Report for 2002KY6B: Impacts of surface mine valley fills on downstream peak flows in eastern Kentucky

- Articles in Refereed Scientific Journals:
  - Phillips, Jonathan D., Submitted, Impacts of Surface Mine Valley Fills on Headwater Floods in Eastern Kentucky , Environmental Geology, 43 p.

Report Follows:

Problem and Research Objectives

The potential impacts of valley fills associated with mountaintop removal/valley fill (MTR/VF) coal mining on downstream flooding in the coalfields of eastern Kentucky and adjacent states have been a subject of both public debate and scientific uncertainty. Previous studies, and basic hydrologic principles, indicate that flood frequencies and magnitudes might be increased or decreased downstream of valley fills. This study explored three aspects of that issue.

Methodology

First, bankful channel dimensions downstream of VF sites were measured and compared to those of similar unmined basins to see if channel hydraulic geometry had adjusted to a new post-fill flow regime. Second, hydrologic models were applied to assess relative runoff production and surface and subsurface flow detention times in the eastern Kentucky coalfields, using input parameters reflecting the range of typical hydrologic conditions at valley fills and undisturbed low-order valleys. Finally, the likelihood of short-range variability of storm precipitation was evaluated by applying the state probability function to NEXRAD radar estimates of precipitation for two 2001 storms which produced flash floods in eastern Kentucky.

Principal Findings and Significance

There was no systematic evidence of changes in bankful channel dimensions downstream of MTR/VF sites. However, most sites were essentially bedrock channels. Even if changes in flow regime have occurred, there has likely been insufficient time for a morphological response in these channels. Channel geomorphology is not a reliable indicator of changes in flow regimes in this situation. While mobile-bed, alluvial channels are able to respond morphologically to changes in flow regime relatively rapidly, the vast majority of channels affected or potentially affected by valley fills in eastern Kentucky are bedrock, or characterized by a thin veneer of sediment above bedrock. The response time for such channels is too long to make channel dimensions and hydraulic geometry a useful tool for addressing the problem of this study.

Results of the hydrologic modeling show that there is a clear risk of increased flood potential (greater runoff production and less surface flow detention) following MTR/VF operations, and suggest that, on balance, valley fills are more likely to increase than to decrease flood potential. However, there is a wide range and variability of outcomes, both qualitatively and quantitatively. Reduced as well as increased flood risks are possible, and the degree of either may vary markedly. The effects of MTR/VF mining on downstream peak flows are highly contingent on local pre- and post-mining conditions, and it would be unwise to apply generalizations to specific sites.

Finally, the occurrence of flash floods downstream of MTR/VF operations when nearby unmined areas did not flood or had less severe floods has frequently been explained in terms of locally greater precipitation. The spatial structure of precipitation from two storms causing flash flooding in 2001 indicates that, at the scale of the analysis (pixel size of approximately 2 km) large local variations in storm precipitation are unlikely. However, local spatial variability in storm precipitation and in runoff response is a well-known phenomenon, and it is likely that in at least some cases flash floods in both VF and unmined headwater basins can be attributed to highly localized precipitation and microscale meteorological phenomena.

The results of this study, including the review of previous work, reflect the difficulties often encountered in developing generalizations in hydrology and fluvial geomorphology. There are numerous variables and controls that affect hydrologic response, and significant variation in those controls and variables. Additionally, drainage basins are strongly influenced by historical factors ranging from their geological evolution to contemporary land management (such as mining and reclamation practices). Thus, it is difficult to state with confidence that MTR/VF does, or does not, increase or even tend to increase peak flows downstream. The situation is analagous to studies of downstream impacts of dams, where it has been shown that many outcomes are possible, that these outcomes are highly contingent on local conditions, and that prediction is not feasible except on a case-by-case basis.

We can say that MTR/VF mining can increase downstream flood risks, and that there is a very high probability that this has occurred and will occur downstream of some fills. On balance, results suggest that an increase in peak flows is more likely than a decrease or no change. However, our results also show that there is likely to be a great deal of variation, and that at a significant number of sites no increase in peak flows or flood risk will occur.

The variability in runoff and flow detention changes at VF sites also suggests that monitoring-based and comparative-watershed studies are likely to be of limited use in providing general or regional-scale answers into the issue of valley fill effects on peak flows, unless a large number of basins can be instrumented. Otherwise, the idiosyncratic nature of hydrologic response makes extrapolation of results problematic. This suggests that future work should be event-based and historical. That is, the question of valley fill effects of downstream peak flows should be approached via the analysis of specific flood events, and historical reconstruction of flow regimes, to specifically address the before- and after-mining flow regimes.

Investigations of flood complaints have generally found that when flood impacts can be directly attributed to mining, drainage and water control structures have been improperly designed, constructed, or maintained by the operators. This, coupled with the variable and highly contingent nature of the hydrologic response of VF sites, suggests that regulatory monitoring and enforcement is critical to reducing downstream flood risk.