Review of "Groundwater and Surface Water Impacts from Surface Mining by North Mountain Shale, Berkeley County, WV" by Grenot and Ahnell (2009)

Joseph J. Donovan, PhD.

91 Grandview Avenue
Morgantown, WV 26501

22 July 2009

Purpose and Scope

This review is an analysis of a report titled "Groundwater and Surface Water Impacts from Surface Mining by North Mountain Shale, Berkeley County, WV", prepared by Charles H. Grenot Jr., P.G., and Gerald Ahnell, P.G. for North Mountain Shale, LLC (NMS) and dated 15 July 2009 (these authors will be referred to hereafter as "GA" for brevity). The review was done at the request of Mr. Paul Fisher, Director, Berkeley County PSD. The terms of reference are to provide an analysis of portions of this report relating to groundwater occurrence along North Mountain in the vicinity of Gerrardstown, WV and of the proposed development. In particular, emphasis was to be placed on potential impacts to aquifers of either current or potential utilization by the PSD.

The review considers only site and regional hydrogeology, and therefore makes no analysis of:

- mine construction or design
- sediment control in runoff passing through or leaving the NMS site
- reclamation of disturbed rock or soils

Specific elements reviewed include:

- completeness of presentation of regional geology and hydrogeology from published work
- GA's general interpretation of the hydrogeology for the NMS site and surrounding areas
- well and spring monitoring data reported from earlier work or collected for this investigation
- GA's addressing of public concerns regarding impact of the NMS project on neighboring water wells and groundwater levels in general
- GA's addressing of public concerns regarding impacts on Mill Creek and Springdale Farms spring
- GA's addressing of potential impacts on PSD wells in this area.

Synthesis of the GA Report

Significant conclusions of the GA report were difficult to ascertain as they are nowhere summarized, either at the end of the report or in Executive Summary form, and the organization of the report is unconventional. The following are drawn as conclusions from various sections of the report:

- the proposed mine will extract Martinsburg shale in a pair of borrow pits between 770 and 900 feet above sea level on slopes from 8-30%, all in the lower slopes of North Mountain. From Figure 1, each pit will be on the order of 40 acres (p. 6)

- environmental mitigation efforts will include erosion and sediment control; an NPDES permit for total suspended solid in water leaving sediment control ponds; avoidance of "beheading" stream heads to minimize sedimentation; and revegetation with topsoil and annual grasses. (p. 7-8)

- well waters and surface waters in the area may be classified as being of apparent clastic source (TDS<200 mg/L) or carbonate source (TDS>250 mg/L) based on degree of mineralization (p. 4)

- the mining operation will have no impact on the local groundwater table (p. 8)

- the mining operation will have no impact on the recharge or water quality of Springdale Farm springs, due to low hydraulic conductivity in the Martinsburg Fm. and to complex geologic structure between the mine and the springs (p. 11-12)

- because sections of Mill Creek and its tributaries are non-perennial, they will not be impacted by the mining operation (P. 11)

- Berkeley PSD area #4 (a potential future groundwater exploration area) is too far from the excavation areas to be impacted by it (p. 13)

Critique of GA report

Points of agreement

GA have compiled the original regional geological sources in an adequate fashion, and represent the geologic setting well. The Silurian-Ordovician units east of the Back Creek fault are highly deformed and steeply dipping, either near vertical or overturned. Minor fold structures and perhaps thrust or reverse fault splays might be expected to occur at small scale within the Martinsburg, to an even larger extent than is mapped by Lessing, Dean, and Kulander.

The future monitoring plan proposed by GA is quite unclear. However, their baseline monitoring of water chemistry is adequate in that they have identified and sampled a reasonable subset of private wells downgradient from the mine. They have also attempted to evaluate water chemistry in the Martinsburg at various depths of groundwater occurrence.

It is agreed that the Tuscarora quartzite will tend to form an effective aquitard ("barrier" is quite too strong a term) between the mine and wells in the vicinity of Glenwood Forest subdivision, belonging to the PSD. Springs occur on both sides of North Mountain, clear evidence that there is a groundwater divide somewhere beneath the crest of North Mountain. Water in wells in Devonian and upper Silurian (above the Tuscarora) strata likely flow northwest. Groundwater on the east side of North Mountain (including the NMS site) likely flows southeast.

