APPENDIX 1: ADDITIONAL PAPERS

AN OVERVIEW OF THE WESTERN MARYLAND COAL COMBUSTION BY-PRODUCTS/ACID MINE DRAINAGE INITIATlVE

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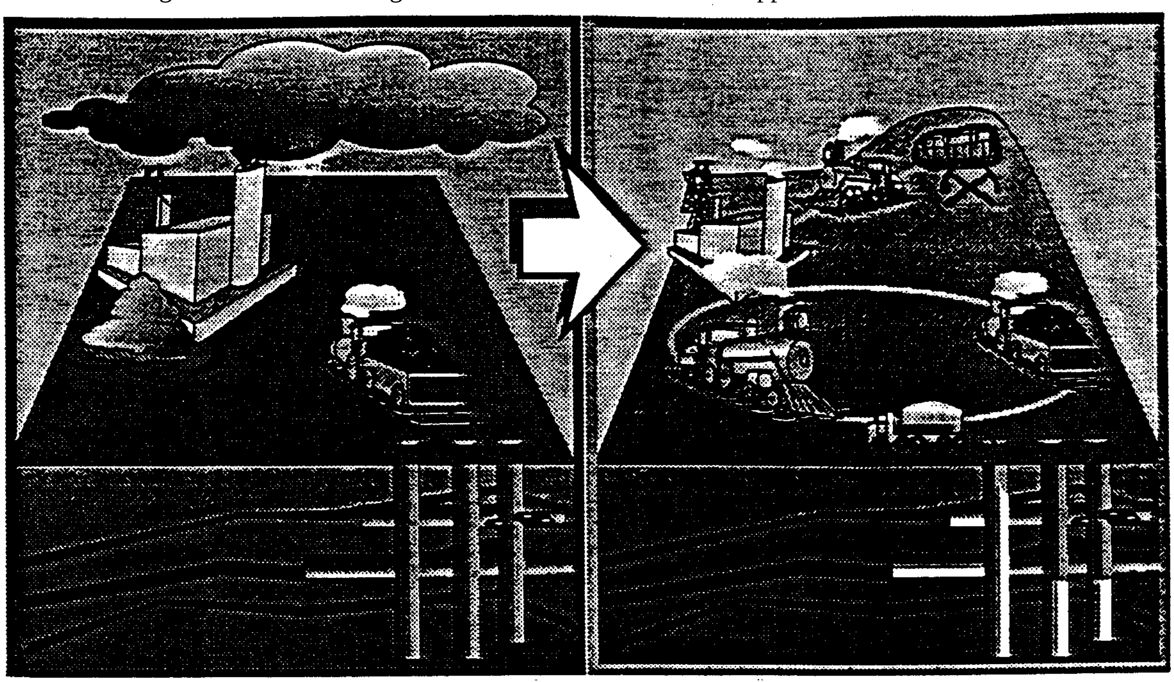
Introduction

The Western Maryland Coal Combustion By-Products (CCB)/Acid Mine Drainage (AMD) Initiative (the Initiative) is a public-private partnership exploring the use of CCBs to eliminate AMD from Maryland's abandoned coal mines. This dynamic partnership will sponsor a series of large scale experiments and demonstrations addressing the engineering problems that characterize the beneficial application of CCBs to prevent acid formation on a scale that is consistent with the large quantity of these materials that will be produced by power plants in or near western Maryland. The initial demonstration is the filling and sealing of a small hand dug mine (the Frazee Mine) under approximately ninety feet of overburden on Winding Ridge near Friendsville, Maryland. The Maryland Department of Natural Resources (DNR) Power Plant Research Program (PPRP)'s partners in this initial demonstration include three coal companies, a power plant operator, an environmental consulting company, and the Maryland Department of the Environment Bureau of Mines (MDE). In addition, personnel of the former U.S. Bureau of Mines, now with the U.S. Department of Energy (DOE), have made a substantial contribution to the Winding Ridge Project. A second demonstration being planned for the Kempton mine complex will involve a partnership of PPRP with at least West Viiginia interests, the Mettiki Coal Corporation, Buffalo Coal Company, and MDE. Subsequent demonstrations will focus on reducing the cost of materials handling and mine injection and solving the engineering problems characteristic of filling abandoned mines in Maryland. Partners are welcome to participate in one or more demonstrations at whatever level is consistent with their interests and resources. The Initiative is the flagship activity in Maryland's overall Ash Utilization Program, the goal of which is to promote beneficial use of all coal combustion by-products (see Figure 1). This presentation is an overview of Maryland's vision that AMD can be eliminated from the inventory of environmental issues the State must address.

Figure 1. The ultimate goal is transition into beneficial applications of all CCBs.

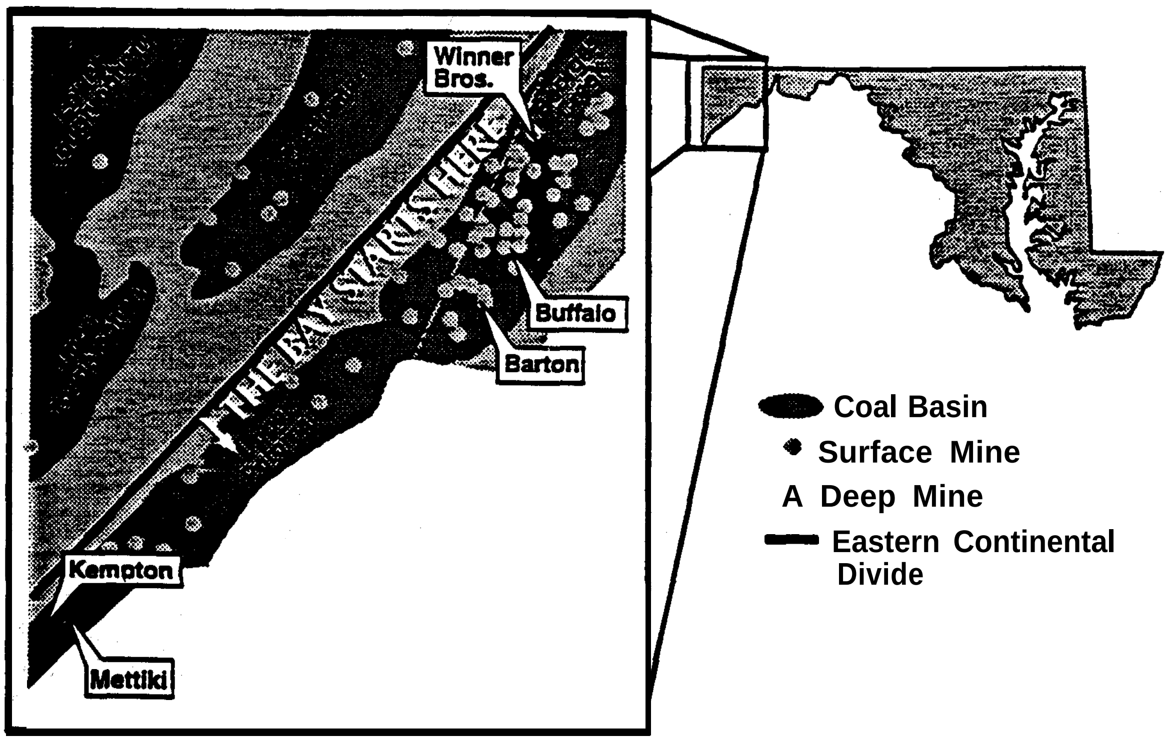


AMD In Maryland

AMD is an old water quality problem in Maryland. It affects approximately 450 miles of western Maryland waterways, and dates to the earliest mines in Maryland starting in the 1840s. AMD is a legacy of coal mining in the last century and up through 1977, when mine reclamation laws. were established. Summing Maryland coal production over the years before 1977 reveals that Maryland mountains have void space created by removal of a quarter billion tons of coal. This seems small if one thinks of it in terms that this entire historical production is equivalent to a current year's production in Wyoming. It is also small compared to that of our neighbors, West Virginia and Pennsylvania. Water quality, however, is very important to Maryland. Maryland's most produced and productive coal basins, the Upper Potomac and Georges Creek Basins (see Figure 2), form the very northwest edge of the Chesapeake Bay watershed. What happens here affects the entirety of the Nation's River (the Potomac River) and the watershed of the Nation's Treasure (the Chesapeake Bay). Maryland's interest is not just an environmental ethic. We have repeatedly demonstrated, such as in our Fish Passage Program, the very practical economic benefits of good environmental stewardship. Consistent with this experience we have subjected our vision of eliminating AMD in Maryland to the classical ***Prudent Man Test:*** 1) Do the resources exist to justify this activity?, 2) Does technology exist to make it economical?, and 3) Can markets be identified for the service?

PPRP has looked at each of these questions having the benefit of extensive background regarding our utility industry, our coal industry, and participation in numerous environmental investigations and programs. I will present an outline of our analysis of each of these above questions that is consistent with the time allowed for this presentation. You are invited to visit with us here or in Annapolis to discuss details of any specific area of interest.

Figure 2. Maryland coal basins and selected mines.



Resources

The sources of CCBs near western Maryland are: 1) Mount Storm (pulverized coal plant, one scrubber in place, two planned), 2) North Branch (fluidized bed combustion (FBC) plant, not operating), 3) Warrior Run (FBC plant, under construction), 4) Morgantown Energy Associates (FBC plant, operating), and 5) Albright (source of fly ash). These sources are estimated to produce two to three million tons per year of CCBs. Even if a million tons per year is reserved for beneficial use in active mining, there will be adequate amounts of CCBs available to treat abandoned mines at a practical rate for the foreseeable future. We made a decision early in our planning to avoid using additives for economic reasons. We have not ruled them out but would prefer to look first at other waste products available to us from Maryland industries, such as waste from Westvaco's paper mill at Luke, Maryland, and waste from our lime, cement, and aluminum industries in the Maryland counties just east of our coal mines. These wastes may be good activators to get the engineering properties we seek with CCBs to fill and seal deep mines to prevent the formation of acid.

In addition to these material resources there is a need for detailed information regarding the impacted waterways. We are fortunate that PPRP has participated with other State Agencies in the past in extensive monitoring of our waterways. The Initiative is the beneficiary of extensive data from the following Programs: 1) Maryland Synoptic Stream Chemistry Survey, 2) Maryland Critical Loads Study, 3) Maryland Biological Stream Survey, 4) Western Maryland Stream Survey, 5) Acid Deposition in Maryland, 6) Fish Passage Program, 7) Study of Maryland Coal Industry, and 8) Warrior Run and other Ash Utilization Studies.

The ultimate resource is capital. This is a priority consideration due to having started the Initiative in a period of meager State and Federal budgets. We are starting with seed money from the Maryland Environmental Trust Fund. We welcome the shift in emphasis at the Corps of Engineers and the Environmental Protection Agency to water quality projects and acceptance of economic impact as justification for support of projects. Ultimately, as we move to full scale implementation this utilization of CCBs must be a viable economic activity for our coal producers who are positioned to provide much of the field work. Our power plant operators and neighboring power plant operators (and their ash brokers) must see treatment of abandoned mines as an economical way to utilize their CCBs, or in the case of mines that are more expensive to fill, as out-of-kind mitigation to compensate for acid deposition. Environmental groups and foundations should also take an interest in the Initiative as it offers a permanent cure to an onerous environmental problem.

Technology

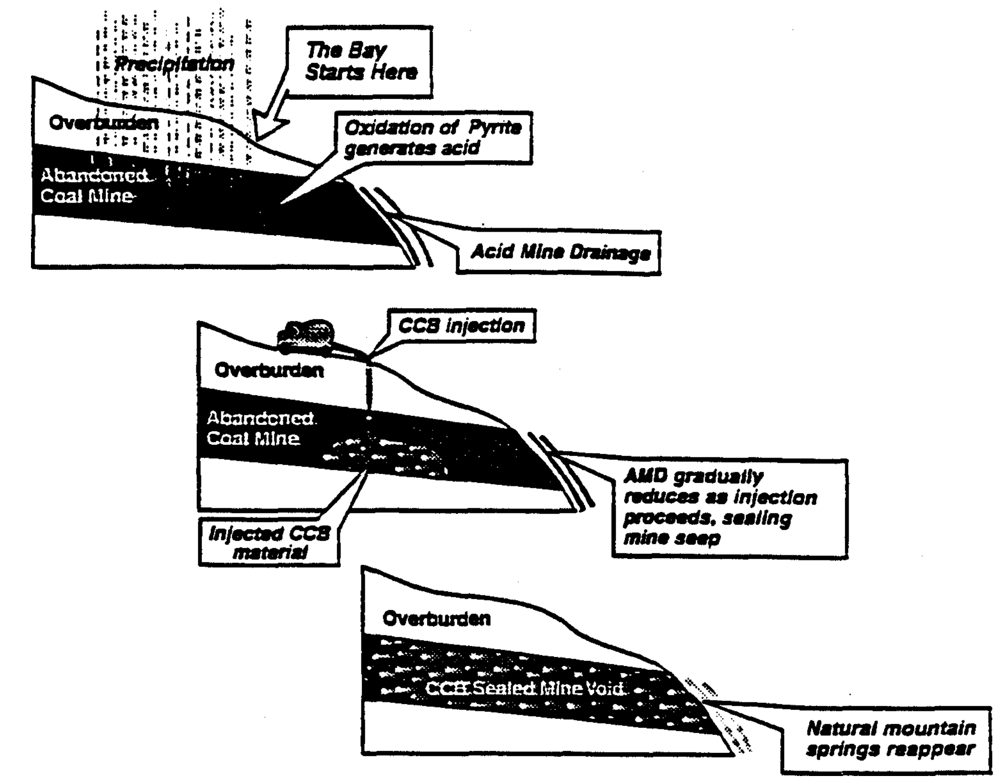
No textbook has yet been written on backfilling deep mines, and no engineering graduates are available who have taken Mine Filling 101. We look to the DOE Program at the University of West Virginia, Southern Illinois University, and the University of Kentucky as an active source of technology development. The historical program at Penn State is an important source of know-how. Other key projects include those of the Pennsylvania Department of Environmental Protection, American Electric Power, Indianapolis Power & Light, and the West Virginia Department of Environmental Protection.

