day during the growing season, and the combined biofiltration by beds of mussels in healthy streams may exceed the system's downstream flushing volume. For instance, Dr. Kreeger estimated that a relic population of 500,000 mussels on the lower Brandywine River in Pennsylvania still filters more than 1 billion liters and removes 26 metric tons of dry total suspended solids (TSS) each summer season. This population is old, may not be reproducing, and represents a fraction of the system's carrying capacity for mussels. Approximately 4 billion *E. complanata* are estimated to reside in the Delaware River Basin today and they collectively filter about 10 billion liters of water per hour in the summer (Kreeger, unpublished).

Water quality and mussel abundance in the main stem and tributaries affect the ecosystem health of the Delaware Estuary. Kreeger and Kraeuter (2010) estimated that populations of all bivalve species in the Delaware Estuary watershed collectively filter more than 100 billion liters of water every hour during warmer seasons (10^8 m^3 hr^{-1}). If true, this represents about 2500 times the volume of freshwater entering the tidal estuary every hour (Kreeger and Kraeuter 2010.) Still, many streams contain no mussels at all, and others, such as the lower Brandywine, host older populations that may not be reproducing.

Biofiltration by mussels has direct implications for reduction of impacts of stormwater runoff and particulate nutrient control. Since much of the material filtered from the water column (e.g. particle bound nutrients, phytoplankton) is metabolized and then either used by the mussels or transformed into usable materials by other organisms, mussels facilitate nutrient control in streams and rivers.

Other important ecosystem functions include serving as prey for wildlife, biogeochemical cycling and remineralization, and in some areas facilitation of microbial denitrification. Freshwater mussels are eaten by many mammals and birds (van Tets 1994, Tyrrell and Hornbach 1998). Mussels therefore represent important links in aquatic food webs by feeding on microscopic matter at the base of the food chain and in turn being eaten by secondary consumers such as vertebrates.

In healthy rivers such as the main stem upper Delaware River where mussels are numerous, base-of–food-web conditions are richer and ecological turnover rates higher, compared to streams with few mussels.

In summary, healthy beds of mussels provide a multitude of structural and functional services including nutrient sequestration and cycling, substrate stabilization, suspended sediment removal, and the transfer of particulate matter from the water column and into easily assimilated foods for other aquatic species, including fish (Bauer and Wächtler 2001, Pusch et al. 2001, Kreeger 2004).

Bioindicator Value

Mussels are long-lived "sentinel bioindicators", meaning their abundance, biodiversity, and physiological health can tell us a great deal about overall environmental conditions (Kreeger et al. 2002; Martel et al. 2003, PDE 2008). Being relatively sessile, long-lived (up to 100 years), and sensitive to environmental conditions, freshwater mussels are excellent bioindicators of

long-term changes in watershed condition. Due to their limited mobility that prohibits their movement to escape suboptimal environmental conditions, mussel fitness and population vigor is therefore directly indicative of local conditions. In addition, they are indicators of long-term habitat stability because their riverbed habitat is dependent on channel hydraulics and sediment transport.

Internationally, suspension-feeding bivalves have long been considered to be among the best bioindicators of aquatic ecosystems (Dame 1996). For example, in 1976 the U.S. instituted the "Mussel Watch Monitoring Program" to examine the environmental impact of pollution in aquatic ecosystems. Although initially conceived as including bivalves in marine, estuarine and freshwater habitats, the concept was embraced primarily by scientists and resource managers in marine habitats, and the program thereafter focused on marine species such as oysters and blue mussels. The program has been extended to the United Kingdom, France, Canada, Australia, Japan, Taiwan, India, South Africa and the Soviet Republic. In 1986, the U.S. program evolved into the National Status and Trends Mussel Watch Project. Today, a diverse array of chemical and biological contaminants is uniformly analyzed in bivalve tissue from more than 280 coastal sites in the U.S. Mussel Watch.

A comparable, bivalve-based biological monitoring program for freshwater systems is technically feasible but not yet developed, although many studies are now using caged mussels to monitor water quality (e.g., Kreeger et al. 2002).

Due to their unparalleled ability to filter water and improve water quality, suspension-feeding bivalves such as mussels are also perceived as top restoration targets, because enhanced mussel populations will promote positive feedbacks for water and habitat quality, which then benefit mussels. Again, where we are fortunate to have healthy mussel colonies, it is essential that they be preserved.

IV. Potential for Impairment of Freshwater Mussels as a Result of Activities Associated with Development of Natural Gas Exploratory Wells

The greatest diversity and abundance of mussels are associated with clean-swept sand and gravel substrates, but as largely sessile organisms, the complex life history traits of mussels make it possible for populations to thrive in a highly dynamic environment where rapid changes in flow and water quality can occur at each rain event. These same adaptations, however, limit the ability of freshwater mussels to withstand, or recover from, lethal and chronic impacts to which these animals are sensitive, such as increased siltation, water quality alteration, hydrologic alteration, and introduced species. These factors are discussed in greater detail below.

Sedimentation

Mortality, injury and stress to mussels from siltation and other types of sedimentation caused by onshore construction (*i.e.*, staging areas and access road use) is more likely to occur near the source, but erosion and siltation in tributaries at distant locations in the watershed can cause damage when this material is flushed downstream. Silt in the form of increased turbidity and suspended sediment transport is detrimental to mussel health and habitat because it reduces the

depth of light penetration leading to alteration of primary productivity, decreases oxygen levels, increases water temperature, irritates or clogs mussel gills, and deposits silt on the substrate.

High turbidity may also interfere with sight lures, such as conglutinates, which attract host fish. Silt that settles from the water column can smother, bury and/or clog the gills of freshwater mussels unable to avoid these effects due to the extent of siltation or particular phase of the animals' annual life history (for example, gravid female mussels hold eggs and young within a specialized gill structure for weeks to months of a year).

Silt deposition also affects mussels by smothering the eggs or larvae of the fish host populations and by reducing food availability for either the fish or the mussels themselves. Siltation also may result in reduced dissolved oxygen and increased organic material at the substrate level (Ellis 1936, Harman 1974) even when it does not blanket the substrate due to quantity or local water velocity. Silt that settles between sand and gravel particles alters water flow, food and oxygen through the gravel. The interstitial space between sand and gravel is vital for spawning habitat and survival of young host fish and juvenile mussels. When this area becomes unsuitable for juvenile mussels, the population may be unable to reproduction even when the adults continue to survive. Finally, alteration of sediment grain size or excessive volumes of highly mobile soft sediments can increase the risk of scour and hinder the sediment-stabilization benefits of mussels

Excessive sedimentation reduces suitable bottom habitat for mussels, leading to reduced populations and reduced ecosystem services.

Excessive sedimentation can smother mussels, causing acute mortality, reduced populations and reduced ecosystem services.

<u>Suspended Sediments</u>

As filter feeders on microscopic food items, mussels are very susceptible to not only acute mortality due to smothering by silt but also high sediment loads in the water. High turbidity can directly hinder or prevent filter-feeding and respiration when mussels close their valves to avoid intake of silt. At sublethal levels, silt interferes with feeding and metabolism in general (Aldrige *et al*. 1987) because the mussels must divert more energy to sort silt particles from food, again resulting in starvation. Over time, this will reduce an animal's fitness through starvation and, at the population scale, decreases biofiltration services.

Finally, chemicals and compounds are often bound to, and mixed with, fine silts due to their high surface area-to -volume ratio and positive charge. While mussels have some ability to select particular particle sizes, they indiscriminately feed on vast numbers of these small particles, both organic and inorganic. Since particle capture is achieved on the soft tissue gills, which are also used for gas exchange (countercurrent), they have a high degree of exposure to any particle-associated chemicals. Furthermore, particle sorting is inefficient on the gills and labial palps prior to ingestion, so these animals unavoidably consume a variety of non-food particles. Although the chemical conditions in the digestive tract of the mussel can metabolize or mobilize some of the particle-associated contaminants, the high surface area-to -volume ratio of the very small particles exposes the animal to higher levels of toxic compounds than non-filter feeding species that consume larger prey.

In summary, filter feeding bivalves such as freshwater mussels are typically exposed to greater amounts of both waterborne dissolved contaminants and particle-associated contaminants than

other aquatic organisms. Although some classes of contaminants can be broken down through metabolism, most tend to be bioaccumulated within the tissues of the animals, leading to either acute mortality, chronic stress, or mediation into the food web as other animals prey on mussels. For these reasons, bivalves are regarded as sentinel bioindicators around the world; e.g. by International Mussel Watch.

Excessive suspended sediments can impair feeding processes of mussels, leading to acute or chronic stress, reduced fitness and populations, and reduced ecosystem services.

Excessive suspended sediments that include contaminants can be efficiently captured and often efficiently bioaccumulated by mussels, leading to acute or chronic stress, reduced fitness and populations, and reduced ecosystem services, as well as facilitating contaminant entry to aquatic food webs.

Brines, Contaminants, Water Quality

Freshwater mussels are very sensitive to water quality and most classes of contaminants. Contaminant exposure can be particle-mediated (discussed above) or direct via dissolved compounds or attributes associated with the water (discussed here.) Because freshwater mussels feed and respire by filtering large volumes of water across many thin tissue layers (e.g., mantel, gills) they are highly exposed to changes in water quality. Therefore, dissolved toxins (e.g. heavy metals, TDS, biocides) are rapidly taken up by direct absorption (Russell and Gobas 1989, Metcalfe Smith et al. 1996, Riedel et al. 1998) and indirectly via the food (Wikfors et al. 1994).

Mussels can temporarily (hours to days) avoid some contaminants or poor water quality (e.g. low dissolved oxygen) by closing their shells, if the contaminant is of a type and at a concentration that the animal can detect.

Suboptimal water quality (e.g. high conductivity) or the presence of waterborne (dissolved) contaminants might cause acute toxicity and mortality by exceeding mussel tolerance levels.

Suboptimal water quality or the presence of contaminants will impart chronic toxicity to mussels, leading to decreased productivity or reproductive output due to stress or bioaccumulation of contaminants in soft tissues.

Stressed mussels consume more oxygen, especially at higher temperatures, potentially contributing to low DO in some deeper areas.

Physiological impairment due to acute or chronic toxicity from chemical or high solute exposure will reduce population-level ecosystem services, especially biofiltration services.

Ecological Flows

As aquatic organisms, freshwater mussels can survive only brief exposure to the atmosphere, particularly when high temperatures rapidly desiccate exposed mussels or when low air temperatures quickly freeze exposed mussels. Very low water can buffer temperature changes to some extent but low water velocity also allows for greater solar exposure in the summer and increased temperature (and decreases in dissolved oxygen) resulting in stress and mortality.

Similarly, low water during colder periods can result in the formation of ice, which in shallow water can reach the substrate, killing any mussels that freeze.

Riverine mussel species depend upon flow for not only food and oxygen but also to maintain water quality and shape the physical habitat. For example, reduced flow increases the likelihood of silt deposition in areas that may typically have velocity that precludes deposition, and contaminants in the water are increasingly concentrated during low flow events.

Sustained low flows, which could result from unregulated withdrawals from headwater streams, can alter quality and quantity of food, causing stress and reproductive failure for mussels.

Low flows can interfere with mussel reproduction if fish hosts are unavailable for mussel larvae, depending on seasonality.

Any physiological impairment due to extreme low or high temperatures associated with low flows or reduced habitable bottom will reduce population-level ecosystem services, especially biofiltration services.

Invasive Species

Activities that result in transfer of water between watersheds have also resulted in the transfer of exotic or invasive species that can cause direct mortality of freshwater mussels through predation, toxicity, and disease or through competition for food or habitat. Resource management agencies have taken great pains in recent years to educate the public and institute practices to prevent the accidental spread of invasive species by anglers, boaters and other recreationists.

Once established in a waterway, zebra mussel populations can become extremely abundant, directly competing with native mussels for food and rapidly covering any exposed surface of a mussel shell. In some locations, populations of native freshwater mussels have been severely reduced, or eliminated, after zebra mussel colonization that altered substrate, flow, and food availability.

In the fall of 2009, Dunkard Creek, a tributary of the Monongahela River located along the border of southwestern Pennsylvania and West Virginia experienced a massive aquatic kill affecting native freshwater mussels, fish and salamanders in a 43-mile reach of the Creek. The kill was associated with a spike in conductivity that may have caused direct mortality of freshwater mussels, but which also contributed to the bloom of an invasive marine alga *Prymnesium parvum* or “golden alga”, a species that proliferates in saline waters more typical of coastal Texas than the Appalachian Mountains of Pennsylvania. Golden algae produce a toxin fatal to other aquatic organisms. The species had never been observed in Pennsylvania waters before the Dunkard Creek aquatic kill but is known to thrive at the higher TDS concentrations that are often associated with mining and drilling activity. Its presence in state waters makes spread of the species to other surface waters of the state highly likely. Transfer of water between basins increases the risk that invasive species like golden algae and zebra mussel will also be inadvertently introduced to the Delaware Basin. Once established, invasive species are very difficult or impossible to remove.

Loss of Forest Cover

Some mussel species depend on leaf litter inputs for their nutrition. Forest loss or fragmentation, especially in areas near streams and rivers, has the potential to significantly impair food quality and quantity as well as degrade stream habitats for mussels by altering nutritional conditions as well as physical and chemical habitat conditions. In streams of southeast Pennsylvania, for example, the only remaining mussel beds are found within heavily forested areas of watersheds such as the Brandywine and Ridley Creeks – mussel abundance decreases dramatically in stream reaches above and below forested segments.

Loss or fragmentation of forests near streams and rivers can impair mussels by altering nutrition support and degrading habitats, thereby reducing mussel populations and ecosystem services.

V. Special Considerations – Dwarf Wedgemussels

The federal endangered dwarf wedgemussel (*Alasmidonta heterodon*) is sensitive to many of the same threats described above for other native species of freshwater mussels. Siltation, hydrologic changes, and contaminants are among the threats to the species survival cited at the time it was listed in 1990 (55 FR 9447 9451; U.S. Fish and Wildlife Service 1993).

Dwarf wedgemussels have characteristics that likely increase their susceptibility to these factors. First, the species is small compared to most other freshwater mussel species, (in the range of about an inch in length); therefore, relatively minor siltation events can deposit a smothering silt layer that reaches a depth that animals cannot push above.

Second, although they require flowing water and occur in a diversity of habitats from small streams to large rivers, dwarf wedgemussel are a thin shelled species that could be easily transported during a scour event. Like many freshwater mussels, dwarf wedgemussel populations tend to occur in areas protected from high-flow events, such as side channels of larger rivers and lower gradient streams. These low to medium velocity areas tend to have finer particle size substrates. Infiltration of relatively smaller amounts of silt between sands and smaller gravel particles can quickly hinder interstitial flow.

In the Delaware River this microhabitat preferred by dwarf wedgemussels tends to be away from the main channel, and therefore it is very susceptible to low flow exposure and associated changes in temperature. The seasonality of low flow and temperature rise may also be critical for dwarf wedgemussel reproduction and nutrition since freshwater mussels require specific food conditions for reproductive conditioning.

Dwarf wedgemussels are sensitive to all of the factors listed in Sections I-IV and potentially more susceptible than other mussel species to sedimentation, low flow, and temperature extremes.

VI. Management Implications for Natural Gas Development

It is our opinion that natural gas drilling activities, including the construction of natural gas exploratory wells, pose a substantial risk to mussel populations in the Special Protection Waters

of the Delaware River Basin but that this risk can be reduced through the mandatory use of protective management practices of the types set forth below:

A. Consistent use of avoidance and minimization measures across the supporting watershed in three states to reduce the risks that siltation, spills or other releases of contaminants, flow changes and the spread of invasive species could adversely affect mussel populations, including the federally listed dwarf wedgemussels that inhabit the upper Delaware River.

B. Implementation of stormwater management and erosion and sedimentation control practices to help minimize sources of sediment during and after construction of natural gas well pads, wells and impoundments.

C. Monitoring of water quality, flow conditions, and invasive species in potentially affected areas before, during and after project construction in order to identify where preventive measures may have failed, where they were effective, and where mitigation or restoration measures are warranted.

D. Monitoring of the diversity, fitness and abundance of freshwater mussel assemblages in potentially affected areas.

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Potential for Development of Natural Gas Exploratory Wells to Adversely Affect Water Resources of the Delaware River Basin

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National Park Service
Geologic Resources Division

in the Matter of
Delaware River Basin Commission
Consolidated Adjudicatory Hearing on
Natural Gas Exploratory Wells

November 23, 2010

Author Background

Patrick M. O'Dell, P.E., Petroleum Engineering, National Park Service
Area of Expertise – Management of Oil and Gas Operations for the Protection of National Park Resources and Values

Mr. Patrick O'Dell has a BS in petroleum engineering from Montana College of Mineral Science and Technology (1982). He is a registered professional petroleum engineer in the State of California (Certificate No. 1529) and has been employed in both the private and public sector.

Mr. O'Dell worked for Marathon Oil Company in Bakersfield, California as a production engineer, where he was responsible for maintaining production and controlling expenses in older oil and gas fields undergoing secondary recovery (e.g., waterflooding and gas cycling). In 1986, he relocated to Anchorage, Alaska with Marathon. In Anchorage, he worked as a reservoir engineer responsible for field development planning, reserve determination, and property evaluation for purchase or sale. While in Alaska, Mr. O'Dell became accountable for the region's new well completions, major workover projects, and the Alaska Region's hydraulic fracture stimulation program. Environmental and safety compliance was a significant part of project design and execution. He also worked on drilling and abandonment operations.

Mr. O'Dell joined the National Park Service in 1992 as a petroleum engineer. He functions as the Service's nationwide technical specialist and authority in the application of best available fluid mineral exploration and development technology to ensure protection of park resources and values. Mr. O'Dell is responsible for assessing impacts of oil and gas activity in and around parks, and developing measures to minimize or remove such impacts via site-specific recommendations and through development of minerals management and training programs.

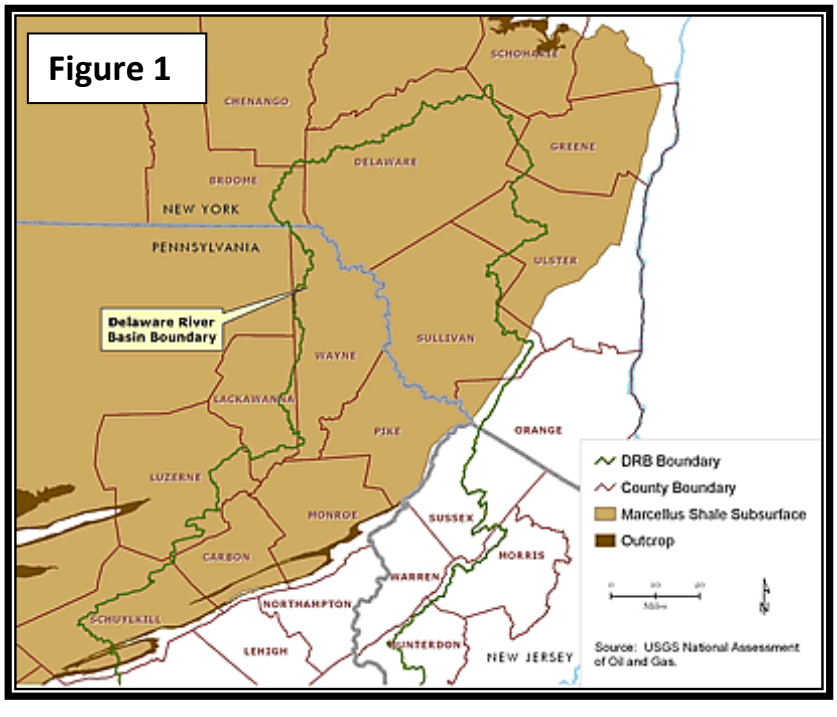
Overview

The Marcellus Shale underlies a significant part of the Delaware River Basin that drains to Special Protection Waters (*also* "SPW"), waters for which the policy is "no measurable change to water quality except toward natural conditions." *See* DRBC Water Quality Regulations, sec. 3.10.3 A.2. It is inconceivable that Marcellus Shale exploration and production will improve water quality in the Special Protection Waters of the Delaware River Basin. It is also improbable that such a widespread and water resource-intensive industrial activity in a rural setting will never adversely affect water quality. The question is whether focused attention by both industry and regulatory agencies can keep water quality and quantity degradation to localized and intermittent events – as opposed to a broad and long-term adverse impact.

