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Appendix C

Review of NYSERDA Commissioned Review of Myers Comments on the 2009 DSGEIS

Prepared by: Tom Myers

11/30/11

Introduction

The New York State Energy and Resource Development Agency (NYSERDA) commission Alpha Geosciences (Alpha) to complete a review of the comments I had prepared for the 2009 Draft Supplemental Generic Environmental Impact State (DSGEIS). This report replies to some of those review comments. Throughout, I refer to the review as "Alpha".

General Points

Alpha divided my comments into various subsets for their response, but they rely very much on several points throughout their response. One is their perception of there being no hydraulic connection between groundwater at depth, in the Marcellus shale, and the near-surface aquifers; they also dismiss the analysis from ICF (2009) on the same basis, even though they have no data with which to dismiss the argument. Their second line of reasoning is the results or conclusions from the 2004 EPA study of coal bed methane fracking.

Alpha rejects the suggestion that a water balance for the project area or subareas "would not serve the purpose of the SGEIS" (Alpha, at 4). They provide no reason for this conclusion, but also state that a "water balance clearly is site-specific" (Id.). A water balance can be useful for any size study area or portion of the study area. A water balance for the overall study area would help to understand the total volume of water involved in fracking; a similar argument can be made for a watershed – a water balance for the groundwater would help to understand whether the water amounts used for fracking is a substantial portion of the local water balance.

Alpha partially rejects my suggestion that a better description of the area's hydrogeology is needed by quoting my statement that "the Marcellus Shale is 'notoriously heterogeneous'" (Alpha, at 4). The request for a better description pertains to the overall area, not specifically the Marcellus shale. Additionally, the statement supports the concept that reported permeability values for the shale may not be representative and that broader scale description are required.

Hydraulic Connection between Shale and Surface

Alpha argues that the "target shales exist as an isolated system from the overlying fresh water-bearing units" (Alpha, at 4). "Isolated" overstates the case even for natural conditions, although the connection may be limited, as I accepted in 2009. Alpha claims that the "shales … are not part of, and are not connected to, the regional hydrogeological systems. Their baseline geologic evidence that fluid

migration to overlying fresh water aquifers is improbable includes studies that show the Marcellus shale has remained isolated from overlying formations for millions of years" (Alpha, at 5). Alpha does not directly provide citations for these "studies", but in the next sentence references the "facts that these units are 'overpressured' and that natural gas and saline water has remained trapped … for millions of years" (Id.) to two industry studies and the GEIS. This all ignores the science, cited in Myers (in review) of the upward movement and artesian pressure, observed during geothermal exploration, in formations above the shale. The salt in the shale may be the source of the salt in overlying formations, with the upward movement of salt balanced by the downward movement of freshwater recharge. This balance could be substantially upset by the changes wrought by fracking on the shale.

The "overpressuring" of the shale does not prove that the shale itself is isolated. Overpressuring is due to the gas being contained in the low permeability, very small pore spaces of the shale. Once fracked, the overpressuring may provide an initial source for water to flow into the formations above the shale.

The isolation argument is invoked again, by Alpha, at 11&12, 20, and 33.

My discussion relied and continues to rely for the 2011 rDSGEIS on the fact that fracking will change those conditions, changing the shale from an almost impervious aquitard into a low-conductivity formation; the previously isolated formation water will no longer be "isolated" because fracking fluid injection will push some into surrounding formations. The "overpressuring" in the shale may suggest that the shale itself is isolated at least in places. Myers' (2009 and in review) argument relies on the connection in the formation above the shale. Once fracked, the shale will have a much higher permeability so that fluids in the shale can move into surrounding formations within which the general groundwater flow will control.

Alpha refers to the fact that shallow water wells may be hydrofractured as "additional evidence that natural fractures and structures are not necessarily transmissive" (Alpha, at 4 and 37). This is a comparison of "apples and oranges". Hydrofracturing water wells may be done to increase their yield when screened in low-transmissivity formations; fracking water wells is done to increase the well yield from a few gallons per minute. The transmissivity of unfracked shale is orders of magnitude less than that in the formations in which a water well may have been screened. The cause for fracking in water wells differs from the cause for fracking a gas well; the comparison is irrelevant and proves nothing about the isolated nature of shale.

A further reliance on "overpressuring" is demonstrated (Alpha, at 5) where Alpha notes that eight research wells in the Marcellus shale had pressure gradients of 0.46 to 0.51 psia/ft when hydrostatic pressure is 0.433 psia/ft. That waters remain contained in the shale even with this overpressuring demonstrates their isolation. Once fracking hydraulically connects the shale with the overlying formations, the overpressuring is a source of pressure that would cause an upward gradient. The pressure would likely dissipate with time, but it would also cause an upward gradient after fracking.

Alpha indicates that my "hypothetical pathway … to ground water is along faults and fractures that intersect the Marcellus or induced fractures that extend beyond the target formation" (Alpha, at 5). This mischaracterizes the argument in two ways. First, it ignores the potential flow through the bulk media, through the primary porosity of the formations; this pathway would be slower, but flow is possible if there is a connection (Myers, in review) with the newly fractured shale. Myers (in review) found this flow to require from 100s to 1000s of years for contaminant transport. Second, natural faults and fractures do not have to "intersect" the shale, just reach its edge. Fluids within the shale would access the natural fractures above the shale, once fracked; the overpressuring would provide an added gradient for flow from the shale to surrounding formations, once fracking releases the fluids.

Alpha's second point is correct; out-of-formation fractures would provide an additional pathway. Although Alpha continues to suggest that out-of-formation fracking is rare, in their view, more current evidence is that it occurs frequently and extends as much as 2000 feet above the target formation (Fischer 2010); Alpha even references a personal communication from Fisher (Alpha, at 24) to recommend that the "SGEIS acknowledge that hydrofracturing has been shown to induce fractures beyond the target formation" (Id.). It appears that Alpha is not familiar with up to date literature or science.

Alpha rejects the "suggestion of 'head level maps'" that I had suggested in 2009 based on their rejection of the concept of saturated conditions from the "top of the target zone to the land surface" (Alpha, at 20). If there is no connection, groundwater levels will show nothing. They also note the isolation argument (at 20, 21) to reject the need for head level maps. Head level maps as recommended by Myers (2009) would confirm or deny the presence of upward head gradients in the formations above the shale. Once released by fracking, contaminants could advect along the flow paths which would be delineated by the hydraulic gradient. Although the fracking itself will change the gradient and potentially increase the potential upward flow, mapping the groundwater levels would assist the NYSDEC in determining where transport is possible. Alpha's recommendation is to basically ignore science and ignore the possibility of upward flow. Alpha replied to my comment suggesting that the rDSGEIS discuss properties resulting from fracking by discussing the direction that fractures would take in the shale (Alpha, at 15). My comments indicated that the rDSGEIS should include hydrogeologic properties, therefore Alphas reply was not responsive to the comment. Alpha's response that my "argument that the fractures will extend to and connect overlying fractures or paleofractures contradicts rock mechanics principles and field observations" is countered by the recent data in Fisher (2010) showing out-of-formation fracking. Alpha is unclear and provides no references as to how the comments contradict "rock mechanics principles".

I had also recommended that the NYSDEC require the industry to monitor post fracking shale properties. Alpha states that "[f]racture monitoring is required by the Proposed Supplementary Permit Conditions … (#33 and #34)" (Alpha at 16). That is incorrect; those permit conditions require the driller report on recorded operations during fracking, including pressure and the amount of injected, but that is not the same thing as doing post-frack monitoring, which could include microseismic surveys or core sampling. They also suggest that "[f]racture monitoring also can be evaluated on a well-specific basis using the

same criteria as the requirement to collect core samples and well logs" (Alpha, at 16). Those requirements are for pre-fracking conditions, not post-fracking.

Myers' Groundwater Modeling and ICF Analytical Modeling

I prepared (Myers 2009) an interpretative numerical groundwater model to consider whether and over what time frame flow could occur from the shale to freshwater aquifers. The "theory supporting Myers' model" is NOT from Hill and Tiedeman (2007) (Alpha, at 23). The reference is to the concept of "interpretative" modeling as opposed to a calibrated, predictive model. "Myers acknowledges that his model is not calibrated and cannot be used for predictive purposes" (Alpha, at 12). An interpretative model is not used for prediction, so Alpha's attack on the model is an attack here is irrelevant. The model does assume that the interburden between the ground surface and top of the shale is saturated, but not through the "isolated shale gas formations" (Id.). Again, the modeling is of the interburden and the shale, once it is fracked to its edge or beyond, is a boundary or a source of both fluids and contaminants. Or, flow through the shale is estimated based on its extremely low in-situ conductivity.

The numerical model I used in 2009 was not "to support [my] opinion" (Id.) but to test my conceptualization as to whether the flow was possible and under what conditions. Alpha criticizes the fact the model "oversimplifies ground water flow and transport". All groundwater models simplify flow; simple applications of Darcy's law are the most oversimplified analyses. The addition of secondary permeability, or fracture flow, to a contaminant transport analysis usually increases the rate that contaminants move, thus my estimated times should be low.

Alpha asserts that my "offered alternate model is not technically defensible" apparently based on their perceived lack of a hydraulic connection. They state that an assumption of a hydraulic connection "contradicts decades of hydrofracturing data and experience in the U.S." (Alpha, at 11) without referencing or outlining the data in support of their contention. They also claim that my analysis is based on "the entire bedrock stratigraphic column [being] highly fractured" (Alpha, at 12). This statement does not reflect the analysis in Myers (2009), for reasons noted above - the conductivity values used for the formations between the shale and surface were based on observed primary conductivity values (Anderson Woessner 1992), not fractured values.

ICF's flow equations are correct (Alpha at 11), but the problem is how they were parameterized and time frame they were applied over. As Myers (2009) discussed, the relevant gradient is not from the well to the aquifers, but from the well to just beyond the influence of the spreading injected fracking fluid, the point at which the background pressure has not changed. Also, the conductivity parameters for the formations between the shale and the aquifers do not reflect fractures, unless specifically parameterized as such. The parameters reflect standard textbook bulk conductivity values for sandstone.

Vertical Contaminant Transport

I had argued that "natural gradients" would allow vertical contaminant transport of frack fluid through advection. Alpha claims that "Engelder refutes that injected frac water would migrate vertically upward

in his slide-presentation review of others" (Alpha, at 24). Aside from the confusing phrase, "slide-presentation review of others", this line of reasoning cannot be correct because frack fluid is lighter than the high-TDS brine found in the shale; buoyancy due to frack fluid being lighter than brine would enhance its upward movement. The movement of high-TDS formation water could be inhibited by its denser nature, but the point is that upward hydraulic gradients cause the flow. The overpressuring discussed above is proof of these upward gradients and suggestive that fracking would release some of this pressure into the formations lying above.

Engelder's "principle of viscosity" (Id.) may apply "to ground water as well as gases", but the fact that low viscosity gases have been contained from vertical migration for millions of years does not mean that fracking will not release contaminants that could migrate upward much quicker. The relevant "containment" is provided in the shale and has nothing to do with the properties of overlying formations. Shale has contained gas for millions of years; fracking will cause that gas to be released in 30 to 50 years (the length of time most wells will produce). This can only occur if the properties that contain the gas will vastly change.

Leaks from Well Bores

The DSGEIS had implied that leaks do not occur from properly-constructed wells, but did not specify how often wells are found to not be properly constructed, and I requested (Myers 2009) that they provide an estimate of the times the wells are not properly constructed. Alpha responded with a quote from an industry source that estimated risk from failures to properly constructed wells is less than one in 50 million (Alpha, at 32). Alpha should have included the entire paragraph from which they selectively chose their quote, because it indicates the wells considered are class II injection wells and are properly constructed. Fracking wells experience a much higher, although much shorter, pressure during operations. They also should realize that the comment had to do with wells that are improperly constructed, because most failures, those that have allowed gas into groundwater, have resulted from improperly constructed wells.

Alpha also protests too much when they discuss my examples of gas in water wells (Alpha, at 33, 34). Incidents not related specifically to fracking are relevant because they show that the gas does move long distances through the groundwater, regardless of the source. Coal bed methane development relies on the gas moving through the groundwater, in coal seams, to the production wells; those production wells commonly pump as much water as do water wells, so, if gas is present to move to the water wells, the conceptual model for flow to water wells is similar. The point has to do with gas moving through aquifers due to any source – direct from the shale or a leak from the well bore.

Comparison to CBM Wells

Alpha used the conclusion to the EPA's 2004 CBM study, that fracking in coal seams poses little or no threat to underground sources of drinking water (Alpha, at 20) to support their conclusion that I had ignored relevant data (EPA's study) and that my arguments were fallacious because CBM wells are a much higher risk. They also state that "[c]oalbed hydrofracturing events approximate conditions where shale hydrofracturing is performed closest to ground water resources" (Id.). This is simply not true, and

it directly contradicts the conditions that the EPA put on their conclusion. EPA relied on the nature of CBM wells for their conclusion. "Although potentially hazardous chemicals may be introduced into USDWs when fracturing fluids are injected into coal seams that lie within USDWs, the risk posed to USDWs by introduction of these chemicals is **reduced significantly by groundwater production and injected fluid recovery**, combined with the mitigating effects of dilution and dispersion, adsorption, and potentially biodegradation" (EPA, 2004, at 7-5, emphasis added).

In fracked shale, there is no intentional "injected fluid recovery" brought about by pumping the injection wells, as in CBM wells. CBM wells pump water toward the gas well; this pumping decreases the hydrostatic pressure which releases the gas from the coal. Water and contaminants in the coal seam flows toward the CBM well. If there were contaminants in the coal, they would be drawn toward the CBM well.

Fracking in a coal seam would require much less pressure as well which would cause less out-of-formation fractures, which would limit the chance for out-of-formation fractures to occur. Additionally, EPA relies on the "high stress contrast between adjacent geologic strata" as a barrier to fracture propagation. The fact the coal is softer and the seams are much shallower and require much less fracking pressure helps to limit the fractures to the coal, much in contrast to shale seams (Fisher, 2010).

Finally, although the EPA's reasoning is reasonable, their methodology for concluding there has been no contamination is suspect; they only considered reported cases of contamination rather than relying on monitoring data. Fracking fluids in water wells near coal seams would be reported only if someone detects a problem. There have been cases of methane reaching water wells in the coal seams, but methane is obvious as it bubbles coming from the faucet.

Alpha claims that "Myers fails to address the historical data presented by ICF (2009, p. 22)" (Alpha at 19). ICF (2009, p 22) does not actually present data, contrary to Alpha's allegation. GWPC (1998), the source of ICF's "data", presents the results of a survey to which officials from states with over 10,000 coal-bed methane wells had responded they had never found groundwater contamination. However, contrary to Alpha's allegation, GWPC did not analyze 10,000 wells' worth of data. GWPC does not present monitoring data as proof, they present survey data from agency personnel claiming there has been no reported contamination. There is no indication whether the agencies ever looked for contamination beyond the claims of well owners. ICF also notes that coal seams may be used as aquifers, but did not indicate how many of the coal seams being developed by the CBM wells in the states replied to by the agency personnel were also aquifers.

Alpha truly mixes apples and oranges by using studies of CBM development, including fracking, to conclude that shale-gas development poses no threat to groundwater.

General Hydrogeology

Alpha's response to comments regarding aquifer depletion is a stretch to show how they actually disagree with my comments. Specifically, my comments about failures to regulate are replied to by stating the various commissions must permit the withdrawal – the problem is that there are really no

specifics provided about how the decision to permit would be granted. The DSGEIS did not specify what standard had to be met, beyond simple reporting, to be granted a permit.

Mitigating Surface Water Impacts

Alpha goes out of its way to find something to criticize in its review of my general surface water comments (Alpha, at 44, 45). My comments were generally qualitative and Alpha's responses are generally not substantial enough to require a reply here.

In Alpha section 4.2, regarding the use of the natural flow regime method, Alpha states that I was incorrect in claiming the NYSDEC would not require its use (Alpha, at 48). The 2011 rDSGEIS states clearly that it is NYSDEC's intent to require use of the NFRM, but the 2009 DSGEIS only states that it is "preferred", not required (2009 DSGEIS, at 7-3).

Alpha responds in detail to my comments regarding the Delaware and Susquehanna River Basin Commissions' methods (Alpha at 46, 47), even though they acknowledge the dSGEIS would require the NFRM. Because the rDSGEIS states the NFRM will be used throughout the project area, there is little reason to reply further to Alpha's comments at this point.

Ultimately, Alpha adapts many of my recommendations regarding surface water flow (Alpha, at 50, 51). They do not specifically endorse the recommendation to minimize the effect on aquatic habitats (outlined at Alpha, p. 47), the RDSGEIS does adapt a recommendation for using the Q60 or Q75 flow by month, which by month is better than my original recommendation.

Setbacks

Alpha discusses vertical setbacks along with my comments on monitoring and the need for water level mapping (Alpha, section 3.1). Much of their response relies on their perceived lack of hydraulic connection among formations, which has been discussed above.

Regarding horizontal setbacks, I had suggested that the recommended values are not based on any data or analysis of their effectiveness. Alpha simply rejects this without providing any reference, data, or results. "Myers assumes the setbacks proposed in the dSGEIS are not based on analysis; however, the setbacks are supported by practical application, experience, and historical analyses" (Alpha, at 43). Alpha repeats this sentence twice, verbatim, on the same page. When stating something as being based on analyses, it is customary scientific practice to cite the references to these analyses, something Alpha has failed to do. Alpha also suggests the "dSGEIS reference SEQRA, NYSDOH, NYC Watershed Rules and Regulations, the Clean Water Protection Act, and public water protection rules from other states" (Id.). Alpha does not indicate where in the dSGEIS these references are made, not indicates that the references include any analysis. Referencing others' rules without analyzing their effectiveness is not a scientific justification for specifying a setback. My statements are not that the setbacks are wrong, but that it is unknown whether they are effective. My recommendations may be larger than those in the dSGEIS, but they are designed to be protective to encourage a site specific analsis.

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Attachment 3

Glenn Miller, Ph.D.

Review of the

Revised Draft
Supplemental Generic Environmental Impact Statement on The Oil, Gas and 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

Prepared for:
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January 6, 2012

This document represents a review of the Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS) regarding proposals to develop natural gas wells using high-volume hydraulic fracturing in New York. I have specifically examined some of the chemical and toxicological issues, particularly related to the fracturing additives used, and the management of the severely contaminated flowback/produced brines. The RDSGEIS, in general, is an improved document compared to the previous draft of the potential environmental impact of the very large number of gas wells being proposed in much of New York. However, several key potentially significant adverse impacts remain inadequately addressed.

The following comments should be considered.

A. The water that flows back immediately following hydraulic fracturing is heavily contaminated (flowback), primarily with the Marcellus formation contaminants, and represents the most problematic chemical contamination potential, due to the large volumes of contaminated water generated. The brines that will be produced during gas production[1] will have higher concentrations of naturally occurring contaminants than flowback water (although lower volumes) and similarly represent a serious chemical contamination potential.

The RDSGEIS recognizes these problems and goes a long way towards evaluation and management of the contaminants; however, it still does not present a comprehensive wastewater management and disposal plan that will handle the anticipated large volumes of heavily contaminated wastewater. Further efforts are required to properly understand the contaminants in the flowback water, and develop management and disposal solutions.

Four problematic components of the flowback water and produced brines are present, including: (1) salts, other inorganic constituents, and metals and metalloids; (2) the radioactive component (NORM); (3) organic substances (from the hydrocarbon formation) and (4) hydraulic fracturing chemical additives.

1. ***Salts, other inorganic constituents, metals and metalloids in the formation water that are brought to the surface both as flowback and as production brines*:** The largest mass component of the formation water is salts and other inorganic constituents. The concentration of these constituents varies widely, as does their toxicity. Because the flowback is proposed to be collected and temporarily stored in closed systems, disposal of these large volumes of water is the largest problem with its management. The RDSGEIS discusses the problems with management of this water, and in

[1] The terms produced brine, production brine, produced water, and produced water brine are used interchangeably throughout these comments for formation water that is produced up the well.

particular the discharge of high total dissolved solids (TDS) water into receiving waters (see, for example pages 7-63), and stipulates that flowback produced water and brines will need to be regulated as industrial wastewater.

Table 5-10 of the RDSGEIS shows that produced waters (from Pennsylvania and West Virginia) containing the formation water are variable in chemical composition, but include not only simple salts (e.g., sodium, potassium, chloride, bromide, sulfate, fluoride, etc.) but also a variety of metals with varying frequency (cadmium, mercury, cobalt, nickel) and metalloids (arsenic, selenium, boron). Some of the constituent concentrations are very high, particularly sodium chloride, which has a mean concentration of over 10% by weight. Some samples had over 30% by weight simple salts plus other contaminants. The extreme contamination of these wastewaters and the high variability of contaminant levels make these waters complicated for treatment and potential reuse, as well as for tracking and disposal. If improperly managed and released to surface or groundwater, severe contamination is a reasonably foreseeable outcome. In particular, if this contaminated water intercepts domestic groundwater sources, the potential exists to permanently damage aquifers as current and future domestic water supplies.

While recognizing the problems with management of this water, the RDSGEIS fails to clearly state how this water will be either disposed in a manner that protects human health and the environment, or otherwise treated to remove the contaminants. While the RDSGEIS provides a range of treatment and disposal alternatives, the RDSGEIS does not sufficiently analyze the environmental or human health impacts associated with any of these treatment and disposal options. Further, the RDSGEIS implies that virtually all of the wastewater generated in New York will be managed out of state, where regulations may be less stringent, due to the lack of treatment capacity for these contaminated waters in New York.

2. ***Radioactive Substances (NORM):*** The RDSGEIS also recognizes the issues associated with management of NORM that comes to the surface either in the flowback or the production brines. However, similar to the salt problem discussed above, it does not explicitly indicate how wastes contaminated with NORM will be regulated and disposed.

   Examples of NORM concentrations in flowback are presented in Table 5-24, and in produced brines in Appendix 13. As expected, the NORM present in the flowback is somewhat lower than in the brines, due to dilutions when fresh water is used for the primary fracturing fluids. Less dilution would be expected if the flowback is reused as a portion of the fracturing fluid for another well.

Only three produced brine samples are shown in Appendix 14, but the level of radioactivity as gross alpha is very high, from about 18,000 pCi /L to 123,000 pCi/L. The standard for safe drinking water is 15 pCi/L (gross alpha).

The RDSGEIS does not propose a disposal solution for residual NORM, if it is separated from the produced water and the flowback water. Dilution of the brines to a drinking standard of 15 pCi/L (gross alpha) will require 1000x to 10,000x dilutions, and is unlikely to be acceptable in any jurisdiction, particularly when the components that are causing the radioactivity are not specified. While some mention of regulatory oversight is made in the RDSGEIS, there are no explicit indications of how these waters will be regulated or managed. The RDSGEIS does not propose a technically sound or viable solution for disposing of these radioactive materials. The RDSGEIS has not examined options such as evaporation-crystallization treatment or chemical precipitation. These processes will produce a very large tonnage of salts containing radioactive and metal waste. The lack of a thorough treatment and disposal analysis presents a serious problem when assessing the risk and potentially significant adverse impacts of these substances. There is effectively no analysis of how these materials will be disposed, other than a general (potential) suggestion that new licensing may be required.

For an adequate environmental analysis, it is also critical to identify the sources of the gross alpha radiation. Gross alpha radiation is defined by the U.S. EPA (40 CFR Parts 9, 141, and 142 [National Primary Drinking Water Regulations; Radionuclides; Final Rule]) as the total amount of alpha radiation minus the alpha radiation coming from uranium and radon. Table 2.3 of the RDSGEIS, which specifies the primary drinking water standards, is unclear as to how New York regulates radioactivity, other than to indicate that it will limit "alpha particles" to 15 pCi/L in drinking water, but does not indicate if that includes uranium. For the three samples of groundwater indicated in Appendix 13, only a small fraction of the components of the gross alpha have been identified, with the largest component being ^{226}Ra. For the three samples provided in Appendix 13, the individual gross alpha contributors can be summed to provide only 14-24% of the gross alpha in the water samples. The RDSGEIS does not identify the source of the remaining 76%+ alpha radiation; this omission constitutes a major flaw in the radioactive waste treatment and disposal analysis.

While it may be difficult to get an exact mass balance, accounting for less than 25% of the alpha radioactivity is insufficient.

It is unclear whether the data in Appendix 13 were based on the EPA gross alpha radiation definition, but the implications are substantial. If the EPA gross alpha radiation definition is used (which is probably the case), some other source of the alpha radiation will be present (e.g., polonium) as was

observed in the Florida phosphate industry (Burnett, et al., 1988). Verifying radioactive waste constituents is particularly important when assessing radioactive waste risk and to develop viable treatment and disposal options. Radioactive materials will also precipitate as scale in equipment; therefore, verifying radioactive waste constituents is also important for determining the radioactive risk as pipes are disassembled when cleaning is needed, or when the wells are disassembled when gas production ceases. If the source of the excess alpha radiation is polonium, the residual radioactivity from water treatment or scale management will potentially be more expensive to manage safely. The RDSGEIS has not analyzed the polonium risk, or treatment and disposal options for radioactive waste containing polonium.

While the U.S. does not have a polonium 210 standard, both Canada and the European Union do (see accompanying comments of Dr. Ralph Seiler), and it is lower or similar to the U.S. radium standard (5 pCi/L). Polonium is soluble in water under reducing conditions, and should be assumed to contribute to the alpha emission from the formation water, unless NYSDEC can rule out the risk. Polonium's risk contribution, however, is not currently analyzed in the RDSGEIS, and is a critical data gap in the NORM analysis. Polonium is a strong alpha emitter, but most importantly, treatment/management of these waters for disposal should require knowledge of the composition of the alpha emitting NORM component. Only then can appropriate methods for treatment and disposal be developed.

An additional component of the naturally occurring radioactivity is radon, a gaseous odorless radioactive element that is responsible for approximately 21,000 deaths from lung cancer each year (ATSDR, 2012), and is second only to cigarette smoking for causing this disease. Southern New York is already recognized as a region where elevated radon (>4 pCi/L) is common. Adding radon to households either from improperly vented gas utilizing appliances or through water systems that have been contaminated with natural gas leaks in groundwater supplies presents an additional risk factor for radon.

Data on radon in natural gas from the Marcellus Shale formation is very scant, and the RDSGEIS does not contain a sufficient amount of data to verify the maximum concentrations of radon expected in Marcellus Shale gas, or any other natural gas that may be developed under the proposed scope of the SGEIS. The amount of radon in natural gas is a critical measurement that should be made, to examine the incremental risk of radon exposure in homes and places of business that use natural gas or well water that could experience higher radon content as Marcellus and other shale gases are produced in NYS. While normal natural gas use in properly ventilated burners is unlikely to contribute to radon concentrations in closed spaces (see accompanying Seiler report), poorly vented areas may result in increased radon concentrations, and certain scenarios (e.g., high use of natural gas for industrial applications, restaurants that use gas burners)

should be subject to risk assessment. The risk of radon exposure from burning natural gas in poorly ventilated areas is likely to be greatest in indoor areas that already have elevated radon exposure levels.

An additional risk is when natural gas from a well leaks into an aquifer used as a well water source. Depending on concentrations of radon in the water, and the use of that water, radon levels can potentially be elevated in homes. This is a separate risk than from burning natural gas, but it is reasonable to develop scenarios where highly radon-contaminated gas moves through the soil profile and into homes. However, there are only scant radon data that can provide a basis for estimating those risks.

Recommendation 1. The SGEIS should clearly identify treatment and disposal options for flowback and wastewater, analyze the range of treatment and disposal alternatives, and propose the best technology and best practices for handling this waste. These technologies and practices should be included in the SGEIS as a mitigation measure, and codified in the NYCRR. The SGEIS treatment and disposal options for flowback and wastewater analysis should include a detailed examination of the waste constituents including, at a minimum: salts and inorganic constituents; NORM; metals and metalloids; organic substances (from the hydrocarbon formation); and fracture treatment additives.

Recommendation 2. The SGEIS should examine the existing wastewater treatment capacity in NYS, compared to the potential volume and composition of wastewater that will be generated by the proposed development, and make specific recommendations to ensure sufficient waste handling capacity exists before authorizing the proposed development. If waste will be transported to other states, the SGEIS should examine the impacts of that waste handling option as well.

Recommendation 3. The components of the gross alpha radioactivity should be identified in the RDSGEIS, and mitigation measures should be proposed to address radioactivity risk. The RDSGEIS does not identify 76%+ of the gross alpha radioactivity. The specific definition of gross alpha radioactivity should also be stated, or the EPA definition should be used.

Recommendation 4. The RDSGEIS should determine whether polonium is a significant component of alpha emission in formation waters, and polonium-contaminated wastewater should be regulated/managed appropriately to limit its discharge to surface or groundwater, as should all of the individual components of NORM.

Recommendation 5. Specific treatment methods to remove radioactive constituents from flowback and produced water need to be identified. If the radioactive constituents are removed from wastewater, management methods and disposal sites for the residual radioactive wastes should be identified. (See further discussion below.)

Recommendation 6. Additional radon measurements are needed to determine the range of concentrations of radon expected in Marcellus Shale gas or any other gas that may be developed under the proposed scope of the SGEIS. Gas measurement should be made at the wellhead, where natural gas is being used, including homes, businesses that use large amounts of natural gas, and in areas where natural gas leaks have been found. The SGEIS should include radon testing requirements as a mitigation measure, and this requirement should also be codified in the NYCRR.

3. ***Hydrocarbons present in the formation water:*** Hydrocarbons present in the flowback and produced water are characteristic of fuel hydrocarbons, and are represented by (a) compounds that, in some cases, are carcinogenic (e.g., benzene, benzo(a)pyrene); (b) common solvents (e.g., toluene, ethylbenze); and (c) the primary fuel components of natural gas, particularly methane. Common solvents and primary gas components, although generally of lower solubility in water, represent a toxic contribution that can be a serious risk, if they are released either into surface water or as a vapor that may subject persons living in the area to exposure.

4. ***Hydraulic fracturing additives:*** The range of hydraulic additives is very large, and difficult to assess from a risk perspective since the list is almost certainly incomplete, specific information on the chemicals is lacking, and the specific rate of usage is not offered. Thus, not knowing the composition of the specific additives and the amounts provides effectively no basis for estimating the risk of these components of the flowback or produced water, and the RDSGEIS falls seriously short in this regard. A mere laundry list of these components does not meet requirements for analysis of their potential impacts. The list is so long, and the data on each component so incomplete, that it falls far short of the data that would normally be contained in a professional scientific risk analysis. Additionally, Tables 5.4 and 5.5 use trade names, and while the New York regulators may have information on the constituents in those products, that information was not available for this review. Additionally, the public does not have access to this information, and thus the public cannot legitimately understand or evaluate the risk of these products to their health or the environment that they live in.

   Table 6.1 reports the constituents found in flowback, and effectively none of the additive compounds used in fracturing were reported in the flowback, except for the hydrocarbons that occur naturally in the hydrocarbon formations (benzene, toluene, xylene, naphthalene, etc.). In fact, the only non-fuel compound found in flowback that is also mentioned as a hydraulic fracturing additive is propylene glycol. This analysis demonstrates a significant problem in examining flowback chemical composition. Either NYSDEC is concluding that chemicals injected into the formation do not return in the flowback (improbable), or NYSDEC has not employed the correct analytical methods to evaluate flowback waste constituents.

It is not clear from the RDSGEIS how many of the additives were actually subjected to analysis in the flowback samples. Most of the chemicals listed in Table 6.1 that are used as additives will not be detected/measured by the standard methods used to determine hydrocarbons and metals. Therefore, the absence chemical additives in the flowback samples shown in the RDSGEIS is likely a function of incomplete laboratory analysis. For example, it is not clear that any attempt was made to actually measure the following three compounds in the flowback water: (1) 1-propanesulfonic acid; (2) 2-propenoic acid, homopolymer, ammonium salt; (3) acetic acid, hydroxyl-, reaction products with triethanolamine. None of the methods used by the Marcellus Shale Coalition (see Chapter 5-109) would, in this reviewer's estimation, be suitable for measuring these compounds. In fact, many, if not most of the additives, require very specialized methods for analysis; some are multiple chemicals (e.g., polymers), and some are relatively unstable (e.g., acrylamide).

There is, however, an implication that since the compounds were not subject to analysis, and thus not observed in the flowback water, they do not exist in the flowback water, which is a scientifically unjustified conclusion and almost certainly not the case.

Table 6.1 should be re-created with an additional column that indicates whether the compounds would have been measured with the analytical scheme utilized (e.g., gc-ms, icp-ms, ion chromatography for anions, etc.). Additionally, the RDSGEIS should list the analytical method required to detect each compound in the flowback. The detection limit for each method should be specified.

A full analysis for all of the additives utilized in hydraulic fracturing is indeed a challenge, but the SGEIS should clearly indicate which compounds could be measured by the protocol utilized, which could not, and what method would be required. It is likely that most if not all of the additives used that are not found in the formation water were not actually measured/determined. Thus, Table 6.1 has very limited value, and provides a distorted view of what is actually being measured.

Recommendation 7. The analytical tables for hydraulic fracturing additives should be revised to clearly show the analytical methods utilized and whether the analytical methods used, and detection limits provided by those methods, are sufficient to protect human health and the environment. The tables should verify if the additives were actually measured in the flowback water.

Recommendation 8. The RDSGEIS should include as a mitigation measure a list of analytically testing methods required to test flowback prior to disposal; these testing requirements should also be codified in the NYCRR.

A detailed risk assessment of each of the potentially toxic additives is a reasonable request. Leakage of flowback water to domestic water has been demonstrated recently in Wyoming by the U.S. EPA (2011) and represents a potential threat to ground water in New York. It is not sufficient to simply argue that gas wells will not leak, since leaks are now apparent in certain well fields (e.g., most recently in Wyoming (US EPA, 2011a)), as well as in Pennsylvania (Pennsylvania DEC, 2011). When leaks occur, it is probable that the greatest risk will be from the naturally occurring substances, but the additives also pose a non-trivial risk.

Practically speaking, it is more efficient and cost-effective to limit the additives used, rather than test for every possible additive in the flowback. Other governments and agencies have developed simplified methods and lists for prohibiting toxic additives, and assessing their risk (e.g., OSPAR PLONOR, C-NLOPB Guidelines, The Norwegian Pollution Control Authority; see accompanying report of Susan Harvey regarding additives). NYS could develop a similar list of prohibited additives, and a process for approving additives for use that will offer a method for reducing risks to both the public and workers.

Some of the additives being used are serious carcinogens, and may be difficult to measure. Two examples of these are acrylamide and acrylonitrile. Both are carcinogenic and, while not long lived in the environment, can create serious exposure concerns to workers and the public.

Acrylonitrile has been found in Pennsylvania and/or West Virginia in water samples taken near hydraulic fracturing operations (data received from individuals who had samples analyzed). It was also observed in flowback water from the Marcellus Shale Coalition (page 5-115 of the RDSGEIS). Acrylonitrile is a carcinogenic (US EPA, 2011b) and exclusively anthropogenic compound. It can be measured in a standard purge and trap gc-ms method, and has been used in Pennsylvania, and is indicated in a patent issued to Halliburton (Halliburton Energy Services, U.S. Patent 7799744). This compound is one of the more toxic compounds used as additives, yet is not even mentioned in the RDSGEIS (Table 5.9). Failure to include a chemical additive that is commonly used and known to be carcinogenic and toxic to humans is a serious deficiency in the RDSGEIS.

Failure to include Acrylonitrile in Table 5.9 raises uncertainty in what other harmful chemical were not listed or examined in the RDSGEIS. Additionally, the RDGSEIS lacks of information on additives use rates. Therefore, the RDSGEIS analysis of the potential significant adverse impact of additive use is, at the least, incomplete.

Acrylonitrile, butadiene and styrene (ABS polymer) are mixed "on the fly" with the uncoated propping agent to create a polymer covering on the propping agent. From the Halliburton patent:

> Some suitable polymers include, but are not limited to, acrylic polymers such as acrylonitrile polymers, acrylonitrile copolymers, and mixtures thereof. Some preferred polymers include homopolymers and copolymers of polyacrylonitrile (including copolymers of acrylonitrile and methyl acrylate, methyl methacrylate, vinyl chloride, styrene and butadiene), polyacylates, polymethacrylates, poly(vinyl alcohol) and its derivatives, and mixtures thereof. As used herein the term "acrylic" polymers refers to any synthetic polymer composed of at least 85% by weight of acrylonitrile units (the Federal Trade Commission definition). Thus, the definition of the term may include homopolymers of polyacrylonitrile and copolymers containing polyacrylonitrile. Usually they are copolymers of acrylonitrile and one or more of the following: methyl acrylate, methyl methacrylate, vinyl chloride, styrene, butadiene. However, polymers that do not meet the definition of an acrylic polymer (such as those having less than 85% acrylonitrile) may also be suitable. For instance, Example 3 uses poly(acrylonitrile-co-butadiene-co-styrene) that contains approximately 25 wt % acrylonitrile.

Further down the patent, the "on-the-fly" process is described.

> In particular embodiments of the present invention, the particulates may be coated with the polymer solution and introduced into the treatment fluid, which acts as the aqueous medium, directly prior to being introduced into a subterranean formation in an on-the-fly treatment.

This process is likely to be inefficient and likely to release substantial amounts of acrylonitrile and styrene into the water used in the fracturing process. Acrylonitrile has been found in flowback water (page 5-115 of the RDSGEIS), and reports are available that show that it has been detected in surface and ground water in Pennsylvania, and is perhaps one of the most unambiguous anthropogenic indicators that off-site contaminated water has been in communication with the water used in the fracturing process. NYSDEC should determine if this polymer and application method is appropriate for use in New York, and require acrylonitrile and styrene as two of the suite of compounds to be analyzed in flowback before it leaves the wellsite.

Recommendation 8. The NYSDEC should re-examine the additives used in hydraulic fracturing and conduct a much more detailed analysis of the risk of these compounds. Specifically , acrylamide and acrylonitrile, a carcinogenic and exclusively anthropogenic compound used in hydraulic fracturing, should be measured in flowback water, and an assessment made as to whether and/or how use of this compound should be permitted. The conclusions of such analysis should be included in the SGEIS as a mitigation measure and codified in the NYCRR.

B. The analytical data presented in Tables 5.10, 5.23, 5.24 and 6.1 all indicate a lack of detailed understanding of the quality of the flowback, and indicate

an inadequate understanding of the methods necessary to fully characterize the wastewater.

The errors in Tables 5.10, 5.23, 5.24 and 6.1 are sufficiently glaring that they need a much more detailed review. For example, in Table 5.10, the dissolved metal concentrations in some cases are higher than total metals. Iron, for example, has a median concentration 29.2 mg/L, but the dissolved median concentration is 63.25 mg/L. Similarly, the mean manganese concentration is 1.89 mg/L, while the dissolved manganese concentration is 2.975 mg/L. There cannot be higher amounts of dissolved iron and manganese than total iron and manganese.

The data from the Marcellus Shale Coalition was not displayed, other than as a table of compound detections. These samples were collected from 19 gas well sites in Pennsylvania and West Virginia. All samples were collected by a single contractor and the analyses performed by a single laboratory, which should reduce the variability. This would appear to be a very valuable data set, but surprisingly, no data were presented regarding concentrations of the analytes. Some comments were provided on the types of compounds detected, although it was not clear which types of water contained these constituents. Additionally, chlorinated hydrocarbon insecticides were detected, which is very surprising, since these compounds could not have been found in the formation water, and have not been used in the U.S. since the 1970's. They are likely false positives, although it is not possible to make that determination, based on the discussion in the RDSGEIS. Data obtained from the Marcellus Shale Coalition should be presented, which compares, for example, flowback water from different wells under similar conditions (e.g., immediate flowback versus flowback in subsequent days).

Finally, the data in Table 6.1, which focuses on the additives used in hydraulic fracturing, is problematic. As discussed above, it is highly unlikely that attempts to determine the concentrations of the fracturing additives were actually conducted, since many of these compounds are difficult to determine. The implication remains, however from Table 6.1, that these compounds were actually considered in some appropriate analytical scheme. This is almost certainly not the case, and Table 6.1 should be clarified.

Recommendation 9. Each of the SGEIS tables of analytical data should be reviewed by an analytical chemist, and the data be presented in a scientifically accurate and quality controlled manner. The data in Table 6.1 should be clarified and the compounds which were not subjected to specific analyses should be identified.

C. Permissible treatment of the flowback and the produced water is not well defined. It is unclear how the post-treatment residual salts and radioactivity will be managed. There does not appear to be any complete treatment of these waters that will be permitted in New York.

There are four possible treatment options for flowback and produced water discussed in the RDSGEIS: (1) reuse, (2) deep well injection, (3) treatment in municipal facilities, or (4) treatment in privately owned facilities. None of these options is properly analyzed in the RDSGEIS, and the potential significant adverse impacts of each are therefore not disclosed nor possible mitigation identified.

"Treatment" of flowback for *reuse* is discussed in Section 5.12. Reuse of the flowback conserves fresh water and allows contaminated water to be used instead during fracturing. However, the RDSGEIS only considered treatments for removal of salts that would allow for reuse in other hydraulic fracturing operations, and evaluated how specific requirements for reuse could be met by various treatment processes (e.g., membrane, ion exchange or evaporative processes). It did not analyze the residual contaminants removed by evaporative or membrane processes and thus concentrated, or how those contaminants would be managed, other than to indicate that the residual salts, or concentrated brine will require "further treatment or disposal." The SGEIS must address how this highly concentrated and toxic residue will be regulated and managed.

Three hundred tons of salt will exist in one million gallons of flowback or produced water brine, if you assume a 7% (70,000 mg/L) salt solution. The source of the alpha emitters also must be identified, as is discussed above. If, as is suspected, polonium is present in the flowback water, it represents an additional management burden of the flowback and produced water that must be evaluated.

Beyond reuse, the disposal options considered in the RDSGEIS only included injection wells (although there are currently no industrial waste injection wells capable of handling this wastewater in NYS), municipal sewage treatment facilities (of which there are currently none that are permitted to accept flowback and produced water), and private treatment plants (of which none currently exist in New York). Therefore the RDSGEIS examines options that do not exist, and does an incomplete job of that examination.

The RDSGEIS did not consider whether there are other, less environmentally harmful, options that exist for treatment and disposal of flowback and produced water. More importantly, the RDSGEIS fails to evaluate the potentially significant adverse environmental impacts and human health risks associated with each treatment and disposal option.

Section 6.1.8.1 indicates that "[f]lowback water may be sent to POTW's", but then describes the limitations that may preclude disposal of these waters in POTWs. The RDSGEIS requires that a "facility must first evaluate the pollutants present in that source of wastewater against an analysis of the capabilities of the individual treatment units and the treatment system as a whole to treat these

pollutants" (page 6-57); however, before such an evaluation can be conducted, the well operator must obtain a complete analysis of the flowback water (which as explained above, has not been done).

Additionally, the diversity of the flowback water quality is such that a POTW would need to conduct an extensive and expensive analysis of each water type that was delivered to the POTW under those guidelines. Since most of the additives are clearly not subject to routine analyses, it appears doubtful that a POTW could ever accept this type of waste. Also, if the limitation of 15 pCi/L of radium in the influent is enforced, a large portion (as yet not determined) of the flowback water could not even be accepted. Finally, the requirement of a complete description of the contaminants in the water is likely to add an additional burden to using POTW's for disposal, that this option may be precluded for most of the flowback water. Therefore, the proposal to use POTWs as a potential treatment and disposal method is scientifically and technically unsupported.

One serious problem with the proposed discharge (dilution) of fracture treatment wastewater via a municipal or privately owned treatment plant is the observed increases in trihalomethane (THM) concentrations in drinking water reported in the public media (Frazier and Murray, 2011), due to the presence of increased bromide concentrations. Bromide is more reactive than chloride in formation of trihalomethanes, and even though bromide concentrations are generally lower than chloride concentrations, the increased reactivity of bromide generates increased amounts of bromodichloromethane and dibromochloromethane (Chowdhury, et al., 2010). Continued violations of an 80microgram/L THM standard may ultimately require a drinking water treatment plant to convert from a standard and cost effective chlorination disinfection treatment to a more expensive chloramines process for water treatment. Although there are many factors affecting THM production in aspecific water, simple (and cheap) dilution of fracture treatment water in a stream can result in a more expensive treatment for disinfection of drinking water. This transfer of costs to the public should not be permitted.

NORM, the inorganic substances, and the organic compounds from the formation also represent serious contamination potential and require an appropriate level of treatment. The exact method of treatment that NYSDEC expects to require for any municipal or private treatment facilities that may be permitted is unclear. The RDSGEIS suggests that there will be some level of wastewater dilution through discharge into a receiving stream, at least in some cases. The analysis should be much more explicit about how wastewaters will be treated, both in-state and out-of-state. New drilling operations should not be permitted until adequate management/disposal of these waters is evaluated, with public comment required on the proposed methods, an analysis of the impacts associated with each, as well as mitigation measures as required by SEQRA.

Injection of the waste fluids into fully permitted underground injection control (UIC) wells is an option also, although this method is problematic due to the lack of permitted wells in New York, and the distance the contaminated water would need to be trucked in order to dispose of it in other states where permitted wells exist (e.g., Ohio). The recent seismic activity in Ohio from disposal of fracturing fluids also raises serious concerns whether this option is safe. Given the difficulties of wastewater treatment, UIC is likely the popular choice for wastewater disposal from the Marcellus region. However, NYS' increase wastewater load, along with increased wastewater generated from the increased drilling in Ohio and surrounding states, will likely pose an injection capacity problem for Ohio UIC wells. The RDSGEIS has not examined whether it is possible, or safe to install disposal wells in NYS' or whether a nearby state has sufficient capacity to inject NYS' incremental waste load, or whether this is the best technical solution. These are all potential significant adverse impacts that should be, but are not, addressed in the RDSGEIS.

Out-of-state management of waste is contemplated in Section 5.13.3.3., but is identified as not being within the regulatory purview of New York. However, simply stating that wastewater will likely be managed "out-of-state" is insufficient. Wastewater handling is an unmitigated significant impact in the RDSGEIS as currently proposed. The proposal to export NYS' wastewater and not examine this significant impact is not justified.

NYSDEC should instead evaluate the impacts of, clear cradle-to-grave oversight and management, identify the best solutions for waste handling, and include those requirements as mitigation measures in the RDSGEIS.

Furthermore, even if some export of wastewater is permitted, SEQRA requires analysis of the impacts of any potential waste management options, even if they are to occur outside of New York.

Finally, road spreading for dust control and de-icing would apparently (and appropriately) not be allowed for flowback water, but could be used under certain conditions for the produced brines. A rationale for this distinction is not provided, and permitting road spreading of produced water is not recommended, since the brines will have higher concentrations of NORM than the flowback water, and may include polonium. Some rationale should be provided for this distinction, particularly since it is apparently unknown if any of the hydraulic fracturing additives are even detected in the flowback water (see Table 6.1). It is clear, however, that the NYSDEC is concerned about using the brines for roads and will require a specific permit for this application. Whether a permit will be granted presumably will depend on the amount of radioactivity present in the water. Under no circumstances should brine solution that has a gross alpha concentration of greater than 15 pCi/L be applied to roads. Ultimately, this practice should not be allowed – there are simply too many questions about the identity and amount of contaminants in these fluids.

Recommendation 10: The RDSGEIS should identify and evaluate the impacts of the various options that are proposed to be permitted for management of wastewater, and identify any proposed mitigation for identified significant adverse impacts, which should be set forth in the proposed regulations.

Recommendation 11. Specific influent contaminant load restrictions need to be explicitly identified including those for: fracking additives, NORM (including gross alpha), TDS and other relevant contaminants in this management description.

D. **Cuttings disposal:** Disposal of cuttings is considered in the RDSGEIS, although the treatment is incomplete. Cuttings from the shales of marine origin such as the Marcellus Shale (particularly the horizontal cuttings) will require further examination to determine if they contain large amounts of salts, similar to the produced brines, or if they contain excessive alpha emitters. While the measurements of radioactivity, based on a gamma detector, do not indicate high levels of radioactivity, further analysis is required to determine the leachability of these cuttings. Polonium is only a very weak gamma emitter, and thus it would not be observed by simple gamma counting. The organic (reducing) components of the shales chemically trap uranium and potentially other radionuclides, and when they are subject to oxidizing conditions, increases in the solubility/mobility of some of the radionuclides (particularly uranium) is likely. The leachability of these cuttings under oxidizing conditions thus requires further analysis, as discussed at the bottom of page 6-65. However, these determinations need to be made, and the risks and potential mitigation identified, *prior* to permitting the wells.

Recommendation 12. The RDSGEIS must fully evaluate the potential significant adverse impacts of cuttings disposal and identify any necessary mitigation to address such impacts, which should be set forth in the proposed regulations.

E. **Odors are a continuing concern from gas wells:** A variety of chemicals are present in hydrocarbon formations that can present a serious odor problem, which can be both a serious human health problem and affect the quality of life of persons living near these sites. A very common, but toxic, constituent is hydrogen sulfide, characterized by a rotten egg smell. Other organic sulfides can also be present, including a variety of alkyl sulfides. Odors are very difficult to regulate, due to the vagaries associated with odor detection, acclimation, and differential effects on different persons. The severity of an odor is in the nose of the beholder. Thus, each well should be assessed to determine the potential of migration of volatile substances from the well operation to surrounding residents. Odor complaints should be taken seriously, and the presumption should be that an odor complaint is valid, and an investigation of the source required.

Hydrogen sulfide is, however, probably the most acutely toxic component present in a potential natural gas leak, and it can pose a serious health risk to surrounding residents, in addition to causing odor complaints. Sulfide monitors should be required at least two points, corresponding to most probable downwind locations at the fenceline. When hydrogen sulfide is detected above the odor thresholds, the source of the odor should be identified and eliminated.

Setbacks from an operating well will help to minimize the impact of odors on the surrounding residents. (Setbacks are discussed in further detail in the accompanying reports being submitted under cover of the Louis Berger Group.)

Recommendation 13. The RDSGEIS must fully evaluate the potential significant adverse impacts associated with odors and hydrogen sulfide emissions, and identify any necessary mitigation to address such impacts, which should be set forth in the proposed regulations.

F. **Monitoring of nearby domestic wells for contamination from gas drilling operations should be conducted at regular intervals during and following hydraulic fracturing.** While the drilling company would be required to test domestic wells for contamination prior to gas development operations, these same wells should be tested during production, and subsequent to discontinuing production to determine if hydraulic fracturing has resulted in contamination (See the accompanying report of Dr. Tom Myers). At present, the documents are silent on this requirement and effectively transfer this responsibility to the well owner. The analytes that should be determined should include, at a minimum, the components of natural gas (methane, ethane, etc.) and also toxic volatiles from the formation water (benzene, toluene, xylenes), salts and relevant inorganic contaminants, and the additives used during the hydraulic fracturing. This list should be developed based on those specific additives used.

Recommendation 14. The RDSGEIS and proposed regulations should require that monitoring of domestic wells situated in close proximity to gas drilling operations to be required at regular intervals during and following hydraulic fracturing. Because of the slow movement of groundwater, routine analysis of those domestic wells should be continued at least 20 years.

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Attachment 4

Ralph Seiler, Ph.D.

Review of the

Revised Draft
Supplemental Generic Environmental Impact Statement On The Oil, Gas and 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

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1/11/12

This document represents a review of the Revised Draft Supplementary Generic Environmental Impact Statement (RDSGEIS) regarding the hydraulic fracturing proposals to develop natural gas wells in New York. I have specifically examined issues related to NORM in the flowback/produced brine, as well as of radon in the gas itself. My comments supplement those of Glenn C. Miller, Ph.D.

Issue 1.

<u>Unidentified sources of gross alpha and beta radioactivity in flowback water and production brine.</u>

Gross alpha radioactivity in the brines (Appendix 13) and flowback water (Table 5-24) can be very high. In the brines, gross alpha is usually from 8,000 to 20,000 pCi/L, with a maximum of 120,000 pCi/L (Well Webster T1). In the brine samples with high gross alpha, the sum of uranium (U) , thorium (Th) , radium-226 (^{226}Ra) and radium-228 (^{228}Ra activities is much less than the measured gross alpha. Individual analyses of flowback water are not given, but the aggregated data similarly suggest that the sum of U, Th, and ^{226}Ra and ^{228}Ra activities is also much less than the measured gross alpha. These results indicate one of two things:

1. There are analytical problems with the gross alpha measurements, probably caused by the high salinity of the water.
2. There is an unidentified alpha emitter present in the water.

High salinity can cause the measured gross alpha to significantly overestimate the actual alpha activity of a sample (Arndt and West, 2007). The recommended mass placed on a planchet for gross alpha is only100 mg, so given a brine Total Dissolved Solids (TDS) of 350,000 mg/L (p. 6-61), only ~0.4 ml of sample should be placed on a planchet. The high TDS means it is easy for too much mass to be placed on the planchet, or the small volume means the mass may be unevenly distributed. Both of these factors can contribute to reduced precision and accuracy in the gross alpha analysis.

Appendix 13 indicates all of the relatively long-lived, naturally occurring alpha emitters in the brines were measured except polonium-210 (^{210}Po). Radon itself would not contribute at all to the measured gross alpha because it is a gas. In the gross alpha measurement, an aliquot of sample water is placed in a planchet and evaporated to dryness. After drying, the planchet is commonly flamed until it glows red to drive off hygroscopic water from the salts. Because of this, alpha radioactivity from radon does not contribute to gross alpha radioactivity.

^{210}Po normally binds strongly to sediment particles and concentrations in fresh groundwater are typically <1 pCi/L. In some geochemical settings ^{210}Po activities have exceeded 500 pCi/L in drinking-water wells in the US (Seiler et al., 2011), however this is extremely rare and fewer than 100 US wells have been reported with >15 pCi/L. ^{210}Po is known to be present in oil-field brines (Parfenov, 1974), however, the reported ^{210}Po activities in the brines were relatively low, about 100 pCi/L.

On p. 6-205 the RDSGEIS states radium is the primary radionuclide of concern, but this may not be the case if the excess alpha radioactivity is caused by the presence of ^{210}Po. If ^{210}Po is present in high levels, it may be much harder and more expensive to treat the contaminated water and manage the waste. Ra can be removed from water with relatively simple technology such as water softeners. On the other hand, Charles County in Maryland found the best way to remove Po from a contaminated public-supply well was with reverse osmosis. Treating millions of gallons of brine with reverse osmosis would be expensive and difficult, and could increase the cost to the public if treated at a public treatment facility. It could cause the gas to be more expensive to the consumer if the operator is made to bear the cost of treatment at an on-site or privately-owned treatment facility.

Gross beta radioactivity in many of the wells in some of the wells is several thousand pCi/L. To evaluate the significance of this, you need to know the potassium concentrations because ^{40}K is the source of almost all natural beta. If gross beta minus a correction factor for K were to exceed 50 pCi/L in a municipal well, the operator would have to identify the major contributors to gross beta. One

potential contributor to gross beta is lead-210 (^{210}Pb), which was not measured. This is potentially important because ^{210}Pb decays to ^{210}Po and could support it in the water.

Issue 1 Recommendations

The cause of the excess alpha radioactivity in the brine and flowback samples needs to be determined. ^{210}Po may be present at high concentrations and could pose a significant risk to health and the environment if oil-field brines are inadequately disposed of because it bioaccumulates. Samples from some of the more contaminated wells should be reanalyzed for the same suite of analytes as before, except this time include ^{210}Po. Redoing the complete suite will provide an idea on how adequately the less expensive gross alpha analysis identifies the presence of ^{210}Po. All samples analyzed for NORM (e.g. p. 6-61) as part of the regulatory process should include ^{210}Po, at least until it has been demonstrated that ^{210}Po is not an important source of alpha radioactivity.

NYSDEC should identify what the important contributors to gross alpha are (probably radium and ^{210}Po) and identify how, if at all, the brine and flowback water will be treated, taking economic considerations into account. Failure to do so constitutes a potentially significant adverse impact that would not have been disclosed or mitigated.

The principal contributer to the gross beta radioactivity is probably potassium-40 (^{40}K), but this should be confirmed because ^{210}Pb can also contribute to gross beta, and if present ^{210}Pb can support aqueous ^{210}Po. An estimated ^{40}K activity, based on the potassium (K) concentrations for the brines, should be added to Appendix 13 so the gross beta measurements can be evaluated. It is presumed that K was measured, even though no major ion analyses for the brines were found in the RDSGEIS. A theoretical activity ratio of 0.818 pCi/mg was reported by Friedlander et al. (1981) and can be used to convert concentrations to activities.

Issue 2.

Documentation of analytical methods

It is important that all analytical methods that will be used to analyze pollutant levels are well documented, but the RDSGEIS does not indicate what they would be.

Issue 2 Recommendations

It is presumed the alpha emitters were analyzed by alpha spectrometry, but the RDSGEIS should confirm this. The RDSGEIS also needs to provide reporting limits for the other analytes, not just provide a list of the analytes to be measured. An analysis for arsenic is useless if the reporting limit is 50 ppb when the drinking water standard is 10 ppb.

Documentation of the method is particularly important for the gross alpha analysis. EPA Method 900.0 for gross alpha allows samples to be composited quarterly and allowed to sit for up to a year before analysis. Unfortunately, the EPA approved analytical method can allow more than 60% of the ^{210}Po in a sample to be lost due to decay during that year (Seiler et al., 2011). A simple statement that Method 900.0 will be followed is inadequate. The RDSGEIS should explicitly state that samples for gross alpha will not be composited and must be analyzed within 3 days of sample collection. Analysis within 3 days is SOP for many agencies and finding labs that can meet that requirement should not be a problem.

Issue 3.

Radon in Natural Gas

Radon is known to be present in natural gas and will be delivered with the natural gas to consumers. Burning of natural gas in stoves, water heaters, and furnaces does not affect the radioactivity of radon and consumers will be potentially exposed to increased levels of atmospheric radon.

The RDSGEIS does not include measurements of radon concentrations in the natural gas, nor does it indicate plans to monitor it. Radon concentrations in natural gas are extremely variable and can be very high. Natural gas from Texas and Kansas had radon concentrations ranging between about 5 and 1500 pCi/L (Dixon 2001,

Table 2). This raises the possibility that radon concentrations in gas from the Marcellus Shale could be much higher values than are in the gas currently being used. In addition, the hydraulic fracturing process would be designed to maximize extraction of natural gas from the formation, and as a consequence may also maximize extraction of radon from the formation.

The pipeline from well heads tapping the Marcellus Shale will be much shorter than the existing 1500 mile pipeline delivering gas from Texas/Louisiana. Assuming the gas moves through the pipeline at 10 mph, it would take 6.25 days for gas from the wellhead to the consumer, and during this time ~68 percent of the radon will decay. If wellheads in the Marcellus Shale are only 100 miles from the consumer then only 7 percent of the radon would have decayed. Because of this, even if the wellhead radon concentrations in gas from the Marcellus Shale were identical to those of the currently used natural gas, consumers would be exposed to greater radon concentrations because the wellheads are closer.

Dixon (2001) provided a risk assessment for the radon in natural gas in the UK. The average radon in natural gas from the UK wells was 5.4 pCi/L, and, as a worst-case scenario, Dixon (2001) assumed that there was instantaneous delivery of the gas so that no radon decay occurred between the wellhead and the consumer. Dixon (2001) concluded there was negligible risk to the public from release of radon in combustion gasses, and that the average dose to the public using 100 cubic meters of gas would be only 4 microSieverts per year (μSv/yr). The greatest risk was to workers in large commercial kitchens who would receive a dose of 19 μSv/yr.

Issue 3 Recommendations

The risk to the public from radon in the natural gas probably is small. Measurements of radon in the gas are needed, however, to confirm that radon levels in the gas are within the expected range. A new risk assessment should be made using actual measurements of radon in gas from the Marcellus Shale and other factors specific to New York, such as the background radon concentration for the area. For

a worst-case scenario the assumption should be made that there is instantaneous delivery of gas from the wellhead to the consumer.

Issue 4.

<u>^{210}Po Buildup in Delivery Pipes</u>

On page 6-205 of the RDSGEIS there is a discussion of scale buildup in pipes and equipment, but the discussion seems to indicate Ra is the principle radionuclide of concern. If radon, ^{210}Pb or ^{210}Po are present at high concentrations in the water or gas, a more significant health risk for workers could be ^{210}Po in the scale. Summerlin and Prichard (1985) evaluated this and concluded that workers cleaning impellers could be exposed to high levels of atmospheric ^{210}Po.

Consumers and State and Local workers may also be exposed to ^{210}Po, which will form in scale on all pipes carrying natural gas with radon in it. The amount of ^{210}Po buildup will depend on the amount of radon in the gas. Plumbers and City/State employees working on the pipes may not know what precautions need to be taken, and thus could be exposed to ^{210}Po in the scale.

Another issue is the volatility of ^{210}Po, which is completely volatile at temperatures above 500°C (Radford and Hunt, 1964). Because of this, ^{210}Po that accumulates near burners that have been turned off may be vaporized when burners are turned on. This could potentially expose consumers to health risks from inhaling ^{210}Po. In cases of accidents or fires involving gas lines, first responders and the public near the incident could also be exposed to ^{210}Po through inhalation. This risk is not specific to gas from the Marcellus Shale. The health risks, however, would be related to the amount of radon in the gas and thus the amount of ^{210}Po that would build up, and this is not known for gas from the Marcellus Shale.

<u>Issue 4 Recommendations</u>

Measurements of radon in natural gas from the Marcellus Shale need to be made. A risk assessment should be made for inhalation of ^{210}Po resulting from scale buildup in delivery pipes.

Issue 5.

<u>^{210}Po drinking-water standards</u>

Table 2-3 presents drinking water standards for radionuclides. The US does not have a standard specifically for ^{210}Po largely because ^{210}Po is extraordinarily rare in drinking water. The US standard for ^{210}Po is exceeded if the gross alpha minus the U activity exceeds 15 pCi/L. Canada and the European Union have set drinking-water standards specific for ^{210}Po at 5.4 and 2.7 pCi/L, respectively (Health Canada, 2007; Commission of the European Communities, 2001). The regulatory use of the gross alpha standard assumes it will adequately identify samples with ^{210}Po levels that exceed health safety standards. For several reasons related to Po chemistry and the gross alpha analytical method, this may not be the case (e.g. Seiler, 2011).

<u>Item 5 Recommendations</u>

For any analysis where there may be actual human exposure, the RSDGEIS should analyze ^{210}Po analyses using alpha spectrometry rather than using gross-alpha analyses as an inexpensive but inadequate surrogate.

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Attachment 5

Susan Christopherson, Ph.D.

Memorandum

To: Kate Sinding, Natural Resources Defense Council

From: Susan Christopherson, Ph.D.

Date: January 11, 2012

This memorandum comments on issues in the sections of the 2011 Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS) and accompanying documents that address the social and economic impacts of natural gas development using high volume hydraulic fracturing (HVHF) proposed for New York, and evaluates the sufficiency of the impact analysis presented and the mitigation measures identified. HVHF describes a stage in the gas extraction process whereby large amounts of water, toxic chemicals, and sand are injected at high pressure to create fissures in low-permeability formations and thereby allow the release of gas. The process is capital intensive, and throughout its duration, poses significant environmental risks. The New York State Department of Environmental Conservation (NYSDEC or the Department) is charged with identifying and evaluating the impacts of gas development using HVHF, including both the benefits and the costs that will be borne by the communities and counties where drilling will occur.

In preparing these comments, the key documents reviewed include:

- The 2009 scope of work for the SGEIS.
- Comments prepared by AKRF and other technical experts on the 2009 draft SGEIS.
- A report prepared by Sammons, Dutton and Blankenship (2010) in response to comments on the 2009 draft SGEIS analysis of socio-economic impacts.
- The RDSGEIS released in September 2011 and particularly sections addressing socioeconomic and community impacts (6.8 and 6.12) and mitigation (7.0).
- The Economic Assessment Report (EAR) prepared by Environment and Ecology LLC to accompany the RDSGEIS.

These comments also draw on my own research on input/output models and community impacts and on research that has been conducted on the social and economic impacts of natural gas drilling in shale gas plays across the United States. Other documents cited in these comments are included in the reference list.

Although NYSDEC has included more information on the social and economic impacts of gas development using HVHF in the RDSGEIS than it did in the 2009 draft, the RDSGEIS still does not effectively assess those impacts or provide appropriate mitigation strategies. These comments identify areas of social and economic impact that require additional or revised research or analysis in the SGEIS. Overall, the discussion of social and economic impacts in the RDSGEIS is poorly organized. Social and economic topics are discussed in several sections of the RDSGEIS and statements are made in some sections that are contradicted by evidence in others. The differences between the social and economic impacts of vertical and horizontal drilling are not addressed in a systematic way. Critical assumptions underlying the socioeconomic

impact analysis were accepted from industry sources (the Independent Oil and Gas Association of New York or IOGA NY) without independent verification.

Substantive concerns include the following:

1. The assessment of economic benefits (jobs and taxes) relies on questionable assumptions about the amount of gas extractable in the New York portion of the Marcellus Shale. The range of estimates for extractable gas appears to be skewed to the high end, leading to an overestimation of economic benefits.

2. The model used to assess social and economic impacts presents natural gas development as a gradual, predictable process beginning with a "ramp-up" period and then proceeding through a regular pattern of well development over time. Experience from shale plays in the Western United States demonstrates that volatility and unpredictability are intrinsic to natural gas extraction, as operating companies assess their commercial options from one shale play to another or within one shale play and allocate rigs to respond to those options. The model used in the RDSGEIS is misleading, giving the impression that communities in the drilling regions will experience economic disruption only once, during a ramp-up phase, rather than periodically, as operating companies repeatedly enter and leave the region. The problems with the model are then compounded, as projected impacts on population, jobs, and housing are predicated on one-time ramp-up and adjustment phases rather than on a process in which rigs may move in, move out, and move in again, in an unpredictable sequence. Because many of the negative social and economic impacts of HVHF gas extraction (such as housing shortages followed by excess supply) are a consequence of unpredictable development, the model used in the RDSGEIS cannot appropriately assess those impacts. The limitations of the model should have been explained with reference to the literature that describes the irregular, unpredictable course of natural gas development, including rig movement among shale plays and the frequency of re-fracturing wells.

3. The RDSGEIS does not assess public costs associated with natural gas development. A fiscal impact analysis of the base costs to the state and localities that will occur with any amount of HVHF gas development is required along with an estimate of how costs will increase and accumulate as development expands. Although some of the potential community character and economic costs associated with the projected drilling scenarios are mentioned in the RDSGEIS, there is no attempt to quantify those costs to the state or localities either as part of the modeling process or separately.

4. The long-term economic consequences of HVHF gas development for the regions where production occurs are not addressed despite a widely recognized literature indicating that such regions have poor economic outcomes when resource extraction ends.

5. Mitigation of enumerated negative social and economic impacts of HVHF gas development is presumed to occur by means of phased development and regulation of the industry, but no evidence or information is provided to indicate whether, and if so how, that would occur. For example, NYSDEC proposes to ask operators to identify inconsistencies with local zoning and other comprehensive land use planning, but there is no explanation of how the inconsistencies will be addressed in the permitting process or regulatory system. All mechanisms that will be relied on to address adverse social

and economic impacts need to be defined and incorporated into enforceable mitigation measures.

Part I of these comments focuses on the socioeconomic impact analysis in section 6.8 of the RDSGEIS. Section 6.8 adopts the assumptions utilized in the EAR and summarizes its more detailed description of anticipated impacts from HVHF gas development. Part I.A pays particular attention to the model employed in the EAR and its assumptions about how the exploratory, drilling, production, and resource depletion phases of development will occur. These assumptions do not adequately consider the uncertainties and risks associated with HVHF gas development. Part I.B comments on particular issues and areas of impact addressed in the RDSGEIS. Part II discusses issues pertaining to the distribution of economic benefits that are raised by the EAR but not addressed in the RDSGEIS. Part III comments on the mitigation proposed for potentially significant social and economic impacts.

I. NYSDEC's Socioeconomic Impact Analysis

A. The Unpredictability of Natural Gas Production and How It Is Treated in the RDSGEIS

The EAR's projections concerning population, jobs, housing, and revenue are predicated on the assumption of a regular, predictable roll-out of the exploratory, drilling, and production phases of the natural gas development process, rather than the irregular pattern typically associated with such development.

Natural gas drilling is a speculative venture and the amount of commercially extractable gas from any particular well is uncertain. Because of the speculative nature of the industry, there are significant economic risks associated with natural gas production. These risks are magnified by the costs involved in natural gas development, which uses capital-intensive technologies such as those engaged in hydraulic fracturing.

The industry is organized in such a way that these risks can be lessened. For example, a limited number of rigs is available nationally, and they are deployed among and within natural gas plays based on calculations of well productivity and commercial return. The drilling labor force is not fixed to a place, but moves with the rigs based on operator company strategies. Work is carried out by contractors on a project-by-project basis to maximize flexibility and efficient deployment of the specialized skills needed.

Because of the speculative character of commercial development of natural gas plays, there are uncertainties in how any shale gas play or portion of a play will be developed. What this means in practical terms is that the regions where shale gas development occurs can experience considerable volatility in the timing of well development and in the scale of well development (in the total number of wells). This central feature of natural gas development has critical implications for the economies of natural gas development regions. As production fluctuates, regions may experience short- and medium-term volatility in population, jobs, revenues, and housing vacancies (Best, 2009; Headwaters Economics, 2011; Jacquet, 2009; Sammons, Dutton and Blankenship, 2010).

The EAR does recognize both production volatility and price volatility in the gas industry. In describing national drilling activity, the authors report: "The number of active gas

drilling rigs fluctuated substantially over the decade, with the number of rigs in the most active quarter being 2.35 times the number in the least active quarter." (EAR, 2-2). In New York, "the average wellhead price for natural gas remained at relatively low levels in the 1990s, generally increased thereafter, reaching a peak in 2008, and then fell sharply in 2009." (EAR, 3-12).

The EAR also briefly mentions the difficulties that the unpredictability and volatility of natural gas development presents for predicting social and economic impacts (e.g., EAR, 4-59, 4-111). The model used to project socioeconomic impacts ignores those issues, however, and assumes instead that the HVHF natural gas development in New York will have a different pattern than that historically associated with such development. Rather than occurring in irregularly recurring waves (or "boom-bust cycles"), development in New York is assumed to be steady and predictable.

The RDSGEIS mentions the uncertainty and variation in well productivity in sections not addressing socioeconomic impacts (RDSGEIS, 2-5, 2-62, 2-74, 4-17). However, the section of the RDSGEIS that specifically addresses socioeconomic impacts (Section 6.8) ignores the evidence of unpredictability in the pace and scale (timing and total well development) of natural gas development from New York counties with vertical well development and from other shale plays. Instead, it reports results from the model used in the EAR to project social and economic impacts from HVHF gas development that assume a regular, incremental, and predictable pattern of well development and production over a 60-year period, both on a statewide basis in three defined regions and under two development scenarios (low and average). Like the EAR, the RDSGEIS neglects the implications of variable well productivity and commercial viability -- critical considerations that will affect the pace and scale of drilling as well as its geographic distribution.

A1. Uncertainties Regarding Well Productivity

<u>The RDSGEIS and accompanying EAR do not meaningfully recognize a central category of uncertainties that will affect the pace and scale of drilling – the uncertainties surrounding well productivity.</u> Instead, NYSDEC states with respect to the low and average development scenarios analyzed:

> Both development scenarios assume a <u>consistent</u> timeline for development and production. Development is assumed to occur for a period of 30 years, starting with a 10-year ramp-up period. The number of new wells constructed each year is assumed to reach the maximum in Year 10 and to continue at this level until Year 30, when all new well construction is assumed to end.

(RDSGEIS, 6-209).