We are interacting with these sources regularly and adapting what we learn to the specific civil engineering problems of filling and sealing abandoned mines in Maryland Just as every mine was unique to the miners who made them, each mine has unique geologic and hydogeologic conditions that must be understood to eliminate the formation of acid in them. That is the goal of the series of large scale experiments and demonstrations we are organizing under the Initiative. Specific experiments and demonstrations that are planned include:

- filling and sealing the Frazee Mine to demonstrate effectiveness of the concept (see Figure 3);
- filling and sealing a mine on the North Branch where streams have been modeled for economic and cost effectiveness studies;

- filling and sealing a mine in the Georges Creek Basin where AMD is highly variable;
- encapsulation of an area of intense acidification where it is not practical to fill an entire mine;
- selective filling of critical tunnels in the Kempton mine complex to restore the integrity of the individual watersheds it affects;
- tilling and sealing a mine in the unique Maryland ecosystem called The Glades; and
- backfilling a previously mined area to enhance remining where it will eliminate AMD.

Figure 3. Technical concept of the CCB/AMD Initiative - the Winding Ridge Project.

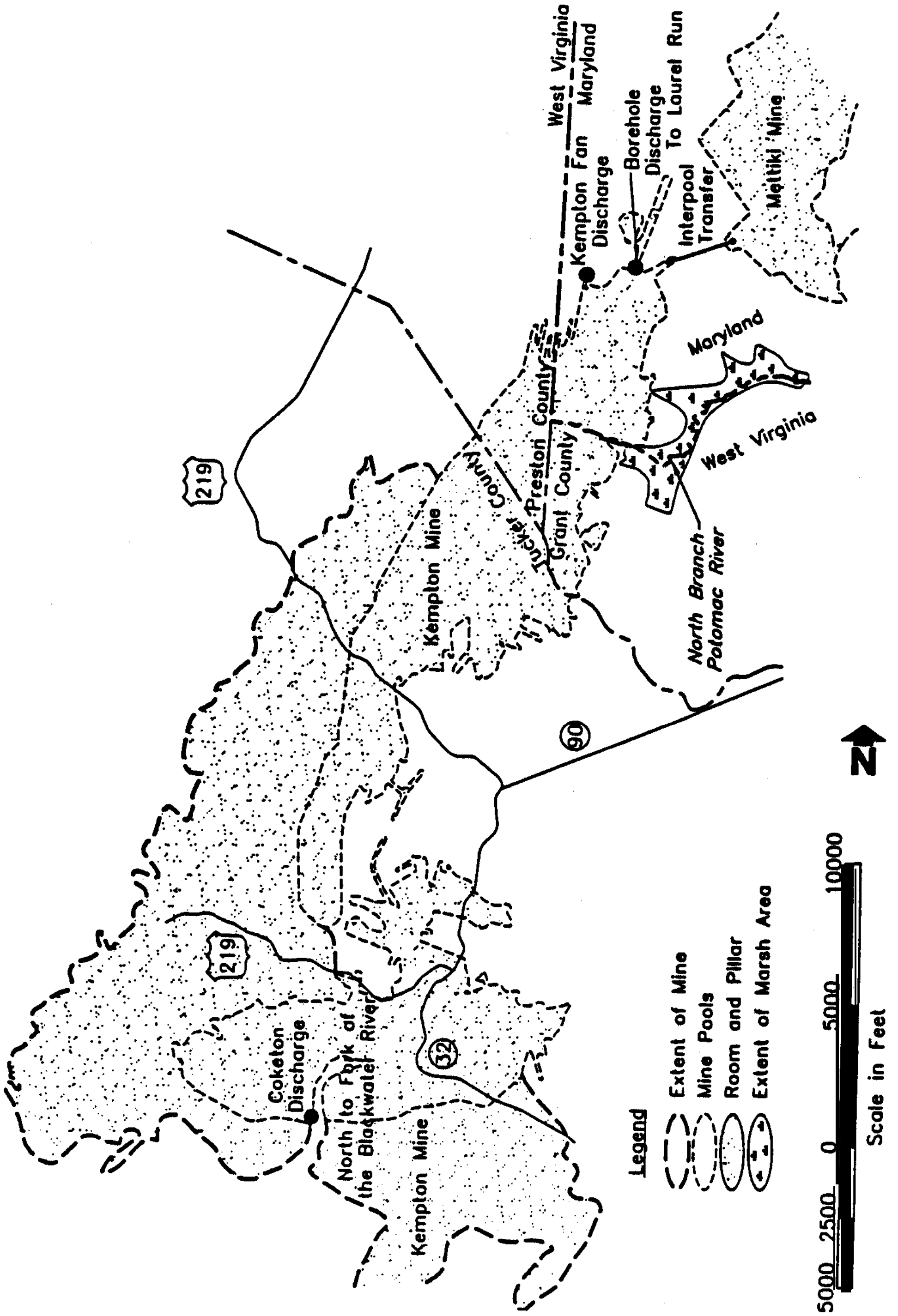


We also want to be in a position to put out an underground fire or stop major subsidence if the opportunity presents itself. We believe such demonstrations will establish a strong technical basis for utilization of CCBs to eliminate AMD in Maryland, demonstrate that costs can be reduced to be competitive with future landfilling costs, and provide the technology for elimination of AMD in all five of Maryland's coal basins.

Market

The Maryland Bureau of Mines has provided PPRP with an inventory of 450 mines. There is space in these mines for all the CCBs our power plants are producing. Filling mines at the rate of one or two million tons of CCBs per year could go on for decades. We have a priority list of the 56 largest producers of acid for more careful study as candidates for our demonstrations. Two decades of activity at the one or two million ton per year rate will eliminate most significant sources of AMD in Maryland since many of our largest mines that produced from the Big *Seam are* not important sources of AMD. One large mine complex is an exception (the Kempton complex, see Figure 4), which we share with West Virginia. This six square mile, twelve mine complex mined the *Upper Freeport Coal* and now produces over 10 percent of the acid discharging into the North Branch of the Potomac River. Unfortunately, it appears to drain good water from the upper reaches of the North Branch and its extensive wetlands into the mine pool. where it is contaminated with acid and flows out into Maryland's Laurel Run. We are determined to kill this AMD monster. Clearly there is a market for the service being developed.

Figure 4. Location of the Kempton mine complex in Garrett County, Maryland and, West Virginia.



A PRELIMINARY EVALUATION OF THE WINDING RIDGE DEMONSTRATION PROJECT

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Introduction

The Winding Ridge Project (the Project) is a small-scale demonstration of the beneficial application of alkaline coal combustion by-products (CCBs) to abate acid mine drainage (AMD) from a Maryland underground coal mine (the Frazee Mine). The Project is the first of its kind to be performed under the Western Maryland CCB/AMD Initiative (the Initiative), a partnership of government and industry exploring the use of CCBs to eliminate AMD in Maryland. The purpose of this paper is twofold:

1) present the status of Phase IV of the Project, which includes the mixing and injection of CCB grout at the Project site; and

2) discuss those issues identified by the Project team as key to the efficient operation and ultimate success of an underground injection project.

Phase Iv Status

Phase IV of the Project commenced in July 1996 with the selection of DYNA Corporation (DYNA) as the mine injection contractor. By mid September, DYNA began mobilizing equipment to the site in preparation for mixing and injection. As of 7 October 1996, full-scale injection of alkaline CCB grout began. And looking ahead, injection is anticipated to cease by early November 1996.

As of the time of this conference, the Project team has injected 4,000 cubic yards of CCB grout into the Frazee Mine, consisting of 2,400 tons fluidized bed combustion (FBC) by-product, 800 tons pulverized coal combustion (PCC) Class F fly ash, 800 tons flue gas desulfurization (FGD) by-product, and 300,000 gallons of water pumped directly from the Frazee Mine pool. To date, the maximum daily grout injection has been 370 cubic yards. However, the typical daily injection total is lower, ranging from 275 to 300 cubic yards.

The CCB grout formula injected into the mine consists of 60% FBC by-product, 20% Class F fly ash, and 20% FGD by-product on a dry weight basis. Once mixed with mine water, the by-products account for approximately 45 to 50% of the total grout volume. Adherence to this grout mix formulation is ensured through the completion of daily batch calculations, which take into account the moisture contents of each of the by-products prior to mixing. Moisture contents of the FBC, Class F fly ash, and FGD by-products are generally 8-10%, 25%, and 30%, respectively.

The freshness of the FBC by-product is crucial to the strength of the resulting grout mixture, as determined by laboratory-scale tests completed by DYNA in late August. As a result, the Project team has used only FBC by-product that is less than one day old in order to maximize the free lime content of the injected grout mixture. This practice has resulted in 14-day unconfined compressive strengths on the order of 100 pounds per square inch (psi), and anticipated 28-day strengths of at least 250 psi.

The 60/20/20 grout formulation also exhibits good flowability, with field spread test results ranging from 7 to 9 inches. In fact, borehole camera logging successfully documented the flow of grout for distances of at least 100 feet, given a 3% slope and a 3-foot-high mine void. The grout was observed to move through even the smallest of crevices, which are abundant in the Frazee Mine due to its severely collapsed nature. Nonetheless. it was also observed that a break in injection activities, however short.

will ultimately limit the flow distances achievable by the grout. As a result, continuous injection is most desirable because it appears to maximize grout flow distances.

The 60/20/20 grout formulation has certainly worked well with the piston pump and steel pipe injection configuration employed by DYNA. The Project team has been able to pump the grout over distances of at least 750 feet to injection boreholes uphill of the batch plant. The steel pipe is moved from borehole to borehole during injection activities as necessary, while the batch plant and piston pump remain stationary at the lower end of the site.

Key Field Operation Issues

As field activities proceed, we learn more about how to successfully execute an underground mine injection project. Over the past month, the Project team has continued to make observations and recommendations regarding the operation of equipment and handling of CCBs. Some of the recommendations have been implemented immediately, while others cannot be addressed until the next mine injection project is conducted. Just as important, however, is the constant evolution of our understanding of the Frazee Mine geometry, based on grout take and observation borehole monitoring during injection. Each of these key issues is discussed below as they relate to the Winding Ridge Project.

Equipment Reliabilitv and Mechanical Difficulties

All equipment used at the site has been subjected to a relatively harsh work environment, including varying levels of dust, low pH mine water, and high pH grout mixtures. These factors are expected to take their toll on mixing and injection equipment over the course of a large-scale injection project.

In addition to the harsh work environment, the everyday use of this equipment affects its reliability over the long term and requires that some maintenance be conducted during the injection program. For example, DYNA has already repaired the transmission on the grout mixer and has arranged for maintenance on the Loadrite weighing system, which is used on the front end loader to measure CCB quantities. The best way to combat these potential production delays is to assure that key spare parts are available at Project site, and that backup methods for completing certain injection-related tasks (e.g., the weighing of CCBs using the Loadrite system) are available to the Project team.

Mechanical difficulties have also been identified at Winding Ridge. These include: 1) the construction and diameter of injection casing; 2) problems associated with the accumulator box and gate; and 3) the handling of CCBs laid on a gravelly, unpaved surface. Each of these is discussed in turn below.

Six-inch diameter steel casing is being used for injection at Winding Ridge. Each casing length is ten feet, and is joined with circular, steel clamps. Smaller diameter flexible rubber hose and steel reducer pipe is placed into the injection borehole to complete the injection line. This configuration has caused difficulties for two reasons: 1) the use of rigid casing increases the amount of time required to move from one injection borehole to another; and 2) the diameter of the flexible hose and reducer pipe is not necessarily conducive to injection boreholes that are less than six inches in diameter. The Project team has mobilized as many lengths of steel casing and extra flexible rubber hose as possible to make injection moves as quick as possible, and a smaller diameter reducer pipe was constructed to facilitate access to the four-inch diameter injection boreholes.