The focus of this report is whether "exploration wells" have the potential, either individually or cumulatively, to have a substantial effect on water resources of the basin, and in particular, whether these projects have the potential to cause "measurable change" to the exceptionally high quality of the basin's Special Protection Waters. This report provides support for the conclusion that exploration wells do indeed have such potential.

Background

Natural gas exploration and production is an industrial activity. Shale gas exploration and production is proving to be very extensive industrial activity with a network of well pads, access roads, compressor stations, and gas transportation lines often dispersed over thousands of square miles.



The Marcellus Shale is a vast, natural gas-bearing formation extending 50,000 square miles from southern New York across Pennsylvania and through West Virginia. USGS Fact Sheets acknowledge that over 300 trillion cubic feet (TCF) of natural gas could ultimately be produced – enough gas to supply the entire United States for about 15 years. Economic and environmental stakes are high.

The horizontal drilling and large multi-stage hydraulic fracturing stimulations being used to tap the shale require large drilling locations and millions of gallons of water per well. Development in the coming years and decades will vary across the play but could ultimately be 4, 8, or even 16 wells per square mile. Infrastructure build out (roads, transmission pipelines, compressor stations, etc.) will be substantial. Today, there are about 100 active rigs drilling the Marcellus. (Baker Hughes, Nov 2010)

The Marcellus Shale formation in northeastern Pennsylvania and southern New York underlies about 5,000 square miles or one-third of the 13,500 square-mile Delaware River Basin (Figure 1). Over 15 million people (approximately five percent of the nation's population) rely on the waters of the Delaware Basin for drinking, agricultural, energy and industrial use, but the watershed drains only four-tenths of one percent of the total continental U.S. land area. (DRBC)

Figure 2 (Photo by Soete)

The 5,000 square-mile area common to the Marcellus Shale and the Delaware River Basin includes a 73.4-mile stretch of the Upper Delaware Scenic and Recreational River, which snakes gracefully through the rural countryside of green rolling hills (Figure 2). Within this same area, The Marcellus Shale includes some of the most promising sections in terms of the thickness of organic-rich shale. Figure 3 is a map of Pennsylvania showing the net feet of organic-rich shale in the Marcellus Formation. John Harper of the Pennsylvania Geological Survey believes that the thickness of organic-rich shale may be more important than the total Marcellus thickness in assessing the production potential of a well site.

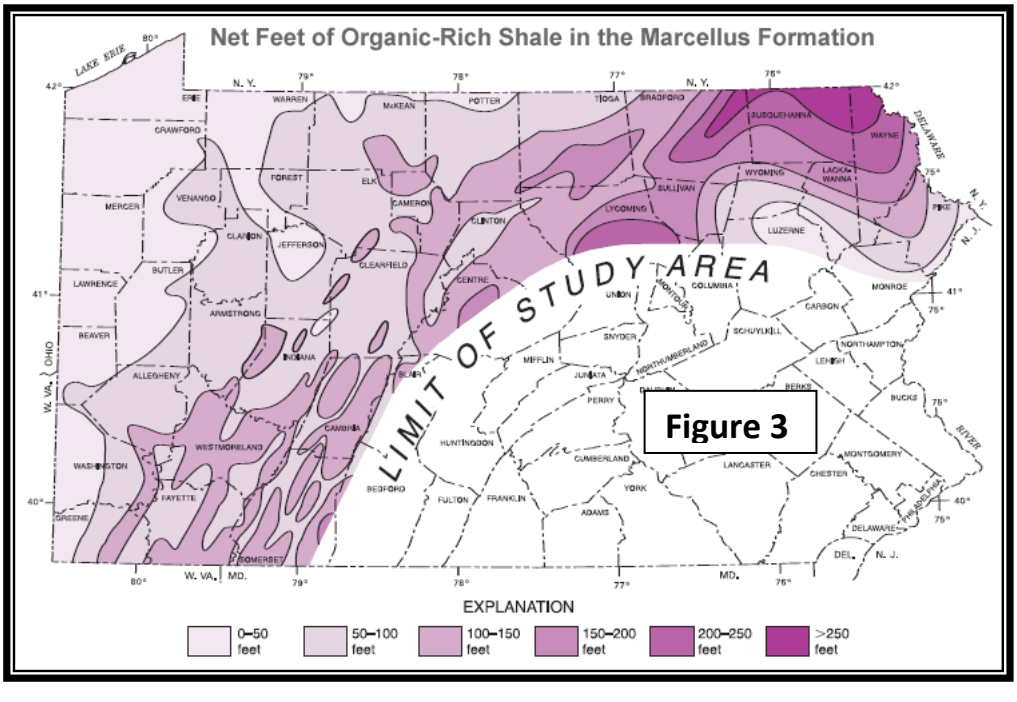


Figure 3

Figure 4 shows a map ranking Pennsylvania counties based on depth, thickness, and thermal maturity of the Marcellus Shale. Note the core area that includes a substantial area within the Upper Delaware River Basin including all of Wayne County, PA and portions of Broome, Delaware, and Sullivan Counties, NY.

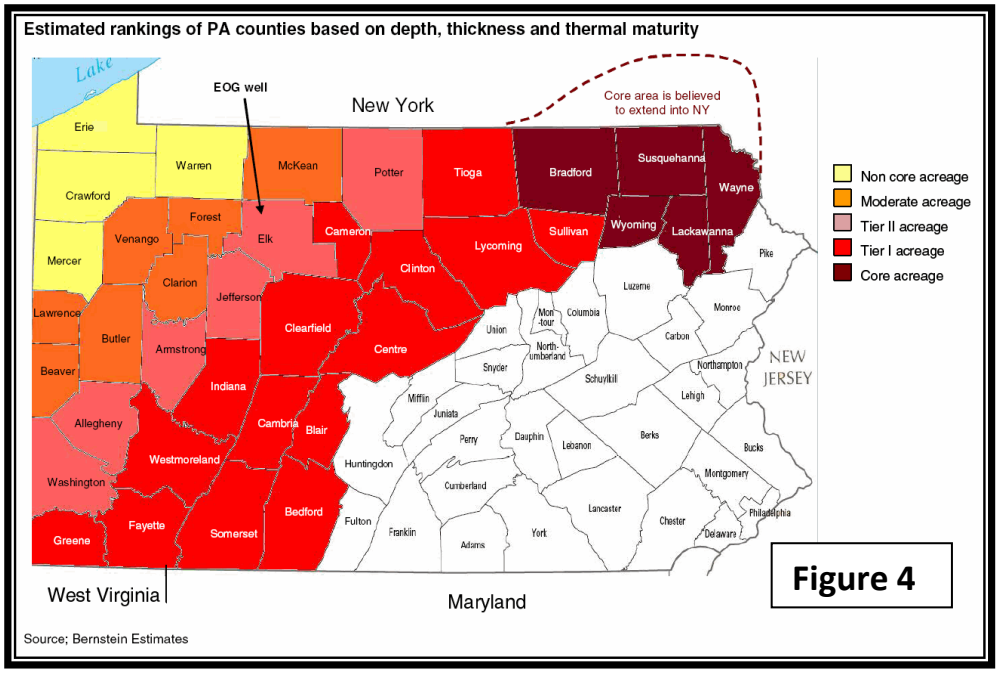


Figure 4

Figures 3 and 4 present the most promising areas of the Marcellus Shale in a slightly different manner, but based on the same geological information.

Figure 5 is a map of Marcellus wells drilled to date in Pennsylvania. Note the concentration of wells in the northeastern counties of Tioga, Bradford, and Susquehanna that correspond to an area mapped in Figures 3 and 4 as having high net feet of organic rich shale. This appears to be industry's confirmation of the focus on net feet of organic-rich shale.

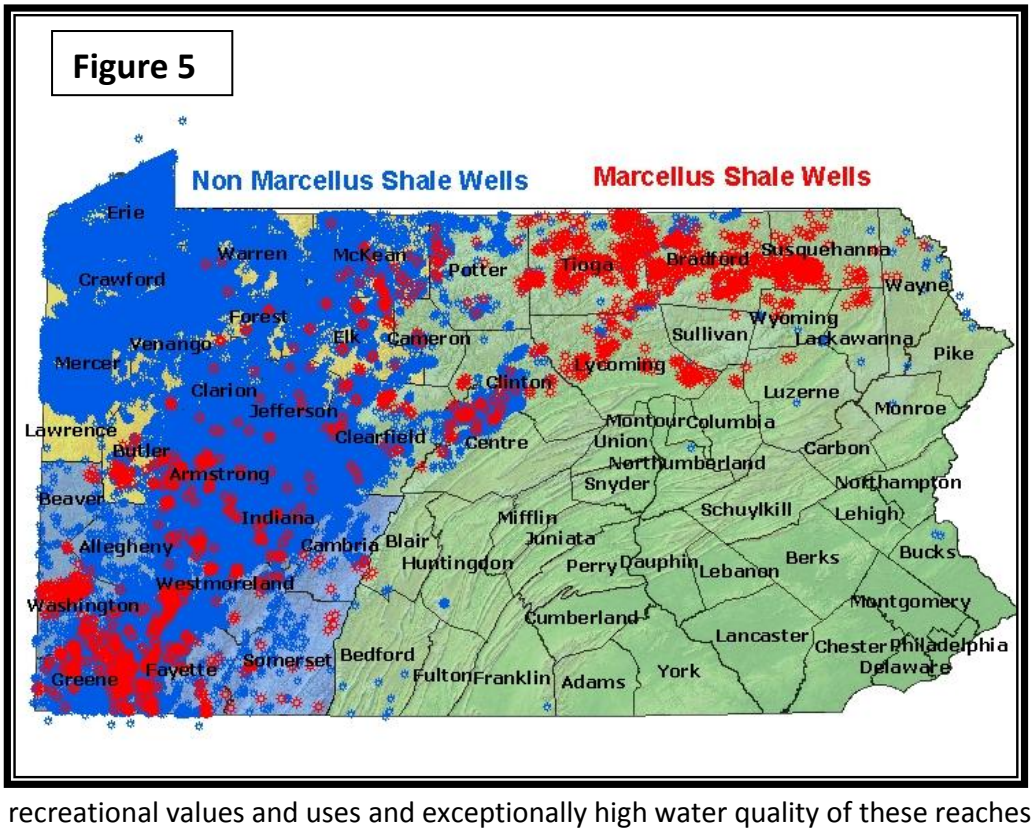


Figure 5

It is reasonable to conclude (and the extent of lease holdings of parties to this hearing confirm) that areas within the Delaware River Basin are of primary interest to the industry.

Federal legislation established the Upper and Middle Delaware River as part of the National Wild & Scenic River Management program in 1978 in recognition of the scenic and recreational values and uses and exceptionally high water quality of these reaches. DRBC's SPW program, established in 1992 and modified in 1994, 2005 and 2008, created an anti-degradation

management regime – the SPW program – to implement the objective established by the Upper Delaware Scenic and Recreational River Management Plan (Conference 1986), and the General Management Plan for the Delaware Water Gap National Recreation Area/ Middle Delaware Scenic and Recreational River (DWGNRA 1987) of preserving and protecting the exceptionally high quality of these waters. For more than three decades, the water resources of the upper and middle Delaware River have been accorded special status and protections by agencies of federal and state government. In my opinion, if the quality of these water resources is to be protected, then natural gas development activity within the Delaware Basin must be undertaken – from start to finish – with this goal as an industry and regulatory agency priority.

The Role of Exploration Wells in Shale Development

In the Delaware River Basin, there is a strong likelihood that a well labeled as an "exploration well" will become a producer. Further, the well site and access road that supports the initial "exploration well" could very likely support additional wells and all the related activities and associated production/transportation facilities. An explanation follows.

In a conventional sense, wells drilled for oil and gas are classified as either exploration or development wells. An exploration well is drilled either in search of an as-yet-undiscovered pool of oil or gas (a wildcat well) or to extend greatly the limits of a known pool. Exploration wells may be classified as (1) wildcat, drilled in an unproven area; (2) field extension or step-out, drilled in an unproven area to extend the proved limits of a field; or (3) deep test, drilled within a field area but to unproven deeper zones.

Development wells are wells drilled in proven territory in a field to complete a pattern of production.

With a continuous or unconventional resource play such as the Marcellus Shale, the "exploration drilling" phase is focused on determining if the shale can be stimulated in such a manner as to obtain gas in sufficient rates and volumes to make the endeavor economical. More importantly, the "exploration" phase is designed to ascertain whether the formation is receptive to a process that is economical (e.g., horizontal wellbores with multi-stage hydraulic fracture treatments) and repeatable. Basically, the driller is seeking to determine whether a technical and financial "assembly line" can be applied to the geology of the shale to make a reasonable rate of return.

Figure X shows the geological differences between the "conventional" oil and gas pools historically sought by the industry and the emerging "unconventional" or "continuous resource" plays now garnering so much attention. In conventional plays, much of the risk is geological. Is there good reservoir rock? Is there a geologic trapping mechanism? Have hydrocarbons migrated into and become trapped in sufficient volumes within the reservoir rock? As to these conventional pools, the exploration well's primary purpose is to address the geologic risk.

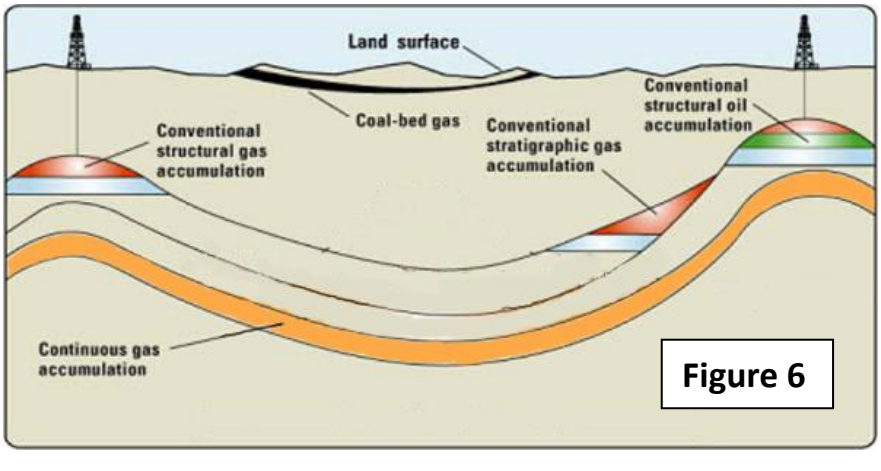


Figure 6

In unconventional plays, the geological risk is exceedingly lower than for conventional

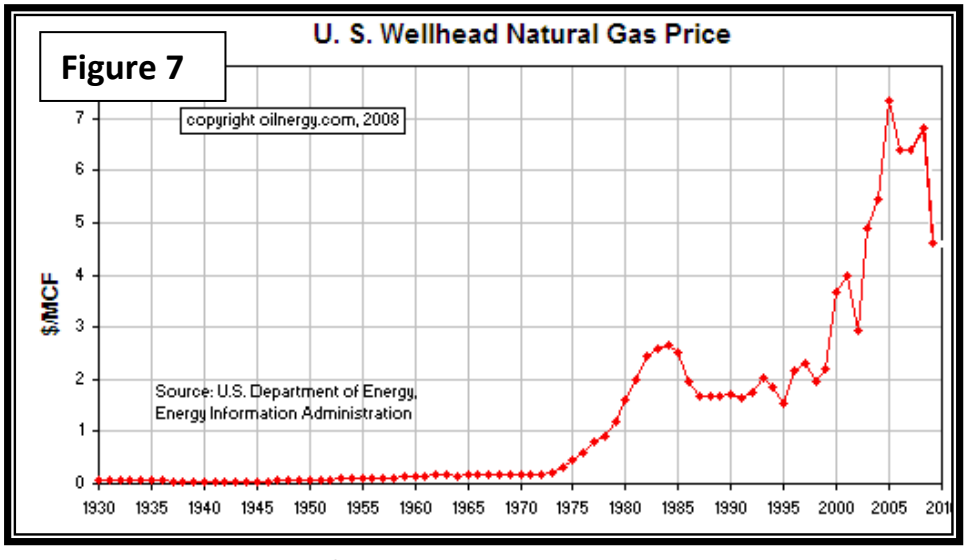
targets. For example, the depth and areal extent of the Marcellus is well known. Enough geologic information is already available to have mapped the net feet of organic rich shale for the Marcellus. True, additional drilling will hone the accuracy of existing maps, but industry activity demonstrates that the primary risks have already shifted from geological to technical and financial. Companies are leasing large acreages at highly competitive prices far from the nearest Marcellus well because, in practice, there is little need for a "discovery" well.

While the "intent" of a well as exploration or development in the Delaware River Basin is inarguable, there can be little doubt that the "first" well establishes the access route and operational location of perhaps decades of drilling and production activity.

Environmental protection from the adverse impacts of an activity hinges on best management practices that consider time, place, and manner. Distance between an activity and the resource at risk is fundamental to that resource's protection. Eliminating the "place" consideration is perhaps the most serious handicap that could be put upon an environmental protection regulatory scheme.

Scope of Anticipated Marcellus Shale Development

Development of the Marcellus is currently following the pattern of other continuous gas shale plays, but at a faster pace.



With natural gas prices off the peaks of the last few years (Figure 7), drilling has generally slowed in gas shales. However, the Marcellus Shale drilling activity has bucked the trends of others. This probably has much to do with the stage of development.

During the early phase of leasing and drilling, holding leases by production has a strong influence on drilling activity. Drillers have an incentive to begin production before a lease expires in order to avoid additional transaction costs and the potential for less favorable terms under a re-negotiated agreement. Once leases are secured by production, supply and demand (natural gas wellhead prices) will have a more profound influence on the rate of development.

The moratorium on production well approvals in the Delaware Basin imposed by the Commission in May of 2010 pending promulgation of new DRBC regulations, no doubt has raised concerns among some lessors (landowners) and their lessee operators that leases will expire before DRBC approvals are issued. It is certainly likely that the existence of an exploration well in the ground and capable of conversion to production may provide both landowner and operator with some comfort that they are in a position to proceed as soon as rules are adopted and approvals can be processed. It is also possible that the Commission's moratorium might inadvertently create an incentive for project sponsors to classify their wells as exploratory in order to meet lease obligations and be poised to produce when the regulations

are in place. By allowing only a limited number of exploration wells to proceed, the Executive Director appears to have balanced the interests of those who had relied on a previous exemption to advance their exploratory well projects. Importantly, she also closed off the potential for a wave of exploratory wells to be drilled without any DRBC review as to their placement vis `a vis valued water resources.

Spacing of oil and gas wells ordinarily is dictated not by environmental concerns but by the extent of the area from which a single well can extract the maximum amount of commercially recoverable oil or gas. The spacing histories of the Barnett, Fayetteville, Antrim, New Albany, Ohio, and Woodford shales as shown in Table 1 all trend from larger to smaller spacing units over time. For the Marcellus Shale, it is reasonable to expect 320-acre or 160-acre spacing initially, and eventually some areas experiencing infill drilling to 80-acre or even 40-acre spacing should infill drilling produce an economic return.

Table 1 – Sample of Well Spacing in Gas Shale Plays

Gas Shale Name	States	Well Spacing
Barnett Shale	TX	• 40- to 160-acre spacing typical • 20-acre spacing being tested
Fayetteville Shale	AR	• 40-acre spacing by rule (Arkansas Oil and Gas Commission Rule B-43) • 80- to 160-acre spacing in practice • 60-acre spacing being tested
New Albany Shale	IL, IN, KY	• 160-acre spacing initially • 80-acre spacing now common
Antrim Shale	MI	• 40- to 80-acre spacing
Ohio Shale	OH	• 40- to 160-acre spacing
Woodford Shale	OK	• 640-acre spacing initially • 160-acre spacing now common • 80-acre spacing proving effective • 40-acre spacing being tested
Marcellus Shale	NY, PA, OH, WV	• 160- to 320-acre spacing initially • 40- to 80-acre spacing can be expected

Source: Modified from Sumi 2008.