This approach is one of the major weaknesses of the RDSGEIS because the assumptions of a 30-year well production cycle and a sub-regionally consistent roll-out of wells that will move through the drilling and production phases over 60 years are not supported by evidence from other shale plays. In fact, there is sufficient evidence of precipitous declines in well productivity and the costs of HVHF gas development relative to ultimate recovery to raise questions about why the 30-year development/60-year productivity profile was adopted (Berman, 2010; Berman and Pittinger, 2011; Hughes,

2011; Urbina, 2011). In an analysis of shale gas wells across shale plays, Berman and Pittinger (2011) found thousands of wells that dropped below commercially viable production between 5 and 12 years after initial drilling. The average commercial life of these wells was 8 years. NYSDEC should not have used data provided only by IOGA to construct the roll-out model; rather, it should have obtained evidence and data from independent sources who do not stand to benefit from the projection of long-term, predictable resource development.

Another example of questionable assumptions that likely over-estimate potential gas extraction from the New York portion of the Marcellus Shale is the well productivity projections used in the EAR. These are presented in Tables 4-3, 4-4 and 4-5 of the EAR. Although ultimate recovery figures are not presented in the EAR, they can be calculated based on the yearly production projections presented in 4.1.3 and the number of wells projected in 4.1.2.

These productivity projections are considerably higher than the well productivity results from existing shale plays found by Berman and Pittinger (2011). In addition, calculations of well productivity over the 60 year period produce ultimate recovery figures for the New York portion of the shale play that, in the medium and high scenarios, exceed most scientific estimates of ultimate recovery (Coleman et al, 2011). Although the 29 Tcf low scenario (for 60 years) does not exceed geologist Terry Engelder's estimate for New York's portion of the Marcellus shale, the productivity projections seem particularly questionable considering that, "The Marcellus fairway in New York is expected to have less formation thickness, and because there has not been horizontal Marcellus drilling to date in New York the reservoir characteristics and production performance are unknown. IOGA-NY expects lower average production rates in New York than in Pennsylvania." (RDSGEIS, 5-139).

Moreover, as pointed out by a group of economists commenting on the EAR assumptions and methods (Barth, Kokkelenberg and Mount, 2011), the range of estimates of productivity is so large as to be meaningless. For example, estimates for well productivity during the 23rd year of production range from 600 billion to 3.6 trillion cubic feet, a variation on the order of 600%. Accuracy in these estimates is critical to derive estimates of tax and employment effects. As it stands, the estimates used in the EAR are no better than bloated "guesstimates."

The use of IOGA's estimates as the sole source of well productivity projections undermines the credibility and accuracy of the EAR and the RDSGEIS. The estimates of well productivity must be revised to more accurately reflect expert opinion on anticipated well productivity in the New York portion of the Marcellus shale. In addition, the RDSGEIS must be updated to reflect the Energy Information Administration's revised estimates of natural gas in the Marcellus shale based on the USGS analysis (Coleman et al, 2011).

The uncertainties associated with the productivity of extraction from the Utica shale must also be addressed, if Utica shale wells are to be included in the SGEIS analysis. In the EAR, the projections for the number of wells to be drilled include those for the Utica shale. There are significant uncertainties about the productivity of that play, the geographic variation in liquid content across that play, whether the well spacing and fracture treatment would resemble those for the Marcellus, and what technologies would be used in Utica shale development (Yost, 2011). These unknowns are significant and

indicate that Utica shale development may proceed differently than Marcellus shale development and utilize different technologies.

The unspecified inclusion of well numbers and productivity figures from the Utica shale also raises questions about the extrapolated employment, housing and tax implications that are attributed to Marcellus shale development.

The issues surrounding productivity are further complicated by the common practice of re-fracturing wells to increase pressure and productivity. If re-fracturing is practiced in New York Marcellus wells, communities will be repeatedly subjected to the environmental disruptions associated with heavy industry.

The uncertainties around and questions raised about long-term well productivity argue for modeling a shorter-term development and production cycle. At the very least, the competing evidence concerning well productivity and the cost of recovery should have been discussed in the RDSGEIS to qualify assumptions concerning the production cycle and estimated ultimate recovery.

A2. Impacts of the Uncertainties Associated with HVHF Gas Development

Evidence from Western shale plays indicates that the volatile pace and scale of natural gas development drives many environmental and social and economic impacts (Best, 2009; Jacquet, 2009; Headwaters Economics, 2010). Impacts directly affected by the pace and scale of drilling include:

1) Labor force needs and behavior. (How much of the workforce remains transient rather than becoming local? A local labor supply cannot develop if gas development is unpredictable.)
2) Demands placed on public services, including health facilities, public safety, and schools. (Can communities adapt over time or are there unpredictable rises and falls in demand?)
3) Community character impacts from increases in traffic, noise, construction disruption, and the transient population. (Do these increases roll out in a regular fashion with the expectation that disruptive “ramp-up” will end or are they unpredictable over a long period of time?)
4) Impacts on rural industries, such as tourism. (Can the scale of noise and traffic be predicted to occur only for a short period or are disruptive activities likely to recur over a longer period of time, for example, with re-fracturing of wells?)
5) Housing demand and cost. (Will there be periodic housing shortages with homelessness and lack of affordable housing for people on fixed incomes, potentially followed by excess housing supply and falling home values?)

To illustrate: As well pad construction begins in an area, jobs increase along with housing construction and business development. A transient population (in addition to transient industry workers) migrates to the area because of the prospect of jobs, increasing the demand for housing and services, including education and health. For a variety of reasons (price of natural gas, availability of higher value opportunities elsewhere, rig availability), natural gas development may drop off in the area within five-ten years of this initial “ramp-up.” Evidence from gas plays in Western states indicates that this drop-off may be sudden. In the wake of this drop in production and the number

of drilling rigs in the area, the transient population leaves and resident communities are left without jobs and revenue. Local governments may still be paying the public costs of ramping up to respond to the initial "boom." If conditions change (rigs become available, prices rise), the rigs may return to the area, causing another production "boom" with all of its attendant costs.

This pattern is described by Spelman (2009) and is associated with a reluctance of business (other than the gas industry) to invest in regions characterized by boom-bust economies. A contemporary example of such reluctance is contributing to the housing crisis in the Williston North Dakota Bakken Shale development. According to interviews conducted there: "Developers have been slow to build more apartments, largely because they got stung by the region's last oil boom that went bust in the 1980s." (MacPherson, 2011).

This volatile pattern is dramatically different from the scenario presented in the EAR and RDSGEIS. In both documents, communities are assumed to be impacted by a boom only once (during "ramp-up") and are gradually able to adjust to natural gas drilling. Many of the economic benefits that the RDSGEIS and EAR associate with natural gas development are predicated on this gradual, regular development scenario. For example, the RDSGEIS assumes that as the industry "matures" in the region, local residents will be trained and hired for drilling jobs. If, as has been the case with vertical drilling in New York State and in the Western US shale plays, development follows a more irregular pattern, then the higher paid technical jobs are less likely to evolve into stable local employment. In addition, the jobs in ancillary industries (retail and services) are likely to disappear and reappear as rigs leave and re-enter the region at unpredictable intervals. The RDSGEIS's use of a model built around regular, predictable development of the shale gas resource raises doubts about the projection of economic benefits based on that model.

A3. Hot Spots, Socioeconomic Impacts, and Public Costs

Contrary to the contention that the regularized development model "does not significantly affect the socioeconomic analysis" (RDSGEIS, 6-209), smoothing out the unpredictability and unevenness of development covers up many of the negative cumulative social and economic impacts that arise from the unpredictability of shale gas development. The RDSGEIS admits that steady, constant well construction is "unlikely" (RDSGEIS, 6-209), but it fails to analyze the implications of this admission and offers no description or evaluation of the adverse impacts of temporally and spatially uneven development.

In contrast with the model used in the RDSGEIS, natural gas development does not resemble a "manufacturing" process. Some wells will have long production phases; others will have dramatic declines in productivity after a relatively short period. Well productivity may be uniformly low across a region, or there may be long-term well productivity in particular "hot-spots." The question of how many wells will exhibit long-term productivity and where they will be located is unknown before exploratory drilling takes place and, even then, well productivity will be unpredictable.

The RDSGEIS admits that its socioeconomic analysis is based on average well productivity (RDSGEIS, 6-210), but the production process in natural gas (pace and scale) is not effectively captured using averages. The uncertainties in the geographic extent of drilling and the potential for intensive development in "hot spots" have

implications for social and economic impacts. For example, if drilling is concentrated in particular locations rather than rolled out uniformly across sub-regions of the landscape for 60 years (as is modeled in the RDSGEIS and EAR), wealth effects and tax revenues also will be concentrated in particular localities. The social and economic costs of spatially concentrated drilling, however, will be experienced across a much wider geographic area, because public services will be required in areas without HVHF development (and therefore not receiving tax revenues from drilling), but close enough to serve the transient population associated with the industry. There is no attempt to address this likely unbalanced distribution of positive and negative impacts in the RDSGEIS.

Finally, the RDSGEIS does not sufficiently model the resource depletion phase of the exploration, drilling, production, and resource depletion cycle and its implications for local and regional economies. Figure 6.13 (RDSGEIS, 6-215) shows the drop in direct and indirect employment following resource depletion. This depiction needs to be accompanied by analyses of how the resource depletion phase will be reflected in royalty payments and tax revenues.

A4. Socioeconomic Impact Analysis Can Accommodate the Uncertain Pace and Scale of Gas Development

If the impacts of volatility are to be mitigated, their prevalence in natural gas extraction regions needs to be acknowledged in the SGEIS. It is difficult to model the unpredictable pace and scale of natural gas production, but that difficulty is no excuse for ignoring adverse social and economic impacts arising from volatile and unpredictable development. Those impacts have been documented in relation to the phases of exploration, construction and drilling, production, and resource depletion, recognizing the company strategies that produce economic volatility in resource extraction regions (Jacquet, 2009; Kelsey, 2009; Sammons, Dutton and Blankenship, 2010).[1]

In cases where it is not possible to model specific cause-effect relationships (such as the relationship between well development and public costs), but where there is evidence of potential adverse impacts, those impacts should be recognized and documented. Sammons, Dutton and Blankenship (2010) take this approach in their report

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[1] From Sammons, Dutton and Blankenship (2010):

> Several recent studies address (social and economic) aspects of natural gas development in the western U.S. They include the *Northwest Colorado Socioeconomic Analysis and Forecasts* prepared for the Associated Governments of Northwest Colorado and the *Sublette County Socioeconomic Impact Study: Phase I Final Report* and *Phase II Final Report,* prepared for the Sublette County, Wyoming Board of County Commissioners. A third report, the *ExxonMobil Piceance Development Project Environmental Assessment - Socioeconomic Technical Report,* prepared by the authors for the U.S. Bureau of Land Management White River Field Office, assesses potential effects of a specific natural gas project in the context of ongoing large scale natural gas development in northeastern Colorado. A more recent journal article, *Energy Boomtowns & Natural Gas: Implications for Marcellus Shale Local Governments & Rural Communities,* published by the Northeast Regional Center for Rural Development, describes a model for impact assessment, presents a case study describing Sublette County's experience with large scale natural gas development and discusses some possible implications for Marcellus Shale development.

commissioned by the New York State Energy Research and Development Authority (NYSERDA) to describe socioeconomic impacts that can be anticipated with HVHF gas development. In addition, NYSDEC needs to quantify known social and economic costs even if their occurrence cannot be synchronized with their scenario model of development. This quantification can be accomplished through examination of comparable cases of impact, a standard method used in fiscal impact analysis (Kotval and Mullin, 2006).

B. NYSDEC's Analysis of Specific Socioeconomic Impacts: Model Assumptions and the Use of Representative Regions

The RDSGEIS presents only a fraction of the material contained in the EAR and acknowledges: "A more detailed discussion of the potential impacts, as well as the assumptions used to estimate the impacts, is provided in the Economic Assessment Report, which is available as an addendum to this RDSGEIS." (RDSGEIS, 6-207). This section identifies questions and concerns regarding the assumptions underlying the model used to predict impacts of HVHF development in New York State. These comments focus particularly on the use of representative regions to project impacts throughout New York State, including those for Utica shale gas drilling.

B1. The Use of Representative Regions

NYSDEC's use of a set of Southern Tier counties to represent all counties in New York that may experience HVHF shale gas drilling (EAR, 6-217) raises concerns about the representativeness of these counties. The EAR and RDSGEIS define three representative regions for the socioeconomic analysis, with Region A representing counties accounting for a high percentage of overall well development, Region B representing counties with about half the development of Region A, and Region C representing counties not expected to have much production but with a history of drilling. In the RDSGEIS, characteristics from a representative region are used to make assumptions about socioeconomic impacts in other New York State regions where drilling may occur. For example, tourism impacts are assumed to be minimal for all regions based on the continued presence of a tourism industry in Region C. The EAR and NYSDEC need to provide evidence (in industrial composition, growth rates, and population composition) to support the assumption that these counties are "representative" of all the counties that may experience drilling.

In addition, the EAR indicates that it addresses "local" impacts, but there is no analysis below the county scale. Analysis of differential economic impacts in urban and rural areas, for example, is critical to understanding the total economic impact picture. For example, counties in Region A in the EAR scenario analysis include both urban areas such as the Binghamton Metropolitan Statistical Area and rural areas where tourism and agriculture are the primary industries. Urban areas will garner more expenditures from natural gas drilling in the region, but are also likely to have negative impacts in the form of increased crime and demand for health services (because of their location in the urban areas). Rural areas will experience intense impacts on their small rural communities, including demand for housing and increases in road damage, as well as potential negative effects on agriculture and tourism. These local impacts, and how the costs and benefits will be distributed, need to be assessed separately.

B2. The Use of a RIMS Input-Output Model to Assess Social and Economic Impacts

A central component of the EAR is use of a Regional Industrial Multiplier System (RIMS) model developed by The Bureau of Economic Analysis. This type of model is useful for comparing different types of investments and for examining inter-industry linkages, but it has a significant drawback as the central model for the RDSGEIS analysis of socioeconomic impacts because it can only project economic benefits. It cannot measure or assess the costs of proposed gas development using HVHF or tell us anything about fiscal impacts.

The purpose of the model is to deduce direct and indirect economic impacts of new expenditures in a region. This type of model is very limited in the types of impacts it can assess. It is typically used to estimate some economic impacts, but is not useful to assess the wide range of social impacts that have been identified as occurring with HVHF shale gas drilling. So, for example, the model can be used to derive population increases and then, to crudely extrapolate potential housing demand. It cannot tell policy makers anything about the impact of housing demand on different population segments or on community character.

The results of this kind of model will always be positive because the model begins with the inflow of expenditures in the region. If the modelers had examined new expenditures flowing into the region's tourism or agricultural sectors those, too, would be positive. The model provided in the RDSGEIS does not allow us to assess opportunity costs, that is, to compare the economic impacts of shale gas drilling with those that might occur with increased investments and expenditures in other industries. This is important not only because shale gas drilling impacts are being considered in "isolation," but because investments in industries such as tourism and agriculture might decrease because of "crowding out" by HVHF activity (Christopherson and Rightor, 2011)

A model of this type is completely dependent on assumptions about the source of expenditures in the region. For example, in the case of HVHF gas development, the model is based on assumptions such as those about where the labor force hired in the drilling phase will spend the money they earn -- in the drilling region or in their home states? These assumptions are critical to the model results and should have been made available so that the accuracy of the model could be analyzed.

The presentation of the model results in the EAR is neither useful nor informative. Much of the text is devoted to tables that present mechanical calculations. These tables should have been relegated to an appendix and the body of the report used to lay out and support the assumptions that underlie the calculations.

In December 2011, the consulting firm that developed the EAR was asked to evaluate costs associated with gas development using HVHF in New York State. Because the RIMS input-output model and the associated scenario approach cannot address the costs of such development, the use of this approach rather than one that addresses costs as well as benefits needs to be justified and re-visited. In addition, because of its inability to address costs, the model does not provide information on impacts that require mitigation. Given the inadequacies of the EAR model and the significance of local and state costs to decisions about shale gas drilling in the state, revised EAR findings

regarding costs must be prepared and an opportunity for public review and comment on the revised EAR afforded before the SGEIS is finalized.

C. NYSDEC Analysis of Selected Social and Economic Impacts

This section comments on section 6.8 of the RDSGEIS, which assesses a selective subset of the many social and economic impacts anticipated with HVHF natural gas drilling. These include: (1) economy and employment, (2) population, (3) housing, (4) government revenue and expenditure, and (5) environmental justice. This section concludes with comments on material presented in the EAR that is not discussed in section 6.8, but which is relevant to the RDSGEIS findings regarding social and economic impacts.

C1. Economy and Employment

Employment. The oil and gas industry is not likely to be a major source of jobs in New York, because of the project-based nature of the drilling phase of natural gas production (rigs and crews move from one place to another and activities are carried out at each well) and because of its capital intensity (labor is a small portion of total production costs) (Jacquet, 2009). The emerging information on actual employment created in Pennsylvania in conjunction with Marcellus drilling shows much smaller numbers than industry-sponsored input-output models projected.

Although the industry points to years of drilling experience in New York, the oil and gas industry employed only 362 people in New York State in 2009 (0.01% of the state's total employment) (EAR, 3-7). 43% of those workers (157) were employed in Region C, the region where vertical natural gas drilling is most significant in New York. Wages for these workers constituted 0.04% of the wages in the two-county region with almost 4,000 active gas wells (EAR, 3-31).

The employment multiplier projected for New York State (2.1766) (derived from the model used in the EAR) is exceptionally high, especially for investment from a capital-intensive industry. (A 2.0 multiplier is considered generous by most regional economic analysts.) This underscores the importance of making the assumptions underlying the model transparent. For example, is the basis for the multiplier used an assumption that expenditures on real estate development resulting from the HVHF gas development will accrue disproportionately to New York state firms? If so, why? Because unrealistic and overly optimistic assumptions made in constructing the models may overstate economic benefits, assumptions underlying this RIMS model need to be available for scrutiny.

Finally, the employment figures presented in Table 4-8 are "full–time-equivalent" (FTE) jobs. These jobs do not correspond with what the ordinary person thinks of as a job – a person employed full-time to carry out certain tasks. They are a composite of part-time and full-time jobs that might be developed from the 410 job activities associated with constructing and drilling a well and from the subsequent production phase. These may not be new jobs, but existing jobs required to sustain industry activity. Finally, the EAR does not provide sufficient context for evaluating the employment impact of gas development using HVHF in the state. Projected employment in HVHF development should be compared with that in other New York industries, including tourism, to place the numbers in perspective. Projected increases in employment in these other

industries should be provided to enable comparison and to estimate costs and benefits of permitting HVHF gas development.

Impacts on other regional Industries. Having described in detail the modeled economic and employment growth from the gas industry, the RDSGEIS then mentions the potential adverse impacts on existing industries in the regions where natural gas development will occur. In a bare two paragraphs, the RDSGEIS admits:

> Conversely, some industries in the regional economies may contract as a result of the proposed natural gas development. Negative externalities associated with the [sic] natural gas drilling and production could have a negative impact on some industries such as tourism and agriculture. Negative changes to the amenities and aesthetics in an area could have some effect on the number of tourists that visit a region, and thereby impact the tourism industry. However, as shown by the tourism statistics provided for Region C, Cattaraugus and Chautauqua Counties still have healthy tourism sectors despite having more than 3,900 active natural gas wells in the region.
>
> Similarly, agricultural production in the heavily developed regions may experience some decline as productive agricultural land is taken out of use and is developed by the natural gas industry.

(RDSGEIS, 6-230).

In contrast with the pages of projected benefits from gas development, the RDSGEIS offers no detailed description and no quantitative analysis of the effects of HVHF development on existing industries and the associated impact on the state of New York's economy. This omission is particularly important for the counties defined in the EAR as "representative" because industries, including agriculture and tourism, are significant employers in those counties and are important to the overall economy of the State. There is no analysis of how the "crowding out" of existing industries may impact the regional or statewide economy or of the implications of the loss of industrial diversity to the long-term prospects for regional economic sustainability.

The inadequate assessment of the impacts on existing industries in the region that will be affected by HVHF gas development is problematic not only because the state does not have adequate information to assess costs and benefits of HVHF gas development, but also because negative impacts on industries such as tourism and agriculture, including dairies and wineries, will undermine state investments intended to support those industries. As discussed in detail below, given the importance of these industries in the state and regional economy, the evidence that they will be negatively affected by HVHF gas development should have been analyzed in detail and quantified when possible.

Tourism. The RDSGEIS makes no effort to quantify the value of tourist activities that may be adversely affected by gas development but rather dismisses any impacts as insignificant.

Nearly 674,000 New York jobs were sustained by tourism activity last year, representing 7.9% of New York State employment, either directly or indirectly. New York State

tourism generated a total income of $26.5 billion, and $6.5 billion in state and local taxes in 2010.

Tourism in the Southern Tier counties includes a wide range of activities, from visits to the Corning Glass Museum to hiking, hunting, and fishing in the rural areas. The Southern Tier Central (STC) Planning District, which includes Chemung, one "fairway" county (where significant natural gas drilling is anticipated because of the geologic formation) located in Region A in the RDSGEIS analysis, has published a study indicating that:

> In 2008, visitors spent more than $239 million in the STC region across a diverse range of sectors. The tourism and travel sector accounted for 3,335 direct jobs and nearly $66 million in labor income in the STC region that year. When indirect and induced employment is considered, the tourism sector was responsible for 4,691 jobs and $113.5 million in labor income. In addition, the travel and tourism sector generated nearly $16 million in state taxes and $15 million in local taxes, for a total of almost $31 million in tax revenue -- a tax benefit of $1,181 per household.

(Rumbach, 2011, page 1).

Tourism is thus a significant contributor to the counties in New York potentially impacted by HVHF gas development. The tourist opportunities and activities also contribute to the quality of life of local residents and attract companies in other sectors, such as manufacturing.

NYSDEC's use of Chautauqua and Cattaraugus Counties as the basis for contending that tourism will not be significantly impacted in New York is not persuasive. First, the evidence offered for the judgment that those counties have "healthy tourism sectors" (RDSGEIS, 6-231) consists of nothing more than the statement that: "In 2009 wages earned by persons employed in the travel and tourism sector in Chautauqua and Cattaraugus counties (Region C) were approximately $77.5 million, or about 3.0% of all wages earned in Region C" (NYSDOL 2009b*)* (see Table 3-37)" (EAR, 3-27). Without comparing Chautauqua and Cattaraugus over time with similar counties where natural gas development has not taken place, it is impossible to determine whether the tourism sector of the Region C counties has been negatively impacted by shale gas drilling.

The contention that those counties represent a tourism success story is contradicted by data presented in the EAR, which shows that from 2007 to 2009, Region C tourism employment declined 17%, and wages declined 13% (EAR, 3-28). While a portion of this decline might be attributable to the recession, there is no justification for describing waning tourism in the region as "healthy."

In addition, there is growing evidence regarding the negative effects of shale gas drilling on tourism in the counties where shale gas drilling takes place (Rumbach, 2011).

> Evidence from other shale plays in the Western U.S. indicates that natural habitat tourism (whether hunting, fishing, birding or hiking) may be disrupted for long periods of time and in some cases where infrastructure, such as compressor plants and pipelines, disrupts habitats, may be permanently altered.

(Sammons, Dutton and Blankenship, 2010). Negative impacts derive not only from the loss of habitat for outdoor sports, but also from the "crowding out" of tourism activities (because of increasing prices in the drilling region and the loss of hotel spaces to gas industry workers) and from the impact of regional industrialization on the tourism brand. For example, tourism centers in Upstate New York, such as the Finger Lakes wineries, may experience losses when tourists looking for a rural retreat find themselves driving through an industrial region with heavy truck traffic and shift their allegiance to quieter and more accessible vacation spots. In addition, the RDSGEIS does not assess the impacts on tourism from degradation of historical and cultural assets.

The EAR also conflates access to private recreational land for purposes of hiking, hunting, and fishing with the success of commercial tourism businesses. The relationship between personal recreational opportunities and natural gas development is presented as one of personal trade-offs in terms of land use. The negative impacts on the options of non-land owning recreationists are mentioned but not addressed (EAR, 4.58).

Rumbach's assessment of HVHF gas development on tourism is that:

> ….individual impacts are unlikely to have serious and long-term consequences, but without mitigation, cumulatively they could do substantial damage to the tourism sector. Examples of such impacts include strains on the available supply and pricing of hotel/motel rooms, shortfalls in the collection of room (occupancy) taxes, visual impacts (including wells, drilling pads, compressor stations, equipment depots, etc.), vastly increased truck and vehicle traffic, potential degradation of waterways, forests and open space, and strains on the labor supply that the tourism sector draws from. All told, the region's ability to attract tourists could be damaged in the long-term if the perception of the region as an industrial landscape outlasts the employment and monetary benefits of gas drilling.

(Rumbach, 2011, page 2).

The RDSGEIS fails to address the long-term costs associated with displacing business in existing industries, such as tourism, that provide economic diversity in the regional economy and thus increase its prospects for sustainability.

<u>Agriculture</u>. <u>Potential negative impacts on agricultural production and land use are noted, but their impact is not assessed nor are any mitigation measures proposed (RDSGEIS, 6-231). There is no analysis of whether and how HVHF gas development will affect sub-sectors of agriculture, such as dairy farming, which are of key importance in the New York economy</u>.

Milk and other dairy products account for more than half the total value of agricultural products sold in New York State, accounting for $2.2 billion in receipts in 2010. According to the US Department of Agriculture, New York ranks third in the US in production and sale of dairy products. Certainly the size and importance of this industry to the New York economy warrants a full analysis of how production and producers will be impacted by HVHF gas development. Instead, the RDSGEIS lacks an economic

assessment of how temporary and long-term agricultural costs and productivity will be affected by HVHF development.

Recent evidence from Pennsylvania indicates that agriculture and particularly dairy farming may be significantly affected by drilling activity. For example: "(Bradford) county's dairy herd has decreased over the last decade from 30,000 head in 2002 to just under 20,000 head today. Another 15 dairies have been sold since the beginning of the year (2011)" (Tomes, 2011). Although evidence from Pennsylvania is anecdotal, there is sufficient information to indicate that one of New York's major industries will be negatively affected by HVHF gas drilling.

Dairy farms are decreasing in areas with natural gas development both because some farmers have another source of income and because costs for dairy farmers are going up as a consequence of the impact of the drilling economy in the county. For example, competition for truck drivers is raising the cost for dairy farmers to transport their milk to processors. In addition to the impacts on the dairy farms themselves, the infrastructure that supports dairy farming in Bradford County is being affected. For example, an agricultural equipment dealer in the County has gone out of business because of an inability to hire and retain a workforce (Tomes, 2011).

There are also land use impacts that affect farmers, including impacts not only from the well pads, but also from the ancillary industrial facilities, such as "laydown yards" (operations and storage sites), pipelines, and compressor stations (Tomes, 2011).

The American Farmland Trust (2011) has submitted comments on the RDSGEIS that summarize its expert assessment of the impact on agricultural production in New York State:

> …the DEC's analysis of the impacts of drilling and hydraulic fracturing to agricultural land is inadequate and encourages specific analysis of the likely impacts of such activities to agricultural land resources. The SGEIS analysis should consider the scale of farmland likely to be converted by both direct drilling activities and the off-site drilling support services and other types of residential and commercial development that is anticipated as a result of natural gas drilling. In addition, it should consider the impacts of such activities to agricultural land values and on the ability of New York farmers to maintain their competitiveness in a global economy.

Upstate New York is currently experiencing a resurgence in its food processing industry, and the State Agricultural and Markets Program has a stated policy of encouraging more dairy production in the state. In July 2011, the State of New York provided $16 million in incentives to a dairy processing company in Chenango County in Central New York. According to a statement by Governor Cuomo: "Agro Farma's expansion in Chenango County will create hundreds of new jobs and increase the demand for milk from New York dairy farms," (press release available at: http://www.governor.ny.gov/press/07212011DairyProductsCompany).

The support from New York's Empire State Development Corporation reflects the significance of this industry to the regional and state economy. A full economic assessment of potential impacts to this industry is warranted. This assessment should include labor costs (from competition for truckers, for example) and impacts on specialty

agricultural producers, such as organic farmers. New York State has the fourth largest number of organic farms in the U.S.

The Finger Lakes wineries, combining agriculture and tourism, are another important subset of New York industries that may also be affected by HVHF gas development in Upstate New York. New York State ranks third nationally in grape production. Tourists visiting the wineries may not want to drive through industrial development and its associated truck traffic in order the reach the wineries, even if the wineries are not locally impacted by the drilling process. Given the importance of this and other sectors of New York's agricultural industry to the Upstate New York "brand" and the investment of State resources to build the industry, the SGEIS needs to separately assess the impacts on this industry and develop mitigation policies to address the negative impacts identified.

Manufacturing. Finally, the RDSGEIS and the EAR focus exclusively on impacts to agriculture and tourism because the use of land by those industries potentially competes with use of land for gas development. Focusing on that competition may make sense for the largely rural representative regions defined in the EAR, but it does not make sense for representative regions with more diversified economies, including substantial manufacturing. A report by the New York State Comptroller's office in 2010 shows that the Southern Tier has 14% of Upstate manufacturing. Manufacturing should be included in the assessment of impacts on existing industries, because of its significance in Region A and because gas development will affect the labor supply and industry wage rates in counties where manufacturing plays a significant role in the economy.

C2. Population

The RDSGEIS and EAR do not address population impacts on community services, such as schools and health, but only population as it relates to employment and the labor market. There was no attempt to look at actual population trends in counties with significant gas drilling and whether they reflect a decline in economic diversity that makes population levels less sustainable. An analysis of the long-term population trends in shale gas drilling counties in the US is necessary to determine the impact of HVHF gas development on New York counties. A projection based on labor demand is not sufficient.

The EAR assumes that, for the first 30 years, the population increases in counties that "host" natural gas drilling will be modest. It notes, for example:

> [A]ctual population impacts may also be less than what is described in the following section because currently unemployed or underemployed local workers could be hired to fill some of the construction and production positions, thereby, reducing the total in-migration to the region.

(EAR, 4-59).

By focusing only on population changes directly related to gas industry employment, the RDSGEIS avoids addressing the potential for long-term population decline beyond the loss of industry workers. Many areas with significant natural gas drilling lose population over time. That has been the case with Chautauqua and Cattaraugus counties (Region C) in New York.

In addition, the RDSGEIS assumes a gradual (rather than disruptive) integration of the unemployed population in the region and of transient workers into the labor force required by the industry. Experience from other states, however, contradicts the assumption of easy integration of the resident workforce and of newcomers to the regional labor force: "In areas of Pennsylvania where Marcellus shale drilling activity is occurring, it has been difficult at times to accommodate the influx of new workers" (Kelsey, 2011). The potential for a low-skilled, transient workforce to migrate into the area is not considered, although there is evidence from Western shale plays that this occurs, and is particularly likely with high national unemployment rates.

> [B]ecause labor markets are imperfect, [and] the availability of a relatively large number of jobs may result in an influx of job seekers, some of whom lack necessary skills and qualifications and may be relatively indigent. To the extent that indigent job seekers are unable to find jobs or do not have resources to secure housing and transportation to work; they can become a burden for local human service agencies. This situation can be exacerbated by weak economic conditions in other parts of the state or country.

(Sammons, Dutton and Blankenship, 2010, page 13).

The RDSGEIS fails to address this evidence of adverse economic impacts.

C3. Housing and Property Values

<u>The potential impacts on the housing supply, housing costs, and housing financing are inadequately assessed in the EAR. In addition, the social and economic impacts of unpredictable shortfalls in housing followed by periods in which there is an excess supply are not addressed.</u>

The report assumes that the current housing stock would be used to house any workers who move to the production region on a "permanent" (more than one year) basis (EAR, 4-107 (concluding "the impact on the supply of permanent housing units would be negligible at the statewide level during the production phase")). Given the quality and age of the housing stock in the region, evidence from Pennsylvania indicates that it is likely that there will be a demand for new single-family housing (Kolb and Williamson, 2011). This new housing stock will create new and additional construction jobs, increasing population pressure, accelerating the "boomtown" phenomenon. This housing may also contribute to sprawl around urban population centers such as Binghamton. When drilling ceases, either temporarily or permanently, the value of this new housing is likely to plummet (Best, 2009).

With respect to temporary housing, the EAR (EAR, 4-111) admits:

> In areas of Pennsylvania where Marcellus shale drilling activity is occurring, it has been difficult at times to accommodate the influx of new workers (Kelsey 2011). There have been reports of large increases in rent in Bradford County, Pennsylvania, as a result of the influx of out-of-area workers (Lowenstein 2010). There have also been "frequent reports" of landlords not renewing leases with existing tenants in anticipation of leasing at higher rates to incoming workers, and reports of

> an increased demand for motel and hotel rooms, increased demand at RV camp sites, and increases in home sales (Kelsey 2011). Such localized increases in the demand for housing have raised concerns about the difficulties caused for existing local, low-income residents to afford housing (Kelsey 2011).

If communities add substantial temporary, short-term housing or single-family housing to accommodate development-phase workers, surplus capacity may exist in all these types of units after development is completed. Based on evidence from other shale gas plays, all of these adverse impacts (initial housing shortage, surplus supply if rigs leave temporarily and depressed value in some areas) may occur (Best, 2009; Sammons, Dutton and Blankenship, 2010).

The EAR (EAR, 4-111) also acknowledges the potential impact of the volatility of the production cycle on the housing market and property values:

> The demand for housing, both temporary and permanent, would be expected to change over time. The demand for housing would be the greatest in the period during which the wells in an areas are being developed, and demand would decline thereafter. This would create the possibility of an excess supply of such housing after the well development period (Kelsey 2011). If well development in a region occurs in some areas earlier than in others, then housing shortages and surpluses may occur at the same time in different areas within the same region.
>
> The natural gas market can be volatile, with large swings in well development activity. Downswings may cause periods of temporary housing surplus, while up-swings may exacerbate housing shortages within the regions.

A recent study of the impact of HVHF gas development in Pennsylvania indicates that impacts on the housing supply are significant, especially for people at the economic margins (Williamson and Kolb, 2011). These impacts pose environmental justice concerns and require mitigation strategies.

With respect to impacts on property value, the EAR authors found that having a well on a property was associated with a 22% <u>reduction</u> in the value of the property; that having a well within 550 feet of a property increased its value; and that having a well located between 551 feet and 2,600 feet from a property had a negative impact on a property's value. Thus,

> …not all properties in the region would increase in value, as residential properties located in close proximity to the new gas wells would likely see some downward pressure on price. This downward pressure would be particularly acute for residential properties that do not own the subsurface mineral rights (EAR, 4-114).

The EAR authors attributed the positive impact on property values of having a well located within 550 feet of a property to <u>the prevention of further gas well development</u> in that area due to a spacing order and setback conditions that prevented well drilling close to existing wells.

The assertion in the EAR that property owners in the drilling region would see an overall increase in property values is based on increased demand and economic activity. Evidence from Pennsylvania and from Western Shale plays indicates that this demand may not occur in the county or locality where the drilling is occurring (Patton et al, 2010).

The EAR's assumption of recovering property values after the completion of HVHF gas development does not take into account the potential for re-fracturing of wells to increase their productivity or the effects of waves of development in which drilling moves in and out of an area. The prospect of industrial activity is what drives down investment in regions open to boom-bust development and also negatively impacts property values (Spelman, 2009). A more definitive analysis of impacts of on property values, including mortgage availability, in regions affected by drilling is needed.

C4. Government Revenues and Expenditures

The RDSGEIS assumes, based on the RIMS model, that economic benefits from HVHF gas development, presumably including benefits to revenue, will be substantial, but there is no fiscal impact analysis or cost-benefit analysis to substantiate that assumption. A fiscal impact analysis is required, given that:

(1) Many purchases by drilling companies are tax exempt (EAR, 4-116).

(2) Costs to the state that will reduce or offset tax revenues are not calculated. For an example of this problem, see the discussion of rail infrastructure in the RDSGEIS section on transportation impacts. The provision of tax rebates to railroad companies and to industry facilities represent lost revenue to the State and the locality. The EAR admits that in addition to tax benefits, "such as expensing, depletion, and depreciation deductions," which reduce taxable income, "New York State offers an investment tax credit (ITC) that could substantially reduce most, if not all, of the net income generated by these energy development companies" (EAR, 4-115 to 4-116).

(3) Substantial negative fiscal impacts are detailed in the EAR that are not quantified or fully acknowledged in the SGEIS:

> High-volume hydraulic fracturing operations would also result in some significant negative fiscal impacts on the state. The increased truck traffic required to deliver equipment, supplies, and water and sand to the well sites would increase the rate of deterioration of the state's road system. Additional capital outlays would be required to maintain the same level of service on these roads for their projected useful life. Depending on the exact location of well pads, the state may also be required to upgrade roads and interchanges under its jurisdiction in order to handle the additional truck traffic. The potential increase in accidents and potential additional hazardous materials spills resulting from the increased truck traffic also would require additional expenditures. Finally, approval of transportation plans/permits would place additional administrative costs on the New York State Department of Transportation (EAR 4-116).

There are now numerous studies available to calculate road damage, and the counties in the "fairway" in New York State have undertaken baseline studies that would enable

accurate calculation of the costs of road damage (Randall 2011). There is plenty of expertise available in the state to draw on, including Cornell Local Roads program, which has completed a thorough analysis of the kind of damage and what it would cost to repair.

The EAR also recognizes additional public costs associated with Marcellus shale gas development:

> Additional environmental monitoring, oversight, and permitting costs would also accrue to the state. In order to protect human health and the environment, New York State would be required to spend substantial funds to review permit applications; to ensure that permit requirements were met, safe drilling techniques were used, and the best available management plans were followed; and to provide enforcement against violations. In addition, the state would experience administrative costs associated with the review of well permit applications and leasing requirements and enforcement of regulations and permit restrictions. All of these factors could result in significant added costs for the New York State government.
>
> The New York State Department of Health would also incur additional costs due to the need to provide additional technical support and oversight services to local governments that would monitor water quality in local drinking water wells (EAR, 4-116).
>
> In addition to the positive fiscal impacts discussed above, local governments would also experience some significant negative fiscal impacts as a result of the development of natural gas reserves in the low-permeability shale. As described in previous sections, the use of high-volume hydraulic-fracturing drilling techniques would increase the demand for governmental services and thus increase the total expenditures of local government entities. Additional road construction, improvement, and repair expenditures would be required as a result of the increased truck traffic that would occur. Additional expenditures on emergency services such as fire, police, and first aid would be expected as a result of the increased traffic and construction and production activities. Also, additional expenditures on public water supply systems may be required. Finally, if substantial immigration occurs in the region as a result of high-volume hydraulic fracturing operations, local governments would be required to increase expenditures on other services, such as education, housing, health and welfare, recreation, and solid waste management to serve the additional population (EAR, 4-138).

The RDSGEIS mentions public costs associated with the increased demand for community social services, police and fire departments, first responders, schools, etc., but makes no attempt to calculate the costs and consider them in the context of a fiscal impact assessment. Experience in other shale gas plays demonstrates that these costs are likely:

> Natural gas development and production-related activities and the incremental population associated with those activities will generate

> demand for the full range of local government facilities and services and for some state government services. For example, during exploration and moderate stages of development, demand is usually limited to law enforcement, emergency response, emergency medical and road and highway maintenance and traffic control. Traffic, vehicle and industrial accidents and issues associated with a single-status, predominately working-age male workforce are the primary drivers associated with emergency response and law enforcement increases. Because many workers are temporary, and do not have local general purpose health care providers, they commonly use hospital emergency rooms for what would be otherwise be routine health care visits.

(Sammons, Dutton and Blankenship, 2010, page 19).

This knowledge regarding public costs and fiscal impacts should have been reflected in the RDSGEIS. These costs may occur even if the amount of commercially extractable natural gas does not reach projected levels. They need to be calculated both in terms of the baseline costs that are likely to occur with <u>any</u> drilling activity and in relation to varying levels of drilling activity.

Addressing the variability is important because there are distinct community character impacts attributable to large-scale development that have been identified and documented in other shale plays.[2] For example:

> …some areas that experience large scale development have reported substantial increases in a variety of crime and social problems including alcohol and drug-related offenses, traffic offenses, disturbances, assaults and domestic conflicts. Although some increases in crime and social problems would be anticipated to accompany any increase in population, some researchers have also attributed the increased levels of crime and social problems to the temporary and transient nature of the workforce and their living conditions. There has been some debate in the social impact assessment literature about whether or not crime and other adverse social indicators increase at higher rates in communities experiencing large-scale development than average rates for all communities. But the implications are clear that increases in crime and social problems are likely with large-scale development, even if they are proportionate to the increase in the numbers of people working and living in affected communities.

(Sammons, Dutton, and Blankenship, 2010).

Given the scale of development being projected, the thresholds for community costs and

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[2] *See* Sublette County Socioeconomic Impact Study Phase I Final Report. Ecosystem Research Group. , January 2008. Pages 54 – 58 and Index Crimes, Arrests, and Incidents in Sublette County 1995 to 2004: Trends and Forecasts, Prepared by J. Jacquet. Sublette County, Wyoming, April 2005, *available at:* http://www.sublettewyo.com/DocumentView.aspx?DID=351; Local Social Disruption and Western Energy Development: A Critical Review, Wilkinson et.al. Pacific Sociological Review Volume 25. July 1982. *available at:* http://www.sublettewyo.com/archives/42/Local_Social_Disruption__Critical_Review_Response_and_Commentary [1]. pdf.

adaptation to the impacts related to population increase or demand for services (administrative, school, health, public safety) must be addressed by the SGEIS. Evidence from Pennsylvania indicates that ability to adapt to these community social and economic impacts is critical to short-term and long-term community well-being (Kolb and Williamson, 2011; Kelsey, 2010, 2011).

(4) Costs will vary with the nature of population increases driven by the permitting of HVHF gas development. For example, indigent job seekers unable to find jobs and without resources to secure housing or transportation to work can become a burden for local human service agencies. This situation may be exacerbated by weak economic conditions in other parts of the state or country.

An example of this phenomenon is documented in a study carried out by Guthrie Hospital/Troy Community Hospital in Bradford County, Pennsylvania, where impacts from HVHF gas development in the county have significantly increased demand for health services (Covey 2010). The hospital is treating a new non-English speaking clientele and has had to hire translators. They have also had to purchase new equipment and have experienced a significantly increased demand on their emergency room services. The new demand affects not only the bottom line of providers, but also the availability of and access to health care for residents of the region in which drilling is occurring.

(5) There is no analysis of the expected lag between immediate costs and anticipated revenues. This lag may be 2-3 years, during which communities will be faced with significant public service costs.

(6) A tax profile needs to be presented over time, not one for a single year, in order to understand how natural gas drilling has fiscally impacted Region C, where most wells are currently located and where wells have increased.

C5. Environmental Justice Impacts

A section on Environmental Justice, included at the end section 6.8 of the RDSGEIS, notes that well permits are currently exempt from screening under NYSDEC Commissioner Policy 29, Environmental Justice and Permitting (CP-29) (RDSGEIS, 6-263). NYSDEC suggests that a drilling permit applicant could, “when necessary,” conduct a GIS analysis to identify potential environmental justice areas. The RDSGEIS should set forth criteria to determine when such an analysis would be “necessary” and should include the requirement in standard permit conditions or regulations. Moreover, given the known housing impacts of gas development on low-income populations, efforts to mitigate significant adverse environmental justice impacts must include not only the “additional community outreach activities” required in the RDSGEIS, but also substantive measures to prevent dislocation and homelessness.

II. Additional Economic Impacts Identified in the EAR But Not Addressed in the RDSGEIS

The RDSGEIS presents only a fraction of the material contained in the EAR and acknowledges: “A more detailed discussion of the potential impacts, as well as the

assumptions used to estimate the impacts, is provided in the Economic Assessment Report, which is available as an addendum to this SGEIS" (RDSGEIS, 6-207). This section comments on material presented in the EAR that is not discussed in section 6.8, but which is relevant to the RDSGEIS findings regarding social and economic impacts.

A. The Distribution of Impacts of HVHF Gas Development in New York State

The socioeconomic impact analysis should systematically describe the geographic distribution of impacts. In New York, as is explained below, the creation of high-paying jobs as a result of expenditures in industries outside the extraction industry is likely to occur outside the production region. This is important because regions where natural resource extraction takes place (and especially rural regions with little economic diversity) have been found to end up with poorer economies at the end of the resource extraction process (Best, 2009; Sammons, Dutton and Balnkenship, 2010). Mitigation measures need to be identified to address long-term costs to the rural counties where extraction will be concentrated.

The EAR calculates the impact of a $1 million increase in the final demand in the output of the oil and gas extraction industry on the value of the output of other industries in New York State (EAR, 3-6). The EAR then makes a series of statements concerning where the economic benefits of HVHF development are expected to occur. For example:

> The proposed use of high-volume hydraulic fracturing would have a significant, positive impact on employment in New York State as a whole and in the affected communities. However, the distribution of these positive employment impacts would not be evenly distributed throughout the state or even throughout the areas where low-permeability shale is located. Many geological and economic factors would interact to determine the exact locations where wells would be drilled. The location of productive wells would determine the distribution of impacts.

(EAR, 4-46; emphasis added).

The location of wells is, however, only one factor affecting the distribution of economic impacts in New York State. Many wells are drilled in rural areas with no or very limited commercial services near-by. If that is the case, then the economic impacts (in the form of expenditures by drillers and companies) will not occur close to the drilling site. Some will occur in centers – perhaps across a municipal or county line – where there are stores and restaurants that the drilling company employees use for meals and supplies. Some economic impacts will occur in far away places, such as New York City, where the drilling company can buy specialized services, such as tax accounting and legal services, to meet their business needs.

This potentially broad distribution of economic impacts is reflected in the multipliers reported in the EAR as follows:

> As anticipated, the direct effect employment multiplier for the State of New York (2.1766) was substantially larger than the multipliers for the individual regions, which had direct-effect employment multipliers of 1.4977 in Region A, 1.3272 in Region B, and 1.4357 in Region C (USBEA

2011a, 2011b, 2011c, 2011d). (EAR, 4-19).

These multipliers are affected by purchases by the gas drillers from other industries in the economy. In this case, the RIMS model used in the EAR indicates that three largest industries in which purchases will be made (and additional employment created) are: (1) real estate and rental; (2) professional, scientific, and technical services; and (3) management of companies). We can anticipate that purchases from these industries would have a strong effect in New York State as a whole because these industries have a strong presence in New York State.

What the multipliers also tell us, however, is that the jobs indirectly created by purchases of goods and services by the natural gas developers are not likely to be located in the counties where HVHF gas development occurs. Multipliers tell us how strong the industry is in a region or state. Higher multipliers indicate that those businesses that the oil and gas industry is likely to purchase goods and services from are present. Lower multipliers indicate a small industry presence and thus a lower likelihood of purchases in that geographic area. So, for example, a natural gas development company would employ professional services as a consequence of expanding drilling in Chautauqua County, but is likely to go to New York City to purchase those services because they are more likely to be available in New York City. Companies providing professional services in New York City are more likely to stay there rather than move to the Southern Tier because they have more opportunities to attract diverse industries to their specialized services in New York City than in Elmira or Jamestown.

If the EAR seeks to project the impact of expenditures on the regions in the state likely to be affected by HVHF gas development, it needs to disaggregate these impacts to show what proportion of the impacts in the three largest sectors (real estate and rental; professional, scientific, and technical services; and management of companies) is actually likely to occur in the representative regions. Although the authors assert that as the natural gas industry grows, more of the suppliers would locate to the representative regions and less of the indirect and induced economic impacts would leave the regions, no evidence is presented to substantiate this assumption. This assumption contravenes economic knowledge about agglomeration economies and company location behavior, which indicates that specialized services will remain in higher order centers (like New York City) and not re-locate to counties, especially rural counties, where drilling is occurring. The more likely outcome is indicated by a study of the impact of gas drilling on Western State economies, which found that natural gas drilling may have positive fiscal impacts at the state level, but negative fiscal impacts for the regions in which it occurs (Headwaters Economics, 2011).

B. The Distribution of Economic Impacts in New York Versus Those in Other States

Nationally, Texas and Oklahoma are the major beneficiaries of natural gas development, wherever production takes place in the United States. According to *Mine K. Yücel and Jackson Thies of* the Dallas Federal Reserve (2011): "An increase in oil and gas production **anywhere** benefits the state (of Texas) and its energy sector, which provides oilfield machinery and energy services to the rest of the world." See also subsection C, below. Nevertheless, because of its capital intensity, natural gas drilling does not have a large employment impact, even in Texas. Gas development thus plays a minor role in the economies of even these resource extraction states.

C. The Distribution of Highly-Skilled Jobs

Petroleum engineers are listed as one of the most common occupations in the oil and gas industry (EAR, 3-8, Table 3-10). The geographical analysis of this occupation by occupational employment statistics indicates that the states with the highest employment in this occupation are Texas, Oklahoma, and Louisiana. In 2010, the total U.S. employment of petroleum engineers was 28,210, of which 15,510 were employed in Texas, and 10,380 of those worked in the Houston metropolitan area. Thus, even in Texas, the employment in this occupation is concentrated in the Houston metropolitan area, not in the drilling areas.

The likely distribution of highly paid occupations is demonstrated by the Bureau of Labor Statistics (BLS) Occupational Employment Statistics Data on one of the most numerically significant skilled occupations, that of petroleum engineer. According to the BLS, only a fraction of petroleum engineers (in the hundreds) are employed in non-metropolitan areas in the U.S. (BLS, 2010). This data, too, suggests that the rural areas of New York that are likely to experience the most intensive gas development will not see an increase in highly skilled and highly paid jobs related to the oil and gas industry.

III. Inadequacy of Proposed Mitigation Measures

A. Mitigation Measures That Address Potential Impacts Related to Volatility in the Pace and Scale of Drilling Should Be Required

The mitigation chapter of the RDSGEIS implies that negative impacts will be mitigated through the permitting process and a secondary level of review triggered by the operator's identification of inconsistencies with comprehensive land use plans. The measures identified are only advisory. The RDSGEIS proposes no requirements to mitigate adverse socioeconomic impacts in this process.

Mitigation measures should be developed that would require operating companies to submit plans for exploration and development in a county or counties to county planning offices for review of cumulative impacts and mitigation (for example truck traffic routing), a model used in Western U.S. drilling regions (Headwaters Economics, 2011). This assessment is also completed for National Environmental Policy Act compliance when development proceeds on public lands.

Because the RDSGEIS acknowledges that the pace and scale of development are difficult to ascertain until exploration and production begin to proceed, it is critical that a permit and regional Plan of Development (POD) review process be set up that alerts local officials to the need for long term planning for land use, schools, public safety and public health. The POD, outlining the pace, scale, and general location in which development will occur, enables local government to anticipate and develop strategies to mitigate cumulative impacts (Sammons, Dutton and Blankenship, 2010). The near-term projections of development activity should include all secondary facilities (e.g., water extraction, waste disposal, pipeline construction) in the area to be affected.
A POD would allow communities in that region to prepare for the disruption and negotiate the least disruptive and damaging development plan.

Another mechanism for reducing the unpredictability and uncertainty of natural gas production at the regional scale is being developed by the Nature Conservancy with pilot projects in the Western States and planned in Pennsylvania (see Kiesecker et al, 2010). Their objective is a science-based, landscape-scale approach to Marcellus gas development that will secure measurable conservation outcomes, while enhancing industry's ability to operate in an environmentally sensitive and cost-efficient manner. To be enforceable, this cooperative approach, based on a partnership between the operating company and local public officials, needs to be codified in a binding agreement. Partnerships of this sort may be useful, but they cannot serve as mitigation for significant adverse socioeconomic impacts unless they are mandatory.

B. Mitigation Should Address Housing and Urban Development Impacts, Including Sprawl and Excess Substandard Housing

Evidence from Pennsylvania and Western shale plays indicates the likelihood of negative impacts on the quality of the temporary and permanent housing stock, a high rate of homelessness for extensive periods, and displacement of low income people from affordable housing. Given the presence of small cities in the region, mitigation measures should include required assistance to cities in the affected region to encourage new housing development in already-developed urban areas and the development of temporary housing that could be transformed to other uses once the influx of transient workers resides. Mitigation measures should also address the impacts of the loss of affordable housing units in the region.

C. Mitigation Should Address Long-Term Social and Economic Impacts

The RDSGEIS and the EAR describe significant adverse social and economic impacts, such as those produced by the volatility of natural gas development on the housing market of regions where development occurs. No mitigation strategies are recommended to alleviate long-term costs that are reasonably assumed to be associated with natural resource development, including HVHF development. Mitigation strategies directed at these long-term costs to the affected regions need to be developed and described in the SGEIS. Mitigation strategies also need to be developed to address the resource depletion phase of the exploration, drilling, development and resource depletion process. In this phase, population and jobs leave the region and tax revenues may be insufficient to pay for the capital investments made to serve the population influx during the drilling and production phases of development. Mitigation strategies should include policies to prevent negative impacts on existing industries, including agriculture, tourism and manufacturing.

D. Mitigation Should Require That Monitoring Reports Projecting Industry Development Plans Be Prepared by the State in Cooperation with Industry and Filed Semiannually

As development activities begin and progress, the information provided in initial projections should be required to be confirmed or revised on a semiannual basis. Information provided in the semiannual assessment and projection should include: (1) employment for each activity; (2) identification and location of contractors; (3) demographic characteristics and residence of employees who will be working in the region. This information is critical to forecasting and meeting housing and service demands.

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Attachment 6

Meliora Design, LLC.

Technical Memorandum

Review and Analysis of the

Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas, and 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

and the

Draft New York State Department of Environmental Conservation SPDES General Permit for Stormwater Discharges from High-Volume Hydraulic Fracturing

January 10, 2012

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Introduction

This memorandum reviews both the *Revised Draft Supplemental Generic Environmental Impact Statement* (RDSGEIS) *on the Oil, Gas and 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* and the Draft *New York State Department of Environmental Conservation SPDES General Permit for Stormwater Discharges from High-Volume Hydraulic Fracturing* (SPDES HVHF GP). The focus of this memorandum is the potential impacts on surface water resources that result from land disturbance and alteration, including impacts related to increased erosion and sedimentation, as well as impacts that result from increased and altered stormwater discharges. The review of both the RDSGEIS and the Draft SPDES HVHF GP are co-dependent, as the Department has indicated that general or (substantially similar) individual SPDES permit coverage will be the primary means of regulatory oversight for HVHF operations (and presumably for other low-volume hydraulic fracturing activities, although this is not explicitly stated).

The land disturbance associated with HVHF construction activity has the potential to negatively impact surface water quality in the same manner as other land disturbance activities, as discussed in Attachment A, and the lack of a local government land development review process increases the potential for greater water quality impacts through the increased disturbance of steep slopes, sensitive areas, proximity to unmapped headwater streams, etc. Furthermore, the land disturbance nature of HVHF operations results in a dispersed industry across a wide area, with a large (and unknown) number of stream crossings and an increase in road traffic and gravel road construction. The documented water quality impacts of roads (including gravel roads) are also discussed in Attachment A.

Summary of Key Findings:

The RDSGEIS provides only a very brief generic discussion on the potential land disturbance and associated stormwater and water quality impacts on surface waters from HVHF (and well drilling in general). While the RDSGEIS acknowledges that this land disturbance has potential for water quality impacts, and the Department has made a positive determination that a SPDES permit is required, the RDSGEIS provides little specific discussion or consideration of the land disturbance and surface water quality impacts. Specifically:

- The RDSGEIS makes no attempt to evaluate the cumulative impacts of HVHF activity on water resources, at either the small (headwater stream) scale, or the larger watershed scale. Even very general cumulative estimates of land disturbance, and its associated water quality impacts, are not provided. Since the 1992 GEIS, the use of improved geographic information system (GIS) software and modeling tools has expanded the ability of scientists, engineers, and regulators to quantify the scale and impact of proposed activities on water resources. Such analysis has become standard industry practice for watershed planning and the development of TMDL (Total Daily Maximum Load) studies to determine the level of pollutant load (and required pollutant load reduction) to meet water quality standards. The RDSGEIS fails to provide any such analysis, and instead only acknowledges stormwater impacts with little industry-specific consideration, and no consideration of total or cumulative impacts. **A more detailed and comprehensive evaluation of the amount of anticipated land disturbance and associated water quality impacts is essential for a full environmental impact analysis, and to inform any determinations by the Department on the appropriate regulatory permitting requirements.**
- The RDSGEIS fails to consider the potential surface water impacts of stream crossing activity associated with HVHF well pads, most notably, stream

crossings associated with gathering lines and access roads (to both well pads and compressor stations). Stream crossings and the associated water quality impacts are not fully addressed in the RDSGEIS, and are specifically not included in the Draft SPDES HVHF GP. It is unclear how many stream crossings may be anticipated, and of these, how many will essentially be unregulated under current Department regulations. It is unclear what the anticipated environmental impacts of these stream crossings will be on water quality and aquatic systems. **The RDSGEIS should provide some estimate of the extent of anticipated stream crossings, potential water quality impacts, and proposed Department requirements to regulate and mitigate these impacts.**

- The RDSGEIS does not adequately address private well setbacks, road spreading of brine, gather lines, fueling areas, on-site disposal of drill cuttings, and acid rock drainage. Each of these has the potential to significantly impact and impair water quality. **The RDSGEIS should provide additional information regarding each of these impacts, specifically with regard to landowner notification of well setbacks, cumulative impacts of road spreading of brine, minimizing stream crossings with gather lines, addressing the non-stationary status of fueling areas, and consideration of ARD impacts from disposal of drill cuttings.**
- With the exception of watersheds that serve as unfiltered drinking water supplies and receive Filtration Avoidance Determination (FAD) status, the RDSGEIS and SPDES HVHF GP do not provide any specific consideration of whether different performance requirements or standards are necessary to protect water quality for higher quality watersheds, impaired streams, or areas of denser well pad development on a watershed basis. There is no documentation to support that proposed setbacks are adequate to protect water quality in all situations (i.e., higher quality streams, percent of land disturbance within a watershed, site specific conditions such as steep

slopes). **The RDSGEIS should provide some analysis or justification as to why a single set of performance requirements is applicable in all watersheds and all situations, regardless of stream designation or current levels of impairment or high quality.**

- Even if the proposed setbacks discussed in Chapter 7 were adequate, they are not clearly coordinated with the EAF requirements in Appendices 4, 5, 6 and 10 and the Draft SPDES HVHF GP mapping and documentation requirements (and the SPDES HVHF GP is presumably the regulatory mechanism for compliance). **The Draft SPDES HVHF GP mapping requirements must be at a scale and level of site-specific detail to accurately reflect the required information, and SPDES mapping requirements must be consistent with those identified in the RDSGEIS.**
- The RDSGEIS fails to provide a clear and accessible process for public and local government access to site specific HVHF activity information. At the same time, DEC expects local governments to provide notice to the Department if a proposed HVHF activity is not in compliance with local zoning or land use regulations. This approach puts the regulatory burden on a local government that wishes to challenge a proposed permit application while simultaneously failing to provide local government with access to the necessary information. **The burden of demonstrating compliance with local government land use requirements should fall on the industry, not local government and the public,** with supporting public access to all information regarding proposed land disturbance activity, and reasonable timeframes and processes for comments and addressing of concerns.
- The Draft SPDES HVHF GP is essentially a compilation of the Department's general permits for both construction activity and industrial activity. The general permit process is essentially "self-regulating," relying on the regulated industry to adhere to certain compliance requirements. Based on the very limited discussion of land disturbance and surface water impacts in the RDSGEIS, it is uncertain whether a general permit process will be

sufficient to protect water quality. It is also not clear that an industry that is NOT subject to local government review and approval, unlike virtually all other land disturbance activities addressed by general permits, can be adequately regulated through a general permit process. This is especially important for a heavy industrial activity that will be occurring in areas not zoned or accustomed to heavy industrial activity at the scale that will occur with HVHF operations.

- The general permit process does not provide a timeframe (and process) for public review, comment, and objection to any or all parts of a general permit coverage. Essentially, permit coverage is automatically granted to the industry by providing notice to the Department and meeting minimum performance requirements. There is no opportunity for public access to information or appeal of permit coverage. **It is essential that the SPDES HVHF GP provide a process for public access to all information associated with HVHF land disturbance and water quality impacts, and that a process and timeline be developed to allow for public comment and appeal of general permit coverage for a specific site *before* general permit coverage is granted. It is essential that the permit coverage timeline be adjusted to provide for public comment and appeal.**

Comments on the RDSGEIS

As previously indicated, the discussion in the RDSGEIS on the total land use impacts and associated water quality impacts as a result of both land disturbance during construction and post-construction stormwater management is extremely limited.

Comment 1:

Chapter 5, Natural Gas Development & High-Volume Hydraulic Fracturing. Section 5.1 of the RDSGEIS discusses the impacts of Land Disturbance, including Access Roads, Well Pads, Utility Corridors, and Well Pad Density. See pages 5-6 through 5-31. Estimates of land disturbance associated with each of these well drilling activities are provided but total or cumulative land disturbance is not addressed.

Comment 2:

Section 5.1 *Land Disturbance* identifies a number of types of land disturbance activities associated with HVHF including utility corridors (including gathering lines), compressor facilities, and access roads associated with compressor facilities. The Draft HVHF SPDES permit (Part III.A.3) does NOT address construction of gathering lines, compressor facilities, or the access roads associated with compressor facilities.

Recommendation: The RDSGEIS must provide a process for regulation and mitigation of the land disturbance impacts associated with gathering lines, compressor facilities, and the access roads associated with compressor facilities. The RDSGEIS cannot identify the SWPPP as "*the principal control mechanism to mitigate potential significant adverse impacts from stormwater runoff*" (Section 7.1.2 SGEIS) without providing for adequate management requirements for all HVHF activities in the Draft SPDES HVHF GP.

Further discussion in Section 5.1 provides some analysis of disturbance areas associated with gathering lines, compressor stations, and access roads to

compressor stations, but specific consideration of the impacts of these activities is not discussed in Chapter 6, and specific recommendations to reduce the impacts of these components (such as co-locating gathering lines along well pad access roads) is not provided in Section 7 or the Draft HVHF SPDES permit.

Comment 3:

Section 5.1.1 *Access Roads* indicates that roads may be placed across ditches, but does not discuss the construction or widening of access roads that cross streams or wetlands. The potential impacts of such crossings are not discussed in Section 6.1.2, *Stormwater Runoff* or other portions of Section 6, nor are the mitigation measures for road crossings of streams and wetlands addressed in Section 7.1.2 *Stormwater.* Setbacks for roads from streams and wetlands are not specifically addressed in either Chapter 7 or the Draft HVHF SPDES permit, nor are requirements for stream and wetland crossings provided. It is not clear as to whether an Article 15 Stream Disturbance Permit from the DEC will be required for HVHF projects and what compliance might entail. It is noted that Photos 5.1 and 5.2 of the RDSGEIS portray access road stream crossings, but the impacts of the stream crossing are not addressed.

Road crossings of streams and wetlands will be unavoidable during the development of HVHF sites. Section 5.1.1 acknowledges that the length of road may be influenced by selecting a route to avoid environmentally sensitive areas, but mitigation measures recommending such route selection are not specifically addressed in either Chapter 7 or the Draft HVHF SPDES Permit. Estimates of the number and extent of anticipated stream and wetland crossings are not provided in Section 5.1.1.

Recommendation: The proximity of roads to streams and wetlands, and the unavoidable need to cross streams and wetlands, increases the risk that erosion and sedimentation will cause measurable impacts on water quality. Poorly constructed stream crossings can directly impact aquatic communities.[3, 7] Excessive sediment

levels are one of the primary threats to US surface waters[10] and have multiple effects on stream health. The RDSGEIS should provide estimates of the anticipated extent of road crossings of streams and wetlands, as well as an evaluation of the potential environmental impacts of these crossings. Furthermore, avoidance and mitigation measures should be addressed in the RDSGEIS and incorporated into the regulatory process. Specific requirements and guidelines to mitigate the impacts of stream and wetland crossings should be provided.

Recommendation: If the SPDES HVHF GP is to be the primary mechanism for regulation, then the permit should include a defined documentation process to require the applicant to reduce the number and extent of stream crossings. This section should be incorporated into Part IV, *Contents of the Construction SWPPP*, as a requirement of Section A.1 and include both mapping requirements and narrative that documents the need for each stream crossing and explanation as to why any individual stream crossings cannot be reduced or combined. Road crossings on areas specifically in conflict with local government land use regulations should be identified, as well as road crossings on steep slopes erodible soils, or intact woodlands.

Comment 4:

Section 5.1.2 *Well Pads* notes that well pad size is determined by site topography, but no estimates are provided regarding the impact of slope on well pad size and disturbance footprint, and the increased impacts on erosion and sediment discharge. The area of disturbance can be increased by up to 50% on slopes exceeding 15 degrees[8] (the Draft HVHF SPDES permit allows disturbance on slopes up to 25% in AA or AA-s watersheds. It is not clear that there is a limit on slope construction in other watersheds). The stormwater and erosive impacts of well pads on steep slopes continues through the life of the well pad. At a minimum, the Draft SPDES HVHF GP should preclude well pad construction on slopes over 25%.

Recommendation: Section 5.1.2 should provide some evaluation of the anticipated increase in well pad disturbance as a function of slope (and required cut and fill) as a result of the impacted terrain conditions specific to New York. Section 7 of the RDSGEIS should provide discussion of specific mitigation measures to reduce the impacts of well pad construction on slopes. The HVHF SPDES permit should include specific requirements to reduce construction of well pads on steep slopes, limits on steep slope construction in all watersheds, and provide discussion and requirement of implementation measures to reduce the long-term water quality impact of well pads on slopes when such systems are constructed. Additional measures to prevent sediment discharge from construction on steep slopes should be defined and required as part of the facility SWPPP. It is not clear that the general requirements of either the 2005 New York State Standards and Specifications for Erosion Control or the 2010 New York State Stormwater Management Design Manual provide sufficient specific guidance to address the additional impacts associated with well pad construction on slopes. Both erosion control measures and stormwater measures must be adjusted in their design to account for the greater water quality impacts of well pad location on slopes.

Comment 5:

Section 5.1.2 *Well Pads* and **Section 5.1.4** *Well Pad Density* do not provide any specific information or estimates of well pad or HVHF facility location or density with regards to watershed drainage areas, or analysis of the anticipated density of well pads within intermittent or perennial headwater stream drainage areas. Section 6 does not discuss the impacts on water quality of well pad density within the drainage area of an intermittent or perennial stream. Headwater and intermittent perennial streams originate with a drainage area of 5.5- to 37-acres[5], increasing the likelihood of a HVHF well pad being within several hundred feet of an intermittent or perennial stream, and the likelihood that the disturbance will represent a sizable portion of the total drainage area to a headwater stream (i.e. 7.4 acres of total disturbance for a multi-well pad during the drilling phase, and 1.5

acres of disturbance during the drilling phase could represent a very large percentage of the drainage area of a headwater or small stream).

Recommendation: Current research[2] indicates a positive relationship between stream water turbidity and well density within a drainage area or watershed. The RDSGEIS does not provide any analysis or consideration of potential levels of watershed disturbance as a result of HVHF activities, and the resulting potential impacts on water quality, although such an analysis is well within current mapping and GIS capabilities and should be included in the RDSGEIS.

Comment 6:

While some mention of gathering lines is included in **Section 5.1.3** *Utility Corridors*, including an estimate of 1.66 acres per well pad, no discussion is made of the anticipated extent of stream crossings, or the cumulative levels of land disturbance associated with gathering lines on a watershed or other basis. No further discussion is provided in Chapters 6 and 7 specific to gathering lines. It is unclear exactly how the current DEC permit process for pipeline stream crossing is adequate to protect water quality from either a land disturbance or stream crossing impact from gathering lines, or how gathering line construction will be addressed and/or coordinated with the Draft HVHF SPDES permit process (which does not currently address gathering lines).

Recommendation: This issue requires additional consideration in the RDSGEIS, and the specific permitting requirements for gathering line stream crossings should either be identified in the Draft HVHF SPDES permit or coordinated with this permit so that impacts are reduced. Specifically, measures to reduce the impact of gathering line stream crossings (and general construction) by coordination of this construction with other well site needs should be required.

Comment 7:

Chapter 6, Potential Environmental Impacts. Section 6.1.2 *Stormwater Runoff*, discusses both stormwater impacts and erosion and sedimentation construction issues. However, this discussion is very general in nature, comprising only 1-1/4 pages within Chapter 6 for both of these topics. No discussion is provided regarding the specific magnitude and issues of concern associated with stormwater and erosion impacts from the various HVHF activities (i.e. well pad construction, and variations on well pad construction such as disturbance footprint from construction on steep slopes). Rather, it is simply noted that the potential for water resource impacts exists, and that these impacts may cause increased runoff volumes, greater erosive forces, heightened sediment loads, etc.

Recommendation: Research data and engineering methodologies are available to quantify the potential adverse water quality impacts, either on a "typical" facility basis or an anticipated watershed basis (using the estimates of acreage developed in Section 5). Such analysis would provide at least some basis for determining whether the requirements of the Draft HVHF SPDES GP are adequate for the industry. These estimates would also provide information on the cumulative impacts of HVHF on water quality and stream health and should be included in the RDSGEIS.

Comment 8:

Chapter 7, Mitigation Measures. Section 7.1.2 *Stormwater,* discusses stormwater management in general terms, with a non-specific discussion of the particular issues associated with HVHF stormwater and erosion. Much of the generic discussion focuses on pollution prevention from exposed industrial activities. Less than one page addresses stormwater management mitigation measures related to land use changes, and one-half page addresses mitigation associated with stormwater and erosion issues from construction activities. Section 7.1.3 discusses spills and

containment, which is also addressed in the SPDES HVHF GP. However, much of this discussion is focused on industrial spill control, not stormwater impacts.

Chapter 7 indicates that the Department intends to issue a single SPDES General Permit that will encompass all issues of construction stormwater and erosion control, post-construction stormwater management, industrial stormwater management, and pollution prevention/spill control. Specifically, page 7-26 states: *The Department has determined that natural gas well development using high-volume hydraulic fracturing would require a SPDES permit to address stormwater runoff, erosion, and sedimentation. The SPDES permit will address the construction of well pads and access roads and any associated soil disturbance, as well as provisions to address surface activities associated with high-volume hydraulic fracturing for natural gas development. Additionally, during production of the natural gas, the Department will require coverage under the SPDES permit to remain in effect and/or compliance with regulations. The Department proposes to require SPDES permit conditions, a Comprehensive SWPPP (stormwater pollution prevention plan), and both structural and non-structural Best Management Practices (BMPs) to minimize or eliminate pollutants in stormwater. The Department is proposing the use of a SPDES general permit for high-volume hydraulic fracturing (HVHF GP), but the Department proposes to use the same requirements in other SPDES permits should the HVHF GP not be issued.*

Recommendation: The HVHF SPDES permit should be specific to this industry and impose requirements that reflect the lack of local government review and approval of the land development activities associated with the industry. The RDSGEIS should specifically identify the areas where additional permit requirements specific to the industry are necessary to protect water resources.

Comment 9:

Section 5.1.1 *Access Roads* notes that roads may be constructed by placing crushed stone or gravel, but Section 6 does not specifically address the water quality issues

associated with the long-term use of gravel roads (after construction), nor does Section 6 provide any estimate of potential pollutant loadings associated with gravel roads, specifically estimates of sediment generation. Research data[4] indicates that gravel roads can be a significant source of sediment pollution, and data to support sediment pollutant load estimates is available but requires an estimate of the anticipated extent and area of gravel access roads to be constructed, which is not provided in Section 5.1.1. Gravel access roads serving HVHF will be subject to undefined levels of truck traffic, which has a greater impact on road condition and erosion than regular vehicle traffic. Section 6.1.2 *Stormwater Runoff* discusses the impacts of sediment on streams and notes that "*steep access roads…pose particular challenges.*" **Section 7.1.2** *Stormwater* indicates that the construction of access roads will be addressed by the SPDES permit, but neither Section 7.1.2 nor the Draft HVHF SPDES permit provide specific recommendations to reduce the length and width of gravel access roads, to reduce construction access roads on steep slopes, or to reduce the specific impacts of gravel road and sediment generation once the construction period has ended. General reference to the State stormwater manual is not sufficient for this issue as it relates to HVHF. There is no requirement in the Draft HVHF SPDES mapping requirements to indicate or accurately depict the length, width, or slope of gravel access roads. Since these areas will generate sediment pollutants through the life of the project, specific guidelines to mitigate pollution from access roads are warranted.

