ALPHA GEOSCIENCE
Geology
Hydrology
Remediation
Water Supply

February 4, 2011

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Re: Review of USGS Comment on dSGEIS

Dear Kathy:

Alpha Geoscience (Alpha) prepared this letter report in response to a comment by the U.S. Geological Survey on the *Draft Supplemental Generic Environmental Impact Statement (dSGEIS) on the Oil, Gas and Solution Mining Regulatory Program*. The comment was included in a December 18, 2009 letter from Ward O. Freeman, Director, U.S. Geological Survey (USGS) to Bradley J. Field, Director, Division of Mineral Resources, New York State Department of Environmental Conservation (NYSDEC). The USGS provided comments on specific sections of the dSGEIS. Alpha was requested to specifically address the issue of Acid Rock Drainage (ARD) from shale cuttings. The USGS inappropriately refers to "Acid Mine Drainage" (AMD) in its comment (below). The term "ARD" is used herein and is preferred because the term AMD pertains to mining and not to drill cuttings.

> ***Section 7.1.9:***
> *"On-site burial of drill cuttings at shale-gas development sites needs careful evaluation. Pyrite is abundant in the high-TOC basal intervals of the Marcellus Shale (Lash and Engelder, 2008). Oxidation and leaching of pyritic shale produces an acidic, metals-rich discharge commonly referred to as AMD (Acid Mine Discharge)). A multi-horizontal well site will generate 500 times the volume of AMD-producing pyritic shale cuttings than that generated at a single-vertical well site. In addition to the potential for AMD, the NORM content of these materials needs to be considered. On-site disposal of cuttings typically are dewatered by puncturing the lower side of the containment liner, which allows the migration of any contaminants from the cuttings to downgradient groundwater and surface water. A strong consideration for on-site containment followed by removal and safe disposal of shale cuttings should be considered."*

RESPONSE:

The average pyrite content of the Marcellus shale is estimated to be 5 percent by weight based on 189 samples of the Marcellus Shale from 48 drill holes in New York, Pennsylvania, Ohio, West Virginia, and Virginia (Hosterman and Whitlow, 1983). Individual samples of the Marcellus Shale collected in six central and southern tier New York State counties have been analyzed and contain between 1 and 17 percent pyrite by weight (Exhibit 1) (NYSGS, personal communication, September 7, 2010). The average pyrite content of the Marcellus Shale in the six wells sampled ranges from 3.5 percent by weight in Onondaga County to 9.8 percent by weight in Tioga County. Pyrite has been found concentrated in the basal, organic rich Union Springs member (New York) of the Marcellus in fine laminae (Lash and Engelder, 2008), but also occurs as small nodules and disseminations throughout the unit (Avary and Lewis, 2008). Exhibit 1 demonstrates a slight upward trend in pyrite content with increasing depth for four of the six wells sampled and a definite downward trend in pyrite content with increasing depth in the Sullivan County well. The Onondaga County well does not show an obvious trend. The lower Marcellus, which is high in total organic carbon in many areas, is the primary gas target zone. Horizontal well bores will extend several thousand feet within this zone, so cuttings containing pyrite will be generated during this stage of drilling.

USGS Comment 7.1.9 states that a multiple horizontal well site will produce 500 times the volume of pyritic cuttings that a single vertical well will generate. The USGS does not provide the details and assumptions used for this estimate. This seems to be an over-estimate and seems to ignore the fact that a substantially larger subsurface area is developed by a horizontal well than by a vertical well. Six horizontal wells on one pad will develop an area of approximately 640 acres. Approximately sixteen (16) vertical wells on a 40 acre spacing would be required to develop the same area as six horizontal wells.

Each horizontal well will penetrate approximately 4500 feet of Marcellus Shale, or a total of 27,000 lineal feet for six horizontal wells. A single vertical well will penetrate approximately 200 feet of the Marcellus Formation, or a total of 3,200 lineal feet for 16 vertical wells. Assuming the vertical wells and horizontal wells are the same diameter, the horizontal wells will produce approximately 8.4 times more Marcellus shale cuttings as the vertical wells to develop an equivalent area.

The pyrite content by weight percent of the cuttings from the horizontal wells will be higher than that of a vertical well, because the horizontal wells will likely target the basal organic-rich portion of the Marcellus that is generally higher in pyrite content . Exhibit 1 provides a summary of Marcellus shale pyrite content based on analytical data provided by the New York State Geological Survey. The average pyrite content of the cuttings from a vertical well that penetrates a 200-foot section of the Marcellus shale is expected to be approximately 6.4 percent (the average of the values shown on Exhibit 1). The average pyrite content of the Marcellus shale cuttings from horizontal wells may be in the range of 7.5 to 9.8 percent (the highest average values shown in Exhibit 1). The ARD potential of Marcellus shale cuttings from horizontal wells can be expected to be greater than from vertical wells based on the greater volume of cuttings and the likely higher pyrite content. Nonetheless, many factors affect whether or not ARD potential is an environmental concern including exposure of the cuttings (or lack thereof) to water, the pH of the water, the size and volume of the cuttings, availability of oxygen, percentage and form of the pyrite (i.e., nodules vs. disseminated), etc. Historically, drill cuttings containing pyrite have not been identified as a significant environmental concern associated with natural gas drilling operations in New York. It is anticipated that this will continue to be the case.