Using 80% of the 5,000 square mile Marcellus area in the Delaware River Basin developed at 160-acre spacing yields 16,000 wells. An 80-acre spacing pattern would result in doubling the number to 32,000 wells. Of course, voluntary restrictions by private agreement may limit this number. For example, NWPOA's current lease with Newfield Appalachia PA, LLC provides for an 80-acre spacing equivalent by

means of a single 8-well drilling pad per each square mile. Such private agreements of course are subject to change by contracting parties.

One of the benefits of horizontal well completions is the ability to site multiple wells on one location. So while each multi-well pad constructed for a group of six or eight or ten horizontal wells may occupy a much larger land area than the pad for a single vertical well, the overall disturbance on an acres/well basis could ultimately be much less than for a traditional vertical well build-out. Also, with the capability to drill horizontal sections ranging up to 5,000 feet, there may be opportunities to site surface operations away from sensitive areas, such as the basin's Special Protection Waters, without losing the ability to recover the gas. However, if the Commission intends to implement its Special Protection Waters program, it will need to find ways to incentivize or compel the industry to develop at a pace and manner that allows for natural gas extraction while simultaneously optimizing water resource protection. Otherwise, my experience indicates that water resources will not be a priority in the industry's rate-of-development, well spacing, and siting equations.

In addition to the Marcellus Shale, the Utica Shale may be targeted for natural gas production within the Delaware River Basin. One shale play on top of another could in theory double the environmental impacts, in particular those related to water resource demands and surface disposal of waste streams to surface waters. In practice however, technical innovation and economic constraints would produce impacts less than double, but certainly greater than one.

Risks to the Water Resource from Surface Operations of Natural Gas Exploratory Well Drilling

For purposes of this report, "exploration" drilling consists of access road and well pad construction followed by drilling and casing of a vertical well through the Marcellus Shale. The effects on and risks to surface and groundwater from well completion, hydraulic fracture stimulation, development well drilling on the same site, installation of gas handling facilities, gathering lines, compressors and waste handling areas, and long-term production and maintenance of wells are directly proportional to the activities' proximity to the water resources. That proximity of drilling is key to water resource protection is acknowledged by the many federal and state oil and gas regulatory agencies that include minimum setbacks in their policies and regulations. It is reasonable to conclude that site selection for both well pads and access roads is a crucial component of mitigating risks and effects on water resources. As noted above, the locations of the exploration well and its access road set the stage for the location of the activities that follow.

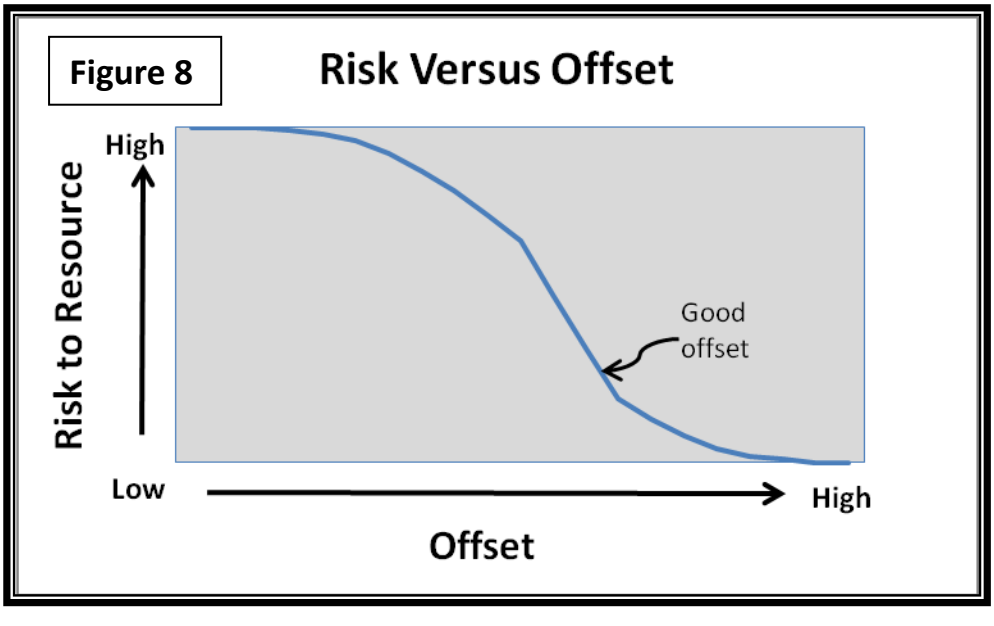


Figure 8 is a graphical representation of a minimum offset being used to reduce the risk

to a resource. At some point the incremental offset begins to accelerate the rate of risk reduction to the resource. This is typically the area where site specific environmental conditions begin to provide time and space to react to accidents or spills so as to prevent or minimize impacts to the resource. Finally, offsets become great enough that incremental offset distance provides very little additional risk reduction. Each site is unique. Environmental conditions may provide natural or human-made barriers that would justify a reduced setback. Site conditions such as steep slopes or annually high precipitation can enhance pathways between the activity and resource, and thus justify greater setbacks. Regulatory establishment of a "good offset" that considers both the activities and the average environmental conditions provides a beginning point for site location considerations. Additionally, having a regulatory process for adjusting site-specific setbacks – either lower or higher – based on project and environmental conditions is the key to successful use of setbacks.

The remainder of this section highlights the primary risks to water resources from Marcellus Shale exploration well drilling. Perfect execution by industry and regulatory agencies is necessary to lower these risks to a level that will not result in measurable impacts to water resources – at least on a localized and short-term basis. Since it is unrealistic to expect perfection over the course of time, it is reasonable to conclude that not only is there a potential for measurable impacts to water resources, but that measurable impacts will occur.

Erosion and Sedimentation

Erosion is a natural process by which the surface of the land is worn away by water, wind or chemical action. Erosion and subsequent deposition of eroded materials to surface waters (sedimentation) are a primary threat to water quality associated with road and well pad construction activities. Realizing the potential for erosion and sedimentation associated with oil and gas development to adversely impact water resources, state and federal oil and gas management agencies have developed best management practices and require operators to use them.

Road and pad construction for an exploration well often involves extensive earth disturbance that can speed erosion. For a vertical Marcellus well, the pad size will most likely be between 2 and 3 acres of level, usable space just to support the drilling operations. Construction on sloped areas can substantially increase the area of disturbance when considering cut and fill requirements.

Vegetation is a significant check on natural erosion rates. Accelerated erosion occurs when human activities increase the rate of erosion above the natural processes.

Road and well pad construction necessitate removal of the vegetation that serves to check the natural rates of erosion. A well pad and half-mile access road may require a footprint of approximately 4 acres on level ground. Placement of roads and pads in the hilly terrain of the Upper Delaware River Basin will involve some degree of cut and fill construction techniques on most, if not all, projects. This increases both the area of disturbance (by up to 50% on slopes exceeding 15 degrees) and the efforts required to mitigate erosion and sedimentation.

In general, the proximity of roads and well pads to surface waters increases the risk that erosion and sedimentation will cause measureable impacts on water quality. Stream crossings will be unavoidable for some projects.

Materials Used or Generated Onsite Create a Potential Source of Water Contamination

In well drilling, sources of potential contamination to surface and ground water include spills of fuels, lubricants, and chemicals used in mud systems or air drilling systems, as well as fluid (or "brine") returned from deep rock formations. While amounts vary, it would not be uncommon to have several thousand gallons of diesel fuel stored on site at any given time, and 4 or 5 fuel deliveries each week. For an 8,500-foot vertical Marcellus Shale well, that could be 20 fuel deliveries. Chemicals such as pH buffers, water loss agents, friction reducers, corrosion inhibitors, biocides, foaming agents, and others are typically used in very low concentrations within mud or air drilling systems. However, these chemicals are stored in concentrated liquid or solid form on location, and if handled improperly, are sources of potential contamination of surface and ground water.

Drill cuttings from an 8,500-foot Marcellus Shale well can amount to approximately 200 cubic yards of material. A portion of the drill cuttings may come from formations bearing heavy metals and elevated levels of naturally occurring radioactive materials (NORM). Shales are also known to contain minerals such as pyrite and sulfides, which when brought to the surface and exposed to air can break down to form sulfuric acid and iron hydroxide. The acid in turn can mobilize metals in the cuttings, creating a potential source of contamination to both surface and ground waters.

If air drilling is utilized, as compressed air and additives (the "air system") are pumped down the hole, water, additives, drill cuttings and formation fluid are returned to the surface. The formation fluid, or "brine" consists of water into which salts and other minerals have leached from the surrounding rock for millennia. Formation fluid from the Marcellus formation tends to be extremely high in total dissolved solids (TDS). With concentrations of as much as 300,000 mg/l of TDS, Marcellus brine is five times as salty as ocean water (35,000 mg/l TDS) (PA EQB 2010). In addition to chlorides, this solution carries high concentrations of barium and strontium and may be radioactive due to the presence of naturally-occurring radium. Although quantities produced during construction of a vertical exploration well will be much smaller than for a horizontal or production well, if not carefully contained, brines or oily water can be sources of contamination to both surface and ground water.

Water Needs

Well drilling requires the use of water. The volume of water varies depending on well depth and the mud system used to drill the well. A typical Marcellus Shale well drilled vertically to 8,500 feet in depth may require 50,000 to 300,000 gallons of water, the lesser volume being associated with air drilling operations. The source of water and the withdrawal methods used may cause or accelerate bank erosion, diminish streamflow, elevate water temperature, and introduce invasive species, all of which may potentially adversely affect water quality and aquatic biota.

Mitigation of Risks to Water Resources

A comprehensive regulatory system helps to ensure that each of the identified risks to water resources is reduced by mandatory use of established protective management practices. The idea that regulation is a necessary means of protecting water (and other resources) from the adverse effects of oil and gas development activities is virtually uncontested, as evidenced by existing state regulatory regimes.

For Marcellus Shale "exploration" well drilling in the Delaware River Basin, examples of best management practices that in my view should be applied in the land development aspects of drilling to protect water resources include, but are not limited to:

- Use and upgrade of existing roads, rather than construction of new roads
- Implementation of strong erosion and sedimentation control plans
- Seasonal or other timing restrictions to avoid construction during periods of high precipitation
- Avoidance of steep slopes
- Well site construction that conforms to the landscape in lieu of insistence on rectangular sites for all locations
- Appropriate setbacks from surface waters, including wetlands
- Minimization of stream crossings
- Stormwater management that ensures discharges are uncontaminated and do not exacerbate erosion
- Strong spill prevention, containment, and response equipment, structures, and methods, designed and implemented throughout the construction and drilling process (for example, bermed locations, with appropriate placement of impermeable liners beneath potential spill sources)
- Closed-loop drilling systems in lieu of earthen (including lined) pits
- Offsite disposal of drilling wastes for sites in close proximity to surface waters or with near-surface groundwater
- Exotic species control
- Establishment of adequate performance bonding and liability insurance standards to ensure that remediation will be provided in the event of accidents or poor operator performance that results in impacts to water resources

In the experience of the National Park Service, it can be fairly said that the most environmentally conscientious operators willingly, but only minimally, comply with those regulatory requirements <u>that serve only to protect</u> a natural, cultural, or recreational resource. [Note: There are many actions taken by industry that serve operational or financial purposes <u>and</u> coincidentally serve to reduce environmental impacts. For example, drilling multiple wells from a single well pad has both operational/financial and environmental benefits.] Any regulatory agency can and reasonably should expect no more from an operator than full compliance with its regulations. The point being that if the public depends on operators in general to voluntarily use measures such as "best management practices" to meet an agency's standards of resource protection, the public will be disappointed. This is because operators are sometimes willing to assume more environmental risk in exchange for a reduction in expense or acceleration of project completion (i.e., time to production).

The recent British Petroleum Mississippi Canyon Well #252 blowout is a spectacular example of a company making choices that increase the risk of an incident in an effort to reduce expenses or speed the time to production. While incidents of the scope experienced in the Gulf are not expected in the Marcellus, the Punxsutawney Hunting Club 36H well incident in Clearfield County, Pennsylvania, is a closer-to-home example of an operator's willingness to take on environmental and human health and safety risk in order to decrease costs or speed the time to production, while at the same time staying within, but perhaps testing the envelope, of regulatory requirements. This incident involved loss of well

control during post stimulation cleanout activities. The Pennsylvania Department of Environmental Protection's (PA DEP) July 12, 2010 letter to operators states, "Over a period of 17 hours, gas and hydraulic fracturing wastewater flowed uncontrolled into the environment and impacted nearby waters." As a result of the post-incident investigation, PA DEP determined the operator used inadequate equipment and practices to maintain control of the well. The PA DEP issued further direction to the Marcellus Shale industry in Pennsylvania that mandated specific equipment and practices necessary to meet regulatory requirements of well control (PADEP July 2010).

Although the Punxsutawney Hunting Club incident occurred during operations associated with a production well, not an exploratory well, the incident illustrates that accidents will occur in development of natural gas, whether as a result of equipment failure, human error, or simply by miscalculations of human safety and environmental risk by project managers. Risk is the probability of an incident occurring multiplied by the consequences of the incident. Reducing the consequences of an incident can and should receive appropriate weighting when selecting the location of roads and well pads. The importance of selecting a well site in full consideration of distance and pathway between the well and the water resource cannot be overstated – particularly when the inevitable accident such as the Punxsutawney blowout occurs.

Simultaneous Regulation by NPS and Other Agencies

Oil and gas operators in units of the National Park System must comply with both NPS regulations and state oil and gas regulations. The National Park Service regulations are generally more restrictive than state regulations on surface use requirements. This does not mean some states may have lax environmental standards, but rather that states typically leave the bulk of surface use issues to be settled between the private landowners and the operators. It has never been the experience of the National Park Service that its rules and state rules contradict each other. Rather, they supplement each other with respect to various environmental issues.

Most states' oil and gas regulations include some provisions that serve to protect the environment and human health. For example, all states' rules contain provisions for the protection of fresh water and for public and worker safety. However, a primary focus of state regulations generally is the conservation of the oil and gas resource and protection of the associated ownership interests.

In contrast, the National Park Service's mission is to prevent or minimize damage to the environment and other resource values and insure that parks are left unimpaired for the enjoyment of future generations. To that end, the NPS controls nonfederal oil and gas development in parks under regulations codified at 36 CFR, Part 9, Subpart B (the "9B" regulations). These regulations oversee an activity that in large part also is regulated by the states – but with a different focus.

The NPS 9B regulations focus on surface use and groundwater issues and require that operators apply methods that will avoid or minimize impacts to park resources and values, as well as public health and safety. These priorities and constraints may also be addressed by state regulations, but they are the sole focus of the NPS program.

Reasonable time, place, and manner considerations are fundamental to the 9B regulation program.

Place. One of the strongest regulatory tools in the 9B regulations is establishment of a 500-foot setback of operations from surface waters (36 CFR §9.41(a)). This requirement gives the operator and the park

resource manager a starting point in locating drilling or other operational sites. The regulations provide a process for increasing or easing the 500-foot setback requirement if the particular conditions of the project warrant an adjustment.

The National Park Service has undergone five park-specific planning efforts to furnish operators and park managers with guidance on implementing the 9B regulations, given the local environments, park uses, and the scope of operations – either ongoing or forecast. The planning effort in each case focused most intensively on identifying sensitive resource areas (e.g., surface waters, wetlands, endangered species habitat, high visitor use areas, etc.) and considering the level of expected impacts for various setbacks. These efforts have resulted in park-specific setbacks ranging from zero to 1,500 feet. For example, short-term foot-traffic-only recording operations for a seismic survey may occur within a wetland with negligible post-operational effects. Conversely, a full-scale drilling operation may require a much more substantial setback from a nature trail to retain a high quality visitor experience.

Manner. An example of how the natural gas drilling requirements imposed by most states and those required by the National Park Service differ relates to the handling of drilling muds and drill cuttings. Drilling muds and well cuttings may contain chemical and material contaminants, including petroleum products. Most states allow the use of earthen pits for storing muds during operations, and for ultimate disposal of drilling waste solids. The NPS requires the use of above ground tanks ("containerized mud systems"). Earthen pits are prone to leaks, which can go undetected for long periods of time and lead to costly cleanup. Above ground tanks provide a higher degree of environmental protection because leaks from the tanks are readily apparent, and the tanks are removed from the site upon completion of the drilling phase of operations. Many companies have voluntarily adopted the NPS approach outside of parks. However, the State of Texas, for example, does not require the use of tanks. Instead, it has developed guidance for Texas Statewide Rule No. 8 (TAC), Protection of Water, which regulates the use of earthen pits through a permitting system. As soil permeability and proximity to water increase, state rules "recommend" but do not require more stringent construction methods for such pits, including the use of leak detection.

Timing. The regulations adopted by most states do not include timing restrictions, though operators may necessarily have to time their operations to meet compliance with other federal laws such as the Endangered Species Act. The National Park Service uses daily, weekly, and seasonal timing restrictions to augment resource protection and visitor experience. For example, limiting oil/fuel hauling to daylight hours has been found to reduce accidental spills. Scheduling mobilization of equipment for a drilling operation to avoid times of heavy visitor use on weekends may serve an operator and park visitors by avoiding conditions adverse to both. Where water resources are of high value, additional protection may be afforded by avoiding construction of roads and pads during seasonally wet periods.

Overlapping NPS authority is sometimes used to back up state resources where the staff of state agencies, charged with a broad range of responsibilities and concerns, are spread thin. For instance, on the day that the surface casing for a well in Padre Island National Seashore is run and cemented, state inspectors for the area may have a dozen or more other active drilling sites, compliance responsibilities for several thousand well sites, and so on. The National Park Service wants 100 per cent monitoring/ inspection of casing and cementing activities. Although state inspectors may be unable to be present, the National Park Service can commit staff resources to ensure that the casing and cementing are completed to NPS standards.

Conclusion

My opinion based on some 18 years of experience with oil and gas development activities on lands managed by the National Park Service is that "exploration wells" have the potential, either individually or cumulatively, to have a substantial effect on water resources of the Delaware River Basin, and in particular, that these projects have the potential to cause "measurable change" to the exceptionally high quality of the basin's Special Protection Waters.

The "place" factor in the "time, place, and manner" equation is most important in terms of ability to protect an environmental resource such as water. The risks created by a poorly selected location cannot easily be overcome with even the best operational methods or timing. Conversely, proper site selection can do much to mitigate the effects of accidents or environmentally unsound practices.

Reverences

36 CFR §9.41. Code of Federal Regulations, Title 36 Chapter 1, Part 9, Subpart b: National Park Service, Minerals Management, Non-Federal Oil and Gas Rights, Operating standards.

36 CFR §9.41(a). Ibid. Section 9.41(a)

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Testimony of Erik Silldorff, Ph.D., Aquatic Biologist, Delaware River Basin Commission
Areas of Expertise: Aquatic Ecology, Ecological & Water Quality Assessment, Statistics

In the Matter of Delaware River Basin Commission Adjudicatory Administrative Hearing on Natural Gas Exploratory Wells
November 23, 2010

Overview

As a Ph.D. biologist with 18 years of professional experience, it is my view that exploratory well drilling projects within the drainage area of Delaware River Basin Special Protection Waters pose a substantial risk to the water quality and ecological condition of these waterways; this risk is expected to increase commensurately with the number of exploratory well projects. In this testimony, I describe many of the unique and sensitive attributes found within the Special Protection Waters region, including the high water quality which motivated the anti-degradation protections for the Delaware River and a number of its tributaries. I then review the multiple mechanisms by which exploratory well projects elevate the risks from environmental damage to these Special Protection Waters, and how the combined risks could lead to substantial effects on the resources, particularly when expanded in scale above the current level of activity. The juxtaposition of highly sensitive resources in an area that could see unprecedented industrial activity through exploratory well projects highlights the need for appropriate environmental safeguards, including review by the DRBC. Such safeguards provide a means to minimize the risks from exploratory wells, risks that could undermine the considerable efforts across the preceding decades to prevent degradation of these resources.