Recommendation: The RDSGIES should provide more detailed information on the specific impacts of gravel access roads with regards to sediment generation, and the estimated extent of potential pollutant loads. Section 7 of the RDSGEIS should provide discussion of specific mitigation measures to reduce the impacts of access road construction. The HVHF SPDES permit should indicate specific requirements for the documentation of access road lengths and widths, and requirements to reduce construction on steep slopes, reduce road width, and implement other measures to reduce the water quality impact of access roads. Measures to maintain

gravel access roads in a manner that prevents sediment discharge (over the life of the project) should be defined and required as part of the facility SWPPP.

Comment 10:

Section 7.1.11.1 *Setback from private well*, Section 7.1.11.1 states that "The Department proposes that it will not issue permits for high-volume hydraulic fracturing within 500 feet of a private water well or domestic supply spring unless waived by the landowner." However, the Draft SPDES permit does not require the applicant to map the location of private water wells or springs that may be within 500 feet, or to notify the landowner. Coverage under the GP is granted within 30 calendar days of the Department receiving the NOI (and meeting the requirements of Part II.B.2). How will the Department or the applicant be aware of the existence of private water wells within 500 feet? This is also not included in Section 5 of the Environmental Assessment Form, but IS included in the Proposed EAF Addendum Requirements for HVHF. It is not clear how 500 feet was determined as sufficient distance to support a private well from HVHF activities as no supportive reasoning is provided.

Recommendation: Require that all private water wells and domestic supply springs within 2,640 feet and 500 feet, respectively, to be located on the Site Map (prepared under Part IV.C.1.b and as a requirement to the Site Map in the SWPPP). The NOI form should require that the applicant confirm that there are no such wells within 500 feet, and provide proof to the Department of landowner waiver receipt (by certified mail or similar means).

Recommendation: The SWPPP should identify the private water well or spring in the narrative (Part XI.3) and identify measures undertaken to protect the private well and to address emergency spill situations.

Comment 11:

Section 7.1.11.2 *Setbacks from Other Surface Water Resources* states "Existing regulations prohibit the surface location of an oil or gas well within 50 feet of any 'public stream, river or other body of water.'" The 1992 GEIS proposed that this distance be increased to 150 feet and apply to the entire well site instead of just the well itself". The Draft HVHF SPDES permit (Section I.D.4) requires a setback of 150 feet from the well pad and perennial or intermittent streams, but does not address setbacks from other HVHF site components.

Recommendation: As discussed later in specific recommendations associated with the Draft HVHF SPDES permit, required setbacks of any length are meaningless unless the water features are accurately identified and located. A USGS 7-1/2 minute topographic map, at a scale of 1" = 2000' is inadequate for this purpose. It is essential that the Draft HVHF SPDES permit require mapping at a scale that can accurately depict both existing natural features (such as steep slopes and headwater streams) as well as proposed HVHF components.

Comment 12:

There are benefits associated with a single SPDES GP (or a single individual SPDES permit) that addresses construction, post-construction stormwater, and industrial stormwater and spill containment for each project in one permit. These benefits include a comprehensive evaluation of each project, potential continuity in responsible facility personnel, and consistency of management practices through both construction and operation.

However, the Department is largely drawing on the current requirements in the existing SPDES general permit for construction (New York State Department of Environmental Conservation SPDES General Permit For Stormwater Discharges From Construction Activity Permit No. GP-0-10-001) and the existing SPDES general permit for industry (New York State Department of Environmental Conservation SPDES Multi-Sector General Permit For Stormwater Discharges Associated With

Industrial Activity Permit No. GP-0-06-002). The Department is combining many (but not all) requirements of these two GPs into one HVHF GP and, in doing so, does not include provisions that would otherwise be required of permittees seeking either of the existing permits alone..

For the issues of site disturbance, stormwater management, setbacks, disturbance of sensitive features, erosion, and other impacts associated with many non-HVHF land development projects and industrial activities, there is an additional level of professional review and regulation in the form of local laws, regulations, plans or policies implemented by the local planning board or authorized board. In other words, for non-HVHF projects, such as land development projects, there is often a local project review of proposed plans by a professional reviewer knowledgeable in local conditions, supported by the review of an authorized board whose members possess local knowledge. Local regulations are likely to impose more rigorous mapping requirements, stormwater calculations, and design detail than those imposed in a Department general permit, and furthermore, project submissions receive local, professional review. In these circumstances, successful design and compliance (with the requirements of Department general permit) is more likely when supported by a secondary level of performance requirements and review at the local level.

The issuance of a single GP for HVHF (that encompasses many requirements of both existing Department GPs) will not have the benefit of local review and specific local performance requirements. The potential impacts of HVHF projects on land disturbance, stormwater, erosion, sensitive sites, etc. is at least as significant (if not more significant) than other, locally regulated land disturbance and industrial activities. HVHF is also a "heavy" industry that will be located in many areas unaccustomed to heavy industry.

Recommendation: The Department should provide the opportunity for local review by revising the SPDES HVHF GP to address compliance with applicable local ordinances. For instance, those activities which would typically require issuance of

GP-0-10-001 should be required to comply with all local ordinance requirements as they apply to HVHF activities. Additionally, the Department should require SPDES HVHF GP permittees to provide written notification to the Department from the affected local governments that the conditions of local ordinances are met to the satisfaction of the local governing authority prior to issuance of the permit. Comment 14 below discusses this further.

Comment 13:

HVHF compliance with the requirements of the GP are largely self-reviewing and self-monitoring, as facilities are required to develop and implement a SWPPP, but there is generally no review of the SWPPP unless the Department elects to request and review the SWPPP for a specific facility. Absent this specific request by DEC, the SWPPP is simply maintained on-site. In addition, DEC does not propose any mechanism that would enable it to effectively evaluate successful implantation of a SWPPP.

Recommendation: The SPDES HVHF GP should be revised to make public all documents, specifically including the SWPPP, available for review by the Department and the public. In all instances, the Department should establish a mechanism to routinely review whether applicants have successfully implemented their SWPPPs. Dated digital photos that support inspection and compliance per permit and SWPP requirements should be a requirement for permit coverage.

Comment 14:

Chapter 8 , Permit Process and Regulatory Coordination; **Section 8.1.1.5** *Local Planning Documents* of the SGEIS states:

> *However, in order to consider potential significant adverse impacts on land use and zoning as required by SEQRA, the EAF Addendum would require the applicant to identify whether the proposed location of the well pad, or any*

other activity under the jurisdiction of the Department, conflicts with local land use laws or regulations, plans or policies. The applicant would also be required to identify whether the well pad is located in an area where the affected community has adopted a comprehensive plan or other local land use plan and whether the proposed action is inconsistent with such plan(s). For actions where the applicant indicates to the Department that the location of the well pad, or any other activity under the jurisdiction of the Department, is either consistent with local land use laws, regulations, plans or policies, or is not covered by such local land use laws, regulations, plans or policies, the Department would proceed to permit issuance unless it receives notice of an asserted conflict by the potentially impacted local government.

This approach is problematic. While it is the responsibility of the applicant to determine whether or not there are any conflicts, it is up to the potentially impacted local government to provide notice to the Department of an asserted conflict that has not been identified by the applicant. Although the RDSGEIS states that the Department would notify local governments of all applications for high-volume hydraulic fracturing in the locality, through the use of an electronic notification system to local government officials (see DSGEIS at 8-4), DEC offers no guarantee that this system will be in place prior to the issuance of permits and does not specifically describe when in the permitting process such notification to local governments will occur. These are critical issues that should be addressed. Further, it is unclear how the Department will determine *"whether significant adverse environmental impacts would result from the proposed project that have not been addressed in the SGEIS and whether additional mitigation or other action should be taken in light of such significant adverse impacts." RDSGEIS at 8-5.* It is also not clear as to whether this determination process applies to all HVHF GP applicants, or only those subject to SEQRA determination.

Recommendation: In consideration of the Department's decision to regulate HVHF under a single SPDES general permit without the important supplemental benefit of local review and local laws, regulations, plans or policies (that virtually all other

land development and industrial construction projects are subject to when obtaining SPDES permit coverage), obtaining General or Individual Permit coverage (for all HVHF projects) should also require the applicant to notify the local government (as well as the Department) that there are no conflicts with local laws, regulations, plans or policies, and to provide supporting documentation of the evaluation to the local government and Department. This will allow local governments to receive the necessary information to "assert" a potential conflict that may not have been identified by the applicant. Without this critical information, local governments cannot be expected to "assert" a potential conflict to the Department.

Comment 15:

As discussed above, Section 5.1 of the RDSGEIS provides estimates of land disturbance for well pads and associated construction activities (roads, utility corridors, compressors, etc.), including total estimated disturbance per pad for multi- and single-well pads. The RDSGEIS notes that most wells will be multi-pad wells with a net disturbance of 7.4 acres per pad (reducing to 1.5 acres per pad during production). A spacing of 640 acres per multi-well pad is presented in Table 5.1 of the RDSGEIS. However, no consideration is provided of the anticipated disturbance and well pad density on a watershed basis, or proximity to streams and anticipated stream crossings, and no consideration is provided on the potential individual and cumulative effects on stream health.

A recently published study of natural gas development in the Fayetteville and Marcellus formations in Arkansas and Pennsylvania[2] used current topographic data, well development data, and readily available land use analysis computer modeling tools (ArcHydro Version 1.3) to evaluate both the overall well pad density per drainage area and well proximity to streams in these formations in Arkansas and Pennsylvania. This desktop analysis was further supported by in-stream turbidity measurements in seven different drainage areas with different well densities.

This report had several significant findings, most notably it "identified a positive relationship between stream water turbidity and well density. Turbidity was not positively correlated to other land use cover variables." (Entrekin, et al, "Rapid Expansion of Natural Gas Development Poses a Threat to Surface Waters, pg 507). The report further concluded that "preliminary data suggest that the cumulative effects from gas well and associated infrastructure development are detectable at the landscape scale."

This study also determined that approximately 17% of the active Pennsylvania wells were within 100 meters (328 feet) of a stream, and all wells were within 300 meters (984 feet) of a stream. Gas wells "were located, on average, 15 km (9.3 miles) from public surface-water drinking supplies and 37 km (23 miles) from public well water supplies." The report noted that "although wells are generally constructed far from public drinking-water sources, there is potential for wastewater to travel long distances given that many of the components, such as brines, will not settle out or be assimilated into biomass." In other words, due to the nature of material from HVHF wells, discharges that reach streams (due to inadequate stream setbacks) may travel to public drinking supplies, even if the surface water supplies are distant to the well.

Chapter 6 of the RDSGEIS broadly identifies potential environmental impacts on water resources (Section 6.1), including polluted stormwater runoff and spills. The RDSGEIS does not specifically discuss the cumulative impacts of land disturbance on surface water quality (i.e. whether turbidity or other measures of stream impact increase with well density). The RDSGEIS makes no attempt to estimate well density and land disturbance on a drainage area basis with regards to water quality impacts or consideration of specific watersheds and designated uses. No specific consideration is given to the topography and stream density of New York State with regards to land disturbance and proximity to surface waters.

Such an analysis would provide a far better estimate of potential surface water impacts and the extent of anticipated land disturbance on a watershed or drainage area basis. This information would inform the state as to the watershed impacts

from HVHF activities, and provide some additional basis for well density in different watersheds. It would also better inform the decisions regarding setback distances discussed in Sections 7.1.5 and 7.1.11.2.

As discussed previously, most headwater and small perennial streams are not indicated on USGS 7-1/2 minute topographic quadrangles, and hence will not necessarily be identified under the current mapping requirements in the Draft HVHF SPDES permit. Headwater streams generally originate with a surface drainage area of 5 to 37 acres.[5] The study discussed above had a stream threshold of 12.4 acres. With a disturbance footprint of 7.4 acres per multi-well pad, drilling activities could potentially impact as much as 60% of the land area in a headwater stream drainage area (assuming 12.4 acres per drainage area). The extent and impact of land disturbance in headwater streams is not addressed in any manner in the RDSGEIS.

Recommendation: The RDSGEIS should provide some technically supported evaluation of the anticipated well density on a drainage area basis, with consideration of water quality impacts. The analytical land use tools, data, and models available today are significantly more robust than the environmental tools available during the development of the 1992 GEIS (and such tools are often used to support TMDL determinations). In other words, the density of anticipated land disturbance and proximity to streams and wetlands could easily be mapped and evaluated using anticipated development rates and relevant information from states such as Pennsylvania. At a minimum, representative watersheds could be evaluated in detail to represent anticipated conditions, and using topographic data and average proximity to streams could be estimated. Relevant well drilling data is also available from other states such as Pennsylvania. High-volume hydraulic fracturing is "distinct from other types of well completion" as noted in the RDSGEIS, and warrants additional consideration.

This type of land use and density evaluation will allow the Department to better assess the potential impacts of high-volume hydraulic fracturing on both watershed

land use and proximity to streams, and can provide a technical basis for HVHF well density and setback decisions. It can also inform decisions regarding well density and setbacks in waters with TMDLs. But at this time there is no watershed impact consideration of HVHF well location and density. It is unclear whether the various setbacks discussed in the RDSGEIS are adequate to protect water resources during HVHF activity, or whether these setbacks merely represent an arbitrarily selected value.

Recommendation: To facilitate Department identification of wells that may have an impact on small headwater streams, the Draft SPDES HVHF GP could require that each well pad application document the total amount of anticipated land disturbance, and the percent of land disturbance within the drainage area of the well pad location. This is not a difficult estimate for the permit applicant to develop using current mapping tools, and will provide some indication that adjacent streams may be small and especially vulnerable to land use impacts.

Comment 16:

Section 7.1.3.1 indicates that fueling tanks are considered "non-stationary" at well pads, and therefore exempt from Department storage and registration requirements. Section 7.1.3.1 does state that secondary containment is required for all fueling tanks, and that fueling tanks would not be positioned within 500 feet of perennial or intermittent stream, storm drain, wetland, lake or pond.

It is unclear how this requirement will be met or maintained, especially in light of the fueling tanks being "non-stationary." Specific requirements are not reflected in the Draft HVHF SPDES permit, either in the general SWPPP requirements or the Fueling Area requirements. It is unclear how this setback will be identified and maintained, and how the Department intends to ensure compliance. The requirements for fueling areas in the Draft HVHF SPDES permit are the same general requirements applied to all industrial facilities and do not have any specific consideration of the nature and conditions of HVHF sites and fueling needs.

Recommendation: The RDSGEIS and Draft HVHF SPDES permit must address the issue of containment for "non-stationary" fueling tanks, and all other non-stationary tanks.

Comment 17:

The RDSGEIS **Section 7.1.7.2 Road Spreading** indicates that NORM concentration data in brines is insufficient to allow road spreading under a BUD, and that as more data becomes available the Department will evaluate the BUD petitions. However, the RDSGEIS is inadequate in that no consideration has been made of the total potential increase in chlorides on roads as a result of the HVHF industry disposing of brines in this manner, and the anticipated levels of chlorides and other compounds in the brine. Again, the RDSGEIS has not considered the cumulative impacts of the generation of this material and the potential volume of material application on roadways. No estimate is made of the volume of production brine that may be disposed of on roadways. No consideration is provided regarding what might be "safe" levels of chlorides (or other compounds) in different situations, or what other additional compounds that may be found in production brine that would preclude the use of the material for roadway application. The requirements in the current BUD have no basis as being sufficient for protecting water quality, and are generally self-monitored by the industry.

Unless the use of production brine is demonstrated as being a beneficial use for the public in roadway safety, application to roadways should not be seen as a viable disposal method. Much more research on the effects of the material on plant and aquatic systems is required.

Recommendation: The RDSGEIS should provide better information regarding anticipated brine production levels and disposal needs as a result of HVHF activity. Future authorization of the application of brines under a BUD should not be allowed until this information has been developed and provided for public review and comment.

Comment 18:

Section 7.1.9 Solids Disposal indicates that the generation of acid rock drainage (ARD) may occur as the result of material from certain portions of the Marcellus shale. The RDSGEIS indicates that an ARD mitigation plan would be required for in-site burial, but is not required for off-site disposal.

No estimate is provided within the RDSGEIS of the potential amount or magnitude of the generation of this material, and whether or not the amount of ARD material is of concern, or within which watersheds such material may be anticipated. The generation of ARD is of significant concern and impact on watershed health, and warrants more detailed analysis of the anticipated locations and extent where ARD may be an issue. It is not clear if this is expected to be an extensive concern, and no consideration is made of the amount and extent of the ARD material encountered in other states such as Pennsylvania, and how much this material has created additional acid discharge problems in other states. This issue is not addressed in the HVHF SPDES draft permit.

Recommendation: Estimates of the anticipated extent of such material should be included in Chapter 6.1.9.2, and coordinated requirements for ARD treatment (as discussed in Section 7) incorporated into the Draft HVHF SPDES permit. This material has significant potential impact to water quality.

Comment 19:

The EAF addendum should clearly define the process and timeline for notification of local government, and for the Department's process for determination of permit applicability when notice is received from the applicant or local governments that a conflict with local laws, regulations, plans or policies exists. Furthermore, the EAF addendum should address the issue of HVHF GP coverage upon NOI submission when such local conflicts exist.

Recommendation: Coverage should NOT begin until proof of notification to local governments has been received by the Department, local governments have been provided sufficient information and time to "assert" any unidentified potential conflicts, and the Department has made project specific determinations regarding the impact of identified or asserted conflicts. A timeline and process must be defined.

Comment 20:

EAF Appendix 12 Beneficial Use Determination (BUD) Notification Regarding Road Spreading states that "Any person, including any government entity, applying for a Part 364 permit or permit modification to use production brine from oil or gas wells or brine from LPG well storage operations for road spreading purposes (i.e. road deicing, dust suppression, or road stabilization) must submit a petition for a beneficial use determination (BUD)." This petition must include sampling data (although the sampling parameters are limited), a map indicating roads where brine is to be spread, and a general narrative of practices to be implemented, including avoiding applying brines within 50 feet of a stream or waterbody, avoiding application during rainfall periods or on slopes greater than 10 percent.

Chlorides are toxic to many plants and freshwater aquatic plants and invertebrates[14] with levels as low as 30 mg/L toxic to plants, and at 1000 mg/L toxic to aquatic plants and invertebrates. Chlorides also impact the use of surface water for potable water sources.

While chlorides are applied to roads during snow and ice conditions for safety reasons, many state Departments of Transportation have begun programs to significantly reduce the use of chlorides and implement alternative de-icing practices to reduce the impacts of chloride on both vegetation and stream system health.

Recommendation: Additional analysis of potential impacts must be done to evaluate potential impacts from road spreading, including analysis to support that the proposed setback criteria are sufficient to protect water quality, as well as to define required sampling requirements for BUD petitions.

Comment 21:

In addition to defining the processes and timelines for review and notification requirements, coordinating permit approvals and public participation activities would ensure compliance with all applicable statutes and eliminate any conflicts that may arise. Regulatory permit tracking, municipal coordination and public outreach and participation should be integrated and automated to the fullest extent possible to ensure satisfactory oversight of gas development operations. This includes the use of internet and GIS technologies for geovisualization, database management, and compliance with all regulatory requirements.

One example of internet-based GIS information sharing is the Pennsylvania Department of Environmental Protection's (PA DEP) eMapPA website. PA DEP uses this online application that is updated on a regular schedule and tied to a multitude of databases which track publicly available information (air quality, water quality, mining/reclamation, natural resources, etc.) on a publicly accessible GIS website. (See http://www.emappa.dep.state.pa.us/emappa/viewer.htm).

Recommendation: With regard to regulatory permit tracking, PA DEP has developed an additional tool called Environment, Facility, Application, Compliance Tracking System (eFACTS). PA DEP staff, as necessary, has internal agency access to this database system, cross-referenced by regulatory program, in which permits and permittees may be tracked and updated with regard to permits issued, violations, etc. This information is also available to the public, in a limited format, via the internet at http://www.dep.state.pa.us/dep/efacts/efacts.html. If not already available through the NYS Department Application Review Tracking (DART) system, the development of such a system would be very beneficial for tracking SPDES

HVHF GPs, as well as other state issued permits associated with gas development projects, including dirt/gravel roads, stream crossings, etc. This information should be linked to any web-based GIS application.

Recommendation: Population of a geodatabase may occur through the submission of GIS data by permittees. Permit application packages could and should be front loaded for digital information by requiring permittees to submit GIS data (i.e., shapefiles in an accepted Metadata format) about their project sites. At a minimum, a project boundary on georeferenced state plane coordinate system should be required. This website should also link each project boundary to any online permit tracking system, including the email address of appropriate personnel to whom comments may be submitted.

Recommendation: In addition to sharing GIS data with local governments, NYSDEC should, if it has not already, implement a requirement for municipal notification similar to those commonly referred to in Pennsylvania as Act 14 notices. Pennsylvania permitting processes include requirements for written notifications to be sent to each municipality and county government in which the permitted facility is or will be located under an amendment to the Commonwealth's Administrative Code. These notifications allow 30 days for specific municipal and county comments.

Recommendation: Additional public participation may be solicited by the publication of notices of pending permits in NYSDEC's Environmental Notice Bulletin (ENB). Certain SPDES permitting actions are already included in the monthly ENB; however, it may be beneficial to provide a section specific to those SPDES permits issued for HVHF gas development on the ENB website and linked to the DART system.

Comments on the Draft SPDES HVHF GP

Impacts to surface water quality from gas exploration and extraction activities 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. Applying specific performance standards and consistent regulatory oversight through a thorough permitting process is essential to ensuring the prevention of water quality impacts. A comprehensive permitting process should include, but not be limited to, the following considerations:

- Clearly defined permitting process and timelines;
- Sound technical guidelines specific to the activities being permitted;
- Compliance with both State and local regulations prior to final permit approvals;
- Opportunities for public participation, outreach, and comment.

These considerations, as well as a comprehensive evaluation of all potential environmental impacts, are essential to the development of permitting procedures that are adequately protective of environmental resources.

The RDSGEIS notes that certain water resources, such as the New York City and Syracuse drinking water supplies, have been the subject of extensive comment and warrant different regulatory requirements (i.e. a prohibition on drilling). Specifically, the "Department finds that standard stormwater control and other mitigation measures would not fully mitigate the risk of potential significant adverse impacts on water resources from high-volume hydraulic fracturing." RDSGEIS at 7-55.

In a paper prepared by Patrick O'Dell, a professional engineer with the National Park Service Geologic Resources Division, Mr. O'Dell noted 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."[8]

Given these comments, and that the Department recognizes that "*standard stormwater control and other mitigation measures would not fully mitigate the risk of potential significant adverse impacts on water resources from high-volume hydraulic fracturing*," and the Department's decision to preclude HVHF in FAD watersheds (Section 7.1.5), the validity and effectiveness of a self-monitoring GP process for other watersheds cannot be assumed to be protective of water resources, and the SPDES permit and associated regulatory activities must be developed to address these concerns.

In comments provided to the Pennsylvania DEP, Dr. James Schmid[14] PhD made the following recommendations that are directly applicable to NYSDEC regarding the HVHF SPDES permitting process in New York:

a. Place all gas-related permit applications, issued permits, and enforcement actions online in an electronic database accessible by public.
b. Include stream encroachment for pipelines *(in the SPDES permit).*
c. Select a significant number of permit applications for file and on-site audit, to ascertain trends in adequacy of permitting process.
d. Disallow general permits in Exceptional Value and High Quality waters (or in New York, require individual permits for AA or A drinking water streams and T or TS trout streams).
e. Require an inventory for all EV or HQ streams within 500 ft of well pads.

f. Make an attained use determination at every stream proposed for impact that has not been studied.
g. Require disclosure of ALL related facilities in each project application, require disclosure of all land and water disturbances for each well or well pad so that projects do not incorrectly fall below thresholds.
h. Require construction of impermeable holding areas sufficient to contain spills and prevent release outside pad.
i. Require accounting of tree clearing. Provide plans and timetable for reforestation.
j. Gathering lines and water pipelines should follow existing roads rather than new ROWs. New ROWs should be demonstrated to reduce stream/wetland crossings.
k. Distinguish between new stream crossings and those made atop existing culverts.

With these and other previously discussed recommendations in consideration, the following comments are provided with regards to the current Draft HVHF SPDES General Permit:

Comment 1: The Draft HVHF SPDES permit is primarily a compilation of the existing Construction SPDES GP (001) and the Industrial Stormwater GP (002). It has not been significantly modified to address the issues specific to HVHF. Additionally, the Draft HVHF SPDES permit should encompass ALL components of a well project (well pads, access roads, water lines, gathering lines, compressor stations, water withdrawals, transportation of materials, waste management) with considerations specific to HVHF, or clearly provided coordination with other permitting requirements specific to these issues.

Comment2: Given the lack of local land use review, the mapping and data requirements for the SWPPP should be coordinated with the mapping/data

requirements of the Environmental Assessment Form, and all information should be available digitally for access by local government, property owners, and the general public. The RDSGEIS Appendix 5 *Environmental Assessment Form Attachment to Drilling Permit Application* does NOT reflect all site data requirements described in Appendix 6 *Proposed EAF Addendum Requirements for High-Volume Hydraulic Fracturing*.

Comment3: The SPDES HVHF GP should be modified to include construction and stormwater discharges related to gathering lines, compressor stations and compressor station access roads, or to clarify how these activities will be addressed under another permit.

Comment 4: In the absence of more explicit requirements, such as the submission of supporting calculations for BMP design, owners/operators are likely to use a generic narrative for multiple wells, with exception of mapping requirements. It is important that the SPDES HVHF GP requirements for mapping be site specific, comprehensive, at a scale that provides info needed. Generic SWPPPs tend to be ignored.

The following comments are in regard to specific sections of the Draft SPDES HVHF GP as noted.

Part I GENERAL PERMIT COVERAGE AND LIMITATIONS

Comment 5:

Section B.2 Maintaining Water Quality – This section places the burden of identifying a violation of a water quality standard on the Department, as opposed to the permittee. In the Industrial Stormwater GP, the burden of identifying such stormwater discharges is placed on the permittee: "*If there is evidence indicating*

that the stormwater discharges authorized by this permit are causing, have the reasonable potential to cause, or are contributing to an excursion above an applicable water quality standard, the permittee must take appropriate corrective action and notify DEC of corrective actions taken." Similar responsibility should be placed on the permittee for HVHF activities.

Comment 6:

Section C.3 Non-Stormwater Discharges – This section authorizes non-stormwater discharges and adds "uncontaminated discharges from well site dewatering operations" to the list of allowable non-storm discharges. Is this section referring to only de-watering of erosion and sediment control measures in site development or to well drilling material? This should be clarified.

Comment 7:

Section D.2 Activities Which are Ineligible for Coverage under this General Permit – This section precludes the construction of HVHF only on locations where the stream designation is AA or AA-s, **and** there is no impervious cover **and** the slopes are greater than 25% or E / F slope designation. Does this mean that if there is some impervious cover on such a site that HVHF is allowed? Does this mean that all other sites have no limits on slope (unless identified by the applicant as addressed in local land use regulations **and** identified as an objection by local government)? Is disturbance of steep slopes allowed in T streams? Should steep slope disturbance be precluded in proximity to water bodies and wells and identified in setbacks? The RDSGEIS notes in Section 6.1.2 that "*Steep access roads, well pads on hill slopes, and well pads constructed by cut-and-fill operations pose particular challenges, especially if an on-site drilling pad is proposed.*" This section should be substantially re-evaluated to preclude or define limits on coverage for steep slopes, etc. in all watersheds. Additionally, the Department should develop specific performance parameters/requirements for coverage of such activities on steep slopes under an Individual Permit for sites not addressed under the GP, rather

than issuing an Individual Permit that is substantially similar to the GP. Additionally, this section should clarify that local land use regulations regarding steep slopes and other environmental constraints apply unless waived by local government.

Comment 8:

Section D.4 Setbacks for Well Pad – These setbacks should reflect further consideration in the RDSGEIS, and include all setbacks discussed and identified in the RDSGEIS and appendices – such as setbacks from private water supply wells and springs, public water supply wells, residences, etc. This section should also clarify where ALL HVHF activities are prohibited (i.e. within 100-year floodplain, within 4,000 feet of unfiltered water supply watersheds, within 2,000 feet of public water supply, etc.).

All setback dimensions should be indicated on the GP mapping requirements.

Additionally, this section should clarify that local land use regulation setbacks also apply unless waived by local government. The permittee should prepare documentation that such land use regulations have been evaluated, and the local government notified if local land use requirements have not been met.

Part II Obtaining General Permit Coverage

Comment 9:

A. Notice of Intent (NOI) Submittal – The applicant is required to submit an NOI form to the Department, and prepare a SWPPP. The SWPPP must be available to the Department (if requested) and maintained on site. This process does not provide for public access and notification (other than the publication in a newspaper, which is easily overlooked by the public).

The public, including immediately adjacent property owners, should have opportunity for notification when such notification is submitted to the Department.

Many local governments have adjacent property owner notification requirements as part of the local zoning and land development process. Since this process does not apply to HVHF, a process of notification to adjacent and potentially impacted property owners should be included in Section II.A. Clarification of the definition of "potentially impacted property owners" requires further consideration in the RDSGEIS. Potentially, notice should be provided to water suppliers, etc.

If coverage under the GP is dependent upon development and implementation of the SWPPP, then the SWPPP must be available for public review upon request. It is likely that most members of the general public would not necessarily know how to request or obtain a copy of the SWPPP. As previously suggested, an on-line database would allow public and Department access to the SWPPP. It is unreasonable to allow the industry to obtain GP coverage without an opportunity for public comment.

Comment 10:

B.2.3.b General Permit Authorization – Given the unique nature of HVHF construction, and the lack of local government review regarding land use disturbance and stormwater management, the permit should impose a time period between preparation and submission of any and all required materials and actual permit coverage. All material should be digitally submitted and all information regarding land disturbance activities should be available and accessible for public review and comment, with a minimum 30-day period for public comment before permit coverage. HVHF practices are different from other industrial practices and coverage under a general permit must provide some process for public review and comment on permit coverage.

Comment 11:

C. Impaired Waters and TMDLs – The RDSGEIS has not provided any documentation or consideration as to whether a general permit is sufficient to prevent further water quality impacts in impaired waters and especially watersheds with TMDLs. A requirement should be imposed for the permit applicant to identify to the Department when the discharge will occur in impaired waters, and what specific additional measures are being implemented to provide protection for the specific pollutants of concern. The Department should maintain specific records and documentation of HVHF activities in impaired waters. Additional monitoring and reporting requirements are warranted in impaired waters, and should be submitted to the Department, not just maintained on site.

Part III – DEVELOPMENT AND ADMINISTRATION OF THE CONSTRUCTION SWPPP

Comment 12:

A.3. Development of the Construction SWPPP – Section 5.1 of the RDSGEIS identifies a number of types of land disturbance activities associated with HVHF including utility corridors (including gathering lines), compressor facilities, and access roads associated with compressor facilities. However, the construction of gathering lines, compressor facilities and the access roads associated therewith is not required to be addressed in the SWPPP. The GP and the required SWPPP contents should be revised to include construction and stormwater discharges related to gathering lines, compressor stations and associated access roads, as well as those facilities currently listed under this section.

Comment 13:

C.1. Disturbance of more than five (5) acres – If phased construction is planned,

with a maximum of five acres disturbed in any phase, the permitting of greater disturbance may be permissible under the SPDES HVHF GP as it is currently written.

Recommendation: The SPDES HVHF GP should be revised to require approval when the soil disturbance activities will result in more than five acres of disturbance at any one time, or more than five acres of disturbance over the life of the project.

Recommendation: The SPDES HVHF GP should be revised to effectively cover all areas not in AA, AA-Special, or FAD areas.

Part IV CONTENTS OF SWPPP

Comment 14:

A. What the Construction SWPPP Must Achieve –The SPDES HVHF GP requires well sites to be *designed to minimize environmental impacts* through the minimization of clearing and grading; and avoidance of sensitive areas such as erodible soils, steep areas, and critical habitats. However, the SPDES HVHF GP does not indicate how the permittee will achieve this.

Recommendation: The SPDES HVHF GP should be revised to clearly indicate how sensitive areas will be identified in permittee submission packages and require the identification to be done so at a mapping scale adequate to clearly identify all potential sensitive areas to ensure clearing and grading will be minimized accordingly. This requirement also applies to setback requirements around waterbodies. (See additional comments under Part IV.C.1. and Part IV.A.)

Comment 15:

B.1.b. and e. Effluent Limitation Requirements – The SPDES HVHF GP requires compliance with erosion and sediment controls to *minimize the discharge of pollutants,* specifically the control of stormwater and sediment discharges, but does not require supporting calculations to be submitted.

Recommendation: The SPDES HVHF GP should be revised to require permittees to submit calculations supporting any claim of compliance with mandatory control of stormwater, sediment, or other pollutant discharges.

Comment 16:

C.1.b. Erosion and sediment control components - The SPDES HVHF GP requires a site map/construction drawing(s) that include information vital to erosion and sediment control considerations, including wetlands, potentially affected surface waters, existing and final slopes, and location(s) of stormwater discharges. However, there is no maximum scale identified for this requirement. It is possible that sensitive features may be overlooked and steep slopes unidentified if mapping is at too large a scale.

Recommendation: The SPDES HVHF GP should be revised to require mapping at a maximum scale no greater than 1" = 100' to ensure adequate identification of features to be avoided or protected during construction.

Comment 17:

C.1.i. Erosion and sediment control components – The inspection schedule, as well as the corresponding inspection reports should be made available with the SWPPP for Department access. At a minimum, the inspection schedule should be made available to the public and include a Department contact where concerns may be reported.

Comment 18:

D.1.b. Post-construction stormwater management practice component - The SPDES HVHF GP requires a well site map/construction drawing(s) that include information vital to post-construction stormwater management practice evaluation,

including the specific location and size of each post-construction stormwater management practice. However, there is no maximum scale identified for this requirement. It is possible that the regulatory review of post-construction stormwater management practices may be inadequate if mapping is at too large a scale.

Recommendation: The SPDES HVHF GP should be revised to require mapping at a maximum scale no greater than 1" = 100' to ensure adequate identification and evaluation of proposed post-construction stormwater management practices.

Comment 19:

D.1.e. Post-construction stormwater management practice component - The SPDES HVHF GP requires a hydrologic and hydraulic analysis for all structural components of the stormwater management control system. However, the SPDES HVHF GP does not require supporting calculations to be submitted in support of these analyses. Without supporting calculations, regulators will be limited in the ability to effectively review the appropriateness of the proposed system.

Recommendation: The SPDES HVHF GP should be revised to require permittees to submit calculations supporting the hydrologic and hydraulic analysis of all structural components of the proposed stormwater management control system. All calculations and information should be available to the public upon request.

Comment 20:

D.1.f. Post-construction stormwater management practice component – The SPDES HVHF GP requires a detailed summary of the sizing criteria that were used to design all post-construction stormwater management practices *including calculations* to be submitted with the SWPPP. The SPDES HVHF GP requires the summary to address, at a minimum, the required design criteria from applicable chapters of the 2010 New York State Stormwater Management Design Manual.

However, the SPDES HVHF GP does not indicate that the calculations are site specific. Given the variability of site conditions throughout any given project, it is essential that the post-construction stormwater management practices be designed to address the unique considerations of both the site conditions and the functional practicality of any proposed post-stormwater management practice.

Recommendation: The SPDES HVHF GP should be revised to require permittees to submit site-specific calculations supporting the design of all proposed stormwater management practices to ensure they are appropriate for site-specific conditions.

Comment 21:

E. Enhanced Phosphorous Removal Standards – The SPDES HVHF GP requires post-construction stormwater management practices to be designed in conformance with the Enhanced Phosphorous Removal Standards included in the 2010 New York State Stormwater Design Manual. However, the SPDES HVHF GP does not require permittees to submit documented implementation of this requirement.

Recommendation: The SPDES HVHF GP should be revised to require permittees to document the implementation of the Enhanced Phosphorous Removal Standards within the SWPPP as part of their permit application package.

Part V-CONSTRUCTION OF WELL SITE – INSPECTION, MAINTENANCE, AND RECORDKEEPING REQUIREMENTS

Comment 22:

D. Recordkeeping – The SPDES HVHF GP requires all inspection reports to be maintained on the *well site* with the *Construction SWPPP*. Without a requirement to submit inspection reports or, at a minimum, a list of violations and corrective actions required, to the Department, the inspection reports may not serve their

intended purpose. Regardless of limitations to staff and funding, the Department should maintain responsibility for ensuring compliance with applicable regulations. The utilization of *qualified inspectors* is only one part of ensuring compliance and should be supplemented with quality control checks by the Department, which may be done by performing random reviews of documents submitted electronically to a Department database similar to that mentioned in previous comments.

Recommendation: The SPDES HVHF GP should require electronic submission of inspection reports or, at a minimum, a list of violations and correctives actions required, to the Department. These submissions should be managed in a Department database similar to that mentioned in previous comments. The Department database should also be accessible to the public in a manner described in previous comments. Additionally, the Department should conduct quality control reviews of inspection documents to ensure compliance is being achieved.

Part VI CONSTRUCTION PHASE COMPLETION

Comment 23:

B. Inspections – The SPDES HVHF GP requires from qualified inspectors, by signature, a statement certifying achievement of final site stabilization. However, the SPDES HVHF GP does not require any documentation supporting this certification.

Recommendation: The SPDES HVHF GP should be revised to require documentation, specifically time/date-stamped digital photographs, to support certification of final stabilization.

Part VII HVHF SWPP

Comment 24:

Part VII General comment – Would an applicant be permitted to submit one

generic document to be applied at multiple sites? If so, it is unlikely that all relevant issues will be adequately addressed.

Recommendation: The SPDES HVHF should be revised to require a site-specific SWPPP as described in previous comments to ensure adequate protection and mitigation measures are proposed.

Comment 25:

A.5. Development of the HVHF SWPPP – The SPDES HVHF GP requires the HVHF SWPPP to be developed by someone knowledgeable in the principles and practices of stormwater management and groundwater protection associated with the HVHF Phase and the Production Phase. The SPDES HVHF GP specifically mentions a Professional Engineer. However, the principles and practices of groundwater protection are often best performed by a Professional Hydrogeologist.

Recommendation: The SPDES HVHF GP should be revised to reference the appropriate professional disciplines necessary to adequately address both stormwater management (Professional Engineer) and groundwater protection (Professional Hydrogeologist).

Comment 26:

A.11 Development of the HVHF SWPPP – The SPDES HVHF GP allows the Department to issue an immediate stop work order upon a finding of significant non-compliance of the HVHF SWPPP or violation of the GP.

Recommendation: The ability to issue a stop-work order is a great option for the Department and should be supplemented by random quality control reviews performed as described in previous comments.

Part VIII HVHF OPERATION REQUIREMENTS

Comment 27:

A.1. and 2. General Requirements – The SPDES HVHF GP requires owners and operators to develop and evaluate alternatives for HVHF Phase fluid additives and to maintain a list of all HVHF Phase fluid additives on-site. The Department must make clear that propriety information must not be excluded from this list.

Comment 28:

A.4. General Requirements – The SPDES HVHF GP requires qualified inspectors to sign a statement certifying achievement of final site stabilization prior to initiating the HVHF Phase. However, the SPDES HVHF GP does not require any documentation supporting this certification.

Recommendation: The SPDES HVHF GP should be revised to require documentation, specifically time/date-stamped digital photographs, to support certification of final stabilization.

Comment 29:

A.6. General Requirements – The SPDES HVHF GP requires Department inspector verification of partial site reclamation. However, the SPDES HVHF GP does not address the procedures necessary if partial site reclamation is not sufficient.

Recommendation: The SPDES HVHF GP should be revised to detail the process for addressing sites where the requirements for partial site reclamation are insufficient.

Part IX CONTENTS OF THE HVHF SWPPP

Comment 30:

A.2. HVHF General SWPPP Requirements – The SPDES HVHF GP requires a site map that includes information critical to adequately review and evaluate the HVHF

SWPPP. Specifically, the SPDES HVHF GP cites a *USGS quadrangle or other map.* While a USGS quadrangle map may be adequate for showing general site location, it is not appropriate for showing detailed information. It is possible that the regulatory review of the HVHF SWPPP may be inadequate if mapping is at too large a scale.

Recommendation: The SPDES HVHF GP should be revised to require mapping at a maximum scale no greater than 1" = 100' to ensure adequate identification and evaluation of proposed post-construction stormwater management practices. Specifically, this section of the SPDES HVHF GP should be revised as follows:

b. Directions of stormwater flow should be shown on a contoured map with contours shown at minimum 5-ft intervals.

e. The scale for maps showing the locations of items listed in this section should be mapped at an appropriate defined scale (e.g. 1"=50' maximum). This section should also include the location of gathering lines.

g. Drainage area maps and stormwater outfall locations should be submitted on a separate stormwater map, attached to the site map, to ensure correct documentation.

i. The procedure for determining areas with significant potential for causing erosion should be defined or, if already defined in other documents, referenced.

Comment 31:

A.4. HVHF General SWPPP Requirements – This section requires the name, classification, and distance from the nearest edge of the well pad to the nearest receiving water(s). Submission of this information in narrative form may be sufficient, but an appropriately scaled map with labeled features would also provide an easily-verifiable document.

Recommendation: The SPDES HVHF GP should be revised to require a map showing the name, classification, and distance from the nearest edge of a well pad to the nearest receiving water(s) at a legible scale.

Comment 32:

A.7. HVHF General SWPPP Requirements – The inclusion of gravel is important when considering the total imperviousness of the well site. The compaction of subsoils and clogging with fine sediment within gravel areas has been shown to function as an impervious surface with regard to stormwater runoff.

Comment 33:

A.7. HVHF General SWPPP Requirements – This section includes an equation for estimating the total imperviousness of a well site as:

> Area of Roofs + Area of Paved and Other *Impervious* Surfaces, including gravel and roads = Total Area of *Well site.*

This equation should be revised as follows:

> Area of Roofs + Area of Paved and Other *Impervious* Surfaces, including gravel and roads = Total Impervious Surface Area of *Well site.*

Comment 34:

A.11. HVHF General SWPPP Requirements – The SPDES HVHF GP requires a summary of discharge sampling data to be maintained on the well site. Without a requirement to submit sampling data to the Department, it is possible that discharges in violation of the SPDES HVHF GP may be overlooked. Regardless of limitations to staff and funding, the Department should maintain responsibility for compliance and enforcement through quality control checks.

Recommendation: Quality control checks should be performed by the Department and facilitated by the submission of sampling data to the Department electronically. Checks should then be verified through cross-checking submitted sampling data

against Department-collected sample data. These submissions should be managed in a Department database similar to that mentioned in previous comments. The Department database should also be accessible to the public in a manner described in previous comments.

Comment 35:

A.13. HVHF General SWPPP Requirements – In addition to identifying the proposed sources or any water to be used at the well site, an estimate of proposed volume to be withdrawn from each source will assist in tracking any pollutants found in that water.

Recommendation: The SPDES HVHF GP should be revised to require permittees to submit estimated volumes to be withdrawn from each identified water source.

Comment 36:

A.16. HVHF General SWPPP Requirements – The SPDES HVHF GP requires the HVHF SWPPP to include a description of stormwater management controls appropriate for the *well site*. However, the SPDES HVHF GP does not indicate that this description will include site specific sizing calculations. Given the variability of site conditions throughout any given project, it is essential that stormwater management controls be designed to address the unique considerations of both the site conditions and the functional practicality thereof.

Recommendation: The SPDES HVHF GP should be revised to require permittees to submit site specific sizing calculations supporting the design of all proposed stormwater management controls to ensure they are appropriate for site-specific conditions. Site-specific stormwater management controls should be evaluated for design and performance through inspection reporting and quality control as described in previous comments.

Comment 37:

A.18.k. HVHF General SWPPP Requirements – The SPDES HVHF GP requires the HVHF SWPPP to include information about partial site reclamation, including a requirement that reclaimed areas be seeded and mulched after topsoil replacement and reestablishment of vegetative cover. Standards for acceptable seeding, maintenance of seeded areas, and soil restoration should be defined in order to ensure reclamation, revegetation, and continued stabilization are achieved.

Recommendation: The SPDES HVHF GP should be revised to include by definition or reference standards for acceptable seeding, maintenance of seeded areas, and soil restoration.

Comment 38:

B.1.p. Required Non-Structural BMPs - The SPDES HVHF GP requires the owner or operator to use absorbents for dry cleanup whenever possible. However, the SPDES HVHF GP does not address the disposal of used absorbents.

Recommendation: The SPDES HVHF GP should be revised to address the disposal of used absorbents in accordance with NYS and EPA guidelines.

Comment 39:

C. Required Structural BMPs – The SPDES HVHF GP requires the HVHF SWPPP to "describe the traditional stormwater management practices…that currently exist or that are planned." However, the SPDES HVHF GP does not require calculations supporting the capacity of existing stormwater management practices to manage additional stormwater from newly constructed well sties, nor does the SPDES HVHF GP require supporting calculations for design of proposed stormwater management practices. Without a thorough review prior to issuance of the GP, it is possible that stormwater management practices will be inadequate to effectively address stormwater runoff from well sites.

Recommendation: - The SPDES HVHF GP should be revised to require the submission of calculations supporting the capacity of existing stormwater management practices and the design of proposed stormwater management practices to effectively manage stormwater runoff resulting from the construction and operation of a well site.

Part X ACTIVITIY-SPECIFIC STRUCTURAL AND NON-STRUCTURAL BMPs AND BENCHMARK MONITORING REQUIREMENTS

Comment 40:

A.5. General – The SPDES HVHF GP states that "if the [HVHF] activities are conducted for less than one (1) calendar year, all stormwater monitoring requirements must be satisfied during the period of activity. If no qualifying storm event occurs during the period of activity, or no qualifying storm event results in a *discharge*, monitoring requirements must be completed during the first qualifying storm that results in a *discharge*." However, the SPDES HVHF GP does not define the term "qualifying storm event." To ensure adequate monitoring of stormwater resulting from HVHF activities, the monitoring and sampling requirements must be clearly defined in order for permittees to satisfy the conditions of the permit.

Recommendation: The SPDES HVHF GP should be revised to include a clear definition of the term "qualifying storm event."

Comment 41:

D. Vehicle and equipment cleaning areas – The SPDES HVHF GP states that "discharge of vehicle and equipment wash waters … are not authorized by the SPDES HVHF GP and must be covered under a separate SPDES permit or discharged to a sanitary sewer in accordance with applicable industrial pretreatment requirements or transported off-site for proper disposal." The intent of the SPDES HVHF GP was to streamline and condense the permitting process for HVHF

activities. Requiring a separate permit for the discharge of vehicle and equipment wash waters seems redundant in light of the ability of the SPDES HVHF GP to cover all other HVHF activities.

Recommendation: The SPDES HVHF GP should be revised to incorporate all the provisions necessary to meet New York State permitting requirements within a single permit, including the provisions necessary to authorize discharges from vehicle and equipment wash waters or require off-site transportation for disposal.

Comment 42:

J. Piping/conveyances – The SPDES HVHF GP requires the HVHF SWPPP to include and describe measures that prevent or minimize the contamination of surface runoff from spills and leaks from piping/conveyance systems used for transferring "fresh water, *flowback* water, *production brine*, well *stimulation* water, sanitary, and other wastewaters." However, the SPDES HVHF GP does not address this requirement for piping/conveyance systems used for transferring the gas produced by each well site. Failure to address the piping/conveyance systems used for gas transmission may result in inadequate protection of surface waters in the event of a leak or spill of gas.

Recommendation: The SPDES HVHF GP should be revised to address all piping/conveyances, including gas transmission systems.

Comment 43:

J.2.p. Piping/conveyances – The SPDES HVHF GP states, "pipelines buried under stream crossings shall be buried below the scouring depth and may require other permits." The SPDES HVHF GP does not require the submission of supporting calculations for determination of scour depth, nor does it clearly define the conditions under which "other permits" may be required. Furthermore, it seems that NYSDEC does not require stream crossing permits for activities other than silviculture. This lack of oversight may result in significant impacts to surface

waters due to the potential thousands of crossings at headwater streams to facilitate HVHF activities.

Recommendation: The SPDES HVHF GP should be revised to require submission of calculations supporting the determination of scour depth for the placement of buried pipeline stream crossings.

Recommendation: The SPDES HVHF GP should be revised to clearly define which "other permits" may be required and the conditions under which those "other permits" are applicable.

Recommendation: NYSDEC should examine current stream crossing requirements and develop more robust regulations to ensure proposed crossings are constructed and maintained appropriately and do not impact water quality.

Comment 44:

M. Freshwater Surface Impoundments and Reserve Pits – The SPDES HVHF GP states, "a closed-loop tank system must be used instead of a reserve pit to manage drilling fluids and cuttings for any of the following: a) horizontal drilling in the Marcellus Shale unless an acid rock drainage mitigation plan for onsite burial of such cuttings is approved by the Department; and; b) any drilling requiring cuttings to be disposed of off-site, as provided in Part 360 of this Title, including at a landfill." However, the SPDES HVHF GP does not define an "acid rock drainage mitigation plan." The SPDES HVHF GP also does not clearly identify the reference to Part 360 in section (b), above.

Recommendation: The SPDES HVHF GP should be revised to include a section defining an "acid rock drainage mitigation plan" which includes the conditions under which the plan must be developed, the issues which the plan must address (including any necessary supporting calculations), and the contents which must be included in the plan.

Recommendation: The SPDES HVHF GP should be revised to clearly identify the statute included in part (b) of this section which references the off-site disposal of cuttings.

Part XII HVHF PHASE MONITORING

Comment 45:

A. Schedule for Monitoring – The SPDES HVHF GP requires a schedule for visual monitoring and examination of stormwater discharges at each outfall after each qualifying storm that must document observed color, odor, clarity, floating solids, settled solids, suspended solids, foam, and oil sheen. However, the SPDES HVHF GP does not require sampling, even if the visual observations indicate the presence of pollutants.

Recommendation: The SPDES HVHF GP should be revised to clearly define sampling requirements. At a minimum, sampling and laboratory testing should be required if a visual examination indicates the presence of pollutants.

Comment 46:

A. Schedule for Monitoring – The SPDES HVHF GP requires visual examination documents to be maintained on the well site. Also, the SPDES HVHF GP does not require photographic documentation to support visual examination reports. The Department should perform quality control checks, which may be done by performing random reviews of documents submitted electronically to a Department database similar to that mentioned in previous comments.

Recommendation: The SPDES HVHF GP should require electronic submission of visual examination reports, including photos, to the Department. These submissions should be managed in a Department database similar to that mentioned in previous comments. The Department database should also be

accessible to the public in a manner described in previous comments. Additionally, the Department should conduct quality control reviews of visual examination documents to ensure compliance is being achieved.

Comment 47:

A. Schedule for Monitoring – The SPDES HVHF GP states, "all samples (except snowmelt samples) must be collected from the *discharge* resulting from a storm event that is greater than 0.1 inches in magnitude and that occurs at least seventy-two (72) hours from the previously measurable (greater than 0.1 inch rainfall) storm event. The 72-hour storm interval is waived if the preceding measurable storm did not result in a stormwater *discharge* (e.g., a storm event in excess of 0.1 inches may not result in a stormwater *discharge* at some facilities)." Is this the intended definition of "qualifying storm event?"

Comment 48:

A. Schedule for Monitoring – The SPDES HVHF GP states, "if a visual examination was performed and the storm event was later determined not to be a measurable (greater than 0.1 inch rainfall) storm event, the visual examination should still be included in the *HVHF SWPPP* records." The inclusion of all visual examination reports in the HVHF SWPPP record should be required.

Recommendation: The SPDES HVHF GP should be revised to state, "if a visual examination was performed and the storm event was later determined not to be a measurable (greater than 0.1 inch rainfall) storm event, the visual examination must still be included in the *HVHF SWPPP* records."

Comment 49:

A.3.c. Schedule for Monitoring – This section of the SPDES HVHF GP requires samples to be analyzed within ten calendar days after they have been collected.

This information may be more logically located in section A.10.b. which discusses collection and analysis of samples.

Recommendation: The SPDES HVHF GP should be revised to move the above referenced requirement for analysis of samples from Part XII.A.3.c. to Part XII.A.10.b.

Comment 50:

A.3.d. Schedule for Monitoring – This section of the SPDES HVHF GP states, "the benchmark concentrations do not constitute direct numeric effluent limitations and, therefore, an exceedance is not a general permit violation." What is the purpose of benchmark monitoring if exceedance of the benchmark concentrations listed in Part X of the SPDES HVHF GP do not result in a general permit violation?

Recommendation: The SPDES HVHF GP should be revised to omit this sentence from the document. Exceeding benchmark concentrations should immediately result in a violation of the GP to ensure proper corrective action is taken to protect water quality.

Comment 51:

A.3.f. Schedule for Monitoring – The SPDES HVHF GP requires benchmark monitoring results to be documented and maintained on the well site. The Department should perform quality control checks, which may be done by performing random reviews of documents submitted electronically to a Department database similar to that mentioned in previous comments.

Recommendation: The SPDES HVHF GP should require electronic submission of benchmark monitoring results, including corrective actions needed, to the Department. These submissions should be managed in a Department database similar to that mentioned in previous comments. The Department database should

also be accessible to the public in a manner described in previous comments. Additionally, the Department should conduct quality control reviews of benchmark monitoring documents to ensure compliance is being achieved.

Comment 52:

A.10.b. Schedule for Monitoring – The SPDES HVHF GP states that "sampling requirements must be assessed on an outfall-by-outfall basis." However, there are no criteria upon which sampling requirements are to be assessed. The SPDES HVHF GP also fails to identify the party responsible for directing sampling requirements at each outfall. Sampling requirements should be directed by NYSDEC guidance criteria, to include frequency of collection and analysis requirements.

Recommendation: The SPDES HVHF GP should be revised to clearly identify the Department as the party responsible for directing sampling requirements at each outfall.

Recommendation: The NYSDEC should develop guidance criteria for sampling requirements for HVHF activities. This guidance criteria should address the conditions under which sample collection is required (i.e., when a visual examination indicates the presence of pollution), location of sample collection, frequency of sample collection, and laboratory analysis requirements for collected samples.

Recommendation: The SPDES HVHF GP should be revised to require sampling in accordance with NYSDEC guidance criteria, to include frequency of collection and analysis requirements.

Comment 53:

A.10.b. Schedule for Monitoring – This section of the SPDES HVHF GP does not reference the ten-day time limit for analysis of collected samples.

Recommendation: This section of the SPDES HVHF GP should be revised to include reference to the ten-day time limit for analysis of collected samples included in Part XII.A.3.c.

Comment 54:

A.10.c. Schedule for Monitoring – This section of the SPDES HVHF GP requires owners/operators to provide the date and duration of sampled storm events, rainfall measurements or estimates (in inches) of the storm event that generated the sampled runoff, time between storm events greater than 0.1 inch, and an estimate of volume sampled. A rain gauge/weather station should be required to ensure rainfall greater than 0.1 inch is accurately recorded. This will also ensure visual examination and sampling is completed for events greater than 0.1 inch.

Recommendation: The SPDES HVHF GP should be revised to require rainfall measurements and remove references to rainfall estimates to ensure monitoring and sampling in compliance with the conditions of the permit.

Part XIII HVHF PHASE REPORTING

Comment 55:

A. Discharge Monitoring Reports (DMR) – The SPDES HVHF GP requires the results of laboratory analysis of samples to be submitted to the Department on preprinted DMRs within ten days of their receipt. The required formatting of DMRs lends itself very easily to standardization for electronic submission to the Department, which would allow for faster submission and reduce the costs incurred by both the Department and permittees by eliminating unnecessary paper and paperwork. Furthermore, the Department should perform quality control checks, which may be done by performing random reviews of documents submitted electronically to a Department database similar to that mentioned in previous comments.

Recommendation: The SPDES HVHF GP should require electronic submission of DMRs, in approved format via online forms, to the Department. These submissions should be managed in a Department database similar to that mentioned in previous comments. The Department database should also be accessible to the public in a manner described in previous comments. Additionally, the Department should conduct quality control reviews of benchmark monitoring documents to ensure compliance is being achieved.

Part XIV MONITORING FOR THE PRODUCTION PHASE AND TEMPORARY SUSPENSION OF THE HVHF PHASE

Comment 56:

A. Schedule for Monitoring – Please see comments 45, 46, 49, 50, 51, 52, 53, and 54, and the corresponding recommendations as they apply to this section of the SPDES HVHF GP.

Part XVI PRODUCTION PHASE REPORTING

Comment 57:

A. Discharge Monitoring Reports (DMR) – Please see comment 55 and the corresponding recommendation as it applies to this section of the SPDES HVHF GP.

Part XXI. STANDARD GENERAL PERMIT CONDITIONS

Comment 58:

F. Duty to Provide Information – The SPDES HVHF GP states, "the NOI, SWPPP and inspection reports required by this general permit are public documents that the *owner or operator* must make available for review and copying by any person within five (5) business of the *owner or operator* receiving a written request by any such

person to review the NOI, SWPPP or inspection reports. Copying of documents will be done at the requester's expense." Many HVHF well sites prohibit access by the general public, and all of the public documents indicated are required by the SPDES HVHF GP to be kept on the well site. In order to expedite requests and eliminate man-hours necessary to escort individuals through restricted areas, as well as provide for the recommendations above, the Department should require the electronic submission of all public documents. These documents should be managed in a Department database similar to that mentioned in previous comments. The Department database should also be accessible to the public in a manner described in previous comments.

Recommendation: The SPDES HVHF GP should be revised to allow for the electronic submission of all public documents. These documents should be managed in a Department database similar to that mentioned in previous comments. The Department database should also be accessible to the public in a manner described in previous comments.

Attachment A

Technical Information in support of comments:

1. Sediment Loads from Gravel Roads

   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 (Scheetz, 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".*

   This research supports that gravel roads can be a significant source of pollutants such as sediment. As discussed in several comments, there is a need for the RDSGEIS to estimate the cumulative impact of gravel road development as a result of HVHF activity.

2. **Water Quality Impacts from Gas Drilling Activities**

   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

References

1. Center for Rural Pennsylvania "the Impact of Marcellus Gas drilling on Rural Drinking Water Supplies", October 2011.

2. Entrekin, Sally, et al, "Rapid Expansion of Natural Gas Development Poses a Threat to Surface Waters", From Frontiers in Ecology 2011; 9(9): 503-511, Oct 2011.

3. Etowah Aquatic Habitat Conservation Plan "Utility Stream Crossings Policy", July 13, 2006.

4. Handlerof, Stephanie; League of Women Voters of Indiana "Marcellus Shale Natural Gas Extraction Study 2009-2010 Study Guide V: Regulation and Permitting of Marcellus Shale Drilling", League of Women Voters of Pennsylvania, 2010.

5. Kaplan, Louis, et al "Protecting Headwaters: The Scientific Basis For Safeguarding Stream And River Ecosystems, A Research Synthesis from the Stroud Water Research Center " 2008.

6. Leopold, Luna B.; "A View of the River", Harvard University Press, Cambridge, MA, 1994.

7. NYDEC "Stream Crossings Protecting and Restoring Stream Continuity" web page at http://www.dec.ny.gov/permits/49060.html.

8. O'Dell, Patrick M., Professional Engineer in Petroleum Engineering, National Park Service Geologic Resources Division, "Potential for Development of Natural Gas Exploratory Wells to Adversely Affect Water Resources of the Delaware River Basin", Nov 23, 2010.

9. Reid, Scott M. and Paul G. Anderson "Effects of Sediment released During Open-cut Pipeline Water Crossings, Canadian water Resources Journal Vol. 24, No 3, 1999.

10. Scheetz, Dr. Barry E. and Steven M. Bloser; Center for Dirt and Gravel Road Studies, The Pennsylvania State University, University Park, PA 16802; "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 1712, FINAL REPORT June 30, 2008, Revised August 29, 2008 and Summary Statement

11. United States Environmental Protection Agency "Erosion, Sediment and Runoff Control for Roads and Highways", Office of Water (4503F) EPA-841-F-95-008d, December 1995

12. United States Environmental Protection Agency, Final Report for Catalog of Federal Domestic Assistance Grant 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" and "Summary of the Results of the Investigation Regarding Gas Well Site Surface Water Impacts", ID No. CP-83207101-1, Kenneth E. Banks, Ph.D. Manager, Division of Environmental Quality and David J. Wachal, M.S. Water Utilities Coordinator

13. United States Environmental Protection Agency, Wadable stream assessment: a collaborative survey of the nation's streams, 2006. EPA 841-B-06-002.

14. Letter from James A. Schmid, PhD, Schmid & Company Consulting Ecologists to Scott E. Walters, Chief General Permits Bureau of Waste Management PaDEP, 8 November 2011.

Attachment 7

The Louis Berger Group, Inc.

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Memorandum

TO: Kate Sinding, Natural Resources Defense Council

FROM: Niek Veraart, Louis Berger Group

DATE: January 11, 2012

RE: Technical Review Comments on the 2011 Revised Draft SGEIS on the Oil, Gas and Solution Mining Regulatory Program and Proposed High-Volume Hydraulic Fracturing Regulations (Proposed Express Terms 6 NYCRR Parts 550 through 556 and 560)

1.0 Introduction

The Louis Berger Group Inc. (LBG) reviewed the 2011 Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS), the proposed Environmental Assessment Form (EAF) and EAF Addendum (RDSGEIS Appendices 5 and 6), the proposed Supplemental Permit Conditions (RDSGEIS Appendix 10) and the proposed High-Volume Hydraulic Fracturing (HVHF) regulations (Proposed Express Terms 6 NYCRR Parts 550 through 556 and 560) for the following topics:

- Noise (RDSGEIS Sections 2.4.13 and 6.10)
- Ground-borne noise and vibration (impacts not addressed in the RDSGEIS)
- Visual impacts (RDSGEIS Sections 2.4.12 and 6.9)
- Land use (impacts not addressed in the RDSGEIS)
- Transportation (RDSGEIS Sections 2.4.14 and 6.11)
- Community character (RDSGEIS Sections 2.4.15 and 6.11)
- Cultural resources (impacts not addressed in the RDSGEIS).
- Aquatic Ecology (RDSGEIS Sections 6.1.1.2, 6.1.1.3 and 6.1.1.4).

For each topic, the following sections address the sufficiency of the RDSGEIS impact analyses and proposed mitigation measures in meeting State Environmental Quality Review Act (SEQRA--6 NYCRR Part 617) requirements. The comments also identify specific improvements and best practice approaches that the New York State Department of Environmental Conservation (NYSDEC) could use to resolve the deficiencies identified and minimize the environmental impacts of High-Volume Hydraulic Fracturing (HVHF) and related development in New York.

2.0 Noise

2.1 Construction Impacts

The 2011 RDSGEIS quantitative construction noise assessment uses information from the Federal Highway Administration's Road Construction Noise Model to estimate noise

levels at various distances from the construction site and represents a substantial improvement over the qualitative analysis in the 2009 Draft Supplemental Generic Environmental Impact Statement (DSGEIS). For quiet rural areas, the results show that construction activities would result in significant adverse impacts under NYSDEC criteria (increase of 6 dBA (A-weighted decibels) or more over existing conditions) at distances exceeding 2,000 feet.

The RDSGEIS provides the requisite construction noise analysis, but fails to appropriately evaluate and discuss the significance of the model results. Instead, a one sentence conclusion is provided: "Such levels would not generally be considered acceptable on a permanent basis, but as a temporary, daytime occurrence, construction noise of this magnitude and duration is not likely to result in many complaints in the project area."

Contrary to this statement, there is no regulatory requirement that access road construction and site preparation be limited to daytime hours. To mitigate this significant adverse impact, a prohibition on nighttime construction should be included in the HVHF regulations or supplemental permit conditions to avoid annoyance and sleep disturbance of nearby residences, along with other construction noise control best practices (See Section 2.6 infra).

Further, the assertion in the RDSGEIS that construction noise impacts are "temporary" ignores the likelihood of large number of wells and pads being concentrated in certain areas, as well as construction noise from related infrastructure development (pipelines, compressors, etc.). The cumulative construction noise impact has not been addressed.

In addition, noise-related complaints are not the appropriate basis for drawing conclusions about the significance of noise impacts under SEQRA because people (and wildlife) can be adversely affected by noise, but choose not to report it. NYSDEC should evaluate the significance of the construction noise impacts in relation to the duration, quality (tonal purity), time of day and year, background noise present, distance to the source, familiarity with the noise and other factors such as the setting. Studies have shown that each listener's subjective perception of appropriateness of a noise in a particular setting can be just as important to annoyance as the objective sound level.[1] Given the rural context of the majority of the areas where natural gas development is expected to occur, many residents and visitors to these areas would find heavy construction activity noise to be out of place and annoying. Construction noise adjacent to parks and other sensitive land areas where natural quiet is expected would be especially problematic and would contribute to adverse economic impacts not accounted

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[1]See: Blauert, J. 1986. "Cognitive and Aesthetic Aspects of Noise Engineering." In *Proceedings of Inter-Noise 86, Cambridge, Massachusetts, July 21–23*, volume 1, 5–13.

Kuwano, S., S. Namba, and H. Miura 1989 "Advantages and Disadvantages of A-weighted Sound Pressure Level in Relation to Subjective Impression of Environmental Noises."*Noise Control Engineering Journal* 33:107–115.

Carles, J.L., I. Lopez Barrio, J.V. de Lucio 1999 "Sound Influence on Landscape Values."*Landscape and Urban Planning* 43:191–200.
Ozawa, K., S. Ohtake, Y. Suzuki, and T. Sone 2003 "Effects of Visual Information on Auditory Presence," Acoustical Letter to Acoustical Science and Technology, 24(2), 97-99.

for in the 2011 RDSGEIS by making areas where gas development is occurring less attractive to visitors.[2]

2.2 Drilling and Fracturing Impacts

2.2.1 Failure to Analyze Multi-Well Pad Impacts

The general approach used in the RDSGEIS quantitative noise impact assessment is reasonable and consistent with the methodology recommended in NRDC's comments on the 2009 DSGEIS for evaluation of the impacts of drilling and fracturing of one horizontal well. However, it fails to analyze the impacts of multi-well pads, which is the primary form of development anticipated. Table 6-59 in the RDSGEIS presents the duration of various construction and operational phases for one well. Each well is estimated to take 28-35 days to drill, while fracturing is assumed to take up to five days. Since drilling or fracking of multiple wells is likely to occur simultaneously, the combined noise levels would be higher than those reported for a single well in the RDSGEIS.

The failure of the RDSGEIS to provide a noise impact assessment for the simultaneous drilling and fracturing of multiple wells is especially problematic because it is inconsistent with the scenario developed for the analysis of transportation impacts (page 6-305). The result of this inconsistency is that the noise impacts of drilling and fracturing are underestimated and do not reflect a reasonably foreseeable worst-case development scenario. The multi-pad horizontal well development scenario in the transportation section of the RDSGEIS assumed three rigs would be operated simultaneously over a 120 day period and that each rig would drill four wells (for a total of 12 wells at the site). With three rigs in operation at the same time, the combined noise level at a distance of 50 feet would be approximately 84 dBA, not 79 dBA as reported for one rig in the RDSGEIS (Table 6.56- Rotary Air Well Drilling).[3]

With respect to the fracturing phase, the RDSGEIS wording is unclear, but appears to suggest sequential fracturing (one well being fractured at a time for a total of 60 days of fracturing noise impacts). The RDSGEIS states "fracturing and completion of the four wells occurs sequentially and tanks are brought in once for all four wells" (page 6-305). This statement is confusing because the scenario being described involves a total of 12 wells, not four wells. If fracturing of multiple wells occurs simultaneously, then the duration of fracturing impacts would be less, but the combined noise level would be higher. For example, fracturing two wells at once would create a combined noise level 3 dBA higher than the fracturing of one well. When drilling and fracturing are occurring at the same time, the total noise level would be entirely driven by the much louder fracturing process (no increase in the total sound level because the difference between the two sound levels is greater than 10 dBA).

At a minimum, NYSDEC should analyze the noise impact from the same multi-pad well development scenario as used in the analysis of transportation impacts. NYSDEC should address the expected number of wells per multi-well site, the timing of drilling and fracturing at each well and the reasonable worst case noise levels that could result from the various combinations of drilling and fracturing at multiple wells on the same site.

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[2] Refer to Susan Christopherson's socioeconomics technical memorandum for more information on impacts to the tourism industry.

[3] Decibels are expressed on a logarithmic scale and thus cannot be added together directly.

2.2.2 Lack of Reasonable Noise Impact Significance Criteria

Similar to the construction impact assessment discussed in Section 2.1, the RDSGEIS presents the model results for the drilling and fracturing noise impacts without a SEQRA-compliant assessment of the significance of the results in various contexts where natural gas development is anticipated. The RDSGEIS does not include noise impact criteria against which the significance of the impacts can be assessed generically or at the site specific review level, which is contrary to the purposes of a GEIS. For information on a recommended framework for developing noise impact criteria, refer to Section 2.8.

The RDSGEIS references NYSDEC's noise policy ("Assessing and Mitigating Noise Impacts,"2001)[4], but this document has a number of significant problems that limit its usefulness in regulating noise. It discusses a 6 dBA increase as potentially significant, but does not define what averaging time period should be used in calculating the increase, does not account for increased sensitivity to noise occurring at night, and does not take into account the total level at the affected receptor. The policy also does not provide a standard for specific highly sensitive land uses, such as passive recreation parks and wilderness areas. The NYSDEC noise policy leaves too much discretion to individual analysts to ensure consistent application of noise control for an activity expected to have widespread and significant impacts across New York. Accordingly, an assessment as to the significance of the potential adverse noise impacts should be made independent of the 2001 policy.

The RDSGEIS acknowledges that drilling and fracturing would take place 24hours per day. People are much more sensitive to noise that occurs at night and interferes with sleep than to noise that occurs only during daytime activities. For this reason, community noise impact assessment metrics such as day-night sound levels (Ldn) apply a 10 dB penalty to sounds occurring at night in determining a 24-hour average energy sound level that better reflects human preferences. Background noise levels are also lower at night, further emphasizing the significance of the increase in sound levels attributable to drilling and fracturing. As noted above in the discussion of construction impacts, non-residential land uses in rural areas vital to the economic health of upstate New York such as parks, recreation areas and campgrounds would be especially sensitive to increases in sound levels.

2.2.3 Fracturing Noise Impacts Exceed Hearing Damage Thresholds

The noise levels associated with the fracturing process are of a relatively short duration on a per well basis (2-5 days), but are of an extremely large magnitude that could adversely affect human health:

- At a distance of 2,000 feet, the fracturing pump truck noise level of up to 72 dBA would be intrusive and interfere with normal conversation.
- At a distance of 500 feet, the fracturing pump truck noise level of up to 84 dBA approaches the level where hearing damage occurs (85 dBA for eight hours).

[4] http://www.dec.ny.gov/docs/permits_ej_operations_pdf/noise2000.pdf

- At a distance of 250 feet, the fracturing pump truck noise level of up to 90 dBA is in the range of noise levels where no more than 15 minutes of unprotected exposure is recommended to prevent damage to hearing.[5]
- At a distance of 50 feet, the fracturing pump truck noise level of up to 104 dBA is of a similar magnitude to a jet flyover at a distance of 1,000 feet and at a level where unprotected exposure over one minute poses a risk of permanent hearing loss.

For context in understanding the sound levels discussed above, Table 1 provides a summary of the decibel level of common sounds sources and the associated effects.