The accumulator box is a rectangular reservoir used to temporarily hold grout that has been discharged from the mixer but not yet released into the piston pump hopper. The longer the grout sits in this accumulator box, the greater the tendency for fly ash particles in the grout to settle out of the mixture. This affects the ability of the accumulator gate to effectively discharge the grout into the hopper, as the settled particles back up against the gate and prevent the smooth flow of grout. The Project team regularly cleans the accumulator box to prevent such collection of fines.

Each of the three CCBs used for the Project are stored in bins underlain by an FBC/gravel surface that was compacted and leveled prior to use. However, because a front end loader is used to transfer by-products to the grout mixer, some of the FBC/gravel surface tends to be gathered up with the CCBs. This causes difficulty in the mixing and injection process because large gravel pieces can collect in the accumulator box or hopper, slowly clogging the injection system. The Project team has decreased the depth to which the front end loader operator scoops the CCBs, but this limits the amount of CCBs recoverable for mixing and injection. The Project team has also continued to clean the accumulator box and place a wire screen (or "grizzly") over the piston pump hopper to assure that the amount of gravel pieces flowing through the injection system is kept to a minimum.

Material Issues

Various material problems have been identified by the Project team over the course of injection, some of which are related to the as-received properties of the CCBs and some of which are associated with CCB truck delivery. CCB moisture and free lime contents are of particular concern, as they directly affect the efficiency of the mixing and injection procedure.

Fit and foremost is the fugitive dust issue that exists at the Project site due to the relatively dry nature of the FBC by-product. For this reason, any personnel working in the CCB handling and storage area is required to wear full-face air-purifying respirators. All remaining personnel working in and around the mixing and injection area typically wear half-face air-purifying respirators. The mixer operator has opted to wear a full-face respirator on particularly dusty days, as the CCBs are dumped into the mixer directly in front of him. The Project team has observed that the FBC by-product is completely unworkable if it is received at less than 4% moisture.

Another concern is the 75-foot distance required for bottom dump trailers to drop the FBC by-product. As the trailers drop the by-product, they can easily become stuck in the material. This decreases the efficiency of the grout mixing process because the front end loader must be used to pull the trailer away from the drop area.

As discussed in the Phase IV status section of this report, the FBC by-product has to be received and used within twenty fours hours of generation to maintain its free lime content. Older FBC by-products tend to absorb moisture from the air, forming chunks that settle in the accumulator box or clog the piston pump hopper. The use of a "grizzly", as discussed above, has prevented most of these chunks from entering the hopper.

The FGD and Class F fly ash materials also have difficulties associated with their moisture contents. Each has a tendency to stick inside the bottom of the dump trucks used to transport them to the Project site. When this occurs, the drivers must shovel out the remaining by-products manually prior to leaving the site.

Finally, an ongoing material issue is the settlement of solids from the grout prior to injection. Solids can settle in the accumulator box, as discussed in the previous subsection, or they can slowly accumulate inside the steel pipeline. Solids have been observed to settle when the mixing and injection of grout is not a continuous operation; that is, when a batch of grout has been mixed but is not immediately transferred from the accumulator box to the hopper and through the injection lines to the injection borehole. The accumulation of solids in the pipeline requires daily cleaning, as the injection activities at Winding Ridge are not a twenty-four hour operation. However, during the course of the work day, the Project team does attempt to minimize the mixing time and maximize grout injection rates to alleviate this problem.

Mine Geometry and Characterization

The availability of a preexisting mine map is preferred for underground injection projects because it allows the Project team to focus on the grout injection sequence. However, many of us working in abandoned underground coal mines do not have that luxury, and have to rely on anecdotal and exploratory borehole drilling information to construct a reasonably accurate mine map prior to planning an injection program. In either case, a clear understanding of the mine geometry is paramount prior to injection activities.

Once the mine geometry has been delineated, the Project team must determine the location and extent of submerged, collapsed, and weathered areas in the mine. The existence of mine pavement debris, whether it be roof fall or material left by the miners as they abandoned the tunnels, can also play an important role in an injection program, depending upon the flowability of the grout.

Prior to implementation of an injection program, the Winding Ridge Project team had developed a detailed mine map based on field data, complete with interpretations of collapsed and submerged areas. As injection progresses, however, we continue to learn that the Frazee Mine geometry is different from our original interpretation, as grout takes and observation borehole monitoring tell us there exists more void space in the Frazee Mine than we were originally aware. Based on these field observations, we mobilized a drilling rig and completed a total of 17 additional exploratory boreholes to refine our interpretation of the mine geometry, as well as to provide additional injection boreholes in the lower elevations of the mine. Even so, the viability of these additional injection boreholes has been limited due to the weathered nature of the bedrock overburden and the degree of collapse and submergence in the mine. The existence of mine pavement debris may also be a factor limiting the grout takes in many of these injection boreholes.

APPENDIX 2: RECORDED DISCUSSIONS

Edited by Kimery C. Vories
USDI Office of Surface Mining

The following is the edited discussions that took place at the end of each presentation and at the end of the each session. The actual comments have been edited to translate the verbal discussion into a format that more effectively communicates the information exchanged into a written format. The organization follows the same progression as that which took place at the forum.

Session I: Coal Combustion By-Product Characterization

1. Sampling Methods Dr. Terry Brown, Western Research Institute, Laramie, Wyoming.

Regulatory Question: If' the variability of the material is as great as you are suggesting in your presentation, how would it be possible to monitor the differences in material as it goes to the disposal site, truck load by truck load and distributed in various different strata at the disposal site? What is the solution to the sampling problems in the field that are further complicated by this additional operational variability?

Answer # 1: You are going to have variability. You need to determine what the range of variability will be for the material you are using. Based on the range of variability of the CCB material you should be able to design the disposal facility to handle it.

Answer #2: When you are doing a research project and you want to have a high level of confidence in your numbers, then the kinds of variability that Dr. Brown mentioned in his presentation becomes a real issue. When it comes to the use of these materials in a real world application, the bulk chemical properties of the ash, even if it varies several percent, aren't that important in the use of the material. If you know the basic bulk chemical characteristics of the material, you can get successful application and not be as concerned with the specific sampling protocol. My comment is not directed to the trace element concentration but to the bulk chemical constituents such as calcium, sulfur, and silica. These are of lesser importance in terms of environmental impact such as what is leachable. These bulk chemical constituents have a major importance in terms of the actual engineering properties of the ash, such as how it will handle when you mix it with water. When you start compacting samples, the variability in mineralogy may change by 5 percent for lime or anhydrite. The influence of this on the structural fill might be a difference in the amount of ettruigite or gypsum that forms. This will not significantly impact the permeability anymore than you would expect when compacting a natural soil material. This level of variability is inherent in all construction fill materials when you work with huge quantities of material compared to a researcher who works with 5 grams or less of the same material. Yes, variability is important and sampling is important, but it plays a greater role in research projects than in actual field applications.

Regulatory Question: You suggested that a publication was coming out about the different types of testing methods. Would this publication suggest that you establish a baseline instead of having so much diversity in sampling methods? Who is doing that and when would it be available?

Answer: A draft publication is now out on sampling heterogenous types of materials. Susan Sorini at WRI is working on developing the standard sample. The coal ash association is involved with this effort. More specific details will be provided in thefinal paper provided in this publication.

Research Question: Should we be talking about what size of bulk samples we should be collecting rather than the type of sampling that Dr. Brown is talking about? What type of variability of bulk sampling is critical for use in engineering design contrasted with the academic assessment of the exact chemical composition of the CCB material?

Answer: *The specific* application is a very important factor in determining the appropriate sampling methods. For example, the use of class C fly ash (high calcium fly ash) in concrete has a specific sampling method. This method requires a bulk sampling process where a composite sample is collected. The sample consists of several subsets of samples that are collected from every truck load of fly ash that leaves the power plant. Eventually they end up with a composite sample that represents 400 tons of material. After conducting more extensive testing on that material, they have found that a composite sample averages out some of the important chemical information related to this use. This testing would suggest that particular truck loads of material should not have been used in this application. The cement and concrete industry is finding that in certain applications, such as high performance concrete or even for standard concrete, they should not use a composite sample because the process of averaging hides important information. The ultimate question is, do you have the information, produced through sampling and chemical analysis, that is most useful for the application you are planning?

2. <u>Leaching Tests: Commonlv Used Methods, Examples of Applications to Coal Combustion By-Products, and needs for the next generation.</u> Susan S. Sorini, Western Research Institute, Laramie, Wyoming Paper Presented by Dr. Terry Brown

Research Question: Because of the variability of results noted in your presentation, which gives better leachate results, available tests or lysimeter tests?

Answer: The lysimeter values were much higher than we obtained from the other tests.

Regulatory Question: Do you recommend a particular sampling or analysis method for testing high pH materials?

Answer *#1:* A lot of the CCB materials have high pH values, in the range of pH 9-12. When you use a TCLP test, you modify that pH to a lower value. In doing so, you are making the elements that are relatively soluble at that high pH relatively insoluble.

Answer #2: Concerning high pH CCBs, I don't think any of the standard tests address secondary mineral phase formation. When you are trying to analyze for trace element mobility in these high pH ashes, be sure that what you are leaching is what is going to be leached in the actual application in the field. In some cases, where these ashes react with the water, that is going to require a long term leaching. There are some minerals that form, ettruigite being a major one, that have the ability to complex and chemically fix certain trace elements in ash such as Boron, Selenium, Arsenic, Vanadium, and Chromium. If you leach ash with an 18 hour test you will often obtain very different results than from a 30 or 60 day leaching test. If you are really interested in what is going to happen to leachates in the field, the current experimental data suggests that these longer tests are necessary.

Regulatory Question: Unless your are disposing of CCB ash in an acidic environment, would the majority of leachate tests even be appropriate in terms of what is going to take place in the field?

Answer #I: Most leaching methods that were presented here do not give a representative measure of what will occur in the field. We need to look at these materials in the long term and how this effects the solubility relationships. We have been looking for a relatively simple method that will give us information on a chemically complex situation. A uniform standard testing method, however, does give us a way to make comparisons between different CCB materials.

Answer #2: At the University of North Dakota, we have developed a test that has been submitted to ASTM. Hopefully this method should address these 'concerns for CCB materials. It involves leaching under environmental conditions that are representative of disposal conditions. It also has a long term component built into it.

Industry Question: What type of testing do you recommend to address the long term aspect of leaching? We have conducted tests where it took three months to get the third pore volume through.

Answer: I would not recommend column leaching under any conditions. With respect to long term leaching, and you are looking at a material that will undergo changes on hydration, you want to look at the material long enough to determine the effect of those changes. We recommend that you sample at 18 hours, sample at 30 days, and if necessary sample at 60 days in order to evaluate the trend. Since it is usually impossible to determine when the concentration changes will achieve an equilibrium, we want to determine if the concentrations of trace elements are going up or down over time? You need to carry the test out long enough to see if that is happening, how long you carry on the test after that depends on what you are trying to learn. We have had tests that have been ongoing for over 7 years.

Industry Question: CCB materials have been classified as non-hazardous by the USEPA. All of this concern about leachate testing seems to be backward.

Answer # 1: I think we would call it environmental responsibility. Although most CCB materials are fairly benign, that is not a universal statement. The purpose of leaching tests should not be to determine how toxic the material is because most are non-toxic. It is a precaution that the specific material you are using is not going to cause any environmental problems. There are some CCB materials that do have constituents that can under the right conditions leach.

Answer #2 When the US EPA ruled on CCB materials being non-hazardous, they left it up to the States as to how they wanted to handle it as a solid waste. The State has to address citizen concerns to insure that it is being used safely and that it won't have a negative impact on the environment. When a product is labeled as a waste there tends to be a prejudice against them that normal commercial materials do not experience. Even when you take a waste product and turn it into a commercial material the product is still under the same regulatory requirements of the product as a waste. It is an unfair situation that results in an unfair playing field for commercialized CCB products. Until people become more comfortable with the'nature of these materials, we are going to have to continue looking at leachate tests and chemical analysis. Although a lot of knowledge about these materials has been accumulated by professionals working in the field, it is apparent that this knowledge has not been effectively communicated to the public.

Public Question: I do not understand how we can be talking about comfort levels when we are talking about materials that often have Uranium, Thorium, and other radionucleotides in them. I have not heard any remark about testing the radioactivity of these materials.

Answer #1: Although we are talking about testing CCB materials, if you apply the same tests to cement, you are going to find the same type of problems and yet no one questions the safety of using cement.

Answer #2: If you tested the natural soil materials outside this building, you would find approximately the same amount of radioactive materials that you find in CCB materials. The radioactivity of CCB materials has been tested and it is not a problem.

Regulatory, *Statement #l: The* determination by the US EPA that CCB materials are non-hazardous, does not make it a non-toxic material. There are some situations where it wouid be toxic. These situations have to be evaluated on a case by case basis. The surface mining regulations would normally consider anything with a pH above 9 to be potentially toxic and many CCB materials have a pH in excess of 9.