A. Physical Geography and Regulatory Context

The Delaware Basin covers an area of approximately 13,600 mi^2 across five states (NY, PA, NJ, DE, and MD). Within this area, the Marcellus Shale spans the drainages of the upper Schuylkill River, the upper Lehigh River, and the Lackawaxen River in PA; the Neversink River, the Mongaup River, and both the East and West Branches of the Delaware River in NY; as well as numerous direct tributaries to the Delaware River within this region of the basin (see Map 1). Among these drainages overlapping the Marcellus Shale, only the Schuylkill River falls outside of the area subject to DRBC's Special Protection Waters regulations. All other regions where the Marcellus Shale and the Delaware Basin overlap are included in the DRBC's Special Protection Waters jurisdiction, with an areal overlap of 4,669 mi^2 (69% of the total Special

Protection Waters drainage area of 6780 mi^2). Thus, the Marcellus formation underlies the large majority of the Special Protection Waters drainage for the DRBC. Other natural gas bearing formations that could be targeted for development (e.g., the Utica shale) extend beyond the Marcellus within the drainage area of the Special Protection Waters.

Within the Delaware River Basin's Water Quality Regulations, the Special Protection Program (§ 3.10.3 A.2) serves as the dominant component of DRBC's antidegradation program. Under these regulations, the quantitative measurement of water quality for both tributaries and the mainstem Delaware River at the time of designation is established as the benchmark for water quality regulations and assessments. These "existing" water quality conditions, codified in the regulations, are typically more protective of water quality and ecological conditions than the traditional effects-based water quality criteria promulgated by the DRBC, the states, and the federal government. For instance, DRBC's effects-based criterion in Zone 1D for in-stream Fecal Coliform is 200 cells/100 mL while Special Protection Waters benchmarks range from 20 to 100 cells/100 mL (*see* § 3.20.5 C.8 and Tables 2C, 2E, and 2I). Likewise, DRBC's effects-based criterion in Zone 1D for in-stream Dissolved Oxygen ranges from 4.0 to 5.0 mg/L while the Special Protection Waters benchmarks range from 7.9 to 8.5 mg/L (§ 3.20.5 C.1 and Tables 2C, 2E, and 2I). Furthermore, the intent and function of the Special Protection Waters regulation is to maintain water quality at the levels measured at the time of designation, unlike typical water quality programs operated through DRBC or the states where water quality is allowed to decline to the point where ambient or forecasted water quality simply attains the numeric criteria. Thus, the DRBC's Special Protection Waters regulations operate in a manner similar to the state and federal antidegradation programs under the Clean Water Act.

B. Delaware River Conditions

The Delaware River is an exceptional river within the eastern United States. The Delaware remains un-dammed on its mainstem for the 330 miles from the Atlantic Ocean to the confluence of its East Branch and West Branch at Hancock, NY, with free-flowing access to the principal headwaters extending an additional 60 miles via the East Branch Delaware and Beaver Kill rivers. As such, it is among the largest un-dammed rivers east of the Mississippi and one of the only large river systems draining to the Atlantic seaboard of the United States without a dam on its mainstem (Benke and Cushing 2005).

The free-flowing condition of the Delaware provides critical functions for the ecology of this large river. The most fundamental of these functions is the free access for migratory fish. The non-tidal Delaware River currently maintains strong populations or runs of many declining

migratory fishes, including American eel, American shad, alewife, and blueback herring. The Delaware thus serves as an important component in the overall maintenance of these economic fisheries as well as the conservation of these fish species (ASMFC 2007, ASMFC 2009). Through the maintenance of these migratory fishes, the undammed river provides further indirect benefits to the ecosystem, as well. For example, recent evidence suggests the most dominant species of freshwater mussel in the Delaware River (*Elliptio complanata*) prefers American eels as its obligate host for juvenile glochidia (W.A. Lellis, USGS, *personal communication*). The free-flowing condition of the Delaware River, through its abundant eel population, therefore likely contributes to the Delaware's high densities of freshwater mussels, further maintaining the function and composition of the river's ecosystem in a form similar to what existed hundreds of year ago (Lellis 2001, Lellis 2002).

Lellis's surveys have also documented the persistence of 9 native mussel species in the mainstem Delaware River, indicating the Delaware remains a northeastern Atlantic slope stronghold for native mussels that are largely declining regionally and nationally (Bogan 1997, Strayer and Jirka 1997, Strayer et al. 2004, Nadeau 2008). These recent surveys on the Delaware River identified previously undiscovered populations of the dwarf wedgemussel (*Alasmidonta heterodon*) in the mainstem river between Hancock, NY, and Callicoon, NY, thus expanding the range of known populations of this Federally Endangered species within the Delaware Basin (Lellis 2001, Lellis 2002). It is significant to note that one of the largest remaining populations of *A.heterodon* lies within the Neversink River (USFWS 2007), located within the drainage area of the Special Protection Waters and underlain by the Marcellus Shale. The upper mainstem populations also lie in the region where the Special Protection Waters overlaps the Marcellus Shale. Thus, a diverse and imperiled mussel fauna occupies the central area within Special Protection Waters and could be affected by any negative environmental impacts from exploratory natural gas development projects in shale formations underlying the area.

High densities of freshwater bivalves can strongly affect water clarity and suspended materials (Caraco et al. 2006, Strayer et al. 2008). Thus, while the diversity and abundance of mussels benefits from the intact ecological conditions of the mainstem Delaware River and its headwater tributaries, the high water quality in the river likely is also enhanced by the high density of these large-bodied filter-feeding mussels.

The extraordinary quality of water within Special Protection Waters streams and rivers can readily be understood through a comparison of water quality data to surface water quality criteria. For instance, total dissolved solids (TDS) is a broad measure of the solid material contained in water but which passes through a standard filter (Eaton et al. 2005). Because of aesthetic issues with drinking water, water quality criteria for TDS have been recommended at 500 mg/L (USEPA 1986). Recent research and monitoring results indicate that high TDS likewise can negatively affect aquatic organisms (Pond et al. 2008), with states such as

Pennsylvania moving to protect both drinking water supplies and aquatic life with revised TDS requirements and criteria that closely match the 500 mg/L criteria recommended by the USEPA (PA Bulletin 2010). Current DRBC regulations likewise include a TDS water quality standard of 500 mg/L basin-wide, and also provide for a maximum increase in TDS of 33% over background by any proposed discharge (or group of discharges) as a means of minimizing effects on aquatic biota and keeping TDS at the more dilute levels seen through much of the basin (DRBC 2008a). Both the existing water quality defined by Special Protection Waters regulations and recent unpublished data (DRBC 2006-2009) indicate that TDS in Special Protection Waters streams and rivers typically ranges between 50 mg/L and 100 mg/L, five-to-ten times below the common 500 mg/L TDS criteria (DRBC 2008a, DRBC *unpublished data*). Thus, the Delaware River and its Special Protection Waters tributaries currently maintain concentrations of dissolved solids (including salts and other compounds) far below EPA-recommended criteria.

Nutrient concentrations in Special Protection Waters likewise are low relative to recommended or adopted nutrient criteria. This condition is notable given the high nutrient levels pervasive in waters throughout the United States and the water quality impairments caused by these excess nutrient levels (Dubrovsky et al. 2010). Among the DRBC and its four primary basin states, only New Jersey has numeric nutrient criteria for streams and only for phosphorus (100 μg/L TP; NJDEP 2010). In 2000 and 2001, the USEPA recommended candidate nutrient criteria for streams based solely on the distribution of nutrients at ecoregional reference sites; in the four ecoregions covering the Delaware River, total phosphorus recommendations ranged from 10 μg/L to 37 μg/L while total nitrogen recommendations ranged from 0.31mg/L to 0.71 mg/L (USEPA 2000a, USEPA 2000b, USEPA 2000c, USEPA 2001). Given these remarkably low recommendation from the USEPA, many states, tribes, and interstate agencies have sought to develop effects-based nutrient criteria rather than simply adopting the reference distribution-based criteria from the USEPA (USEPA 2008). New York is among the states developing such effects-based criteria, with recently-developed candidate criteria ranging from 30 to 65 μg/L for total phosphorus, and 0.7 mg/L for total nitrogen (Smith et al. 2006, Smith and Tran 2010). Yet the observed concentrations of nutrients in the mainstem Delaware for the Marcellus region have typically been around 30 μg/L total phosphorus and 0.50 mg/L total nitrogen (DRBC 2008). Recent results from tributaries around the Delaware Water Gap National Recreation Area (all within SPW; the PA tributaries overlapping Marcellus region) likewise indicate low nutrient concentrations, with median values around 20 μg/L for total phosphorus and 0.30 mg/L for total nitrogen (Hickman and Fischer 2007). Thus, both the mainstem Delaware River and SPW tributaries typically maintain nutrient concentrations in the range of the various recommended criteria, and far below the only established nutrient criterion in the basin of 100 μg/L total phosphorus (New Jersey). Again, for a water quality parameter central to maintaining the quality and health of the Delaware River and its tributaries, data indicate that the Delaware River maintains a quality comparable to regional reference conditions. Indeed, the Delaware River

was selected as a regional reference site for the 2008-2009 National Rivers and Streams Assessment by USEPA (J. Kurtenbach, *personal communication*).

This combination of extraordinary qualities in a single river system helps maintain a high level of overall ecological health and diversity within the Special Protection Waters streams and rivers. This ecological health has been recognized, in part, through the disproportionate designation of streams in the region with the states' highest levels of anti-degradation protections. As noted above, such ecological distinction can also be seen in the high density of freshwater mussels in the Delaware River and the maintenance of the regional diversity of this increasingly imperiled group of organisms. Recent surveys of the fish community in the Delaware Water Gap National Recreation Area and the Upper Delaware Scenic & Recreational River likewise document the persistence and relatively strong populations of many native fishes (Horwitz et al. 2008).

The brook trout (*Salvelinus fontinalis*) is another species that provides evidence of the relatively intact ecological conditions of Special Protection Waters and their tributaries. While declining through much of its native range in the United States, brook trout populations within the Special Protection Waters watershed have persisted, and these populations remain vital for the conservation of this species both within the Delaware Basin and within the states of Pennsylvania, New Jersey, and New York (Hudy et al. 2008). Brook trout are noted for their sensitivity to elevated water temperatures, among other parameters, with forest clearing and riparian disturbance playing a key role in the decline of this species within the mid-Atlantic region (e.g., Stranko et al. 2008)

The extraordinary condition of the Delaware River is further demonstrated by its native aquatic plant community, with many species of aquatic plants continuing to thrive in the Delaware River (TNC 1994). Most notable among these is the single species from the family Podostomaceae within the United States, *Podostemum ceratophyllum* (common names of threadfoot or riverweed), a state-listed species across much of its distribution including New York (state-threatened; Young 2010). The Delaware River population remains the single largest remaining *Podostemum* population in the region, with a limited number of additional populations in Special Protection Waters tributaries (Munch 1993). This fast-water obligate plant is particularly relevant because of its acute sensitivity to mining activity, with complete elimination of the species in the Lehigh River and other Pennsylvania streams below the first mine drainage stream (Munch 1993). Thus, *Podostemum* may be among the most sensitive species to industrial activity within the Delaware basin, with the most abundant populations of this sensitive indicator within the overlapping areas of Marcellus Shale and Special Protection Waters.

More broadly, biological surveys of stream conditions within the Special Protection Waters region document the relatively pristine status of these streams' ecological structure. Such

surveys are largely based on collections of benthic invertebrates, with the overall diversity across the Delaware Basin documented at more than 800 species (Bilger et al. 2005). These surveys have found the invertebrate communities to be diverse and abundant, maintaining a complement of sensitive species comparable to the highest quality reference streams for the region (DRBC 2008b, NYSDEC 2008, NJDEP 2009, NYSDEC 2010, DRBC 2010, PADEP 2010).

The Delaware River thus remains an exceptional river within the eastern United States, supporting diverse population of native mussels, fishes, plants, and invertebrates. Both its free-flowing status and its high water quality play critical roles in supporting and maintaining this healthy ecological condition. Moreover, many of these species are declining or imperiled within the larger region in which they historically thrived, further demonstrating the vital role the Delaware basin populations play in their overall conservation and underscoring the need to maintain the exceptional conditions upon which these species depend. The DRBC's Special Protection Waters program, adopted in 1992 (for control of point source discharges) and 1994 (for control on non-point source discharges), is the centerpiece of current protection efforts, but the region and the nation have invested in conserving the qualities of the non-tidal Delaware River for more than three decades, beginning with the designation of over 100 miles of the upper and middle Delaware to the federal Wild & Scenic Rivers System in 1978. Development of natural gas resources underlying the Special Protection Waters region must be undertaken deliberately and with great care if the qualities for which the region's exceptional water resources have been managed for more than three decades are to be protected.

C. Risk to SPW Resources Posed by Natural Gas Development

The exploration and development of natural gas shales, made possible by the application of horizontal drilling and hydraulic fracturing technologies, represents a new industrial activity for the Delaware River Basin. During the exploration phase alone, both novel landscape activities and expansions of existing human uses will occur. These activities and uses include:

- grading of exploratory well site pads
- construction of drilling pits
- storage of fuel and chemicals in previously undeveloped locations
- operation of heavy machinery
- improvement or construction of access roads
- clearing of natural vegetation, including forests
- mixing, use, and re-capture of drilling fluids

- transport of hazardous materials
- storage and disposal of deep-well drill cuttings
- direct interconnection of formerly isolated geologic formations
- diversion of surface waters

Each of these activities involves risks of environmental degradation affecting water resources. Such degradation can be direct (e.g., release of a toxic material into a stream) or indirect (e.g., hydrologic alterations from roads and site development), but the effects from these activities on water quality and aquatic organisms are well-established in the scientific literature. Below, I briefly review the mechanisms by which such environmental impacts can occur to document the risk that the development of natural gas exploratory wells may have a substantial adverse effect on DRBC's Special Protection Waters.

As I review these effects, it is important to note that the likelihood of environmental damage and ecological impacts increases with the extent of exploratory well drilling. For the majority of the impacts identified herein, limited exploratory well activity leads to a relatively low risk that environmental damage will be measureable and significant. Such low risk arises from two processes. First, the magnitude of the human alteration remains low for a small number of activities. Second, the likelihood of a single low-probability event (e.g., catastrophic spill) occurring with only a small number of actions remains low. Yet with increased activity, both of these processes increase. First, the magnitude of human alteration increases both locally and regionally, leading to greater effects within smaller watersheds and increased likelihood that effects will promulgate to larger streams and rivers. Second, low-probability events become increasingly likely to occur as the number of actions increases. To date, the exemptions allowed under the DRBC Supplemental Executive Director Determination (14-June-2010) provide opportunities for approximately twelve exploratory wells within the Delaware Basin. My understanding is that the actual number may be fewer. By contrast, the number of exploratory wells that could be developed and drilled in the Delaware basin without DRBC review in the absence of this Supplemental Determination would be unlimited and is not known. An increase by one to two orders of magnitude beyond the current activity would be accompanied by a commensurate increase in the risk to water quality and ecological conditions, with such an expansion possible if the exemption from DRBC review were to be extended indefinitely for all exploratory wells.

Site Preparation: Early in the exploration process, construction activities on the well-pad sites, including site grading and drilling pit excavation, increase the likelihood of higher sediment yields into receiving streams of DRBC's Special Protection Waters area (Wolman and Schick 1967, Williams et al. 2008). Such sedimentation within stream channels leads to multiple direct and indirect effects on water quality and biological communities (see reviews by Waters 1995, Wood and Armitage 1997). Reduced light penetration, increased bed scour, and direct

deposition on benthic substrates negatively affect primary producers, the organisms at the base of these stream food webs. Sediment deposition can affect habitats and food quality of benthic invertebrates, and can cause direct fouling on filtering structures and on respiratory structures for different species. For fish, increases in fine sediments negatively affect spawning habitats and the survival of immature fish stages associated with sediments. Increased sediments also cause fouling of gills, and affect food quality and foraging efficiency. Increased sediment yield from exploratory well pad construction therefore provides many mechanisms for possible water quality changes, habitat alterations, and ecological effects throughout the aquatic food web.

Site Access: The expansion and improvement of the road network to transport equipment and materials to and from exploratory well pads provides multiple pathways for environmental contamination and degradation to Special Protection Waters. First, the roads themselves lead to negative effects on water quality and ecological conditions through altered hydrology, increased sediment yields, increased hydrocarbon and metals penetration into the landscape, altered stream channel dynamics, increases in water temperature, increased salt concentrations, interruption of dispersal pathways, and other mechanisms (Forman and Alexander 1998, Trombulak and Frissell 2000). Second, the development of exploratory wells will lead to increased industrial traffic and increased transport of fuels and chemicals into the region, thus increasing the probability of accidental spills of harmful compounds into surface waters and surficial aquifers (e.g., Hartle 2006). Third, road networks and increased road traffic elevate the risk from the introduction and spread of invasive species, putting native species and habitats at greater risk for ecological change and species replacements (Trombulak and Frissel 2000, Jodoin et al. 2008).

Operation and Maintenance of Exploratory Wells and Well Pads: The suite of industrial chemicals used in the operation and maintenance of exploratory wells and well pads includes many compounds with acute and chronic effects on a broad range of aquatic organisms (Cranford et al. 1999, Barlow and Kingston 2001, DRBC 2008a, USEPA 2009, Colburn et al. *in press*, Emofurieta and Odeh *in press*). The storage and use of fuels and industrial chemicals on drilling sites increases the risks that these materials will be released into surface waters. Recent widespread problems with fuel and chemical storage (e.g., MTBE groundwater contamination; see USEPA 2005) indicate that the risks from storage of such chemicals have not been eliminated. Moreover, the drilling of natural gas wells in shales involves the mixing, use, and re-capture of industrial chemicals on-site, further increasing the risk of accidents. The flammable and explosive potential from pressurized natural gas likewise presents a risk for catastrophic events, the severity of which may be magnified by the close proximity to industrial chemicals. The suite of these on-site activities further increases the risk of release of harmful chemicals into the surrounding landscape, leading to elevated risks to Special Protection Waters and the biological resources inhabiting them.

Storage and Disposal of Drilling Wastes: The storage and disposal of drill cuttings also poses a risk to Special Protection Waters. The combination of poorly weathered sediments, natural accumulations of metals and radioactive materials in formation rocks, and the addition of materials to assist in drilling operations provides a source of new material that is expected to differ strongly in composition and concentration compared to surficial soils in the Special Protection Waters region (see Resnikoff 2010). Weathering of these materials provides an additional source of environmental change, with documented effects from drill cuttings in other aquatic environments highlighting the potential for these materials to affect both water quality and the biota of Special Protection Waters (e.g., Trannum et al. 2010).

Hydrologic Alteration: The need to protect in-stream flows highlights an additional risk from the water withdrawals for exploratory wells (up to 100,000 gallons per well). The maintenance of in-stream flows, not solely during low flow periods but throughout the year and throughout the hydrologic cycle, has increasingly been recognized as a vital link in maintaining the ecological health of aquatic communities (Arthington et al. 2006, Acreman and Ferguson 2010). Seasonal flow cues, habitat protections at low and high flows, elimination of rapid flow ramping, and durations for low-flow and high-flow events are all important components to the flow regime that, if altered, can lead to negative effects on water quality and the living aquatic resources inhabiting streams and river. Thus, indiscriminate abstraction of water from Special Protection Waters streams and their tributaries has the potential to alter the hydrology of these systems and thus negatively affect these aquatic resources (e.g., Freeman and Marcinek 2006, Carlisle et al. 2010).