Table 1
Decibel Levels of Common Sound Sources

Sound	Noise Level (dB)	Effect
Jet Engines (near)	140	
Shotgun Firing Jet Takeoff (100-200 ft.)	130	
Rock Concerts (varies)	110–140	Threshold of pain begins around 125 dB
Oxygen Torch	121	
Discotheque/Boom Box Thunderclap (near)	120	Threshold of sensation begins around 120 dB
Stereos (over 100 watts)	110–125	
Symphony Orchestra Power Saw (chainsaw) Pneumatic Drill/Jackhammer	110	Regular exposure to sound over 100 dB of more than one minute risks permanent hearing loss.
Snowmobile	105	
Jet Flyover (1000 ft.)	103	
Electric Furnace Area Garbage Truck/Cement Mixer	100	No more than 15 minutes of unprotected exposure recommended for sounds between 90–100 dB.
Farm Tractor	98	
Newspaper Press	97	
Subway, Motorcycle (25 ft.)	88	Very annoying
Lawnmower, Food Blender Recreational Vehicles, TV	85–90 70–90	85 dB is the level at which hearing damage (8 hrs.) begins
Diesel Truck (40 mph, 50 ft.)	84	
Average City Traffic Garbage Disposal	80	Annoying; interferes with conversation; constant exposure may cause damage
Washing Machine	78	
Dishwasher	75	
Vacuum Cleaner, Hair Dryer	70	Intrusive; interferes with telephone conversation
Normal Conversation	50–65	
Quiet Office	50–60	Comfortable hearing levels are under 60 dB.
Refrigerator Humming	40	
Whisper	30	Very quiet
Broadcasting Studio	30	
Rustling Leaves	20	Just audible
Normal Breathing	10	

Source: http://www.nidcd.nih.gov/health/education/teachers/pages/common_sounds.aspx

The minimum setbacks in the proposed regulations (currently 100 feet from a residence) must be revised to protect the health and well-being of nearby residents during fracking. Landowners should not have the power to waive the minimum setback requirement. The

[5] http://www.nidcd.nih.gov/health/education/teachers/pages/common_sounds.aspx

landowners should not be presented with the temptation to trade their family's health for financial gain. An additional problem with granting landowners the ability to waive setback requirements is that tenants of a landowner's property would not have any say in the landowner's decision to waive setback requirements essential for health.

The drilling phase sound levels are substantially lower than the fracturing noise levels, but their duration is much longer (approximately one month of 24-hour drilling per well). Drilling sound levels would drop to below 70 dBA at a distance of 250 feet from the well pad. However, 70 dBA is still 40 dBA greater than the nighttime background sound level in rural areas of 30 dBA, further supporting the need for noise impact criteria and mitigation requirements to protect the soundscapes of rural areas

2.2.4 Other Comments

Tables 6.56, 6.57 and 6.58 are all incorrectly labeled as showing "estimated construction noise levels."

The equipment assumed in the analysis and sound levels associated with each piece of equipment are based on "confidential industry sources." NYSDEC should disclose the basis for the equipment assumptions and sound levels so that these important inputs can be independently validated.

Table 6.57 has footnote "2" for the rig drive motor and generator sound levels, but the explanation for footnote 2 is missing. In addition, it appears that footnote #1 on Table 6.57 should be associated with the "Distance in Feet/SPL (dBA)" portion of the table and not the sound levels associated with the top drive, draw works and triple shaker.

2.3 Transportation Noise Impacts

The RDSGEIS discusses the potential for noise impacts related to truck traffic, but fails to conduct a meaningful analysis of typical transportation noise impacts for various phases of well pad development. This failure is particularly problematic given that the detailed truck trip generation information necessary for conducting a traffic noise assessment was developed for the transportation section of the RDSGEIS.

NYSDEC should use the Federal Highway Administration's (FHWA) Traffic Noise Model (TNM) version 2.5 and the truck trip generation information to fully consider truck traffic noise impacts. While site-specific impacts cannot be assessed, NYSDEC could easily examine a hypothetical, yet realistic development scenario for one well. The analysis could look at one single public road segment from which the well site would be accessed. Receptors at various distances (50 feet to 1,000 feet) would help show the potential extent of the area where impacts could occur. A range of non-natural gas related background traffic on the modeled road could be considered to show how the increase in sound levels would be much higher for local roads with low traffic volumes than for roads with high volumes under existing conditions. Traffic noise impacts for the various receptor distances could be assessed using well established New York State Department of Transportation (NYSDOT) and FHWA criteria.[6]

[6]FHWA's noise impact assessment and mitigation procedures are defined under 23 CFR 772. NYSDOT's latest noise policy (revised April 2011) for implementing the FHWA requirements is

For the purposes of the SGEIS level of analysis, a number of simplifying, conservative assumptions could be employed in the TNM analysis (assuming flat terrain, no existing barriers, analyze one worst-case peak hour and one worst-case off-peak hour etc.). These assumptions would allow NYSDEC to complete a meaningful traffic noise analysis without extensive cost or delay to the review process.

2.4 Effects on Wildlife

Animals rely on sounds for communication, navigation, avoiding danger and finding food. Industrial and transportation noises associated with natural gas development create noise levels that can interfere with the sounds used by animals, which in turn can affect wildlife behavior and populations. The RDSGEIS acknowledges that noise could contribute to impacts on wildlife (page 6-68), but does not provide any analysis of this issue. NYSDEC should review the available scientific literature on this topic, qualitatively assess impacts and ensure appropriate mitigation measures are implemented. Key references to assist NYSDEC in this aspect of the environmental review are provided below:[7]

FHWA. Synthesis of Noise Effects on Wildlife Populations. http://www.fhwa.dot.gov/environment/noise/noise_effect_on_wildlife/effects/

Barber, J.R., K.R. Crooks, and K. Fristrup. 2010. The costs of chronic noise exposure for terrestrial organisms. Trends Ecology and Evolution 25(3): 180–189. Available at: http://www.sciencedirect.com/

Bayne, E.M., L. Habib and S. Boutin. 2008. Impacts of Chronic Anthropogenic Noise from Energy-Sector Activity on Abundance of Songbirds in the Boreal Forest. Conservation Biology 22(5) 1186-1193. Available at: http://oz.biology.ualberta.ca/faculty/stan_boutin/uploads/pdfs/Bayne%20etal%202008%20ConBio.pdf

Dooling R. J., and A. N. Popper. 2007. The effects of highway noise on birds. Report to the California. Department of Transportation, contract 43AO139. California Department of Transportation, Division of Environmental Analysis, Sacramento, California, USA. Available at: http://www.dot.ca.gov/hq/env/bio/files/caltrans_birds_10-7-2007b.pdf

Francis, C.D., C.P. Ortega and A. Cruz. 2009. Noise Pollution Changes Avian Communities and Species Interactions. Current Biology, Aug 25;19(16):1415-9 10.1016/j.cub.2009.06.052. Available at: http://www.sciencedirect.com/science/article/pii/S0960982209013281

Habib, L, E.M. Bayne and S. Boutin. 2007. Chronic industrial noise affects pairing success and age structure of ovenbirds Seiurus aurocapilla. Journal of Applied Ecology 44: 176-184. Available at: http://oz.biology.ualberta.ca/faculty/stan_boutin/ilm/uploads/pdfs/Habib%20etal%202

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available at https://www.dot.ny.gov/divisions/engineering/environmental-analysis/manuals-and-guidance/epm/repository/4_4_18Noise.pdf

[7] The suggested list of references is adapted from the USFWS paper entitled "The Effects of Noise on Wildlife." Available at: http://www.fws.gov/windenergy/docs/Noise.pdf

007%20JAE.pdf

Schaub, A, J. Ostwald and B.M. Siemers. 2008. Foraging bats avoid noise. The Journal of Experimental Biology 211: 3174-3180. Available at: http://jeb.biologists.org/cgi/content/full/211/19/3174

Swaddle, J.P. and L.C. Page. 2007. High levels of environmental noise erode pair preferences in zebra finches: implications for noise pollution. Animal Behavior 74: 363-368.

2.5 Cumulative Impacts

The RDSGEIS does not address the cumulative noise impacts of the anticipated natural gas development. Key considerations in developing a cumulative impact analysis for noise include the following:

- Analyze the cumulative noise impact of multi-well pads. The RDSGEIS analysis only addresses a single well.
- Analyze the cumulative noise impact from well site construction, drilling and fracturing in combination with the construction of pipelines and the operation of compressor stations. Pipelines and compressor stations are a reasonably foreseeable form of "induced growth" that needs to be considered.
- Examining the Ldn sound levels that would result at residences that are exposed to drilling, fracturing and truck traffic noise. The combination of these sources could result in impacts more significant than any individual source examined separately.
- Discuss regional-scale traffic noise impacts that would result from wide spread natural gas development and related economic development and temporary population growth.
- Discuss regional-scale noise impacts on human beings and wildlife, including the potential for disturbance of noise-sensitive species, such as the ovenbird (*Seiurus aurocapilla*).[8]

2.6 Mitigation

2.6.1 Mitigation for Construction Impacts

Construction noise impact mitigation is not addressed in Section 7.10 of the RDSGEIS. NYSDEC should require the use of construction noise mitigation best practices, such as those outlined in FHWA's Construction Noise Handbook. At a minimum, these measures should include:

- Requiring the use of construction noise control measures in construction contract documents. Specific noise levels can be established to ensure the protection of sensitive receptors.

[8] http://oz.biology.ualberta.ca/faculty/stan_boutin/ilm/uploads/pdfs/Habib%20etal%202007%20JAE.pdf

- Limitations on the time periods when construction could occur (e.g., prohibiting nighttime construction).
- Requiring the use of less noisy equipment and mufflers.
- Requiring temporary noise barriers when significant impacts cannot be addressed through other means.

2.6.2 Mitigation for Drilling, Fracturing and Transportation Impacts

The general types of noise mitigation measures for drilling, fracturing and trucking suggested in the RDSGEIS are reasonable, but there is no guarantee which measures, if any, will actually be required in specific circumstances. Therefore, it is likely that significant impacts will not be mitigated at the site level. In addition, the RDSGEIS states that detailed noise modeling and consideration of mitigation measures will only be required for receptors within 1,000 feet of the well pad. This requirement is illogical given the impact analysis results that show impacts extending beyond 2,000 feet. Under NYSDEC's proposed 1,000 feet distance for noise modeling, well operators could avoid assessing site specific impacts and mitigation by locating wells just beyond the 1,000 feet threshold. This could result in unmitigated significant adverse impacts for residences between 1,000 and 2,000+ feet from the well pad.

Table 2 summarizes the noise mitigation commitments in the RDSGEIS and shows that many of these commitments were not carried through to the EAF, EAF Addendum or the proposed regulations. The mitigation measures not included in the EAF or regulations are not enforceable.

The proposed supplemental permit conditions (Appendix 10) state that NYSDEC can require noise mitigation "deemed necessary," but this is meaningless without a clear basis for determining when noise impacts that warrant mitigation occur. The proposed supplemental permit conditions do not contain any of the mitigation measures in Table 2 that were not addressed by the EAF or the regulations. The proposed supplemental permit conditions do contain specific requirements to mitigate air quality impacts (Appendix 10, Attachment A), therefore it would be reasonable and consistent to also include many of the site-specific noise mitigation measures in Table 2 as supplemental permit conditions. A few of the mitigation measures in Table 2 are general enough that they should be incorporated in the proposed regulations, rather than as supplemental permit conditions. These are indicated in the "notes" column of Table 2.

Finally, NYSDEC should develop an adaptive management framework for monitoring the effectiveness of measures implemented to avoid, minimize, or mitigate noise impacts at HVHF sites, and use this information to refine the noise mitigation requirements for future permit applications.

Table 2
Noise Mitigation Matrix

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated into Supplemental Permit Conditions	Notes
Compliance with regulatory spacing and siting restrictions. (7-128)	No	Yes (553.1)	No	
Unless otherwise required by private lease agreement, the access road must be located as far as practicable from occupied structures, places of assembly, and occupied but unleased property. (7-135)	Yes (A6-6)	Yes (560.6(a))	No	Regulation adds an additional qualifier where this provision potentially does not apply- to avoid bisecting agricultural land.
The well operator must operate the site in accordance with a noise impacts mitigation plan consistent with the SGEIS. (7-135)	Yes (A6-6)	No	No	Applies to all wells, should be in regulations
The operator's noise impacts mitigation plan shall be provided to the Department along with the permit application. (7-135)	Yes (A6-5)	No	No	Applies to all wells, should be in regulations
Additional site-specific noise mitigation measures will be added to individual permits if a well pad is located within 1,000 feet of occupied structures or places of assembly. (7-135)	Partial(A6-5)	No	No	Permit applicants are required to identify mitigation measures in the noise mitigation plan, but there is no regulatory requirement that mitigation is included in permit conditions. Applies to all wells, should be in regulations
Modifying speed limits or restricting truck traffic on certain roads. (7-130)	No	No	No	
Noise modeling for any site within 1,000 feet of a noise receptor. (7-130)	No (noise mitigation plan is required, modeling is not mentioned)	No	No	The 1,000 feet distance is arbitrary and inconsistent with the 2011 RDSGEIS analysis results which show significant impacts out to 2,000+ feet from the well pad. Applies to all wells, should be in regulations

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated into Supplemental Permit Conditions	Notes
Potential site-specific permit condition: Requiring the measurement of ambient noise levels prior to beginning operations. (7-130)	No	No	No	All of the following site specific measures are required "as practicable," but no procedure or criteria for determining practicability is specified.
Potential site-specific permit condition: Specifying daytime and nighttime noise level limits as a permit condition and periodic monitoring thereof. (7-130)	No	No	No	Daytime and nighttime noise limits should be established as part of the SGEIS and regulatory process, not on a permit by permit basis that does not allow for public review. The noise limits should be consistent and included in regulations.
Potential site-specific permit condition: Placing tanks, trailers, topsoil stockpiles, or hay bales between the noise sources and receptors. (7-131)	No	No	No	
Potential site-specific permit condition: Using noise-reduction equipment such as hospital-grade mufflers, exhaust manifolds, or other high-grade baffling. (7-131)	No	No	No	
Potential site-specific permit condition: Limiting drill pipe cleaning ("hammering") to certain hours .(7-131)	No	No	No	
Potential site-specific permit condition: Running of casing during certain hours to minimize noise from elevator operation. (7-131)	No	No	No	
Potential site-specific permit condition: Placing air relief lines and installing baffles or mufflers on lines. (7-131)	No	No	No	
Potential site-specific permit condition: Limiting cementing operations to certain hours (i.e., perform noisier activities, when practicable, after 7 A.M. and before 7 P.M.). (7-131)	No	No	No	
Potential site-specific permit condition: Using higher or larger-diameter stacks for flare testing operations. (7-131)	No	No	No	

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated into Supplemental Permit Conditions	Notes
Potential site-specific permit condition: Placing redundant permanent ignition devices at the terminus of the flow line to minimize noise events of flare re-ignition. (7-131)	No	No	No	
Potential site-specific permit condition: Providing advance notification of the drilling schedule to nearby receptors. (7-131)	No	No	No	
Potential site-specific permit condition: Placing conditions on air rotary drilling discharge pipe noise, including: -orienting high-pressure discharge pipes away from noise receptors; - having the air connection blowdown manifolded into the flow line. This would provide the air with a larger-diameter aperture at the discharge point; - having a 2-inch connection air blowdown line connected to a larger-diameter line near the discharge point or manifolded into multiple 2-inch discharges; - shrouding the discharge point by sliding open-ended pieces of larger-diameter pipe over them; or -rerouting piping so that unusually large compressed air releases (such as connection blowdown on air drilling) would be routed into the larger-diameter pit flow line to muffle the noise of any release. (7-131)	No	No	No	
Potential site-specific permit condition: using rubber hammer covers on the sledges when clearing drill pipe. (7-131)	No	No	No	
Potential site-specific permit condition: Laying down pipe during daylight hours. (7-131)	No	No	No	
Potential site-specific permit condition: Scheduling drilling operations to avoid simultaneous effects of multiple rigs on common receptors. (7-131)	No	No	No	
Potential site-specific permit condition: Limiting hydraulic fracturing operations to a single well at a time. (7-131)	No	No	No	
Potential site-specific permit condition: Employing electric pumps. (7-131)	No	No	No	

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated into Supplemental Permit Conditions	Notes
Potential site-specific permit condition: Installing temporary sound barriers (see Photo 7.2, Photo 7.3, and Photo 7.4) of appropriate heights, based on noise modeling, around the edge of the drilling location between a noise generating source and any sensitive surroundings. Sound control barriers should be tested by a third-party accredited laboratory to rate Sound Transmission Coefficient (STC) values for comparison to the lower-frequency drilling noise signature. (7-131)	No	No	No	

2.7 EAF and EAF Addendum

The EAF requires land use information for a distance of one-quarter (1/4) mile around the well pad. This distance is insufficient, as many impacts (including noise and visual) extend far beyond this distance. The EAF should require the identification and mapping of land uses within one mile of the well pad, as well as additional land use mapping along local roads that would be affected by heavy truck traffic (as identified in the required transportation plan) outside the one mile area. The EAF Addendum should specifically require the identification of land uses that are especially sensitive to noise, including protected open space, recreational areas, places of worship, campgrounds, hotels, schools, and healthcare facilities.

The details of the noise mitigation plan required by the EAF Addendum are not sufficiently defined to ensure impacts are mitigated. There is a need for a standardized noise impact assessment procedure and criteria for determining the reasonableness of various levels of mitigation expenditure (e.g., the cost per benefited receptor approach used by DOTs). Without standardized requirements for assessing and mitigating noise impacts, residents in areas affected by gas development will not receive fair or consistent treatment. The NYSDEC noise guidance document does not provide sufficient detail and criteria to ensure appropriate noise analyses conducted at the site level. At a minimum, NYSDEC should provide the detailed requirements of the noise mitigation plan, addressing the following components:

- Scope of study area for the mitigation plan (recommend one-half (1/2) mile around well pad plus sensitive areas adjacent to the local roads that would experience the largest percent increase in truck traffic).
- Methodology for establishing existing noise levels (recommend requiring 24-hour measurements at a few representative receptors).
- Required protocol for assessing noise impacts: what noise metrics should be used (Ldn, Lmax, peak hour Leq, percent time audible etc.); what sources need to be considered (transportation, drilling and fracking); acceptable software modeling packages; and sources of information on appropriate sound emission levels to assume for various types of the equipment.
- Required criteria for determining which impacts are significant and require mitigation and which do not.
- Required criteria for determining how much expenditure on mitigation is reasonable to address significant adverse impacts.

One template for NYSDEC to consider adopting to specify the requirements of noise impact analysis and mitigation plans is the Alberta Energy Resources Conservation Board (ERCB) Noise Control Directive (#38), which is described below in Section 2.8.

2.8 Best Practice Recommendation for Noise Standards and Site-Specific Impact Assessment Protocol

The Alberta ERCB Noise Control Directive was developed through an extensive scientific review process and is recognized as one of the most stringent in the world. The Noise Control directive is based on the calculation of a permissible sound level (PSL) at

the worst case receptor in terms of equivalent energy sound level (Leq)[9] for the daytime period and the nighttime period. The PSL calculation takes into account all the important factors that influence human annoyance due to noise:

- Daytime noise is allowed to be higher than nighttime noise, reflecting the greater sensitivity to noise occurring at night.
- Existing noise levels are taken into account based on dwelling unit densities and transportation infrastructure or through ambient monitoring.
- A sliding scale of adjustment factors based on the duration of the noise accounts for the fact that people are more tolerant of a brief period of noisy activity than a noise source that continues for months or years.

As a simple example, the PSL in a low density rural area not near a major transportation corridor would be calculated as follows for the drilling of one well (35 days):

Nighttime Drilling PSL= 40 dBA basic sound level + 5 dBA adjustment due to the duration
Nighttime Drilling PSL= 45 dBA

The daytime PSL for drilling in this simple example would be 10 dBA higher, or 55 dBA.

For five days of fracking, the PSL in a low density rural area not near a major transportation corridor would be calculated as follows:

Nighttime Fracking PSL= 40 dBA basic sound level + 10 dBA adjustment due to the duration
Nighttime Fracking PSL= 50 dBA

The daytime fracking PSL would be 10 dBA higher or 60 dBA. This daytime limit would be exceeded even at a distance of 2,000 feet from the well pad based on the RDSGEIS analysis without mitigation, which estimated 72 dBA at this distance, or approximately twice as loud as the standard.

The Alberta ERCB Noise Control Directive also outlines detailed requirements to standardize the modeling of noise impacts and the preparation and documentation of noise studies that would be appropriate for NYSDEC to consider in regulating noise from HVHF in New York.

3.0 Ground-Borne Vibration and Noise

Page 6-251 of the RDSGEIS acknowledges the potential for ground-borne vibration impacts in the discussion of potential effects on property values: “Gas well development could impact local environmental resources and cause noise and vibration impacts, and trucks servicing the well development could also impact the surrounding areas.” Despite this statement, no vibration impact analysis (or an explanation of why an analysis was not conducted) is presented in the 2011 RDSGEIS. NYSDEC should analyze vibration impacts addressing the following issues:

[9] Leq refers to the constant sound level that conveys the same energy as the variable sound levels during the analysis period.

- Construction-period vibration impacts for access road and well pad development. Recommended procedures are provided in Section 12.2 of the Federal Transit Administration's *Transit Noise and Vibration Impact Assessment* guidebook. A simple qualitative assessment may be appropriate in this case. While construction activities do not typically create vibration levels capable of damaging most buildings, fragile historic buildings are more sensitive and should be avoided in the siting of access roads and well pads. Ground vibration from construction can also be an annoyance to adjacent land uses.

- Operation vibration impacts associated with drilling and fracking. This assessment should include information on drilling vibration levels from existing natural gas development in New York and other locations. While it is difficult to generalize vibration effects from one area to another due to the effects of local soils and geologic conditions, this information would provide a rational basis for identifying a screening distance for determining when a more detailed vibration impact assessment should be required at the site level. If no receptors are within the screening distance at which perceptible vibration levels could occur, then no vibration assessment would be required in the site level review.

- Operation low-frequency ground-borne noise impacts. Ground vibration can create a phenomenon known as ground-borne noise, a rumble associated with the movement of the interior surfaces of a room.[10] Special considerations apply when assessing low-frequency noise because of the non-linearity of human hearing which causes sounds dominated by low-frequency components to seem louder than broadband sounds that have the same A-weighted level. As a result, even low levels of low-frequency noise (generally defined as the frequency range below 200 Hz) can be perceived as highly annoying and contribute to sleep problems and other health problems caused by sleep disruption. In addition to sleep disturbance and physiological stress, there is strong evidence that noise exposure can contribute to cardiovascular diseases.[11] NYSDEC should assess the potential for the various phases of well development and production to generate ground-borne noise, including any on-site equipment such as condensers that have been anecdotally reported generating high vibration levels in Pennsylvania.

Based on the ground-borne noise and vibration impact assessment conclusions, the NYSDEC should identify ground-borne noise and vibration impact mitigation measures and ensure that information necessary to identify and mitigate ground-borne noise and vibration impacts at the site level is required as part of the EAF Addendum, supplemental permit conditions and/or regulations.

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[10]Both ground-borne noise and vibration are issues associated with the inside of buildings and are generally not annoying outdoors.

[11] See Cardiovascular effects of noise. Noise Health. Vol. 15 Issue 52. http://www.noiseandhealth.org/showBackIssue.asp?issn=1463-1741;year=2011;volume=13;issue=52;month=May-June

4.0 Visual

4.1 Impact Assessment

The RDSGEIS describes in very broad terms the potential direct and cumulative impacts of various phases of natural gas development on NYSDEC-designated visually sensitive resources. The RDSGEIS considers and incorporates information from two studies by others that addressed the visual impact of high-volume hydraulic fracturing.[12] The public disclosure of significant adverse visual resource impacts should be improved by providing the following:

- Discussion of the various viewer groups (local residents, through travelers, tourists, etc.) that would experience changed views as a result of natural gas development and their relative sensitivity. For example, local residents are familiar with local views and may be very sensitive to changes in views they consider important. Tourists visiting an area in part to experience high visual environment quality would also be much more sensitive than general through travelers that would have passing views of natural gas development from roadways while commuting. NYSDEC should describe how natural gas development at the scale anticipated in the socioeconomic impact study would affect viewer perceptions.

- To aid in the identification and understanding of impacts, landscape similarity zones (rural open areas, rural wooded areas, villages, cities, etc.) should be identified statewide and computer modeling conducted to create three dimensional photo simulations of various phases of the well development process at various distances for each zone. NYSDEC would not need to develop this analysis from scratch—significant consultant costs could be saved by using the New York State Office For Technology's "Generic Visual Impact Assessment" prepared for the 2004 Statewide Wireless Network (SWN) DGEIS as a starting point.[13] The SWN Generic Visual Impact Assessment is an excellent example for NYSDEC to follow in comprehensively addressing visual impacts at the GEIS stage. The landscape similarity zones and representative photos selected for photo simulations used in the SWN analysis could likely be used with no to little modification. The main additional work required would be to define the components of a typical well pad development at various phases in sufficient detail and re-run the simulation model.

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[12]Upadhyay and Bu. 2010. Visual Impacts of Natural Gas Drilling in the Marcellus Shale Region. Cornell University, Dept. of City and Regional Planning: CRP 3072 Land Use, Environmental Planning, and Urban Design Workshop

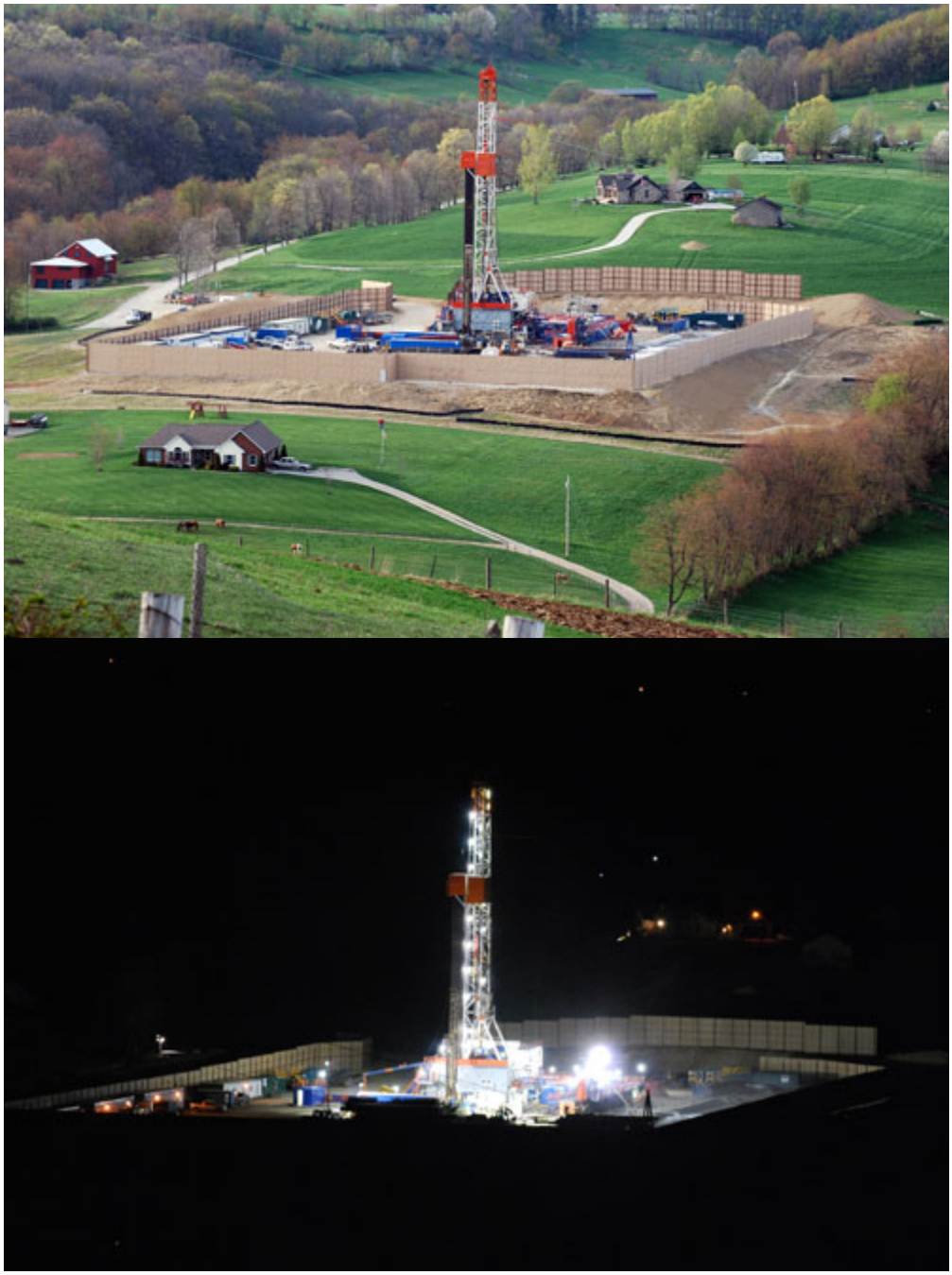
Rumbach, Andrew. 2011. Natural Gas Drilling in the Marcellus Shale: Potential Impacts on the Tourism Economy of the Southern Tier

[13]New York State Office for Technology. 2004. *Draft Generic Environmental Impact Statement for the New York State Statewide Wireless Network*. Cultural Resources Appendix B. Prepared by Environmental Design & Research, P.C. (now EDR Companies)

- Analysis of light pollution impacts of nighttime lighting and flaring. The RDSGEIS analysis focuses on daytime visual impacts and downplays nighttime light impacts as a "temporary impact" that most of the viewing public would not be exposed to (see page 6-281). Light pollution impacts would not be temporary when the duration of drilling, fracturing and production activities is considered for multi-well pads and cumulatively as numerous well pads are added throughout the region over the 60 year development timeframe contemplated in the RDSGEIS. The RDSGEIS ignores the visual impact to local residences that comes with the loss of pristine dark nighttime skies in rural areas. Residences are not even mentioned in the impact assessment. In many cases the nighttime impact will be more significant than the daytime visual impact because the lighting will make the well site a pronounced focal point. In addition to evaluating the visual impact of light pollution on humans, NYSDEC also needs to evaluate the impact of nighttime lighting and flaring on migratory birds.[14]

The photographs of a PA well site below illustrate the dramatic visual impact of natural gas development in a rural residential setting during the day and night.

[14] Poot, H., B. J. Ens, H. de Vries, M. A. H. Donners, M. R. Wernand, and J. M. Marquenie. 2008. Green light for nocturnally migrating birds. *Ecology and Society* **13**(2): 47. http://www.ecologyandsociety.org/vol13/iss2/art47/
For background information on light pollution impacts on wildlife see: http://www.darksky.org/index.php?option=com_content&view=article&id=719



Day and Night Views of Chappel Unit 1H-10H in Hopewell Township, Washington County PA. Source: http://www.marcellus-shale.us/Chappel-Unit.htm

4.2 Mitigation

The RDSGEIS mitigation section for visual resources suggests that mitigation measures would only be considered when designated significant visual resources (parks, historic resources, scenic rivers, etc.) are present and within the viewshed of proposed wells. This approach fails to consider visual impacts on nearby residences or tourists in areas where a significant visual resource is not present. In these situations, no mitigation would be required for individual wells to be consistent with the RDSGEIS. NYSDEC should make basic and low-cost mitigation measures mandatory for all well development sites (such as keeping lighting levels at the minimum level required and directing lights downward to minimize light pollution), regardless of whether or not significant visual resources are present. In addition, a broader menu of more sophisticated and costly mitigation measures should be provided for those development sites that do have the potential to impact designated visual resources.

Table 3 summarizes the visual impact mitigation commitments in the RDSGEIS and shows that many of these commitments were not carried through to the EAF, EAF Addendum, regulations or supplemental permit conditions. The mitigation measures not included in the EAF, regulations or permit conditions are not enforceable. The proposed supplemental permit conditions do contain specific requirements to mitigate air quality impacts (Appendix 10, Attachment A); therefore it would be reasonable and consistent to also include many of the visual impact mitigation measures in Table 3 as supplemental permit conditions. A few of the visual impact mitigation measures that are general enough and are applicable to all well sites should be incorporated into the proposed regulations. These mitigation measures are identified in the notes column of Table 3.

Table 3
Visual Impacts Mitigation Matrix

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
Prepare visual impacts mitigation plan (A6-6 and Supplemental Permit Conditions).	**Yes**	No	**Yes**	Applies to all wells, should be in regulations
Flaring would only occur during initial flowback at some wells, and the potential for flaring would be limited to the extent practicable by permit conditions, such that the duration of nighttime impacts from flaring typically would not occur for longer than three days. (6-281)	No	No	No	Applies to all wells, should be in regulations
The development of measures to reduce impacts on visual resources or visually sensitive areas would follow the procedures identified in NYSDEC DEP-00-2, "Assessing and Mitigating Visual Impacts." (7-121)	No	No	No	Applies to all wells, should be in regulations
Design and siting measures, as described in NYSDEC DEP-00-2, would typically consist of screening, relocation, camouflage or disguise, maintaining low facility profiles, downsizing the scale of a project, using alternative technologies, using non-reflective materials, and controlling off-site migration of lighting (NYSDEC 2000). (7-122)	No	No	No	Design and siting mitigation measures would be primarily site specific, but some measures could be incorporated in regulations (see the mitigation measure below regarding avoiding ridgelines and minimizing light pollution).
Relocating well sites to avoid ridgelines or other areas where aboveground equipment and facilities breaks (sic) the skyline; and minimizing off-site light migration by using night lighting only when necessary and using the minimum amount of nighttime lighting necessary, directing lighting downward instead of horizontally, and using light fixtures that control light to minimize glare, light trespass (off-site light migration), and light pollution (sky glow). (7-125)	No	No	No	Applies to all wells, should be in regulations

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
The study also recommends the development of a best practices manual for Department staff and the industry, which would provide information on what is expected by the Department in terms of well siting and visual mitigation, and the identification of instances where visual mitigation may be necessary. (7-126)	No	No	No	
Develop a feedback mechanism in the project review process to confirm the success of measures to avoid, minimize, or mitigate visual impacts, based on the analysis of results for prior projects. (7-126)	No	No	No	
The maintenance activities described in NYSDEC DEP-00-2 should be implemented to prevent project facilities from becoming “eyesores.” Such measures would typically consist of appropriate mowing or other measures to control undesirable vegetation growth; erosion control measures to prevent migration of dust and/or water runoff from a site; measures to control the off-site migration of refuse; and measures to maintain facilities in good repair and as organized and clean as possible according to the type of project. (7-126)	No	Partial- mostly related to stormwater and erosion control	Partial- SWPPP required	Applies to all wells, should be in regulations

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
The decommissioning activities described in NYSDEC DEP-00-2 should be implemented when the useful life of the project facilities is over; these activities would typically occur during the reclamation phase for well sites. Such activities would typically consist of, at a minimum, the removal of aboveground structures at well sites. Additional decommissioning activities that may also be required include: the total removal of all facility components at a well site (aboveground and underground) and restoration of a well site to an acceptable condition, usually with attendant vegetation and possibly including recontouring to reestablish the original topographic contours; the partial removal of facility components, such as the removal or other elimination of structures or features that produce visual impacts (such as the restoration of water impoundment sites to original conditions); and the implementation of actions to maintain an abandoned facility and site in acceptable condition to prevent the well site from developing into an eyesore, or prevent site and structural deterioration. (7-127)	Partial- site reclamation plans required, but no specific measures are required.	Partial (560.7 Reclamation)	Partial (reclamation plans required)	
The offsetting mitigation described in NYSDEC DEP-00-2 should be implemented when the impacts of well sites on visual resources or visually sensitive areas are significant and when such impacts cannot be avoided by locating the well pad in an alternate location. Per guidance in NYSDEC DEP-00-2, offsetting mitigation would consist of the correction of an existing aesthetic problem identified within the viewshed of a proposed well project. (7-128)	No	No	No	

4.3 EAF and EAF Addendum

There are a number of problems with the EAF and EAF Addendum requirements as currently drafted that will result in significant unmitigated adverse visual impacts if not corrected.

The EAF does not require sufficient information to properly identify receptors that would experience views of proposed wells. The EAF requirement is to identify the distance to the closest occupied building or outdoor facility. The EAF Addendum requires identification of "[a]ll residences, occupied structures or places of assembly within 1,320 feet." This is not a sufficient distance for assessing visual impacts and does not take into account the fact that the closest structures may not be the most impacted depending on local vegetation and topography patterns.[15] A more reasonable distance for identifying sensitive resources and receptors in most instances would be one mile.[16] The EAF addendum should require a visibility analysis to determine where the well site facilities would be visible from public roadways, parks, residences and other sensitive receptors. The number of viewers exposed and the activities viewers would typically be engaged in during exposure needs to be evaluated to determine the extent of visual impacts and the need for mitigation at the site level. NYSDEC has developed excellent guidance on this topic ("Assessing and Mitigating Visual Impacts") and a useful visual EAF addendum. These best practice approaches to visual impact assessment and mitigation should be required as part of the EAF for proposed well development sites.

Unlike the noise and traffic mitigation plans, a visual impacts mitigation plan is not a required component of the submittals to NYSDEC with the permit application, EAF and EAF Addendum. The visual impacts mitigation plan does not even have to be prepared prior to issuance of the well drilling permit and is not subject to prior approval by NYSDEC. The only apparent requirement is that the visual resource mitigation plan is prepared by the applicant in conformity with the SGEIS and made available to the NYSDEC on request. This procedure offers no opportunity for public review or even notice to affected local residents. A visual resources mitigation plan that is not subject to public review and that does not require NYSDEC approval is not an adequate mitigation measure.

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[15]The RDSGEIS acknowledges that on-site equipment would be a prominent landscape feature at distances of up to double 1,320 feet used in the EAF Addendum. Page 6-274: "On-site equipment would be the most visible sign of fracturing activity and, when viewed from relatively short distances (i.e., from 1,000 feet to 0.5 miles) are relatively prominent landscape features."

[16] Although drilling activity during the daytime would be most prominent within ½ mile, a one mile distance is reasonable to account for areas with topography that could make well sites prominent features for more distant views and to address nighttime lighting impacts (which could be prominent at greater distances than the physical appearance of the well site equipment during the day.

5.0 Land Use

5.1 Impact Assessment

The RDSGEIS fails to provide any analysis of the reasonable foreseeable cumulative land use impacts that would result if high-volume hydraulic fracturing was permitted in New York. To comply with SEQRA, NYSDEC should provide the following information:

- An overview of statewide existing land uses patterns and land use planning framework. Much of this information and mapping could be adopted directly from Section 3.3.2.2 of the 2004 Statewide Wireless Network DGEIS and associated appendices. This would provide an appropriate baseline to use in assessing potential land use impacts.

- A quantitative analysis of potential land cover change at the county level. This analysis could use readily available GIS land cover data for existing conditions and assume that well development would impact land cover proportionate to the existing percentage of land cover types in each county (excluding water and developed land). Impacts could be assessed using the average 7.4 acres of disturbance per multi-well pad used in the RDSGEIS (page 5-6) and an estimate of the number of well pads by county consistent with the economic impact study county-level estimates. Cumulative impacts associated with existing trends and known major development proposals should be evaluated, taking into account the lack of capacity of rigorous land use regulation throughout most rural areas of the Southern Tier.

- A qualitative assessment of the compatibility of natural gas development with various adjacent land uses, taking into consideration impacts associated with truck traffic, noise and visual impacts. Appropriate buffer zones should be recommended between natural gas development and incompatible land uses such as residences, parks and schools to minimize impacts.

- A qualitative assessment of the consistency of natural gas development with local and regional plans. Specific land use plans and zoning regulations could not be analyzed in detail in a GEIS, but generalized planning areas common to many areas of the Marcellus shale region could be considered (e.g., rural residential, agricultural, commercial, etc.). Natural gas development should not be permitted to undermine local land use laws, especially planning in rural areas that emphasizes resource protection, open space, and scenic quality. Potential inconsistencies with plans prepared pursuant to New York's Local Waterfront Revitalization Program should be specifically considered in this assessment.

The failure of the RDSGEIS to analyze land use impacts is inconsistent with the scope for the SGEIS, which included a commitment to conduct an "[e]valuation of whether any aspect of multi-well site development or high-volume hydraulic fracturing of shale wells could be expected to change the GEIS's conclusion that major long-term changes to land use patterns, traffic and the need for public services are not anticipated as the result of gas well development. This will include review of the compatibility of shale gas development with other land uses such as agriculture, tourism, and alternative energy

development."[17] The RDSGEIS is deficient because it does not contain a land use impact assessment addressing compatibility with agriculture, tourism, and alternative energy development.

5.2 Mitigation

The RDSGEIS fails to provide any discussion of mitigation measures for land use impacts. Based on the additional analyses of land use impacts recommended above, mitigation measures such as buffer distances for incompatible land uses should be described and incorporated into enforceable regulations or supplemental permit conditions, as appropriate. The RDSGEIS should make it clear that such mitigation measures are intended to supplement any local zoning or other land use planning addressing the location of industrial uses, including gas development.

Finally, NYSDEC should develop an adaptive management framework for monitoring the effectiveness of measures implemented to avoid, minimize, or mitigate land use impacts at HVHF sites, and use this information to refine the land use mitigation requirements for future permit applications.

5.3 EAF and EAF Addendum

The topic of consistency with local plans was not addressed in the EAF and EAF Addendum in the 2009 DSGEIS. The addition of a requirement related to the review of local plans and assessment of consistency as part of the EAF Addendum in the RDSGEIS is an improvement. The term "land use plan" should be broadly defined in the EAF Addendum to ensure it encompasses comprehensive plans, zoning ordinances, subdivision regulations, site plan review requirements, hazard mitigation plans, open space plans, agricultural/farmland protection plans, Local Waterfront Revitalization Program plans, historic districts/historic resource protection plans, economic revitalization and tourism plans, ecological and water resource protection/restoration plans etc.

With respect to the avoidance of land use compatibility impacts, the requirements of the EAF Addendum in the RDSGEIS remain extremely vague. Permit applicants are required to attest that "[u]nless otherwise required by private lease agreement, the access road will be located as far as practical from occupied structures, places of assembly and unleased property." There are no definitional or other criteria for determining what is "as far as practical" concerning location of the access road in relation to occupied structures, places of assembly and unleased property. Nor is there any required explanation by the applicant to support its affirmation or submission of a map showing such structures and uses in relation to the access road. Nor is there any required hierarchy in determining which uses of land require greatest distance from the access road in the event that movement of the access road away from one use would bring it closer to another. All that is required of the applicant is a bare affirmation that it has located the access road.

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[17] NYSDEC. 2009. *Scope for the 2009 Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program*. Page 41

The EAF Addendum requires the identification of "[a]ll residences, occupied structures or places of assembly within 1,320 feet." However, as noted previously, there is evidence that significant impacts (such as noise) extend beyond 1,320 feet. In order to comply with SEQRA, NYSDEC must require that the applicant identify all land uses within one mile of a proposed well. These land uses should include, but not be limited to hospitals, senior citizen residences, schools, places of worship, and residential uses.

6.0 Transportation

6.1 Impact Assessment

Additional analysis is provided in the RDSGEIS regarding truck trip generation (e.g., the number of truck trips to and from the well site at varies stages), but the impact on roadway congestion and safety has not been adequately addressed. The impacts of a typical multi-well development on congestion and safety should be analyzed in detail, as well as a cumulative traffic effects analysis using a reasonable worst case development scenario. The reasonable worst case development scenario for regional traffic impacts should include indirect traffic generation associated with increased economic development and population growth attributable to natural gas extraction and related industries. Finally, the statewide impact on vehicle miles traveled (VMT) should be reported, taking into account the long distance truck trips that would be required to haul produced water and brine waste out of state for disposal.

6.1.1 Traffic Congestion and Safety Impacts of a Typical Multi-Well Pad

The detailed analysis of the traffic congestion and safety impacts of one typical multi-well pad development serves an important purpose in terms of disclosing the general types of impacts that could occur in many similar locations, but also in terms of creating an analysis template for permit applicants to follow in developing their transportation plans for specific development proposals. A hypothetical well site could be identified in the area where the greatest drilling is expected (Region A) or an actual well site in an area of Pennsylvania representative of similar areas in New York could be analyzed. Once the hypothetical or actual well site is located, the following tasks should be undertaken:

- Identification of the project area where transportation impacts would be most likely based on actual or hypothetical information on trip origins and routes for workers, equipment and water deliveries to the site.
- Characterization of existing conditions in the project area using NYSDOT traffic counts, local data and additional traffic counts as needed. Topics to be addressed should include traffic volumes, intersection level of service, crash rates, etc.
- Analysis of impacts on traffic volumes, intersection congestion and safety consistent with the 2010 Highway Capacity Manual, NYSDOT procedures for traffic impact assessment and good transportation engineering practice.
- Development of mitigation measures to address significant impacts, such as changes in signal timing, temporary traffic signals, limitations on the routes used by water trucks, etc.

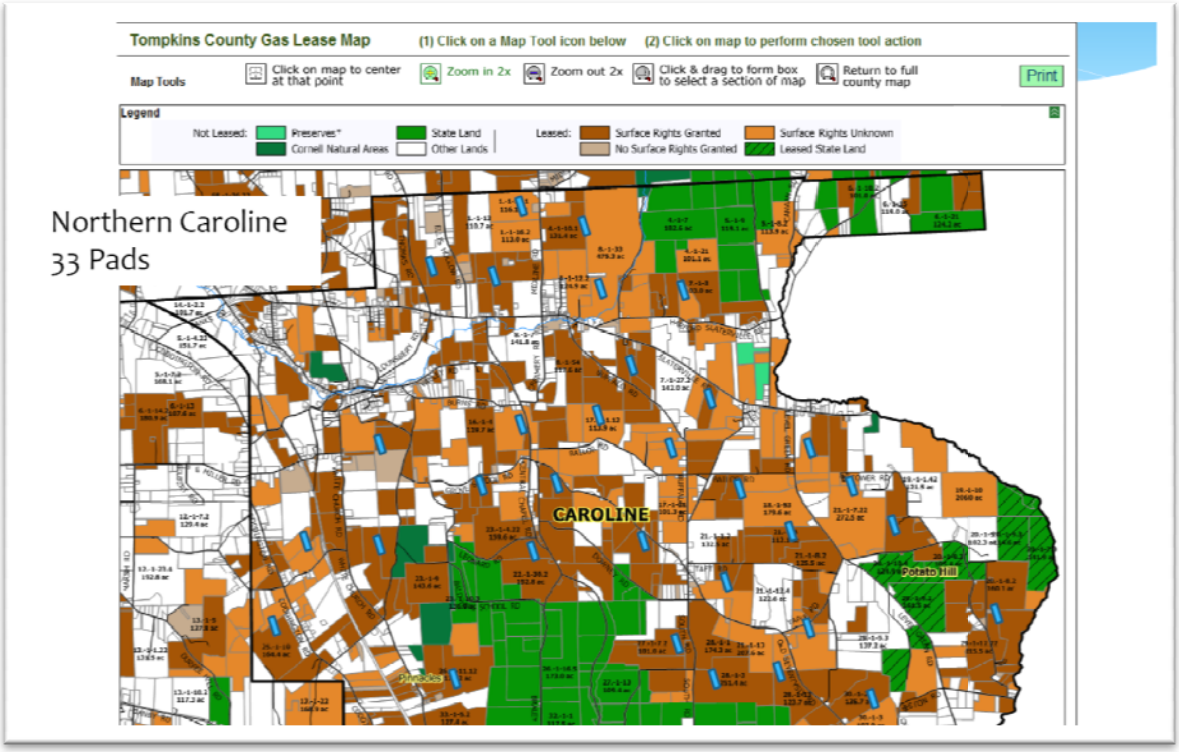
6.1.2 Regional Traffic Congestion and Safety Impacts

In addition to analyzing one well site in detail, it is important for NYSDEC to analyze regional cumulative impacts because these types of impacts will not likely be considered at the site level in the review of individual permits. The regional analysis would consider changes in traffic volumes on major roadways and the resulting potential for increased congestion and crashes from the combined effects of truck traffic to individual wells, as well as traffic related to additional employment and population growth. One methodology for conducting a meaningful regional analysis would be to use an existing travel demand model within the Marcellus and Utica shale regions. Unfortunately, neither New York State nor the Metropolitan Planning Organizations (MPOs) in Region A have a statewide or regional travel demand model. However, there are still several possible options for NYSDEC to conduct a meaningful regional scale transportation modeling analysis.

One option would be to use an analysis of Tompkins County as a surrogate for similar regional scale impacts that could occur in other places. There are several advantages to this approach:

- The Ithaca-Tompkins County Transportation Council (ITCTC) has an existing travel demand model that covers all of Tompkins County.

- The Tompkins County Council of Governments Task Force on Gas Drilling has identified realistic scenario of potential well locations for Tompkins County based on a GIS analysis and information from the 2009 DSGEIS.[18] An example map output from this analysis is provided in the figure below.



[18] http://www.tompkins-co.org/tccog/Gas_Drilling/Focus_Groups/Mapping.html

Example of Well Pad Placement Assessment for the northern portion of the Town of Caroline, Tompkins County. Source: http://www.tompkins-co.org/tccog/Gas_Drilling/Focus_Groups/Mapping%20Minutes/Section%203%20-%20TC%20Mapping%20Analysis.pdf

The travel demand model could be run for multiple scenarios but, at a minimum, future no action and action (peak year of traffic generation) scenarios should be run. Key considerations in setting up the model should include identifying the traffic analysis zones that would experience increased population and employment and appropriately defining the trips attracted to well sites and other important destinations, such as hypothetical water source areas and waste disposal areas. These parameters could easily be established by a team composed of a travel demand modeling expert and a person familiar with hydraulic fracturing well site development stages and trucking needs (making the assumptions available for public review). A cooperative study in partnership with the ITCTC could be particularly beneficial to take advantage of their familiarity with local conditions and the existing model.

Once the model runs are complete, the results should be post-processed and used to develop an informative impact analysis and mapping (e.g., link volume change maps, volume/capacity ratio maps, etc.). This type of regional analysis is routinely conducted by MPOs as part of the long-range transportation planning process. There are numerous examples and guidance sources available to NYSDEC on how to conduct regional transportation analyses for planning that are equally applicable to generic regional traffic impact analysis.[19]

6.1.3 Statewide Vehicle Miles Traveled Impact

Vehicle miles traveled (VMT) is a key indicator used in transportation planning to compare various future scenarios and investment decisions. Increases in heavy truck VMT provide a basis for drawing general conclusions about the effects of HVHF on the transportation system, as well as effects on air pollutant emissions from mobile sources. While information on the number of trips is discussed in the transportation impacts section of the RDSGEIS, VMT impacts are not addressed. The failure of the transportation section to address VMT impacts is especially problematic because statewide VMT estimates were developed for the air quality analyses in the RDSGEIS (see page 6-176). As discussed in further detail below, the RDSGEIS VMT estimates for air quality should be revised to take into account out-of-state waste disposal and incorporated into the transportation impact assessment section, as well as the air quality section.

As discussed in Glenn Miller's accompanying technical memorandum, the waste disposal requirements for produced water and brines cannot be met at any existing disposal facilities in New York. This means that a significant number of long-distance heavy truck trips would be needed to move wastes out of state for disposal. VMT information for the RDSGEIS air quality analyses was generated using average truck trip

[19]See: NCHRP Report 546: Incorporating Safety into Long-Range Transportation Planning.

FHWA. 2003. "Tools for Assessing Safety Impacts of Long-Range Transportation Plans in Urban Areas."

length information provided by the industry.[20] The industry data was from Bradford County, PA. The data collection methodology and the number of well sites upon which the industry average truck trip length estimates were developed were not disclosed in the RDSGEIS or the industry memo providing the estimates to NYSDEC. Industry estimated 100 truck trips for produced water disposal from each horizontal well, with each waste disposal truck traveling an average distance of 24 miles (one-way).[21] While supporting calculations are not provided to ascertain how the distance of 24 miles was computed, it would appear that the industry's data set was weighted heavily towards well sites where produced brine was reused at other nearby wells. This does not take into account the final disposal transportation impacts. A review of Pennsylvania Department of Environmental Protection (PADEP) waste reports[22] for Bradford County show two primary final disposal sites for brines from wells in the county:

- Pennsylvania Brine and Treatment, Inc. in Franklin, PA (approximately 200 miles from Bradford County municipalities such as Troy).
- Waste-Treatment Corporation in Warren, PA (approximately 140 miles from Bradford County municipalities such as Troy).

The 24-mile trip average distance for waste disposal provided by industry does not reflect the long distance waste hauling that occurs in Bradford County and would be expected to occur in New York. To correct this deficiency, NYSDEC should independently reevaluate the average trip length information provided by industry and develop revised truck trip length estimates that take into account final waste disposal transportation impacts. The assumptions used in generating the average truck trip length estimates should be disclosed for public review. This will allow for a more realistic assessment of the potential transportation and air quality impacts that will result from the statewide increase in VMT.

6.2 Mitigation

The majority of the transportation mitigation discussion in the RDSGEIS is focused on damage to roadways and road use agreements. While this remains an important issue, the RDSGEIS does not give sufficient attention to traffic impact mitigation measures. A list of generic mitigation measures for traffic impacts is provided (Section 7.11.3), but it is not clear when specific mitigation measures would be required because no impact criteria have been defined. For example, at what level of predicted intersection level of service would mitigation have to be considered? NYSDEC should make clear what traffic impact criteria would trigger the need for mitigation measures and include a process for local government and public review of the transportation plans for proposed well sites before NYSDEC issues a permit.

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[20] March 16, 2011 Letter from ALL Consulting to IOGA New York, obtained through a FOIL request. The footnote referencing this letter (footnote #100) was missing from the RDSGEIS.

[21] See Exhibit 19A in the March 16, 2011 ALL Consulting letter

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[22] Pennsylvania Oil and Gas Well Statewide Waste Report by Reporting Period. Jan - Jun 2011 (Marcellus Only, 6 months)
https://www.paoilandgasreporting.state.pa.us/publicreports/Modules/DataExports/DataExports.aspx

Table 4 summarizes the transportation mitigation commitments in the RDSGEIS and shows that many of these commitments were not carried through to the EAF, EAF Addendum, regulations or supplemental permit conditions. The mitigation measures not included in the EAF, regulations or permit conditions are not enforceable. The proposed supplemental permit conditions do contain specific requirements to mitigate air quality impacts (Appendix 10, Attachment A); therefore it would be reasonable and consistent to also include many of the transportation mitigation measures in Table 4 as supplemental permit conditions. Other mitigation measures are general enough to apply to all well sites and should be incorporated into regulations as described in the “notes” column of Table 4.

Finally, NYSDEC should develop an adaptive management framework for monitoring the effectiveness of measures implemented to avoid, minimize, or mitigate transportation impacts of HVHF, and use this information to refine the transportation mitigation requirements for future permit applications.

Table 4
Transportation Impacts Mitigation Matrix

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
Development of Transportation Plans, Baseline Surveys, and Traffic Studies. (7-136)	Yes	Yes (560.3)	Yes- transportation plan must be approved by NYSDEC and is "incorporated by reference" into the permit	The details of the transportation plan related-requirements should be described in greater detail in the EAF Addendum, along with an example transportation plan to provide clear guidance to industry on the level of data collection and analysis NYSDEC and NYSDOT expect.
Municipal Control over Local Road Systems. (7-137)	N/A	N/A	N/A	This is a mitigation measure that cannot be implemented by NYSDEC- it relies on municipalities with very limited planning resources to be proactive in protecting their roads.
The owner or operator should attempt to obtain a road use agreement with the appropriate local municipality; if such an agreement cannot be reached, the reason(s) for not obtaining one must be documented in the Transportation Plan. The owner or operator would also have to demonstrate that, despite the absence of such agreement, the traffic associated with the activity can be conducted safely and that the owner or operator would reduce the impacts from truck traffic on local road systems to the maximum extent feasible. (7-138)	Partial- copy of road use plan must be submitted if there is one.	No	Partial- copy of road use plan must be submitted if there is one.	Applies to all wells, should be in regulations
Route selection to maximize efficient driving and public safety, pursuant to city or town laws or ordinances as may have been enacted under Vehicle and Traffic Law §1640(a)(10). (7-138)	No	No	No	Applies to all wells, should be in regulations
Avoidance of peak traffic hours, school bus hours, community events, and overnight quiet periods, as established by Vehicle and Traffic Law §1640(a)(20). (7-139)	No	No	No	Applies to all wells, should be in regulations

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
Coordination with local emergency management agencies and highway departments. (7-139)	No	No	No	Applies to all wells, should be in regulations
Upgrades and improvements to roads that will be traveled frequently for water transport to and from many different well sites, as may be reimbursable pursuant to ECL §23-0303(3). (7-139)	No	No	No	Refers to provision of ECL that allows municipalities to request from NYSDEC "funds from the oil and gas fund to reimburse the municipality for costs incurred in repairing damages to municipal land or property. Such requests shall include such explanatory material and documentation as the commissioner may require."
Advance public notice of any necessary detours or road/lane closures. (7-139)	No	No	No	Applies to all wells, should be in regulations
Adequate off-road parking and delivery areas at the site to avoid lane/road blockage.(7-139)	No	No	No	Provision of large parking and delivery areas may increase the footprint of the well development sites, increasing ecological and water quality impacts.
Use of rail or temporary pipelines where feasible to move water to and from well sites. (7-139)	No	No	No	
Prior to site disturbance, the operator shall submit to the Department and provide a copy to the NYSDOT of any road use agreement between the operator and local municipality. (7-139)	Yes	No	Yes	Applies to all wells, should be in regulations
The operator shall file a transportation plan, which shall be incorporated by reference into the permit; the plan will be developed by a NYS-licensed Professional Engineer in consultation with the Department and will verify the existing condition and adequacy of roads, culverts, and bridges to be used locally. (7-139)	Yes	Yes	Yes	

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
Mitigating Incremental Damage to the State System of Roads. (7-141)	N/A	N/A	N/A	Damage to the state road system is identified in the RDSGEIS as an unmitigated impact. The Final SGEIS and HVHF regulations should include a transportation fee on permit applications to compensate for the costs of repairing HVHF-related damage to the state road system.
Limiting truck weight, axle loading, and weight during seasons when roads are most sensitive to damage from trucking (e.g., during periods of frost heaving and high runoff). (7-141)	No	No	No	
Requiring the operator to pay for the addition of traffic control devices or trained traffic control agents at peak times at identified problem intersections or road segments. (7-141)	No	No	No	
Providing industry-specific training to first responders to prepare for potential accidents. (7-141)	No	No	No	
Road use agreements limiting heavy truck traffic to off-hour periods, to the extent feasible, to minimize congestion. (7-141)	No	No	No	
Providing a safety and operational review of the proposed routes, which may include commitments to providing changes to geometry, signage, and signaling to mitigate safety risks or operational delays. (7-141)	No	No	No	
Avoiding hours and routes used by school buses. (7-141)	No	No	No	

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
1.0 Where appropriate the Department would impose specific construction windows within well construction permits in order to ensure that drilling activity and its cumulative adverse socioeconomic effects are not unduly concentrated in a specific geographic area. Those 2.0 measures, designed to mitigate socioeconomic impacts and impacts on community character, can also be employed to minimize operational and safety impacts where such impacts are identified. (7-142)	No	No	No	The effectiveness of this measure is difficult to assess because the RDSGEIS does not explain what criteria would trigger a limitation on well permits within a specific area. Applying an adaptive management approach is logical, but it requires substantial resources and planning to monitor well development pressures at the local level. NYSDEC has not explained how such a monitoring system would be implemented, and thus this mitigation measure is likely to be ignored or forgotten once NYSDEC starts issuing permits.
Reducing trucking through different technology, such as on-site treatment. (7-142)	No	No	No	
The operator will provide specific information on the types and quantities of hazardous materials expected to be transported through the jurisdictions that they will be operating in and brought on site as part of the permitting process. (7-142)	Yes	Yes (560.3)	Yes	
All fracturing fluids and additives are transported in “DOT-approved” trucks or containers. (7-142)	N/A	N/A	N/A	This measure cannot be enforced by NYSDEC- depending on federal or NYSDOT oversight of hazardous material movement.
First responders and emergency personnel would need to be aware of hazardous materials being transported in their jurisdiction and also be properly trained in case of an emergency involving these materials. Permit conditions may require the operator to provide first responder emergency response training specific to the hazardous materials to be used in the drilling process if a review of existing resources indicates such a need. (7-143)	No	No	No	Applies to all wells, should be in regulations

RDSGEIS Mitigation Commitment	Incorporated in EAF or EAF Addendum	Incorporated in Proposed Regulations	Incorporated in Supplemental Permit Conditions	Notes
Transportation plans may provide that sensitive locations be avoided for trucks carrying hazardous materials. (7-143)	No	No	No	To make this mitigation measure meaningful, it would be helpful for NYSDEC to identify the specific categories of sensitive facilities that permit applicants must identify and avoid in developing trucking routes (bridges over drinking water supply reservoirs for example).

6.3 EAF and EAF Addendum

A transportation plan is a required component of the EAF Addendum. The scope of the transportation plan is discussed in RDSGEIS Section 7.11.1.1 and includes "the number of anticipated truck trips to be generated by the proposed activity; the times of day when trucks are proposed to be operating; the proposed routes for such truck trips; the locations of, and access to and from, appropriate parking/staging areas; and the ability of the roadways located on such routes to accommodate such truck traffic." NYSDEC should provide details on the scope of the specific analyses that should be performed for the transportation plan to ensure a uniform approach is used.

7.0 Community Character

7.1 Impact Assessment

Community character is an amalgam of various elements that give communities their distinct "personality." These elements include a community's land use, architecture, visual resources, historic resources, socioeconomics, traffic, and noise (CEQR Tech. Manual). The community character impact assessment portion of the RDSGEIS lists some of the community character impacts that could be expected (focused on demographic and economic impacts), but does not analyze the significance of these impacts or draw conclusions on how proposed new natural gas development in the Marcellus and Utica shales would affect community character in the short-term and long-term. The impact assessment does not mention the contribution of visual, land use or historic resource impacts to community character. The discussion of traffic and noise impacts is superficial (two sentences each).

The community character impact assessment in the RDSGEIS appears to be based on the *Impacts on Community Character of Horizontal Drilling and High Volume Hydraulic Fracturing in Marcellus Shale and Other Low-Permeability Gas Reservoirs* report prepared by NTC Consultants for NYSERDA. To the extent the analysis in the RDSGEIS derives from or relies upon this report, it is significantly flawed in that for the most part it considers a few of the elements of community character individually (visual, noise, traffic), without drawing conclusions on the cumulative impact of all the changes associated with the expected level of new development. Much of the cumulative impact discussion in the report focuses on attempting to explain why a regional cumulative impact assessment based on a reasonable worst case development scenario is not necessary or helpful. The report also states:

> "The approach for addressing regional cumulative impacts is to focus on the proactive siting of well pads as discussed in previous sections of this report. If the location and construction of each well pad is based on 'Best Practices' (See Appendix A) then the potential impacts will be lessened and/or eliminated. **When applications are reviewed, it is recommended that DEC examine any negative issues that have occurred on adjacent well pads to determine if there is a potential problem in the area that needs further scrutiny**." Page 38. Emphasis added.

The suggested approach is to let the impacts occur and then do something about those impacts if there is a problem. NYSDEC adopted this approach in the form of the vague mitigation commitment to monitor the pace of well development and respond through limits on permits in specific areas to minimize cumulative socioeconomic impacts (see page 7-120). This is contrary to SEQRA, the intent and spirit of which is to consider impacts *before* making a decision to approve the proposed action. NYSDEC must address regional cumulative community character impacts and not defer the issue to the future after the impacts have occurred. An adaptive management framework to addressing HVHF impacts is useful (as discussed further below), but this does not excuse the omission of a complete community character impact assessment in the RDSGEIS.

7.2 Mitigation

The community character mitigation section of the RDSGEIS focuses on the EAF Addendum requirement related to consistency with local plans. There is also a mitigation commitment requiring site-specific review and additional mitigation measures of disturbance of 2.5 acres or more within an agricultural district. However, the agricultural district mitigation commitment is not enforceable because it is not included in the EAF Addendum, regulations or supplemental permit conditions.

The community character mitigation section also references the visual, noise, transportation and socioeconomic mitigation commitments in Chapter 7. However, as noted in the other sections of this review, enforceable mitigation has not been provided for those topics, which means that the unmitigated impacts in those subject areas will contribute to unmitigated community character impacts.

Finally, NYSDEC should develop an adaptive management framework for monitoring the effectiveness of measures implemented to avoid, minimize, or mitigate community impacts of HVHF, and use this information to refine the community impacts mitigation requirements for future permit applications. NYSDEC contemplates such a similar approach in the discussion of mitigation for socioeconomic impacts (page 7-120), but the details of how this monitoring system would work need to be defined and circulated for public review and comment.

7.3 EAF and EAF Addendum

Community character impacts are not addressed as a distinct topic in the EAF or EAF Addendum.

8.0 Cultural Resources

8.1 Impact Assessment

Cultural resources, also referred to as historic properties, link a community with its past. These are finite resources and are provided protections through local, state, and federal authorities. In the 1992 GEIS, cultural resources were addressed as one of the major environmental issues. In GEIS Chapter 6, a background of these environmental resources and a review of the then-existing authorities (in addition to SEQRA) was

provided, noting "the revised, shortened and simplified EAF should still remain as an attachment to the drilling permit application form (FGEIS page 31)." The simplified EAF includes cultural resources and offers the New York State Office of Parks, Recreation, and Historic Preservation (OPRHP, the State Historic Preservation Office) as a source for information along with the DEC Division of Construction Management-Cultural Resources Section and the DEC Division of Regulatory Affairs-Regional Office. There was limited discussion of the potential cultural resource issues beyond that identified on pages 6-16, 7-7, and 16-11 through 16-12. Further, although the 1992 GEIS highlighted the need for consultation between NYSDEC and the OPRHP, there was no formal process for consideration of cultural resources outlined.

Despite the length of time since the 1992 GEIS was issued, the 2009 DSGEIS and the RDSGEIS provide no update or reaffirmation of the authority-driven procedures for taking potential impacts to cultural resources into account beyond referring back to the 1992 GEIS. For example, how will tribal consultation be addressed given the 2009 DEC policy, *Contact, Cooperation, and Consultation with Indian Nations*:

> "'Affecting Indian Nation interests' means a proposed action or activity, whether undertaken directly by the Department or by a third party requiring a Department approval or permit, which may have a direct foreseeable, or ascertainable effect on environmental or cultural resources of significance to one or more Indian Nations, whether such resources are located on or outside of Indian Nation Territory."

In the RDSGEIS there is limited new discussion of cultural resource issues despite comments provided during the scoping process by the New York Archaeological Council (NYAC) dated December 11, 2008, outlining the potential loss of valuable scientific information should no consideration be given to these finite resources. NYAC reinforces the direct impacts to archaeological deposits that can result from any ground disturbing activity and offers comments on potential indirect impacts, such as vibration from drilling and increased vehicular traffic that could impact fragile archaeological deposits, or the potential for loss or degradation of the information that could be gleaned from specialized analyses of archaeological features that may result from changes to the soil matrix with the introduction of chemical additives as well as the potential for indirect (visual, vibration) impacts to historic architectural resources. Despite the availability of these comments, the additions to the RDSGEIS focus solely on the potential for visual impacts but disregard NYAC's other recommendations, a notable deficiency in the 1992 document.

In \RDSGEIS Chapter 3, there is no mention of cultural resources relative to SEQRA beyond the reference back to the 1992 findings. In Chapter 6, there is no discussion of cultural resources; while the 1992 document and its findings are incorporated by reference and this chapter is intended to address new issues, this is a missed opportunity to consider potential impact to cultural resources. Consider the potential situation where a cultural resource, such as the remnants of an old water-powered mill complex that once was the economic hub for a small community or what remains of an historic vessel scuttled during a military skirmish, is submerged or partially submerged in an anaerobic environment. With a reduction in stream flow there is the potential to degrade the resource, rendering it subject to deterioration and potential loss. Without consideration of a broadly defined area of potential effect at the outset when the siting application and all its associated contingencies (e.g., well pads, gathering lines,

distributions lines, access roads, resource or water needs, etc.) is reviewed, there is the potential to impact cultural resources.

The RDSGEIS does note in Chapter 8, Table 8.1, that OPRHP has a role in "well siting" and in "new in-state industrial treatment plants" but these are shown with an asterisk, with the caveat "role pertains in certain circumstances." On page 8-6, it is noted that "[i]n addition to continued review of well and access road locations in areas of potential historic and archeological significance, OPRHP will also review locations of related facilities such as surface impoundments and treatment plants." On page 8-37, the State Historic Preservation Act (SHPA) is brought into play with respect to dam safety permitting criteria and thresholds for resource consideration. And in Appendix 14 (Department of Public Service Environmental Management & Construction Standards and Practices –Pipelines), cultural resources are listed under the portion of the checklist for "Procedures for the Identification and Protection of Sensitive Resources."

Thus, the big issue that has not been adequately outlined and addressed is how cultural resources will be handled in the overall permitting process; in particular, what is the procedural means and proposed agency coordination for cultural resources identification, and impact evaluation, minimization, avoidance, mitigation?

8.2 Mitigation

The RDSGEIS mitigation section for visual resources suggests that mitigation measures would be considered when designated significant visual resources associated with historic resources are present and within the view shed of proposed wells. However, in order to determine whether there is a view shed impact on a historic resource the resource itself must be identified, and evaluated before a determination of impact can be made. Because the RDSGEIS does not, as noted, indicate how this will be done, it is impossible to evaluate whether the process for impact identification and mitigation pursuant to SEQRA will be adequate.

The same can be said for ***all*** potential cultural resource impacts, such as those to archaeological sites which are rarely visible on the surface – mitigation measures would be considered once any resources have been identified, evaluated for significance, and a determination made that the impact cannot be avoided or minimized. It is expected that this process is to be undertaken during consideration of well siting applications (which should take into account gathering and distribution lines, access roads, all potential ground-disturbing impacts as well as potential indirect impacts [i.e., vibration, chemical, visual, etc.]). Unfortunately, this approach does not allow the public adequate review of possible mitigation efforts.

Finally, NYSDEC should develop an adaptive management framework for monitoring the effectiveness of measures implemented to avoid, minimize, or mitigate cultural resource impacts of HVHF, and use this information to refine the cultural resource mitigation requirements for future permit applications.

8.3 EAF and EAF Addendum

As noted above, the process for addressing potential cultural resource impacts is not fully developed beyond the EAF checkboxes and DEC review of the application.

9.0 Aquatic Ecology

The assessment of aquatic ecology issues focused on the following items:

- Potential for impairment of the "best use" classifications of the State's surface waters due to cumulative impacts.
- Potential for the alteration or degradation of critical aquatic habitat for aquatic species with limited distributions and sensitivity to water quality, such as trout and salamanders (e.g., the common mudpuppy (*Necturus maculosus*).
- Potential for aquatic habitat fragmentation (i.e., the isolation of existing populations).

LBG's review of Sections 6.1.1.2, 6.1.1.3 and 6.1.1.4 of the RDSGEIS indicates that the document does not fully characterize the potential environmental impacts leading to the potential degradation of a stream's best use classification, and the alteration of aquatic habitats and ecosystems due to direct and cumulative impacts. The RDSGEIS inadequately addresses the potential for the regulated development of high-volume hydraulic fracturing to alter critical aquatic habitat for sensitive species, specifically trout and salamanders, and no provisions are made in sections 7.1 and 7.4 to require standard mitigation measures to ensure degradation is avoided.

Pursuant to NY State Environmental Conservation Law regulations, Chapter X - Division of Water, Article 2, Part 701, all fresh surface water classes have a general condition that does not allow the discharge of wastes to impair the best usage of the receiving water, and all surface water use classifications "shall be suitable for fish, shellfish, and wildlife propagation and survival." The regulations provide for further discharge restrictions to surface waters that occur within the RDSGEIS study area, including:

- Part 701.20: c.2 – waters that contain "critical aquatic habitat for fishes, amphibians, or aquatic invertebrates listed as endangered, threatened, or of special concern in Part 182 of this Title"; d.3 "small trout spawning streams;"
- Part 701.25 a. – waters that are labeled with the symbol (T) are "classified waters in that specific item are trout waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout or trout waters applies;" and,
- Part 701.25 b. – waters that are labeled with the symbol (TS) are "classified waters in that specific Item are trout spawning waters. Any water quality standard, guidance value, or thermal criterion that specifically refers to trout, trout spawning, trout waters, or trout spawning waters applies."