Regulatory Statement #2: Concerning the US EPA determination that CCB materials are non-hazardous, the rulemaking in 1993 related very narrowly to the four large volume wastes generated at coal tired utilities. The US EPA is in the process of completing its regulatory determination by April of 1998 on "remaining wastes." With respect to beneficial reuse there was a brief statement that the US EPA is comfortable with beneficial reuse when handled in an environmentally safe manner. They are in the process of revisiting beneficial reuse from a "remaining waste" standpoint. The data that is being presented at this meeting still has a lot of relevance from a regulatory standpoint particularly at the Federal level.

Public Question: We have looked at 37 diierent leaching tests for disposal of CCBs at surface coal mines and all of the tests have indicated that the primary drinking water standards have been exceeded for one or more constituents and most for several. The pH of all of these samples have been between 10 and 13. The corrosivity cut off under the Resource Conservation and Recovery Act (RCRA) for determining that a waste is hazardous is 12.5. If this were any other waste produced by industry, it would go to a hazardous waste landfill. The unfairness is, that if it is produced by an electric utility, it can go to mine in Indiana without a liner or a viable ground water monitoring system. The unfairness is the politically motivated exemption of CCBs produced by electric utilities from the hazardous waste requirements of RCRA. Where is the unfairness to beneficial reuse of CCBs, when in lndiana the State Solid Waste program exempts CCBs from its requirements when the material is considered a beneficial reuse or when it is disposed of on a surface coal mine?

Answer tf 1: Speaking as a person who is actively working to find ways to beneficially reuse these materials, if we told cement producers that they had to apply leachate tests to their materials because they utilized CCB materials in their product it would not be accepted because "cement" is considered sacred as a commercial material. If you would test Portland cement for pH you would find that it has a pH of 12.5. A hydrated lime that is commercially used in agriculture will have a pH of 12.5. Although the high pH of some CCB materials may affect the paint on trucks used to haul it or the dozer cleats used to grade it, after the material has been placed in a disposal area its chemistry begins to change and in a very short period of time our tests show that the pH returns to a nontoxic, noncorrosive range of 7-7.5. The formation of minerals in that material over time changes its pH There are a lot of things that happen to the CCB material after it is placed in the environment that tend to make it more benign. The materials you are talking about have exceeded the drinking water standards by 5 to 25 times. In order to be classified as a hazardous waste, it would have to exceed the drinking water standard by 100 times or more.

Answer #2: You need to understand the difference between pH and the total amount of alkalinity and alkaline capacity. Just because you have a material with a pH of 12.5, you may not have a material that has the capacity to produce large amounts of alkalinity.

Research Statement: Care should be taken in comparing CCB materials to cement. Portland cement is used to make concrete, which is a solid material, as opposed to CCB materials which are a powdered material. When it comes to the stability of a material, the most important consideration is the ratio of its surface area to its particle size or volume. Concrete, as a solid material, has a surface area that is relatively insignificant compared to a material that is a powder in terms of its potential to generate leachate. In this context, a comparison of cement to CCB material is not a fair comparison.

3. <u>Bulk Chemical and Mineralogical Characteristics of Coal Combustion By-Products</u>. Jodie Tishmack, Purdue University, West Lafayette. Indiana

Regulatory Question: When utilizing CCB materials as a soil component, have you tested the plant materials produced to determine if elements like aluminum or other trace elements are being accumulated at toxic levels'?

Answer #I: We have done testing on total metals and leachable metals of each of the materials utilized to create this artificial soil, including the CCB material. We are also trying to determine what these leachate characteristics will be over time. We haven't seen anything with trace metals that we are concerned about. We are closely monitoring nitrates and sulfate from this material because of their greater potential impact to groundwater quality.

Concerning the materials agronomic effects, the trace elements found in the CCB materials are plant micronutrients. We suspect that some of the increased plant growth we are experiencing may be due to providing micronutrients that have become depleted from natural soil materials. We are pursuing plans now to expand our project to an ash embankment where we will use a subsoil cover coat then place a layer of synthetic topsoil in order to revegetate the area.

Answer #2: We have been using PFBC ashes to treat very acid soils (pH of around 2) and comparing that with calcium carbonate applications alone in the green house. We are seeing an increased plant growth of 10 to 20 percent with the ash material compared to treatments with calcium carbonate alone. We are attributing this difference in plant growth to the presence of micronutrients available in the ash materials that are not available in the calcium carbonate or the acid soils.

Regulatory Question: On your fill experiment what were the lift thicknesses and how much compaction were you doing?

Answer: The lift thickness started at about 12 inches but has been increased to about 18 inches as we have gained experience with the material. Based on our experience gained over the last 2 years, we have varied the lift thickness, level of compaction, and addition of water. We have a target of about 70-80 pounds per cubic foot of compaction.

In the lab we discovered that some of the testing methods had to be modified to give accurate results on the compaction curves when working with CCB materials. The lab normally puts the sample in an oven at 105 degrees centigrade and measures how much free water is given off. At this temperature some of the ettruigite and gypsum that has formed in the CCB material will dehydrate. This water that was bound up in the ettruigite and gypsum crystals will register as free water. Since density is a function of wet weight divided by 1 plus the moisture content, you overestimate your water content. This results in an underestimation of the dry density. As a result, we have now reduced our oven temperature to between 55 to 60 degrees centigrade. This does not dehydrate the ettruigite and gypsum and gives us a much more accurate compaction density figure.

In conclusion, we have found that building with CCB ash fill material requires much less quality control than building with natural soil materials. We get a very good fill material without having to specify things like plus or minus 5 percent of the moisture or plus or minus 2 percent of the dry density. We have allowed the contractor latitude to use his experience in building with fill to determine how much compaction needs to be applied. We will have a fmal report on the results by the spring of 1997.

Regulatory Question: Have you placed any of these fill materials is areas that could be flooded or in contact with ground water?

Answer: No.

4. Engineering/ Regulatory David Hassett, Director of Applied Chemistry, Energy and Environmental Research Center, Grand Forks, North Dakota

Regulatory Question: Concerning overburden testing on surface coal mines, how do we take existing testing systems for analysis of CCB materials and relate it to data already generated in a SMCRA permit to predict impacts to water quality and plant growth? The concern being how should this be incorporated into mine reclamation planning‘?

Answer #I: The question may to be too complex to answer here. One thing that should be understood about laboratory data, is that laboratory testing does not simulate the natural environment. The are no laboratory tests that I am aware of that are going to tell you what concentrations of leachate will result when the CCB material is placed in a disposal area. What the laboratory tests will tell you are general things (such as, for a given quantity of CCBs, what is the potential for it to leach a given trace element). An important thing to remember, when evaluating trace elements, is that toxicity is a function of concentration and not a function of identity. From this, I can give you an estimate of how much of the total amount available would be likely to leach out. I can't tell you how long it will take, the liquid to solid ratio, or the actual field concentrations that will result. I can give you an estimate of the general potential for any of the trace elements to reach concentrations that would be considered toxic or hazardous.

In conclusion, based on most analyses of CCB ash materials, I can say that there is no potential for these materials to generate hazardous concentrations of trace elements. Most CCB ash materials have very little total volumes of trace elements. In most of these materials, the trace elements are not in a form that is readily available for leaching. Some of the materials, that do have potentially toxic concentrations of trace elements that leach readily, also form ettruigite and in a very short period of time, geologically speaking (a few months), tend to tie up these elements and become self remediating. Also when you talk about disposal into a mine, the leachate potential does not end at the border of the mine. We can not predict how the natural hydrogeologic conditions will alter the chemistry of the leachate. All of the elements that exist on the mine site following reclamation and disposal of CCB materials, existed on the mine site prior to disturbance. You have not introduced any new materials. You have only changed their forms. The question is, whether you have changed the form in a beneficial or a harmful way. That is the question we are trying to answer.

Answer #2: I am not sure if you are going to be able to use a lot of the data that is in a SMCRA permit for this type of evaluation. An example would be acid/base accounting data. Acid/base accounting only gives you an indication of potential acidity rather than what will actually occur in the field. Also, different labs use different methods of analysis which limits the usefulness of this information for comparison with sites other than the site it was collected on. We have tried to predict what would happen when you mix CCB ash material in a soil. We have used an EQ geochemical computer model that was developed at the Lawrence laboratory. I am not sure if these models give you very much information, however, because of the lack of a high quality data input.

Regulatory Question: Most of the experience with CCB materials concerning disposal has shown that there is little reason for environmental concerns when the disposal area has been properly designed. My question is, whether the States should change their emphasis on permitting of CCB disposal from utilizing leachate tests, that try to predict environmental impact, to putting more emphasis on proper design of the disposal area'?

Answer: I would agree that priorities should be changed, but think that some leachate testing will still be necessary. Most, though not all, field tests have shown that CCB ash materials are benign. In one case in North Dakota the natural ground water did not meet drinking water standards but the leachate coming from the CCB ash material did. I think that the need now is to have more laboratory studies correlated with field studies.

Regulatory Question: Based on the information presented in this session, it appears that comparing the testing of high pH CCB ash to that of Portland cement is a fair comparison.

Answer *#l:* Making the comparison of high pH CCB ash to Portland cement is a fair comparison, however what is not fair is the standards and stringency of testing to which CCB ash materials are held. The high pH characteristic of CCB ash materials is one its best attributes. In order to form ettruigite, you have to be between the pH range of 11.5 to 12.5. This is the pH you get when you mix lime with water, As a result of the clean air standards placed on coal fired power plants, we are now finding that virtually all of the CCB materials being generated are now ettruigite formers.

Answer #2: Concerning leachate from CCB materials, the surface area is a very important factor. In solid-liquid relationships, the surface area is not just an important factor. it is the only factor. If you have a large concrete block, the surface area is negligible when compared to the same amount of material in a powder form.

Public Question: How do you distinguish between coal combustion by-product materials that are utilized in some type of economic product and coal combustion waste materials that are not valuable and are disposed of? My understanding is that, in Illinois, a coal combustion by-product can not be taken back to the mine site, but in Indiana everything is regarded as a coal combustion waste. What is the difference between CCBs and CCWs?

Answer: No substantive difference. It is just a diierent name for the same material.

Industry Question: Could Jodi Tishmack tell us more about her work with creating an artificial soil from CCB materials? I think that it is this type of research that will remove a lot of the public fears and uncertainties about CCB materials.

Answer: I am using bottom ash and fly ash from the fluidized bed unit and the stoker and mixing it with plant residues. We will be publishing the results soon. We will also have information on ground water studies done in association with these artificial soil experiments.

Regulatory Question: What is the reactivity of the CCB ash material when placed at a surface mine under oxygen rich conditions, as compared to being placed in an underground mine in conditions devoid of oxygen?

Answer: The oxygen conditions are really not important when placing scrubber sludge materials.

Regulatory Question: Will the properties of CCB ash materials, when placed in a fill, break down over time?

Answer: Although we really don't know the long term situation, most indications are that the materials will last for a long time. Most studies are fairly recent and do not address the time factor. Because you do not have clay materials in CCBs, you do not have the settlement problems that you would expect utilizing natural soil materials. Permeability may increase slightly (from 10 to the minus 7 to 10 to the minus 5) and the strength of the material may be slightly reduced (from 1500 pounds per square inch to 800), compared to a natural soil material that would only have about 200 pounds per square inch of strength. Relatively speaking the fill from CCB materials is still much stronger over the long term than a fill with natural soil material.

Regulatory Question: What are the environmental advantages or disadvantages of CCB materials in disposal areas related to the submergence of the material in ground water?

Answer: The chemical reactions you have with CCB materials will happen whether you have a large amount of water available or only a little water. If the CCB material has cementing properties it will be come a large concrete block if it is in contact with water. If you have a CCB ash material produced by eastern bituminous coal, it will not form a concrete block unless you have added a source of lime to achieve the cementing properties. Those CCB materials that have had lime added such as scrubber sludge would have this cementing characteristic.

Public Question: Is the quality of the low grade concrete produced by the CCB material dependent upon the amount of water added in the design of the fill?

Answer: Yes this is true. However, the till produced by CCB material that does not develop into a low grade concrete is still many times stronger than a fill made of natural soil material.

Session II: Site Characterization

1. Western Perspective J. Matthew Tanner, Environmental Compliance Coordinator, Texas Utilities Services, Inc., Dallas

Regulatory Question: Has Texas Utilities, in their experience with this material, conducted any economic studies to determine how much could be saved as a result of things like reduced compaction requirements? A knowledge of how savings could result from the use of these materials would be useful.

Answer: We don't have that kind of information,

Question: *You* said your disposal costs were in the range of $15-18 million. Could you relate this to a cost per ton of material disposed or a cost per kilowatt hour of generation?

Answer: We don't have any numbers for that, however as a percentage of the total cost of electrical generation, it would be a small amount. Disposal costs at the plant would be about $1.50 per yard of material disposed.

Question: *You* have used CCB bottom ash materials for short term ballast on railroad spurs, is it possible to use the material for long term ballast applications?

Answer: *Our* understanding is that is will not hold up under long term use because the material is too soft. Our bottom ash comes from the burning of lignite coal which is very soft compared to other coals.

2. Mid-Western Perspective Dr. Robert Darmody, University of Illinois, Department of Natural Resources and Environmental Sciences, Urbana

Question: Could you expand on your comment that CCB fly ash minerals are more reactive than older minerals? How long a period of time are you referring to?