Invasive Species: In addition to the effects on hydrology, the diversion of surface water for exploratory wells creates a risk for invasive species introductions and spread. The Delaware River basin now harbors populations of the invasive diatom alga, *Didymosphenia geminata*, commonly known as "Didymo" or "rock snot" (NYDEC 2010, PFBC 2010). This stalked diatom can dominate the periphyton community in streams and can foul the stream substrate, with implications for the entire ecological food web (e.g., Shearer et al. 2007, Gillis and Callifour 2010). A potentially even more serious threat is the discovery of the golden alga, *Prymnesium parvum*, within Pennsylvania (Renner 2009). This species of algae thrives at higher TDS concentrations, a particularly high risk in areas with extensive mining activity. And most alarmingly, blooms of *P.parvum* can cause widespread mortality among many aquatic life forms from the production of toxins (e.g., Reynolds 2009). The use of water diversion equipment in connection with well drilling throughout the Special Protection Waters region of the Delaware Basin will increase the likelihood that one or more invasive species, such as Didymo or *P.parvum*, will be transported to new areas where the invasives may cause important shifts in the ecological systems.

In conclusion, exploratory well drilling both heightens the risks via expanded human activity and creates novel environmental threats to water quality for both the tributaries and the mainstem Delaware River designated as Special Protection Waters. When combined, these individual risks lead to a cumulative probability of impacts that is not trivial. Should these risks be maximized through inadequate oversight and insufficient regard for the environmental hazards, I believe the potential exists for substantial impacts to water quality of Special Protection Waters. Because the risk of substantial effects directly attributable to activities associated with exploratory well drilling or operations is manifest, a regulatory regime is needed to: (a) reduce the risks to the extent possible; (b) institute pre-and post-development monitoring requirements in order to identify measurable adverse effects and institute measures to stop degradation before it becomes irreversible; and (c) ensure that operators responsible for adverse effects have the resources necessary and the legal obligation to mitigate them.

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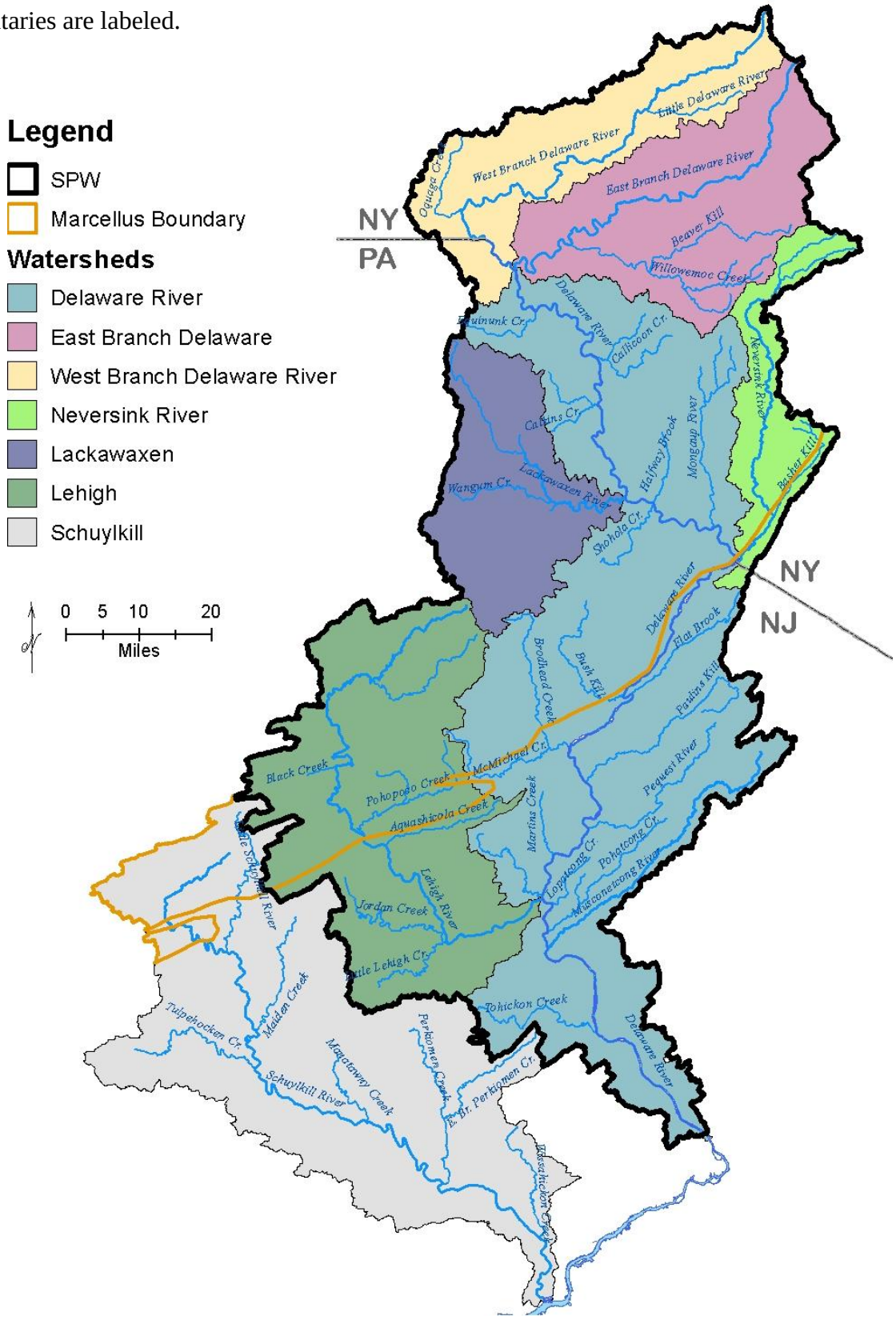
Map 1. Marcellus Shale and Special Protection Waters Areas within the Delaware River Basin. Major rivers within the region are highlighted with separate color schemes, and significant tributaries are labeled.



Expert Report on the Relationship Between Land Use and Stream Condition (as Measured by Water Chemistry and Aquatic Macroinvertebrates) in the Delaware River Basin

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I. Link between land use and water chemistry – Although differences among sites can be a reflection of underlying geology, soils and vegetation covering the land, changes in land and water use also can change the concentrations of major ions, nutrients, and organic compounds, and introduce elements or compounds to a waterway that were not there naturally.

The link between water chemistry and underlying geology, soils and vegetation is well known, and covered in most limnology and stream ecology texts (e.g., Wetzel 2001 and Allan and Castillo 2007). Our research in the drinking water watersheds of New York City, which include the East and West Branches of the Delaware as well as the Neversink River and lower Hudson River tributaries (SWRC 2008), identified a number of differences in water chemistry among groups of sites that illustrate the variation in water chemistry (i.e., base cations) that occurs naturally. The gray dashed line in Figure 1 is a regression that describes the relationship between base cations (e.g., calcium, magnesium, sodium, potassium) and alkalinity (acid neutralizing capacity, primarily bicarbonate) for sites in the Catskill Mountains that are forested (>97% forest cover in the EBD, WBD, NRD) and do not have known point sources. It shows the consistent, positive relationship between alkalinity and base cation concentration - base cation concentration increases as alkalinity increases. The range of values along this line reflects differences in underlying geology, soils, and vegetation that occur naturally between basins and sub-basins across the Catskill Mountains (e.g., consistently low concentrations in the Neversink River, higher and variable concentrations in the West and East Branches of the Delaware River). Data points above the gray dashed line in Figure 1 reflect increases in cation concentration relative to alkalinity that is presumably a result of anthropogenic land and water uses such as salts used to deice roads, fertilizers applied to fields or lawns, or treated sewage discharged to land or waterways.

When examining changes in differences in water chemistry among sites, we have found that one of the best single predictors of these changes is often % forest cover in the watershed. As the percentage of upstream forests is reduced (i.e., converted to other land uses and covers), we have observed higher values for a number of parameters that are a reflection of changes in cations and anions such as conductivity, sodium, potassium, calcium, magnesium, and chloride as well as changes in nitrogen and phosphorus (Figure 2). We have also observed higher concentrations of elements or compounds that are directly or indirectly waste products or residuals from human activity or human-related land uses. For example, sulfate is often associated combustion engine exhaust, motor oil, and tires, and its concentration tends to be higher when road density is higher (Figure 3).

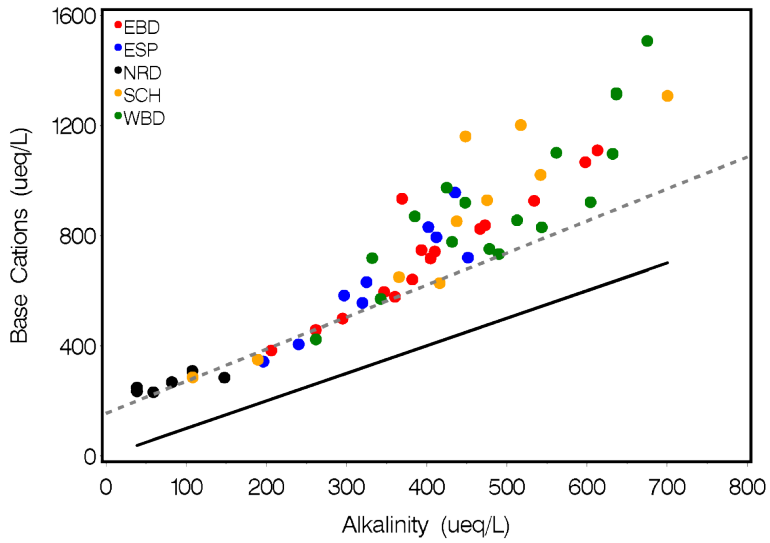

Fig. 1. Plot of alkalinity and base cation concentration for streams draining the Catskill Mountains. This includes Delaware River sites in the East Branch (EBD) and West Branches (WBD), and the Neversink River (NRD) as well as sites in Rondout (NRD), Esopus (ESP) and Schoharie (SCH) Creeks. The gray dashed line is a regression between base cations and alkalinity for forested sites (>97% forest cover in the EBD, WBD, NRD) that do not have known point sources. The solid black line is the 1:1 line.

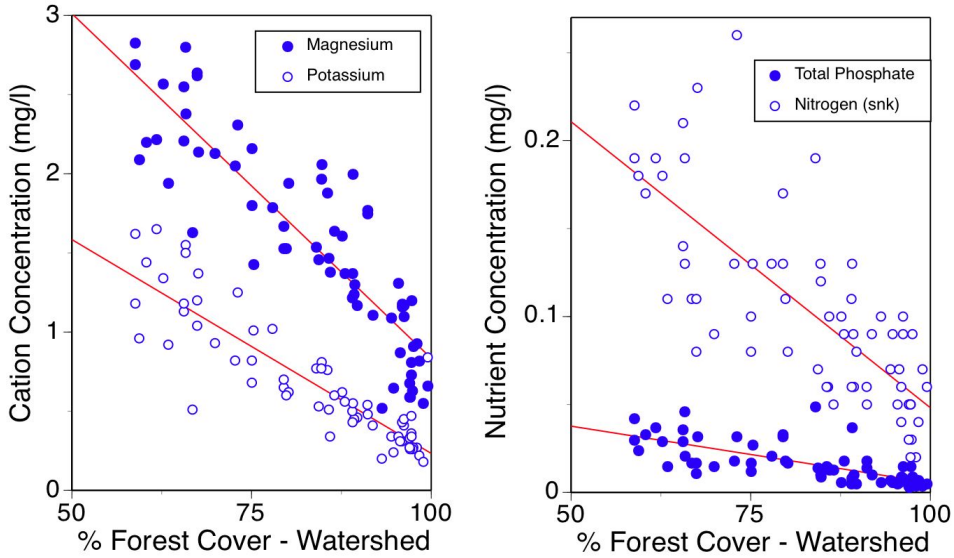

Fig. 2. Plot of cation (magnesium and potassium) and nutrient (total phosphorus and nitrogen) concentrations versus % forests cover at the watershed scale for streams draining the Catskill Mountains. This includes Delaware River sites in the East Branch and West Branches, and the Neversink River as well as sites in Rondout, Esopus and Schoharie Creeks.

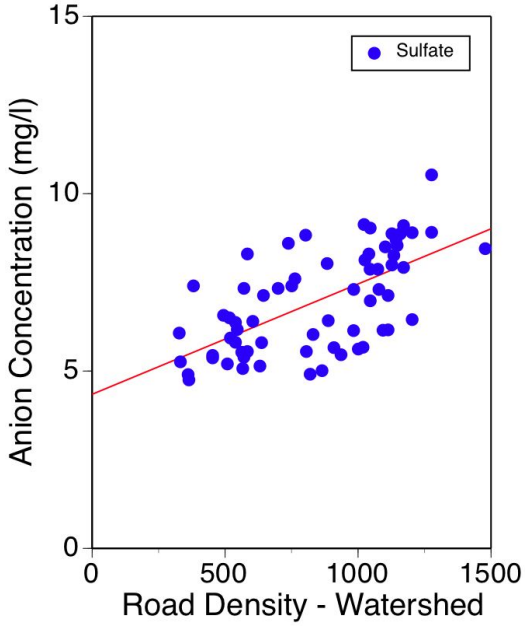

Fig. 3. Plot of anion (sulfate) concentrations versus road density at the watershed scale (m per 100 sq. km) for streams draining the Catskill Mountains. This includes Delaware River sites in the East Branch and West Branches, and the Neversink River as well as sites in Rondout, Esopus and Schoharie Creeks.

II. Stream macroinvertebrates as indicator of water quality

Stream macroinvertebrates (primarily insects, but also other invertebrates such as aquatic worms, crayfish, and molluscs) have provided water quality assessment programs with valuable insight for more than 100 years (Rosenberg and Resh 1993). The presence or conspicuous absence of certain macroinvertebrate species at a site is a meaningful record of environmental conditions during the recent past, including ephemeral events that might be missed by assessment programs that rely on periodic water chemistry samples. Local, state, and federal agencies have developed a wide variety of stream bioassessment protocols that rely on macroinvertebrates. Stream macroinvertebrates are commonly used and widely accepted tools in water quality monitoring programs for a number of reasons.

(1) Most river and stream ecosystems have relatively diverse aquatic insect assemblages (100-200 species), with species from several different orders [e.g., Ephemeroptera (mayflies), Trichoptera (caddisflies), Plecoptera (stoneflies), Coleoptera (beetles), Diptera (true flies)]. Each of these species is to some degree evolutionarily unique; as a result, each potentially possesses different tolerances to changes in environmental conditions. Thus, together, the aquatic insects are a sensitive measure of environmental change and stress.

As an example of stream macroinvertebrate biodiversity, we sampled seven high quality tributaries to the Delaware River near the Water Gap in 2008 and 2009 (Stroud Water Research

Center, unpublished data). Among the seven sites, we identified 236 different macroinvertebrate species or taxonomic groups (i.e., identified to genus or higher taxonomic level and therefore may have represented more than one species), and the number at any one site ranged from 97 to 150 species. Many of these species are known to be pollution sensitive such as the mayflies, stoneflies and caddisflies (i.e., Ephemeroptera, Plecoptera, Trichoptera, or EPT). Among the 236 different species or taxonomic groups identified in the Water Gap tributaries, 105 (44%) were EPT species. The species in these insect orders are often grouped together and used as a pollution indicator (e.g., the number of EPT species, also known as EPT Richness). Because these seven Water Gap tributaries were clean streams draining well forested watersheds with limited anthropogenic activity, each supported a variety of these pollution-sensitive EPT species (43-53 per site) that together represented 37-46% of the macroinvertebrate species identified at a site.

Similar taxonomic richness was observed among Catskill Mountain tributaries in the headwaters of the Delaware River when we sampled 3-6 times between 2000 and 2005 (SWRC 2008, unpublished data). For example, across 15 tributary and main stem sites for the East Branch of the Delaware River, we identified 285 different macroinvertebrate species or taxonomic groups, 117 (41%) of which were pollution-sensitive EPT species. Individual sites had between 84 and 154 species, including 35-60 EPT species (34-47%). Similarly, we identified 287 different macroinvertebrate species or taxonomic groups (including 108 (38%) that were pollution-sensitive EPT species) across 17 tributary and main stem sites for the West Branch of the Delaware River, and 183 different macroinvertebrate species or taxonomic groups (including 73 (40%) that were pollution-sensitive EPT species) across four tributary and main stem sites for the Neversink River.

The same samples used above to describe the biodiversity for stream macroinvertebrate can also be used to describe abundance. For example, the Water Gap tributaries had an average macroinvertebrate density of 6,091 individuals/m^2 (Stroud Water Research Center, unpublished data). The upper Delaware River sites supported higher densities: 21,923 individuals/m^2 among the 15 West Branch sites, 20,981 individuals/m^2 among the 17 East Branch sites, and 15,606 individuals/m^2 among the 4 Neversink sites (SWRC 2008). Thus, the Delaware River and its tributaries support a diverse and abundant macroinvertebrate community that includes many pollution-sensitive species.

III. Response of stream macroinvertebrates to changes in land and water use

In general, concentrations of selected ions, nutrients, and organic compounds increase as forests are converted to other land uses. Concentrations of anthropogenic compounds (e.g., herbicides, insecticides, heavy metals, oil-derived compounds) that are associated in these new land and water uses also increase. For the Delaware River basin, examples of these relationships can be seen in Figures 1, 2, and 3, above.

Parallel changes in macroinvertebrate faunas have also been observed as forests are replaced by other land uses (which often is accompanied by different water uses such as domestic, commercial, and industrial consumption and waste and storm water runoff). Many streams in the

Delaware River basin drain watersheds that are almost completely forested and are high quality (Figure 4), but they already show evidence of stress (e.g., changes in relative abundance but without local macroinvertebrate species extinctions) in response to local changes in land and water use (Figure 5). More intensive changes in land cover and water use are generally accompanied by the loss of pollution-sensitive macroinvertebrate species (Figure 6). In some cases, local land and water use changes have already resulted in moderate to severe impairment of the macroinvertebrate species (i.e., a loss of 50-75% of the pollution-sensitive species). In many cases, the cause of stream degradation is a current activity such as erosion from recently plowed fields or outflow from a poorly functioning wastewater treatment plant. In other cases, present degradation reflects past land use decisions, including how and where changes were implemented, sediment and erosion control practices, and management of wastestreams. For example, most of the anthracite coal field in the Schuylkill River basin have not been actively mined for decades yet many of the streams in contact with the waste piles or mine outflows are currently some of the severely impaired in the basin because they still have excessive acid and metals in the water (Figure 8).

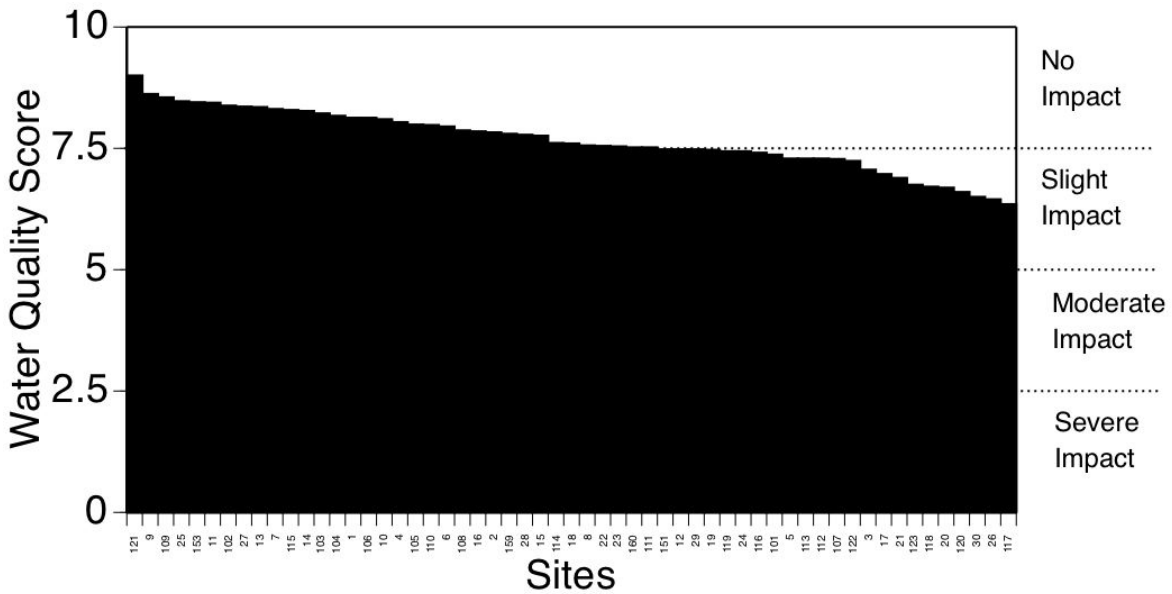

Fig. 4. Plot of Water Quality Score (sorted from highest to lowest) for 57 stream sites draining the Catskill Mountains. This includes Delaware River sites in the East Branch and West Branches, and the Neversink River as well as sites in Rondout, Esopus and Schoharie Creeks.

