Geotechnical
Water Resources
Environmental and
Ecological Services

Technical Memorandum

Identification of Issues in Regard to the "Pond et al. Study" on Effects of Mountaintop Mining and Valley Fill on Benthic Invertebrate Communities

1.0 Background

Mountaintop mining and valley fill is a mining technique used presently and historically in coal mining in the central Appalachian region of the eastern United States. Excess overburden from the mining operations is deposited in valleys which usually contain ephemeral or intermittent stream systems. To control potential excess sedimentation, sediment ponds are often constructed downstream of the overburden fills. Pond et al. (2008) (Pond/Passmore Study) indicated that mountaintop mining with valley fill techniques are detrimental to the stream ecosystems, as measured with bioassessment of benthic invertebrate communities. This technical memorandum identifies several areas of concern that should be further investigated in order to validate or qualify the findings of the Pond/Passmore Study.

2.0 Issues Raised by the Study

2.1 Multimetric Indices Used

The Pond/Passmore Study was intended to contrast two multimetric invertebrate indexes that have been developed for use in West Virginia. The first is the WVSCI, a family-level index developed several years ago, which according to the original publication apparently did a good job of discriminating between reference and impacted streams (Tetra Tech 2000). The other is GLIMPSS, a draft, unpublished genus-level index recently developed by several scientists who are also co-authors of the Pond/Passmore Study (Pond et al. unpublished draft report). The Pond/Passmore Study concluded that the WVSCI underestimated impairment to West Virginia streams and concluded that the GLIMPSS index did a superior job of discriminating between reference and impacted streams.

2.2 Conductivity as the Controlling Factor?

The Pond/Passmore Study relied heavily on conductivity measures to corroborate their findings of "stream impairment" using the GLIMPSS index. Conductivity is often used as a surrogate measure of other, often complex, water chemistry parameters, and is influenced by numerous organic and inorganic compounds.

The surrogate use of conductivity measurements in the Pond/Passmore Study is possibly inappropriate. For example, Armstead (2006) cited several cases of high invertebrate metric scores (WVSCI) even with high conductivity, as well as high invertebrate metric scores in the presence of variable conductivity. These case studies included streams within the West Virginia coal mining belt. Because conductivity is only a surrogate for other water chemistry variables, findings associated with conductivity should be investigated further to determine which specific compounds may be responsible for changes in conductivity, as it may not be possible to identify which compounds those are – or if the specific compounds vary with location. Furthermore, the arbitrary division of low (<500 µS/cm), medium (500 – 1000 µS/cm), and high (>1000 µS/cm) conductivity in the Pond/Passmore

Study should also be investigated to determine if these cutoff values represent streams that are actually behaving similarly within the individual groupings.

2.3 Other Possible Reasons for Patterns Observed

There are a number of confounding factors related to valley fill conditions and the patterns observed by Pond/Passmore that may be unrelated to conductivity. For example, the relations between the settling ponds associated with valley fill and resultant stream chemistry, water quality, food quality, and invertebrate community composition could be an important causal agent for the changes in invertebrate community structure. On p. 718 (2nd full paragraph), Pond et al. (2008) stated that there are sediment control structures and ponds associated with mountaintop mining and valley fill and indicate that fine sediments may still bypass those controls. However, they did not state if sediment control structures were in place for all or part of the mining sites used in their analysis.

In fact, the presence of sediment ponds (and not any "elevated conductivity" below the valley fill itself) may be, in part, responsible for any observed changes in invertebrate community composition downstream of those ponds.

2.3.1 Hydrologic Modification?

Armstead (2006) suggested that the valley fill and the sediment control ponds may retain water and release it more slowly to the stream channels than normal surface flows. This may result in the streams behaving more like a perennial spring system than an intermittent/ephemeral stream system – i.e., systems with more constant flows for longer time periods (including year-round). Water chemistry and even biological communities in such perennial "spring-like" systems are often vastly different from those of intermittent/ephemeral and even more variable downstream systems (Williams 1987).

This aspect of the stream hydrologic change should be investigated for these study streams, perhaps by comparing a range of stream conditions similar to those found in the Pond/Passmore Study streams to natural spring systems. This comparison could evaluate the potential influence that conversion of the ephemeral/intermittent stream system to a perennial spring-type system might have to alter the community composition in the streams.

2.3.2 Changes in Food Resources?

Armstead (2006) cited several publications regarding increases in the "collector" functional feeding groups (especially filter feeding hydropsychid caddisflies) below impoundments. Past research indicated shifts in community structure within the hydropsychid community downstream of impoundments, suggesting that changes to the entire community might not be unexpected. It is possible that food resources discharged from the surface release of the settling ponds are rich in components fed on by hydropsychid caddisflies and other filter-feeding organisms, increasing their densities and competitively displacing other organisms, such as mayflies (which tend to be scrapers and collector-gatherers). This shift in community composition may be a natural occurrence below impoundments (and is observed below lakes) and deserves further investigation.

2.4 Trophic Function Maintained?

Although taxonomic changes in the community are evident, a more detailed examination of the results of the Pond/Passmore Study demonstrate that the functional structure of the community (both in terms of functional feeding groups and invertebrate "habits" – which are both used in development of multimetric indices) are actually relatively similar between mined and unmined streams. This suggests that the overall function of the benthic invertebrate communities remained relatively unchanged even though the taxonomic composition did change (Tables 1 and 2).

Table 1: Proportional abundance of functional feeding groups in the Pond/Passmore Study.