The purpose of the discharge designations is to provide further protection to these waters by defining their best use as the maintenance of aquatic species diversity and populations of sensitive or diminishing species that are sensitive to the degradation of water and habitat quality. The combined land use changes caused by well pad development, roadway network improvements and expansion, and supporting

infrastructure should be described within the RDSGEIS at a watershed scale that is practical to the management of aquatic resources.

To assist in defining a potential scale, LBG prepared maps that depict the frequency, spatial distribution and arrangement of discharge restricted sensitive aquatic environments (trout streams) at two watershed scales (See Figures 1 and 2). Figure 1 shows the distribution of streams with NYSDEC discharge designations for trout within the Unadilla river watershed, a large tributary to the Susquehanna River with a 520 square mile watershed. Figure 1 shows the number of and connectivity between patches of existing stream habitat and populations of trout, and presumably other sensitive aquatic species. Figure 2 shows the Lower Butternut Creek watershed at the Hydrologic Unit Code (HUC) 12 level, with a 52.16 square mile watershed. Lower Butternut Creek is a tributary of the Unadilla River. At this scale, Figure 2 can be used as a planning level tool to depict aquatic habitat cores, islands, and corridors for a single or multiple populations of aquatic species. The scale is also practical for relating well pad and ancillary features with potential impacts and mitigation considerations. In the RDSGEIS, NYSDEC should use similar planning tools to evaluate more thoroughly potential impacts to aquatic habitat.

Table 5 below summarizes the watershed features of size, length of trout supporting (T) and trout spawning (TS) designated waters, and length of existing roads for both figures.

Table 5
Watershed Statistics

Watershed	Watershed Size (sq. miles)	Non-Trout Waters (miles)	Trout Supporting/ Trout Spawning Waters (miles)	Existing Roads (miles)
Unadilla River	520	587.63	461.85	1488
Lower Butternut Creek	52.16	88.26	49	134

Construction of well pads, access roads and supporting infrastructure may impact two major watershed processes which could have multiple cumulative effects on surface waters.

The first process is the increase in concentrated runoff from construction sites due to precipitation or snow melt through the re-routing and concentrating of diffuse overland sheet flow into roadside ditch networks, and the reduction in soil infiltration and permeability due to land development (or changes in water supply distribution) (Rosgen 2006, Forman et al. 2003, Leopold and Langbein 1960).

Second, the increase in sediment from the introduction of miles of new access roads with a gravel base, unpaved shoulders, and/or unconsolidated drainage conveyances/ditches, and stream crossings is a process that can lead to changes in sediment supply. Gravel roads, even when properly constructed and maintained, provide a source of sediment, especially during high traffic periods (Rosgen 2006, Forman et al. 2003, Reid and Dunne 1984). Each of these items is discussed below.

9.1.1 Land Use

Sections 5.1.1, 5.1.2 and 5.1.3 of the RDSGEIS describe the extent of land disturbance during the drilling and fracturing stage for a well pad and ancillary features (access

roads, utility corridors, compressor stations, etc.). The average total disturbance was estimated at 7.4 acres for a multi-well pad and 4.6 acres for a single well pad.

Section 5.1.4.2 of the RDSGEIS states that the spacing of disturbances from horizontal wells with multiple wells drilled from common pads is "up to 640 acres," which is approximately one well pad per square mile. An "on average" spacing estimate is not provided; therefore, a typical disturbance footprint spacing has not been quantified. Analyses of cumulative impacts at a watershed scale require a practical spacing or range of spacing to better evaluate the need for regulatory limitations on well pad densities. If truly representative of the affected acreage, a single 7.4 acre multi-well pad represents approximately 1.5 percent of the area within a square mile.

A common component of construction is the clearing, grading and compaction of land within the disturbance footprint. These actions impact the naturally occurring drainage patterns outside of the disturbance footprint by re-routing and concentrating diffuse overland sheet flow produced by precipitation or snow melt (Leopold and Langbien, 1960; Leopold, 1994), re-directing this water through surface conveyances such as a ditch network (Foreman et al. 2003), which can change the timing and path of water supplied to surface waters within the watershed (Rosgen, 2006) or the hydrologic regime (Poff et al., 1997). The RDSGEIS does not specifically address these processes or address potential mitigation measures for inclusion as permit conditions within the regulatory program.

In reference to partial reclamation of the well pad, Section 5.16.1 states that "[s]ubsequent to drilling and fracturing operations, associated equipment is removed. Any pits used for those operations must be reclaimed and the site must be re-graded and seeded to the extent feasible to match it to the adjacent terrain. Department inspectors visit the site to confirm full restoration of areas not needed for production."
The intention of partial reclamation of a pad during the production phase is to further reduce the footprint of the disturbance. However, this section does not describe details about how long each phase lasts, does not provide a reclamation time table, or performance standards. Therefore, it is difficult to classify the disturbance as a temporary or permanent impact. The section provides insufficient elaboration or methods and does not define the industry standards or success criteria for reclamation activities and the environmental benefits they may provide; therefore, the value of reclamation as mitigation is also unclear.

Land use restrictions using impervious area thresholds are used to maintain brown trout populations in suburban watersheds in Delaware, Maryland and Pennsylvania (Kauffman and Brant, 2000) which is based on limiting impervious surfaces to less than 10% coverage of a watershed. Brook trout populations, the very species associated with T and TS stream designations in NY have become extirpated in watersheds with impervious land uses above 4% coverage, and stress upon brook trout populations was inversely related to impervious watershed coverage (Stranko et al., 2008). Brook trout population presence is shown to have a positive relationship with forested watershed coverage above 68% (Hudy et al. 2008). Collectively, this information demonstrates that cumulative watershed land use changes induced by HVHF that impact forested land and increase impervious cover is likely to cumulatively impact NY State designated trout and trout spawning waters which could well lead to the loss of the waters' best use designations. NYSDEC should address these issues in the RDSGEIS. In addition, related impacts to tourism are not discussed here but should be as these impacts are an

indirect effect of natural habitat degradation and natural habitat is an established State tourism asset.

9.1.2 Access Roads

Section 5.1.1 of the RDSGEIS states “industry estimates an average access road size of 0.27 acre, which would imply an average length of about 400 feet for a 30-foot wide road. Permit applications for horizontal Marcellus wells received by the Department prior to publication of the 2009 DSGEIS indicated road lengths ranging from 130 feet to approximately 3,000 feet.” The Executive Summary, Chapter 2 summary of the RDSGEIS states “the Department has determined, based on industry projections, that it may receive applications to drill approximately 1,700 - 2,500 horizontal and vertical wells for development of the Marcellus Shale by high-volume hydraulic fracturing during a ‘peak development’ year. An average year may see 1,600 or more applications. Development of the Marcellus Shale in New York may occur over a 30-year period. Those peak and average levels of development are the assumptions upon which the analyses contained in this RDSGEIS are based.” Based only on the averages considered in the RDSGEIS, an average of 1,600 wells annually, each requiring 400 feet of new road, according to the RDSGEIS would result in over 121 miles of new, likely gravel, roads annually. This would be over 3,600 miles of new roads over 30 years. The RDSGEIS does not address the potential impact of the additional roads on aquatic resources, especially streams with sensitive species.

Stream drainage density relative to road density across a watershed is indicative of the interconnectivity of the roadway drainage system with the stream ecosystem (Foreman et al. 2003). In a regional study of the distribution of brook trout in their native range, average road densities of 3.2 km/sq. km was shown to be a predictor of watersheds that are not likely to support intact brook trout habitat (Hudy et al. 2008). Road density within the lower Butternut Creek watershed is 2.57 miles/sq. mile and the stream density is 2.63 miles/sq. mile. Within the lower Butternut Creek watershed, the stream network is less likely to be designated as Trout or Trout Spawning in areas where roads cross the stream more frequently. For instance, the stream network is designated as Trout or Trout Spawning stream segments are crossed by roads 38 times, and non-trout where stream segments are crossed by roads 54 times or more (Figure 2). While other land use factors can be at play here, road density within a watershed is positively correlated with stream habitat condition. The RDSGEIS should exam available literature on this topic to aid in the assessment of potential long term impacts to trout populations within affected watersheds due to watershed level changes. It is likely that some watersheds currently supporting trout populations are at or near the tipping point of trout sustainability. The RSDGEIS does not address how future HVHF development may affect native trout populations and other sensitive aquatic species.

Road crossings have been identified as a source of habitat fragmentation within linear aquatic systems by forming barriers to fish passage and altering the continuity of fluvial processes (e.g. sediment transport and disconnecting a stream from its floodplain) (Foreman, 2003). Road crossing structures can also change the transport of Large Woody Debris (LWD) (Foreman et al. 2003). LWD is important as an indicator of trout habitat quality (Flebbe and Dolloff, 1995) and in routing, storing and sorting sediment in fluvial landforms (Fisher et al. 2010, Lassettre and Harris 2001, Gomi et al. 2001 and Montgomery et al. 1995).

The alteration of fluvial processes caused by watershed development includes increased peak flows and mobilization of sediment from watershed and stream channel sources (Leopold 1994). Gravel roads, particularly construction and repair of gravel roads, have been shown to be a source of sediment in watersheds (Rosgen 2006) and contribute to habitat degradation (Logan, 2003). Heavy vehicle traffic on gravel roads, up to four heavy vehicles per day, has been shown to contribute up to 130 times more sediment to streams than paved roads (Reid and Dunne, 1984). The drilling and fracturing process can require tens to hundreds of trips by heavy vehicles each time a new well is constructed, thus increasing the likelihood of new sediment loadings to the local stream.
Currently New York State provides no regulatory guidance for stream crossing design which maintains Aquatic Organism Passage (AOP). Vermont Department of Environmental Conservation, Watershed Management Program has developed stream crossing design guidance and stream crossing assessment tools which support AOP and natural channel morphology (The Vermont Culvert Geomorphic Compatibility Screening Tool, 2008 and The Vermont Culvert Aquatic Organism Passage Screening Tool, 2009). These tools can be used to design habitat sensitive crossings at new roads and find mitigation through retrofit or replacement of existing non-habitat sensitive crossings. The Massachusetts Department of Environmental Protection has developed guidance for maintaining gravel roads, ditch networks and stabilizing cut slopes to prevent erosions and reduce sediment inputs to the watershed (The Massachusetts Unpaved Roads BMP Manual, 2001). The adoption or incorporation of these practices as standard BMP measures within the regulatory program should be addressed within the RDSGEIS as a means to minimize potential impacts.

Section 6.4.3 of the RDSGEIS provides an incomplete characterization of potential environmental impacts to endangered and threatened species. While Chapter X, Part 701.20: c.2 states “critical aquatic habitat for fishes, amphibians, or aquatic invertebrates listed as endangered, threatened, or of special concern in Part 182 of this Title” includes discharge designations for waters with species of special concern, the RDSGEIS does not adequately recognize critical habitats for aquatic species of special concern, nor does it provide a complete list of species of special concern that are dependent on aquatic habitats as part of their natural life cycle. There is insufficient evaluation of species of special concern and potential cumulative impacts to threatened, endangered or special concern species within the RDSGEIS.

9.1.3 Recommendations

Based on the review of the RDSGEIS, LBG has found that the document does not adequately address the potential direct and cumulative impacts of HVHF on aquatic resources, New York State designated trout and trout spawning waters, and the potential for the loss of the waters’ best use designations. Recommendations to address the deficiencies of the RDSGEIS are provided below.

1. The RDSGEIS should provide a technically supported evaluation method to assess the anticipated changes to land use and road networks at a watershed level and the potential impact to aquatic habitat and sensitive aquatic species.

2. The RDSGEIS should define the restoration standards and success criteria for well pads, access roads and other short term and long term disturbances,

and timelines so that the temporal impacts of these activities and the environmental benefits of site reclamation are clearly defined.

3. Currently New York State does not provide regulatory guidance for stream crossing design which maintains Aquatic Organism Passage (AOP).The adoption or incorporation of these practices as standard BMP measures within the regulatory program should be addressed within the RDSGEIS as a means to minimize potential impacts.

9.1.4 Aquatic Ecology References

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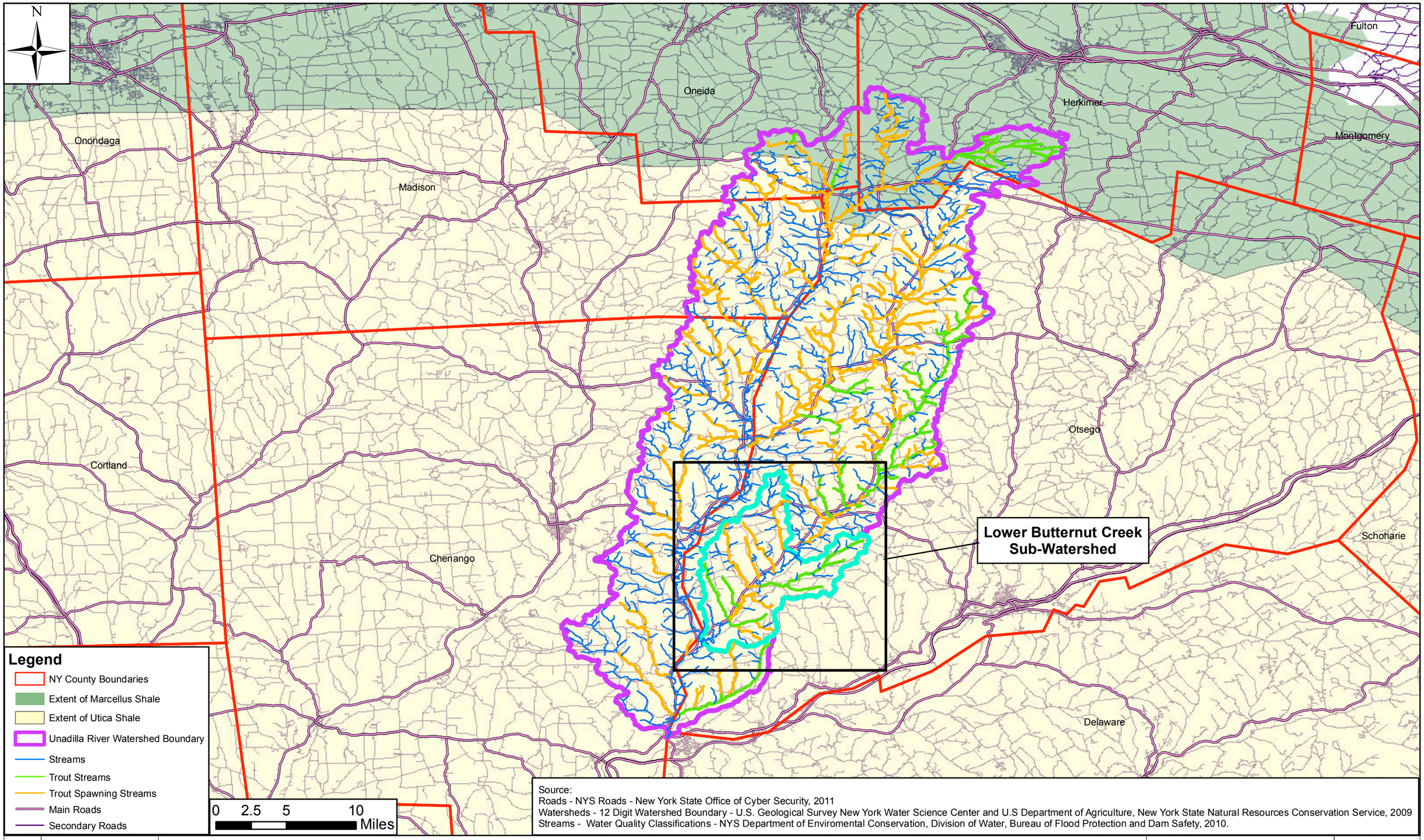


Source:
Roads - NYS Roads - New York State Office of Cyber Security, 2011
Watersheds - 12 Digit Watershed Boundary - U.S. Geological Survey New York Water Science Center and U.S Department of Agriculture, New York State Natural Resources Conservation Service, 2009
Streams - Water Quality Classifications - NYS Department of Enviromental Conservation, Division of Water, Bureau of Flood Protection and Dam Safety, 2010.

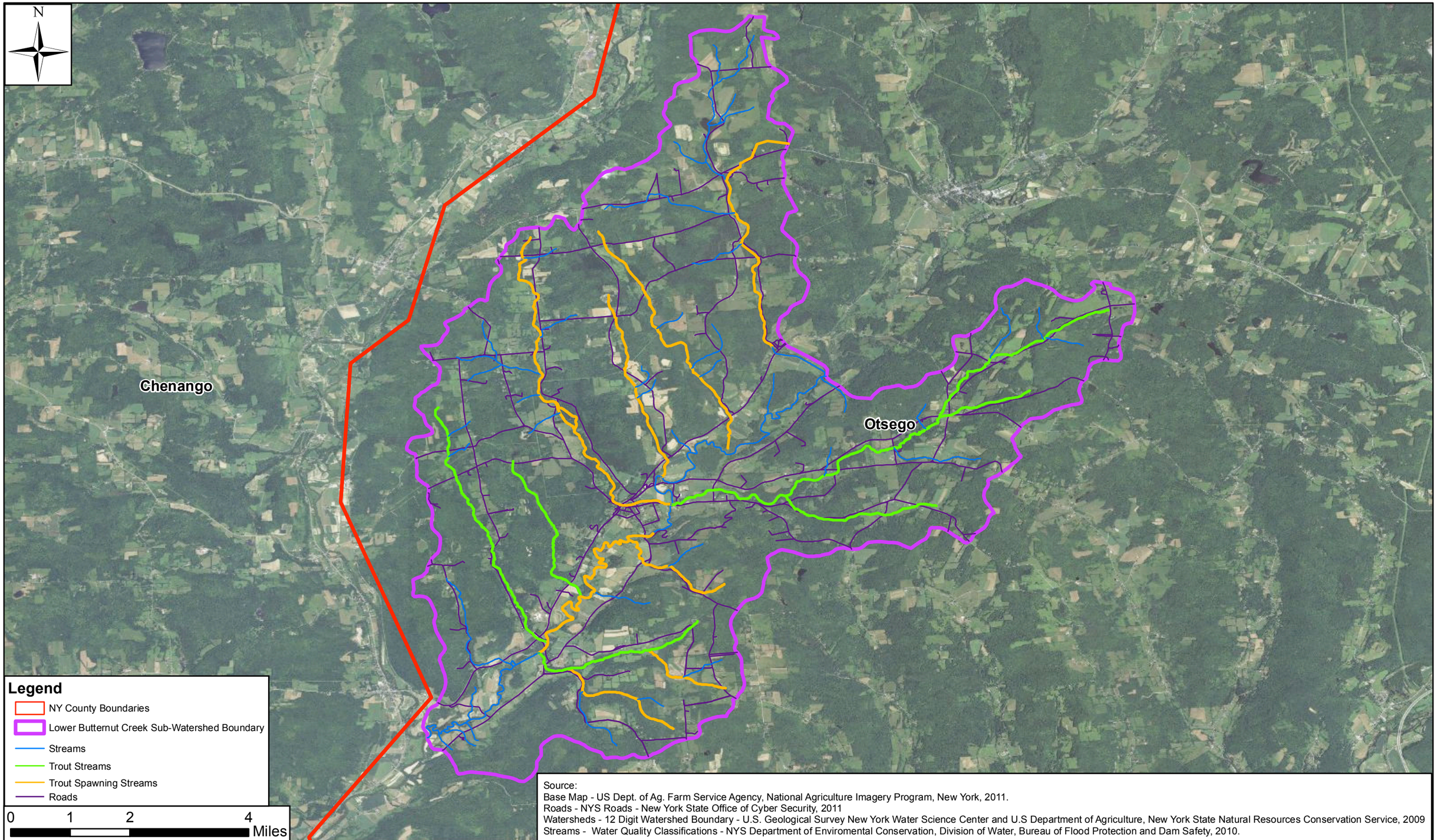
Natural Resources Defense Council

UNADILLA RIVER WATERSHED MAP

NEW YORK

The Louis Berger Group, Inc.
412 Mt. Kemble Ave
Morristown, NJ

FIGURE 1



Source:
Base Map - US Dept. of Ag. Farm Service Agency, National Agriculture Imagery Program, New York, 2011.
Roads - NYS Roads - New York State Office of Cyber Security, 2011
Watersheds - 12 Digit Watershed Boundary - U.S. Geological Survey New York Water Science Center and U.S Department of Agriculture, New York State Natural Resources Conservation Service, 2009
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Natural Resources Defense Council

LOWER BUTTERNUT CREEK SUB-WATERSHED MAP
NEW YORK

The Louis Berger Group, Inc.
412 Mt. Kemble Ave
Morristown, NJ

FIGURE 2

Attachment 8

Kevin Heatley, M.EPC LEED AP

Professional Review & Comment

on

Revised Draft Supplemental Generic Environmental Impact Statement on the Oil, Gas and Solution Mining Regulatory Program (Revised September 7, 2011)

January 5, 2012

Prepared for:

Delaware Riverkeeper Network

Prepared By:

Kevin Heatley, M.EPC LEED AP

Restoration Ecologist

EXECUTIVE SUMMARY

This review of the New York State Department of Environmental Conservation (NYDEC) revised draft Supplemental Generic Environmental Impact Statement (RDSGEIS) on the Oil, Gas and Solution Mining Regulatory Program (issued September 7, 2011) was prepared in response to a request by the Delaware Riverkeeper Network to provide expert opinion on issues of terrestrial and restoration ecology. The ecological health and integrity of the forested landscapes located within watersheds has a direct bearing on both the water quality and the biotic composition of the streams and aquatic resources of the Delaware River and other major drainages of the Marcellus and Utica region. Mitigation of land disturbance impacts, such as those associated with unconventional fossil fuel extraction, is critical to ecological sustainability.

The NYDEC recognizes in section 1.2 of the RDSGEIS that it is required by NY state law to "conserve, improve and protect its natural resources and environment . . ." However, the agency openly, and correctly, acknowledges that this mandate cannot be achieved for terrestrial habitats and wildlife resources in the state under the proposed RDSGEIS mitigation recommendations. According to section 7.4.1, "Significant adverse impacts to habitats, wildlife, and biodiversity from site disturbance associated with high-volume hydraulic fracturing in the area underlain by the Marcellus Shale in New York will be unavoidable." The agency presents no mitigation option, such as aggressive region-wide restrictions on the spatial and/or temporal scale of this land disturbance sufficient to negate the undesirable ecological impacts of shale gas development.

The RDSGEIS identified four major areas of concern with respect to ecosystems and wildlife:

1. Fragmentation of habitat
2. Potential transfer of invasive species
3. Potential impacts on endangered and threatened species
4. Use of certain state-owned lands

While the RDSGEIS correctly emphasizes the importance of habitat fragmentation on terrestrial vertebrate species (in particular avian organisms) it fails to document the long term ecological consequences of fragmentation, deforestation, increasing forest edge and reduced surface permeability on desirable forest regeneration, surface water quality, soil chemistry, biodiversity, and sustainable ecosystem services.

Unfortunately, the mitigation measures proposed fail to fully address fragmentation and landscape connectivity issues for the majority of the affected ecosystems. In addition, the proposed invasive species best management practices lack the following key components:

- Quantifiable control metrics
- Latent seed bank management
- Forest edge management

The RDSGEIS also fails to provide any effective regulatory guidance and/or mandates regarding the final ecological restoration of ecosystem structure and function to well pads, pipelines, access road sites, and other related infrastructure upon cessation of natural gas extraction activities.

As written, the revised draft RDSGEIS presented by the NYDEC assures that widespread, dramatic changes in both the current integrity, and the future successional trajectory, of the watersheds and forests in the Marcellus and Utica regions will occur should the anticipated level of landscape industrialization occur. Changes in the successional trajectory (the type of tree species regenerating in the forest understory and that will ultimately comprise the forest canopy) will cause cascading ecological consequences. These changes are likely to result in an undesirable diminution of the ecosystem benefits and services currently provided by these biotic communities. Cascading ecological effects and consequences are probable and will require costly management interventions of significant spatial and temporal scale in order to achieve system restoration.

DISCUSSION

A careful review and analysis of the draft NYDEC RDSGEIS reveals a number of areas of concern with respect to the maintenance of the ecological integrity of terrestrial ecosystems and the corresponding impacts upon aquatic resources. In particular the RDSGEIS does not adequately provide for the protection and sustainable regeneration of critical headwater forests within the Delaware River drainage. Forested ecosystems are the dominant land cover type (57%) within the areas of potential shale gas extraction in the State of New York. This canopy cover is of extreme importance to both the quality and quantity of water that flows within the Delaware River drainage.

Forests filter contaminants, moderate stream temperatures and buffer flow volumes associated with precipitation events. They are the structural foundation upon which the ecological integrity and health of the basin's biological resources are built. The link between percent forest cover and water quality is clearly established in the scientific literature. As an example, reductions in forest cover are directly correlated with negative changes in water chemistry, such as increases in nitrogen, phosphorus, sodium, chlorides, and sulfates, and with reductions in stream macroinvertebrate diversity (Jackson and Sweeny 2010).

A healthy, viable forest canopy creates tangible economic value that accrues directly to local and regional communities. This value comes both from forest-dependent industries and from the ecosystem services (air filtration, climate regulation, water purification, etc.) that the forest provides. For instance, a 2002 survey of 27 water suppliers found that for every 10% increase in forest cover within a municipal watershed, the costs of water treatment and purification decreased by approximately 20% (Ernst, Caryn, Gullick and Nixon 2004). In New York State, forest-dependent industries are estimated to generate nine billion dollars of economic activity on an annual basis (North East State Foresters Association 2001).

Forest fragmentation as a result of anthropogenic landscape modification is well recognized within biogeographic theory and conservation biology as a leading cause of local species extinctions (extirpation). It can also cause dramatic shifts in the floral and faunal composition of woodland communities. Sub-lethal impacts to floral and faunal

populations (population isolation, reduced genetic fitness and diversity) have also been associated with disruptions to forest connectivity (Clark, et.al. 2010).

Species dependent upon large, intact areas of interior, or "core" forest and those with limited dispersal abilities are at particular risk from forest fragmentation. A large body of scientific literature associated with neotropical migratory birds clearly links the survival of many of these species to the preservation and restoration of core forest habitat. The Cerulean warbler *(Dendroica cerulean*), a species of special concern in New York State, is a prime example. These populations are already in decline due to massive reductions in the amount of intact core forest. Even if the remaining interior forest habitat is preserved, the extensive fragmentation of the rest of the forested landscape will effectively preclude these areas from reconnection and restoration as interior forest habitat.

As pointed out by Semlitsch and Bodie (2003), the long-term persistence of many amphibian populations depends on the availability of vernal (seasonal) woodland pools and the surrounding, connective forest habitat. The ability of local populations to safely disperse is critical for the survival of these species. For instance, while many species of salamanders return to where they hatched to breed and lay eggs, it has been shown that they will use other vernal pools for breeding if their vernal pool of origin has been disturbed (if it is within their migration distance capacity). Linear disturbance corridors such as roadways and pipeline right-of-ways can create impermeable barriers to movement and effectively isolate populations of these organisms from alternative breeding sites. Isolated populations are at greater risk for extirpation (local extinction). The Jefferson salamander (*Ambystoma jeffersonianum*), another species of special concern in

New York, is an example of an amphibian that will be at risk should significant forest alterations occur.

The development of shale gas infrastructure in the New York and Pennsylvania region will have profound forest fragmentation impacts. Recent modeling work performed by the Pennsylvania Chapter of The Nature Conservancy indicates that approximately 2/3rds of the Marcellus well pads to be built in Pennsylvania will be located in what is currently forested habitat (TNC 2010). Coupled with the associated connective infrastructure of access roads and pipeline right-of-ways (ROWs), disruption of vital ecological processes is assured.

Fragmentation creates an increase in the amount of forest edge (the interface between forest and non-forest). This transitional zone or "ecotone" is fundamentally different in structure and functionality from an interior forest system. Edge habitat is characterized by increased light levels on the forest floor, reduced soil moisture, and a high degree of biological invasion from non-native invasive organisms. Dramatic changes can occur in the soil chemistry and associated micro biota. The top layer of the soil profile, the rich organic duff, begins to dry out and the primary decomposition community begins to shift from fungal to bacterial. Changes in the soil micro biota will result in shifts in the macro biotic community structure. The regeneration of desirable tree species (the successional trajectory) will be affected, potentially impacting the level of valuable ecosystem benefits supplied by the forest. These changes have direct economic implications to both landowners and society. Invasive species, for instance, have been estimated to cost the U.S. economy approximately $120 billion dollars per year (Pimintel et al. 2004).

Invasive organisms within terrestrial forest environments tend to be early successional species that respond favorably to site disturbance. Disruption of native plant cover and the exposure of the forest floor to sunlight provide an opportunity for these organisms to establish satellite populations. These populations eventually radiate out into the adjacent forest, displacing native species and retarding desirable tree regeneration (Bennet et al. 2011). Dispersal (vectoring) mechanisms and/or corridors are required in order for these non-native species to colonize new locations and the access roads, pipelines, and vehicular traffic associated with natural gas extraction are ideally configured to serve this function. Long beyond the point when wells are decommissioned, the landscape legacy of forest edge spreading outward from pipeline corridors, access roads, well pads, and related infrastructure will continue to disrupt ecosystem functioning as non-native organisms repeatedly colonize exposed areas and impede desirable tree regeneration.

Invasive species suppression and the eventual restoration of these disturbed sites to forested systems will require resources of a significant financial and temporal scale. While published information is scarce, it is in the professional experience of restoration practitioners in this region that the reasonable reconstruction of forest canopy and understory diversity can cost between $4,000 and $10,000 per acre. The suppression of invasive plant species is also a major, recurring expense with the initial years' treatment often costing between $1,000 and $2,500 per acre. Invasive treatment in subsequent years typically drops in cost by approximately 50% per year during the first three years of suppression. Treatment and monitoring will need to continue on an annual basis until forest canopy closure is re-established and the resulting changes in light penetration and soil conditions begin to favor native species.

As the effects of forest fragmentation may not immediately manifest themselves following the disturbance, monitoring is often suggested as a methodology to balance and modify the level of fragmenting activity in accordance with the conservation of forest-related ecosystem services. Unfortunately, these effects may not be linear in nature and thus are not always amenable to an adaptive management approach. Biological systems may possess thresholds that provide little indication of impending adverse impacts until sudden system collapse.

It is from within this conceptual framework that a review of the NYDEC Revised Draft RDSGEIS was undertaken and the following concerns identified:

Infrastructure Density-related Ecological Impacts -

- While mandatory unitization of production areas is in effect in New York, this spacing regime is geared toward maximization of gas extraction and not natural resource protection. Preliminary research results already point towards pad density as a significant indicator of potential landscape level impacts to water quality (Academy of Natural Sciences 2011). The RDSGEIS makes no mention of utilizing ecological planning units (such as the sub watershed) or ecological carrying capacity models. This is necessary to assure the industrial development pattern is consistent with the maintenance of ecological integrity.

- Density of infrastructure is also directly correlated to percent impermeable surface within subwatersheds. Increased impermeable surface area will disrupt both surface and subsurface hydrologic regimes within currently forested systems

resulting in shifts in species composition and functional benefits. For instance, it is widely accepted among watershed managers that negative changes in water quality and quantity become clearly evident when impermeable surface begins to exceed 10% of a given watershed area. The RDSGEIS-proposed mitigation strategies do not address allowable levels of impermeable surface within ecological planning units such as the subwatershed.

Forest Fragmentation

- While the requirement for ecological assessments and site-specific mitigation measures on well pads placed in grasslands of greater than 30 acres (in grassland focus areas) and for forest patches of greater than 150 acres (in forest focus areas), is helpful this approach is, in essence, ironically fragmented. It completely fails to address the importance of landscape connectivity between patches. As such, it will not protect the landscape-level ecological processes that maintain regional forest integrity. It will also fail to protect connective corridors vital to the movement of plant and animal populations in response to climate change. A preferable methodology would be to set maximum allowable levels of deforestation and fragmentation based upon ecological planning units such as the subwatershed.

- It is strongly recommended that a comprehensive, ecosystem-based plan guide the decision-making and permitting process in place of the piecemeal approach to land use planning and the protection of watershed resources set forth in the RDSGEIS. Setting maximum thresholds and spatial parameters for percent forest cover loss

and forest connectivity would assure that density levels and cumulative impacts of natural gas extraction do not exceed the ability of the regional ecosystem to absorb these activities.

- The RDSGEIS correctly emphasizes the importance of minimum patch sizes and landscape connectivity in protecting terrestrial wildlife habitat and/or the human recreation associated with such wildlife. However, no discussion or analysis is present regarding the impact that fragmentation and increasing edge habitat will have upon long term forest successional trajectory and associated biodiversity.

- No analysis has been presented in the RDSGEIS regarding the potential diminution of critical ecosystem services associated with the disruption of forest cover and soils (carbon sequestration and storage, air filtration, watershed flow rates and volume, surface water quality and thermal condition).

- Section 6.4.1.2 estimates that a mere 7% of the forest cover underlain by the Marcellus Shale in NY occurs on State-owned land. However, section 7.4.4 proposes a ban on surface disturbance within state forests and state wildlife management areas only. It is important to understand that this prohibition is not based upon any substantive <u>ecological</u> differences between forests under different ownership.

- Section 7.4.4 gives several reasons for prohibiting surface disturbance on State-owned land including: "Increased light and noise levels would be likely to have significant impacts on local wildlife populations, including impacts on breeding, feeding and migration" and "The local wildlife populations could take years or even

decades to recover." These concerns are equally applicable to privately-owned forests, yet full mitigation of these identified impacts to wildlife is not addressed for the remaining 93% of the forest cover in the state. In particular, noise reduction strategies are entirely omitted from section 7.4.1.1 (BMPs for Reducing Direct Impacts at Individual Well Sites).

- Section 7.4.1.1 requires full cutoff (downward) lighting only during bird migration periods. As the ecological impacts of artificial night lighting across a range of species are well documented in the scientific literature, this requirement should be extended year-round.

- Section 7.4.1.1 fails to address BMPs for placement and maintenance of gathering pipelines. As this infrastructure is fundamental to well pad development, and has the potential to disrupt a greater net acreage than the actual pad, BMP recommendations should be developed.

- Section 7.4.1.1 fails to address BMPs for placement and mitigation of compressor station impacts.

- Section 7.4.1.2 indicates that for forest patches of 150 acres or more (within Forest Focus Areas) where the DEC issues a disturbance permit after reviewing the required Ecological Assessment, "enhanced monitoring of forest interior birds during the construction phase of the project and for a minimum period of two years

following the end of high-volume hydraulic fracturing activities (i.e., following date of well completion) would be required." While this is an important recommendation, such enhanced monitoring should be extended to less mobile species sensitive to the radical changes in forest floor light and moisture levels that forest fragmentation will cause. Forest-dwelling amphibian species are at a particular risk of extirpation (local extinction) following the loss of interior forest conditions given their limited ability to traverse across linear landscape barriers such as roadways and pipeline ROWs.

- As connectivity between forest patches is critical to allowing for species migration, dispersal, and the continued genetic fitness of terrestrial species, mitigation strategies protective of this landscape level feature should be required. The RDSGEIS does not presently address protection of landscape connectivity and mitigation of disruptions to connective corridors.

- Definition of a disturbed area – clarification should be made as to the minimum size that defines a disturbed area.

- Section 7.4.1.3, *Monitoring Changes in Habitat* recommends, on parcels meeting the threshold criteria in grassland and forest focus areas, that monitoring of disturbance effects should occur during the drilling process and for a minimum of two years following well completion. While monitoring is indeed a valuable tool, effective implementation of operational changes (adaptive management) following and in

response to ecosystem disruption is not always possible. Ecosystem response to disturbance may not follow a linear pattern as previously unknown tolerance thresholds may be crossed. Sudden system collapse and the loss of valuable structural and functional features of an ecosystem may occur even in the absence of discernible advance indicators of stress. A more appropriate response would be to apply the precautionary principle and study the likely impacts prior to widespread, and potentially irreversible, landscape modification.

Invasive Species Introduction & Management

- It is recommended that section 6.4 be expanded to include an analysis of the threat potential to forest health from the inadvertent introduction and facilitation of the spread of invasive terrestrial invertebrates and pathogens. The current analysis only considers invasive plants and aquatic organisms.

- The construction of infrastructure necessary to develop the Marcellus and Utica shales will entail the movement of large fleets of vehicles and equipment from various sections of North America. It will also entail the movement of large numbers of transient laborers and technical personnel from across the United States. This activity carries an inherent risk of acting as a vectoring mechanism for a number of threats to forest health. The RDSGEIS should review this potential mechanism of invasive threat and propose mitigation strategies.

- Section 6.4 should also be expanded to include an analysis of the impact that massive increases in forest edge habitat will have upon the incursion and establishment of invasive plant species. Edge habitat is inherently attractive to the type of plant species that display invasive characteristics. Invasive plants tend to be early successional species adapted to disturbed sites. The ecotone between forest and grassland is an area generated by recent disturbance and thus presents ideal conditions for these opportunistic, rapidly-reproducing species. Periodic re-infestation of edge habitat by invasive plant species is also highly probable given the high light levels and frequent deposition of wind-borne and bird-deposited seeds in such areas. The creation of edge habitat on the scale anticipated by natural gas infrastructure is likely to result in chronic, regional infestations of undesirable species that will require regular, and expensive, control interventions. The creation of forest edge is, in and of itself, an important precursor to biological invasion.

- Section 7.4.2.1 fails to include compressor stations and pipeline ROWs in the requirements for invasive species best management practices.

- Section 7.4.2.1 indicates that an invasive species survey "should be conducted by an environmental consultant familiar with the invasive species in New York." It is recommended that the word "should" be replaced by "must".

- It is recommended that the invasive species survey required under section 7.4.2.1 stipulate that percent aerial cover be classified <u>for each</u> identified invasive plant

species on the site. Identification of baseline infestation levels is critical to determining target levels of cover reduction and control.

- Section 7.4.2.1 fails to provide any measurable metric, such as percent cover reduction from pre-disturbance levels, for quantifying levels of invasive control. The recommendation strategy that, "Any new invasive species occurrences found at the project location should be removed and disposed of appropriately" should be qualified to include the latent seed bank in the soil.

- Section 7.4.2.1 fails to define the temporal timeframe of responsibility for invasive suppression. The seeds of many invasive plant species can lie dormant in the soil for years. This latent seed bank creates a reservoir for future outbreaks following soil disturbance. It is critical that a long term monitoring and treatment program be implemented for all sites and associated infrastructure. Monitoring and suppression treatments should continue until final site reforestation and effective closure of the tree canopy.

- Section 7.4.2.1 fails to provide a spatial framework for the area of invasive species control responsibility. Invasive species are highly mobile and akin to a wildfire in their dispersal from initial point of infestation. At a minimum, site developers should be required to manage invasive infestations within all forest edge environments surrounding new pads, pipeline ROWs, and newly constructed access roads. Failure to do so will result in migration of these species off-site and the transfer of the financial burden of control onto adjacent property owners.

- As prevention is more cost effective than control, requirements should be adopted mandating independent site inspections by a qualified ecologist on no less than a semiannual basis until final reforestation and canopy closure occurs. Failing to provide for frequent site inspections assures compliance will be minimal.

Site Restoration

- The RDSGEIS fails to provide any meaningful guidance regarding the ultimate restoration of well pads, pipeline ROWs and access roads to full ecosystem functionality upon decommissioning. Effective restoration requires a comprehensive, site-level assessment of the existing plant community prior to disturbance and the use of local reference ecosystems as templates for restoration. Ecological restoration is based upon the concept of rebuilding degraded areas such that they are structurally and functionally similar to pre-disturbance conditions. Reclamation is NOT restoration. Grassy fields neither function in a biologically similar manner as a forest nor supply the ecosystem benefits of a forest system. The replacement of a decades-old, complex assemblage of woodland species with a simple mix of grasses is not "restoration". It may retard erosion but it does not replace the original functionality and structure of the displaced ecosystem.

- Restoration objectives and planning should be integrated into best management practices and developed based upon a landscape-level analysis. Re-establishing forest connectivity should be a primary goal.

- As the service life of gas extraction infrastructure such as transmission pipelines may extend for decades, mitigation banks and sites where restoration of previously degraded systems might off-set the disturbance for the interim period should be utilized. This will help assure that no net loss of ecosystem benefits occurs within the region.

- Requirements for an independent, qualified restoration ecologist to oversee and inspect site restoration should be developed in order to assure effective compliance.

Summary

As currently proposed, the NYDEC RDSGEIS does not provide an adequate assessment of likely impacts associated with the rapid conversion of forested and rural ecosystems to industrial sites. It also fails to recommend potential mitigation strategies and options that would offset and reduce the "significant" impacts anticipated for native terrestrial ecosystems. Protection of these terrestrial ecosystems is critical to the continued health of the regions' aquatic resources. Inadequate attention has been given to the following vital considerations: density related impacts of infrastructure, forest fragmentation, invasive species, and site restoration. Should the RDSGEIS be adopted in its current form, widespread disruption to forest ecosystems within the upper Delaware River Basin and other watersheds underlain by the Marcellus and Utica formations will occur. Restoration of these systems following the eventual cessation of natural gas extraction will be a monumental cost incurred by both the taxpaying public and adjacent private property owners. It is strongly recommended that the NYDEC

consider a more comprehensive approach to protecting the integrity of the forested landscapes in New York. Setting maximum thresholds and spatial parameters for percent forest cover loss, forest connectivity, and core forest integrity within ecological planning units, such as the subwatershed, would assure that density levels and cumulative impacts of natural gas extraction do not exceed the ability of the regional ecosystem to absorb these activities.

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Attachment 9

Kim Knowlton, DrPH

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40 West 20th Street, 11th floor
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January 8, 2012

Re: Comments on the RDSGEIS on NY Marcellus Shale Natural Gas Hydraulic Fracturing

These comments are submitted regarding the Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS) governing high-volume, hydraulic fracturing as a method of natural gas drilling in the Marcellus Shale and similar formations in New York State.

I am Senior Scientist in the Health and Environment Program at the Natural Resources Defense Council in New York City, and Assistant Clinical Professor in the Department of Environmental Health Sciences at the Mailman School of Public Health of Columbia University. I received my doctorate in Public Health from Columbia University, and much of my research considers the effects of climate change on human health (my CV is attached). These comments relate to climate change and public health concerns raised by the information described in the RDSGEIS.

Although the RDSGEIS describes greenhouse gas emissions that would be generated by Natural Gas Hydraulic Fracturing operations in the Marcellus and other shale formations in NY State (sec. 6.6), and the means to reduce those health-harming emissions (sec. 7.6), the RDSGEIS lacks critical information about the exacerbating effect climatic changes will have on the uncertainties of drilling operations. Further, climate change is likely to increase the risk to public health from HVHF operations if these operations are conducted without regard to the effects of climate change on the environmental context of drilling operations.
Climate change is likely to increase several key uncertainties in shale gas natural gas hydraulic fracturing operations which are not addressed in the RDSGEIS, yet should be. Several of these climate change and public health-relevant omissions are described below:

1. **More frequent extreme rainfall events.** The public health risks of drill pad operations and waste fluid disposal are likely to be affected by more frequent extreme rainfall events in New York State, as climate change continues. These events and the flooding they can cause need to be factored into the RDSGEIS. Measured changes in the heaviest precipitation events in the Northeastern US increased 67% over the period 1958-2007; and the trend toward heavier precipitation is projected to increase into the 2090s.[1] In New York State in the last 60 years from 1948 to 2006, there has been a statistically significant 56% increase in the most extreme rainfall events, according to the a 2007 study by Environment America.[2] As climate change continues, these extreme rainfall events are projected to continue to occur more frequently.[3] The New York Panel on Climate Change (or NPCC), an expert group of university researchers and climate modelers, investigated climate change's effects on New York City and the surrounding region, and projected that annual precipitation in the New York region will "more likely than not" increase, with mean annual precipitation increasing up to 5% by the 2020s, 10% by the 2050s, and

5-10% by the 2080s.[4] The New York State Climate Action Council's Nov. 2010 *Climate Action Plan Interim Report* noted in its Executive Summary (ES) that, "Summertime rain is expected to fall more often as heavy downpours, leading to more flooding; at the same time, the periods between these rainstorms are likely to be drier, leading to droughts. … Public and private entities will need to assess whether new investments in infrastructure, particularly long-lived infrastructure like power plants and transportation, will be consistent with a low-carbon future, both in terms of GHG emissions and in terms of vulnerability to a changing climate. We should avoid investments that are not highly adapted to a modified climate, such as infrastructure sited in low-lying floodplains."[5] ***DEC should act consistently with the recommendations of the New York Climate Action Plan Interim Report by prohibiting HVHF operations and infrastructure in low-lying areas***.

2. **Changes in floodplain location.** The locations of 50-, 100- and 500-year floodplains are likely to change in New York State, owing to the effects of climate change. Extreme rainfall events are becoming more frequent in the US.[6] This trend was also noted in the recently-released NY State ClimAID report: "Intense precipitation events (heavy downpours) have increased in recent decades, and are likely to increase in future."[7] These extreme precipitation events are occurring in tandem with a long-term increase in annual average precipitation of 0.37 inches per decade since 1900.[8] The advent of extreme precipitation events taken together with a general increase in average precipitation is likely to alter the location and size of floodplains. Altered floodplain locations could dramatically compromise the siting and safety of drilling operations, as well as waste disposal and transport. With the trend to heavy downpours over the past 50 years projected to continue, an increase in localized flash flooding in hilly regions across the state is expected. "Flooding has the potential to increase pollutants in the water supply and inundate wastewater treatment plants and other vulnerable development within floodplains."[9] The most recent state of the science on the effects of climate change on the extent of local floodplains should be applied in the RDSGEIS's consideration of the potential impacts of proposed new drilling in NY State.

   Because increasingly frequent and extreme rainfall events could threaten drilling infrastructure, operations and disposal, such investments should be avoided without a full, detailed mapping of areas at greatest risk from storm and flood damage. This is in line with the Nov. 2010 recommendations of the NY State Climate Action Council in their Climate Action Interim Report.[10] Floodplain maps must be fully updated to include the latest information on how climate change will affect local flood plain locations, taken from downscaled climate model projections.[11]

   Although DEC proposes prohibiting surface disturbances in 100-year floodplains[12], this approach is problematic for several reasons. First, DEC should also prohibit subsurface activity in these areas. Second, the prohibition should apply to additional matters involved in HVHF, such as the siting of pipelines and other potentially sensitive infrastructure, the construction of impoundment ponds, the location of temporary waste storage tanks, etc. Third, not only does DEC acknowledge that FEMA is currently updating Flood Insurance Rate Maps (FIRMs) in several high-flood areas in the state,[13]

but the Department also admits that the increased frequency and magnitude of flooding has raised a concerns regarding the reliability of the existing FIRMs in the Susquehanna and Delaware River basins.[14] Given this acknowledgment, DEC should extend this prohibition to 500-year floodplains. In general, ***no permits should be issued anywhere in the state before updated floodplain maps are in place for the entire region and these maps are reflected in DEC's environmental review and regulations***. These maps should be reflective of anticipated changes that may result from climate change, namely the increase in frequency and severity of storm events. To permit any activities before properly mapping prohibited areas is inconsistent with SEQRA.

3. **Potential changes in groundwater flow patterns.** Hydrological assumptions about groundwater flow patterns through the Marcellus and other shale formations could be altered by water demands from drilling activities, if coupled with increasingly frequent seasonal drought and/or flood periods in NY State, as climatic instability increases. More frequent alternation between periods of extreme wet and dry periods could, over time, result in changes in groundwater flow patterns[15] and unanticipated movement of production fluids and other groundwater in subsurface fractures and fissures. While challenging to predict, such migration could threaten drinking water supplies. Subsurface hydrological modeling studies have been undertaken to account for some of these climate change effects,[16] yet such studies were ignored by the RDSGEIS. ***No permits to drill near groundwater resources should be issued until climate change-based subsurface hydrological modeling studies have been incorporated into the DEC's review and regulations***.

4. **Changing seasonal precipitation patterns.** Increasing temperatures have already caused spring snowmelt to occur earlier in the year, and climate change will continue to bring changing patterns of seasonal precipitation across the state, with more annual precipitation falling as rain rather than snowfall.[17] This could affect the frequency, intensity and timing of overland flooding events at drill pad sites. In 2011, Hurricane Irene caused extensive flooding across the Catskills and upstate NY, in part because the soils were already so saturated from record-breaking heavy precipitation during the summer. As the USGCRP 2009 report attests, "…water-saturated soils can generate floods with only moderate additional precipitation."[18] In addition to prohibiting water withdrawals during low stream flow, ***the RDSGEIS should explicitly address shifting precipitation patterns resulting from climate change, increased flooding risks, and the public health issues they may create***.

5. **Increasing temperatures could exacerbate chemical volatilization and fugitive emissions from drill sites.** Ambient temperatures are projected to increase across NY State, due to the warming climate.[19] Volatilization of fracking chemicals and fugitive emissions may increase due to higher evaporation rates from higher temperatures. Exposures to workers and the community could increase, exacerbating associated health risks. ***Adverse human health impacts resulting from increased volatilization of fracking chemicals and fugitive emissions should be explicitly addressed in the RDSGEIS.***

6. **Conflicting demands on water use during drought periods are likely to be exacerbated by climate change.** Hydrofracking operations will require enormous quantities of water in drilling, in operations, and as wastewaters are disposed of. Marcellus development is projected over a thirty-year life cycle.[20] The average year would see 1,600 or more wells.[21] The amount of water consumed in each well is projected between 2.4 and 7.8 million gallons,[22] and the average well consumes 4.2 million gallons of water.[23] Based on these numbers, approximately 201,600,000,000 gallons of freshwater will be permanently removed from New York State surface and groundwater sources for the purpose of HVHF operations. The effect of these freshwater diversions in light of predicted climate change impacts to water supplies was not analyzed in the RDSGEIS. Because climate change is likely to disrupt the timing of precipitation's seasonality, the enormous water demands from hydrofracking operations could periodically conflict, during periods of local drought, with those of populations who rely on local surface and groundwater sources for drinking, domestic, municipal, business and agricultural uses. ***The potential for conflicts between HVHF operators and the public over dwindling water supplies resulting from climate change, including the adverse environmental and human health impacts associated with unprecedented freshwater diversions, should be examined in the RDSGEIS, and operators should be prohibited from consuming water from underground, surface, and municipal sources if doing so would exacerbate local drought conditions.***

7. **Nitrous oxide is an extremely potent GHG that the RDSGEIS fails to properly analyze.** Even in its current discussion of greenhouse gases (GHG) generated during drilling operations, the RDSGEIS lacks sufficient information in Sec. 6.6.2 about nitrous oxide (N_2O) as a greenhouse gas (GHG) of concern. The RDSGEIS states that because N_2O is produced in small quantities it need not be explicitly discussed in terms of its treatment or disposal.[24] However, N_2O has a global warming potential 289 times greater than carbon dioxide (CO_2), and an atmospheric lifetime 114 times longer than CO_2.[25] It is injudicious to entirely negate N_2O's effect on climate change in the RDGEIS without fuller discussion of the volumes that would be generated, from what sources, and potential treatment methods. ***The RDSGEIS should identify the impacts associated with N_2O emissions and proposed mitigation measures to curb these emissions.***

8. **Public health impacts.**. Climate change impacts can jeopardize the safety of drilling operations and exacerbate the consequences of HVHF operations on New York State, leading to adverse environmental human health impacts. ***DEC should conduct a comprehensive Health Impact Assessment (HIA) as part of the state's environmental review*** in order to evaluate potential risks to human health from gas development in New York, including the dynamic between HVHF operations (impacts on water quantity and quality, waste runoff, air pollution, etc.) and climate change (water shortages, floods, temperature rise, etc.). ***To assist in the review of comments received, at least one Public Health professional should sit on the team who evaluates the comments received by DEC on the RDGEIS***. Their expertise would be helpful in assessing other potential areas of significant health concern, ranging from air quality, water quality, worker exposure, waste management, etc...

Based on the foregoing, the RDSGEIS is incomplete in its current form. The RDSGEIS is deficient because it does not ever come to grips with the challenges to safe HVHF operations posed by climate change: it does not consider changes in the frequency of extreme rainfall events, changes in floodplain location, changes in groundwater flow patterns, changes in seasonal precipitation patterns, changes in average temperature, potential water use conflicts, the effects of nitrous oxide on climate change, or the public health impacts of climate change in association with HVHF operations. The RDSGEIS fails to include current information relevant to climate change's potential effects on New York State, which will pose potentially significant adverse environmental and public health threats in conjunction with HVHF operations that should be identified and mitigated to the maximum extent possible.

Thank you for consideration of these comments.

Respectfully,

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(212) 727-2700 x4579 (telephone); (212) 727-1773 (fax)

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[1] Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson (eds.). US Global Change Research Program (USGCRP), Cambridge University Press, 2009, p.32.

[2] Madsen T, Figdor E. 2007. When It Rains, It Pours: Global Warming and the Rising Frequency of Extreme Precipitation in the United States. Environment America's Research & Policy Center (December 2007).

[3] IPCC Summary for Policymakers of the Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX), Nov. 18, 2011. Available at: www.srex.org and www.ipcc.ch.

[4] New York City Panel on Climate Change (NPCC). 2009. Climate Risk Information. Available at: http://www.nyc.gov/html/om/pdf/2009/NPCC_CRI.pdf.

[5] New York State Climate Action Council's Nov. 2010 *Climate Action Plan Interim Report*, Executive Summary, pp.4-5.

[6] USGCRP (2009).

[7] Rosenzweig C, Solecki W, DeGaetano A, O'Grady M, Hassol S, Grabhorn P (Eds.). 2011. *Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation. Technical Report.* (Ch.1, p.16). New York State Energy Research and Development Authority (NYSERDA), Albany, New York. Available at: www.nyserda.ny.gov.

[8] ClimAID Report (2011), p.81 sec. 4.2.2.

[9] Nov. 2010 *Climate Action Plan Interim* Nov. 2010 Report, Overview, p.10.

[10] NY State Climate Action Council, 2010. Climate Action Interim Report, Overview, pp.10, 43, and 48.

[11] Cooney CM 2012. Downscaling Climate Models: Sharpening the Focus on Local-Level Changes. *Environ Health Perspect* 120:a22-a28. http://dx.doi.org/10.1289/ehp.120-a22.

[12] 2011 RDSGEIS, Additional Precautionary Measures, Section 1.8, p. 1-18.

[13] 2011 RDSGEIS, Flood Zone Mapping, Section 2.4.9.2, p. 2-33.

[14] *Id*.

[15] USGRCP (2009), Water sector report, pp. 46-47.

[16] Goderniaux P, Brouyere S, Fowler HJ, et al. 2009. Large scale surface-subsurface hydrological model to assess climate change impacts on groundwater reserves. *Journal of Hydrology* 373:122-138.

[17] ClimAID (2011), Sec. 4.2.1, p.81.

[18] USGCRP (2009), Water Sector report, p.45.

[19] ClimAID (2011), Ch.1, pp.30-36.

[20] 2011 RDSGEIS, Cumulative Water Withdrawal Impacts, 6.1.1.7, p. 6-6.

[21] 2011 RDSGEIS, Description of Proposed Action, Chapter 2, p. 2-1.

[22] 2011 RDSGEIS, Hydraulic Fracturing Procedure, 5.9, p. 5-93.

[23] 2011 RDSGEIS, Cumulative Water Withdrawal Impacts, 6.1.1.7, p. 6-10.

[24] 2011 RDSGEIS, Emissions from Oil and Gas Operations, 6.6.2, p. 6-188.

[25] 2007 Intergovernmental Panel on Climate Change (IPCC), Fourth Assessment Report (AR4), Working Group 1 Technical Summary, Chapter 2, p.212, "Changes in Atmospheric Constituents and Radiative Forcings."

Attachment 10

Gina Solomon, M.D., M.P.H

MEMORANDUM

TO: Kate Sinding
FROM: Gina Solomon, M.D., M.P.H., Senior Scientist, NRDC; Clinical Professor of Health Sciences, UCSF
DATE: January 9, 2011
RE: NRDC Comments on RDSGEIS, NY Marcellus Shale Natural Gas Hydraulic Fracturing relative to Public Health concerns and Health Impact Assessments

Numerous health concerns have been associated with natural gas development using hydraulic fracturing, including air pollution, potential contamination of groundwater or surface water that may be used for drinking or recreation, toxicity of chemicals used in fracturing fluids, safety concerns such as fire or explosion, increased vehicle traffic, altered social conditions, and the health effects of noise, vibration, and light at night. The RDSGEIS addresses some aspects of a subset of these health issues, but fails by (1) omitting several important health issues entirely, (2) addressing only some aspects of other issues such as air, water quality and traffic without fully considering the health impacts in those areas (Note: this issue is addressed more fully in comments on those sections of the RDSGEIS submitted as part of this package), and (3) failing to consider health issues as a group in a formal Health Impact Assessment (HIA), including the interactive effects on the health of local residents and communities.

The failure to conduct a full HIA as part of the RDSGEIS is an important omission because the health effects of numerous chemicals used and emitted in the course of natural gas development have been well-described.[1] In addition, there are already numerous reports of health complaints among people who live near natural gas drilling and fracturing operations in other states. These health complaints have received coverage in the media,[2] and some cases have been investigated by researchers or government agencies.[3] Reported health issues in residents near natural gas drilling operations include: eye irritation, dizziness, nasal and throat irritation, sinus disorders, bronchitis and other respiratory symptoms, depression, nausea, fatigue, headaches, anxiety, difficulty concentrating, and a range of other symptoms.[4] Just last week, the nation's top environmental health expert

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[1] Colborn, T.; Kwiatkowski, C.; Schultz, K., and Bachran, M. Natural gas operations from a public health perspective. Human & Ecological Risk Assessment. 2011; 17(5):1039-1056. http://www.endocrinedisruption.com/chemicals.journalarticle.php. Accessed January 9, 2011; Witter R, Stinson K, Sackett H, et al. Potential Exposure-Related Human Health Effects of Oil and Gas Development: A White Paper. University of Colorado Denver, Colorado School of Public Health, Denver, Colorado, September 15, 2008. Witter R, Stinson K, Sackett H, et al. Potential Exposure-Related Human Health Effects of Oil and Gas Development: A Literature Review (2003-2008) University of Colorado Denver, Colorado School of Public Health, Denver, Colorado, August 1, 2008. http://docs.nrdc.org/health/hea_08091702.asp. Accessed January 9, 2011.
[2] See eg. ProPublica. Science Lags as Health Problems Emerge Near Gas Fields. http://www.propublica.org/article/science-lags-as-health-problems-emerge-near-gas-fields/single. Accessed January 3, 2012.
[3] See eg. ATSDR Health Consultation. Garfield County. http://www.atsdr.cdc.gov/hac/pha/Garfield_County_HC_3-13-08/Garfield_County_HC_3-13-08.pdf. Accessed January 3, 2012; Subra W. Health Survey Results of Current and Former DISH/Clark, Texas Residents. Earthworks, Dec 17, 2009. http://www.earthworksaction.org/library/detail/health_survey_results_of_current_and_former_dish_clark_texas_residents/. Accessed January 3, 2012.
[4] Ibid.

affirmed his view that more research is necessary regarding the impacts of natural gas drilling on human health.[5] Although much research needs to be done to investigate specific associations between the reported symptoms and nearby gas extraction operations, there is sufficient information on health issues associated with the chemicals and other environmental stressors at these sites to demand performance of a full HIA.

> *Health impact assessment is a systematic process that uses an array of data sources and analytic methods and considers input from stakeholders to determine the potential effects of a proposed policy, plan, program, or project on the health of a population and the distribution of those effects within the population. Health impact assessment provides recommendations on monitoring and managing those effects.*
>
> National Research Council, 2011

Rationale for a Health Impact Assessment in New York State

In September 2011, the National Research Council of the National Academies of Science (NAS) issued a report entitled: *Improving Health in the United States: The Role of Health Impact Assessment*. The report recommended the greater use of HIA in decision making in the United States, saying that: "systematic assessment of the health consequences of policies, programs, plans, and projects is critically important for protecting and promoting public health; as indicated, lack of assessment can have many unexpected adverse health (and economic) consequences."[6]

According to the Centers for Disease Control and Prevention (CDC), the HIA framework is used to bring potential public health impacts and considerations to the decision-making process for plans, projects, and policies that fall outside of traditional public health arenas, such as transportation and land use.[7] The National Environmental Policy Act (NEPA) requires federal agencies to consider the environmental impact of their proposed actions on social, cultural, economic, and natural resources prior to implementation. In New York, the State Environmental Quality Review Act (SEQRA) regulations [see 617.2(l)] define Environment as: "…the physical conditions that will be affected by a proposed action, including land, air, water, minerals, flora, fauna, noise, resources of agricultural, archeological, historic or aesthetic significance, existing patterns of population concentration, distribution or growth, existing community or neighborhood character, and *human health*" (emphasis added).[8]

In the United States, HIA is a rapidly emerging practice. HIA is also regularly performed in Europe and Canada. Some countries have mandated HIA as part of a regulatory process. In the U.S., some version of an HIA is arguably required by NEPA and by many state "mini-NEPAs,"[9] including most explicitly, the New York SEQRA,

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[5] CDC scientist: tests needed on gas drilling impact. Associated Press. January 4, 2012. http://online.wsj.com/article/AP8338b702930849f49d22a5d96b7d1b2d.html. Accessed January 5, 2012.
[6] National Research Council. Improving Health in the United States: The Role of Health Impact Assessment. Washington, DC: The National Academies Press, 2011, pp. 4-5.
[7] Centers for Disease Control and Prevention. http://www.cdc.gov/healthyplaces/hia.htm. Accessed January 3, 2012.
[8] See also Environmental Conservation Law § 8-0103(5) ("…it is the intent of the legislature that the government of the state take immediate steps to identify any critical thresholds for the health and safety of the people of the state and take all coordinated actions necessary to prevent such thresholds from being reached).
[9] Bhatia, R and Wernham, A. Integrating Human Health into Environmental Impact Assessment: An Unrealized Opportunity for Environmental Health and Justice. Environmental Health Perspectives. 2008;116(8): 991-1000.

which clearly specifies the mandate for a full characterization of the effects on human health. The National Academies of Science committee on HIA recommended: "improving the integration of health into EIA under NEPA and related state laws…[to] serve the mission of public health and the goals of HIA….[In order t]o ensure reasonable priority of health issues under NEPA, public-health agencies should be afforded a substantive role in the scoping and oversight of health-effects analysis in EIA, and health-effects analysis must be afforded resources commensurate with the task.[10]

There is precedent for performing formal HIAs for drilling activities. In 2007, an HIA of proposed oil and gas development projects in Alaska's North Slope was performed by the local government.[11] The HIA evaluated predicted impacts on fish and wildlife and the consequences for diet and health in the local population. It also identified potential social changes such as drug and alcohol use. The HIA led to new requirements for air quality analysis and monitoring of any oil-related contaminants in subsistence foods, and to a new requirement for worker education on drugs, alcohol and sexually transmitted diseases.

A draft HIA was done in Colorado for a proposed gas drilling development in Battlement Mesa. This draft HIA identified eight major areas of health concern (stressors) associated with natural gas development and production: air emissions, water and soil contaminants, truck traffic, noise/light/vibration, health infrastructure, accidents and malfunctions, community wellness, and economics/employment.[12] Several physical health outcomes linked to potential exposures were considered, including respiratory, cardiovascular, cancer, psychiatric, and injury/motor vehicle-related impacts on vulnerable and general populations in the community. The study concluded: "The key findings of our study are that [the] health of the Battlement Mesa residents will most likely be affected by chemical exposures, accidents or emergencies resulting from industry operations and stress-related community changes."[13] The researchers went on to recommend a set of mitigation measures to reduce the health threats to local residents. Although the Battlement Mesa HIA was halted by the local Board of County Commissioners, apparently for political reasons,[14] it demonstrated the feasibility and utility of HIA for evaluating risks to the health of local residents from hydraulic fracturing and natural gas drilling operations.

In October of 2011, hundreds of health professionals signed a letter to Governor Cuomo specifically requesting that the draft SGEIS be "supplemented to include a full assessment of the public health impacts of gas

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[10] National Research Council. Improving Health in the United States: The Role of Health Impact Assessment. Washington, DC: The National Academies Press, 2011, p. 111-113.

[11] Wernham A. Building a Statewide Health Impact Assessment Program: A Case Study from Alaska. Northwest Public Health. Fall/Winter 2009; Health Impact Project. Case Study: Oil Development of Alaska's North Slope. http://www.healthimpactproject.org/resources/case-study-oil-development-of-alaskas-north-slope. Accessed January 5, 2011.

[12] Witter R, McKenzie L, Towle M, et al. Health Impact Assessment for Battlement Mesa, Garfield County Colorado. Colorado School of Public Health, University of Colorado, Denver, September 2010. http://www.garfield-county.com/public-health/documents/1%20%20%20Complete%20HIA%20without%20Appendix%20D.pdf. Accessed January 4, 2012.

[13] Battlement Mesa Health Impact Assessment (2nd Draft). March 1, 2011. http://www.garfield-county.com/public-health/battlement-mesa-health-impact-assessment-draft2.aspx. Accessed January 4, 2012.

[14] Vote Ends work on Battlement Mesa HIA. May 4, 2011. http://www.healthimpactproject.org/news/in/vote-ends-work-on-battlement-mesa-hia. Accessed January 4, 2012.

exploration and production."[15] The letter pointed out that, "there is a growing body of evidence on health impacts from industrial gas development," and specifically stated that: "A comprehensive Health Impact Assessment (HIA) would be the most appropriate mechanism for this work." The Director of the Agency for Toxic Substances and Disease Registry (ATSDR), Dr. Christopher Portier, also supports more thorough assessment of the health impacts of gas drilling, stating: "Studies should include all the ways people can be exposed, such as through air, water, soil, plants and animals."[16]

In summary, the requirements of SEQRA and recommendations of the National Academies of Science argue strongly for the need for a New York HIA of the health impacts of gas drilling and hydraulic fracturing. A similar investigation in Colorado revealed a set of potentially significant human health impacts associated with chemical exposures, accidents, and stress-related community changes, all of which were insufficiently considered in the New York RDSGEIS. Without a full assessment and mitigation of the impacts of the risks, the health of New York State residents and communities is likely to suffer.

[15] Abramson A, Abrams J, Alexander M, et al. Letter to The Honorable Andrew M. Cuomo. October 5, 2011. http://www.psehealthyenergy.org/resources/view/198813. Accessed January 5, 2012.
[16] CDC scientist: tests needed on gas drilling impact. Associated Press. January 4, 2012. http://online.wsj.com/article/AP8338b702930849f49d22a5d96b7d1b2d.html. Accessed January 5, 2012.

Attachment 11

Briana Mordick

January 10, 2012

To: Kate Sinding

From: Briana Mordick

Subject: Technical analysis of hydraulic fracturing-induced seismicity provisions in the New York State Revised Draft Supplemental Generic Environmental Impact Statement On the Oil, Gas & Solution Mining Regulatory Program

Introduction

The following report is a technical review and analysis of the hydraulic fracturing-induced seismicity provisions of the New York State (NYS) 2011 Revised Draft Supplemental Generic Environmental Impact Statement (RDSGEIS) 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. This report includes recommendations for properly managing the risks associated with induced seismicity.

Analysis

The RDSGEIS fails to require operators of HVHF wells to consider the risk of induced seismicity when siting wells and designing hydraulic fracture treatments, concluding that,

"There is a reasonable base of knowledge and experience related to seismicity induced by hydraulic fracturing. Information reviewed indicates that there is essentially no increased risk to the public, infrastructure, or natural resources from induced seismicity related to hydraulic fracturing. The microseisms created by hydraulic fracturing are too small to be felt, or to cause damage at the ground surface or to nearby wells. Accordingly, no significant adverse impacts from induced seismicity are expected to result from high-volume hydraulic fracturing operations."[1]

Since the RDSGEIS was written, hydraulic fracturing has been confirmed to have caused induced seismicity strong enough to be felt at the surface. In a report commissioned by United Kingdom-based Cuadrilla Resources, researchers concluded that a series of earthquakes in Lancashire, UK were likely caused by hydraulic fracturing. Two relatively large earthquakes, with magnitudes 2.3 and 1.5, and 48 smaller events occurred in the hours after several stages of the Preese Hall 1 well were fracked.[2] A separate report written by a seismologist at the Oklahoma Geological Survey concluded that a swarm of about 50 earthquakes in Garvin County, Oklahoma, ranging in magnitude from 1.0 to 2.8, could also have been induced by hydraulic fracturing.[3]

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[1] Revised Draft SGEIS 2011, Executive Summary, Page 19

[2] de Pater, C.J., and Baisch, S., 2011, *Geomechanical Study of Bowland Shale Seismicity: Synthesis Report*, prepared for Cuadrilla Resources Ltd, 71p., available at: http://www.cuadrillaresources.com/cms/wp-content/uploads/2011/12/Final_Report_Bowland_Seismicity_02-11-11.pdf

[3] Holland, A., 2011, *Examination of Possibly Induced Seismicity from Hydraulic Fracturing in the Eola Field, Garvin County, Oklahoma*, Oklahoma Geological Survey, Open-File Report OF1-2011, 31p., available at: http://www.ogs.ou.edu/pubsscanned/openfile/OF1_2011.pdf

The RDSGEIS concedes that, "There are no seismic monitoring protocols or criteria established by regulatory agencies that are specific to high volume hydraulic fracturing,"[4] and recognizes that, "It is important to avoid injecting fluids into known, significant, mapped faults when hydraulic fracturing."[5] However, instead of developing such protocols and requiring operators to demonstrate that they have accounted for seismic risks in the siting of wells and design of hydraulic fracture treatments, the RSDGEIS assumes that, "Generally, operators would avoid faults because they disrupt the pressure and stress field and the hydraulic fracturing process,"[6] and, "It is in the operator's best interest to closely control the hydraulic fracturing process to ensure that fractures are propagated in the desired direction and distance and to minimize the materials and costs associated with the process."[7]

To justify why no additional analysis or monitoring is required to prevent induced seismicity, the RDSGEIS states, "The routine microseismic monitoring that is performed during hydraulic fracturing serves to evaluate, guide, and control the process and is important in optimizing well treatments,"[8] and, "Monitoring beyond that which is typical for hydraulic fracturing does not appear to be warranted, based on the negligible risk posed by the process and very low seismic magnitude."[9] However, earlier in the document, NYSERDA's consultant ICF International concludes that, "…fracture monitoring by [microseismic fracture mapping] is **not regularly used** because of cost…"[10] So in fact, seismic monitoring would rarely be employed during a routine hydraulic fracture treatment.