Answer: *The* CCB ash materials have no water associated with them. When placed in a till they hydrate, generate heat, take on carbon dioxide, possibly cement, and weather rather rapidly. This is quite different from natural soil materials that are the result of thousands of years of weathering and do not change much when moved around.

Question: Could you expand on your comment that some soils in Illinois are deficient in some minerals? Which elements are usually deficient?

Answer: Some Illinois soils show a response to the addition of boron where alfalfa is the crop being grown. Generally older soils are prone to have more nutrient mineral deficiencies.

3. Eastern Perspective Barry Stewart, American Coal Ash Association, Alexandria, Virginia

Question: *Is the* change in water holding capacity that you have observed a long or short term phenomenon? Is the water available to plants?

Answer: It should be a long term property. As the CCB material weathers, the water holding capacity may actually increase. The water is available to plants.

Question: Could you expand on concerns about Boron, Cadmium, and Selenium concentrations increasing relative to surface mining reclamation?

Answer: The overall concentration of the elements will increase. Boron will probably dissipate quickly because it leaches very fast. Some of the other metals may increase on a whole soil basis.
Question: If Boron leaches does it decontaminate the soil but contaminate the water?

Answer: Some of the Boron will precipitate but some of it is attenuated by the soil as it goes to the ground water.

Public Question: Do high Boron levels have an adverse impact on crop growth?

Answer: They can.

Session III: Regulatory Requirements

1. Indiana Mike Sponsler, Director, Division of Reclamation

Public Question: You referred to a list of 6 sites out of 500 as identified by the US EPA as being a problem in EPAs determination that CCB materials were not hazardous. Did that list include the Michigan City and Bailey sites in Indiana?

Answer: My slide showed those two sites. The situation there is that they found migration down gradient but not off site. There was no attenuation of trace elements to the soils because it was very sandy. At the Bailey site, they had other industrial wastes as a factor, due to its proximity to a heavily industrialized part of Gary, Indiana.

Public Question: Are most slurry ponds in Indiana, that contain large amounts of CCB materials, outfitted with ground water monitoring wells? It is our understanding that there is very little ground water monitoring going on at most sites where large CCB slurry ponds are located.

Answer: It is my understanding that this is not required. I believe the power industry is sampling them for their own information. This would be a requirement if the disposal activity was located on a coal mine in Indiana.

Public Question: By referring to the US EPA report on CCB materials, are you saying that the US EPA classification of hazardous under RCRA has anything to do with the determination of “toxic forming” under SMCRA?

Answer: What I am saying, is that it is a material we felt we could manage. Concerning toxicity, SMCRA requires that you provide special handling in order to protect the hydrologic balance. The Indiana program requires this type of handling for toxic materials.

Public Question: What about the other attributes of CCB materials, such as high or low pH, high hydroxide, or flocculent concentrations that may be toxic to fish or aquatic life?

Answer: If you look at the US EPA report you do not find any mention of damage to living things. Taking a laboratory leachate result and assuming that living things are going to be exposed to those concentrations is no more realistic than making the same assumption concerning a compliance sample of a sewage lagoon. The question is, what conditions are going to occur after the water gets off site. Until the water gets off site it is part of the treatment system. The important thing to note from the US EPA study is that very little high concentration leachate was migrating off site.

Public Question: Many of the States surrounding Indiana have separate laws pertaining to CCB materials. Indiana has memorandum 92-1, which has been created by the Indiana Department of Natural Resources. If there is a case where water is contaminated by CCB materials, what recourse do citizens of Indiana have with respect to damages?

Answer: The adjacent State of Illinois also does not have any specific laws concerning CCB materials. The content of memorandum 92-1 was a product of the requirements related to protecting the hydrologic balance under the Surface Mining Control and Reclamation Act of 1977. The law in Indiana then would be the State equivalent to SMCRA.

2. Kentucky Gary Hahn, Department of Mines, Frankfort

Regulatory Question: In Kentucky, you require CCB placement to be 4 feet above the seasonal high water table established after mining. Is that based on information in the applicants permitting package related to the probable hydrologic consequences to determine the seasonal water table? It is my understanding that it can take years for the actual water table to be reestablished.

Answer: It is important to identify the final ground water level because we want to keep the materials out of the ground water. We try to use good technical scientific information.

Academic Question: Are low volume wastes defined by reference to US EPA documentation or is it defined by the State?

Answer: Coal combustion by-products means fly ash, bottom ash, scrubber sludge, and waste from fluidized bed combustion produced by the combustion of coal. Coal combustion by-products do not include boiler slag and residue from refuse derived fuels such as municipal solid wastes, tires, and solvents.

Industry Question: Does Kentucky have any limitations on the amount of CCB materials that can be placed back in a surface coal mine?

Answer: The limit is, the tonnage of CCB materials placed in a surface mine can not exceed the tonnage of coal removed from a specific permit area.

Question: Concerning Kentucky's requirement that CCB material be placed above the water table, do you have any specific data that shows a difference between the wet placement versus a dry placement?

Answer: This is just what we have in the law. There is a concern about the volumes that must ultimately be disposed, and how much can be disposed of in underground mines.

3. Pennsylvania Nevin Strock, Chief, Surface Mine Permit Section

Regulatory Question: In Pennsylvania, is there any way to know, after the mine and CCB disposal are gone from the scene, that later land owners will know that CCB materials were disposed of on their property'?

Answer: The CCB ash disposal must be recorded with the county recorder of deeds.

Public Question: There must the CCB ash material be placed relative to the ground water table?

Answer: It must be placed a minimum of 4 feet above the premining seasonal ground water table.

Public Question: In your ground water monitoring requirements, do you have a standard for water quality, that if exceeded. would require Pennsylvania to do anything?

Answer: In Pennsylvania, there are trigger levels based on ground water parameters. If those levels are exceeded that would require an assessment and remediation.

Question: Concerning constraints placed on the fill structure, why does Pennsylvania have requirements for the level of compaction and the maximum lift thickness?

Answer: *The* primary reason concerns the final stability of the site. Pennsylvania is currently reevaluating this and other requirements to determine what the need is. The State has not experienced any stability problems with CCB materials.

4. <u>New Mexico</u> Monte Anderson, Hydogeologist, Mining and Minerals Department

Public Question: Does New Mexico require ground water monitoring of CCB disposal sites and would the State be required to do anything if certain levels of contaminants were exceeded?

Answer: There is ground water monitoring at all sites. If New Mexico ground water standards were exceeded, State action would be required.

Regulatory Question: Is there anything that would trigger additional CCB material chemical analysis after the initial permit approval process?

Answer #l: In Pennsylvania, there is a minimum of one analysis every 6 months and may require quarterly monitoring if the need arises. Indiana requires quarterly analysis and may require additional analysis if a supplier where changed. If significant changes in the materials were demonstrated, then the permittee would be required to apply for a significant permit revision.

Answer #2: Missouri has three programs that deal with CCB materials. These are Land Reclamation, Solid Waste Management, and Water Pollution Control. The Land Reclamation program does not regulate CCB material directly but looks at those aspects of CCB disposal that may ultimately impact successful reclamation such as approximate original contour, grading, revegetation, and timeliness of reclamation. The Solid Waste Management program regulates CCB disposal. This would include exemptions for CCB materials used for a beneficial use or its use for reclamation where there is not a public health hazard created. Special surface and ground water monitoring is required. Although Missouri mines have historically disposed of CCB materials, currently no active mines are disposing of this material.

Industry Question: How many sites in Pennsylvania have received CCB materials? Have any of these sites exceeded trigger levels for corrective action? What is the total tonnage of materials being disposed of?

Answer: Pennsylvania has 70 active sites that since 1986 have utilized CCB materials beneficially as a fill material or as a soil additive. We haven't had any problems, with the exception of one site with sulfate. Pennsylvania is currently working on the compiling and analysis of all of its' data on CCB material monitoring in order to evaluate long term effects. Many of the sites were permitted back in the late 1980s. The tonnage of material disposed of has been gradually increasing since 1986 and was 6 million tons in 1995.

Public Question: What are the requirements of Kentucky and Missouri to take corrective actions if water quality standards are exceeded due to CCB materials'?

Answer: Kentucky would reevaluate the monitoring program and possibly require additional monitoring sites and could potentially stop the disposal of the CCB material. The critical standards would be the drinking water standards. In Missouri, the water must be suitable for its intended use. In most cases you are not dealing with well defined aquifers that have extremely low hydrologic conductivity and in most cases there is no current use of the ground water. The surface mining requirements would require the operator to replace water supplies that became contaminated. At the time of final bond release, it would also be possible to deny the release if the water was no longer suitable for its intended use. In most cases, however this is unlikely due to the lack of water use in the areas where coal is mined.

Question: Two States allow CCB disposal on the pit floor and two States require it to be 4 feet above the water table. What is the reason for the differences?

Answer: When New Mexico required placement on the pit floor it was with the knowledge it was already above the water table. In other situations we require the material to be above the water table. In Pennsylvania, we are trying to avoid contact with water movement along the high wall and along the pit floor. Indiana does not have any requirements related to water tables. The reason being that the US EPA study was on sites that were mostly in contact with water, usually in flood plains and sand and gravel aquifers. If you have high pH materials we would expect the crystal formation and concrete like characteristics of the material when associated with water contact to immobilize the chemical constituents. These studies would indicate that water contact with CCB materials is not a problem.

Question: What happens when an operator would request to place a CCB material in association with an acidic environment on a mine site?

Answer: Potentially the operator would be asked to revise the permit or it could be denied if problems with potential toxicity could be expected to occur.

Regulatory Question: It is my understanding that the Kentucky program does not accept any CCB material where the leachate analysis indicates that RCRA standards have been exceeded. Does Kentucky actually use drinking water standards or RCRA standards as its trigger levels for monitoring ground water adjacent to CCB disposal sites?

Answer: The Kentucky program is quite new in this area. Kentucky has only had one permit approved for CCB disposal and disposal has not yet begun. As such, we can not really address what measures Kentucky would take in the event of circumstances that have never happened.

Session1 IV: Design/Engineering/Planning

1. Assessment of environmental impacts including health and safety Gary Brendell, GAI Consultants, Monroeville, Pennsylvania

Engineering Question: Have you had any experience with the placement of structural CCB material fill in cool wet seasons, and if so, what are your recommendations?

Answer: CCB ash material has been placed under all types of weather conditions. Cool is not as much of an issue as cold. We have had situations where it was so cold that water in the ash would freeze and then you don't get adequate compaction. In this case, we were able to bring CCB ash materials directly from the power plant while it was still hot so that it could be placed and compacted before it had time to cool down and freeze. In cases where the material gets too wet, you again have problems with getting adequate compaction. If this is the case, you may need to shut the job down until the material can dry out or bring fresh dry material in that can be mixed with the material on site so that you can get the optimum density for compaction. Things do go better in the summer.

Regulatory Question: Has your firm actually done some of the risk assessment procedures that you have recommended in your talk including the long term laboratory tests?

Answer: We have not done any of the long term laboratory tests. In the current regulatory environment, we have run the leaching tests based on site specific State recommendations.

Engineering Question: What type of dust control measures do you use'?

Answer: We use water trucks 98 percent of the time. If CCB ash is going to be exposed for a long period of time, we might cover it with bottom ash to prevent the lighter material from being blown around.

Question: Of the fill materials you have used, do you prefer to use CCB ash till or do you prefer some other till material? How would you rank CCB ash as a fill material?

Answer: CCB fly ash compares favorably with many soil materials. There are some soils that you would prefer to work with if they were available. The advantage to CCB fly ash is that it is available in bulk quantity and can reduce or eliminate the cut and fill operation expense. A good example would be that, in Pennsylvania, there is a lot of rock and highway construction which requires a lot of blasting to level the grade and generate the fill materials. If you knew ahead of time you could get 300,000 tons of CCB fly ash, you could avoid all of that blasting. As long as you can build a till that meets the construction design specifications, it does not matter that it is not the ultimate till material. The economic advantage of CCB fly ash is primarily a function of the haul distance from the power plant.

2. Materials handling including dust control Paul Petzrick, Maryland DNR, Annapolis, Maryland

Engineering Question: What was the mixture of CCB material you were using?

Answer: The mixture we used consisted of 60 percent Fluidized Bed Combustion Ash, 20 percent class F fly ash, and 20 percent FGD material. We then added water to get a moisture range of 47 to 53 percent.

3. Design and Management of Coal Combustion Bv-Product Mine Backhaul Placement Areas, Bill Giles, Freeman United Coal Co., Farmersville, Illinois

Industry Question: Do you have any information on transportation of this material by barge and truck?

Answer: I am not aware of any situation where it has been handled with barges. Most of my experience has been with rail transportation and then loaded into haul trucks. It would seem, however that the technology of handling cement could be applied to handling most CCB materials.

4. Planning and Design for CCB Utilization in Abandoned Mined Land Settings: A Case Study John Gasper, ATC Environmental Consultants, Indianapolis, Indiana

Regulatory *Question:* What is the additional cost involved with creating the POZO-TEC product from CCB ash material?