Functional Feeding Group	Unmined Sites	Low Mining Activity	Moderate Mining Activity	High Mining Activity
Gather-collector	29%	23%	24%	24%
Scraper	14%	17%	4%	8%
Filter-collector	12%	20%	24%	24%
Predator	21%	26%	20%	28%
Shredder	21%	14%	28%	12%
Piercer	2%	0%	0%	4%

Table 2: Proportional abundance of habit groups in the Pond/Passmore Study.

Habit Group	Unmined Sites	Low Mining Activity	Moderate Mining Activity	High Mining Activity
Swimmer	14%	17%	16%	12%
Clinger	62%	71%	68%	80%
Burrower	5%	0%	0%	0%
Sprawler	17%	11%	16%	8%
Climber	2%	0%	0%	0%

2.5 Basis for GLIMPSS Index?

The Pond/Passmore Study also relied heavily on the results from the recently developed and still unpublished GLIMPSS multi-metric invertebrate index. The Pond/Passmore Study indicated that the GLIMPSS index “performed better” than the previously established WVSCI index. However, there are several aspects of the development and use of the GLIMPSS index that should be investigated further.

Hundreds of metrics are available for use in developing a multimetric index (this fact is admitted in the GLIMPSS document), but development of the GLIMPSS index started with only 36 metrics, which was reduced to 9 metrics for the final index. The choice of metrics was based on the following: 1) sufficient metrics were chosen to span the metric categories of richness, composition, tolerance, and function; 2) some metrics had been used in the WVSCI and other national and regional biomonitoring programs; and 3) some metrics were excluded for biological reasons (e.g., Odonata metrics were not included because odonates are usually rare in riffle habitat – *although we note they are present in most of the sites in the Pond/Passmore study*). These are generally appropriate reasons for including or excluding some metrics from analysis. However, given the computing power available today, the original 36 metrics remains a small, somewhat arbitrary list of metrics to use as the initial list for development of a comprehensive, general-purpose, regional multimetric index. Furthermore, the initial list especially appeared to be lacking in diverse habit metrics (using clingers only) and few tolerance value-based metrics (using “sensitive” taxa with tolerance values <3 or <4 only). Exclusion of the other available metrics that would identify tolerant taxa could have resulted in an overemphasis in the GLIMPSS development on the intolerant taxa and, thus, an overestimation of “impairment”.

The EPT Orders were separated for individual analysis instead of applying the commonly used EPT index (in which they are summed), due to the apparent *a priori* bias of the authors regarding the potential influence of “tolerant” hydropsychid taxa on the EPT index (p. 728). This may have resulted in the elimination of Trichoptera metrics from the final index and perhaps caused an overemphasis on Ephemeroptera metrics.

The draft GLIMPSS document stated the criteria used to identify sites as attaining reference ("least disturbed") site condition, particularly emphasizing water quality parameters, habitat parameters, and lack of any evidence of anthropogenic disturbance. There was no identification of discrimination within potential disturbances to the "stressed" sites used in development and calibration of the GLIMPSS index. This leads to the natural dichotomy of "least disturbed" or "stressed", with no middle category wherein there may be influences on the metrics, but they are insufficient to cause significant changes to the community structure and function.

The development of a general-use multimetric index, such as GLIMPSS is purported to be, requires that the "stressed" sites be representative of the spectrum of anthropogenic influences. However, if one particular anthropogenic influence is heavily represented in the development of the multimetric index, then that index will necessarily be useful primarily for the identification of that particular anthropogenic influence. Figure 3 of the GLIMPSS document shows that a large portion of the sites used for both metric development and validation of the Central Appalachian Region index metrics were located in the Coal and Guyandotte watersheds, where many of the sites in the Pond/Passmore Study were also located. This would suggest that it is possible that many of the "stressed" sites used in development and validation of the GLIMPSS index were mine-related sites. Therefore, the identification of "impaired" sites by GLIMPSS techniques in the Pond/Passmore Study being related to valley-fill mines might be expected, since the index may be inadvertently geared toward identification of mined sites rather than general disturbances. The selection of sites for the development and validation of the GLIMPSS index should be investigated to determine if they do reflect the spectrum of anthropogenic influences or are overly represented by mined sites.

The GLIMPSS document indicated (p. 47) that it does not perform well in streams with significant limestone geology and associated groundwater discharges (high alkalinity and low temperatures leading to low invertebrate diversity). An investigation should be undertaken to determine if the sites examined in the Pond/Passmore Study are limestone dominated, a fact which might indicate that GLIMPSS was inappropriate for use.

Additionally, there may be possible changes to the nature of the affected streams as described above, in which the streams behave more like a perennial, spring-fed stream than an intermittent/ephemeral stream system – an overall stream condition influence that may not be accounted for in the GLIMPSS development.

3.0 Summary

In summary, while the findings of the Pond/Passmore Study appear on the surface to strongly indicate a causal agent of conductivity to "impairment" of invertebrate communities, as related to variable valley-fill mine influence, our preliminary review indicates that there are a number of other factors which could account for those patterns. It is clear that additional study of these patterns should be conducted to determine if conductivity is potentially providing a "false signal" and if, in fact, there are other reasons for the observed changes in invertebrate community structure.

4.0 References

Armstead, M. Y. 2006. *Status of the Industry Understanding of the Effects of Mountaintop Mining and Valley Fills on Aquatic Resources*. Report prepared for Jackson & Kelly, PLLC, Charleston, WV.

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