Points of contention

1. A potentiometric map of well and spring heads is strongly needed to demonstrate hypotheses for groundwater flow stated in this report. The absence of such a map from a

report of this type is puzzling. If insufficient data are available for interpolation (often the case), then modeling simulations could be performed.

2. GA may understate the potential for dewatering. They state (p. 7 top para.) that pumping is required to lower potentiometric levels in groundwater around the excavation. That is incorrect. If ground surface elevation of a pit is lower than the water table, seepage will flow into the pits from its perimeters (lateral and upslope) without pumping and lower the surrounding water table. The question is: will the floor of the pit be excavated to below the water table? If the answer is no, then it will proceed as they predict. If the answer is yes, then there will be dewatering of shallow groundwater under gravity conditions. In the absence of geotechnical borings and water table wells, it is unclear how they know where the water table is (and I am surprised they are able to document their resource without these data). The water table will be higher, in all likelihood, between drainages than in the stream itself (groundwater is after all flowing towards these drainages). So if they only plan to mine unsaturated materials – how thick is that, and (alternately) what will they do if they encounter shallower water tables than they expect?

   It would be useful to know how deep NMS is planning on excavating and what they plan to do if they encounter shallow water tables. It is also be germane to what elevations the excavations will be refilled/recontoured upon reclamation and whether dewatering impacts are short term or long term.

3. GA assert, without supporting evidence, that the natural groundwater flow through the Martinsburg, Elbrook, and other units will be reasonably slow. They make no attempt to quantify this despite availability of regional estimates (Kozar and Mathies, 2001; McCoy and Kozar, 2008). No hydraulic heads are calculated or presented even though such data would have been readily available from springs, watercourses, ponds, and water levels in wells. A potentiometric map would have been a very useful product for this report, even if there is the potential (or likelihood) for preferred flow pathways along fractures that would not be reflected in a potentiometric map. To develop a basic potentiometric map, however, would provide more information and confidence than the large yellow arrow offered by GA.

   I do not believe that groundwater flow through the Martinsburg is as slow as the authors suggest. It is a calcareous shale, esp. in its lower units, and has been known to offer decent well yields in locations where it is fractured (Zewe, 1991). It is also not clear how small folds or faults might "inhibit east to west flow" (p. 11). The opposite is more likely true – tight folds and small faults are usually more highly fractured zones, and increased fracturing likely increases permeability.

   All that being said, I would agree with GA that there will likely be no depression of the water table downgradient of the mine (below about 750 feet elevation), even if some dewatering does occur around the mine itself. This would support that negligible impacts are expected at bedrock wells in the Gerrardstown area. It would be prudent practice to institute long-term water level monitoring downstream of the mine, e.g. near well GW mon 01.

4. The chemical analyses are very incomplete in spots – see the large number of samples for which Ca, Na, K, NO3, and Cl were not analyzed. GA seems to have determined that "non-carbonate waters" would not contain alkali or alkaline-earth cations. As documentation of baseline conditions, complete chemistry would be needed. If these sample bottles are still available, these ions should be analyzed.

Source water protection

No mention was made in the GA report of source water protection. Given that public water supplies (as well as private supplies) are potentially downgradient of NMS and that the mine could be considered as a Potential Contamination Source (PCS), it would be prudent for source water planning to be undertaken. Source water plans identify recharge areas upgradient (hydrogeologically) from wells used for public or private supply, and also identify PCS locations within such areas. There is a strong possibility that the NMS mine would lie within the source water areas for much of PSD Area 4, for the Springdale Farms springs and wells, and for many of the private wells in Gerrardstown. The potential threat is that of a future contamination event introducing soluble contaminants to the aquifer beneath either of the excavations. I would pose this as a risk that could be planned for and managed. It is the same risk, for example, that is managed by the City of Martinsburg at their Big Spring plant, which harvests water from the Cambro-Ordovician karst beneath Martinsburg shale pits. So this is not to infer that the mine is an unacceptable risk to aquifer water quality. It does mean, however, that steps should be taken to identify PCS locations and mechanisms and to minimize the potential for contamination from these sites.