Answer: The product came to us at no cost. The cost was incurred by the power plant. The benefit came from its superior structural properties and its ability to tie up metals. The power plant considered this a good trade off to having an uncontrolled sloppy fill.

Regulatory Question: Could you expand on the relationship of moisture content to design considerations?

Answer #l: As received moisture content varies considerably depending upon whether it is fresh or has been preconditioned. The more reactive CCB ash materials require larger amounts of water in order to get the right compaction characteristics. Class F ash materials do not require as much water as do other ash materials. Some of the physical characteristics change as the material hydrates. Initial hydration causes the material to break down like quick lime. Additional hydration will cause heat to be generated as the lime is converted to slake lime. Moisture will be driven off by the heat, requiring additional water inputs.

Answer #2: Concerning moisture content, it is important to note that at less than 4 percent moisture the

FBC material becomes virtually unworkable. At less than 4 percent moisture the material will suck itself right out of the bucket of a front end loader. Our FBC material would not mix at less than 47 percent moisture. It would not become a homogeneous material. At a moisture content greater than 53 percent, it suddenly became slop. The moisture content is a case by case requirement depending upon the material used and the application.

Question: Does the SGLP test have any disadvantages or costs relative to other tests?

Answer: No.

Question: What material handling methods are used to mix the POZO-TEC material?

Answer: This material is generated by the power plant utilizing hoppers to put the quick lime in the mix. The sludge is blended in belt lines which and is discharged as POZO-TEC in a pile at the end of the belt line.

Question: Is there any way to arrive at a representative unit weight for the material?

Answer: There is no good way. The only thing you can do is measure the in place density.

Academic Question: Dr. Hassett, you pointed out that column leaching experiments should not be considered as a leaching procedure. Could you comment on this?

Answer: When you look at an ash monofill, it is easy to visualize it as a column leaching phenomena that would occur in nature. It probably does not work that way because most of these materials are fairly impermeable. Because of this, water spends a lot of time reacting with the material. A column leaching experiment in the laboratory has a column of material where you run liquids through in order to allow for a collection of leachate at a fairly fast rate of pore volume exchange. This rarely occurs in nature. The other thing that happens is that the results are frequently misinterpreted. The column may be leached with a progression of different pH level fluids, assuming that the results reflect a particular level of acid leaching. Instead, the ash material is reacting with the leaching fluid over a wide range of pH levels. The only way it can be evaluated is to section the column after the experiment and see what is happening mineralogically section by section. Batch leaching experiments give you absolute control over what is happening. You can do a leaching at specific pH levels. You need the data from several batch leaching experiments in order to interpret what is happening in the column concerning pH, concentration, and fluids. Also the rate of fluid flow is so high in most column leaching tests that the mineralogical reactions that occur in the column do not occur in nature. In order to duplicate what would occur in nature you would have to use a rate of one pore volume every 60 to 90 days.

Academic Question: Dr. Bradley Paul is a proponent of column leaching tests. Could **you** provide a response to Dr. Hassett's concerns?

Answer: I would agree with a lot of what Dr. Hassett said about column leaching experiments, particularly in regard to the rate of fluid flow through the column. The ASTM column test has been standardized and dictates that you use a pore volume per day. There are other column experiments where the fluid is allowed to percolate through the column under the influence of gravity and get some of the slower reactions. I like the column leaching experiment rather than the batch experiments because you do not get 20 parts of liquid to one part of solid in the field. Although column leaching is not a perfect simulation of what happens in the field, a properly run column experiment is a much closer simulation of what is happening in the field than a batch leaching experiment. If you want to understand everything that is happening in a column, then you have to have the type of information recommended by Dr. Hassett. The column leaching experiment will give you results that are defensibly close to field conditions. It will not give you every mineralogical detail. The column leaching tests are useful for engineering applications. We have been very successful using open percolation columns without using high rates of water flow in combination with computer simulation to get very accurate predictions of what has occurred in the field.

Question: What is the relative utility of impounded ash versus dry ash material?

Answer #I: In regards to class F fly ash materials, both can be used. Impounded ash may need to be dredged and stockpiled in order to reduce the moisture content. From an environmental point of view, any leachable constituents of the impounded ash may have already leached out prior to placement in a structural fill. We have found that impounded ash material water quality is near drinking water standards. An additional problem with some impounded material is that it may have been codisposed with bottom ash materials where differential settling will take place. This presents problems when you are trying to maintain a uniform quality of material for the fill operation. It is best to handle impounded material when the weather is warm and dry. When using FGD filter cake, the high moisture content can cause it to freeze up in the truck beds during the winter. The practical limit for hauling impounded ash in the winter is 20 degrees Fahrenheit. Otherwise, it freezes in the truck beds. Also, Flue Gas Desulfurization sludge is not a construction material; it is a construction nightmare.

Answer #2: *Our* experience has been that within two days of dredging the impounded material, the water content was low enough that the material can be handled. As a practical guide, we used the observation that if the material pumped out ahead of where you were driving on it, the moisture content was too high. The only way to determine this was actually working with the material.

Question: Could you comment on types of compaction equipment to use in the field?

Answer: Compaction criteria depends upon use. In general, rubber tired equipment works better than tracked equipment, vibratory rollers are the only way, sheep's foot rollers do not work at all. Heavy rollers that can compact to 18 inches are preferable. Light vibratory rollers do not compact more than 12 inches.

Academic Comment: Leaching tests are a dynamic test. In nature, our underground water quality was more in a static condition. When we placed a camera down the bore hole for 400 feet, in order to look at the abandoned underground mine works, we found that the water had stratified in this mine which had been abandoned for 45 years. Whenever the camera would touch something like a mine support timber, it would generate an enormous cloud of sediment. It suggests that hydrologic conditions occurring 400 feet above were not effecting the water in the mine. I think that we need a specific ASTM test developed that would represent this static condition.

Session V: Environment: Land And Water

1. <u>Bituminous Fly Ash Chemical Pronerties and Influence on Water Quality</u> Dr. Bill Evangelou, Agronomy Department, University of Kentucky at Lexington.

Question: Would the acid generated from a normal application of fertilizer on CCB ash be enough to begin leaching the CCB material?

Answer A normal application of fertilizer is usually enough to begin leaching metals from the CCB ash material.

2. <u>Ground Water Quality</u> Dr. Bradley Paul, Mining and Engineering Department, Southern Illinois University at Carbondale

Public Question: What is the potential for the formation of colloids or flocculent from the attenuation of high pH CCB ash and resulting potential toxicity to fish or other aquatic life?

Answer: We did monitor the water at two sites and found no such problems. Although any neutralization of acid mine drainage has the potential to produce chemicals that could be damaging to aquatic life, acid mine drainage by itself is also toxic to aquatic life.

3. Coal Combustion Residues as Soil Amendments: Surface Coal Mining Dr. Ron Korcak, Agricultural Research Service, Beltsville, Maryland

Question: *You* said that calcium sulfite mixed with soil produced sulfur dioxide which is toxic to plants. Before that could happen, wouldn't calcium sulfite when exposed to air convert to calcium sulfate, also called gypsum and is a plant nutrient?

Answer: *If the* CCB material is allowed to mix with air sufficiently, prior to placement in the soil, this is the case. It is only when it has been placed prior to mixing with air that sulfur dioxide is created in the soil. I do not have any data on the rates of conversion, but that data should be available at the ARS office in Beckley, West Virginia.

4. Public Concerns Regarding the Management of Coal Combustion Wastes Tom Fitzgerald, Kentucky Resources Council, Inc., Frankfort, Kentucky.

Academic Comment: *If* people are concerned about radionucleotides in CCB ash materials, a good source of information would be publications by Bob Finkleman of the USGS and a book by Dals Swain called "Trace Elements in Coal." With respect to the Oak Ridge article on the subject, that article is responsible to science what Jeffery Dahlmer was to freedom of expression. In general, a good way to look at radionucleotides is to do a bulk analysis of the CCB ash to determine if there is anything there to leach.

Public Question: What percentage of the coal combustion waste produced in Kentucky is reused?

Answer: Kentucky encourages the beneficial reuse of CCB materials and requires the same sort of material characterization related to environmental concerns as materials that are land filled. Although we don't have any numbers for Kentucky, nationwide we know that about 25 percent of the CCB materials have been reused for the last 10 years.

Public Comment: A recent paper presented to the Indiana Academy of Sciences outlined water quality problems in Grant County, Indiana due to oil and gas drilling over 100 years ago. Current coal mine applications suggest that they will improve the environment by creating a pool of ground water that can be used in the futur. Now the mines are applying for permits to dispose of CCB materials in these same areas. Much of the current discussion concerning CCB disposal on mine sites revolves around what exactly is happening with the chemistry of these materials and what is going to be the water quality situation 1, 5, or 10 years in the future. Are we setting up problems for future generations because of generalizations being made about these materials which may not be true on a site specific basis?

Regulatory Comment: Based on recent conversations with the heads of the Indiana and Kentucky geologic surveys, radionucleotides are not a problem in the Illinois coal basin or in the Kentucky coals.

Industry Question: Dr. Paul could you comment on the use of acid/base accounting to evaluate the application of CCB ash materials to amend an acid mine drainage situation?

Answer # 1: The procedure most frequently used usually evaluates the sulfur and iron of the spoil material, its pyrite content, and its total potential to generate acidity. This is compared with the ability of the carbonates of the mix to neutralize the acidity. Based on this result, it is usually recommended that carbonates be added to achieve a safety factor or 2 units of alkalinity to 1 unit of acidity or sometimes a 4 to 1 safety factor. Application rates derived from this method are not thought to result in situations where acid mine drainage would occur. I have used acid/base accounting when the project involved mixing of CCB materials with mine spoil. I have not used acid/base accounting when I am using the CCB material to provide a an impermeable layer over acid-forming materials.

Answer #2: Acid/base accounting is a perfect test for a CCB ash that has no heavy metals in it. The test will determine how much alkalinity it has and how much surface neutralization it can produce. Many States require you to multiply this amount or potential neutralization capacity by 5 to 20 times to provide an actual application rate for the CCB ash material. However, pH has absolutely nothing to do with the release of a metal like cadmium. The reactions that regulate the release of these metals is more difficult to predict. If you try to use CCBs to neutralize an acid spoil with a lot of iron, the neutralization will cause the iron to be released. If you use CCBs to neutralize an acid spoil without iron, the neutralization will cause the heavy metals in the CCB materials to be released. Acid-base accounting would not be an adequate test if the CCB materials contain heavy metals.

Regulatory Question: Could you comment on the differences between the field results indicated by Dr. Paul's work and the laboratory results of Dr. Evangelou's work?

Answer *#l:* I see no conflict between the work of Dr. Evangelou in the lab and the work we have done in the field. The analysis we performed was very limited because we were only trying to get site specific results. Our analysis, under the pH and environmental conditions of that site, would be in agreement with the results that Dr. Evangelou would get if he made the tests in the lab under the same set of environmental factors. The work of Dr. Evangelou in the lab is doing testing over a full range of pH values and testing in the presence of other salts to see if the metals would desorb under certain conditions. This is very important to a good fundamental chemical analysis. In an applied field study, we are only looking at one set of environmental conditions that would exist unchanged for hundreds of years.

Answer #2: It is very easy for inexperienced people to look at fundamental chemical data and misinterpret it. The lab data and the field data are in agreement. The laboratory tests can tell you what will happen to the CCB ash material after it has had maximum exposure to carbon dioxide. In the field, you have diffusion limitations and barriers. If you see in the field the pH stabilizing at pH 12 and it will take 2 years, it is because the carbon dioxide is not available to react with it. All of this has to be integrated with kinetics. If you put CCB ash materials in soil, soil and CCB ash do not titrate much differently. In fact, soil is not a good buffer. It buffers itself at pH 5 and pH 7. In a Midwestern climate, the farmer must lime every 4 to 6 years and, if he is raising tobacco, every 2 years. The reason is, because the soils do not have any buffering capacity. Most crops need to be grown at a pH of 6. In the same way, CCB ash materials have little buffering capacity and their neutralization ability is quickly exhausted.

Public Question: The environmental concern would be the mobilization of heavy metals from the CCB materials and the movement of these at potentially toxic concentrations in the surrounding water systems. What are the chances that these CCB materials could result in the mobilization of potentially toxic concentrations of heavy metals in off site water systems?

Answer *#I:* During the 1994 legislative session in Kentucky, a representative of TVA indicated that migration off site was not a concern for their ash ponds. When I questioned this point, I was provided with three pages of literature that documented contamination outside of the disposal area. This documentation will be provided as part of the final publication. This literature would suggest that if you have an area that is flooded you may have a problem with contamination versus an area that is high and dry or has an impermeable cap.

