running dump trucks filled with contaminated sediments up and down neighborhood streets and highways. In short, is "mass removal equals risk reduction" a testable hypothesis? To my knowledge, this hypothesis has not been tested. Therefore, I would like to make three recommendations.

It seems appropriate that the work of the NRC committee that produced this report should be extended to address three issues that are particularly relevant to environmental remediation:

- First, we should develop improved site assessment and characterization techniques, including monitoring techniques, to assess the efficacy of remedial alternatives after implementation.
- Second, we should improve the linkage between site assessments and risk assessments. This effort should include the development of models that predict reductions in risks for various remedial options, including natural recovery, as John Connolly suggested. In other words, we need improved decision-making tools before we start spending millions of dollars on remedies that may not have any effect.
- Third, we need to test the hypothesis that mass removal equals risk reduction, and we need to do this at multiple sites to better understand when mass removal might or might not make sense.

Mining Perspective

Paul Ziemkiewicz

I will focus on the interests of the coal industry as a user or recipient of some of these sediments. This material has a lot of potential in the coal industry. We are near many sources of sedimentation along the East Coast, where we have two types of mining settings. There are abandoned mine lands, which are pre-1977 mines and are, in a sense, orphans of the state. There are also active mines. Thus, we have two very different types of regulatory environments.

We also have underground mines and surface mines. To give you some idea of how much volume can be involved, a relatively small underground mine of 10 mi^2 (25.9 km^2) in the Pittsburgh basin, or even in the anthracite country here, normally has 25 million yd^3 (19.1 million m^3) of storage capacity, or something along those lines. Of course, you need to find out several things: Is the roof in good shape? Has it fallen in yet? Have the pillars collapsed? Structural things have a lot to do with the geology of the area and how long it has been since the mining was completed. But the potential volumes are very high.

In a surface mine, if you put a 2-ft (.6 m) layer of sediment on an acre of ground, you probably can get something like 30 to 100 tons per acre of dredged sediments, given the densities I have heard for this material. For example, within 80 mi (128.8 km) of New York City is the anthracite region in northeastern Pennsylvania, where extensive underground workings have existed for a long time. You also have 10,000 acres (4050 ha) of unreclaimed surface mines and tailings in the Luzerne and Lackawanna county areas. We are looking at transportation costs to get materials from New York City to that area.

In the coal industry, we always assume 10 cents to load per ton, and 10 cents/mi (6 cents/km). This means transportation costs—running legally on a 22-ton dump trailer—would be in the range of $8/ton to move it from New York City to Wilkes-Barre, Pennsylvania. What does it cost to get dredged material hauled? We have made slurries and mine grouts out of coal ash and other materials, and we need to bring in the ash and the cementing agent, normally concrete kiln dust or some type of scrap. We normally get them hauled for something less than $5/ton. I know nothing about dredging costs or port handling issues.

What are the applications for this type of material in the mining setting? One is mine grouting. A lot of mines, when we are finished with them, wind up with 50 percent voids, because we must keep about 50 percent of the coal in place to hold up the roof. When we pull out, there are enormous underground reservoirs of 10 to 30 mi^2 (25.9 to 77.7 km^2), which might be tipped at 30 degrees or be relatively flat. They eventually start filling up with water, particularly if they are below the natural water table. We wind up with an anoxic environment, reducing conditions, carbon dioxide gas, saturation in the water, and often very strongly acid water.

There are many occasions when you start pushing water up out of the ground again, and you can actually get "blowouts," in which the side of the hill fails and tens of millions of gallons of pH 2.5 water show up overnight. Blowouts can kill people; these are very serious events. Blowout protection, which involves trying to control the pressures inside these mines, is a major interest of the state abandoned mine land (AML) agencies and the active industry.

There is the potential of replacing these acid-forming voids or reservoirs with an inert grout. To turn sediments into grout, we would need to add a cementing agent. We would need to make sure the material would remain stable in the weathering environment of low-pH reducing conditions in an underground mine. A lot needs to be done to realize this idea, but it has major potential.