The following statement by the USGS is incorrect with regard to both ARD potential from pyritic cuttings and to the potential presence of NORM.

> *On-site disposal of cuttings typically are dewatered by puncturing the lower side of the containment liner, which allows the migration of any contaminants from the cuttings to downgradient groundwater and surface water* (USGS Comment 7.1.9)

Chapter 9, section H.8 of the original GEIS on Oil Gas and Solution Mining Regulatory Program clearly states that all waste fluids, including fluids from cutting pits, must be removed from the well site and disposed in an environmentally acceptable manner within 45 days of the cessation of drilling. This is according to 6NYCRR Part 554.1(c)(3). Some operators may use oil or polymer-based muds when drilling the horizontal portion of a well bore as indicated in part 5.2.3 of the dSGEIS. The operator must remove all of the cuttings generated using oil or polymer-based muds from the site for disposal in a solid waste landfill and hence, ARD potential at the site is no longer an issue. This, however, is not the case all of the time. Cuttings generated by air drilling and fresh water-based drilling may be disposed on site.

Section 5.13.1 of the draft SGEIS states that only cuttings from air or fresh water drilling may be disposed on-site; they could be buried on-site. Given the ARD potential of the fresh pyritic cuttings (e.g. Smith et al, 2006), their disposal on-site during well-pad reclamation should be subject to specific best management practices (BMP) for this type of material. Drill cuttings generated from formations stratigraphically above the Marcellus are not considered to be significantly pyritic (Hosterman and Whitlow, 1983) and, hence, would not contribute to the ARD potential of the cuttings. Depending on the mineralogy of these cuttings (specifically, the carbonate mineral content), these cuttings may act as a partial buffer to any acid produced by the reaction of the fresh pyrite with oxygen and water, thus reducing the overall ARD potential. Pyritic cuttings generated by air or fresh water drilling may be suitable for on-site burial when mixed with more basic cuttings. The NYSDEC may consider requiring any operator that proposes to bury drill cuttings with ARD potential on site to implement BMPs or to propose and support other measures to identify and mitigate ARD potential. Some BMPs that may address ARD potential include:

- Mixing acidic pyritic and basic carbonate cuttings until leachate from the mix is not acidic .
- Mixing pyritic Marcellus Shale cuttings with waste lime and burying the mix in a fill area enveloped with limestone waste rock. This method was used by PennDOT and PADEP to abate ARD during the construction of U.S.Route 22 near Lewiston, PA in 2004.

- Segregate the non-pyritic and pyritic cuttings, and remove the pyritic cuttings from the site for disposal in an environmentally acceptable manner (e.g. permitted landfill).

NORM is thoroughly discussed in chapters 4 through 7 of the dSGEIS. Section 7.8.2 discusses the regulation of NORM in NYS. The dSGEIS acknowledges that wells drilled into the Marcellus in NYS and other states show significant variability in NORM content both between wells in different portions of the formation and at a given well over time. NYSDEC plans to require sampling and analysis to assess this variability during initial Marcellus Shale development efforts. Data collected will be used to determine if additional mitigation is necessary to adequately protect the environment and public health of NYS.

References cited above that were used to prepare this response include the following:

Avary, K.L. and J.E. Lewis, 2008. New Interest in Cores Taken Thirty Years Ago: the Devonian Marcellus Shale in Northern West Virginia.

Hosterman, J.W. and S.I. Whitlow, 1983. Clay Mineralogy of Devonian Shales in the Appalachian Basin: U.S. Geological Survey Professional Paper 1298, 31 p.

Lash, G.G. and Engelder, T., 2008. Tracking the Burial and Tectonic History of Devonian Shale of the Appalachian Basin by Analysis of Joint Intersection Style: Geological Society of America Bulletin.

New York State Geological Survey, September7, 2010; personal communication.

Smith, M.W., J.P. Varner, J.P. Mital, D.J. Sokoloski, 2006. Remediation of Acid Rock Drainage from Highway Construction in the Marcellus Shale, Mifflin County, Pennsylvania. (Abstract at http://gsa.confex.com/gsa/2006NE/finalprogram/abstract_100515.htm).

Please feel free to contact me with any questions you have regarding this response.

Sincerely,
Alpha Geoscience

Thomas M Johnson

Thomas M. Johnson
Hydrogeologist

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