Answer #2: If you take any agricultural soil and you put it in a column and start leaching, it will turn acid even though leached with distilled deionized water, Eventually it will start leaching metals such as aluminum. So under these conditions, natural soil itself is toxic. CCB ash material is no different. Some would make that the argument that the soil is a given, you just need to manage it, and the **only** way to manage it is to raise the pH to an acceptable level. Every soil has a unique capacity to store heavy metals. When you add CCB ash materials that contain heavy metals to the soil, in the long run, if you keep adding CCB ash materials or other refuse materials to the soil, you will eventually saturate this capacity and heavy metals will be leached from the soil. Even if the soils are actively managed to maintain an optimum pH of 6.5, continued input of heavy metal containing soil amendments such as CCB materials or sewage sludge will result in the potential for releasing heavy metals.

Answer #3: From an engineering and geological perspective, no mineral, rock, or coal ash will last forever. Eventually everything is going to break down and the elements will be transported via natural forces in the environment. The question is not whether these minerals will be reintroduced into the environment, but the rate at which they are reintroduced. Based on my experience with CCBs from the Illinois coal basin, there are very few metals present in levels that could be toxic. I have found an initial high leaching profile that tapers off very quickly. Whether or not you will get a significant contaminant plume in ground water, is a combination of the concentration level of the contaminant and the duration of the contaminant level. Based on the studies we have performed, we are not generating the type of long duration flush necessary to produce a significant contaminant plume. You also need to consider, that on the mine site, the soils have a lot of attenuation capacity. At one site we did leach boron and molybdenum. Within 15 meters of the disposal site, the boron made it to the monitoring well, the molybdenum did not.

Regulatory Question: *If* I had a the situation as a regulator where I had the current speakers as the experts that would evaluate a permit to dispose of CCB materials on a mine site, I would not have any problem with the speaker's ability to determine the applications suitability. Is the expertise represented by the speakers at the this forum available as a technical guide to regulatory permitters for their use in approving permit applications?

Answer #I: *No* it is not, and that is precisely what needs to be developed. Typically, State regulators dealing with coal mining look at iron, manganese, pH, acidity, alkalinity, and neutralization potential of the overlying strata and will not gather baseline data or characterize that data on the full range of metals that are of concern. These metals are concentrated and more available in the CCB materials and are being placed back in an environment that is more hydrologically accessible and permeable than existed prior to mining. It is my hope that this type of guidance would be a result of the forum because there is a great deal of difference in how each State is managing and characterizing CCBs. Although Dr. Paul's data shows a decrease in metals over time, the situation I have experience with has shown an increase in metals over time. Someone should determine what are the proper tests for each situation. Should the States be using the long term tests advocated by the researchers in North Dakota in conjunction with short term tests? The States are not currently providing these long term tests. In some cases in Illinois, the ground water table will not be restored prior to the end of the 5 year liability period following coal mine reclamation. In this case, ground water contamination may not be detectable at the time of bond release. In this case, a much closer look should be taken of the characterization of the material and the validity of modeling the reestablishment of the hydrologic regime. State regulators are not currently looking at the impact of CCB disposal on the long term impact of surface coal mining to the hydrologic balance of the area.

Answer #2: From an agricultural perspective, I have dealt with a number of waste products including CCBs No matter what type of waste I am dealing with, the first thing I request is a total chemical analysis. I usually look at that analysis as it relates to trace elements that I assume will ultimately be available to the environment. That is what we tried to do in our manual on land application of Fluidized Bed Combustion materials. In these flow diagrams we have maximum loading rates for the different metals. This addresses the concern that, in 100 years, the soil will still be utilizable for agricultural purposes.

Answer #3: There are some CCB ashes that are no problem to use as soil amendments. The question is, when they do show some level of heavy metal concentration, should you use them in a situation where they have the potential to contaminate the water of vegetation. One of the things that should be looked into is the classification of CCB materials. For example, if I have a silica based CCB ash that contains arsenic, I will not put it on an agricultural soil because I know the arsenic will be released. If I had an iron oxide CCB ash with the same amount of arsenic, I would be less hesitant to apply it to an agricultural soil. So far, we have not really addressed these differences in basic CCB chemistry in any systematic way that could be utilized in evaluating their suitability for different environmentally related applications. Our analysis has been based on its content rather than on its reactivity. A lot of work remains in order to classify these materials to determine its suitability for different types of disposal and use.

Regulatory Comment: I would strongly disagree with any type of a checklist mentality in connection with producing a guidance document. Currently, we have a number of States that have developed the guidance for implementing these programs in their State that meets their specific conditions. If we try to develop a checklist for a one size tits all program, we will end up with a very dissatisfied customer base including the citizens that live near the coal mines. We have already seen four or five different how to CCB programs in the U.S. We should not lump these together because of the variety of conditions experienced by the different States. A State like Pennsylvania, with a lot of acid mine drainage, may need to do something very different from a State in the Illinois coal basin that has very little acid mine drainage.

Answer: I don't think anyone here is saying that you should develop a one size fits all type of guidance document or program. There are certain things that should be done in all cases, such as adequate characterization of the CCB material and the fate and transport of that material in the environment. A lot of the questions that should be asked are new to people conducting these types of permit review.

Regulatory Comment: We have been discussing a lot of tests that concern what may or may not be leached by the CCB materials. These are not tests that will tell you whether or not to approve a permit application. In most cases, the question is how to manage the material, which depends upon site specific factors such as climate, hydrogeology, topography, and land use. You have to look at what is in it, where is it going, and how are you going to manage it.

Public Comment: In Indiana, the citizens believe that an adequate evaluation of the fate, transport modeling, and characterization of wastes is not being done. This is not a need for a checklist, but for minimum safeguards that delineate what is required by SMCRA when coal mines are used for disposal areas. This is something that the citizen's feel that the framers of SMCRA did not envision.

Industy Comment: Texas has had a CCB program in place for over 25 years. It covers a lot of the questions that have been asked here. It is a very stringent process that requires a lot of modeling and characterization such as we have been discussing. My experience with our utility that burns 32 million tons of coal per year, is that no contamination has ever left any of the land fills where the CCB materials have been placed. The electric power research institute (EPRI) has spent over $20 million in CCB research that should be accessed in any future work in this area.

Academic Comment: Concerning comments made about regional environmental differences, I would like to give an example. If you took a truck load of CCB ash containing boron to California, and tell a farmer I would like to put this on your field as a boron soil amendment, he will chase you away with a shotgun. This is because he knows that boron will kill his crops. The reason is that there is no rainfall in California. and boron has built up in the soils. At about 2 ppm of boron in the soil water, boron becomes toxic to plants. In the Midwest, however, there is no boron problem in the soils and some soils have boron deficiencies. You have a different problem with heavy metals because they are chemically bound in a reversible fashion. If you have heavy metals in the CCB ash material, then it is very difficult to predict the potential release of these metals into the environment in terms of concentration and under what set of conditions a release would be expected to take place. If the CCB ash material does not contain heavy metals, then this is not a problem, but some do. Someone needs to systematically evaluate the CCB ash characteristics and the environmental conditions under which that material could be expected to exist. For example, if you grow tobacco on CCB ash amended soils and the soil pH drops to 4 every time you fertilize it, then you will flush out any heavy metals in the CCB ash materials. For this reason, research scientists are hesitant to make general recommendations for the agricultural application of CCB ash materials as soil amendments. In order to evaluate its potential usefulness as an agricultural amendment, you would need to know what is in it, where will it be used, what will be grown on it, how will it be managed, and what are the long term consequences of this application.

Public Comment: We do not feel than an adequate risk assessment of disposal of CCBs at surface coal mines has been demonstrated. The Federal and State regulators need to develop definite regulatory criteria for CCB disposal to adequately protectwater resources and water users from contamination.

Session VI: Monitoring And Evaluation

1. Coal Combustion By-Products and Contaminant Transport in Ground Water Edward Mehnert, Illinois State Geological Survey, Urbana, Illinois

No questions.

2. Geochemical Modeling & Impact Assessment Dr. Gary Dreher, Illinois State Geological Survey, Urbana. Illinois

Academic Question: One of the limitations of these models is the use of them by amateurs. These models assume that you have physical mixtures of crystals. But if you wet a heterogenous mass of crystals and then dry them and run the model again, that model will have lost all of its ability to predict anything because the minerals have become mixtures of minerals and the delta "gs" have changed. That is a big limitation for these models.

Answer: I agree. Models are not for the amateur. You have to know a lot of chemistry and mineralogy before you can use it or understand what it is telling you.

Academic Question: The models that you have talked about are based on natural systems. None of the models that I am aware of take into account things that happen in alkaline CCB material. This would include the formation of ettruigite monophase and subsequent formation of tomasite, all of which decompose into very sorptive materials like aluminum oxide hydroxides. These kind of phases are responsible for the solution chemistry and concentrations of arsenic, boron, chrome, molybdenum, selenium, sulfur, and vanadium. Do you know if anyone is trying that data inputted into these models? Also when you look at CCB ash material, this is composed of 60 to 80 percent amorphous material that is not crystalline. I don't think we know anything about how these amorphous materials behave in solution. Is anything being done to adjust the models accordingly so they will work with CCB ash materials?

Answer: These models are limited to crystalline phases and will not work with amorphous materials. I do not know of any work to solve that problem. You have a problem in the lack of thermodynamic data and a lack of defined mineralogy.

3. Instrumentation Dr. Steve Esling, Geology Department, Southern Illinois University at

Regulator?/ Question: Did you use a neutron meter? It is able to go to much greater depths.

Answer: That is a useful instrument for monitoring volumetric moisture content, but it requires a licensed operator that we did not have. Neutron meters can take readings in a bore hole that is already cased. The time domain reflectometer we used becomes impractical below a depth of one meter.

Academic Comment: These systems are great for collecting water samples but they have great limitations for analysis of water solutions. One of the problems in analyzing alkaline environments is the partial pressure of carbon dioxide. A man named Suarez at the Selenium Laboratory of the Federal Station of the University of Riverside in California has developed an instrument that can be used to maintain a constant partial pressure of carbon dioxide while removing solutions.

Public Question: Could you comment on what an appropriate positioning of monitoring wells relative to a CCB material disposal sites, the length of time for monitoring once an equilibrium has been achieved, and how long a time that might be?
Answer: At one site, we finally got a boron reading in a down gradient monitoring well 15 meters from the disposal site. There was a significant attenuation from 100 parts per million in the disposal site to 10 ppm at the monitoring site. At this point, I do not think we have seen the concentration of boron peak yet at this site. We are just seeing the outer edge of the plume coming through. The movement through these CCB materials and the mine spoil is very slow. We have monitoring wells no more than 15 meters from the disposal site where it took a year for the water from the disposal site to reach the well. The modeling would suggest that we may have to wait much longer to see the maximum concentration of pollutants that would occur at that monitoring well. It depends upon what the overall hydrologic conductivity of the material is. I would recommend that a couple of down gradient monitoring wells be placed as close to the disposal area as possible. It will be years before you pick up anything in monitoring wells 20 to 40 meters from the disposal site. You need to have monitoring wells at several distances down gradient. The only way you will ever be able to figure out the porosity is to be able to take readings in more than one monitoring well. Although research with CCBs has been occurring for some time, one thing that is still missing is good field data due to the length of time necessary to get good data.

Public Comment: A concern for citizens is that we are not finding, in permit applications, information on what the effects of CCB disposal will be to the down gradient water quality after the mine site reaches a hydrologic equilibrium. Because of the extent of mine dewatering that occurs during mining, there is a cone of depression that will take years to reach equilibrium. In the permit applications, there is no information as to the time when hydrologic equilibrium will be reached and when the monitoring wells will be providing information on potential contaminant concentrations from the disposal sites. In the Illinois coal basin, there seems to be agreement from all parties that the reclamation bond can be released prior to ever getting an actual reading of potential pollutant levels from monitoring wells installed down gradient from CCB disposal areas. Although monitoring wells can be located in the CCB ash materials directly, we do not believe that this data is representative of what will occur down gradient or ultimately off site from the disposal and mine site.

Academic Question: If there are as many required assumptions in modeling as you have suggested, what is the point of modeling?

Answer # 1: The model should bracket the problem and suggest what you might see in a field situation. In terms of a mine situation in Indiana, where they are pumping out a lot of ground water, I can assume a water level in the mine and based on the geology put in a hydrologic conductivity value and give you a quick number like 5 years. If you give me better (more site specific) information, we will conduct field testing, I use "MOD FLOW," I put in a layered situation, I add some more complexity to the model, and I may be able to tell you that it will be 3.5 years. If we determine that fractured flow is occurring rather than porous flow then we could use a model for that.

Answer #2: In the case of chemical equilibrium modeling, we are at the state of the art. The next step is chemical kinetics, which is a big step. There is not a lot of data available for the kinds of things we need to look at. A chemical kinetics model (if and when it is developed) would be a lot more realistic because it would not have to assume a chemical equilibrium.

Academic Question: In the laboratory, I am trying to study as many ions together as possible in order to see how they behave in the presence of other ions. For example, you take a simple ion like potassium and you can estimate a constant rate of diffusion. Then you add ammonium and that estimate is no longer valid. If you add another more reactive ion, such as calcium, the estimate of the constant rate of diffusion is lost altogether. Based on this, I question the monitoring of 20 ions simultaneously. Some of these are potentially determining ions that modify surfaces. In this case, you would need 10 times as many differential equations on the chemical component as you would on the transport component. In essence, the water transport component is very simple by comparison. The chemistry component becomes almost non solvable in the sense that it would any way be realistic. Trying to look at arsenic and iron together would be au impossibility.