It would be prudent for the PSD to request the source-water protection issue be included as a planning point for this mine. Mining law (SMCRA), Safe Drinking Water Act, and public concerns should all be considered when developing a Source Water Protection strategy.

Summary of key review points

1. The GA report contains adequate summary of the geological conditions, but there are some number of errors and omissions in their treatment of the hydrogeology. The most significant of these are: misinterpretation of the potential for groundwater drainage into the excavations; an "arm-waving" approach (no potentiometric map) to assessment of downgradient impacts; and incomplete reporting/analysis of chemical baseline results.

2. Limited downgradient impacts are expected on groundwater availability for existing or potential PSD wells or for private wells in Gerrardstown. This is predicated on the depth of excavation proceeding to no deeper that 750 feet elevation. It is also likely that the inferred groundwater divide of North Mountain will not substantially migrate and that PSD wells at Glenwood Forest will be unaffected. **Monitoring to ensure this occurs should be recommended.** Fractured bedrock and karst hydrogeology is complex and requires more caution than diffuse groundwater movement.

3. There may be local drainage of springs and shallow groundwater along North Mountain upslope and lateral into the excavations, even without pumping, depending on how deep

clay is excavated. Discharge of very nearby springs may be reduced. This water will return to the hydrologic system below their sediment ponds.

4. Source water protection was not addressed in the GA report and should be a feature of the mine planning, requested by the PSD

In summary, the real impacts of this mine on groundwater may be very minor. Nonetheless, given its position in the recharge area for both private and future public water supplies, it would be prudent to plan to make sure that this mine does not become a source of chemical contamination.

I am adding some additional references for the benefit of GA. There are probably some others but these for sure would be useful to them.

Recommendations

1. NMS should, if possible, complete its chemical analyses of monitoring samples already collected to include all common analytes (Ca, Mg, Na, K, Fe, Al, Mn, alkalinity, pH, Cl. NO3, SO4), not an arbitrary subset for different samples. These samples are a timely baseline for evaluation of future post-mining changes.

2. NMS should make a realistic estimate on pit dewatering flows (both peak and average), and identify what, if any, springs outside the excavation may be lowered in flow or dried up. If they really do feel there will be zero dewatering flows, they should provide evidence for this claim that their excavations won't extend to below the current water table.

3. The PSD should ensure it continues adequate chemical monitoring of its own wells at Springdale Farms and Glenwood Forest that it does to meet US EPA and WVDHHR requirements. This will allow future determinations of any changes in baseline condition with respect to potential contamination that might be introduced from the NMS mine.

4. Specific monitoring locations close to the mine should be established for continuous unattended water level recording to assure no long-term water availability impacts. If these wells are unused and available for monitoring, my suggestions for locations would be "GW Mon 01" and "PSWD Well 03". Sealed pressure loggers that are virtually maintenance-free should be used. At these two locations, groundwater storage declines would have the best chance of being observed first. Infrequent periodic chemical sampling of water from these sentry well locations during mining would also be prudent, provided they are done following rigorous protocols for well purging and sample collection/preservation/chain of custody.

5. Source-water protection plans should be developed or updated for the area of Figure 1 in the GA report, including well/spring sources at Glenwood Forest, Gerrardstown, and PSD area #4. This would be a good time to update source-water delineations for these areas and to determine if the NMS pits lie within these. I am under the understanding that the new WV Rural Water program to map statewide protection areas has started and

that Lew Baker has included Berkeley County in this program. This may be an opportunity to do source water planning downgradient of NMS in a setting where both PWS sources and private sources could be affected.

REFERENCES

Early, Jason S., 2005. Regional scale steady-state groundwater flow model of a steeply-dipping karst aquifer, Shenandoah Valley of West Virginia-Virginia. Unpublished M.S. thesis, West Virginia University, 105 pp.

Kozar, M.D., and Mathes, M.V., 2001, Aquifer-characteristics data for West Virginia. U.S. Geological Survey Water Resources Investigation Report 01-4036, 74 p.

McCoy, Kurt, and Kozar, Mark, 2008. Use of sinkhole and specific capacity distributions to assess vertical gradients in a karst aquifer . Environmental Geology, Volume 54, Number 5, May 2008 , pp. 921-935(15)