The RDSGEIS further assumes that no additional analysis of seismic risk is needed due to the fact that, "The locations of major faults in New York have been mapped (Figure 4.13) and few major or seismically active faults exist within the fairways for the Marcellus and Utica Shales."[11] There are two fatal flaws with this assumption. First, in both the UK and Oklahoma incidents, the earthquakes likely occurred due to slippage on minor, sub-seismic faults. Therefore, knowing the locations of only "major faults" is not sufficient to assess the potential risk of induced seismicity from hydraulic fracturing. Second, it is precisely the injection of fluids which induces previously inactive faults to become active. Therefore, whether a fault is currently or even recently seismically active is not sufficient to predict whether it could become active due to human activity – the definition of induced seismicity. A paper on earthquake hazards from deep well injection prepared by the U.S. Geological Survey for the U.S. Environmental Protection Agency concludes that predicting and mitigating seismic hazard risks in the Eastern United States is particularly problematic, as the causes of natural earthquakes and location of faults are not well understood.[12]

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[4] Revised Draft SGEIS 2011, Page 6-322
[5] Id.
[6] Id.
[7] Revised Draft SGEIS 2011, Page 6-323
[8] Revised Draft SGEIS 2011, Page 6-323
[9] Revised Draft SGEIS 2011, Page 6-328
[10] Revised Draft SGEIS 2011, Page 5-88, emphasis added
[11] Revised Draft SGEIS 2011, Page 6-327
[12] Nicholson, C., and Wesson, R., 1990, *Earthquake Hazard Associated With Deep Well Injection – A Report to the U.S. Environmental Protection Agency*, U.S. Geological Survey Bulletin 1951, 86p., available at: http://pubs.usgs.gov/bul/1951/report.pdf

Induced seismicity could result in unwanted and dangerous consequences, depending on the size and location of the earthquake. Fault movement may potentially endanger groundwater by creating or enhancing migration pathways between the zone being hydraulically fractured and underground sources of drinking water. Seismicity can also compromise wellbore integrity. The induced seismicity event in the UK caused ovalization of the production casing over hundreds of feet, with more than a half-inch of ovalization occurring over an approximately 250 foot length.[13] Such damage could compromise the cement bond, allowing methane or fluids to migrate up the back side of the casing to groundwater.

Even a relatively small earthquake could cause damage over a large area. The USGS report cited above states that, "Earthquakes in the Central and the Eastern United States typically cause damage over much larger areas as compared to earthquakes of the same size in the Western United States. This is primarily the result of the lower attenuation of seismic waves in the East versus the West, but other factors also may be involved."[14] Earthquakes could cause property damage including to private homes and public buildings and could also put at risk the aqueducts, tunnels, and infrastructure that deliver the New York City drinking water supply. In a report prepared for the New York City Department of Environmental Protection, environmental engineering firm Hazen and Sawyer concluded that, "…liner cracks can be anticipated to develop as the tunnels age, due to normal geologic activity (e.g., seismic activity), and to changes in subsurface conditions associated with widespread hydrofracturing, gas reservoir depletion/withdrawal and injection well operation," and, "Detrimental effects [to tunnel liners] could include liner cracks, which would facilitate infiltration of pressurized fluids."[15] In addition to natural seismic activity, induced seismicity could also be expected to create additional liner cracks. The authors also concluded that, "Hydraulic fracturing operations in proximity to the naturally occurring fracture systems that intersect DEP tunnels will increase the risk of (a) contaminating drinking water with drilling and fracturing chemicals and poor quality formation water; (b) methane accumulation around and within DEP subsurface infrastructure; and (c) tunnel liner structural failure. Mitigation of risks to drinking water quality and infrastructure integrity will require revision of current setback provisions to reflect the occurrence of laterally extensive subsurface faults, fractures, and brittle structures."[16] If earthquakes are induced along faults that intersect the DEP tunnels, these risks could be further exacerbated.

Even in the absence of actual damage, induced seismic events will have financial and manpower costs associated with the investigation of the causes and effects of the earthquake and from the suspension of operations until such studies are completed.

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[13] Id. at 2
[14] Id. at 13
[15] Hazen and Sawyer, 2009, *Impact Assessment of Natural Gas Production in the New York City Water Supply Watershed: Final Impact Assessment Report,* prepared for New York City Department of Environmental Protection, 100p., available at:
http://www.nyc.gov/html/dep/pdf/natural_gas_drilling/12_23_2009_final_assessment_report.pdf
[16] Id., Appendix D

The RDSGEIS provides insufficient analysis and scientific evidence to support its conclusion that regulations to reduce the risk of induced seismicity from hydraulic fracturing are not necessary.

Recommendation

The RDSGEIS should require operators to provide a site-specific analysis of the risk of induced seismicity due to hydraulic fracturing. This should include a detailed analysis of the geology, including the locations of known faults and an assessment of the seismic history of the region. Operators should be required to provide an analysis detailing the maximum magnitude of an earthquake that could be triggered based on anticipated injection volume and the probability that such an earthquake may occur based on site-specific geologic and geophysical parameters such as fault and fracture density, lithology, minimum horizontal stress, and anticipated pore pressure as a result of fluid injection.[17] Operators should then be required to use this data to properly design their hydraulic fracture treatment to reduce the risk of triggering induced seismicity. Operators should be required to perform seismic monitoring during hydraulic fracturing to ensure that any seismicity that occurs is within design parameters.

[17] See, e.g., Shapiro,S. A., C. Dinske, and J. Kummerow (2007), Probability of a given magnitude earthquake induced by a fluid injection, Geophys. Res. Lett., 34, L22314, doi:10.1029/2007GL031615.

Attachment 12

Expert Resumes

Harvey Consulting, LLC.

- Susan Harvey

Tom Myers, Ph.D.

Glenn Miller, Ph.D.

Ralph Seiler, Ph.D.

Meliora Design, LLC.

- Michele Adams, P.E.
- Ruth Sitler, P.E.

The Louis Berger Group, Inc.

- Niek Veraart, AICP, ASLA
- Raed EL-Farhan, Ph.D.
- Hope Luhman, Ph.D., RPA
- Edward Samanns, PWS, CE
- Leo Tidd
- Dane Ismart

Kevin Heatley

Kim Knowlton, DrPH

Gina Solomon, M.D.

Briana Mordick

HARVEY CONSULTING, LLC.

Oil & Gas, Environmental, Regulatory Compliance, and Training

Susan L. Harvey, Owner

Susan Harvey has 25 years of experience as a Petroleum and Environmental Engineer, working on oil and gas exploration and development projects. Ms. Harvey is the owner of Harvey Consulting, LLC, a consulting firm providing oil and gas, environmental, regulatory compliance advice and training to clients. Ms. Harvey held engineering and supervisory positions at both Arco and BP including Prudhoe Bay Engineering Manager and Exploration Manager. Ms. Harvey has planned, engineered, executed and managed both on and offshore exploration and production operations, and has been involved in the drilling, completion, stimulation, testing and oversight of hundreds of wells in her career. Ms. Harvey's experience also includes air and water pollution abatement design and execution, best management practices, environmental assessment of oil and gas project impacts, and oil spill prevention and response planning. During Governor Knowles Administration, Ms. Harvey headed the Industry Preparedness Program for the Alaska Department of Environmental Conservation, Division of Spill Prevention and Response; she was responsible for oil spill prevention and response oversight of all Alaska industry operations that produce, store or transport hydrocarbons. Ms. Harvey taught air pollution control engineering courses at the University of Alaska in the Graduate Engineering Program.

Education Summary:

Environmental Engineering
Masters of Science
University of Alaska Anchorage

Petroleum Engineering
Bachelor of Science
University of Alaska Fairbanks

Consulting Services:

- Oil and gas, environmental, regulatory compliance advice and training
- Oil spill prevention and response planning
- Air pollution assessment and control

Employment Summary:

2002-Current	Harvey Consulting, LLC., Owner
2005-Current	Harvey Fishing, LLC., Co-owner
2002-2007	University of Alaska at Anchorage Environmental Engineering Graduate Level, Adjunct Professor
1999-2002	State of Alaska, Department of Environmental Conservation Environmental Supervisory Position
1996-1999	Arco Alaska Inc. Engineering and Supervisory Positions held
1989-1996	BP Exploration (Alaska), Inc. Environmental, Engineering, and Supervisory Positions held
1987-1989	Standard Oil Production Company *(purchased by BP in 1989),* Engineering Position
1985-1986	Conoco, Production Engineer and New Mexico Institute of Mining and Technology Petroleum Research & Recovery Center, Laboratory Research Assistant

Harvey Consulting, LLC
PO Box 771026 Eagle River, Alaska 99577
Email:sharvey@mtaonline.net; Phone: (907) 694-7994; Fax: (907) 694-7995

Employment Detail:

2002-Current **Harvey Consulting, LLC.**
Owner of consulting business providing oil and gas, environmental, regulatory compliance and training to clients.

2005-Current **Harvey Fishing, LLC.**
Co-owner and operator of a commercial salmon fishing business in Prince William Sound Alaska.

2002-2007 **University of Alaska at Anchorage**
Environmental Engineering Graduate Level Program, Adjunct Professor Air Pollution Control.

1999-2002 **State of Alaska, Department of Environmental Conservation**
Environmental Supervisory Position
Industry Preparedness and Pipeline Program Manager, Alaska Department of Environmental Conservation, Division of Spill Prevention and Response. Managed 30 staff in four remote offices. Main responsibility was to ensure all regulated facilities and vessels across Alaska submitted high quality Oil Discharge Prevention and Contingency Plans to prevent and respond to oil spills. Staff included field and drill inspectors, engineers, and scientists. Managed all required compliance and enforcement actions.

1996-1999 **Arco Alaska Inc.**
Engineering and Supervisory Positions held
Prudhoe Bay Waterflood and Enhanced Oil Recovery Engineering Supervisor. Main responsibility was to set the direction for a team of engineers to design, optimize and manage the production over 120,000 barrels of oil per day from approximately 400 wells and nine drill sites, from the largest oil field in North America. Responsible for six concurrently operating drilling and workover rigs.

Prudhoe Bay Satellite Exploration Engineering Supervisor for development of six new Satellites Oil Fields. Main responsibility was to set the direction for a multidisciplinary team of Engineers, Environmental Scientists, Facility Engineers, Business Analysts, Geoscientists, Land, Tax, Legal, and Accounting. Responsible for two appraisal drilling rigs.

Lead Engineer for Arco Western Operating Area Development Coordination Team. Lead a multi-disciplinary team of engineers and geoscientists, working on the Prudhoe Bay oil field.

1989-1996 **BP Exploration (Alaska), Inc.**
Environmental, Engineering, and Supervisory Positions held
Senior Engineer Environmental & Regulatory Affairs Department. Main responsibilities included: air quality engineering, technical and permitting support for Northstar, Badami, Milne Point Facilities and Exploration Projects.

Senior Engineer/Litigation Support Manager. Duties included managing a multidisciplinary litigation staff to support the ANS Gas Royalty Litigation, Quality Bank Litigation and Tax Litigation. Main function was to coordinate, plan and organize the flow of work amongst five contract attorneys, seven in-house attorneys, two technical consultants, eight expert witnesses, four in-house consultants and twenty-two staff members.

Senior Planning Engineer. Provided technical, economic, and negotiations support on Facility, Power, Water and Communication Sharing Agreements. Responsibilities also included providing technical assistance on recycled oil issues, ballast water disposal issues, chemical treatment options, and contamination issues.

Production Planning Engineer. Coordinated State approval of the Sag Delta North Participating Area and Oil Field. Resolved technical, legal, tax, owner and facility sharing issues. Developed an LPG feasibility study for the Endicott facility.

Reservoir Engineer. Developed, analyzed and recommended options to maximize recoverable oil reserves for the Endicott Oil Field through 3D subsurface reservoir models, which predicted fluid movements and optimal well placement for the drilling program. Other duties included on-site wellbore fluid sampling and subsequent lab analysis.

Production Engineer. North Slope field engineering. Duties included design and implementation of wireline, electric line, drilling and rig completions, well stimulation, workovers and well testing programs.

1987-1989 **Standard Oil Production Company, Production Engineer**
Production Engineer. North Slope field engineering. Duties included design and implementation of wireline, electric line, drilling and rig completions, well stimulation, workovers and well testing programs.

Engineering Internship, Barry Waterflood Oklahoma City OK.

1986 **Conoco, Production Engineer**
Production Engineer. Engineering Internship, Hobbs New Mexico.

1985-1986 **New Mexico Institute of Mining and Technology**
Petroleum Research & Recovery Center
Laboratory Research Assistant, Enhanced Oil Recovery, Surfactant Research.

Harvey Consulting, LLC, Major Projects and Publications

Northeast Natural Energy, LLC. and Enrout Properties, LLC vs. The City of Morgantown, West Virginia, technical support to The City of Morgantown, 2011.

Arctic Oil and Gas Project, technical support to Pew Charitable Trust, 2010-2011.

Stockport Mountain Corporation, LLC vs. Norcross Wildlife Foundation, Inc., technical support to Norcross Wildlife Foundation, Inc., 2011.

Nikaitchuq Oil and Gas Development Project, technical review and advice to North Slope Borough, 2011.

Valdez Marine Terminal, Oil Spill Prevention Audit, report prepared for Prince William Sound Regional Citizens Advisory Council, 2011.

Great Bear Petroleum Exploration Oil Spill Prevention and Response Plan, technical review and comments prepared for North Slope Borough, 2011.

Recommendations to Improve the December 9, 2010 Delaware River Basin Commission (DRBC) Proposed Natural Gas Development Regulations, report prepared for Delaware Riverkeeper Network, 2011.

Oooguruk Oil and Gas Development Project, technical review and advice to North Slope Borough, 2011.

Trans-Alaska Pipeline Oil Discharge Prevention and Contingency Plan, technical review and comments prepared for North Slope Borough, 2011

Shell Beaufort Sea Exploration Plan, technical support to North Slope Borough, 2007-2011.

Canadian National Energy Board, Offshore Drilling Review, technical support to WWF-Canada, 2011.

Shell Chukchi Sea Exploration Plan, technical support to North Slope Borough, 2010-2011.

SINTEF Behavior of Oil and Other Hazardous and Noxious Substances (HNS) spilled in Arctic Waters (BoHaSA) Report, technical review and advice to WWF, 2011.

Milne Point Oil & Gas Project, technical review and advice to North Slope Borough, 2011

National Commission Report on the BP Deepwater Horizon Oil Spill and Offshore Drilling, the Challenges of Oil Spill Response in the Arctic, technical analysis and recommendations prepared for Pew Charitable Trust, 2010.

Appeal of U.S. Forest Service Plan of Operations Denial for Wolcott Gold Mining Operation, technical report and appeal filing for Wolcott Gold Mining, 2010.

Valdez Marine Terminal Oil Spill Prevention and Response, technical support Prince William Sound Regional Citizens Advisory Council, 2002-2011.

Environmental Impacts and Regulation of Natural Gas Production, E2 Environmental Entrepreneurs, Presentation, 2011.

Petroleum and Natural Gas Systems, Subpart W, Mandatory Reporting of Greenhouse Gases, technical support to Natural Resources Defense Council and Sierra Club, 2010-2011.

Delaware River Basin Commission (DRBC) Consolidated Administrative Hearing on Grandfathered Exploration Wells, report prepared for Delaware Riverkeeper Network, 2010.

Recommendations for Australian Government Commission of Inquiry Montara Well Head Platform Uncontrolled Hydrocarbon Release, - Final Findings Document Post Commission of Inquiry Proceedings, report prepared for World Wide Fund for Nature Australia, 2010.

Gas Well Risk Management Controls, Protection of Groundwater Resources and Safe Well Construction, Operation and Abandonment, analysis prepared for Environmental Defense Fund and Sierra Club, 2010.

Recommendations for Pennsylvania's Proposed Changes to Oil and Gas Well Construction Regulations, report prepared for Earthjustice and Sierra Club, 2010

Ohio Senate Bill 165 Implementation Workgroup, revised Oil and Gas Standards for Ohio, Engineering Support to Environmental Defense Fund and Sierra Club, 2010.

New York State (NYS) Casing Regulation Recommendations, report prepared for Natural Resources Defense Council, 2009.

2011 Arctic Oil & Gas General NPDES Permit (Arctic GP) Heavy Metal Discharges (Mercury and Cadmium) in Drilling Muds and Cuttings, report to North Slope Borough, 2010.

Onshore Seismic Exploration Best Practices & Model Permit Requirements, report prepared for Natural Resources Defense Council, 2010.

Comparison of 2009 Timor Sea Well blowout to Gulf of Mexico Well blowout, report prepared for World Wide Fund for Nature Australia, 2010.

Recommendations for Profitable Greenhouse Gas Reductions from Oil and Gas Facilities in New Mexico, report to Natural Resources Defense Council, 2010.

EPA's Proposed Reissuance of Arctic Offshore NPDES Permit for Facilities Related to Oil and Gas Extraction, technical advice to the North Slope Borough, 2009-2010.

Oil & Gas Exploration and Production Operations Inspector Training and Manual, prepared for North Slope Borough, 2010.

Crude Oil Storage Tank 14, American Petroleum Institute Tank Inspection Record Review, Audit and Corrosion Calculations, report prepared for Prince William Sound Regional Citizens Advisory Council, 2010.

Minerals Management Service Outer Continental Shelf Five Year Oil and Gas Leasing Program 2012-2017, comments prepared for Aleutians East Borough, 2010.

Alaska Regional Response Team Dispersant Use Guideline Revision Workgroup, technical support for the North Slope Borough, 2009-2010.

Alaska Oil and Gas Conservation Commission Proposed Regulation Changes, Title 20, Chapter 25, Alaska Administrative Code Annular Disposal of Drilling Waste, technical review and comments prepared for North Slope Borough, 2010.

Outer Continental Shelf, Oil & Gas Lease Sale, North Aleutian Basin, Cooperating Agency, technical support to Aleutians East Borough, 2009.

Review of Shell Exploration and Production Company's August 2008 Analysis of the Pros and Cons of Zero Discharge of Muds and Cuttings During Exploration Drilling in the Alaska Beaufort Sea Outer Continental Shelf, and Shell's May 2009 Supplemental Information on Annular Injection and Barents Sea Exploration Permits, report to North Slope Borough, 2009.

Best Management Practices for Cementing and Casing, analysis prepared for Earthjustice, 2010.

Recommendations for Australian Government Commission of Inquiry Montara Well Head Platform Uncontrolled Hydrocarbon Release- Initial Findings Document Prior to Commission of Inquiry Proceedings, report prepared for World Wide Fund for Nature Australia, 2010.

Alaska Oil and Gas Conservation Commission Proposed Regulation Changes, Title 20, Chapter 25, Alaska Administrative Code Well Safety Valve System Requirements, technical review and comments prepared for North Slope Borough, 2010.

Analysis and Recommendations on Shell Oil's Beaufort Sea Exploration Program, analysis prepared for Pew Charitable Trusts, 2010.

Comments to EPA on Proposed Mandatory Reporting of Greenhouse Gas: Petroleum and Natural Gas Systems - Docket EPA-HQ-OAR-2009-0923, prepared for Clean Air Task Force, Environmental Defense Fund, Natural Resources Defense Council, Sierra Club, 2010

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, Review of DSGEIS and Identification of Best Technology and Best Practice Recommendations, report prepared for Natural Resources Defense Council, 2009.

Commercial Recreation Operations, permit applications, standards, and model stipulations prepared for North Slope Borough, 2008-2010.

North Slope Village Residential and Commercial Operations, permit applications, standards, and model stipulations prepared for North Slope Borough, 2008-2010.

Alaska Coastal Impact Assistance Program Grant Applications for Seismic, LNG, and Resource Development Projects, prepared for the Aleutians East Borough, 2009-2010.

Oil & Gas Exploration and Production Operations, permit applications, standards, and model stipulations prepared for North Slope Borough, 2008-2010.

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ExxonMobil Point Thomson Exploration Drilling Operations, reports and technical advice to North Slope Borough, 2008-2010.

Oil & Gas Assembly Workshop, conducted for Aleutians East Borough, 2009.

IHLC Historical Site Protection During Oil & Gas Exploration and Production Operations, permit applications, standards, and model stipulations prepared for North Slope Borough, 2008-2010.

Western Climate Initiative (WCI) Working Group on Oil and Gas, technical support to Natural Resources Defense Council, 2009-2010.

Alyeska Pipeline Service Company, Ship Escort Response Vessel System, Audit of Fishing Vessel Readiness to Support a Catastrophic Tanker Spill, report prepared for Prince William Sound Regional Citizens Advisory Council, 2009

Western Regional Air Partnership (WRAP) Working Group on Oil and Gas Exploration & Production (E&P) Greenhouse Gas (GHG) Accounting Protocol, technical support to Natural Resources Defense Council, 2009-2010.

Oil Spill Prevention and Response Improvements for Oil and Gas Exploration and Production in Alaska's North Slope, and Chukchi and Beaufort Seas, recommendations prepared for the North Slope Borough, 2010.

Beechey Point Unit Oil and Gas Master Plan and Proposed Amendment to the Official Zoning Map to Rezone all Lands Needed for Development of the Beechey Point Unit to Resource Development, recommendation prepared for the North Slope Borough, 2010.

Audit of July 2010 Valdez Marine Terminal Surprise Drill, Personnel Availability, Training and Qualifications, report prepared for Prince William Sound Regional Citizens Advisory Council, 2010.

CGGVeritas, Inc. Onshore and Offshore 3D Seismic Data Plan, technical review completed for the North Slope Borough, 2010.

Crude Oil Storage Tank 10, American Petroleum Institute Tank Inspection Record Review, Audit and Corrosion Calculations, report prepared for Prince William Sound Regional Citizens Advisory Council, 2010.

Brooks Range Petroleum Company Northshore Oil Development Project, technical review completed for the North Slope Borough, 2009.

Oil & Gas Comprehensive Plan, technical advice to the North Slope Borough, 2009-2011.

ConocoPhillips Chukchi Sea Exploration Plan, technical review completed for the North Slope Borough, 2008.

Brooks Range Petroleum Company Northshore Development Project, technical review completed for the North Slope Borough, 2009.

Industrial Waste Water System and Manhole Repairs in Secondary Containment System, Valdez Marine Terminal, technical advice to Prince William Sound Regional Citizens Advisory Council, 2009.

North Slope Oil Spills, technical support and advice to the North Slope Borough on a variety of actual oil spills, 2002-2011.

Tract 75 Contaminated Site, technical advice to the North Slope Borough, 2009-2010.

Strategic Plan for Retaining Crude Oil Tanker Tug Escorts for Prince William Sound, plan prepared for Prince William Sound Regional Citizens Advisory Council, 2009.

Arctic Technologies Workshop - Key Learnings, report prepared for the Aleutians East Borough, 2009.

Not So Fast: Some Progress in Spill Response, but US Still Ill-Prepared for Arctic Offshore Development, A review of US Department of the Interior, Minerals Management Service's (MMS) Arctic Oil Spill Response Research and Development Program – A Decade of Achievement, report prepared for World Wildlife Fund, 2009.

Environmental Liability Baseline Assessment for Crazy Horse Oilfield Pad, technical review and recommendation prepared for the North Slope Borough, 2009.

Valdez Marine Terminal Oil Spill Prevention Audit, report prepared for Prince William Sound Regional Citizens Advisory Council, 2009.

EPA's Proposed Reissuance of General NPDES Permit for Facilities Related to Oil and Gas Extraction, comments prepared for the North Slope Borough, 2009.

Cape Simpson Oil Spill and Contaminated Site: Cleanup Action Requested, technical advice to the North Slope Borough, 2009-2010

Particulate Matter Emissions from In Situ Burning of Oil Spills, Alaska's In Situ Burning Guidelines, technical advice and comments prepared for Prince William Sound Regional Citizens Advisory Council, 2009

Arctic Multiple Oil and Gas Lease Sale for the Beaufort and Chukchi Seas, technical review and comments prepared for the North Slope Borough, 2008.

Current Offshore Waste Disposal Regulations, Permitting Process and Practices in Alaska Waters from Exploration and Production Operations, report prepared for the North Slope Borough, 2008.

Liberty Offshore Oil Production Plan, technical review for the North Slope Borough, 2008.

Northeast National Petroleum Reserve Alaska, Lease Sale Environmental Impact Statement and Lease Sale, technical support for Cooperating Agency participation in EIS preparation for the North Slope Borough, 2007-2008.

Oliktok Point Dredging Permit, technical review for the North Slope Borough, 2008.

Kuparuk Seawater Treatment Plant, Waterflood Operations, technical review for the North Slope Borough, 2008.

Lisburne Oil Production Facility Secondary Containment for Hydrocarbon Storage, technical review for the North Slope Borough, 2008.

Alpine Oil Development Oil Discharge Prevention and Contingency plan, technical review completed for support for the North Slope Borough, 2008.

UltraStar Exploration Drilling Program, technical review completed for the North Slope Borough, 2008.

EPA Vessel Discharge General Permit AK0808-13AA, comments prepared for Prince William Sound Regional Citizens Advisory Council related to crude oil tankers, 2008.

Oooguruk Oil Production Facility Development Plan, technical review for the North Slope Borough, 2008.

MMS Pipeline Regulations, Proposed Revisions to 30 CFR Part 250, 253, 254, 256, Oil and Gas and Sulfur Operations in the OCS – Pipelines and Pipeline Rights-of-Way, recommendations and comments prepared for North Slope Borough, 2008.

Valdez Marine Terminal Oil Spill Prevention and Contingency Plan, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2008.

Alpine Oil Development Master Plan Rezone Application, technical advice and reports to the North Slope Borough, 2006-2008.

Prudhoe Bay Oil Production Facility Reserve Pit Closures and Pad Abandonment, technical advice and reports to the North Slope Borough, 2008.

Strategic Plan for the NSB Wildlife Department, plan prepared for North Slope Borough, 2008.

Revision to Title 19, Oil and Gas Land Use Ordinance, recommendations prepared for the North Slope Borough, 2008-2010.

Shell Offshore Exploration Plan, Air Permit Appeal to Environmental Appeals Board and 9th Circuit Court, technical advice and reports to the North Slope Borough, 2008-2009.

Oil and Gas Infrastructure Risk Assessment for Alaska, comments prepared for the North Slope Borough, 2008.

Crude Oil Storage Tanks 9 & 10, Notice of Violation, Breach in Secondary Containment, Valdez Marine Terminal, technical advice to the Prince William Sound Regional Citizens Advisory Council, 2008.

Oil and Gas Facilities Operating on North Slope of Alaska, Air Pollution Inventory, prepared for the North Slope Borough, 2008.

Oil Spill Prevention and Response Training, conducted for the North Slope Borough, 2006-2010.

Coville Tank Farm Oil Discharge Prevention and Contingency Plan, technical review and comments prepared for the North Slope Borough, 2008.

Northstar Oil Facility Inspection and Audit, completed for the North Slope Borough, 2008.

XTO Energy Oil Discharge Prevention and Response Plan, prepared for XTO Energy's Cook Inlet Oil and Gas Production Operations, 2007.

Prudhoe Bay Oil Production Facility Flare Upgrade, technical review for the North Slope Borough, 2008.

Alpine Oil Facility Air Permit, comments prepared for the North Slope Borough, 2008.

BHP Billiton Tundra Damage and Spill Notices of Violation, technical advice to the North Slope Borough, 2008.

Kuparuk Oil Discharge Prevention and Contingency Plan, technical review and comments prepared for the North Slope Borough, 2007.

Meltwater Oil Production Operations, inspection and audit completed for support for the North Slope Borough, 2007.

Renaissance Umiat, LLC., Northeast National Petroleum Reserve- Alaska Exploration Program, technical review prepared for the North Slope Borough, 2007.

Ballast Water Treatment Facility Abatement of Hazardous Air Pollution, at Valdez Marine Terminal, technical advice and reports for Prince William Sound Regional Citizens Advisory Council, 2005-2009.

U.S. States Court of Appeals for the Ninth Circuit, Northwest Environmental Advocates, et al., Plaintiffs-Appellees; Petitioners, and the States of New York, et al. Plaintiff-Intervenors Appellees.-v.- US EPA Defendant-Appellant; Respondent and the Shipping Industry Ballast Water Coalition, Defendant-Intervenor Appellant, on Appeal from the US District Court for the Northern District of California, Brief of Amicus Curiae, for the Aleutians East Borough, technical support for Aleutians East Borough filing prepared by Walker and Levesque, LLC., 2006-2007.

Chevron North America Exploration and Production, North Slope Exploration Program "White Hills", technical advice and reports to the North Slope Borough, 2007.

City of Valdez Oil & Gas Tax Appeal, technical support to Walker & Levesque, LLC., 2006-2007.

Conoco Phillips Proposed Ultra Low Sulfur Diesel Facility, at Kuparuk River Unit CPF-3, technical analysis and recommendation prepared for North Slope Borough, 2006.

Application of Norway's Best Practices for Oil & Gas Operations to US Arctic Operations, report prepared for the North Slope Borough, 2008.

Air Strippers and Regenerative Thermal Oxidizers, proposal to install at Valdez Marine Terminal, technical review for Prince William Sound Regional Citizens Advisory Council, 2008.

Northstar Air Permit, technical review and comments prepared for the North Slope Borough, 2007.

Nikaitchuq Oil Development Plan, technical review completed for support for the North Slope Borough, 2006-2009.

Aleutians East Borough Title 40, Planning, Platting and Land Use Code Revision for Oil and Gas Exploration and Production Operations, technical advice to Aleutians East Borough, 2006-2007.

Natural Gas LNG North Slope Facility Proposal, technical review completed for support for the North Slope Borough, 2006.

Milne Point Unit Oil Discharge Prevention and Contingency Plan, technical review and comments prepared for the North Slope Borough, 2006.

Oooguruk Oil Production Facility Air Permit and Oil Spill Plan, technical review for the North Slope Borough, 2006.

Crude Oil Storage Tank 5, Alleged Integrity Concerns Preliminary Investigation, Valdez Marine Terminal, reports prepared for the Prince William Sound Regional Citizens Advisory Council, 2006 and 2007.

Proposed Changes to 11 AAC 83 Bonds and Plans for Dismantlement, Removal and Restoration of Oil and Gas Facilities, technical review and comments prepared for the North Slope Borough, 2006.

Non-indigenous Species Control Options and Risks Associated with Crude Oil Tanker Traffic, database of all technical and regulatory publications and research available, prepared for Prince William Sound Regional Citizens Advisory Council, 2006

Prudhoe Bay Oil Discharge Prevention and Contingency Plan, technical review and comments prepared for the North Slope Borough, 2006.

Petro-Canada (Alaska) Inc., Western NPR-A Exploration Drilling Program, technical review prepared for the North Slope Borough, 2006.

Crude Oil Storage Tank 16, Alleged Integrity Concerns Preliminary Investigation, Valdez Marine Terminal, report prepared for the Prince William Sound Regional Citizens Advisory Council, 2006.

DOT Pipeline Safety: Protecting Unusually Sensitive Areas from Rural Onshore Hazardous Liquid Gathering lines and Low-Stress Lines, comments prepared for the North Slope Borough, 2006.

Nikaitchuq Air Permit, technical review and comments prepared for the North Slope Borough, 2006.

Prince William Sound Oil Tanker Spill Prevention and Contingency Plan, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2007.

EPA's Proposed Regulations for Development of Clean Water Act National Pollutant Discharge Elimination System Permits for Discharges Incidental to the Normal Operation of Vessels, comments prepared for the North Slope Borough, 2007.

Fuel Storage Tank 55, Alleged Integrity Concerns Preliminary Investigation, Valdez Marine Terminal, report prepared for the Prince William Sound Regional Citizens Advisory Council, 2006.

Oil & Gas Exploration and Production Economic Opportunities and Capacity Building, report to the Aleutians East Borough, 2005.

Kuparuk Oil Facility Inspection and Audit, completed for the North Slope Borough, 2007.

Balboa Bay Regional Port Study Concept, LNG Tanker Terminal, prepared for Aleutians East Borough, 2007.

Alpine Oil Facility Inspection and Audit, completed for the North Slope Borough, 2007.

Surface Coal Mining Control and Reclamation Act Proposed Draft Regulations Title 11, Alaska Administrative Code, Chapter 90 (11 AAC 90), technical review and comments prepared for the North Slope Borough, 2007.

Crude Oil Storage Tank 93, Alleged Integrity Concerns Preliminary Investigation, Valdez Marine Terminal, reports prepared for the Prince William Sound Regional Citizens Advisory Council, 2006.

DeCola, E., T. Robertson, S. Fletcher, and S. Harvey, Offshore Oil Spill Response in Dynamic Ice Conditions: A Report to WWF on Considerations for the Sakhalin II Project, report to the World Wildlife Fund, 2006.

Savant Alaska, LLC Kupcake Prospect 2007 Exploration Well East of Endicott, technical advice to the North Slope Borough, 2005.

Prince William Sound Oil Tanker Tug Fleet Workshop and report, prepared for Prince William Sound Regional Citizens Advisory Council, 2006.

Crude Oil Storage Tank 1, American Petroleum Institute Tank Inspection Record Review, Audit and Corrosion Calculations, report prepared for Nuka Research and Planning Group, LLC., 2006.

Analysis of 1995-2005 Oil and Gas Facility Oil Spills on the North Slope of Alaska, report prepared for North Slope Borough, 2005.

Endicott and Badami Oil Discharge Prevention and Contingency Plan, technical review and comments prepared for the North Slope Borough, 2004.

Alpine Satellite Oil Development at CD-5, Bridge Construction and Pad Development, technical advice to the North Slope Borough, 2006-2008.

Valdez Marine Terminal, 203,000 Barrel Oil Spill Drill Evaluation, report prepared for Prince William Sound Regional Citizens Advisory Council, 2006.

Oil and Gas Bond Regulations, Proposed Changes to 11 AAC 83, comments prepared for the Aleutians East Borough, 2006.

Oil & Gas Lease Sales Brochure, prepared for the Aleutians East Borough, 2005.

Wastewater General Disposal Permit for Class I UIC Injection Wells, technical review and comments prepared for the North Slope Borough, 2005.

Oil & Gas Potential in the Aleutians East Borough, prepared for the Aleutians East Borough, 2005.

United States Air Force Oil Spill Response Training Manual and Training Program Implementation, prepared for and delivered to UASF under subcontract with Olgoonik Environmental Services, 2005-2007.

Oil and Gas Workshop, Cold Bay Alaska, conducted for the Aleutians East Borough, 2005.

Ballast Water Treatment Technology Options for Crude Oil Tankers, 15 Fact Sheets, prepared for Prince William Sound Regional Citizens Advisory Council, 2005

Alaska Peninsula Areawide Oil & Gas Lease Sale, Preliminary Best Interest Finding and Coastal Management Program Consistency Analysis, report prepared for the Aleutians East Borough, 2005.

Non-indigenous Species carried by Crude Oil Tankers into Prince William Sound, 17 Fact Sheets, prepared for Prince William Sound Regional Citizens Advisory Council, 2005

Armstrong Alaska, Inc. Oil Discharge Prevention and Contingency Plan for Rock Flour Prospect Drilling Program, technical review prepared for the North Slope Borough, 2005.

Proposed Changes to 18 AAC 75 Alaska's Oil and Hazardous Substances Pollution Control Regulations: Phase II Oil Spill Prevention, comments prepared for North Slope Borough, 2005-2006.

Preparing for Oil and Gas Development in the Aleutians East Borough: Potential benefits and impacts, prepared jointly under subcontract with Glenn Gray and Associates, for the Aleutians East Borough, 2005.

Minerals Management Service Outer Continential Shelf Five Year Oil and Gas Leasing Program 2007-2012, comments prepared for Aleutians East Borough, 2005.

Oil and Gas Economic Development, presentation to the Aleutian Pribilof Island Association, prepared for the Aleutians East Borough, 2005.

Valdez Marine Terminal Title V Air Quality Control Operating Permit No. 082TVP01, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2005.

Proposed Changes to 18 AAC 75 Alaska's Oil and Hazardous Substances Pollution Control Regulations: Phase II Oil Spill Prevention, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2005

Minerals Management Service Outer Continental Shelf Five Year Oil and Gas Leasing Program 2007-2012, comments prepared for North Slope Borough, 2005.

Oil and Gas Workshop, Nelson Lagoon Alaska, conducted for the Aleutians East Borough, 2005.

Alyeska Pipeline Service Company's Proposed Strategic Reconfiguration Project, Technical Review of Oil Terminal Crude Oil System, Internal Floating Roofs, Power Generation, Vapor Combustion, Ballast Water Treatment, Operation and Maintenance and Other Ancillary Systems, report prepared for Prince William Sound Regional Citizens Advisory Council, 2004

Harvey, S. L., MACT Standards Issued to Reduce Mercury Emissions from Mercury Cell Chlor-Alkali Plants, *Air Pollution Consultant*, Vol. 14, Issue 1, ISSN 1058-6628, 2004.

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Alaska Peninsula Areawide Oil & Gas Lease Sale, Mitigation Measure Recommendations, report prepared for the Aleutians East Borough, 2004.

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Oil and Gas Website for Upcoming Onshore and Offshore Oil and Gas Exploration, prepared for the Aleutians East Borough, 2004.

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Harvey, S. L., Final MACT Standards Issued for Iron and Steel Foundries, *Air Pollution Consultant*, Vol. 14, Issue 2, ISSN 1058-6628, 2004.

National Emission Standard for Hazardous Air Pollutants for Organic Liquid Distribution Facilities Petition for Review to EPA, prepared jointly with the Law Firm of Walker and Levesque, LLC. for Stan Stephens, 2004.

Harvey, S. L., Chevron to Spend $275 Million on Emission Controls in Settling Alleged CAA Violations, *Air Pollution Consultant*, Vol. 14, Issue 2, ISSN 1058-6628, 2004.

Harvey, S. L., Supreme Court Backs EPA's Authority to Overrule State BACT Determinations, *Air Pollution Consultant*, Vol. 14, Issue 3, ISSN 1058-6628, 2004.

Harvey, S. L., Final MACT Standards Issued for Boilers and Process Heaters, *Air Pollution Consultant*, Vol. 14, Issue 4, ISSN 1058-6628, 2004.

Harvey, S. L., MACT Standards Finalized for Plywood and Composite Wood Products Manufacturers, *Air Pollution Consultant*, ISSN 1058-6628, 2004.

Harvey, S. L., Santee Cooper to Spend $400 Million on Emission Controls to Settle Alleged Clean Air Act Violations, *Air Pollution Consultant*, ISSN 1058-6628, 2004.

Zubeck, H., Aleshire, L., Harvey, S.L. and Porhola, S., Socio-Economic Effects of Studded Tire Use in Alaska, University of Alaska School of Engineering Publication, jointly prepared with the University of Alaska, Institute of Socio-Economic Research, 2004

Harvey, S. L., EPA's Hazardous Air Pollutant Emission Limits for Copper Smelters Upheld by Federal Appeals Court, *Air Pollution Consultant*, ISN 1058-6628, 2004.

United States Air Force Oil Spill Response Training Manual and Training Program Implementation, prepared for and delivered to UASF under subcontract with Hoeffler Consulting Group, 2003-2004.

Cook Inlet Oil and Gas Lease Sale, Report and Lease Sale Documents, prepared under subcontract to Petrotechnical Resource Associates, for the Alaska Trust Land Office for Public Lease Sale Offering of Lands for Oil and Gas Exploration on the West Side of Cook Inlet, 2003

Analysis of Oil Spill Response Equipment Required by the State of Alaska for the Valdez Marine Terminal and the Prince William Sound Tanker Vessel Fleet, Tax Case and Appeal, report prepared for Walker & Levesque, LLC., 2003.

Harvey, S. L., Interim Final Rule Addresses "Sufficiency" of Monitoring Requirements in Operating Permits, *Air Pollution Consultant*, Vol. 13, Issue 1, ISSN 1058-6628, 2003.

Harvey, S.L., EAB Denies Review of PSD Permit for Michigan Power Company, Air *Pollution Consultant*, Vol. 13, Issue 1, ISSN 1058-6628, 2003.

Harvey, S.L., New Source Review Reform, *Air Pollution Consultant*, Vol. 13, Issue 2, ISSN 1058-6628, 2003.

Environmental Sensitivity Ranking Systems for the Cook Inlet Oil and Gas Lease Sale, Report, prepared under subcontract to Petrotechnical Resource Associates, for the Alaska Trust Land Office for Public Lease Sale Offering of Lands for Oil and Gas Exploration on the West Side of Cook Inlet, 2003

Harvey, S. L., Court Rules Notifications at Ohio Power Plant Should Have Undergone NSR, *Air Pollution Consultant*, Vol. 13, Issue 6, ISSN 1058-6628, 2003.

Valdez Marine Terminal Oil Spill Prevention and Contingency Plan, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2003.

Proposed Amendments to 18 AAC 75 Alaska's Oil and Hazardous Substances Pollution Control Regulations Phase 1: Oil Exploration and Production Facility Regulations, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2003.

Harvey, S. L., Final MACT Standards Issued for Refractory Products Manufacturing, *Air Pollution Consultant*, ISSN 1058-6628, 2003.

Hazardous Air Pollution Emission Estimate for the Valdez Marine Terminal, Ballast Water Treatment Facility, Oil Loading Tanker Terminal in Valdez Alaska, Appeal of EPA Rulemaking on the National Emission Standard for Hazardous Air Pollutants for Organic Liquid Distribution Facilities, prepared for Prince William Sound Regional Citizens Advisory Council, 2003

Trans-Alaska Pipeline System Pipeline Oil Discharge Prevention and Contingency Plan, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2003

Valdez Marine Terminal Oil Spill Prevention and Response Coordination Workgroup, technical support to Prince William Sound Regional Citizens Advisory Council, 2003-2010.

Proposed Amendments to 18 AAC 75 Alaska's Oil and Hazardous Substances Pollution Control Regulations Phase 1: Oil Exploration and Production Facility Regulations, comments prepared North Slope Borough, 2003

Harvey, S.L., Federal Facility to Be Assessed "Economic Benefit" and "Size of Business" Penalty for CAA Violations, *Air Pollution Consultant*, Vol. 12, Issue 7, ISSN 1058-6628, 2002.

Prince William Sound Oil Tanker Spill Prevention and Contingency Plan, comments prepared for Prince William Sound Regional Citizens Advisory Council, 2002.

Valdez Marine Terminal Air Quality Oversight Project, report prepared for Prince William Sound Regional Citizens Advisory Council, 2002.

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Curriculum Vitae

Objective: To provide diverse research and consulting services to nonprofit, government, legal and industry clients focusing on groundwater modeling, hydrogeology, environmental forensics and compliance, NEPA analysis, federal and state regulatory review, fluvial morphology and environmental and water policy.

Education

Years	Degree	University
1992-96	Ph.D. Hydrology/Hydrogeology	University of Nevada, Reno Dissertation: Stochastic Structure of Rangeland Streams
1990-92		University of Arizona, Tucson AZ Classes in pursuit of Ph.D. in Hydrology.
1988-90	M.S. Hydrology/Hydrogeology	University of Nevada, Reno Thesis: Stream Morphology, Stability and Habitat in Northern Nevada
1981-83		University of Colorado, Denver, CO Graduate level water resources engineering classes.
1977-81	B.S., Civil Engineering	University of Colorado, Boulder, CO

Special Coursework

Years	Course	Sponsor
2011	Hydraulic Fracturing of the Marcellus Shale	National Groundwater Association
2008	Fractured Rock Analysis	MidWest Geoscience
2005	Groundwater Sampling Field Course	Nielson Environmental Field School
2004	Environmental Forensics	National Groundwater Association
2004 and -5	Groundwater and Environmental Law	National Groundwater Association

Professional Experience

Years	Position	Duties
1993-Pr.	Hydrologic Consultant	Surface, groundwater and systems modeling, hydrogeology studies, stream restoration design, watershed modeling studies and expert testimony for industry, nonprofit groups, and government agencies.
1999-2004	Great Basin Mine Watch Executive Director	Responsible for reviewing and commenting on mining projects with a focus on groundwater and surface water resources, preparing appeals and litigation, writing reports about mining, fundraising, organizational development, supervision and personnel management.
1992-1997	University of Nevada, Reno Research Associate	Research on riparian area and watershed management including stream morphology, aquatic habitat, cattle grazing and low-flow and flood hydrology.
1990-1992	University of Arizona, Tucson Research and Teaching Assistant	Research on rainfall/runoff processes and climate models. Taught lab sections for sophomore level "Principles of Hydrology". Received 1992 Outstanding Graduate Teaching Assistant Award in the College of Engineering
1988-1990	University of Nevada, Reno Research Assistant	Research on aquatic habitat, stream morphology and livestock management.
1983-1988	US Bureau of Reclamation, Boulder City, NV Hydraulic Engineer	Performed hydrology planning studies on topics including floodplains, water supply, flood control, salt balance, irrigation efficiencies, sediment transport, stream morphology, flood frequency, rainfall-runoff modeling and groundwater balances.
1981-1983	Faulkner-Kellogg and Assoc., Lakewood Co Design Engineer	Basic drainage, grading and subdivision design. Flood control studies.

Representative Reports, Presentations and Projects

Myers, T., 2011. Hydrogeology of Cave, Dry Lake and Delamar Valleys, Impacts of pumping underground water right applications #53987 through 53092. Presented to the Office of the Nevada State Engineer On behalf of Great Basin Water Network.

Myers, T., 2011. Hydrogeology of Spring Valley and Surrounding Areas, Part A: Conceptual Flow Model. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Hydrogeology of Spring Valley and Surrounding Areas, Part B: Groundwater Model of Snake Valley and Surrounding Area. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Hydrogeology of Spring Valley and Surrounding Areas, PART C: IMPACTS OF PUMPING UNDERGROUND WATER RIGHT APPLICATIONS #54003 THROUGH 54021. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Rebuttal Report: Part 2, Review of Groundwater Model Submitted by Southern Nevada Authority and Comparison with the Myers Model. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T. 2011. Rebuttal Report: Part 3, Prediction of Impacts Caused by Southern Nevada Water Authority Pumping Groundwater From Distributed Pumping Options for Spring Valley, Cave Valley, Dry Lake Valley, and Delamar Valley. Presented to the Nevada State Engineer on behalf of Great Basin Water Network and the Confederated Tribes of the Goshute Reservation.

Myers, T., 2011. Baseflow Selenium Transport from Phosphate Mines in the Blackfoot River Watershed Through the Wells Formation to the Blackfoot River, Prepared for the Greater Yellowstone Coalition.

Myers, T., 2011. Blackfoot River Watershed, Groundwater Selenium Loading and Remediation. Prepared for the Greater Yellowstone Coalition.

Myers, T., 2010. Planning the Colorado River in a Changing Climate, Colorado River Simulation System (CRSS) Reservoir Loss Rates in Lakes Powell and Mead and their Use in CRSS. Prepared for Glen Canyon Institute.

Myers, T., 2010. Technical Memorandum, Updated Groundwater Modeling Report, Proposed Rosemont Open Pit Mining Project. Prepared for Pima County and Pima County Regional Flood Control District

Myers, T., 2009. Monitoring Groundwater Quality Near Unconventional Methane Gas Development Projects, A Primer for Residents Concerned about Their Water. Prepared for Natural Resources Defense Council. New York, New York.

Myers, T., 2009. Technical Memorandum, Review and Analysis of the Hydrology and Groundwater and Contaminant Transport Modeling of the Draft Environmental Impact Statement Blackfoot Bridge Mine, July 2009. Prepared for Greater Yellowstone Coalition, Idaho Falls, Idaho.

Myers, T., 2008. Hydrogeology of the Carbonate Aquifer System, Nevada and Utah With Emphasize on Regional Springs and Impacts of Water Rights Development. Prepared for: Defenders of Wildlife, Washington, D.C.. June 1, 2008.

Myers, T., 2008. Hydrogeology of the Muddy River Springs Area, Impacts of Water Rights Development. Prepared for: Defenders of Wildlife, Washington, D.C. May 1, 2008

Myers, T., 2008. Hydrogeology of the Santa Rita Rosemont Project Site, Numerical Groundwater Modeling of the Conceptual Flow Model and Effects of the Construction of the Proposed Open Pit, April 2008. Prepared for: Pima County Regional Flood Control District, Tucson AZ.

Myers, T., 2008. Technical Memorandum, Review, Record of Decision, Environmental Impact Statement Smoky Canyon Mine, Panels F&G, U.S. Department of the Interior, Bureau of Land Management. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno NV.

Myers, T., 2007. Groundwater Flow and Contaminant Transport at the Smoky Canyon Mine, Proposed Panels F and G. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno NV. December 11, 2007.

Myers, T., 2007. Hydrogeology, Groundwater Flow and Contaminant Transport at the Smoky Canyon Mine, Documentation of a Groundwater Flow and Contaminant Transport Model. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno NV, December 7, 2007.

Myers, T., 2007. Review of Hydrogeology and Water Resources for the Final Environmental Impact Statement, Smoky Canyon Mine, Panels F and G and Supporting Documents. Prepared for Natural Resources Defense Council, San Francisco, CA and Greater Yellowstone Coalition, Idaho Falls, ID. Reno, NV. December 12, 2007.

Myers, T., 2007. Hydrogeology of the Powder River Basin of Southeast Montana Development of a Three-Dimensional Groundwater Flow Model. Prepared for Northern Plains Resource Council. February 12 2007.

Myers, T., 2007. Hydrogeology of the Santa Rita Rosemont Project Site, Conceptual Flow Model and Water Balance, Prepared for: Pima County Flood Control District, Tucson AZ

Myers, T., 2006. Review of Mine Dewatering on the Carlin Trend, Predictions and Reality. Prepared for Great Basin Mine Watch, Reno, NV

Myers, T., 2006. Hydrogeology of Spring Valley and Effects of Groundwater Development Proposed by the Southern Nevada Water Authority, White Pine and Lincoln County, Nevada. Prepared for Western Environmental Law Center for Water Rights Protest Hearing.

Myers, T., 2006. Potential Effects of Coal Bed Methane Development on Water Levels, Wells and Springs of the Pinnacle Gas Resource, Dietz Project In the Powder River Basin of Southeast Montana. Affidavit prepared for Northern Plains Resource Council, April 4 2006.

Myers, T., 2006. Review of Hydrogeology and Water Resources for the Draft Environmental Impact Statement, Smoky Canyon Mine, Panels F and G, Technical Report 2006-01-Smoky Canyon. Prepared for Natural Resources Defense Council.

Myers, T., 2006. Review of Nestle Waters North America Inc. Water Bottling Project Draft Environmental Impact Report / Environmental Assessment. Prepared for McCloud Watershed Council, McCloud CA.

Myers, T., 2005. Hydrology Report Regarding Potential Effects of Southern Nevada Water Authority's Proposed Change in the Point of Diversion of Water Rights from Tikapoo Valley South and Three Lakes Valley North to Three Lakes Valley South. Prepared for Western Environmental Law Center for Water Rights Protest Hearing

Myers, T., 2005. Review of Draft Supplemental Environmental Impact Statement, Ruby Hill Mine Expansion: East Archimedes Project NV063-EIS04-34, Technical Report 2005-05-GBMW. Prepared for Great Basin Mine Watch.

Myers, T., 2005. Hydrogeology of the Powder River Basin of Southeast Montana, Development of a Three-Dimensional Groundwater Flow Model. Prepared for Northern Plains Resource Council, Billings, MT in support of pending litigation.

Myers, T., 2005. Nevada State Environmental Commission Appeal Hearing, Water Pollution Control Permit

Renewal NEV0087001, Big Springs Mine. Expert Report. Prepared for Great Basin Mine Watch, Reno NV.

Myers, T., 2005. Potential Effects of Coal Bed Methane Development on Water Levels, Wells and Springs In the Powder River Basin of Southeast Montana. Prepared for Northern Plains Resource Council, Billings, MT.

Myers, T., 2004. An Assessment of Contaminant Transport, Sunset Hills Subdivision and the Anaconda Yerington Copper Mine, Technical Report 2004-01-GBMW. Prepared for Great Basin Mine Watch.

Myers, T., 2004. Technical Memorandum: Pipeline Infiltration Project Groundwater Contamination. Prepared for Great Basin Mine Watch.

Myers, T., 2004. Technical Report Seepage From Waste Rock Dump to Surface Water The Jerritt Canyon Mine, Technical Report 2004-03-GBMW. Prepared for Great Basin Mine Watch.

Myers, T., 2001. An Assessment of Diversions and Water Rights: Smith and Mason Valleys, NV. Prepared for the Bureau of Land Management, Carson City, NV.

Myers, T., 2001. Hydrogeology of the Basin Fill Aquifer in Mason Valley, Nevada: Effects of Water Rights Transfers. Prepared for the Bureau of Land Management, Carson City, NV.

Myers, T., 2001. Hydrology and Water Balance, Smith Valley, NV: Impacts of Water Rights Transfers. Prepared for the Bureau of Land Management, Carson City, NV

Myers, T., 2000. Alternative Modeling of the Gold Quarry Mine, Documentation of the Model, Comparison of Mitigation Scenarios, and Analysis of Assumptions. Prepared for Great Basin Mine Watch. Center for Science in Public Participation, Bozeman MT.

Myers, T., 2000. Environmental and Economic Impacts of Mining in Eureka County. Prepared for the Dept. Of Applied Statistics and Economics, University of Nevada, Reno.

Myers, T., 1999. Water Balance of Lake Powell, An Assessment of Groundwater Seepage and Evaporation. Prepared for the Glen Canyon Institute, Salt Lake City, UT.

Myers, T., 1998. Hydrogeology of the Humboldt River: Impacts of Open-pit Mine Dewatering and Pit Lake Formation. Prepared for Great Basin Mine Watch, Reno, NV.

Peer-Reviewed Publications

Myers, T., in review. Potential contaminant pathways from hydraulically fractured shale to aquifers. *Ground Water*.

Myers, T., 2009. Groundwater management and coal-bed methane development in the Powder River Basin of Montana. *J Hydrology* 368:178-193.

Myers, T.J. and S. Swanson, 1997. Variation of pool properties with stream type and ungulate damage in central Nevada, USA. *Journal of Hydrology* 201-62-81

Myers, T.J. and S. Swanson, 1997. Precision of channel width and pool area measurements. *Journal of the*

American Water Resources Association 33:647-659.

Myers, T.J. and S. Swanson, 1997. Stochastic modeling of pool-to-pool structure in small Nevada rangeland streams. *Water Resources Research* 33(4):877-889.

Myers, T.J. and S. Swanson, 1997. Stochastic modeling of transect-to-transect properties of Great Basin rangeland streams. *Water Resources Research* 33(4):853-864.

Myers, T.J. and S. Swanson, 1996. Long-term aquatic habitat restoration: Mahogany Creek, NV as a case study. *Water Resources Bulletin* 32:241-252

Myers, T.J. and S. Swanson, 1996. Temporal and geomorphic variations of stream stability and morphology: Mahogany Creek, NV. *Water Resources Bulletin* 32:253-265.

Myers, T.J. and S. Swanson, 1996. Stream morphologic impact of and recovery from major flooding in north-central Nevada. *Physical Geography* 17:431-445.

Myers, T.J. and S. Swanson, 1995. Impact of deferred rotation grazing on stream characteristics in Central Nevada: A case study. *North American Journal of Fisheries Management* 15:428-439.

Myers, T.J. and S. Swanson, 1992. Variation of stream stability with stream type and livestock bank damage in northern Nevada. *Water Resources Bulletin* 28:743-754.

Myers, T.J. and S. Swanson, 1992. Aquatic habitat condition index, stream type, and livestock bank damage in northern Nevada. *Water Resources Bulletin* 27:667-677.

Zonge, K.L., S. Swanson, and T. Myers, 1996. Drought year changes in streambank profiles on incised streams in the Sierra Nevada Mountains. *Geomorphology* 15:47-56.

Selected Abstracts, Magazine and Proceedings Articles

Myers, T., 2006. Modeling Coal Bed Methane Well Pumpage with a MODFLOW DRAIN Boundary. In MODFLOW and More 2006 Managing Ground Water Systems, Proceedings. International Groundwater Modeling Center, Golden CO. May 21-24, 2006.

Myers, T., 2006. Proceed Carefully: Much Remains Unknown, *Southwest Hydrology 5(3)*, May/June 2006, pages 14-16.

Myers, T., 2004. Monitoring Well Screening and the Determination of Groundwater Degradation, Annual Meeting of the Nevada Water Resources Association, Mesquite, NV. February 27-28, 2004.

Myers, T., 2001. Impacts of the conceptual model of mine dewatering pumpage on predicted fluxes and drawdown. In MODFLOW 2001 and Other Modeling Odysseys, Proceedings, Volume 1. September 11-14, 2001. International Ground Water Modeling Center, Golden, Colorado.

Myers, T., 1997. Groundwater management implications of open-pit mine dewatering in northern Nevada. In Kendall, D.R. (ed.), Conjunctive Use of Water Resources: Aquifer Storage and Recovery. AWRA Symposium, Long Beach California. October 19-23, 1997

Myers, T., 1997. Groundwater management implications of open-pit mine dewatering in northern Nevada. In Life in a Closed Basin, Nevada Water Resources Association, October 8-10, 1997, Elko, NV.

Myers, T., 1997. Uncertainties in the hydrologic modeling of pit lake refill. American Chemical Society Annual Meeting, Las Vegas, NV, Sept. 8-12, 1997.

Myers, T., 1997. Use of Groundwater modeling and geographic information systems in water marketing. In Warwick, J.J. (ed.), Water Resources Education, Training, and Practice: Opportunities for the Next Century. AWRA Symposium, Keystone, Colo. June 29-July 3, 1997.

Myers, T., 1995. Decreased surface water flows due to alluvial pumping in the Walker River valley. Annual Meeting of the Nevada Water Resources Association, Reno, NV, March 14-15, 1995.*

Select Testimony in Litigation and Administrative Hearings

Northeast Natural Energy LLC v. City of Morgantown, Monongalia Circuit Court, Civil Action No. 11-C-411. 2011. Submitted to Deposition. Case dismissed on constitutional grounds.

Nevada State Engineer, Protest Hearing for Southern Nevada Water Rights Application, #s 53987-53992, 54003-54021. September 26 through November 14, 2011, Spring Valley, Cave Valley, Dry Lake and Delamar Valley. Testimony on behalf of protestants Great Basin Water Network, Confederated Tribes of the Goshute Reservation.

Nevada State Engineer, Protest Hearing for Southern Nevada Water Rights Application, #s 53987-53992, Cave Valley, Dry Lake, and Delamar Valley, NV. February 4 through February 14, 2008. Testimony on behalf of protestant Great Basin Water Network.

Cole et al v. J.M.Huber Corp. and William DeLapp. U.S. District Court for the District of Wyoming. Case No. 06-CV-01421. Written evidence reports and deposition. Case settled.

Nevada State Engineer, Protest Hearing for Southern Nevada Water Rights Application, #s, 54003-54021, Spring Valley, NV. Testimony on behalf of protestant Great Basin Water Network. September 11-26, 2006.

Nevada State Engineer, Protest Hearing for Southern Nevada Water Rights Application, #s, 54003-54021, Spring Valley, NV. Testimony on behalf of protestant Great Basin Water Network. September 11-26, 2006.

Montana 22nd Judicial District Court, Big Horn County. Diamond Cross Properties, LLC, and Northern Plains Resource Council, and Tongue River Water Users Association v. State of Montana, Pinnacle Gas Resources. Civil Cause No. DV 05-70. Affidavit provided.

Nevada State Engineer, Protest Hearing for Southern Nevada Water Rights Application, #s 72787 – 72797, Tickaboo/Three Lakes Basin. Testimony on behalf of Sierra Club, Indian Springs. November 28 – 30, 2005.

Earlier, several cases before the Nevada State Environmental Commission, on behalf of Great Basin Mine Watch.

CURRICULUM VITAE

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Born November 17, 1950

Education:

University of California, Santa Barbara, CA	B.S. Chemistry	1972
University of California, Davis, CA	Ph.D. Agricultural Chemistry	1977

Employment:

Univ. of Nevada, Reno	Aug-2009-present	Professor, and Director of the Graduate Program in Environmental Sciences
	2008-2009	On leave for 11 months serving as Manager, Environmental Exposure Assessment, Valent USA Corporation, Walnut Creek CA
	2007-2008, 2010-present	President UNR Nevada Faculty Alliance
	1995-2006	Director, Graduate Program in Environmental Sciences and Health
	1998-2004	Director, Center for Environmental Science and Engineering
	1989-	Professor
	1983-89	Associate Professor
	1979-83	Assistant Professor
	1978-79	Lecturer
Environmental Protection Agency	1977-78	Research Chemist

Professional Societies:

American Chemical Society, Agrochemicals Division and Environmental Division
American Association for the Advancement of Science
Society of Environmental Toxicology and Chemistry
Sigma Xi

Awards:

Thornton Peace Prize (1982)
Junior Faculty Research Award (1982)
UNR Foundation Professor (1991)
Conservationist of the Year, Nevada Wildlife Federation (1995)
College of Agriculture Researcher of the Year (1998)
Friend of the Lake Award, League to Save Lake Tahoe (2001)

Other Professional Activities

Environmental Protection Agency: Competitive Grants Review Panel 1985-1995
Environmental Protection Agency: Advisory Committee on Mining Waste 1991-1993
Environmental Protection Agency: Stakeholder Advisory Committee on Commodity Mercury 2007
Nevada Division of Environmental Protection: Technical Advisory Committee on the Carson River Superfund Site 1991-1994
American Chemical Society, Division of Environmental Chemistry: Chair of the Student Awards Committee 1988-1992
American Chemical Society, Division of Environmental Chemistry: Chair of the Awards Committee 1997-2002
UNR Environmental Studies Board: Chairman 1987-1991
UNR Environmental Science and Health Graduate Program: Director 1995-2006
Consultant to various public interest organizations, companies and law firms
Hydrology/Hydrogeology Graduate Faculty: Member 1989-present
Reviewer for numerous environmental chemistry journals
Co-owner and vice-president: Nevada Environmental Laboratories (Las Vegas and Reno) 1990-1999
Manager, Environmental Exposure Assessment, Valent USA Corporation 8/2008- 8/2009

Courses Taught

Humans and the Environment: Environment 100
Environmental Toxicology: NRES 432/632
Environmental Chemicals: Exposure, Transport and Fate: NRES 433/633
Analysis of Environmental Contaminants: NRES 430/630
Risk Assessment, NRES 793C
Global and Regional Issues in Environmental Science: NRES 467/667

Community and Conservation Service Activities

City of Reno, Charter Review Commission: Chairman 1990-93
Peavine Grade School PTA: Co-President 1990-1992
Sierra Club Mining Committee (national): Co-Chair 1989-1992
League to Save Lake Tahoe Board of Directors: 1986-1999
Mountain and Desert Research Fund: 1987-present
Dupont-Conoco Environmental Leadership Award in Mining Committee: 1989-1994
Nevada Interagency Reclamation Award Committee: 1990-1992
Washoe County School District Science Advisory Board: 1992-2000
Chairman, 1993-94
Earthwords: Board Member 1999-present
Tahoe Baikal Institute: Board Member 1998-present, Chair 2002-2003
Environmental Law Alliance Worldwide Board Member: 2000-present, Chair:2009
Great Basin Mine Watch: Board Member 1994-present, Chair 2001-2006
Center for Science in Public Participation: Board Member 1998-present
Great Basin Institute, Board Member 2000-present, Chair 2001-present
United Nations Environmental Program Committee for Development of a Code for Use of Cyanide in Mining: 2000-2002
Mining, Minerals and Sustainable Development, Assurance Group Committee Member, 2000-2002
National Research Council committee on Methyl Bromide: 1999-2001
National Research Council committee on Mining Technology: 2000-2002

National Research Council committee on USGS Mineral Resources Program, 2000-2003
US Environmental Protection Agency Committee on Management of Mercury Stores in the U.S. 2007

Research Interests: Remediation of mine waste contamination. Mining pit lake water quality. Fate and transport of organic compounds in soils and the atmosphere. Methods of remediation of gasoline contaminated soils; Photochemical transformation of organic contaminants on soil surfaces. Instrumental development of chromatographic systems.

Grants Received: (1982-present)

$ 14,550 "Atmospheric Photolysis of Pesticides," A Junior Faculty Research Award from the UNR Research Advisory Board, 1982.

$ 3,000 "Photolysis of CGA-41065," CIBA GEIGY Corporation, 1982.

$ 4,000 "Chemotaxonomy of Sagebrush Using High Performance Liquid Chromatography," Intermountain Research Station USDA, 1984.

$ 83,000 "Analysis of Bovine Tissue for Chlorinated Hydrocarbons," Environmental Protection Agency, 1984-85.

$ 18,300 "Photooxidation of Sulfide Containing Pesticides on Soil Surfaces," Western Regional Pesticide Impact Assessment Program, 1984.

$ 2,500 "Identification of Sagebrush Taxa Based on Liquid Chromatographic Analyses of Phenolics" Research Advisory Board, 1986.

$235,500 "Factors Affecting the Photolysis of Dioxins on Soil Surfaces," U.S. Environmental Protection Agency, 1986-89.

$ 15,160 "Vapor Phase Photolysis of Phorate," American Cyanamid Corporation, 1987.

$ 2,500 "Identification of Sagebrush Taxa Based on Liquid Chromatographic Analyses of Phenolics," UNR Research Advisory Board, 1987.

$ 48,792 "Upgrading Municipal Wastewater Effluents for Urban Water Reuse through Phytochemical Oxidations: System Development and Operational Criteria," U.S. Geological Survey, State Water Research Institute Program (Co-P.I. with Richard Watts), 1986-88.

$ 17,200 "Vapor Phase Photolysis of Malathion," American Cyanamid, 1988.

$ 16,460 "Aging Groundwater: A comparison of the Fluorocarbon Method to the Tritium Method," U.S. Geological Survey, State Water Research Institute Program (Co-P.I. with K. Sertic), 1988-89. (Competitive Grant, State of Nevada) Terminated 6-89.

$206,000 "In Situ Treatment of Organic Hazardous Wastes in Surface Soils Using Fenton's Reagent." U.S. Environmental Protection Agency (Co-P.I. with Richard Watts), 1988-89. (Competitive Grant, national)

$ 23,200 "Evaporation of Gasoline from Soils," Nevada Division of Environmental Protection Co-P.I. with Susan Donaldson), (Contract).

$ 50,000 "Photolysis of Pesticides on Soils," American Cyanamid Corporation (Unrestricted Grant, noncompetitive)

$ 15,600 "Vapor Phase Photolysis of Diazinon and Methyl Parathion" Western Region Pesticide Impact Assessment Program (USDA) (competitive) 1989-90

$ 30,000 "Interface for a Capillary electrophoresis Effluent and a Mass Spectrometer" Linear Corporation 1989-90. (Co P.I. with Murray Hackett) (contract)

$ 15,000 "UV-Gas Chromatographic Dectector" Linear Corporation 1990. (Co P.I. with Murray Hackett) (Noncompetitive grant)

$153,000 "Enhancement of Photodegradation of Pesticides in Soil by Transport Upward in Evaporating Water" (USGS Competitive) 1991-94

$ 50,000 "Pit Water from Precious Metal Mines" U.S. Environmental Protection Agency, 1992-94

$ 91,000 "Remediation of Acid Mine Drainage at Leviathon Mine" Lahontan Water Quality Control Board. (Contract, Co P.I. with Tom Wildman, Colorado School of Mines) 1992-94.

$159,000 " Ecological Toxicology of Metam Sodium and it Derivatives in the Terrestrial and Riparian Environments of the Sacramento River" California Fish and Game, 1992-1995 (G.C. Miller project, part of a larger project with George Taylor at the Desert Research Institute)

$43,092 “Atmospheric Transport and Deposition of Organophosphates and Other Pesticides as Input to Sierra Nevada Surface Waters” USDA-NRI. 1995-98. Co-P.I. with P.I. James N. Seiber. Task 2.

$80,427 “Linked Techniques for Contaminant Removal from Soil in Arid/Semiarid Environments” Dept. of Energy. 1993-96. Co.P.I with James N. Seiber.

$107,000 “Chemical Environmental Problems Associated with Mining” NIEHS 1993-96. Core B portion. This was a project of a larger Superfund Grant to UNR. James N. Seiber, P.I.

$36,900 “Protocol for Evaluation of Pesticide Photodegradation” Dow-Elanco. 1995-97. (Contract)

$45,000 “Photolysis of Pesticides” Dupont Chemical Company. 1995-98. Unrestricted gift to support ongoing research.

$275,000 “Remediation of Acid Mine Drainage at the Leviathan Mine”. Nevada Division of Environmental Protection. 1996-99

$5000 “Evaluation of Limnology and Water Quality of a Porphyry-Copper Pit Mine Lake” Public Resource Associates 1996.

$767,000 Geochemical, Biological and Economic Impacts of Arsenic and Related Oxyanions on a Mining-Impacted Watershed” NSF-EPA, 1997-01

$46,000 “Remediation of Acid Mine Drainage at the Leviathan Mine”. Lahontan Regional Water Quality Control Board, 2000-2001

$30,000 "Use of Sulfate-Reducing Bioreactors to Remove Zinc in Mine Drainage" Placer Dome Corporation. 2000-2001

$50,000 “Release of Gasoline Constituents from Marine Engines to Lake Tahoe” Lahontan Regional Water Quality Control Board, 1998-1999

$70,000 "Impact of Marine Engine Exhaust on Pyramid Lake" U.S. Environmental Protection Agency, in cooperation with the Pyramid Lake Paiute Tribe. 2000-2001.

$570,000 "An Environmental Assessment of the Impacts of Polycyclic Aromatic Hydrocarbons in Lake Tahoe and Donner Lake" California Regional Water Quality Control Board, Lahontan Region. 2001-2003.

$126,000 "Operation of a Bioreactor at the Leviathan Mine" Contract with ARCO, 2001-2002

$75,000 Trifluroacetic Acid in Antarctic Ice, National Science Foundation 2001-2004

$190,500 “Mercury Deposition Associated with Mining, U.S. Environmental Protection Agency, 2002-2004

$53,000 Passivation of Acid Generating Rock at the Golden Sunlight Mine, Placer Dome Corporation 2002-2003

$520,000 “Operation of a Bioreactor at the Leviathan Mine" Contract with ARCO, 2003-2007

$250,000 “Risk Assessment and Fate of Polyacrylamide and Acrylamide in Irrigation Canals and Receiving Water” A subcontract from the Desert Research Institute on a project from the U.S. Bureau of Reclamation. 2004-2008

$55,000 Passivation of Acid Generating Rock, Freeport McMoran, 2009-2010

$75,000 Biofuel crops on arid lands, Co-P.I. U.S. Department of Energy, 2010-2011

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Ralph L. Seiler

PROFESSIONAL EXPERIENCE

Hydrologist
1979-2010 (retired) U.S. Geological Survey Carson City, NV

- Principal investigator for numerous water-quality investigations of surface water and groundwater, including identifying sources of phosphorus in the Carson River, sources of nitrate and bacteria in groundwater, and sources and distribution of TCE in groundwater near a landfill on an Air Force Base in Utah.
- Principal investigator for USGS Fallon leukemia investigation of ground-water quality which involved working closely with CDC, ATSDR, and the State of Nevada. Participated in many public meetings with State and Federal Agencies to explain results of findings related to the presence of arsenic, tungsten, uranium, and polonium-210 in Fallon area groundwater.
- Author of journal articles describing geochemical processes that result in exposure of the public to toxic trace elements and radionuclides.

PUBLICATIONS

Seiler and Wiemels, *in review at Environmental Health Perspectives*. Occurrence of ^{210}Po and biological effects of low-level exposure: The need for research.

Seiler, 2011a, Physical setting and natural sources of exposure to carcinogenic trace elements and radionuclides in Lahontan Valley, Nevada. Chemical-Biological Interactions [Epub ahead of print DOI:10.1016/j.cbi.2011.04.004]

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EDUCATION

Ph.D. Environmental Chemistry
1996-1999 University of Nevada, Reno Reno, NV

B.S./M.S. Biology
1969-1975 University of Utah Salt Lake City, UT

Michele C. Adams, P.E.
LEED AP
Principal Water Resources Engineer

Meliora Environmental Design, LLC

Relevant Experience

Ms. Adams is a Principal Engineer and founder of Meliora Environmental Design. For more than 25 years, her work has encompassed environmentally sensitive site design and sustainable water resources engineering. Building on a multi-disciplinary approach, her work includes both master planning and design for campuses, urban restoration projects, commercial, industrial and residential installations, public facilities, and environmental education centers. In all her work, Ms. Adams seeks to combine sound engineering science with an understanding of natural systems. She is a frequent lecturer and educator on the topics of water and sustainability, and has provided technical expertise to clients ranging from watershed advocacy organizations to corporations. Ms. Adams was one of the principle authors of the Pennsylvania Stormwater Manual, and serves on the U.S. Green Building Council's Technical Advisory Group for Sustainable Sites. She frequently serves as an expert witness with regards to stormwater and water quality issues. Current design projects in which Ms. Adams is engaged include the following:

Stormwater Management for Green and Public Properties, City of Philadelphia: Led a team of engineers, landscape architects, and planners in developing stormwater designs for the City of Philadelphia public properties. The stormwater and landscape designs are intended to reduce impacts to the City's combined sewer system, provide economic cost savings, and promote green infrastructure. Projects have included parks, schools, recreation facilities, and "green streets". A number of projects have been documented through construction and are being (or have been) built.