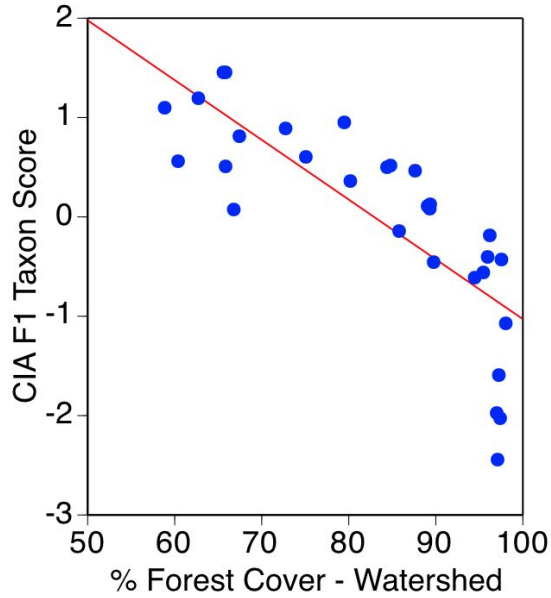

Fig. 5. Plot of macroinvertebrate community structure (as expressed by Co-Inertial Analysis Factor 1) versus % Forest Cover at the watershed scale for 30 stream sites draining the Catskill Mountains. This includes Delaware River sites in the East Branch and West Branches, and the Neversink River as well as sites in Rondout, Esopus and Schoharie Creeks.

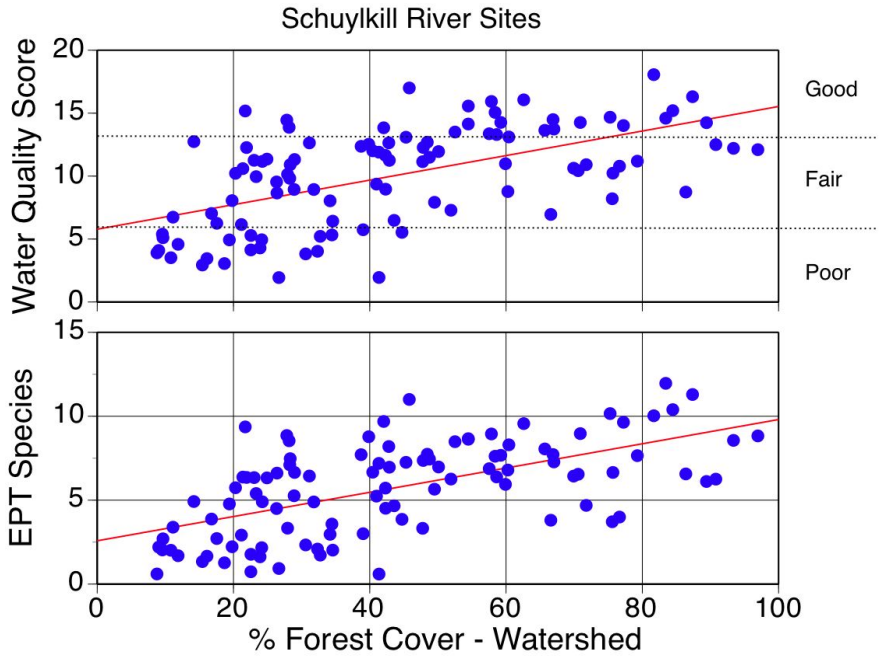

Fig. 6. Plot of macroinvertebrate community structure (as expressed by MAIS Score and EPT Richness) versus % Forest Cover at the watershed scale for 104 sites in the Schuylkill River basin, the largest tributary to the Delaware River.

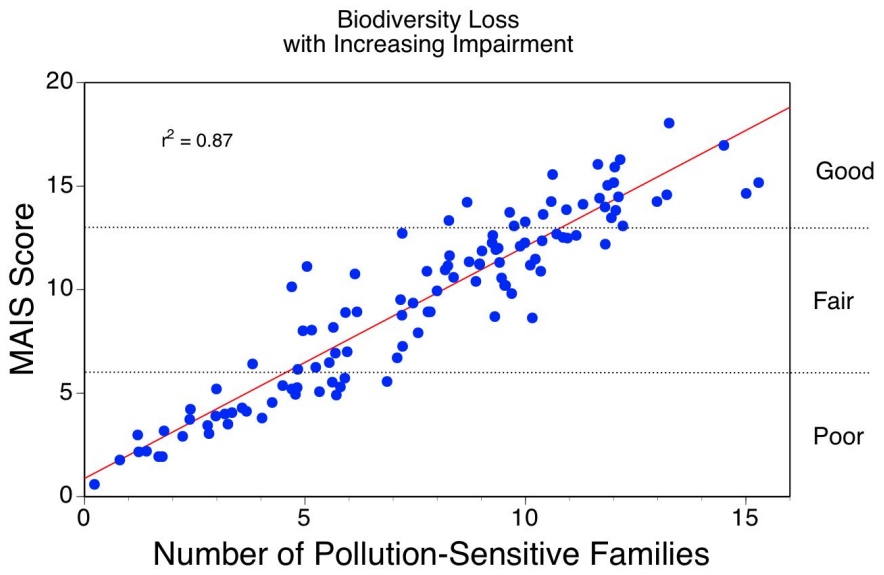

Fig. 7. Plot of macroinvertebrate community structure (as expressed by MAIS Score) versus the number of pollution-sensitive macroinvertebrates in the Schuylkill River basin, the largest tributary to the Delaware River.

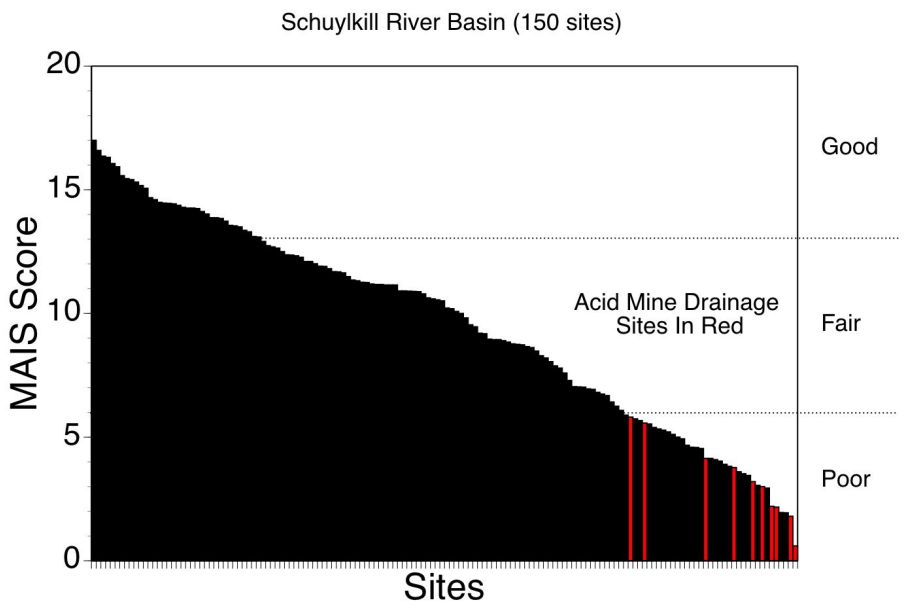

Fig. 8. Plot of MAIS Scores for 150 sites in the Schuylkill River basin, sorted from highest to lowest score. Sites with clear evidence of acid mine drainage are shown in red.

IV. Stream and watershed changes associated with Marcellus Shale exploration and development

The potential for stream degradation associated with Marcellus Shale exploration and development depends on the location and intensity of changes in land cover and water use that may then result in changes in changes in stream habitat, water quality and/or water quantity. Because many of these watersheds are well forested, Marcellus Shale exploration and development are going to result in replacing forests with other land uses. Changes in land and water use may result from the construction, expansion, and maintenance of drill sites, roads, stream crossings, and pipelines as well as additional infrastructure in support of the new industry (e.g., new or modified sites, roads, stream crossings, pipelines, and power lines). This can lead to stream degradation if it results in changes in local hydrology (flood maxima and low base flow, sediment erosion in the stream corridor and in upland areas, warming of the waterways (from reduced shading) as well as the presence or increase in naturally occurring chemicals (silt, salts, naturally occurring radioactive material), chemicals resulting directly from drilling and fracking process, and potential pollutants associated with additional developed lands (directly and indirectly associated with exploration and production) or more intensive use of previously developed lands (e.g., more traffic and people resulting in more road salt, heavy metals, oil-derived compounds).

The effects from land use changes (e.g., converting forest to agricultural, industrial, commercial, or residential uses) on water chemistry and macroinvertebrate communities are well established in areas both within and outside of the Delaware Basin. Based on these scientific studies, impacts to water chemistry and aquatic communities could potentially result from land use changes associated with Marcellus shale exploration and development (e.g., replacing forests with infrastructure associated with or in support of the new industry). As a result, careful review and regulation of land use changes associated with all shale gas well development activity, including exploratory well development, appears warranted to minimize the extent to which the sensitive aquatic resources in the Delaware River basin are affected.

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In the Matter of Delaware River Basin Commission Consolidated Administrative Adjudicatory Hearing on Natural Gas Exploratory Wells

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Overview

The Delaware River is a high quality water source which provides roughly 15,000,000 people, 5% of the United States population, with water from ground or surface water sources in the basin. The Delaware River watershed is also maintained to support aquatic and terrestrial life – plant, animal and microbial species – which also provide ecosystem services for human health but are a major consideration in their own right. Clean and plentiful water resources are necessary to maintain public health, economic activity, recreational and esthetic values, and social and emotional health. Ecosystem health is also predicated on sufficient water quality and quantity to support the web of life. Exploratory Marcellus Shale drilling impacts present water management problems that can threaten both human and ecological health.

This testimony is in two parts. Part I describes the potential impacts to surface and groundwater from exploratory well drilling. Also presented in Part 1 is a peer-reviewed chain of causation model, which is used to support the contention that development of natural gas from the Marcellus Shale has the potential to result in substantial adverse effects on water quality, the environment and public health. Ground-surface disturbances associated with well drilling, including site clearing, and the construction of access roads, drill pads and impoundments, can produce impacts associated with stormwater, erosion and sedimentation of surface waterways, which in turn may lead to higher levels of water turbidity, total dissolved solids, conductivity and salinity. Increases in water turbidity are associated with increases in gastro-intestinal illnesses, even if water is treated to US EPA Safe Drinking Water Act (SDWA) standards. In addition to the impacts associated with surface activities are those associated with deep well drilling. Wells drilled to depths of 7,000 to 8,000 feet to reach the Marcellus formation create pathways for the migration of naturally-occurring contaminants into usable quality aquifers, and involve the disposition on the surface of drill cuttings and formation waters that also may contaminate ground and surface water. Contaminants associated with natural gas drilling in the Marcellus include toxic heavy metals and elements, organic compounds, radionuclides and acid producing sulfide minerals, and natural gases and sulfide producing gases, which can threaten surface and groundwater sources.

The cumulative environmental and pollution impacts from oil and gas drilling operations are significant in areas of oil and gas exploration across the country. Exploration for and production of oil and gas have caused detrimental impacts to soils, surface and groundwaters, and ecosystems in the 36 producing states in the United States and thus, in my view, pose a threat to public and ecological health.

A number of the impacts associated with oil and gas development generally are also associated with exploratory wells. Although it is unclear that even a strong regulatory program can prevent these adverse effects, in my view, the risk of damage to water resources and the environment should be reduced to the extent possible through mandatory use of best practices; ground and surface water quality monitoring to facilitate the detection and measurement of adverse effects; and the mandatory remediation by operators of any environmental damage caused by spills or other releases of contaminants from drilling sites.

Part II of this testimony is a presentation and analysis of violations of state oil and gas act regulations for the States of Pennsylvania, West Virginia and Utah. Violations data are important indicators of spills, leaks, erosion and sedimentation problems, incidents and accidents, and intentional and unintentional waste scattering and pollution problems associated with gas and oil drilling and extraction activities. Patterns of violations from oil and gas drilling operations include encroachment on wetlands and sensitive habitat, failure to restore sites following drilling and construction activities, improper erosion and sedimentation controls, improper well casing, inadequate pollution prevention, spills of drill cuttings/sediments/wastewater/and “unspecified materials” (a term used by regulators in describing spills and other violations), and failure to plug wells. These violations are frequent in Pennsylvania and the other states analyzed. All of these violations may occur in connection with the development of exploratory wells. These data and their analysis strongly suggest that exploratory drilling in the Marcellus Shale formation is likely to be accompanied by some degree of contamination of surface and/or groundwater and that regulatory controls to protect water resources and the public health are warranted, not only to minimize the risks of surface and ground water contamination, but to ensure that adverse impacts from exploratory drilling, when they occur, are measured and remediated. The fact that the Commonwealth of Pennsylvania makes no distinction between exploratory and production wells in applying a multitude of state oil and gas regulatory requirements supports this contention.

Part I. Public Health and Ecosystem Impacts of Exploratory Marcellus Shale Formation Well Drilling and Analysis

The drilling of exploratory wells into the Marcellus formation at depths of 7000 – 8000 feet below the surface of the earth, is a highly industrialized process with numerous sub-operations. Risks to water resources are associated with ground-surface aspects of the activity as well as with the well drilling itself, including disposition of drill cuttings and formation fluids. These risks are discussed in turn below.

Potential impacts associated with surface activities. The cumulative environmental and pollution impacts from oil and gas operations are significant in oil and gas exploration regions across the country (Otton et al., 2002). Pollution impacts to soils, surface and groundwaters, and ecosystems in the 36 producing states in the United States have been caused by exploration for and production of oil and gas (Richter and Kreitler, 1993; Kharaka and Hanor, 2003).

Ground surface disturbances associated with drilling of natural gas exploratory wells include but are not limited to site clearance of several acres per well, construction of access roads, and other land modifications (Kharaka, Y.K. and Dorsey, N.S., 2005). Generally, a driller needs to develop or improve access roads for transporting heavy drilling equipment, power supplies, fuel, cement and strings of well pipe and casings to the drilling site. Additionally a pad area is created, generally 3 to 5 acres in size, to accommodate one or more wellheads; and pits are constructed for holding fresh water, drill cuttings, formation water and drilling muds. Site preparation involves clearing the land of trees, shrubs and other vegetation and laying gravel over the surface of the roads and well pad. Site clearance and truck traffic combine to promote erosion. This puts soil sediments into water that runs off as stormwater. Increased sediment in water increases water turbidity, which has been shown to be associated with increases in gastrointestinal disorders (Egorv A. et al., 2003; Gaffield et al., 2003; Monis, RD et al., 1996; Schwartz et al., 1997).

Heavy metals, oils, other toxic substances and debris from drilling area traffic and spillage also may be absorbed by soil and depending on their solubility,

transported into the groundwater or vadose zone horizons (unsaturated soils between the ground surface and the water table) (Hemond, H. and E. Fechner-Levy. 2000). Pesticides and fertilizers used along roadway rights-of-way and adjoining land may pollute surface waters and ground water when they filter into the soil or are blown by wind from the area where they are applied (US EPA, 1995).

Part II of this report on violations shows that erosion and sedimentation violations on both Marcellus and non-Marcellus well sites are a common occurrence. Accordingly, not only are construction and post-construction stormwater and sediment and erosion controls necessary to prevent the transport of soil and contaminants from drilling sites to surface waters (Viel, 2010), but in my view monitoring and remediation requirements are also essential to detect and prevent lasting damage to the environment, including water resources, in the event that precautionary practices fail.

Potential impacts associated with drilling. The wellbore can be a conduit for the migration of natural gas and contaminants to usable-water-bearing zones. Oil and gas wells can develop leaks of natural gases and sulfide contaminants along the casing, either during production or years after production has ceased and a well has been plugged and abandoned (Dusseault, M.B. et al., 2000). Some of the gas may enter shallow aquifers, where traces of sulfurous compounds, organic compounds and heavy metals, including toxicants, can make groundwater non-potable, or where the methane itself can cause effects in well systems and tap water, including gas locking of household wells, and gas entering household systems that can be released when the tap is turned on (Dusseault, M.B. et al., 2000). Methane gas in water can be an explosion hazard, especially for households that rely on private wells. In “Why Oilwells Leak: Cement Behavior and Long-Term Consequences” Dusseault and co-authors state that there are certainly tens of thousands of abandoned, inactive, or active oil and gas wells that currently leak gas to the surface in North America (Dusseault, M.B. et al., 2000). These authors demonstrated that leaks occur because of cement shrinkage at depth with subsequent gas and fluid migration outside of the casing. Gas and fluids are transported up the string into groundwater aquifers. The authors further state that once this phenomenon occurs it is not likely to attenuate. Rather, methane migration will become worse over time, with more and more gas and fluids accumulating in the ground water aquifer.

Drilling to depths of as much as 8000 feet to tap the Marcellus shale requires employment of numerous casing strings that must be cemented to form hydraulic seals that isolate deep strata from the atmosphere and groundwater. Because of the great depth of these wells, the potential for cement shrinkage and cracking, accompanied by transfer of gases and fluids upwards is greater than in shallow wells.

Disposal of drill cuttings and muds from Marcellus shale wells also poses concerns for water resources. The Marcellus Shale is a Middle Devonian, carbonaceous black shale (Faill, 1998). Black shales have long been known to contain levels of trace elements and metals above levels found in the crustal earth. A summary report published in 1970 of sedimentary provinces in the United States and Canada examined beds of metal-rich black shale, including Devonian shales (Vine, J.D. and Tourtelot, E.B., 1970).

The investigators analyzed for trace elements 20 sets of samples (comprising 779 individual samples) selected as representative of a wide variety of geologic environments of black shale deposition. These samples include black shale and associated organic-rich rocks transitional with black shale. Statistical methods were used to determine the composition of the average black shale and the normal range in composition of black shale and to provide a definition of metal-rich black shale for any one of 21 trace elements. A black shale sample was defined as metal-rich if any minor element was found to occur in excess of the 90th percentile as determined from the sum of the percent frequency distribution of elements in the 20 sets of black shale samples.

Statistical analysis of chemical data indicate that the detrital mineral fraction of most black shale deposits is characterized by the elements aluminum, titanium, gallium, zirconium, and scandium and may also include any of the following elements: beryllium, boron, barium, sodium, potassium, magnesium, and iron. The carbonate fraction of black shale deposits commonly includes calcium plus magnesium, manganese, or strontium. These elements are readily available from solution and are regarded as mobile. The organic fractions of black shale deposits are locally enriched in other mobile elements including silver, molybdenum, zinc, nickel, copper, chromium, vanadium, and, less commonly cobalt, lead, lanthanum yttrium, selenium, uranium, and thallium.

Elemental and metal contaminants in drill cuttings and debris can be moved as soluble dissolved constituents in runoff water or by entrainment of cutting/debris particles in runoff water. Since drilling sites are cleared of vegetation, fewer plants are available to take-up potentially toxic elements and metals, increasing their likelihood of entering both surface and groundwater. These elements and metals can have varying toxic impacts on human and ecological health, depending on exposure and dose.

Certainly gas-bearing shales also contain numerous organic hydrocarbons. We know, for example, that the Marcellus contains from 3-12% organic carbon (OC), the Barnett: 4.5% OC, and the Fayetteville: 4-9.8% OC (Arthur et al, 2008). We also know that produced waters (formation waters) from gas production contain low molecular-weight aromatic hydrocarbons such as benzene, toluene, ethyl benzene, and xylene at higher levels than do produced waters from oil operations. Produced water from oil and gas operations contains: aliphatic and aromatic carboxylic acids, phenols, and aliphatic and aromatic hydrocarbons. While the quantity of formation fluid flowback from an exploratory well may be considered to be minor compared to that from a production well, drill cuttings from the Marcellus layer itself will necessarily be enriched with organic compounds that could be released into surface and groundwater. These organic hydrocarbons can have varying toxic impacts on human and ecological health, depending on exposure and dose.