Answer: There are going to be some things that are nearly impossible to model. There are models available that link ground water flow with equilibrium chemistry but you do need the constants. Research has been put together to look at some of the important ones but perhaps not for CCB materials.

Session VII: **Case Studies**

1. Engineering Design of the Injection of Alkaline CCB to Abate AMD Paul Petzrick, Maryland Department of Natural Resources Power Plant Assessment Division, Annapolis, Maryland

No questions.

2. Fluid Placement of Fixated Scrubber Sludge to Reduce Surface Subsidence and to Abate Acid Mine Drainage in Abandoned Underground Coal Mines R. James Meiers, Indianapolis Power and Light, Indiana

Engineering Question: How did you determine how much grout to put in each hole?

Answer: We would experience high pressure. While we were injecting in one bore hole, the material would flow out and fill a room, then the pressure would build up as the room filled. The pressure would go up to 300 to 400 psi and then drop off to 0 psi. What had occurred was the grout had now started flowing into another room. We shut down when we were maintaining 500 to 600 psi.

Regulatory Question: You stated that you were doing this for subsidence control. Are you conducting monitoring for subsidence for more than 1 year?

Answer: Based on the compressive strengths that have been met and the documentation on the amount of void that has been tilled, the contractor has assumed that the subsidence has been eliminated in this area. One hundred psi should be more than adequate strength to reduce subsidence. The ground water monitoring is also over and these are the final results.

Academic Question: You stated that the CCB material was produced from an inhibited oxygen cycle. From that, I assume that it was placed as sulfite rather than sulfate. However, most of your ground water monitoring was for sulfate. Did you do any sulfite monitoring?

Answer: The leachate testing we did conduct found that the material leached sulfate not sulfite.

3. Use of Stabilized FGD Material for Reclamation of Acidic Mine Lands Shan Mafi, American Electric Power, Columbus, Ohio

Academic Comment: Your work has shown that alkalinity plays a major role in controlling the apparent production of acid mine drainage. Considering what we understand about the process that drives pyrite osidation, just because acid mine drainage is not currently occurring as a result of you treatment, that does not mean that you have turned off the pyrite oxidation mechanism. If you look at the pyrite osidation processes, you find that at pH 3 oxidation increases because of microbial oxidation and at pH 5 oxidation declines and as the hydroxide increases the pyrite oxidation increases. When the bicarbonate increases, the oxidation of pyrite doubles. You will not see this in your data because you have 1500 ppm sulfate. That tells me you are dealing with gypsum. What you are observing is the solubility of gypsum going into your water. All of these reactions are surface driven reactions. Eventually you may find, in 10 to 20 years or so, that you will have to treat the area again because all of you alkalinity has been coated with iron oxides. This means that the performance of your system may decline over time.

Answer: We are going to continue to monitor the pond as long as it exists because Ohio DNR has plans to continue using FBC materials for reclamation and will receive an impermeable cap within the next year. Our plan was to stop the acid mine drainage as a result of the surface water. I think that by placing a cap with this type of permeability we have been able to do that. What we have not been able to do is stop the acid mine drainage that may result from exposure to ground water. If we stop the recharge from the surface, we expect decreasing levels of oxidation and a lowering of the ground water table with time.

Engineering Question: What advantage was gained by adding cement kiln dust?

Answer: We added lime kiln dust to increase the strength of the FGD material. If you increased the strength to around 400 psi and exposed it to the elements, then freeze thaw action would not impact it. For the pond liner and the channel we wanted to increase the strength. Lime kiln dust was the most economical option for achieving this strength requirement.

4. Characterizing Ash Comnosition and (versus) Projecting Environmental Impacts for Purposes of Permitting CCB Disposal: Two Annroaches Chuck Norris, Geo/Hydro Inc., Denver, CO

Industy Question: Although there are 10 to 15 monitoring wells at the Prides Creek site in the Midwest, looking at your study area in New Mexico you did not install one monitoring well even though there may be perched water tables or intermittent ground water in the area. Concerning your call for responsibility in site characterization, there was no attempt to obtain permeabilities or porosities in the study that you ran. Not even the climatological data was from the site. This seems contradictory to me.

Answer: The mine in New Mexico involves' the mining of a ridge between two drainages and all of the mining is to occur above the drainages. There had not been any ground water found as a part of all of the exploration drilling on the site. The closest ground water where the company was able to construct a well was 2 to 2.5 miles away. There just isn't any ground water on the ridge in the premining condition that would permit sampling. This is why we conducted leaching of the spoil material in order to establish that any ground water that occurred on the ridge after mining would be similar to the ground water we found a couple of miles away. There was no known premining ground water on the site. The climatological data that was available was used. You don't have 20 to 30 years of weather data in the Raton basin. So you use the closest weather data that is available.

5. Baker Soil Test Development and Field Case Studies ProvideTheory and Data Showing that Plants don't Grow in Soils, Dale E. Baker, Land Management Decisions, Inc. State College, Pennsylvania

Academic Question: At the beginning of your talk, you pointed out that looks can be deceiving by showing a slide where everything looked well but you stated that there were deficiencies. At the end of your presentation you showed us sites where plants grew well when you amended all of these materials with sludge. But then you didn't show us the nutrient content of the plants growing on these sites.

Answer: We have analyzed them and the nutrient content is as it should be.

Industry Question: Could you address how the Baker Soil Test is used for heavy metals?

Answer: The Baker soil test uses a complexer that mimics soil adsorption properties so that I could characterize it with constants. The chelator diethylamine, triamine, pentaacetic acid (DTPA) was chosen for doing that. This reflects the adsorption properties of the soil.

6. Leachate Quality from Coarse Coal Refuse Mixed with Coal Fly Ash: Effects of Ash Blending Rates
Dr. Barry R. Stewart, Virginia Tech CSES, Blacksburg, Virginia

No questions.

APPENDIX 3: RESULTS OF WORK GROUPS

The following comments were the products of small work groups of 15 to 20 people based on interest and experience. The discussions reflect the thinking of people in the groups at the time of the forum but may not represent any particular consensus or plan of action.

Session I: Coal Combustion By-Product Characterization

A summary of the discussion of the group was as follows:

The TCLP test probably should not be used to characterize CCB ash materials for disposal on surface coal mines. The synthetic ground water leaching procedure appears to be a better procedure for predicting what will come out of CCB materials under a surface coal mining situation. The critical aspect of that test is that we need to understand the ground water system at the site and be correlated properly to the test. This procedure requires long term (60 day) leaching. It is important that tests be conducted for a long period of time because of the changes these materials undergo.

If the leachate products released by the synthetic ground water leaching procedure exceed the RCRA standards, then that CCB material should probably not be disposed of on surface mines.

If we do use SGLP, it is probably as good as most of the other overburden tests that we use such as acid/base accounting, ammonium bicarbonate, DTPA, and total element analysis in predicting water quality.

Session II: Site Characterization

The main concerns discussed were related to hydrology.

The preconditions for the permit sites should be characterized when the original permit is being prepared. If they are not, any right to dispose of CCB's should be forfeited.

There was a great concern with the long-term effects to the groundwater.
There was a desire to have the precondition site characterization information made more readily available to the public.

There was an interest about what strata or zones had to be identified in the site characterization.

One of the participants would like to see water tested by specific strata or zones.
Another felt tbat the existing water testing method was appropriate.

There was an interest about how long the water quality should be tested.

One of the participants would like the water quality tested for at least nine months throughout three different seasons.
Six months is the minimum time required for testing water quality.

A possible solution for the concerns is to have interaction between all the different communities involved with the hope of arriving at a resolution.

Session III: Regulatory Requirements

No conclusions were arrived at by the work group. A list of issues that were developed by the work group is as follows:

- The role of SMCRA concerning waste disposal on the mine site.
- Regulatory uncertainty
- Duplicative regulations
- Utility deregulation
- Public participation
- Bonding authority
- Interstate trausfer
- Recycling barriers
- Federal regulatory standards for both permitting and performance
- Ground water monitoring and trigger levels for recycling and disposal
- Waste characterization
- Clarify the difference between coal combustion waste (CCW) and coal combustion by-product (CCB)
- Cofueling
- Risk/cost benefit analysis

Session IV: Design/Engineering/Planning

The discussion was subdivided under four categories: 1) Planning including sampling, site characterization, site planning; 2) designing the utilization project; 3) materials handling; and 4) post placement studies.

<u>Planning:</u>

1. Planning must be site specific for the specific CCBs to be utilized or managed.
2. Meaningful leaching tests need to be developed to assess the field leaching potential of the CCBs. The use of TCLP for leaching tests is counterproductive to the beneficial use of CCBs.
3. Sampling protocols based on observed variability and for different management options need to be developed.
4. Develop simple field tests to indicate the variability of CCBs. This work is currently being done at SIUC.

Items number 2 and 3 should be developed with in the next couple of years. In order to do item number 3 we need to develop a database on the variability of engineering and environmental characteristics of CCBs Some work has been done by EPRI. This information should be collected, synthesized, and used to develop the initial sampling protocols.

<u>Site Characterization:</u>

The process is very site specific. Controlled performance experiments to account for host geology, geochemistry, and hydrology must be done. The results of the leaching tests are not in agreement with what we are experiencing in the field. We should also be collecting more data on the field environmental impacts on ongoing projects. Develop predictive empirical models that can be used by industry in the near term.

<u>Site Planning</u>:

We need to establish the relationships between CCBs placement location and ground water resource location. Should CCBs be placed above or below the water table? This should be a high priority in order to provide a higher level of comfort to the regulatory agencies. We need to study the short and long term hydrologic conductivities of the environments where CCBs are placed. Management of CCBs needs to be an integral part of the process. Interaction between CCBs and the environment need to be considered.

Design of the uroiect area:

The structural stability issues are the most critical. We need to know how applicable existing technologies are to CCBs management. What are the appropriate tests that need to be conducted. What are the appropriate stability analysis tests? Long term durability studies are very important. Liquefaction potential tests should be used in seismically active areas. The beneficial use of CCBs is at a disadvantage because of the regulated nature of surface coal mines.

Materials Handling:

Dust control is the most import issue. Occupational health and safety associated with handling the materials. Cost effective back haul transport system. Can we come up with less expensive ways of mixing than pug mills. Identify more efficient compaction equipment. What are more efficient ways for preconditioning FBC by-products?

Post placement studies:

We need to establish minimum requirements for cover around structural fills and embankments so that vegetation can be established.

What are the mineralogical changes in CCBs when managed in the near surface materials?

What is the trace element take up by vegetation, and can we establish vegetation for the long term?

What are the near term and long term changes in engineering and hydrologic properties of CCBs?

Session V: Environment: Land And Water

The results of this discussion focused on five main issues or concerns as follows:

Agriculture:

What are the long term effects of repeated applications of CCBs as a soil amendment, especially as it relates to biological accumulators such as selenium?

Hydrology:

We need better information on the adequacy of monitoring wells and modeling efforts to predict the long term effects to water supply. What is the role of monitoring data to ultimate bond or liability release? What would constitute appropriate mitigation of potential contamination?

Guidance for surface mining permit review and approval:

What is the best science available for evaluation of CCB disposal or beneficial use at the mine site? Could such guidance be developed to account for most differences related to differing types of CCB materials, climate, hydro geologic environments; and disposal method

Acidic spoil treatment:

What are the long term effects of: (1) the injection of CCB materials into underground mines, (2) its use as a liming agent for acidic spoil; or (3) its use as a clay cap in connection with acidic spoils?

Communication with the public:

What are the best methods for communicating the results of CCB technical information that would indicate that disposal can be done safely and that beneficial use is to be promoted?

Session VI: Monitoring And Evaluation

No two CCB materials are alike and no two CCB disposal sites are alike.

CCB materials suitable for one application may not be suitable for others.

A classification system that would rate application suitability is needed.

Soil properties of the CCB materials need to be evaluated as well as the geochemical properties. This should be compared to a similar evaluation of the native soils at the site.

Reasons for monitoring in the vadose zone are: (1) early detection of problems when these materials are used for impermeable liners or caps for evidence of failure; (2) monitoring the effects of the material on soil water, (3) data collected in the vadose zone can assist in improving existing empirical models.

Are we paying enough attention to surface water monitoring?

Where should monitoring wells be located? The needs of researchers are different from that of regulators. Should you use long screens or short screens? Are you trying to determine three dimensional flow and delivery of a particular contaminant at a particular point in your flow system? Are you just trying to gather contaminant information in general?

How far should monitoring wells be located from disposal sites? This information currently exists. You can use the literature values for the material properties of the soils and regional data on ground water gradients. This should give you a reasonably good estimate of how far monitoring wells need to be located in order to detect contamination in a reasonable time or prior to bond release.

How long do you need monitoring?

If you are monitoring, how do you determine that contamination has occurred? We need to get involved with newer US EPA statistics for evaluating down gradient contamination.

We need to do post audits of monitoring sites where models have been used to verify model results in the field.

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