Purdue University Stormwater Plan: Development of a Stormwater Plan for retrofitting an urban campus to implement an LID approach and incorporate green infrastructure to improve water quality and reduce stormwater runoff volumes. Protection and recharge of drinking water source (groundwater) and water quality protection is a key component of recommendations.

Purdue University Site and Stormwater Improvements at the Mackey Football Fields and Ross-Ade Stadium Parking Lot, West Lafayette, IN: Design of nearly 3 acres of infiltration beds located beneath the Purdue Boilmaker's football practice fields to manage stormwater for the upper campus athletic complex. At the Ross-Ade Stadium, design of bioretention systems to pre-treat runoff from the parking lot and bordering roadways, a drainage area of nearly 6 acres, before the system connects to the infiltration beds under the adjacent football practice fields.

Stroud Water Research Center Environmental Education Center, Academy of Natural Sciences, Avondale, PA: For one of the nation's premier water research and education facilities, provided sustainable site design engineering related to stormwater management including rain gardens, water reuse, and green roof.

U.S. Botanic Garden Bartholdi Park, Washington, D.C.: Designing stormwater management measures in the landscape to serve as demonstration sites as well as to demonstrate compliance with the new Federal Regulations for stormwater management as part of Section 438 of the Energy Independence and Security Act. The project is also seeking certification from the Sustainable Sites Initiative.

High Performance Landscapes, New York City Parks and Recreation: Ms. Adams served as one of four authors in development of the New York City's *High Performance Landscapes* document, specifically addressing water issues. This publication will be the third in the series that began with *High Performance Buildings*.

Special Qualifications

Twenty-five years of experience in civil and water resources engineering.

Sustainable site design engineering, including Stormwater Best Management Practices, Low Impact Development, (porous pavement, bioretention, tree trenches, vegetated roofs, etc) and alternative wastewater treatment systems (wetlands, drip irrigation, recirculating filters). Design for projects seeking LEED certification.

Watershed studies, computer modeling, stormwater sampling, stream flow monitoring, NPDES permit applications, mixing zone analyses, pollution prevention plans.

Professional Credentials

Bachelor of Science Civil Engineering
Pennsylvania State University, State College, PA, 1984

Graduate Coursework Water Resource Engineering
Villanova University, PA 1997-2001

Registered Professional Engineer in Delaware, Pennsylvania, Virginia, Maryland

LEED Accredited Professional

Waterview Recreation Center, City of Philadelphia and Pennsylvania Horticultural Society: For an existing urban recreation center, design of "green infrastructure" stormwater elements to improve community amenities and reduce combined sewer overflows. Elements include stormwater tree trenches, stormwater planter boxes, and a cistern for the community garden. *This project has recently been the subject of a GreenTreks video on stormwater.*

Greenstreets Design, East Falls: Led a team of design professionals (traffic engineers, landscape architects, pedestrian designers, stormwater engineers) in the design of a "complete" street for an urban neighborhood, including two design charettes with regulatory and design professionals from various city and state agencies. The goal was to develop a complete street that addressed stormwater, various transportation modes, and neighborhood greening and revitalization.

University of Pennsylvania Shoemaker Green, Philadelphia: Design of a passive open space on Penn's Campus that captures runoff generated by new and existing impervious surfaces into site and landscape features throughout the site. The project is also seeking certification from the Sustainable Sites Initiative.

Three Groves Ecovillage: Evaluating the Zoning Overlay for the proposed Ecovillage as well as designing the Water system, Wastewater Collection system, and stormwater measures for the site. Consisting of small residential buildings, community greenhouses, community buildings, natural pools, a constructed wetland treatment system, and bioswales, the proposed Ecovillage development is a model sustainable "green" neighborhood.

Philadelphia Zoo Master Plan: Development of water and environmental recommendations for the Zoo Master Plan, with focus on stormwater measures integrated into the Zoo's landscape to address flooding problems while promoting sustainability.

Greening and Stormwater Retrofits for Urban Schoolyards, Philadelphia: For two existing urbanized school yards (Greenfield School and Independence Charter School) that previously consisted only of asphalt, designed elements intended to both capture the first inch of runoff and provide greening, environmental education, and reduce heat island effects. Components include rain gardens, porous asphalt, porous pavers, and vegetated swales. *Greenfield School has recently been the subject of a GreenTreks video on stormwater.*

Stormwater Plans and Environmental Site Design Analysis for Maryland Projects: For the Chesapeake Bay Foundation and Audubon Society, Ms. Adams led an effort to evaluate various project sites in Maryland and provide recommendations and cost estimates for implementing landscape and stormwater measures to achieve the goals of Maryland's ESD process.

Okehocking Nature Center, Willistown Township, PA: Sustainable site design engineering for new Environmental Education Center, including stormwater management and wastewater treatment systems that are integrated with the natural landscape restoration.

Levin Tract Wooded Wetland Park, Radnor, PA: For the urbanized Radnor, PA area, developed a restoration concept design to convert an abandoned vacant parcel into a wooded wetland park area that will improve water quality from a 40-acre urban drainage area by creating a series of low, wooded wetland depressions and planting areas.

Professional Employment History

2007- Present
Principal Engineer and Founder
Meliora Environmental Design
Kimberton, PA

1997- 2007
Principal Engineer
Cahill Associates, West Chester, PA

1991-1997
Project Manager
Roy F. Weston, Inc., West Chester, PA

1984-1991
Project Engineer
Cahill Associates, West Chester, PA

Professional Memberships

U.S. Green Building Council – Sustainable Sites Technical Advisory Committee (SS TAG)

Member, American Society of Civil Engineers, Environmental Water Resources Institute

Member, Pennsylvania Association of Environmental Professionals

Member, American Water Resources Association

Visiting Guest Lecturer; University of Pennsylvania Schools of Architecture and Landscape Architecture; Philadelphia University, and Temple University

East Vincent Planning Commission Chairman

Ralston House, University of Pennsylvania: Design of stormwater elements to support an urban landscape restoration at an existing healthcare facility for the elderly.

Tyler Arboretum Path System: Designed a system of porous asphalt paths through an existing arboretum to improve access and address localized erosion problems.

Hershey Gardens Stormwater Plan: Developed program of rain gardens, wetlands, and restoration measures to address existing erosion and flooding problems.

North 3rd Street Corridor Sustainable Affordable Housing Plan, Philadelphia: With SMP Architects, designing guidelines for sustainable affordable housing, including stormwater measures to reduce combined sewer overflows and meet new City of Philadelphia ordinances.

Hamilton Children's Zoo at the Philadelphia Zoo: Design of site elements, including stormwater elements that provide educational opportunities, such as wetlands, green roofs, porous paths, and cisterns.

Oxford Library: Sustainable site design and engineering for a library addition to an urban library that includes porous pavers, rain gardens, and public outdoor gathering spaces to promote environmental education.

Mount Saint Joseph Academy Stormwater Improvements: With the Pennsylvania Horticultural Society, design of landscape-based restoration measures to improve stormwater management and educational opportunities at an existing school.

Chanticleer Garden: Stream daylighting of buried tributary and floodplain restoration.

Fire Engine 38: Site design of a new Fire Station in Philadelphia to include green roof, bioretention, and landscape restoration. Project will be LEED certified.

John Hopkins Sustainability House: Site design of a building at John Hopkins to create a Sustainability House and define sustainability criteria for University.

Stroud Model My Watershed: Providing technical expertise in the development of an educational watershed modeling tool being developed through funding from the National Science Foundation. Tool will allow interactive evaluation of development impacts on water balance and water quality, and allow alternative designs to be evaluated for benefits of groundwater restoration, stream health, and water quality.

Panther Hollow Watershed Restoration: Developing a watershed restoration plan which includes hydrologic modeling of the natural and existing conditions, using WinSLAMM, and design of two pilot projects to include elements such as an infiltration trench to capture adjacent street runoff, and retentive grading/infiltration berms to manage compacted lawn on a golf course.

For ten years prior to forming Meliora (1997 – 2007), Ms. Adams was a Principal Engineer with Cahill Associates, where she successfully directed and participated in all aspects of a number of projects.

Pennsylvania Stormwater Best Management Practices Manual, Pennsylvania DEP, co-author of State Manual describing structural and non-structural BMPs, Control Guidelines, calculation methodologies, and specifications, including a volume-based approach to stormwater.

Environmental and Stormwater Master Plan, UNC Chapel Hill, NC, Environmental master planning for sustainable stormwater approach to address large university expansion plan. Detailed hydrologic computer modeling performed in US EPA SWMM to evaluate existing infrastructure and recommend stormwater measures. Represented new LID approach in stormwater for UNC and was recognized by Sierra Club as a "Top Ten Building Better II" project.

Grey Towers National Monument, National Forest Service, Sustainable site design, including various stormwater measures for historic gardens, porous pavement, water and wastewater systems.

Washington National Cathedral, D.C., Restorative stormwater measures for Cathedral site and woods, including various infiltration measures (at source of runoff), infiltration for road system, channel stabilization, etc. Second phase included infiltration trenches integrated in to new outdoor amphitheater.

Mill Creek Community Garden and Clark Park Urban Stormwater Projects, Philadelphia, PA, Design of urban stormwater systems that collect runoff from City streets and infiltrate/manage water in urban green spaces such as community gardens and new basketball courts.

Cusano Center at John Heinz National Wildlife Refuge, Tinicum, PA, Sustainable site design for educational center, including various stormwater elements.

Springbrook Low Impact Development, Lebonon County, PA, Design of full LID stormwater system for 247 residential units in karst area, including over 120 individual stormwater systems (vegetated infiltration beds, infiltration trenches, rain gardens, porous pavements, etc.).

Bartrams Garden Master Plan, Philadelphia, PA, Restorative stormwater management recommendations for Master Plan of historic garden.

Regent Square Gateway, Nine Mile Run, Pittsburgh, PA, Concept and schematic design for urban stream and park "gateway".

Ford Rouge Stormwater Management, Dearborn, MI, Stormwater planning and design for major industrial facility re-development (Porous pavement, bioretention swales, vegetated systems).

Woodlawn Library, Wilmington, DE, Design of urban stormwater measures at new public library to reduce stormwater in combined sewers. Porous parking, bioretention, cisterns with re-use, stormwater planter boxes.

From 1991 through 1997, Ms. Adams was a Project Engineer and Project Manager at Weston.
Stormwater Management Programs and NPDES permitting Between 1992 and 1996, Ms. Adams developed and implemented stormwater management and sampling programs at over fifty industrial, commercial, and military facilities throughout the United States, including the Bureau of Engraving and Printing, Philadelphia International Airport, and various industrial facilities. These programs focused on reducing stormwater and water quality impacts from existing facilities.

Hydrologic, Hydraulic, and Mixing-Zone Modeling For a variety of watershed studies including Act 167 Plans, Ms. Adams conducted hydrologic and hydraulic modeling using various mathematical computer models, including USDA TR-20, EPA SWMM, and COE HEC models. Ms. Adams also performed floodway

Expert Testimony within Past Three Years

2010 **Blue Mountain Preservation Association vs Alpine Development Rose Resorts;** Pennsylvania Environmental Hearing Board. Expert witness on behalf of BMPA on issues related to stormwater management and water quality.

2010 **Koziell and Perrini vs Madison Township; Lackawanna Court of Common Pleas;** Expert witness on adverse stormwater impacts of road improvements.

June 2010 **West Vincent Zoning Hearing Board; Flather Property;** Testimony on behalf of Green Valleys Association and PennFuture related to impacts of **water** quality on variance request for stream buffer and wetland setback requirements.

Jan 2010 **West Pikeland Zoning Hearing Board;** Testimony on behalf of Green Valley Association related to impacts of water quality and stream health on variance requests to environmental ordinances.

2009/2010 **Tim and Jamie Lake vs The Hankin Group;** Court of Common Pleas Chester County; Expert witness on stormwater design and flooding.

2008-2009 **Crum Creek Neighbors vs DEP, et al;** Pennsylvania Environmental hearing Board; Expert witness on stormwater design review and impacts on flooding and water quality.

2007-2008 **Glenhardie Condominium vs. Realen Associates; Appeal of NPDES Post-construction Stormwater Management Permit;** Expert witness on behalf of Glenhardie related to stormwater design and flooding. Permit was withdrawn.

Expert Analysis and Comment within Past Three Years

2009/2010 **Pennsylvania Turnpike Expansion Project;** on behalf on National Park Service Valley Forge National Park and Valley Creek Coalition. Expert services related to review and comment of stormwater design and impacts on water quality and stream conditions.

2009/2010 **City of Philadelphia Longterm Control Plan;** on behalf of Natural Resources Defense Council and PennFuture; review of technical reports, policy documents, and draft permit conditions on issues related to stormwater management, water quality, stream health, and compliance with Clean Water Act and EPA Longtern Control Policy.

2010 **City of Chattanooga MS4 Permit**: For City of Chattanooga, providing technical guidance for incorporation of stormwater measures to address and restore impaired streams and meet TMDL requirements. Training sessions for municipal officials and program development.

Publications

Design for Flooding: Architecture, Landscape, and Urban Design for Resilience to Climate Change; By Donald Watson and Michele Adams; Wiley Publishing, Hardcover Nov 2010.

Park Design for the 21st Century: High Performance Landscape Guidelines; New York City Parks Department and NYC Design Trust; Nov 2010.

Porous Asphalt Pavement: 20 Years and Still Working, Michele Adams, Published in Stormwater Magazine May/Jun 2003

Presentations and Conference Proceedings

2010

Nov Greenbuild USGBC National Conference; New Directions in Stormwater Management and LEED
Nov AWRA National Conference; New Direction in Water Management
Oct Delaware Valley Green Building Council; New Directions in Stormwater Management in Philadelphia
Sep Pittsburgh Parks Conservancy; Michele Adams; "What's Going on in Panther Hollow" and examples of innovative engineering solutions to stormwater impacts on the watershed; Pittsburgh, PA
May "Sustainable Stormwater Management for Municipal Officials"; Lecture series for municipal officials sponsored by Brandywine Valley Association
Apr "Stormwater Management in Pennsylvania", Environmental Law Forum, Harrisburg, PA
Apr "Rainwater Management", Institute for Conservation Leadership
Mar "How to Challenge a Stormwater Permit and Win: A Look at the Crum Creek Neighbors Decision" Michele Adams, James Schmid, and John Wilmer; Schuylkill Watershed Congress; Pottstown, PA

2009

Dec "Bio-retention, Vegetative roofs, rain gardens, stormwater management" sponsored by East Nantmeal Township Environmental Council
Oct "Regenerative Urban Stormwater: Example Projects in the Philadelphia Region" Michele Adams and Susan McDaniels Pennsylvania Stormwater Conference; Villanova, PA
Oct Housing and Water: Syncing Neighborhood Development, Stormwater Management, and Water; AIA Design on the Delaware
Oct "Sustainability and Stormwater Management: Green Infrastructure" American Planning Association National Conference
Sept LID and Stormwater; 16th Annual Erosion Control Conference
May "Green Infrastructure and Urban Revitalization" Greening the Heartland Conference, Detroit, MI
May "Protecting Our Natural Resources: Design Leadership for the Next 100 Years" AIA National Conference, San Francisco.
May "Putting It Into Practice: Low Impact Development And Stormwater Management Training" Pennsylvania Land Conservation Conference
May "Reconnecting Water, Soils, and Vegetation: Stormwater Management in the Built Environment" ASLA PA/DE Annual Meeting.
Mar "Water, Soils, and Vegetation: Sustainable Site Design" Purdue University Sustainability Conference
Mar "Promoting LID Redevelopment in the Anacostia Watershed" Washington, DC

2008

Jan AIA/DVGBC, Philadelphia; Porous Pavement: How, Why, and When
Mar DVGBC Best of GreenBuild

2007

Nov USGBC GreenBuild, Chicago; Michele Adams; UNC Chapel Hill: A Campus-wide approach for Growth and Sustainability

Aug "Urban Stormwater and LEED"; Michele Adams, Energy Coordinating Agency of Phila; Demystifying LEED for Homes Event.

May "Low Impact Development: What's Important and What Should be Monitored"; Michele Adams and Wesley Horner; Tampa; 9th Conference on Stormwater Research & Watershed Management; Fla DEP

May "Low Impact Development"; Wesley Horner and Michele Adams; ASCE EWRI World Environmental &Water Resources Congress; Conference; Orlando, Fla

April "Integrating Sustainable Stormwater into the Campus"; Michele Adams and Thomas Cahill; Baltimore, MD; Smart and Sustainable Campuses Conference, EPA/Society for College and University Planning.

April; "Stormwater Management at UNC Chapel Hill: A Plan for Growth and Sustainability"; Jill Coleman, UNC, and Michele Adams; Wilmington, NC, 2nd National Low Impact Development Conference

April "Using the BMP Manual to Meet NPDES Requirements"; Michele Adams; State College, PA; Chesapeake Bay Foundation Confluence 2007, Connecting Communities to Creeks.

March "Porous Pavements"; Michele Adams, Public information session hosted by the City of Wichita

2006

Nov "Urban Stormwater BMPs: Finding Space for Stormwater in the Urban Environment", Michele Adams; Baltimore, MD; AWRA 2006 Annual Water Resources Conference

Nov "Sustainable Site Design"; Michele Adams; Philadelphia, PA; Design on The Delaware AIA Regional Conference

Sept "Stormwater Site Design: porous Asphalt and Other Innovative Stormwater Techniques"; Michele Adams; Kansas City, MI; American Public Works International Congress and Exposition

Sept "Sustainable Stormwater Management"; Michele Adams; Pittsburgh, PA; 3 Rivers Wet Weather 8th Annual Sewer Conference

Sept "Regent Square Gateway Vision for Nine Mile Run"; Marijke Hecht and Michele Adams; University of Pittsburgh, PA

Sept "The Etowah Habitat Conservation Plan and Runoff Limits"; Michele Adams; Atlanta, GA; Public workshops sponsored by Etowah Watershed Organization and the River Basin Center Institute of Ecology University of Georgia.

June Blair County LID Workshop; Michele Adams; Hollidaysburg, PA;

June Penn State Visitor Center LID Design; Michele Adams; State Colege, PA; Penn State Computational Methods in Stormwater Management

May "Rams Head Extensive Green Roof Design at UNC Chapel Hill"; Andrew Potts and Michele Adams; Boston, MA; Green Roofs for Healthy Cities Conference

May Penn State Visitor Center LID Demonstration Tour; Michele Adams; Pennsylvania Association of Environmental Professionals.

Mar "Porous Asphalt Pavement: The Right Choice"; Michele Adams; Orlando, FLA; NAPA World of Asphalt

Jan "Sustainable Stormwater Management"; Michele Adams; Atlantic City, NJ; NJ ASLA Annual Meeting
Various Dates and Locations in PA: Stormwater Management Workshops for Municipal Officials and Engineers; Sponsored by the Pennsylvania Environmental Council

2005

Dec "Sustainable Design in Our Communities"; Michele Adams and Tavis Dockwiller; Sturbridge, MA; presented by Green Valleys Institute

Nov "Designing Bio/Infiltration Best Management Practices for Stormwater Quality Improvement"; Michele Adams; Madison, WI; University of Wisconsin Professional Development Course

Oct "Springbrook: Residential LID in a Limestone Area; Andrew Potts and Michele Adams; Villanova, PA; 2005 Pennsylvania Stormwater Management Symposium

July "Sustainable Site Design"; Michele Adams; Trenton, NJ; AIA NJ Tectonics of Sustainable Design

June Penn State Visitor Center LID Design; Michele Adams; State Colege, PA; Penn State Computational Methods in Stormwater Management

April "Urban Stormwater BMPs: Finding Space for Stormwater in the Urban Environment"; Wesley Horner and Michele Adams; Tampa, FLA; 8th Biennial Conf on Stormwater Research & Management.

Mar "Sustainable Site Design"; Michele Adams and Tavis Dockwiller; sponsored by Fulton County, PA

Ruth Ayn Sitler, P.E.
Water Resources Engineer

Meliora Environmental Design, LLC

Relevant Experience

Ms. Sitler is a Water Resources Engineer at Meliora Environmental Design with over seven years of civil engineering experience that includes low impact development and sustainable stormwater management design. To date, her experience has provided her with a vast multi-disciplinary background from which to draw for innovative design projects of all scopes and sizes, and includes commercial and residential construction, educational facility construction, stream restoration projects, abandoned mine reclamation, and pavement management and design. Ms. Sitler also has experience in environmental permitting as well as local government operations.

Current designs in which Ms. Sitler has been engaged include the following:

Greenstreets Design, East Falls: Part of a team of design professionals (traffic engineers, landscape architects, pedestrian designers, stormwater engineers) in the design of a "complete" street for an urban neighborhood, including two design charettes with regulatory and design professionals from various city and state agencies. The goal was to develop a complete street that addressed stormwater, various transportation modes, and neighborhood greening and revitalization.

Three Groves Ecovillage: Evaluating the Zoning Overlay for the proposed Ecovillage as well as designing the Water system, Wastewater Collection system, and stormwater measures for the site. Consisting of small residential buildings, community greenhouses, community buildings, natural pools, a constructed wetland treatment system, and bioswales, the proposed Ecovillage development is a model sustainable "green" neighborhood.

Panther Hollow Watershed Restoration: Developing a watershed restoration plan which includes hydrologic modeling of the natural and existing conditions, using WinSLAMM, and design of two pilot projects to include elements such as an infiltration trench to capture adjacent street runoff, and retentive grading/infiltration berms to manage compacted lawn on a golf course.

Philadelphia Zoo Master Plan: Development of water and environmental recommendations for the Zoo Master Plan, with focus on stormwater measures integrated into the Zoo's landscape to address flooding problems while promoting sustainability.

Special Qualifications

Seven years of experience in civil and water resources engineering.

Sustainable civil/site design engineering, including Stormwater Best Management Practices, Low Impact Development, (porous pavement, bioretention, etc).

Integrated water resource planning; regional watershed planning; computer modeling; environmental , transportation, and construction permitting; local ordinance development and implementation.

Professional Credentials

Post-Graduate Coursework
Coastal Engineering
Old Dominion University, VA
2012-present

Master of Engineering
Environmental Engineering
Pennsylvania State University, PA, 2007

Bachelor of Science
Civil Engineering Technology
Pennsylvania College of Technology, PA 2004

Registered Professional Engineer in Pennsylvania

Certified Surveyor-in-Training in Pennsylvania

Professional Employment History

2011- Present
Water Resources Engineer
Meliora Environmental Design
Phoenixville, PA

Expert Testimony within Past Three Years

Jan 2012 **London Grove Zoning Hearing Board;** Testimony on behalf of Three Groves Ecovillage Development, L.P., related to site design engineering components and conformance to local ordinance standards for conditional use approval.

2010 **Butler County Act 167 Stormwater Management Plan Public Hearing;** Testimony on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Butler County Act 167 Stormwater Management Plan.

2010 **Crawford County Act 167 Stormwater Management Plan Public Hearing;** Expert witness on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Crawford County Act 167 Stormwater Management Plan.

2010 **Mifflin County Act 167 Stormwater Management Plan Public Hearing;** Testimony on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Mifflin County Act 167 Stormwater Management Plan.

2010 **Montour County Act 167 Stormwater Management Plan Public Hearing;** Testimony on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Montour County Act 167 Stormwater Management Plan.

2010 **Potter County Act 167 Stormwater Management Plan Public Hearing;** Expert witness on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Potter County Act 167 Stormwater Management Plan.

2010 **Venango County Act 167 Stormwater Management Plan Public Hearing;** Expert witness on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Venango County Act 167 Stormwater Management Plan.

2010 **Warren County Act 167 Stormwater Management Plan Public Hearing;** Testimony on behalf of the Pennsylvania Department of Environmental Protection related to the adoption and implementation of the Warren County Act 167 Stormwater Management Plan.

2008-2011
Civil Engineer Manager and Sr. Civil Engineer
Comm. of Pennsylvania:
PA Dept. of Env. Prot.
(Bur. of Aban. Mine Rec.)
(Bur. of Watershed Mgmt.)
PA Dept. of Transportation
(Bur. of Maint. And Oper.)
Harrisburg, PA

2006-2007
Project Manager
Navarro & Wright Consulting Engineers, Inc.
New Cumberland, PA

2006-2006
Project Designer
Raudenbush Engineer, Inc.
Middletown, PA

2005-2005
Project Designer
Morris & Ritchie Associates
York, PA

2004-2005
Transportation Engineer I
Buchart-Horn, Inc.
York, PA

Professional Memberships

Member, American Society of Civil Engineers, Environmental Water Resources Institute

Expert Analysis and Comment within Past Three Years

2011 **AML-1: The Abandoned Mine Land Inventory Manual;** on behalf of the Pennsylvania Department of Environmental Protection, Bureau of Abandoned Mine Reclamation; Technical review and comment of revisions to the Department of interior, Office of Surface Mining's regulatory standards for addressing abandoned mine lands.

2011 **Alternate Pavement Type Bidding**: on behalf of the Pennsylvania Department of Transportation, Bureau of Maintenance and Operations; Expert analysis of alternate pavement type bidding policies as implemented on highway design projects in Pennsylvania.

Publications

Streambank Stability: Modeling Channel Evolution and Pollutant Transport in an Urban Stream; Ruth A. SItler; Pennsylvania State University, Masters Paper; Dec 2010.

Geographic Variability of Rainfall Erosivity Estimation and Impact on Construction Site Erosion Control Design; Shirley E. Clark, Aigul Allison, and Ruth A. Sitler; *Journal of Irrigation and Drainage Engineering*; American Society of Civil Engineers; July 2009.

Special Experimental Project No. 14 (SEP-14) Alternate Pavement Type Bidding Initial Report; Pennsylvania Department of Transportation and the Federal Highway Administration; Feb 2011.

Porous Asphalt Pavement: 20 Years and Still Working, Michele Adams, Published in Stormwater Magazine May/Jun 2003

Presentations and Conference Proceedings

2011

Sep Low impact Development Symposium; Ruth A. Sitler; "Impact of the Rainfall Event Method on the Water Capture Quantity Efficieny of Bioretention Devices"

May 2011 World Environment & Water Resources Congress; Ruth A. Sitler and Shirley E. Clark; "Impact of Bioretention Design of the Calculation Method for the 95th Percentile Rain Event"

2009

Mar "Act 167 Stormwater Management;" Harrison City, PA

May 2009 World Environment & Water Resources Congress; Christine Y. Siu, Shirley E. Clark, Ruth A. Sitler and Katherine Baker; "Looking Upstream and Into the Watershed for the Big Picture of Stream Health"

June "Act 167 Stormwater Management – Municipal Implementation Models;" Mercer, PA

July "Introduction to Hydrologic Modeling with HEC-HMS;" Harrisburg, PA
"Building a Project and Running a Simulation with HEC-RAS;" Harrisburg, PA

Oct 2009 Pennsylvania Stormwater Management Symposium; Ruth A. Sitler, Aigul Allison, and Shirley E. Clark; "Geographic Variability of Rainfall Erosivity Estimation and Impact on Construction Site Erosion Control Design"

2008

Feb "Small Watershed Hydrology Modeling with WinTR-55;" Middletown, PA
"AutoCAD;" Middletown, PA
Mar "Erosion Control and NPDES Permitting;" Middletown, PA
Apr "Introduction to HEC-RAS;" Middletown, PA
"HEC-HMS: The Hydrologic Engineering Center's Hydrologic Modeling System;" Middletown, PA
May "Planning to Protect Water Resources: Stormwater Management;" Hershey, PA
Sep "Understanding the Regulatory Environment: DEP Headwaters Initiatives and Stormwater BMPs;" Monroeville, PA
Oct "Integrated Water Resource Planning through Act 167;" Harrisburg, PA
Nov "Stormwater Management: Act 167 and Its Implementation;" Harrisburg, PA

2007

Mar "Engineering Overview of Erosion Control and NPDES Permitting in Central Pennsylvania;" New Cumberland, PA
Oct 2007 Pennsylvania Stormwater Management Symposium; Ruth A. Sitler and Shirley E. Clark; "Streambank Stability: Modeling Channel Evolution and Pollutant Transport in an Urban Stream"

NIEK VERAART, AICP, ASLA Project Manager

Mr. Veraart is vice president with LBG with more than 20 years of diverse experience in environmental planning, including EIS in accordance with NEPA, SEQRA and CEQR and other environmental statutes. His environmental planning assignments have encompassed a wide range of projects, including transportation infrastructure (airports, highways, ports, rail/transit) industrial facilities (solid waste management, energy, water and wastewater facilities), large-scale development projects (residential, commercial, mixed use, recreational and transit-oriented development), ecological and sustainable development (watershed management, LEED compliance, waterfront restoration, wetland banking) and cultural resources (memorials, tourist attractions, national parks). He is familiar with regulatory requirements at federal, state, and local levels and has integrated such requirements on multilevel environmental documents, including such high-profile assignments as the World Trade Center Memorial and Redevelopment GEIS. Mr. Veraart is especially familiar with construction impacts and assisted federal and state agencies with the development of Environmental performance Commitments (EPCs) for the rebuilding of Lower Manhattan. Mr. Veraart is familiar with upstate watershed issues through his completion of several SEQRA assignments, including an EIS for the Hackensack River in Clarkstown, New York; infrastructure improvements for the Bear Mountain Bridge (for NYSDOS); and the EIS for Kensico Watershed Water Pollution Control Program (for NYCDEP). Mr. Veraart's experience with third-party EIS review is extensive and includes multiple EISs for US Army Corps of Engineers, EIS review for local public interest environmental organizations and for the New York State Public Service Commission.

Several of the projects led by Mr. Veraart have received prestigious state and national awards. Mr. Veraart has presented at national conferences on subjects of environmental planning and his research contributions in the transportation and environmental planning fields have been published by the National Academy of Sciences, Transportation Research Board.

FIRM Louis Berger Group

EDUCATION
- MS, Regional Planning and Land Planning
- BS, Land Planning and Landscape Architecture

REGISTRATIONS / CERTIFICATIONS
- American Institute of Certified Planners
- American Society of Landscape Architects
- American Society of Civil Engineers, Affil.
- International Association for Impact Assessment

YEARS EXPERIENCE 24
YEARS WITH FIRM 16

RELEVANT PROJECT EXPERIENCE

Lower Manhattan Development Corporation (LDMC), GEIS for World Trade Center Memorial and Redevelopment Plan (SEQRA, NEPA EIS), New York, New York. Project director. Mr. Veraart directed LBG's work for the WTC GEIS, which was co-prepared by LBG with another consulting firm. Under Mr. Veraart's direction, transportation analyses were conducted for the redevelopment of the World Trade Center site and construction scenarios were developed for input into the Traffic, Air Quality and Noise analyses. The GEIS process for this high-profile; complex project was completed within a record time of 12 months from the start of environmental review. Mr. Veraart also directed noise, infrastructure, utilities as well as issues of cumulative impacts.

US Army Corps of Engineers New York District, Third-Party EIS, Meadowlands Mills Regional Mall, Bergen County, New Jersey. Project director. Mr. Veraart was Task manager for the independent third-party review of the developer's EIS and preparation of a federal FEIS and Section 404(b) Permit Alternatives Analysis for the development of a 600-acre site for the construction of a mixed use regional mall, office and recreation complex, located three miles from New York City. The project would involve the filling of approximately 200-acres of wetlands and extensive wetland creation and enhancement.

US Army Corps of Engineers New York District, Meadowlands Comprehensive Restoration Implementation Plan Programmatic Environmental Impact Statement, New Jersey. Provided QA/OC review of the Programmatic Environmental Impact Statement (PEIS) for the Meadowlands Comprehensive Restoration Implementation Plan (MCRIP). The PEIS provides an evaluation of environmental, social and economic issues and alternatives to achieve project goals and objectives, while avoiding/minimizing adverse impacts, providing the USACE with the necessary NEPA compliance documentation for MCRIP implementation. The PEIS is a comprehensive document that considers a number of related actions proposed in the MCRIP, including cumulative, direct, and indirect impacts.

New York City Department of Environmental Protection, Kensico Watershed Water Quality Sustainable Management Plan EIS, Westchester County, New York. Project manager. The EIS evaluated the beneficial effects on water quality resulting from several alternative measures, including the development of stormwater Best Management Practices (BMPs), such as wetland basins, streambank stabilization and waterfowl management. Pollutant reductions were subsequently modeled for each of the streams and subwatershed discharging into the Kensico Reservoir. Transport of contributing pollutants within the reservoir and to the water intakes was then modeled. In addition to the evaluation of the effectiveness of various program alternatives, their impact on the environment was assessed,

including socioeconomic and ecological impacts.

Metropolitan Transportation Authority New York City Transit, Fulton Street Transit Center NEPA EIS, New York, New York. Project director. Directed the preparation of the FEIS and Section 4(f) for the $1.4B federally funded Fulton Street Transit Center (FSTC) in Lower Manhattan. Mr. Veraart supervised the approach to alternatives analysis and cumulative effects analysis and supervised preparation of technical assessment of environmental impacts, including traffic and transportation, air, noise, socio-economic analyses and the analysis of adaptive reuse of the historic Corbin Building in Lower Manhattan. A key aspect of the analysis was the assessment of cumulative impacts of the FSTC and other Lower Manhattan Recovery Projects. Mr. Veraart presented the analysis of cumulative construction in Lower Manhattan to a National Panel of government agencies under auspices of the FTA.

US Department of Agriculture, Final Environmental Impact Statement (FEIS - SEQRA, NEPA) Gull Hazard Reduction Program, JFK International Airport, Jamaica, New York. Project manager. Managed the preparation of the SEQRA/NEPA EIS for the implementation of the Gull Hazard Reduction Program at JFK International Airport in New York City.

Parcel B EIS Third-Party Review and Environmental Support Services, Purchase Environmental Protection Association, Purchase, New York. Project manager. Analyzed SEQRA documentation submitted for an office development in Purchase, New York. The expert review team lead by Mr. Veraart reviewed all relevant aspects of the analyzed by the developer and identified numerous deficiencies and inaccuracies in the environmental documentation, including historic resources (impacts on Olmstead landscapes and resources listed on the State/National Register of Historic Places), flooding and stormwater management, incompatibility with zoning regulations, density inconsistencies, traffic safety and congestion issues, ecological impacts and direct and indirect wetland impacts.

Dormitory Authority of the State of New York (DASNY), Chenango Countywide 911 Communications Upgrade EIS, Chenango County, New York. Project Director. Led the preparation of the SEQRA EIS. The project included a GIS-based viewshed analysis of tower visibility. The viewshed analysis included the identification of sensitive resources (e.g. parks and historic areas) within five miles of each tower. The project objective was to improve emergency services communication capabilities through the construction of six radio communication antenna towers and ancillary infrastructure, and upgrades to facilities at an additional three sites

US Army Corps of Engineers New England District, South Coast Rail Project Third-party NEPA EIS (in progress), Massachusetts. Project manager. Mr. Veraart is managing the preparation of an Alternatives Analysis and NEPA EIS for new 60-mile transit service between Boston and the south coast of Massachusetts, including New Bedford and Fall River. Alternatives being evaluated include Bus Rapid Transit and rail. Key impact areas addressed included wetlands, water resources, threatened and endangered species, noise and vibration and coordination with Native American tribes.

Township of Randolph, Third-Party Environmental Review and Site Suitability Analysis Services, Randolph, New Jersey. Project manager. Conducted an independent third-party review of the environmental documentation for the 154-acre Nitti Mountain development project in the Township of Randolph, New Jersey. The review assessed all applicable resources including soils, geology, wetlands, hydrology, slopes/engineering, ecology; land use and zoning, landscape and visual, traffic/circulation and access, cultural resources and socioeconomic impacts. The report provided comments and recommendations regarding technical methodologies, data gaps and data quality, compliance with applicable regulations and appropriateness, projected cost and feasibility of proposed mitigation measures.

City of New City, New York, FEIS, Hackensack River Natural Area Improvement and Flood Management Project, Clarkstown, New York. Project director. Mr. Veraart directed the preparation of the FEIS for flood control measures in the Hackensack River. Flood control measures include the construction of backwater prevention berms, dredging of river sediment and widening of the river in order to improve flow.

NYS Bridge Authority, EA (SEQR) Bear Mountain Bridge Rehabilitation, Bear Mountain,

New York. Project director. Directed environmental permitting and regulatory issues for rehabilitation of the Bear Mountain Bridge across the Hudson River.

Port Authority of New York and New Jersey, Newark Liberty International Airport, Terminal A NEPA Draft Environmental Assessment. Newark. New Jersey. Project manager. Preliminary Environmental Assessment for construction of a new Terminal A facility, including a 1.3 million sf. airport terminal building, surrounding site conditions, including streams and wetlands, roadways and airside facilities. The EA was prepared in close coordination with sustainable planning and design efforts ongoing concurrently towards a LEED certified facility.

LMDC and the National September 11 Memorial & Museum, Pedestrian Simulation Modeling - World Trade Center (WTC) Memorial, New York, New York. Project director. Oversaw the development of origin/destination projections for pedestrian travel patterns on the World Trade Center (WTC) Memorial including the plaza, visitor's center, and museum and the entire WTC Site for the opening year and stabilized year of the WTC Memorial on both a weekday and Saturday. Also developed assumptions for the development program, pedestrian profiles, pedestrian itineraries, and site demand projections. The projected pedestrian movements were modeled to determine if adequate space would be provided for pedestrians based upon the site design and site plan

State University of New York at Binghamton. New Student Housing, State. Town of Vestal, Broome County, New York. Project Director. Directed the preparation of a SEQRA EAF and Supplemental Studies for replacing the 40 years old Newing and Dickinson residence buildings with new buildings to accommodate approximately 3,000 students on the East Campus of Binghamton University. The impact assessments focused on a matrix of potentially affected environmental resources, including storm water/wastewater infrastructure, threatened and endangered species, air quality, and noise.

American Marine Rail, LLP, Dredge Permitting, SEQR Environmental Assessment Statement. And Facility Plan Development. American Marine Rail Intermodal Transfer Terminal, Bronx, New York. Project director. Managed the development of facility layout and directed preparation of permits and state and city environmental regulatory review for a 5,200 tons-per-day intermodal barge-to-rail facility solid waste transfer station. Mr. Veraart supervised the preparation of a Title 6 NYCRR Part 360 Solid Waste permit application to the New York State Department of Environmental Conservation (NYSDEC), a Joint Tidal Wetland Permit from the NYSDEC and the USACE and air quality compliance, as well as compliance with other regulatory requirements**.**

South Jersey Transportation Authority (SJTA) Alternative Energy Vehicle Deployment Plan. Project Director. Directed the preparation of an AEV deployment plan for SJTA, pursuant to the SJTA Alternative Energy Management Plan, prepared by The Louis Berger Group for SJTA. Specific four areas included evaluation of Alternative Energy sources for the SJTA fleet and operations, as well as users of SJTA facilities. Alternative energy sources evaluated include electric, Compressed Natural Gas (CNG), biodiesel and hydrogen.

National September 11 Memorial, Economic Impact of National September 11 Memorial. Project director. Directed the study to analyze impact of the National September 11 Memorial operations on the economy of New York City, New York State and the U.S. Impacts are driven by Memorial operational expenditures, employee household spending and visitor spending. Assessed the effect of the Memorial on Lower Manhattan in terms property tax revenues and business revenues.

NYCDOS, Draft Environmental Impact Statement (DEIS - SEQR, CEQR), Fresh Kills Landfill, Staten Island, New York. Project director. Executive responsibility for the preparation of the DEIS for the Fresh Kills Landfill on Staten Island. For the continued operation of the 2,200-acre landfill, NYCDOS applied for a NYCRR Part 360 Permit for a solid waste management facility from the New York State Department of Environmental Conservation (NYSDEC). For this purpose, the NYCDOS submitted an EIS pursuant to both State Environmental Quality Review (SEQRA) and City Environmental Quality Review. The DEIS was deemed complete by NYSDEC prior to the City's decision to close the Fresh Kills Landfill.

RAED EL-FARHAN, PHD Principal-in-Charge

Dr. EL-Farhan, vice president of LBGs science and water resources division, has more than 20 years of experience as a consultant, professor, and university researcher. His areas of expertise include water resources, ecosystem restoration, stormwater management, water and wastewater treatment systems, water quality permitting and compliance, aquatic chemistry, and the fate and transport of contaminants in the environment. Dr. EL-Farhan has used this diverse expertise in support of EPA headquarters and its regional offices in their BEACH, EMPACT, and TMDL programs, where he has characterized, assessed, and modeled water quality; wrote and reviewed technical reports; and prepared training materials and workshops. He has worked extensively with various states to provide water resources planning services throughout the Mid-Atlantic region, and continues to support the EPA's Assessment and Watershed Protection Division through the Technical Support for the National Watershed Protection Program. Dr. EL-Farhan is working on multiple assignments with U.S. Army Corps of Engineers, Institute for Water Resources (USACE IWR), Engineer Research and Development Center (ERDC), Districts, Headquarters, and Assistant Secretary of the Army (CE) to provide technical review of feasibility studies, conduct facilitations at USACE strategic sessions, assist the USACE with development of quality of life metrics, evaluate the USACE model certification process, and evaluate and certify models. Dr. EL-Farhan is a member of the American Water Resources Association and participates in national dialogues related to water resources issues. He also serves on the planning committee of the National Conference on Ecosystem Restoration (NCER) where he has worked alongside many of the USACE restoration experts.

FIRM Louis Berger Group

EDUCATION

- PhD, Environmental Engineering
- MS, Environmental Engineering
- BS, Civil Engineering

YEARS EXPERIENCE 21
YEARS WITH FIRM 10

RELEVANT PROJECT EXPERIENCE

USACE Kansas City, Project Initiation and Planning for Programmatic EIS for the Missouri River Recovery/Restoration Plan and the Public Relations Strategy and Internal Communication Plan Needs Assessment for the Missouri River Recovery Program. Director. Dr. EL-Farhan worked closely with the project manager to coordinate the technical leads, experts, academics, and subconsultants. He not only provides management, but also technical support. He is providing technical support and is responsible for the development of the Research Compendium that will serve as the scientific guideline and basis during the alternatives development phase of the project. Also, Dr. EL-Farhan is assisting with the development of the public outreach and communications strategy and plan for implementation for the Missouri River Recovery Program. This includes both an external public relations strategy and an internal communications plan.

USACE Baltimore, Anacostia River Watershed Restoration Plan. Program manager. Managed a comprehensive watershed restoration plan for the Anacostia River Watershed; its objective is to produce a systematic 10-year restoration plan for environmental and ecological restoration within the entire watershed to mitigate the impact of stormwater runoff to the Anacostia River watershed. The plan was conducted under the USACE General Investigations Program. The study was authorized in a resolution of the Committee on Public Works and Transportation, U.S. House of Representatives.

USACE IWR, Analytical and Professional Support Services. Program manager for this $25 million, five-year contract that provides technical and analytical support services that are generally not available within USACE, including the following principal areas: program management, water resources, environmental protection and restoration, navigation, information systems, and homeland security. Under this contract and Dr. EL-Farhan's leadership, LBG is providing technical review of feasibility studies, conducting facilitations at USACE HQ strategic sessions, assisting USACE with development of quality of life metrics, evaluate the USACE model certification process and certifying models.

USACE Mobile District IDIQ for Environmental Studies for BRAC Actions. Program manager. Under $6 million IDIQ contract, Dr. EL-Farhan oversees overall project management, subcontractor management, project scheduling, quality assurance and control, deliverable production, project accountability to USACE Mobile, and maintains the administrative record. Currently working on environmental, engineering, and planning services in preparation of Phase II of the feasibility study and EIS for the ecosystem restoration and flood damage reduction for the 23 square-mile Upper Turkey Creek Basin in Kansas. Scope includes engineering analysis for the plan formulation to accomplish flood protection, environmental restoration, and improve water quality and recreational facilities.

USACE Baltimore, IDIQ for Planning Projects, Various Locations. Program manager. Under $5 million IDIQ contract, LBG is managing multiple task orders, preparing siting and facility studies and other planning documents. Specifically, Dr. EL-Farhan has worked on Potomac

Park Levee–EA and Section 106 project, for design and construction of an improved flood control project within the National Mall and Constitution Gardens in Washington, DC, to address the potential impacts to cultural and environmental resources. Also includes St. Martin Ecosystem Restoration–assisted in the evaluation of the feasibility study for aquatic ecosystem restoration in the St. Martin River Watershed in Maryland, under the authority of Section 206 of WRDA.

EPA Assessment and Watershed Protection Division, Technical Support for the National Watershed Protection Program. As program and project manager, developed dozens of watershed TMDL studies nationwide and has prepared training materials and conducted workshops. For these projects, conducted source assessment and watershed characterization to support watershed simulation and development of allocations. Presented TMDL results at a series public meetings. The Bayou Lafourche TMDLs, Louisiana included a comprehensive water quality monitoring plan, developing and submitting a QAPP for EPA's approval, setting up and calibrating Louisiana's QUAL2E model, and calculating the TMDL for the bayou.

Review of the Upper Mississippi River Illinois Waterway Feasibility Report. To help ensure the adequacy of this recommendation to Congress, Dr. EL-Farhan and the LBG team provided a review of the UMRS Chief's Report, the Rock Island District Commander's Feasibility Report, the NRC Reports on the UMRS, and related documents. The purpose of the review was to evaluate the actions proposed by the Chief of Engineers and District Commander in relation to external reports by the NRC and other parties, as well as prior Assistant Secretary of the Army (CW) correspondence to OMB to determine potential courses of action for the Assistant Secretary of the Army (CW) in transmitting his report to OMB and the Congress. The LBG report highlighted known and unknown information relevant to the ability to recommend an action to Congress, noted any deficiencies in needed information and recommended an appropriate course of action.

Transportation Research Board (TRB) of the National Academies. Senior technical reviewer. Dr. El-Farhan serves as a senior technical reviewer for the Transportation Research Board of the National Academies. He is responsible for reviewing documents and providing recommendations. Dr. El-Farhan will be reviewing papers for consideration as part of the program for the TRB 87th Annual Meeting in January 2008 and publication in the Transportation Research Record.

EPA Region 3, pH TMDL for Buckhannon River, West Virginia. Served as technical support for TMDL development for Acid Mine Drainage. Screened the available water quality data for the Buckhannon River to determine the frequency of water quality standards violation of pH and heavy metals. Reviewed models and methods applicable for predicting instream pH in streams. Developed a mass balance model based on inflow of alkalinity and acidity to predict the instream pH of the Buckhannon River.

HOPE LUHMAN, PHD, RPA Cultural Resources

Dr. Luhman manages LBG's New England and Northeast cultural resource operations from the Albany, New York, office. She is responsible for all archaeological, architectural, and historic preservation planning projects involving historic and precontact resources, as well as general business development. Dr. Luhman coordinates interdisciplinary and multitask studies; interfaces with clients and subconsultants; participates in public outreach and education programs; maintains project schedules; evaluates budgets; prepares technical reports, agreement documents, and special exhibits; and provides expert witness testimony.

FIRM Louis Berger Group

EDUCATION

- PhD, Anthropology
- MA, Anthropology
- MA, Social Relations
- BA, Anthropology

REGISTRATIONS/ CERTIFICATIONS

- Accredited by the Register of Professional Archaeologists

YEARS EXPERIENCE 28
YEARS WITH FIRM 16

RELEVANT PROJECT EXPERIENCE

Immigration and Naturalization Service (INS), Phase I and II Archaeological Survey, INS Border Patrol Station, St. Lawrence County, New York. Principal investigator.

GSA Northeast and Caribbean Region, Photographic Documentation, Phase IB Archaeological Survey, and Data Recovery Investigations, Proposed U.S. Courthouse, Buffalo, Erie County, New York. Project manager/principal investigator.

New York Army National Guard, Cultural Resource Surveys: New York Army National Guard (NYARNG). Project manager/principal investigator. Projects have included Phase IA archaeological surveys for the Rome, Lockport, Jamestown, Dunkirk, Cortland, and Dryden armories; Phase IA and IB surveys for the Walton, Kingston, Leeds, Latham, Orangeburg, Geneseo and proposed Queensbury armories; Phase IB survey for the Auburn Armory; and Phase II and III archaeological investigations for the Kingston Armory.

PARS Environmental for 77th Regional Readiness Command, Phase IB Archaeological Survey, Kerry P. Hein United States Army Reserve Center, Town of Shoreham, Suffolk County, New York. Project manager/principal investigator.

PARS Environmental for 77th Regional Readiness Command, Section 106 Compliance, Rocky Point/Brookhaven Nike Missile Launch Facility, Shoreham, Suffolk County, New York. Project manager/principal investigator.

77th Regional Readiness Command, Phase IA Archaeological Surveys, New York and New Jersey. Project manager/principal investigator.

U.S. Army Corps of Engineers (USACE) Mobile, Phase I Archaeological Survey, Fort Totten BRAC, Queens County, New York. Project manager/principal investigator.

Engineering Field Activity Northeast, Naval Facilities Engineering Command (NAVFAC), Archaeological Monitoring, Palmer Hall Geothermal Loop Field, U.S. Merchant Marine Academy, King's Point, New York. Project manager/principal investigator.

U.S. Military Academy, Cultural Resources Support, Family Housing, USMA, West Point, New York. Project manager/principal investigator.

Engineering Field Activity Northeast, NAVFAC, Archaeological Monitoring, Barry Hall Geothermal Loop Field, U.S. Merchant Marine Academy, King's Point, New York. Principal investigator.

Denver Service Center (DSC), Direct Labeling of Artifacts Recovered from the Archeological Excavations Conducted at Fort Stanwix National Monument for Willett Center Construction, Oneida County, New York. Project manager.

Phase I Archeological Survey, Proposed Mongaup Interpretive Center, Upper Delaware Scenic and Recreational River, Lumberland, Sullivan County, New York. Project manager/co-principal investigator and cultural resource task leader.

Archeological Survey for Roosevelt Farm Lane Rehabilitation Project, Home of Franklin Roosevelt National Historic Site, Hyde Park, Dutchess County, New York. Project manager.

Archeological Survey for the Construction Staging, Sediment Dewatering, and Sediment Dispersal Areas, Val-Kill Pond Restoration Project, Eleanor Roosevelt National Historic Site, Hyde Park, Dutchess County, New York. Project manager.

DASNY, Report on the Phase II and III Archaeological Investigations, The DASNY Site, 515 Broadway, Albany, Albany County, New York. Project manager.

DASNY, Phase IA Newing College Dormitory, State University at Binghamton, Broome County, New York. Project manager.

DASNY, Phase IA Archaeological Survey, Chenango Countywide 911 Communications System Upgrade, Chenango County, New York. Project manager.

Ammann & Whitney, and New York State Bridge Authority, Cultural Resource Services, Bear Mountain Bridge Cable Strengthening Study, Rockland and Westchester Counties, New York. Project manager.

Ammann & Whitney, Phase IA Cultural Resource Sensitivity Assessment, Proposed Amsterdam Pedestrian Bridge, City of Amsterdam, Montgomery County, New York. Project manager.

EBI Consulting, Cultural Resource Services for Wireless Carriers, New England. Contract and project management/principal investigator. On-call contract for performance of cultural resource surveys in New York, Massachusetts, New Hampshire, Vermont, Connecticut, Rhode Island, and Maine. Archaeological desk reviews, archaeological resource assessment reports, and reconnaissance/intensive surveys have been conducted throughout New York, Massachusetts, New Hampshire, Vermont, Connecticut, and Rhode Island.

USACE New England, Review of Cultural Resource Investigations, South Coast Rail Project, Southeast Massachusetts. Project manager/principal investigator.

New York State Education Department (NYSED)/New York State Department of Transportation (NYS DOT), Cultural Resource Services. Contract manager. Five-year contract (beginning 2007) to provide cultural resource services primarily associated with NYS DOT Regions 8-11, but may also include other state agency undertakings. Project-specific studies for all phases of archaeological investigations and architectural resource surveys. To date, 28 task orders received; four examples of completed projects are listed below.

- Cultural Resource Reconnaissance Survey, Site Examination and Data Recovery Plan, Shaker/Powell Hotel Site, Route 155 and Old Niskayuna Road Intersection Improvements, PIN 1132.15.101, Town of Colonie, Albany County, New York. Project manager and principal investigator.
- Archaeological and Architectural Reconnaissance Survey, Gorham Street Bridge and Approach Removal, PIN 3805.50.101, Village of Waterloo, Seneca County, New York. Project manager and principal investigator.
- Reconnaissance (Phase I) Survey, Republic Airport Development Aircraft Hangar, PIN 0903.55.101, Town of Babylon, Suffolk County, New York. Project manager and principal investigator.
- Cultural Resource Reconnaissance Survey, Jericho Turnpike, PIN 0042.27.121, Towns of Huntington and Smithtown, Suffolk County, New York. Project manager and principal investigator.

EDWARD SAMANNS, PWS, CE Aquatic Ecology

Mr. Samanns is the director of environmental sciences at LBG with more than 20 years of experience managing environmental investigations for a variety of projects and clients. Mr. Samanns specializes in ecological restoration/mitigation and related topics including stream and wetland ecology, permitting, threatened and endangered species studies, invasive species management, and NEPA compliance. Mr. Samanns serves as the project manager/director for several environmental and restoration contracts for public sector clients and was responsible for preparing data collection and analysis protocols, developing and implementing vegetative and hydrology monitoring methodologies, and developing habitat restoration designs. Mr. Samanns is a key member of LBG's ecological restoration unit, a unique assemblage of key scientists and engineers that have been combined to conduct restoration projects including wetland mitigation banks, endangered species habitat enhancement, coral reef creation, and tidal marsh restoration. He was the principal investigator and author of NCHRP Synthesis 302 Mitigation of Ecological Impacts (2002), is currently conducting research for NCHRP on Habitat Fragmentation, and has published/presented several papers on wetland mitigation and wildlife crossings. Mr. Samanns is also a co-author of the USACE, Waterways Experiment Station, Engineering Specification Guidelines for Wetland Plant Establishment and Subgrade Preparation (1998). Mr. Samanns also performs QA reviews of technical reports and restoration designs and provides independent research on environmental topics for clients.

FIRM Louis Berger Group

EDUCATION
- MS, Geography
- BS, Biology

REGISTRATIONS/ CERTIFICATIONS
- Professional Wetland Scientist
- Certified Geologist

YEARS EXPERIENCE 25
YEARS WITH FIRM 23

RELEVANT PROJECT EXPERIENCE

County of Rockland, Minisceongo Creek Nor'easter Repair Project, Rockland County, New York. Project manager. Responsible for overseeing the wetland and stream delineation for the project area and preparation of the Environmental Investigation Report. Also evaluated project for compliance with NEPA CATX requirements of FEMA and coordinated with project engineers to assess project alternatives to stabilize an area of mass wasting and slope failure, protect existing infrastructure from river erosion, re-establish fish passage, and establish self mitigating construction approach. Responsible for ongoing coordination of NYSDEC and ACOE permits for construction.

Marsh Resources, Meadowlands Mitigation Bank Phase 3, Carlstadt, New Jersey. Project director of the permitting, design and upcoming construction of a 60-acre tidal and freshwater wetland mitigation bank in the Hackensack Meadowlands. Responsibilities include federal and state permit application preparation and acquisition, banking instrument preparation, negotiation and approval by the interagency MIMAC, and site concept designs. Analysis has included assessment of on-site resources, functional value assessment, credit determination, innovative designs to minimize wetland fill and control invasive species, tidal data analysis and tide gate assessment. Planting plan also addressed potential treatments for acid soil conditions. Responsible for developing construction and planting plans as a design/build project employing marsh excavation and dredge methods to create enhanced tidal habitat of mud flat and low and high marsh interspersed by tidal channels and upland islands and freshwater forested wetlands.

New York Thruway Authority and NYSDOT, Stewart Airport Access Improvement, Wetland and Vernal Pool Mitigation Site Selection and Design. Project manager. Responsible for conducting a site selection and design study for the creation of 1.5 acres of vernal pool habitats within forested uplands to compensate for wetland habitat losses as requested by the NYSDEC. Evaluated physical features within project area leading to the identification of potential sites. Developed concept plans for each vernal pool site. Also responsible for the design of 15 acres of forested, scrub shrub and emergent wetlands at an off-site location. Prepared full plans and specifications to support bid documents. Additional task included preparation of a Biological Assessment for the Federal and State endangered Indiana bat along the project corridor, and coordination with the USFWS and NYSDEC.

PANYNJ, Goethals Bridge Replacement Project, Staten Island. Project supervisor. Responsible for overseeing the tasks related to the preparation of the natural resource components of a NEPA EIS and the preparation of environmental permits required for issuance of the Record of Decision by the US Coast Guard. Also supervising the wetland mitigation site selection and wetland mitigation design tasks that are necessary to support the preparation of a Mitigation Plan for the Corps permit application. Permit applications include addressing purpose and need, alternatives analysis, coastal zone consistency reviews, EFH assessments, and other topics.

USACE Baltimore District, Integrated Natural Resource Management Plan Environmental Support Services, 99th Regional Readiness Command. Project supervisor. Responsible for overseeing the preparation of an Invasive Species Management Plan and Endangered Species Management Plan as part of an INRMP for use on 184 properties in five states under the command of the 99th Regional Readiness Command. The invasive species management plan was developed to maintain compliance with EO 13112 Invasive Species and the Army Policy Guidance for Management and Control of Invasive Species. The endangered species management plan was updated to maintain compliance with the Endangered Species Act, Bald and Golden Eagle Protection Act, DoD Instruction 4715.3, and AR 200-3. The management plans address existing conditions and habitats, target species and appropriate management actions and estimated costs.

Molly Ann Brook Watershed Management Plan, Passaic County, New Jersey. Project director. Responsible for the coordination and completion of all field studies, meetings, workshops, report preparation, staffing, schedule and budget for this project. The project involves development of a Geodatabase as part of a watershed characterization effort that includes Rosgen stream reach classification, USGS Visual Assessments, and point source locations. Baseline analysis also included collection of hydrologic data and development of stream rating curves, incorporation of fecal coliform and other water quality data, benthic macroinvertebrate data, and assessments of potential nonpoint pollution sources within watershed. Prepared and conducted two public workshops to educate and gather information from interested citizens and public officials. Developed a prioritized list of effective BMP's and prepared a concept design and constructability assessment of the six best candidates for installation.

PANYNJ, Environmental Assessment, Newark Airport, Newark and Elizabeth, New Jersey. Environmental scientist. Responsible for overseeing the preparation of natural resource sections of an FAA Environmental Assessment (EA) for the expansion and modernization of Terminal A at Newark Liberty International Airport. Provided oversight of field investigations and baseline conditions analysis. In addition, provided technical input on options to minimize and mitigation wetland and open water impacts on-site through the use of innovative design options.

Brookhaven Science Associates and US Department of Energy, Peconic River Restoration Project, Brookhaven National Laboratory, Suffolk County, New York. Project manager. Responsible for the development and implementation of a Wetland Restoration Design as part of a three phase remediation of 14,700 linear feet of contaminated stream and freshwater wetlands. Also prepared and obtained NYSDEC wetlands equivalency permits, and long term monitoring plan. Project included developing a habitat assessment for the state threatened Banded Sunfish, developing and implementing protocols for the collection and transplanting of wetland plant material into restored wetlands, and collection and transplanting dormant trees using tree spades.

NYSDOT, Term Agreement for Ecological and Water Resource Studies, and Training. Project manager. Responsible for managing three consecutive four-year on-call services term agreement to provide wetland and water services to NYSDOT Regions 8, 10 and 11, and other upstate regions. Services performed include the delineation of state and federal regulated wetlands, wetland functional assessments, wetland permitting support under the New York State Freshwater Wetlands Act and Section 404 of the Clean Water Act, stream assessments and restoration design, and water quality assessments modeling. Additional services include providing training to NYSDOT staff, evaluating alternative alignments to avoid, minimize and reduce wetland impacts, evaluate wetland mitigation sites, and conducting and preparing wetland mitigation monitoring reports for submission to USACE/NYSDEC. Over one hundred task orders have been completed.

Federal Bureau of Prisons, NEPA EA/EIS Preparation for Proposed Federal Correctional Facilities Nationwide. Team leader. Conducting wetland delineations, wetland assessments, biological inventories, and impact assessments for multiple EAs and EISs for proposed federal prison facilities. Also performed Section 404/State 401 permitting and mitigation site selection and design for several of the projects. Managed staff, subconsultants, and report preparation to complete tasks on time and on budget. Projects are located in over fifteen states and have required interaction with state regulatory agencies and USFWS.

LEO TIDD Noise, Land Use, Indirect and Cumulative Impacts

Mr. Tidd's work at LBG has been focused on conducting environmental analyses for proposed projects and preparing documents to demonstrate compliance with state and federal environmental laws and regulations. He has been lead author and editor of complex EISs required as a result of prior environmental litigation. On these projects Mr. Tidd serves as the primary author, synthesizing the work of various technical specialists into a logical and concise narrative that addresses regulatory compliance and ensures that the lead agency took the requisite "hard look" at environmental issues. In addition, he is responsible for technical environmental analyses on topics that include, noise, indirect and cumulative impacts, air quality, habitat fragmentation/edge effects, wetlands and water resources. Mr. Tidd has completed noise impact modeling for a new connector roadway to the Atlantic City International Airport in New Jersey, as well as comprehensive noise evaluations for off-road vehicle use at the National Park Service (NPS) at Yellowstone National Park and the Lake Meredith National Recreation Area. Mr. Tidd has prepared or contributed to the indirect and cumulative impact assessments for several projects where litigation on indirect and cumulative impact issues occurred in the past or is anticipated, including the Circ-Williston Transportation Project in Vermont, the I-93 Improvements Project in New Hampshire, the Gaston East- West Connector in North Carolina, and the Birmingham Northern Beltline in Alabama. Mr. Tidd is a contributing author of the Legal Sufficiency Criteria for Adequate Indirect Effects and Cumulative Impacts Analysis as Related to NEPA Documents report prepared for AASHTO Standing Committee on the Environment as part of NCHRP Project 25-25.

FIRM Louis Berger Group

EDUCATION

- MPA, Environmental Science and Policy
- BS, Environmental Studies

TRAINING

- Transit Noise and Vibration Impact Assessment, National Transit Institute, 2011
- Highway Traffic Noise: Basic Acoustics, National Highway Institute, 2011
- EPA and FHWA Particulate Matter Quantitative Hot Spot Analysis Training, 2011
- AERMOD Dispersion Modeling Training, Lakes Environmental, 2011
- EPA and FHWA MOVES2010 Training, 2010
- EPA and FHWA Draft MOVES2009 Training, 2009
- Introduction to Transportation Conformity, National Transit Institute, 2008

YEARS EXPERIENCE 6
YEARS WITH FIRM 6

RELEVANT PROJECT EXPERIENCE

Peninsula Corridor Joint Powers Board, Dumbarton Rail Corridor Noise and Vibration Study, California. Task manager. The Dumbarton Rail Corridor Project EIS is being prepared for a proposed new rail service on a corridor spanning San Francisco Bay connecting the existing Caltrain San Jose-San Francisco line alignment in Redwood City, San Mateo County to Newark, Union City and other cities in Alameda County. The noise and vibration study being prepared by Mr. Tidd includes short-term noise monitoring at sensitive receptor locations, train and grade-crossing bell noise impact assessment using Federal Transit Administration procedures, train horn noise impact assessment using Federal Railroad Administration's horn noise spreadsheet program, and a screening analysis of bus noise impacts using FHWA's Traffic Noise Model.

NPS, Yellowstone National Park Winter Use Plan EIS, Wyoming, Montana and Idaho. Planner. Mr. Tidd was the lead author of the EIS chapters addressing the impacts of various levels of snowmobile and snowcoach use on air quality and natural soundscapes as part of the Yellowstone Winter Use Plan Draft EIS. Mr. Tidd summarized the available monitoring data to describe existing conditions in the park, and coordinated extensively with the NPS Natural Sounds program that was responsible for developing the impact thresholds and detailed soundscapes modeling effort. One key challenge addressed by Mr. Tidd was identifying the potential for cumulative impacts to natural soundscapes from actions by others, including oil and gas development in the region, aircraft overflights, and population growth/land development.

NPS, Lake Meredith National Recreation Area Off-Road Vehicle Management Plan EIS, Texas. Planner. Mr. Tidd wrote the EIS chapter describing the existing condition of natural soundscapes within two ORV areas based on monitoring data of percent time audible and sound levels. Mr. Tidd also assisted NPS with the development of soundscapes impact thresholds for the various action alternatives under consideration in the management plan and prepared the soundscapes impact assessment. The purpose of the Lake Meredith National Recreation Area Off-Road Vehicle plan/EIS is to manage ORV use in the national recreation area for visitor enjoyment and recreation opportunities, while minimizing and correcting damage to resources.

South Jersey Transportation Authority, Atlantic City Expressway/Atlantic City International Airport Direct Connector Road Noise and Air Quality Studies, Egg Harbor Township, New Jersey. Task manager. Mr. Tidd prepared air quality screening analyses based on changes in level of service and traffic volumes to address Federal Aviation Administration and conformity requirements for a new roadway and interchange in Egg Harbor Township, New Jersey. Mr. Tidd also conducted traffic noise modeling for the project using TNM2.5 and prepared the traffic noise study technical memorandum. Mr. Tidd developed the noise impact criteria for this project based on FHWA and FAA regulations. The noise modeling effort involved 41 receptor locations. In addition, Mr. Tidd prepared GIS mapping illustrating the location of environmental justice communities in the project area using 2010 U.S. Census data.

Vermont Agency of Transportation (VTrans), Circ-Williston Transportation Project EIS, Chittenden County, Vermont. Deputy project manager. The Circ-Williston EIS is a "fresh look" at a transportation project that was stopped as a result of environmental litigation just prior to construction. Mr. Tidd was responsible for editing the EIS and technical reports, creation of a comment database tracking system and was the lead author of the responses to comments on the Draft EIS and Final EIS. Mr. Tidd coordinated extensively with the various technical discipline specialists and subconsultants involved with the project to ensure a comprehensive and legally sufficient environmental documentation. Mr. Tidd's technical accomplishments on this project have included a detailed analysis of wildlife habitat edge effects and fragmentation, a GIS-based wetland mitigation site search analysis, a project-level greenhouse gas emissions analysis, and a deicing salt loading analysis.

New Hampshire DOT, I-93 Improvements (Salem to Manchester) Supplemental EIS (SEIS), New Hampshire. Deputy project manager. Mr. Tidd was the lead author of the I-93 supplemental environmental impact statement (SEIS), which was prepared in response to a court order requiring analysis of the effects of induced population and employment growth on secondary road traffic and air quality. In addition to editing all components of the SEIS, Mr. Tidd was also responsible for several technical analysis tasks, including a regional emissions sensitivity analysis for ozone precursors, and a cumulative impact analysis assessing the aggregate consequences of the project combined with other reasonably foreseeable projects and forecasted levels of population and employment growth in Southern New Hampshire. The project involves widening I-93 from two-lanes to four-lanes in each direction for a distance of 20 miles between the Massachusetts state line and Manchester, New Hampshire.

USACE, South Coast Rail EIS, Massachusetts. Planner. As part of the third-party review conducted by LBG, Mr. Tidd was responsible for the preparation of technical memorandums reviewing proposed methodologies for assessing indirect and cumulative impacts, and greenhouse gas emissions for the South Coast Rail project. Mr. Tidd was also responsible for editing portions of the DEIS/DEIR, assisting with quality assurance reviews and addressing comments on draft documents.

North Carolina Turnpike Authority, Gaston East-West Connector Indirect and Cumulative Effects Study, North Carolina. Task manager. Mr. Tidd prepared a quantitative indirect and cumulative impact assessment for a proposed toll road extending from I-85 west of Gastonia in Gaston County to I-485 near the Charlotte-Douglas International Airport in Mecklenburg County. As part of this study, Mr. Tidd defined watershed-based study area boundaries and developed metrics to translate household and employment growth into indicators for environmental impacts, such as increases in impervious surface cover and loss of forest cover. Mr. Tidd was responsible for developing and implementing the GIS-based analysis methodology for this project, as well as preparing the final technical report.

DASNY, Chenango Countywide 911 Communications Upgrade EIS, Chenango County, New York. Planner. Assisted in preparation of the SEQRA EAF, scoping document and EIS. Responsible for a GIS viewshed analysis of tower visibility using the ESRI 3D Analyst extension. The viewshed analysis included the identification of sensitive resources (e.g. parks and historic areas) within five miles of each tower. The project objective is to improve emergency services communication capabilities through the construction of six radio communication antenna towers and ancillary infrastructure, and upgrades to facilities at an additional three sites.

DANE ISMART Transportation

Mr. Ismart has 28 years experience with FHWA and 11 years with LBG. While with the FHWA, he served in many capacities including area engineer, research engineer, urban planner, and intermodal team leader. As part of the Office of Environment and Planning, Mr. Ismart specialized in systems transportation planning, intermodal planning, traffic engineering, and policy. He is a nationally recognized expert in transportation planning and models, highway capacity analysis, access management, and site impact analysis. During Mr. Ismart's tenure with FHWA, he conducted and authored the materials for more than 400 short courses on quick response urban planning models, traffic operations, freight planning and models, highway capacity, innovative highway and transit finance, transportation and environmental planning, land use planning, access management, and site impact analysis.

FIRM Louis Berger Group

EDUCATION

- MS, Civil Engineering
- BS, Civil Engineering

YEARS EXPERIENCE 28
YEARS WITH FIRM 17

RELEVANT PROJECT EXPERIENCE

Walmart versus Historic Preservation Society of Civil War Battlefields, Orange County, Virginia. Expert witness. Served as an expert witness for the Historic Preservation Society on the traffic impacts of a proposed Walmart development in Orange County, Virginia on the Wilderness Civil War Battlefield.

I-93 SEIS. Technical analyst. Developed traffic forecasts by using the New Hampshire Statewide Traffic Forecasting Model. Various scenarios are being analyzed and the results are being used for determining how well the projects purpose and scope are being met. As part of this project, an estimate of the potential changes in land use and indirect impacts due to adding capacity to the I-93 corridor are being developed.

Intermodal Terminal Innovative Finance Study. Technical writer. Developed a case study for the NCHRP study evaluating innovative funding techniques for improving access to intermodal facilities. The case study was for the Port of Palm Beach's Sky Bridge over Route 1.

Virginia Research Council. Author and instructor. Developed a financial management of federal aid course for Virginia Research Council.

Highways for Life Leap Not Creep Innovation of Technology Course. Subject matter expert technical advisor and senior instructor. Developed technical material on the application of new innovative techniques for long lasting construction and construction techniques to reduce maintenance of traffic delays and construction impacts.

FHWA, Predictive Performance of Traffic Simulation Models. Project manager. Developed a series of case studies for FHWA to assist transportation planners and traffic engineers in applying traffic simulation models. The case studies included several applications of simulation models forecasting traffic during construction as well as after completion of the projects. A brochure and how-to manual for troubleshooting the application of the simulation models to better replicate actual travel conditions was developed.

FHWA, Access Management Primer and Video. Project manager. Developed the FHWA Primer and Videotape entitled, "Safe Access is Good for Business." The primer discusses in detail methods for improving access to business during construction of corridor access improvement projects.

National Highway Institute. Instructor. Certified NHI instructor for the Federal-Aid 101 Course, Access Management Course, Innovation of Technology Course, and the Highway Capacity Course.

Update of Federal-aid 101. Author. Revised the FHWA Federal-aid 101 Course Material. The material was updated to include the latest planning, finance, construction, and environmental requirements required by SAFTEA-LU. The material and curriculum are used to train FHWA personnel.