Elevated concentrations of naturally occurring radioactive materials (NORM), including 238U, 232Th and their progeny, are found in underground geologic deposits and are often encountered during drilling for oil and gas deposits (Rajaretnam G, and Spitz HB., 2000). Drill cuttings from the Marcellus may be enriched in radium radionuclides and off-gas the radioelement radon. Also, the activity levels and/or availability of naturally occurring radionuclides can be significantly altered by processes in the oil, gas and mineral mining industries (B. Heaton and J. Lambley, 2000)**.** Scales in drilling and process equipment may become enriched in radionuclides producing technologically enhanced naturally occurring radioactive materials (TENORM). Exposure to TENORM in drilling equipment may exceed OSHA and other regulatory authority standards for the protection of both human and ecological health. The occurrence of TENORM concentrated through anthropogenic processes in soils at oil and gas wells and facilities represents one of the most challenging issues facing the Canadian and

US oil and gas industry today (Saint-Fort et al., 2007). The risk of contamination of surface water and ground water by TENORM accompanies the risk of soil contamination, as TENORM generated may runoff of drilling equipment during rain events or if on the soil surface into surface water sources and/or enter groundwater by transport through the unsaturated zone.

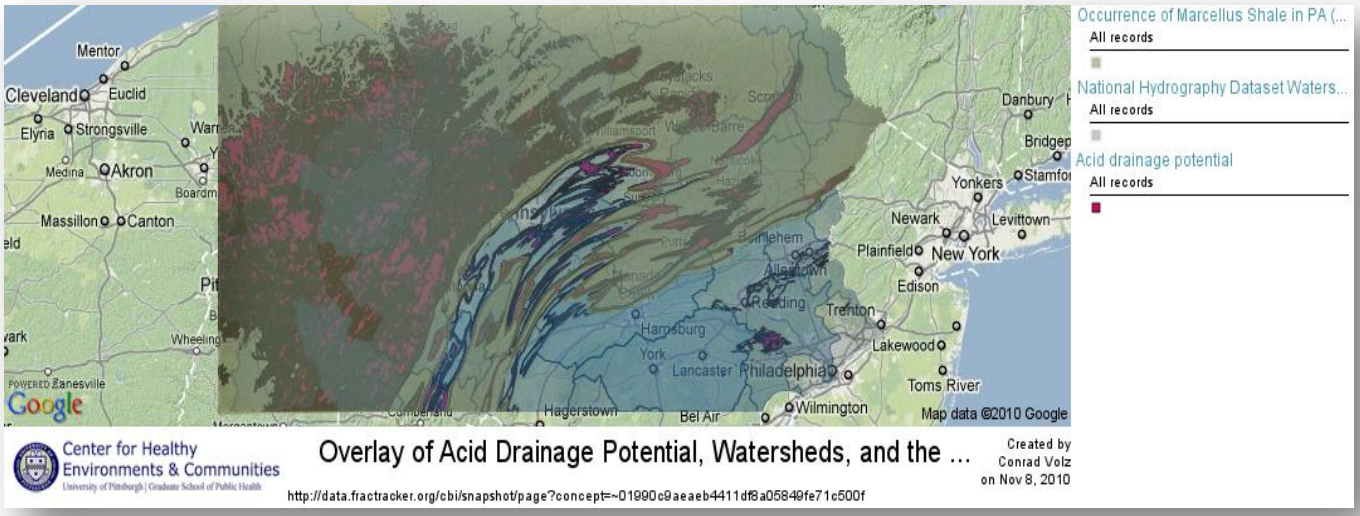
Drilling through numerous layers of geologic formations will necessarily increase the likelihood of contacting sulfide-containing rocks. Drill cuttings and debris open to the environment, including rain and wind dispersion, have the potential to form sulfuric acid in a process that is analogous to the formation of acid mine drainage, if on a localized and smaller scale. A similar phenomenon is predicted in connection with exposure of natural gas well drill cuttings. Sulfides within the rock extracted from the borehole can create sulfuric acid after reacting with air and water, and further mobilize toxic elements and metals, which may then be transported to both surface water sources and ground water.

Documentation of this type of non-traditional acid drainage effect was demonstrated in a paper entitled "Evaluation of acid-producing sulfidic materials in Virginia highway corridors" (Orndorff, Z.W. and Lee, E.W., 2004). The authors found that road construction through sulfidic materials in Virginia has resulted in localized acid rock drainage (ARD) that threatens water quality, sedimentation, integrity of building materials, and vegetation management. Geologic formations associated with acid roadcuts were characterized by potential peroxide acidity (PPA), expressed as calcium carbonate equivalence (CCE), and total sulfur (total-S) in order to develop a statewide sulfide hazard rating map. They found that the Marcellus Shale had PPA<60 Mg CCE/1000 Mg; total sulfur < 2.6% similar to the Millsboro Shale, thus placing it near the high end of PPA among geologic formations that could be disturbed by roadcuts (the formations with the highest PPA were the Chattanooga shale and Quantico slate at PPA<99 Mg CCE/1000 Mg; S<3.9%, followed by the Chesapeake Group, Lower Tertiary deposits, Millboro shale, Marcellus shale, and Needmore Formation at PPA<60 Mg CCE/1000 Mg; S<2.6%, followed by the Ashe formation at PPA<18 Mg CCE/1000 Mg; S<2.0% , and the Tabb formation at PPA CCE/1000 Mg; S<0.2%). The authors conclude that sulfide hazard analysis should be an essential step in the pre-design phase of highway construction and other earth-disturbing activities. Based on this report, and given that drill cuttings stored on the ground surface or buried on site may be exposed to weathering, the risk of localized acid formation leading to increased mobilization of toxic elements and heavy metals cannot be overlooked. Once

mobilized by acid waters these elements and heavy metals may enter both ground and surface waters.

A map entitled "Geologic Units Containing Potentially Significant Acid-Producing Sulfide Minerals" was produced by the Bureau of Topographic and Geologic Survey of the Department of Conservation and Natural Resources, the Department of Environmental Protection, and the Pennsylvania Department of Transportation (PennDOT) in 2005, and revised in 2006 (Open-File Miscellaneous Investigation (OFMI) Report 05–01.1: Geologic Units Containing Potentially Significant Acid-Producing Sulfide Minerals (2005; rev. 3/2006). This map was put onto the fractracker.org web-based system and overlaid with watersheds in the Marcellus Shale region, including Pennsylvania. A map visualizing this relationship is shown in Map 1, Overlay of Acid Drainage Potential, Watersheds and the Marcellus Shale Layer. Acid producing strata are outlined in red, the Marcellus in yellow overlay and watersheds in blue.

The creators of "Geologic Units Containing Potentially Significant Acid-Producing Sulfide Minerals" stress that this map is meant to provide a general reference for the extent of acid mine drainage risk and should not be read to assert that rock-cutting or drilling activities within the designated areas will necessarily lead to acid mine drainage while similar activities undertaken outside such areas will not. Sulfide-containing rock is found throughout the Commonwealth and is thus a potential problem for any shale drilling operation.

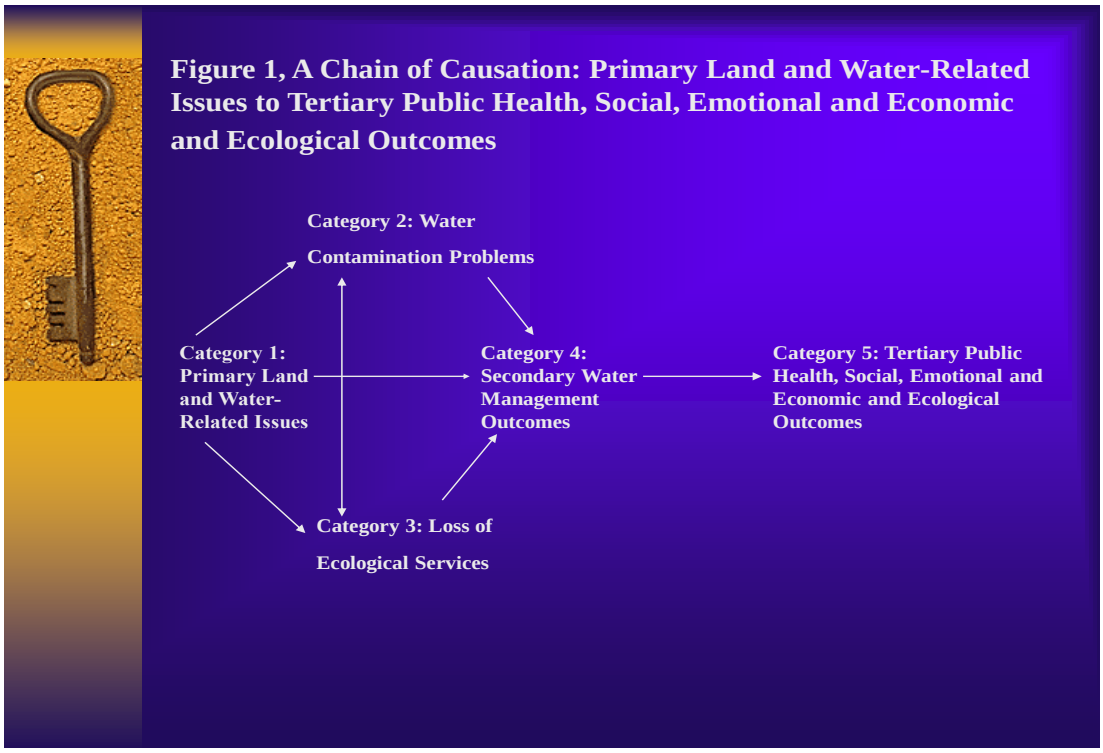


Map 1, Overlay of Acid Drainage Potential, Watersheds and the Marcellus Shale

Chain of Causation Model

I have developed a Chain of Causation Model to understand and predict how water-related issues can lead to significant human and ecological consequences of numerous types. This model is peer reviewed and has been used as a:

- Basis for an integrated water management plan by the Regional Water Task Force planning group for the Southwestern Pennsylvania area and Upper Ohio River Watershed, which includes portions of the States of Pennsylvania, Ohio, New York, West Virginia, Maryland and Virginia (Miller, T. Editor, Volz, C. D., Author; 2007).
- Conceptual model to help environmental health professionals, public health officials and occupational – environmental physicians understand how water, land management, ecological and contamination issues interact to produce tertiary public health, ecological, medical, social and economic problems (Volz, C. D.; 2007a).
- Planning tool for NATO efforts at peacekeeping. Inter- and intrastate conflicts and political problems often have as their proximal causes issues related to water management, including quality, quantity, erosion and sedimentation and flooding (Volz, C.D., 2007b)



The model is presented in Figure 1, above, "A Chain of Causation: Primary Land and Water-Related Issues to Tertiary Public Health, Social, Emotional, Economic and Ecological Outcomes." Succinctly, Category 1, Primary Water-Related Problems either cause or exacerbate Category 2, Water Contamination Problems, and Category 3, Loss of Ecological Services. Categories 2 and 3 may combine to exacerbate Category 1 issues. A feedback loop exists from Category 3 to Category 2 as well, in that ecological degradation hinders natural purification of water, so that contaminants in the water build up over time, in turn further eroding the ecosystem's ability to purify water. The problems in Categories 1, 2, and 3, alone or in combination, result in Category 4, Secondary Water Management Outcomes, such as decreased production of clean surface water and groundwater, increased stormwater/snowmelt runoff, and increased contaminant loads in surface water and groundwater. Finally, these secondary outcomes result in Category 5, Tertiary Environmental and Ecological, Public Health, Medical, Social, Emotional, and Economic Outcomes. These can include increased stormwater management costs, increased cost of water purification, decreased recreational and aesthetic value, decreased economic growth, loss of aquatic and terrestrial species, increased cost of flood insurance, and increased risk of cancer and waterborne diseases.

In this model I have borrowed the classifications of primary, secondary, and tertiary from the field of public health to show where interventions can most successfully be applied to break the chain of causation. In public health, primary care (e.g., immunization) is always ethically and economically better than secondary care (e.g., treating the infected), which in turn is better than relying on tertiary care (e.g., hospitalizing very sick individuals for extremely intrusive and costly treatment).

It is my contention that exploratory drilling in the Marcellus formation in the Delaware River basin is a primary threat to the production of clean and adequate water resources. Regulatory measures are appropriate and necessary at this very early stage in the natural gas development process in my view to reduce the risk of degradation of water resources and prevent the far-reaching consequences, including contamination and loss of ecosystem services, that accompany such degradation in the long-term.

Part II Violations

Violations data are important indicators of spills, leaks, erosion and sedimentation problems, and intentional and unintentional waste scattering and pollution problems associated with oil and gas drilling activities. The issuance of a violation is of course dependant on direct inspection of the operator's process and/or paperwork by agency enforcement staff. Therefore, violation data indicate patterns of environmental and pollution violations but should be regarded as a subset of the total universe of violations of state oil and gas act regulations.

Violations data for oil and gas drilling and extraction operations were analyzed for Pennsylvania, West Virginia and Utah pertaining to both "conventional" and "unconventional" extraction activities. Activities involving stimulation techniques such as hydraulic fracturing of horizontal wells are deemed to be "unconventional."

In Pennsylvania violations history exists for three types of gas and oil wells: shallow oil and gas wells, vertical Marcellus wells (primarily gas wells, but oil may also be generated) that have been hydrofractured, and horizontal Marcellus wells that have been hydrofractured. Pennsylvania does not distinguish "exploratory wells" from production wells. Due to the depth of the Marcellus wells, the need

for more casing strings and cement, longer drilling times, the penetration of more geologic layers, and the generation of commensurately more drilling waste, the potential for violations in connection with vertical exploratory wells is greater than for shallow gas and oil wells, though less than for Marcellus production wells. Violations data from all wells drilled, however, demonstrate patterns of violation that can be expected to accompany drilling activity generally, including exploratory drilling, in the Marcellus Shale.

Whether considered in sub-categories or in combination, conventional, unconventional, stimulated and non-stimulated oil and gas well development activities generate significant numbers of violations and high ratios of violations to wells drilled in the three states analyzed.

Pollution-related violations in Pennsylvania for all wells include encroachment on wetlands and sensitive habitat, failure to restore the site following drilling and construction activities, improper erosion and sedimentation controls, improper well casing, inadequate pollution prevention, spills of drill cuttings/sediments/ wastewater/and or unspecified materials, and failure to plug wells. These categories of violations are frequent in Pennsylvania as well as in the other two states analyzed. All of these types of violations may occur during the construction of exploratory wells. Violations in each of the three states are considered below.

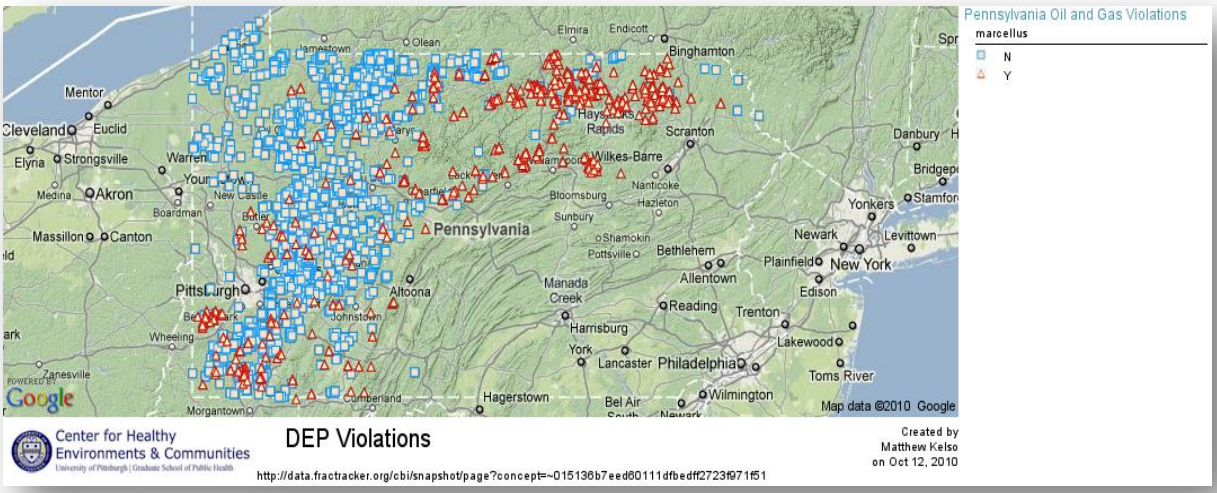
Pennsylvania

Datasets of wells drilled from 1998 to 9/30/2010 and violations of the Pennsylvania Oil and Gas Act from 2007 to 9/30/2010 were provided by the Pennsylvania Department of Environmental Protection (PADEP) Oil and Gas Bureau in response to the request of CHEC researcher Mr. Matt Kelso on 9/15/2010. These datasets were uploaded onto CHEC's fractracker.org web-based information system by Mr. Kelso, who added and verified location coordinates based on address information. These datasets were visualized on CHEC's web-based fractracker.org program by the author on 11/13/2010. Map 2, entitled "All PA DEP Violations," shows all recorded violations of the Pennsylvania Oil and Gas Act from 2008 through 9/30/2010 at Marcellus and non-Marcellus wells. This visualization shows violations over the entire geographical range of oil and gas extraction activities, which is confirmed by Map 3, "Violations of Pennsylvania Oil and Gas Act Regulations by Wells Drilled from 1998 through 9/30/2010." Map 3

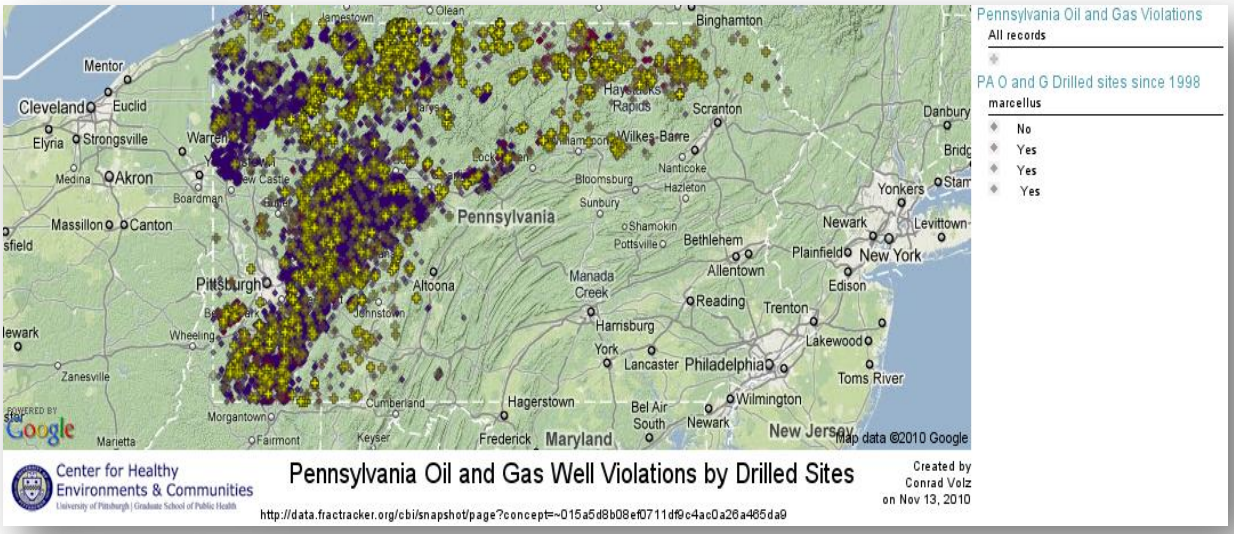
shows non-Marcellus wells as blue diamonds, Marcellus wells as red diamonds and violations as yellow crosses. Again, these violations cover all oil and gas extraction areas of Pennsylvania, including the Marcellus "greenway".