The other possibility is surface applications. We are looking at manufactured soils, what type of material you need to add to them, how suitable they are for growing crops versus other types of vegetation (e.g., forest cover), and so forth. I am sure that a lot of work has been done on this, but it certainly has not been documented to the point that the coal industry is either comfortable with it or aware of all of it. Most of the costs will be related to material handling, transportation, slurrying, bringing in cementing agents, and drilling.

What do we need to make this happen? No coal operator or AML agency would want to turn a plain-vanilla coal mine, no matter how bad it looks, into a Superfund site. Therefore, they need to know ahead of time how suitable a material is for their application and what the potential liabilities are. For that reason, it is necessary to have a classification system, not just "good" and "bad" sediment but several classes of it, indicating whether the material will pose a potential problem. If it will, they need to know that up front. They either have to encapsulate the material or take some special precautions.

A neat thing about moving this material underground is that the whole operation can be handled hydraulically. There would be no dust; the PCBs would not be mobile. To a large extent, mine acid is a sedentary agent. It contains a lot of acid and ferric iron, so there may be some dechlorination potential; this issue has not been explored yet.

The recipient states will develop their own guidelines at some point, if this gets to be an application. It would be beneficial if EPA or some other federal agency came out with guidance documents, pooled all the information, tried to develop at least guidelines for a classification system, and then let the states take it from there. In terms of the other issues, we need regulatory coherence. We need to define the relationship between the states and federal agencies. The liability issues also need to be simplified, and then we need research on suitability classification and on quality assurance and quality control (QA/QC) issues.

We need to have a QA/QC program so that a truck could come on site, and within a day or so, an analysis could be performed indicating whether or not the material meets the specifications for that particular classification. We cannot have a six-month test if we want an ongoing delivery system. These tests need to be collapsed into a relatively simple QA/QC procedure. We need to know mix formulations, their suitability, their stability in a chemical environment, and their strength.

We need, for example, materials that can develop unconfined compressive strengths of 200 to 300 lbs/in^2 to ensure roof control in underground mines. We need to know the flowability, which determines how many drill holes you will need and what your ultimate delivery costs will be. Ultimately, we need well-documented demonstrations on site so that state agencies and the public can be comfortable—or at least know how these various procedures will work for them and whether they will create an environmental benefit or another risk.

Inland Waterways and Lakes Perspective

Stephen Garbaciak, Jr.

I want to talk about an item that kept popping up during the presentations and breakout sessions, at least the two in which I participated. That item is uncertainty, and its role in a variety of issues related to dealing with contaminated sediments, for both remediation projects and navigational dredging. I think we heard some uncertainty about who this audience is; we heard a reference to this symposium as a dredging meeting. We heard talk about whether dredging is a presumptive remedy when it comes to reducing risk. The issue of uncertainty—including what it means for the selection and implementation of effective remedial options—is where the contaminated sediments debate is going. That would be a recommendation for the future.

We heard about uncertainty in assessment techniques, in establishing remedial objectives, and in what the beneficial reuse markets might be or how we can develop them. We heard uncertainty about the regulations. Do we have enough regulations? Are they being applied correctly or incorrectly? We heard about the uncertainty regarding dredged material among the potential processors and developers of beneficial reuse products. How can we overcome that uncertainty?

We heard uncertainty—and I was a little disappointed at this—when Tommy Myers and Dennis Timberlake reviewed the technology recommendations of the NRC report and expressed skepticism about natural recovery. They put bounds on it and were careful to say that natural recovery is limited to a select few cases. I understand the caveats that USACE would put on it, because we have to remove material for navigational dredging purposes. But EPA's contaminated sediment management strategy is clear in identifying natural recovery as the first option to be evaluated, indicating that we should only proceed to more invasive (and therefore more expensive and complex) remedial options after we eliminate the possibility that natural recovery will achieve the same risk-reduction