FHWA Bottleneck Initiative Workshops. Lecturer/ technical advisor. Conducted Regional workshops and created technical material for the FHWA Bottleneck Initiative. The presentation included techniques for identifying potential corridor bottlenecks due to recurring and non-recurring events and applying innovative solutions for maintaining traffic

and reducing delay.

FHWA, Operations CBU Task Order. Key technical task leader. Directed technical teams for a series of FHWA tasks orders involving intermodal planning and policy analysis, freight movements, ITS, and traffic operations.

University of Tennessee, Planning Courses. Instructor. Developed and conducted travel demand forecasting, site impact, access impact, and highway capacity courses for the University of Tennessee and the Tennessee Department of Transportation.

University of Maryland. Instructor and course developer. Developed and conducted site impact, access management, and highway capacity courses for the University of Maryland and the Maryland State Highway Administration.

Central Arkansas Regional Transportation Study. Project manager. Conducted an analysis of the 200-mile freeway system in central Arkansas. The study developed a series of recommendations for improving the freeway system. The study also includes a feasibility study of a fourth bridge crossing over the Arkansas River in Little Rock, Arkansas and a financial plan for funding.

Florida Department of Transportation. Project manager. Conducted a study to evaluate and develop recommendations for improvements to the NHS intermodal connectors of FDOT's District Six.

Klingle Road EIS, Washington, D.C. Traffic technical lead. Conducted the traffic analysis and forecast for the Klingle Road EIS. Using the MWCOG model the project estimated the traffic and traffic patterns if Klingle Road was repaired and open to traffic.

NPS Potomac Boathouse EIS, Arlington County, Virginia. Traffic technical lead. Conducting the traffic analysis to determine the traffic and parking impact for the construction of a new Boathouse facility on the Potomac in Arlington County.

Wisconsin Avenue and Military Road Phase 1 and 2 Corridor Studies, Washington, D.C. Technical director. Conducted a corridor study for the Wisconsin Ave. Corridor and the Military Road Corridor in Washington, D.C. The study developed a series of transportation improvement recommendations for improving the flow of traffic. The study included public meetings and an analysis of future land use development in the corridor.

Washington, D.C., Evacuation Planning Study. Technical model leader. Developed a system-wide traffic forecasting tool to be used in rerouting traffic during man-made and natural disasters that cause corridor or system-wide disruption of traffic.

DC Office of Planning, Washington, D.C. Comprehensive Plan. Model director. Applied the Washington DC COG model as part of the development and evaluation of the Comprehensive Transportation Plan Element.

SHRP 2 R11: Strategic Approaches at the Corridor and Network Levels to Minimize Disruption from the Renewal Process. Principal investigator. Leading the team to create the Work Zone Impact Strategy Estimation (WISE) tool and technical primer. Planning and Operations modules will assist in assessing strategies including economic impact across networks and corridors with user-defined or default value performance measures.

BRAC Bethesda Medical Traffic Study. Traffic engineer. Directing an effort to analyze the impact that the transfer of the Walter Reed staff and patients to the Bethesda Naval Center will have on the access points and internal traffic of the Bethesda Naval Center. A mitigation program to relieve future congestion on the Center is being proposed and developed.

Route 29 Corridor Study, Fauquier County, Virginia. Principal investigator. Analyzing and recommending a series of innovative corridor improvements for Fauquier County, Virginia. A report is being written and improvements such as roundabouts, directional left turns, and restricted access movements are being analyzed.

Kevin Heatley, LEED AP

Employment

2010 – current	Biohabitats, Inc., Baltimore, MD, Senior Scientist
2006 - 2010	Biohabitats Invasive Species Management, Inc., ISM Vice President
2005 - 2006	Penn State College of Technology, Williamsport, PA, Substitute Instructor, Natural Resource Management Department
2005 - 2006	Invasive Plant Control, Inc., Nashville, TN, Director of Development Northeast Region
1997 – 2005	ACRT Inc., Akron, OH, Senior Forester/Regional Manager
1984 – 1994	Bartlett Tree Experts, Lancaster, PA, Area Manager/Arboricultural Consultant

Education

Masters Environmental Pollution Control, Penn State University, Harrisburg, PA, 2006
B.S., Natural Resource Management, Cook College, Rutgers University, New Brunswick, New Jersey 1982

Professional Registration

Certified Arborist #PD-0029, 2000
LEED Accredited Professional for New Construction (USGBC), 2009

Experience

Mr. Heatley has over 20 years of experience in the environmental sector with an extensive background in ecosystem characterization, integrated vegetation management, invasive species suppression and community-based forestry. As a senior ecologist at Biohabitats, Mr. Heatley is responsible for technical and logistical oversight of restoration projects across the continental United States. His work has primarily focused upon the urban/rural interface and on incorporating green infrastructure into sustainable land use planning and management. An expert in the field of invasive species suppression, Mr. Heatley designed the first fully integrated invasive treatment prioritization model in the United States for Fairfax County, Va. He has successfully integrated resource valuation modeling into strategic and budgetary management plans for a variety of land management entities. He has also been instrumental in providing the conceptual design for a leading GIS-based vegetation management software system.

In addition to his technical expertise, Mr. Heatley is skilled at conducting entertaining and informative public speaking engagements and professional workshops. He has lectured on a variety of natural resource topics throughout the United States and the Caribbean.

Representative Project Experience

NPS Revegetation Eastern States IDIQ, Eastern US. Mr. Heatley successfully served as the Biohabitats project manager on a 2.5 million dollar National Park Service Revegetation IDIQ contract. He coordinated and lead project planning and technical assistance services on a wide variety of ecological restoration task orders including revegetation, invasive species control, plant procurement, seeding, plant protection efforts, marsh restoration, and site characterization. Biohabitats has subsequently been awarded a $20 million dollar follow-up contract for National Park Service revegetation services across the Eastern United States and the Caribbean. Mr. Heatley is currently the project manager and technical lead on this contract.

Burgundy Farm Country Day School Ecological Site Assessment, *Alexandria, VA*. Biohabitats Inc. performed an ecological assessment of the campus and developed recommendations for the sustainable use and conservation of the school's asset. Proactive identification of both ecological assets and landscape challenges enabled the School to cost-effectively integrate site ecology into the master planning process.

Fairfax County Parks Invasive Plant Site Prioritization Model, *Fairfax County, VA.* Biohabitats ISM developed a comprehensive response strategy and site treatment prioritization model as a decision-making tool to be used by the Park Authority to rank the relative value of different sites within their approximately 24,000-acre park system. Based on the principle of "protect the best first" the model shifted the focus in the parks system away from "acres treated" towards "acres restored," allowing the County to maximize the return on its investment in invasive plant control by assuring that treatment sites reflect both the core ecological and cultural values that exist.

Lehigh University, *Bethlehem PA.* Desiring to more fully understand potential atmospheric carbon mitigation opportunities on the college campus, Lehigh University contracted with Biohabitats to undertake an analysis of the direct sequestration and avoided emissions associated with the schools landscape tree cover. Utilizing US Forest Service models, Mr. Heatley performed a comprehensive inventory of 600 acres of naturalized forest and over 220 landscape trees. Information gathered was integrated into strategic recommendations for enhancing this forest benefit and achieving a sustainable level of forest canopy.

Duke University*, Durham NC.* Concerned about the need to understand the ecological processes occurring in a high-visibility, centrally-located stand of campus woodland, Duke University contracted with Biohabitats to undertake an ecological analysis and natural capitol valuation of the campus area known as "Chapel Woods". Mr. Heatley inventoried the vegetation, performed an assessment of the functional benefits, and developed a management plan focused upon forest sustainability. As a function of this effort, Mr. Heatley also performed invasive species suppression within the forest understory.

Valley Road Stream Restoration and Riparian Wetland Creation, *Hagerstown, MD.* Mr. Heatley provided technical recommendations and coordinated invasive plant species suppression in support of the Valley Road Stream Restoration project in Hagerstown, MD. Project involved restoration of an urbanized stream corridor and significant modification of a highly disturbed riparian plant community.

Reforestation Consulting & Invasive Species Suppression, *Rockville, MD.* In order to assure the success of a reforestation effort on a 220 acre tract in Rockville, MD., Fallsgrove Associates, a private development firm, contracted with Biohabitats ISM to oversee tree planting and invasive species suppression. Biohabitats ISM developed and implemented a sampling protocol assessing tree stocking levels and produced biannual reports on supplemental planting levels needed to assure adequate canopy cover. As a component of this effort Biohabitats ISM performed planting contractor coordination and oversight. Biohabitats ISM also created a phased, multi-year, invasive plant suppression strategy. After conducting a comprehensive evaluation of the percent cover for each of the invasive species present on the site, Biohabitats ISM created a target metric for measuring the effectiveness of invasive control efforts. Seasonally selective treatments are currently being undertaken by Biohabitats ISM.

Woodland Restoration of Episcopal High School Alexandria, *Alexandria, VA.* Driven by a desire to integrate a 35 acre woodland resource into the fabric of campus life, the Episcopal High School of Alexandria, Va. contracted with Biohabitats ISM to develop a sustainable campus forest management plan and implement invasive species suppression. This effort involved campus ecosystem characterization, functional benefits modeling, and stakeholder vision sessions. Botanical communities on campus were defined and their respective ecosystem services, in the form of air pollutant interception and carbon sequestration, quantified. Several action items identified during the plan development have subsequently been implemented by Biohabitats including; trail design and construction, ecotone modification, and invasive species suppression. Ecotone modification involved the development of a forest edge planting plan addressing issues of wind vectoring and regeneration. Invasive species interventions have been conducted during 2007 and 2008 in a phased approach designed to enhance native regeneration and minimize opportunities for additional invasive colonization of the woodland.

Episcopal High School, *Baton Rouge, LA.* Recognizing the need to integrate sustainable design principles into future development on their 40 acre campus, the Episcopal High School contracted with Biohabitats (in conjunction with NK Architects) to develop a new Master Plan for the school. Mr. Heatley coordinated Biohabitats participation and involvement in this interactive process. He was directly

responsible for developing recommendations and strategies addressing stormwater retrofitting, green infrastructure expansion, and natural capital valuation.

Missionary Ridge Noxious Weed Inventory and Treatment, *Durango, CO.* During the final year of a three year project, Mr. Heatley provided technical oversight and coordinated the GPS/GIS component of the Missionary Ridge invasive species mapping and suppression effort. As part of an adaptive management approach, data collection protocols were modified and additional field staff were hired and trained by Mr. Heatley.

Woodland Management Plan for Episcopal High School, *Alexandria, VA.* Located in the Washington DC metropolitan area, the 150 years of stable land ownership at Episcopal High School has resulted in a significant legacy woodland on the campus. Recognizing the inherent educational, recreational, and inspirational value of their forest, the school contracted with Biohabitats to develop an integrated woodland management plan. The development of this plan involved a GIS-based forest stand delineation, ecological characterization, invasive plant mapping, ecosystem benefits modeling, and stakeholder vision session. As the project manager, Kevin Heatley developed the final document which provides a framework for sustainable management of this green component of the school infrastructure.

Fort Detrick, *Frederick MD.* The US Army operates Fort Detrick on over 1,200 acres of property in Frederick MD. The mixed land use pattern and competing mission objectives create special challenges regarding natural resource management. To aid in understanding field conditions and assist in budgetary justification, Fort Detrick contracted with Mr. Kevin Heatley (in conjunction with Heartwood Consulting LLC.) to undertake a resource analysis and characterization. The primary components of this project included: a GPS Landscape Tree Inventory (with tagging), GIS Database Integration, UFORE Modeling of the Environmental Impact of Forest Stands, and a Five Year Management Plan (with economic tree valuation). Mr. Heatley in addition was contracted with Fort Detrick to undertake a carbon mitigation feasibility analysis. This project examined the potential to use green infrastructure in the mitigation of vehicular greenhouse gas emissions on the base.

Representative Project Experience Prior to Biohabitats

Atkins Arboretum, *Ridgely MD.* Encompassing 400 acres on the Eastern Shore of Maryland, Atkins Arboretum is a unique facility that highlights native plant communities. With strong educational and research objectives as the primary focus of its efforts, the Arboretum enlisted the aid of Kevin Heatley (ACRT Inc.) to develop and implement a GIS-based vegetation database. Mr. Heatley supervised all aspects of the project including; high resolution aerial photogrammetry, GPS mapping of plant communities, the establishment of a thematic research plot layer, and the construction of a multi-thematic, GIS-based, vegetation database.

Tree Preservation Specifications Manual for Association for Zoological Horticulture, *Allison Park, PA.* The Association for Zoological Horticulture, an organization representing the interests of botanists, horticulturalists, and landscape professionals involved with the management of vegetation in zoological parks, contracted with Mr. Heatley for the creation of a set of standard tree preservation specifications. This document was initiated in response to excessive canopy loss during infrastructure construction and renovation projects. It was designed to promote an integrated, comprehensive approach to tree conservation appropriate for vegetation management within the challenging environment of a zoological park. It also contains an extensive specifications section suitable for use as an attachment on construction contracts.

Villanova University Five-Year Canopy Management Plan, *Villanova, PA.* Mr. Heatley as the project manager provided high resolution aerial photogrammetry, GPS/GIS vegetation and infrastructure mapping, and database design, of approximately 250 acres of this historic campus located in Villanova, Pennsylvania.

Swan Point Cemetery Five-Year Canopy Management Plan, *Providence, RI.* Mr. Heatley as the project manager provided GPS/GIS vegetation and infrastructure mapping, “seamless” GIS providing a work tracking database, and budget information of over 300 acres of this historic cemetery located in downtown Providence, Rhode Island.

Professional Associations

Society of American Foresters
International Society of Arboriculture
Society of College & University Planners

Selected Publications, Technical Reports & Presentations

Greater Everglades Ecosystem Restoration Conference, Naples, Fl, July 2010

Land Trust Alliance Annual Rally, Portland , OR, November 2009

Professional Grounds Management Society, Louisville, KY, October 2009

Mid-Atlantic Exotic Pest & Plant Council, Johnstown, PA. July 2009

Society of American Foresters, Western New York Chapter, April 2008

11th Caribbean Urban Forestry Conference, St. Croix, Virgin Islands, June 2006

St. Croix Environmental Association Tree Conservation Workshop, St. Croix, Virgin Islands, June 2006

Southeast Exotic Pest & Plant Council Annual Meeting, Raleigh, NC, May 2006

Association for Zoological Horticulture, *Tree Preservation Specifications Manual* (Industry Standard), 2005

Penn State Invasive Pest, Plants & Weeds Workshop, Luzerne County, PA, October 2005.

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CURRENT POSITIONS

2007-present Natural Resources Defense Council, New York, NY
Senior Scientist, Global Warming and Health Project
Conduct research and offer educational outreach to the public and policymakers on the impacts of climate change on health. Leads NRDC's Global Warming and Health Project. Among the scientists participating in the Intergovernmental Panel on Climate Change 2007 Fourth Assessment Report; published research has looked at heat- and smog-related health problems, climate change's effects on pollen, allergies and asthma, flooding and infectious diseases, especially among vulnerable communities.
(see www.nrdc.org/climatemaps)

2005- present Mailman School of Public Health, Environmental Health Sciences Department
Columbia University's Climate and Health Program
Assistant Clinical Professor
Teaching and research on the health impacts of climate change, and devising strategies to increase societal preparedness to cope with global warming.

2011-present: Co-Convening Lead Author for the Human Health chapter of the 2013 Synthesis of the National Climate Assessment (NCA)

2011-present: Field Editor, Epidemiology, International Journal of Biometeorology

2009-present: Chair, Committee on Global Climate Change & Health, American Public Health Association's Environment Section

EMPLOYMENT HISTORY

2001-2005 Mailman School of Public Health, Columbia University
Post-Doctoral/Doctoral Research Associate
Analyzed health impacts of climate change for the New York Climate and Health Project, multi-disciplinary program linking climate, air quality, and land use change modeling projections.

1998-2001 Queens College/CUNY, Center for the Biology of Natural Systems (CBNS)
Medical Screening Coordinator
Designed/coordinated clinical studies, administration, reporting, and recruitment for the Worker Health Protection Program, medical screening offered to thousands of nuclear weapons workers.

1996-1998 Beth Israel Medical Center, New York, NY
Project Manager
Coordinated CDC study of occupational injuries and illnesses among health care workers.

1996-1997	Office of the New York City Public Advocate, New York, NY **Researcher and co-author** (with S Mattei), *Unhealthy Closure: The Need for a Full Environmental Impact Statement on the Department of Sanitation's Long-Term Plan to Control Pollution from Fresh Kills.*
Sept.1994- Sept. 1996	Radioactive Waste Management Associates, Inc., New York, NY **Research Associate** Provided expertise as geologist and health scientist on reviews of environmental impact statements for radioactive waste disposal and decommissioning projects across the US & Canada.
June 1992- Sept.1994	Natural Resources Defense Council, New York, NY **Environmental Consultant** Researched and wrote a critique of EPA's methods for assessing risks from chemical exposures.
June 1992- Aug. 1992	Los Alamos National Laboratory, Los Alamos, NM **Research Assistant** Provided support on environmental and regulatory reviews of hazardous/radioactive waste issues.
Mar. 1978- May 1979	Colorado State Geological Survey, Denver, CO **Field Geologist** Collected and analyzed samples & conducted field surveys of uranium deposits at former mine sites.

TEACHING EXPERIENCE

2008- present	**Mentor** to Columbia University Earth Institute students on Research Projects on climate change impacts and adaptation in the New York City region, as part of an innovative Climate Change Adaptation Initiative.
2005- present	**Lecturer** on Global Warming and Health, Environmental Health Sciences Core Course, Mailman SPH, Columbia University, New York, NY; as well as at Yale University, New York University, The New School for Social Research, Rutgers University, and the University of California at San Francisco Medical School.
Fall 2006	**Mellon Teaching Fellow**, Barnard College, New York NY: Co-Instructor, "Ecotoxicology;" **Doctoral Seminar Instructor**, The Earth Institute, Columbia University, New York, NY: Public Health Seminar Leader, "Environmental Science for Sustainable Development;" **Mentor** to Barnard undergraduates on their Senior Thesis research projects
Spring 2006- 2007	**Instructor**, Mailman SPH, Columbia University, "Public Health Impacts of Climate Change;" Designed and co-taught with Dr. Patrick L. Kinney a new course offering in the Department of Environmental Health Sciences, which received a Dean's Commendation for Excellence in Teaching; and became the foundation of what has developed into Mailman's new ground-breaking Master's Program in Climate Change & Public Health, lead by Dr. Kinney.
2004- present	**Mentor** to undergraduate research interns who assist on NOAA-funded research.

Fall 2003 **Teaching Assistant**, Mailman SPH, Columbia University, "Topics in Environmental Health Science;" Co-designed and conducted masters seminars in conjunction with Prof. Kinney on climate change and health (*piloted ideas that are now being applied in Spring 2006 course*)

Fall 2002 **Teaching Assistant**, Mailman SPH, Columbia University, "Air Pollution;" helped introduce masters students to concepts of atmospheric structure, air pollution sources, regulation, and health effects

ACADEMIC RESEARCH AND TRAINING

2006-2007 "Profiling Carbon Dioxide, Pollen Concentrations and Asthma in the New York City Region," as a 2006-2007 APERG Scholar in the Mid-Atlantic States Section of the Air and Waste Management Association (MASS-A&WMA) Air Pollution Educational Research Grant Program (APERG); *Objectives:* to investigate relationships between the timing and length of spring tree pollen seasons and hospital admissions for respiratory illnesses, and to survey spatial and temporal variations in carbon dioxide across the NY metropolitan region

2006-2007 Research investigating differences in greenhouse gas emissions from four different household types, defined by income and urban versus non-urban location

2004-2007 "Climate Variability, Air Quality and Human Health: Measuring Regional Vulnerability for Improved Decision-Making," funded by National Oceanic and Atmospheric Administration (NOAA); *Objectives*: Assess the degree to which weather and air pollution act independently and/or jointly in contributing to health effects, and to develop and analyze highly resolved exposure and health maps over the state of New York for 1988-2002

2001-2005 "The New York Climate and Health Project: Modeling Heat and Air Quality Impacts of Changing Land Uses and Climate," funded by US Environmental Protection Agency (EPA); *Objectives*: Develop an integrated modeling framework to assess regional climate and air quality under alternative scenarios of global climate change and regional land use change, and corresponding human health risks.

March 26-April 2 2006 DISsertations Initiative for advancement of Climate-Change ReSearch (DISCCRS) Pacific Asilomar, CA
Funded by the National Science Foundation (NSF) to meet challenges in building Successful interdisciplinary careers among recent PhD graduates in climate change impacts. One of 36 fellows selected from doctoral programs throughout the world.

July 2004 NCAR Summer Colloquium on Climate and Health, Boulder, CO (July 2004). Participated in the first summer colloquium on climate and health, held by the Advanced Study Program and Environmental and Societal Impacts Group, National Center for Atmospheric Research.

EDUCATION

October 2005 **Doctor of Public Health, Environmental Health Science**
Mailman School of Public Health, Columbia University, New York, NY

Dissertation: "Mortality in Metropolitan New York Under a Changing Climate"

Projections of future climate changes have often been made at the continental scale, yet more finely resolved projections are needed at regional scales in order for local health impacts and adaptive planning options to be evaluated. To meet these needs, a regional health risk assessment was applied to a dynamically downscaled global-to-regional model system for the tri-state New York metropolitan region. The objective was to project climate-related changes in summer heat stress and ground-level ozone concentrations and their impacts on acute mortality from all internal causes, including respiratory and cardiovascular illnesses.

The health risk assessment used model simulations of future temperature conditions and ozone concentrations developed by the New York Climate and Health Project (NYCHP). In the NYCHP model system, the NASA-Goddard Institute for Space Studies (GISS) general circulation model at 4x5° resolution was linked to the Penn State/NCAR Mesoscale Model 5 (MM5) at 36 kilometer (km) resolution to simulate future daily temperatures. The Community Multiscale Air Quality (CMAQ) atmospheric chemistry model at 36 km horizontal grid resolution was linked to the GISS/MM5 model system to simulate future daily ozone concentrations, in five summers of selected future decades across the 31-county New York metro study area. Concentration-response functions from the epidemiological literature were applied to project relative risk of heat- and ozone-related mortality in New York City in each decade. To isolate the effects of climate change on mortality, population was held constant at Census 2000 levels.

Results under the Intergovernmental Panel on Climate Change (IPCC) A2 (relatively fast-growth) scenario assumptions show that summer heat-related mortality could increase 36% by the 2020s, nearly double (95% increase) by the 2050s, and more than triple (250% increase) by the 2080s as compared to the 1990s. There is a median 4.5% increase in ozone-related acute mortality projected across the 31 counties by the 2050s. Synthesizing the heat and ozone results, for a typical summer in the 2050s, projections of additional overall mortality attributable to climate changes are 96% heat- and 4% ozone-related. The downscaled regional projections revealed heterogeneities in the temperature and ozone simulations: relatively dense population areas tend to coincide with relatively high temperatures, and relatively lower population density with relatively high ozone.

A time series analysis of daily summer mortality from 1990-1999 investigated the independent and joint effects of heat and ozone, and whether the relative risk of heat- and ozone-related mortality among urban populations exceeded that of non-urban. Poisson regression modeled daily death counts as a function of same-daily mean temperature and 1-hour daily maximum ozone concentrations averaged over the same and previous day, adjusting for day of week effects and periodic cycles. Results suggest that the heat effect (RR 1.037 per 10°F; 95% C.I. 1.028, 1.047) is less robust than ozone (RR 1.058 per 100 ppb; 95% CI 1.032, 1.085). There is a significant difference in heat-related mortality risk in urban (RR 1.062; 95% CI 1.048, 1.075) vs. non-urban (RR 1.017; 95% CI 1.006, 1.029) counties, but this is not the case for ozone. This type of health risk assessment modeling could be a useful tool for application in other metropolitan areas to evaluate the relative effects of direct (heat) and indirect (ozone) climate-health impacts that are possible under a changing climate.

June 1993 — **Master of Science, Environmental & Occupational Health Science**
Hunter College, City University of New York, New York, NY

January 1978 — **Bachelor of Arts, Geological Sciences**
Cornell University, Ithaca, NY

AWARDS

2006-2007 — Air Pollution Educational and Research Grant (APERG) Scholarship Program Award recipient, to support research on the relationships between the timing and length of spring tree pollen seasons and hospital admissions for respiratory illnesses, and to survey spatial and temporal variations in carbon dioxide across the NY metropolitan region

2006 Awarded Doctoral Degree with Distinction; I.B.Weinstein Award for Academic Excellence

1993 George H. Kupchik Award, Outstanding Environmental Health Graduate; NIOSH Scholarship Recipient

1973 High School Class Valedictorian; Bausch and Lomb Science Award; NY State Regents Scholarship Recipient

JOURNAL PUBLICATIONS

As lead author:

Knowlton K, Rotkin-Ellman M, Geballe L, Max W, Solomon GM. 2011. Six Climate Change–Related Events In The United States Accounted For About $14 Billion In Lost Lives And Health Costs. Health Affairs 30(11):2167-2176 (Nov. 2011).

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. 2009. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. *Environmental Health Perspectives* 117:61-67 (January 2009).

Knowlton K, Rotkin-Ellman M, King G, et al. 2009. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. *Epidemiology* 19(6):S323(Nov. 2008).

Knowlton K, Lynn BH, Goldberg R, Rosenzweig C, Hogrefe C, Rosenthal J, Kinney PL. 2007. Projecting heat-related mortality impacts under a changing climate in the New York City region. *American Journal of Public Health* 97:2028-2034.

Knowlton K, Rosenthal JE, Hogrefe C, Lynn B, Gaffin S, Goldberg R, Rosenzweig C, Civerolo K, Ku J-Y, Kinney PL. 2004a. Assessing ozone-related health impacts under a changing climate. *Environmental Health Perspectives* 112: 1557-1563.

Knowlton K, Rosenzweig C, Goldberg R, Lynn B, Gaffin S, Hogrefe C, Civerolo K, Ku J-Y, Solecki W, Small C, Oliveri C, Cox J, Rosenthal J, Kinney PL. 2004b. Evaluating global climate change impacts on local health across a diverse urban region. *Epidemiology* 15 (4): S100-S100 (July 2004).

Knowlton K. 2001. Urban history, urban health. *American Journal of Public Health* 91(12):1944-1946.

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As co-author:

Bell, M.L., Goldberg R., Hogrefe, C., Kinney, P.L., Knowlton K., Lynn B., Rosenthal J., Rosenzweig C., and Patz J. 2007. Climate change, ambient ozone, and health in 50 U.S. cities. *Climatic Change* 82:61-76.

Chavarria G, Knowlton K, Atchley D. 2010. The human-climate-wildlife nexus. *Bulletin of the Atomic Scientists* (January/February 2010):48-56 (DOI: 10.2968/066001007).

Civerolo KL, Hogrefe C, Lynn B, Rosenzweig C, Goldberg R, Rosenthal J, Knowlton K, and Kinney PL. 2008. Simulated effects of climate change on summertime nitrogen deposition in the eastern US. *Atmospheric Environment* 42(9):2074-2082.

Civerolo KL, Hogrefe C, Lynn B, Rosenzweig C, Goldberg R, Rosenthal J, Knowlton K, and Kinney PL. 2007. Estimating the effects of increased urbanization on surface meteorology and ozone concentrations in the New York City metropolitan region. *Atmospheric Environment* 41(9):1803-1818 (Mar 2007).

Hogrefe C. S., B. Lynn, K. Civerolo, J.-Y. Ku, J. Rosenthal, C. Rosenzweig, R. Goldberg, S. Gaffin, K. Knowlton, and P.L. Kinney. 2004. Simulating changes in regional air pollution over the eastern United States due to changes in global and regional climate and emissions. *J Geophysical Res - Atmospheres* 109:D22301 (Nov 17 2004).

Hogrefe C, Rosenzweig C, Kinney P, Rosenthal J, Knowlton K, Lynn B, Patz J, Bell ML. 2004. Health impacts from climate-change induced changes in ozone levels in 85 United States cities. *Epidemiology* 15(4): S94-S95 (July 2004).

Kinney PL, K Knowlton, C Hogrefe, et al. 2007. Melding measurements and models to enrich the study of climate, air quality, and health. *Epidemiology* 18(5):S131(Sept 2007).

Kinney PL, Bell M, Hogrefe C, K Knowlton, et al. 2007. Climate change, air quality, and health: Assessing potential impacts over the eastern US. Epidemiology 18(5):S133(Sept 2007).

Patz JA, Kinney PL, Bell M, Ellis H, Goldberg R, Hogrefe C, Khoury S, Knowlton K, Rosenthal J, Rosenzweig C, Ziska L. 2004. *Heat Advisory: How Global Warming Causes More Bad Air Days*. NY: Natural Resources Defense Council.

Rosenthal JK, Sclar ED, Kinney PL, Knowlton K, Craudereef R, Brandt-Rauf PW. 2007. The links between the built environment, climate and population health: interdisciplinary environmental change research in New York City. *Ann Acad Med Singapore* 97(11):2028-2034.

Sheffield PE, Knowlton K, Kinney PL. 2011. Modeling of regional climate change effects on ground-level ozone and childhood asthma. *American Journal of Preventive Medicine* 41(3):251-257.

Ziska LH, Knowlton K, Rogers CA, Dalan D, Tierney N, Elder MA, et al. 2011. Recent warming by latitude associated with increased length of ragweed pollen season in central North America. *PNAS* 108(10):4248-4251 (March 8, 2011).

BOOK CHAPTERS

As lead author:

Knowlton K. February 10 2011. Globalization and Environmental Health. In: Nriagu JO (ed.) *Encyclopedia of Environmental Health*, vol.2, pp.995-1001. Burlington: Elseveier.

Knowlton K. April 2010 webinar presentation on "Climate Change, Vulnerable Populations and Adaptation" - Chapter 5 on Public Health Adaptation Strategy in CDC/APHA printed guidebook, *Climate Change: Mastering the Public Health Role* (in print April 2011).

Knowlton K, Hogrefe C, Lynn B, Rosenzweig C, Rosenthal J, Kinney PL. 2008. Impacts of heat and ozone on mortality risk in the New York City Metropolitan Region under a changing climate. *In:* Climate Information for the Health Sector. Advances in Global Change Research (Thomson M, Garcia Herrera R, eds.).

Hogrefe C, Ku J-Y, Civerolo K, Lynn B, Werth D, Avissar R, Rosenzweig C, Goldberg R, Small C, Solecki WD, Gaffin S, Holloway T, Rosenthal J, Knowlton K, and Kinney PL. 2004. Modeling the impact of global climate and regional land use change on regional climate and air quality over the northeastern United States. *In:* Air Pollution Modeling and Its Application XVI (Borrego C, Incecik S, eds.). New York: Kluwer Academic/Plenum, pp.135-144.

As co-author:

Kinney PL, Rosenthal JE, Rosenzweig C, Hogrefe C, Solecki W, Knowlton K, Small C, Lynn B, Civerolo K, Ku J-Y, Goldberg R, Oliveri C. 2006. "Assessing Potential Public Health Impacts of Changing Climate and Land Use: The New York Climate and Health Project." *In:* Regional Climate Change and Variability: Impacts and Responses (Ruth M, Donaghy K, Kirshen P, eds.). Cheltenham, UK and Northampton, MA: Edward Elgar, pp.161-189.

Rotkin-Ellman M, Knowlton K, Apatira L, Solomon G. 2011. "Lessons from the Past and Needs for the Future: Place-Based Case Studies of Vulnerability to Climate Change" (book chapter; in press).

Lead author of NRDC Briefing Papers & Fact Sheets on a variety of climate-health topics, including climate change's effects on ground-level ozone smog; pollen, allergies and asthma; heat waves; infectious diseases; harmful algal blooms; and strategies to help prepare to meet these health challenges; available online at: www.nrdc.org/health/globalwarming (2007-present).

PRESENTATIONS

Organizer & Moderator of Sessions on Climate Change and Health, Adaptation in Vulnerable Communities, and Indicators of Vulnerability and Resilience; for the 2011 and 2010 American Public Health Association Annual Meetings.

Organizer & Moderator of Symposia on Climate Change and Health at the 2009 and 2008 American Association for the Advancement of Sciences (AAAS) Annual Meetings.

As presenter:

Session on Climate Change, Air Pollution, and Adaptation in Vulnerable Communities; for the 2010 American Public Health Association Annual Meeting, Denver, Colorado, USA (November 2010).

Capitol Hill Oceans Week, Invited Speaker at Panel on the "Health Impacts of Today's Energy Choices," June 9, 2010, Washington, D.C.

Workshop on Modeling and Mitigation of the Impacts of Extreme Weather Events to Human Health Risks, Rutgers University, June 3, 2010 (Invited Speaker on Heat Wave morbidity, response, adaptation)

International Research Institute for Climate and Society, May 2010 and 2009, Columbia University, New York, NY, Invited Lecturer at Summer Symposium on Climate and Health.

National Environmental Public Health Conference, "Vulnerable Communities & Climate Change: Air Pollution in Metro NY" Centers for Disease Control & Prevention, Atlanta GA, October 26, 2009

National Center for Atmospheric Research Summer Symposium on Climate and Health, Invited Lecturer, July 2009.

American Museum of Natural History, New York, NY, April 2, 2009, "Exploring the Dynamic Relationship Between Health and the Environment" (poster presentation on dengue fever and climate change)

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. 2008. The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Oral presentation at ISEE/ISEA Joint Meeting, Pasadena, CA, October 15, 2008.

Knowlton K, Kinney PL, Bell ML, Hogrefe C, Rosenzweig C. 2005. Assessing potential health impacts of ozone and $PM_{2.5}$ under a changing climate. Poster P-AQ1.8, US Climate Change Science Program (CCSP) Workshop: Climate Science in Support of Decision Making, November 14-16, 2005, Arlington VA.

Knowlton K, Rosenthal J, Rosenzweig C, Goldberg R, Lynn BH, Gaffin S, Solecki WD, Oliveri C, Cox J, Small C, Hogrefe C, Clverolo K, Ku J-Y, Kinney PL. 2004. Projecting the local impacts of global climate change on public health in New York City. American Public Health Association Annual Meeting, November 6-10, Washington, DC.

Knowlton K, Rosenzweig C, Goldberg R, et al. 2004. Evaluating global climate change impacts on local health across a diverse urban region (poster). ISEE/ISEA Mtg, 1-4 August, New York.

Knowlton K and Rosenthal J. 2004. The New York Climate & Health Project: Global and local environmental change and public health. The New York Academy of Sciences, Environment Section (10 May 2004).

Knowlton K (invited speaker). 6 Mar 2004. "Projecting Local Impacts of Global Climate Change." Long Island Univ Annual Biology Conference: The Scientific, Biological, Social, and Economic Impacts of Fossil Fuels. Brooklyn, NY.

Knowlton K, Rosenthal J, Lynn B, Gaffin S, Kinney P, Hogrefe C, Biswas J, Civerolo K, Ku J-Y, Rosenzweig C, Goldberg R. 2003. Assessing Public Health Impacts of Heat and Air Quality Under a Changing Climate in the NYC Metropolitan Area. Amer Geophysical Union Fall Mtg, 8-12 December, San Francisco. Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract U32A-0028.

Knowlton K, Rosenthal JE, Gaffin S, Rosenzweig C, Goldberg R, Lynn B, Kinney PL. Modeling Public Health Impacts of Climate Change in the New York Metropolitan Region. Fifth International Conference on Urban Climate (ICUC-5), 1-5 September 2003, Lodz, Poland.

As co-author:

Civerolo K, Biswas J, Hogrefe C, Rosenthal J, Knowlton K, Lynn B, Ku J-Y, Goldberg R, Rosenzweig C, Kinney PL. 2004. Modeling Future Climate and Air Quality in the New York City Metropolitan Area, Presented at the Symposium on Planning, Nowcasting, and Forecasting in the Urban Zone, 84th AMS Annual Meeting, Jan. 11-15, Seattle, WA.

Hogrefe C, Lynn B, Rosenzweig C, Goldberg R, Civerolo K, Ku J-Y, Rosenthal R, Knowlton K, Kinney PL. 2005. Utilizing CMAQ Process Analysis to Understand the Impacts of Climate Change on Ozone and Particulate Matter. Models-3 Users' Workshop, September 26-28, Chapel Hill, NC. Online: http://www.cmascenter.org/html/2005_conference/abstracts/3_2.pdf.

Hogrefe C, Knowlton K, Goldberg R, Rosenthal J, Rosenzweig C, Lynn BH, Kinney PL. 2005. Integrating observations and MM5/CMAQ predictions to study the link between climate variability, air quality and health in New York State: Project description and initial results. Presented at the NOAA/EPA Golden Jubilee Symposium on Air Quality Modeling and Its Applications, September 20-21, Research Triangle Park, NC.

Hogrefe C, Civerolo K, Ku J-Y, Lynn B, Rosenthal J, Solecki WD, Small C, Gaffin S, Knowlton K, Goldberg R, Rosenzweig C, Kinney PL. 2004. Air quality in future decades – determining the relative impacts of changes in climate, anthropogenic and biogenic emissions, global atmospheric composition, and regional land use. Preprints of the 27th NATO/CCMS International Technical Meeting on Air Pollution Modeling and Its Applications, October 25 - 29, Banff, Canada, pp. 158-165.

Hogrefe C, Civerolo K, Ku J-Y, Lynn B, Rosenthal J, Knowlton K, Solecki WD, Small C, Gaffin S, Goldberg R, Rosenzweig C, Kinney PL. 2004. Modeling the Air Quality Impacts of Climate and Land Use Change in the New York City Metropolitan Area. Models-3 Users' Workshop, October 18-20, Research Triangle Park, NC. Online:

http://www.cmascenter.org/html/2004_workshop/abstracts/Climate%20Multiscale/Hogrefe_abstract.pdf.

Hogrefe C, Biswas J, Civerolo K, Ku J-Y, Lynn B, Rosenthal J, Knowlton K, Goldberg R, Rosenzweig C, Kinney PL. 2003. Climate change and ozone air quality over the eastern United States: A modeling study. Fall Meeting 2003, San Francisco, CA, December 8-12. Eos Trans. AGU, 84(46), Fall Meet. Suppl., Abstract U32A-0027.

Hogrefe C, Biswas J, Civerolo K, Ku J-Y, Lynn B, Rosenthal J, Knowlton K, Goldberg R, Rosenzweig C, Kinney PL. 2003. Climate change and ozone air quality: applications of a coupled GCM/MM5/CMAQ modeling system. Proceedings of the 2nd Models-3 Users' Workshop, October 27-29, Research Triangle Park, NC. Online at: http://www.cmascenter.org/2003_workshop/presentations/session2/hogrefe_abstract.pdf.

Kinney PL, Hogrefe C, Lynn BH, Rosenzweig C, Rosenthal J, Knowlton K. 2005. Independent and joint impacts of heat and ozone mortality risk under a changing climate. Wengen Tenth Annual Workshop on Global Change Research, September 12-14, Wengen, Switzerland.

Kinney P, Knowlton K, Rosenthal J, Rosenzweig C, Solecki WD, Hogrefe C, Lynn B, Avissar R. 2003. Heat Stress Modeling in the NYC Metropolitan Area: Estimates for the 2050s Using a Linked Global-Regional Climate Modeling System. 2003 Open Mtg: Human Dimensions of Global Environmental Change, Montreal, Canada, October 16-18.

Rosenthal JR, Kinney PL, Knowlton K. 2004. Reshaping the built environment to reduce public health impacts of the urban heat island effect. American Public Health Association Annual Meeting, November 6-10, Washington, DC.

OTHER OUTREACH, ADVOCACY, MEDIA COVERAGE

Developed NRDC webpages on *Climate-Health Vulnerability* (www.nrdc.org/climatemaps) and *2011 Extreme Weather* (www.nrdc.org/extremeweather)

December 2011 invited presentation on Climate Change, Aeroallergens and Health to the Northern Central Weed Science Society, Milwaukee, WI

2011: Webinars on Climate Change and Health for National Nurses groups for continuing medical education credits; for Faith Community Leadership groups

Nov 2011 presentation at NJ Climate Change Adaptation Workshop at Rutgers University

Oct.29-Nov.3, 2011: presentations at the American Public Health Association Annual Mtg, Washington, DC on communicating climate-health vulnerability; and organizer of two panels, including a Special Session on "Climate Change & Health: The Global Challenge"

Sept 24-25, 2011: invited presentation at workshop on health, economics, and climate change, Boston, MA

May 26-27, 2011: International Research Institute for Climate Change, Columbia University, NY, NY – Climate Change & Health presentations and trainings for international experts and researchers

March 28-20, 2011: Indo-US Heat Vulnerability Workshop, Ahmedabad, India

Invited speaker, April 2010, Barnard College panel with Dr. Mary Robinson on climate change, NYC.

January 2010 Lecture on the health impacts of global warming as part of the *Cambridge Forum* lecture series - one of public radio's longest running public affairs programs heard on NPR stations across the US - titled, "After Copenhagen," online at: http://forum-network.org/lecture/health-impacts-global-warming.

Speaking about the impacts of changing climate conditions on infectious diseases like dengue fever in a segment titled, "Outbreak" on *Planet Green* television, October 2009.

Testimony to NYC Council on climate change, infrastructure adaptation and health, May 2008.

CARE International Executive Committee Meeting, New York, NY: *Developing Responses to the Climate Crisis* (7 June 2007).

Testimony to New York City Council (Environment Committee) on climate research findings in support of proposed Local Law No.661 to limit greenhouse gas emissions in NYC (June 2006, June 2005).

The New York Times. Worked with journalists to clarify research issues: "Forecast for New York this century: Hotter and wetter" (*New York Times*, Metro Section, 27 June 2004); "Climate scientists zoom in on changes" (*New York Times*, Metro Section, 9 December 2003).

National Public Radio. "Degrees of Concern: Climate Change and New York City," K Knowlton on West Nile virus and climate variability, broadcast interview on *Living on Earth*, nationally syndicated NPR show, 11 October 2003.

The American Museum of Natural History, Dartmouth College, The 92nd Street Y (NYC), *Science News*, *Greenwire*, *New York Daily News*, *The Poughkeepsie Journal* and *Downtown Express*.

OTHER PROFESSIONAL ORGANIZATIONAL AFFILIATIONS

American Association for the Advancement of Science; American Academy of Allergy, Asthma and Immunology; American Geophysical Union; American Meteorological Society; New York Academy of Sciences; International Society for Environmental Epidemiology.

1/11/2012

GINA M. SOLOMON M.D., M.P.H.

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EMPLOYMENT

Senior Scientist, ***Natural Resources Defense Council, 1996 - present***
Conduct research and investigation into priority environmental hazards with a focus on threats to children's health. Advocate for policy changes to improve laws and regulations to protect health. Represent NRDC in the press, legislative and agency hearings, and public fora. Supervise 7 full-time staff and numerous interns and students. Raise and manage an annual budget of over $800,000.

Director, UCSF Occupational and Environmental Medicine Residency Program, ***2008-present***
Manage all aspects of the physician training program in occupational and environmental medicine at UCSF, including directing the interview and selection process, shaping the educational requirements, managing the budget, and maintaining funding and accreditation. Supervise an associate director, program coordinator, and 4-7 residents and fellows.

Health Sciences Clinical Professor, ***University of California San Francisco, 2011 – present***
Precept occupational and environmental medicine (OEM) residents and fellows in clinic. Teach at journal club, case conference, grand rounds, and summer didactics. Teach Epi 170.16 Environment and Health course for medical and nursing students. Supervise residents from four medical centers for month-long rotations at NRDC.

Associate Director, Pediatric Environmental Health Specialty Unit, ***University of California San Francisco, 2003 - Present***

Associate Clinical Professor of Medicine, ***University of California San Francisco, 2006 –2011***

Assistant Clinical Professor of Medicine, ***University of California San Francisco, 1998 - 2006***

Clinical Instructor in Medicine, ***University of California San Francisco, 1996 - 1998***

Consultant, Ergonomics Evaluation Project, ***Massachusetts Division of Industrial Accidents, 1996 - 1997***

Fellow, Occupational and Environmental Medicine, ***Harvard School of Public Health, 1996***

Clinical Instructor in Medicine, ***Harvard University School of Medicine, 1991 - 1995***

Resident, Primary Care Internal Medicine, ***Mount Auburn Hospital, 1991 - 1995***

Research Assistant in Environmental Medicine, ***Institute of Medicine, Washington DC, 1994***

PROFESSIONAL ACTIVITIES

Science Advisory Board, *U.S. Environmental Protection Agency, 2011-2014*

Editorial Board, *Environmental Health Perspectives, 2010 – present*

Scientific Guidance Panel, *California Environmental Contaminant Biomonitoring Program, 2007-present*

Tracking Implementation Advisory Group, *California Department of Public Health, 2006 - present*

Board of Directors, *San Francisco Bay Area Physicians for Social Responsibility, 2000 – present*

Committee on Human and Environmental Exposure Science in the 21st Century, *National Research Council, 2010 – 2012*

Board of Scientific Counselors, *National Toxicology Program*, *2008 – 2011*

California Adaptation Advisory Panel, *Governor of California*, 2010

Science Advisory Board Drinking Water Committee, *U.S. Environmental Protection Agency, 2004-2010*

Science Advisory Board Acrylamide Panel, *U.S. Environmental Protection Agency, 2007 – 2008*

Reviewer, *American Academy for the Advancement of Sciences* LSDF 09-01: Innovative research programs to improve health and health care, 2009

Committee on Toxicity Testing and Assessment of Environmental Agents, *National Research Council, 2004 -2007*

Childhood Lead Poisoning Prevention Expert Advisory Committee, *California Department of Health Services, 2004 - 2006*

Scientific Advisory Group, Environmental Epidemiology and Biomonitoring, *CA Dept of Health Services Environmental Health Investigations Branch, 2000-2004*

SB702 Expert Working Group on Public Health Tracking, *California Department of Health Services, 2002 - 2004*

Science Advisory Board Trichloroethylene Panel, *U.S. Environmental Protection Agency, 2002*

Strategic Advisory Committee, *National Center for Environmental Health, CDC, 2001 - 2002*

Endocrine Disruptor Screening and Testing Advisory Committee, *U.S. Environmental Protection Agency, 1996 - 1998*

Board of Directors, *Consortium for Environmental Education in Medicine, 1998 - 2000*

Pesticides and Environmental Education for Health Providers Committee, *National Environmental Education & Training Foundation*, *1998 - 2000*

Peer Reviewer: *Journal of the American Medical Association (JAMA); American Journal of Public Health; Climatic Change; Environmental Health Perspectives; Canadian Medical Association Journal; Environmental Science and Technology; Journal of Occupational and Environmental Medicine; Environmental Research; Environmental Geochemistry and Health; Indoor Air; International Journal of Occupational and Environmental Health; Tobacco Control; European Journal of Clinical Nutrition; American Journal of Preventive Medicine; Environmental Pollution; Chemosphere; Journal of Epidemiology and Community Health.*

EDUCATION

Masters in Public Health, *Harvard School of Public Health, 1994*
Doctorate of Medicine, *Yale School of Medicine, 1991*
Bachelor of Arts, Comparative Literature, Magna cum Laude, *Brown University, 1986*

CERTIFICATION AND LICENSING

National Board of Medical Examiners, 7/92
American Board of Internal Medicine, 8/95, Recertified 5/05
American Board of Preventive Medicine, 2/98, Recertified 12/08
California Medical License number: G 083110

AWARDS AND RECOGNITION

CAAT Recognition Award, *Johns Hopkins University Center for Alternatives to Animal Testing, 2009*
Certificate of Appreciation, *Center for Community Action and Environmental Justice, 2007*
Certificate of Appreciation, *California Safe Schools, 2004*
Clean Air Award for Research, *American Lung Association of the Bay Area, 2004*
Ten Women's Health Pioneers, *The Green Guide, 2004*
Environmental Heroes Award, *The Breast Cancer Fund, 2002*
Will Solimene Award for Excellence in Medical Writing, *American Medical Writers Association, 2000*
Occupational Physicians Scholarship Fund Award, *1993, 1995*
Farr Scholarship Award, *Yale Medical School, 1988, 1989*
Phi Beta Kappa, *Rhode Island Chapter, 1986*

SCIENTIFIC PUBLICATIONS

Knowlton K, Rotkin-Ellman M, Geballe L, Max W, Solomon G. Six Climate Change–Related Events in the United States Accounted For About $14 Billion in Lost Lives and Health Costs. Health Affairs. 30(11): 1-10. 2011.

Rotkin-Ellman M, Wong KK, Solomon GM. Seafood Contamination after the BP Gulf Oil Spill and Risks to Vulnerable Populations: A Critique of the FDA Risk Assessment. Environ Health Perspect, 2011. http://dx.doi.org/10.1289/ehp.1103695.

Solomon G, Huddle A, Silbergeld EK, Herman J. Chapter 8. Manganese in Gasoline: Are We Repeating History? In: Clapp R (Ed.). From Critical Science to Solutions: The Best of Scientific Solutions. Baywood Publishing Inc., 2011. ISBN: 978-0-89503-404-5.

Rotkin-Ellman M, Navarro KM, Solomon GM. Gulf oil spill air quality monitoring: lessons learned to improve emergency response. Environ Sci Technol. 44(22):8365-6, 2010.

Solomon G, Janssen SJ. Health Effects of the Gulf Oil Spill. JAMA, 304(10):1118-9, 2010.

Solomon G, Janssen SJ. Communicating with Patients and the Public About Environmental Exposures and Reproductive Risk. In: Woodruff TJ, Janssen SJ, Guillette LJ, Giudice LC (eds), Environmental Impacts on Reproductive Health and Fertility. Cambridge Press, Cambridge, UK, 2010.

Rotkin-Ellman M, Solomon G, Gonzales CR, Agwaramgbo L, Mielke HW. Arsenic Contamination in New Orleans Soil: Temporal Changes Associated with Flooding. Environmental Research, 110(1):19-25, 2010.

Krewski D, Acosta D Jr, Andersen M, Anderson H, Bailar JC 3rd, Boekelheide K, Brent R, Charnley G, Cheung VG, Green S Jr, Kelsey KT, Kerkvliet NI, Li AA, McCray L, Meyer O, Patterson RD, Pennie W, Scala RA, Solomon GM, Stephens M, Yager J, Zeise L. Toxicity testing in the 21st century: a vision and a strategy. Toxicol Environ Health B Crit Rev. 13(2-4):51-138, 2010.

Solomon G, Huang A, Godsel R. Contaminants in the Air and Soil in New Orleans After the Flood: Opportunities and Limitations for Community Empowerment, In: Bullard R, Wright B (eds). Race, Place, and Environmental Justice After Hurricane Katrina. Westview Press, Boulder, CO, 2009.

Solomon G. Physicians' Duty to Be Aware of and Report Environmental Toxins. Virtual Mentor, 11(6):434-442, 2009. http://virtualmentor.ama-assn.org/2009/06/ccas2-0906.html.

Knowlton K, Rotkin-Ellman M, King G, Margolis HG, Smith D, Solomon G, Trent R, English P. The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits Environ Health Perspect, 117: 61-67, 2009. http://www.ehponline.org/members/2008/11594/11594.pdf.

Woodruff T, Zeise L, Axelrad D, Guyton KZ, Janssen S, Miller, M, Miller G, Schwartz J, Alexeef G, Anderson H, Birnbaum L, Bois F, Cogliano J, Crofton K, Euling SY, Foster P, Germolec D, Ginsberg G, Gray E, Hattis D, Kyle A, Leubke R, Luster M, Portier C, Rice D, Solomon G, Steinmaus C,

Vandenberg J, Zoeller T. Meeting Report: Moving Upstream: Evaluating Adverse Upstream Endpoints for Improved Risk Assessment and Decision Making. Environ Health Perspect, 116:1568–1575 (2008). http://www.ehponline.org/members/2008/11516/11516.pdf.

Humphreys EH, Janssen S, Heil A, Hiatt P, Solomon G, Miller MD. Outcomes of the California Ban on Pharmaceutical Lindane: Clinical and Ecologic Impacts. Environ Health Perspect, 116:297-302 (2008). doi:10.1289/ehp.10668.

Humphries E, Solomon G. Helping Your Patients Manage Asthma: Focus on the Source. Medscape, http://www.medscape.com/viewarticle/572573.

Solomon GM, Janssen S. Talking with patients and the public about endocrine disrupting chemicals. In: Endocrine-disrupting Chemicals: From Basic Research to Clinical Practice. Ed. Andrea C. Gore. Part of "Contemporary Endocrinology," series editor P. Michael Conn, Humana Press, Totowa, NJ, 2007.

Karr C, Solomon GM, Brock-Utne A. Health effects of common home, lawn and garden pesticides. Ped Clin N Am 54(1):63-80, 2007.

Thundiyil J, Solomon GM, Miller MD. Transgenerational exposures: Persistent chemical pollutants in the environment and breast milk. Ped Clin N Am 54(1):81-101, 2007.

Solomon GM, Hjelmroos-Koski M, Rotkin-Ellman M, Hammond K. Air quality in New Orleans, Louisiana after flooding: Mold, endotoxin, and particulate matter, October - November 2005. Environ Health Perspect 114(9):1381-1386, 2006.

Solomon GM, LaDou J, Wesseling C. Environmental Exposures and Controls, in LaDou (Ed.) Occupational and Environmental Medicine. Fourth Ed. Appleton and Lange, Stamford CT, 2006.

McDaniel P., Solomon G, Malone RE. The ethics of industry experimentation using employees: The case of taste-testing pesticide-treated tobacco. Am J Public Health 96(1):37-46, 2006.

McDaniel PA, Solomon G, Malone RE. The Tobacco Industry and Pesticide Regulations: Case Studies from Tobacco Industry Archives. Environ Health Perspect 113(12):1659-1665, 2005.

Bailey D, Solomon G. Pollution Prevention at Ports: Clearing the Air. Environ Impact Assess Review 24:749-774, 2004.

Solomon G, Humphreys E, Miller M. Asthma and the Environment: Connecting the Dots: what role do environmental exposures play in the rising prevalence and severity of asthma? Contemp Pediatrics 21(8), 2004.

Solomon GM, Hawes A, Quintero A, Widess E. Approaches to Occupational and Environmental Law in: Rosenstock L and Cullen M. (Eds.) Textbook of Clinical Occupational and Environmental Medicine, Second Edition. WB Saunders/Mosby/Churchill Livingstone, Philadelphia, 2004.

Solomon GM, LaDou J, Jackson RJ. Environmental Exposures and Controls, in LaDou (Ed.) Occupational and Environmental Medicine. Third Ed. Appleton and Lange, Stamford CT, 2003.

Solomon GM, Balmes J. Health Effects of Diesel Exhaust. Clinics in Occup & Environ Med 3:61-80, 2003.

Miller M, Solomon G. Environmental Risk Communication for the Pediatrician. Pediatrics 112:211-221, 2003.

Miller M, Solomon G. Pesticides, in: Etzel RA and Balk SJ (Eds). Handbook of Pediatric Environmental Health, Second Ed. American Academy of Pediatrics, Elk Grove Village, IL, 2003.

Solomon GM. Rare and Common Diseases in Environmental Health. San Francisco Medicine 75(9):14-16, 2002.

Solomon GM, Huddle AM. Low levels of persistent organic pollutants raise concerns for future generations. J of Epi and Commun Health. 56(11):826-827, 2002.

Solomon GM and Schettler T. Endocrine Disruption. In McCally M. (Ed.) Life Support: The Environment and Human Health. MIT Press, Cambridge MA, 2002.

Solomon GM, Weiss P. Chemical Contaminants in Breast Milk: Time Trends and Regional Variability. Environ Health Perspect 110(6): A339-A347, 2002.

Pandya RJ, Solomon GM, Kinner A, Balmes JR. Diesel Exhaust and Asthma: Potential Hypotheses and Molecular Mechanisms of Action, Environ Health Perspect 110(suppl 1):103-112, 2002.

Chaisson C, Solomon G. Children's Exposure to Toxic Chemicals – Modeling their World to Quantify the Risks. Neurotoxicology 22:563-565, 2001.

Solomon GM, Schettler T. Emerging Issues in Environmental Health: Endocrine Disruption. Canadian Med Assn Journal 163(11): 1471-1476, 2000.

Solomon GM. Hormones, Chemicals, and Public Policy. Chem and Engineering News, 78(32): 66-67, 2000.

Schettler T, Solomon GM, Valenti M, and Huddle AM. Generations at Risk: Reproductive Health and the Environment. Massachusetts Institute of Technology Press, Boston, June 1999.

Milton DK, Solomon GM, Rossiello RA, Herrick RF. Risk and Incidence of Asthma Attributable to Occupational Exposure among HMO Members. Am J Ind Med 33(1):1-10, 1998.

Solomon GM. Reproductive Toxins: A Growing Concern at Work and in the Community. J Occ Env Med 39:105-107, 1997.

Solomon GM, Huddle AM, Silbergeld EK, Herman D. Manganese in Gasoline: Are We Repeating History? New Solutions 7(2):17-25, 1997.

Frumkin H, Solomon GM. Manganese in the U.S. Gasoline Supply. Am J Ind Med 31:107-115, 1997.

Solomon GM, Morse E, Garbo M, Milton DK. Stillbirth after Occupational Exposure to N-Methyl-2-Pyrrolidone: A case report and review of the literature. J Occ Env Med 38:705-713, 1996.

Esswein E, Trout D, Hales T, Brown R, Solomon GM. Exposures and Health Effects: An Evaluation of Workers at a Sodium Azide Production Facility. Am J Ind Med 30:343-350, 1996.

Parker J, Solomon GM. Decades of Deceit: The History of Bay State Smelting. New Solutions 5:80-89, 1995.

REPORTS

Knowlton K, Solomon G, Rotkin-Ellman M. Fever Pitch: Mosquito-Borne Dengue Fever Threat Spreading in the Americas. Natural Resources Defense Council, New York, NY, 2009. http://www.nrdc.org/health/dengue/files/dengue.pdf.

Rotkin-Ellman M, Solomon G. Poisons on Pets II: Toxic Chemicals in Flea and Tick Collars. Natural Resources Defense Council, New York, NY, 2009. http://www.nrdc.org/health/poisonsonpets/files/poisonsonpets.pdf.

Rotkin-Ellman M, Quirindongo M, Sass J, Solomon G. Deepest Cuts: Repairing Health Monitoring Programs Slashed Under the Bush Administration. Natural Resources Defense Council, New York, NY, 2008. http://www.nrdc.org/health/deepestcuts/deepestcuts.pdf.

Wall M, Rotkin-Ellman M, Solomon G. An Uneven Shield: The Record of Enforcement and Violations Under California's Environmental, Health and Workplace Safety Laws. Natural Resources Defense Council, New York, NY, 2008. http://www.nrdc.org/legislation/shield/shield.pdf.

Knowlton K, Rotkin-Ellman M, Solomon GM. Sneezing and Wheezing: How global warming could increase ragweed allergies, air pollution, and asthma. Natural Resources Defense Council, New York, NY, 2007. http://www.nrdc.org/globalWarming/sneezing/sneezing.pdf.

Cohen A, Janssen S, Solomon GM. Clearing the Air: Hidden Hazards in Air Fresheners. Natural Resources Defense Council, New York, NY, 2007. http://www.nrdc.org/health/home/airfresheners/airfresheners.pdf

Solomon GM, Nance E, Janssen S, White WB, Olson E. Drinking water quality in New Orleans: June-October 2006. Natural Resources Defense Council, New York, NY, January 2007. http://www.nrdc.org/health/effects/katrinadata/water.pdf.

Solomon GM, Rotkin-Ellman M. Contaminants in New Orleans Sediment: An Analysis of EPA Data. Natural Resources Defense Council, New York, NY, February 2006. http://www.nrdc.org/health/effects/katrinadata/sedimentepa.pdf.

Solomon GM, Campbell TR, Feuer GR, Masters J, Samkian A, Paul KA. No Breathing in the Aisles: Diesel Exhaust Inside School Buses. Natural Resources Defense Council, New York, NY, 2001. http://www.nrdc.org/air/transportation/schoolbus/schoolbus.pdf.

Solomon G, Ogunseitan OA, Kirsch J. Pesticides and Human Health: A Resource for Health Care Professionals. Physicians for Social Responsibility, San Francisco, CA, 2000. http://www.psrla.org/pahk.pdf

Solomon GM, Mott L. Trouble on the Farm: Growing up with Pesticides in Agricultural Communities. Natural Resources Defense Council, New York, NY, 1998. http://www.nrdc.org/health/kids/farm/farminx.asp.

PUBLISHED ABSTRACTS

Knowlton K, Solomon G, Chavarria G. Preparing for the Health Impacts of Climate Change: Science and Societal Strategies. AAAS Annual Meeting Abstract, 2008.

Janssen S, Solomon G, Chavarria G. Measuring Human Exposures to Hormone-Disruptors: Scientific Tools for Global Health. AAAS Annual Meeting Abstract # 090-096, 2008.

Rotkin-Ellman M, Solomon G. Soil Contamination in New Orleans: Arsenic and Lead Before and After Katrina. APHA Annual Meeting Abstract #163091, 2007.

McDaniel P, Malone R, Solomon GM. The Tobacco Industry and Pesticide Regulations. Society for Research on Nicotine and Tobacco, 10th Annual Scientific Sessions, 2004.

Solomon GM. Mercury and other Persistent Fish Pollutants: Risks to the Fetus and Child. APHA Annual Meeting Abstracts, 2003

Solomon GM. Endocrine Disruptors and Current Science Policy Developments. APHA Annual Meeting Abstracts, 4185, 2000.

Solomon GM. Special Risks to Children in Agricultural Settings. Neurotoxicology, 2000.

Solomon GM, Mott L. Disproportionate Exposures and Susceptibility: Pesticide risks to farm children. Neurotoxicology 20:1, 1999.

Solomon GM, Schettler T, Huddle A, Valenti M. Endocrine Disruptors: A lens on low dose health effects. Epidemiology 9(4): S54, 1998.

Solomon GM, Huddle AM, Schettler T, Valenti M. The Tradition of Statistical Significance: An impediment to prudent public health? Epidemiology 9(4): S75, 1998.

Solomon GM. Protecting Human Health From Endocrine Disruptors: Are toxicology and risk assessment up to the challenge? APHA Annual Meeting Abstracts, 2024, 1998.

Solomon GM. The Reproductive and Developmental Effects of Organic Solvents: The dilemma of identifying a culprit. APHA Annual Meeting Abstracts, 10, 1996.

Solomon GM, Milton DK. The Occupational Asthma Incidence Study: A pilot project. APHA Annual Meeting Abstracts, 177, 1996.

Garbo M, Milton D, Morse EP, Solomon G. From DBCP to NMP: Have we progressed? APHA Annual Meeting Abstracts, 408, 1996.

SELECTED PRESENTATIONS

Congressional Testimony and Briefings:

Cancer and the Environment
Safer Chemicals Healthy Families Congressional Briefing, 4/7/11

Cancer Clusters and the Environment
Hearing of the Senate Committee on Environment and Public Works, Washington, DC, 3/29/11

Reproductive Health and the Environment
Pew Charitable Trusts Congressional Briefing, 6/11/10

Health Effects of the Gulf Oil Spill
Hearing of the House Committee on Energy and Commerce, Subcommittee on Energy and the Environment, Washington DC, 6/10/10

Protecting Children from Environmental Threats
Hearing of the Senate Committee on Environment and Public Works, Washington, DC, 3/17/10

Endocrine Disrupting Chemicals in Drinking Water
Hearing of the House Committee on Energy and Commerce, Subcommittee on Energy and the Environment, Washington DC, 2/25/10

Biomonitoring: A Tool for Public Health Policy
American Chemistry Society Congressional Briefing, 3/09

Health Risks to Children and Communities from Recent EPA Decisions on Air and Water Quality
Hearing of the Senate Committee on Environment and Public Works, Washington, DC, 2/07

Selected TV and Radio Appearances:

Gulf Oil Spill Health Effects
PBS Need to Know, National TV, 6/10
CBS Evening News, National TV, 6/10
CNN Evening News, National TV, 5/10
CBS The Early Show, National TV, 5/10

Cancer Cluster in Fort Chipewyan, Alberta
Canadian Broadcasting Company National Radio, 5/10

Protecting Children from Toxins in the Home
Childhood Matters, KISS-FM Radio, San Francisco, CA, 7/05; 9/07

EPA's Chemical Testing Program
NPR's Living on Earth, 6/07

Protecting the Body from Heat
MarketWatch Special Report: An Investors Guide to Global Warming (Web Video), 5/07

Mold Testing in New Orleans Post-Katrina
National Public Radio, Living on Earth, 11/05
CNN News, 11/05

Diesel Exhaust Inside School Buses
National Public Radio, Science Friday, 2/01

Selected Scientific and Educational Presentations:

Children's Health and the Gulf Oil Spill
Pediatric Academic Societies Annual Meeting, 5/11

Toxicity Testing in the 21st Century
National Academy of Sciences Conference, 5/09

Biomonitoring: A Tool for Public Health Policy
UC Berkeley School of Public Health, 3/09
UCSF School of Medicine, 1/09

Preparing for Climate Change in California
UCSF Continuing Medical Education Course, 11/09
UCSF School of Medicine, 1/08, 3/09
Public Policy Institute of California, 12/08
UCLA School of Public Health, 10/07

Health Effects of Global Warming

Governor's Global Climate Summit, 9/09
Grantmakers in Health Annual Conference, 3/09
UCSF Advances in Internal Medicine Course, 5/08
California Joint Legislative Briefing, Sacramento, CA, 8/06

Health Hazards to Day Laborers
UCSF School of Medicine FCM 184, 12/08, 11/09
Clinica Martin Baro, 3/10

Taking an Environmental History
Kaiser San Francisco Internal Medicine Residents, 10/09
SFGH Internal Medicine Residents, 7/09
UCSF School of Medicine, 1/09
N245 UCSF Nursing School, 2/09
UCSF Family and Community Medicine Residents, 12/08
UCSF Integrative Medicine Course, 5/08

Pediatric Environmental Health "Toolkit" for Pediatricians
San Francisco General Hospital Pediatric Grand Rounds, 10/07
Stanford Lucile Packard Children's Hospital Grand Rounds, Palo Alto, Ca, 4/07
Oakland Children's Hospital, Oakland, CA, 5/07
O'Connor Hospital Combined Grand Rounds, San Jose, CA, 4/07
Kaiser Santa Teresa Hospital, San Jose, CA, 6/07
Kaiser Oakland, Oakland, CA, 10/06

Cancer and the Environment
Institute for Functional Medicine Annual Meeting Plenary Address, 5/10
Northern California Cancer Center, 3/08, 10/08
UCLA Ted Mann Family Resource Center Insights Into Cancer Lecture, Los Angeles, CA, 3/07

Mold Contamination in New Orleans Post-Katrina
UC Irvine Medicine Grand Rounds, 12/07
Stanford Law School, 10/07
CDC National Environmental Public Health Conference, Atlanta, GA, 12/06

Healthy Food in Healthcare
Stanford Medical School, Palo Alto, CA, 10/05, 10/06, 11/09
UCSF Medical Center, San Francisco, CA, 3/06 & 5/06
CleanMed National Conference, Seattle, WA, 4/06
John Muir Medical Center Combined Grand Rounds, Walnut Creek, CA, 3/06

Endocrine Disruptors in the Home and Community
Heinz Conference on Women and the Environment, Boston, MA, 10/06

Controlling Environmental Hazards in Communities of Color
National Legal Aid and Defenders Association Conference, Snowbird, UT, 6/06

Breastfeeding in a Contaminated World
March of Dimes Perinatal Conference, Chicago, IL, 3/06

Mercury and Current Fish Consumption Guidelines for Children
American Academy of Pediatrics Annual Conference, San Francisco, CA, 9/05

Why Should an Internist Care About Environmental Disease?
U.C. Davis Internal Medicine Grand Rounds, Sacramento, CA 7/10
Kaiser Permanente Medical Grand Rounds, San Francisco, CA, 4/04
UCSF Alice Hamilton Memorial Lecture Grand Rounds, San Francisco, CA, 3/04

BRIANA E. MORDICK

PROFESSIONAL EXPERIENCE

NATURAL RESOURCES DEFENSE COUNCIL *Washington, DC*
OIL & GAS SCIENCE FELLOW *September 2010 – Present*

Technical advisor on oil and gas related issues. Provides scientific expertise and analysis in support of advocacy efforts. Engages with and serves as a liaison to the scientific community.

ANADARKO PETROLEUM CORPORATION *January 2005 – September 2010*

Greater Natural Buttes Natural Gas Field, Uinta Basin, UT (June 2009 – September 2010)
Senior Geologist & Team Lead

- Geologist responsible for drilling 50+ wells and selecting 500+ new drilling locations
- Worked to develop new criteria and methods for selecting optimal well locations
- Lead a team of four co-workers who were responsible for two drilling rigs and hundreds of wells; organized and lead meetings; provided weekly updates to management; served as point of contact for extended team members

Salt Creek Field CO_2 Enhanced Oil Recovery Project, Natrona County, WY (Nov 2006 – June 2009)
Geologist II

- Described and analyzed core data to develop full field depositional model
- Analyzed well logs, core, and production data to determine flow pathways of oil and CO_2
- Assisted in construction of digital 3D geologic reservoir model used for oil and CO_2 flow simulation modeling

Ozona Natural Gas Field, Crockett County, Texas (Jan 2005 – Nov 2006)
Geologist I

- Geologist responsible for drilling 100+ natural gas wells, analyzing logs, and recommending zones to be completed for production
- Remapped subsurface geology, resulting in greater predictability of productive zones in wells
- Successfully presented underdeveloped natural gas prospect at the North American Prospect Expo (NAPE) and engaged a partner to develop these prospects

ANADARKO PETROLEUM CORPORATION *The Woodlands, Texas*
GEOSCIENCE INTERN *September 2004 - November 2004*

Evaluated the Baxter shale in active Wyoming oil and gas fields for shale-gas production potential.

EDUCATION

UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL *Chapel Hill, North Carolina*
MASTER OF SCIENCE, GEOLOGICAL SCIENCES *September 2002 – May 2005*

Thesis: Pyroxene thermobarometry of basalts from the Coso and Big Pine volcanic fields, California

BOSTON UNIVERSITY *Boston, Massachusetts*
BACHELOR OF ARTS, EARTH SCIENCE *September 1998 – May 2002*

Senior Thesis: Provenance of discrete ash layers from the Izu-Bonin Arc system using Laser Ablation-Inductively Coupled Plasma-Mass Spectrometry

BRIANA E. MORDICK

PUBLICATIONS

Mordick, B.E., Glazner, A.F., 2006, Clinopyroxene thermobarometry of basalts from the Coso and Big Pine volcanic fields, California: Contributions to Mineralogy and Petrology, v. 152, no. 1, p. 111-124.

SELECTED PRESENTATIONS

- October 19, 2010:
  - Forum: National Research Council of the National Academies, Board on Earth Sciences and Resources, Committee on Earth Resources
    - Meeting Title: "Meeting Our Nation's Natural Resource Needs: Balancing Risks and Rewards"
    - Presentation Title: "Environmental Impacts of Oil and Gas Production"
- March 11, 2011:
  - Forum: EPA Hydraulic Fracturing Study Technical Workshop
    - Meeting Title: Well Construction and Operations
    - Presentation & Abstract Title: "Risks to Drinking Water from Oil and Gas Wellbore Construction and Integrity: Case Studies and Lessons Learned"
- June 1, 2011:
  - Forum: Environmental Entrepreneurs Monthly TeleSalon
    - Meeting Title: "Natural Gas in the Mix: Finding the Balance"
    - Presentation Title: "Environmental Impacts of Natural Gas Production"

- September 27, 2011:
  - Forum: University of Wyoming Hydraulic Fracturing Forum
    - Meeting Title: Hydraulic Fracturing, A Wyoming Energy Forum
    - Presentation Title: Hydraulic Fracturing Best Practices: Mitigating Environmental Concerns