Some violations correspond to oil and gas wells that were drilled prior to 1998. These are denoted on Map 3 by yellow crosses without corresponding diamonds indicating wells drilled. The Pennsylvania Spatial Data Access (PASDA) system maintains a list of over 123,000 oil and gas locations in the state, based on Department of Environmental Protection (DEP) data, and CHEC has found over 6,000 more locations from permit information available on the DEP website, bringing the total number of oil and gas drilling locations known to exist in the Commonwealth to over 129,000. The significance of this number increases when one considers that in Pennsylvania wells continue to produce pollution violations long after they have been drilled. Moreover, large amounts of salts and organics can be found in soils and groundwater after more than 65 years of natural attenuation, following cessation of oil and gas extraction activities (Kharaka, Y.K. and Dorsey, N.S., 2005). Exploration for and production of oil and gas have caused local pollution impacts to soils, surface and groundwaters, and ecosystems in the 36 producing states in the United States (Richter and Kreitler, 1993; Kharaka and Hanor, 2003).

Map 2, All PA DEP Violations



Map 3, Violations of Pennsylvania Oil and Gas Act Regulations by Wells Drilled from 1998 through 9/30/2010.



The violation dataset provided by the Pennsylvania Department of Environmental Protection for violations from 2007 to the present contained 9,370 violations associated with 3,661 discrete wells. The original dataset included 109 violation categories, which were collapsed into 12 categories for ease of analysis. I note that some of these categories were relatively simple to collapse. For example, wastewater spills and brine spills clearly belong together. Other examples were less clear. One of the original categories was “Improper storage of residual waste,” which does not explain whether or not a spill occurred. For that reason, this category was included with, “Inadequate pollution prevention,” although the violation might well have been issued after a spill of drilling debris or the overflow of an impoundment.

Figure 2, “Categories of Violations Issued by the PA DEP from 2008 to Present,” shows the 12 collapsed categories of violations by “all Marcellus wells” (that is, both vertical and horizontal Marcellus wells), “non-Marcellus wells” and “total wells”. Focus here will be on violations for total wells because exploratory wells do not exist as a category in the PA DEP database, and for the purpose of violations data, Marcellus exploratory wells were considered to resemble both “all Marcellus wells” and “non-Marcellus wells” to some extent. Of the 9,370 violations, 106 were for permit problems; 3,073 were administrative and paperwork problems; 119 were related to encroachment onto wetlands, stream

and river borders of the Commonwealth, and other ecologically sensitive areas; 1,111 were for failure to plug wells; 22 were for improper erosion control procedures and events; 439 related to failure to restore the drill site (which may result in long-term erosion and sedimentation problems); 180 specified improper well casings; 2,938 violations were for inadequate pollution prevention techniques and precautions; 9 pertained to safety regulations; 24 concerned spills of drill cuttings or sediments; 1,043 were for unspecified spills; and 306 violations were for spills of oil and gas wastewater.

Figure 2, Categories of Violations Issued by the PA DEP from 2008 to Present

Violation Type	Horizontal Marcellus	Vertical Marcellus	Non-Marcellus	Total
Activity requires permit	4	0	102	106
Administrative	538	212	2323	3073
Encroachment	40	11	68	119
Failure to plug well	1	4	1106	1111
Failure to restore site	13	19	407	439
Improper erosion control	3	0	19	22
Improper well casing	49	14	117	180
Inadequate pollution prevention	595	260	2083	2938
Safety violation	6	0	3	9
Spill, drill cuttings or sediments	0	0	24	24
Spill, material not specified	188	78	777	1043
Spill, wastewater	30	10	266	306
Grand Total	1467	608	7295	9370

Violation Type by Well Type, 1-1-2007 through 9-30-2010

Collapsed categories of violations that can have a direct effect on surface and groundwater quality, including additions of toxic heavy metals and elements, organic compounds, radionuclides, turbidity, and total dissolved solids include: encroachment; failure to plug a well; failure to restore a site; improper erosion control; improper well casing; inadequate pollution prevention; and spills of drill cuttings and sediments, wastewater, and unspecified materials. The total of the spill categories was 1,373 violations, which accounted for 14.7% of all violations reported in this time-period. Serious pollution related violations that could affect

surface and groundwater quality accounted for 6,182 of the 9,370 total violations or 70% of all violations in the time-period.

The number of violations per well type was calculated for wells with any violations. Figure 3, Violations per Well for any Well with at Least One Violation, shows by well type the number of violations for wells with at least one violation, and the average frequency of violations for any well with at least one violation. There were a total of 3,661 wells with violations from 2007 to the present and a total of 9,370 violations concerning those wells, for a rate of 2.56 violations per well for all wells with at least one violation. There were 7,295 violations at 3,069 distinct non-Marcellus wells for a rate of 2.38 violations per well with any violations.

Figure 3, Violations per Well for any Well with at Least One Violation

Well Type	Violations	Wells	Frequency
Marcellus, Horizontal	1497	399	3.75188
Marcellus, Vertical	578	193	2.994819
Total Marcellus	2075	592	3.505068
Non Marcellus	7295	3069	2.376996
Total Wells	9370	3661	2.55941

Violations per Offending Well by Well Type Table, 1-1-2007 Through 9-30-2010

Figure 4, "Chart of Average Frequencies of Violations for Any Well with a Violation," shows the relationship between violation rates of types of wells with at least one violation. Horizontal Marcellus wells have the highest average frequency of violations per well with a violation (3.36), followed by all Marcellus wells (3.51), Vertical Marcellus wells (2.99), all wells including Marcellus and non-Marcellus (2.56), and all non-Marcellus wells (2.38). To be clear the analysis presented in Figure 4 does not suggest that an average of 2.56 violations per well is occurring in Pennsylvania. Information as to the number of wells drilled—that is, denominator data – are needed to calculate a violations rate per well, and such data are not currently available in Pennsylvania, as I explain at greater length below. The data do show, however, that when a PA DEP inspector determines

that a notice of violation must be issued, he or she typically cites the operator for more than one problem.

Figure 4, Chart of Average Frequencies of Violations for Any Well with a Violation

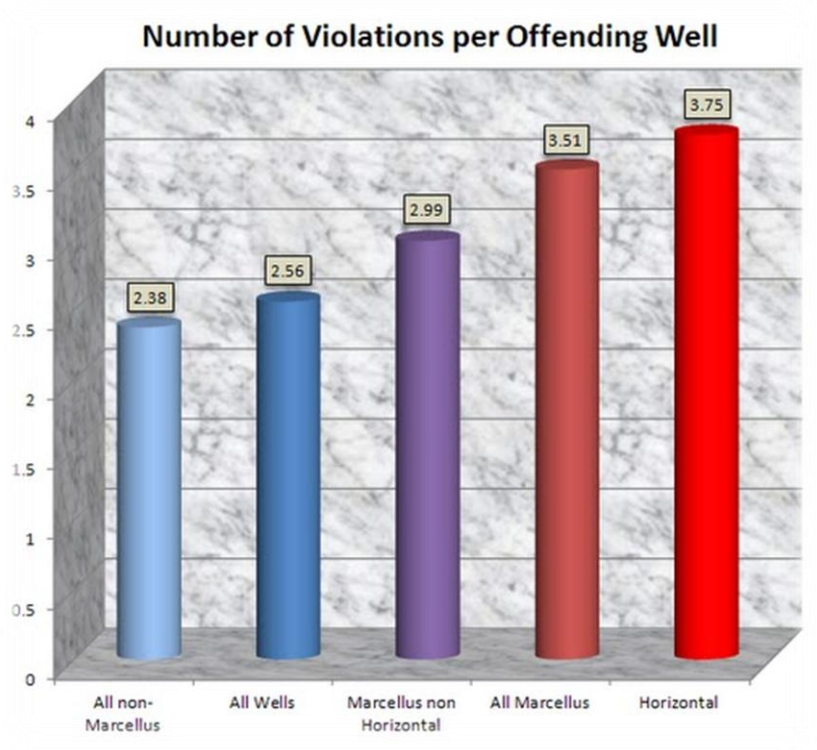


Figure 5, Total PA DEP Violations by County by Type of Well, shows by county the number of violations by well type and the total number of violations in that county from 2007 to present. Violations are seen across all counties where oil and gas extraction activities occur. The three contiguous counties in the north central/east quadrant of the Commonwealth—Bradford, Susquehanna, and Tioga—account for a majority of the Marcellus Shale violations. Two northwestern counties—McKean and Venango—have noticeably more violations than the rest of the counties in terms of oil and gas operations that are drilled into other formations.

Analysis of violations per total wells drilled is difficult because oil and gas activity has been ongoing in Pennsylvania since before the turn of the 20th Century PA DEP databases do not contain data on oil and gas wells drilled before 1998, . let alone those drilled in the early part of the 20th century.

County	Horizontal Marcellus	Vertical Marcellus	Non-Marcellus	Total
Allegheny	0	2	128	130
Armstrong	15	10	289	314
Beaver	0	0	2	2
Bedford	0	0	2	2
Blair	9	0	0	9
Bradford	453	48	59	560
Butler	5	10	37	52
Cambria	0	1	68	69
Cameron	42	12	4	58
Centre	9	8	11	28
Clarion	0	2	486	488
Clearfield	54	23	193	270
Clinton	20	6	14	40
Columbia	0	1	0	1
Crawford	0	0	54	54
Elk	10	8	122	140
Erie	0	0	201	201
Fayette	3	41	124	168
Forest	4	4	741	749
Greene	21	22	216	259
Indiana	1	6	255	262
Jefferson	0	1	154	155
Lycoming	167	54	19	240
McKean	4	2	1452	1458
Mercer	0	0	56	56
Potter	51	46	279	376
Somerset	12	13	52	77
Sullivan	1	0	0	1
Susquehanna	225	139	23	387
Tioga	257	51	64	372
Venango	0	0	1199	1199
Warren	0	6	474	480
Washington	47	66	187	300
Wayne	0	5	10	15
Westmoreland	13	7	320	340
Wyoming	44	14	0	58
Grand Total	1467	608	7295	9370

Number of Violations by Well Type by County, 1-1-2007 thorugh 9-30-2010

Figure 5, Total PA DEP Violations by County by Type of Well

CHEC estimates there have been over 129,000 wells drilled for oil and gas in the Commonwealth of Pennsylvania since recordkeeping began. Using this denominator would dilute the number of violations per drilled well, however, because many of the 129,000 wells have been plugged and are no longer actively inspected. However, CHEC was able to obtain from the PA DEP a database of all wells drilled from 1/1/1998 through 10/21/2010. These data were compared to the database of all violations from 1/1/2007 to 9/30/2010 and results are presented in Figure 6, "Number of Violations by Well Type for Wells Drilled Between 1/1/1998 and 10/21/2010."

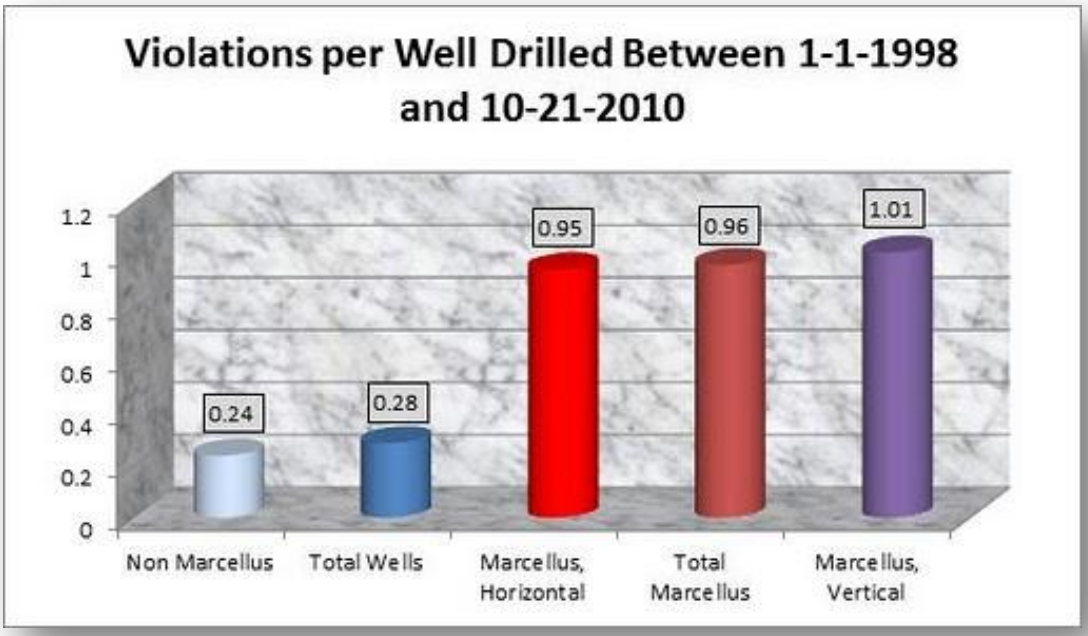
A total of 33,109 wells of various types were drilled between 1/1/1998 and 9/30/2010. For these wells, 9,370 violations were reported between 1/1/2007 and 9/30/2010. This corresponds to an arithmetic mean of 0.28 violations per well drilled. Non-Marcellus wells had 0.24 violations per well on average; and vertical Marcellus wells had 1.01 violations on average.

Well Type	Violations	Number of Wells	Violations per Well
Marcellus, Horizontal	1497	1584	0.9450758
Marcellus, Vertical	578	572	1.0104895
Total Marcellus	2075	2156	0.9624304
Non Marcellus	7295	30953	0.2356799
Total Wells	9370	33109	0.2830046

Figure 6, Number of Violations by Well Type for Wells Drilled Between 1/1/1998 and 10/21/2010; Violations Filed Between 1/1/2007 and 9/30/2010

Fgure 7, "Chart of Average Violations per Well for Wells Drilled Between 1/1/1998 and 10/21/2010; Violations Filed Between 1/1/2007 and 9/30/ 2010," compares average violations by well type in Pennsylvania. It is not possible to establish violation rates for exploratory Marcellus wells, since there are no data explicitly covering them. In my opinion, vertical Marcellus wells that are not hydrofractured could be expected to have a violation rate above that for Non-Marcellus wells and below that for Vertical Marcellus wells (Range 0.24 – 1.01 violations per well). There is certainly a strong probability that any well drilled will have a pollution violation, and that probability increases with additional exploratory wells drilled into the Marcellus Shale.

Figure 7, Chart of Average Violations per Well for Wells Drilled Between 1/1/1998 and 10/21/2010; Violations Filed Between 1/1/2007 and 9/30/ 2010



West Virginia Violations

Unlike other states in which violation data has had to be requested, the West Virginia DEP provides access to separate spills and violation databases on the WV DEP website. The spills database includes 488 records between the dates of January 1, 2000 and September 30, 2010, and the violation database includes an additional 245 records from the same time-frame. Figure 8, "Spill Type by Year of Incident and Total Spills" shows the details for spills of drill cuttings, drilling additives, crude oil, contaminants related to operations, and wastewater as well as gas leaks from the years 2000 through 2009.

Figure 8, Spill Type by Year of Incident and Total Spills

	YEAR OF INCIDENT										Total
Spill Type	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	Spills
Drill Cuttings	1			1	2	1	1	2	1		9
Drilling Additives		2	5	2	4	4	2	8	3		30
Gas Leak		3	3	5	2	3	4	14	14	12	60
Crude Oil	31	21	33	43	29	30	20	32	21	18	278
Operations Contaminants	2		2	1	2	3	2	1	3	4	20
Wastewater	6	6	7	11	9	8	5	25	8	6	91
Total Spills	40	32	50	63	48	49	34	82	50	40	488

West Virginia Spills Incidents by County from 1-1-2000 through 9-30-2010.

It should be noted that the six different spill types in Figure 8 were condensed from an original list of 134. Most of the category combinations were straightforward. For example, brine spills and wastewater spills clearly belong together and were combined as “Wastewater.” A few, such as “Substance From Gas Well” required some degree of interpretation and were combined with “Operations Contaminants,” which included other materials, such as hydraulic fluids and sewage. According to the website, the West Virginia Department of Environmental Protection, Office of Oil and Gas is responsible for over 55,000 active and 12,000 inactive oil and gas wells in the state. The author does not have a detailed dataset for wells drilled in West Virginia or documentation of the inspection frequency of active wells, although these data have been requested. Still, these data indicate that any wells drilled have the potential to generate pollution problems, and if observed by inspectors, violations.

The 245 violations records are broken out by various legal codes, explanations for which have been requested from the West Virginia authorities.

Utah Oil and Gas Industry Overview

Utah’s Oil and Gas Permitting Manager and Petroleum Geologist Brad Hill provided CHEC with data concerning Utah’s new oil and gas industry. From Mr. Hill, we learned that while there has been discussion of shale gas extraction in the state, no wells in Utah currently are producing natural gas from shale. Mr. Hill did

indicate that most of the wells in the state had been stimulated to some degree with hydraulic fracturing.

Well Type	Horizontal	Total	Percentage
Gas	17	2096	0.81%
Oil	45	1485	3.03%
Water Disposal	1	14	7.14%
Unspecified	1	1	100.00%
Grand Total	64	3596	1.78%

Frequency of Horizontal Wells in Utah by Type, 2003 through 9/29/2010

There were 4,499 oil and gas wells drilled in Utah from 2003 through 9/29/2010. A breakdown of these wells by well type is shown in Figure 9, "Oil and Gas Wells by Type Drilled in Utah from 2003 through 9/29/2010."

Figure 9, Oil and Gas Wells by Type Drilled in Utah from 2003 through 9/29/2010

Well Types	2003	2004	2005	2006	2007	2008	2009	2010	Grand Total
Total Gas Wells	1	1	1	415	393	917	789	479	2996
Directional				76	80	206	334	363	1059
Horizontal				3	4	4	3	3	17
Vertical	1	1	1	336	309	707	452	113	1920
Total Oil Wells				146	160	435	373	371	1485
Directional				17	74	219	59	96	465
Horizontal					3	15	11	16	45
Vertical				129	83	201	303	259	975
Total Test Wells						1			1
Vertical						1			1
Total Water Disposal Wells						6	7	1	16
Directional						1			1
Horizontal						1			1
Vertical						4	8	2	14
Total Unspecified Wells								1	1
Horizontal								1	1
Grand Total	1	1	1	561	553	1359	1170	853	4499

Directional, Horizontal, and Vertical Oil and Gas Permits in Utah, 2003 through 9/29/2010

The Utah data are relevant insofar as the great majority of gas and oil wells in the state are vertical wells, not horizontal wells, and reportedly, the newer wells are exploratory in nature.

Figure 10, "Frequency of Horizontal Wells in Utah by Type, 2003 through 9/29/2010," shows that only 0.81% of gas and 3.03% of oil wells are horizontal wells—the remainder are vertical wells.

Figure 11, "Oil and Gas Violations in Utah by County, 2003 through 9/29/2010," shows a breakdown of all oil and gas violations into 8 collapsed categories. There were a total of 518 violations over this time-period, including 32 fires, which can have serious impacts on water quality as a result of pyrolysis of site materials, including impoundment liners and petrochemicals. Other pollution-related violations included gas leaks, oil spills, sediment spills, other unspecified spills, and wastewater spills. The violation rate in Utah is .12 violations per well drilled, which is 12 violations per hundred wells drilled.

Figure 11, Oil and Gas Violations in Utah by County; 2003 through 9/29/2010

County	Fatality	Fire	Injury	Gas Leak	Oil Spill	Other Spill	Sediment Spill	Wastewater Spill	Total Violations
Carbon	1	1		1	2	1		28	34
Duchesne		9		13	77	6		60	167
Emery				8	6		1	2	17
Garfield									1
Grand		1		2	9			5	19
Salt Lake		5							10
San Juan		1		1	8	2		9	23
Sanpete			2						2
Sevier								1	1
Summit						1		4	5
Uintah		15	8	11	68	9	1	126	238
Wayne					1				1
Grand Total	1	32	0	36	171	19	2	235	518

Oil and Gas Violations in Utah by County, 2003 through 9/29/2010

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